BMC MINERALS (NO.1) LTD

KUDZ ZE KAYAH PROJECT

RESPONSE TO YESAB EXECUTIVE COMMITTEE ADEQUACY REVIEW OF KZK

PROJECT PROPOSAL

July 2017

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Acronym	Definition
ABM	A. B. Mawer
AEG	Alexco Environmental Group
AET	Actual Evapotranspiration
AQ	Air Quality
ARD	Acid Rock Drainage
ARMP	Aquatic Resources Monitoring Plan
ARSD	Alberta Sustainable Resource Development
ASCE	American Society of Civil Engineers
BBS	Breeding Bird Survey
BCMOE	British Columbia Ministry of Environment
CAAQS	Canadian Ambient Air Quality Standards
CAC	Criteria Air Contaminants
CCME	Canadian Council of Ministers of the Environment
CNG	Compressed Natural Gas
COPC	Constituents of Potential Concern
COPI	Constituents of Potential Interest
COSEWIC	Committee on the Status of Endangered Wildlife in Canada
CPUE	Catch per Unit Effort
CRCP	Conceptual Reclamation and *Closure Plan*
CWTS	Constructed Wetland Treatment Systems
DEM	Digital elevation model
DFO	Fisheries and Oceans Canada
DO	Dissolved Oxygen
EAP	Employee Assistance Program
ECCC	Environment and Climate Change Canada
EEM	Environmental Effects Monitoring
EQS	Effluent Quality Standards
ERCB	Alberta Energy Resources Conservation Board
FAA	Fisheries Act Authorization
FCH	Finlayson Caribou Herd
FHCP	Fish Habitat Compensation Plan
FIFO	Fly-in, Fly-out
FMEA	Failure Modes Effects Analyses
FOP	Fisheries Offsetting Plan
GHG	Greenhouse Gas Emissions
GIS	Geographical Information System

Acronym	**Definition**
GPS	Global Positioning System
GSI	Geological Strength Index
HDPE	High Density Polyethylene
HPW	Government of the Yukon Highways and Public Works
HRIA	Heritage Resource Impact Assessment
HRMP	Heritage Resource Management Plan
HSERP	Health, Safety and Emergency Response Plan
HSI	Habitat Suitability Index
IMO	International Maritime Organization
INAC	Indigenous and Northern Affairs Canada
IUCN	International Union for Conservation of Nature
KZK	Kudz Ze Kayah
LFN	Liard First Nation
LMB	Land Management Branch.
LNG	Liquified Natural Gas
LSA	Local Study Area
LWMP	Lower Water Management Pond
MMER	Metal Mining Effluent Regulations
MOE	Ministry of Environment
MPERG	Mining and Petroleum Environmental Research Group
MRB	Mineral Resources Branch
NAG	Net Acid Generation
NIR	National Inventory Report
NP	Neutralization Potential
OEM	Original Equipment Manufacturer
ORP	Oxidation Reduction Potential
PAG	Potentially Acid Generating
PEM	Predictive Ecosystem Map
PET	Potential Evapotranspiration
PFS	Pre-feasibility Study
PQRA	Preliminary Quantitative Risk Assessment
PWQO	Preliminary Water Quality Objective
QML	Quartz Mining Licence
RCH	Robert Campbell Highway
RCP	Reclamation and Closure Plan
RMR	Rock Mass Rating
RQD	Rock Quality Designation
RRDC	Ross River Dena Council

Acronym	Definition
RSA	Regional Study Area
SARA	Species at Risk Act
SEPA	Socio-economic Participation Agreement
SSE	Senior Site Executive
SSWQO	Site-Specific Water Quality Objective
SWMP	Surface Water Management Plan
TEM	Terrestrial Ecosystem Map
TOC	Total Organic Carbon
TPM	Total Particulate Matter
TSP	Total Suspended Particles
TSS	Total Suspended Solids
USGS	United States Geological Survey
UTM	Universal Transverse Mercator
VEC	Valued Ecosystem Component
VOC	Volatile Organic Compounds
WKA	Wildlife Key Areas
WMP	Water Management Plan
WPP	Wildlife Protection Plan
WQO	Water Quality Objectives
WSC	Regional Water Survey of Canada
WSF	Waste Rock Storage Facility
WTP	Water Treatment Plant
WUL	Water Use Licence
YG	Yukon Government
YAAQS	Yukon Ambient Air Quality Standards
YBGO	Yukon Big Game Outfitters
YCDC	Yukon Conservation Data Centre
YESAA	Yukon Environmental and Socio-economic Assessment Act
YESAB	Yukon Environmental and Socio-economic Assessment Board
ZOI	Zone of Influence

1 INTRODUCTION

BMC Minerals (No.1) Ltd has submitted the Kudz Ze Kayah Project Proposal to the Yukon Environmental and Socio-economic Assessment Board (YESAB) for adequacy review.

In order for YESAB to determine the adequacy of the proposal, they have requested further information and clarification regarding certain aspects of the proposal. As indicated in correspondence of March17, 2017, BMC Minerals has committed to the submission of supplementary information without delay. For clarity and ease of understanding BMC Minerals have listed the responses to each request with the same numbering adopted by YESAB which follow the headings as the chapters in the Project Proposal.

The YESAB Executive Committee has also identified information that does not require a response from BMC Minerals for the purposes of the adequacy review. BMC will endeavour to review this information during the Seeking Views and Information Stage.

2 FIRST NATIONS AND COMMUNITY CONSULTATION

YESAB ISSUE

Yukon Big Game Outfitters and holders of trapline concessions are listed as Tier 1 and 2 stakeholders, but it is not clear from the consultation record how they have been included.

Other tourism operators exist in the project area, and it is not clear whether they have been contacted for their views. The Tourism Industry Association of the Yukon can be used to ensure that all tourism operators are consulted on the Project.

R1

"Provide an updated effects assessment to understand how project activities may effect outfitters, tourism operators and trapline concession holders and possible mitigation measures and alternatives."

As described in Chapter 15 of the Project Proposal, the Project is within outfitting concession number 20, which is held by Yukon Big Game Outfitters, owned and operated by [Name Redacted] The Project Proposal is also within two registered trapline concessions; a single trapline concession #250 held by [Name Redacted] , and a group trap line concession #405 held by the RRDC.

There are no known tourism operators that operate within the local Project area; however, in the regional area north of the Project, both Inconnu Lodge and Frances Lake Lodge offer fishing and a variety of other experiences to their clients. Given the distance of these operators from the Project activities, no effects are predicted.

BMC has considered the potential of flights for crew changes affecting these tourism operations and assessed these will not overlap with the lodges. Similarly, there are no water quality effects predicted in the regional area where the lodges are located. Notwithstanding, BMC will update its Consultation and Engagement Plan to include Inconnu Lodge and Frances Lake Lodge; such that if concerns are raised by these parties, BMC can work with the lodge owners to resolve the concerns.

The following provides the requested assessment of effects for outfitters and trapline concession holders.

Guide Outfitters

Yukon Big Game Outfitters (YBGO) is owned by [Name Redacted] . BMC has had numerous discussions with [Name Redacted] since the purchase of the Project and has developed a good working relationship with [Name Redacted] through work at the Kudz Ze Kayah exploration project as well as BMC's other mineral claims in the region. Through this working relationship, BMC and YBGO regularly update one another on each party's planned activities in the area to determine overlap of activities, working together on minimizing potential effects. The most recent discussion was on June

19th, 2017. BMC will continue to communicate openly with [Name Redacted] and provide regular updates on our proposed plans for development at KZK. Consequently, no significant effects are predicted.

Note that the discussions, relevant action items, and commitments to YBGO have been and will continue to be recorded in BMC's communications log. However, for the purposes of the Project Proposal the consultation information included was based on guidance provided by YESAB technical staff and followed YESAB's draft "Proponents Guide for Consultation", which specifies that the consultation presented in the Project Proposal is to include consultation with Communities and First Nations. Therefore, the consultation with the various other stakeholders and interested parties was not included in the Application (as it is not required under the *Environmental Assessment Act* or the draft guidelines).

Traplines

Section 15.5.1 of the Project Proposal includes an assessment on potential Project effects to Traditional Economic Activities (including trapping). This information is re-iterated, with minor clarifications, as follows:

Effects Characterization

Traditional economic activities, hunting, fishing, gathering, and trapping, form an important part of life for both Kaska citizens and non-First Nation Yukoners. They are particularly important to the RRDC, the LFN, the traditional land stewards of the area, and the Ross River group trappers. Environment Yukon also has an interest through its responsibilities and activities connected to hunting, fishing, and trapping throughout Yukon.

The construction and operations of the Project is likely to have a number of effects on traditional economic activities, particularly hunting and trapping. Potential effects include:

- Improved access to an area through improved maintenance of existing roads can make pursuing traditional economic activities, such as hunting, easier for local people, both Kaska citizens and non-First Nation;
- Increased ease of access, however, can also lead to increased hunting pressures from people outside the region and thereby limit the ability of local residents to continue these activities;
- Increased traffic and industrial activity in the region may act to deter wildlife from frequenting the immediate site and along the road corridors to the Project. The Finlayson Caribou Heard is of special concern in this context (potential effects to wildlife from increased traffic both on and off site are assessed in Chapter 13);
- If Project employees hunt in the region, they play a role in increasing hunting pressures and possibly reducing traditional economic activities; and
- Opportunities to pursue traditional economic activities are reduced in proportion the amount of time spent in the paid labour force.

For Kaska citizens, trapping is not just an effort to earn part of an individual's income. It also plays an important role in continuing the individual and collective connection to, and stewardship of, the land. Therefore, the value of trapping is not just the dollar value of the fur harvested. Although there is no access to the harvest data for the region around the Project or for the traplines (RTC 405 and 250), trapping harvest data collected for other projects shows a pattern of wide annual variations in harvest levels (for example, data from the Ketza River Project). The variation in harvest is likely the result of a combination of factors: variation in animal populations (especially lynx, as they go through their population cycle), variation in fur prices, and varying levels of trapping effort for other reasons including the traditional management practice of ceasing trapping in an area for several years to allow populations to recover.

For the Kaska there is an ongoing tension around access to the land, especially for hunting in Kaska Traditional Territory. A recent example is the lawsuit by the RRDC for YG to consult with the RRDC before issuing hunting licences that allow non-Kaska people to hunt in their Traditional Territory. Partially underlying that tension is the traditional approach to shifting the focus of activities and land use in response to environmental changes within an overall structure of traditional land stewardship practiced by different extended families over different areas. The development and operation of the Faro mine from the 1960s through to the late 1990s caused a general shift in land use and traditional activities away from Faro and to the east and south, including the area around the Project (Appendix F-3 of the Project Proposal).

Mitigation Measures

BMC will be implementing several mitigation measures to reduce any adverse effects of the Project on traditional economic activities, including:

- All firearms on the Company's mineral claims and in particular on the Proposal Site are currently and will continue to be prohibited unless otherwise authorized by BMC management (Appendix A-8 of the Project proposal);
- All hunting of wildlife by any method by employees, contractors and visitors to the company's sites are strictly prohibited, as outlined in the No Firearms Policy (Appendix A-8 of the Project Proposal); this policy will continue to be communicated to all employees and contractors during the site orientation and is strictly enforced;
- Recreational use of all-terrain vehicles (ATVs) and snowmobiles are prohibited (Appendix A-11 of the Project proposal);
- Access and use of the Tote Road has been strictly controlled since the 1990s and there will be ongoing access control to the mine site, as per the requirements of the Tote Road Licence. Use of the Access Road during Project operations to access recreational areas for ATV and snowmobile use will be strictly prohibited;
- Implementation of the Traffic and Access Management Plan (see Section 18.12 of the Project Proposal) will mitigate the adverse effect of increased traffic on area wildlife; and
- As part of the Socio-economic Participation Agreement (SEPA) BMC has agreed to pay a land use interruption supplement to mitigate the effects of the Project on the RRDC

citizens who hold trapping rights under the registered group trapline, and operated trap lines within the Project area. BMC has also initiated discussions with the trapline owners of Trapline concession 250 in order to reach commercial agreement on the payment of land use interruption payments once the mine construction and operation commences.

The application of mitigation measures is expected to result in no residual effects to increased access and employee hunting, as a component of traditional economic activities.

Increased traffic and activity along the Robert Campbell Highway, even with mitigation in place, is predicted to have a low adverse residual effect.

BMC has agreed to pay a land use interruption supplement to mitigate the effects of the Project on the RRDC citizens who hold trapping rights under the registered group trapline, and operated trap lines within the Project area, and a low adverse residual effect is predicted.

Residual Effects and Significance Determination

The increased traffic and industrial activity caused by the Project in the region may act to encourage wildlife to avoid the immediate project area of influence. This adverse effect has a likely probability of occurrence but is reversible in the short term and the magnitude is low. It is assessed to be not significant.

The Project is likely to cause some disruption and loss of access in relation to traditional economic activities; however, magnitude is low, community resilience is high to this form of change and it is reversible in the short term. The effect is assessed to be not significant.

Note that BMC regularly updates RRDC regarding the group trapline and BMC's plans and activities taking place in their traditional territory. BMC has also been in preliminary discussions with the other trappers and will ensure to engage with them well in advance and prior to any activities taking place over their trapline area, such that if concerns are raised by these trappers, BMC will work with them to resolve the concerns.

3 PROJECT LOCATION

No information required.

4 PROJECT DESCRIPTION

4.1 PERMAFROST AND STABILITY

YESAB ISSUE

According to Appendix C-4, permafrost was not encountered in the test pits or observed in the thermistors within the footprint of the Class A facility. The sampling indicates that there may be permafrost at the site. However, given the reported depth to bedrock is 2.5 m to 5 m, the potential implications of future thaw settlement may be low even if permafrost is present. In the conclusions section of Appendix C-6, it is stated that the presence of permafrost within the facility footprints should be re-assessed once the installed thermistors reach equilibrium with ground temperatures and all logged data is collected.

R2

"Provide an analysis of thermistor data. Based on this analysis, verify the conclusion that permafrost is absent under the storage facilities. If this conclusion cannot be verified from available data, describe the potential effects of permafrost being present under the storage facilities and possible mitigation."

Appendix C-4 of the Project Proposal refers to the Class A Waste Storage Facility and Appendix C-6 of the Project Proposal refers to the Class B, C and Overburden Storage Facilities Stability Assessment and Design letter. The appendices include a discussion of the potential effects of permafrost if it were present.

Conservative, preliminary soil strength parameters were used in stability modelling of all the facilities. The geotechnical conditions beneath the Class A, B, C Waste Storage and Overburden Storage Facilities will be further investigated in the 2017 Site Investigation, and design, seepage and stability assessments will be updated accordingly during detailed design.

Note that the current design of the Class A Waste Storage Facility includes removal of all unsuitable material beneath the facility, and removal of all overburden material underneath the buttress.

R3

"Regarding Section 3.3 of Appendix C-3, were the thermistors installed in the winter of 2016 (i.e., February) or in the summer of 2016?"

Five thermistors were installed in February 2016 and nine were installed in the summer of 2016. The 2016 Site Investigation report was issued in December 16, 2016, incorporating thermistor data recorded between July and September 2016. Thermistor data from the site was downloaded in May 2017 and is included as **Appendix 1** to this Response Report.

R4

"Section 4.3 of Appendix C-3 stated that none of the thermistors installed in the Class A Facility indicate freezing conditions in their data records. Why were freezing conditions not found in winter at the ground surface as would normally be expected?"

The thermistors in the Class A Waste Storage Facility were installed in the summer of 2016 and at the time of reporting had not recorded temperatures through a winter season, as noted in R3. Data is now available through the winter of 2016/2017, with site-wide data downloaded in May 2017. This new data is included in **Appendix 1** of this Response Report**.** Near freezing temperatures have been recorded at or very close to surface in the Class A Waste Storage Facility during winter, but there is no evidence of frozen ground below the active layer.

For completeness, thermistor data from the Class A Waste Storage Facility is included in Figure 4-1to Figure 4-3, demonstrating that freezing conditions were not recorded. Analysis and interpretation of this data will be included in the planned 2017 Site Investigation report.

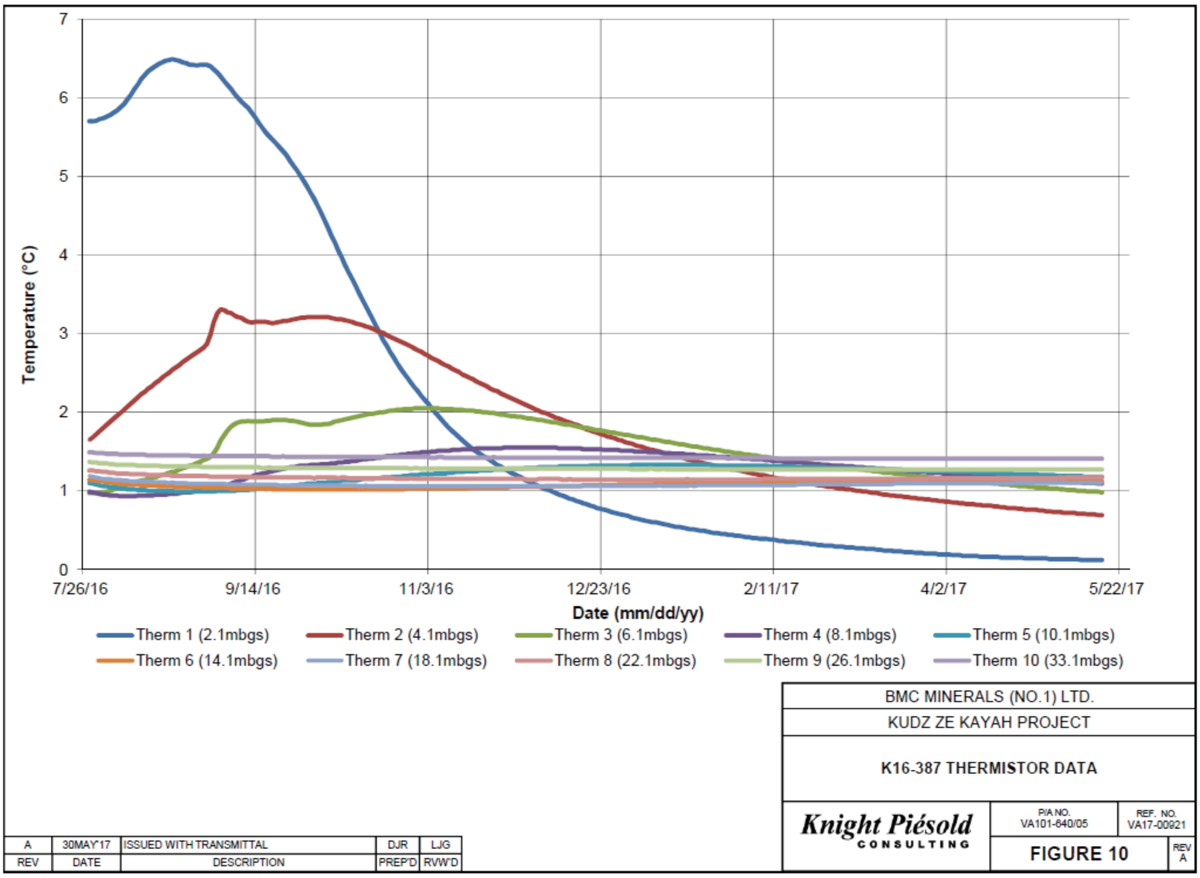


Figure 4-1: K16-387 Thermistor Data

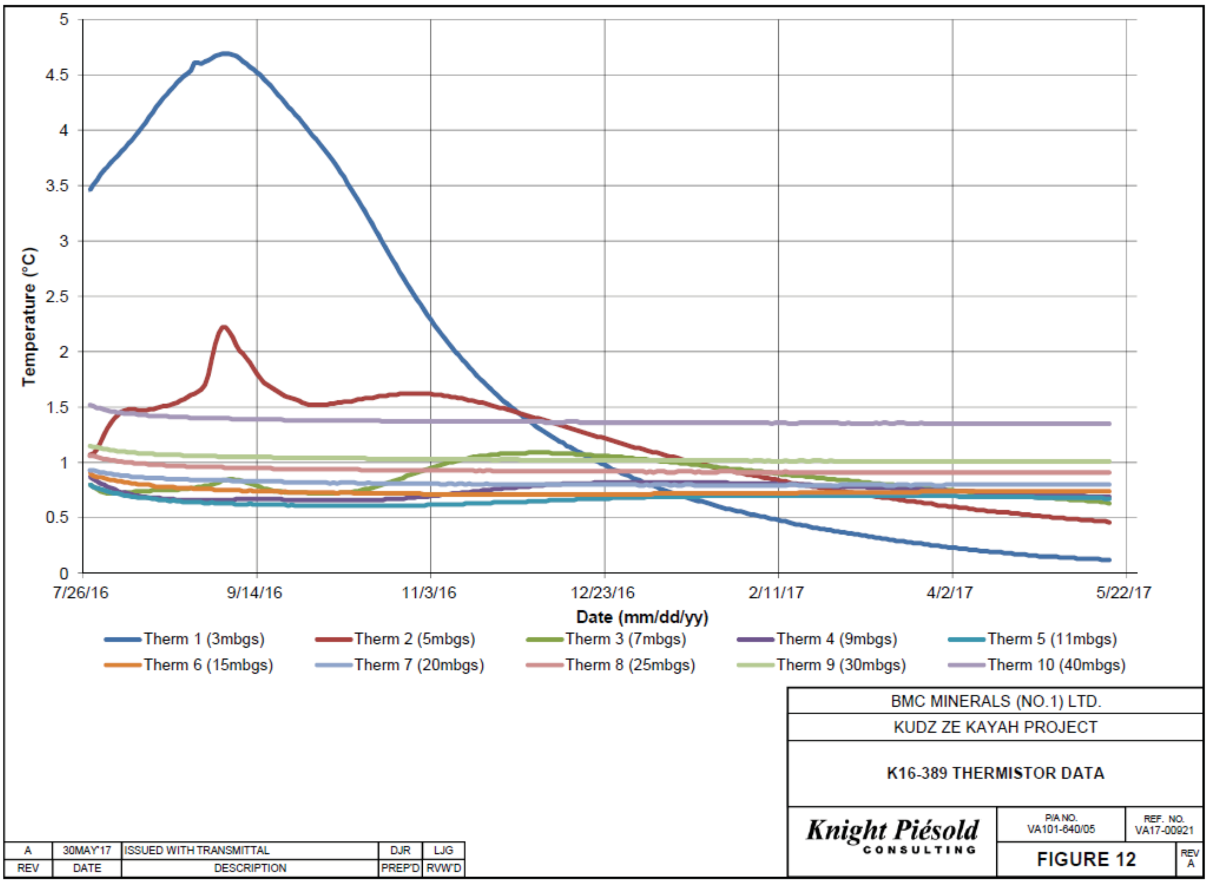


Figure 4-2: K16-389 Thermistor Data

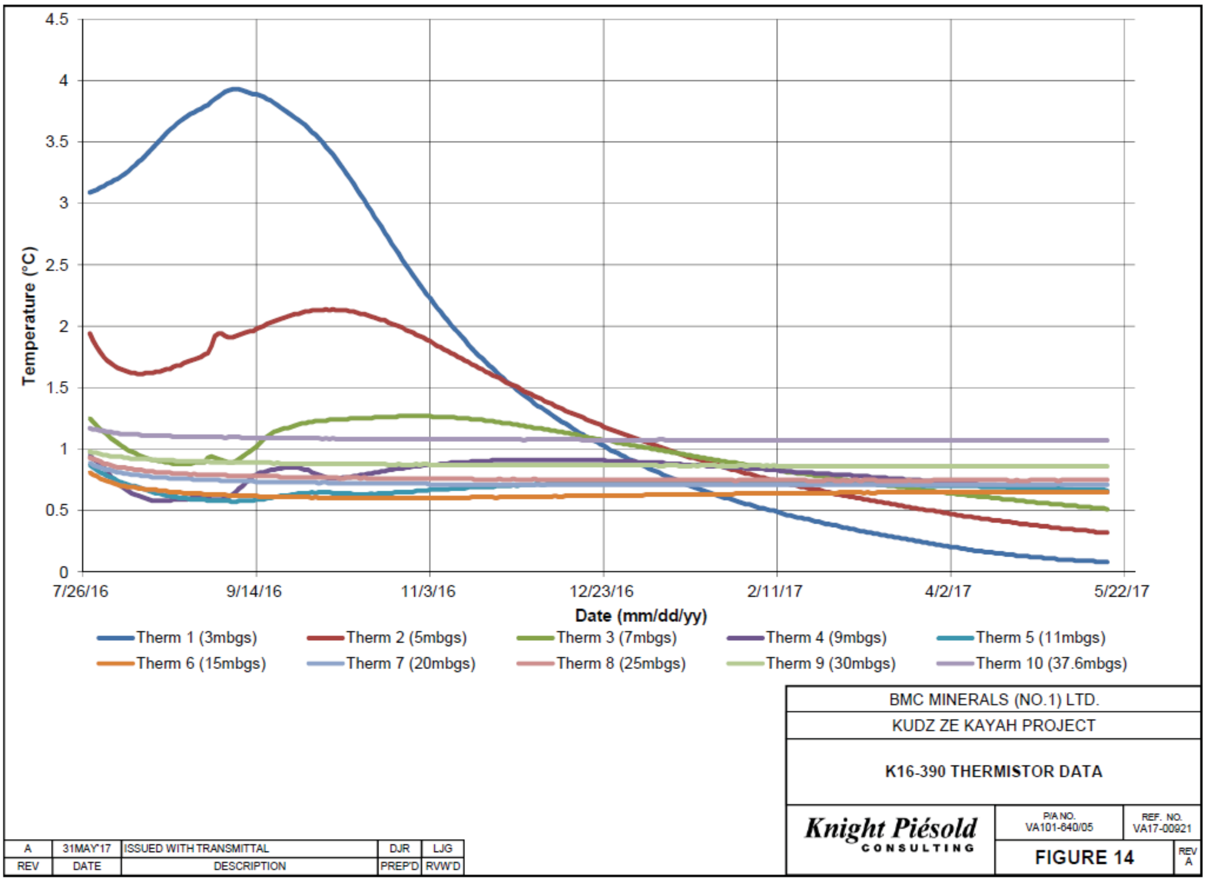


Figure 4-3: K16-390 Thermistor Data

YESAB ISSUE

The Proponent's discussion of the effects of permafrost on waste pile stability is generally consistent with current practice. The development of excess pore water pressures in rapidly thawing fine-grained permafrost can lead to a condition of zero effective stress within the thawing soils. For predominantly coarse-grained soils, the development of excess pore water pressures is less likely. (refer to McRoberts, E.C. 1978. Chapter 7 Slope Stability. In "Geotechnical Engineering for Cold Regions", McGraw Hill). Creep deformation of permafrost soils is a time-stress-temperature dependent phenomenon and is independent of the excess pore water pressure issue.

R5

"Is creep deformation potentially leading to excessive deformation or creep rupture a potential mechanism to be addressed? Provide further analysis of the risks, potential effects and proposed mitigation if creep rupture is potentially a mechanism for excessive deformation."

Unsuitable/permafrost material encountered during construction of the Class A and B Waste Storage Facilities will be removed, therefore creep deformation due to permafrost conditions is not considered to be an issue for stability. Any additional potential for creep will be addressed during detailed design for the facilities where foundation preparation does not include removal of all overburden materials.

R6

"Were the strength properties of the overburden assumed such that it was considered to be a sensitive soil in the stability analysis? If not, provide a rationale for the assumptions used."

The strength properties of the overburden were not assumed to be a sensitive soil as any sensitive soil material would be removed beneath the Class A Waste Storage Facility during construction.

R7

"Does the critical failure surface occur though the overburden shell or the Class A tailings?"

The critical failure surface occurs through the tailings material.

YESAB ISSUE

The Class A containment structure was modelled as tailings only (i.e., without SPAG rock). This assumption is valid and conservative if the shear strength of the Class A rock is higher than the tailings or if the tailings and rock are mixed in the structure. This assumption may not be conservative where there is significant co-disposal of tailings and waste rock (Class A) in a manner where it is either not compacted properly or saturated. This should be verified during the detailed design stage.

R8

"Was co-disposal incorporated into stability design? If so, provide a rationale as to why modelling the Class A containment structure as tailings only is sufficient."

Class A material (tailings and rock) will be placed and compacted within the facility in controlled lifts. The Class A tailings material is anticipated to have a lower shear strength than the waste rock material; therefore, the stability model (which only includes tailings material) is considered conservative and appropriate for the stage that the Project is at (i.e. effects assessment vs. Permitting). When the material is co-disposed in the facility, the waste rock will increase the shear strength and thus the overall factor of safety.

The Class A material (tailings and waste rock) co-disposal strategy will continue to be developed and refined by BMC mine planners and their engineering consultants (Knight Piesold) during the detailed design phase. The co-disposal strategy used will aim to optimise operational efficiencies while maximising geotechnical and geochemical stability over both the operational phase and the long term.

YESAB ISSUE

The shear strength of tailings was assumed as Tau/sigma = 0.55. The slope stability is sensitive to the relationship adopted. The stability results from a sensitivity analysis performed for lower values of shear strength would be beneficial, to determine stability in lower shear strength conditions than assumed. The tau/sigma shear strength relationship appears to be high for the anticipated tailings material.

R9

"What is the basis and rationale for the tau/sigma relationship that was assumed?"

The tau/sigma value was selected based on a sensitivity check of the laboratory-determined value. A tau/sigma value of approximately 0.6 was determined from a single remolded three-point Consolidated-Undrained test. The sensitivity check considered various combinations of tau/sigma values and Class C cap thicknesses. The tailings will be mixed with Class A waste rock, which will increase the overall strength of the tailings mass (as described in R8). Tau/sigma = 0.55 is a 10% reduction of the lab-determined value and represents a penalty for variability (i.e., possible lower strength with more lab testing and possible higher strengths from mixing with Class A waste rock). Additional tailings lab testing will be completed as the Project advances to the detailed design stage.

R10

"Was a sensitivity analysis performed on the tau/sigma parameter?"

A sensitivity analysis on the tau/sigma parameter has not been completed at this time. As noted in R9, the assumed tau/sigma relationship used for stability assessment purposes incorporated a 10% reduction that was determined through laboratory testwork. The sensitivity of stability to the tau/sigma parameter will be assessed at the final design phase.

YESAB ISSUE

Typically a textured liner is used to improve slope stability.

R11

"Provide a rationale as to why an 80mil Smooth HDPE Geomembrane was recommended on the 2.5H:1V slopes and how this type of geomembrane will ensure sufficient slope stability?"

The 80 mm Smooth HDPE Geomembrane liners proposed for the Upper Water Management Pond, Lower Water Management Pond, Class A, Class B, Class C, and Overburden Collection Ponds, Pit Rim Pond, and Fault Creek Diversion provide low permeability, and high chemical and ultraviolet resistance properties and were not assumed to impact the overall stability of these structures.

Slope stability of the Water Management Facilities is provided from the detailed engineered design of these facilities, with the 80 mm Smooth HDPE Geomembrane liners providing water retaining and water directing attributes, without affecting the overall integrity of the Water Management Facilities.

If further design indicates that an alternative to the smooth HDPE is required then an alternative with equal or better hydrological properties will be sourced and installed. The liners are assumed to be used during the operations and active closure phases but decommissioned for final closure. Liners will be inspected and repaired as required during the mine life.

Monitoring and inspection of all engineered facilities associated with water (including pond liners) will be required under the Water Licence, typically captured in the Physical Inspection Plan. The Adaptive Management Plan (AMP) will be designed to include monitoring to detect if ponds were leaking (either pond water levels/balance or downstream in groundwater wells or surface water monitoring locations).

YESAB ISSUE

Geomembranes are typically covered to provide protection from the elements. The conceptual drawings appear to leave the geomembrane exposed.

R12

"Is the 80mil HDPE geomembrane designed to remain durable upon exposure to the elements (UV exposure, etc.)? Describe the potential implications and effects of the geomembrane being exposed to the elements for their intended lifespan and proposed mitigative measures."

The 80 mm HDPE geomembranes used in the construction of the water management and collection ponds will have the required specifications to remain durable upon exposure to the elements for the required lifespan of these facilities and will be installed under appropriate QA/QC controls to ensure that they meet the longevity requirement. The synthetic pond liners will be inspected periodically and deficiencies will be repaired and liner replaced if necessary. The liners will be decommissioned at final closure, and as such they are only expected to function and require inspection and replacement during the Operations and Active Closure Phases of the Project.

YESAB ISSUE

In Appendix C-4, Table 1 states the depth to bedrock is 2.5 m to 5 m. However, Section 4.1 states "Surficial deposits ranged in depth from 0.2 m to 10.4 m bgs."

R13

"Verify the correct depth to bedrock."

The reference of 0.2 m to 10.4 m refers to the site-wide conditions encountered in the 2016 Geotechnical Site Investigation. The revised statement should read "Surficial deposits range in depth from 0.2 m to 10.4 mbgs site wide, with overburden thicknesses in the Class A facility footprint varying between 2.5 m and 5 m."

4.2 ORE PROCESSING

YESAB ISSUE

Section 4.8.3.5 (page 4-51), the Proponent states that, "the tailings thickener overflow water will flow to the process water pond for reuse. Thickener underflow that has been dewatered to nominally 60% solids w/w."

In Section 4.8.3.5 (page 4-51) the Proponent states tailings "...will be fed to a splitter box which evenly distributes the flow between two agitated filtration feed tanks. Each filtration tank will feed a filter which dewaters the tailings to a produce a filter cake with a moisture content of approximately 15% with the assistance of flocculant".

While having a thickener before filtration is a good practice for hard rock tailings, achieving 60% w/w from thickener may be challenging and will depend on the composition of the tailings, feed consistency and the design and performance of the thickener. The tailings could be out of specification and pose challenges at the storage facilities.

R14

"Provide details on the tailings composition and test data (pilot scale) if available and a summary of findings for evaluations on the proposed concept's efficacy. Provide information on the gradation and mineralogy for the tailings feed and information regarding the proposed thickener and filter if available."

Mineralogical analysis of the composition of tailings from XRD was provided in Table 5-10 of Appendix D-5 of the Project Proposal, and is reproduced here as Table 4-1, for ease of reference.

Gradational analysis of tailings has been completed as part of thickening and filtration testwork using laser diffraction size distribution as shown in Figure 4-4 below.

Table 4-1: Mineralogy of Tailings Samples from XRD

	Mineralogy (wt.%)											
	Sulphides			Carbonates			Silicates, Oxides and Sulphates					
Sample ID	**Pyrite**	**Pyrrhotite**	**Chalcopyrite**	**Calcite**	**Ankerite-Dolomite**	**Siderite**	**Quartz**	**Illite-Muscovite**	**Clinochlore**	**Magnetite**	**Gypsum**	**Barite**
Test 29 - Zn Ro Tail Cyc 1-6	51.1%	3.1%	0.7%	-	10.7%	4.2%	9.1%	9.9%	4.2%	3.6%	0.9%	2.4%
A17107 (Test #1-20)	51.9%	3.0%	-	2.2%	10.0%	4.2%	8.6%	9.8%	4.4%	2.2%	0.8%	3.0%

Outotec	Test Report	TESTING 7.2.12
Sales	TEST CASE NO.: 115964 T1 – T5	47 / 50

Appendix 12 Zinc tails PSD

microanalysis australia

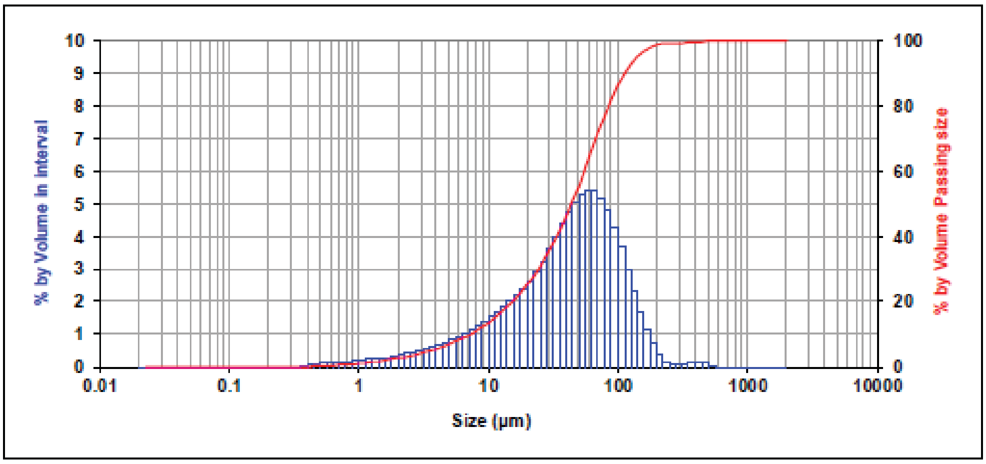
37 Kensington Street
East Perth
WA 6004

Client: Outotec
Client ID: S2876TA Tails
Job No : 16_1299
Lab ID No : 16_1299_07

Analysis: Laser diffraction size distribution following ISO13320-1:1999

Dispersant:	Water	**RI/ABS:**	2.74 / 0.1
Additives:	10 millitres sodium hexametaphosphate	**Analysis Model:**	General purpose
Sonication:	10 min sonication	**Result units:**	Volume

Concentration:	0.0292 % vol	**Vol. Weighted Mean D[4,3]:**	54.863 µm	**d(0.1):**	7.302	µm
Obscuration:	15.99 %	**Surface Weighted Mean D[3,2]:**	13.658 µm	**d(0.5):**	43.984	µm
Weighted Residual:	0.768 %	**Specific Surface Area:**	0.439 m²/cc	**P80:**	85.117	µm
				d(0.9):	112.59	µm



Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %	Size (µm)	Vol Under %
0.020	0.00	0.142	0.00	1.002	1.09	7.096	9.72	50.238	55.84	355.656	99.55
0.022	0.00	0.159	0.00	1.125	1.29	7.962	10.88	56.368	61.15	399.052	99.68
0.025	0.00	0.178	0.00	1.262	1.51	8.934	12.16	63.246	66.58	447.744	99.84
0.028	0.00	0.200	0.00	1.416	1.75	10.024	13.56	70.963	71.96	502.377	99.98
0.032	0.00	0.224	0.00	1.589	2.02	11.247	15.10	79.621	77.15	563.677	100.00
0.036	0.00	0.252	0.00	1.783	2.31	12.619	16.78	89.337	81.97	632.456	100.00
0.040	0.00	0.283	0.00	2.000	2.64	14.159	18.62	100.237	86.28	709.627	100.00
0.045	0.00	0.317	0.00	2.244	3.00	15.887	20.62	112.468	89.97	796.214	100.00
0.050	0.00	0.356	0.00	2.518	3.40	17.825	22.81	126.191	92.97	893.367	100.00
0.056	0.00	0.399	0.05	2.825	3.84	20.000	25.21	141.589	95.29	1002.374	100.00
0.063	0.00	0.448	0.12	3.170	4.33	22.440	27.85	158.866	96.96	1124.683	100.00
0.071	0.00	0.502	0.21	3.557	4.87	25.179	30.78	178.250	98.09	1261.915	100.00
0.080	0.00	0.564	0.31	3.991	5.48	28.251	34.02	200.000	98.78	1415.892	100.00
0.089	0.00	0.632	0.44	4.477	6.15	31.698	37.63	224.404	99.15	1588.656	100.00
0.100	0.00	0.710	0.58	5.024	6.91	35.566	41.62	251.785	99.33	1782.502	100.00
0.112	0.00	0.796	0.73	5.637	7.75	39.905	46.00	282.508	99.41	2000.000	100.00
0.126	0.00	0.893	0.90	6.325	8.68	44.774	50.76	316.979	99.47		

Figure 4-4: Particle Size Distribution of Tailings Sample

Dynamic thickening tests were completed for a range flux rates and flocculant doses, with results detailed in Table 4-2 below. The conclusion of the thickening testwork was that the tailings can be thickened by high rate thickening over a range of fluxes, with tailings densities of 73.8 to 75.7 % solids (w/w) achieved over flux rates of 0.50 to 1.50 t/(m²h).

Table 4-2: Tailings Dynamic Thickening Testwork Results

	Feed		Flocculant		Underflow		Overflow
Run No.	Flux (t/(m²h))	Liquor RR (m/h)	Type	Dose (g/t)	Meas. Solids (% (w/w))	Yield Stress (Pa)	Solids (mg/L)
1	0.50	2.97	Magnafloc 155	10	75.7	126	<100
2	1.50	8.90	Magnafloc 155	10	73.5	85	<100
3	1.50	8.90	Magnafloc 155	5	73.8	55	<100
4	1.50	8.90	Magnafloc 155	2.5	73.3	35	120
5	0.78	4.63	Magnafloc 155	5	75.5	96	<100
6	1.00	5.93	Magnafloc 155	5	75.1	80	<100

Vacuum filtration testing of tailings was completed for both horizontal vacuum belt and rotating vacuum disc technologies. Results from the horizontal vacuum belt filtration testwork, using the filter cloth S90 were:

- Test filtration rate 3,756 kgDS/m²hr
- Cake moisture content 15.1 %wt
- Cake thickness 42 mm

Results from the rotating vacuum disc filtration testwork, using the filter cloth S2510 were:

- Test filtration rate 4,356 kgDS/m²hr
- Cake moisture content 13.9 %wt
- Cake thickness 23 mm

The conclusion of the filtration testwork was that both horizontal vacuum belt and rotating vacuum disc technologies can dewater tailings to the PFS design moisture content of 15%.

R15

"What type of filtration technology will be used (vacuum or pressure)?"

BMC expects to utilise vacuum filtration technology for the production of tailings for placement in the Class A Waste Storage Facility however it reserves the right to modify this depending upon the relative costs and efficacy of technology available at the time of construction.

R16

"Is there a plan to conduct a pilot test? If no pilot test is planned, what would be the basis for filter design and the tailings management plan?"

BMC does not intend to conduct pilot tests further to that discussed in R14. The filtration testwork for the PFS has been completed by an internationally recognised filtration technology supplier in accordance with their recommended test methodology, and is sufficient for the supplier to specify the design of the tailings filtration system. A tailings management plan will be developed and incorporated into the Mill Development and Operations Plan required for approval of a Quartz Mining Licence by the Department of Energy, Mines and Resources.

R17

"Please describe if the 15% moisture content is a design basis for the filter cake and if the filtration system will be designed to achieve this target. Success of the filtration will depend on the gradation, mineralogy and technology selected."

A moisture content of 15% is the design basis for the tailings filtration system, as supported by the filtration testwork described in R14. Filtration testwork completed to date has demonstrated that a 15% moisture content filter cake can be readily produced.

4.3 TAILINGS TECHNOLOGY

YESAB ISSUE

In Chapter 4, Section 4.16.2 (page 4-147), it is stated, "BMC proposes to filter tailings to a nominal 15% moisture content for disposal in the Class A WSF or for use in producing paste backfill". There are certain advantages and disadvantages for adopting filter technology for a given project.

A tailings option assessment is typically completed for this type of project.

R18

"Provide the rationale for proposing filter technology."

As detailed in R19, a Tailings Management Alternatives Assessment was completed that considered two methods of tailings storage technology (slurry and filtered tailings), coupled with assessment of potential tailings storage sites within 10 km of the ABM Deposit. The conclusion of the Alternatives Assessment was that the use of filtered tailings was the preferred option when ranked against the Alternatives Assessment Performance Criteria.

R19

"Was an option assessment completed and what other technology was evaluated? Otherwise, what are the specific advantages of the filtered tailings technology for this project, comparing it to other technologies and methods such as beaching?"

Yes, an option assessment was completed for technology to produce tailings. This is detailed in Section 4.15.4.1 of the Project Proposal. BMC retained internationally renowned experts Knight Piesold Consulting (Vancouver office) to undertake a Tailings Management Alternatives Assessment to support mine design decisions during the completion of the Prefeasibility Study. The Alternatives Assessment considered two methods of tailings storage technology (slurry and filtered tailings), coupled with assessment of potential tailings storage sites within 10 km of the ABM Deposit.

For clarity, slurry tailings as used in the Alternatives Assessment was considered to include the full range of pumpable tailings, from conventional slurry tailings, through to thickened tailings and paste tailings. All pumpable tailings require construction of a tailings slurry storage dam to contain and manage the water content of the pumped tailings.

Four tailings storage alternatives were assessed in detail after the application of pre-screening criteria:

- Slurry tailings facility located in Geona Creek;
- Slurry tailings facility located in the East Hanging Valley;
- Filtered tailings facility located near the current exploration camp, at the confluence of Geona and Finlayson Creeks; and
- Filtered tailings facility located on the western hillside of Geona Creek.

On application of Alternatives Assessment performance criteria, both slurry tailings alternatives were assessed to be least preferred, primarily due to the 'Amenability to Reclamation' criteria. Construction of a filtered tailings facility located on the western hillside of Geona Creek was determined to be the Preferred Option.

R20

"Is there a preferred alternative (second best) tailings technology that could work as a back-up plan?"

BMC's preferred alternative for tailings storage is the use of filtered tailings. As detailed in R19, the Tailings Management Alternatives Assessment also considered the use of slurry tailings (conventional slurry, thickened or paste tailings). While the use of slurry tailings technologies is technically viable to implement as a backup plan, the conclusion of the Tailings Management Alternatives Assessment was that the use of filtered tailings was the preferred technology.

YESAB ISSUE

Chapter 4, Section 4.16.2 (page 4-148) states, "...as this has been successfully implemented at a number of mines already, BMC does not believe that the required operational practices will be unreasonable to implement and maintain". Filtration technology is widely used in arid environments, where water recycling is critical, and also for places with difficult foundation conditions for the tailings storage facility design. There are particular challenges to implement this technology in a northern climate; the Proponent referenced Greens Creek Mine in Alaska, often referred as a successful dry stacking facility in a northern climate; however, it took many years of operation and learning to develop feasible operational practices at Greens Creek Mine.

R21

"Describe if and how the tailings management plan has incorporated operational learnings and best practices from similar facilities and operations such as Greens Creek Mine, Alaska."

Dry stack tailings technology has evolved significantly around the world over the last 30 years and it is now used in locations that range from dry, hot arid climates to northern (and southern) cold climates. It is not reasonable to request, nor is it feasible to attempt to summarise the 30 years of advances in knowledge into a response document of this type. However, BMC recognises that it took Greens Creek Mine years of operation and learning to optimise the operational practices of the filtered tailings facility on Admiralty Island. There has been a similar learning curve at the Pogo Mine in Central Alaska. Despite the operational challenges at the commencement of the above two mines, the operational practices at the respective dry stack facilities were feasible. The fact that Greens Creek continues to be successfully operated within the Admiralty Island National Monument is a testament to the fact that a dry stack tailings facility in a cold climate is not only feasible but can be operated successfully in an environmentally sensitive area for decades.

There are lessons to be learned from both operations and these will be included in the Tailings Management Plan as it is further developed for the QML Application. There is likely to be a period of optimisation of operational practices at the Kudz Ze Kayah Project. The timeline for the optimisation will be dependent upon local climatic and operational conditions; however, it will be lessened due to operational lessons learnt from similar operations.

The Tailings Management Plan is conceptual at this stage; however, as the Project progresses and more operational data becomes available it will be developed for inclusion in the Mill Development and Operations Plan required for approval of a Quartz Mining Licence by the Department of Energy, Mines and Resources.

Note that BMC has engaged Knight Piesold, an internationally recognised specialist is this field to advise us on the tailings management designs and operations. In providing their specialist advice, Knight Piesold has incorporated both their personal and published experiences from many mines including Greens Creek.

R22

"What mitigation strategies or alternatives have been considered in the event that the operation of the KZK mine cannot consistently meet design output?"

It is unclear what design outputs are being referenced. On the assumption, from context, that the reference is to the efficiency and effectiveness of the filtration technology, then all testing to date indicates that target outputs are achievable. In the event of the design outputs being consistently unmet then the Mill Development and Operations Plan will be adjusted accordingly and if necessary modifications made to the thickening and filtration circuits. This is normal practise in the commissioning process for new mines.

YESAB ISSUE

A target of 15% moisture content for filter tailings appears reasonable and may have been set based on the success achieved at other metal mines.

R23

"Demonstrate why a target of 15% moisture content for filter tailings is realistic for this project and can be maintained."

The target of 15% moisture content for filtered tailings is realistic and has been demonstrated by the tailings filtration testwork completed to date, as described in R14.

YESAB ISSUE

The Proponent considers co-disposal of filtered tailings and acid generating waste rock. There are various methods of co-disposal available such as a) co-mingle, b) layered, c) zonations, etc.

R24

"Has a feasible co-disposal method and plan been developed? If yes, provide details on this plan."

As noted in Section 4.9.4.4 of the Project Proposal, the specific comingling method for Class A waste rock and tailings had not been defined at the time of submission of the Project Proposal, and will be determined during the final design phase. Comingling methods could include one or more of the following options:

- Waste rock and tailings placed in lifts;
- Waste rock placed in cells and surrounded by tailings; and
- Waste rock mixed with tailings and placed in lifts.

International use of co-disposal has successfully utilised all three of these methods and it is reasonable to expect that all three will be successful from a technical perspective at the Project.

Geotechnical analysis of the three different methods of comingling will be undertaken as part of the final design phase to assess the characteristics of each method. The geotechnical analysis will be considered in conjunction with geochemical sensitivity analysis work to select the preferred method(s) of comingling waste rock with tailings. The preferred method(s) will be tested in the field during Project commissioning and revised where appropriate to reflect experience gained from operating within the site-specific conditions.

4.4 CONCEPTUAL CLOSURE AND RECLAMATION PLAN

4.4.1 Final Landform Design for Waste Storage Facilities

YESAB ISSUE

The submission proposes progressive construction of a closure cover system over each of the storage facility landforms as areas of the stockpiles reach their final design elevation. The cover system designs vary depending on the level of net percolation reduction required which is based on the results of downstream water quality modelling; however, each cover system design includes an upper 0.3 m thick growth media layer, comprising a mixture of local topsoil and glacial till materials, to support growth of a sustainable cover of native plant species. Until the vegetation covers mature, the growth media layer will be susceptible to erosion, particularly for longer and steeper slopes and on larger terrace footprints (i.e., from slope catchments above the terrace during contributing to run-on from spring freshet and storm events).

R25

"What is the risk and associated effects of the reclaimed slopes being susceptible to increased gully erosion as a result of runoff waters from upper terraces discharging over the crest?"

The risk of gully erosion on the reclaimed slopes of the storage facilities is that if not rectified the resultant erosion would expose the cover material and eventually the encapsulated material with the potential of ARD /ML in the case of the Class A and Class B Waste Storage Facilities. Gully erosion would cause increased runoff velocity and thus increased sediment load on all the facilities.

Risks associated with increased gully erosion of the Class A, B and C Waste Storage Facilities will be mitigated through the inclusion of benches to reduce the length of the overall slope. The benches will be sloped appropriately to minimise down slope flow, while the slopes will be contoured to minimise the potential for erosion. The upper terraces of the facilities will be graded to a slope of 2% to convey water at a reduced velocity and reduce ponding water. Concurrent reclamation and revegetation will minimise the areas susceptible to erosion during operations and the majority of the longer steeper slopes will be revegetated prior to the active closure phase. This design concept is commonly used for reducing the potential for gully erosion and has become accepted practise throughout the mining industry.

If gully erosion is observed in areas on the storage facilities it will be remedied by a combination of some or all of: armoring, backfilling, recontouring, and revegetation.

YESAB ISSUE

The estimated footprint of the upper terrace for each storage facility landform at closure is not provided. As well, no information is provided on typical slope profiles for natural, glaciated landforms in the region.

The physical and hydrologic characteristics of natural landforms with substantial topographic relief should be examined in support of designing slope profiles for final landforms relief; natural slopes have evolved over thousands of years in response to site-specific climatic, vegetation, and soil conditions.

R26

"What is the estimated footprint of upper terraces for each storage facility landform at closure?"

The estimated areas of the upper terraces for each storage facility at closure are as follows:

- Class A Facility: 0.32 km^2
- Class B Facility: 0.16 km^2
- Class C Facility: 0.93 km^2

On-going Project development and detailed design will include refinement of the closure plan for the facilities, including shaping and/or re-sizing of the upper terraces to mimic pre-mining conditions and natural landforms.

R27

"What is the physical and hydrologic comparison between the proposed closure landforms and similarly sloped natural regional landforms (topographic relief and slope aspects)?"

It is agreed that it is important for the surrounding natural landforms to be considered in support of designing slope profiles for final landforms. Existing slopes within the proposed footprint of the waste storage facilities and in the immediate surrounding landscape typically range from less than 2% (50H:1V) to greater than 50% (2H:1V). Typical slopes of the existing natural landforms in the location of proposed storage facilities, and their proposed slopes are shown in Table 4-3 (all slopes presented as H:V).

Table 4-3: Proposed Maximum Slopes compared to Typical Existing Slopes, by Waste Facility

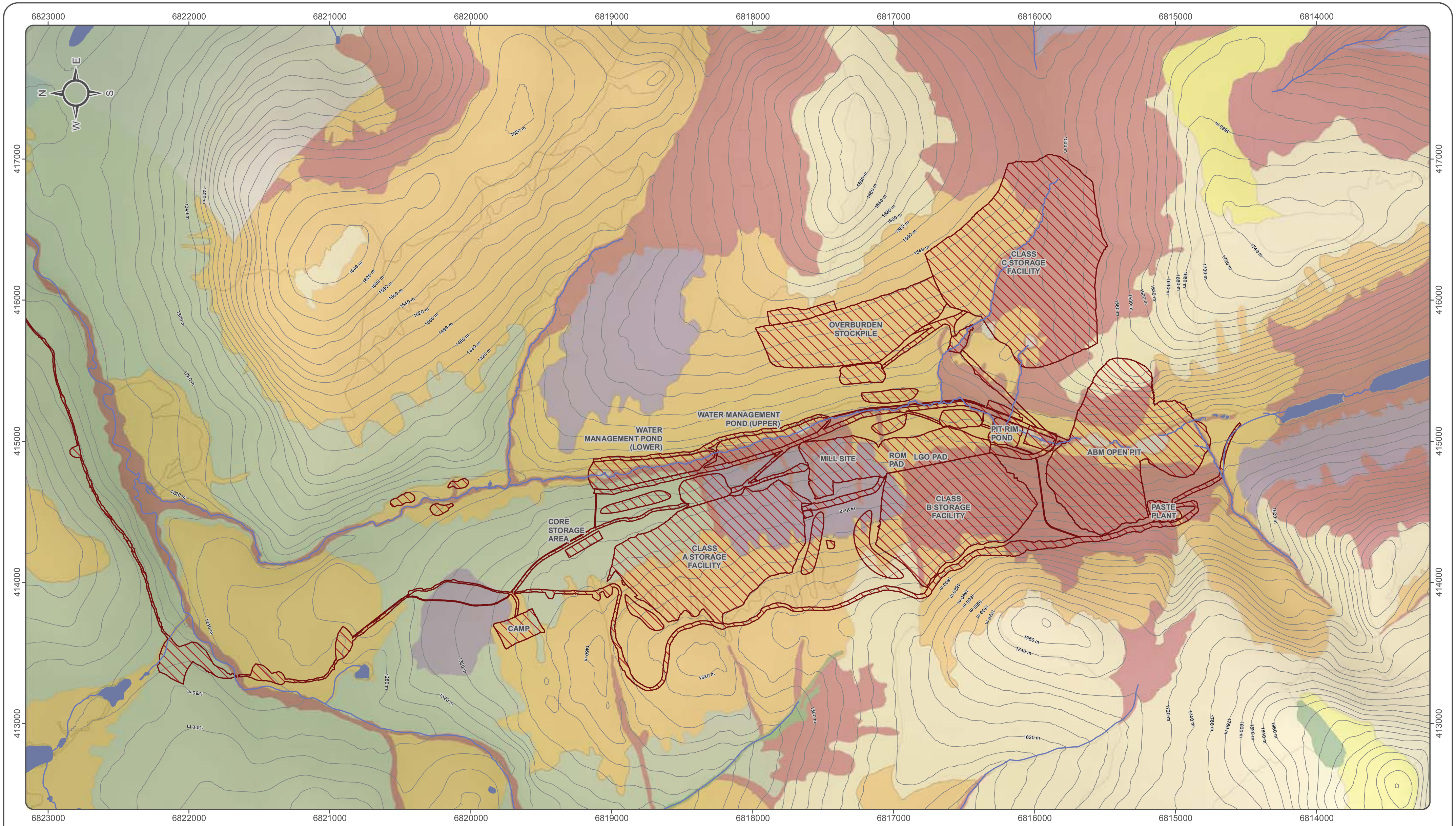
Facility	Typical Existing Slope Range	Proposed Maximum Facility Slope
Class A	4:1 – 6:1	4:1
Class B	3:1 – 4:1	3:1
Class C	4:1 – 10:1	3:1

The proposed slopes for the Class A and Class B Storage Facilities are within the range of typical slopes for their respective locations. The Class C Storage Facility is proposed in a flatter region of the site, and the proposed facility landform is predominantly terrace (flatter surface, as opposed to sloped face) which is similar to the existing flatter topography of the area. Approximately 50% of the footprint of the Class C Storage Facility consists of slopes of 12% or less, including regions with slopes less than 2%.

It is also agreed that surrounding physical and hydrologic characteristics require examination in designing closure landforms and surface treatments for mine waste facilities. This was undertaken starting in the planning process as illustrated in Table 7-1, General Reclamation and Closure Objectives and Measures for Project Final Closure of Appendix H *Conceptual Reclamation and Closure Plan Kudz Ze Kayah Project*, February 2017, which outlines relevant general closure objectives related to physical stability, ecological conditions and sustainability, land use and aesthetics. The closure criteria and measures are further refined in Tables 7-7, 7-10 and 7-13 of Appendix H with design criteria that outline how:

- Revegetation prescription and methods consider ecosystem unit and cover material properties to minimise erosion/slope failure potential;
- Facility design maintains natural slopes, aspect, and elevations similar to the surrounding area; and
- Revegetation planned and executed in consideration of pre-existing vegetation communities and final facility features (elevation, slope, aspect) to maximize revegetation success and use by wildlife.

To deliver on these criteria in the planning process, the planning team determined appropriate target ecosites for facility aspects, which informed the selection of both short and long term revegetation treatment prescriptions. This was accomplished by evaluating existing ecosites mapped as described in the December 2016 *Terrestrial Ecosystem Map Report, Kudz Ze Kayah* Project (Project Proposal Appendix E-6: *Vegetation Baseline Report*, December 2016). Figure 7-1 in the *Conceptual Reclamation and Closure Plan, Kudz Ze Kayah Project* (Appendix H of the Project Proposal, February 2017) presents the existing ecosystems and project footprint. Section 7.1.2 in Appendix H identifies how locations, slopes and aspects of proposed waste facilities were compared with information for existing/neighboring ecosystems to determine target ecosites and moisture regimes for waste facility landforms and surface reclamation treatments. This information considered topography (slope, aspect), soil texture and drainage characteristics, and permafrost potential. Table 7-2 from Appendix H documents the results of this work, and the resultant predicted ecosystems are displayed on post-mining landforms in Figure 7-2 of Appendix H. The figures referenced above are reproduced below as Figure 4-5 and Figure 4-6. Table 7-1 is also reproduced and presented below as Table 4-4.



National Topographic Data Base (NTDB) compiled by Natural Resources Canada at a scale of 1:50,000. Cadastral data compiled by Natural Resources Canada. Reproduced underlicense from Her Majesty the Queen in Right of Canada, Department of Natural Resources Canada. All rights reserved.

Datum: NAD 83; Map Projection: UTM Zone 9N

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ECOSYSTEMS BY LEADING SPECIES

- Carex species
- Dwarf shrubs
- Scrub Birch
- Subalpine Fir
- Graminoids
- Black Spruce
- White Spruce
- Willow species
- Mine Development Footprint
- Watercourse
- Waterbody

BMC MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-5
EXISTING ECOSYSTEMS AND PROJECT FOOTPRINT

JUNE 2017

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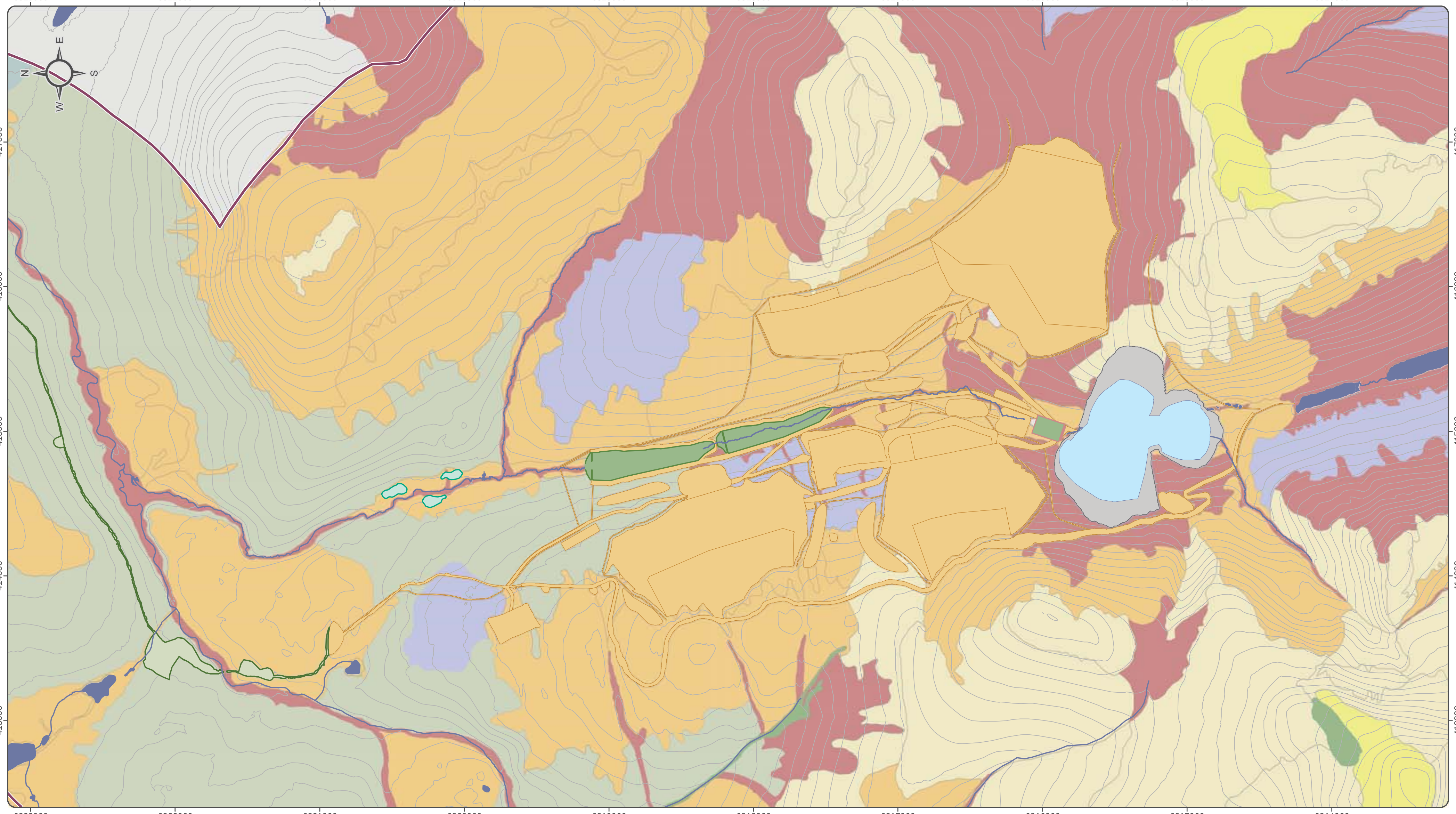

ECOSYSTEMS BY LEADING SPECIES

- Carex species
- Dwarf shrubs
- Scrub Birch
- Subalpine Fir
- Graminoids
- Black Spruce
- White Spruce
- Willow species
- Bare Rock
- Local Study Area
- ABM Lake @ 1380 masl
- Fish Habitat Compensation Pond
- Watercourse
- Waterbody

Datum: NAD 83; Map Projection: UTM Zone 9N

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MINERALS

KUDZ ZE KAYAH PROJECT
CONCEPTUAL RECLAMATION AND CLOSURE PLAN

FIGURE 4-6
EXISTING AND PREDICTED ECOSYSTEMS BY LEADING SPECIES

JUNE 2017

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Table 4-4: Post-Mining Land Use - Revegetation Objective and Potential Wildlife Use by Facility

Facility	Facility Sub-Area	Area (ha)	Target Ecosite # / Nutrient-Moisture Regime	Short-term Target Revegetation Treatment and Rationale	Long-term Target Post-Mine Vegetation Association	Estimated Post-Mine Habitat Suitability
Class A Storage Facility						
	Top	32.9	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings. Research planting with native *Vaccinium spp.* (blueberry and lowbush cranberry) if final overburden pH, nutrients, and soil moisture are favorable to restore grizzly habitat.	Scrub birch, willow, and crowberry.	Caribou rut, moose post-rut, grizzly bear, wolf, small mammals, and upland game birds.
	Slopes	53.9	Subalpine 11/ Poor-Subxeric	Low growing species to allow for monitoring physical and chemical stability of facility.	Scrub birch, and lichen.	Moose post-rut, and wolf.
				Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.		
Class B Storage Facility						
	Top	16.0	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings. Research planting with native *Vaccinium spp*. (blueberry and lowbush cranberry) if final overburden pH, nutrients, and soil moisture are favorable to restore grizzly habitat.	Scrub birch, willow, crowberry.	Caribou rut, moose post-rut, grizzly bear, wolf, small mammals, and upland game birds.
	Slopes	50.7	Subalpine 11/ Poor-Subxeric	Low growing species to allow for monitoring physical and chemical stability of facility.	Scrub birch, and lichen.	Moose post-rut, and wolf.
				Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.		
Class C Storage Facility						
	Top	65.3	Subalpine 23/ Poor-Mesic (70%)	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings.	Scrub birch, willow, and crowberry.	Caribou rut, moose post-rut, wolf, ptarmigan, voles, and mice.
		28.0	Subalpine 31/ Poor-Subhygric (30%)		Fir-scrub birch, feathermoss, and lichen.	
	Slopes	32.3	Subalpine 22/ Poor-Submesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Research with inoculation to restore lichens and mosses in biological soil crusts.	Scrub birch, feathermoss, and lichen.	Caribou rut, moose post-rut, and wolf.

Facility	Facility Sub-Area	Area (ha)	Target Ecosite # / Nutrient-Moisture Regime	Short-term Target Revegetation Treatment and Rationale	Long-term Target Post-Mine Vegetation Association	Estimated Post-Mine Habitat Suitability
Overburden Stockpile						
	Slope	46.1	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, fertilize. Plant scrub birch seedlings.	Scrub birch, willow, and crowberry.	Moose post-rut, and wolf.
ABM Open Pit						
		83.1	Flooding	No revegetation.	ABM lake.	Waterfowl.
Water Management Ponds						
	Constructed Wetland	1.6	Subalpine 42/ Poor-Hygric	Engineered design and species selection based on water treatment requirements. Full design will be completed during operations.	Carex spp.	Waterfowl, passerines, moose, grizzly bear, and small mammals.
	Water management ponds	6.5	Subalpine 42/ Poor-Hygric (30%)	Locally-collected willow staking.	Willow, horsetail, forbs, and grass.	Waterfowl, passerines, moose, grizzly bear, and small mammals.
		15.2	Subalpine 35/ Rich-Subhygric (70%)	Supplement organics.		
	Seepage collection ponds	18.7	Subalpine 23/ Poor-Mesic	Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Scrub birch, willow, and crowberry.	Moose, small mammals, and passerines.
Process Plant and Ancillary Facilities						
	Process Plant and ore pads	35.9	Subalpine 23/ Poor-Mesic	Scarify. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Scrub birch, willow, and crowberry.	Moose, small mammals, and passerines.
	Other disturbed areas	39.5	Subalpine 01/ Medium-Mesic	Contour and scarify where needed. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	Subalpine fir, scrub birch, willow, feathermoss.	Moose, small mammals, and passerines.
Access Road Right of Way						
	Access road and site roads	121.7	Boreal and Subalpine 01/ Medium-Mesic	Scarify. Grasses and forbs. Seed with commercial and locally collected native seed mix, and fertilize.	White spruce, willow, forbs, and feathermoss in Boreal High.	Caribou, moose, small mammals (including bats), and passerines.
					Scrub birch, willow, feathermoss in Subalpine.	

R28

"Describe how the proposed final landforms for the waste storage facilities are viable with reference to the following criteria:

a. visual blending with the surrounding landscape;
b. limiting the potential for unacceptable sedimentation of receiving surface water bodies due to soil loss from the reclaimed slopes;
c. limiting long-term maintenance liabilities; and,
d. overall long-term integrity and potential for increased metal leaching / acid rock drainage production?"

Defining appropriate design criteria for these facilities and advancing designs that meet these criteria are key aspects of BMC's approach to closure and reclamation planning, as outlined in Section 2 of Appendix H of the Project Proposal– *Conceptual Closure and Reclamation Plan, Kudz Ze Kayah Project* (February, 2017). These design criteria support BMC's overall closure goal:

- To return the mine site and affected areas to viable and, wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with traditional land use activities.

The proposed landforms for the waste facilities are not final. As the design level for these facilities advances through subsequent regulatory phases, landform design details will advance in a commensurate fashion, consistent with the 'design for closure' philosophy that underpins all planning for the Project. The information provided below is at a level of detail appropriate to support the assessment of potential effects, how the design (or closure measures) of the proposed waste facilities meet the identified criteria.

a. visual blending with the surrounding landscape – Generally speaking, upon final reclamation the Waste Storage Facilities will have overall slopes which are similar to the surrounding topography, as well as localized varying slopes which will assist in creating a natural appearance. Final height, slope, aspect, soil texture, permafrost potential and soil moisture regime of existing and adjacent ecosystems were all examined and utilized in creating target ecosites and revegetation treatments for the reclamation of the waste facilities.

b. limiting the potential for unacceptable sedimentation of receiving surface water bodies due to soil loss from the reclaimed slopes – the proposed slopes for the waste facilities are comparatively low, thus sedimentation potential will also be low. All slopes, including facility faces, will be amenable to standard soil stabilization and erosion control measures. The order of priorities for mitigating unacceptable sedimentation are:

1. runoff control – easiest and most effective
2. erosion control – more difficult/expensive and less effective
3. sediment control – most difficult, most expensive and least effective

Designed runoff control will mitigate erosion and subsequent sedimentation potential. Further facility design work will minimize drainage catchment areas and runoff velocities, and facility slopes will include benches as appropriate to facilitate runoff conveyance and limit erosion potential.

Section 7.1.2 of Appendix H of the Project Proposal discusses revegetation measures proposed for the waste facilities, including short-term revegetation prescriptions which employ graminoids to establish a rapid vegetative cover that stabilizes soils. Other erosion control measures planned to augment runoff control include placement of overburden cover materials in a 'rough and loose' fashion, and placement of retained large woody debris which also serves to help retain nutrients and promote revegetation. Sediment control ponds and water management ponds will provide a final mitigation to sediment release during active/transition closure periods as these surfaces establish and successive vegetation develops.

c. limiting long-term maintenance liabilities - Limiting long term maintenance is recognized as an important factor in the design of the final landforms for the Waste Storage Facilities. As such, the proposed designs include low slope angles of a maximum of 4H:1V for the Class A Storage Facility, and a maximum of 3:1 for the Class B, and Class C Storage Facilities. Diversion of run-on water to the Class A and Class B Storage Facilities will assist in limiting surface flows, reducing long-term maintenance requirements for water conveyance structures on the facilities. As the closure designs are progressed as part of the advancement of the facility designs, the stability and long-term serviceability of any water conveyance structures will be considered and incorporated.

The design of each storage facility will be to ensure the long-term integrity of these facilities and will be achieved by incorporating conservative design assumptions. The design for long-term stability will by its nature limit long term maintenance liabilities.

d. overall long-term integrity and potential for increased metal leaching / acid rock drainage production? The design of each storage facility includes consideration of potentially unsuitable foundation conditions including the presence of permafrost. Long-term integrity of these facilities will be achieved by incorporating conservative design assumptions and removal, if necessary, of suspect foundation materials which could affect the long-term integrity of the facilities. The long-term static factor of safety of each facility will be equal to or greater than 1.5. The cover for the Class B and Class A Storage Facilities will lower water infiltration, limiting the leaching of metals from these waste storage facilities. In particular, the low permeability cover on the Class A Storage Facility will substantially lower infiltration such that only a minor amount of drainage, if any, is anticipated from the Class A Storage Facility.

4.4.2 Waste Storage Facility French Drains at Closure

YESAB ISSUE

In the mid-2000's, a reactive waste rock stockpile at Sullivan Mine near Kimberly, BC was partially reclaimed, which involved covering a toe drain. The arrangement led to oxygen deprivation at a monitoring station located along the buried toe drain and resulted in four fatalities at this site in May 2006. The likelihood of creating oxygen deprivation conditions along the toe of the Project's waste storage facilities post-closure is uncertain. Also, it is unclear whether monitoring stations will be established along the toe drains of the waste storage facilities and whether monitoring will occur at these stations post closure.

R29

"Provide an evaluation on the potential for low-oxygen conditions for this project, potential effects and how they will be addressed through mitigative measures or alternatives."

BMC notes that the waste rock stockpile near Sullivan Mine near Kimberley, BC being referenced above was in fact a reactive sulphide rock stockpile with voids of up to 30% and covered by 1 m of till cover. This situation is not comparable to the KZK Project proposal.

At present, BMC is not proposing monitoring stations (to be built similar to that of the Sullivan Mine); however, if they are required (as a permit requirement) then the design of these will incorporate the lessons and recommendations from the various investigations into and reports of that tragedy.

During all phases of operation and in all areas of the site, applicable confined space safety procedures and monitoring will be required as part of the mine operations and safety plans.

4.4.3 Cover System Design for Class A and B Waste Storage Facilities

YESAB ISSUE

The designer anticipates that a substantial portion of the estimated "runoff" for both cover systems will be diverted as interflow, not surface runoff. There is no indication of the estimated volume of interflow and, more importantly, how interflow waters will be managed to prevent excessive build-up of pore-water pressures (and potential softening or ponding) near the toe of the reclaimed facilities.

R30

"What is the basis for estimating evapotranspiration to be approximately 30% of mean annual precipitation for both the Class A and B facility cover systems?"

The basis for estimating evapotranspiration (to be approximately 30% of mean annual precipitation) for both the Class A and B Storage Facility cover systems was the Project site hydrometeorology study, (Hydrometeorology Baseline Report, Appendix D-2 of the Project Proposal), and the Project water balance, (Receiving Environment Water Balance Report, Appendix D-6 of the Project Proposal). Mean annual total precipitation was calculated to be 612 mm and mean annual evapotranspiration, as a combination of actual evapotranspiration (AET) and sublimation, was calculated to be 188 mm.

This is consistent with the lower end of evapotranspiration ranges on north to middle aspect slopes at elevations around 1,200 masl at similar projects in the Yukon (AET of 20% to 50% of precipitation). The Class A and B Storage Facilities generally face east-northeast at elevations ranging between 1,400 and 1,600 masl.

R31

"What is the differentiation between "surface runoff" and "interflow" volumes in the mean annual water balances completed for each waste storage facility cover system?"

The sum of these two flows make up the total run-off value. The surface run-off is the proportion of the precipitation that flows down the slope on the upper organic media layer. The interflow run-off is the proportion of the flow that is diverted by the underlying cover layers (e.g. very low permeability material layer in the Class A Storage Facility and the low permeability compacted till layer in the Class B Storage Facility), such that this diverted water runs through the overlying material.

A simplified water balance for each cover was provided in Conceptual Cover Design Report, provided as Appendix A to the Conceptual Reclamation and Closure Plan (Appendix H of the Project Proposal). These water balances describe the mean annual conditions. At this level of assessment, the water balance (ΔS) does not account for water storage within the cover system, as this is an optimization for a later stage once more site specific information has been obtained.

The Class A Storage Facility assumes a cover system water balance of no more than 2% of total annual precipitation will pass through the very low permeability layer. With approximately 30% evapotranspiration, 68% either flows along the upper organic growth layer as surface run-off or infiltrates into the upper frost protection layer until it reaches the very low permeability layer and flows along the surface of this layer until captured by the collection ponds.

The Class B Storage Facility assumes a cover system water balance of no more than 25% of total annual precipitation will pass through the low permeability layer. With approximately 30% evapotranspiration, 45% either flows along the upper organic growth layer as surface run-off or infiltrates into the upper frost protection layer until it reaches the very low permeability layer and flows along the surface of this layer until captured by the collection ponds.

YESAB ISSUE

There is the potential for shallow instability of cover layers above the reduced permeability layers (liners).

R32

"How will interflow waters be managed to prevent excessive build-up of pore-water pressures within the cover system in the lower slope regions and limit the potential for shallow instability of cover layers above the reduced permeability layers?"

This is an important design consideration, and the detailed design process will ensure that the rock used is sized, graded, and sloped appropriately, and placed so as to be stable. The planned drainage diversions around the waste facilities will reduce upslope run-on waters contributing to this potential, and the proposed slopes of the facilities and covers will further reduce this potential.

Design and operational management practices will further address this consideration as facility cover design proceeds.

YESAB ISSUE

Higher or lower evapotranspiration will affect the predicted net percolation rate, which ultimately affects seepage rates from base of the waste storage facilities.

R33

"How will higher or lower evapotranspiration rates from the 30 % estimate affect seepage rates from the base of the waste storage facilities and what are the implications to stability and water management?"

This is an important design consideration that is addressed through the landform design of the facility, and water management structures.

Less evapotranspiration would be associated with increased surface runoff, not necessarily increased seepage from the foundation of the facility. This will additionally be addressed though future detailed design studies and ongoing reclamation research during operations to determine the compaction and thickness of the lower permeability and frost protection layers, such that saturated flow conditions are not developed at the base of the Class B Storage Facility. Saturated conditions will not develop at the base of the Class A Storage Facility as the very low permeability layer will prevent sufficient seepage from creating these conditions.

4.4.4 Long-term Physical Integrity of Cover System Reduced Permeability Layers

YESAB ISSUE

The Class A and B facilities' cover system designs incorporate a reduced permeability layer. If the underlying foundation materials or stockpiled waste undergoes differential settlement, then the potential exists for cracks and other defects to develop in the reduced permeability layers. This may lead to substantial increases in net percolation rates into the waste. As well, geosynthetic products have a finite service life due to various factors that cause geosynthetic fibres to age or deteriorate over time. The submission does not indicate the required longevity of the geosynthetic liner proposed for the Class A Storage Facility cover system.

R34

"How will the Class A and B Storage Facilities be constructed to prevent unacceptable differential settlement (due to the foundation materials and stockpiled waste) and how will the long-term integrity of the cover system be maintained?"

It is agreed that landform design and maintenance are important considerations for the long-term integrity of the cover system to maintain performance. The design of the Class A and B Storage

Facilities includes removal of all unsuitable material beneath the facilities. The design of the Class A Storage Facility buttress includes removal of all overburden material underneath the buttress (excavation to bedrock).

The co-disposed Class A tailings and waste rock material will be placed and compacted in controlled lifts to increase the integrity of the facility and limit differential settlement due to consolidation. Class B and C waste rock material will also be placed in controlled lifts with dozer and truck compaction to increase the integrity of the facility and limit differential settlement due to consolidation.

The cover system will be maintained as per standard practice in terms of inspections and monitoring, and conducting regular maintenance. A description of the monitoring and maintenance for the Class A and B Storage Facilities is provided in Section 7.11.1 of the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal. With diligent monitoring and maintenance, it is reasonable to expect that the cover systems can perform as designed. Key aspects of maintenance will include routine inspection, repairing cracks, erosion, and any settling that creates concavity to concentrate flow, as well as regular preventive maintenance to deter erosion and gullying. Maintenance of the cover system will also be aided by establishing a plant cover without delay after terraforming and progressive reclamation is a key component of the Company's proposal.

Typically, extra inspections would occur immediately following freshet or any high rainfall, or combination of freezing and thawing, which could induce cracking or settling. As part of final engineering design, the time required to achieve the final settled density will be estimated. This is the period in which more frequent inspections and maintenance would be expected. It is not unusual for a cover design to account for erosion, and still maintain the integrity of the cover to achieve the designed outcomes.

There is always the potential for an extreme event that may necessitate a major repair or partial replacement. The triggers for requiring maintenance will be determined during the detailed design phase. The trigger for replacing all or a portion of the cover would be determined during the advancement of the Adaptive Management Plan. The framework for the Adaptive Management Plan is provided in Section 7.12.2 of the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal. One of the key mitigating strategies will be to progressively reclaim the Waste Storage Facility in question by carrying out the terraforming of the Facility to final slope angles as early as possible. This reworking of the waste material aids in compaction and reduces the opportunity for failure during an extreme weather event.

In summary, BMC will use internationally accepted practises for consolidation of earthen dams and the use of manual compaction. Overall the design, operating methodology and method of compaction will be signed off by the design engineers prior to final granting of the QML.

R35

"What is the expected service life of the geosynthetic liner as part of the design of the proposed storage facility (ies)? Describe the risks and potential effects once the liner reaches the end of its intended lifespan. Describe potential mitigative measures and alternatives for these effects."

The service life of the very low permeability layer in the Class A Storage Facility is an important aspect of the design maintenance and monitoring costs. It should be noted that a geosynthetic liner is only one of the options being considered as the very low permeability layer. However, this response is specific to the question posed.

Should a geosynthetic liner be selected as the very low permeability layer for the Class A Storage Facility, the triggers for major maintenance or repair will be determined during the detailed design phase. The service life of geosynthetic liners is highly dependent on site-specific conditions, with short term failures most commonly being a result of punctures or stresses during construction. Depending on the material of the liner and the exposure conditions the expected lifetime can range from decades to centuries.

The Failure Modes Effects Analysis process will refine the Closure Plan elements, such as advancing the cover designs, as well as defining mitigation measures and alternatives. The process is described in Section 7.12.1 in the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal.

R36

"How will the cover system performance affect the acceptable environmental loadings to the aquatic receiving environment over the long term?"

The relationship between the waste facility cover system performance and acceptable environmental loading in the receiving environment is an important consideration, and in fact, the environmental loading was a key factor in determining the design basis and performance criteria of the cover systems selection. More specifically, water quality objectives were calculated and a site water/loading model developed, to quantify the source terms to the point of compliance. Design and mitigative measures were then revised in order to achieve the accepted range of water chemistry at these points of compliance. Thus, it was recognized that for the tailings and waste rock facilities that a combination of a lower permeability cover, to reduce the flux of water, with short term water treatment would be required to meet preliminary Water Quality Objectives (pWQOs). Should the covers not be sufficient to consistently meet pWQOs, continued water treatment and water management would be required and or other mitigation measures such as recontouring.

The water quality objectives are described in the Preliminary Water Quality Objectives Report, provided as Appendix D-8 of the Project Proposal, and the site water/loading model is discussed in the Surface Water Quality Model Report, provided as Appendix D-7 of the Project Proposal.

These cover systems will need to be maintained in the long term to ensure design performance criteria continue to be met. The final design of the cover systems will include a monitoring and maintenance plan to ensure these objectives are met and to identify if the cover is performing as designed. If the design underperforms, additional measures will be required to reduce the environmental loading to those proposed in the conceptual design.

The cover systems will be coupled with short term water treatment during operations (and throughout active and transitional closure) and ABM Pit Lake treatment and constructed wetland treatment systems during post-closure to ensure pWQOs are met.

The potential exists for an extreme event that would affect the cover system that may necessitate a major repair or partial replacement. The triggers for requiring maintenance will be determined during the detailed design phase. The trigger for replacing all or a portion of the cover would be determined during the advancement of the Adaptive Management Plan. The framework for the Adaptive Management Plan is provided in Section 7.12.2 of the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal.

R37

"Describe how the cover system will be monitored to ensure it continues to achieve design objectives. Describe mitigative measures or alternatives that may be implemented in the event that the cover system is not performing as expected."

It is agreed that the cover systems will need to be monitored to ensure performance criteria are being achieved. The details of the monitoring, mitigation measures, and alternatives will be advanced during the detailed design phase. Independent of the details of the cover design, the following points will apply to any of the cover system design or material selected.

A description of the monitoring and inspections for the Class A and B Storage Facilities, including the cover systems, are provided in Section 7.11.1 of the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal.

The collection ponds will be the first point to evaluate performance of the cover systems as the seepage from the Class A or Class B Storage Facilities is drained directly into these ponds. Additionally, throughout operation and into active closure there will be a groundwater and surface water monitoring program that will identify if seepage is being discharged from either of these facilities. The surface water monitoring network is provided in Chapter 8, Section 8.6, of the Project Proposal and is summarized in Table 8-49 of that section. The groundwater monitoring network of these facilities is provided in Chapter 9, Section 9.6 of the Project and summarized in Table 9-11.

In the case of the Class A Storage Facility there are currently three groundwater monitoring wells (MW15-09S, MW16-14D, and BH95G-15D) and three surface water monitoring sites (KZ-9, KZ-17 and KZ-37) located downgradient of the facility. For the Class B Storage Facility, there are currently three groundwater wells (BH95G-33D, MW16-7D, and MW16-07S) and two surface water sites (KZ-7 and KZ-9) located downgradient.

The Class A and B Storage Facilities will be progressively reclaimed throughout operations, and if issues are identified during facility construction it will be possible to adapt the closure design to remedy these issues. An Adaptive Management Plan will be advanced during the detailed design of these facilities and will include defined triggers to identify when actions such as a cover replacement or redesign must be undertaken. This plan may include extending the collection and treatment of the seepage beyond operations until an alternative measure is determined, implemented and shows evidence that the risk to the environment has been mitigated. The framework for the Adaptive Management Plan is provided in Section 7.12.2 of the Conceptual Reclamation and Closure Plan, provided as Appendix H of the Project Proposal.

4.5 OPEN PIT AND UNDERGROUND MINING

4.5.1 Open Pit

YESAB ISSUE

In Section 4.6.2.1, a minimum 5 m wide bench at the pit crest is proposed to catch any material raveling down the pit wall slopes. The proposed bench width is very narrow. The rationale behind the selection of this bench width is not clear, and it is not clear that this will be sufficient to minimize the risk of rock fall to an adequate level.

R38

"Provide the rationale for selecting a 5 m wide bench and any relevant numerical analysis confirming the adequacy of the bench width."

As stated in Section 4.6.2.1 of the Project Proposal: "*A* **minimum** *5 m wide bench at the pit crest is required to catch any material ravelling down the slopes*." (Emphasis added.) The minimum crest bench width will be 5 m and the slopes of the overburden will have a maximum slope of 30°. Note that 5 m is a fairly standard minimum and is in accordance with custom & practise internationally in small circumferences and relatively shallow pits such and ABM and Krakatoa. The overburden thickness varies between 2 and 20 m and the designed width of the crest bench will be sufficient to catch all material that could potentially be dislodged from the slopes of the overburden. The bench width may be increased in areas due to a number of factors including; overburden thickness, material gradation, consolidation, and moisture content.

Numerical analysis has not been completed for the ABM Zone pit, given that the project has been completed to PFS level. This work will be completed as part of the Feasibility Study work programme that will be completed prior to applying for a Quartz Mining Licence from the Department of Energy, Mines and Resources. In the interim, BMC has used industry standard assessment of stability based upon its visual examination of relevant drill core by qualified geotechnical engineers and the historical reports from world renowned specialists Golder Associates (Jan 26, 1996).

YESAB ISSUE

Golder Associates (January 26, 1996) stated in its Executive Summary that "groundwater levels are generally high and follow the topography, with some of the holes in the valley floor exhibiting artesian flow". In the Mine Dewatering section, the report stated that additional drain holes will also be required to investigate the potential for artesian pressure in the south wall.

R39

"Provide additional information related to rock characteristics and the potential for artesian conditions. Provide any additional detailed plans that are available and if they are not, describe the future investigations that will occur to check rock characteristics and artesian conditions."

The hydrogeological setting of the Project and dewatering strategy is presented in the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon report (Appendix D-4 of the Project Proposal). As part of the design work required for permitting, future site investigations will be undertaken to refine the hydrogeological model and rock characteristics.

4.5.2 Underground Mining (HydroGeology)

YESAB ISSUE

The submission outlines in Section 3.5.2 that no hydrogeological study has been conducted for underground Krakatoa and that the geomechanical assessment assumed little water inflow or a dry condition. The hydrogeological study has high importance in assessing underground excavations. Section 8 of the Rockland report states, "the review of drill holes indicated the presence of foliation, faults, structures, damage zone and micro-defect zones". This statement is confirmed by the RMR classification and low local RQD values shown in the report.

R40

"Using information in response to R137, provide a comprehensive description of the hydrogeological setting of the Project, potential effects on mine operations and proposed mitigation."

The hydrogeological setting of the Project is presented in the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon report (Appendix D-4, of the Project Proposal). As stated in the Rockland report (**Appendix 2** of this Response Report) (Section 8, Recommendations) the next stage of the underground design will involve hydrogeological investigations:

> "*VII. A hydrogeological study should be carried out to provide information on water inflow as mining progresses at Krakatoa. Further, the rock quality calculations in this report assumed "dry condition" underground. The ground water inflow (through main faults, joints, lakes, river or others) should be monitored to provide an estimate on water inflow, permeability, joints' water pressure. Subsequently, the analyses in this report should be reviewed and adjusted as information on the ground water inflow becomes available.*"

R41

"Using information in response to R137, is there the potential for inflow rates into areas of underground mining to be higher than envisioned, and what mitigation is proposed to ensure the safety of workers, the stability of the mine and maintenance of environmental conditions?"

Groundwater inflows to the mine pit and underground workings were estimated using the groundwater numerical model presented in the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon report (Appendix D-4, of the Project Proposal). As with all groundwater calculations, there is an uncertainty range associated with these estimates. However, because the model was well-calibrated to site field measurements, and based on the experience of BMC management at other mines, it is BMC's view that the modeling uncertainty is within a range that is easily manageable in a practical mining sense. In final design, appropriate factors-of-safety will be applied to the inflow estimates to ensure that fixed infrastructure and additional operating and standby pumping equipment are in-place to handle higher inflow rates (if these occur). There will also be sufficient redundancy in the pumping systems to handle situations when components of the primary equipment are non-operative due to mechanical failure or periodic maintenance.

YESAB ISSUE

The presence of faults can create highly permeably zones that discharge the groundwater into the underground excavation at a higher rate than bulk rock mass will produce. These discretized flows can be a challenge for safety and stability of the mine workings.

R42

"How will high permeability zones within the rock mass and fault zones be evaluated for stability and safety and how will it be addressed?"

BMC recognises that the presence of faults can create highly permeable zones that discharge water at a higher rate than bulk rock mass will produce. BMC staff have previously developed mines with high permeability zones and fault zones and these scenarios are commonly dealt with every day in mines around the world. There are many different approaches to dealing with fault zones and high permeability zones in mines and the selection of the appropriate response will be determined by the company, taking into account the relevant site conditions. The selection of the appropriate detailed response will therefore be the responsibility of the mine site technical team in accordance with normal industry practise based on observed site conditions.

The Project consists of an open pit and a small underground. The underground mine development will commence from within the pit late in year 2. It is normal practise in this type of situation for the precise design of excavations, ground support and pumping system design to be informed by geological and geotechnical mapping in the open pit in the years prior to commencement of the underground development. In addition to this, a detailed hydrogeological study will be undertaken to provide information on water inflows to the underground mine as mining progresses in the open pit above. Once this information becomes available, then an evaluation of the impact on stability and potential hazards will be conducted. This evaluation will form part of the basis of an Adaptive Management Plan that will address the concerns for stability and safety and will include a requirement for pre-mining investigations, dewatering and/or grouting, enhanced ground support and monitoring of these zones.

R43

"What rock mass classification was used in the stability evaluation? If a classification other than minimal or dry was used, please provide a rational and the potential implications on your conclusions for the effects assessment."

The stability evaluation method in the Rockland Report used rock mass rating (RMR) rock mass classification assuming generally dry conditions (**Appendix 2** to this Response Report). This is based on general conditions observed during drilling for the majority of drill holes and experience gained during feasibility studies and operations of nearby projects by the author. In the next stage of assessment, a detailed hydrogeological study has been recommended to provide information on water inflows to the underground mine. Once this information becomes available, then it is worthwhile to evaluate the impact on stability and potential hazards.

4.5.3 Underground Mining (Rock Mass Classification)

YESAB ISSUE

In Section 3.5.2. of the Rockland report, rock mass classification was performed using the Rock Mass Rating (RMR) proposed by Bieniawski in 1976. This classification was significantly updated in 1989 to incorporate the effect of joint conditions and some correction factors on the stability of underground excavations.

R44

"Update the rock mass classification referenced in the Rockland report using the 1989 Rock Mass Rating (RMR)."

Krakatoa's rock mass classification data was collected based on two well established rock mass classifications; RMR76 and Q. The data for each classification is presented in various tables side by side in the Rockland report. If the application of RMR 76 is not considered appropriate, Q rock mass classification data could alternatively be used. BMC, and the author of the Rockland report, are fully aware of various versions of RMR classification, however, RMR76 is extensively used around the world in geotechnical aspects of mine design, either open pit or underground. The "Guidelines for Open Pit Slope Design" by Read and Stacey published in 2011 is a leading reference book with respect to open pit design methods. This book describes RMR76 and changes made in RMR79 and RMR89. Read and Stacey commented on RMR versions "*Because of these changes, it is important to indicate which version of the system is being used*". This statement warns of the errors that could be produced if parameters from RMR 76 are used in equations relating to RMR 89. The use of RMR76 in the Rockland report is considered legitimate due to the fact that, since its RMR introduction, various investigators around the world continuously collected data, using RMR76, and several correlations have been developed between various geotechnical parameters using this version. Therefore, this allows the use of these relationships developed for geomechanical mine design and also comparisons of geotechnical parameters for mine design purposes. As an example of this Krakatoa's stability assessment for stope design was carried out based on relation developed by Ouchi et al. (2004). This relationship is shown in Figure 7 of the Rockland report which uses data collected based on RMR76 (**Appendix 2** of this Response Report).

BMC understands that ongoing geotechnical evaluations will be required for further design work and prior to these studies an evaluation will be made as to the most appropriate Rock Mass Rating to be used to deliver the required parameters.

YESAB ISSUE

The Geological Strength Index (GSI) classification is not addressed in the Rockland report. This can be done using the equation proposed by Hoek and Brown (1997) using RMR 1989. GSI classification is required to provide rock mass strength parameters.

R45

"Provide the Geological Strength Index (GSI) in order to understand the rock mass strength parameters. Use the appropriate GSI when updating the rock mass classification as per the 1989 Rock Mass Rating (RMR)."

BMC acknowledges that assessment of rock mass strength among other rock mass properties is important for understanding and assessing the impact on the proposed underground mine. However as noted in R44, BMC does not agree that it is necessary to adopt RMR89 as the basis for rock mass assessment. Similarly, given the current level of assessment of the underground mine rock mass, BMC does not believe that determination of the GSI is appropriate until the next programme of assessment has been completed. This will then also be supplemented by visual examination of rock quality and geotechnical structures (including field and face mapping) in the underground mine area. The combination of all the above will then be used to confirm the appropriate underground ground support designs.

The main goals of the Rockland report were stability assessment and ground support recommendations, which do not require an assessment of the GSI (**Appendix 2** of this Response Report). As part of Rockland report, required future studies were identified. Several recommendations are provided in the report including dedicated geotechnical drilling (for underground geotechnical investigation), determination of other intact rock parameters such as Young Modulus and Poisson's Ratio for the next stage of investigation. Once representative parameters have been identified for the various underground lenses, rock strength parameters will be established for detailed geomechanical design purposes, which may include GSI if considered appropriate. These detailed parameters will be used for the detailed designs required for the Quartz Mining Licence and Class A Water Licence.

4.5.4 Underground Mining (Structural Geology)

YESAB ISSUE

The Rockland report does not provide detailed information regarding the joint system for the mine. Section 3.5.2 stated "though good orientation data was collected from holes drilled for pit wall design purpose, orientation data from these underground holes were inconsistent. Even in the good rock quality that can be pieced together for successive run, the orientations did not line up."

For detailed design the joint condition, frequency and orientation should be updated with enhanced mapping of the geology encountered at the site; the data collected should be significantly more detailed. The details of the local faults and associated fault zones (extend and thickness) are not defined in the report and should be addressed by further investigation and logging. Without the discontinuity analysis nothing can be concluded about the hazards for underground excavation, should there be a high discharge zone or should there be wedge failures, etc. Section 5.0 stated "the bolt length and spacing are the function of a number of parameters including rock quality, presence of shears/faults, joint spacing, state of stress, etc." Of these parameters only rock quality was discussed in detail in this report.

Detailed investigation and design, assessing discontinuities and shear zones, are likely suited to permitting with the Ministry of Energy, Mines and Resources.

R46

"What is the plan for investigating and evaluating discontinuities, fault and shear zones for the detailed underground mining design? To what extent could this information inform and change your proposed underground workings?"

As outlined in the Rockland report (**Appendix 2** of this Response Report) as the next stage of assessment, a dedicated geotechnical drilling program will be planned to obtain representative geotechnical information across the main lenses and where other important infrastructure, such as the ramp system, will be located underground. The drilling will be, at a minimum, oriented core drilling with major joint sets, discontinuities and shear zones being defined. Further, as mentioned in Section 8 of the Rockland Report, a laboratory program will be planned to establish required parameters such as Young's Modulus and Poisson's ratio for the main Krakatoa rock types. This information will be used to define potential failure mechanisms and recommend ground support accordingly.

These results will be incorporated in the designs and documentation required for approval of a Quartz Mining Licence by the Department of Energy, Mines and Resources, including the preparation of a Mine Development and Operations Plan.

However, it should be noted that, in accordance with accepted industry practise, final expected ground support designs will not be confirmed until mining of the open pit has commenced and visual confirmatory evidence is available regarding local rock and structure data around the proposed underground portal area. This data collection and design review will be an ongoing management matter over the life of the mine.

R47

"Has the potential for significant weak discontinuities, unfavourable discontinuity orientations, and faults and shear zones been considered in the preliminary feasibility assessment of underground mining? What are the potential effects of these geological characteristics and what is your proposed mitigation in the event of significant adverse effects?"

Yes, all currently available data was considered in the preliminary feasibility assessment of underground mining. As stated in the Rockland report (**Appendix 2** of this Response Report, Section 8 Recommendations), in the next stage of assessment, a dedicated geotechnical drilling program will be planned to obtain representative geotechnical information and this will identify significant weak discontinuities, unfavorable discontinuity orientations, and faults and shear zones if present. This information will be used to inform the designs and documentation required for approval of a Quartz Mining Licence by the Department of Energy, Mines and Resources, including the preparation of a Mine Development and Operations Plan. The mapping of rock quality and geotechnical structures underground will continue over the life of the mine and will be used to inform ongoing and regular reviews of the adequacy of ground support design which will then be modified by qualified site personnel as required.

4.5.5 Underground Mining (In-Situ Stresses and Possible Failure Mechanism)

YESAB ISSUE

Section 3.4 states, "for the purpose of the underground mining at Krakatoa, the major and intermediate stresses are assumed to be 2.5 and 1.5 times the vertical stress respectively (Martin et.al. 2003)." It is correct that in Canada the horizontal stress is greater than vertical stress. However, it should be noted that Martin et al. is based on their investigation at the Underground Research Lab (URL) located in Manitoba.

Potential failure mechanisms such as structurally controlled failure (i.e., wedge failure) and stress-induced failure (i.e., spalling and slabbing) have not been discussed in the Rockland report.

The in-situ horizontal to vertical stress ratio will be the input for the underground mine design, support design, excavation geometry, potential failures (progressive or sudden) and other considerations. This information is normally obtainable by in-situ tests such dilatometer tests or plate load tests.

R48

"At this stage, and considering the underground design report is at its pre-feasibility stage, a generic stress ratio can be assumed; however, the ratio should be verified as per the site condition. The ratio should be defined prior to any detailed design, so the mitigation measures can be foreseen in case of high horizontal stress magnitude. What is the proposed strategy to

address in-situ stress measurement at the mine and what is the plan to verify the proposed horizontal to vertical stress ratio?"

There are significant differences between stress measurement in hard rock in the Canadian Shield and Krakatoa's faulted/jointed orebody. In the past, the author of the Rockland report has conducted stress measurements where the ground is jointed/faulted using expert contractors. However, after extensive review of available methodologies and lack of certainty in the results, direct stress measurements are found to be of little value. Therefore, stress measurements for Krakatoa were not recommended at this time. Using project experiences in jointed and faulted ground and empirical/numerical methods, the stress magnitude will initially be estimated. As mining progresses, using field mapping of rock quality and structures combined with back analyses, the stress magnitude will be adjusted and / or verified.

R49

"What are the expected potential failure mechanisms (both structural failure and stress-induced)?"

As stated in the Rockland report (**Appendix 2** of this Response Report, Section 8 Recommendations), in the next stage of assessment, a dedicated geotechnical drilling program will be planned in order to obtain representative geotechnical information across the main lenses and where other important infrastructures such as the ramp will be located underground. The drilling will be oriented core drilling and therefore major joint sets will be defined. Further, as mentioned in Section 8, a laboratory program will be planned to establish required parameters such as Young's Modulus and Poisson's ratio for the main Krakatoa's rock types. This will subsequently be supported by geological and geotechnical mapping within the open pit. This information set will be used to define potential failure mechanisms and recommend ground support accordingly.

R50

"How have the outlined mitigation measures accounted for the potential scenario where assumptions made in the preliminary design are non-conservative?"

As stated in the Rockland report (**Appendix 2** of this Response Report, Section 8 Recommendations), in the next stage of assessment, a dedicated geotechnical drilling program will be planned to obtain representative geotechnical information across the main lenses. Subsequently, geotechnical domains will be identified for Krakatoa and ground support will be recommended accordingly. Where locally, the recommended ground support are found to be insufficient, analytical /empirical/numerical methods will be used to assess stability and recommend ground support.

Should the assumptions made in the preliminary design be found to be non-conservative (as an example if it was determined that fibrecrete reinforcement of the main ramp was necessary), BMC will revise ground support designs to ensure that the integrity of the underground mine is maintained and that safety of underground personnel is not compromised. BMC has allowed for financial and production contingencies within the planning of the mine to ensure that flexibility in ground support design can be maintained when required.

R51

"What are the gaps in information and what is the plan for addressing these gaps for the detailed design and operations?"

As noted in R48, the measurement of in-situ stresses has not been recommended by BMC's consultants to be completed at this time. Notwithstanding this, detailed design for the underground mine will be informed by additional data generated between completion of the PFS and commencement of underground mining, including additional geotechnical drilling, in pit mapping and experience gained with the rock mass during the first two years of open pit mining, prior to commencement of the underground mine.

Once the underground mine is in operation, data gathering and analysis will continue throughout the mine life to monitor the performance of ground support design, which will be updated where appropriate to reflect changes in understanding of the *in situ* rock mass and its response to mining activities.

4.5.6 Underground Mining (Additional Investigations)

YESAB ISSUE

Section 3.5.2 states, "in the next stage of assessment, a dedicated geotechnical drilling program should be carried out to obtain representative geotechnical information across the main lens and where other important infrastructures such as ramp which will be located underground".

The preliminary underground mining report in its current form is based on borehole logs that are not located within the underground excavation footprint. This absence of subsurface information presents uncertainty to the potential hazards associated with underground mining, such as squeezing ground, high influx of groundwater, crushed/fault zone areas, etc. The comments provided in underground report are more a 'generic' comments without solid background. One statement in the report revealed, "the design is based on dry condition assumption".

R52

"Demonstrate your awareness of the geotechnical hazards identified in previous reports through: describing the uncertainty related to the absence of subsurface information at the underground mine footprint; identifying the risks and potential effects of this uncertainty; and proposed mitigation measures or alternatives."

IR52, IR53, and IR54 are related, and this response will serve for all three. It is important to recognize that there will be at least one more detailed geotechnical investigation for Krakatoa. The major aspects of this investigation are summarized here (paraphrased from the Rockland report, Section 8 Recommendations) (**Appendix 2** of this Response Report).

In the next stage of assessment, a dedicated geotechnical drilling program will be planned to obtain representative geotechnical information across the main lenses. The drilling will be oriented core drilling and dip directions of major geological features will be identified. Also, a detailed hydrogeological study will be carried out to provide information on water inflow as mining progresses at Krakatoa. The main objective is to establish geotechnical domains. Once geotechnical domains are established, geomechanical analyses, consisting of analytical/empirical/numerical methods will be carried out to assess stability and, if required, the recommended ground support will be adjusted accordingly. This information will be required before any final designs are submitted for the appropriate permitting. However, these support designs in themselves will be preliminary and will be subject to further refinement as the development of the open pit and underground mine proceeds and visual examination and geological/geotechnical mapping of the fresh rock exposed during the mining process occurs.

Prior to mine operation, a detailed document, "Ground Control Management Plan" will be prepared for Krakatoa. The objective of the Ground Control Management Plan is to provide the strategies aimed at eliminating or minimizing the risk of instability including falls of ground or collapse in the underground operations which may result in fatalities, injuries, equipment damage or loss of production. Excavation of the Krakatoa underground portal will not commence until this plan is prepared and signed off by suitably qualified managers within the company.

R53

"Provide additional information on the ground model in relation to the underground mine works that addresses, at minimum, the rock mass rating, joints, hydrogeology and related information in order to develop the mine safely and reliably. Provide information on how this will be incorporated into the design of the underground mine."

See R52.

R54

"Describe your plans for conducting a more detailed investigation to facilitate a safe and reliable mine design."

See R52.

4.5.7 Underground Mining (Support design)

YESAB ISSUE

Section 5.0 stated, "the recommended ground support assumes a non-acid generating environment underground with generally dry condition". It is understood at this level of analysis and with the presented information, there is insufficient information to evaluate the support design; however, there is nothing in the report or any reference made in this report that makes the case for the presence of a non-acid generating condition.

R55

"Provide evidence supporting the assumption that the underground will be a non-acid generating environment with generally dry conditions."

The dry condition is based on general condition observed during drilling for majority of the drill holes and experience gained during feasibility studies and operation of nearby projects. It is also based upon the expected life of the underground mine and commonly accepted international mining practise where the practical costs and productivity differences between ground support non-acid generating mine conditions and potentially acid generating mine conditions is minimal. However, as stated in the Rockland report, (**Appendix 2** to this Response Report) in the next stage of assessment, a detailed hydrogeological study has been recommended to provide information on water inflow as mining progresses at Krakatoa. Similarly, as the mine development progresses, geological examination of the rock types will allow an easy assessment of the potential for acid generation and modifications of ground support can be made accordingly. This simple and time effective process is common international practise.

R56

"How will acid rock drainage sampling and testing be tested and assessed?"

The methodology of acid rock drainage sampling and testing, and results, is presented in Appendix D-5 - Waste Rock and Tailings Geochemistry Characterization Report, of the Project Proposal.

It is inferred that this question is in relation to the quality of the ground support regime and how the impact of an acid generating environment (should such conditions be present in the underground mine) will be managed. The specific management of this scenario will be assessed and presented in the Mine Development and Operation Plan that will be prepared as part of securing a Quartz Mining Licence from the Department of Energy, Mines and Resources. General management practices are expected to include:

- Visual inspection and mapping of the country rock and geotechnical structures in the development headings and where the rock type/structure/mineralogy dictates, appropriate modifications will be made to the recommended ground support regime for that area;
- Periodic inspections of installed ground support for evidence of corrosion, with areas of concern subjected to more regular monitoring to review the quality of the installed support;
- A regular testing program of installed ground support as part of a QA/QC process to verify that installed ground support is achieving the designed support loadings; and
- The use of galvanised ground support alternatives to reduce the impact of corrosion on the installed ground support.

R57

"Should acid generating conditions be discovered, what is the feasibility of the recommended ground support design?"

The feasibility of the recommended ground support design under acid generating conditions depends on several parameters including presence or absence of moisture, ground water, length of time the excavation will remain open among others. In today's underground mining, ground support systems are available for a variety of environmental conditions, including acid generating conditions. If acid generating conditions are determined, tests will be required to establish a pH level, or a range of pH levels, relative to the time of exposure. Once these are established, the recommended ground support system will be adjusted, as and if required. Modern underground ground support designs and materials are designed to be flexible and can be practically varied on short notice.

R58

"Are there alternatives considered and feasible to mitigate an acid generating underground mining environment, for this project?"

Underground mining commonly occurs in acid generating and non-acid generating mining environments. In recent decades, a multitude of various alternatives have been implemented to mitigate acid generating conditions. Once acid generating conditions are determined, based on the severity and how widespread they are, various mitigative measures would be investigated and implemented accordingly.

Such measures may include cement grouting of bolts, use of chemical or mechanical anchors, use of galvanised steel bolts or mesh instead of ungalvanized, replacement of friction bolts with point anchor or full contact solid steel bolts, use of non-metal ground support materials such as shotcrete or many other common practises.

5 EFFECTS ASSESSMENT METHODS

No information required.

6 AIR QUALITY

YESAB ISSUE

Emissions of Criteria Air Contaminants (CACs) from off-site traffic along the highway have not been assessed either to Watson Lake or to the port in Stewart for any of the project phases.

R59

"Include emissions from off-site Criteria Air Contaminants (CACs) in the air quality assessment or provide a justification as to why this is not necessary."

Emissions from off-site CACs were included in the air quality assessment, as they are a relevant consideration. Off-site traffic during operations phase (highest volumes) was considered to be a lower risk interaction during the initial step of effects characterization, which is outlined in Section 6.4.1 of the Project Proposal. Table 6-11 is reproduced below (Table 6-1), and presents the results of the interaction screening, where ranking 0, 1, or 2, is made in consideration of the Project activities and consultation efforts to indicate:

0 – Nominal risk interactions;

1 – Lower risk interactions- *the interaction will not result in residual effect due to the application of the practices known to effectively mitigate predicted effects;* and

2 – Higher risk interactions- *it is reasonably foreseeable that residual effects may result.*

The off-site traffic interaction was considered to be lower risk for air quality as any potential air quality effects would be intermittent in nature and much lower magnitude than those as a result of on-site activities. As identified in Table 6-1, all residual effects for air quality were considered not significant. It should be noted however, that potential effects (project-related traffic + baseline) on air quality along the highway can be estimated be broadly comparable within an order of magnitude to the currently closed Wolverine Mine during its operating period.

Table 6-1: Interaction Matrix for Air Quality

Project Activity	Criteria Air Contaminants	Greenhouse Gases
Construction		
Tote Road upgrade to Access road	1	1
Finlayson Lake airstrip upgrade	0	1
Site preparation and clearing	2	1
Site grading, including soil and overburden removal and stockpiling	2	1
Off site traffic (construction equipment and materials delivery)	0	1
On site traffic	1	1
ABM open pit development (including dewatering and Fault Creek diversion)	2	1
Infrastructure construction	1	1

Project Activity	Criteria Air Contaminants	Greenhouse Gases
Waste handling	1	1
Water use and management	1	1
Power generation	2	2
Worker transport	1	1
Construction camp operation	1	1
Workforce, procurement and hiring	0	0
Operations		
ABM open pit operations (including blasting and dewatering)	2	1
Underground operations	0	1
Ore processing	2	1
On site traffic	1	1
Off-site traffic (highway)	0	1
Finlayson Lake airstrip operations	0	1
Storage facilities management (Class A, B, and C)	1	1
Progressive reclamation of storage facilities	1	1
Water use (potable and non-potable)	1	1
Mine water management and treatment (including effluent discharge)	1	1
Waste management	1	1
Power generation	2	2
Worker transport	1	1
Camp operation	1	1
Workforce, procurement and hiring	0	0
Closure		
Processing plant decommissioning and reclamation	1	1
ABM lake filling	0	0
Final storage facilities reclamation	1	1
Support infrastructure removal and reclamation	2	1
Water management, treatment and discharge	1	1
On-site traffic	1	1
Off-site traffic	0	1
Access road reclamation	1	1
Workforce, procurement and hiring	0	0

YESAB ISSUE

BMC identified SO2, TSP, CO, $PM_{2.5}$ and PM_{10} as measurable parameters for the CACs valued subcomponent. However, volatile organic compounds (VOCs), which are part of this group, are not *mentioned or assessed, even though they are followed closely by Environment and Climate Change Canada (ECCC) in the long-term goal of minimizing the risks of CACs.*

VOCs are emitted from different sources mentioned in the project description, including combustion sources (mobile and ON and OFF road equipment) and storage tanks.

R60

"Assess volatile organic compounds (VOC) emissions in chapter 6 of the proposal from all sources of emissions associated with the Project, including combustion sources and storage tanks."

BMC's consultants have thoroughly reviewed all COCs against relevant guidelines in developing the supporting work referenced. The initial scoping of this work identified that VOCs are not typically modeled for mining projects, and there are no terms of reference or guidelines against which to compare modeling results for VOCs. The inclusion of these additional CACs would not be material to the project effects assessment.

R61

"Identify measures to mitigate VOC emissions associated with the Project."

Mitigation measures aimed at reducing gaseous contaminants and greenhouse gases are presented in Chapter 6 of the Project Proposal, and will also contribute to reducing VOC emissions. Such measures include the use of pollution control devices, avoiding engine idling, ensuring proper maintenance of vehicles and equipment, waste reduction and recycling, waste segregation, incinerator operation for optimum combustion and regular inspection of the incinerator.

YESAB ISSUE

The proponent has declared the use of stationary diesel engines during the construction and closure phases of this proposed project (24 hours a day for the camp and 12 hours a day for the process plant), and the use of dual fuel engines during the operational phase (24 hours a day for the process plant):

- *Unknown is the make generators being installed, whether they are Tier 1, 2, 3 or 4 compliant, (and the type of control technologies being used other than catalysts).*
- *There does not appear to be any discussions on other components of the power plant. The proponent mentions using waste heat generated from the engines for heating purposes, which, would improve the energy efficiency of the Project.*

The proponent has declared the use of dual fuel generators using 99% natural gas and 1% diesel, during the operational phase of the Project:

- *The proponent needs to confirm the type of natural gas and diesel fuel being consumed for power generation.*

- *Needs to confirm the fuel ratio or substitution rate (natural gas to diesel). The proponent has declared a 1% substitution rate, which appears low.*

GHG and CACs emissions for the project are provided using the output of an air quality model. While useful, this approach makes it difficult to estimate, on an absolute basis, the total project emissions as well as the emissions from the individual components of the projects (power plant, mine operation, etc.). Based on available information, ECCC has estimated the CO2eq yearly emissions from the power plant to be between 31,800 and 64,600 tonnes, the TPM yearly emissions between 2.6 and 26.3 tonnes, NO_x yearly emissions between 58 and 1,354 tonnes and CO yearly emissions between 515 and 1,678 tonnes. Emission estimates of these levels are consistent with project of significant sizes. Due diligence is warranted as no absolute emissions estimates were provided and the higher limits of above estimated emission ranges are significant enough to justify an increase in estimation accuracy.

R62

"Identify the power generation technology and after-treatment devices used for the site power supply."

During the construction phase, stationary diesel engines will be used for power generation. While the specific models used during construction will depend on what each contractor sources for their particular work packages, it is expected that rental generators similar to the following will be utilised during construction of the processing facility:

- Up to six of 18kW Cat XQ20, or similar;
- Up to two of 60kW Cummins C60 D6R, or similar;
- One of 80kW Cummins C80 D6R, or similar.

Power for the camp during the construction phase will also be produced by a rented stationary diesel engine, such as a 250kW Cummins C300 D2R, or similar. All generators used in the construction phase will be equipped with standard OEM after-treatment devices as made available by equipment rental providers.

During the operations phase, power is proposed to be generated using dual fuel (natural gas / diesel) engines, using Wartsila 9L34DF generators or similar. These generators are capable of operating over a wide range of natural gas (NG) and diesel fuel blends from 100% diesel up to 99% NG with 1% diesel required to ignite engine combustion.

When operating in gas mode, the Wartsila 34DF engine is already compliant with IMO Tier III regulations without any secondary exhaust gas purification systems. In liquid fuel oil mode, the Wartsila dual fuel engines are fully compliant with the IMO Tier II exhaust emissions regulations.

Six generating units will be installed on site, with four expected to be in operation at any one time. As indicated in Section 4.11.15 of the Project Proposal, full heat recovery from the generators will be utilized to provide heating to the processing facility. The specific final engineering aspects of the heat recovery system have not been designed at this time.

During the closure phase, rental units similar to that used for the construction phase will be utilized for power generation. These will typically be:

- Up to six of 18kW Cat XQ20, or similar for approximately six months for plant decommissioning;
- Up to two of 180kW Cummins C200 D2RE, or similar for site pumping and water treatment plant operation;
- One 250kW Cummins C300 D2R or similar for power to the camp; and
- In addition to the above there will be a small number of backup generators of similar sizes for use in the case of generator failure.

All generators used in the closure phase will be equipped with standard OEM after-treatment devices as made available by equipment rental providers.

R63

"Identify fuel quality and yearly fuel usage by fuel type of the site power supply."

Fuel for power generation used for the construction and closure phases will be commercially available diesel as sourced from reputable local suppliers. During operations, fuel for power generation will be sourced from a combination of commercially available diesel and natural gas as sourced from reputable local suppliers. The final fuel quality specifications for contracted deliveries will be established as BMC enters into supply agreements with fuel suppliers.

Fuel usage during the construction and closure phases will vary depending on the level of activity in progress at any one time. Estimated maximum yearly usage for the construction period is 856,000 litres of diesel fuel and in the closure phase it is estimated that a maximum of 324,000 litres of diesel fuel will be used per year.

While it is expected that natural gas will be the primary fuel source during operations, this will vary depending on relative pricing of the two fuel sources. Assuming that a ratio of 99% natural gas to 1% diesel is achieved during operations, 981,300 GJ of natural gas and 245,000 litres of diesel are expected to be consumed each year for power generation.

R64

"Indicate the absolute emissions of Greenhouse Gas Emissions (GHG) and Criteria Air Contaminants (CACs) for the individual components of the projects (e.g. site power supply, mining operation, etc.)?"

Table 6-18 of the Project Proposal presents the average annual GHG emissions per project phase and project component. Assuming two years for the construction phase, ten years for the operation phase and three years for the active closure phase, absolute GHG emissions were compiled in the table below (Table 6-2), which is based on Table 6-18.

Table 6-2: Project GHG Emissions per Project Phase (tonnes of CO_2 equivalent) and Total Absolute Emissions

	Construction Phase CO_2e (tonnes)	Operation Phase CO_2e (tonnes)	Closure Phase CO_2e (tonnes)	All Phases CO_2e (tonnes)
Diesel Generators	5,579	0	3,567	**9,146**
Dual-fuel Generators	0	241,318	0	**241,318**
Boiler	3,164	15,820	4,746	**23,730**
Incinerator	3	14	4	**22**
Diesel Fired Equipment	14,775	264,578	22,003	**301,356**
Light Vehicles	21	204	195	**420**
Heavy Vehicles	253	68,143	2,630	**71,026**
Air Travel	1	64	1	**67**
TOTAL	**23,796**	**590,141**	**33,147**	**647,084**

A similar exercise was carried out to compile absolute CAC emissions and results are shown in Table 6-3 to Table 6-8.

Table 6-3: Project TSP Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	3	0	2	**5**
Dual-fuel Generators	0	567	0	**567**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	8	140	12	**161**
Light Vehicles	0	0	0	**0**
Heavy Vehicles	0	1	0	**1**
TOTAL	**11**	**708**	**15**	**734**

Table 6-4: Project PM_{10} Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	3	0	2	**5**
Dual-fuel Generators	0	466	0	**466**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	6	115	10	**132**
Light Vehicles	0	0	0	**0**
Heavy Vehicles	0	1	0	**1**

	Construction Phase	Operation Phase	Closure Phase	All phases
TOTAL	**9**	**583**	**12**	**604**

Table 6-5: Project $PM_{2.5}$ Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	2	0	1	**4**
Dual-fuel Generators	0	390	0	**390**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	5	97	9	**110**
Light Vehicles	0	0	0	**0**
Heavy Vehicles	0	1	0	**1**
TOTAL	**8**	**487**	**10**	**505**

Table 6-6: Project CO Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	25	0	16	**41**
Dual-fuel Generators	0	4,455	0	**4,455**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	62	1,103	98	**1,263**
Light Vehicles	0	0	0	**1**
Heavy Vehicles	1	13	2	**15**
TOTAL	**88**	**5,571**	**116**	**5,775**

Table 6-7: Project NOx Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	60	0	38	**98**
Dual-fuel Generators	0	1,053	0	**1,053**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	146	2,608	232	**2,986**
Light Vehicles	0	0	0	**1**
Heavy Vehicles	2	45	6	**53**
TOTAL	**207**	**3,706**	**276**	**4,189**

Table 6-8: Project SOx Emissions (tonnes) per Project Phase and Total Absolute Emissions

	Construction Phase	Operation Phase	Closure Phase	All phases
Diesel Generators	0	0	0	**0**
Dual-fuel Generators	0	10	0	**10**
Boiler	0	0	0	**0**
Incinerator	0	0	0	**0**
Diesel Fired Equipment	0	2	0	**3**
Light Vehicles	0	0	0	**0**
Heavy Vehicles	0	0	0	**0**
TOTAL	**0**	**12**	**0**	**13**

YESAB ISSUE

Criteria Air Contaminants (CACs) selected in the assessment are SO_2, TSP, CO, $PM_{2.5}$, PM_{10}, and NO_2. The Project's list of CACs is not exhaustive, *mining can be expected to produce other CACs, for example: metals in dusts; NH_3; volatile organic compounds (VOCs); polycyclic aromatic hydrocarbons (PAHs); petroleum Hydrocarbons (PHCs); and diesel PM.*

(Proposal Section 6.1.2) Environment Yukon has AQ standards for SO2, O3, TSP, CO, PM2.5, PM10 and NOx – we support Health Canada's adequacy comments about other CACs that are relevant to the proposed activity. The proponent should provide justification for the exclusion of VOCs, PAHs, metals in dust, NH3, PHCs and diesel PM. Preferably, the proponent should include these additional CACs in their proposal.

R65

"Update the assessment to include relevant Criteria Air Contaminants (CACs) or provide justification for the exclusion of: metals in dusts; NH3; volatile organic compounds (VOCs); polycyclic aromatic hydrocarbons (PAHs); petroleum Hydrocarbons (PHCs); and diesel PM."

BMC's consultants have thoroughly reviewed all CACs against relevant guidelines and in doing so have been rigorous in providing adequate information for a relevant assessment of potential effects. These additional CACs are not typically modeled for mining projects, and there are no terms of reference or guidelines against which to compare modeling results for the additional CACs listed. The inclusion of these additional CACs would not be material to the project effects assessment.

YESAB ISSUE

The assessment of $PM_{2.5}$ refers to the Yukon Ambient Air Quality Standards (YAAQS) which are less conservative (at 28 $\mu g/m^3$) than the 2020 CCME Canadian Ambient Air Quality Standards (CAAQS) guidelines of 27 $\mu g/m^3$. The proposed Project will be operational when the 2020 CAAQS for PM2.5 come into effect (27 $\mu g/m^3$ for 24 hr averaging time).

The CAAQS for SO_2 will come into effect in 2020, with more stringent guidelines coming into effect in 2025. The new CAAQS guidelines for SO_2 are lower than the YAAQS guidelines used in the air quality assessment of 1-hour 172 ppb and an annual mean of 11 ppb. The proposed Project will be operational when the 2020 CAAQS for SO2 come into effect with a red management level of 1-hour 70 ppb SO2 and an annual mean of 5 ppb. The red management level will be reduced in 2025 to 1-hour 65 ppb SO2 and an annual mean of 4 ppb.

(Table 6.2) In addition to Health Canada's comments (Items #2 and #3, Air Quality Guidelines),

Environment Yukon will be updating YAAQS to reflect any amendments made to the CAAQS in accordance with the federal timelines, specifically for PM2.5 and SO2.

R66

"Update the air quality assessment of $PM_{2.5}$ using the federal guideline."

BMC has committed to following all applicable standards and acting in accordance with all applicable regulations and guidelines. BMC used the standard approach of assessing modeling results against existing guidelines (YAAQS). However, the $PM_{2.5}$ model results also fall below the future (2020) CCME Canadian Ambient Air Quality Standards (CAAQS) guidelines of 27 µg/m³. Project Proposal Table 6-14 showing predicted $PM_{2.5}$ concentrations is reproduced below, as Table 6-9, for comparison.

Table 6-9: Predicted $PM_{2.5}$ Concentrations

Receptor	Maximum 24-hr Concentration (µg/m³)			Annual Concentration (µg/m³)		
	Construction Phase	Operations Phase	Closure Phase	Construction Phase	Operations Phase	Closure Phase
YAAQS	28			10		
Baseline	4			1		
Camp	4	6	4	<1	<1	<1
Baseline + Camp	8	10	8	1	1	1

R67

"Update the air quality assessment of SO_2 using the 2025 federal guideline."

BMC has committed to following all applicable standards and acting in accordance with all applicable regulations and guidelines. BMC used the standard approach of assessing modeling results against existing guidelines (YAAQS). However, the SO2 model results also fall below the future (2020) CCME Canadian Ambient Air Quality Standards (CAAQS) (red management level of 1-hour 70 ppb SO2 and an annual mean of 5 ppb) as well as the future (2025) red management levels (1-hour 65 ppb SO2 and an annual mean of 4 ppb). BMC will abide by all applicable standards as they apply during each phase/year of the Project. Project Proposal Table 6-17 showing predicted SO2 concentrations is reproduced below, as Table 6-10, for comparison.

Table 6-10: Predicted SO_2 Concentrations

Receptor	Maximum 1-hour Concentration (ppbv)			Maximum 24-hour Concentration (ppbv)			Annual Concentration (ppbv)		
	Construction Phase	Operations Phase	Closure Phase	Construction Phase	Operations Phase	Closure Phase	Construction Phase	Operation s Phase	Closure Phase
YAAQS	172			57			11		
Baseline	0			0			0		
Camp	<1	<1	<1	<1	<1	<1	<1	<1	<1

YESAB ISSUE

The air quality assessment claims there will be no significant effects on air quality from the Project and states: "The EA for air quality identified no significant effects. Furthermore, the Air Quality Management Plan (Section 18.11) will be in place and will aim to eliminate all exceedances identified through modelling as those are predicted during worst meteorological and operational conditions. Therefore, no monitoring is proposed."

R68

"Develop and describe a monitoring program to: understand baseline conditions for environmental media, such as air, water, soil and country foods; monitor for increases in the environmental media as a result of project-related activities; provide relevant mitigative measures and alternatives to manage future risks."

The baseline monitoring programs, baseline conditions, mitigation measures and future monitoring for air, water and soil are presented in the Project Proposal as follows:

- Baseline conditions for air quality are summarized in Section 6.3 of the Project Proposal. Mitigation measures to minimize changes in air quality are presented in Section 6.4.2 of the Project Proposal. Given the low levels of changes predicted for air quality no monitoring is proposed. However, triggers for contingency dust suppression or other mitigations, in addition to dry or windy weather conditions, may include complaints or reduced visibility, and will be based on professional judgement.
- Baseline conditions for water are summarized in Section 8.3 and presented in detail in Appendix D-1 (2015-2016 KZK Surface Water Quality Baseline Report) of the Project Proposal. Mitigation measures to reduce or minimize potential effects on water quality are presented in Section 8.4.2 of the Project Proposal. Proposed monitoring of water quality is presented in Section 8.6 as well as in Section 18.4 (Surface Water Management Plan) of the Project Proposal.
- Baseline conditions for soil are summarised in Section 11.3.8 and 11.3.9 and presented in detail in Appendix E-6 (Vegetation Baseline Report) of the Project Proposal. Mitigation measures to reduce or minimize potential impacts on soil are presented in Section 11.4.2.3, with the proposed monitoring program presented in Section 11.6 of the Project Proposal.

In addition, a Preliminary Quantitative Risk Assessment (PQRA) has been conducted (as per IR267) and is included as **Appendix 3** of this Response Report. Note that potential changes in the quality of country foods is addressed in the PQRA.

YESAB ISSUE

The only specific receptor referred to in the air quality and noise assessments is the worker camp, which the assessment considered a sensitive receptor.

However, traditional activities in the region identified in Section 15 of the proposal include hunting, trapping, gathering, and fishing. There are also cabins located near the project boundary at North Lakes, Wolverine Lakes, Money Peak, Frances Lake, Pelly Banks and Money Creek.

R69

"Include the following as receptors in the air quality and noise assessments:

a. cabins located near the Project

b. any areas where traditional activities are taking place"

A PQRA has been conducted (as per IR267) and is included as **Appendix 3** of this Response Report. As no significant effects are predicted for the closest receptor (i.e. in the camp), receptors at farther distances (i.e. potential seasonally used cabins or areas of traditional use) will also not be effected due to predicted changes in air quality or noise.

YESAB ISSUE

A component of $PM_{2.5}$, BC has been shown to have significant local impacts, especially in Arctic regions-BC lands on snow and ice, accelerating warming of the atmosphere and melting of snow and ice, and off-road transportation is a significant contributor to emissions. As a powerful climate forcer, reducing BC emissions can provide significant near-term benefits including the slowing of the rate of ice, snow, and glacier melt, and reversal of adverse precipitation changes.

R70

"Calculate and include BC emissions as a component of PM2.5 using Canada's Black Carbon Inventory 2016. https://ec.gc.ca/air/3F796B41-0B87-4C14-76D-899D23CD0295/Black%20Carbon%202016-ENFinal.pd"f

BMC's consultants have thoroughly reviewed all air contaminants against relevant guidelines. Black carbon is not typically modeled for mining projects, and there are no terms of reference or guidelines against which to compare modeling results for black carbon. The inclusion of black carbon would not be material to the project effects assessment.

YESAB ISSUE

The document cites the National Inventory Report as the source for Yukon's emissions in comparison to Canada-wide totals. The Yukon government has established the NIR as inaccurate for Yukon, as illustrated with the Yukon Transportation Report (attached). The NIR is approximately 75% inaccurate for Yukon.

R71

"Utilize data from the Yukon Transportation Report instead of the National Inventory Report to more accurately represent Yukon's greenhouse gas emissions."

The report "Yukon Greenhouse Gas Emissions: The transportation sector" (Taggart, 2015) provides re-calculated GHG emissions for Yukon, based on the solid fuel consumption data provided by YG Finance. Revised numbers were added to Table 6-8 of the Project Proposal (and presented here as Table 6-11), in comparison to numbers provided in the NIR.

Table 6-11: National and Territorial GHG Emissions (in kilotonnes of CO_2 equivalent/year)

Year	Canada Total Emissions	Canada Emissions - Mining Sector	Yukon Total Emissions (NIR)	Yukon Total Emissions Re-Calculation (Taggart, 2015)
1990	613,000	6,000	531	
2000	747,000	6,000	505	
2005	696,000	7,000	459	
2010	706,000	7,000	344	630
2011	710,000	8,000	384	695
2012	718,000	8,000	393	639
2013	731,000	8,000	351	586
2014	732,000	8,000	268	

Even with the higher revised numbers, Yukon emissions still represent less than 0.1% of total Canadian emissions. When comparing the predicted average annual Project emissions to the 2013 total territorial re-calculated GHG emissions, they represent about 2% of the Yukon emissions during the construction and closure phases and about 10% during operations, which are smaller fractions than those reported in Chapter 6 of the Project proposal. This revised comparison does not change the outcome of the effects assessment.

ISSUE

The proposal indicates open burning of plastics as a disposal plan. This will not be permitted. Therefore, waste management plans will need to be updated.

R72

"Provide plans for waste management given that open burning of plastics will not be permitted."

Plastics will be collected separately, compressed and packaged for shipment to a designated waste management facility, preferably Whitehorse Waste Management Facility, as part of backhaul of material shipped to site. BMC understands that this component of waste management for the Kudz Ze Kayah mine, along with all specific details, schedules, signage, policies and procedures of the waste management program will be developed during the permitting stage, once the YESAB environmental and socioeconomic assessment has concluded.

YESAB ISSUE

(Proposal s. 8.11.3.3) This section states that "Ambient monitoring results above YAAQS will trigger contingency measures …", however, there is no description for the monitoring plan.

R73

"Provide an ambient air quality monitoring plan which describes the contingency measures and how they are triggered for implementation."

The statement "*Ambient monitoring results above YAAQS will trigger contingency measures …*" presented in Section 18.11.3.3 is erroneous, as no ambient air quality monitoring is proposed. Triggers for contingency measures, in addition to dry or windy weather conditions, may include complaints or reduced visibility, and will be based on professional judgement.

YESAB ISSUE

(Proposal s.6.6.1) This section states that "no monitoring is proposed", based on the EA identifying no significant effects. This is in conflict with #4 (above) which describes that ambient monitoring results will be used to determine contingency efforts.

R74

"Revise section 6.6.1 of the proposal to reflect the proposed monitoring plan."

The EA for air quality identified no significant effects and consequently no ambient air quality monitoring is proposed. While Section 6.6.1 of the Proposal doesn't require revision, the statement "Ambient monitoring results above YAAQS will trigger contingency measures …" presented in Section 18.11.3.3 is erroneous and this section should read as follows:

"If weather conditions or forecast show strong winds and/or dry conditions, preventative dust management actions will be taken. In addition to dry or windy weather conditions, triggers for contingency measures may include complaints or reduced visibility, and will be based on physical observations and professional judgement. Contingency measures may include:

- Increased frequency of watering/dust suppressant application to road and other exposed areas;
- Traffic re-routing and work reduction in areas where dust is generated;

- Early surface preparation and scheduling of revegetation activities for disturbed areas so that they may be seeded as early as possible; and
- Adjust timing of dust generating activities to reduce cumulative effects;
- Consider reducing drop heights from conveyors, if practicable;
- Limit material transfer points;
- Installation of additional sprinklers/misters along conveyor;
- Pre-watering of areas prior to earthworks;
- Review of dust control equipment, control measures and overall management plan as needed; and
- Wind barrier (windrow) construction such as crushed rock, soil berms or fences upwind of roads and exposed areas.

The following methods would be considered when placing barriers to prevent dust emissions:

- Wind barriers are most effective when placed perpendicular to the direction of the prevailing wind, but will have little or no effect when the wind direction is parallel to the barrier;
- When choosing wind barriers, solid barriers provide significant reductions in wind velocity for relatively short leeward distances, whereas porous barriers provide smaller reductions in velocity for more extended distances; and
- Wind barrier height (i.e., greater than 2 metres).

Air quality concerns and corrective actions will be periodically reviewed by the respective Area Managers and the Environmental Manager to determine if additional contingency measures and/or Project design, or operational changes are required."

YESAB ISSUE

(Proposal s.4.10.3.2) Clarification is required about the types of air pollutant sources and mitigation efforts that will be applied.

R75

"Provide a Dust Management Plan that meets the criteria set out in Yukon Government – Department of Environment's Dust Management Guideline, including: description of all sources, and for each source a description of the primary dust control measures, thresholds/triggers for management and contingency dust control measures."

BMC recognizes the importance of managing all emissions from the Project, including dust emissions. Emission sources for each Project phase were described in the Air Dispersion Model report (Rev0 December 12, 2016) (Appendix E-1 of the Project Proposal). Mitigation measures, including dust control measures, are presented in Section 6.4.2 of the Project Proposal. Many of the dust control measures will address the cumulative effect of several sources and are not specific to one source. A conceptual Air Quality Management Plan (including contingency measures) is also presented in Section 18.11 of the Project Proposal. A more detailed Air Quality Management Plan will be submitted in support of the regulatory permit applications at the appropriate time.

7 NOISE LEVELS

YESAB ISSUE

With the exception of blasting, the effects of tonal, impulsive and highly impulsive noise were not considered in the noise assessment.

R76

"Update the noise assessment to consider the impacts of tonal, impulsive, and highly impulsive noise on human health (e.g., from activities such as hammering and pile driving). Refer to Health Canada's "Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise", available here: https://www.canada.ca/en/services/health/publications/healthy-living.html#a2.5"

BMC's consultants have thoroughly reviewed all relevant guidelines and there are no specific terms of reference or guidelines regarding tonal, impulsive and highly impulsive noise in the British Columbia Oil and Gas Commission standards (BC OGC, 2009) or the Alberta Energy Resources Conservation Board (ERCB) Directive 038 (ERCB, 2007). Health Canada recommends the use of sound character adjustments (in dBA); however, because all scenarios modelled were chosen to be very conservative (where all non-continuous sources were assumed to be in operation at the same time and when source specifications were unknown, the loudest option was selected). Also, only design mitigations were incorporated in the model. The inclusion of additional adjustments would result in unrealistically conservative scenarios, and the information provided allows for an appropriate and comprehensive health effects assessment to be conducted.

YESAB ISSUE

Health Canada's Useful Information for Environmental Assessments guidance document suggests identifying all potential noise sources during construction, operation, and decommissioning (e.g., blasting, traffic, heavy equipment, or transformer).

Refer to Health Canada's "Useful Information for Environmental Assessments" guidance document available here: http://publications.gc.ca/collections/collection_2015/sc-hc/H128-1-10-599-eng.pdf

R77

"Specify the noise types and levels emitted by specific equipment or processes and update Table 7-5 of the proposal accordingly."

Detailed lists of noise sources and associated location, sound pressure level and usage for each Project phase are presented in Tables 4-1 to 4-3 of the Noise Prediction Modelling Report Rev0_161209 (Appendix E-2of the Project Proposal) and are reproduced below as Table 7-1, Table 7-2, and Table 7-3. Note that total sound pressure values and usage for each source were chosen to be very conservative in order to provide a worst case scenario model. As an example, most equipment usage periods are identified as 24h/day for use in the model.

This does not allow for time that equipment will not be operational including shift changes, meal breaks and maintenance and in practice equipment usage will be more likely to be 18 to 20 hours per day. Table 7-5 of the Project Proposal is intended as a summary of Project activities and interaction and is standard across all disciplines.

Table 7-1: Noise Sources Construction Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Diesel Generator	Camp	102.0	12h/day
Diesel Genset	Process Plant Facility	111.0	14h/day
Pump	Open pit – overburden sump	65.1	24h/day
Pump	Open pit well 1	61..5	24h/day
Pump	Open pit well 2	61.5	24h/day
Pump	Open pit well 3	61.5	24h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Drill 1	Open pit	86.8	24h/day
Drill 2`	Open pit	86.8	24h/day
Welding plant (x6)	Process Plant Facility	75.9	14h/day
Bulldozer	Open pit	89.0	4h/day
Excavator	Open pit	95.5	14h/day
Crane (x6)	Process Plant Facility	105.0	2 to 4h/day
Excavator	Process Plant Facility	95.5	12h/day
Elevated Work Platform (x6)	Process Plant Facility	80.4	8h/day
Bulldozer	Class A Storage Facility	89.0	6h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	6h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	10h/day
Grader	Class C Storage Facility	92.4	1h/day
Bulldozer	Overburden Stockpile	89.0	12h/day
Grader	Overburden Stockpile	92.4	1h/day
Crane	Mine workshop	76.6	4h/day
Excavator	Explosive Facility	86.4	12h/day
Fuel and lube truck	Fuel farm to pit	49.9*	50 trips/ day
Explosives Truck (MMU)	Open pit to Explosives Facility	40.1 *	6 hours/day
Heavy Truck	Process Plant Facility to Waste Storage Facility (WSF)	49.2 *	40 trips/day
Bus	Highway to Site	30.9 *	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trips/day

Source	Location	Total Sound Pressure (dBA)	Usage
Heavy Truck	Open pit to Class A WSF	45.7 *	18 trips/day
Heavy Truck	Open pit to Class B WSF	50.5 *	55 trips/day
Heavy Truck	Open pit to Class C WSF	53.1 *	99 trips/day
Heavy Truck	Open pit to Overburden Stockpile	54.9 *	153 trips/day
Heavy Truck	Mine Workshop to WSF as required	49.2*	40 trips/day
Light Truck	Camp to Process Plant Facility	36.5*	8 trips/day
Light Truck	Open pit to Class A Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Class B Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Class C Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Overburden Stockpile	32.3*	3 trips/day

* Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in the Project Proposal, and road gradient obtained from DGM (only provided as an indication as model input is by road segment)

Table 7-2: Noise Sources Operation Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Boiler	Camp	89.6	24h/day
Dual Fuel Genset	Process Plant Facility	111.0	24h/day
Crusher	Process Plant Facility	118.0	24h/day
Grinding Mills	Process Plant Facility	105.4	24h/day
Material Handling and Transfer	Process Plant Facility	125.0	24h/day
Pump	Open pit – overburden sump	65.1	24h/day
Pump	Open pit well 1	61..5	24h/day
Pump	Open pit well 2	61.5	24h/day
Pump	Open pit well 3	61.5	24h/day
Pump	Pit Rim Pond	65.1	24h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Fan	20 m inside the HW portal	70.3	24h/day
Compressor	Main ramp portal (Year 3 and 4)	115.0	24h/day
Drill 1	Open pit	86.8	24h/day
Drill 2`	Open pit	86.8	24h/day
Bulldozer	Open pit	89.0	4h/day
Excavator	Open pit	95.5	20h/day
Truck	From underground into pit	91.9	20 trips/day
Loader	Process Plant Facility	77.1	24h/day
Forklift	Reagent Store and Warehouse	100.0	6h/day

Source	Location	Total Sound Pressure (dBA)	Usage
Bulldozer	Class A Storage Facility	89.0	2h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	8h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	14h/day
Grader	Class C Storage Facility	92.4	2h/day
Bulldozer	Overburden Stockpile	89.0	2h/day
Grader	Overburden Stockpile	92.4	1h/day
Loader	Paste Fill Plant	77.1	5h/day
Explosives Truck (MMU)	Open pit to Explosives Facility	40.1 *	6 h/day
Heavy Truck	Tailings Filter Area to Class A WSF and Paste Fill Plant	53.4 *	106 trips/day
Bus	Highway to Site	30.9*	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trip/day
Concentrate Truck	Process Plant Facility to Highway	48.1 *	19 trips/day
Heavy Truck	Open pit to Class A WSF	46.6 *	21 trips/day
Heavy Truck	Tailings Filter Area to Class A WSF	52.1 *	79 trips/day
Heavy Truck	Open pit to Class B WSF	53.3 *	103 trips/day
Heavy Truck	Open pit to Class C WSF	56.8 *	236 trips/day
Heavy Truck	Open pit to Overburden Stockpile	48.6 *	35 trips/day
Heavy Truck	Tailings Filter Area to Paste Fill Plant	53.4 *	106 trips/day
Light Truck	Camp to Process Plant Facility	38.3*	12 trips/day
Light Truck	Around Mill and Paste Fill Plant	41.3 *	25 trips/day
Light Truck	Open pit to Class A Storage Facility	33.5 *	3 trips/day
Light Truck	Open pit to Class B Storage Facility	33.5 *	3 trips/day
Light Truck	Open pit to Class C Storage Facility	32.3 *	3 trips/day
Light Truck	Open pit to Overburden Stockpile	31.7 *	2 trips/day

* Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in the Project Proposal and road gradient obtained from DGM (only provided as an indication as model input is by road segment)

Table 7-3: Noise Sources Closure Phase

Source	Location	Total Sound Pressure (dBA)	Usage
Diesel Generator	Camp	102.0	12h/day
Diesel Genset	Process Plant Facility	111.0	12h/day
Pump	Class A Collection Pond	65.1	As required
Pump	Class B Collection Pond	65.1	As required
Pump	Lower Water Management Pond	65.1	As required
Loader	Open pit spillway	114.0	2 weeks, 8h/day

Source	Location	Total Sound Pressure (dBA)	Usage
Crane (x6)	Process Plant Facility	105.0	2 to 4h/day
Bulldozer	Process Plant Facility	89.0	6h/day
Elevated Work Platform (x6)	Process Plant Facility	80.4	8h/day
Bulldozer	Class A Storage Facility	89.0	4h/day
Grader	Class A Storage Facility	92.4	1h/day
Bulldozer	Class B Storage Facility	89.0	4h/day
Grader	Class B Storage Facility	92.4	1h/day
Bulldozer	Class C Storage Facility	89.0	3h/day
Grader	Class C Storage Facility	92.4	1h/day
Loader	Overburden Stockpile	114.0	8h/day
Loader	Topsoil Stockpile	114.0	8h/day
Crane	Mine workshop	76.6	4h/day
Crane	Explosive Facility	76.6	4h/day
Crane	Paste Fill Plant	76.6	4h/day
Bulldozer	Mine workshop	89.9	6h/day
Bulldozer	Explosive Facility	89.0	6h/day
Bulldozer	Paste Fill Plant	89.0	6h/day
Loader	Fault Creek Diversion, Water Diversion Ditches, Water Management Ponds	114.0	8h/day
Crane	Process Plant Facility to Laydown area (WSF)	76.6	4h/day
Heavy Truck	Process Plant Facility to Laydown area (WSF)	42.1 *	8 trips/day
Bus	Highway to Site	30.9 *	1 trip/day
Heavy Truck (supplies)	Highway to Site	41.7 *	7 trip/day
Heavy Truck	Overburden Stockpile to Class A WSF, Topsoil Stockpile to Class A WSF	47.25 *	26 trips/day
Heavy Truck	Overburden Stockpile to Class B WSF, Topsoil Stockpile to Class B WSF	48.3 *	33 trips/day
Heavy Truck	Overburden Stockpile to Class C WSF, Topsoil Stockpile to Class C WSF	46.3 *	21 trips/day
Heavy Truck	Explosives facility, Mine Workshop facility, Paste Fill Plant to laydown	35.9 *	2 trips/day
Light Truck	Camp to Open Pit	36.6 *	6 trips/day
Light Truck	Camp to Process Plant Facility	39.6 *	12 trips/day
Light Truck	Open pit to Class A Storage Facility	36.6 *	6 trips/day
Light Truck	Open pit to Class B Storage Facility	36.6 *	6 trips/day
Light Truck	Open pit to Class C Storage Facility	35.3 *	6 trips/day
Light Truck	Open pit to Overburden Stockpile	35.3 *	6 trips/day
Light Truck	Open pit to Topsoil Stockpile	35.3 *	6 trips/day

* Calculated from TNM for average of all road surfaces, speed of 30 km/h on site and 50km/h on the mine access road, estimated traffic volume provided in the Project Proposal, and road gradient obtained from DGM (only provided as an indication as model input is by road segment)

YESAB ISSUE

The proposal does not contain any information about how increased noise from truck traffic may affect residents in the community of Watson Lake. While the proponent states in its Consultation and Engagement Plan that its open house consultations will discuss the subject of "public highway traffic including number of concentrate haul tracks and supply vehicles per day during operations," the subject does not appear in the proponent's consultation materials or in the consultation record except when prompted by meeting participants.

R78

"If trucks will be travelling at night through the communities of Watson Lake and Upper Liard, what is the anticipated frequency and volume of night-time traffic?"

Approximately one trucking movement per hour (on average) is expected during night-time. However, BMC plans to implement convoying the trucks in groups of 2 to 3 (where practicable) (Section 13.4.2 and Section 18.12.3.1 of the Project Proposal). Therefore, night truck traffic frequency through Watson Lake could be as low as one small convoy every three hours as opposed to one every hour.

R79

"Provide baseline daytime and night-time noise measurements in the communities of Watson Lake and Upper Liard and apply appropriate modelling techniques to assess the significance of increased road traffic."

Given that only a single truck movement per hour (on average) is expected during night time hours, a detailed baseline night-time model would not materially add to the evaluation of potential noise traffic noise impacts during the night.

Given that expected truck movements during daytime hours are approximately two movements per hour (on average), a detailed baseline modelling of the potential effects of increased road traffic is also not considered to be necessary to add to the evaluation of potential noise traffic impacts during the day.

Based on the low increase in traffic frequency both during the day and night, the appropriate conclusion is that the Project related increases in noise would be of low magnitude and not significant. The traffic will not materially or substantially impact the communities of Watson Lake or Upper Liard.

R80

"Describe steps that will be taken in future consultations with Liard First Nation and the Municipality of Watson Lake to address potential increases of highway noise."

Community consultation will be ongoing prior to and during the Project life. This will take the form of community meetings and formal meetings with the local municipal councils and Liard First Nation

Chief & Council. BMC's commitment to ongoing consultation is presented in the BMC Consultation and Engagement Plan (Appendix B-2 of the Project Proposal).

8 SURFACE WATER QUALITY AND QUANTITY

8.1 WASTE ROCK AND TAILINGS MANAGEMENT

YESAB ISSUE

The most critical deficiency in this assessment of water quality was the absence of acidic drainage estimates in the water quality modelling for post closure conditions. The use of the leach test results for neutral conditions represents a deficiency for water quality predictions over the long term. This also has implications for the proposed use of passive treatment with engineered wetlands after closure.

It was acknowledged in the geochemical assessment that the PAG waste rock and tailings, in the Class A stockpile, and the waste rock in the Class B stockpile will produce acid in the future. The depletion of the neutralization potential will result in times to onset of acid drainage that are expected to be after the proposed mine closure period. Nonetheless, the PAG materials will eventually produce acid drainage even though the drainage will be mitigated to some extent by lower infiltration covers. The significance of the acid drainage is that the low pH will be accompanied by increased loadings, and concentrations, of many metals and other constituents that can adversely affect water quality. Although mitigation of the stockpiles by limiting infiltration with covers is planned, the increased concentrations and loadings associated with acid conditions compared to those predicted for neutral pH in this assessment will result in increased loadings and concentrations in the residual drainage from the covered piles. This will increase the loadings and concentrations requiring mitigation post closure. The acidic drainage with higher concentrations that those in the neutral drainage may not be treatable in a passive engineered wetland system.

R81

"Provide an estimate of the loading rates for acidic conditions in the potentially acid generating (PAG) rock that is estimated to occur after closure of the operation and after the onset of acidic conditions and production of acidic drainage."

The importance of developing geochemical source terms to predict Waste Storage Facility loading rates under acidic drainage conditions is recognized. Kinetic tests have been carried out by the company on Class A (reactive and acid generating "AG") and Class B (potentially acid generating "PAG") rock for nearly 2 years and are continuing. Acidic conditions have only recently started to develop in one kinetic test column (C-7, which comprises Class A waste rock). As it may take many years of kinetic testing to deplete the neutralization potential (NP) of the material before leachate becomes acidic, two additional kinetic tests will be commissioned using Class A (comingled tailings and Class A waste rock) and Class B material that have been pre-treated to deplete NP before commencement of the test. In these kinetic tests the generation of acidic drainage will be accelerated and the leachate data can be used to predict acidic drainage loading rates. Once sufficient data are collected from the NP-depleted kinetic tests, the acidic loading rates can be developed and water quality models and predictions can be updated.

An assessment of metal loading under acidic conditions for the Class A and Class B Storage Facilities has been prepared using sequential net acid generation (NAG) testing of the material that is in the Class A trickle leach column C-10 (tailings and Class A waste rock mixture) and the recent kinetic data from the Class A waste rock column C-7 which is now starting to release acidic drainage.

The sequential NAG test on the Class A tailings and waste rock material in column C-10 was operated for three cycles. Filtered leachate from each cycle (pH 2.1 to 2.6) was combined and analyzed for sulphate and dissolved metals. For the Class A material, it was assumed that the sulphate loading rate under acidic conditions would be 10 times the sulphate loading rate observed at circumneutral pH based on a literature review of laboratory kinetic test data. The sulphate-to-COPI ratios in the sequential NAG test of the C-10 material were calculated assuming the COPIs are released due to the oxidation of sulphide material. Then, the "steady-state" (average of most recent 2 months) sulphate loading rate from column C-10 (i.e. circumneutral release rate) was multiplied by 10 and the COPI loading rates were calculated by multiplying this 10x sulphate loading rate by the sulphate-to-COPI ratios calculated from the NAG test. These preliminary COPI acidic loading rates for the Class A Storage Facility calculated using this method are provided in Table 8-1 below.

For the Class B material, the percentage change in the COPI loading rate for column C-7 moving from circumneutral conditions in the first two months of the test (average of cycles 2 to 10; pH 6.8 to 7.2) to that under the most recent acidic conditions (average of last four cycles 57 to 61; pH 4.1 to 4.4) was calculated. The percentage increase observed was applied to the "steady-state" (average of last two months of data) neutral COPI loading rates previously developed for the Class B storage facility (shown in Table 8-1). The loading rates for those COPIs that exhibited a decline in loading under acidic conditions for column C-7 (i.e., antimony, selenium) were not modified (i.e., the higher circumneutral COPI loading rate was retained).

Table 8-1: Preliminary Acidic Loading Rates for Class A and Class B Storage Facilities

	Class A		Class B	
	C-10 Neutral pH (average last 2 months kinetic data)	C-10 Acidic pH Calculated Loading Rates	Class B Neutral pH (average last 2 months kinetic data)	Class B Acidic pH Calculated Loading Rates
	mg/kg/wk			
Antimony	0.000017	0.000048	0.00021	0.00021
Arsenic	0.000012	0.0030	0.00026	0.0010
Cadmium	0.000019	0.0013	0.00000046	0.0000012
Copper	0.0000072	0.040	0.0000048	0.00027
Iron	0.000046	3.7	0.000012	0.0036
Lead	0.000010	0.025	0.00000077	0.000026
Manganese	0.006	0.058	0.00038	0.00080
Nickel	0.00031	0.0014	0.000013	0.000018
Silver	0.000000	0.00033	0.000000062	0.000000062
Selenium	0.0001	0.0019	0.000018	0.000018
Uranium	0.000014	0.000097	0.000084	0.00031
Zinc	0.0061	0.18	0.000031	0.00033

R82

"Using the above estimates, provide an assessment of the effects of the proposed mitigation of infiltration rates by engineered covers on the mine rock stockpiles and the residual loadings of constituents of potential concern (COPC) from the stockpiles and from the pit walls."

The unsubmerged portion of the pit wall above the final surface water elevation of ABM lake at closure will be primarily composed of geodomains that are largely Class C, non-acid generating rock (Table 8-2). Overall, the pit wall rock above the final water level is predominantly not potentially acid generating. Nevertheless, any acidic load that does wash down into ABM lake will be neutralized by the circumneutral waters of ABM lake, with only minimal associated loading such that no significant effects to downstream water quality are anticipated.

Table 8-2: Approximate Proportions of Unsubmerged (Above 1,380 masl) Pit Wall Surface Area by Geodomain, the Proportion of Each Geodomain by Waste Classification and the Proportions of Total Unsubmerged Pit Wall by Waste Classification

Geodomain	Exposed Pit Wall Area	% Class A	% Class B	% Class C	Net Acid Generating Potential
AK RHYv	15%	0%	27%	73%	Predominantly acid consuming
CA CL MAF	5.0%	0%	100%	0%	All acid consuming but potential for metal leaching
CARB MDS/RHY	1.5%	23%	44%	33%	Predominantly potentially acid generating
MDS	25%	3%	8%	89%	Predominantly acid consuming
MU PY RHY	2.1%	25%	38%	38%	Predominantly potentially acid generating
PY AK RHYc	2.3%	8%	45%	47%	Equal parts potentially acid generating and acid consuming
PY AK RHYv	18%	5%	43%	52%	Equal parts potentially acid generating and acid consuming
PY CL RHY	1.1%	46%	24%	29%	Predominantly potentially acid generating
RHYi	1.2%	42%	42%	17%	Predominantly potentially acid generating
Massive Sulphide	0.1%	100%	0%	0%	Potentially acid generating
Overburden	28%	0%	0%	100%	Non potentially acid generating
Total	**100.0%**	**3.8%**	**22.1%**	**74.1%**	

The preliminary acidic release COPI loading rates presented in Table 8-1, reproduced above, were applied in the water quality model at Year 10 for Class A and Year 30 for Class B under both the mean and 1/10 dry year precipitation scenarios. The resulting estimates of COPI water quality for the near field site KZ-37 under the most conservative 1/10 dry year scenario (i.e. the scenario that results in the highest concentrations in the receiving environment) are reproduced below (Figure 8-1). The preliminary water quality objectives (pWQO) are presented for comparison for each COPI [note that some pWQO thresholds are dependent on hardness (cadmium, copper, lead, zinc) or sulphate (selenium) concentrations, giving rise to changing pWQO levels for these COPIs as the hardness and sulphate concentrations vary throughout the year and phase of the Project].

The updated model with preliminary acidic source terms estimates that in post-closure only concentrations of arsenic (May and June) and cadmium (May through August) exceed water quality objectives at KZ-37. The exceedances do not exceed 1.8 and 1.5 times the respective the water quality objectives for arsenic and cadmium, respectively. It is important to note that the model does not incorporate any natural attenuation that would occur along flow paths between the Class A and Class B Waste Storage Facilities, the wetlands and Geona Creek that may lower arsenic and cadmium concentrations. It is also important to note that arsenic and cadmium exceedances are not predicted at KZ-15 (Upper Finlayson Creek) downstream of KZ-37.

Acidic source terms will be refined upon the availability of NP-depleted kinetic testing data and the models and predictions will be updated accordingly. Appropriate refinements to the mitigation measures may be also be made at that time.

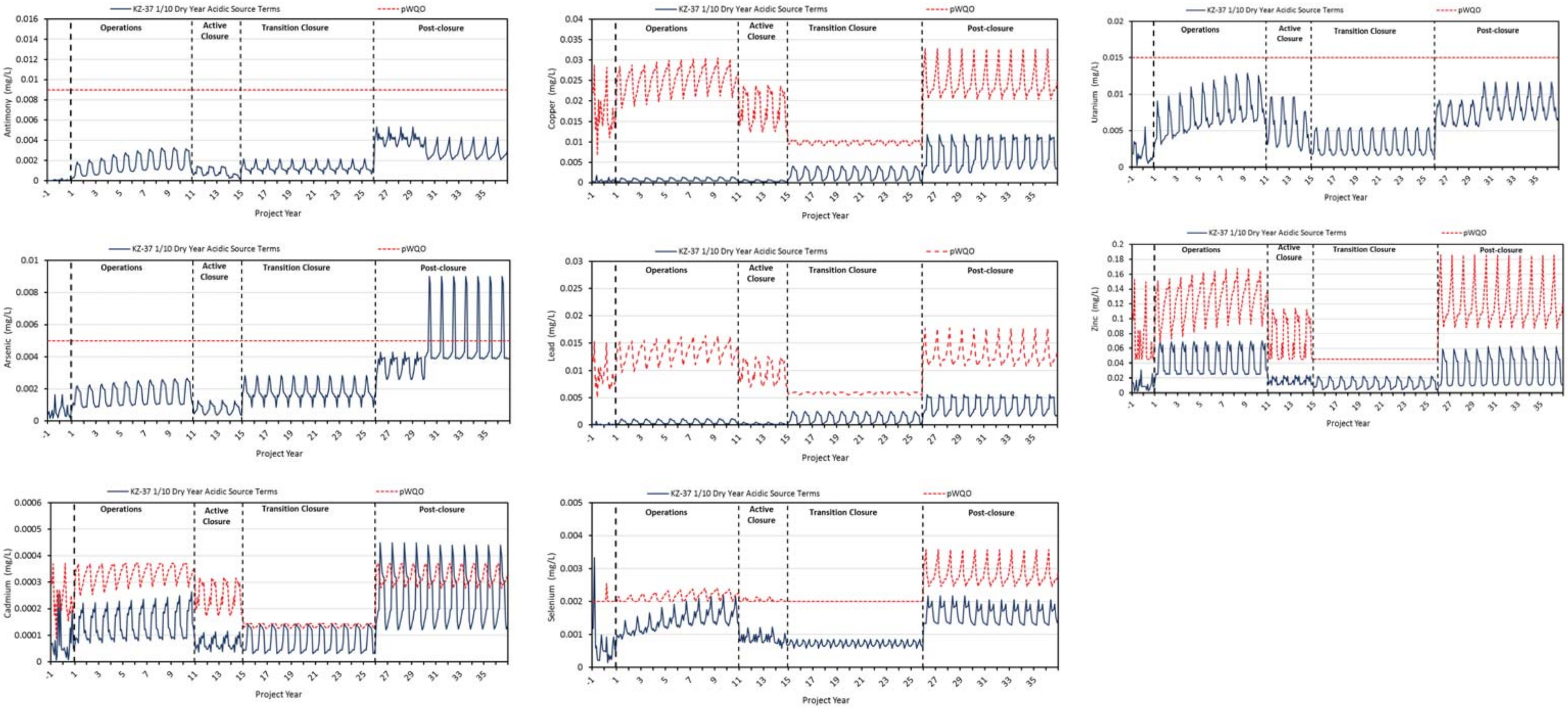

Figure 8-1: Updated Water Quality Predictions at KZ-37 in the 1/10 Dry Year Scenario Using Preliminary Acidic Drainage Loading Terms for Antimony, Arsenic, Cadmium, Copper, Lead, Selenium, Uranium, and Zinc

YESAB ISSUE

The use of adjustment factors (referred to as "scaling factors" in the reports) to address water contact and storage of soluble loads, seasonally during the year, in the waste rock/tailings stockpiles are not well-founded and unnecessarily bias the laboratory loading rates to lower values for field loading rates. Clarification is therefore required on the use of scaling factors for covers on the class A and B stockpiles.

Adjustment factors were proposed for the use of engineered covers on class A, B and C stockpiles. These were listed in Table 3-7 of Appendix D-7 as 0.05, 0.25 and 0.90 for the class A, B and C stockpiles, respectively. If these values refer to the reduction of infiltration into the stockpiles, then these values appear to be appropriate and are likely achievable with the appropriate cover designs.

However, there is also a discussion of reduced loads from the class A, B and C stockpiles in Section 7.2 that are not the same as those shown in Table 3-7. The load reductions presented in Section 7.2 referred to reduced loads by 98%, 75% and 10% for the class A, B and C facilities, respectively. These appear to be referring to the same adjustment factors, except that for the class A stockpile. Table 3-7 refers to a value of 0.05, referring to a reduction of 95% of the load, while the 98% reduction referred to in Section 7.2 would represent an adjustment factor of 0.02 rather than 0.05.

R83

"Clarify whether the adjustment factors are intended to be the same or if they have been applied separately and therefore represent double accounting of the adjustment factors. Provide rationale for the chosen approach."

The adjustment factors are intended to be the same and are applied once (i.e. not double counted) in order to scale loading rates. The adjustment factors used in modelling for the reduction of infiltration to Class A, Class B and Class C Waste Storage Facilities are 98% (scaling factor of 0.02), 75% (0.25) and 10% (0.9), respectively. *Note: Table 3-7 in Appendix D-7 Water Quality Model should state the Cover Water Contact Scaling Factor for Class A as 0.02 not 0.05.*

The inclusion of a scalar to account for the lower degree of flushing that a large field waste rock pile will experience, compared to laboratory humidity cell of column experiments, is commonly applied in industry when scaling laboratory data to the field. Flushing of the waste rock is required to transport constituents away from the rock pile; if the rock is not flushed it will not release COPI loading. Preferential pathways will form over time within a rock pile such that the entire field rock pile will not experience uniform flushing. Certainly, the flushing experienced will be much lower compared to well flushed humidity cells or the trickle leach laboratory column. The laboratory humidity cells and trickle leach columns receive approximately 26 and 2 L/kg/year, respectively, whereas the estimated annual precipitation on the Class A, B and C Waste Storage Facilities as a function of final mass stored in each is 0.04 L/kg/year, 0.01 L/kg/year, and 0.006 L/kg/year, respectively. It was acknowledged in the Project proposal that applying a scaling factor on these magnitudes (i.e., 1/50 to 1/approximately 4000) may underestimate loading rates. Furthermore, water contact is subject to significant variability based on the magnitude and frequency of precipitation events. Therefore, more conservative scaling factors that decline as the waste storage facilities grow were applied (Table 3-6 of Appendix D-7 of the Project Proposal).

The water quality model assumed that no load was released during winter months, and that a fraction of this stored winter load was released during snowmelt in May and June. Approximately 50% of the load accumulated during the winter months was modelled to remain within each waste storage facility since the development of oxidized "crusts" would likely limit the full release of such accumulated COPI winter load; however, the model has since been adjusted such that the full stored load is now modelled to be released and is distributed throughout the year, weighted as a function of run-off volume (Table 8-3). This has not made a material difference to the estimates of water quality in the receiving environment.

Table 8-3: Modelled Proportion of Stored Load that is Flushed Each Month from Waste Storage Facilities

Month	Previous Load Proportion Flushed for all Waste Storage Facilities	Revised Load Proportion Flushed		
		Class A	Class B	Class C
January	0	0.02	0.13	0.14
February	0	0.02	0.11	0.10
March	0	0.02	0.11	0.10
April	0.1	0.19	0.43	0.40
May	1.5	3.49	2.96	2.86
June	1.1	3.81	3.13	3.03
July	1	1.62	1.54	1.60
August	1	1.37	1.31	1.36
September	1	1.31	1.31	1.38
October	0.5	0.10	0.57	0.60
November	0	0.02	0.25	0.26
December	0	0.02	0.16	0.18
SUM	***6.2***	***12***	***12***	***12***

Finally, it is important to note that documented comparisons in the literature between laboratory (humidity cells and column experiments) metal release rates and field waste rock storage area metal release rates have demonstrated scaling factors of <1% were required to scale the laboratory data to the field (Kirchner and Mattson, 2015). As such, the scaling factors employed here are considered conservative and appropriate.

YESAB ISSUE

The data suggest that the predicted selenium concentrations and/or loading rates associated to drainages from the stockpiles may be substantially underestimated.

Data provided in Appendix D-7 and Section 6.2.2.1 of the proposal show that the selenium leaching rates for waste rock are a function of the selenium content in the solids, a phenomenon that is observed at other mines, and indicates that a further assessment of selenium content in the mine rock is warranted.

Other results from the test program also suggest that selenium will be high in drainage from the tailings. The results of the field barrel tests as shown in Section 5.2.1.3 also indicate elevated concentrations of selenium in drainage.

Also, It was not clear whether the results from the tailings leach tests that included the humidity cell HC-3 and column test C-10 were used to estimate loading rates from the Class A storage facility that will contain the tailings along with the high sulphur waste rock.

R84

"Reassess the predicted loading rates for the mine rock in stockpiles at the site in the context of the known selenium contents in the rock. The relationship between selenium content and steady-state loading rates will provide information to enable adjustment of the loading rates by rock type to account for the 8% of the rock samples that had selenium contents greater than 6 mg/kg."

The loading rate for selenium, and all COPIs and modelled parameters, were calculated using kinetic testing data of waste rock and tailings samples that were selected to be representative of the Project geodomains and the material stored in the Class A, B and C Waste Storage Facilities. The relationship between selenium content and loading rates is captured within the kinetic tests and the characterization of selenium leaching from the geodomain units, tailings and Class A, B and C waste classifications. In particular, the trickle leach column C-7 used to calculate loading rates from the Class A Waste Storage Facility was a composite of samples ranging from 0.2 to 63.2 mg/kg selenium with a composite selenium content of 9.1 mg/kg and trickle leach column C-4 used to calculate loading rates from the Class B Waste Storage Facility was a composite of samples ranging from 0.9 to 30.6 mg/kg with a composite selenium content of 9.3 mg/kg.

Additionally, to clarify as requested, the results from tailings leach tests humidity cell HC-3 (average selenium content of 8.4 mg/kg) were used in loading rate determination for the Class A Waste Storage Facility and were weighted proportionally to the ratio of tailings to waste rock stored in the facility.

Given the availability of leaching data acquired from kinetic tests of KZK material containing relatively high selenium content the current selenium loading rates presented are deemed appropriate and an alternate method unique to selenium is not required.

R85

"Incorporate the leaching rates for selenium from the tailings into the predicted concentrations in drainage from the class A facility that will include the tailings."

As stated in the response to R84, the leaching rates for the Class A Waste Storage Facility as currently presented were calculated using tailings and representative rock samples with selenium content greater than 6 mg/kg.

R86

"Reconsider, and update if necessary, the predicted selenium concentrations in the context of water treatment technology that will be used and the effects on selenium removal during operations."

In consultation with our specialist consultants, BMC have reconsidered the matter of selenium concentrations in the context of water treatment technology and we confirm that as stated in responses to R84 and R85, the methods currently used to calculate selenium leaching rates are consistent with other parameters and reflect the selenium content in rock and tailings for the KZK Project. These leaching rates have been used to guide selenium removal requirements for water treatment during operations.

In order to assist assessment a water treatment memo has been included as **Appendix 4** to this Response Report.

8.2 WATER MANAGEMENT

YESAB ISSUE

The current baseline hydrometric program, as reported in Section 3.1.2.2 of the report, comprised a network of ten flow monitoring installations of which seven were continuous. The information provided in the report for the current baseline hydrometric program is from the end of April 2015 to late March 2016. Data for the continuous flow monitoring installations are available from the end of April 2015 to the Fall of 2015, are within the order of five spot measurements made from the Fall of 2015 through March of 2016, and are used to infer streamflow for that period.

Typically, the minimum period considered for collection of baseline hydrometric data to characterize streamflow response is three years. This is required to begin to understand the natural variability of hydrometric data. The hydrometric network coverage is considered good and data collected in the current hydrometric program considered reasonable, however, only eleven months of data are available. The 1995 hydrometric data are considered useful for general information purposes only, as these data are sparse, have gaps, and their quality cannot be confirmed.

The limited hydrometric information for the local study is considered an information gap. This information gap is important as results from the hydrometric monitoring program are used to calibrate and verify developed water balance models which are used to make projections related to receiving water quantity and quality. Additional hydrometric monitoring information would be useful to verify the work completed to-date and provide additional confidence in projections. Notwithstanding, it is anticipated this information could be collected through the next project phase and used to further verify developed water balance models and projections related to receiving water quantity and quality

R87

"Provide a detailed overview of the work planned to collect additional hydrometric monitoring information through the next project phase to further verify developed water balance models and projections related to receiving water quantity and quality."

Model validation and calibration will continually improve the precision and accuracy of the predictive tool. The Receiving Environment Water Balance (Appendix D-6, January 2017) of the Project Proposal used hydrometeorological data collected up to September 2016 for model calibration (outlined in Section 3.3) and collection of monthly surface water discharge (continuous and discrete measurements) and meteorological data collection continues.

Surface water quantity monitoring is continuing at a monthly sampling frequency at all baseline stations including site KZ-37, which was added to the monitoring program in February 2017. Further, monitoring has been outlined in Table 8-49 of the Project Proposal identifying monitoring during operations of the project, which will be used during operations to further refine the model.

BMC will undertake revisions to modelling which will be based on this data, at future stages of Project permitting. However, we will undertake any revisions to the work plan for any potential re-modelling in consultation with the Yukon Water Board Secretariat (and their technical consultants). We recognize that it is important that our methodology for doing so is supported by the licensing agency.

R88

"Updated hydrometric baseline information, water quality objectives, and water models (e.g., water quality model, site and watershed balance models, surface water flows, etc.) for the site are required to be submitted prior to the Executive Committee drafting the screening report. To develop a reasonable understanding of short-term variability, sampling is required to be conducted and reported on at least two sampling events, including one during low-flow conditions and one during high-flow conditions, for each year in which 5 samples are collected in 30 days."

BMC appreciates that the review and eventual approval of Kudz Ze Kayah will undergo a number of stages, governed by separate legislation and specialized agencies. While we view the entire regime as a whole system, we recognize it is comprised of discrete segments. For example, groundwater modelling we submitted at the YESAB stage has been prepared and submitted to support YESAB's effects assessment at this stage. Because we continue to collect site water quality data as we progress, we will be in apposition to update modelling with additional data as required during the water licensing stage. At this stage in the Project it will be important to undertake our work with support of the specialist agency, the Yukon Water Board and their technical staff and consultants.

We appreciate that this means that YESAB's effects assessment must be based on data submitted with the Application.

R89

"Provide further analysis to understand whether the information collected in the current (2015/2016) hydrometric monitoring program is representative of mean, dryer, or wetter than normal conditions. This could be undertaken by comparison to pertinent regional data. It was indicated in Appendix D-2 of the project Proposal that this was not undertaken as regional data for 2015 was unavailable. However, it is anticipated this regional data for 2015 would now be available."

Of the regional WSC stations listed in Table 3.1-1 of Appendix D-2 (Hydrometeorology Baseline Report RevC_161222) of the Project Proposal, seven have hydrometric data available for 2015. Total runoff for the year 2015 was compiled for those stations and compared to the mean annual runoff for the period of record (provided in Table 3.1-1 of Appendix D-2 of the Project Proposal). Table 8-4 below shows the comparison and % difference between 2015 and mean annual runoff. For some stations, 2015 was up to 15% wetter than average while others were up to 15% dryer, therefore no clear regional trend emerges. Runoff is influenced by several local characteristics such as topography, soil, gradient, vegetation, lakes and ponds, and regional observations cannot be easily generalized or applied to the Project area. Continued site data collection as planned will allow further refinement of the Project hydrometric baseline conditions characterization.

Table 8-4: Mean Annual Runoff and 2015 Total Runoff for Regional Water Survey of Canada (WSC) Stations

Station ID	Name	Area (km^2)	Median Elevation (masl)	Minimum Elevation (masl)	Maximum Elevation (masl)	Date Range	MAR (mm)	2015 Total Runoff (mm)	% difference
10AA005	Big Creek	1,010	1,176	779	2,006.50	1989-2014	246	209	-15
09BA002	Pelly River below Fortin Creek	5,020	1,214	871	2,105	1986-94, 2013-14	472	487	3
10AA004	Rancheria River	5,100	1,231	691	2,248	1986-2014	332	300	-10
09BA001	Ross River at Ross River	7,310	1,068	679	2,533	1960-2014	287	331	15
10AB001	Frances River	12,800	1,157	657	2,337	1962-2014	396	434	10
09BC004	Pelly R. below Vangorda Creek	21,900	1,131	626	2,533	1972-2014	289	332	15
10AA001	Liard River at Upper Crossing	32,600	1,140	609	2,333	1960-2014	366	354	-3
Mean	*All Stations with 2015 data*		*1,160*	-	-	-	*341*	*349*	*2*

YESAB ISSUE

A water balance modeling exercise was completed for average, wet, and dry climatic scenarios: average precipitation, 1 in 50 year precipitation, and 1 in 10 year dry precipitation. While it does not seem to be *specified in the Water Balance Model Report, we understand that the water balance modeling exercise is for operations at year 10.*

The water balance modelling exercise does not provide information for all phases of the mine life from construction through operations, and the active, transition, and post closure phases. This is not considered consistent with industry standards and is considered to be an information gap. Typically, through the different phases of mine life there are changes in the volumes of water generated from various sources, and how it is managed and discharged to the environment and these should be accounted for in the assessment.

Appendix D-6, s.1.2 Modelling Philosophy. The proponent refers to a Microsoft Excel spreadsheet format developed for the Finlayson Creek watershed model. The proponent should provide a functioning copy of the spreadsheet water balance.

The proponent states "The modelling goal was to estimate surface water discharge for mean, 50 year wet and 10 year dry precipitation years".

R90

"Update the detailed water balance model for the project site to include all phases of the mine life from construction through operations, and the active, transition, and post closure phases."

Water balances for the site for all phases of the mine life were provided in the original Proposal document supplied to YESAB. The site water balance for operations was provided in Appendix C-7, (Water Balance Model Report) of the Project Proposal. For construction and closure phases of the project, the site water balance has been incorporated in the Receiving Environment Water Balance Report, Appendix D-6 of the Project Proposal.

R91

"Provide rationale for return periods used in modelling.

The dry and wet years were modelled to undertake sensitivity analysis using the maximum proposed discharge concentrations from the Lower Water Management Pond and resulting concentrations in Geona Creek and Finlayson Creek to determine potential effects on surface water using the preliminary water quality objectives. The 1 in 10 dry year was modelled as this is a typical scenario used in the Water Licencing proposed to establish effluent quality standards for compliance locations.

In addition, using the updated water balance model, evaluate the following scenarios:

- ***a. impact of an event, such as the 24-hour design events used in sizing of water management facilities;***
- ***b. impact of an event such as extreme summer and winter low flows (7Q20 and 7Q10);***
- ***c. greater than normal snowfall accumulation; and***
- ***d. shorter and more critical snowmelt durations."***

These scenarios, and other sensitivity analyses (which may include precipitation variability, pit groundwater inflow rates, potential implications related to climate change, etc.), will be modelled as part of the detailed design phase and on-going water balance model development.

R92

"Undertake a sensitivity analysis to assess variability of model predictions given variation in key model input parameters and assumptions."

No updates to the water balance were warranted or provided in response to question R90, and therefore the Surface Water Management Plan has not been updated. All management plans will be updated as Project planning progresses if preceding work is materially updated.

YESAB ISSUE

No information is provided on the detailed water balance computations illustrating the breakdown of typical water balance components (e.g., storm water, groundwater, seepage, evaporation/evapotranspiration, water management facility operations inclusive of projected pond water levels, and inter-basin water transfers). This information is important in understanding the Project Site water balance.

R93

"Include summary water balance model computations to the Water Balance Model Report, including the breakdown of typical water balance components, such as but not limited to: storm water; groundwater; seepage; evaporation/evapotranspiration, and; water management facility operations and inter-basin transfers."

Appendix C-7, Water Balance Model Report, of the Project Proposal describes the water balance components and Figure 3.1 Water Balance Flow Schematic illustrates the treatment of the components with regard to the water balance model. The schematic is reproduced below as Figure 8-2 to clarify the inputs that have all been included in the model.

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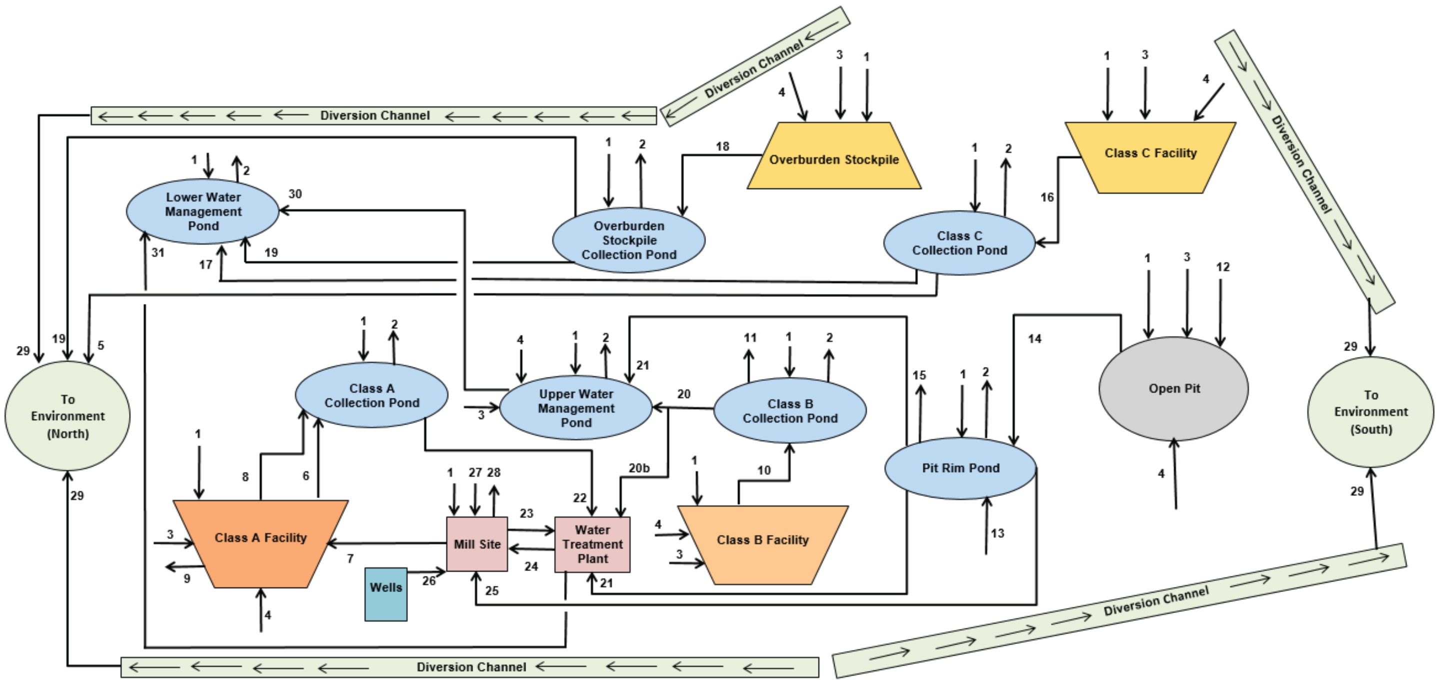


FLOW PATHS

1	Direct Precipitation
2	Evapotranspiration
3	Undiverted Runoff
4	Diversion Ditch Leakage
5	Collection Ditch Leakage
6	Seepage
7	Water in Tailings
8	Runoff from Class A Facility
9	Void Losses
10	Runoff from Class B Facility
11*	Dust suppression
12	Groundwater Inflow to Open Pit
13	Groundwater Inflow from Underground Workings
14	Open Pit Dewatering
15	Water to Paste Plant
16	Runoff from Class C Facility
17	Surplus from Class C Collection Pond
18	Runoff from Overburden Stockpile
19	Surplus from Overburden Stockpile Collection Pond
20	Surplus from Class B Collection Pond
20b	Suprlus from Class B Collection Pond to WTP
21	Surplus from Pit Rim Pond
22	Surplus from Class A Collection Pond
23	Mill Site Runoff
24	Mill Reclaim
25	Freshwater Source 1
26	Freshwater Source 2
27	Water in Ore
28	Water in Concentrate
29	Diversions to Environment
30	Surplus from Upper Water Management Pond
31	Treated Runoff from Water Treatment Plant
*	Water for dust suppression can be supplied from various sources, depending on water quality, if required (i.e. Class B Collection Pond, Pit Rim Pond, Lower Water Management Pond, etc.).

Figure 8-2 Water Balance Flow Schematic

YESAB ISSUE

Values of potential evapotranspiration (PET) in Table 2-24 are high (April 51.3; May 84.5; June 106.2) and winter months list PET which would not be expected to occur.

Appendix D-6. s.3.2.4 Evapotranspiration, Sublimation and Soil-Moisture Storage. The reported annual value of 30 mm (19 percent) sublimation seems low.

R94

"Provide an explanation of how potential evapotranspiration estimates were derived. Please address concerns with high values in April, May and June as well as values for winter months."

Potential evapotranspiration values presented in the Hydrometeorology Baseline Report (December 2016, Appendix D-2) of the Project Proposal were calculated using the standard approach of the American Society of Civil Engineers (ASCE) standardized reference evapotranspiration equation (Penman-Monteith), written directly into the site Campbell Scientific meteorological station program code. It uses measured air temperature, relative humidity, wind speed, solar radiation as well as latitude, longitude, elevation and anemometer height from the meteorological station. However, as this equation is based on vegetation specific parameters, it may not be entirely appropriate for the northern location of the Project and this explains the higher than expected values obtained in winter and spring.

For water balance purposes, actual evapotranspiration (AET) was calculated from measured potential evapotranspiration (PET) using USGS Thornthwaite Monthly Water-Balance model approach, but the method overestimated AET. Therefore, PET was adjusted by a simple factor (F_E) to balance the model during calibration. The USGS method is described below.

AET is equal to the total soil water input (P_{total}) plus the amount of soil water that can be withdrawn from the water already stored in the soil. The soil storage withdrawal (STW) is dependent on the ratio of the volume in storage to the soil storage capacity (STC), computed as follows:

$$STW = ST_{i-1} - \left[abs(P_{total} - PET) \times \left(\frac{ST_{i-1}}{STC}\right)\right],$$

where ST_{i-1} is the soil-moisture storage from the previous month. When PET is less than STW, AET is equal to PET. PET is less than the soil storage withdrawal in all months such that PET is adjusted by a factor (F_E); otherwise AET is too high to allow the model to balance. Actual monthly evapotranspiration values used in the Receiving Environment Water Balance (Appendix D-6, January 2017) of the Project Proposal are shown in Table 8-5 (below):

Table 8-5: Actual Evapotranspiration (AET) used in the Receiving Environment Water Balance Model

	Month												
Water losses	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**June**	**July**	**Aug**	**Sept**	**Annual**
AET (mm)	0	0	0	0	0	0	0	37.2	46.7	33.7	26.2	14.8	159

R95

"Provide an explanation of how potential sublimation estimates were derived. Please address concerns with low values."

Sublimation was calculated as a simple mm/day factor. The factor was calibrated by altering it until the water balance model produced a total snowpack volume at the end of March comparable to that observed in 2016. Low values therefore result from observed snowpack conditions in 2016.

YESAB ISSUE

An assumed Diversion Ditch Efficiency of 50% is specified in Table 2.1 of the Appendix C 7. It is unclear what is meant by Diversion Ditch Efficiency and how related assumptions impact the Project Site water balance and management. For instance, does an assumed Diversion Ditch Efficiency of 50% mean that 50% of non-contact runoff to the north and south of the project area will enter the Project Site and have to be managed accordingly?

R96

"Clarify what is meant by Diversion Ditch Efficiency and how flow volumes associated with diversion ditches are considered in the water balance model for the Project Site."

A Diversion Ditch Efficiency of 50% assumes that 50% of the water is captured and conveyed in the ditches and 50% reports into the Project area and is collected and managed. The flows are included as such in the water balance model.

YESAB ISSUE

The Surface Water Management Plan (SWMP) is based on a water balance modelling exercise that does not provide information for all phases of the mine life from construction through operations and closure. This is not considered consistent with industry standards and is considered to represent an information gap. Typically, through the different phases of mine life there are changes in the volumes of water generated from various sources, and how it is managed and discharged to the environment and the variation in volumes should be assessed.

R97

"Update the Surface Water Management Plan as appropriate based on the updated water balance model (requested in R90 of this Report)."

Water balances for the site for all phases of the mine life were provided in the original Proposal document supplied to YESAB. The site water balance for operations was provided in Appendix C-7, (Water Balance Model Report) of the Project Proposal. For construction and closure phases of the project, the site water balance has been incorporated in the Receiving Environment Water Balance Report, Appendix D-6 of the Project Proposal.

No updates to the water balance were warranted or provided in response to question R90, and therefore the Surface Water Management Plan has not been updated. All management plans will be updated as Project planning and permitting progresses if preceding work is materially updated.

YESAB ISSUE

Water management structures include ponds and diversions. While design criteria are provided for the proposed ponds in Table 18-6, no design criteria are provided for the proposed diversions. However, it is noted in Section 4.10.1.1 (Water Diversions and Ditches) of the Proposal that all diversion ditches will be designed to manage a 1 in 200-year flood event. For both the ponds and diversions, no information is provided to assess if the provided volumes/designs are sized sufficiently to manage the stated design criteria or how the overall SWMP functions during the stated design conditions.

R98

"Provide design criteria for the diversions and provide supporting computations to demonstrate that the diversions have been sized accordingly."

The design criteria is the 1 in 200 year flood event and the diversions will be designed to manage this flood event. Details of the diversion structures will be developed during the detailed design phase.

R99

"Provide computations demonstrating that proposed ponds as specified in the Proposal have sufficient storage volumes necessary to meet stated design criteria and safely convey the applicable Inflow Design Flood."

The design criteria for the Upper and Lower Water Management Ponds and the Class A and B Collection Ponds is the 1 in 200 year flood event.

The design criteria for the Class C and Overburden Collection Ponds is the 1 in 10 year flood event.

Details of the water management structure designs will be refined during the detailed design phase in preparation for licensing.

R100

"Provide water balance model computations demonstrating the Site Water Management Plan and proposed water management structures can function, on an overall basis, as intended under stated design conditions for all phases of the mine life."

Water balance model computations were completed as part of the water balance modelling (Appendix C-7of the Project Proposal, Water Balance Model Report), which balanced the inflow and outflow rates to the water management ponds based on the predicted maximum total required capacity. The design basis for the ponds was to store the required inflow design flood events. Contact water is released as required so the ponds do not exceed their design volumes.

YESAB ISSUE

Proper drainage is important to insure water is collected and managed according to the SWMP. No internal drainage network is shown or discussed for the Class A Storage Facility to manage surface water without excessive erosion from rilling and channel formation. In addition, no perimeter ditching is shown for the Class B Storage Facility, Class C Storage Facility, and Overburden Stockpile to collect and convey storm water and seepage to respective collection ponds.

R101

"Provided information on how surface water will be managed for the Class A Storage Facility, and how perimeter storm water and seepage will be managed for the Class B Storage Facility, Class C Storage Facility, and Overburden Stockpile."

Diversion ditching is included for all facilities to divert non-contact water and collect and convey contact water, as illustrated in Chapter 4, Section 4.3.3, Figures 4-2 and 4-3 of the Project Proposal. Contact water will be collected in the various Collection Ponds identified on the figures to effectively manage surface water to meet the site Water Management Plan requirements.

YESAB ISSUE

Several items typically considered within a Sediment and Erosion Control Plan have not been considered in the Proposal. These include the management of water from dewatering activities and construction timing restrictions (e.g., for in-water/near water work).

R102

"Update the Sediment and Erosion Control Plan to address:

a. management of water from dewatering activities; and

Management of water from dewatering activities is outlined in the Surface Water Management Mitigation Measures Section 18.4.3, specifically Sections 18.4.3.1, 18.4.3.2 and 18.4.3.3. Water and associated sediment encountered during overburden dewatering activities will be first managed by a trench approximately 15 to 20 m deep and sumps within the area of the proposed open pit. As water levels are reduced in the overburden by pumping from the sump, the trench will be further extended to the south along the channel of Geona Creek until it reaches the southern extent of the ABM open pit. Permanent sumps will be established at the north and south ends of the trench to remove water on a continual basis. A sump may also be excavated in the Krakatoa Zone area to enhance drainage of the overburden material in advance of the extension of the trench. Water and any associated sediment from the sumps will be pumped to the Pit Rim Pond. The Pit Rim Pond will be 60,000 m3 to allow for settling of solids during the construction period.

b. construction timing restrictions (e.g., for in-water/near water work)."

Construction timing restrictions to protect grayling during their most sensitive life history stages, will mean in-stream works shall not occur during a timing window of April 15 to June 15 of any year.

During any of the Project phases if maintenance activities/construction occur within the wetted perimeter it shall comply with the turbidity compliance limits presented in Table 8-6.

Table 8-6: Maximum Allowable Increase in Turbidity

Type of Water	Background (Ambient) Water Quality (NTUs)	Maximum allowable Increase in Turbidity
Clear Flow	< 8 NTU	8 NTU above background
High Flow	8 – 80 NTU	8 NTU above background
	> 80 NTU	10% Allowable increase in turbidity above background

The compliance sampling points will be located 50 m and 100 m downstream of activities and sampled at a minimum frequency of every two hours during activities within the wetted perimeter. If the limits are exceeded, turbidity generating activities will be stopped or adjusted to ensure compliance.

YESAB ISSUE

It is uncertain if the proposed sediment collection pond volumes as specified in the Proposal have sufficient storage volumes to provide the hydraulic retention time necessary to achieve the design criterion identified.

Section 18.6.3.2 of the Proposal states that sediments ponds will be:

Designed to trap sediment particles of 10 microns in size or larger with flow volumes equivalent to a 1:200 year, 24-hour rainstorm for the Class A and Class B Storage Facilities Collection ponds and 1:10 year, 24-hour rainstorm for the Class C Storage Facilities Collection and Overburden Stockpile ponds.

R103

"Provide computations demonstrating that collection pond volumes as specified in the Proposal have sufficient storage volumes to provide the hydraulic retention time necessary to achieve the stated design criteria."

Detailed sediment pond designs will be included as part of the detailed design phase prior to application of the Water Licence.

YESAB ISSUE

Information provided in Table 16-9 of Section 16.6.1 provides a list of typical high and very high confidence findings related to climate change. However, no analyses related to the water balance analyses have been provided which consider changes in climatic input design assumptions or change in type of design events.

R104

"Undertake a sensitivity analysis, in support of the discussion of effects and mitigation measures associated with both extreme events and climate change, using the water balance models developed for the Project to obtain an understanding of potential effects on water management structures and discharges strategies with variation in both model input assumptions and type of events."

As stated in the Project Proposal Section 16.6.*3 "The likelihood of climate change occurring is overall likely; however, changes will occur over the long term and the magnitude of changes likely to occur over the Project's life is small."*

Extreme events have been allowed for in the design of the water containment structures which will be designed to operate with a 1 in 200 year precipitation event. Mitigation measures have been included in Chapter 17 of the Project Proposal, Malfunctions and Accidents, in the unlikely event that the maximum precipitation event design parameters are exceeded. The mitigations are elaborated on in Section 17.2.5 of the Project Proposal.

The water balance model used in the Project Proposal is conservative and any fluctuations in model inputs, or types of event will be allowed for within this conservatism.

YESAB ISSUE

The issue of downstream flow changes associated with the Project, specifically those related to alteration of natural hydrologic flow regime and associated impacts on downstream erosion, stream morphology and riparian vegetation may not have been assessed.

R105

"Provide an assessment of impacts associated with the Project on erosion, stream morphology and riparian vegetation of all affected drainages from projected downstream flow changes during all Project phases."

During the construction phase, flows in Geona Creek are anticipated to initially increase above baseline due to dewatering (which offsets the loss of flow from Fault Creek) at least during the first 10 months, after which a decrease in flow will result during the open water season. During the winter, water pumped as a result of dewatering makes up a larger portion of the net flow and as such this translates into an overall increase in base flow from freeze-up until spring melt. This predicted flow pattern in Geona Creek translates into a similar pattern in Finlayson Creek but with a proportionally lower percent influence as discussed in Chapter 10 of the Project Proposal, Aquatic Ecosystem and Resources (Chapter 10). The effect is more pronounced at KZ-15 (immediately downstream of the Geona Creek confluence) than at KZ-26 in lower Finlayson Creek during the open water months, where it is negligible. Overall the difference in flow from baseline during open water season is a maximum of 21.5% for the mean year scenario at KZ-15. The difference in winter flow rates is much more dramatic and again this is due to dewatering input which will remain at a high level throughout mine construction while winter baseline flows are substantially lower due to freezing.

The predicted change in flows in Geona Creek, South Creek and Finlayson Creek for each mine phase are illustrated in Figures 10-8, 10-9, and 10-10 respectively, of Chapter 10 of the Project Proposal Aquatic Ecosystem and Resources. Details concerning the effects mine development will have on groundwater are included in Chapter 9 of the Project Proposal (Groundwater Quality and Flow) and how that translates into effects on surface water quality and flow is detailed in Chapter 8 of the Project Proposal (Surface Water quality and Quantity). The aquatic effects discussed considers the influence the Project will have on water flows and how that influence translates into flows and water quality in the three waterways.

Due to minimal changes in water levels in Finlayson Creek during all stages of mine development and the stability of the bank and beds in the system, no changes to erosion potential, stream morphology or riparian vegetation are expected in Finlayson Creek. However, all physical attributes of the system will be monitored throughout the life of the Project and water discharge will be augmented if/when required.

As the South Creek channel will be constructed to handle high water events, originating in Fault Creek, no increases to erosion potential or changes in stream morphology are anticipated. Immediately downstream are two large lakes/ponds which will temper any downstream impacts.

In the near term, Geona Creek is an erosional system that will continue to evolve/change especially during high water events which would largely be responsible for the creeks overall width and morphology. Changes in flows originating from the Project are not anticipated to result in any changes in stream morphology as extreme events will be tempered as a result of the water management ponds and the ponds constructed as part of the Fisheries Offsetting Plan (FOP), and as a result channel-forming events should be less frequent and lower in magnitude than currently occurs.

8.3 FUTURE ACIDIC CONDITIONS AT CLOSURE AND POST-CLOSURE

YESAB ISSUE

The mitigation measures proposed for the Class A, B and C stockpiles involve some types of engineered covers to be constructed at closure. It was assumed that the loadings from each stockpile will decrease by effectively limiting the infiltration into each facility.

The initial loadings prior to mitigation by the constructed covers were assumed to be the same as those predicted from the results of the neutral pH laboratory and field barrel tests. The use of these initial loadings is inconsistent with the understanding that the Class A rock and tailings, and Class B rock piles will eventually produce acidic drainage. Therefore, the predicted loadings after closure are biased low because they are based on the neutral pH leaching results. Once acidification occurs, the loading rates for many metals and other constituents would be expected to increase substantially above those that were estimated for neutral pH conditions. And, although the loadings from the stockpiles will be mitigated to some extent by reducing infiltration rates, the much greater intrinsic loading rates within the piles will affect the residual loadings of COPCs from each of the A and B stockpiles.

Ignoring the future acidic drainage conditions in the A and B stockpiles represents a critical deficiency in the water quality predictions and may represent a flaw in the assumption that passive treatment will be possible in an engineered wetland system after closure. Acidic drainage will be accompanied by substantial loading rates of many metals and other constituents and the final drainage from the facilities may not be treatable in a wetland system to the extent required to protect the receiving environment.

R106

"Provide an assessment of the long-term loadings and water quality associated with the acidic drainage that will eventually be produced in the A and B stockpiles as well as from the pit walls above the final water level."

The unsubmerged portion of the pit wall above the final surface water elevation of ABM lake at closure will be primarily composed of geodomains that are largely Class C, non-acid generating rock (Table 8-7 below). Overall, the pit wall rock above the final water level is predominantly not acid generating. Nevertheless, any acidic load that does wash down into ABM lake will be neutralized by the circumneutral waters of ABM lake, with only minimal associated loading such that no significant effects to downstream water quality are anticipated.

Table 8-7: Approximate Proportions of Unsubmerged (Above 1,380 masl) Pit Wall Surface Area by Geodomain, the Proportion of Each Geodomain by Waste Classification and the Proportions of Total Unsubmerged Pit Wall by Waste Classification

Geodomain	Exposed Pit Wall Area	% Class A	% Class B	% Class C	Net Acid Generating Potential
AK RHYv	15%	0%	27%	73%	Predominantly acid consuming
CA CL MAF	5.0%	0%	100%	0%	All acid consuming but potential for metal leaching
CARB MDS/RHY	1.5%	23%	44%	33%	Predominantly potentially acid generating
MDS	25%	3%	8%	89%	Predominantly acid consuming
MU PY RHY	2.1%	25%	38%	38%	Predominantly potentially acid generating
PY AK RHYc	2.3%	8%	45%	47%	Equal parts potentially acid generating and acid consuming
PY AK RHYv	18%	5%	43%	52%	Equal parts potentially acid generating and acid consuming
PY CL RHY	1.1%	46%	24%	29%	Predominantly potentially acid generating
RHYi	1.2%	42%	42%	17%	Predominantly potentially acid generating
Massive Sulphide	0.1%	100%	0%	0%	Potentially acid generating
Overburden	28%	0%	0%	100%	Non potentially acid generating
Total	**100.0%**	**3.8%**	**22.1%**	**74.1%**	

The importance of developing geochemical source terms to predict waste storage facility loading rates under acidic drainage conditions is recognized. Acidic conditions have only recently started to develop in one kinetic test column (C-7, which comprises Class A waste rock). As it may take many years of kinetic testing to deplete the neutralization potential (NP) of the material before leachate becomes acidic, two additional kinetic tests will be commissioned using Class A (comingled tailings and Class A waste rock) and Class B material that have been pre-treated to deplete NP before commencement of the test. In these kinetic tests the generation of acidic drainage will be accelerated and the leachate data can be used to predict acidic drainage loading rates. Once sufficient data are collected from the NP-depleted kinetic tests, the acidic loading rates will be refined and water quality models and predictions can be updated.

An assessment of metal loading under acidic conditions for the Class A and Class B Storage Facilities has been prepared using sequential net acid generation (NAG) testing of the material that is in the Class A trickle leach column C-10 (tailings and Class A waste rock mixture) and the recent kinetic data from the Class A waste rock column C-7 which is now releasing acidic drainage.

The sequential NAG test on the tailings/Class A waste rock material in column C-10 was operated for three cycles. Filtered leachate from each cycle (pH 2.1 to 2.6) was combined and analyzed for sulphate and dissolved metals. For the Class A material, it was assumed that the sulphate loading rate under acidic conditions would be 10 times the sulphate loading rate observed at circumneutral pH based on a literature review of laboratory kinetic test data. The sulphate-to-COPI ratios in the sequential NAG test of the C-10 material were calculated assuming the COPIs are released due to the oxidation of sulphide material. Then, the "steady-state" (average of most recent two months) sulphate loading rate from column C-10 (i.e. circumneutral release rate) was multiplied by 10 and the COPI loading rates were calculated by multiplying this 10x sulphate loading rate by the sulphate-to-COPI ratios calculated from the NAG test. These preliminary COPI acidic loading rates for the Class A Storage Facility calculated using this method are provided in Table 8-8 below.

For the Class B material, the percentage change in the COPI loading rate for column C-7 moving from circumneutral conditions in the first two months of the test (average of cycles 2 to 10; pH 6.8 to 7.2) to that under the most recent acidic conditions (average of last four cycles 57 to 61; pH 4.1 to 4.4) was calculated. The percentage increase observed was applied to the "steady-state" (average of last two months of data) neutral COPI loading rates previously developed for the Class B Storage Facility (shown in Table 8-8). The loading rate for those COPIs that exhibited a decline in loading under acidic conditions for column C-7 (i.e., antimony, selenium) was not modified (i.e., the higher circumneutral COPI loading rate was retained). These preliminary acidic release COPI loading rates were applied in the water quality model at Year 10 for Class A material and Year 30 for Class B material under both the mean and 1/10 dry year precipitation scenarios. The resulting estimates of COPI water quality for the near field site KZ-37 are shown in Figure 8-3 below.

The updated model with preliminary acidic source terms, estimates that in post-closure only, concentrations of arsenic (May and June) and cadmium (May through August) exceed water quality objectives at KZ-37. The exceedances do not exceed 1.8 and 1.5 times the respective the water quality objectives for arsenic and cadmium, respectively. It is important to note that the model does not incorporate any natural attenuation that would occur along flow paths between the Class A and Class B Storage Facilities, the wetlands and Geona Creek that may lower arsenic and cadmium concentrations. It is also important to note that arsenic and cadmium exceedances are not predicted at KZ-15 (Upper Finlayson Creek) downstream of KZ-37.

Acidic source terms will be refined upon the availability of NP-depleted kinetic testing data and the models and predictions will be updated accordingly. Appropriate refinements to the mitigation measures may be also be made at that time.

Table 8-8: Preliminary Acidic Loading Rates for Class A and Class B Storage Facilities

	Class A		Class B	
	C-10 Neutral pH (average last 2 months kinetic data)	C-10 Acidic pH Calculated Loading Rates	Class B Neutral pH (average last 2 months kinetic data)	Class B Acidic pH Calculated Loading Rates
	mg/kg/wk			
Antimony	0.000017	0.000048	0.00021	0.00021
Arsenic	0.000012	0.0030	0.00026	0.0010
Cadmium	0.000019	0.0013	0.00000046	0.0000012
Copper	0.0000072	0.040	0.0000048	0.00027
Iron	0.000046	3.7	0.000012	0.0036

	Class A		Class B	
Lead	0.000010	0.025	0.00000077	0.000026
Manganese	0.006	0.058	0.00038	0.00080
Nickel	0.00031	0.0014	0.000013	0.000018
Silver	0.000000	0.00033	0.000000062	0.000000062
Selenium	0.0001	0.0019	0.000018	0.000018
Uranium	0.000014	0.000097	0.000084	0.00031
Zinc	0.0061	0.18	0.000031	0.00033

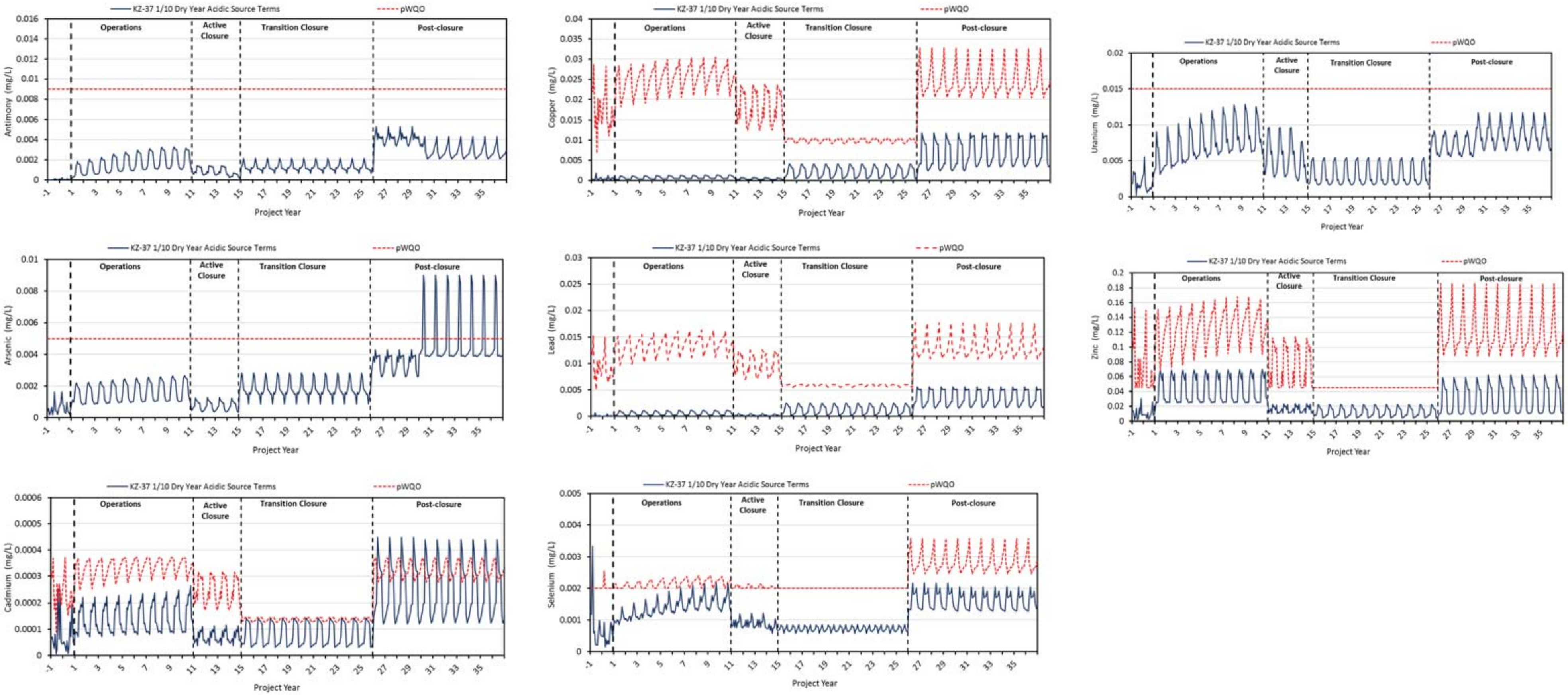


Figure 8-3: Updated Water Quality Predictions at KZ-37 in the 1/10 Dry Year Scenario Using Preliminary Acidic Drainage Loading Terms for Antimony, Arsenic, Cadmium, Copper, Lead, Selenium, Uranium, and Zinc

8.4 CONSTRUCTED WETLAND TREATMENT SYSTEMS

YESAB ISSUE

The constructed wetland treatment system (CWTS) proposed for the Site has been developed to a conceptual level only at this time, reviewers require additional information to evaluate the long-term environmental effect of the site. We recognize that design and implementation of a wetland treatment system will be site-specific and an iterative process. However, it is not clear to reviewers if the Proponent has a sufficiently developed plan to ensure that this can be achieved during the life of the Project.

R107

"Provide a schedule for completion of each phase of the constructed wetland treatment system development to be conducted over the mine operation and provide rationale to support the feasibility of the schedule. The schedule should include consideration of designing for neutral and potential future acidic conditions for site waters during post-closure."

The Conceptual Reclamation and Closure Plan, Section 8 of Appendix H, of the Project Proposal presents the closure execution strategy and schedule for proposed closure activities, including a coarse construction schedule for the CWTS installations. Table 8-9 further details this strategy and schedule, and is presented below. *Note: The timing for the implementation and commissioning of the South CWTS was not explicitly identified, and has been inserted into the reproduction of this table below.*

Table 8-9: Closure Schedule and Execution Strategy Summary

Development Period	Years (after Construction)	Site Conditions	Closure Activities
Mine Construction	-2 to -1	Construction of mine facilities and stripping of pit and waste facility footprints	• Removal and stockpiling of topsoil/overburden from ABM open pit and Waste Storage Facility footprints
Mining Operations	1 to 10	Active mining operations underway	• Continued removal and stockpiling of topsoil/overburden from Waste Storage Facility footprints • Construction of demonstration scale treatment wetland near Process Plant and water treatment plant • Progressive reclamation of Class A and Class B Waste Storage Facilities
Active Closure	11 to 13	Active mining operations completed	• Removal of pit equipment and infrastructure • Removal of underground infrastructure and equipment, and sealing of portals • Remove Fault Creek diversion, direct Fault Creek into ABM open pit, pit lime/carbon water treatment begins, active water treatment if/as required • Place waste covers • Decommission infrastructure and remove from site

Development Period	Years (after Construction)	Site Conditions	Closure Activities
Transition Closure	14 to 15	Pit filling	• LWMP Wetland constructed and commissioned – stabilization period • ABM lake water treatment continues as required using lime and carbon sources; active water treatment if/as required • ABM open pit spillway constructed • Some roads decommissioned • Routine monitoring and maintenance
	16 to 26	Pit finishes filling	• *South Wetland constructed and commissioned – stabilization period* • Routine monitoring and maintenance • ABM lake water treatment continues as required using lime and carbon sources; active water treatment if/as required • CWTS preparation for pit water • UWMP decommissioned following confirmation that storage facility covers and the CWTS are meeting performance criteria
Post-Closure	27 to 36	ABM lake Outflow to Geona Creek	• Routine monitoring and maintenance • Active water treatment if/as required until closure water quality objectives achieved

Each phase in the development of the CWTS provides progressively more detailed information to inform on the CWTS design and ensure optimal operation and function the CWTS. Table 8-10 below provides an estimate of the time required for completion of each phase of constructed wetland treatment system development. The earliest period of mine operation in which that Phase could be undertaken is also indicated. The duration and schedule of each phase is based on the nature of the work undertaken, as well as Contango's extensive experience with the types of activities carried out in the phased implementation of a CWTS. Details of the completed and proposed work within Phases 1-4 are provided in Section 3 of the memorandum *Conceptual Wetland Design based on Water Quality Objectives and Predicted Outflow Concentrations* (Contango Strategies Ltd., January 2017 - Appendix B of Appendix H of the Project Proposal). Further detailed designs will be submitted during the QML and Water Licencing processes and any subsequent changes will be in accordance with accepted engineering standards and license obligations.

Table 8-10 below combines the information referenced above with actual timing windows available in the mine planning and operational schedule. This is provided as schedule rationale, illustrating how there is ample time in the schedule to accommodate all the phases of CWTS planning, construction and commissioning.

As outlined in response to R109, volumetric runoff from Class A and B Storage Facilities is minor compared to neutral outflow from ABM lake, thus CWTS will not receive acidic influent at closure. No additional design or design time is required for this consideration.

Table 8-10: Conceptual schedule of completion of phased implementation of constructed wetland treatment system

<table>
<tr><th colspan="2">Phase</th><th>Time Required</th><th>Available Time in Operational/Closure Schedule</th><th>Earliest Period Applicable</th></tr>
<tr><td>Phase 1a</td><td>Information gathering and site assessment</td><td colspan="2" rowspan="2">3-6 months (completed)</td><td>Pre-operational</td></tr>
<tr><td>Phase 1b</td><td>Conceptual design and sizing</td><td>Pre-operational, once water quality predictions are available</td></tr>
<tr><td>Phase 2</td><td>Off-site bench-scale testing and optimization</td><td>3-6 months</td><td rowspan="2">2.5 years until start of Mine Construction, and another 1.5 years during Mine Construction</td><td>Pre-operational, once water quality predictions are updated</td></tr>
<tr><td>Phase 3</td><td>Off-site pilot-scale testing and optimization</td><td>8-16 months</td><td>After Phase 2 is complete</td></tr>
<tr><td>Phase 4</td><td>On-site demonstration-scale implementation and monitoring</td><td>2-5 years</td><td>10 years during Mining Operations</td><td>Operational period</td></tr>
<tr><td rowspan="2">Phase 5</td><td>Full-scale implementation – North CWTS</td><td rowspan="2">1 year for construction and 2 years for commissioning</td><td rowspan="2">2 years during Transition Closure as Pit is filling for construction
10 years during Transition Closure as Pit finishes filling for commissioning</td><td rowspan="2">After size refinement in Phase 4</td></tr>
<tr><td>Full-scale implementation – South CWTS</td></tr>
</table>

YESAB ISSUE

The discussion of the transition and post closure periods for the mine as discussed in Section 7.2 of Appendix D-7 indicates that there are treatment factors for the wetlands that are proposed for passive treatment after closure. The treatment factors are constituent-specific and affected by hydraulic retention time of the system. Appendix B of Appendix H-1, states that "proxies were applied from other projects with as similar of chemistry and conditions as possible". However, there is no indication of what the treatment factor values are and how they affect the water quality leaving the wetlands. Clarification of the treatment factors is required.

R108

"Provide details on the assumed water quality adjustment factor. Discuss these factors in the context of the predicted effluent concentrations for an engineered wetland in Tables 4 and 5 of the Contango report (Appendix B – Conceptual Wetland Design - of Appendix H-1 Conceptual Reclamation and Closure Plan)."

Treatment rate coefficients are developed for each constituent at each site, and are used as a tool to assist in the prediction of effluent concentrations, and/or to inform CWTS sizing requirements. They have been developed for and applied at numerous sites in North America (Huddleston and Rodgers, 2008; Murray-Gulde et al., 2008; Spacil et al., 2011; Schwindaman et al., 2014).

The information requested is provided in Section 7.2 of the memorandum *Conceptual Wetland Design based on Water Quality Objectives and Predicted Outflow Concentrations* (Contango Strategies Ltd., January 2017 - Appendix B of Appendix H of the Project Proposal). This section is reproduced below. The removal rate coefficients (Table 3, reproduced as Table 8-11) that were applied to determine the predicted effluent concentrations in Tables 4 and 5 are proxies that were developed for other projects with similar chemistry and conditions to the Project site, in advance of the development of removal rate coefficients specific to the Kudz Ze Kayah Project. The calculations provided in Equations 1-4 describe the formula for determining the removal rate coefficient for each COPC based on known influent and effluent concentrations, as well as a variation of the formula that applies to the coefficient to determine predicted effluent concentrations. As indicated below, project specific treatment rate coefficients will be further refined during future pilot-scale and/or demonstration-scale testing. These elements of the reclamation research program are outlined in Section 2.5.3 of Appendix H.

7.2. Removal Rate Coefficients and Calculations

An important factor for wetland design is the rate of treatment, also known as the treatment rate coefficient (k). The treatment rate coefficient is based on the treatability of a specific constituent and the hydraulic retention time of the system, both of which are site-specific based on water chemistry, wetland designs, and characteristics of the system. Because site-specific treatment rate coefficients (k) have not yet been developed for the Project, proxies were applied from other projects with as similar of chemistry and conditions as possible in order to conceptually assess the CWTSs outflow concentrations given the pre-determined size of each wetland for the Project (Table 2).

The treatment rate coefficients applied here are intended to be a conservative estimate for theoretical outflow concentration purposes, and will need to be refined through pilot-scale (off site), and demonstration-scale (on site) testing, as removal rate coefficients are highly site-specific and must be developed in a site-specific manner, for each element of interest. While they may sometimes be applied in a conceptual manner to other situations/sites (as was done here), caution should be taken in applying a removal rate coefficient developed for one design and water chemistry to a very different chemistry or design basis. It is also often the case that the treatment rate coefficient (k) must be calculated and applied for different ranges of certain constituents, which can be further refined with pilot-scale and demonstration-scale testing.

Based on experience from treatment wetlands being used and developed in Yukon and Northwest Territories, the treatment rate coefficient (k) applied for As and Se follow a zero-order reaction kinetic, while the rate coefficients for Cd and U follow first-order kinetics. The treatment rate coefficients for As and U were derived from pilot-scale testing that has been conducted for a mine in the Northwest Territories, while the coefficients for Cd and Se were *derived from demonstration-scale testing that is ongoing at a mine in Yukon (Contango, January 2017). There was no rate coefficient available specific to Sb, and so the rate coefficient from As was used as a proxy.*

In Equation 1-4, Cf is final concentration, Ci is initial concentration, V is volume of water in the system, and Q is flow rate. Using the removal rate coefficients (k) in Table 3 and equations 1-4, parameters can be rearranged to solve for those of interest. The volume of water in each CWTS is calculated using the conceptual wetland size multiplied by the calculated water depth of the conceptual design. For this analysis, a conceptual water depth of 80 cm was used, which is calculated from the assumptions of a horizontal surface flow wetland with 30 cm of free water at the surface and 1.5 metres of substrate with an expected 33% pore space filled with the water. Using the conceptual volumes and predicted flow rates and initial concentrations, Equations 1 and 2 can be rearranged to calculate the theoretical outflow concentration (Cf) of each constituent for each CWTS. For conservativism, Cf values that are below the Geona Creek pWQO are set to equal that concentration.

Table 8-11: Elements considered in treatment wetland models, with respective treatment rate coefficient (k) values.

Element	*k*[1]
Zero order reaction kinetic	
As	0.01032
Se	0.000384
Sb	0.01032
First order reaction kinetic	
Cd	0.19272
U	0.192

$$k = \frac{-\ln\left(\frac{Cf}{Ci}\right)}{V} \, x \, Q \qquad k = \frac{-\ln\left(\frac{Cf}{Ci}\right)}{V} \, x \, Q$$

Equation 1 — Equation for calculation of first-order removal rate coefficient.

$$Cf = Ci \times e^{-k \, x \, \frac{V}{Q}}$$

Equation 2 — Equation for calculation of first-order removal rate coefficient, rearranged to solve for outflow concentration.

$$k = \frac{(Ci - Cf)}{V} \, x \, Q \qquad k = \frac{(Ci - Cf)}{V} \, x \, Q$$

Equation 3 — Equation for calculation of zero-order removal rate coefficient.

$$Cf = Ci - k\,x\,\frac{V}{Q}$$

Equation 4 — Equation for calculation of zero-order removal rate coefficient, rearranged to solve for outflow concentration.

YESAB ISSUE

The Proposal recognized the potential for ARD to develop over time in the class A and B materials. There is a need to evaluate the potential effects of acidic drainage on wetland treatment performance. It is likely that the quality of inflow water to the wetland will change in the future as ARD develops in Class A rock and tailings, and the Class B rock. For example, as ARD develops, greater loading of metals such as aluminum, cadmium, copper, iron, manganese, nickel and zinc can be expected.

R109

"Provide cold weather case studies for passive wetland treatment systems designed for acidic conditions as well as case studies for passive wetland treatment systems that have successfully transitioned from treating neutral drainage to effectively treating acidic drainage with increased metal loadings."

Any acidic drainage from either the Class A or Class B Waste Storage Facilities is expected to be volumetrically minor compared to the neutral to mildly alkaline outflow from the ABM lake at closure. Consideration of the monthly runoff volumes from the Class A and B Waste Storage Facilities indicates that the Class A and Class B runoff would contribute approximately 0.3% and 3.3% of the flow to the constructed wetland, respectively. Given the year-round dilution from the ABM lake outflow, and the neutralizing capacity of the ABM lake discharge water, the constructed wetland treatment system is expected to only receive circumneutral influent.

As part of the site-specific CWTS design process, aspects that would facilitate continued treatment throughout cold-climate or freezing conditions are thoroughly assessed. Phase 3 of the CWTS design (off-site pilot-scale testing) incorporates freezing trials to inform on the effect that cold weather would have on treatment. While treatment wetlands are common place worldwide, including in cold-climates, there are several reported cases in peer-reviewed scientific literature of successful CWTS treatment in cold weather conditions, as provided in the as case studies in Table 8-12 below.

Predictions for wetland effluent concentrations for Kudz Ze Kayah were based on predicted influent water chemistry for the site, and developed though an iterative process that involved the integration of covers, diversion of water, and in pit treatment. Should the predictions for water influent chemistry change, the passive water treatment approach will be re-evaluated and designs will be adjusted accordingly. This is part of the process built into the phased approach to CWTS wetland design (R107 Response; Section 3 of Appendix B of Appendix H of the Project Proposal), allowing for assessment of designs, optimization, and adjustment as needed through the mine life, long prior to CWTS construction and commissioning timelines. Generally speaking, CWTS designed to treat constituents in neutral drainage and CWTS designed to treat acidic drainage conditions may have different designs, and are not expected to be readily transitioned from one to the other, nor should they be. Having said that, the CWTS implementation timeline outlined in the response to R107 includes contingencies in the form of additional time to reassess and reconfigure the CWTS design should any unanticipated water chemistry conditions arise.

Table 8-12: Summary of Selected Case Studies/References that have Treated Kudz Ze Kayah COPCs using Wetlands

Water Source	Location	Constituents (mg/L) [1]					Wetland Type	Freezes	Comments	Reference
		As	Cd	Se	Sb	U				
Smelter landfill	Trail, BC	150 to <0.5	4.7 to <0.02	n/a	n/a	n/a	On-site pilot scale	Yes	Year-round treatment, 15,000 L/d	Duncan (2010)
Gold-cobalt-bismuth-copper mine	Fortune Minerals Mine, NWT	0.48 to 0.11	n/a	n/a	n/a	n/a	Natural wetland	Yes	Information from natural wetland treatment utilized for pilot-scale design and testing	Contango (2014)
Silver-cooper-bismuth mine	Terra mine, NWT	0.05-0.08 to 0.005-0.07	n/a	n/a	n/a	n/a	Natural wetland	Yes	Natural wetland receiving mine tailing discharge	Sealey (2011)
Gold mine	Finland – Peatland 1	0.041 to 0.0082	n/a	n/a	0.16 to 0.12	n/a	Full scale	Yes	Natural peat wetlands receiving mine tailings discharge. Year round treatment with snow cover from November to May and mean annual temperatures between -3°C and 6°C.	Palmer et al. (2015)
	Finland – Peatland 4	0.14 to 0.014	n/a	n/a	0.036 to 0.0068	n/a				
Uranium mine	Curilo, Western Bulgaria	0.01-0.59 to <0.01-<0.1	0.01-0.12 to <0.01	n/a	n/a	0.28-4.82 to <0.10	Full-scale	Yes	Natural and CWTS receiving mine tailings discharge	Groudev et al. (2008)
Mine, milling, and smelting discharge	Butte Hill, Colorado	25.5 to 11.9 (CT)[2]	40.5 to 0.51; 39.6 to 1.2[2]	n/a	n/a	n/a	Demonstration-scale	Yes	Series of CWTS receiving mine, milling, and smelting discharge	Gammons et al. (2000)
Natural runoff and agricultural irrigation drainage	Great Falls, Montana	n/a	n/a	Se (0.026 to <0.001)	n/a	n/a	Full-scale	Yes	Engineered natural system separated into 6 ponds using dikes.	Zhang and Moore (1996)

[1] Maximum mean inflow concentration and corresponding outflow concentration.
[2] Concentrations measured in µg/kg

R110

"Performance results for passive wetland treatment systems are usually expressed as a percent reduction of contaminant of potential concern (COPC) loads from inflow to outflow. Wherever possible, present performance as flow volumes treated and concentrations of COPC in the inflow and outflow."

Percent reduction of COPC loads is an accurate way to express wetland performance, as it considers seasonal fluctuations and flow variability. The concentration of each COPC is multiplied by the flow rate to determine the load removed over a period. That value is then applied to calculate the percent load reduction for each COPC over a period. The flow volumes, and the inflow and outflow COPC concentrations that were utilized to determine the percent load reduction in the conceptual CWTS design are provided in Tables 4 and 5 respectively of the memorandum *Conceptual Wetland Design based on Water Quality Objectives and Predicted Outflow Concentrations* (Contango Strategies Ltd., January 2017 - Appendix B of Appendix H of the Project Proposal), Table 4 is provided below as Table 8-13.

Table 8-13: Conceptual outflow concentrations (Cf)1 for 1.7 hectare South Wetland for year 27 post mine closure in the Mean, Wet, and Dry predicted scenarios

Scenario		Flow (m^3/day)	Antimony				Arsenic				Cadmium				Uranium			
			mg/L		Removal		mg/L		Removal		mg/L		Removal		mg/L		Removal	
			C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)
Mean	Jan	2,492	0.013	0.009	30.8	10.0	0.020	0.005	74.9	37.2	0.0008	0.0003	57.9	1.2	0.023	0.015	34.8	19.9
	Feb	2,198	0.013	0.009	30.8	8.8	0.020	0.005	75.0	33.0	0.0008	0.0003	57.9	1.0	0.023	0.015	34.8	17.6
	Mar	1,846	0.013	0.009	30.8	7.4	0.020	0.005	75.1	27.8	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	14.8
	Apr	4,508	0.013	0.009	30.8	18.0	0.020	0.005	75.1	68.1	0.0008	*0.0004*	44.1	1.6	0.023	0.015	34.8	36.1
	May	12,683	0.013	0.009	30.8	50.7	0.020	*0.009*	40.5	140.4	0.0008	*0.0007*	18.7	1.9	0.023	*0.019*	18.6	54.3
	Jun	14,047	0.013	0.009	30.8	56.2	0.020	*0.010*	48.3	140.4	0.0008	*0.0007*	17.0	1.9	0.023	*0.019*	17.0	54.8
	Jul	8,236	0.013	0.009	30.8	32.9	0.020	0.005	74.6	121.0	0.0008	*0.0006*	27.3	1.8	0.023	*0.017*	27.2	51.5
	Aug	7,479	0.013	0.009	30.8	29.9	0.020	0.005	74.8	110.7	0.0008	*0.0006*	29.6	1.8	0.023	*0.016*	29.5	50.7
	Sep	7,914	0.013	0.009	30.8	31.7	0.020	0.005	74.8	117.3	0.0008	*0.0006*	28.2	1.8	0.023	*0.017*	28.1	51.2
	Oct	5,090	0.013	0.009	30.8	20.4	0.020	0.005	7.8	75.5	0.0008	*0.0005*	40.2	1.6	0.023	0.015	34.8	40.7
	Nov	3,898	0.013	0.009	30.8	15.6	0.020	0.005	74.9	58.2	0.0008	*0.0004*	49.0	1.5	0.023	0.015	34.8	31.2
	Dec	3,035	0.013	0.009	30.8	12.1	0.020	0.005	75.0	45.4	0.0008	0.0003	57.8	1.4	0.023	0.015	34.8	24.3
Wet	Jan	2,611	0.013	0.009	30.8	10.4	0.020	0.005	74.9	39.0	0.0008	0.0003	57.9	1.2	0.023	0.015	34.8	20.9
	Feb	2,289	0.013	0.009	30.8	9.2	0.020	0.005	75.0	34.3	0.0008	0.0003	57.9	1.1	0.023	0.015	34.8	18.3
	Mar	1,904	0.013	0.009	30.8	7.6	0.020	0.005	75.1	28.6	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	15.2
	Apr	5,852	0.013	0.009	30.8	23.4	0.020	0.005	75.1	88.4	0.0008	*0.0005*	36.1	1.7	0.023	0.015	34.8	46.8
	May	18,240	0.013	0.009	30.8	73.0	0.020	*0.012*	38.4	140.4	0.0008	*0.0007*	13.4	2.0	0.023	*0.020*	13.3	56.0
	Jun	23,381	0.013	0.009	30.8	93.5	0.020	*0.014*	30.4	140.4	0.0008	*0.0007*	10.6	2.0	0.023	*0.021*	10.6	56.8
	Jul	20,021	0.013	0.009	30.8	80.1	0.020	*0.013*	35.6	140.4	0.0008	*0.0007*	12.3	2.0	0.023	*0.020*	12.2	56.3
	Aug	10,539	0.013	0.009	30.8	42.2	0.020	*0.006*	67.2	140.4	0.0008	*0.0006*	22.0	1.9	0.023	*0.018*	21.9	53.2
	Sep	13,008	0.013	0.009	30.8	52.0	0.020	*0.009*	54.4	140.4	0.0008	*0.0007*	18.2	1.9	0.023	*0.019*	18.2	54.4
	Oct	5,507	0.013	0.009	30.8	22.0	0.020	0.005	74.8	81.7	0.0008	*0.0005*	37.9	1.7	0.023	0.015	34.8	44.1
	Nov	4,147	0.013	0.009	30.8	16.6	0.020	0.005	74.9	61.9	0.0008	*0.0004*	46.8	1.6	0.023	0.015	34.8	33.2
	Dec	3,205	0.013	0.009	30.8	12.8	0.020	0.005	75.0	48.0	0.0008	*0.0004*	55.9	1.4	0.023	0.015	34.8	25.6

Scenario		Flow (m^3/day)	Antimony				Arsenic				Cadmium				Uranium			
			mg/L		Removal		mg/L		Removal		mg/L		Removal		mg/L		Removal	
			C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)	C_i	C_f	%	Load (g/day)
Dry	Jan	2,099	0.013	0.009	30.8	8.4	0.020	0.005	74.9	31.4	0.0008	0.0003	57.9	1.0	0.023	0.015	34.8	16.8
	Feb	1,896	0.013	0.009	30.8	7.6	0.020	0.005	75.0	28.4	0.0008	0.0003	57.9	0.9	0.023	0.015	34.8	15.2
	Mar	1,653	0.013	0.009	30.8	6.6	0.020	0.005	75.1	24.9	0.0008	0.0003	57.9	0.8	0.023	0.015	34.8	13.2
	Apr	3,749	0.013	0.009	30.8	15.0	0.020	0.005	75.1	56.7	0.0008	*0.0004*	50.3	1.5	0.023	0.015	34.8	30.0
	May	10,037	0.013	0.009	30.8	40.1	0.020	*0.006*	69.7	140.4	0.0008	*0.0006*	23.0	1.8	0.023	*0.018*	22.9	52.9
	Jun	10,751	0.013	0.009	30.8	43.0	0.020	*0.007*	66.2	140.4	0.0008	*0.0006*	21.6	1.9	0.023	*0.018*	21.6	53.3
	Jul	5,513	0.013	0.009	30.8	22.1	0.020	0.005	74.6	81.0	0.0008	*0.0005*	37.8	1.7	0.023	0.015	34.8	44.1
	Aug	5,428	0.013	0.009	30.8	21.7	0.020	0.005	74.8	80.4	0.0008	*0.0005*	38.3	1.7	0.023	0.015	34.8	43.4
	Sep	5,763	0.013	0.009	30.8	23.1	0.020	0.005	74.8	85.4	0.0008	*0.0005*	36.5	1.7	0.023	0.015	34.8	46.1
	Oct	3,910	0.013	0.009	30.8	15.6	0.020	0.005	74.8	58.0	0.0008	*0.0004*	48.8	1.5	0.023	0.015	34.8	31.3
	Nov	3,069	0.013	0.009	30.8	12.3	0.020	0.005	74.9	45.8	0.0008	0.0003	57.4	1.4	0.023	0.015	34.8	24.5
	Dec	2,474	0.013	0.009	30.8	9.9	0.020	0.005	75.0	37.0	0.0008	0.0003	57.9	1.1	0.023	0.015	34.8	19.8

[1]For conservativism, *Cf* values that are below the Geona Creek pWQO are set to equal that concentration. Where the *Ci* or *Cf* concentration is greater than Geona Creek SSWQO, the value is indicated with italic font.

Ci – Initial Concentration (Inflow); *Cf* – Final Concentration (Outflow).

8.5 SURFACE WATER QUALITY AND QUANTITY

YESAB ISSUE

In their water quality model, BMC made predictions at KZ-37 (Geona Creek) instead of at an existing water quality monitoring station. KZ-37 is depicted as a "surface water quality monitoring station with prediction" on Figure 5-1 of this report but it is not shown on Figure 1-2 of, or mentioned at all in, the 2015-2016 Surface Water Quality Baseline Report. Instead, the median monthly water quality for select modelled parameters at this location is estimated using median monthly baseline water quality and flows at KZ-9 and KZ-18. This is problematic because it results in the comparison of water quality predictions generated by the water quality model to estimated water quality at KZ-37, rather than measured water quality at this location.

It would be beneficial to collect water quality data at the same location as the modelled water quality. However, KZ-37 and KZ-17 may be essentially equivalent if there is no additional water flowing into Geona Creek between the locations.

R111

"Provide rationale and a discussion for using KZ-37 as a surface water quality monitoring station with predictions including:

a. how baseline information from sites KZ-9 and KZ-18 are representative of conditions at site KZ-37;

Station KZ-9 on Geona Creek is located approximately 100 m upstream of KZ-37 with only one tributary between the two locations on Geona Creek, which is station KZ-18. Given the proximity of KZ-9 to KZ-37 and the only additional source of surface water is the KZ-18 tributary, the method of calculating KZ-37 is appropriate.

b. consideration for establishing KZ-37 as a surface water quality monitoring station; and

KZ-37 has been monitored as a surface water quality monitoring station since February 2017 and is now monitored monthly. The next iteration of the water quality model will incorporate the KZ-37 water quality results along with other data collected since the report was issued.

c. consideration for using an alternative existing station such as KZ-17."

Modelling at KZ-37 is the most suitable location for water quality predictions in Geona Creek as this will be the location immediately downstream where discharge from the Water Management Pond and Geona Creek will mix. Station KZ-17 is over 2.5 km downstream of the proposed discharge location to Geona Creek and is not considered to be as relevant when compared to station KZ-37.

YESAB ISSUE

A statistician with a background in WQO derivation was recently contracted by Yukon government to prepare a statistical justification for baseline water quality data requirements for quartz mining projects.

The statistician was provided with available, relevant water quality data collected in Yukon, including data from the Wolverine mine, a mining project nearby and analogous to the proposed Kudz Ze Kayah project. The statistician concluded that three years of recent, continuous baseline water quality data is the minimum duration required to (a) generate a reasonable understanding of natural variability of water quality, and (b) detect systematic changes in water quality over time, if present.

R112

"Provide a detailed overview of the work planned to collect additional water quality monitoring information through the next Project phase to further verify developed water quality model and projections related to receiving water quality."

Contrary to the suggestion in the lead up to this request, the Wolverine Mine is not analogous to the proposed Kudz Ze Kayah Project except by proximity, as it is hosted in different rock types and the ore body has a number of very different geochemical characteristics. It is critical to dispel this perception as it is clearly underpinning lines of questioning related to the Kudz Ze Kayah Project.

Surface water quality monitoring is continuing at a monthly sampling frequency at all baseline stations including site KZ-37, which was added to the water quality sampling program in February 2017. Further, monitoring has been outlined in Table 8-49, Chapter 8, Surface Water Quality and Quantity of the Project Proposal, which will be used during operations to further refine the model.

R113

"Updated water quality baseline information, water quality objectives, and water models (e.g., water quality model, site and watershed balance models, surface water flows, etc.) for the site are required to be submitted prior to the Executive Committee drafting the screening report. To develop a reasonable understanding of short-term variability, sampling is required to be conducted and reported on at least two sampling events, including one during low-flow conditions and one during high-flow conditions, for each year in which 5 samples are collected in 30 days."

BMC appreciates that the review and eventual approval of the Project will undergo a number of stages, governed by separate legislation and specialized agencies. While we view the entire regime as a whole system, we recognize it is comprised of discrete segments. For example, data and modelling we submitted at the YESAB stage has been prepared and submitted to support YESAB's effects assessment at this stage. Because we continue to collect site water quality data as we progress, we will be in a position to update modelling with additional data as required during the water licensing stage. At this stage in the Project it will be important to undertake our work with support of the specialist agency, the Yukon Water Board and their technical staff and consultants.

YESAB ISSUE

The water balance modeling exercise at the watershed scale was for operations at year 10 and several closure conditions. No information was provided in this report for the construction phase or any of the projected years of operation. This is not considered consistent with industry standards and considered an information gap.

The watershed water balance model was calibrated with data from the 2015/2016 hydrometric monitoring program. Additional hydrometric data would be useful to further calibrate the watershed water balance model, verify model development and *model parameter assumptions, verify work completed to-date, and provide additional confidence in projections.*

R114

"Update the watershed model to include all phases of the mine life from construction through operations, and the active, transition, and post closure phases."

Water balances for the site for all phases of the mine life were provided in the original Proposal document supplied to YESAB. The site water balance for operations was provided in Appendix C-7 of the Project Proposal (Water Balance Model Report). For construction and closure phases of the project, the site water balance has been incorporated in the Receiving Environment Water Balance Report, Appendix D-6 of the Project Proposal.

R115

"Undertake a sensitivity analysis to assess variability of model predictions given variation in key model input parameters and assumptions."

No updates to the water balance were warranted or provided in response to question R90, and therefore the Surface Water Management Plan has not been updated. All management plans will be updated as Project planning progresses if preceding work is materially updated.

YESAB ISSUE

The proposed threshold criteria for surface water quantity and quality used to assess the magnitude of projected changes in the receiving environment seem arbitrary. For example, for water quality, exceedance of a pWQO is often considered to be a high effect, whereas the Proponent is proposing a threshold of 10 times the pWQO or greater to represent a high level effect.

R116

"Provide justification and rationale for the proposed threshold criteria for surface water quantity and quality used to assess the magnitude of projected changes in the receiving environment."

Water quality objectives have been established using a use-protection approach. The majority of the objectives have been established based on guidelines established by CCME or BCMoE for the protection of aquatic life. The CCME and BCMoE guidelines have been developed with safety factors relative to chronic toxicity literature values which are often 10-100 times greater than the guidelines. These chronic toxicity thresholds are taken from the most sensitive organism and life stages. Given a potential adverse effect to aquatic organisms would require long term exposure to chronic toxicity concentrations, the definition of high magnitude effect was established as 10 times the water quality objectives since concentrations at the generic guidelines would not have residual effects.

YESAB ISSUE

The Preliminary Water Quality Objectives report states that "The derivation of these pWQO has been performed following the methods outlined by Canadian Council of Ministers of the Environment (CCME) (2003) and is consistent with other permitted mining projects in Yukon;" however, it is not demonstrated that this is the approach used to develop the preliminary WQO for selenium.

The Proponent has indicated groundwater quality in the local study area (LSA) will be measured against applicable water quality guidelines as listed in the Project Proposal (9.1. Assessment Approach, pp 9-3). Further, the Proponent noted they identified natural exceedances of the water quality guidelines and would consider developing site specific water quality objectives at compliance monitoring locations.

ECCC notes that the use of natural background concentrations at Kud Ze Kayah may not be appropriate as there have been insufficient information to support the background approach. Further, the Proponent has neither indicated the approach to the site specific water quality objectives nor appropriate background studies completed.

R117

"Provide additional rationale for the derivation of Preliminary Water Quality Objectives (pWQO), including reference to recent, peer-reviewed literature, for the proposed approach to developing a water quality objective (WQO) for selenium. The discussion should include consideration of alternative approaches."

The derivation of most of the project pWQOs has been performed following the methods outlined by Canadian Council of Ministers of the Environment (2003) and is consistent with other permitted mining projects in Yukon. The methodology used to derive the pWQOs is described in detail in the Preliminary Water Quality Objectives Report, Kudz Ze Kayah Project (December 2016, Appendix D-8 to the Project Proposal.)

BMC agrees that the method utilized to develop a site-specific water quality objective (SSWQO) for selenium is not one of those outlined in CCME 2003, as acknowledged in both the executive summary, and in Section 2.2.1 of Appendix D-8 of the Project Proposal. BMC is not suggesting that the presence of sulphate eliminates the uptake of selenate, but rather that it reduces it in a linear and reproducible manner that is consistent with first principles. Evaluation of the incorporation of selenate into primary producers is appropriate because incorporation at the bottom of the food chain dictates selenium concentrations in higher trophic level organisms; literature suggests that there is relatively little increase in selenium concentrations from primary producers to invertebrates or invertebrates to fish (Presser and Luoma 2010). Lo et al (2015) documented linear decreases in selenium accumulation with increasing sulphate concentration, supporting sulphate as important in modifying selenium uptake by primary producers.

The literature cited by YG Environment regarding selenium bioavailability, toxicity, and its relationship to sulphate are all at least 10 years old (and up to 28 yrs old). The science of selenium toxicity has advanced enormously in the past 10 years, and therefore most of the research work already referenced in BMC's rationale for the approach selected (Appendix A – Chemistry of the Preliminary Water Quality Objectives Report, Appendix D-8 of the Project Proposal) has been conducted and published within the last 7 years. The work undertaken to support the development of a site-specific selenium objective was led by aquatic ecotoxicology professionals with recent and relevant experience in contributing to the state of selenium aquatic toxicity science. The rationale provided here, including the references to recent peer reviewed literature, supports their selected approach.

In addition to the already referenced research and literature, Deforest et al. (2017) have recently completed work in which they have developed a quantitative relationship, using numerous sources and sites, between sulphate concentrations and selenium enrichment factors. This work adds to the weight-of evidence of a linear relationship between selenium accumulation and sulphate concentrations and proposes a formulaic relationship applicable to lotic environments. The relationship identified by Defrost et al. will be compared with the relationship developed for the KZK Project, and evaluated accordingly.

It is expected that the pWQOs and related water quality assessments will be refined as additional baseline water quality data are collected; however, sufficient data are available to support the pWQOs presented and to develop the water quality assessments in the Project Proposal.

YESAB ISSUE

The Proponent proposes variable pWQOs for several water quality parameters, including sulphate, nitrite, selenium, cadmium and zinc. However, the Proposal does not clarify how such variability could be applied in a practical sense to control emissions during each phase of the Project (e.g. as part of licensing).

Variable WQOs may be justified from a toxicological perspective but can prove difficult to apply for regulatory purposes. It is common to reduce the complexity of variable objectives by applying a fixed

WQO, a site specific WQO, or a seasonal WQO. In all cases, the most conservative WQO is generally applied.

R118

"Provide details on how variable Preliminary Water Quality Objectives (pWQOs) would be applied and enforced on an operational basis from a practical perspective."

Variable pWQOs (i.e. those that are hardness, sulphate, or chloride-dependent) will be calculated for each sample using actual dependency values and compared to the measured constituent concentration. Managers will have simple calculation tools developed to determine an immediate pWQO value upon receipt of analytical results.

As part of the operational Adaptive Management Plan both short term (i.e., for each sampling event) and long-term (i.e., annual or longer) water quality thresholds will be established which will outline specific responses should receiving water quality values trend towards the exceedance of the pWQOs in the receiving environment.

R119

"Provide evidence of other sites where this approach has been applied."

Variable water quality objectives and effluent quality standards have been incorporated into Water Licences by the Yukon Water Board on previous projects including the Minto Mine (QZ14-031), and Sa Dena Hes Mine (QZ16-051) and their respective Adaptive Management Plans.

YESAB ISSUE

The operations water management strategy proposes a proportioned discharge rate to Geona Creek and Finlayson Creek. However, the Proposal does not clarify how release volumes will be controlled to achieve this threshold.

A flow proportioned discharge rate is a valid approach for managing downstream water quality but it requires greater effort to measure downstream flows and to control the discharge rate. This can prove difficult, especially during ice-bound conditions.

R120

"Clarify how the 3:1 ratio at KZ-37 and 2:1 ratio at KZ-15 will be achieved and verified."

Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured daily or weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter.

During freshet and significant rain events, discharge within the creeks will be monitored more frequently than weekly using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct daily spot checks to verify flow rates when week to week changes are suspected.

YESAB ISSUE

The Proponent's assessment of potential effects on the receiving environment assumes that a high degree of treatment efficiency will be achieved. The Proponent's conclusion of no significant adverse effects to surface water quality is substantially tied to the assumed treatment efficiencies. However, the Proposal does not provide sufficient information to defend the assumed efficiencies.

R121

"Provide justification for the assumed treatment efficiencies."

BMC have requested a supplementary report from specialists Integrated Sustainability (IS) on potential treatment methods to achieve the required discharge limits and treatment efficiencies. This report is included as **Appendix 4** to this Response Report (Water Treatment Summary).

The report summarizes the process selection criteria and modelling work that has been completed to advance the water treatment plant design.

Based on the site-specific requirements and recommended approach form IS, BMC proposes that a staged effluent treatment system be used that is designed to focus on bulk removal of dissolved and suspended species, as well as polishing to achieve the required discharge standards.

The proposed active water treatment systems include the unit processes oxidation, chemical addition, media and/or membrane filtration, and ion exchange to meet the discharge water quality requirements. Provisions have been made to develop a treatment approach that can be adapted as more data becomes available and engineering work progresses. This approach will have the added advantage of being capable of being flexible enough to adequately deal with any unexpected new data and as a result will deliver the required outcomes for the Project.

The staged treatment system proposed will include a combination of technologies including precipitation (via lime or sulphide addition), multimedia filtration, membrane filtration by nanofiltration or reverse osmosis, and ion exchange. A combination of these technologies was modelled and achieved the assumed treatment efficiencies.

Other candidate technologies capable of treating water to the requirements include:

- Advanced multi-stage ion exchange
    - Ion exchange is a common process and capable of removing various species of inorganic contaminants, heavy metals and selenium in different valence states. To account for variable selenium species, this process may include specialized, advanced reactive media.

- Thermal processes
  - Evaporation and/or crystallization for bulk removal of the key contaminants is expected to have extensive pre-treatment requirements
- Electrodeionization
  - Electrodeionization is used for very challenging wastewater and has precedent in ultra-pure water treatment applications
  - Suitable for low total dissolved solids (TDS) water (~150-200 ppm)
  - It is often used as an alternative to mixed bed deionization, since it does not require chemical addition for regeneration

R122

"Provide contingency options in the event that proposed water treatment options do not achieve their intended efficiencies."

As referenced in the response to R121, the proposed development methodology for the appropriate water treatment option will be flexible enough to enable BMC to deal with any contingency that may arise. The possibility that water treatment options do not achieve their intended efficiencies will be handled depending on which of the specific criteria is not being achieved. There are two main classes of criteria that potentially may not be achieved:

- Throughput too low- If the target throughputs are not met then additional modules will be put into service in parallel. The base design will include allowance for redundancy due to the high variability in throughput throughout the calendar year. Any indications that there may be problems achieving treatment of the required volumes will be apparent before the Water Treatment Plant is operating at design capacity and the plant can be easily expanded at that time.
- Water Treatment Plant Discharge targets not met-The solution to this will depend on which constituent is not being removed to the appropriate level. There are a number of methods to mitigate for this including adding additional treatment systems, both in parallel and as part of the polishing circuit, adjustment of dosing rates of chemicals, and adjustments of flow rates in parts of the circuit. Similar to 1), indications that the performance criteria are not being met will become apparent early in the operation of the treatment plant and will be mitigated prior to full operational status.

YESAB ISSUE

There is little discussion of drinking and recreational water in this project proposal. The surface water quality and quantity assessment states "Discussions with local Kaska citizens indicated that surface water at Fault Creek is used as a drinking source...". The assessment of groundwater quality and flow states "Also, direct use of groundwater resources, such as drinking water wells, is highly dependent on groundwater quality." Table 4.1 in Appendix F-3 also highlights concerns of the Ross River Dena Council over impacted drinking water quality in Cache Creek and Ketza River.

R123

"Identify potential sources of water used for drinking and recreational purposes in the region of the proposed Project."

The only creek in the Project area that was specifically identified by First Nations as being used for drinking water purposes is Fault Creek. However, other creeks in the local study area (as defined in Chapter 8 of the Project Proposal) may also be used for drinking water purposes when people are hunting or fishing in the area. Note that it is unlikely that Geona Creek is used for drinking water purposes as it is a low flowing stream that visibly does not look potable. Consultation with First Nations and the Public did not identify any specific waterbodies that are used for recreational purposes (i.e. swimming).

A PQRA has been conducted (as per R267) and is included as **Appendix 3**, of this Response Report.

R124

"Provide an assessment of the potential for adverse human health effects from drinking and recreational waters impacted by the proposed Project."

A PQRA has been conducted (as per R267) and is included as **Appendix 3**, of this Response Report.

YESAB ISSUE

Comments provided by Mineral Resources Branch describe deficiencies related to waste management, *options assessment, and the conceptual reclamation and closure plan. Furthermore, limited details are provided concerning the proposed in situ treatment of the ABM Lake or the conceptual constructed wetland treatment system. The removal rates and treatment factor used in the water quality model are not justified. It is not possible to assess potential significant, adverse effects to the downstream receiving environment without this information.*

R125

"Provide a report that details the proposed treatment methods, justifies site-specific treatment rate coefficients, and predicts the chemistry of the treated effluent. Based on the information in this report, provide an updated water quality model (i.e., with updated mine source loads) and, if necessary (e.g., if new contaminants of potential concern are identified), an updated water quality objectives report."

The *in situ* pit treatment and Constructed Wetland Treatment System (CWTS) conceptual designs and treatment details have been developed by acknowledged experts in passive and semi-passive mine water treatment. The proposed treatment methods have been effectively applied in a wide range of mining applications and conditions, and the treatment rate coefficients have been conservatively and appropriately selected based on the experts' substantial experience and professional judgement. The wetland assessment and conceptual design work, including identifying the treatment mechanisms and treatment rate coefficients, was conducted by Contango Strategies Ltd., industry leaders and experts in passive water treatment, constructed wetland treatment systems, and biogeochemical water treatment processes. Contango has led passive water treatment design efforts on numerous projects in Yukon, and on other cold-climate location projects, such as the Giant Mine in the NWT and Mount Polley in BC.

The information regarding the proposed methods is presented at the appropriate conceptual level, and reflects the current Project level of design. The design detail for the treatment installations and infrastructure will be appropriately advanced with further development of site facility designs and with the collection of additional water quality information. This will be provided in applications to support the regulatory permitting process.

As cited in the Project Proposal, Water Quality Model (Appendix D-7) and Conceptual Reclamation and Closure Plan (Appendix H), the *in situ* treatment method proposed for ABM lake has been successfully implemented at numerous pit lakes in the USA to treat the same COPCs [e.g., Sweetwater, WY (Harrington, 2002); Barite Hill, SC (Harrington et al., 2009); Anchor Hill, SD (Harrington et al., 2004)]. These studies, alongside related *in situ* treatment experience of flooded underground mine workings (e.g., Harrington et al., 2015), were the basis for the conservative COPC reduction percentages used in the water quality model for ABM lake (Table 6-16 of Appendix D-7).

Contango's technical memorandum titled Conceptual Wetland Design based on Water Quality objectives and Predicted Outflow Concentrations [January 2017, Appendix B of Appendix H of the Project Proposal (Conceptual Reclamation and Closure Plan, February 2017)] reports the treatment mechanisms (Page 7; Section 6), site-specific treatment rate coefficients (Page 11-13 and Table 3; Section 7.2), and equations (Page 12-13 and Equations 1-4; Section 7.2) used in predictions of water chemistry exiting the proposed North and South treatment wetlands. Predictions for the CWTSs were based on removal rates observed at other sites they have worked on in the north and cold climates and also in off-site pilot-scale studies. These include Capstone Mining Corp.'s Minto mine in the Yukon (Haakensen et al., 2015 and Appendix A2 of Capstone, 2017), Fortune Minerals' NICO project in the Northwest Territories (Contango, 2014), the Kumtor mine at high altitude (4,200 m) in Kyrgyzstan (Friesen et al., 2016), and numerous other sites in North America (Huddleston and Rodgers, 2008; Murray-Gulde et al., 2008; Spacil et al., 2011; Schwindaman et al., 2014).

The site-specific treatment information for the *in situ* pit and constructed wetland treatment systems as referenced above is appropriate, and is already incorporated into the Project Proposal (Appendix D-7, Water Quality Model, Kudz Ze Kayah Project). This report presents expected effluent concentrations for the site closure phases, and compares these concentrations with proposed water quality objectives for the project. The reports referenced in the question above do not warrant any updates on the basis of the information provided or referenced in this response.

YESAB ISSUE

A water treatment plant is proposed for the management of water quality during the operation. The necessity of a water treatment plant is based on the acknowledgement that the high sulphur PAG material will produce drainage during operations that requires management before release to the environment. The assumption of reverse osmosis technology for water treatment is reasonable.

However, reverse osmosis is an expensive treatment option and the feasibility of treating large quantities of waste water should be proven.

In addition, the byproduct of reverse osmosis is a high concentration effluent that also requires management and this was not acknowledged or considered in water management or in the water quality model during the operation. The disposal of high contaminant concentration waste generated by the use of reverse osmosis can be problematic. The current assumptions for treated water quality are summarized in Table 5-15 and Appendix D-7. Treatment technologies other than reverse osmosis will lead to different concentrations than those shown in Table 5-15 for treated water and will alter the water quality predictions during operations.

R126

"Provide rationale and justification for the use of reverse osmosis as a feasible treatment option considering the large quantities of waste water needed to be treated."

BMC commissioned water treatment specialists Integrated Sustainability to prepare a report on potential treatment methods to achieve the required discharge limits and treatment efficiencies. This report is included as **Appendix 4** Water Treatment Summary.

The processes selected for Kudz Ze Kayah consist of the following treatment processes:

- High density sludge – Addition of lime, sulphide and/or ferric to encourage precipitiation of metals, and flocculation to improve separation of metals and metalloids. Ballast may be included to increase the settling rate of the particles to reduce the footprint of the clarifier
- Multi-media filtration – Filtration to prevent carryover of precipitated metallic and non-metallic solids from the HDS and flocculation clarification system to the ion exchange and/or membrane systems. This improves the removal of precipitated species and protects the ion exchange system.
- Ion exchange – Achieves removal of selenium and other trace metals via exchange of target species within a fluidized resin bed
- Membrane filtration – ultrafiltration, nanofiltration or reverse osmosis may be included to achieve a high degree of removal of trace elements including fluoride and selenium in oxy-anionic forms. Filter backwash from the multi-media filter will be returned to the front-end of the process the volume of waste generated from this process.

These staged processes are modelled to achieve the discharge requirements at the predicted flow rates while minimising the by-product produced and are feasible using currently available proven technology.

The quantities treated, while large, are not without precedent. Capstone's Minto Mine treats larger quantities utilizing reverse osmosis as part of their water treatment process.

R127

"Provide details on how the by-product of a reverse osmosis water treatment plant will be addressed. This can be done by either including the by-product in the assessment or proposing an alternate treatment process. If an alternative to reverse osmosis is considered, update Section 5.2.1.7 of Appendix D-7 (Water Quality Report) of the proposal based on the revised assumptions for the quality of treated water."

Both Reverse Osmosis and Nanofiltration systems will ultimately generate a reject stream. Preliminary modeling estimates that up to 21% of the inlet flow will be retained as reject. Incorporating further RO passes will decrease the volume of reject, however additional chemical dosage will be required to prevent scaling (an example of which would be $CaSO_4$ saturation occurring at the RO membrane surface).

The management of this reject stream has been carefully considered in the planning work to date on WTP design and process selection.

The Kudz Ze Kayah Process Plant will be able to effectively manage up to 7.5 m3/hr (180 m3/d) of RO reject, whereas preliminary modelling indicates that the RO reject stream is likely to exceed this amount in a two-pass configuration. Additional treatment of the waste stream such as a thermal process (e.g. by evaporator/crystallizer or humidification/dehumidification process) will be considered and implemented if required to further reduce the volume of the waste stream.

To most economically manage the reject volume while achieving discharge objectives, consideration will be made for a chemical optimization program, in which the capital expenditures and operating expenses of increased RO passes and increased anti-scalant dosage would be compared against the costs of a thermal process.

YESAB ISSUE

It is not clear if the capacities of the water management ponds are sufficient to accommodate both demands, and if not, how this would affect water management, specifically release volume controls and discharge to Geona Creek and Finlayson Creek.

The operations water management strategy states that the discharge to Geona Creek and Finlayson Creek will be limited to discharge volume ratios no less than 3:1 at KZ-37 and 2:1 at KZ-15. The Proposal does not clarify how it intends to achieve this at all times.

R128

"Provide details and justification to support sufficient capacity in the water storage ponds to accommodate the design storm during a wet year, and how the water management ponds will be managed to achieve release volume controls at all times."

The capacity of the water management ponds is the total inflow design flood (the 1 in 200 year 24 hour event), plus the anticipated maximum operating water volume, plus freeboard. The design basis for the water management ponds is to store the required inflow design flood event. The pond design includes allowance for freeboard, as well as an emergency spillway to pass flows exceeding the inflow design flood event.

The water balance model was used to balance the inflow and outflow rates to the water management ponds based on the predicted maximum total required capacity, and the allowable surplus water discharge rate.

Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous week's discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter.

During freshet and significant rain events, discharge within the creeks will be monitored more frequently than weekly using the staff gauges and rating curves established for KZ-37 and KZ-15 to conduct daily spot checks to verify flow rates when week to week changes are suspected.

YESAB ISSUE

The water quality assessment assumes that covers for the Class A, B and C storage facilities will be in place for the transition closure phase and will reduce loadings of COPCs by 98%, 75% and 10%, respectively.

The load reductions are proposed as a result of reducing infiltration through the cover systems to 2, 25 and 90% of the mean annual precipitation for the A, B and C facilities, respectively. Typically, exposed waste rock will have infiltration rates greater than 50% (as suggested in Figure 2-5 in Appendix A of Appendix H-1) but less than 100% of precipitation. If a typical value of 60% of precipitation is assumed for exposed waste rock, then a reduction of infiltration to 2% of precipitation represents a 96.7% reduction in infiltration compared to the uncovered rock. This will equate to a 96.7% reduction of load for a constant soluble load in the rock, not a 98% reduction in load as suggested in the water quality model report.

The conceptual design for the Class A cover to achieve an infiltration rate equivalent to 2% of mean annual precipitation is presented in Appendix A of Appendix H-1 (Conceptual Reclamation and Closure Plan). The conceptual design includes the key theoretical components of a low permeability cover including a frost protection layer, a "liner" and a bedding layer to protect the liner. In theory, the infiltration may be controlled to 2% of precipitation through a cover system with this ideal conceptual design. However, it is questionable whether the technical and/or cost challenges of constructing such a cover in this northern climate can be overcome.

R129

"Clarify whether the reduction of infiltration was applied to achieve 2% of precipitation through the cover or applied as a 98% reduction in loadings for the water quality model as these are not the same."

The factors associated with water contact and the rationale as to how they were applied to scale kinetic test results for mass loading rates are discussed in Section 3.2.2 of Water Quality Model, Kudz Ze Kayah Project (Appendix D-7 of the Project Proposal). These factors are separate from those that reflect the decrease in load that would be expected due to the reduced infiltration resulting from the cover placement. The infiltration reduction factors from cover placement assume that the estimated loading rates prior to cover placement will decrease by the same degree that infiltration decreases. Thus, scaling factors of 0.02 (reduction of 98%), 0.25 (75%) and 0.9 (10%) are applied to the Class A, B and C loading rates, respectively.

Note: a typographical error was present in Table 3-7 of Section 3.2.2 of Appendix D-7. The Cover Water Contact Scaling Factor for the Class A Storage Facility should be 0.02 as opposed to 0.05. The corrected table is provided below as Table 8-14.

Table 8-14: Water Contact Scaling Factors for Covers on Class A, B and C Storage Facilities at Closure

	Cover Water Contact Scaling Factors
Class A	0.02
Class B	0.25
Class C	0.90

R130

"Provide examples of cover systems in similar climate conditions that have demonstrated reductions in infiltration rates on waste rock and/or tailings representing 2% or less of mean annual precipitation."

The most comprehensive report to date on design of covers is the Cold Regions Cover System Design Technical Guidance Document (O'Kane Consulting, 2012) prepared for Mine Environment Neutral Drainage (MEND). The most comprehensive compilations of constructed full scale and trial covers in cold climates is the Mine Waste Covers in Cold Regions Report (SRK Consulting, 2009) also prepared for MEND. The SRK report included a table of 85 cold region sites with soil covers on mine wastes, of which at least 15 were geosynthetics (GCLs, HDPE liners, and clay liners), or other very low permeability cover (SRK, 2009). One of these very low permeability covers was installed at the Whistle Mine in Ontario in 2004, where O'Kane Consulting installed a compacted clay barrier overlain by a protective layer. A performance study completed by O'Kane found that net percolation was approximately 2.7% in 2006, 2.7% in 2007, 1% in 2009, and 1% in 2010 (Ayres et al., 2012).

YESAB ISSUE

The equations used to predict surface water quality include an attenuation factor yet the Proposal does not specify the values used or their justification. The chemical loading discharged to the receiving environment may attenuate through various chemical, biochemical or physical process (other than dilution). The attenuation for nitrogen compounds may be high in headwater creeks, such as those which characterize the receiving environment. However, the attenuation for most metals may be low. It is common to conservatively assume no attenuation for those parameters having low potential for attenuation.

R131

"Provide the attenuation factors used in the model for each contaminant of potential concern (COPC) and provide justification for their use."

To clarify; the "attenuation factors" used in the model are better described as calibration factors rather than attenuation factors. The "attenuation factors" or calibration factors were applied to the model as part of calibrating the baseline scenario when comparing the predicted baseline concentrations to the actual baseline concentrations. For a few parameters in instances where there was not good agreement, the factors were calculated by comparing baseline monitoring data for each month to the predicted baseline concentration to more accurately represent the actual observed load along a flow path between the monitoring stations compared to the modelling points (KZ-37 to KZ-15 and KZ-15 to KZ-26). These calibration factors in some cases may reflect attenuation processes, however they more accurately address load that may enter above a modelling node from surface runoff or groundwater contribution. These factors only apply to the baseline load and not to the additional load during construction, operations and closure.

YESAB ISSUE

The attenuation of nitrogen compounds (ammonia, nitrite, nitrate) is expected to be high for headwater creeks, such as those which characterize the receiving environment. However, the Proposal does not specify the values used or their justification.

In such creeks, ammonia generally nitrifies to nitrite followed by rapid oxidation of nitrite to nitrate. As such, the ammonia concentration is expected to attenuate during ice-free periods at a rate greater than dilution, and nitrate is expected to be elevated above the diluted concentration. Nitrite is expected to be negligible. The results presented differ from expectations.

R132

"Provide the attenuation factors used in the model for nitrogen compounds and provide justification for their use."

As mentioned in response R131, attenuation factors used in the model were only applied to baseline loads as a calibration factor and the nitrogen loads during construction, operations and closure were not attenuated within the receiving environment.

9 GROUNDWATER QUALITY AND QUANTITY

YESAB ISSUE

Groundwater conditions at the site have not been adequately described. The continuous data set on groundwater only began in May 2015 and continues until November 2016 – roughly a year and a half.

Upon review of the baseline data presented with the proposal, which shows very high variability between years, ENV recommends at least three years of continuous monitoring to adequately describe groundwater conditions at the site. This understanding is needed to set appropriate design standards for water and wastewater facilities (i.e. water treatment plant, seepage collection ditches, etc.). This understanding will also support development of preliminary water quality objectives, site-specific discharge standards and water quality objectives.

In addition, the most current groundwater baseline report does not mention artesian conditions in their assessment. In contrast, site investigations in 1995 and in 2015 described artesian groundwater conditions in some locations of the project footprint.

R133

"Provide a detailed overview of the work planned to collect additional groundwater quality and quantity monitoring information through the next project phase to further verify developed groundwater quantity and quality models."

BMC agrees that additional data collection for groundwater quality and quantity is important for the next phase of the Project. At this stage in the Project it will be important to undertake our work with support of the specialist agency, the Yukon Water Board and their technical staff and consultants. The 2017 groundwater program has been initiated which includes continued sampling of 32 groundwater wells at quarterly intervals. Sampling parameters include collecting *in situ* field parameters, (pH, temperature, ORP, specific conductance, and dissolved oxygen) static water levels, and groundwater samples, as well as a thorough QA/QC program. Additionally, the eight continuous level loggers currently deployed will be maintained and monitored throughout the year, building on the existing dataset.

R134

"Updated groundwater quality and quantity baseline information and water models (e.g., groundwater quantity and quality models, etc.) for the site are required to be submitted prior to the Executive Committee drafting the screening report."

BMC continues to collect additional groundwater quality data as we have identified above, and we will therefore be in a position to undertake revisions to modelling based on this data, at future stages of Project permitting. However, we will undertake any revisions to our work plan for any potential re-modelling in consultation with the Yukon Water Board Secretariat (and their technical consultants). We recognize that it is important that our methodology for doing so is supported by the licensing agency.

YESAB ISSUE

In order to determine impacts due to the Project, physical and hydraulic properties of existing permafrost should be understood.

The Proponent has indicated that discontinuous permafrost to exist in the project area. "The Project is located in an area with discontinuous permafrost. Norecol, Dames & Moore Ltd. (1996) noted that permafrost is present on north and west facing slopes along the Geona Creek valley, especially above 1,400 masl."

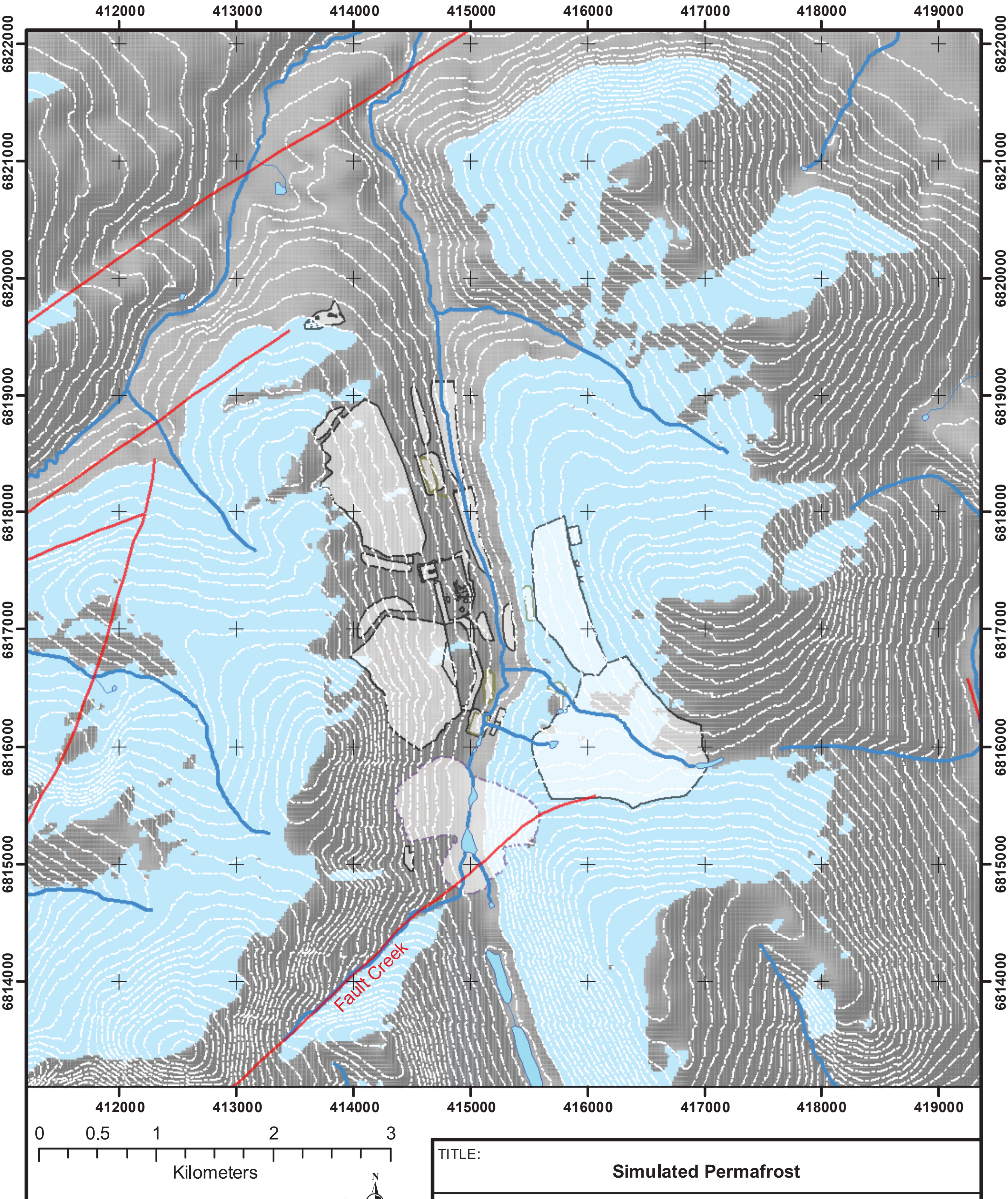
Despite the Proponent's conclusion, ECCC notes that groundwater permafrost interaction is an important component of project impact assessments and water license process. Potential groundwater-surface water interactions at the valley aquifer and Geona Creek can likely be influenced by the presence or absence of permafrost conditions slopes where groundwater recharge occurs. For ECCC to assess impacts to quality and quantity of groundwater and surface water, the groundwater-permafrost interactions need to be adequately characterized. As such, the potential impact of dewatering (overburden, bedrock) to quality and quantity of groundwater, Geona Creek, South Creek, Finlayson Creek and other surface water cannot be assessed based on the insufficient information with respect to nature of the permafrost. The Water license process requires the Proponent to determine whether there is a likely hydraulic connectivity between groundwater aquifers and permafrost.

R135

"Ensure the distribution, extent, and hydraulic properties of the permafrost areas are included in the groundwater flow and quality characterization."

BMC has engaged experienced groundwater specialists (hydrogeologists from Tetratech EBA and hydrogeologists from Alexco Environmental Group). BMC and their groundwater consultants agree that permafrost characterization is important to understanding groundwater flow and quality. An adequately detailed description of the permafrost at the KZK site has already been assessed for the numerical groundwater model. A conceptual model of the distribution and extent of the permafrost areas, as well as effects on groundwater hydrology was described and incorporated into the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon, included as Appendix D-4 to the Project Proposal. Figure 2.4.5 from the model report (provided as Figure 9-1 below) indicates the areas containing, and not containing, permafrost as used in the numerical groundwater model.

As per standard practice, the numerical groundwater model treated permafrost as a low-permeability material that was initially assigned a hydraulic conductivity of 1. x 10-8 m/s, and which was modified slightly during calibration. The model also assumed that there was very little recharge below permafrost areas, with the assigned value being 3.7 mm/yr. Again, this is consistent with normal scientific practise.



TITLE:

Simulated Permafrost

LOCATION:

Kudz Ze Kayah Project, Yukon, CA

TETRA TECH

APPROVED	CKG	FIGURE
DRAFTED	CKG	9-1
PROJECT#	EBA-KZK	
DATE	09-28-16	

YESAB ISSUE

Mine dewatering creates stress on groundwater flow regimes. Assessment of potential effects of mine dewatering on the quantity and quality of groundwater and related surface water are critical aspects of the EA. For ECCC to understand the effect of mine dewatering on quality and quantity of groundwater and surface water hydrology at Kudz Ze Kayah, a thorough understanding of groundwater inflow estimates with respect to the various mine phases is required.

The Proponent has indicated that overburden dewatering will initially be performed for a six-month period to permit access to the bedrock. Overburden dewatering will result in a reduction of the base flow to Geona Creek around the proposed open pit and immediately to the north. The Proponent has proposed flow augmentation in Geona Creek by discharging the ABM pit water into the creek, and is expecting that dewatering of the overburden will not to have any adverse effects on groundwater quality.

Groundwater quality in the overburden will likely differ from the water quality in Geona Creek. Further, mixing of groundwater in the pit from shallow overburden aquifer and bedrock aquifers will result in water quality different from Geona Creek. The overburden and bedrock dewatering will likely have adverse effects on water quality in the receiving environment. The Proponent's plan to discharge the ABM pit water to Geona Creek requires clarification. Further, the discharge water management plan (pp 9-20) has not clearly indicated the types of treatment that will be applied and the resulting water quality to be discharged into the receiving environment.

ECCC notes that the mineralized zone in the pit and underground workings could likely contribute contact groundwater with elevated concentrations of contaminants of concern. In addition, elevated concentrations of contaminants could mix with shallow groundwater via structures and impact water quality of shallow groundwater and receiving environment.

R136

"Provide an assessment of the potential impacts of mine dewatering on quantity and quality of the head waters of Finlayson Creek, unnamed creeks south and southwest of the ABM pit, and the North Lake Systems."

The information requested is an important part of the water quality and quantity assessment. It is provided in the Proposal document appendices, and is referenced and summarized here. The Receiving Environment Water Balance (Appendix D-6 of the Project Proposal) and Water Quality Model (Appendix D-7 of the Project Proposal) both consider the effects of dewatering on the water quality and quantity in Geona Creek, (at site KZ-37), Finlayson Creek (KZ-15 and KZ-26), and South Creek (KZ-13, upstream of the North Lakes).

Water balance modelling (Appendix D-7) included the effects of the Project construction phase (i.e., dewatering) on the receiving water quantity. During the construction phase of the Project, Fault Creek and the catchment areas upstream of the ABM open pit will be diverted into South Creek. Modelling predicted minimal impact on water quantity in Finlayson and Geona Creeks as a result of these diversions. The predicted changes in discharge in South Creek (modelled at KZ-13, upstream of the North Lake systems) due to the proposed diversions are discussed in the Receiving Environment Water Balance Report (Appendix D-6) and are predicted to be 33 to 36%. However, these modelled values are likely exaggerated slightly due to the drawdown from the small ponds at the top of South Creek throughout the construction and operations phases.

The Water Quality Model (Appendix D-7) estimated constituents of potential interest (COPI) in the Geona Creek and Finlayson Creek receiving environment to be comparable to, or slightly lower than the baseline due to the diversion of Fault Creek and dilution from discharge of ABM open pit dewatering water. Only fluoride was predicted to very marginally exceed its preliminary water quality objective (pWQO) in Geona Creek (at KZ-37) and upper Finlayson Creek (at KZ-15) due to the contribution from pit dewatering. Changes in South Creek (at KZ-13) water quality were predicted for cadmium, selenium and zinc due to the elevated baseline concentrations of these elements in Fault Creek relative to South Creek; however, despite the higher COPI concentrations in the diverted Fault Creek, no constituents were estimated to exceed their respective water quality objectives. As such, the predicted water quality effects of the south diversion to South Creek are of low magnitude.

Although the North Lakes are not included in the current water quality sampling program (2015-present), the North Lakes water quality was examined in the Cominco baseline water quality characterization (Cominco, 1996). Cominco data collected between 1994 and 1995 indicated that metal concentrations in the North Lakes system, both upstream and downstream of the confluence with South Creek, were comparable to, or slightly lower than those observed in South Creek (Cominco, 1996). Low concentrations of metals/metalloids, including the COPIs, were reported such that water quality guidelines were not exceeded in the North Lakes system (Cominco 1996). Additional water quality data were collected between 2002 and 2016 in North Lakes Creek (site KZ-27) as part of the bi-annual aquatic monitoring program under Water Licence QZ97-026 (Laberge Environmental Services and Can-Nic-A-Nick Environmental, 2015, 2017). These studies also reported low metal concentrations that were below water quality guidelines and similar to, or lower than concentrations observed in South Creek. Given the comparable metal concentrations observed in the North Lakes system to that in South Creek, a similar low magnitude effect on water quality in the North Lakes is also anticipated.

YESAB ISSUE

The hydrogeological conceptual model is unnecessarily simplified and did miss key components; the potential groundwater-surface interactions, artesian flows, permafrost, recharge and discharge locations. As indicated in (Golder, 1999b), pp 5), the potential interaction between overburden aquifer, bed rock aquifer, and the surface water have not been sufficiently described. Preferential flows via high permeability zones associated with structural features have not been sufficiently addressed.

ECCC notes that, the unnamed tributary south and southeast of the ABM pit will likely be impacted due to mine dewatering and underground workings. The unnamed tributaries are also likely hydraulically connected to the North Lakes Systems. As such, the potential impact to quantity and quality of the North Lakes due to Mine dewatering should be incorporated in the hydrogeological conceptual models.

ECCC notes that the conceptual hydrogeological description showed neither potential flows via structures such as fault zones (Fault zones) nor the likely interaction between the overburden aquifer, fractured bedrock, and the surface water.

R137

"Provide conceptual hydrogeological models for the project site that show groundwater flow regimes both during mine operation and completion of mining and closing of the underground workings. The conceptual hydrogeological models should incorporate key components including:

a. recharge and discharge zones;

b. preferential flow pathways;

c. hydraulic gradient and the likely connectivity of overburden aquifer;

d. bedrock aquifer; and

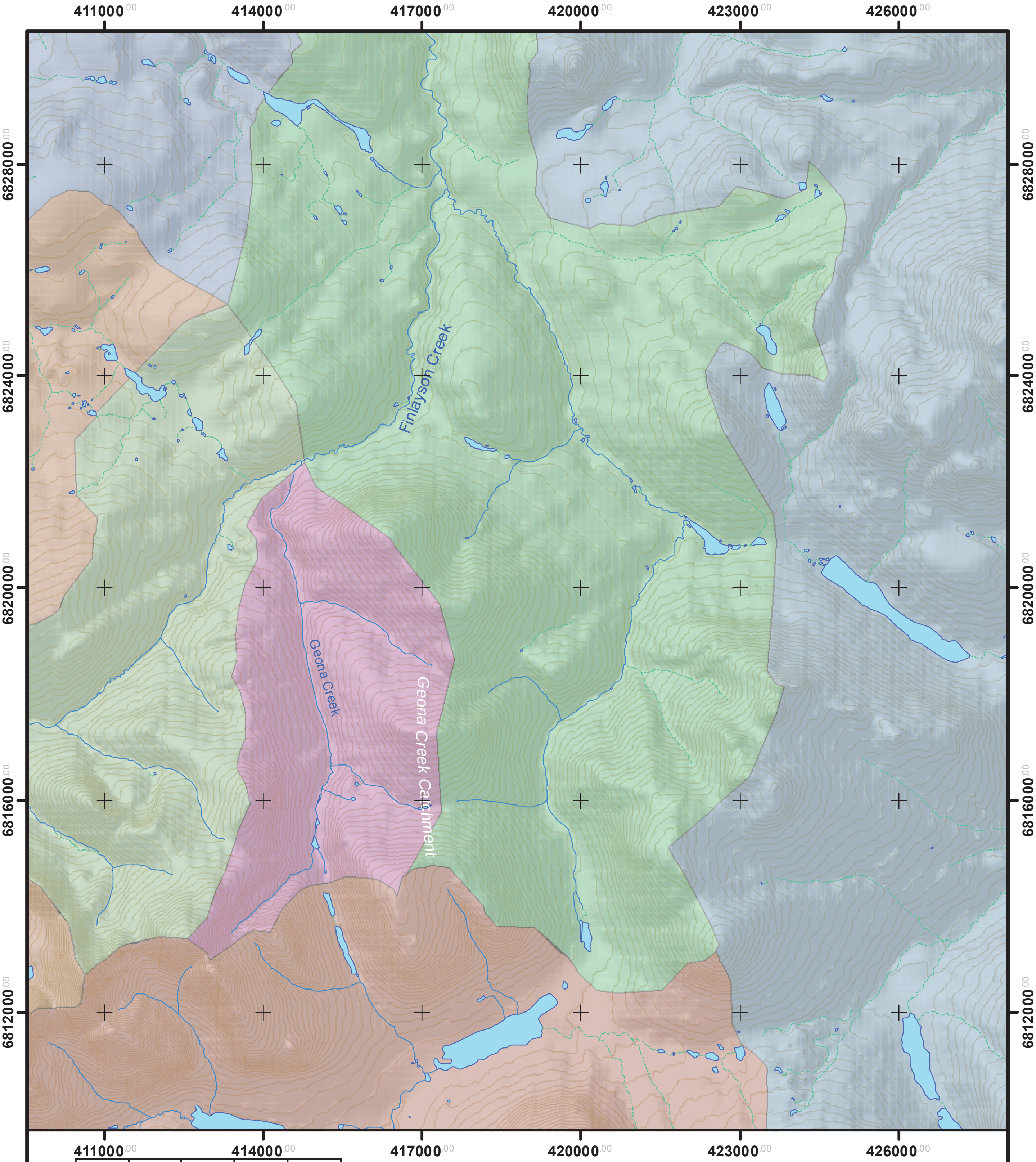
e. surface water."

BMC's specialist hydrogeological consultants reviewed this request and agree that this assessment information is important. An adequately detailed description of the conceptual hydrogeology model for the Kudz Ze Kayah Project has been developed by groundwater professionals, and this description is provided in the February 2017 Alexco Environmental Group 2016 Hydrogeology Baseline Report (Appendix D-3 of the Project Proposal) and the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon (Appendix D-4 of the Project Proposal) that has been provided to YESAB. These two reports collectively provide detailed descriptions of the site hydrogeology including: recharge and discharge zones, preferential flow paths, hydraulic gradient, and the hydraulic interactions between the overburden aquifer, bedrock aquifer, and surface water. The numerical groundwater model specifically evaluated pre-mining, operational, and post-closure conditions. For the operational and post-closure periods, boundary conditions were applied in the model to simulate the presence of the pit and underlying mine workings for both dewatered and reflooded conditions.

Section 3.2.2 of the Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon (Appendix D-4 of the Project Proposal) indicates that preferential flow paths (conduits) were explicitly incorporated into the numerical groundwater model. These conduits included the NW-SW fault at the northern end of Geona Creek and three faults in the pit area. Through the calibration process, each of these features had the potential to become high permeability conduits. The final hydraulic conductivities assigned to the features were determined through model calibration.

Section 4 of the Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon (Appendix D-4 of the Project Proposal) describes how the numerical groundwater model was used to simulate the hydrologic effects of dewatering associated with the proposed nine-year excavation of the pit and underground workings. The model was also used to simulate the post-closure effects of closing the underground workings, redirecting Fault Creek to discharge into the pit causing the pit to fill with water, and monitoring the associated return to post-closure steady state conditions.

Section 2.5 of the Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon (Appendix D-4 of the Project Proposal) provides information on the simulation of streams and lakes. The report states that the "drainage of groundwater in the model occurs through a network of streams and lakes." The numerical groundwater model used three MODFLOW packages to evaluate groundwater-surface water interactions: the stream flow routing package (SFR2), the lake package (LAK3), and the drain package (DRN). The lake and creeks included in the numerical model report are shown on Figure 2.5 of Appendix D-4 of the Project Proposal and reproduced here as Figure 9-2.



Legend

- Stream (Close proximity with simulated flow)
- Stream (> 5 Km Distance)
- Watershed Boundaries

TITLE:	**Streams and Surface Water Bodies**
LOCATION:	Kudz Ze Kayah Project, Yukon, CA

TETRA TECH

APPROVED	CKG	FIGURE
DRAFTED	CKG	9-2
PROJECT#	GWTR03021	
DATE	04-05-16	

YESAB ISSUE

The surficial geology below the Class A waste rock facility suggests variable ground conditions, comprised of morainal tills, glaciofluvial complex and fan deposits. Further, the glaciofluvial deposits constitute the "downstream" toe of the S-PAG dump; extending in direction to downgradient of the potential capture influence of the lower-most water management pond (Figure 3).

ECCC notes that there are no monitoring wells installed in the vicinity of Class A Storage Facility to assess the potential impact of infiltration out of the facility on the receiving environment. In addition, there has been insufficient information with respect to the potential capture of infiltration out of the Class A Storage Facility.

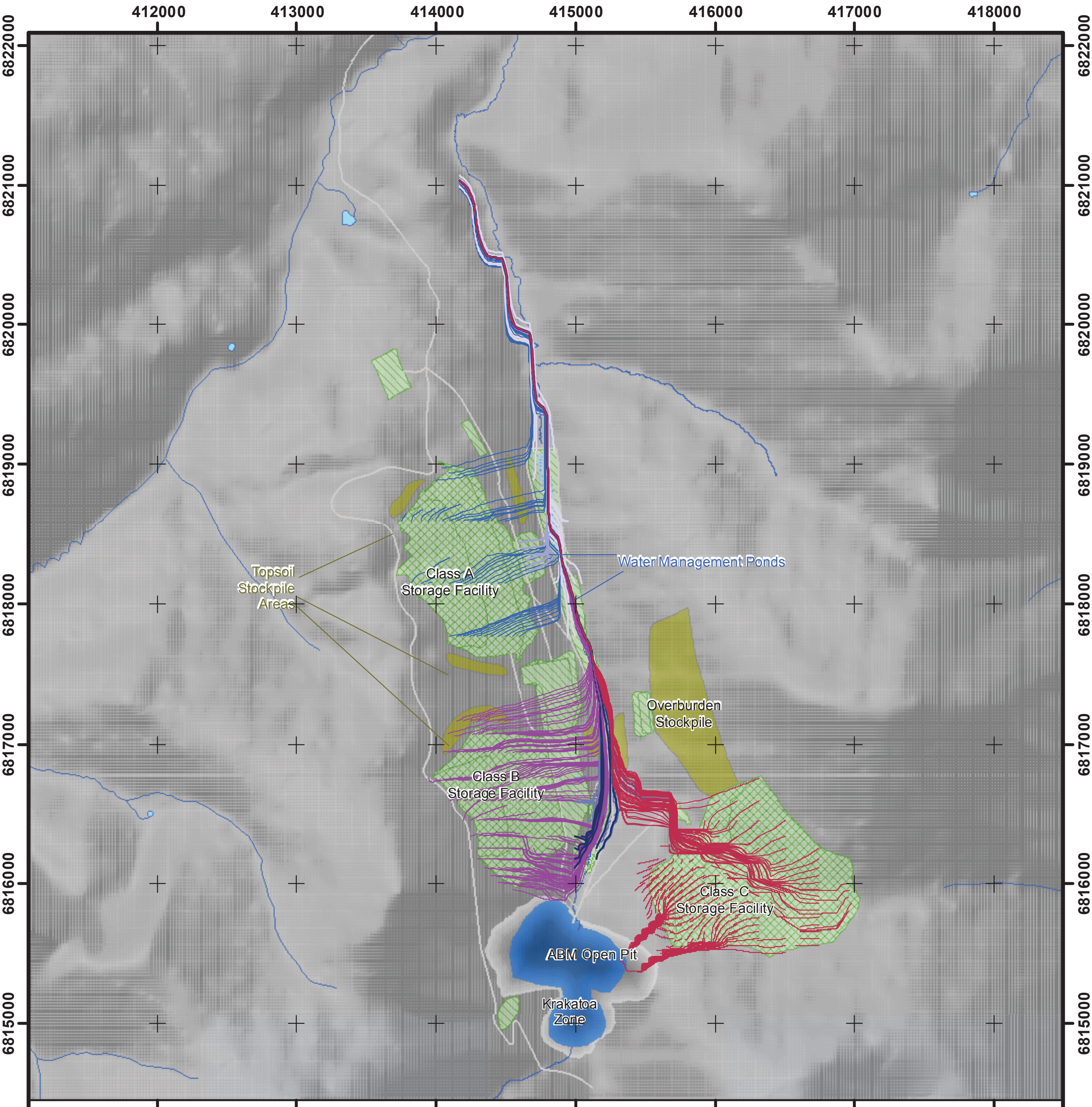
Further, ECCC notes that the saturated screen lengths used to monitor groundwater quality didn't comply with standard procedures and recommendations as provided in BC MOE 2009b. As recommended by BC MOE, maximum saturated screen lengths should be limited to 1.8 m within the target hydrostratigraphic unit. The use of longer screens for water quality monitoring would cause dilution of constituents and water quality data from such wells should not be compared directly with groundwater quality standards unless supporting rationale can be provided.

R138

"Produce a conceptual hydrogeological model of the Class A Storage Facility. This may form part of the conceptual hydrogeological models for the project site requested above in R137."

BMC's consultants reviewed this request and agree that this assessment information is important. An adequately detailed description of the hydrogeological conceptual model for the Class A Storage Facility has already been provided by groundwater professionals within the February 2017 Alexco Environmental Group 2016 Hydrogeology Baseline Report (Appendix D-3 of the Project Proposal) and the December 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon (Appendix D-4). The detailed descriptions of the site hydrogeology for the Class A facility from these two reports includes: seepage flow paths, hydraulic gradient, and the hydraulic interactions between the overburden aquifer, bedrock aquifer, and surface water.

The numerical groundwater model provides a particle tracking model that simulates where the Class A material contact water would go if there was any downward leakage through the bottom liner (Section 4.5.2 Post-Mining Waste Rock Particle Tracking, Appendix D-4, December 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon). For this hypothetical scenario, water leaking from the facility would contact the shallow groundwater system and then follow the groundwater flow paths until it surfaced. Note that flow rate was not evaluated and only the migration trajectory of affected water along the theoretical flow path was evaluated (as shown on Figure 4.5.2 of Appendix D-4 and reproduced here as Figure 9-3).



Legend

Particle Origin
- Water Mgmt Pond
- Class A
- Class B
- Class C
- Class A Water Collection Pond
- Class B Water Collection Pond
- Class C Water Collection Pond
- Pit-Rim Pond

Facilities
- Constructed Wetland
- Engineered Cover
- Covered with Overburden; Revegetated
- Materials used for Reclamation

- Roads
- Watercourses
- ABM Lake
- ABM Open Pit
- Waterbodies

0 0.5 1 2
Kilometers

N W E S

TITLE:	Post-Closure Waste Rock Particle Tracking
LOCATION:	Kudz Ze Kayah, Yukon, CA

TETRA TECH

APPROVED	CKG	FIGURE
DRAFTED	CKG	9-3
PROJECT#	GWTR03021	
DATE	11-04-2016	

R139

"Provide a groundwater monitoring plan in order to assess seepage, baseflow, and groundwater flow downstream of the facility."

BMC's consultants reviewed this request and agree that a groundwater monitoring plan to assess seepage, baseflow, and groundwater flow downstream of the Class A Storage Facility is important. This information has been provided in Chapter 9, Section 9.6 of the Project Proposal. Table 9-11 from the Proposal is provided below (Table 9-1), and includes the groundwater monitoring program for the Class A Storage Facility. The surface water monitoring network is provided in Chapter 8, Section 8.6, and summarized in Table 8-49 of that section in the Project Proposal.

The current monitoring network for the Class A Storage Facility is a combination of groundwater monitoring wells (MW16-14D, BH95G-15D, and MW15-09s) and surface water sites (KZ-9, KZ-37, and KZ-17). The down gradient surface water sites would monitor any effects of potential groundwater seepage, as all shallow groundwater flow paths come to surface.

Table 9-1: Kudz Ze Kayah Groundwater Quality Monitoring Program Summary

Site	Description	Aquifer	IN SITU MEASUREMENTS					EXTERNAL LAB ANALYSIS							
			Level	pH	Temperature	Specific Conductivity	Oxidation and Reduction Potential	Dissolved Metals (ultra-low levels including hardness phosphorus, and mercury)	pH	Specific Conductivity	Total Dissolved Solids	Anions (incl. nitrate, nitrite)	Alkalinity	Ammonia	WAD Cyanide
MW15-09S	Downgradient of Lower Management Pond	Overburden	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW15-09D	Downgradient of Lower Management Pond	Bedrock	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW15-10S	Downgradient of Lower Management Pond	Overburden	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW15-10D	Downgradient of Lower Management Pond	Bedrock	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW15-07S	Downgradient of Process Plant	Overburden	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW15-07D	Downgradient of Process Plant	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW16-13	Upgradient of Class A Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW16-14D	Downgradient of Class A Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
BH95G-15D	Downgradient of Class A Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q
MW16-12S	Downgradient of Class B Storage facility	Overburden	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MW16-12D	Downgradient of Class B Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
BH95G-33S	Downgradient of Class B Storage facility	Overburden	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
BH95G-33D	Downgradient of Class B Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MW16-16D	Downgradient of overburden stockpile	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MW15-06	Downgradient of Class C Storage facility	Overburden	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
BH95G-30	Downgradient of Class C Storage facility	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
BH95G-31	Downgradient of ABM pit	Bedrock	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MW16-15S	Upgradient of ABM pit	Bedrock	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MW16-15D	Upgradient of ABM pit	Bedrock	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
BH95G-29	Upgradient of ABM pit in South Creek watershed	Overburden	C	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MWF-01S	Upgradient of ABM pit in South Creek watershed	Overburden	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-
MWF-01D	Upgradient of ABM pit in South Creek watershed	Bedrock	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	Q	-

Notes:

C	Continuous	Ms	Monthly (May to Oct)
C-WD	Continuous While Discharging	M/Q	Monitoring to occur monthly for first 12 months, reverting to quarterly thereafter
D	Daily	Q	Quarterly
D-WD	Daily While Discharging	A	Annually
W	Weekly	SA	Semi Annually/ twice per year
W-WD	Weekly While Discharging	BA	Bi-Annually (every 2 years)
M	Monthly	-	Not Applicable

R140

"Provide rationale for using saturated screen length longer than 1.8m in the groundwater monitoring program and discuss the effect on water quality samples."

BMC's consultants review determined that the use of longer screen lengths at the KZK site was appropriate. In many wells across the site, seasonal water levels vary by several metres, with a maximum measured variation of 14 m. Use of longer screen lengths is justified at the KZK site to avoid wells becoming dry at certain times of the year.

The purpose of the monitoring network is to identify chemical excursions in the groundwater system downgradient of mine facilities. For this purpose, it is more appropriate to use longer screen lengths so that significant portions of the aquifer are not missed. The goal is to avoid a situation where potentially affected groundwater is not picked up in a well because the affected aquifer exists above or below the screened interval. It is recognized that if chemicals are present in a very limited thickness of an aquifer, a longer-length well may lead to dilution; however, such a well provides a better chance to identify the presence of affected groundwater. If affected groundwater is identified at a particular location, there would be an opportunity to further characterize its vertical extent by installing additional wells with shorter screen lengths.

If a change in groundwater quality occurs at a monitoring well, it will be measurable against the pre-mining baseline, even if the sample is somewhat diluted due to the well having a longer screen length.

R141

"Provide well decommissioning information for the abandoned wells that will not be used for the monitoring program."

Existing wells that are not incorporated into the monitoring network will be decommissioned as per Protocol No. 7 Groundwater Monitoring Well Installation, Sampling and Decommissioning from the *Contaminated Sites Regulation* under the *Environment Act,* once it is determined that those wells will not be required for future monitoring.

YESAB ISSUE

The Proponent has not conducted sensitivity analysis to capture those uncertainties associated with fault zone hydraulic properties. Faults may act as a barrier to groundwater flow, or as a conduit. Further analysis of the conductivity of the fault zones is required using the available site data.

R142

"Conduct a sensitivity analyses for the predictive hydrogeological model in order to assess potential impacts on quantity and quality of groundwater inflow to the pit and its impact on surface hydrology. The analysis should address uncertainties associated with fault zone hydraulic properties."

BMC's specialist consultants reviewed this request and in general support the concept of sensitivity analysis as a useful tool; however, upon review of the model it was determined that there is no apparent material benefit as the hydraulic characteristics of the fault zones are reasonably characterized through model calibration and there would be little benefit in performing a formal sensitivity analysis.

The numerical groundwater model includes an adequately detailed description of the preferential flow paths (potential conduits), as these were explicitly incorporated into the model. Discussions of these features are provided in the December 14, 2016 Tetra Tech EBA Hydrogeological Model, Kudz Ze Kayah Project, Yukon, (Appendix D-4 of the Project Proposal). The model included the NW-SW fault at the northern end of Geona Creek and three faults in the pit area. No initial assumptions were made regarding the significance of these features on groundwater flow. Through calibration, each of these features had the potential to become high permeability conduits. The final hydraulic conductivities assigned to the features were determined through model calibration, with informal sensitivity being performed during the calibration process. In the final calibrated model, these features did not greatly affect the groundwater flow system. However, this result was not due to pre-modeling assumptions, but rather to the process of model calibration. Assigning significantly higher hydraulic conductivities to these features (as evaluated through informal sensitivity), resulted in a less well calibrated numerical model.

Furthermore, the groundwater input to the ABM pit is included in the February 2017, Alexco Environmental Group report, Water Quality Model, Kudz Ze Kayah Project (Appendix D-7 of the Project Proposal), which includes conservative assumptions regarding the groundwater chemistry (the 75th percentile of COPI concentrations in bedrock monitoring well samples from the ABM pit vicinity). Given this conservatism, sensitivity testing is not considered warranted.

10 AQUATIC ECOSYSTEM RESOURCES

YESAB ISSUE

The Proponent has proposed in their preliminary offsetting plan an option involving restoration of fish passage for the Robert Campbell Highway culvert crossing of Finlayson Creek.

The Proponent has identified that this culvert crossing structure is the responsibility (ownership) of the Yukon Government Highways and Public Works.

DFO's preference is for an open bottom structure (clear span or arch culvert) that mimics the natural stream channel to have confidence in the permanence of fish passage restoration.

Baseline information is available for Genoa Creek as well as for some locations in East Creek and in Finlayson Creek upstream of the Robert Campbell Highway; however, there is limited baseline information for areas in Finlayson Creek downstream of the Robert Campbell Highway and in the surrounding areas of the Finlayson River. The baseline data is required for both upper and lower reaches in sufficient quantity as to clearly demonstrate what the gaps in fisheries productivity are. The intent of offsetting measures is to result in increased fisheries productivity. The effectiveness monitoring plan and associated performance measures, in conjunction with the baseline data, should be robust enough to demonstrate that an overall increase in fisheries productivity has resulted and not simply a redistribution of fisheries productivity.

The Proponent cites two recent DFO guidance documents for the proposed Fish Offsetting plan in Appendix E-4:

- *Fisheries and Oceans Canada (DFO). 2013a. Implementing the New Fisheries Protection Provisions under the Fisheries Act. Discussion Paper. Fisheries and Oceans Canada, April 2013.*

- *Fisheries and Oceans Canada (DFO). 2013b. An Applicant's Guide to Submitting an Application for Authorization under Paragraph 35(2)(b) of the Fisheries Act, November 2013.*

However, the most recent Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO, 2013c) is not cited and it is not clear if this guidance was used. The proposed offsetting plan generally includes most of elements prescribed by DFO (2013c). However some suggested components are not included in the plan. Losses and gains are not particularly well quantified and uncertainty is not accounted for.

R143

"Provide additional information in relation to the Fish Offsetting Plan as presented in Appendix 4. Details should include a discussion on:

a. ***the feasibility of including the culvert restoration as part of the plan given it is the jurisdiction of the Government of Yukon;***

b. other potential offsetting measures that have been explored with reasons for discounting them;

c. how the plan will take into account the most recent DFO policy, Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO, 2013c), including how the guidance will be incorporated into a revised offsetting plan (e.g., quantifying losses and gains, and accounting for uncertainties)."

a. the feasibility of including the culvert restoration as part of the plan given it is the jurisdiction of the Government of Yukon

Discussions with several staff with the Government of the Yukon, Highways and Public Works (HPW), during the summer of 2016 indicated that they would be in favor of an endeavor to provide fish passage through the culvert to allow migratory species to access fish habitat upstream of the highway, as they are aware that the culverts are currently a barrier to fish passage (A. McCoy 2016. Manager Environmental Affairs HPW, pers. comm. 23 August). Approvals however, would be dependent on review from the Highway Engineering department, HPW. This has been identified as an opportunity to collaborate with BMC as there are no plans to replace the culverts for at least the next 10 years.

b. other potential offsetting measures that have been explored with reasons for discounting them

A list of potential fish habitat compensation options considered by BMC is provided below for evaluation. A preferred option(s) has been selected and a plan developed as discussed in detail in the following. The plan remains flexible in order to ensure it is adequate to provide sufficient fish habitat creation and improvement to offset losses. Any changes to the plan will be determined during the detailed design phase of the Fish Offsetting Plan (FOP), or if necessary, prior to that phase as a result of discussions with DFO and/or First Nations. Options considered are listed and discussed in detail below.

Each of these options was assessed based on the proximity of the Offsetting measures to the habitat that will be impacted, the similarity of the habitat to the impacts, if the area of compensation or the benefits gained are comparable, the environmental benefit, and the community/First Nations benefit (Table 10-1 and Table 10-2).

Table 10-1: Ratings Used to Compare Potential Fish Habitat Compensation Projects

Classification	Criteria/Rating	Value
Proximity to Impacted Habitat	Within LSA	1
	Within RSA	0
	Outside RSA	-1
Similarity to Impacted Habitat	Same	1
	Different	-1
Approximate Area of Compensation/Equivalence	Larger than Impacted Habitat	1
	Similar to Impacted Habitat	0
	Smaller than Impacted Habitat	-1

Classification	Criteria/Rating	Value
Environmental Benefit	High	1
	Moderate	0
	Low	-1
Community/Aboriginal Benefit	High	1
	Moderate	0
	Low	-1

Table 10-2: Comparison of Potential Fish Habitat Compensation Projects

Option	Proximity	Similarity/ Connectivity	Area Equivalence	Environmental Benefit	Community/ Aboriginal Benefit	Sum
Cominco FHCP	1	-1	0	0	-1	-1
East Creek Fish Passage	1	-1	-1	-1	-1	-3
South Lakes habitat enhancement	1	1	-1	-1	-1	-1
Finlayson Fish Passage	0	-1	1	1	1	2
Geona Creek habitat replacement	1	1	-1	0	-1	0

Cominco FHCP

The previous owners of the KZK property (i.e., Cominco Ltd) successfully obtained a *Fisheries Act* Authorization (FAA) in 1997 under previous requirements of the *Fisheries Act* (Authorization Yukon Area 1997-03), which allowed the company to undertake harmful alteration of fish habitat in the upper Geona Creek valley. The FAA largely relied on a Fish Habitat Compensation Plan (FHCP) to "ensure no net loss of fish production." The plan consisted of stocking two barren lakes in the local area primarily with Arctic grayling that were salvaged from upper Geona Creek and creation of new habitat, including an Arctic grayling spawning area in the upper South Creek drainage, resulting from a permanent diversion of Fault Creek from the Geona Creek watershed to the South Creek watershed.

Although previously approved by DFO in 1997 as an acceptable FHCP, the previous mine development had a larger footprint than the current design and intended to permanently divert Fault Creek into the South Lakes system (Section 1.3, Appendix E-4 of the Project Proposal). BMC has designed their Project footprint to have less impact on the Geona Creek watershed, and intends on restoring the site to as close to pre-existing conditions as practicable, which includes restoring Fault Creek back to the Geona Creek watershed during mine closure (Section 6 of Appendix E-4).

For these reasons the Cominco FHCP received the second lowest ranking. In addition, very few Arctic grayling actually inhabit Geona Creek. Therefore, the stocking program would have to access fish from outside the watershed to have any chance of success and would not provide any community benefit.

East Creek

The East Creek drainage appeared to be devoid of fish upstream of the beaver dams, based on extensive electrofishing in that area over the study period. Hubert et al. 1995 reported over 700 grayling moving upstream captured in a fish trap at the confluence with Geona Creek; however, current populations appear much lower (Section 4.2.1, Appendix E-4 of the Project Proposal). Numerous large beaver dams are now fish migration barriers, especially at low flows, reducing spawning availability and appear to have impacted the population. BMC considered opening up East Creek for passage as part of its FOP, but this plan received a low score based on the fact that is it a small creek, and although recruitment might increase marginally in Geona Creek as a result, it would provide low environmental benefit, and no community benefits. Additionally, keeping the creek free of beaver impoundments would be an ongoing issue.

South Lake Creek

The temporary diversion of Fault Creek into the upper reach of the South Creek/Lake system during operations will result in the creation of approximately 800 m^2 of fish habitat during the life of the mine. BMC considered the incorporation of fish habitat enhancement measures as part of the options assessment, as quality spawning habitat appears to be limiting to fish populations throughout the LSA. This plan received a low score given the fact that the diversion is temporary, and as a result would ultimately provide a low (short term) environmental benefit and no community benefit.

Finlayson Fisheries Passage

Concerns were noted by the Ross River Dena Council during public meetings, regarding the lack of fish passage through the twin culverts on Finlayson Creek at the Robert Campbell Highway (Table 2-3 in Chapter 2 of the Project Proposal). As a result, BMC investigated the crossing in the summer of 2016 as a potential FOP (Section 7.2 of Appendix E-4 of the Project Proposal). BMC fisheries biologists identified that the culverts appeared to be a complete barrier to fish passage under current conditions. As such, BMC included the possibility of providing fish passage by the way of a culvert backflood or bypass channel at the highway as part of the comparison of potential FOPs.

The Fish Passage plan for Finlayson Creek received the highest rating according to the comparison of potential FOPs based on the fact that it would provide a high Environmental Benefit by allowing migratory fish to once again access fish habitat in the Finlayson Creek watershed, including Geona Creek, and provide a community benefit with an increase in recruitment in the watershed by opening up 40 km of potential spawning habitat. This is discussed further in Section 7.2 of Appendix E-4, of the Project Proposal. The main shortcoming of this option is the distance from the project site that the measure would occur; however, this is outweighed by the magnitude of the increase in potential spawning habitat which would extend to the project site.

Geona Creek Habitat Enhancement

Current mine plans will result in a loss or isolation of approximately 5.4 km of Geona Creek, therefore the first area that was considered for a potential FOP was in the immediate area downstream of the habitat loss. As described in the application, the watershed will be divided to accommodate construction of mine and waste storage facilities, and the conveyance of clean (non-contact) water downstream of mining operations. Potential fish habitat offsetting opportunities identified, included the development of pond habitat in lower Geona Creek to replace and offset loss of pond habitat in upper Geona Creek, and the development of Arctic grayling spawning habitat at the heads of the created ponds to replace and offset loss of grayling spawning habitat in upper Geona Creek.

Although the preferred option would be to complete the entire FOP in the Geona Creek watershed, limited opportunities were available. As a result of the incised nature of the valley, and short length of the stream (9.1 km), only an opportunity to compensate for the pond habitat was identified.

The pond replacement and spawning habitat creation FOP received the second highest rating during the comparison. Rating was lowered by the facts that habitat compensation only replaced pond habitat and there was no community benefit.

Summary

Even though the avoidance and mitigation measures are extensive, there will still be a residual impact to the fish and fish habitat of Geona Creek. There was limited opportunity to complete the required FOP in the Geona Creek watershed, as it was determined that only the pond habitat could be replaced. Therefore, BMC compared other opportunities within the RSA to compliment the creation of pond habitat in Geona Creek.

Four FOP opportunities were identified within the RSA and compared for their respective benefits; including benefits to the environment and community (presented in Table 10-2 above). A potential fish passage problem on the Robert Campbell Highway, as identified by the community, received the highest rating when compared to other potential projects and was further investigated by BMC (Table 10-2, above).

The comparison of potential FOP projects indicated that no project would fully replace the impacted habitat if conducted alone. However, the combination of Finlayson Creek Fish Passage and Geona Creek Pond/Spawning Habitat Replacement would result in a benefit/positive impact for each of the five rating categories used to compare the potential habitat improvement projects.

Therefore, three major offsetting measures are proposed in this plan to offset the impacts to fish habitat and to maintain or enhance the productive capacity of the system for Arctic grayling include:

- Development of pond habitat in lower Geona Creek to replace and offset loss of pond habitat in upper Geona Creek;
- Development of Arctic grayling spawning habitat at the heads of the created ponds to replace and offset loss of grayling spawning habitat in upper Geona Creek; and
- Reconnect fish habitat in Finlayson Creek by enhancing fish passage through the culverts at the Robert Campbell Highway that are currently acting as a barrier to fish passage in lower Finlayson Creek to replace the 5.4 km loss in Geona Creek with approximately 40 km of newly accessible fish habitat.

c. ***how the plan will take into account the most recent DFO policy, Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO, 2013c), including how the***

guidance will be incorporated into a revised offsetting plan (e.g., quantifying losses and gains, and accounting for uncertainties)."

BMC has incorporated mitigation measures into the Project design to ensure there is not likely to be serious harm to fish as a result of the Project. However, the loss of fish habitat in upper Geona Creek is unavoidable. To compensate for the loss of fish habitat, in accordance with the *Fisheries Productivity Investment Policy: A Proponent's Guide to Offsetting (DFO, 2013c)* BMC has developed a plan to undertake offsetting measures to counterbalance the unavoidable residual loss of habitat. Offsetting measures, also known as offsets, are measures that are undertaken to counterbalance unavoidable harm to fish resulting from a Project, with the goal of maintaining or improving the productivity of the commercial, recreational or Aboriginal fishery.

The proposed Fisheries Offsetting plan developed by BMC, includes increasing the productive capacity for fish in Geona Creek and providing over a 10 fold increase in the amount of available habitat for migratory species in Finlayson Creek by allowing access for fish upstream of the Robert Campbell highway, which is currently impedes fish passage (Aquatic Ecosystem Baseline Report; Appendix E-3 of the Project Proposal).

R144

"Provide baseline information for areas in Finlayson Creek downstream of the Robert Campbell Highway and in the surrounding areas of the Finlayson River. Contact Fisheries and Oceans Canada to determine what the specifics of baseline information requirements related to the Fish Offsetting Plan."

Baseline data has been collected immediately downstream of the Robert Campbell Highway (RCH) (site KZ-26) as part of the baseline monitoring program and to meet the compliance monitoring requirements of the Water Use Licence (WUL-QZ97-026). KZ-26 is approximately 200 m downstream of the RCH and was identified during preliminary assessments as a representative site for baseline/future monitoring. At this site surface water quality, fish, benthic invertebrates and stream sediments have been conducted every two years since 2002. The baseline information for KZ-26 is presented in Appendix E-3 of the Project Proposal (Aquatic Ecosystems and Resources Baseline Report) and Appendix D-1 (Kudz Ze Kayah Water Quality Baseline Report).

Owing to the depth and velocity of Finlayson Creek further downstream, for safety reasons and accessibility no other sampling stations were monitored.

BMC has developed an Aquatic Resource Monitoring Plan (ARMP) (Chapter 19 – Section 19-8 of the Project Proposal) as a component of its submission for assessment under *YESAA*. This will be further developed in consultation with DFO and others, as the project moves forward. In general, the ARMP has been developed to monitor impacts from mining development and operations on aquatic biota in the receiving environment. Considerable baseline data has been collected over the last two decades in the vicinity of the KZK Project with a more intensive program undertaken in 2015 and 2016. Therefore, impacts from mining development and operation activities on aquatic biota and habitat will be measurable. Additional monitoring to specifically determine the efficacy of offsetting measures will also be implemented.

A semi-quantitative fish sampling program will be conducted on an annual basis to monitor fish use in Geona, Finlayson, and South Creeks as has been done in previous years (Appendix E-3 of the Project Proposal). Additional sampling will be conducted in the developed pond habitat in Geona Creek, once they are constructed. Sampling will be conducted in the spring, summer, fall and winter (overwintering determination). Fish sampling methods will include electrofishing, minnow trapping, beach seining, angling, and visual observations. Overwintering sampling may only include minnow trapping and visual observation which may be aided by the use of an underwater camera. All fish captured will be identified and enumerated, measured for fork length (mm) or total length, weighed, observed for abnormalities, and released at the location of capture. Results will be reported as Catch per Unit Effort (CPUE) to enable spatial and temporal comparisons as well as to provide a semi-quantitative assessment. Additional supporting information that will be collected includes: physical description and photo documentation of sampling locations, in situ water parameters (temperature, dissolved oxygen, conductivity) as well as weather conditions at time of sampling. A scientific collection licence that allows for fish sampling will be obtained from the DFO prior to sampling and a final report will be prepared and submitted to DFO at the termination of the assessment period as will be required as a condition of the permit.

Arctic grayling spawning surveys in Geona and Finlayson Creeks will be conducted on ground. Surveys will focus on habitat most likely to support grayling spawning based on knowledge gleaned from 2015 to 2016 habitat investigations (Appendix E-3 of Project Proposal) and will also focus, once constructed, on grayling spawning habitat developed as part of the offsetting measures. Surveys will occur post-freshet (i.e., mid-May – early June) and once water temperatures are increasing and in the 4°C range (low temp range that will trigger grayling to spawn) or higher.

Overwintering potential of the proposed constructed ponds will be investigated during winter months. Investigations will include determining volume of liquid water available in the ponds, winter flow through the ponds and dissolved oxygen content.

Finlayson Creek Fisheries Population/Spawning Assessments

In addition to the fish monitoring identified above, BMC will develop and install a fish counting fence in order to determine the current passage up and down stream at the Robert Campbell Highway (RCH) and in turn determine the success of the fish passage system at the highway following the re-construction of the culvert. The fish counting fence/trap will be installed immediately upstream of the RCH in the late summer of 2017, in order to capture any fish, including juvenile grayling, migrating downstream prior to freeze up. The fence will then be installed at break-up in the Spring of 2018 to capture any spring spawning fish that are able to navigate the crossing while migrating upstream to access spawning habitat. The installation of the fence in 2017, will provide two years of fisheries passage use at the culvert prior to the FOP construction at the crossing, and provide a baseline to measure the success of the fish passage project following construction and during the life of the mine.

To ensure the fish fence/trap will capture juvenile grayling moving down in the fall, the design will be consistent with a smolt fence (Barber, 2010). The fence will consist of fence panels intersecting the creek that funnel fish into a pipe leading into a trap box. Fence panels will be constructed from a 4' x 8' long 2 x 4" frame covered with ¼ inch galvanized hardware cloth. Panels will be placed into the streambed and anchored with gravel, sandbags, and wooden backstays. Plastic sheeting will be used to create a seal at the base of the panels and prevent fish from passing underneath them. Trap panels place in the creek in a V-weir shape to increase the surface area, thus decrease surface pressure on the screens. The panel shape will also encourage migrating fish to funnel into the 4" flexible plastic pipe that leads into to the 6' x 4' wooden trap box with a lid. Trap panels will be maintained by daily cleaning to ensure screens do not become clogged with leaf litter or other debris.

The trap will be monitored in the morning daily in spring (approximately mid-May – June) and fall (Sept – freeze-up), by a BMC biologist and/or an Environmental Technician) between now and construction and then for 5 years post-construction to monitor the effectiveness of the culvert replacement. Other sample metrics will include daily water quality parameters including: temperature, turbidity (ntu), conductivity, dissolved oxygen (D.O.), percentage oxygen saturation (%sat) and average water depth. Each day, all fish in the trap will be caught using a dip net, and placed in a 5 gallon bucket half filled with creek water. Fish will then be identified to species, counted, measurements taken for fork length (e.g. Grayling and Whitefish (sp)) or total length (e.g. Northern Pike and Burbot) and overall condition prior to being released over the fence at a suitable location.

The fish counting fence will allow BMC biologists to get a measure of absolute abundance of grayling adults and juveniles migrating up and down the system; a measure which is difficult to obtain with any other means. In combination with the spawning surveys, the counting fence will allow BMC to determine absolute abundance of spawning grayling, and calculate the number of juveniles produced per female that enters the system, therefore enabling the determination of the overall success of spawning, incubation and rearing (i.e. freshwater survival rates), before and after the installation of the fisheries culvert bypass as part of the FOP. Additionally, biologists will able to determine the number of spawning fish that return based on the number of juveniles that migrate out of Finlayson Creek, therefore enabling the determination of grayling river or lake survival rates.

To assess the effectiveness of the fish passage at the RCH, in addition to the fish monitoring identified above, BMC will develop and undertake a mark/recapture study. Fish captured with a variety of methods (i.e. gill-netting, minnow traps and angling) downstream of the crossing will be marked (e.g., adipose fin clip or polymer tag) and released downstream. Fish captured upstream as part of the routine sampling program described above, and/or in the fish fence will be observed for marks. Marking effort will occur when fish are moving upstream during the spring/early summer period. Adult and juveniles will be targeted. In addition to the mark/recapture study visual observations of the fish passage system combined with physical measurements of flow (velocities, discharge, and depth) will be conducted throughout the open water season to determine if the passage system is working as designed or if modifications are required.

Federal effluent regulations for the metal mining industry (*Metal Mining Effluent Regulations* (MMER) of the *Fisheries Act*) came into effect in June 2002 and were last updated in May 2016. These regulations, administered under the federal *Fisheries Act*, apply to mining and milling operations that discharge effluent(s) at a rate greater than 50 m^3/day. The MMER outline requirements for routine effluent monitoring, acute lethality testing, and Environmental Effects Monitoring (EEM). The objective of EEM is to determine whether mining activity is causing an effect on fish, benthic invertebrate communities and/or the use of fisheries resources (based on mercury accumulation in fish tissues). Once the Project becomes subject to the MMER (i.e., when the operation begins discharging effluent at more than 50 m^3/day) BMC must submit a study design for undertaking an EEM program within one year. The study design must also be submitted at least six months prior to conducting the program. The study design will follow guidance provided by the "Metal Mining Technical Guidance for EEM" (Government of Canada, 2014). With respect to aquatic resource monitoring BMC will be required to undertake studies every three years to monitor effects from mining operations on the fish and benthic invertebrate communities downstream of its effluent discharge point. The annual fish monitoring program described above will serve to support the requirements under EEM but an EEM specific study on fish will have to be developed for each three year cycle. In addition to monitoring the fish and benthic communities every three years the EEM program also requires undertaking an effluent characterization program and sub-lethal toxicity testing on two plant species, an invertebrate, and fish embryos throughout each year of operation.

YESAB ISSUE

The Proponent has characterized impacts to fish habitat in terms of alterations in water flow. Further, the proposed flow alterations involve various combinations of increase/decrease over time.

R145

"Provide a characterization of effects in relation to related to areal extent (m^2) alterations (i.e., area affected) as well as an accounting of this area by habitat type and reach. Details should include:

a. effects between each stage of these alterations should be evaluated and accounted for;

b. areal extent changes as a result of groundwater changes;

c. riparian clearing required for the Project;

d. impacts to fish habitat from the footprints for the overburden storage facility, Storage Facilities A/B/C and the associated runoff collection ponds"

a. effects between each stage of these alterations should be evaluated and accounted for;

As discussed in Chapter 10 (Aquatic Ecosystem and Resources) and in the Fish Offsetting Plan (FOP-Appendix E-4) of the Project Proposal the upper half of Geona Creek will be isolated from access by fish. This isolation will occur as a result of water management ponds being constructed at the downstream end of the Project site. The lower pond will be converted to a passive wetland treatment system at closure, thereby isolating this habitat in perpetuity. Therefore, effects to habitat as a result of mine development are considered above and below the Lower Water Management Pond. The upper Geona fish habitat is not considered by each phase of development as it will be isolated in its entirety regardless of flow alterations.

Upper Geona

Mine infrastructure will be situated in upper Geona extending from the upper end of Reach 1 where the Lower Water Management Pond will be constructed to the top end of Reach 4 where Fault Creek joins Geona Creek and where the ABM open pit will be developed. In this section of the creek (upper Reach 1 through Reach 4) riparian habitat is low quality with respect to fish habitat. The creek is lined with some grasses and shrubs in certain sections but there is little to no cover. Cover is provided mainly by boulders in certain sections of the creek. The creek is highly braided in certain areas and thus much of the creek in these areas provides shallow flow. The upper section contains the majority of the pond habitat which does cover a comparatively large area but in general the ponds are shallow with organic bottom substrate and little to no overwintering fish habitat.

As mentioned in the FOP (Appendix E-4, Section 6.1.1 of the Project Proposal) approximately 5.4 linear km of fish habitat in upper Geona Creek (including linear distance through the ponds) will be isolated due to mine infrastructure development. This includes 13 ponds with a total surface area of approximately 5.0 ha. The areal extent of flowing habitat that will be removed is also approximately 5.0 ha. This is based on channel width; however, much of the time the wetted width is much narrower. For instance, based on measurements of wetted width in August 2015 the amount of wetted flowing habitat that would be removed is approximately 3.1 ha.

The result of the removal/isolation of this fish habitat in upper Geona is the loss of grayling spawning, rearing and overwintering habitat. Geona Creek is a low fish productivity system, as determined through the baseline studies; however, the FOP has been developed and the offsetting measures proposed for Geona Creek should result in more optimal spawning, rearing and overwintering habitat and thus at a minimum maintain the current grayling productivity of the system, and potentially will result in an increase within the system.

Lower Geona

Lower Geona Creek, outside of mine development, falls entirely within Reach 1. This Reach is described in Section 3.2.2.2 of Appendix E-3(Aquatic Ecosystems and Resources Baseline Report of the Project Proposal). In general, it is less braided than upper Geona Creek reaches and primarily flows within a single channel alignment. Thus, the extent of aquatic habitat that increases or decreases in response to changes in flow is not as pronounced relative to upper reaches in the system. The effect of predicted flow alterations on the waterways in the mine vicinity for each mine development phase is described in Chapter 10, Section 10.4 Project-specific Effects. With respect to lower Geona Creek, no significant alteration to fish and fish habitat is predicted as a result of Project development and associated flow alterations.

Flow in Geona Creek is subject to wide fluctuations between dry periods/winter conditions and freshet or high rainfall events. Therefore, fish habitat in the system also fluctuates substantially and the small population of grayling that live in the system have adapted to these conditions. Mine development will influence baseline flows in the system to an extent, however water management will ensure that flows stay within the normal range of low and high flows. Slightly higher flows (20%) will occur during the construction phase with a greater percentage of wetted area within the creek channel throughout the year. The predicted 40% increase during a dry year is based on 40% above baseline in a dry year which would result in flow more in line with a normal year.

Although some habitat loss may result from overall lower flows in Geona Creek during the operation phase it is not anticipated to affect the grayling using the system and would be difficult to predict. The ponds to be constructed as an offsetting measure will provide the most optimal habitat for grayling in the system. Pond water levels and thus habitat will remain largely unchanged as flow regime changes between mine phases. The lower flows will still be adequate to ensure fish can migrate in the system between habitats.

At closure, flows are only predicted to be reduced by 20% from baseline and therefore are not anticipated to have an effect on the grayling populations in the system. At post-closure, the system will return to near baseline conditions.

b. areal extent changes as a result of groundwater changes;

The predicted change in Geona Creek flows for each mine phase is illustrated in Figures 10-8, 10-9, 10-10 in Chapter 10 (Aquatic Ecosystem and Resources) and Figure 6-2, 6-3, 6-4 (Appendix E-4 of the Project Proposal) in the Fish Offsetting Plan. These predictions account for changes in groundwater inputs into the Geona Creek, South Creek and Finlayson Creek systems. Details concerning the effects mine development will have on groundwater are included in Chapter 9 of the Project Proposal (Groundwater Quality and Flow) and how that translates into effects on surface water quality and flow is detailed in Chapter 8 of the Project Proposal (Surface Water quality and Quantity). The aquatic effects discussed considers the influence the Project will have on groundwater flows and how that influence translates into flows and water quality in the three waterways. Impacts to fish habitat as a result of changes in groundwater inputs are considered not significant and have been considered in overall impacts to fish habitat discussed above (a).

c. riparian clearing required for the Project;

Riparian clearing for the Project will be limited to within the upper Geona Creek watershed, except where habitat replacement ponds will be constructed as part of the FOP. Actual clearing of riparian habitat in upper Geona will occur as a result of the ABM pit development, construction of the water management ponds, Class C Waste Storage Facility and construction of ditches, pipelines and creek crossings.

Approximately 10.1 ha of riparian habitat occurs along the upper Geona Creek, based on a 10.0 m riparian zone allocated along the creek and perimeter of the ponds. An approximate additional 6.0 ha of riparian habitat exists along two small non-fish bearing tributaries in Reach 4 (Appendix E-4, of the Project Proposal, Preliminary Fisheries Offsetting Plan, Figure 4-2) that will be removed in order to construct the Class C Storage Facility.

Clearing of riparian zones can result in bank instability and mobilization of sediments. In order to mitigate for this effect bermed water diversion channels will be constructed to divert flow around the riparian zones that require clearing. Certain channels such as those constructed to divert water around the ABM pit will remain in place throughout the mine life. The channels that will be constructed to divert flow around the water management ponds will be temporary as once constructed water will flow through the ponds (except for non-contact clean water which will continue to be diverted around the ponds). Once in place the water management ponds will also serve to capture solids mobilized upstream as a result of disturbances to the riparian zone.

Fish will be isolated and/or removed from upper Geona as described in the FOP (Section 5.2.2, Appendix E-4 of the Project Proposal) prior to initiation of clearing riparian zones.

The riparian zone in upper Geona Creek provides little to no cover in the system and therefore provides little temperature modifying benefit. As such the loss of riparian habitat should not impact the temperature regime in the system.

Riparian zones can act as filters reducing inputs of sediments, and nutrients such as phosphorus, nitrates into a system. Where possible riparian habitat in upper Geona Creek will be maintained. In the areas where a substantial amount of riparian vegetation will have to be removed (i.e. ABM pit, water management ponds, Class C Storage Facility) surface water will be collected and directed to the water management ponds and treated as necessary.

d. impacts to fish habitat from the footprints for the overburden storage facility, Storage Facilities A/B/C and the associated runoff collection ponds"

There will be no predicted additional impacts to fish habitat, in addition to what is discussed above, as a result of the construction of mine infrastructure. This is described in Section 6.1, Appendix E-4 of the Project Proposal; in summary, none of these facilities will directly impact fish habitat. Storage facilities are all greater than 195 m away from fish and aquatic habitat (Table 10-3 below). BMC has substantially reconsidered mine infrastructure design and placement of waste facilities from what was proposed and licensed by the previous owners in the 1990s in order to "reduce the duration, intensity or extent of adverse effects to fish and fish habitat that cannot be completely avoided."

Table 10-3: Class A, B, and C Storage Facility Size and Distance from Geona Creek

Site	Distance to Geona (m)	Area (m^2)
Class A to Geona	405	75.70
Class A Buttress	275	11.02
Class B to Geona	195	66.70
Class C to Geona	460	125.52

R146

"Provide a characterization of impacts to stream substrate recruitment and flushing in downstream areas of Genoa Creek."

BMC recognises that following the construction of the water management ponds (WMPs) they will naturally interrupt and trap sediment, limiting material to downstream reaches. If the temporary decrease from the WMPs interception of the sediment supply is large, relative to the transport capacity, the downstream response may be bed degradation, as well as armoring and coarsening of the sediments. Conversely, if the transport capacity is reduced more than the sediment supply, the downstream channel will undergo temporary aggradation, typically with finer grained sediment that passes through the WMPs, or those which are supplied from downstream tributaries.

Additionally, the construction of WMPs may cause a temporary change in peak flows, thereby reducing the high flows required for flushing and removing fine, deleterious sediments from spawning and rearing gravel downstream. Thus, the sediment-transport capacity of Geona Creek downstream of the WMPs may be temporarily reduced as a function of the reduction of flood magnitudes.

Currently there are five ponds in the headwaters of Geona Creek that encompass approximately 5 ha of total surface area. Geona Creek is naturally low in total suspended solids (TSS) as the outlet of the headwater ponds generally ranged 1 – 3 ntus during the open water period in 2016. These ponds currently serve as a natural sediment sink. As these ponds will be lost during mine development the construction of the WMPs will basically mimic pre-construction conditions and minimal change is expected in sediment recruitment as a result of their construction.

During the construction phase, flows in Geona Creek are anticipated to initially increase above baseline due to dewatering (which offsets the loss of flow from Fault Creek) at least during the first 10 months, after which a decrease in flow of up to 25% will result during the open water season in dry conditions. During the winter, water pumped as a result of dewatering makes up a larger portion of the net flow and as such this translates into an overall increase in base flow from freeze-up until spring melt.

These changes in flow due to the Project are not anticipated to affect downstream habitat in Geona Creek. However, the reduction in the number of extreme events in the system during the open water season may result in a slight reduction in transport capacity, thereby resulting in areas of channel aggradation from sediments entering the system from downstream tributaries. This impact is expected to be temporary and not significant, as Geona Creek is expected to return to near baseline conditions during closure.

YESAB ISSUE

The proponent has chosen Arctic grayling for monitoring aquatic health among fish species. To identify potential effects they state they will monitor for changes in fish distribution (presence/absence data), abundance estimates and fish condition factor. As it is currently written, the proponent has only used presence and absence electrofishing techniques to establish their baseline. They did not adequately sample for abundance, nor did we see estimates of condition factor.

The data above will aid in standardizing the sampling effort and therefore allow for repeatability when estimating abundance. To adequately address fish abundance the proponent should include the following:

- *To adequately sample for abundance the proponent must establish electrofishing stations of a defined length.*
- *UTMs should be reported at the top and bottom of each station (So that repeat trials can occur within each station, among years).*
- *Water conductivity and temperature, for each station, at the time of each sampling should be reported.*
- *Stream stage should be reported (How deep was the section (station) of stream, where and when it was sampled).*
- *Wetted width should also be reported within the section (station) area.*
- *Preferably, each station should be block netted and a removal method employed to allow for a reasonable assessment of abundance. Several sweeps (passes) should occur within each station*
- *Control stations should be established outside any potential impact area.*
- *Estimates or indices, of species abundance should be established for each station.*

R147

"Demonstrate how abundance estimates and fish condition factor have been considered in the sampling to date and proposed sampling moving forward."

During the 2015 and 2016 baseline monitoring programs, only one adult Grayling was captured during the sampling in Geona Creek and very low numbers of juveniles were encountered in each sampling event (i.e. < 10). As it is very difficult to calculate condition factor with any certainty for juvenile fish in such a rapid state of development, condition factor data were not presented.

R143 presented the monitoring plan moving forward. Spawning surveys will continue as indicated in R143.

The replacement of lost pond habitat as part of the FOP, will be constructed to provide higher quality habitat for both overwintering and spawning, which are considered limiting factors in Geona Creek.

With the implementation of the FOP, BMC expects fish recruitment to increase within Finlayson and Geona Creeks. With the corresponding increase in adult fish, population estimates and condition factors will be possible to calculate and included in annual reports.

YESAB ISSUE

Section 10.6.5 of the Proposal states that fish tissue monitoring for heavy metals and selenium will be conducted as per the existing water license, every two years, at Finlayson Creek stations, using slimy sculpins as the target species. There is no mention of how the fish tissue quality data will be interpreted, *for example, by examination of trend, or by comparison to fish tissue guidelines. In the latter case, fish tissue guidelines, such as the BCMOE guidelines for selenium or others, have not been identified in the Proposal.*

Metals Testing in fish was limited to Slimy Sculpin from the Geona Creek and Finlayson Creek systems. The South Creek, North Creek, and North Lakes systems have also been under represented for metals sampling. This sampling is of particular importance for the North Lake which is an important fisheries resource for First Nations in the area.

R148

"Identify the criteria to be used in the interpretation of fish tissue monitoring data over the course of the Project."

Fish tissue monitoring will continue as part of the Aquatic Effects Monitoring Program throughout the life of the Project. As discussed, very few fish are found in Finlayson Creek, but the three fish sampling sites are currently used as part of the water licence sampling program, and are known to have adequate populations of slimy sculpin to complete a tissue sampling program every two years throughout the life of the Project. These sites are located on Finlayson Creek (KZ15, KZ16, and KZ26) and are distributed throughout the upper reaches of the watershed. There are no sculpin in Geona Creek and very few Grayling, and therefore we are unable to include Geona Creek in the tissue sampling program.

The most upstream site in Finlayson Creek is at KZ16 (which is located along the Tote Road crossing of Finlayson Creek) approximately 10 km north of the BMC exploration camp and upstream of the confluence with Geona Creek. This site serves as a reference site. The site elevation is approximately 1,260 masl and is situated in a sub-alpine ecology consisting of expanses of dwarf birch and several species of riparian willow.

Site KZ15 on Finlayson Creek is just below the Geona Creek confluence, approximately four kilometres downstream of site KZ16. KZ15 represents a fish monitoring site for receiving waters originating from Geona Creek. The elevation of this site is 1,220 masl with riparian habitat consisting of large overhanging willows and patches of tall mature spruce trees forming a canopy with a moss covered forest floor.

Site KZ26 is at the location where the Robert Campbell Highway crosses Finlayson Creek. Two large multiplate culverts are installed at this location to convey flows of Finlayson Creek. Previous assessments have suggested that the crossing may act as a velocity barrier to upstream movement of fish during high flow periods. Quantitatively, site KZ26 represents the best aquatic habitat values compared to the other monitoring sites. The site also serves as a monitoring location that is well downstream and away from the exploration activities. The site is located just above the Finlayson River confluence at an elevation of approximately 964 masl and is characterized with dense stands of mature spruce and willow that dominate the riparian area.

Fish tissue sampling will be conducted in late summer. The presumption is that during the late summer fish distributions are at a maximum throughout the drainage. Late summer (July and August) also corresponds to a temporal period where streams reach their maximum temperatures and have their greatest densities of benthic organisms. The summer is the primary growth period for northern species of fish who forage on food items throughout the drainage, including reaches that are likely inaccessible during winter low flow periods.

Because of their importance in nutrient cycling and as a food source for fish, benthic invertebrates can provide a means of metals transfer to higher trophic levels. A major component of the diet of slimy sculpins is benthic invertebrates, particularly aquatic insect larvae. Sculpins from the three sites on Finlayson Creek will be sampled continually on an annual basis for metals throughout the life of the project.

Fish tissue samples will be compared to previous samples collected as part of the Water Licence and compared among sites. Sample results will be additionally be compared to the current CCME (2004) guidelines for the protection of wildlife consumers of aquatic biota, that address those substances for which aquatic food sources are the main route of exposure. These guidelines apply to any aquatic species consumed by wildlife, including fish, shellfish, invertebrates, or aquatic plants. The tissue recommended guidelines (TRGs) represent the concentration of the specific contaminant in an aquatic organism that is not expected to result in adverse effects if consumed by other wildlife.

Conversely, the Canadian Food Inspection Agency (2009) has also developed TRGs for chemical contaminants and toxins in Canadian fish and fish products. These guidelines were prepared to promote product and processing standards that contribute to the achievement of acceptable quality and health safety of fish and seafood products in the consumer marketplace. For comparative purposes, the values for three of the elements (arsenic, lead and mercury) listed by the Canadian Food Inspection Agency will be compared to whole body slimy sculpins sampled from the three monitoring sites.

Note that, no impacts are predicted in North Lakes; therefore, it is not considered prudent to intrusively sample these lakes.

R149

"Provide rationale for not sampling and conduction metals testing on Arctic Grayling."

With the low populations of Arctic grayling in Geona Creek and only encountered at one site below the culvert at the Robert Campbell Highway (RCH) in Finlayson Creek, tissue metal analysis for Arctic grayling would extirpate the population in Geona Creek within a couple of seasons and no Arctic grayling are found in the main stem of Finlayson Creek upstream of the culvert at the RCH to the confluence with Geona. The use of Arctic grayling for baseline tissue metal analysis is therefore not possible.

YESAB ISSUE

Section 10.6.3 of the Proposal states that sediment quality (metals, TOC, particle size) will be monitored every two years and evaluated in terms of trends over time. There is no indication that sediment quality *guidelines will be considered. In the Aquatic Ecosystem and Resources Baseline Report (p.29) metal concentrations were compared to CCME sediment quality guidelines. It would be useful to know if these guidelines will be used to evaluate sediment monitoring data over the course of the Project.*

R150

"Identify the criteria to be used in the interpretation of sediment monitoring data over the course of the Project."

The sediment monitoring data for the project will be compared to the CCME sediment quality guidelines for the protection of aquatic life.

YESAB ISSUE

Predictions for phosphorus are compared to the trigger range (Table 10-8) and specifically to the upper value of that range (p.10-42) for the appropriate trophic category in the Proposal. However, the Proposal does not mention what the appropriate trophic category is for the Geona Creek control point, KZ-37. Since the average baseline phosphorus is 0.008 mg/L at KZ-37 (p.10-43) we assume the appropriate category is "oligotrophic" which has an upper value of 0.01 mg/L. Only 14.4% of predictions exceed, yet the mean phosphorus is 0.012 mg/L, suggesting a higher frequency of exceedance. It would be helpful if the selected trophic category and the phosphorus limit used for each location could be clearly stated.

R151

"Provide the selected trophic category and the phosphorus limit used for each location in Genoa Creek and Finlayson Creek."

Low flow water quality predictions for phosphorus in Geona Creek (KZ-37) and Finlayson Creek (KZ-15) were compared to the upper limit of the trophic level associated with baseline concentrations on a monthly basis. Table 10-4 and Table 10-5 below show the monthly phosphorus predictions, baseline concentrations and associated trophic level upper limit. Values in red exceed the respective monthly trophic level upper limit. The trigger range exceedance frequencies for phosphorus presented in Project Proposal Tables 10-6 and 10-7 are calculated from the number of monthly predictions above the corresponding monthly upper limit of baseline trophic level. For KZ-37, 36 monthly P predictions (out of 180 for Year-1 to Year 13) are in exceedance (26/180*100=14.4%) and for KZ-15, 3 monthly P predictions are in exceedance (3/180*100=1.7%).

Table 10-4: Low Flow Phosphorus Predictions in Geona Creek (KZ-37), Baseline concentrations and associated upper limit of trophic level (mg/L)

	Year 1	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	KZ-37 Baseline	KZ-37 upper limit of trophic level (baseline)
January	0.006	0.007	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.005	0.005	0.005	0.006	0.010
February	0.005	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.005	0.005	0.005	0.005	0.010
March	0.005	0.010	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.007	0.005	0.005	0.005	0.005	0.010
April	0.001	0.004	0.002	0.002	0.002	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.002	0.002	0.002	0.001	0.004
May	0.011	0.005	0.012	0.013	0.014	0.015	0.016	0.017	0.018	0.019	0.019	0.018	0.013	0.013	0.013	0.011	0.020
June	0.001	0.002	0.017	0.018	0.018	0.019	0.020	0.021	0.021	0.021	0.021	0.021	0.015	0.015	0.015	0.010	0.020
July	0.011	0.004	0.016	0.017	0.018	0.020	0.020	0.021	0.022	0.023	0.023	0.022	0.016	0.016	0.016	0.011	0.020
August	0.015	0.010	0.016	0.017	0.018	0.020	0.021	0.022	0.023	0.023	0.023	0.023	0.016	0.016	0.016	0.014	0.020
September	0.022	0.015	0.012	0.013	0.015	0.016	0.017	0.018	0.019	0.020	0.020	0.019	0.014	0.014	0.014	0.012	0.020
October	0.011	0.009	0.015	0.016	0.017	0.019	0.020	0.020	0.021	0.022	0.022	0.021	0.014	0.014	0.014	0.014	0.020
November	0.009	0.008	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.005	0.005	0.005	0.007	0.010
December	0.006	0.006	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.005	0.005	0.005	0.006	0.010

Table 10-5: Low Flow Phosphorus Predictions in Finlayson Creek (KZ-15), Baseline concentrations and associated upper limit of trophic level (mg/L)

	Year 1	Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7	Year 8	Year 9	Year 10	Year 11	Year 12	Year 13	KZ-15 Baseline	KZ-15 upper limit of trophic level (baseline)
January	0.003	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.004
February	0.003	0.004	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.004
March	0.006	0.008	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.010
April	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.004
May	0.014	0.012	0.012	0.012	0.012	0.012	0.013	0.013	0.013	0.013	0.013	0.013	0.016	0.016	0.016	0.014	0.020
June	0.000	0.001	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.004
July	0.003	0.001	0.003	0.003	0.003	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.003	0.004
August	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.004
September	0.006	0.004	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.004
October	0.004	0.003	0.003	0.003	0.004	0.004	0.004	0.004	0.004	0.004	0.005	0.004	0.005	0.005	0.005	0.006	0.010
November	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.004
December	0.002	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	0.004

YESAB ISSUE

The preliminary WQOs specified in Appendix D-8, Table 3-1, are presented for four receiving water locations (KZ-9, KZ-13, KZ-15 and KZ-26). It is not clear if the Proponent is suggesting that both effluent limits and water quality limits for specified receiving water control points will become the basis for future license conditions.

R152

"Identify the effluent quality parameters, the water quality parameters and control points that could be proposed to be specified for future license condition development."

The final point of compliance, parameters and standards will be determined by the Yukon Water Board in the Water Use Licensing process. It is proposed that KZ-8, Lower Water Management Pond discharge location, will be the final control point where the effluent quality standards will be established. An additional control point will be the discharge from the water treatment plant (KZ-12). The parameters for effluent quality will primarily be related to those contaminants of potential interest (COPI) for which treatment is required to maintain concentrations in the receiving environment that are compatible with the water quality objectives and will include but are not limited to pH, TSS, ammonia, cyanide, arsenic, cadmium, copper, nickel, lead, selenium and zinc. The preliminary water quality objectives report (Appendix D-8 of the Project) indicates the water quality parameters that will be evaluated at sites KZ-13, KZ-37, KZ-15, and KZ-26. These will be incorporated into a monitoring, surveillance, and Adaptive Management Plan to ensure environmental protection.

Further, the Water Quality Model Report (Appendix D-7 of the Project Proposal) outlines Water Treatment Plant effluent water quality for select parameters in Table 5-15 and Table 5-16 presents the maximum discharge concentrations used in the model from KZ-8.

R153

"Provide details of a monitoring program for flows and water quality to be conducted prior to licensing that will provide sufficient support for licensing."

The flow and water quality monitoring programs that have been conducted to date are described in Appendix D-1 (Kudz Ze Kayah Surface Water Quality Baseline Report) and D-2 (Hydrometeorology Baseline Report) of the Project Proposal. These programs will continue up to and including the licensing stage of the Project.

YESAB ISSUE

The proposed procedures for "careful control" of Project discharge water to meet WQOs in the receiving environment at all times are not clearly defined. The surface water management strategy described in Section 18.4.2 of the project proposal states that "Water will be discharged to both Geona Creek and Finlayson Creek at established water quality discharge standard concentrations and at discharge volume ratios no less than 3:1 (receiving water volume: effluent volume) for Geona Creek at KZ-37 and

2:1 for Finlayson Creek at KZ-15 to meet water quality objectives in the receiving environment". However, in Section 8.4.2 we do not see a description of how the effluent discharge will be controlled to ensure the WQOs are met. On one hand, the Proponent has suggested that the effluent meet MMER standards for release of deleterious substances. On the other hand, many of the proposed WQOs are variable, as discussed in section 6.3.3, and are adjusted based on water hardness or other parameters in the receiving environment.

It is important for reviewers to understand how the Proponent will manage effluent during releases to meet the WQOs. For example, is the Proponent suggesting that receiving environment conditions that affect the WQOs be considered prior to discharge to ensure no exceedance of WQOs upon discharge?

R154

"Provide details to demonstrate that there will be adequate storage capacity for effluent to allow holdback and controlled release of effluent."

The Upper and Lower Water Management Ponds have capacities of 250,000 m^3 and 500,000 m^3, respectively, and are both designed for 1:200 year 24-hour storm events, as stated in Section 18.4, Chapter 18 of the Project Proposal. The estimated water volumes present in the combined water management ponds on a monthly basis are shown in Table 10-6 (from Table 5-4, Appendix D-7 of the Project Proposal). Considering the highest estimated monthly volume (1/50 wet year, March), 54,000 m^3 of additional capacity would be available at minimum for effluent holdback and release.

Table 10-6: Estimated Water Volume Present in the water management ponds on a Monthly Basis (m^3) (Table 5-4, Appendix D-7)

	Mean	1/50 Wet Year	1/10 Dry Year
January	137,500	396,000	296,500
February	252,250	534,000	427,750
March	389,500	695,750	574,500
April	367,500	634,750	560,500
May	286,000	565,750	289,500
June	267,000	599,000	68,000
July	69,000	245,000	39,000
August	37,000	214,000	0[a]
September	27,000	0[a]	3,000
October	0[a]	114,000	46,000
November	3,000	181,000	97,500
December	50,000	274,500	183,000

[a] In practice, the WMPs would not be pumped to a volume of zero.

For clarity, the Proponent is not suggesting that receiving environment conditions that affect the WQOs be considered prior to discharge to ensure no exceedance of WQOs upon discharge. It would not be feasible to measure COPI concentrations in the receiving environment and then adjust the concentrations in the discharge. Instead, the EQS could be set based on the dry year modelled scenario, at the lowest mixing ratio within Geona Creek and using the most sensitive month for each COPI. This should result in no (or very few) WQO exceedances. This approach is outlined in the response to R156.

R155

"Describe how discharge rate and flows in the receiving environment will be monitored in real time, and how the quality of the discharge and receiving waters will be monitored."

Discharge rate from the Lower Water Management Pond (KZ-8) will be monitored continuously using a totalizer flow meter with a datalogger. Daily onsite measurements of key parameters for KZ-8 such as pH, conductivity, and selected metals, will be completed to ensure compliance, in addition to the weekly external samples. The effluent quality for KZ-8 and minimum creek:effluent discharge ratios have been identified to ensure environmental protection of Geona Creek and Finlayson Creek.

In Geona Creek (KZ-37) and Finlayson Creek (KZ-15) where discharge from the mine will first enter the receiving environment, stilling wells with staff gauges will be used to collect continuous data where rating curves will be established and used to determine instantaneous discharge measurements. Weekly discharge and water quality samples will be collected at these locations when the Lower Water Management Pond is discharging. The water quality results for KZ-37 and KZ-15 will be compared to the Water Quality Objectives and their associated adaptive management thresholds.

R156

"Provide clear procedures around discharging that will ensure that water quality objectives (WQOs) are met at all times."

Effluent quality standards (EQS) will be established for the Lower Water Management Pond discharge (KZ-8) and will be the primary control for ensuring WQOs are met all the time. These EQS will be established during the water licencing process using updated versions of the water quality model and Water Quality Objectives. The calculations of the EQS will incorporate the minimum mixing ratio of for Geona Creek (3:1 at KZ-37) and Finlayson Creek (2:1 at KZ-15), the Water Quality Objectives and utilise the 1 in 10 year dry water balance flows. This approach will determine the maximum discharge concentration for KZ-8 as a standard for the most sensitive month by parameter.

Discrete discharge at sites KZ-37 (Geona Creek) and KZ-15 (Finlayson Creek) will be measured weekly and recorded continuously by a datalogger in a stilling well. The maximum discharge rate for the Lower Water Management Pond (KZ-8) will be set at the beginning of each week based on the previous week's discharge measured in Geona Creek and Finlayson Creek. The Lower Water Management Pond discharge will be recorded daily and monitored continuously via a totalizer flow meter.

During freshet and significant rain events, discharge within the creeks will be monitored more frequently increasing from weekly to daily, using the staff gauges and rating curves established for

KZ-37 and KZ-15 to conduct spot checks to verify flow rates when week to week changes are suspected.

Daily onsite measurements of key parameters for KZ-8 such as pH, conductivity, and targeted metals, will be completed to ensure compliance in addition to the weekly external samples. Weekly water quality samples in Geona Creek (KZ-37) and Finlayson Creek (KZ-15) will be collected when the Lower Water Management Pond is discharging. The water quality results for KZ-37 and KZ-15 will be compared to the Water Quality Objectives and their associated adaptive management thresholds.

An additional control point will be the discharge from the water treatment plant (KZ-12). The parameters for effluent quality will primarily be related to those COPI for which treatment is required to maintain concentrations in the receiving environment that are compatible with the Water Quality Objectives and will include but not limited to pH, TSS, ammonia, cyanide, arsenic, cadmium, copper, nickel, lead, selenium and zinc. The water treatment plant discharge quality will be monitored internally daily for key performance parameters and externally weekly for the full suite of parameters.

11 TERRAIN AND SOILS

11.1 GEOTECHNICAL SITE CHARACTERISTICS AND PERMAFROST

YESAB ISSUE

Thermistors were installed in drill holes K15-335, K16-392, and K16-395 during the 2016 site investigation program. None of the thermistors in the Mill Site area indicate the presence of frozen ground between the months of February and September 2016. It seems highly unlikely; given the location of the Project and that the thermistors were presumably read in February and other winter months, that no negative ground temperatures were recorded by the thermistors, even near the ground surface where seasonal freezing would occur. This may be just an instance of imprecise wording.

R157

"Provide additional information on the data from the thermistors including whether they indicated unfrozen ground."

Additional thermistor data was downloaded in May 2017 and is included as **Appendix 1** to this Response Report.

From the above document:

> "None of the thermistors installed on site in 2015 or 2016 have identified permafrost conditions, however discontinuous permafrost is anticipated to be present on site, based on previous site investigation results. The thermistors installed in 2015/16 indicate the seasonal active layer is in the order of 1 to 4 mbgs based on the record of information collected."

R158

"Describe whether the term "frozen ground" in the Mill Site Area Characterization Report relates to seasonally frozen ground or "permafrost"."

At the time of issuing Appendix C-2 of the Project Proposal, Mill Site Area Geotechnical Characterization, no thermistors in the Mill Site area had recorded frozen ground temperatures (seasonal active layer or permafrost) in the uppermost node of each thermistor.

Additional thermistor data was downloaded in May 2017 and is included as **Appendix 1** to this Response Report. On-going monitoring of the three thermistors in the Mill Site area indicates the presence of an active layer of seasonally frozen ground above the upper most node (in the range of 1.5 mbgs); however, no permafrost has been indicated.

R159

"Provide ground temperature data that covers a sufficient timeframe, geographical area and depth to establish the presence or absence of permafrost within the project area. Use this

information to update the ground temperature data including annual "trumpet curves" of the ground temperatures."

At the time of preparation and submission of the Proposal, information was only available from February 2016 through September 2016, and therefore there was no recorded data through a winter period. Updated thermistor data is now available, as a site wide download was completed in May 2017. The updated data, including "trumpet curves" is included in **Appendix 1** to this Response Report.

YESAB ISSUE

In Section 11.3.4, and in Appendix C-3 (Section 3.3) it was stated that the 1995/1996 field program included 35 test pits that encountered permafrost and a further 40 test pits observed ice lenses and ice segregation, which was interpreted as an active layer rather than permafrost. Test pits that contain ice lenses and ice segregation is likely permafrost. Ice does not form in the "active layer", as traditionally defined. The report's use of "active layer" is in contrast to the standard definition. The International Permafrost Association Glossary of Permafrost and Related Ground Ice Terms (2005) defines the active layer as "the thickness of the layer of the ground that is subject to annual thawing and freezing in areas underlain by permafrost". The active layer is typically ice-free (besides winter season), although ice may often accumulate at the base of the active layer as water percolates down to the top of the permafrost table and freezes.

According to Section 11.3.4, permafrost was not identified in any of the 2016 thermistors; however, frozen soil and ice were encountered in samples at approximately 1.5 m and 5.0 m depths from a drill hole within the Class C Storage Facility footprint. The absence of actual thermistor data in the report renders it impossible to assess the validity of this statement. There is implied contradiction in the report.

Section 4.1 of Appendix C-3 stated that sub-zero temperatures were measured between 3 m and 14 m depth below ground surface was evident. This observation indicates permafrost at that borehole location rather than seasonal freezing.

Section 6 of Appendix E-5 stated that the terrain analysis highlighted permafrost and periglacial processes to be widespread across the Study Area. This terrain analysis report supports the contention that permafrost is widespread through the Project. This is in contrast to other reports in the application package, particularly reports citing borehole logs and thermistor cables, which seem to indicate the absence of permafrost.

Although quite rare, ice-rich bedrock is possible. At the Raglan Mine in northern Quebec, thick (several centimetres) ice lenses were encountered in igneous bedrock to depths of about 8 m below ground surface. Depending on the method of drilling, such ice lenses might not be identified.

The data presented in the reports were, in some cases approximately 20 years old. In other cases, more recent thermal data was presented but it was either incomplete (not a full year) or contradictory (no freezing temperatures measured, even in the middle of winter).

R160

"Confirm if the data available is sufficient to draw definitive conclusions on the distribution and character of permafrost at this site."

The Project site lies in an area of discontinuous permafrost. As part of the on-going characterization of the character and distribution of permafrost, a desktop terrain hazard assessment and two site investigations have been completed and presented in factual data reports. The terrain hazard assessment is included as Appendix E-5 (Kudz Ze Kayah Project - Findings of Terrain Analysis) of the Project Proposal. **Appendix 1** to this Response Report provides additional thermistor data.

BMC confirms that the data obtained to date is fully adequate to draw conclusions relating to permafrost that are appropriate for this phase of design and permitting. However, investigations have been and will continue to be focused on areas of infrastructure development. Additional site investigations and monitoring of existing and future instrumentation will continue to provide input to the understanding of the character and distribution of permafrost on site, which will be utilized to inform detailed design prior to any construction.

R161

"Given discrepancies between the various statements regarding the absence or presence of permafrost, how are these apparent contradictions regarding the evidence for permafrost at the project site being addressed?"

In accordance with sound engineering design practice, BMC has used conservative assumptions in the stability assessments of the Class A, B, C Waste Storage Facilities and Overburden Storage Facilities. The designs have assumed the presence of permafrost and have been designed with this in mind, with either removal or mitigation of the permafrost. Following this policy of conservative reassurance, any new information to confirm or refute presence of permafrost in a specific site could only potentially support construction techniques with less conservative measures.

11.2 ACCESS ROAD AND MINE SITE TERRAIN ANALYSIS (TERRAIN STABILITY, GEOHAZARDS AND RISKS)

YESAB ISSUE

The study provided by the Proponent provides neither terrain stability mapping nor detailed definitions for the terrain stability classes presented. A preliminary hazard inventory (Terrain Analysis Map) is presented but it appears preliminary and coarse. Field assessment to confirm the extent and hazard processes has not been conducted. Appendix E-5 of the submission states that recent debris floods have impacted an active fan at Fault Creek in the proposed Open Pit footprint.

The proponent should produce a terrain map, terrain stability and hazard map for the mine footprint and access road (including associated methodology and analysis). The terrain stability and hazard maps should follow YESAB's geohazard guidelines for recommended scale, methodologies, and data collection. The guidelines can be found at:

http://www.yesab.ca/wp/wp-content/uploads/2015/11/Geohazards-Guide-Nov-1-2015-2.pdf

R162

"Provide a terrain map, terrain stability and hazard map for the mine footprint and access road (including associated methodology and analysis) that:

a. Identifies surficial geology and related geomorphologic processes;

b. Identifies the type, nature, relative frequency and magnitude of hazards (baseline map);

c. Evaluates how current hazard dynamic may be altered due to changes in climate;

d. Identifies specific risks to the proposed infrastructure; and,

e. Identifies specific risks to the environment from the proposed project (e.g.: changes to slope stability). The risk map should include consideration of climate change over the life of the Project."

Updated terrain hazard mapping and risk assessment will be completed as part of the detailed design phase. Work conducted to date is sufficient to support an effects assessment and the required data can be sourced in the Project Proposal. Details of a), and, b) are in the relevant sections of Appendix E-5 Kudz Ze Kayah Project - Findings of Terrain Analysis, and Section 11.3.6 of the Project Proposal. Details of specific risks to infrastructure (d) are included in Section 17.2 of the Project Proposal while the likely effects of climate change (c, and e) are outlined in Section 16.6 of the Project Proposal.

R163

"Describe how have permafrost degradation processes at the proposed Water Management Ponds footprint been addressed?"

Appendix E-5, Kudz Ze Kayah Project – Findings of Terrain Analysis, of the Project Proposal identified the possibility of permafrost degradation along the Geona Creek Valley floor being exacerbated by the development of the Water Management Ponds, and recommended that this was identified as a geotechnical consideration to be addressed in further studies.

Thermistor K15-336 installed in 2015 and proposed thermistor K17-C (to be installed in summer 2017) will continue to monitor ground temperatures in the area of the Upper and Lower Water Management Ponds. On-going monitoring and geotechnical site investigations will be included in updated site wide geotechnical, terrain hazard and permafrost characterization studies.

Geotechnical design considerations related to permafrost degradation in the area of the Water Management Ponds will be included in the detailed design study. Final design of these facilities will be completed prior to submission of permit applications to the regulatory authorities and will include mitigation for any identified hazards.

R164

"Describe how has the debris flood hazard at the proposed Open Pit been addressed?"

The debris flood hazard at the proposed site of the Open Pit will be addressed by removing the cause of the hazard and mitigating the existing hazard.

The existing alluvial fan and the recent flood debris deposit were created from material carried by Fault Creek during periods of peak flow. The diversion of Fault Creek, rerouting flow to the south, during operations, will remove the mechanism that created the alluvial fan and associated flood deposit. Appendix E-5, Kudz Ze Kayah Project – Findings of Terrain Analysis, of the Project Proposal recommended that consideration be given to developing a deflection berm on the south part of the fan in order to protect the Open Pit and the proposed access road from debris floods.

The existing debris flood deposit and alluvial fan will be excavated as part of the overburden stripping during the mining process. As part of the mine design a safety bench will be left at the crest of the pit to prevent the entry of any material from the surrounding overburden and debris flows. The slope of the overburden will be a maximum of 30° and the width of the safety bench will be a minimum of 5m.

11.3 ACCESS ROAD AND MINE SITE TERRAIN ANALYSIS (PERMAFROST AND RELATED HAZARDS)

YESAB ISSUE

The Proponent indicates that "terrain analysis highlighted permafrost and periglacial processes to be widespread across the Study Area"*. However, permafrost areas have not been clearly identified nor explicitly linked to existing and potential hazards and terrain stability (e.g., solifluction and debris slides). The report in Appendix E-5 states that solifluction instability are affecting the footprints of the open pit, the three waste storage facilities and the access road.*

The report does not indicate how the proposed infrastructure may impact the permafrost regime. The Proponent identifies that extensive areas of solifluction have been mapped within the project site area and the Proponent indicates that solifluction areas "should be assumed to be unstable with respect to development and mitigation measures will be needed to prevent slope instability"*. The Proponent should address the concerns related to permafrost and solifluction concerns.*

The Proponent indicated that "Although the terrain is predominantly gently inclined, the terrain analysis highlighted local geohazards including four debris slides on moderate slopes adjacent to Geona Creek. These landslides may have been caused in part by permafrost degradation"*. The preliminary terrain analysis also highlights that there is evidence of permafrost degradation (i.e., thaw lakes and thermal erosion features). A map of permafrost degradation potential and related analysis has not been provided.*

Section 11.3.6 describes the ground conditions at the proposed mine facilities. The conditions described highlight the presence (or potential for) permafrost and areas of known instability (e.g., solifluction and fan areas). For the Class A and B facilities, the Proponent indicates that the permafrost within the *overburden soils will be removed, resulting in a low residual hazard. The Proponent indicates that the remaining facilities are exposed to different levels of hazards such as solifluction, thaw settlement, thermal erosion, etc. An analysis of risk has not been provided.*

The Appendix E-5 terrain analysis report states that permafrost is widespread through the site. However, the typical cross section for conventional cut and fill road construction (Drawing No. 1356-2-Typroad-xsections-002) reflects non-permafrost conditions. There is considerable case history literature on performance issues associated with applying non-permafrost cut and fill design methods to permafrost terrain. The Proponent is referred to:

- *McHattie, R.L. and Vinson, T.S 2008. Managing ice-rich permafrost exposed during construction. Proceedings, 9th International Permafrost Conference, Fairbanks, Alaska: 1167 – 1172.*
- *Berg, R. and Smith, M. 1976. Observations along the pipeline haul road between Livengood and the Yukon River. US Army CRREL Special Report 76-11. October 1976.*

R165

"Describe how have permafrost conditions been considered in design of mine infrastructure and the access road improvement construction and in the roads' operation and integrity during operations?"

Below is a summary of the design considerations (relating to permafrost) for each project area. These design considerations are intended to account for risk due to the presence of permafrost.

Class A Waste Storage Facility: The design, construction and stability assessment for the Class A Waste Storage Facility assumes that all unsuitable material will be removed prior to placement of Class A material, including beneath the buttress. Unsuitable material would include organics, saturated or frozen ground and fine grained material that could be susceptible to saturation and instability.

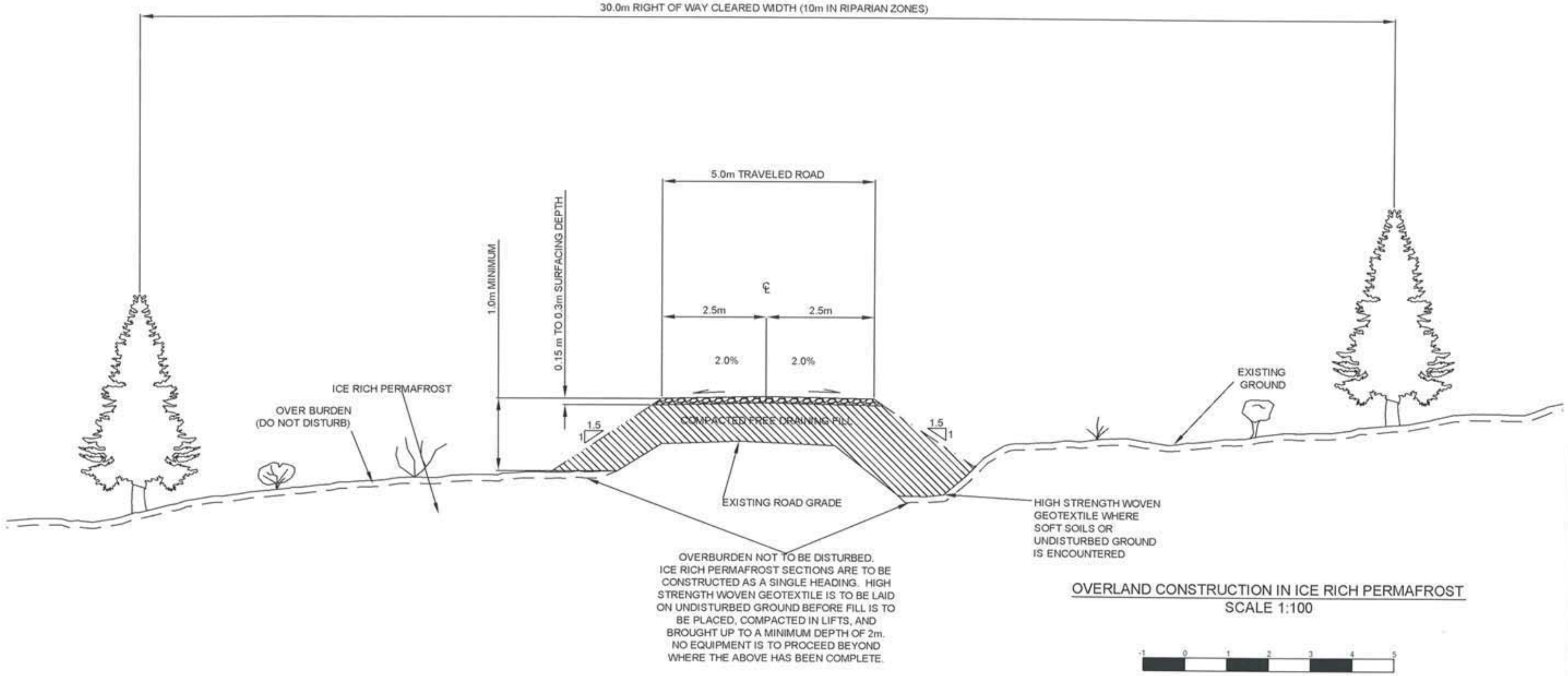
Class B, Class C and Overburden Facilities: The design, construction and stability assessments for the Class B, C and Overburden Facilities assumed that the foundation material typically consists of sand and gravel soils with some silt. These soils are expected to consolidate at the same rate as thawing occurs, therefore exhibiting an effective shear strength similar to unfrozen soils during any thawing. Additionally, the stability models assumed fully saturated conditions for the foundation materials, which accounts for any buildup of fluid within the soil pores during thawing. Additionally, the Class C Facility is located in a confined valley with a shallow basin grade, thus limiting the potential for movement.

Access Road: Identified ice rich permafrost sections of the access road will be constructed using overland construction (fill only embankment) which will minimize disturbance to the existing vegetative cover.

In areas where the existing road traverses sections of undisturbed, shallow, ice-rich permafrost, the existing organic layer will be left intact. In permafrost, where proposed fill slopes extend beyond either side of the existing road prism, the portion of fill beyond the existing road edge will be constructed by filling over a geotextile separation layer. Once the geotextile is in position, fill is to be placed, compacted in lifts and brought up to the designed grade.

Care will be taken to minimize the amount of vegetative cover to be cleared, limiting the amount of soil exposed to reduce permafrost degradation and thaw along the roadway. This will also reduce the potential for soil erosion and sediment deposition in riparian and wetland ecosystems. A typical cross section of overland construction in ice-rich permafrost was provided in Appendix C-8 (Proposed Right of Way for Access Road and Typical Cross Section for Road Upgrade) in the Project Proposal and reproduced as Figure 11-1 below.

Additional site wide characterization of permafrost conditions will be completed as part of the on-going project development and collection and monitoring of geotechnical data and instrumentation will occur during all phases of the operation to ensure that problems are identified and suitable mitigation strategies are implemented.



PREPARED FOR:	PREPARED BY:			
BMC MINERALS	ONSITE ENGINEERING LTD. COASTAL OPERATIONS 1040 CEDAR STREET CAMPBELL RIVER, BC, V9W 7E2 PH.: 250-287-9174 FAX: 866-235-6943	FIGURE 11-1 TYPICAL CROSS SECTIONS: OVERLAND CONSTRUCTION IN ICE RICH PERMAFROST DWG No: 1356-2-TYPROADXSECTIONS-003	DESIGN BY: MATT DICKIE, EIT DESIGN DATE: SEPTEMBER 30, 2016 REVIEWED BY: JEREMY ARAKI, P. ENG. DRAWN BY: MATT DICKIE, EIT SITE VISIT: ONSITE ENGINEERING LTD. SITE VISIT DATES: FILE NAME: TYPROADXSECTIONS.DWG SCALE: AS NOTED REVISION NUMBER: REVISION DATE: ALL MEASUREMENTS IN m UNLESS OTHERWISE NOTED.	SEAL OF Y.T. P.ENG. ISSUED FOR PERMIT APPROVAL

R166

"Will the proposed conventional unfrozen road building design for the access road widening and upgrades be feasible and durable in the permafrost terrain?"

As described in R165 and Figure 11-1 above, identified ice rich permafrost sections of the access road will be constructed using overland construction (fill only embankment) which will minimize disturbance to the existing vegetative cover.

In areas where the existing road traverses sections of undisturbed, shallow, ice-rich permafrost, the existing organic layer will be left intact. In permafrost, where proposed fill slopes extend beyond either side of the existing road prism, the portion of fill beyond the existing road edge will be constructed by filling over a geotextile separation layer. Once the geotextile is in position, fill is to be placed, compacted in lifts and brought up to the designed grade.

Care will be taken to minimize the amount of vegetative cover to be cleared, limiting the amount of soil exposed to reduce permafrost degradation and thaw along the roadway. This will also reduce the potential for soil erosion and sediment deposition in riparian and wetland ecosystems.

YESAB ISSUE

Only a limited permafrost discussion has been provided in the submission. The proponent should produce a more comprehensive permafrost study, including mapping and related analysis indicating permafrost distribution within the mine footprint and access road area. The investigation should include an analysis of the permafrost degradation potential. The analysis should include a baseline scenario (current condition) and potential changes during the project operation (due to climate change and impact from proposed infrastructure). Sufficient detail should be provided in areas where surface water runoff is expected to be altered (e.g., water management ponds) and where existing geohazards may be exacerbated. The investigation should include a detailed permafrost hazard map (predictive) with an associated methodology and analysis identifying permafrost related hazards in the study area, including: type, nature and magnitude. The study should identify specific risks to the Project from the permafrost hazard map. The risk map should include consideration of climate change over the life of the Project. The study should also identify specific risks to the permafrost regime from the Project (e.g. potential permafrost degradation exacerbated by water management ponds, changes to slope stability due to the construction of road, stockpiles and storage facilities). The risk map should include consideration of climate change over the life of the Project.

R167

"Provide a comprehensive permafrost study, including mapping and related analysis indicating permafrost distribution within the mine footprint and access road area. Indicate the magnitude and extent of soil erosion potential within this area that is attributed to thermal erosion of permafrost."

A preliminary permafrost study has been completed with thermistors installed in the footprints of the major infrastructure components. Results of this investigation are included as **Appendix 1** to this

Response Report. A preliminary terrain hazard analysis (Appendix E-5 of the Proposal) has indicated areas of soil erosion that could possibly be attributed to the presence of permafrost. A more comprehensive study will be completed as part of the on-going project development and the detailed design phase.

12 VEGETATION COVER AND COMPOSITION

No information required.

13 WILDLIFE AND WILDLIFE HABITAT

YESAB ISSUE

According to the proposal, the Common Nighthawk is being represented by raptors. According to the submission, bird surveys conducted included cliff-nesting raptor surveys, point-count surveys following a modified Breeding Bird Survey (BBS) methodology, and waterfowl surveys. Survey methodology for cliff-nesting raptors is inappropriate for the Common Nighthawk and point count surveys based on the BBS methodology are not sufficient as they are not conducted during the time of day when the Common Nighthawk is commonly or best detected.

R168

"Conduct surveys for the Common Nighthawk using standard methodologies using appropriate timing for the area and with particular emphasis on lower elevation habitats (e.g. along the Tote Road and the airstrip)."

The field studies for birds were completed to determine presence and an unadjusted estimate of relative abundance. The surveys completed in baseline studies were not completed at crepuscular (twilight) or night hours and therefore common nighthawk (*Chordeiles minor*) were not detected. However, a common nighthawk was recorded in the wildlife log as flying over camp in September 2016 thus they are confirmed to occur at the Project site. Additional surveys can be completed prior to construction using standard methods, but a new field survey will not change the results of the environmental assessment. In the interim, for the YESAB assessment, sufficient ecological information is available such that an effects assessment can be completed and mitigation measures determined. Details in the Wildlife Protection Plan will include provisions for checking for common nighthawk activity at sunset that could indicate the presence of nests prior to earthmoving around quarries or sand and gravel areas during prime nesting periods.

R169

"In accordance with SARA subsection 79(2) provide an effects assessment for the Common Nighthawk. For the habitat suitability model please include:

a. justification for the map and rank classes,

b. data limitations and any modifications or enhancements made and

c. methods and results of any validation analyses conducted."

It is acknowledged that the common nighthawk is listed as Threatened under SARA and requires a species-specific assessment. Under SARA subsection 79(2), "*the person must identify the adverse effects of the project on the listed wildlife species and its critical habitat and, if the project is carried out, must ensure that measures are taken to avoid or lessen those effects and to monitor them. The measures must be taken in a way that is consistent with any applicable recovery strategy and action plans*."

Common nighthawk use a wide variety of habitats and prefer nesting in open sandy areas, including agricultural fields, burned areas, and some mixed and coniferous forests (COSEWIC, 2007a). Loss of insects for food and reforestation are some of the threats noted in the recovery plan, but there are many unknown aspects to its habitat use and decline (COSEWIC, 2007a). Common nighthawk habitat is likely to increase with Project construction as more open areas are developed. Reclamation of rock storage facilities will result in open areas that are also likely to result in a net gain in habitat.

Habitat suitability modelling was determined not to be warranted since there are many uncertainties concerning common nighthawk habitat use in this region and suitable habitat is expected to increase with development. It was determined that potential adverse effects would be the potential disturbance of nests which is protected under the *Migratory Birds Convention Act* and managed through provisions in the Wildlife Protection Plan. Details in the Wildlife Protection Plan will include provisions for checking for common nighthawk activity at sunset that could indicate the presence of nests prior to earthmoving around quarries or sand and gravel areas during prime nesting periods.

YESAB ISSUE

The selection of some subcomponents (notably cliff-nesting raptors and olive-sided flycatchers) and the use of these subcomponents to represent the habitat of other species could lead to an inaccurate assessment of potential project effects on other bird species, including species at risk, and consequently inadequate mitigation and monitoring measures for these species.

Raptors: Cliff-nesting raptors will not adequately represent habitat use for common nighthawk and short-eared owl.

Passerines and red-necked phalarope: The use of olive-sided flycatcher to represent habitat use by bank swallow, barn swallow, red-necked phalarope and rusty blackbird may underestimate the potential effects of the Project on these species at risk.

Small mammals: The assessment and mitigation measures that are identified for collared pika will likely provide protection for hoary marmot but will not likely be relevant for the other small mammal species identified as of cultural importance by the Ross River Dena Council and Liard First Nation. As such, further mitigation measures for those species not represented by collared pika should be considered.

Wood frog. Amphibians are known to be sensitive to environmental change and are often identified as key species or subcomponents for environmental assessments. Wood frogs, although there is no baseline information, are likely to occur in the project area.

Fisher: Fishers, which are rare in the Yukon, have been identified in the project area through baseline studies. This species should still be considered in the assessment due to its specific habitat use and conservation status in the Yukon (S2S4).

R170

"Comment on the risk of underestimating the potential effects of the Project on common nighthawk and short-eared owl by excluding the impacts of the Project on preferred habitats for these at-risk species."

BMC must comply with the *Migratory Birds Convention Act* and commits to this through addressing effects on individual species at risk in its Wildlife Protection Plan. Mitigation measures to prevent nest disturbance are presented in Section 18.7 of the Project Proposal.

The risk of underestimating the potential effects of the Project on common nighthawk and short-eared owl is low. The Project area does not contain any defined critical habitat for either species. Both species prefer open fields which is currently not extensive but is expected to increase which would result in an overall net gain during operations and potentially into post-closure. It should be noted that the Wildlife Protection Plan is a living document and will be updated through the adaptive management program if unexpected effects on birds or other wildlife are detected as discussed in Section 18 of the Project Proposal.

R171

"Comment on the risk of underestimating the potential effects of the Project on bank swallow, barn swallow, red-necked phalarope and rusty blackbird by using olive-sided flycatcher to represent habitat use by these at-risk species."

BMC must comply with the *Migratory Birds Convention Act* and commits to this through addressing effects on individual species at risk in its Wildlife Protection Plan as is currently undertaken through BMC's exploration Environmental Management Plan.

The effects assessment used olive-sided flycatcher (*Contopus cooperi*) to assess the magnitude of habitat loss. This is a conservative assessment since olive-sided flycatcher has specific habitat needs between riparian and treed habitat. This is more conservative than if a habitat generalist such as the dark-eyed junco (*Junco hyemalis*) was used which would result in the order of 10% habitat loss. The resulting estimated 20% loss of suitable habitat for olive-sided flycatcher was similar to the estimated 20% suitable habitat loss for waterfowl. Red-necked phalarope (*Phalaropus lobatus*) and rusty blackbird (*Euphagus carolinus*) also each occupy a habitat niche in riparian and wetland habitats and should be a similar magnitude of suitable habitat loss as the olive-sided flycatcher or waterfowl in general. As a result, there is little risk of underestimating habitat loss for red-necked phalarope or rusty blackbird.

Little habitat is currently available in the local study area (LSA) for bank swallow (*Riparia riparia*) which prefers sandy-silty banks for excavating nesting burrows. Similarly, barn swallow (*Hirundo rustica*) prefers caves and ledges on cliff faces and currently has little suitable habitat in the LSA. The risk of underestimating potential effects for either swallow species is considered very low.

R172

"Provide information as to how the Wildlife Protection Plan will be updated to include measures to protect those species not adequately represented by collared pika."

BMC's consultants' assessment and mitigation measures will minimize effects for all potential wildlife species, whether assessed directly or indirectly using a representative species. As presented in Table 13-1 of the Project Proposal, culturally important small mammals represented by collared pika (*Ochotona collaris*) include groundhog or hoary marmot, squirrel, and gopher. As presented in Section 18.7 of the Project Proposal, the general wildlife protection measures such as; worker no feeding, no hunting, and no trapping policies, proper waste management, minimizing disturbance, and progressive reclamation will minimize effects on small mammals. There are no other small mammals that are of conservation or cultural concern that would be significantly affected by the Project. It should be noted that the Wildlife Protection Plan is a living document and will be updated through implementation of the Adaptive Management Plan if unexpected effects on small mammals or other wildlife are detected as discussed in Section 18 of the Project Proposal.

R173

"Develop and incorporate measures to protect wood frog and wood frog habitat in the Wildlife Protection Plan."

It is appreciated that wood frog (*Lithobates sylvaticus*) are likely present in the Project area and are sensitive to environmental change. Wood frog are wide ranging in Yukon and secure. They are found in wetland, pond habitats, and the surrounding forests. They are a species of least concern by IUCN, and a low priority candidate for COSEWIC. The Government of Yukon published a Management Plan for Yukon Amphibians in 2013 because amphibians are threatened globally. The management objectives of this plan are to improve the knowledge of distribution and abundance, identify and maintain key habitat, assess and mitigate threats, and increase public appreciation. The risks or potential effects to wood frog at the Project are from habitat clearing and potential contaminants similar to fish, waterfowl, small mammals, and moose. The potential effects will be mitigated and managed by the general wildlife protection measures that are presented in Section 18.7 of the Project Proposal. These mitigation and management measures include minimizing clearing, pond creation, and progressive reclamation. There are no other species-specific mitigations needed.

R174

"Develop and incorporate measures to protect fishers and fisher habitat in the Wildlife Protection Plan."

BMC's consultants' assessment and mitigation measures will minimize effects for all potential wildlife species, whether assessed directly or indirectly using a representative species. Fisher (*Pekania pennant*) is not listed under COSEWIC but has an S1S2 rank in Yukon (Environment Yukon, 2015a) mainly due to its limited range. Fisher have limited distribution in Yukon and the Project area is in the northern extent. Fisher were not identified in any track surveys. One fisher was recorded in the wildlife log but was suspected to be a wolverine since it was observed in the alpine and fisher prefer riparian forests with a dense canopy (Environment Yukon, 2015a). If fisher do use the Project area, their preferred habitat would be riparian forest found along the Tote Road which is not expected to be significantly affected by the Project. Mitigation and management measures to minimize effects on fisher and fisher habitat (if any occurs near the Project) are the same as the general measures described in Section 18.7 of the Project Proposal and included in the Wildlife Protection Plan. Key mitigation measures include minimizing clearing, progressive reclamation, speed limits, and access management. There are no other species-specific mitigations needed.

YESAB ISSUE

An effects assessment for the Olive-sided Flycatcher is appropriate as per subsection 79(2) of SARA.

R175

"For the habitat suitability model provide justification for the rank classes, data limitations and any modifications or enhancements made and methods and results of any validation analyses conducted."

Justification for the habitat suitability model for olive-sided flycatcher is included in Section 13.5.1 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. The terrestrial ecosystem map for the LSA was used in combination with a set of criteria that define the quality of habitat and predict areas that olive-sided flycatcher likely use. Table 13-1 (shown below) of Appendix E-8 summarizes the habitat suitability criteria chosen to rank habitat suitability based on structural stage, bioclimate subzone, and watercourses.

Table 13-1: Olive-sided Flycatcher Habitat Suitability Criteria

Suitability Rank	Structural Stage	Bioclimate Subzone	Watercourses
High	Leading ecosite >=50% structural stage 6 or 7	Boreal High-Boreal Subalpine	<500 m from waterbody
Medium	Leading ecosite >=50% structural stage 6 or 7	Boreal High- Boreal Subalpine	>500 m from waterbody
Low	Everything else	Boreal High- Boreal Subalpine	Everything else

Olive-sided flycatcher is a migratory bird that comes to the Yukon for nesting and feeding prior to migrating south for the winter. Olive-sided flycatcher nest at the edges of mature and old growth forests. Open areas may be forest clearings, forest edges located near natural openings, burned forest or openings within old-growth forest stands. Tall, live trees or snags for perching are associated with mature trees and large dead trees (i.e., structural stage 6, 7). Generally, forest habitat is either coniferous or mixed wood. In the boreal forest, suitable habitat is more likely to be in or near wetland areas (COSEWIC, 2007b). Suitable habitat for olive-sided flycatcher may occur in subalpine and boreal forest. Olive-sided flycatcher were heard or observed at locations in the LSA that aligned well with the predicted areas of suitable habitat.

As mentioned in Section 1.2 of Appendix E-8 of the Project Proposal, the olive-sided flycatcher habitat suitability mapping was completed to support the Project effects assessment. Observations are plotted on the habitat suitability map in Figure 13-2 as a simple validation. The model has a moderate reliability based on the definitions in the 1999 BC Wildlife Habitat Rating Standards, (i.e., Moderate Reliability. Available information is based mainly on studies, reports and expertise on the species-habitat relationships gained within British Columbia. Some information from ecosystems in the study area, but mostly extrapolated from similar ecosystems. No verification or limited verification has been done).

YESAB ISSUE

Information on methods is missing in the proposal. As noted in Chapter 5, Section 5.1 (effects assessment approach), the existing conditions should be described in enough detail to provide the benchmark against which the project effects will be evaluated. It is, therefore, important that an adequate baseline assessment is completed, including providing detailed description of methods and results.

R176

"Provide a complete description of the passerine survey methods, including information on number of times each station was visited, description of the point count methodology, and information on settling periods."

The Passerine survey methods are described in Section 13.3.1 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. A point-count survey was conducted by a qualified biologist capable of identifying songbirds based on their visual appearance and mating songs. A point-count consisted of an observer remaining stationary and silent at the designated site for a 5-minute interval recording all birds detected by sight and sound. This is a modification of the North American Breeding Bird Survey (BBS) 3-minute methodology used by the Canadian Wildlife Service and United States Geological Survey (USGS, 2001; Environment and Climate Change Canada, 2016). When the surveyor arrived at a station, one minute of recovery time was taken to allow the birds to settle.

Most point-count sites were accessible by foot. Sites that were not accessible by foot were accessed with a Bell Jet Ranger Helicopter. The helicopter landed and powered down at a safe location near the point-count site. The observers walked to the point-count site and began the survey (including a one minute settling time). Results from the wetland and reference sites accessed by helicopter in 2015 and 2016 were not noticeably different in abundance or richness between road and helicopter accessed sites (see **Appendix 5** to this Response Document, Figures A5-1 to A5-7 in response to R177).

Alpine, subalpine, and boreal sites around the proposed Project footprint were generally visited once in each of 2015 and 2016. Seven additional road sites (RS_8 to RS_14), two alpine sites (BB_17 and BB_18), and three reference sites (REF_3 to REF_5) were added in 2016; four sites (BB_13 to BB_16) were not surveyed in 2016. Wetland sites were visited once in 2015 and 2016 except ABR-1 had two point counts and ABR-2 had three point counts in 2016. The main objective of the wetland surveys was to identify all species using the wetlands and point counts gave an indication of relative abundance.

The objective of the surveys was to identify and inventory bird species at the Project and obtain an unadjusted estimate of relative abundance. The BBS method was appropriate for identifying presence and was modified from 3-minute to 5-minute counts to increase the potential for detection.

As mentioned in Section 13.6.1 of the Project Proposal, the species of conservation concern observed in the Project site were consistent with the data and detection frequency for the area found in the Finlayson Lake Breeding Bird Surveys from 1992 to 2014 (USGS, 2014). It is evident that most bird species have been detected for site based on the species accumulation graph in Figure 13-1 (below).

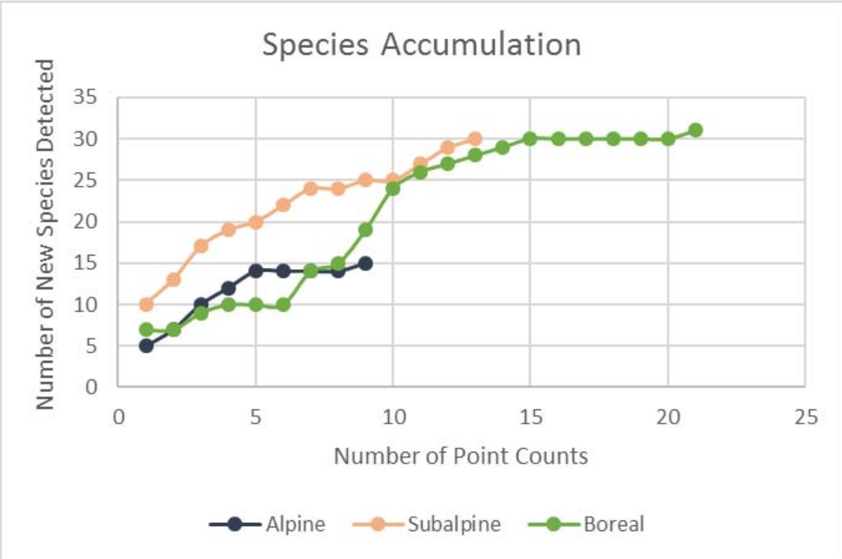
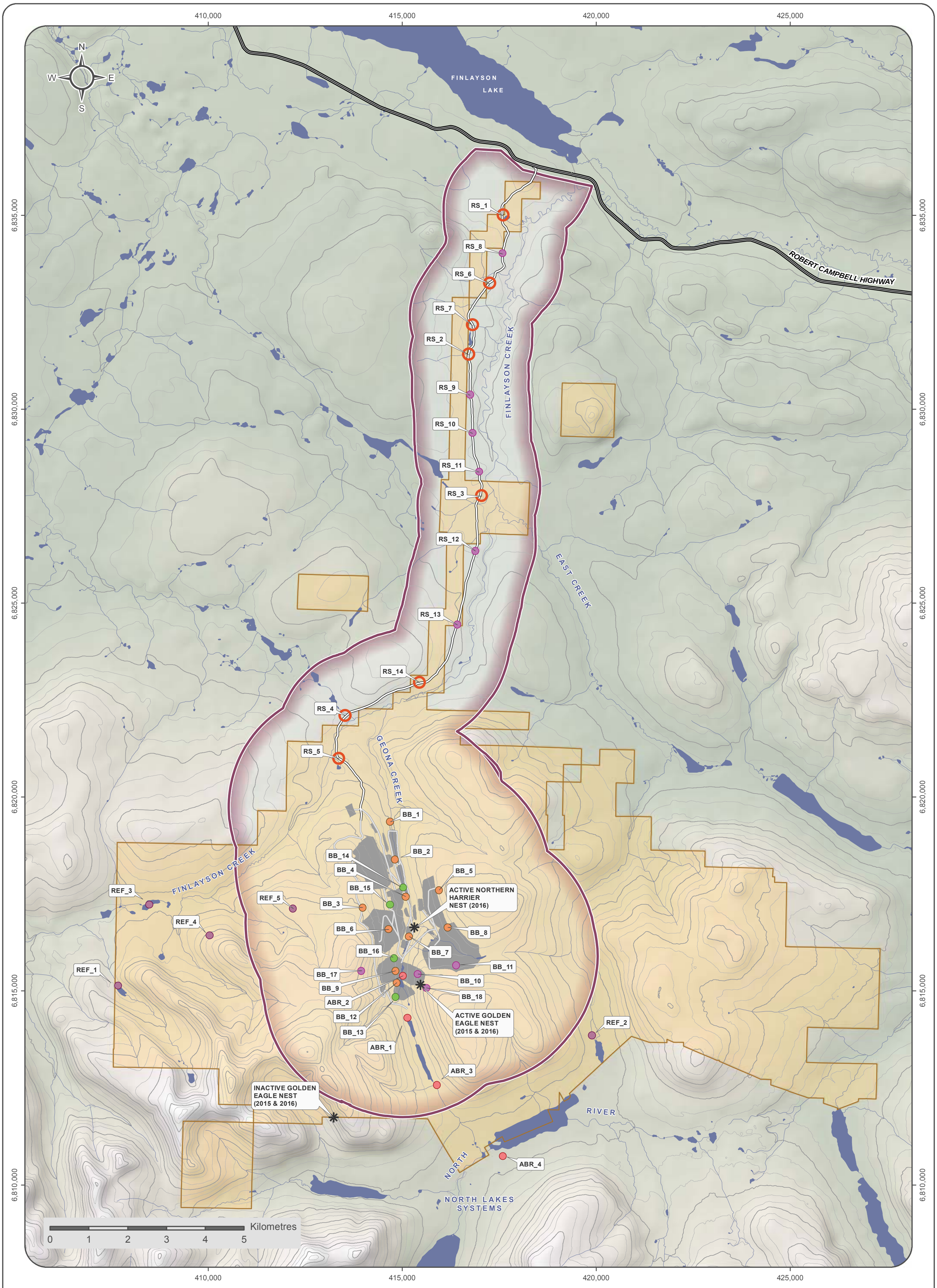


Figure 13-1: Species Accumulation from Surveys in the Project Area by Bioclimate Zone

R177

"Clarify the inconsistencies in the sections on passerine surveys (refer to the list of examples, above). Are survey data for 2016 available?"

BMC recognizes that there were a number of inconsistencies that occurred between the text and data. Figure 13-2 (below), Bird Survey Locations, has been updated from Figure 13-1 in the Wildlife Baseline Report, Appendix E-8 (to include all point count locations from the 2015 and 2016 surveys).



- Breeding Bird Survey (2015-2016)
- Breeding Bird Survey (2015)
- Breeding Bird Survey (2016)
- Bird Habitat Potential
- Wetland Survey Location
- Tote Road Survey Location
- Raptor Nest
- Tote Road/Proposed Access Road
- Proposed Mine Road
- Contour (40 m interval)
- Local Study
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Mineral Claim Areas

BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 13-2
BIRD SITE SURVEY LOCATIONS
2015-2016

Datum: NAD 83; Projection: UTM Zone 9N

AEG

JUNE 2017

D:\Project\AllProjects\Kudz_Ze_Kayah\Maps\03_Study\Wildlife\Small_Mammals_Birds\08-Baseline_Report\Bird\2015_2016\BirdSurvey_2015-2016_20170627.mxd (*Last edited by: amatlashevska; 27/06/2017/09:26 AM*)

In Appendix F of the Wildlife baseline Report (Appendix E-8 of the Project Proposal), the 2016 survey results were omitted. Therefore, the results from each point count survey and graphs summarizing numbers of individuals and species richness by habitat are included in this Response Document as **Appendix 5** (Table A5-1 to Table A5-4 and Figure A5-1 to Figure A5-7). For clarification, there are a total of 18 sites near the Project infrastructure (denoted BB), 14 sites along the road (denoted RS), four wetland sites (denoted ABR), and five reference sites (donated REF). Not all sites were surveyed in both years. Table 13-1 from the Wildlife Baseline Report, Appendix E-8, is revised below (in Table 13-2) to correct the number of sites surveyed and species counts during the 2015 and 2016 surveys. All survey sites along the Tote Road are now recorded as boreal forest habitat.

The inconsistencies do not change the results of the effects assessment or the mitigation planning.

Table 13-2: Summary of Passerine Survey Data for all Point-Count Sites in 2015 and 2016

Habitat Type	# of sites		# of species		average # species per site	
	2015	2016	2015	2016	2015	2016
Wetland	4	4	17	24	9.0	6.7
Subalpine Riparian	5	4	19	17	7.8	7.0
Boreal Forest	7	14	14	26	2.6	6.0
Subalpine	8	5	24	15	8.3	6.4
Alpine	3	5	10	13	5.3	3.3

R178

"Provide a summary of relative abundance of species by habitat type, based on the point count surveys. If there were habitat types that supported a higher proportion of detections, these habitat types could be identified as important for passerines and mitigations around protecting the habitat types could be developed."

Table 13-3 below summarizes species detected in 2015 and 2016 from most to least abundant (unadjusted). Table 13-4 then presents indices of species richness, evenness, and diversity calculated for each broad habitat type of alpine, subalpine, boreal, riparian, and wetland for 2015 and 2016. The least number of species were found in alpine habitats. Species were distributed evenly in each habitat with little dominance by any one species, with the exception of wetland habitats where aggregating waterfowl (in this case *Scaup sp.*) resulted in a lower evenness index. Diversity was relatively high in all habitats for the sample area. For background, the Shannon diversity index is logarithmic and will approach 7 when there are hundreds of species present; the Simpson diversity index ranges from 0 at infinite diversity to 1 with no diversity.

Table 13-3: Species Detected by Decreasing Abundance at Kudz Ze Kayah

Species	# Detected in 2015	# Detected in 2016	Total #		Species	# Detected in 2015	# Detected in 2016	Total #
Scaup species	50	60	110		Chipping Sparrow	2	2	4
White-crowned Sparrow	38	31	69		Common Loon	3	1	4
American Tree Sparrow	30	30	60		Violet-green Swallow	4	0	4
Wilson's Warbler	21	18	39		Orange-crowned Warbler	0	3	3
Dark-eyed Junco	8	20	28		Say's Phoebe	2	1	3
American Robin	8	19	27		Bank Swallow	0	2	2
Gray-cheeked Thrush	5	16	21		Barn Swallow	0	2	2
Yellow Warbler	17	1	18		Canada Goose	0	2	2
Blackpoll Warbler	6	11	17		Gold-crowned Sparrow	0	2	2
Savannah Sparrow	4	13	17		Golden Eagle	0	2	2
Ruby-crowned Kinglet	5	9	14		Northern Flicker	0	2	2
Common Redpoll	4	10	14		Pine Grosbeak	0	2	2
Lesser Yellowlegs	7	7	14		Swainson's Thrush	0	2	2
Red-necked Phalarope	4	10	14		Townsend's Solitaire	0	2	2
Gray Jay	2	11	13		Horned Lark	1	1	2
Spotted Sandpiper	4	9	13		Northern Harrier	1	1	2
Lincoln's Sparrow	8	4	12		Solitary Sandpiper	1	1	2
Olive-sided Flycatcher	4	8	12		Black-capped Chickadee	2	0	2
Common Yellowthroat	5	7	12		Northern Waterthrush	2	0	2
Alder Flycatcher	7	5	12		Rusty Blackbird	2	0	2
Green-winged Teal	0	11	11		Bonaparte's Gull	0	1	1
Common Goldeneye	0	10	10		Bufflehead	0	1	1
Willow Ptarmigan	3	7	10		Common Raven	0	1	1
Yellow-rumped Warbler	4	6	10		Hermit Thrush	0	1	1
Fox Sparrow	3	6	9		Northern Pintail	0	1	1
Mallard	0	9	9		Red-breasted Merganser	0	1	1

Species	# Detected in 2015	# Detected in 2016	Total #		Species	# Detected in 2015	# Detected in 2016	Total #
Tree Swallow	4	4	8		Yellow-bellied Flycatcher	0	1	1
Barrow's Goldeneye	3	4	7		Spruce Grouse	1	0	1
Semi-palmated Plover	1	6	7		Mew Gull	1	0	1
Northern Shrike	4	2	6		Tennessee Warbler	1	0	1
Boreal Chickadee	0	5	5		Red-winged Blackbird	1	0	1
Bohemian Waxwing	0	4	4					

Table 13-4: Bird Species Richness, Evenness, and Diversity by Habitat

	Alpine	Subalpine	Boreal	Subalpine Riparian	Wetlands
2015					
Species Richness	10	24	14	20	17
Evenness	0.95	0.91	0.95	0.87	0.75
Shannon Diversity (H)	2.18	2.88	2.50	2.61	2.14
Simpson Diversity (D)	0.13	0.07	0.09	0.11	0.21
2016					
Species Richness	13	15	26	17	24
Evenness	0.87	0.89	0.90	0.91	0.79
Shannon Diversity (H)	2.24	2.41	2.93	2.57	2.52
Simpson Diversity (D)	0.14	0.11	0.07	0.10	0.15

The similarity between habitat types was also assessed and summarized with the Bray-Curtis distance index which is the complement to percent similarity of two populations, and the Jaccard coefficient of similarity (Sj = number of common species/total number of species in both habitats). The indices of similarity are summarized in Table 13-5 below. The species composition shows low similarity between the alpine, subalpine, boreal, and wetland habitats. The results do not change the effects assessment or indicate a need for any changes in mitigation strategies. Results will be used to refine the ongoing monitoring program.

Table 13-5: Bird Species Similarity Between Habitats

	Habitat Comparison	Bray-Curtis Distance	Jaccard Coefficient
2015			
	Subalpine - Alpine	0.70	0.36
	Subalpine - Boreal	0.73	0.36

	Habitat Comparison	Bray-Curtis Distance	Jaccard Coefficient
	Subalpine - Wetland	0.62	0.41
	Subalpine - Subalpine Riparian	0.38	0.41
	Riparian - Wetland	0.61	0.27
	Alpine - Boreal	0.82	0.20
2016			
	Subalpine - Alpine	0.60	0.33
	Subalpine - Boreal	0.71	0.28
	Subalpine - Wetland	0.74	0.27
	Subalpine - Subalpine Riparian	0.41	0.52
	Riparian - Wetland	0.75	0.29
	Alpine - Boreal	0.67	0.18

YESAB ISSUE

As noted in Chapter 5, Section 5.1 (effects assessment approach), the existing conditions should be described in enough detail to provide the benchmark against which the project effects will be evaluated. Given this approach, it is important that an adequate baseline assessment is completed, including providing detailed description of methods and results. Consistency with methods and results is important to provide a reliable baseline review.

R178A

"Provide a complete description of survey methods, including survey effort; survey frequency; protocols used; and dates, duration and linear distance of waterfowl/shorebird surveys. What is the rationale for using 5-minute point count stations?"

The waterfowl survey methods are described in Section 13.3.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. The objective of the waterfowl survey was to identify and create an inventory of bird species in the Project area. The methodology used to survey the wetlands consisted of either a walk around the wetland or a scan of the wetland surface area using binoculars and a spotting scope, as well as a 5-minute point-count at each wetland following the Breeding Bird Survey methodology used for passerines. This is a modification of the North American Breeding Bird Survey (BBS) 3-minute methodology used by the Canadian Wildlife Service and United States Geological Survey (USGS, 2001; Environment and Climate Change Canada, 2016).

R178B

"Provide a summary of species detected per wetland and year and ensure that Table 13-2 is complete? What are the results from the 2015 survey?"

The waterfowl species detected at the Project are presented in text in Section 13.4.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. Species counts from the 2015 survey are included in Appendix F of the Wildlife Baseline Report. Species counts from the 2016 survey are included here in **Appendix 5** of this Response Report. Table 13-2 in the Project Proposal includes the observed behaviour of aquatic bird species in 2016. Behavioural observations were not recorded in 2015 and therefore there were no 2015 survey results to be presented in Table 13-2. A summary description of species detected per wetland and year is presented below.

A total of 20 species of waterfowl and other aquatic birds were observed during the surveys conducted in 2015 and 2016. This included seven species of duck, seven shorebird, three gull, one loon, one swan, and one goose species. Predominant waterfowl using the wetlands within the LSA and reference wetlands were scaup (*Aythya spp.*; at ABR_1, ABR_2, ABR_3) and goldeneye (*Bucephala spp.*; at ABR_1). Other waterfowl include green-winged teal (*Anas crecca*; at ABR_1, ABR_2), northern pintail (*Anas acuta*; ABR_1, ABR_3), mallard (at pond on Tote Road near the highway), bufflehead (*Bucephala albeola*; at a reference site), and red-breasted merganser (*Mergus serrator*; ABR_2). Waterfowl nesting on the wetlands within the LSA include mallard, green-winged teal, and northern pintail. Waterfowl nesting on the reference wetlands outside the LSA include goldeneye, scaup, and an unidentified dabbling duck. Trumpeter swans were observed in 2015 and 2016 on reference wetlands outside the LSA. It is assumed they are nesting on those wetlands given their defensive behaviour and the timing of observations. In addition, two juvenile trumpeter swans were observed with adults at the east end of North Lakes (not in the LSA) on July 10 and August 1, 2015.

Seven species of shorebird were observed within the LSA, including spotted sandpiper (*Actitis macularius*; at ABR_1, ABR_2, ABR_3), semipalmated plover (*Charadrius semipalmatus*; at ABR_1, ABR_2, ABR_3), lesser yellowlegs (*Tringa flavipes*; at ABR_1, ABR_2, ABR_3), solitary sandpiper (*Tringa solitaria*; at ABR_2), least sandpiper (*Calidris minutilla*), American golden-plover (*Pluvialis dominica*) and red-necked phalarope (*Phalaropus lobatus*).

YESAB ISSUE

Since habitat suitability mapping is utilized to define change in suitable habitat in the effects assessment, with the magnitude of the effect tied to this assessment, an accurate and validated habitat suitability model is an important component of the baseline assessment.

The habitat suitability modelling exercise should include a clear description of model assumptions, validation, reliability, and the incorporation of zones of influence, as appropriate. If the effects assessment, as is the case here, applies a fixed buffer to suitable habitat, in lieu of zones of influence for the modelling exercise, to account for indirect habitat loss, this should be noted in the baseline assessment.

R179

"Provide information on model assumptions, validation, reliability and zones of influence for the three habitat suitability maps for birds."

The descriptions of the habitat suitability models for olive-sided flycatcher, waterfowl, and cliff-nesting raptors are presented in Sections 13.5.1, 13.5.2, and 13.5.3 of the Wildlife Baseline Report (Appendix E-8 of the Project Proposal). The models used the Terrestrial Ecosystem Map (TEM) to determine where breeding habitat was located assuming preferred habitats for each species or group of species.

Model assumptions are captured in the criteria for each group as described and summarized in each table (repeated below). Olive-sided flycatcher is a migratory bird that comes to the Yukon for nesting and feeding prior to migrating south for the winter. Olive-sided flycatcher nest at the edges of mature and old growth forests. Open areas may be forest clearings, forest edges located near natural openings, burned forest or openings within old-growth forest stands. Tall, live trees or snags for perching are associated with mature trees and large dead trees (i.e., structural stage 6, 7). Generally, forest habitat is either coniferous or mixed wood. In the boreal forest, suitable habitat is more likely to be in or near wetland areas (COSEWIC, 2007b).

Table 13-6: Species Accumulation from Surveys in the Project Area by Bioclimate Zone

Suitability Rank	Structural Stage	Bioclimate Subzone	Watercourses
High	Leading ecosite >=50% structural stage 6 or 7	Boreal High-Boreal Subalpine	<500 m from waterbody
Medium	Leading ecosite >=50% structural stage 6 or 7	Boreal High- Boreal Subalpine	>500 m from waterbody
Low	Everything else	Boreal High- Boreal Subalpine	Everything else

Highly suitable waterfowl habitat was defined as any habitat type within 100 m of a water body (i.e., wetland and creek), including the water body itself. Moderately suitable waterfowl habitat was defined as any habitat type within 100 to 200 m from a waterbody. Low suitable waterfowl habitat was defined as all other habitat that does not meet the high or moderate ranking. These suitability rankings for preferred waterfowl habitat were based on data from Hickie (1985), which states that most nests in or near wetlands occur within 100 m of water.

Table 13-7: Waterfowl Habitat Suitability Criteria

Suitability Rank	Wetland Type	Nesting Area Around Wetland
High	Wetland / creeks	100 m
Medium	Wetland / creeks	100-200 m
Low	Everything else	All other

Highly suitable cliff-nesting raptor habitat was defined as any habitat that displayed a slope greater than 30° and was at an elevation greater than 1,300 masl. Moderately suitable cliff-nesting raptor habitat was defined as any habitat that displayed a slope between 15° and 30° and was at an elevation greater than 1,300 masl. Low suitability cliff-nesting raptor habitat was defined as any habitat that displayed a slope between 0° and 15° and covered all ranges of elevation. The parameters for suitability rankings for preferred cliff-nesting raptor habitat were based on a known preference for cliff-nesting raptors to select nest sites on steep rock faces or rocky outcrops, as well as reviewing actual nest site locations around the Project site.

Table 13-8: Cliff-nesting Raptors Habitat Suitability Criteria (above 1,300 masl)

Suitability Rank	Slope (degrees)
High	>30
Medium	15-30
Low	<15

Each model used detections from the bird surveys as a simple validation of the predicted areas of suitable habitat. The objective of the modelling is to provide a visual representation of the distribution of predictive suitable habitat and quantitative assessment based on the known TEM for site and the literature. The model has a moderate reliability based on the definitions in the 1999 BC Wildlife Habitat Rating Standards, (i.e., *Moderate Reliability. Available information is based mainly on studies, reports and expertise on the species-habitat relationships gained within British Columbia. Some information from ecosystems in the study area, but mostly extrapolated from similar ecosystems. No verification or limited verification has been done*).

For the zone of influence, the modelling was completed for baseline conditions with direct loss predictions quantified as the ultimate footprint of the Project and indirect loss based on a 50% reduction for the 300 m buffer around the Project footprint. This level of quantifying habitat loss from the Project was considered appropriate for the level of information and uncertainties. Additional modeling for different stages of the Project would unlikely change the magnitude of the effects assessment or the mitigation and management plans.

Note that three bird groupings were assessed to determine the general level of magnitude of effects on birds in general and determine overall mitigations. Species-specific details (highlighting species of conservation concern) will be included in the final Wildlife Protection Plan. Unforeseen effects detected by ongoing monitoring will be managed through application of the Adaptive Management Plan.

R180

"For the olive-side flycatcher map, is this for breeding habitat? Can you provide a more thorough literature review to support the assessment?"

The olive-sided flycatcher comes to Yukon for nesting and feeding prior to migrating south for the winter and the map is for all life requisites during this time (i.e. breeding). The COSEWIC 2007 reference used in Section 13.5.1 and Figure 13-2, Olive-sided Flycatcher Habitat Suitability Map, contained in the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, is already based on an extensive literature search. Two further references were found that further supports the description and criteria chosen in Section 13.5.1. The preferred breeding habitat for olive-sided flycatchers are conifer or mixed-conifer forests with open canopies and at mid-high elevations (Shuford and Gardali, 2008). Olive-sided flycatchers prefer to use spruce and fir trees as nesting substrate, because their branching and leafing structure is suitable for the types of woven nests that they use (Robertson and Hutto, 2006). Therefore, Boreal High and/or Boreal Subalpine are the most suitable bioclimate subzone and mature and/or old forests are more suitable for the olive-sided flycatcher.

R181

"For the waterfowl map, what species (or groups of species) does the habitat suitability represent? Can you provide a more thorough literature review to support the assessment?"

The waterfowl map, Figure 13-3 Waterfowl Habitat Suitability (Appendix E-8 of the Project Proposal) represents the waterfowl species that occurred at and around the Project area in 2015 and 2016 including Barrow's goldeneye, bufflehead, common loon, green-winged teal, mallard, red-breasted merganser, greater and lesser scaup, and trumpeter swan.

The description and criteria chosen in Section 13.5.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, defined wetlands within 100 m of a waterbody as highly suitable and wetlands between 100-200 m as moderately suitable for all waterfowl species identified. This is supported by additional literature. Waterfowl is a broad grouping and therefore waterfowl habitat suitability is also broad. The most important habitat requirement for waterfowl is access to shallow waters (Hickie, 1985). These waters produce high numbers of small aquatic invertebrates and form a high-quality diet for egg-laying females and actively growing young. Waterfowl may nest in water, on the edge of water, or near water (Hickie, 1985). Because of their affinity to water, waterfowl are unlikely to nest where there is no source of water nearby. Additional literature has found that the green-winged teal, mallard, greater, and lesser scaup all commonly use wetlands as their preferred habitat (Stralberg et. al, 2011). According to *The Birds of North America* (Rodewald (Ed.), 2017), all of the identified waterfowl will nest near water.

R182

"For the raptor map, provide a more thorough literature review to support the modelled criteria for cliff-nesting raptor habitat suitability? Which raptors is the model developed for?"

Section 13.5.3 and Figure 13-4 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, presents a description, summary and map of habitat suitability criteria for cliff-nesting raptors. The cliff-nesting species that have been identified to occur at the Project based on the 2015 and 2016 studies and wildlife log include gyrfalcons, golden eagles, and peregrine falcons. Literature has confirmed that these species of raptors typically nest in cliffs (Richardson and Miller, 1997; Poole and Bromley, 1988). Literature of a study undertaken in the Northwest Territories found that golden eagles, which nest the highest of the species, had an average nest height of 13 m on cliffs that average 22.8 m tall; peregrine falcons, which nest the lowest of the four species, had an average nest height of 9.7 m on cliffs that average 16.5 m tall (Poole and Bromley, 1988). Section 13.5.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, states that slopes >30^0 are highly suitable for cliff-nesting raptors and cliffs 15-30^0 are moderately suitable for raptors. These criteria are further supported by Romin and Muck (2002), where cliff-nesting raptor species will prefer wider, deeper and more stable crevices and cliff ledges. These cliff ledges are more probable on steeper slopes. The slope angle categories for defining cliff habitat were based on observed landscape features for various slopes and actual nesting in the Project area.

13.1 CARIBOU

YESAB ISSUE

The proposal does not adequately address all effects to caribou because key aspects of caribou ecology have not been discussed and included in the effects assessment and mitigation measures. Further discussion on each sub-point is available in the SLR technical memo.

R183

"Provide additional information on project interactions and effects with caribou in the context of each of the following parameters:

a. Migration

b. Predator/prey dynamics

c. Predator efficiency

d. Displacement

e. Calving habitat and neonatal calf mortality

f. Snow patches

g. Influence of fidelity to seasonally used areas

h. Population decline and caribou distribution

i. 'Range rotation' and increase in Finlayson Lake use during some seasons

For topics a) through d) listed above, consider also the indirect effects of the Project. For topics e) through i) listed above, provide information that will help determine how significant this geographic area is with respect to caribou population dynamics, rather than just to habitat suitability."

BMC appreciates the importance of the potential direct and indirect effects of the Project on the Finlayson Caribou Herd (FCH). BMC's baseline studies, habitat modelling, and effects assessment on FCH were led by Rick Farnell who is a Yukon expert on the FCH. Mr. Farnell was Environment Yukon's caribou biologist from 1978 to 2006 and authored many publications on caribou including the 2009 publication, *Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management*. Mr. Farnell continues to conduct surveys and consults on caribou in Yukon. The effects assessment focused on the key potential effects based on Mr. Farnell's extensive experience on factors affecting the FCH.

a. Migration

Use of specific migration paths in the study area are not presented because they are unknown at this time. Providing observations at this level would require intense study (camera traps, high intensity aerial survey, frequent track counts, etc.) beyond the scope of environmental assessment studies and would be unprecedented. Much more specific migration path data in relation to the Project area will become available during the operational phase of the Project. Large scale migratory use of the area is clearly evident from range use maps that are provided in Chapter 3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. Detailed use by individuals and groups of caribou remains indefinable.

b. Predator/prey Dynamics

It is agreed that distribution and abundance of significant predators and prey and how this relates to caribou is a significant component of caribou population dynamics. It is also agreed that shifts in the predator/prey system can lead to caribou population declines. Any shifts in predator/prey relationships should be closely monitored by responsible wildlife agencies to determine not only proximate but also ultimate causes of population declines.

c. Predator Efficiency

It is fully acknowledged that linear features can result in increased predator efficiency (most notably, for wolves), which can lead to increased predation risk to caribou. Use of the road by wolves during winters is documented by aerial surveys. The road, which was built in the late 1990s would have resulted in easier access and hunting efficiency by wolves. The access road is the single linear movement corridor which will be used by the Project. During the operational phase, increased traffic intensity may deter wolves from using the road.

d. Displacement into Areas of Higher Mortality Risk

It is fully acknowledged and agreed that caribou behaviour (seasonal habitat use, range use) is largely influenced by predator avoidance. Therefore, displacing the caribou could result in increased mortality risk. For example, an impact of concern from oil and gas development on the caribou herds in northern Yukon and Alaska was increased mortality from shifting/displacing the herd from the coastal plain calving grounds to the foothills where there are more predators and less suitable forage (Griffith et al, 2002). It should be noted however that the FCH occurs at low density compared to previous numbers and has ample alternate range in which to disperse. Furthermore, the FCH does not have a key critical range outside of winter range such as the Porcupine caribou herds calving grounds in Alaska. The Project affects a small portion of the FCH winter range.

e. Calving Habitat and Neonatal Calf Mortality

It is acknowledged that neonatal calf mortality is one of the most significant components of caribou population dynamics. It is well known that woodland caribou are widely dispersed during calving as an anti-predation tactic and 50% mortality of calves by predation is normal during their first 10 days of life. The calving period for Yukon caribou extends from approximately May 6th to June 6th with a peak around May 16th. From Mr. Farnell's considerable personal experience studying this possibility, it became evident that caribou are so efficient at calving dispersal that biologists presently do not have a way to evaluate neonatal calf mortality. Unfortunately at present there is no way to answer this concern.

f. Snow Patches

It is acknowledged that snow patches were identified as important for avoiding insect harassment but there is no information about key snow patches in the study area or effects and measures to mitigate project disturbance in these areas. Snow patches are an important habitat for caribou in summer. Climatic evidence has shown they are diminishing. A comparison can be made between the post-calving locations and locations of snow patches that can be seen on Google Earth and the post-calving locations are essentially equivalent to the locations of snow patches. In the LSA, snow patches are mainly on the ridges west of the proposed mine infrastructure and occasionally on the mountain to the east. Therefore, the degree that the Project interferes with snow patches would be equivalent to the habitat loss calculation for the post-calving assessment (i.e. 1.8% loss of highly suitable post calving habitat in the regional post calving study area).

The elevation of the snow patches may provide an indication of their longevity with climate change. The snow patches just west of the mine are around 1800 m elevation and located about 1.8 km from the centre of the mine infrastructure so there is a high likelihood that these patches will be abandoned during the construction and operations phases. Throughout the regional range, the snow patches appear to range from 1600 to 2150 m elevation. With climate change, the snow patches around the Project are unlikely to be the first to go, but unlikely to be the last either.

Mitigations to minimize caribou disturbance are already included in Section 18.7.3 of the Project Proposal for employees and equipment to remain within Project boundaries and in Section 18.10.3 for noise reduction measures. The post-calving monitoring program will be modified to take GPS locations and pictures of the boundaries of a number of reference snow patches to help track snow patch changes over time.

g. Influence of Fidelity to Seasonally Used Areas

It is acknowledged there is concern that caribou tend to show high fidelity to calving areas and to some rutting areas (meaning that they tend to return to the same areas year after year). This can mean that the potential loss of areas with consistent use and consistently higher calf survival may be of more significance than calculating a percentage loss of habitat would indicate. Fidelity to specific calving sites by cows has been documented in the FCH and elsewhere to a very low degree of prevalence. Fidelity to larger range use patterns such as rutting areas is far more prominent as reported. Clearly the FCH has traditional rutting areas during normal years – with some annual shifts in abundance. Disparity in calf survival between large, geographically separate rutting areas is well documented. Over the years higher calf survival by the rutting season has been documented for ranges north of the Robert Campbell Highway, while lower survival has been documented south of the highway and is supported by years of data. This is generally where two-thirds of the herd have traditionally ranged and the location of the Project area. The fidelity to rutting range may mean that caribou take longer than anticipated to return to local rutting habitat post-closure.

h. Influence of the Observed Finlayson Caribou Population Decline

It is acknowledged that when caribou populations decline, their distribution generally contracts and that may influence potential effects from the Project. Withdrawal of range use coincident with decline in population size has been well document for the more widespread arctic and interior Alaska caribou herds. However, this is so clear for woodland caribou, particularly in Yukon. Extirpation from an entire range of woodland caribou populations is well documented elsewhere, however experience shows that Yukon woodland caribou go through substantial population size shifts without losing or gaining home range. There are no anticipated changes in range use for the FCH as a result of density.

i. Influence of 'Range Rotation' During Winter

It is understood that there are concerns that the Finlayson Lake area may see more use from caribou than expected with climate change. Elements of the FCH made use of the Finlayson Lake area, often interacting with the lower access road, during the low snowfall years of both 2007 and 2016. Large numbers were also found here during the 2017 late winter ungulate survey. There is considerable uncertainty on what local changes on snowpack will take place with climate change and in what time frame. All winter range will be considered extremely important and management planning will include mitigation measures for wintering caribou in all years. The Robert Campbell Highway and Finlayson Lake airstrip are public lands. It is not clear how the proponent can influence their uses.

YESAB ISSUE

The proponent developed HSI models for the Finlayson Caribou Herd for the rut and post calving periods, but not for late winter habitat. Finlayson Caribou are known to use the area during the late winter season.

R184

"Provide a late winter habitat suitability index (HSI) model to assess direct and indirect effects on late winter caribou habitat."

Late winter habitat is recognized as an important season for the Finlayson Caribou Herd. For caribou, the rut, post calving, and late winter surveys were conducted to align with long-term government surveys. The rut and post-calving periods were chosen to model habitat suitability for caribou for the KZK Project since these were the most sensitive life stages that overlap with the Project footprint. This approach was presented and agreed to with Environment Yukon and the regional biologist in 2015.

Recent surveys have shown that more caribou make use of area around the lower access road than previously thought during winter. The late winter caribou distribution was presented in Figure 3-7 of the *Wildlife Baseline Report*, Appendix E-8 of the Project Proposal. There is merit in evaluating caribou interaction with project activities during late winter. However, rather than plotting vegetation cover, landscape features, and snow cover variables, actual late winter distribution of caribou was available and is more indicative of actual habitat suitability rather than a predictive model. Rather than developing a late winter HSI model, the data draws on the benefit of having thousands of animal location data from six intensive winter range population estimate surveys. These provide precise use of habitat since 1984 over a range of population densities. Thus we used the data to determine total range used by caribou over decades relative to area that could potentially be affected by the project.

Finlayson Caribou Herd, Late Winter Observations, shows late winter caribou distribution from the KZK 2015 to 2017 studies as well as previous government-led late winter surveys of the herd from 1982 to1984, 1986, 1990, 1996, 1999, and 2007. These distributions show the heart of the FCH late winter range to be in the Pelly lowlands with extensions east out to the lowlands south of Finlayson Lake. The distributions show where snow depths and access to lichen are preferred which appears to vary from year to year, possibly with variability in snow depth; however, there is insufficient data to determine a correlation.

The winter distribution is discussed in Section 13.3.1 of the Project Proposal and the reader was referred to Appendix E-8 for more detail. The focus of the FCH effects assessment in Section 13.4.1 of the Project Proposal was on the post-calving and rutting areas where the most interactions are expected with the mine. Nonetheless, the assessment in Section 13.4.1.1 addresses the winter period and states, *"There is also expected to be interaction with caribou along the Access Road along Geona Creek during the post rut/early winter period as caribou move from adjacent alpine rutting grounds to their lowland winter range along the Pelly River. Interactions are also expected in the winter range of the Pelly River lowlands with scheduled flights and activity at the Finlayson Lake airstrip."*

Further in Section 13.4.1.1, there is discussion of Project interactions and the impacts on movement patterns and mortality risk with the wintering range and caribou movement from the rutting grounds to late winter ranges. The mitigation and management plans include no hunting policy, traffic controls, access control, emergency egress, snow management, and minimizing barriers to minimize these effects on caribou movement to, movement from, and use in the late winter range.

YESAB ISSUE

The caribou effects assessment seems to be based largely on percentage of habitat disturbed. This overlooks aspects of caribou ecology and potential stressors which could influence the outcome of the effects assessment for caribou.

R185

"Revise the caribou effects assessment, taking into consideration the significance of factors outlined below. Focus on caribou habitat and use related to proposed activities.

a. Rutting areas

b. Traditional use of post-calving areas

c. Snow patch use during post-calving

d. Calving success in the project area vs. the overall range

e. Stressors outside of post-calving season"

a. Rutting areas

FCH range-wide rutting areas are well documented from over 30 years of annual rut counts and during the 2015 and 2016 surveys. Traditional rutting areas are well documented and do occur within the study area and in close proximity to the Project site. This has been stated as such as presented in Section 13.4.1.1 of the Project Proposal and has been a major focus of BMC's wildlife studies and mitigation planning.

b. Traditional Use of Post-calving Areas

As presented in Chapter 3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, seven range-wide post-calving surveys were carried out by YG from 1982 to 1998. The number of caribou found in the FCH range was 270-2108 individuals. BMC carried out post-calving surveys within the Project study area in 2015 and 2016 and found 93 and 145 caribou, respectively. There was no indication that specific areas were traditionally used similar to those found during the rutting period.

c. Snow Patches Use During Post Calving

It is generally held that there are fewer persistent snow patches in the northern Pelly Mountains relative to most other Yukon mountain ranges, likely owing to lower mean elevations in the region. Snow patches are an important habitat for caribou in summer. A comparison can be made between the post-calving locations and locations of snow patches that can be seen on Google Earth. The post-calving locations are essentially equivalent to the locations of snow patches. In the LSA, snow patches are mainly on the ridges west of the proposed mine infrastructure and occasionally on the mountain to the east. Therefore, the degree that the Project interferes with snow patches will be equivalent to the habitat loss calculation for the post-calving assessment (i.e. 1.8% loss of highly suitable post calving habitat in the regional post calving study area).

The elevation of the snow patches may provide an indication of their longevity with climate change. The snow patches just west of the proposed mine infrastructure are around 1,800 m elevation and located about 1.8 km from the centre of the mine infrastructure so there is a high likelihood that these patches will be abandoned during the construction and operations phases. Throughout the regional range, the snow patches appear to range from 1,600 to 2,150 m elevation. With climate change, the snow patches around the Project are unlikely to be the first to go, but unlikely to be the last either.

Mitigations to minimize caribou disturbance are already included in Section 18.7.3 of the Project Proposal for employees and equipment to remain within Project boundaries and in Section 18.10.3 for noise reduction measures. The post-calving monitoring program will be modified to take GPS locations and pictures of the boundaries of a number of reference snow patches to help track snow patch changes over time.

d. Calving Success in the Project Area vs. the Overall Range

Rut count results consistently show a pattern of higher calf survival in ranges north of the Robert Campbell Highway as opposed to those south where generally two-thirds of the herd are found during counts. Disparity in calf survival across rutting areas has been observed for other Yukon woodland caribou herds and seems to be a trait with the FCH as well. Calving success in the Project area compared to the overall range does not affect the results of the effects assessment or the proposed mitigations.

e. Stressors Outside of Post-calving Season

Chapter 3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, and Section 13.4.1.1 Caribou Effects Characterization describe the key stressors and factors affecting the FCH in all seasons. Other stressors beyond those presented do not change the results of the effects assessment or the proposed mitigations.

R186

"Stress effects on health: What are the "stressors" identified in section 13.4.1.1 Project Interactions of the proposal, regarding health effects that occur outside of just the post-calving season?"

The stressors referred to in Section 13.4.1.1 of the Project Proposal include disturbance from activities such as blasting, equipment and vehicle operation, and human presence. These activities can affect the health of the herd with respect to increased energy use on responding to or moving away from the disturbance rather than using the energy on eating, growing, and breeding. It is acknowledged that the stress effects were just discussed for the post calving period, but increased energy use can affect caribou health in other seasons. Section 13.4.1.1 stated, for post calving, that energetic stress can cause the caribou to move to suboptimal habitats and result in increased energy expenditure. The focus was on post-calving, summer habitat since this is the season where there is the most interaction with the Project infrastructure, and as stated, caribou have a limited time span during summer for growth and building new fat reserves for coming winter. It is also stated that negative stimuli from human activities such as aircraft overflight affect body condition of females which in turn affects their probability of becoming pregnant in fall and calf survival the following year (Gerhart, 1995). It is acknowledged that increased stressors and the resulting increase in energy output from the disturbance occurs in other seasons, but the effects were not considered as significant as during the post-calving period. As discussed in the section on aircraft overflights (Section 13.4.1.1 p. 46) which could interact with the FCH winter range, caribou have been known to habituate to regular flights which reduces the effects on energetics.

The recognition of project disturbance stress on other seasons does not change the proposed mitigation measures or results of the effects assessment.

R187

"Traffic effects on other caribou herds: What are the potential effects of increased hauling traffic on other Yukon caribou populations along the haul route between the mine and the boundary with B.C. (Little Rancheria and Horseranch herds)?"

Three alternative haul routes were reviewed during Project design, including a western route through Carmacks to Port of Skagway, and two eastern routes through Watson Lake and then to either Port of Skagway or Port of Stewart. Yukon Government indicated that the western route was not preferred due to the potential traffic impacts on FCH winter range. The eastern routes go along the edge of the Little Rancheria and Horseranch herd ranges and will result in an increase of approximately 26 trucks per day on the small portion of the Alaska Highway between Watson Lake and Upper Liard, and the northern part of Highway 37. The effects of increased traffic from hauling on the Alaska Highway and Highway 37 have not been assessed. There is a significant road collision problem with caribou on the Highways that are managed through signage and advisories (EDI, 2015). The highways are public facilities managed by the Department of Highways and Public Works with inputs from the Department of Environment concerning wildlife issues. BMC does not have the legal authority to manage highway traffic.

YESAB ISSUE

Model methods have not been clearly disclosed. Information on the model methods will enable its adequacy to be evaluated and will assist in interpreting the model outputs.

R188

"Provide further detail on the parameters used in developing the model (elevation, vegetation cover, slope, and aspect.) In addition, provide the following information regarding the caribou habitat suitability model:

a. Sex/age classes: How many data points are in each age/sex class for each of the development and evaluation phases of the caribou HSI model?

b. Calving success and habitat alteration: Why has calving success not been used as part of the model for post-calving? Does the model take into account habitat alteration?

c. Expert opinion: Who provided expert opinion and for what aspects of the model?

d. Predictive Ecosystems Map: What is the accuracy of the PEM used?

e. Model equation: What model equation was used?"

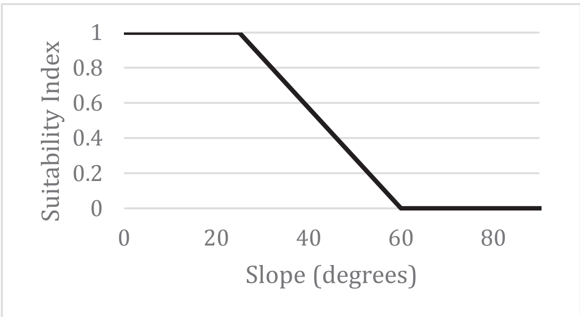
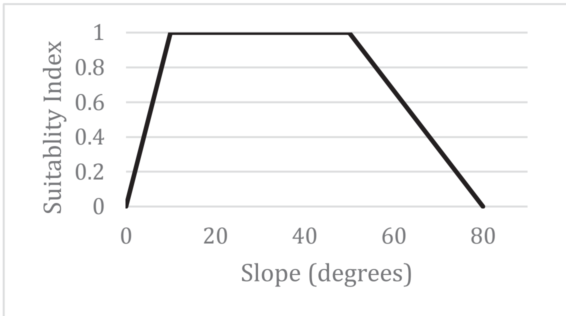
Parameters used to develop the Habitat Suitability model for the FCH are described in detail in Appendix B Caribou Habitat Suitability Report, of Appendix E-8 Wildlife Baseline Report, of the Project Proposal. The discussion on variables is reproduced below.

The four variables: elevation, slope, aspect, and vegetation cover were selected as model parameters to develop the caribou Habitat Suitability Index (HSI) for the rut and post calving seasons. These parameters describe the geographical context for habitat requirements and were the most readily available for assessing habitat suitability for the large range area being assessed. Other parameters such as minimum area, isolation, adjacency, and edge can also be used for suitability mapping (Clarke, 2012); however, the geographical context parameters captured key caribou habitat preferences described in the literature. The data used for model calibration and validation determined whether these four parameters provided an accurate model.

For each season the respective variables were divided into classes ranging from 0 to 1, with 0 representing not suitable habitat (nil) and 1 representing highly suitable habitat (high). The classes within the variable were ranked based on their significance for caribou during the specific season. Significance of each class was determined using the distribution and frequency of observations from the calibration dataset.

Elevation data was interpreted from the 25 m digital elevation model (DEM) and was computed as a continuous variable for the purpose of the HSI. A linear fuzzy membership function was applied to determine the suitability ranking between suitable and not suitable habitat, based on elevation breaks derived from the frequency of occurrences of satellite and relocation data points at a given elevation. Suitable habitat for caribou during the post calving season is at a higher elevation than the rut season as caribou avoid predation, heat, and insects on high elevation ridges and plateaus (Ion and Kershaw, 1989). The equation and function used for post calving and rut seasons are shown in Table 13-9.

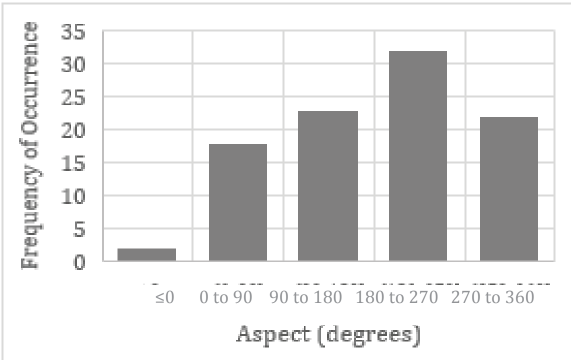
Table 13-9: Equation and Function Used for Post calving and Rut Seasons

Caribou Rut Season	Caribou Post Calving Season
Slope linear function $f(x) = \begin{cases} 0, & x \geq 60 \\ \left(\frac{x-25}{60-25}\right) & 25 < x < 60 \quad x \in X \\ 1, & x \leq 25 \end{cases}$	Lower slope linear function $f(x) = \begin{cases} 0, & x \leq 0 \\ \left(\frac{x-0}{10-0}\right) & 0 < x < 10 \quad x \in X \\ 1, & 10 \leq x \leq 50 \end{cases}$ Upper slope linear function $f(x) = \begin{cases} 0, & x \geq 80 \\ \left(\frac{x-50}{80-50}\right) & 50 < x < 80 \quad x \in X \\ 1, & 10 \leq x \leq 50 \end{cases}$
	

Aspect was derived from the 25 m DEM using the aspect tool in ArcGIS. Aspect was classified into four quadrants of cardinal direction and treated as a discrete variable for the HIS. The satellite and relocation collar data was used to calibrate the aspect variable and provided the distribution shown in Table 13-10. Aspect did not show as strong of a variance between class values and as a result received a lower variable weighting in comparison to the other variables.

Table 13-10: Distribution and Class Ranking for Aspect Suitability

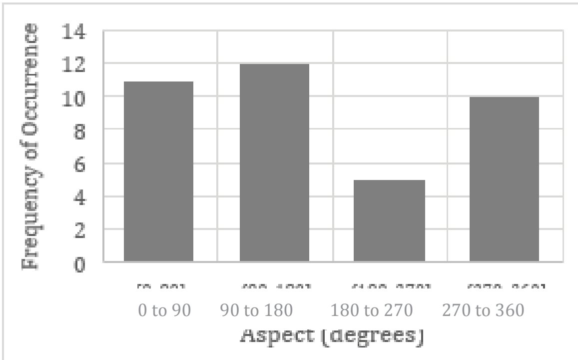
Caribou Rut Season



* x-axis represents range of values within a bin width of 90 degrees

Variable Class	Suitability Index Ranking
0-90	0.5
90-180	0.7
180-270	0.7
270-360	0.5
≤0	0.4

Caribou Post Calving Season



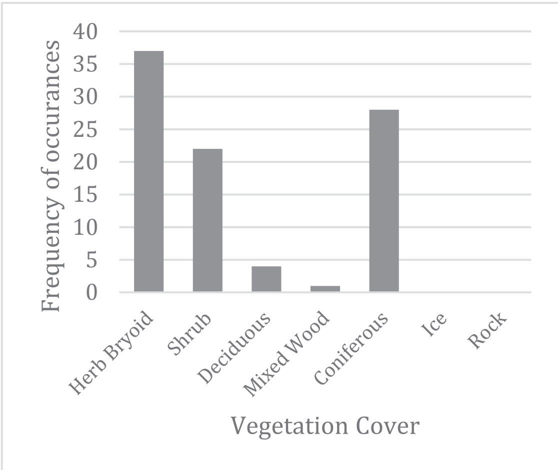
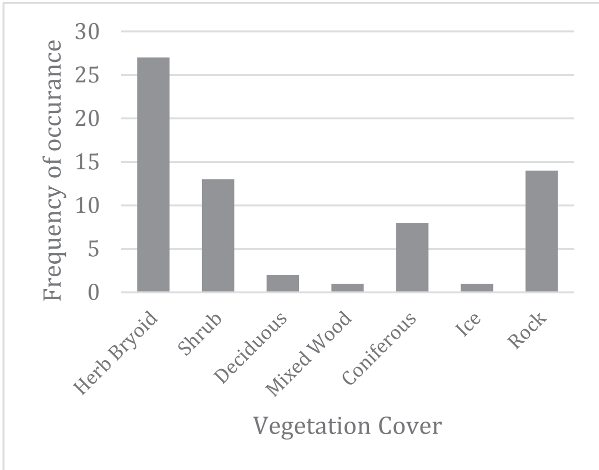
* x-axis represents range of values within a bin width of 90 degrees

Variable Class	Suitability Index Ranking
0-90	0.7
90-180	0.7
180-270	0.2
270-360	0.5
≤0	0.4

Note that <=0 aspect refers to flat ground that does not have an aspect.

Vegetation cover type was classified based on the Regional Ecosystems of *East-Central Yukon Predictive Ecosystem Map* (PEM) that was completed in 2013 by Makonis Consulting Ltd (Grods et al., 2013). The PEM spatial data and methodology was received from Environment Yukon. The PEM product was developed using land cover, surficial material, and base features (watercourses, waterbodies, and elevation) as a means to predict the broad ecosystem units in the defined study area. The final product was evaluated by ground-truthing, polygon interpretation through ecosystem plots measurements, and boundary traverses. The PEM is recommended to be used at a scale of 1:100,000 or smaller (Grods et al., 2013). For the purpose of the model, the PEM was classified into the dominant vegetation cover, not utilizing the landscape classification as these aspects were already addressed in the model. Satellite and relocation data were intersected with the PEM and the suitability index rating was developed based on the data distribution and expert knowledge as shown in Table 13-11.

Table 13-11: Distribution and Class Ranking for Vegetation Cover Suitability

Caribou Rut Season	Caribou Post Calving Season
	

Caribou Rut Season

Variable Class	Suitability Index Ranking
Herb Bryoid	1.0
Shrub	0.8
Deciduous	0
Mixed Wood	0
Coniferous	0.5
Ice	0
Rock	0

Caribou Post Calving Season

Variable Class	Suitability Index Ranking
Herb Bryoid	1.0
Shrub	0.5
Deciduous	0
Mixed Wood	0
Coniferous	0.1
Ice	0
Rock	0.3

a. Sex/age classes: How many data points are in each age/sex class for each of the development and evaluation phases of the caribou HSI model?

BMC does not have the data to provide this information. The age and the sex may be available from YG for the satellite collar location and relocation telemetry data. The breakdown of sex/age classes would not change the results of the effects assessment or the proposed mitigations.

b. Calving success and habitat alteration: Why has calving success not been used as part of the model for post-calving? Does the model take into account habitat alteration?

There is insufficient information about area-specific calving success surrounding the Project and the survey area to be included in the model. Long-term average calf:cow ratios for the FCH are similar to other Yukon caribou herds (Hegel, 2013). Habitat alteration was not considered in the model as the model only assessed baseline habitat suitability.

As presented in Appendix B, Caribou Habitat Suitability Report of Appendix E-8, Wildlife Baseline Report of the Project Proposal, the post-calving habitat model uses elevation, aspect, slope, and vegetation cover variables. The resulting model had a strong correlation (tau correlation coefficient = 1) with the 548 post-calving observations. Therefore, it was determined that no further variables were needed for the model to accurately define suitable post-calving habitat.

c. Expert opinion: Who provided expert opinion and for what aspects of the model?

BMC's baseline studies, habitat modelling, and effects assessment on FCH were led by Rick Farnell who is a Yukon expert on the FCH. Mr. Farnell was Environment Yukon's caribou biologist from 1978 to 2006 and authored many publications on caribou including the 2009 publication, *Three Decades of Caribou Recovery Programs in Yukon: A Paradigm Shift in Wildlife Management*. Mr. Farnell continues to conduct surveys and consult on caribou in Yukon.

d. Predictive Ecosystems Map: What is the accuracy of the PEM used?

As presented in Section 4.6 of Appendix B, Caribou Habitat Suitability Report of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the Regional Ecosystems of East-Central Yukon Predictive Ecosystem Map (PEM) was completed in 2013 by Makonis Consulting Ltd (Grods et al., 2013). The PEM spatial data and methodology was received from Environment Yukon. The final product was evaluated by ground-truthing, polygon interpretation through ecosystem plots measurements, and boundary traverses. The PEM is recommended to be used at a scale of 1:100,000 or smaller (Grods et al., 2013).

e. Model equation: What model equation was used?

The following are the equations used in the models:

Post calving Model: 0.5 * [Elevation] + 0.15 * [Slope] + 0.05 * [Aspect] + 0.3 * [vegetation]

Rut Model: 0.5 * [Elevation] + 0.15 * [Slope] + 0.05 * [Aspect] + 0.3 * [vegetation]

YESAB ISSUE

There are unclear points and inconsistencies in presentation of information which make it difficult to assess adequacy of the model.

R189

"Provide clarity on the inconsistencies detailed below.

a. Model methods and metrics inconsistency: The methods say that "observation density" was used to evaluate the model (p. 18) but the Results section (p.19) reports relationships between

suitability classes and the number of occurrences (rather than the density). Clarify what metric was used to evaluate the model.

The stated number of occurrences in Appendix B, Caribou Habitat Suitability Report of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal was incorrect. Observation density was used to evaluate the model rather than total number of observations as the latter is proportional to the surface area corresponding to each suitability class.

b. Aspect class clarification: Clarify what the aspect class ≤0 is. In what situation would an aspect be <0 degrees?

The dataset used in the model input for aspect is comprised of numbers from 0 to 359 to indicate aspects. The value of "0" is for North, 90 is East, 180 is South, etc. The value of -1 is used to indicate areas that are flat and hence have no aspect.

c. Measure of availability not included: It is useful to look at use, and use in relation to availability, when assessing value of a habitat category. What is the availability of each of the aspect and vegetation cover classes in relation to caribou use?"

Habitat availability was not considered in the model as the model only assessed baseline habitat suitability assuming no development/use. There were no limitations for access to habitats that affect availability in the area modelled for baseline conditions.

As presented in Appendix B, Caribou Habitat Suitability Report of Appendix E-8, Wildlife Baseline Report of the Project Proposal, the post-calving habitat model use elevation, aspect, slope, and vegetation cover variables. The resulting Habitat Suitability (HS) post-calving model had a strong correlation with actual densities (tau correlation coefficient = 1) based on 548 post-calving observations. The rut HS (p-value = 0.0278) suggests a significant correlation between related habitat suitability and actual densities within each class while the strength of the correlation is strong (tau correlation coefficient = 0.7333) based on 2124 rut observations. Therefore, it was determined that no further variables were needed for the model to understand the availability of suitable habitat for the purposes of the effects assessment and mitigation planning.

YESAB ISSUE

The Assessment Endpoint/Threshold Criterion for "Health condition" appears to be an error as it does not address health condition.

R190

What is the Assessment Endpoint/Threshold Criteria for Health condition for caribou?"

The health thresholds for subcomponents Finlayson Caribou Herd, moose, grizzly bear, grey wolf, wolverine, and collared pika should be corrected to qualitative, with no observable deterioration of physical condition. These thresholds were in error in Table 13-3 Wildlife Subcomponents, Measurable Parameters, Threshold Criteria, and Threshold Rationale of the Project Proposal, with table reproduced below with corrected thresholds as Table 13-12.

Table 13-12: Wildlife Subcomponents, Measurable Parameters, Threshold Criteria, and Threshold Rationale

Subcomponents	Measurable Parameters	Assessment Endpoint/Threshold Criteria	Threshold Rationale/Source
Finlayson Caribou Herd	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: <10% change in RSA moderate-high to high suitability rut or post calving habitat Moderate: >10% but <15% change in RSA moderate-high to high suitability rut or post calving habitat High: >15% change in RSA moderate-high to high suitability rut or post calving habitat	Environment Canada (2011); Andrén (1994); Swift and Hannon (2010) Anderson et al (2002)
	Change in wildlife movement Change in population distribution	Qualitative - no barriers to seasonal movement patterns	Professional opinion
	Change in wildlife mortality directly from Project activities (i.e., vehicle collisions and hunting)	No injuries or fatalities (unless required for human safety) directly attributed to the Project	Hegel (2013) BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Moose	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: <10% change in RSA moderate-high to high suitability post rut or late winter habitat Moderate: >10% but <15% change in RSA moderate-high to high suitability post rut or late winter habitat High: >15% change in RSA moderate-high to high suitability post rut or late winter habitat	Environment Canada (2011); Andrén (1994); Swift and Hannon (2010)
	Change in wildlife movement Change in population distribution	Low: road density <0.2 km/km^2 Moderate: road density 0.2 to 0.4 km/km^2 High: road density >0.4 km/km^2	Beyer et al. (2013)
	Change in wildlife mortality directly from Project activities (i.e., vehicle collisions)	No injuries or fatalities (unless required for human safety) directly attributed to Project activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]

Subcomponents	Measurable Parameters	Assessment Endpoint/Threshold Criteria	Threshold Rationale/Source
Grizzly Bear	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: <10% change in RSA moderate to high suitability denning habitat Moderate: >10% but <15% change in RSA moderate to high suitability denning habitat High: >15% change in RSA moderate to high suitability denning habitat	Environment Canada (2011); Andrén (1994); Swift and Hannon (2010) Dykstra (2004) and AXYS (2002)
	Change in wildlife movement and direct disturbance	High: road density >0.6 km/km^2	Beazley et al. (2004) Boulanger and Stenhouse (2014)
	Change in wildlife mortality directly from Project activities (i.e., vehicle collisions, dispatched for human safety)	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Grey Wolf	Prey availability	Low: if moderate rating for loss of suitable habitat either caribou or moose and low for the other, or low for both Moderate: if high rating for loss of suitable habitat either caribou or moose and low for the other, or moderate for both High: if high rating for either loss of suitable habitat caribou and moose and moderate for the other, or high for both	Hayes and Harestad (2000); Farnell (2009)
	Mortality	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Wolverine	Habitat Avoidance	High: road density >0.6 km/km^2	Beazley et al. (2004)
	Mortality	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Collared Pika	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: 0-10% in LSA high suitability habitat Moderate: 10-25% in LSA high suitability habitat High: >25% in LSA high suitability habitat	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]

Subcomponents	Measurable Parameters	Assessment Endpoint/Threshold Criteria	Threshold Rationale/Source
Little Brown Bat	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: 0-10% in LSA high suitability habitat Moderate: 10-25% in LSA high suitability habitat High: >25% in LSA high suitability habitat	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below
	Mortality	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Cliff-Nesting Raptors	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: 0-10% in LSA high suitability habitat Moderate: 10-25% in LSA high suitability habitat High: >25% in LSA high suitability habitat	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Passerine birds (represented by Olive-sided Flycatcher)	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: 0-10% in LSA high suitability habitat Moderate: 10-25% in LSA high suitability habitat High: >25% in LSA high suitability habitat	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below
	Mortality	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Waterfowl	Change in suitable habitat from baseline conditions (including both direct and indirect habitat loss)	Low: 0-10% in LSA high suitability habitat Moderate: 10-25% in LSA high suitability habitat High: >25% in LSA high suitability habitat	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below
	Mortality	No injuries or fatalities (unless required for human safety) directly attributed to mine activity	BMC conservation philosophy[1]
	Health condition	Qualitative. No observable deterioration of physical condition.	BMC conservation philosophy[1]
Bumble bees	Change in available habitat	Low: 0-10% in LSA Moderate: 10-25% High: >25% in LSA	Habitat thresholds for birds and wildlife are determined from work by Swift and Hannon (2010); Andrén (1994); and others – see text below

[1] BMC has a conservation philosophy demonstrated through its environmental, no hunting/no fishing, no firearms, and no feeding of animals policies presented in Appendix A.

YESAB ISSUE

Residual effects to caribou may not be considered fully. Although each individual effect may not be considered significant, the overall (additive) effect of all the effects combined is also important in assessing the impact to caribou.

R191

"Provide additional discussion on the additive effect of all residual effects of the project to caribou."

As presented in Section 13.4.3.1 Caribou, (Residual Effects, Consequence, and Significance Rating) and in Table 13-31 Significance of Residual Effects - Finlayson Caribou Herd in the Project Proposal, effects are low magnitude and local for loss of direct and indirect rut and post-calving habitat, disturbance of movement corridors between the Pelly River lowlands and the alpine areas around the Project, direct mortality from collisions with vehicles, and disturbance from flights using the Finlayson Lake airstrip. When these effects are taken together, caribou could be affected from Project disturbance in most seasons which could cumulatively affect the energetics of some individuals and result in lower birth rates and calf survival. Reduced energetics and displacement could also affect predation rates. However, the northern mountain ecotype has shown plasticity in seasonal habitat use and distributions (COSEWIC, 2014a) so the additive effects are uncertain. Overall, the combined effective habitat loss will still be low magnitude with respect to the herd range. The additional information does not change the proposed mitigations or the results of the assessment.

YESAB ISSUE

The threshold being used for the effects assessment is based on boreal caribou ranges, not an area of northern mountain caribou.

The implication of using a threshold based on a relationship that was not developed for the northern caribou ecotype is that the conclusions drawn about the level of significance of potential adverse effects may be inappropriate. Also, a percentage does not take into account traditional use of areas by caribou, or geographic-specific areas where calving survival may be higher.

R192

"Provide rationale for the use of a 10% threshold, considering other information is available. Clarify how the boreal caribou habitat relationship is applicable to assessing effects on seasonal ranges/habitats for northern mountain caribou. Consider the differences in the use of range and natural disturbances."

Even though there is ample research carried out on boreal caribou, direct reference to northern mountain ecotype is not always applicable. They are ecologically quite different. Boreal caribou are sedentary at low density in lowland habitats with unique life history strategies. Northern mountain caribou are gregarious and use open upland habitats. Both occur as part of very different multi-predator/prey systems. Less is known about northern mountain ecotype – particularly regarding anthropogenic effects.

Nonetheless, the population trends of northern mountain and boreal ecotypes respond similarly to anthropogenic and natural habitat disturbance as shown in the figure below (Figure 2, Anderson et al (2002)) even though their habitat use and life histories differ. This provides some ecological basis for the threshold. However, the 10% threshold for effective habitat change is more of an industrial target and social acceptance threshold as defined by Anderson et al (2002). A threshold needs to be measurable, practical, and realistic for the assessment. Applying a purely ecological threshold would not be practical since it measures when change happens which is too late for mitigation and management measures to be employed. Anderson et al (2002) recommends an effective habitat or zone of influence threshold be considered even though northern mountain caribou populations are limited by predation, forage availability, snow conditions, and insects rather than habitat. These limiting factors are further discussed in Section 13.3.1 Caribou Existing Conditions and Section 13.4.1.1 Caribou Effects Characterization of the Project Proposal.

Habitat thresholds for management of caribou herds with expanding industrial development have not yet been set in Yukon and more data are needed at the regional level to track population trends and causes of change. For the Project Proposal, the measurable, practical, and realistic 10% threshold is conservatively used to assess the habitat magnitude of change.

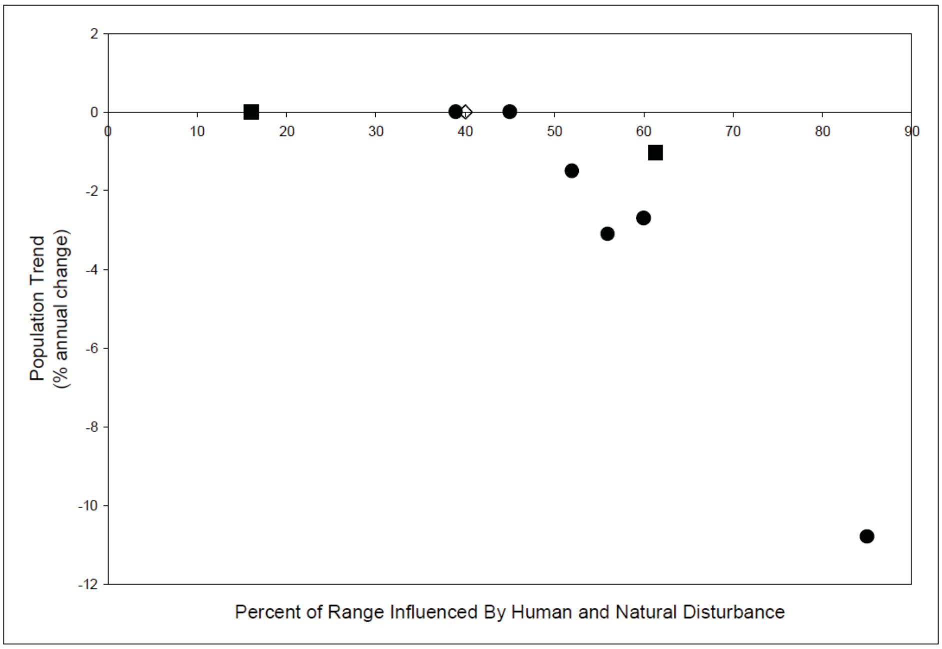


Figure 2. Approximation of woodland caribou habitat disturbance and population rates of change for several herds in western Canada. Data presented for boreal (●) and northern mountain (■) woodland caribou were derived from the Boreal Caribou Committee (2001), Dzus (2001), Florkiewicz et al. (2002), and T. Sorensen (pers. comm.). The datum presented for southern mountain (◇) woodland caribou represents a minimum suitable winter habitat threshold for occupation, as suggested by Simpson et al. (1997).

YESAB ISSUE

Some of the surveys in 2015 and 2016 (and possibly in 1996) appear to have been conducted when exploration activities were occurring. Exploration activities could have affected distribution of caribou during those surveys. The authors do not address how the explorations activities may have affected survey results, which could affect some interpretations.

R193

"Clarify if exploration activities were occurring during surveys and, if so, detail the extent. Discuss how exploration activities may have influenced caribou distribution during these surveys and how this impacts interpretations of survey data."

Exploration activity at the Project area in 2015 included four drills operating from July to early December. In 2016, the camp opened on April 1st. The drilling program ramped up to four drills, one drill at a time from May to July and then scaled back to two drills from mid August to mid October. Drilling may have locally influenced caribou distribution results during the fall rut surveys in 2015 and 2016 and the early winter ungulate survey in 2015; however, there was no discernible change from historical distributions.

It should also be noted that a number of wildlife surveys were carried out when the camp was not operating. Of greater importance, it should also be noted that the outfitter was guiding caribou hunts before and during the 2015 and 2016 fall field season - an activity out of BMC's control. The outfitter has a permanent camp located 12.5 km to the west of the Project site. It is assumed that all large mammal survey areas were large enough to detect species that may have been displaced from human activity so the overall observation numbers and interpretations were not affected.

YESAB ISSUE

If caribou are using the area near Finlayson Lake in deeper snow winters on the main winter range, then it suggests that the area around Finlayson Lake is important when winter conditions may be more limiting. If caribou are using the area during winters of low snow accumulation and lower snow levels are expected due to climate change, we should expect to see more use of the area.

R194

"Discuss the implications of the use of the area around Finlayson Lake during the late winter surveys of 2007 and 2016. Particular focus should be given to the displacement effects of increased traffic on the Robert Campbell Highway and the Finlayson air strip."

Please refer to response to R184. The detailed distribution of the FCH winter range was mapped from six winters of animal location data. Maps of this data are not presented here, at the request of YG. Some caribou may be displaced somewhat to areas further away from the lowlands near the roads and Finlayson Lake airstrip. The area of this key range affected by the Project will be treated as sensitive caribou habitat and management planning will provide the highest mitigation measures practicable.

The winter distribution is discussed in Section 13.3.1 of the Project Proposal and the reader was referred to Appendix E-8 of the Project Proposal for more detail. The focus of the FCH effects assessment in Section 13.4.1 of the Project Proposal was on the post-calving and rutting areas where the most interactions are expected with the Project. Nonetheless, the assessment in Section 13.4.1.1 addresses the winter period and states, “There is also expected to be interaction with caribou along the Access Road along Geona Creek during the post rut/early winter period as caribou move from adjacent alpine rutting grounds to their lowland winter range along the Pelly River. Interactions are also expected in the winter range of the Pelly River lowlands with scheduled flights and activity at the Finlayson Lake airstrip.”

Further in Section 13.4.1.1, there is discussion of Project interactions and the impacts on movement patterns and mortality risk with the wintering range and caribou movement from the rutting grounds to late winter ranges. The mitigation and management plans include no hunting policy, traffic controls, access control, emergency egress, snow management, and minimizing barriers to minimize these effects on caribou movement to, movement from, and use in the late winter range.

YESAB ISSUE

Section 3.5.2 reports that fewer caribou were seen during post-calving surveys in 2015 and 2016 but does not consider how the population decline may have influenced the lower number of observations. As caribou populations decline, their ranges tend to contract, which could contribute to fewer caribou seen during surveys in 2015 and 2016.

R195

“What are the implications of the low calf:100 cow ratios during the post-calving surveys in 2015 and 2016? Provide a more thorough discussion about calf survival, including neonatal mortality, substantiated with references.”

Caribou calves tallied during post-calving surveys were not considered recruits to the population as calf mortality rates are higher during this first summer. Significant research over the past 30 years indicates that five-month-olds tallied during rut counts do represent recruitment. Sample sizes from these post-calving counts have no power to make inferences of demographic trends. Therefore, they were not treated that way. The effect of the FCH decline on data results are repeatedly emphasized in the literature. Range use expansion and contraction relative to population recurrent fluctuation has been well documented for arctic and interior Alaska herds but puzzlingly not for Yukon woodland caribou herds in our limited time of reference. It is intuitive that caribou herds have a ‘centre of habitation’, the core range where all needs are met as proposed by Skoog (1968). All the evidence of range use studies for the FCH point to the notion that the Project area does fall within part of the perceived ‘center of habitation’ for the FCH. As presented in Sections 13.4.2.1 and 13.4.2.2 of the Project Proposal, mitigation and management plans will provide the highest mitigation measures practicable to minimize effects on the FCH.

R196

"Discuss the geographical importance of the project area to caribou considering their continued use of the area despite population decline."

As presented in Figure 3-1, Finlayson Caribou Herd Seasonal Distribution and Habitat Ranges, in the Wildlife Baseline Appendix E-8 of the Project Proposal, the Project is located in the southern portion of the Finlayson Caribou Herd range in part of the southern defined rutting area. The Project does not overlap the defined main post-calving or wintering areas. Figure 3-8 from the Wildlife Baseline Appendix E-8, confirms caribou are distributed mainly to the Project during post-calving. The FCH is migratory and moves to different habitats within their home range along seasonal routes to meet specific life cycle needs (Adamczewski et al., 2010). In the spring, two-thirds of the herd begin moving from their wintering grounds in the forested lowlands east of the Pelly River to the Pelly Mountains in the southeast. The remaining one-third of the herd travels to the mountains north of Finlayson Lake. As summer approaches, female caribou disperse in the mountains to calve on ridges and upper plateaus to avoid predators (Bergerud et al., 1984; Bergerud and Page, 1987; Bergerud, 1992). They remain dispersed in small bands in the uplands through summer, and seek out snow patches to escape insect harassment and warm temperatures (Morshel and Klien, 1997). The FCH's summer and fall ranges are primarily on alpine plateaus south of Finlayson Lake, which overlaps the Project area. A number of caribou utilize the areas adjacent to KZK for post calving and rutting, as identified by YG as Wildlife Key Areas (WKA) located south of the Project (Environment Yukon, 2013a).

The cause for the herd decline before 1982 was not established; however, the wolf control program proved that predation is a key limiting factor to the FCH population size (see Figure 3-2 of the Wildlife Baseline Appendix E-8 of the Project Proposal).

It is acknowledged that when caribou populations decline, their distribution generally contracts and that may influence potential effects from the Project. Withdrawal of range use coincident with decline in population size has been well documented for the more widespread arctic and interior Alaska caribou herds. Their ranges get smaller coincident with lower population size and vice versa. However, this is not so clear for woodland caribou, particularly in Yukon. Extirpation from an entire range of woodland caribou populations is well documented elsewhere, however experience shows that Yukon woodland caribou go through substantial population size shifts without losing or gaining home range. There are no anticipated changes in range use for the FCH as a result of density.

As presented in Sections 13.4.2.1 and 13.4.2.2 of the Project Proposal, mitigation and management plans will provide the highest mitigation measures possible to minimize effects on the FCH.

YESAB ISSUE

Inconsistencies in interpretations of information or inappropriate conclusions drawn from data could lead to inaccuracies in assessing effects of the Project on caribou.

The potential questions for this set of issues all relate to resolving inconsistencies in interpretations of information or correcting inappropriate conclusions drawn from data. The points are very specific and *detailed, but individually and collectively they could lead to inaccuracies in assessing effects of the Project on caribou.*

R197

"Range boundaries inconsistency: Why does the Finlayson Caribou Herd (FCH) range boundary shown in Figure 13-1 (Chapter 13) and Figure 3-1 (Appendix E-8) differ from Yukon Government's FCH herd boundary (Hegel and Russell 2013)? How does this difference in boundaries affect the effects assessment and the selection of projects identified for the cumulative effects assessment?"

Boundaries used in this analysis are based on direct animal observations through GIS projects at the 95% kernel index polygon that has been in use by YG for many years. It is herd specific and not a gross representation of Yukon-wide woodland caribou herd distribution mapped at a cruder scale as in (Hegel and Russell, 2013). The discrepancies in boundaries should not change the effects assessment identified for the cumulative effects assessment.

R198

"Rut survey interpretation: What is the density of individuals (individuals/km2), and density of groups (groups/km2) for each 5-km concentric ring? Revise the discussion of use of the area surrounding the proposed Project by caribou as a function of distance category to reflect these densities."

It is acknowledged that caribou density can be a useful metric to describe caribou distribution. However, the radii to outer distance of concentric circles are not uniform and varied in topography; therefore, simple density would not accurately compare densities at distance from the Project. A visual estimation of observations, which cannot be published, at the request of YG, indicates that densities in their preferred habitats are very similar in each of the zones which would not be fully reflected by density metrics.

R199

"Spring migration timing conclusion: Are there any other data to substantiate the timing of spring migration other than those presented in Appendix E-8, Section 3.4.5? If so, please provide."

There are no data for the timing of spring migration, which varies from year to year, but the movement of caribou from the winter range to calving grounds is important. Actual spring migration movements confound studies because of its variability. It is acknowledged that the wording in the discussion in Section 3.4.5 (Survey Results: Incidental Observations) of the Wildlife Baseline Appendix E-8 of the Project Proposal indicating that caribou begin moving from their wintering grounds to the upland calving areas in April and peaking in May was too definitive. The mitigation measures presented in Section 18.7.3 of the Project Proposal will be employed to minimize effects along the Access Road and will minimize effects on caribou movement for all movement periods.

R200

"Recruitment rates vs calf:100 cow ratios: Revise the discussion: calf-cow ratios during post-calving surveys should be discussed as calf:cow ratios, not recruitment rates, for clarity and consistency with other studies."

Post-calving calf:cow ratio have not been used as recruitment estimates -- appropriately so. The terminology should be avoided when citing calf:cow ratios observed at post-calving and was incorrectly stated in Section 3.5.2 (Post-Calving Surveys) of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal.

R201

"Calf:cow ratio sustainability inconsistency: Statements in sections 3.5.3 and 3.5.5 describe the "sustainability" of 27 calves per 100 cows. Provide more information on the basis of this threshold."

Sections 3.5.3 and 3.5.5 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, were discussing different data sets. The discussion in Section 3.5.3 referred to a 26 calves per 100 cow ratio where a herd was noted to stabilize as inferred by observed ratios of caribou herds experiencing rapid population growth, stability, and decline with long-term data as published in Hayes et al (2003). The rates discussed in Section 3.5.5 were discussing the changes after the wolf control program had stopped. A decline to 27.1 calves per 100 cows was measured from 1991 to 1996, but the ratios had not stabilized from the wolf control program so the ratios and the population were still in decline to a ratio of 18.7 calves per 100 cows in 2007.

YESAB ISSUE

The baseline information needs to be adequate, and to be adequately described, to provide a solid basis upon which to build the effects assessment. Some of the points are related to lack of clarity or lack of information about methods and others are suggestions for additional information that will help in interpretation of the baseline data.

R202

"Provide additional information on baseline surveys and maps as detailed below.

a. Use of historical post-calving surveys: Are locations from historical post-calving surveys, available? If so, provide a map that displays these for the whole range of the herd.

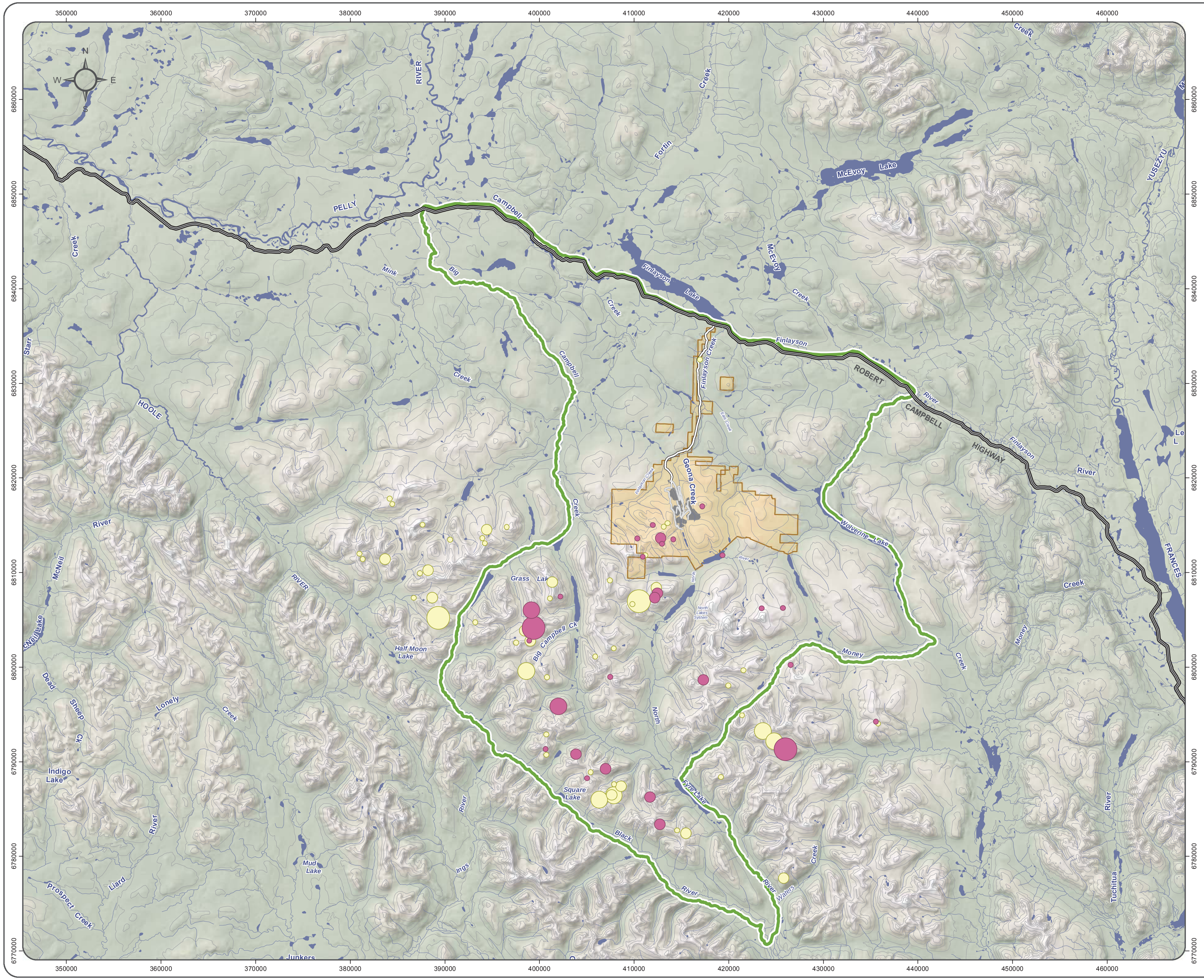
BMC has compared the historical and current post-calving survey observations. The locations confirm continued use and dispersion throughout the FCH southern post-calving range. The confidential map (containing the historical data) that was used for this comparison has not been included in this Response Report, in order to avoid potential conflict with the caribou data sharing agreement between YG and BMC.

b. Air survey methodology clarifications: How was the low number of caribou seen during the 2015 late winter survey influenced by the type of aircraft used (i.e. fixed-wing)? What type of aircraft was used for the early winter surveys described in section 3.3.1?

There is an inherent observability bias between the uses of fixed-wing aircraft and helicopters for early and late winter ungulate surveys. This likely accounted for the lower number of observations in the 2015 late-winter survey. The 2015 and 2016 early-winter surveys and the 2016 late-winter survey used a Bell Jet Ranger helicopter.

c. Improvement in post-calving information: Display locations for 2015 and 2016 in different colours on Figure 3-8 and comment on consistency in area use between the two years.

Figure 13-3 presents the corrected figure for Finlayson Caribou Herd, Post-calving Observations 2015-2016, from the Wildlife Baseline Report, Appendix E-8 of the Project Proposal and includes the 2016 observations in a different colour. Post-calving observations were distributed throughout the mountains south of the Project. There were more observations closer to the Project area in 2015 than in 2016 and the 2016 observations extended further to the west than in 2015.



BMC MINERALS

KUDZ ZE KAYAH PROJECT
WILDLIFE BASELINE REPORT

FIGURE 13-3

FINLAYSON CARIBOU HERD POST-CALVING OBSERVATIONS 2015-2016

MAY 2017

NUMBER OF OBSERVATIONS

2015 Survey	2016 Survey
1 - 2	1 - 2
3 - 5	3 - 5
6 - 8	6 - 8
9 - 19	9 - 16

OTHER MAP FEATURES

- Tote Road/ Proposed Access Road
- Proposed Mine Road
- Watercourse
- Waterbody
- Game Management Sub Zone 10-07
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Mineral Claim Area

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

1:385,000 when printed on 11 x 17 inch paper

0 5 10 15 Kilometres

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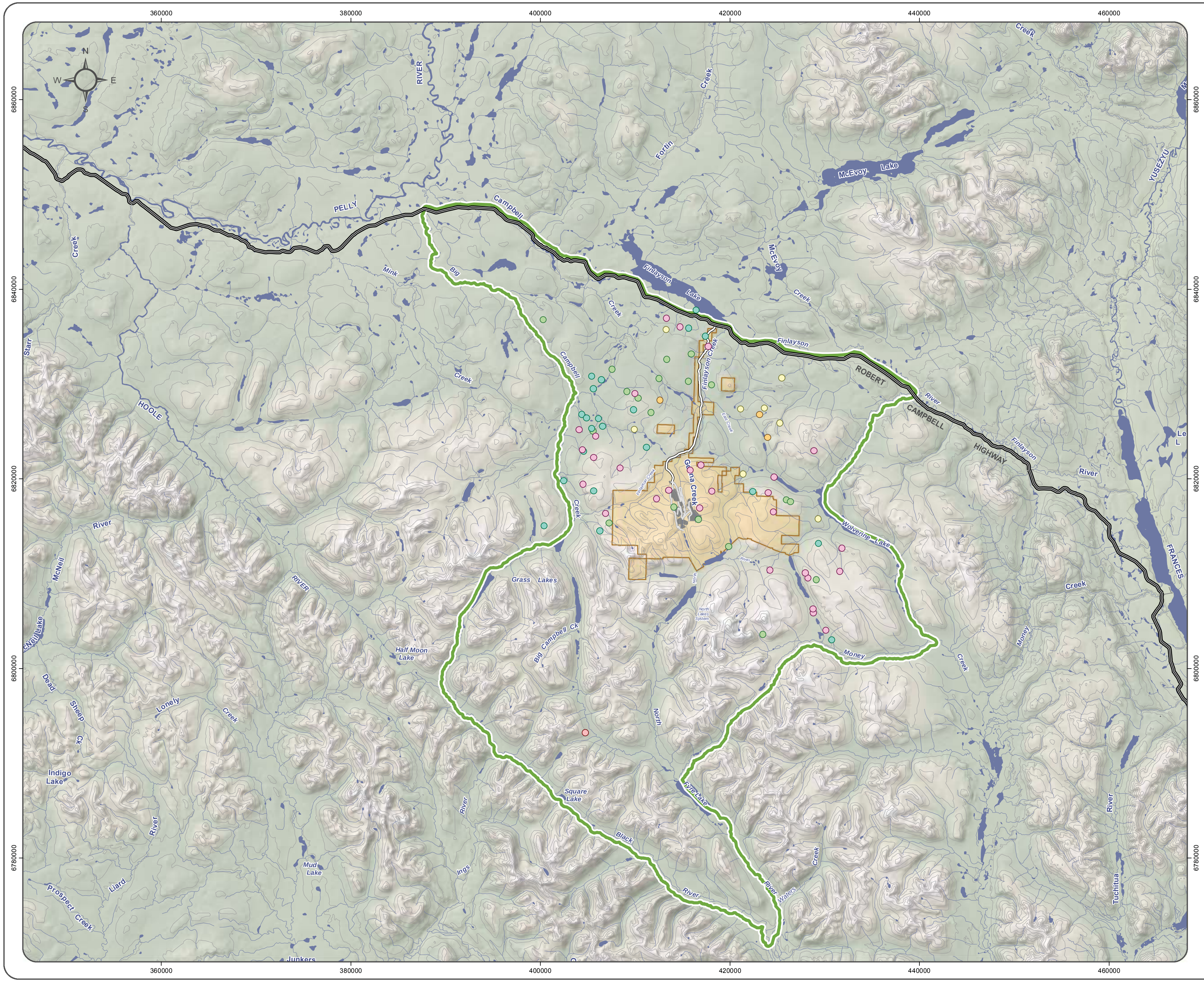
d. Methodology clarification for caribou distribution analysis: What do the categories in the "Radius from project" represent in Table 3-4? The actual radius, or radius categories? Revise interpretations if necessary.

The distance categories for Table 3-4 represent intervals of 0-5 km, 5-10 km, and 10-15 km even though they were expressed as <5 km, <10 km, and <15 km. Note that the radii are not uniform and are intended to provide information about the distribution while avoiding publishing exact locations during the hunting season.

e. Further information on early winter surveys: Provide a map showing caribou locations for 2015 and 2016 early winter surveys.

Caribou observations from the November 18-20, 2015 and December 5-6, 2016 ungulate surveys are presented in Figure 13-4. These observations were discussed in Section 3.5.4 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. Surveys of caribou in early winter (a time when caribou are not normally scheduled for surveys) show that there is indeed annual variation in their post rut movements towards winter range. While November was assumed to be the fall migration period of the FCH to winter range, these surveys clearly show that these conditions can vary a great deal – possibly due to late fall weather conditions.



BMC MINERALS

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FIGURE 13-4
FINLAYSON CARIBOU HERD
2015-2016 EARLY WINTER OBSERVATIONS

JUNE 2017

NUMBER OF OBSERVATIONS

Incidental observations during moose survey.
Number of occurances indicated in brackets.

- Caribou Sighting, Nov 2015 (19)
- Caribou Sighting Dec 2016 (29)
- Caribou Tracks, Nov 2015 (8)
- Caribou Tracks, Dec 2016 (21)
- Caribou/Moose Tracks, Nov 2015 (1)
- Caribou/Wolf Tracks, Nov 2015 (3)

OTHER MAP FEATURES

- Tote Road/ Proposed Access Road
- Proposed Mine Road
- Watercourse
- Waterbody
- Game Management Sub Zone 10-07
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Mineral Claim Area

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

1:385,000 when printed on 11 x 17 inch paper

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f. Results of 2016 rut survey missing: Provide the results of the 2016 rut survey.

Results from the 2016 rut survey are included in Section 3.4.3 and Figure 3-11 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. Due to the potential detriment to caribou by providing location data during hunting season, YG has requested that the caribou rut location information not be made public. Instead, the caribou distribution data is presented in terms of relative distance from the Project without providing direction. Location data was compiled for the period from 1982 through 2016 and is presented as a percentage of distribution within 0-5 km, 5-10 km, and 10-15 km from the Project footprint.

13.2 MOOSE

YESAB ISSUE

There is no indication of surveys completed to assess habitat use by moose in the Local Study Area (LSA) or Regional Study Area (RSA) during calving, post-calving, and summer.

Late winter moose surveys for this project have been conducted at the Game Management Subzone (GMS) scale. As described in the Wildlife Baseline Document, moose populations are assessed at the scale of the Moose Management Unit, not at a GMS level. Surveys conducted at the GMS scale are not a reasonable representation of a moose population.

R203

"Complete and provide data and analysis on aerial and/or ground surveys during calving, post-calving, and summer in order to demonstrate the use of habitat. Effects on habitat use in the vicinity of the proposed activities may be characterized at the RSA scale, but data demonstrating use of these habitats would be required in additional seasons (calving, post-calving, summer). These surveys should be completed at the scale of the Moose Management Unit."

It is acknowledged that moose calving, post-calving, and summer habitat is important. The post rut and late winter periods were chosen to model habitat suitability for moose for the KZK Project since these survey periods produce the most reliable data and correspond to the long-term government surveys. The regional study area was set at GMS 10-07. Moose population estimates/densities are currently available by GMSs providing context for assessing Project and cumulative effects on the local and regional moose population. Also, harvest data is based on the GMSs. This study area is large enough to provide wildlife managers with information on the proportion of the moose population affected by the Project footprint. Population level effects are not the objective of the KZK baseline program. Studies have focused on the local range extent and annual variation of moose more specifically interacting with the Project so that mitigation plans can be developed. This approach was presented and agreed to with Environment Yukon and the regional biologist in 2015. Moose population monitoring and management cannot be the responsibility of the proponent since they do not have any authority over hunting and conservation policies and regulations.

Information reviewed and preliminary consultations by the wildlife team suggested that moose surveys during calving, post-calving, and summer would not provide material benefit for the KZK

Project effects assessment. As mentioned above, the program was discussed in 2015 with Environment Yukon and these studies were not specifically requested. The convention of the Yukon Government (YG) has always been to evaluate moose during early and late winter surveys when foliage is on the ground, there is snow cover, and moose are well aggregated. YG does not conduct moose surveys during the calving, post-calving, and summer periods. There is very little likelihood that surveys during these periods will provide accurate information of any use or correlation to larger studies.

As presented in Section 4.1 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, "*Moose are dispersed throughout the LSA during the year, utilizing different habitats throughout the seasons. In the spring, summer, and fall, they prefer shrub-dominated ecosystems near forest cover such as treeline edges, riparian, or wetland complexes, and regenerating burn areas (Franzmann et al., 2007). The wetland and riparian corridors within the LSA are particularly important moose habitat as they provide an abundant food supply. Moose are not generally found in alpine habitats because they provide little cover and food availability*." This dispersed distribution for the calving, post-calving, and summer periods has been confirmed through incidental moose and calf sightings and signs recorded in the wildlife logs, wildlife camera captures, and during other baseline studies. Although not described in the effects assessment, the magnitude of loss of habitat from the project for these spring and summer periods are anticipated to be similar to the post-rut and late winter periods as presented in Section 13.4.1.2 and Table 13-12 of the Project Proposal, which is to say direct and indirect loss of moderately high to highly suitable spring and summer habitat would be less than 5% of the RSA.

BMC suggests that resources would be best spent on implementing the Wildlife Protection and Access Management Plans and conducting an effective monitoring program that provides the best estimate of distribution and density changes and ties in with Yukon Government's moose surveys. Through the Adaptive Management Plan, if unanticipated changes are seen in the distribution and numbers of moose during the post rut and late winter surveys then further monitoring survey designs can be developed with Environment Yukon and RRDC to identify other sources of effects.

YESAB ISSUE

Late winter surveys were conducted to assess moose distribution patterns and abundance in the project area. Late winter surveys are only useful to describe late-winter moose distribution in deep snow years, when late-winter habitat can be a limiting factor for moose populations.

R204

"Describe the snow conditions of the late winter surveys (i.e. depth of snow) and discuss how snow depth impacts moose distribution."

Snow depth is a limiting factor for the winter distribution of moose in Yukon. However, there have been no deep snow years during surveys to make comparisons of its effect on moose distribution in the region around the KZK Project. More than 20 years of snow course survey along the Robert Campbell Highway have never measured threshold snow depth for moose (90 cm; Coady, 1974) and have averaged about 40 cm. Snow depths in lowland wintering areas do not appear to be a serious limiting factor in this area.

YESAB ISSUE

A post-rut moose survey was completed in 2016, but the results have not been included or incorporated into the discussion.

Information on ungulate survey methods is not sufficient to determine if methodology was sound.

The presentation and discussion of moose survey data is not clear enough for reviewers to understand movements of moose through the seasonal range.

R205

"Provide the results from the additional 2016 post-rut moose survey, and incorporate these results into the discussion and conclusion."

A total of 154 moose were observed including 31 bulls, 100 cows, and 23 calves in 49 groups (Table 13-13). These observations result in a recruitment rate of 23 calves per 100 cows, and a sex ratio of 31 bulls per 100 cows. These results should be used with caution, however, as many bulls had cast their antlers by early December and were recorded as cows. This skews the data for useful ratio assessment. All but two moose (1.3%) were found in upland shrub zone and treeline area in a similar distribution to 2015 (Figure 13-5). Forty-eight moose were found within the Project claim block area. Group sizes ranged from solitary to 12 individuals and averaged 3.1 moose. The 2016 survey was carried out over two days and did not cover all of GMS 10-07 therefore comparisons of density estimates were not carried out.

Table 13-13: 2016 Post-rut Moose Count

Observation #	Cows	Bulls	Calves	Group Size	Habitat/Behaviour
2	1		1	2	bedded down, open spruce hillside
34	7	3		12	large group located in alpine
35	1			1	Located in alpine
38	3			3	
39	3			4	
42	1			2	
43	3			3	
45	1			2	
48	4	1		7	Bedded down
49	4			6	Subalpine
51	1		1	2	Subalpine
54	2		2	2	Hillside; subalpine
55	1			1	Hillside; subalpine; running
56	1			1	Standing; subalpine
60	7	1	1	9	Subalpine

Observation #	Cows	Bulls	Calves	Group Size	Habitat/Behaviour
62	1		1	1	
65	1	3		4	Running; subalpine
66	2		1	2	Running; alpine
67	1	1	2	2	alpine
73	2		2	2	Standing near alpine
74	1		1	2	Standing, subalpine
77	3			3	Alpine - plateau
79	2			3	
82	4			5	Alpine - plateau
83	2		1	2	Alpine - plateau
84	1	1		3	Standing at treeline
85	1	1		2	Standing; riparian area at subalpine
91	2			2	near alpine
92	2	1		3	near alpine
93	2			2	near alpine
94	1		1	2	Subalpine fir valley
95	2	1		4	Bedded down at treeline
96	5	6	1	11	
97	7	2	1	10	Subalpine valley
98	1			1	Subalpine valley
99	1	1	1	2	Subalpine valley
100		2		2	Subalpine valley
101	1			1	Subalpine - hillside
103		2		2	Subalpine valley bottom
104	1			2	Subalpine valley bottom
106	5		1	5	alpine
107	1		1	1	Subalpine valley bottom
108	1			1	
109	1		1	1	Near treeline
110		3		3	riparian, valley bottom
111	1			1	Near treeline
114	2	1		4	Near treeline
116	1			2	Alpine valley
117	2	1		4	Valley bottom
Totals:	**100**	**31**	**23**	**154**	

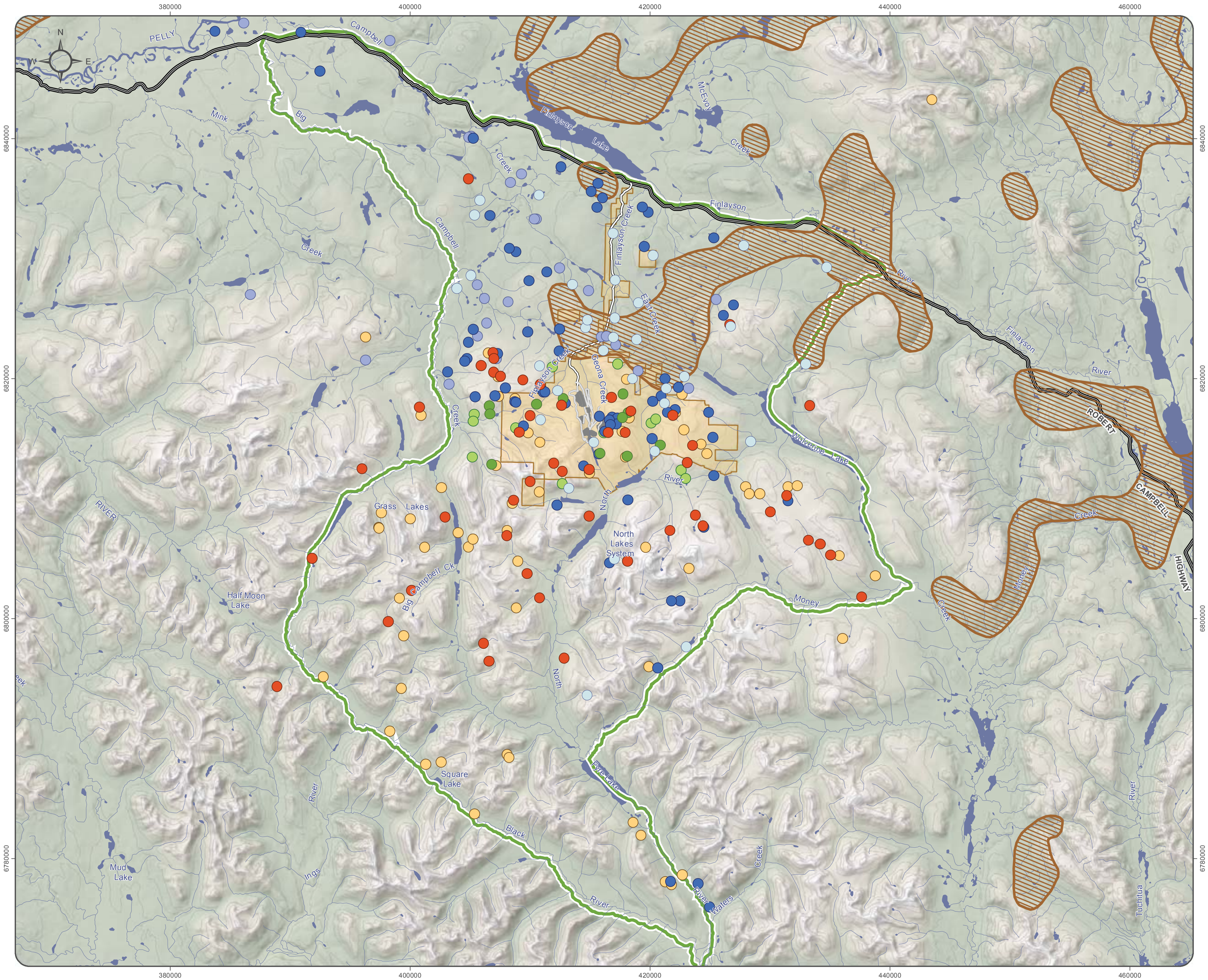
A late-winter ungulate survey was carried out March 23 and 24, 2017. A Jet Ranger helicopter was used for the late winter survey for a total survey time of 11.3 hours. A total of 57 moose were observed including 11 cows, 12 calves and the remaining 34 of unknown sex (Table 13-14). Approximately half of observations were solitary moose with the remaining in groups of two to four. Moose were scattered throughout much of the study area but were absent in the southern portion.

There was a significant difference between the 2015, 2016, and 2017 late winter surveys of the number of moose observed. Thirty-one were observed in 2015, 115 in 2016, and 57 in 2017. One explanation for the difference could be the fresh snowfall prior to the commencement of the 2016 survey that aided in the detection of moose.

Table 13-14: 2017 Late-winter Moose Observations

ID #	Bulls	Cows	Calves	Unknown	Group Size
16	1			1	2
17			1		1
18	1			1	2
19	1			1	2
36			3		3
38			1		1
39	1			1	2
40	1			1	2
41	1			2	3
42			1		1
43			2		2
44			1		1
45			1		1
46	1			1	2
47	1			1	2
48	1			1	2
49			1		1
50			1		1
51			1		1
52			1		1
53			1		1
54			1		1
55			3		3
56	1			1	2
57			1		1
58			2		2
62			1		1
68			1		1
70			1		1
72			2		2
75			1		1
77			2		2
82			4		4
83	1			1	2
Total	**11**	**0**	**34**	**12**	**57**

This additional information does not change the mitigation measures or results of the effects assessment.



BMC MINERALS

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FIGURE 13-5
2015, 2016 AND 2017
MOOSE SIGHTINGS

JUNE 2017

Moose Observations

- 2015 Late Winter Sightings (25)
- 2016 Late Winter Sightings (69)
- 2017 Late Winter Sightings (34)
- 2015 Early Winter Sightings (60)
- 2016 Early Winter Sightings (49)
- 2015 Summer Sightings (incidentals) (12)
- 2016 Summer Sightings (incidentals) (11)

Other Map Features

- Moose Key Area - Late Winter Range
- Regional Study Area (Game Management Subzone 10-07)
- Tote Road/ Proposed Access Road
- Proposed Mine Road
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Mineral Claim Areas

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

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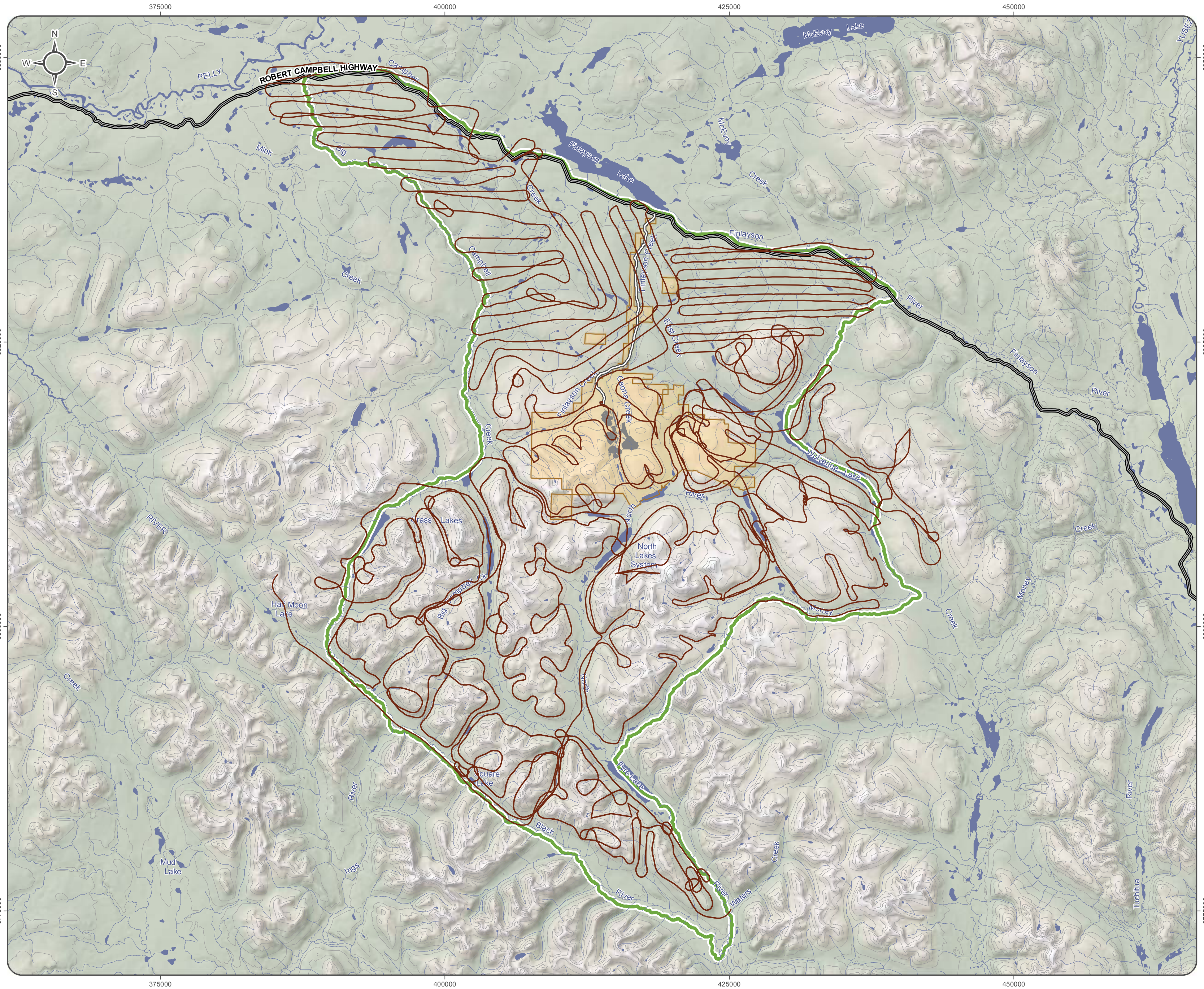
R206

"Provide details on survey methods and protocols used, including area covered or total length of survey paths."

Survey methods for the moose surveys are presented in Section 4.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. The survey area covered the RSA which is defined as GMS 10-07 (as requested by YG).

The November 18-20, 2015 post rut survey was conducted using a Cessna 208 (Caravan) and an AS350-B2 A-star helicopter. The helicopter was necessary for part of the survey as wind conditions were too strong for a fixed wing plane to continue the survey. Surveys were flown at an average elevation of 200 m above ground; forested areas were flown at lower elevations compared to open spaces such as alpine habitats. The average speed during the survey was 105 km/h. The total time taken to accomplish the survey was 15 hours. From December 5-6, 2016, the post-rut survey was replicated using the same protocols for 16 hours of survey flight time.

Figure 13-6 and Figure 13-7 show the flight paths for the 2015 and 2016 post-rut moose surveys, respectively.



BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 13-6
2015 MOOSE POST RUT SURVEY FLIGHT PATHS

JUNE 2017

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

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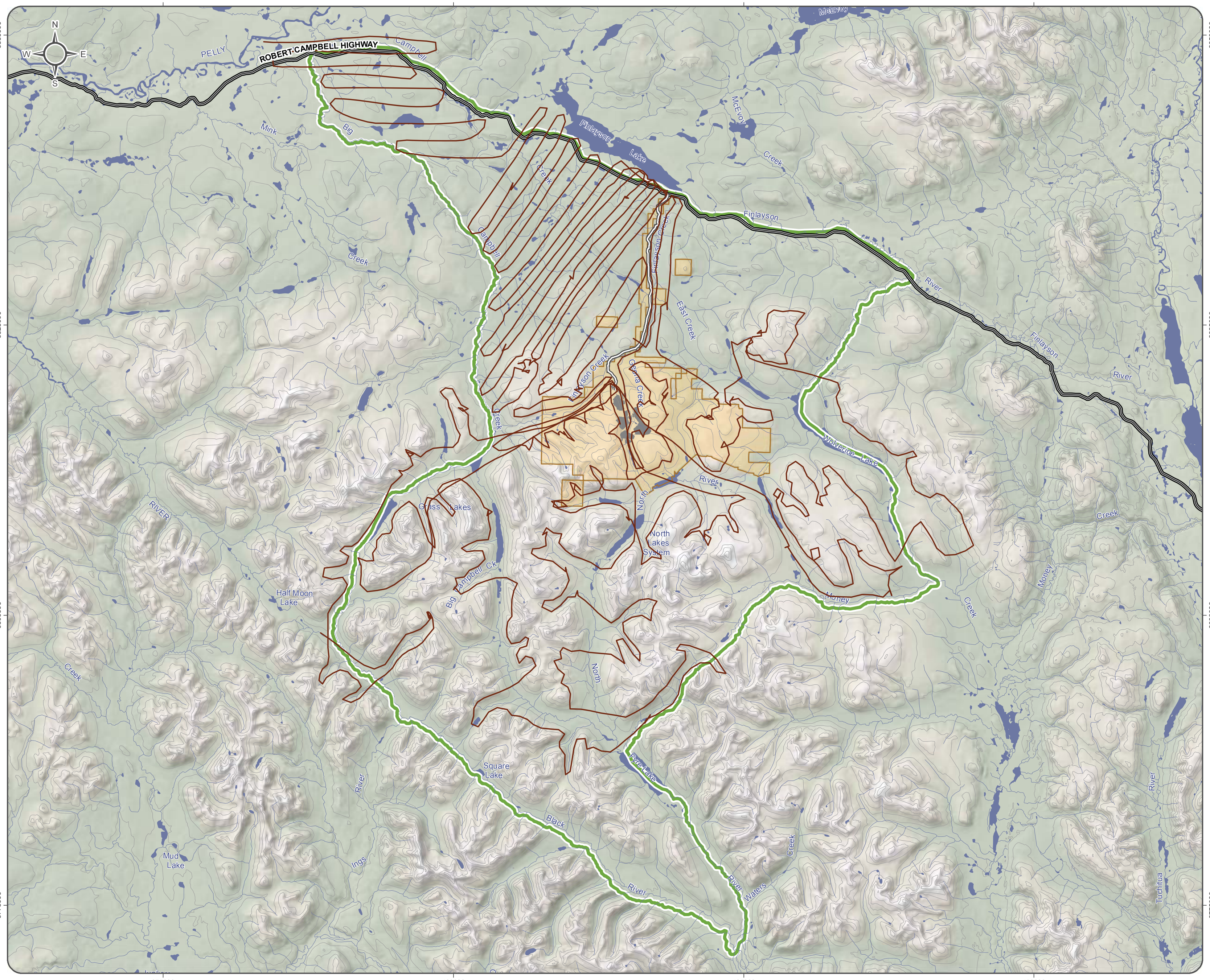

KUDZ ZE KAYAH PROJECT

FIGURE 13-7
2016 MOOSE POST RUT SURVEY FLIGHT PATHS

JUNE 2017

- Post Rut Moose Survey Flight Line
- RSA (GMS 10-07)
- Location of Proposed Mine Infrastructure
- BMC Minerals (No.1) Ltd. Mineral Claim Areas
- Tote Road/Proposed Access Road
- Watercourse
- Waterbody

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Datum: NAD 83; Projection UTM Zone 9N

1:325,000 when printed on 11 x 17 inch paper

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R207

"Revise Figure 4-1 to make seasonal patterns of moose distribution clear."

Figure 4-1 has been revised and included with these responses as Figure 13-5 (above) and includes observations from the December 5-6, 2016 post-rut survey and March 23-24, 2017 late-winter survey. From the observations, moose are distributed throughout the mountain valleys in fall and generally move to Pelly and Finlayson lowlands in the winter.

YESAB ISSUE

Clear articulation of methods and assumptions is required to properly assess the suitability of the HSI model.

Interspersion of habitat: It is unclear why the habitat suitability index (HSI) model does not account for the interspersion of available habitat (available forage with security and thermal cover). Moose are known to be rely on access to forage that is closely associated with security and thermal cover.

Interspersion of habitat: It is unclear why the habitat suitability index (HSI) model does not account for the interspersion of available habitat (available forage with security and thermal cover). Moose are known to rely on access to forage that is closely associated with security and thermal cover.

Elevation range used in model. It is unclear why Table 4-2 shows relationships with suitability and elevation for a range of 800 to 1800 masl when as per page 3 the elevation range of the entire Project area is 1300 to 1900 masl.

R208

"Articulate methods and assumptions used in the moose habitat suitability index model as indicated below.

a. ***Interspersion of habitat: Consider adapting the HSI model to account for the interspersion of available habitat.***

As presented in Appendix C, Moose Habitat Suitability Report of Appendix E-8, Wildlife Baseline Report of the Project Proposal, the post-rut and late winter habitat models use elevation, aspect, slope, and vegetation cover variables. The post rut HSI (p-value = 0.0083) suggests a significant ($p<0.05$) correlation between the model and actual densities while the strength of the correlation is strong (tau correlation coefficient = 0.87) based on 47 observations. The late winter HSI (p-value = 0.028) suggests a significant correlation while the strength of the correlation is strong (tau correlation coefficient = 0.73) based on 86 observations. The tau correlation coefficients increased to 0.94 for both post-rut and late winter models, respectively, with the addition of the 2016 post-rut and 2017 late winter survey data for a total of 91 post-rut and 119 late winter observations. Therefore, it was determined that no further variables were needed for the model to understand the availability of suitable habitat for the purposes of the effects assessment and mitigation planning.

b. *Interspersion of habitat: Specify why the habitat suitability index (HSI) model does not account for the interspersion of available habitat (available forage with security and thermal cover) as this will directly impact model outputs.*

As presented in Appendix C, Moose Habitat Suitability Report of Appendix E-8, Wildlife Baseline Report of the Project Proposal, the objective of the habitat suitability modelling for moose was to understand the availability of suitable habitat to grow, reproduce, and survive (RIC, 1999). The moose populations are not under pressure in the Project area and available mapping for the RSA is bound by the available Predictive Ecosystem Mapping level of detail. The model was then built on observations and the expert opinion of moose distributions by R. Farnell who has considerable experience conducting ungulate surveys in Yukon.

Elevation, aspect, slope and vegetation cover variables were determined to be the best available variables to define the observed moose distribution. The evaluation of the model showed a significantly high level of accuracy with observed distributions (tau correlation coefficient of 0.94 as discussed above). Interspersion can assist with refining habitat suitability; however, it is not always needed. Food suitability index was determined to be less accurate than an edge index (interspersion of food and cover) at identifying preferred habitat at finer scales (Dussault et al, 2006). Therefore, it was determined that no further variables were needed for the model to understand the availability of suitable habitat for the purposes of the effects assessment and mitigation planning.

c. *Elevation range used in model: Clarify if adjusting the suitability and elevation range to correspond with the area modelled change the outputs.*

As presented in the Terrestrial Ecosystem Map and Report in the Vegetation Baseline Report, Appendix E-6 of the Project Proposal, treeline elevation is somewhat variable ranging from ~1,490 masl on northern aspect and 1,550 masl on southern aspect slopes. This accounts for the discrepancy between the caribou and moose habitat suitability reports. The variable treeline was accounted for in the model. The minimum elevation range used in the modelling corresponded to the area modelled for the RSA which has a lowest elevation of 800 masl. Indeed, all elevations in and around the Project area were used in the developing the HSI. The elevation suitability ranking, developed using fuzzy membership functions and expert opinion, returned a suitability of zero for elevation above 1,700 masl for post rut and 1,600 masl for late winter. The dataset used to test the model (Moose Aerial Survey Points 2015-2016) acquired by AEG did not include any moose sightings above 1,750 masl during post rut and above 1,650 masl during late winter. No change is needed in the models.

d. *Segregation of habitat use: Clarify how suitable habitat for moose during the late season was segregated and provide the corresponding model outputs.*

As presented in Appendix C, Moose Habitat Suitability Report of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, segregation by sex (male/female) was not explicitly defined in the modelling for moose habitat suitability; however, the vegetation suitability index was corrected to account for some bull moose segregation into somewhat higher elevation shrub habitat than the lower conifer forest preferred for cows in winter. Model changes would not change the results of the effects assessment and mitigation planning.

e. Model equation: Clarify how models were developed for each season and provide the equation used.

The models were developed based on expert knowledge and observations of the distribution of local moose populations from the post-rut and late winter surveys. These are often more accurate models for the population of interest than models based on distribution patterns found in other geographical areas. The survey data verified the models' accuracies.

The following are the equations used in the models:

Post Rut Model: (0.5 * [Elevation]) + (0.15 * [Slope]) + (0.05 * [Aspect]) + (0.3 * [Vegetation])

Late Winter Model: (0.4 * [Elevation]) + (0.25*[Slope]) + (0.05*[Aspect]) + (0.3 * [Vegetation])

f. Model assumptions: Provide the model assumptions.

The assumptions for the models are presented in Section 4 of Appendix C, Moose Habitat Suitability Report of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal.

Post-rut Assumptions: moose prefer elevations between 1,300 and 1,600 masl, and are unlikely to be found at elevations below 1,300 or above 1,600 masl. Moose will select areas where the slope is slight, up to 20 degrees, and suitability will decrease as slope increases beyond 20 degrees. Moose prefer northeast and southeast facing aspects during the post-rut season. Moose were found most often in shrub habitat (suitability 1.0) in post-rut period followed by a preference for coniferous forest (suitability 0.6).

Late Winter Assumptions: Moose use all elevation equally and prefer elevation just at or below the treeline (1,450 m), as there is less snow and more vegetation, although some larger males will reside in upper elevation mountain draws. Moose will select areas where the slope is slight, up to 20 degrees, and suitability will decrease as slope increases beyond 20 degrees. Moose prefer northeast and northwest aspect during the late winter. Moose distribution showed higher frequency occurrence in coniferous forest, but the band distribution was fairly even between shrubs and conifer habitat. To further accommodate the segregation of bulls to shrub habitat in late winter, shrub habitat was rated as 1.0 and coniferous forest was rated as 0.6.

g. Zones of influence: Are zones of influence incorporated into the model, accounting for functional habitat use? If not, please provide the rationale for this and discuss how this may affect the outcome of the effects assessment for moose habitat.

For the zone of influence, the modelling was completed for baseline conditions with direct loss predictions quantified as the ultimate footprint of the Project and indirect loss based on a 50% reduction for the LSA around the Project footprint. This level of quantifying habitat loss from the Project was considered appropriate for the level of information and uncertainties. Additional modeling for different stages of the Project would unlikely change the magnitude of the effects assessment or the mitigation and management plans. Unforeseen effects detected by ongoing monitoring will be managed through the Adaptive Management Plan.

YESAB ISSUE

Failure to include moderate suitability habitat in the project area during the effects assessment could lead to underestimating impacts to moose.

R209

"Include moderate suitability habitat for moose in the assessment."

Moderately high to high suitability habitat were included to determine habitat loss in the effects assessment. Inclusion of moderate habitat in the calculations would result in a slight increase in percent habitat loss for late winter and a decrease in percent habitat loss for post rut. The results have been reproduced in Table 13-15 below. Therefore, inclusion of moderate habitat does not change the effects assessment or mitigation planning.

Table 13-15: Moose Habitat Loss Differences with Range of Habitat Suitability Categories

	Post Rut			Late Winter		
Habitat Suitability Categories	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Loss of RSA*	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Loss of RSA*
Moderately High to High	9.4 km²	63.3 km²	-4.7%	8.4 km²	83.0 km²	-3.9%
Moderate to High	9.5 km²	82.6 km²	-4.0%	9.7 km²	93.7 km²	-3.9%

*Percent change after direct loss and 50% indirect loss of habitat in LSA.

13.3 GRIZZLY AND BLACK BEARS

YESAB ISSUE

The proponent uses thresholds about acceptable amounts of habitat loss and disturbance for grizzly bears. It is unclear how thresholds were established. The primary reference provided for Grizzly Bear thresholds in Table 13-3 is for woodland caribou (Environment Canada. 2011. Scientific assessment to inform the identification of critical habitat for woodland caribou (Rangifer tarandus caribou), boreal population, in Canada. Ottawa, ON, pp. 102.)

R210

"Provide a reference for the thresholds used regarding acceptable amounts of habitat loss and disturbance for grizzly bears."

Regarding thresholds, the reference for the grizzly bear threshold in Table 13-3 of the Project Proposal was incomplete. The correct reference list should have included Dykstra (2004) and AXYS (2002). Threshold habitat areas required to sustain grizzly bear populations were determined to be 700 to 10,000 km² to sustain a population of 35 to 70 grizzly bear in Yellowstone and from 8,556 to 17,843 km² to sustain a population of 200 to 250 grizzly bear in British Columbia (Dykstra, 2004).

Since overall habitat areas are not known to be limiting in Yukon and there is limited information on grizzly bear and their habitat use in this area of Yukon, a more conservative and general threshold of habitat change was chosen in line with other wildlife habitat thresholds (i.e. 0-10% low, 10-15% moderate, and >15% high) for assessing effects. This provides an industrial target and social acceptance threshold for the effects assessment that is measurable, practical, and reasonable (AXYS, 2002).

YESAB ISSUE

The proponent conducted bear den surveys within a 10km radius from the open pit and found 3 dens about 5 km from the pit. Proponent indicated that surveys were conducted in 2015 (April 23, May 4 and 15) and (April 17 and 27) 2016.

The maps are unclear as to the location of bear den locations.

R211

"Provide an updated map that more clearly identifies the locations of grizzly bear dens."

The specific locations of dens are not published on the map to protect grizzly bears from poaching and other disturbance throughout the denning period. The locations can be provided to Environment Yukon, if requested, through a confidentiality agreement.

YESAB ISSUE

Surveys to assess the degree of use of the area near the mine site are limited to mid-April to mid-May. Habitat use of the area near the mine for summer and fall does not seem to be addressed in the proposal or wildlife baseline study. The baseline document identifies numerous sightings near the mine site but no discussion is provided about habitat values or impacts to these values seasonally.

R212

"Discuss grizzly bear use of the area near the mine beyond the denning season."

Grizzly bear are habitat generalists and omnivores (COSEWIC, 2012). Therefore, their habitat use and distribution typically follows available food sources ranging from ground squirrels and marmot in alpine areas, to berries in shrublands, and/or following moose and caribou distributions. Grizzly bear were found to range throughout the LSA in boreal, subalpine, and alpine areas as documented through the wildlife logs and with incidental observations during other vegetation and wildlife surveys as presented in Figure 6-1 and Section 14 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. From the wildlife logs in 2015 and 2016, there were no seasonal elevation changes in observed grizzly bear distribution. The focus of the grizzly bear studies for the effects assessment focused on important and potentially limiting habitat where there was the greatest potential for interaction with the KZK Project which was determined to be denning habitat. The study design was provided to and commented on by Environment Yukon in 2015, and conducted with an Environment Yukon biologist.

YESAB ISSUE

The proposal contains insufficient analysis of mortality rates. In the baseline report, the proponent only describes harvest history in GMA 10-07 and not surrounding GMAs or bear management unit.

R213

"Discuss the population of grizzly bears and mortality rates in the area. This should include a discussion of mortality of female bears."

BMC recognizes the importance of safe practices when working in bear country and adopting proper waste management so as not to attract bears. There have been no adverse grizzly bear interactions during BMC's exploration work on the KZK Project. Grizzly bear mortality rates are dependent on risk factors which are changing as companies and contractors implement better practices. The discussion in the Project Proposal was short but not for a lack of importance. More discussion could have been included on mortality rates and the importance of female bears, however the focus was on minimizing risk. The importance and sensitivities of grizzly bears is presented more fully in Section 6 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. As indicated in Table 13-3 of the Project Proposal, the threshold or target for the Project is preventing grizzly bear mortalities (i.e., no injuries or fatalities (unless required for human safety) directly attributed to mine activity). This is the primary focus of the mitigation and management measures in place for exploration and proposed Project development. As further indication of importance, the reason for not including specific locations of dens on the maps was to protect female bears.

The regional study area was GMS 10-07 since KZK Project residual effects are not expected outside of this area. The focus of study on GMS 10-07 was presented and commented on by Environment Yukon for baseline studies and no request was made to expand this area for grizzly bear. Nonetheless, additional harvest data was received but not reported. Table 13-16 (below) presents harvest data for GMSs 10-06, 10-07, 10-08, and 10-09 (Environment Yukon). From these data, grizzly bear mortality from reported hunting in these surrounding management zones is low. Further, in the 2015-2016 season six grizzly bear were harvested in Zone 10 and ten grizzly bear were harvested in Zone 11 (Environment Yukon, Yukon Hunting Regulation Summary, 2016-2017). These data do not change the results of the effects assessment or the mitigation plans.

Table 13-16: Yukon Government Grizzly Bear Harvest for Regional Game Management Areas

Year	Game Management Area			
	10-06	10-07	10-08	10-09
1995		5		
1998				2
1999		1		
2006		1		
2007	1	2		
2008	1	1		

Year	Game Management Area			
	10-06	10-07	10-08	10-09
2009		1		
2010		2		
2011		1		
2012		1	1	
2013	1			
2014	1			
Grand Total	**4**	**15**	**1**	**2**

R214

"Provide information on bear conflict history in the area. This should include an examination of mortality from vehicle collisions and potential increased mortality along highways from increased traffic associated with the project."

There have been no bear conflicts, including vehicle collisions or mortalities associated with the Project to date. The importance and sensitivities of grizzly bears is presented more fully in Section 6 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. As indicated in Table 13-3 of the Project Proposal, the threshold or target for the Project is preventing grizzly bear mortalities (i.e., no injuries or fatalities (unless required for human safety) directly attributed to mine activity). This is the primary focus of the mitigation and management measures in place for exploration and proposed Project development.

YESAB ISSUE

Aerial den surveys focused on modelled high and moderate suitable grizzly bear den habitat. If the surveys were completed based on a model that may need to be refined then the spatial focus of these surveys may have been incorrect.

Lack of use of Yukon information. Please make use of geographically/ecologically appropriate literature as background to the habitat suitability model.

Slope thresholds and den site selection. A focus on geographically and biologically appropriate information may influence model inputs and outputs. This may influence the delineation of grizzly bear denning habitat.

The lack of information on model assumptions, model reliability and model validation make it not possible to fully assess the adequacy of the model.

R215

"Which model was used to provide focus for the den surveys?"

As presented in Section 6.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, prior to fieldwork, a model displaying high to moderately suitable grizzly denning habitat in the study area was completed. The model was created using a geographical information system (GIS), a digital elevation model (DEM), and aerial photogrammetry. The parameters to model and map grizzly bear den habitat suitability were assessed based on the following criteria:

- 20 to 40° slopes;
- 600 to 1,500 masl elevation; and
- Exclusion of wet habitat types.

R216

"Why are two different sets of parameters identified? Which parameters were used to model grizzly bear denning habitat for the aerial surveys?"

As presented in Section 6.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the model parameters for preparation for the field den surveys were broad categories (20-40^{o} slopes, 600-1,500 masl elevation, and exclusion of wet habitat types) to identify a wide range of potential denning habitat. The categories were further refined for the habitat suitability (HS) mapping presented in Section 6.5 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. The final HS map criteria separated out high, medium, and low suitability to take into account results from the denning surveys and further refinement from the literature. Aspect and a narrower categorization of slope were added to the criteria for the final mapping.

R217

"What survey methods standards were used for den surveys? What was the survey effort by date? Provide information on the daily flight lines. How was the Project area stratified? How many observers were there and what were their qualifications?"

As presented in Section 6.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the study area for the model was centred on the proposed Project footprint and extended out in a 10 km radius [centred on the open pit since it is the nearest Project component to denning habitat] to balance the large range of these animals with the inclusion of suitable landscape elements and potential habitat. The total area surveyed was 314 km^2 (Figure 6-1, of the Wildlife Baseline Report). The 2015 bear den surveys consisted of three one-day aerial surveys spaced at approximately 10-day intervals to cover the grizzly bear den emergence period on April 23, May 4, and May 15. The 2016 surveys took place on April 19 and April 27. The 2015 and 2016 surveys were conducted by helicopter with each survey taking two to three hours. The helicopter contoured the mountainsides along the treeline at approximately 200 m above ground [covering the 10-km radius survey area]. The focus of the surveys was placed on the areas modelled as moderate to high quality denning habitat, and was adjusted based on conditions observed at the time of surveying. When bear tracks were located, the crew determined the direction of travel and followed the tracks back to try and locate the den. All active dens, bear sign, and other significant wildlife observations were documented and mapped.

There were three qualified observers in 2015 including Lisa Knight (AEG Biologist), Kelcy Tousignant (YG Carnivore Technician), and Dorothy Dick (RRDC elder and BMC Environmental Technician). Observers in 2016 included Lisa Knight, Traci Morgan (YG Wildlife Technician), and Dorothy Dick.

There are no Yukon or BC grizzly bear den survey standards. The methodology followed is based on general British Columbia's Resources Information Standards Committee (RISC) standards for detecting presence where the habitat and survey is stratified based on desktop planning, the timing is standardized to the period of interest, and the observers and level of effort are standardized.

The denning surveys were successful and appropriate for confirming denning habitat use surrounding the Project for the effects assessment and mitigation planning.

R218

"Provide further consideration of slope thresholds making use of readily available and geographically appropriate literature to support model development for slope thresholds, i.e., Reynolds et al. (1974), Harding (1976), McLoughlin et al. (2002), Schwartz et al. (2003) and Libal et al. (2012)."

It is acknowledged that additional literature can be reviewed to further define slope thresholds. The Predictive Ecosystem Mapping in the RSA is limited to map microscale site selections as presented in Libal et al (2012). It should also be noted that there are considerable differences in preferred denning habitat between geographic areas as presented by Reynolds et al. (1974). Site-specific use of the Project area is limited. Therefore, the grizzly bear denning habitat suitability model can continue to be refined as more site-specific grizzly bear use observations are obtained. However, the current model provides an appropriate level of accuracy for the effects assessment and mitigation planning for the Project.

R219

"What were the model assumptions that were used to build the model? Was model reliability determined? Was the model statistically validated?

As presented in Section 6.5 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the habitat suitability model used the Predictive Ecosystem Mapping for the RSA. Criteria for aspect, slope, materials (relates to moisture), and elevation were defined for the suitability categories as presented in Table 6-2 (and reproduced here as Table 13-17 . The model assumed equal weighting of the criteria as in the following equation.

Grizzly bear denning: 0.25 * [Elevation] + 0.25 * [Slope] + 0.25 * [Aspect] + 0.25 * [vegetation]

Table 13-17: Grizzly Denning Habitat Suitability Criteria

Suitability Rank	Slope (degrees)	Aspect	Materials	Elevation
High	30-38	South and Southeast	Colluvium/Moraine	Alpine
Medium	22-29 or 39-40	South and Southeast	Colluvium/Moraine	Alpine/Subalpine

Suitability Rank	Slope (degrees)	Aspect	Materials	Elevation
Low	All other	All other	All other	All other

The model has a moderate reliability based on the definitions in the 1999 BC Wildlife Habitat Rating Standards, (i.e., "*Moderate Reliability. Available information is based mainly on studies, reports and expertise on the species-habitat relationships gained within British Columbia. Some information from ecosystems in the study area, but mostly extrapolated from similar ecosystems. No verification or limited verification has been done"*). There was insufficient field data to statistically validate the model.

Habitat suitability models can continue to be refined as more site-specific grizzly bear use observations are obtained; however, the current model provides an appropriate level of accuracy for the effects assessment and mitigation planning.

YESAB ISSUE

The proposal does not substantiate claims that the Project area does not support a large population of black bears. Black bears are primarily crepuscular (Ayres et al. 1986; Gaines and Lyons 2003) and can be difficult to monitor without appropriate effort and application of survey standards.

R220

"Why were black bear surveys not conducted?"

As presented in Table 13-2 of the Project Proposal, black bear is secure in Yukon and is known to occur along the Tote Road and the Robert Campbell Highway. Proposed studies, correspondence and engagement with Environment Yukon and RRDC since 2015 have not requested black bear studies nor indicated black bear as a species of conservation importance with respect to the Project. Nonetheless, five black bear sightings were recorded from May through July in the 2015 wildlife log and four black bear sightings were recorded in August in the 2016 wildlife log. Black bear observations were mainly along the Tote Road.

General mitigation and management measures to minimize effects on wildlife as presented in Section 18.7 of the Project Proposal will mitigate potential effects on black bear. Key measures that will be included in the Wildlife Protection Plan, that will also minimize effects on black bear include effective waste management, giving wildlife the right of way, bear awareness and safety training, speed limits, and access management. Any unexpected effects will be addressed through the Adaptive Management Plan.

R221

"Are black bear surveys planned?"

BMC is committed to minimizing effects on all wildlife. Black bear were not scoped into the effects assessment and no black bear studies are planned. Observations of black bear will continue to be noted in the wildlife log and incidentally through tracking, aerial, and other surveys.

R222

"Provide information on the reliability of the predicted environmental effects on black bears."

As presented in Table 13-2 of the Project Proposal, black bear is secure in Yukon and is known to occur along the Tote Road and the Robert Campbell Highway. Proposed studies, correspondence and engagement with Environment Yukon and RRDC since 2015 have not requested black bear studies nor indicated black bear as a species of conservation importance with respect to the Project. As a result, black bear was not scoped in as a subcomponent in the effects assessment.

YESAB ISSUE

Inaccurate assumptions about survey methods will lead to unwarranted conclusions about how well wildlife is protected – in this instance black bear dens may not be identified.

R223

"How will mitigation for grizzly bears be adapted to also protect black bears, given the differences in den site use between the species?"

Black bear is secure in Yukon and is known to occur along the Tote Road and the Robert Campbell Highway. Black bear denning habitat varies and is not well known in this area of Yukon. There are no proposed mitigations for black bear denning for the Project.

General mitigation and management measures to minimize effects on wildlife are presented in Section 18.7 of the Project Proposal and are expected to mitigate key potential effects on black bear. Key measures to be included in the Wildlife Protection Plan that will also minimize effects on black bear include waste management, giving wildlife the right of way, bear awareness and safety training, speed limits, and access management.

13.4 OTHER WILDLIFE SPECIES

YESAB ISSUE

YG anticipates that additional data is available to document wildlife baseline, including wolverine, but this data has not yet been provided for the record. Wolverine were recommended by YG Department of Environment as a VEC to the proponent in 2013*, and the proponent was advised to conduct track count studies. The proponent identified wolverine as a VEC in their August 2015 "Kudz Ze Kayah Project Planned Baseline Studies." The Department of Environment is aware that the proponent's consultants conducted additional on-the-ground track count surveys for wildlife in late March 2017.*

BMC notes that the date in the YESAB Issue is incorrect as BMC did not purchase the Project until 2015.

BMC also notes that Wolverine was not identified as a VEC in the referenced document. The only mention of wolverine is as follows: "Wolverine were observed in the spring of 1995, but there is lack knowledge of potential denning sites. Simple winter tracking surveys are planned"

R224

"Provide results of the 2017 winter track surveys in the baseline report, including:"

Although no bullet points followed "including" in this information request, provided below are the results of the 2017 surveys.

The 2017 winter track survey was completed after the Project Proposal submission as part of the ongoing monitoring programs. As with any submission, a temporal endpoint in the monitoring program needs to be selected for baseline data collection and project design. The table in response to R239 presents the March 2017 track survey results.

The 2017 survey consisted of revisiting nine of the 14 transects from 2016, and created an additional four transects in the Project area. Not all transects could be reached in 2017 due to an increased amount of snow and limited access compared to 2016. Additional transects were located at the weather station, in riparian and mixed forest adjacent to Fault Creek, adjacent to the Geona Creek wetlands, and along the Tote Road in subalpine habitat. The transect sampling method was the same in 2017 as in 2016. A total of 51 tracks with nine species were observed (eight species in the Project footprint).

The most abundant tracks observed in the Project area were snowshoe hare, both along the Tote Road and in the proposed mine infrastructure area. It is difficult to quantify the number of hare tracks observed, but it can be concluded that hare tracks were continuously observed throughout the entire Project area. The abundance of hare within the Project area is important for many other furbearing species that prey on hare such as lynx, marten, and wolverine.

Three separate observations of fresh wolverine tracks were along the Tote Road. It is likely that the three observations were separate animals as the tracks were fresh (i.e., within 24 hrs), spaced out by multiple kilometres, and were travelling in opposite directions.

The 2017 winter track survey results do not change the effects assessment or proposed mitigation and management measures for wolverine.

R225

"A map of regional distribution of wolverines in the winter (ground based track counts)."

Wolverine is a valued wildlife subcomponent in the effects assessment. As mentioned in Section 8.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the YCDC lists the wolverine as vulnerable with no current population estimate for the Yukon (YCDC, 2015; Environment Yukon, 2015b). COSEWIC (2014b) lists the species as special concern. Insufficient information is available to produce a regional distribution of wolverines. Wolverines are known to occur in the LSA and RSA based on the snow track surveys, incidental sightings during other baseline surveys, and two observations in May and June of 2016 on the Tote Road noted in the wildlife log. A regional distribution map would not change the effects assessment or proposed mitigation and management measures for wolverine.

R226

"A map of wolverine denning habitat including expert opinion of trappers."

Wolverine is a valued wildlife subcomponent in the effects assessment. Mapping of denning habitat at the Project area is difficult since wolverine denning habitat varies greatly and preferences are not known for this population. Snow depth is a factor for denning which is near threshold levels for denning at KZK so other habitat types are likely used, but unknown. Information is currently unavailable from relevant trapline holders.

R227

"A population estimate of the regional wolverine population if winter track surveys indicate that wolverines utilize habitat along the access road and around the mine site."

Wolverine is a valued wildlife subcomponent in the effects assessment. Wolverine are a wide-ranging species that is very difficult to study (Magoun et al, 2010; COSEWIC, 2014b). Wolverine studies are not undertaken by Yukon Government. The approach for the KZK Project has been ground-based track counts and aerial counts incidental to ungulate surveys. As presented in the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, no wolverine tracks were observed in 2015, but wolverine sightings and signs were recorded during aerial surveys at sites shown in Figure 8-2 of Appendix E-8. The 2017 winter track survey was completed after the Project Proposal submission as part of the ongoing monitoring programs, with wolverine tracks observed at three transect locations along the Tote Road, but none were found around the mine site. These observations address local interaction with, and provide an indication of abundance at the Project.

Wolverine population estimates have been completed for various studies. Some of the nearest included an estimate of 5.6 resident wolverine per 1000 km^2 was made in Kluane Game Sanctuary by Banci (1987) and 9.7 (5.6 to 15.0) per 1000 km^2 were estimated in coastal southeast Alaska by Magoun et al (2010).

To obtain a population estimate and regional distribution at KZK would require capture-recapture studies using live trapping, hair snagging, camera trapping, or radio telemetry which would be challenging and expensive to implement. It is also uncertain whether an accurate estimate could be obtained, the information would be of any use in relation to developing additional mitigation for the KZK Project, or if the data would correlate to larger studies. Correlations and monitoring population trends with trapping data is also extremely challenging (COSEWIC, 2014b).

As discussed in Section 13.4.1.5 and Section 13.4.3.5 of the Project Proposal, effects assessments on wolverine in the literature are best documented in relation to road density. Wolverine habitat use and populations have been shown to be correlated to road density (Beazley et al, 2004). Effects of the KZK Project road densities of 0.35 km/km^2 (representing the level of disturbance) on wolverine were determined to not be significant since they are moderate magnitude but only in the local area.

Wolverine are lightly harvested and for the most part secure in Yukon. Given the low densities seen at the Project site, it is suggested that resources would be better spent on minimizing effects through mitigation and management, and continued track surveys to determine the frequency of wolverine use in the LSA through the ongoing monitoring program.

YESAB ISSUE

Although RISC (2001) standards were identified as being used, the methods described vary in some important aspects from these standards.

Completing a total of fourteen 75-m transects (1,050 m total length) within an LSA that is 11,321 hectares may be inadequate to reflect actual baseline conditions.

To determine the baseline conditions for a project it is important that:

a. *Appropriate survey standards are utilized, so that results are comparable and reliable; and*
b. *An appropriate level of effort is completed for an adequate assessment of baseline conditions. Completing a total of fourteen 75-m transects (1,050 m total length) within an LSA that is 11,321 hectares may be inadequate to reflect actual baseline conditions.*

R228

"Provide rationale for the methods used, including how sample sites and transect lengths were selected."

As presented in Section 8.1 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the protocol used for the snow track survey was based on the British Columbia RISC Committee Ground Based Inventory Methods for Ungulate Snow-track Survey (MOE, 2006). The snow track survey is intended to be a presence/non-detection level study to discern the variety of wildlife utilizing the Project footprint and Tote Road, as well as, to locate main sites of wildlife interaction with the proposed mine infrastructure.

Best sites for snow tracking are along riparian corridors and along mountain passes where wildlife can travel between adjacent valleys. Also, at pinch points, where movement is constrained as a result of natural barriers such as steep cliff faces and rivers. These areas were identified through desktop analysis and confirmed as active wildlife sites in the field in an effort to maximize track detection. Nine of the transects were located around the proposed Project footprint in the upper Geona Creek valley and five transects were located along the Tote Road. The rationale for selection of the sample sites is that the transects were established in habitat types that commonly occur within the LSA to assess habitat use in the area directly affected by the Project. In total, the survey consisted of establishing fourteen 75 m transects, and then identifying and recording the number of tracks per mammal species that intersected within 2 m either side along the length of the transect.

The length of each transect was determined based on terrain and the number, variety of species tracks encountered, and accessibility. There is a high level of confidence that the 2016 and 2017 snow track surveys, 2015 and 2016 wildlife logs, and the various other aerial and terrestrial baseline studies on the property have identified most species that use the LSA and RSA.

R229

"Were surveys timed with consideration for snow fall events?"

Yes, surveys were timed with consideration of snowfall events. It is optimal that track transects be surveyed between 24 and 72 hours after a significant snowfall (>1 cm). During the 2016 snow track survey, March 23rd, 2016 was overcast with light snow fall and temperature reaching approximately -5°C. The survey was completed after a recent snowfall of about 10 cm which had fallen in the past 48 hours. In some areas, tracking conditions were affected by light ongoing snow precipitation and blowing wind which filled in tracks, sometimes making identification difficult. Snow conditions varied between sites during the 2017 track survey with surveys taken from 24 hours after the last snowfall, to four hours previously and it was still snowing at two sites.

The objective was to detect wildlife presence and provide an indication of relative abundance. Any suboptimal snowfall conditions for some of the survey sites do not affect the results of the effects assessment and mitigation planning.

R230

"Are transect lengths sufficient to provide reliable baseline information on habitat use in the area affected by the Project?"

The snow track survey is intended to be a presence/non-detection level study to discern the variety of wildlife utilizing the Project footprint and Tote Road, as well as, to locate main sites of wildlife interaction with proposed mine infrastructure and vicinity. The winter track survey transects were established in habitat types that commonly occur within the LSA to assess habitat use in the area directly affected by the proposed Project. For this purpose, the transect lengths are considered sufficient to provide reliable baseline information at the key areas within the Project footprint and Tote Road.

YESAB ISSUE

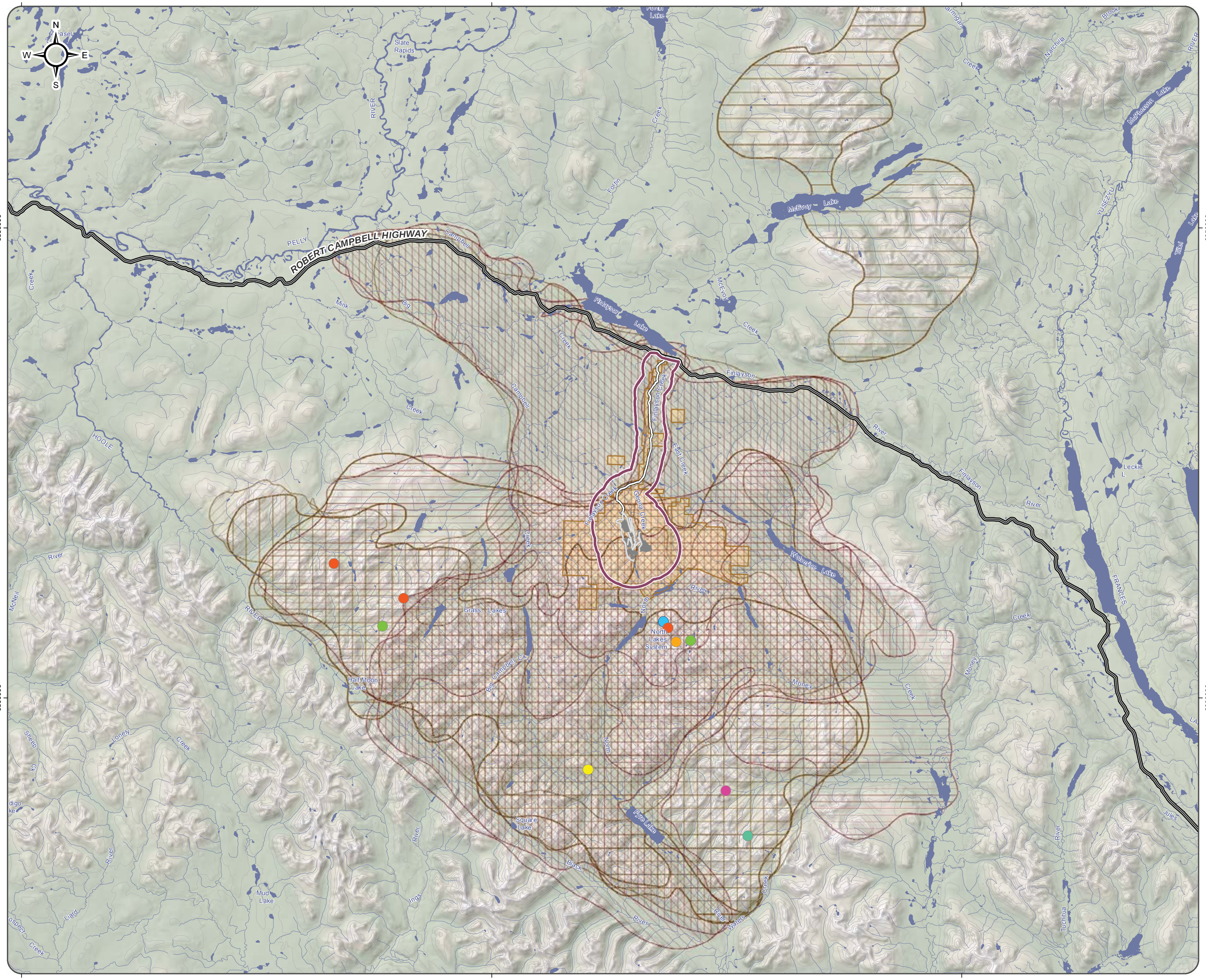
The proponent states in the Baseline Report that the only sheep-focused work involved checking areas shown to be sheep WKA's closest to the project to confirm the presence of sheep. They found that sheep were using some of these areas, but these WKA's were not in close proximity to the proposed project infrastructure or on the flightpath from the Whitehorse to Finlayson Lake Airstrip.

R231

"Provide results outlining the timing and extent of these surveys in the baseline report."

Thinhorn sheep were initially identified as a potential valued subcomponent but were determined to not occur in the KZK LSA through baseline studies. Over 102 hours of aerial surveying were carried out during the surveys for fall caribou rut, moose post rut, late winter ungulate, bear denning, and caribou post calving in 2015 and 2016, and the 2017 late winter ungulate survey. As shown in Figure 5-1 of the Wildlife Baseline Report (Appendix E-8 of the Project Proposal), 55 stone sheep were observed over the two years, but they were all observed south of the Project LSA. Figure 13-8 (below), Thinhorn Sheep, Incidental Observations During Aerial Surveys, shows the sheep locations in relation to the areas covered by the survey flights. This further confirms that stone sheep do not use habitat in the LSA and use only the southern portion of the RSA, not in the area of influence of the Project.

While the sheep population is very sparse in this area, there are three decades of sheep observations incidental to all YG caribou post-calving and rut count surveys that provide evidence that sheep do not occur in the KZK LSA.



BMC MINERALS

KUDZ ZE KAYAH PROJECT

FIGURE 13-8

THINHORN SHEEP INCIDENTAL OBSERVATIONS DURING AERIAL SURVEYS

JUNE 2017

INCIDENTAL SHEEP OBSERVATION DURING DIFFERENT SURVEYS

- 2015 Bear Den Survey (6)
- 2015 Caribou Post Calving Survey (6)
- 2015 Caribou Rut Survey (12)
- 2015 Late Winter Ungulate Survey, Tracks
- 2015 Post Rut Moose Survey (12)
- 2016 Caribou Post Calving Survey (7)
- 2016 Caribou Rut Survey (20)
- 2015 Bear Den #1 Survey
- 2015 Caribou Rut Survey
- 2015 Late Winter Ungulate Survey
- 2015 Post Rut Moose Survey
- 2015 Caribou Post Calving Survey
- 2016 Caribou Post Calving Survey
- 2016 Caribou Rut Survey
- 2017 Late Winter Ungulate Survey
- Local Study Area
- Location of Proposed Mine Infrastructure
- Tote Road/Proposed Access Road
- Proposed Mine Road
- BMC Minerals (No.1) Ltd. Mineral Claim Areas

* Numbers in brackets represent the number of individual sighted.

ALEXCO ENVIRONMENTAL GROUP

Digital elevation model created by the Yukon Department of the Environment interpolated from the digital 1:50,000 Canadian National Topographic Database (NTDB Edition 2) contour and watercourse layers. Obtained from Geomatics Yukon.

Canvec compiled by Natural Resources Canada at a scale of 1:10,000 - 1:50,000. Reproduced under license from Her Majesty the Queen in Right of Canada, as represented by the Minister of Natural Resources Canada. All rights reserved.

Datum: NAD 83; Projection UTM Zone 9N

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(Last edited by: mducharme; 6/8/2017/17:41 PM)

R232

"Provide maps showing the proposed flight path between Watson Lake and Finlayson Lake and Whitehorse and Finlayson Lake in relation to the WKA's in the baseline report."

Sheep are known to be sensitive to aircraft. Regarding flight paths, it is the responsibility of Ministry of Transport through the *Air Regulations* and Navigation Orders to determine routings. Aircraft already occasionally fly between Ross River and Watson Lake and the route taken is dependent on weather conditions. It is expected that the airlines follow the Environment Yukon Flying in Sheep Country guidelines. However, if the sheep areas south and east of the Project need to be further avoided, the aircraft flight paths would require a Notice to Airmen in the Canada Flight Supplement.

YESAB ISSUE

Monitoring of collared pika is limited to the Wildlife Records Program. The proponent states that the objective of monitoring is "to check if collared pika will be disturbed more than expected from project activities".

R233

"What further monitoring programs will be implemented for the Collared Pika?"

It is expected that there will be little and only indirect disturbance to these colonies (Section 13.4.1.6, Table 13-14 and Figure 13-15 of the Project Proposal) which is not significant (Section 13.4.3.6); therefore, the monitoring program as proposed in the Proposal is not extensive, but is considered appropriate. An unexpected disturbance would be if a colony is abandoned. An absence of collared pika observations in the wildlife logs would be a trigger to change the monitoring program through the Adaptive Management Plan.

YESAB ISSUE

The little brown myotis is listed as endangered under the Species at Risk Act (SARA) and by the Committee on the Status of Wildlife in Canada (COSEWIC), as is the northern myotis. Under Section 37 of SARA a recovery strategy (proposed) has been developed for these two species (Environment Canada, 2015). This recovery strategy details the threats and issues associated with these bats and the justification for required protections. This includes habitat loss and degradation as well as heavy mortality that have occurred in eastern Canada as a result of white nose syndrome.

Bat capture program. It is recognized that the calls of some bat species, in particular some Myotis species, can be difficult to distinguish through echolocation analysis alone. As such, it is typical that a bat capture program, under approved permit where required, co-occurs with echolocation surveys to aid in species detection confirmation.

Survey period length. Surveys completed in 2015 and 2016 were limited to 7 days and 18 days, respectively. Given the seasonality of habitat use, including migration, this is a very short survey period *which will not fully account for the potential occurrence of bats within the Project area during their active seasons.*

Analysis of recordings. Information on the methods used for the analysis of recordings is missing.

The assertion that non-detection results for subalpine habitats equate to non-occurrence is not supported. Considering the limited deployment of detectors, the potential seasonal occurrence of use of subalpine habitats by bats is potentially missed.

According to Government of Yukon comments, "Baseline monitoring conducted in 2016 had "several instances" of bat detections."

R234

"Would a bat capture survey improve baseline information on bats?"

A bat capture survey may provide more information; however, the objective of the surveys conducted in the Project area in 2015 and 2016 was presence or absence which can be determined through non-invasive methods. Invasive capture methods have a higher risk of mortality and infection and are not needed to meet the survey objective. The overall effects on bat habitat and mortality from the road are rated as not significant (Section 13.4.3.7 of the Project Proposal) and likely not measurable; therefore, invasive bat surveys are not recommended.

R235

"What does "several incidences" of Myotis spp. Mean? The results for the bat detection surveys note that "The detector established at the wetland at km 5 along the Tote Road had "several incidences" of Myotis spp." and is further stated that it "It is unknown how many bats "several incidences" equates to."

As presented in the Project Proposal in Appendix E-8 (Wildlife Baseline Report, Section 12.4) there were several instances of bats at the 5 km station on three days in 2016. Unfortunately, the number could not be discerned due to significant ambient noise, but it was more than one.

As presented in Section 13.4.1.7, Table 13-15 and Figure 13-16 of the Project Proposal, effects on bats are within the boreal forest zone along the road corridor and not at the mine site. An estimated 1.5% of high quality roosting habitat would be directly lost and a 14.3% of moderate roosting habitat indirectly affected. No barrier effects or mortalities from collisions are expected. The overall effects are rated as not significant (Section 13.4.3.7) and likely not measurable; therefore, a bat monitoring program has not been proposed.

R236

"Does the life history stage model only represent roost site selection for little brown myotis? The current habitat suitability model does not appear to account for the dispersion of roosting habitat with foraging habitat."

A description of the habitat suitability model for little brown bat is presented in Section 12.5 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal.. The habitat suitability model is for roosting habitat. As discussed, little brown bat will move more than 5 km to forage; therefore, foraging habitat was not a limiting factor in the model since all sites in the LSA along the Tote Road are within 5 km of Geona Creek and other waterbodies.

R237

"Provide a description of model assumptions, validation, reliability and zones of influence."

The description of the habitat suitability model for little brown bat is presented in Section 12.5 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. The model used the Terrestrial Ecosystem Map (TEM) to determine where roosting habitat was located assuming little brown bat prefers to roost and forage in mature/old growth boreal forest adjacent to wetlands (Randall et al, 2014; Slough and Jung, 2008; COSEWIC, 2013; Environment Canada, 2015). This habitat equates to structural stage 6 and 7 in the TEM as is re-presented in the criteria table below (Table 13-18).

Little brown bats were detected at the northern two survey locations and not at the southern detectors, which aligned with the predicted areas of suitable habitat. The objective of the modelling is to provide a visual representation of the distribution of predictive suitable habitat and quantitative assessment based on the known TEM for site and the literature. The model has a moderate reliability based on the definitions in the 1999 BC Wildlife Habitat Rating Standards (i.e., "*Moderate Reliability. Available information is based mainly on studies, reports and expertise on the species-habitat relationships gained within British Columbia. Some information from ecosystems in the study area, but mostly extrapolated from similar ecosystems. No verification or limited verification has been done"*).

For the zone of influence, the modelling was completed for baseline conditions with direct loss predictions quantified as the ultimate footprint of the Project and indirect loss based on a 50% reduction for the 300-m buffer around the Project footprint. This level of quantifying habitat loss from the Project was considered appropriate for the level of information and uncertainties. Additional modeling for different stages of the Project would unlikely change the magnitude of the effects assessment or the mitigation and management plans. Unforeseen effects detected by ongoing monitoring will be managed through the Adaptive Management Plan.

Table 13-18: Little Brown Bat Habitat Suitability Criteria

Suitability Rank	Structural Stage	Bioclimate Subzone
High	Leading ecosite >=70% structural stage 6 or 7	Boreal High
Medium	Leading ecosite <70% structural stage 6 or 7	Boreal High
Low	Everything else	Boreal High, Boreal Subalpine, Alpine

YESAB ISSUE

No methodology is described for monitoring waterfowl use at water management facilities, water treatment ponds, and ponds built for fish habitat compensation.

R238

"Provide methodology to monitor ponds for waterfowl use."

Waterfowl use at water management facilities will vary by facility and purpose, and details will be finalized in the Wildlife Protection Plan (as part of licencing). In general, the BC Resource Inventory Committee, Standards for Components of British Columbia's Biodiversity No. 18, Inventory Methods for Waterfowl and Allied Species (1999) or similar updated protocol will be followed. For water management facilities that are part of the mine site infrastructure (other than those where waterfowl access is controlled), waterfowl will be monitored with a total count from an observation station to determine presence/absence.

For monitoring the fish habitat ponds, more than one observation station will be set up and a total count survey will be completed. This will preferably occur in the spring nesting period and will be integrated into the program described in the FOP. Determining presence is the main objective of this program.

YESAB ISSUE

Additional on-the-ground count surveys for wildlife conducted in late March 2017 not included.

R239

"Provide additional 2017 wildlife survey data, any associated analyses and effects assessment."

The 2017 winter track survey was completed after the Project Proposal submission as part of the ongoing monitoring programs. As with any submission, a temporal endpoint in the monitoring program needs to be selected for baseline data collection and project design. Table 13-19 below summarizes the March 2017 track survey results.

The 2017 survey consisted of revisiting nine of the 14 transects from the 2016 survey, and created an additional four transects in the Project area. Not all transects could be reached in 2017 due to an increased amount of snow and limited access compared to 2016. Additional transects were located at the weather station, in riparian and mixed forest adjacent to Fault Creek, adjacent to the Geona Creek wetlands, and along the Tote Road in subalpine habitat. The transect sampling method was the same as in 2016. A total of 51 tracks with nine species were observed (eight species in the Project footprint). Wolf tracks were not seen in 2017; however, lynx tracks were observed which did not occur in 2016.

Table 13-19: March 2017 Track Survey Counts

Transect number		Habitat	Number of Tracks and Species									
			Snowshoe hare	Lynx	Weasel	American Marten	Red fox	Porcupine	Wolverin e	Red Squirrel	Ptarmigan	Incidental Observations
			Lepus americanus	*Lynx canadensis*	*Mustela sp.*	*Martes americana*	*Vulpes vulpes*	*Erethizon dorsatum*	*Gulo gulo*	*Tamiascurus hudsonicus*	*Lagopus sp.*	
1	Proposed Mine infrastructure	Shrub (willow scrub birch), scarce spruce	3									
4		Mixed shrubs and subalpine fir	10	1			1				1*	
8		Spruce tree old stand, willow and birch understory	1*	2						1		Moose
9		Subalpine fir, white spruce with shrub undercover, riparian	5	2				1				Grey Jay
15		Spruce forest	4								1	
16		Spruce forest, willow shrubs	1			1						
17		Spruce forest, willow shrubs	1*		1	2						
18		Spruce forest, willow shrubs					2				1	
		Subtotal	***23****	***5***	***1***	***3***	***3***	***1***	***0***	***1***	***3****	
10	Tote Road	Open riparian, tall shrubs, graminoid	1*	1				1				Moose
11		Mature white spruce, open shrubby understory				1*	1		1*			Moose, Grouse
12		Mature white spruce, some shrubs, drainage				1			1			Moose
13		Edge of wetland, carex and shrubs, some trees	1			1			1			Moose
14		Mature white spruce, willow shrub	1			1			1			Moose, Caribou
		Subtotal	***2****	***1***	***0***	***3****	***1***	***1***	***3****	***0***	***0***	
		Total	**25***	**6**	**1**	**6***	**4**	**2**	**3***	**1**	**3***	

* Multiple tracks were noted but it was uncertain whether they were made by one or multiple individuals.

YESAB ISSUE

The proponent's proposed mitigation measure for cliff-nesting raptors lacks specific details.

R240

"Provide mitigation measures for cliff-nesting raptors including: timing windows and disturbance buffer distances (in the event that an active nest is found)."

Table 18-8, Sensitive Seasonal Periods for Focal Wildlife and Mitigations, in the Project Proposal suggested a minimum 15 m buffer around identified nesting. Buffer zones will be updated and defined for specific species in the final Wildlife Protection Plan and will follow Environment and Climate Change Canada and Yukon guidance.

The Yukon standard for the no disturbance buffer for cliff-nesting is 300 m (Yukon Forest Resources Act, 2014). In Yukon, cliff-nesting raptors occupy nests around the 15th of March – the 31st of April (Hayes and Reid, 2014). If helicopter flights are necessary near cliff-nesting raptor nests between this period, BMC will avoid repeat aerial disturbance, where practicable. Routine flights during this period will be as far away as are safe and practical. In addition, approach to nests would be along a tangential visible path to avoid approaching cliff nests from behind.

YESAB ISSUE

Insufficient detail regarding future monitoring plans throughout the life of the project.

The proponent states that the monitoring program will occur every three years (or more frequently if adaptive management plan deems required), and will follow baseline study protocols with focus on key species and seasons.

R241

"For the construction, operations, decommissioning and post-closure phases of the project, provide details on the monitoring plans including:

a. methods

b. timing

c. duration

d. frequency

e. location

f. personnel conducting surveys, etc."

The information regarding the monitoring plan for wildlife is provided in Section 13.6 of the Project Proposal and is summarized in Table 13-20 (below). Note that the table has been updated from the table that was presented in the Project Proposal. The proposed monitoring for the caribou rut is annual while the late winter ungulate surveys are every three years. Species-specific details will be further defined in the final Wildlife Protection Plan as the Project progresses into detailed design and also refined through the Adaptive Management Plan.

Table 13-20: Wildlife Monitoring Program Summary

Monitoring Program Component	Project Phase	Methods	Timing	Duration	Frequency	Location	Personnel Conducting Surveys
Wildlife Records Program	Construction, operations, decommissioning and post-closure	Observations and locations reported by employees and contractors on site and along access road recorded in onsite log.	Ongoing, reported annually.	Ongoing	Ongoing	Project site and access road	All employees and contractors for the project. Assistance with species recognition will be provided by onsite environmental staff.
Winter Wildlife Monitoring	Construction, operations, decommissioning	Surveys will include snow track surveys to be completed at least every month shortly after fresh snow fall. This will provide information on presence and use of Project areas by small and medium furbearers as well as larger mammals.	Each month where there is snow cover. Survey to be conducted approximately between October to April each year that the survey is scheduled (dependent on weather and snow conditions).	2 days, once per month (~Oct-Apr)	Surveys will be carried out every three years depending on the results following the adaptive management plan.	Project site and access road at baseline transect sites	Onsite environmental staff, First Nation members, and/or external experts.
Finlayson Caribou Herd Fall Composition Counts	Construction, operations, decommissioning	Aerial surveys to be carried out by helicopter during the fall rut period. Survey will be consistent with the methods and area surveyed in 2015 and 2016. Late winter ungulate surveys consistent with baseline surveys.	During the fall rut period (from late- September to early October) and late winter (March - April)	2 days	Annual for rut. Every three years for late winter.	Survey areas as per baseline surveys. Late winter habitat in GMS 10-07.	Onsite environmental staff, YG, First Nation members, and/or external experts.
Moose Late Winter Survey	Construction, operations, decommissioning	Aerial surveys of ungulates in late winter in the study area to locate critical late winter habitat. Survey will be consistent with the methods and area surveyed in 2015 and 2016.	Survey to be conducted in late winter (March - April).	2 days	Surveys will be carried out every three years depending on the results following the adaptive management plan.	Late winter habitat in GMS 10-07 around site, in particular east and west of the Access Road	Onsite environmental staff, First Nation members, and/or external experts.

Monitoring Program Component	Project Phase	Methods	Timing	Duration	Frequency	Location	Personnel Conducting Surveys
Grizzly bear	Construction, operations	The main purpose of the grizzly bear monitoring program is to prevent the disturbance of mining on hibernating bears. The area surrounding the open pit will be monitored during the pre-denning period to determine if there are any bears that show indications of preparing to den near the open pit.	Conducted in conjunction with the caribou fall rut survey (from late September to early October)	Weekly during pre-denning period	Annual	Area around open pit	Onsite environmental staff.
Breeding Bird Counts	Construction, operations, decommissioning	Point count surveys to determine trends in nesting bird species and relative abundance in local study areas. Control sites established outside of Zone of Influence.	Survey to be conducted from Spring May – June.	2 days	Surveys will be carried out every three years depending on the results following the adaptive management plan.	At baseline survey sites at the Project site and along the Access Road	Onsite environmental staff, First Nation members, and/or external experts.
Facility Monitoring	Construction, operations, decommissioning	Routine checking for wildlife issues on the site. Include checks to remove/prevent potential nesting locations during the pre-nesting period. Regular checks of wildlife species use of water management ponds. Regular inspections of beaver dams to ensure culverts and creeks are flowing and not inhibiting correct operation of water management facilities.	Emphasis on bird migration periods spring (~April - June). Checks will be carried out regularly during the spring, summer and fall.	Ongoing	Ongoing	Project infrastructure	Onsite environmental staff

YESAB ISSUE

The proponent used wildlife cameras to monitor the use of a mineral lick south of the LSA from April to October in 2015 and 2016.

YG recommends a full year of camera trap monitoring on all licks that are within 1km of any proposed footprint.

R242

"Provide rationale as to why the lick monitoring limited to April to October."

Mineral licks are recognized as important habitat features. As presented in Section 14.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the mineral lick is located south of the Project. The lick is more than 1 km from the Project footprint, at a distance that would not likely be affected by mine activities given the surrounding topography, and not of high importance. The mineral lick was not monitored in the winter when the ground was frozen and snow cover made it inaccessible for wildlife use.

R243

"Will monitoring of the lick be continued throughout the life of the project?"

As presented in Section 14.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the mineral lick is located south of the Project. The exact location was not indicated in the report to protect the wildlife; however, it is more than 1 km from the Project footprint, and at a distance that would not likely be affected by mine activities given the surrounding topography. Study of the lick indicated it is a low use location with only occasional encounters by moose and caribou. It is not characterised by radiating linear trails from common traditional use. It was identified incidentally due to intensive surveys that found mostly caribou over repeated intensive overflights and was noted as a mineral source for animals. The mineral lick was not monitored in the winter when the ground was frozen and snow cover made it inaccessible for wildlife use. The camera trap monitoring was used to determine its importance; however, the lick is not of high importance and not affected by the Project so no further monitoring is proposed.

YESAB ISSUE

The Wildlife Protection Plan (WPP) is a primary tool used to support the protection of wildlife and wildlife habitat. The use of qualifying phrases introduce a lack of clarity as to when mitigation measures would be applied minimizes the value of the mitigation measures as they are presented. The lack of specific details for many mitigation measures hinders assessment of their adequacy and makes it unclear how the effectiveness of these measures could be evaluated.

R244

"Provide information on mitigation measures and their implementation through the Wildlife Protection Plan, including:

a. ***Equipment laydown areas: What distance will equipment laydown areas be from known wildlife trails or wildlife road crossings?***

The main equipment laydown area will be located near the processing plant. During construction to widen the Tote Road, temporary equipment laydown areas will be established along the road. The locations will be set during final design but likely located at a few of the borrow areas shown in Figure 4-19 of the Project Proposal. As presented in Section 18.7.3.1 of the Project Proposal, equipment laydown areas will be distant from known wildlife trails or wildlife road crossings. The distance will be finalized during final design on a case-by-case basis depending on the specific trail, topography, and borrow material location.

b. ***Guidelines for wildlife encounters: Provide guidelines to understand how this measure will be applied and to assess how effective it will be. The guidelines should include, for example, the distance an animal is from activity for it to be to be considered "encountered" and to have "left the area", and how wildlife encounters with different species might be managed.***

As presented in Section 18.7.2 of the Project Proposal, BMC is committed to wildlife protection as evidenced through its existing Environment Policy, No Firearms Policy, and No Feeding of Animals Policy. As included in Section 18.7.3.3 and 18.7.3.4 of the Project Proposal, the mitigations for construction and operation are to stop activities if ungulates, bears, or wolverines are encountered during Project activities, or as long as it is safe to do so, until the animal(s) has left the area. Wildlife will be given the right of way. The intent of these and the other mitigation measures presented in Section 18.7 are to minimize disturbance to wildlife while constructing and operating a mining operation. Definitions and details of "distance", "encountered", and "left the area" will be defined when the Wildlife Protection Plan is finalized, during permitting. These details do not change the conclusion of the effects assessment.

c. ***Avoidance of caribou calving grounds: Where are calving grounds located and what is the seasonal period for post-calving?***

As presented in Sections 3.2.2 and 3.3.2 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal,caribou cows are dispersed in the uplands south of the Project footprint during calving in spring in late May. Post calving, in late June to mid-July, caribou congregate in alpine areas south of the Project.

d. ***Revegetation in relation to vehicle access and predator efficiency: What measures will be taken once reclamation of the Tote Road has been completed to ensure that vegetation can re-establish to prevent motorized vehicle access and reduce predator efficiency?***

The closure measures for the Access Road are detailed in Section 7.9 of the Conceptual Reclamation and Closure Plan (Appendix H-1 of the Project Proposal). During reclamation and closure activities, while the road is still in use, public access will be restricted to the same extent as it currently is (as per the Tote Road Lease). Post-closure the access restriction strategies to prevent motorized vehicle access may include: additional gates, signs and barriers. Road reclamation will involve the removal of the culverts and drainage structures and decommissioning of the roadbed. The roadbed will be contoured and rounded throughout its length. All exposed soils along the length of the road will be stabilized and contoured to prevent surface erosion, then seeded with an appropriate seed mix. The ongoing reclamation research program will help to optimize the seed mix for successful revegetation. Preventing vehicle access and reducing predator efficiency on the road will be key objectives for road closure.

e. ***Provide details on how effectiveness monitoring will be included in the Wildlife Protection Plan and the metrics that will be used to measure effectiveness.***

Effectiveness monitoring will be included in the Wildlife Protection Plan (WPP) through the monitoring program, as provided in Section 13.6 of Project Proposal and summarized in R241. The tasks for implementing and monitoring the WPP effectiveness will be overseen by BMC's Environmental Manager. Tasks include:

- Ensuring that the WPP is adhered to through internal auditing;
- Wildlife observation reports and incident reports will be compiled and reviewed regularly to identify and implement required corrective actions on a regular basis;
- Annual review of monitoring data and incident reports to determine if modifications are required to the WPP through the adaptive management plan (metrics are the expected changes and thresholds included in the effects assessment);
- Regular review of site inspection records including, but not limited to, waste storage and disposal, security of attractants;
- Review of employee and contractor recommended modifications to improve wildlife protection procedures; and
- Liaising with the Kaska, regulatory agencies, regional biologists, Conservation Officers, and local communities regarding wildlife issues.

f. ***Sensitive periods: The identification of sensitive periods during which mitigation measures will be applied is important information for assessing adequacy of these mitigation measures. What is the basis for the sensitive periods identified in Table 18-8? Please provide references.***

Sensitive periods were determined from background literature, observations and data collected in the baseline environmental surveys. The references column has been added to Table 18-8 of the Project Proposal, and reproduced below in Table 13-21, to identify references for the sensitivity periods.

Table 13-21: Sensitivity Periods References

Species	Approximate Dates	Sensitivity	Mitigations or Activities to Avoid	Reference
Ungulates	January 1 – March 31	Late-winter conditions	Give ungulates right of way; where practicable do not block movement corridors; minimize disturbance to animals during this time of year; keep snow banks less than 1 m and create passages in banks where trails and tracks are evident at least every 100 m.	Adamczewski et al., 2010 Farnell, 2009 Farnell and McDonald, 1989
Caribou	May 1 – May 31	Calving period	Minimize working in alpine areas during this period to the extent practicable.	Chisana Caribou Recovery Team, 2010. Environment Canada. 2011.
Raptors	May 1 – July 31	Nesting period	Blasting to be restricted to the active mine and crushing Project area and if required outside that area.	McIntyre, C.L., and Schmidt, J.H. 2012
Breeding Birds	June 1 – July 31	Nesting period	Conduct breeding bird surveys prior to clearing during the nesting period; establish 15 m buffers around active nests.	Zone B8 - Environment Canada. 2017. General nesting periods of migratory birds in Canada. Available at: http://www.ec.gc.ca/paom-itmb/default.asp?lang=En&n=4F39A78F-1#_03
Caribou	September 25 – October 31	Rutting period	Minimize working in alpine and subalpine areas during this period to extent practicable.	Environment Canada. 2011 Adamczewski et al., 2010
Bears	1 Nov – 15 April	Denning period	There are bear dens located approximately 4.5 km from site. A preconstruction survey will be undertaken for bear dens and appropriate set back distances from the construction area will be applied until the bears leave the den, if bear dens are observed. During operations, the area will be monitored. Periodic checks will be conducted around the ABM open pit perimeter during the pre-denning period. If bears are observed in the vicinity of the ABM open pit, the conservation officer and RRDC will be contacted to discuss deterrence measures to prevent bears from denning in close proximity to the work areas.	MPERG (Mining and Petroleum Environmental Research Group). 2008a

g. Species coverage: Provide information as to how the WPP will be updated to include measures to protect other species, including denning animals and breeding raptors.

The WPP provided in Section 18.7 of the Project Proposal is a conceptual management plan. As noted in Section 18.7.2, the WPP will be the primary document that BMC will use to implement wildlife and habitat protection. The WPP is a "living document" that will undergo review on an annual basis and adjusted to ensure an appropriate level of wildlife protection is achieved. As more information is gathered through monitoring the presence and behaviour of wildlife interactions with the KZK Project and personnel, additional mitigation measures may be developed and integrated into the WPP.

h. Traffic on the Robert Campbell Highway: Please incorporate mitigation for potential effects on wildlife of increased traffic on the Robert Campbell Highway into the relevant management plans.

Traffic management mitigation measures for wildlife protection are provided in Section 18.12.3.1 of the Project Proposal, and although the focus is on the Tote/Access Road, a number of mitigation measures will also apply to the traffic on the Road Campbell Highway. BMC will implement driver education (including the wildlife and road operation decision matrix as shown in Figure 18-7 of the Project Proposal). Wildlife incidents (e.g., collisions) will be reported to the Environmental Manager as soon as possible within 24 hours, and an investigation to try to identify the cause and remedial measures will be implemented.

YESAB ISSUE

Use of qualifiers. The use of terms such as "where practicable" minimizes the value of the mitigation measures as they are presented unless the criteria for applying mitigation measures are defined.

Bird nest protection. Inadequate mitigation methodology may lead to unacceptable risk, and non-compliance, for migratory birds and species at risk protected under the Migratory Birds Convention Act and the Species at Risk Act. Information is incomplete on nest identification and use of buffer zones and mitigation plans are not consistent with the most recent guidelines from Environment Canada on reducing risk to migratory birds.

Winter monitoring plans. There is insufficient information to assess the adequacy of these plans.

Use of breeding bird surveys for population trends. Breeding bird counts are subject to variability due to many factors and should not be used as a measure of population abundance.

R245

"Provide clarity as to the circumstances under which mitigation measures will be applied (in the assessment and in the WPP), especially for measures where the phrases such as "where practicable" are used to qualify the application of mitigation."

The Company does not intend that the word "practicable' should be interpreted as an excuse to avoid its obligations to implement mitigation measures. Rather, it seeks to clarify that there may from time to time exist specific circumstances that mean that a "possible" action will not be the preferred mitigation action implemented.

The use of the word practicable applies to the mitigating plans or actions that BMC will apply where it is feasible to do so and where enacting the measure(s) does not compromise another aspect of the project such as for example creating an unintended or worse environmental or safety risk or other outcome.

In using the phrase "practicable" the company is drawing the distinction between actions that may be theoretically possible against those that are sensible and feasible to successfully implement and that in the proponents' professional judgement (acting reasonably) are likely to result in a successful outcome.

R246

"Update mitigation plans relating to bird nest protection that reflect the recommended mitigation methods. (e.g.) Incorporate nest identification and use of buffer zones."

Table 18-8, Sensitive Seasonal Periods for Focal Wildlife and Mitigations, in the Project Proposal suggested a minimum 15 m buffer around identified nesting. Buffer zones will be updated and defined for specific species in the final Wildlife Protection Plan and will follow Environment and Climate Change Canada and Yukon guidance. The regional nesting period of birds in the Yukon is early May to late August (Environment Canada and Climate Change Canada, 2017). If active migratory bird nests are found or suspected within the active Project area, a suitable no-disturbance buffer zone, based on species, level of disturbance and surrounding area, will be established. If a suitable buffer zone is unable to be established or followed, activities will be postponed until nesting is complete. For non-migratory birds, suitable buffer zones will also be established. For non-migratory birds, if the buffer zone is unable to be followed, written permission may be obtained from Environment Yukon to disturb nests (YESAB, 2016). Instead of trying to directly locate nests, a non-intrusive search method will be applied. This method searches for evidence of nesting by observing the presence of birds, alarm calls, distraction displays, ideal nesting habitat, etc. to determine whether there are likely nesting birds in the area.

Several specific recommended buffers are as follows:

- The recommended buffer for the olive-sided flycatcher is 300m at high disturbance, 150m at medium disturbance, and 50m at low disturbance (Environment Canada, 2009).
- For the trumpeter swan, the recommended buffer is 800m at all disturbance levels set by the Alberta Sustainable Resource Development (ARSD, 2011).

R247

"Please re-evaluate the proposed use of breeding bird surveys to monitor population trends."

The purpose of the bird monitoring program is to determine presence or absence and relative abundance throughout the Project area. The monitoring will assess whether similar species continue to use the area or return to disturbed areas after reclamation. Relative abundance will give an indication of whether the densities of reclaimed habitat are similar to baseline conditions.

R248

"Provide more information on winter monitoring plans, including details on the location and number of transects to be used.

a. How effective will fixed-transect snow track surveys be in identifying wolf dens?

b. Will any additional measures be taken to identify wolf dens?"

Winter monitoring will be as described in Section 13.6 of the Project Proposal. Every three years, snow track surveys will be completed at least every month shortly after fresh snow fall. This will provide information on presence and use of Project areas by small and medium furbearers as well as larger mammals. The transects will be located at the baseline locations.

a. Fixed transects will have limited use in identifying wolf dens; however, they will help identify wolf presence and identify areas with higher abundance of wolfs that may indicate nearby dens.

b. Yukon Government records have noted presence of wolf dens in the Finlayson lowlands; however, it has not been confirmed where the dens are located and whether they are still used. Additional time will be added to late-winter ungulate surveys to attempt to locate wolf dens.

YESAB ISSUE

Likelihood of occurrence. The conclusions that rare plants were not expected in the LSA is not backed up in the references provided. This conclusion influences the baseline assessment of rare plant presence or absence and, subsequently, the effects assessment.

Survey timing.

This information is needed to alleviate the concern that the potential for rare plants to be in the Project area may have been underestimated.

Knowing whether the surveys were timed during peak detectability of target plants helps assess the likelihood that the plants would have been found if it were there.

R249

"Provide information as to whether any of the rare plants that were targeted in the survey are Beringian, or associated with hot springs, limestone, or alkaline wetlands."

None of the targeted rare plants in the survey are Beringian or associated with hot springs, limestone, or alkaline wetlands as identified by the Yukon Rare Plant Information sheet released by the Yukon

Conservation Data Centre (YCDC, 2017). Table 5-1 of the Vegetation Baseline Report, Appendix E-6 of the Project Proposal, shows the associated habitat for each of the targeted rare plant species. Column four was added to the table (Table 13-22 below) in this response to include the global distribution of each of the species, clarifying that none of the target species are of Beringian origin.

Table 13-22: Species of rare plants that may exist within the Project area

Rare Plant	Yukon Rank	Associated Habitat	Global Distribution	Most Detectable Period
Parry's Arnica, also known as Nodding Leopardbane (*Arnica parryi*)	SH – last reported 1944	Alpine meadows, steep ravines and ledges	Cordilleran	Late July
Northern Beech Fern (*Phegopteris connectillis*)	S1/S2	Moist alpine cliffs and rocky areas	Circumboreal	June- August
Leafy Thistle (*Cirsium foliosus*)	S2	Moist soil, grasslands, meadows, edges and openings in boreal forest, riverbanks	North America	June- August
Mount Sheldon Ragwort (*Senecio sheldonensis*)	S2/S3 – last reported 1970	Sub-alpine meadows, wet to moist meadows, and forest openings in montane to alpine zones	Endemic to mountains in North West Canada	July – early August
Spiny-spored Quillwort (*Isoetes echinospora*)	S2/S3	Silty lake or pond margins, often submerged, granitic gravel/cobbles	North America	July - August
Maritime Quillwort (*Isoetes maritima*)	S2/S3	Shallow water, lakes and streams, granitic gravel/cobbles	North West North America	July - August
Water Mudwort (*Limosella aquatica*)	S2/S3	Semi-aquatic, mud or wet sand adjacent to wetlands or slow moving water	Circumtemperate	July - August
Common River Grass (*Scolochloa festucacea*)	S1	Shallow waters or wet marshes	Circumpolar	Late July – Early August
Blunt-leaf Pondweed (*Potamogeton obtusifolius*)	S1	Small, shallow lakes and ponds	Amphi -Atlantic	Late July – Early August

Note: NatureServe designates conservation status as follows:
Geographic scale of assesment: G = Global, N = National, S = Subnational.
Rank: 1 = critically imperiled, 2 = imperiled, 3 = vulnerable, 4 = apparently secure, 5 = secure, X = presumed extinct or extirpated, H = historical - possibly extinct or extirpated, NR = status has not yet been assessed, U = unrankable with present information (YCDC, 2015). All rankings presented in the above table relate ONLY to the Yukon.

R250

"What period is each of the targeted rare plants most detectable? Note: If rare plant surveys occurred when the target species were at a cryptic stage in their life cycle, then the likelihood of incorrectly concluding the plant is absent is higher.

It is acknowledged that each of the targeted rare plant species has flowering and seed producing periods which allow them to be more easily detected and identified. The periods for the targeted rare plant species are presented in Table 5-1 of the Vegetation Baseline Report, Appendix E-6 of the Project Proposal, and in column five of Table 13-22 in response to R249. Rare plant surveys were conducted at the beginning and end of July in 2015 and 2016, respectively to best capture the peak growth development season for all the targeted rare plants.

Mitigation procedures will be conducted prior to disturbing areas of likely occurrence of rare plants as presented in the vegetation management plan in Section 18.8.2 of the Project Proposal. The rare plant chance-find procedure states, if equipment operators (or anyone else) encounters a potential rare plant, clearing in that area will stop immediately, the plant and surrounding vegetation will be cordoned off, and the site environmental officers will be notified. The environmental officers will then have the identification confirmed by a qualified person. If the plant is determined not to be rare, then the environmental officers will give approval to continue work in that area. If the plant is confirmed to be rare, the Environmental Manager will contact Yukon Environment and the designated RRDC environmental contact to determine the appropriate mitigation measures to be taken if the area cannot be avoided.

YESAB ISSUE

For surveys in 2015 and 2016 that were conducted when exploration activities were occurring, exploration activities could have affected distribution of caribou during those surveys. The authors do not address how the explorations activities may have affected survey results, which could affect some interpretations.

R251

"Were exploration activities occurring during any surveys?

a. If so, which ones, and how extensive?

b. Explain how exploration activities may have influenced caribou distribution during the affected surveys and subsequent interpretations of the survey data."

As responded to for R193, exploration activity at the Project area in 2015 included four drills operating from July to early December. In 2016, camp opened April 1st. The drilling program ramped up to four drills one drill at a time from May to July and then scaled back to two drills from mid August to mid October. Drilling may have locally influenced caribou distribution results during the fall rut surveys in 2015 and 2016 and the early winter ungulate survey in 2015.

Use of helicopter was minimized during the rut and calving periods as per the exploration permit requirements.

It should also be noted that a number of wildlife surveys were carried out when the camp was not operating. Of greater importance, it should also be noted that the outfitter was guiding caribou hunts before and during the 2015 and 2016 fall field season, an activity out of BMC's control. The outfitter has a permanent camp located 12.5 km to the west of the project site. It is assumed that all large mammal survey areas were large enough to detect species that may have been displaced from human activity so the overall observation numbers and interpretations were not affected.

YESAB ISSUE

The assessment is limited to defining habitat suitability within Geona Creek. The baseline assessment assumes that no other areas within the LSA will support beaver. Given that there are several other streams and small waterbodies within the LSA, this assumption is not supported.

There are inconsistencies in the report regarding the suitability of habitat for beaver in this upper reach of Geona Creek.

The information on modelling methods, model assumptions, reliability and validation is needed to assess the reliability of the model outputs, which form part of the effects assessment.

R252

"What is the rationale for only including Geona Creek in the assessment?

As presented in Section 9 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, regional beaver presence and activity was reviewed. The review of historical information for the site noted that beavers have been observed in Finlayson, Geona, and North Lake drainages (Norecol, Dames and Moore, 1996). The field study focused on Geona Creek as it is the main creek that will be affected by the Project.

a. How was the Allen (1982) model adapted and applied to the LSA?

As described in Section 9.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, a Habitat Suitability Index (HSI) was used for Geona Creek to determine the suitability of the creek for beaver occupancy. The criteria used to determine the HSI was based on the 1982 habitat assessment model developed by A. Allen from the U.S. Department of Fish and Wildlife (Allen, 1982). To assess the quality of beaver habitat, a desktop and field examination of the Geona riparian corridor system was undertaken and interpreted based on four criteria:

- Stable hydrological system providing adequate water (number of deep pools);
- Channel gradient of less than 15%;
- Quality food species present in sufficient quantity; and
- Signs of beaver occupancy.

The above criteria definitions are based on those defined in Allan (1982). Stable hydrological system means there is a regular and constant flow of water throughout the year, and there are pools deep enough so beavers can swim to access food and cover during winter. A channel gradient of less than 15% is required, a preferable gradient is usually less than 6%. Quality food species in order of preference are aspen (*Populus tremuloides*), willow (*Salix* spp.), cottonwood (*Populus balsamifera*), and alder (*Alnus* spp.). Beavers switch to herbaceous vegetation during the summer, but are reliant on caches of woody vegetation to feed them during the winter. Lastly, evidence that beaver are actually living and breeding in the area is a strong indicator that the habitat is of sufficient quality to support a colony. The model was adapted for the LSA by identifying local vegetation species that have been used for food and building materials by beavers in the local area.

b. Provide information on model assumptions, an assessment of model reliability and model validation.

Other than the preliminary habitat suitability model to guide the field study (as presented in Section 9.3 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal) a beaver habitat assessment model was not developed specifically for the effects assessment.

c. Provide information on whether the model delineates habitat suitability within the LSA.

The methods and results of the baseline beaver survey are presented in Sections 9.3 and 9.4 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal. Maps, aerial photography and aerial survey were used to delineate beaver habitat in Geona Creek as per the criteria used for the preliminary habitat suitability model. As noted above, a model was not used for the effects assessment.

The best beaver habitat observed during this survey was in the lower 1.2 km of Geona Creek (upstream of the confluence with Finlayson Creek). This area had forest within 10 m of the water channel, abundant willow, and deep pools (average 0.8 m deep) created by resident beavers. There were also signs of current beaver use in this area, and it was classified as moderate grade habitat.

Beaver habitat from 1.2 km to 6 km upstream was poor quality. Although there were pools, they were shallow with minimal vegetation complexity. The upper 2.7 km of Geona Creek was rated poor to moderate quality habitat because of the high number of wetlands in the area, which provided cover and ample food for beavers; however, pond depth was shallow, averaging 0.3 m deep.

d. Provide a clearer justification for the assumption that the upper 2.7 km of Geona Creek is poor beaver habitat.

As presented in Section 9.4 of the Wildlife Baseline Report, Appendix E-8 of the Project Proposal, the upper 2.7 km of Geona Creek was rated poor to moderate quality habitat because of the high number of wetlands in the area, which provided cover and ample food for beavers; however, pond depth was shallow, averaging 0.3 m deep.

There is evidence that Geona Creek has been historically occupied by beavers; however, in most cases the dams have been breached and the lodges are in a state of disrepair. No signs of freshly harvested shrub or tree boles or limbs were observed during the survey, as well as no scat or signs of actively used trails were present. The lack of poplar stands in this area probably prevent the habitat from being highly suitable for beaver usage; beaver are limited to using large willow for building dams or lodges and for winter diet.

Although the habitat meets the criteria for channel gradient, the habitat is lacking in suitable pool depth, lack of poplar stands, and lack of recent evidence of use.

YESAB ISSUE

The assessment may underestimate the potential effects of the Project on caribou, moose, grizzly bear, waterfowl, collared pika, cliff-nesting raptors and passerine birds related to habitat loss through the exclusion of moderate suitability habitat.

Threshold criteria for grizzly bear for change in wildlife movement and direct disturbance is based on a reference that does not support the threshold selected and there is an error in the reference provided for the threshold criteria for moose (it is a caribou reference).

The absence of a detailed assessment of the Project's effects on wolverine and wolf at the RSA scale may lead to inadequate mitigation measures and monitoring.

R253

"Provide discussion and rationale regarding the inclusion or exclusion of specific habitat suitability ratings. Include assessment of the risk of underestimating the potential effects of the Project on wildlife by excluding moderate suitability habitat."

Area and percent losses for all suitability classes are presented in Tables 13-7 and 13-8, Tables 13-10 and 13-11, and Table 13-13 of the Project Proposal for caribou, moose, and grizzly bear, respectively. Area and percent losses of high, moderate, and low suitability habitat are presented in Tables 13-18, 13-14, 13-16, and 13-17 of the Project Proposal for waterfowl, collared pika, cliff-nesting raptors, and olive-sided flycatcher, respectively. The chosen suitability classes were presented because they are the most conservative estimates of percent loss in most cases; however, full information is presented in the tables of the Project Proposal for transparency and so the reader can make their own assessment.

The exclusion of moderate and low suitability habitat for the assessment of magnitude carries very little risk for underestimating potential effects. For caribou, the loss in rut habitat reduces from 3.0% to 2.8% and the loss in post-calving habitat increases from 1.8% to 2.2% in the zone of influence (regional study area for caribou) with the inclusion of moderate suitability habitat. For moose, post rut loss decreases from 4.7% to 4.0% and late winter habitat remains at 3.9%. Grizzly bear denning habitat loss increases from 1% to 3%. The change remains approximately the same for waterfowl and collared pika when moderate suitability habitat is included. Habitat loss increases for cliff-nesting raptors from 7% to 15% and decreases for olive-sided flycatcher from 20% to 14%. Tables showing the changes are included in the response to R254 and R255.

This does not change the overall effects assessment or mitigation planning.

R254

"Why is potential loss of moderate-suitability habitat excluded from the assessment for caribou, moose and grizzly bear?"

Area and percent losses for all suitability classes are presented in Tables 13-7 and 13-8, Tables 13-10 and 13-11, and Table 13-13 of the Project Proposal for caribou, moose, and grizzly bear, respectively. High and moderately high suitability changes were presented because they are the most conservative estimates of percent loss in most cases.

Table 13-23 to Table 13-26, below, present the habitat change for high to moderately high suitability habitat and for moderate to high suitability habitat. The change in habitat is very similar and remains low magnitude in all cases. This does not affect the effects assessment or the proposed mitigations.

Table 13-23: Caribou Rut Habitat Change with Range of Habitat Suitability Categories

	Rut					
Habitat Suitability Categories	Habitat in FCH Range	Habitat in Zone of Influence (ZOI)	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Change in FCH Range*	% Change in ZOI*
Moderately High to High	3,577.2 km^2	1,071.6 km^2	7.8 km^2	47.7 km^2	-0.9%	-3.0%
Moderate to High	5,715.0 km^2	1,499.6 km^2	9.3 km^2	66.2 km^2	-0.7%	-2.8%

*Percent change after direct loss and 50% indirect loss of habitat in LSA

Table 13-24: Caribou Post-Calving Habitat Change with Range of Habitat Suitability Categories

	Post-Calving					
Habitat Suitability Categories	Habitat in FCH Range	Habitat in Zone of Influence (ZOI)	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Change in FCH Range*	% Change in ZOI*
Moderately High to High	2,295.7 km^2	841.2 km^2	1.2 km^2	27.8 km^2	-0.7%	-1.8%
Moderate to High	3,318.7 km^2	1,144.3 km^2	4.9 km^2	40.3 km^2	-0.8%	-2.2%

*Percent change after direct loss and 50% indirect loss of habitat in LSA

Table 13-25: Moose Habitat Change with Range of Habitat Suitability Categories

	Post Rut				Late Winter			
Habitat Suitability Categories	Habitat in RSA	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Change in RSA*	Habitat in RSA	Directly Affected (Project footprint)	Indirectly Affected (LSA)	% Change in RSA*
Moderately High to High	875.7 km^2	9.4 km^2	63.3 km^2	-4.7%	1,296.5 km^2	8.4 km^2	83.0 km^2	-3.9%
Moderate to High	1,286.0 km^2	9.5 km^2	82.6 km^2	-4.0%	1,442.5 km^2	9.7 km^2	93.7 km^2	-3.9%

*Percent change after direct loss and 50% indirect loss of habitat in LSA

Table 13-26: Grizzly Bear Denning Habitat Change with Range of Habitat Suitability Categories

	Denning			
Habitat Suitability Categories	**Habitat in RSA**	**Directly Affected (Project footprint)**	**Indirectly Affected (LSA)**	**% Change in RSA***
High	191.6 km²	0.04 km²	4.9 km²	-1%
Moderate and High	778.5 km²	1.9 km²	45.1 km²	-3%

*Percent change after direct loss and 50% indirect loss of habitat in LSA

R255

"Why is only high-suitability habitat included for waterfowl, collared pika, cliff-nesting raptors and passerine birds?"

Area and percent losses of high, moderate, and low suitability habitat are presented in Tables 13-18, 13-14, 13-16, and 13-17 of the Project Proposal for waterfowl, collared pika, cliff-nesting raptors, and olive-sided flycatcher, respectively. High suitability changes were presented because they are the most conservative estimates of percent loss in most cases. It should be noted that the habitat suitability models have a moderate reliability, literature focuses on what is the most suitable habitat, and local variability will be influenced by site-specific variables and interspecies interactions that aren't included in the models. Therefore, it must be kept in mind that the objectives of the habitat suitability models are to provide an estimate of magnitude of effects and assist with understanding the spatial distribution of effects for mitigation planning.

Table 13-27 to Table 13-30, below, present the habitat change for only high suitability habitat and for both moderate and high suitability habitat. There is no significant change for waterfowl and collared pika. Habitat loss increases for cliff-nesting raptors from 7% to 15% and decreases for olive-sided flycatcher from 20% to 14%. The effects assessment for cliff-nesting raptors would change from a low to a moderate magnitude effect; however, the proposed mitigations do not change. The percent loss is approximately the same for waterfowl and collared pika when moderate suitability changes are added, and the proposed mitigations remain the same

Table 13-27: Waterfowl Habitat Change with Range of Habitat Suitability Categories

Habitat Suitability Categories	Habitat in LSA	Directly Affected (Project footprint)	Indirectly Affected (300 m buffer)	% Change in LSA*
High	18.2 km²	1.9 km²	3.4 km²	-20%
Moderate and High	34.4 km²	3.4 km²	6.4 km²	-19%

*Percent change after direct loss and 50% indirect loss of habitat in 300 m buffer

Table 13-28: Collared Pika Habitat Change with Range of Habitat Suitability Categories

Habitat Suitability Categories	Habitat in LSA	Directly Affected (Project footprint)	Indirectly Affected (300 m buffer)	% Change in LSA*
High	8.7 km^2	0.0 km^2	0.1 km^2	-0.6%
Moderate and High	9.7 km^2	0.0 km^2	0.1 km^2	-0.6%

*Percent change after direct loss and 50% indirect loss of habitat in 300 m buffer

Table 13-29: Cliff-nesting Raptors Habitat Change with Range of Habitat Suitability Categories

Habitat Suitability Categories	Habitat in LSA	Directly Affected (Project footprint)	Indirectly Affected (300 m buffer)	% Change in LSA*
High	1.7 km^2	0.1 km^2	0.1 km^2	-7%
Moderate and High	20.3 km^2	2.1 km^2	1.7 km^2	-15%

*Percent change after direct loss and 50% indirect loss of habitat in 300 m buffer

Table 13-30: Olive-sided Flycatcher Habitat Change with Range of Habitat Suitability Categories

Habitat Suitability Categories	Habitat in LSA	Directly Affected (Project footprint)	Indirectly Affected (300 m buffer)	% Change in LSA*
High	10.9 km^2	0.6 km^2	3.1 km^2	-20%
Moderate and High	17.7 km^2	0.7 km^2	3.6 km^2	-14%

*Percent change after direct loss and 50% indirect loss of habitat in 300 m buffer

R256

"Provide additional information for the threshold criteria selected for moose and grizzly bear."

As presented in Section 13.1.2 of the Project Proposal, a disturbance threshold of 10% is consistent with disturbance thresholds summarized in Swift and Hannon (2010) and Andrén (1994). The habitat disturbance thresholds used for caribou, moose and grizzly bear are more conservative than those used for birds and small mammals to ensure a high likelihood of the desired outcome and a very low level of risk is assumed for the large mammal species that are known to be more sensitive to disturbance.

Similar to the rationale for thresholds for caribou as presented in the response to R192, the 10% threshold for effective habitat change is more of an industrial target and social acceptance threshold as defined by Anderson et al (2002). A threshold needs to be measurable, practical, and realistic for the assessment. Applying a purely ecological threshold would not be practical since it measures when change happens which is too late for mitigation and management measures to be employed.

As presented in the response to R210, the reference for the grizzly bear threshold in Table 13-3 of the Project Proposal was incomplete. The correct reference list should have included Dykstra (2004) and AXYS (2002). Threshold habitat areas required to sustain grizzly bear populations were determined to be 700 to 10,000 km^2 to sustain a population of 35 to 70 grizzly bear in Yellowstone and from 8,556 to 17,843 km^2 to sustain a population of 200 to 250 grizzly bear in British Columbia (Dykstra, 2004). Since overall habitat areas are not known to be limiting in Yukon and there is limited information on grizzly bear and their habitat use in this area of Yukon, a more conservative and general threshold of habitat change was chosen in line with other wildlife habitat thresholds (i.e. 0-10% low, 10-15% moderate, and >15% high) for assessing effects. This provides an industrial target and social acceptance threshold for the effects assessment that is measurable, practical, and reasonable (AXYS, 2002).

For road density thresholds for grizzly bear, Boulanger and Stenhouse (2014) should be included as a reference. The same threshold of 0.6 km/km^2 was found to apply to grizzly bear as for wolverine.

Moose conservation status is secure and there are few habitat limitations in the Project area. Thresholds for moose follow the same rationale as for caribou and grizzly and were kept consistent for the assessment.

R257

"What is the rationale for limiting the scale of the assessment to the LSA for wolverine and wolf, given the large home ranges of individuals of these species?"

The effects characterization in Sections 13.4.1.4 and 13.4.1.5 of the Project Proposal provides a description of the potential effects on wolf and wolverine relative to their large range. As presented, it is expected that effects on wolf are expected to be directly related to the Project effects on ungulates which are described at the local and regional scales. The magnitude of effects was assessed at the more conservative LSA scale and where there is the most potential for interaction with the Project.

Similarly, the description of effects on wolverine recognized that wolverine require large tracts of undisturbed wilderness. Wolverine effects were described for the LSA which provides a more conservative magnitude of effects. There are few roads in the RSA which would lead to lower road densities and lower magnitudes of effects than when assessed in the LSA.

Given there is minimal development in the RSA, assessment of the magnitude of effects on wolverine and wolf in the LSA does not change the results of the assessment or proposed mitigation. As a result of use of the LSA scale for the assessment, furbearers, in particular wolf and wolverine were taken forward into the cumulative effects assessment in Section 13.5.1.4 of the Project Proposal where effects were described and assessed at the FCH-range scale taking into consideration effects from the surrounding activities.

14 HERITAGE RESOURCES

YESAB ISSUE

The project proposal summarizes heritage assessment work conducted for the proposed project in 2015 but does not include a copy of the relevant report (Permit 15-10ASR) in the supporting documents and may not fully detail the extent of baseline data gathering studies.

R258

"Provide the report for work completed under permit 15-10ASR in the supporting documents."

The requested report is included as **Appendix 6** of this Response Report.

YESAB ISSUE

Proposed improvements to the Finlayson Lake Airstrip (Section 4.12.2) and the mine access tote road (Section 4.12.1) have not been assessed for heritage resources and related effects to heritage resources cannot yet be determined.

R259

"Provide a heritage overview assessment for the Finlayson Lake Airstrip and mine access tote road."

In 2015, a Heritage Resource Impact Assessment (HRIA) was conducted for the KZK Project. The HRIA included an assessment of both the proposed mine site and Tote Road (under Permit 15-10SR). The results of this assessment are included as **Appendix 6**, to this Response Report. In 2016, as a follow-up to the 2015 field work a subsequent HRIA was conducted, which is included as Appendix F-1 of the Project Proposal.

Chapter 14 (Section 14.4.2) of the Project Proposal states that a heritage assessment of the Finlayson Lake Airstrip will be conducted. A heritage overview assessment of the proposed Finlayson Lake Airstrip expansion was not conducted in 2015 or 2016, as BMC had not yet identified the areas of the proposed expansion. The area of the proposed expansion was not identified until the winter of 2016, which prevented any additional heritage field work from being undertaken. Given the location of the airstrip, it is likely to have some high potential areas and therefore BMC's heritage consultant is currently in the process of applying for a heritage permit to conduct an HRIA at the airstrip.

This additional work is being conducted as per the mitigation measures described in Section 14.4.2 of the Project Proposal and as per the Heritage Resources Management Plan (Appendix F-2 of the Project Proposal) both of which stated the following:

> Effects to heritage resources are most common during ground disturbances and construction and closure but can be avoided by identifying and avoiding effects prior to construction by

avoidance or mitigation. As noted above the adverse effects to archaeological sites can be mitigated through systematic data recovery.

However complete and thorough, every heritage resource may not have been identified by impact assessment field efforts and remaining unrecorded heritage resources may be affected by the Project. As such, a Heritage Resource Management Plan (HRMP) was prepared for the Project and is intended to be used through the life of the Project from exploration, mining, reclamation and closure. This HRMP is included as Appendix F-2 and summarized in Section 18.13 of the Environmental Management Plan Chapter. This HRMP is based on four Action Items and four Communications Protocols which will be employed on an on-going basis. The four Action Items are:

- Heritage Resources Review of Any New Proposed Ground Disturbing Activities;
- Revisit and Reflag all Heritage Resource Sites Prior to Construction;
- Site by Site Management Efforts; and
- Identification of Any Newly Recorded Heritage Sites.
- The four Communication Protocols are:
- Ground Disturbing Activities;
- Chance Finds Procedures;
- Planned Impacts of Known Sites; and
- Continued Communication with First Nations and the Heritage Resources Unit.

These Action Items and Communication Protocols will work in coordination to ensure any ground disturbing activities are reviewed for past heritage assessment work and if an assessment was not conducted then an HRIA for the area in question is required. An example of this is the proposed extension of the existing Finlayson Lake airstrip adjacent to the Robert Campbell Highway and any proposed borrow pits or improvements along the Tote Road. Since the proposed airstrip extension has not be the subject of HRIA efforts, and it is located along an area of increased archaeological potential near a small lake and a known trail, HRIA efforts are required prior to ground disturbance. Likewise, proposed improvements to the Tote Road, would be reviewed and assessed as needed prior to ground disturbance.

If any heritage resources are located they will be assessed and managed on a site by site basis. If sites are planned to be avoided then the area of the resource will be inspected on foot and reflagged prior to impacts. If any chance finds are discovered, work in the area will cease and the finds will be managed as per the HRMP, and all assessment results, recommendations, chance finds, and management plans will be shared with the RRDC, LFN, and the Heritage Resources Unit of the Yukon Government.

15 SOCIO-ECONOMIC EFFECTS ASSESSMENT

YESAB ISSUE

The Socio-economic Baseline Report is intended to provide a baseline against which future project effects can be predicted, assessed and monitored. However, based on the information provided in the Kaska Ethnographic Overview it appears as though the proponent has not fully integrated information relating to Traditional Knowledge within the study area into the Socio-economic Baseline Report.

R260

"Incorporate all relevant Traditional Knowledge from the Kaska Ethnographic Overview into the Socio-economic Baseline Report."

The Socio-economic Baseline Report was prepared by a local socio-economic practitioner with decades of experience in preparing socio-economic baseline reports in Yukon. The current content of the socio-economic baseline is considered to adequately describe the socio-economic conditions of the potential effected communities (including First Nations). The Ethnographic Overview Report was prepared by a Traditional Knowledge expert, with over a decade of experience working with First Nations. Any relevant socio-economic baseline information that is contained in the Ethnographic Report has already been integrated and considered in the assessment of socio-economic effects (Chapter 15 of the Project Proposal). Subsequently, there is no value in also integrating the information into the socio-economic baseline, as it would not change the results of the effects assessment.

YESAB ISSUE

The Socio-economic Baseline Report does not provide any analysis about economic stability within the communities of the study area. Information provided in Tables 3 and 4 of the Socio-economic Baseline Report is not further analyzed. An understanding of financial resiliency at the community level is needed to assess the effects of the boom and bust cycle.

Further, the proposal does not provide details about the 'conservative assumptions' made in the prefeasibility study as they relate to operation of the mine and temporary or unplanned closures.

R261

"Provide historical top-line municipal tax revenue and inflation-indexed municipal tax rate trends for Faro and Watson Lake and provide accompanying analysis about the stability of the tax base in these communities over time within the Socio-economic Baseline Report."

Property taxes are a relatively minor component of overall municipal revenues. While property taxes are susceptible to fluctuations in local economic activity and of course do contribute to municipal revenues, the overall impact is overshadowed by Federal and Yukon government grants, transfers and spending in local economies. According to the Federal Department of Finance, in 2017, Yukon Government received approximately $25,884 per person in fiscal support from the Federal Govt.

This combination of Territorial equalization payments, formula financing, health transfers and other funding calculations, is provided irrespective of the particular economic situation in the communities. This amount will be amended annually over the life of the Kudz Ze Kayah Project, and by agreement will account for inflation. Federal contribution to the Yukon annual budget, which includes contributions for municipal budgets, provides baseline fiscal stability for municipal revenues.

R262

"Identify situations or scenarios where the project might operate on a reduced scale (including temporary or unplanned closure). This should include detail about assumptions made in the financial assessment of the prefeasibility study (referred to in Section 17.4 of the proposal). Characterize the potential effects of these scenario's and proposed mitigation."

As the Kudz Ze Kayah Project is a private sector economic venture based on revenues exceeding expenses, an unforeseen significant decrease in revenues or increase in expenses could temporarily upset the economic balance of the Project. In the worst case scenario, production could potentially be temporarily halted to allow commodity prices to increase, and/or to retool any aspects of production costs that would result in a resumption of production.

The financial analysis of the Kudz Ze Kayah Project, which includes third party review of the Prefeasibility Study by internationally recognized accounting firm Ernst & Young, sets out the case for a robust economic performance of the Project which can withstand minor to moderate upsets in either revenue or expense forecasts. Economic modelling for the Project has a high degree of confidence.

A catastrophic weather, seismic or other event either naturally occurring or caused by human error could potentially result in a temporary cessation of operations until the situation was rectified. The Kudz Ze Kayah Project will be staffed by experienced mining tradespeople and professionals, who are experienced in rapid response to exigencies and will be well prepared to deal with any emergency situation promptly and adroitly. The protection of human health and safety is of paramount concern for BMC, and as such the inculcation of a 'worksite safe' culture, supplemented by continual safety training will be hallmark of the Project.

YESAB ISSUE

The proponent has identified a desire to source goods and services locally. Additional information about the timing of the need for these goods and services will allow the local community to anticipate these needs and be more likely to fill them.

R263

"In order to assess how the proponent has considered competing demands for goods and services within communities, provide tables with anticipated procurement needs by project phase."

BMC is committed to ongoing consultation with the goods and services providers in the local communities, RRDC and LFN's development corporations, and mayor and councils of the local communities with respect to the goods and services that are available or could be available during each of the project phases. Competing demands will largely be based on the timing of Project construction and overlap with other projects. Due to the uncertainty of both these factors, the development of detailed lists of procurement needs by Project phase is not considered warranted at this stage. However, BMC will continue to consult with the parties listed above to ensure that there is capacity to provide the goods and services in advance of when they are needed.

Note that preliminary confidential lists have been provided to RRDC and their development corporation, as part of BMC's ongoing commitment to working with RRDC to ensure that they have capacity to work with BMC during all Project phases so as to maximise where practicable local input metrics.

YESAB ISSUE

The Socio-economic Effects Assessment notes that higher incomes and education levels tend to be correlated with better individual health outcomes. However, this section should also make broader reference to drug and alcohol abuse, mental health, and occupational health and safety risks that also have an impact on individuals employed in the mining industry.

R264

"Provide an effects assessment of individuals employed for this project in relation to the drug and alcohol abuse, mental health and occupational health and safety risks often associated with the mining industry."

The health and safety of BMC's employees is of paramount importance to the company and is underpinned by BMC's corporate policies that have been included in Appendix A of the Project Proposal. These include but are not limited to the following policies:

- Fitness For Work;
- Occupational Health and Safety;
- Employment and Ant-Discrimination; and
- Personnel Management.

Chapter 15 of the Project Proposal presents the socio-effects assessment (which includes the general public and BMC employees). Section 15.6 (Health and Well-being) includes an effects assessment on drug and alcohol abuse (Section 15.6.3) and Worker Health and Safety (Section 15.6.6). While mental health is not explicitly assessed; mental health is a component of all of the Socio-economic valued components and subcomponents assessed in Chapter 15 and is also explicitly referenced in the Company's Fitness for Work policy.

The key mitigation measures (presented in Section 15.6.3.2) to minimize drug and alcohol abuse include:

- The camp will be dry through all phases of the Project; no alcohol or recreational drugs will be permitted.
- BMC will follow the industry standard and institute mandatory drug and alcohol testing for potential new employees and random testing thereafter (see BMC's Fitness for Work Policy in Appendix A-5) in accordance with Territorial and Canadian federal laws; and
- BMC will also support the provision of information regarding health and wellness education programmes and access to counselling services will be made available to all employees and their families through the engagement of a third-party specialist provider to establish the company's Employee Assistance program (EAP), as required.

The key mitigation measures (presented in Section 15.6.6.2) to promote worker health and safety include:

- The company will rigorously follow all applicable safety laws and regulations in all aspects of its operations.
- All employees will receive the safety training they require to do their jobs properly and safely. A rigorously enforced dry camp will also improve workplace safety.
- There will be a fully trained nurse/Emergency Medical Technician on site at all times along with all required medical supplies and equipment. Included in that equipment will be a properly equipped vehicle dedicated for medical evacuations, if necessary. In addition, helicopter medevacs will be available when needed.
- In addition to the equipment and training above, the Company will ensure the establishment of a suitably equipped and trained Mines Rescue team on site.
- Underground mining can pose its own unique workplace safety risks. The planned approach to the underground portions of the Project is to have a specialized underground mining contractor do the work. BMC will ensure that the contractor rigorously follows all applicable safety laws and regulations for the underground operations.
- Implementation of BMC's Occupational Health and Safety Policy (Appendix A-6) and Safety, Health, and Emergency Response Plan (conceptual level detail of the plan provided in Section 18.15).

In addition to the above measures, all other mitigation measures presented in Chapter 15 will cumulatively minimize potential mental health effects of BMC employees.

With the mitigation measures applied, no significant adverse socio-economic effects are predicted to employees in relation to drug and alcohol abuse, mental health and occupational health and safety risks.

YESAB ISSUE

Aside from statistical data about divorces and separations, the Socio-economic Baseline Report does not contain any information or analysis relating to family structure in the project communities. Families in small communities with little-no access to childcare may experience additional stress based on the fly-in, fly-out shift structure.

R265

"Provide additional statistical data about family structure in the project communities, with a particular focus on single parent households and couples with children."

BMC understands that the information requested does not exist for the communities or is not publicly available.

However, the evolution of workforce housing from the past practice of mines establishing mining towns was the subject of a national discussion in Canada in the mid to late 1980s. The negative situation of abandoned mining towns after mines were depleted was the subject of concern from government and industry. The discussion on the subject including government and industry representatives resulted in the adoption of the fly-in, fly-out model (given the acronym "FIFO"), with temporary worker camps located at new remote mining sites. The decision to adopt the policy of FIFO was based in environmental and socioeconomic considerations. There have been criticisms of the model mostly by mining companies themselves, nevertheless government policy is to serve any and all new mines from existing centres, with temporary camps located at mining sites.

It is noted that that staff are likely to be between 1.5 to6 hours drive from family and less than 1 hr flight in any family crisis.

YESAB ISSUE

The proposal recognizes that substance abuse may be an issue in local communities and could be exacerbated by higher incomes. Mitigation measures are proposed, but with no baseline information it is unclear how the proponent plans to monitor the success of these measures and refine them as needed.

R266

"BMC has proposed mitigation measures on how to manage alcohol and drug abuse in local communities. Provide additional information on how you will be monitoring the effectiveness of proposed mitigation measures."

As mentioned in Section 15.6.3 Reducing Alcohol and Drug Abuse and Section 15.6.3.1 Effects Characterisation repeated below:

"Substantial increases in income can lead to increases in drug and alcohol abuse as these substances become relatively more affordable. Although BMC cannot be responsible for any employee's actions while on their own time, the company will promote a reduction in drug and alcohol abuse among its

employees and the employees of any Project contractors to help ensure a safe worksite, reduce employee turnover, and to help protect the general health and well-being of its employees and their communities."

BMC has outlined measures that it intends to adopt to support its employees, its contractors, and employees immediate and extended families living in local communities to cope with a range of potential risks that may manifest as an unintended consequence of the operation of the Kudz Ze Kayah mining project. These risks may include the increased risk of drug and alcohol abuse due to the improved economic circumstances of members of the community.

BMC intends to adopt the following industry standard management measures that have been successful on other mining projects around the world:

a) The camp will be dry through all phases of the Project; no alcohol or recreational drugs will be permitted. BMC has mandatory drug and alcohol testing for potential new employees and random testing thereafter (refer BMC's Fitness for Work Policy in Appendix A-5 of the Project Proposal).
b) BMC will also support the provision of information regarding health and wellness education programmes, and access to counselling services will be made available to all employees and their families through its independent Employee Assistance Program (EAP). The presence of an EAP service provider operating in the local communities offers other community members access to these services. EAP support is offered on a confidential basis and is subject to normal patient – doctor privilege. However, the company will be advised monthly on a non-specific basis, as to the quantity, general nature and cost of the support that has been provided by the EAP to our employees and contractors. Experience on other mining projects has shown that significant changes in the level of demand and the type of demand for support services is a useful indicator as to the effectiveness or otherwise of company policies and management tools. If required these tools can then be modified to provide better support for employees and thereby better outcomes.
c) The company currently has in place a Mentor program for First Nation personnel employed at the Kudz Ze Kayah project. The initial purpose of this program was to support potential First Nations employees to become 'job ready' and to support them in successfully applying for, preparing for and maintaining employment on the project site. However, this program will be expanded to become a more general support program for all site personnel. While it is not specifically discussed in the Project Proposal, this program will act as a useful personnel management feedback loop for the company since the Mentor is often the first point of contact for local personnel experiencing difficulties at work or at home. Where "at risk" circumstances are identified the opportunity for corrective actions by the Company exists and can be acted upon such as engaging with the EAP program. The mentor also has the capacity to propose to the Senior Site executive mitigation measures based on his or her special knowledge of the matter at issue, the person and the immediate family/social situation.
d) The company will also provide general training to site supervisors and managers that will enable them to be better prepared to recognise the signs and symptoms of employees that may be either at risk of, or be suffering from, substance abuse either directly or indirectly. Once identified, support mechanisms can be initiated.
e) BMC has stated that its intended employment point will be local communities within the Yukon including Ross River, Faro, Watson Lake and Whitehorse. The company will seek to avoid wherever practicable, employment of personnel outside the Yukon on long fly-in fly-

out (FIFO) commutes. The practical effect of this will be that company supervisors and managers will be embedded into the local community and will therefore be more aware of local issues and social stresses that may lead to unintended social outcomes either for the community or for individual family groups within the community. Our experience is that social networking will provide a level of information flow that might not be available in work places that operate in a predominantly longer distance FIFO structure.

f) BMC has a strong relationship with Ross River Dena Council and is seeking to establish similarly strong relationships with local governments of Watson Lake, Liard First Nation, Faro and Whitehorse. These relationships will be supported by regular meetings between company representatives and government bodies. It is anticipated that unintended social and community issues including drug and alcohol abuse will be a routine topic in those discussions and will be a valuable source of feedback information for the company.

g) To help and encourage employees and their families to maintain good health, BMC will negotiate on behalf of all employees for favourable arrangements with suppliers of life and property insurance to significantly reduce the costs of these products and offer a dental and health plan for employees.

h) BMC's hiring process will also ensure extensive screening of employees to gauge their suitability for shift work and to help educate them on the potential effects of shift work on family health and welfare.

YESAB ISSUE

The proposed Project is located in close proximity to areas where traditional activities are taking place (e.g. hunting, trapping, fishing, gathering plants, etc.). There are also registered traplines and First Nations' cabins in the areas of North Lakes, Wolverine Lakes, Money Peak, all of which are adjacent to the local study area.

This project proposal did not include an assessment of human health, with the justification that there are no permanent or semi-permanent residents nearby.

However, people using the cabins at the project boundary were not considered in the assessment.

There was no assessment of the Project's effects on country foods and the potential for human health impacts.

However, the project proposal notes that culturally significant species are hunted (caribou, moose, sheep) and fished (grayling, trout, jackfish, whitefish, sucker fish) in the Ross River Dena Council and Liard First Nation traditional territory which overlaps with the Project footprint.

R267

"Provide a preliminary quantitative Human Health Risk Assessment for each stage of the project. This assessment should be informed by Heath Canada's Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA) Version 2.0 (2012). At minimum this assessment will address the following:

a. risks associated with human use of the area (e.g. the cabins at the project boundary or for traditional activities such as hunting, trapping, harvesting) potentially impacted by the project;

b. risks associated with consumption of country foods (e.g., fish, caribou, migratory birds, and other animals exposed to environmental contaminants from the project in the air, water, or soil) harvested through traditional hunting, fishing, and gathering activities; and

c. risks associated with consumption of surface and ground well water used for drinking potentially impacted by the project."

The requested Assessment is included as **Appendix 3,** to the Response Report.

YESAB ISSUE

Traffic safety around the project footprint is described in detail but there is very little description of the proponent's plans to mitigate traffic risks in Watson Lake or along the truck route to port facilities.

R268

"Provide additional information on the identification of risks, effects of increased traffic along the entire route, and mitigations. Include communities, other road users, and wildlife in addition to the following:

a. strategies for avoidance of school children at the beginning and end of the school day,

b. logistics to reduce risks of driver fatigue in long haul truckers, and

c. risks to other users based on the transportation of fuel, supplies, and ore concentrate."

a) Once off the property and onto the Robert Campbell Highway and other highways, traffic out of and into the Kudz Ze Kayah Mine will operate using existing roadways and traffic corridors, which include identified industrial trucking routes through municipalities. The largest category of vehicular traffic will be KZK-specific contract concentrate haul trucks, which will be appropriately lit including strobe lights, as well as high intensity driving lights for the long stretches of unlit highway during winter operations.

With the exception of Watson Lake, the municipalities through which Kudz Ze Kayah concentrate haul trucks will travel do not intersect school zones. Heavy truck haul routes have been designed to eliminate the intersection of industrial traffic and school zones. During community consultations and in meetings with the Mayor and Town Council of Watson Lake regarding the Kudz Ze Kayah Mine, this issue was identified. Under the current road arrangement, the truck route through Watson Lake runs in front of the school. In this section of the haul route, trucks will obey the school zone speed limit of 15 kilometres per hour.

Any school bus zones that occur along the truck route will be identified as part of driver orientation and training program prior to the first trip of any new drivers. New driver orientation sessions will also include briefings on known high incidence areas of wildlife crossings along the route, which will be updated with new sightings as they occur as part of the Wildlife Management Plan.

b) All long-haul trucking operations will be operated in accordance with *Yukon Occupational Health and Safety Regulations* in Yukon and in British Columbia the *BC Motor Vehicle Act* and other pertinent workers health and safety statutes and regulations regarding maximum allowable driver working durations.

c) Both the Yukon and BC also have modern statutes and regulations governing the transportation of hazardous goods on public roadways, designed to protect public safety.

In fact, past experience in Yukon has shown that the addition of regular traffic by professional drivers equipped with basic first aid supplies and reliable communication capabilities on remote highways has proven to be a welcome safety feature for the public. In many instances in the past during mining operations in remote areas such as Yukon, concentrate haul and supply trucks have played pivotal roles in providing critically needed and otherwise unavailable timely roadside assistance. BMC assumes that this reality will not go unobserved in the socioeconomic assessment of this aspect of the Kudz Ze Kayah Project.

YESAB ISSUE

A shortage of rental housing capacity in Whitehorse was brought up at one of the meetings in the consultation record. However, the proponent states in its proposal that Whitehorse is understood to have the capacity to absorb an in-migration of workers, which is likely to happen during the construction phase of the project.

R269

"Provide additional information to support the assumption that there is sufficient rental housing capacity in Whitehorse. Provide an understanding of the current rental housing capacity in Whitehorse and projections that consider likely demands and in particular demand from other proposed mining developments such as the Coffee Gold mine (Goldcorp Inc.) and the Casino mine (CMC Inc.)."

A brief survey of available houses for sale showed 101 advertisements for residential property within 10 km of Whitehorse.

It should also be noted that the proponent is assuming that a significant proportion of the employees will be sourced locally from either unemployed, or personnel that are currently part time or are seeking full time employment. In the Yukon Employment Annual Review (2016) published by the Yukon Bureau of Statistics, Yukon's unemployment rate of 5.6% was the lowest in Canada. However, it also showed that in 2016, of the 6,900 persons who were not in the labour force, 500 did want to work. It is a reasonable hypothesis that these 500 are currently resident in the Yukon and have housing. As such, employment of a small portion of these people at the Project will not put stress on the existing housing market.

To the best of the proponent's knowledge, neither the Casino nor the Coffee mine is permitted and the proponent does not consider it to be reasonable to be expected to make definitive "what if" analyses and statements about projects where the proponents have made no decision to commence construction. To answer this question requires a degree of knowledge about the timing of the other projects that BMC is not aware of.

Note that during the public consultation period prior to submission of the Kudz Ze Kayah Project Proposal to YESAB, BMC representatives met with municipal government representatives in Faro, Watson Lake and Whitehorse to discuss the Project in general and housing in particular. These discussions yielded useful information and served to alert municipal planners that an intensification of housing requirements was likely to accompany the coming resurgence of mining activity throughout the Yukon. From these discussions, BMC understands that perhaps the most pressing housing needs occurred in Whitehorse.

R270

"Describe mitigative measures and alternatives that may be utilized in the event that the rental housing capacity in Whitehorse is unable to serve the needs of this project."

To alleviate the potential housing/rental shortage, a creative and flexible solution needs to be developed to facilitate short-term housing needs created by this and other cyclical industries – in the communities affected by the nearby mines – and also in Whitehorse. Clearly, this issue is bigger than something that can be solved by BMC alone. Over the next few years while we are in the assessment and licensing stage, BMC would be pleased to participate in roundtable discussions with other mining companies who have projects nearing construction stage, Government of Yukon, First Nations, municipal planners and political leadership, to find solutions that could be applied to housing shortage that would be supported by stakeholders.

Ultimately, if a satisfactory housing solution is not developed and implemented, then the workforce of this and any new mine will by necessity consist of a more than optimal number of non-Yukon residents.

YESAB ISSUE

In order to assess effects from project waste, YESAB requires further information on where the following types of waste will be disposed of: beverage containers and other recyclables, steel/copper/rubber, tires, batteries, antifreeze (and used containers), solvents (and used containers), and all other forms of hazardous waste.

R271

"Identify the final destination for each type of waste that will be disposed of off-site, including licensed recycling or disposal facilities."

BMC will develop a fully equipped and properly designed Solid Waste Management Facility on site, in accordance with appropriate regulations under the *Environment Act.* In addition, KZK will have a hydrocarbon-contaminated soil remediation facility on site; this facility will also be designed, built and operated in accordance with *Environment Act* regulatory requirements.

Any special waste as defined by the *Environment Act Regulations* would be transported off site and out of the Yukon to authorized sites in Southern Canada. Collection and transportation of wastes will be handled by authorized contractors, with the responsibility for sourcing these outside facilities.

16 EFFECTS OF THE ENVIRONMENT ON THE PROJECT

YESAB ISSUE

Most, if not all of the extreme weather event discussion involves impacts to operations of the Project (e.g., reduction of activities, minimize traffic, damage to infrastructure). There is no information with respect to potential impacts on the environment (e.g., to water quality in nearby streams).

Return periods associated with design 24-hour precipitation events (Table 16-5) and likelihood of flooding from infrastructure (Table 16-6) appear to be calculated with respect to historical and not projected future climate.

Although some general information on climate change is provided (including associated temperature and precipitation maps over the region associated with various emission scenarios and future time periods), there is no information or analyses regarding how these projections will be reflected in changes to extreme 24-hour precipitation and associated flooding events. It is therefore difficult to discern if there will be significant future changes to hydrological flow regimes in watercourses around the Project area affecting water conveyance and storage systems or surrounding infrastructure.

R272

"Incorporate climate change information to re-assess the return periods associated with design 24-hour precipitation events and likelihood of flooding from infrastructure."

As stated in the Project Proposal Section 16.6.*3 "The likelihood of climate change occurring is overall likely; however, changes will occur over the long term and the magnitude of changes likely to occur over the Project's life is small."*

Extreme events have been allowed for in the design of the water containment structures which will be designed to operate with a 1 in 200 year flood event. Mitigation measures have been included in Chapter 17 Malfunctions and Accidents of the Project Proposal, in the unlikely event that the maximum precipitation event designs are based on is exceeded. The mitigation measures are outlined in Section 17.2.5 of the Project Proposal.

The water balance model used in the Project Proposal is conservative and any fluctuations in model inputs, or types of event will be allowed for within this conservatism.

R273

"Given this information, re-assess whether there will be significant future changes to hydrological flow regimes in watercourses around the Project area affecting water conveyance and storage systems or surrounding infrastructure."

Given that the magnitude of effects of climate change over the Project's life are small, (Section 16.6.3 of the Project Proposal), there is little likelihood of future changes of hydrological flow regimes in watercourses around the Project area and thus no significant effects on water conveyance and storage systems.

17 MALFUNCTIONS, ACCIDENTS AND UNPLANNED CLOSURE

YESAB ISSUE

In Accidents and Malfunctions a discussion of the impacts on fish and fish habitat and the associated affects to Commercial, Recreational or Aboriginal (CRA) Fisheries that would result from a catastrophic failure of the water management ponds on Genoa Creek should be provided. The expectations for this analysis would be a robust assessment of potential impacts and risks to CRA Fisheries that would include modelling of wave inundation and erosional forces associated with an event that occurred during a dry or wet year in combination with a dry (piping) or wet (precipitation) event. This assessment would include discussion of how far the inundation wave would travel, how far erosional forces would extend, the range of potential effects.

R274

"Provide a discussion of the impacts on fish and fish habitat and the associated affects to Commercial, Recreational or Aboriginal (CRA) Fisheries that would result from a catastrophic failure of the water management ponds on Genoa Creek"

The potential impacts of a failure of the proposed WMPs to CRA fisheries resources under current conditions would be considered negligible. As discussed in the Aquatic Ecosystem Baseline Report (Appendix E-3 of the Project Proposal), fisheries resources through the length of Geona Creek are considered minimal as only a very few resident grayling inhabit the system and do not contribute to CRA Fisheries. Similarly, fisheries resources in Finlayson Creek downstream of the confluence with Geona are also considered limited with only slimy sculpin captured during two years of baseline data collection upstream of the Robert Campbell Highway.

From a sedimentation perspective, the combination of a large beaver impoundment immediately downstream of the WMP location and the ponds to be constructed as part of the Fisheries Offsetting Plan (FOP), should act as a sink for a large majority of any potential catastrophic release of particulates from a WMP failure, which would additionally ease any clean-up that may be required.

Potential impacts to water quality would also be considered minimal if the lower water management pond (LWMP) failed, as the water held in the LWMP will contain water that is within three times the long term/chronic water quality guidelines and would not exceed the short term/acute guidelines. It will also not contain significant sediments.

Preliminary examination of the hydrological impacts following a WMP failure anticipates a large influence in the Geona Creek watershed but smaller in Finlayson Creek decreasing to undetectable by the Finlayson River confluence. This will be modelled when final WMP designs are completed, to quantify potential impacts.

Under current conditions, the preliminary assessment of a potential failure of the WMPs indicated that impacts to Geona Creek CRA fisheries would be limited to areas downstream of the Robert Campbell Highway to the confluence with Finlayson River. As these potential impacts appear minimal, BMC will incorporate mitigative measures into the final WMP detailed design to restrict potential impacts to areas upstream of the RCH.

YESAB ISSUE

Section 17.4 references the additional cycle of boom and bust that would occur in the event of unplanned closure and recognizes the negative effect this may have on employees. Several mitigation measures have been provided for this effect. However, the proposal does not mention the risk of this event to local contractors and businesses. There is also no detail on how BMC will ensure that the mitigation measures proposed for employees will be carried out.

R275

"Provide additional information on the risks of temporary or permanent unscheduled closure of the Project focusing on socio-economic effects to employees, contractors, and businesses, and others who have been impacted economically. Include details and description on how adverse socio-economic effects will be mitigated and financed, particularly if an unscheduled closure occurs (i.e., how will BMC be able to finance the costs associated with mitigation measures)."

1. Risk of Closure:

Any unplanned or temporary closure of the project is most likely to occur through some unanticipated technical or financial occurrence that renders the mine either uneconomic or otherwise unfeasible to operate.

Prior to submitting and in preparation of the Project Proposal to YESAB, BMC has carried out feasibility studies that include likely technical and economic project elements. These studies have been carried out by experienced industry professionals both in house and through world renowned specialist mining consultancies that have a demonstrated track record of developing mining projects worldwide. At all stages of the investigations to date, BMC has been conscious of the technical and economic risks that can beset a mining project and has ensured that there is an appropriate level of conservatism in the assumptions and the technical and economic assessments. For example, BMC does not use short term metal price and exchange rate data in our project assessments but rather uses long term consensus forecasts provided by industry specialists in such diverse fields as commercial and merchant banking, metals and commodity traders, government economic groups, central banks, and mining industry bodies. In addition to adopting a longer term view, BMC has carried out its own internal stress testing of project economics under a range of scenarios including unplanned unfavourable short and long term movements in metals prices and exchange rates outside expected norms. The work completed to date has helped us to form our view regarding the financial metrics for the Project. Final financing decisions with respect to Project development will incorporate provision of various scenarios in relation to product pricing and technical risk to ensure that BMC is able to finance costs related to any temporary closure.

2. Mitigation of outcomes from an unplanned closure:

a) The effects on employees of an unplanned or temporary closure;

As outlined in the Socio-Economic report, the local region around the project and the Yukon generally has a relatively low level of mining employment and an overall high rate of youth and other unemployment. There are also a high number of working age people who have never had the opportunity to hold a full time or steady job due to the lack of availability of an opportunity. The proposed Project offers local community members the possibility to gain employment and improves their potential for future employment should this employment end after a period of time. Once workers have a demonstrated record of employment and transferable work skills, future employment is more likely.

Furthermore, BMC has certain programs already in place that promote education and on the job training. The most public of these is the current three year BMC-Kaska Scholarship program. This program is designed to run until June 2019 at which time it is expected that it will be superseded by the final mining related program. The current program:

- Supports and encourages Kaska secondary students to complete their final year of school;
- Encourages and supports completion of trade certificates and apprenticeships through Yukon College;
- Encourages and supports completion of certain technical studies that will result in achievement of diplomas, certificates and other recognisable qualifications through Yukon College; and
- Supports degree level technical studies in both mining related and other fields of study through any recognised university in Canada. Scholarship holders for mining related degrees studies are further supported by a guarantee of vocational employment to gain work experience.

In 2016, the above program provided direct support to 27 Kaska members and it is expected that the 2017 and 2018 programs will provide benefits to similar or greater numbers. By the time the proposed mine is in operation, it is likely that over 100 local Kaska members will have enhanced their education due to the BMC-Kaska Scholarship program.

During the operation of the proposed mine, the company intends to continue a similar program to the above but will supplement this program by:

- Various on the job training programs; and
- Employment of apprentices and trainees.

The above programs will result in an overall upskilling of the workforce over the life of the project which is independent of the time that the project is open. Unplanned closure or interruption of operations either for a short period or longer period will not detract from this outcome. It should also be noted that the skills and experience gained through the projects life will be transferrable across different mine sites and across different industries. This upskilling will result in project employees being seen as valuable additions to any workforce in the Yukon or Canadian as well as the international mining industry or in any non-mining employment scenario that they choose to go into. As a result of the increased experience, the upskilling of the workforce and the mobility of that experience and skills gained, it is expected that any temporary closure of the project should not result in undue financial hardship for employees unless they choose to not take up work with other employers.

b) The effects on local contractors of an unplanned or temporary closure

The above explanation a) is no different for local contractors who will all gain through experience, contracting history and upskilling of their workforce. This will lead to an increase in their ability and capacity to compete for contracting opportunities both within the Yukon mining industry and in outside industries.

BMC has a policy of supporting local businesses with an established track record. In 2016, the BMC awarded over 70% of its major contracts at the Kudz Ze Kayah project to local First Nation and other Yukon companies. In the event of a planned or unplanned temporary closure of the project the company anticipates maintaining support for local businesses through BMC policy and practise.

c) Funding mitigation measures around an unplanned or temporary closure event

The Company is an international mining company with significant funds and funding commitments established. In order to develop the project, the company will generate additional funding through a combination of equity and debt. This funding level will be calculated to take into consideration working capital requirements and the risk of temporary cessation of revenue from project activities. Where there exists a risk from metal price and foreign exchange the company may put in place certain hedging arrangements or other financial measures should the Directors in consultation with the Company's bankers and other advisors deem that it is prudent to do so.

In addition to this, the extensive studies that have been carried out on behalf of the company to date have demonstrated that the project is economically viable under a broad range of economic and technical conditions. The company expects to make a profit from the project and intends to adopt prudent and well tested cash management policies in order to ensure that it retains sufficient cash reserves on hand to adequately deal with any unforeseen revenue interruption over the project life.

Finally, it is normal practise for regulators to impose environmental bonding obligations on mine developers prior to issuing licences and permits to construct and operate. These bond requirements are normally calculated by the regulator to ensure that sufficient funds are available for an orderly closure of the mining project at any stage of its life. The company expects that this project will be no different in that regard and has included allowances within its financial models for this to occur.

18 CONCEPTUAL MANAGEMENT PLAN

No information required.

19 SUMMARY AND CONCLUSIONS

No Information required.

20 NEW IFORMATION REQUESTS (JUNE 8)

YESAB ISSUE

A thorough options assessment is a critical component of project planning and MRB (Mineral Resources Branch) would have expected the proponent to have conducted an assessment not only on the waste disposal locations but also on management methods and facility risks for all stages of the project. This options assessment needs to rigorously assess all feasible options and must describe the rationale for the selected option in a transparent manner.

In light of the long-term liability of the waste management facilities, particularly the Class A Facility, after closure to Yukon, it is imperative that all reasonable options for waste management are examined. These options need to be examined, not just in the light of the operational and near post closure period, but in the light of the benefits and costs over the long term. MRB strongly suggests that the proponent conduct a thorough options analysis coupled with a multiple accounts analysis, and a comprehensive risk assessment, which considers different mechanisms for disposal of mine waste.

R276

"Additional information on how the options assessment was conducted, the parties involved, and the criteria and ranking systems used;"

The options assessment conducted during the conceptual and preliminary design stage of Kudz Ze Kayah Project was not a risk assessment; rather, it was an internal exercise based on classic alternatives assessment methodology, conducted by engineering staff at BMC's Vancouver and Perth offices. The only component of the mine design that was conducted by external consultants was the tailings disposal method and location, due to its complexity and magnitude of influence on overall mine design/operations. This component was conducted by Knight Piesold, whose alternatives assessment supported the company's preference to construct a dry stack tailings facility as opposed to depositing slurried tailings behind an earthen valley fill dam (**Appendix 8** to this Response Report).

The criteria and ranking system used for the Alternatives Assessment is presented in Section 4.15 of the Project Proposal. The ranking system was designed to meet the requirements as set out in *Yukon Environmental and Socioeconomic Assessment Act* to determine which components of the Project would have alternative methods of being undertaken that would avoid or minimize environmental or socio-economic impacts.

R277

"Provide the reports referenced in Section 4.15.4 in support of the Options Assessment."

The following reports were listed in Section 4.15.2 of the Project Proposal:

- Golder Associates Ltd. 1996b. Tailings Embankment Design Report - Kudz Ze Kayah Project. Retrieved from Unpublished Technical Document Submitted to Cominco Ltd.

- Knight Piesold Ltd. 2016a. Prefeasibility Design Report. Retrieved from Unpublished Technical Document Submitted to BMC Minerals (No.1) Ltd.
- Knight Piesold Ltd. 2016b. Tailings Management Alternatives Assessment (Rev A). Retrieved from Unpublished Technical Document Submitted to BMC Minerals (No.1) Ltd.

Golder Associates (1996b) and Knight Piesold Ltd (2016b) are provided as **Appendix 7 and 8,** in this Response Report. Note that the tailings tonnages and density reported in the Knight Piesold report were preliminary and have since been superseded.

The Knight Piesold (2016a) Prefeasibility Design Report contains confidential Project costing information and therefore will not be released for public consumption.

R278

"Provide a risk assessment for mine waste management facilities including a failure modes effects analysis."

Failure Modes Effects Analyses (FMEA) are useful tools for evaluating a proposed system or structure, identifying possible failures in design, and ranking the hazards associated with those failures. The risk register can then be utilized to prioritize and guide risk mitigation measures, and to track the 'running risk' that the project poses to a range of identified values.

Given the Project focus on designing for closure, the FMEA process has been identified in the Conceptual Closure and Reclamation Plan (Section 7.12.1, February 2017, Appendix H of the Project Proposal), and BMC is committed to utilizing this planning tool to advance the design and closure measure aspects of the waste management facilities. This will be undertaken to support the advancement and refinement of the facility design, and will be a component of the more detailed Reclamation and Closure Plan that will be developed in accordance with YG's 2013 Guidance Document: *Reclamation and Closure Planning for Quartz Mining Projects guide by Yukon Government and the Yukon Water Board.*

YESAB ISSUE

Section 9 of the CRCP includes a preliminary closure liability estimate, MRB would like to note that the estimate provided is not consistent with the 2013 guidance document prepared by Yukon government (YG) and the Yukon Water Board entitled "Reclamation and Closure Planning for Quartz Mining Projects." Specifically the estimate does not provide for indirect costs such as reclamation research, engineering design, interim care and maintenance and other costs associated with the development of closure plans. Given the uncertainty surrounding the waste disposal methods and treatment of impacted water, it is important for the proponent to give full consideration to the costs associated closure plan development and implementation.

R279

"Provide an updated Conceptual Reclamation and Closure Plan demonstrating that the mine site will remain chemically and physically stable in the long-term using proven technologies demonstrated to work in northern climates."

BMC is committed to the selection of the most appropriate technologies for maintaining long-term stability of the Project site and for meeting all other closure goals and objectives. The CRCP provided as Appendix H to the Project Proposal proposes closure measures that are either routine, industry standard practices (e.g. runoff diversion, regrading, revegetation, low permeability mine waste covers) or Project-specific and developed by industry experts with substantial experience in the application of these technologies in comparable situations in the mining industry (e.g. *in situ* carbon-based water treatment, constructed wetland treatment systems [CTWS]).

Additional support for the application of some of these technologies at the Project is provided in responses to IR109 (CWTS), IR125 (*in situ* pit treatment, CWTS) and IR130 (waste cover systems). A detailed Reclamation and Closure Plan will be developed in accordance with YG's 2013 Guidance Document: *Reclamation and Closure Planning for Quartz Mining Projects guide by Yukon Government and the Yukon Water Board.* This plan will provide additional support for the application of site-specific closure measures.

R280

"Provide an updated closure liability estimate consistent with the 2013 Reclamation and Closure Planning for Quartz Mining Projects guide by Yukon Government and the Yukon Water Board."

BMC commits to conforming to Yukon Government's Mine Closure Guidance Policy, including the provision of financial security against current liabilities at the Project development. The guidance document referenced is applicable to the development of *detailed* Reclamation and Closure Plans (RCPs). BMC's RCP for the Project is currently and appropriately developed at the conceptual level, as a planning tool to support Project conceptual design and for the purpose of supporting the assessment of potential effects arising from the Project development. Likewise, the costing is provided at the conceptual level, as an indication of the scale of actual costs associated with reclamation and closure of the Project. This is provided in support of the effects assessment, not for the determination of security requirements. Closure costs have little if any bearing on assessing effects of a project, beyond the risk of insolvency on the part of a proponent. Detailed closure costing, following the 2013 guidance document, will be submitted in support of permit applications and for the determination of security in accordance with YG's Mine Closure Policy.

YESAB ISSUE

In the Project Description (pages 4-106 and 4-107), borrow sources information is lacking. The current land lease does not speak to borrow sources and no other authorization from LMB has been granted for Borrow Sources. LMB considers Borrow Sources to be a quarry; as a result, a quarry lease and permits would need to be applied for.

R281

"Provide information on borrow sources for the mine site, access road and airstrip upgrade including:

a) the locations of borrow sources;

b) description of dimensions of borrow source excavations including area and depth of excavations;

c) the estimated quantities of suitable borrow material available;

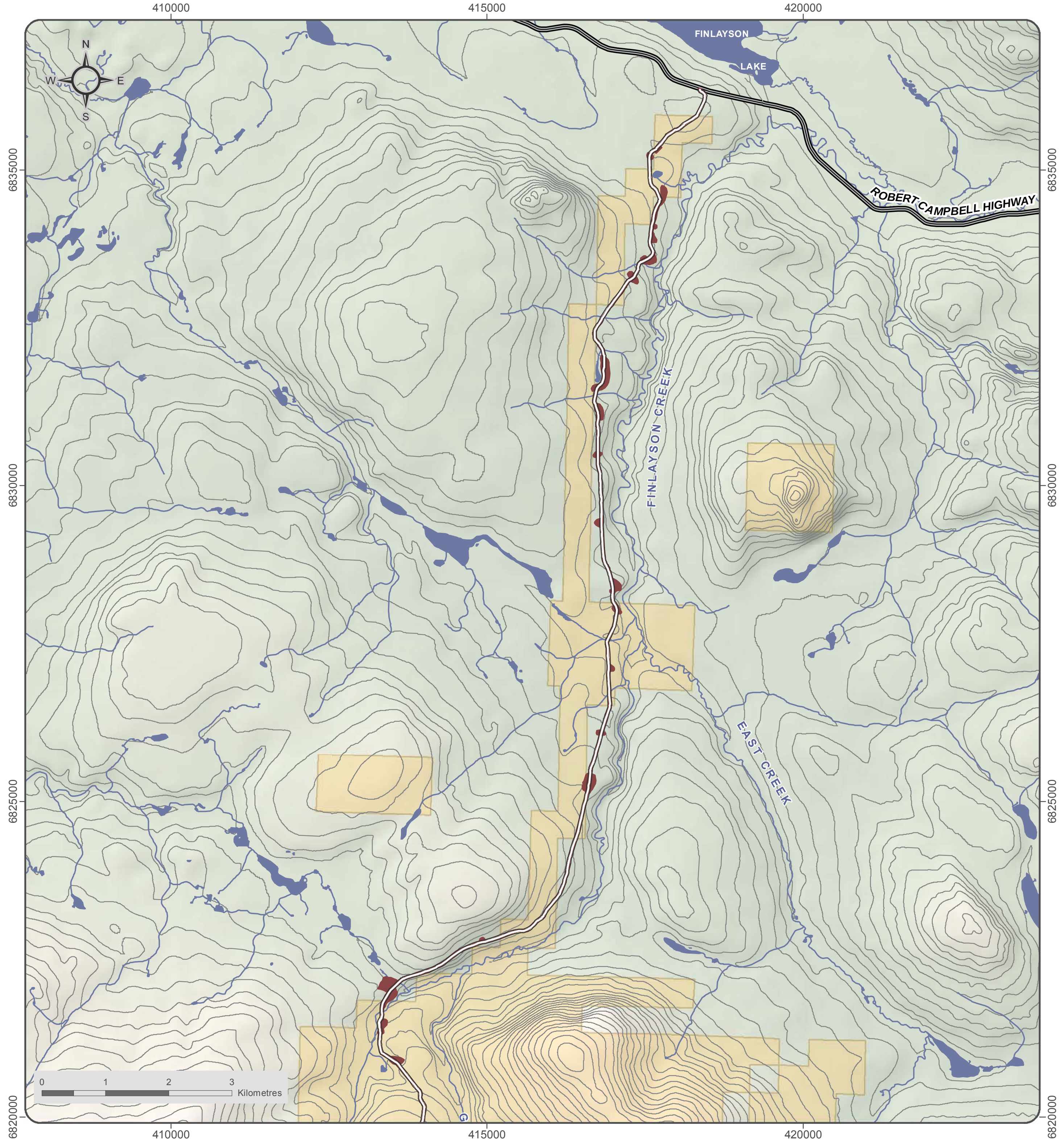
d) the quantity of borrow material required for engineered mine components;

e) length of time individual sources will be used for; and

f) proposed mitigation measures to minimize potential adverse effects associated with the development and use of the proposed borrow sites."

Borrow Sources for Tote Road Upgrade

Multiple borrow sources have been identified and sampled in the field, with the locations of all potential borrow sources for the access road illustrated in Figure 4-19 of the Project Proposal (reproduced as Figure 20-1, below). These locations were largely those that had previously been identified and utilised as borrow sources for the construction of the Tote Road in 1995. While all potential borrow sources have been identified on this Figure, only some of them will be required for construction purposes, and the selection of specific borrow sources for construction is intended to be determined by the construction contractor during detailed planning of construction activities.



Tote Road/Proposed Access Road

Potential Borrow Sources

BMC Minerals (No.1) Ltd. Mineral Claim Areas

Waterbody

Watercourse

Contour (40 m interval)

KUDZ ZE KAYAH PROJECT

FIGURE 20-1

ACCESS ROAD ALIGNMENT AND POTENTIAL BORROW SOURCES

JUNE 2017

Datum: NAD 83; Projection: UTM Zone 9N

AEG

BMC MINERALS

D:\Project\AllProjects\Kudz_Ze_Kayah\Maps\01_Overview\03-SpecificTopics\Tote_Road\Borrow Sources\Access_road_Borrow_Sources_20161219.mxd

For greater clarity, the location, area, classification and material source for each borrow source identified by Onsite Engineering Ltd. (Onsite, 2016) is detailed in Table 20-1.

Table 20-1: Borrow Site Locations and Specifications

Borrow ID	Centroid Location (UTM ZONE 9)		Area (Ha)	Classification	*Material Source
	Northing (m)	Easting (m)			
OEL-64-2	6835334	417698	0.59	Pit	Surfacing
OEL-64-1	6835220	417579	0.59	Pit	Surfacing
OEL-63	6834317	417703	5.1	Pit	Surfacing
OEL-62	6833582	417564	2.48	Pit	Subgrade
OEL-61	6833297	417312	1.63	Pit	Surfacing
OEL-59	6831760	416842	6.32	Pit	Surfacing
OEL-57/OEL-58	6831176	416775	2.42	Pit	**Surfacing/Subgrade
OEL-56	6830498	416748	0.75	Pit	Surfacing
OEL-55	6829416	416771	1.09	Pit	Surfacing
OEL-54	6828413	417031	2.46	Pit	Surfacing
OEL-30	6828047	417050	1.3	Pit	Subgrade
OEL-53	6827754	417041	1.54	Pit	Surfacing
OEL-21	6827111	416963	0.72	Pit	***Mix
OEL-51	6826088	416796	0.78	Pit	Surfacing
OEL-50	6825294	416615	4.56	Pit	Subgrade
OEL-6	6822804	414923	0.47	Pit	**Surfacing/Subgrade
OEL-2	6821375	413321	0.83	Pit	Surfacing
OEL-1	6820903	413565	2.05	Pit	Surfacing
OEL-10	6819438	413915	0.27	Quarry	Riprap
OEL-11	6819107	413905	0.28	Quarry	Riprap
OEL-12	6819024	413937	0.4	Quarry	Riprap
OEL-13	6818895	414009	0.22	Quarry	Riprap
OEL-14	6818447	414092	0.22	Quarry	Riprap
OEL-19	6817784	414227	0.04	Quarry	Riprap
OEL-15	6817447	414268	0.27	Quarry	Riprap
OEL-16	6817070	414395	0.3	Quarry	Riprap
OEL-17	6816748	414542	0.12	Quarry	Riprap
OEL-18	6816306	414725	2.02	Pit	Surfacing
OEL-4/OEL-5	6822107	413436	4.6	Pit	Surfacing
*Surfacing sources are suitable for use as subgrade					
**The area delineated exceeds the area expected to be usable for use as surfacing with portions of the pit only suitable for subgrade material					
*** This pit on its own may not be used as surfacing. It may be used to meet assigned surfacing gradation bands by mixing with other deposits					

All borrow sources identified in Table 20-1 have been considered as the largest possible size, dictated by the expected extents of the desired deposit. Volumes to be extracted from each source have not been specified at this time in order to allow the construction contractor a degree of flexibility (while staying inside the designated sites) with which to manage how they meet final material gradation bands, and to maximize their productivity based on the equipment available. Note that the total road construction material will be significantly less than the total available material identified in the above study.

Estimated volumes of material expected to be sourced from borrow sites are:

- Subgrade material 31,510m^3;
- Surfacing material 17,991m^3;
- Riprap material 1,400m^3.

With the identification of specific borrow sources not expected to be completed until final construction drawings are prepared, it is not possible to specify how long each individual borrow source will be used for. However, road construction is expected to be completed within a three to four month period during the summer period, and therefore the maximum time that any borrow source is expected to be used for is four months.

The identified borrow sites have been classified as quarries or pits. Quarries are primarily composed of bedrock and will be established by working into the back wall of the borrow site (the excavation will start at the road edge and work into the slope as material is required, ensuring minimal disturbed area). Quarry construction will require the site to be cleared and stripped of organic and mineral soil, with stripped organics stored for later use in reclamation at the edge of the borrow site. Once the bedrock is exposed it will be blasted or ripped, then sorted (if required), loaded, and hauled to the necessary location.

Borrow pits primarily target organic-free, surficial materials that are to be excavated with an excavator, loader, or bulldozer. Like quarries, they will be stripped of the organic soil layer before use, with stripped organics stored for later use in reclamation at the edge of the borrow site. They will be established by working into the cut slope as required. Once the site has been stripped the material will be excavated, reworked as necessary, and hauled to the required location.

As borrow sources are no longer required for construction purposes, the cut slopes will be reduced to match the cut slopes specifications applicable to the ground type at the site, to provide long-term stability of the site. The organics previously stored will be spread and reclamation of the sites will be commenced.

Borrow Sources for the Mine Site

Borrow sources for mine site construction purposes have not been specifically identified at this time, however it is BMC's expectation that borrow material will be sourced from within the footprints of planned infrastructure, including the open pit, waste storage facilities and process plant site. BMC will be completing additional site investigation works during the 2017 summer period to confirm the material to be sourced from these locations.

Borrow Sources for the Airstrip

As noted in Section 4.12.2.2 of the Project Proposal BMC proposes to utilise two Yukon Government borrow pits for the Finlayson Lake airstrip upgrade. These borrow pits are located approximately 2km from the airstrip, on the Robert Campbell Highway. These borrow locations have not been assessed as to the quality or quantity of suitable borrow material available, however the estimated volume of borrow material required for construction of the airstrip upgrade is 3,500m^3.

Construction of the Finlayson Lake airstrip upgrade will be completed during a nominal six to ten week period during the summer, and therefore the maximum length of time that the borrow sources are expected to be used is ten weeks. The same mitigation measures to minimise potential adverse effects associated with the development and use of the borrow sites identified for the construction of the access road will be utilised for the construction of the airstrip upgrade.

YESAB ISSUE

The Project Proposal (Section 4.12.1.3; page 4-105) talks about the 30m wide RoW for the access road upgrade. It states that "in areas where cut and fill slopes extend outside of the 30 m cleared corridor, the clearing width will be increased to 3m beyond the extent of the cut slope and/or 10m beyond the extent of the fill slope".

R282

"Clarify the maximum width of disturbed area along the access road."

The maximum width of disturbed area along the Access Road will usually be 30 m (as described in Section 4.12.1.3 of the Project Proposal). There are approximately ten sections along the 20 km length of Access Road that will require the additional disturbance and the length of each section varies from 10 m to 40 m. This will be necessary to allow for the impact of cut and fill requirements in steeper sloped terrain. These sections do not include the borrow sources which will not be part of the final road limits.

YESAB ISSUE

The project proposal does not contain sufficient information on the LNG power plant and storage area to evaluate risks and potential effects.

R283

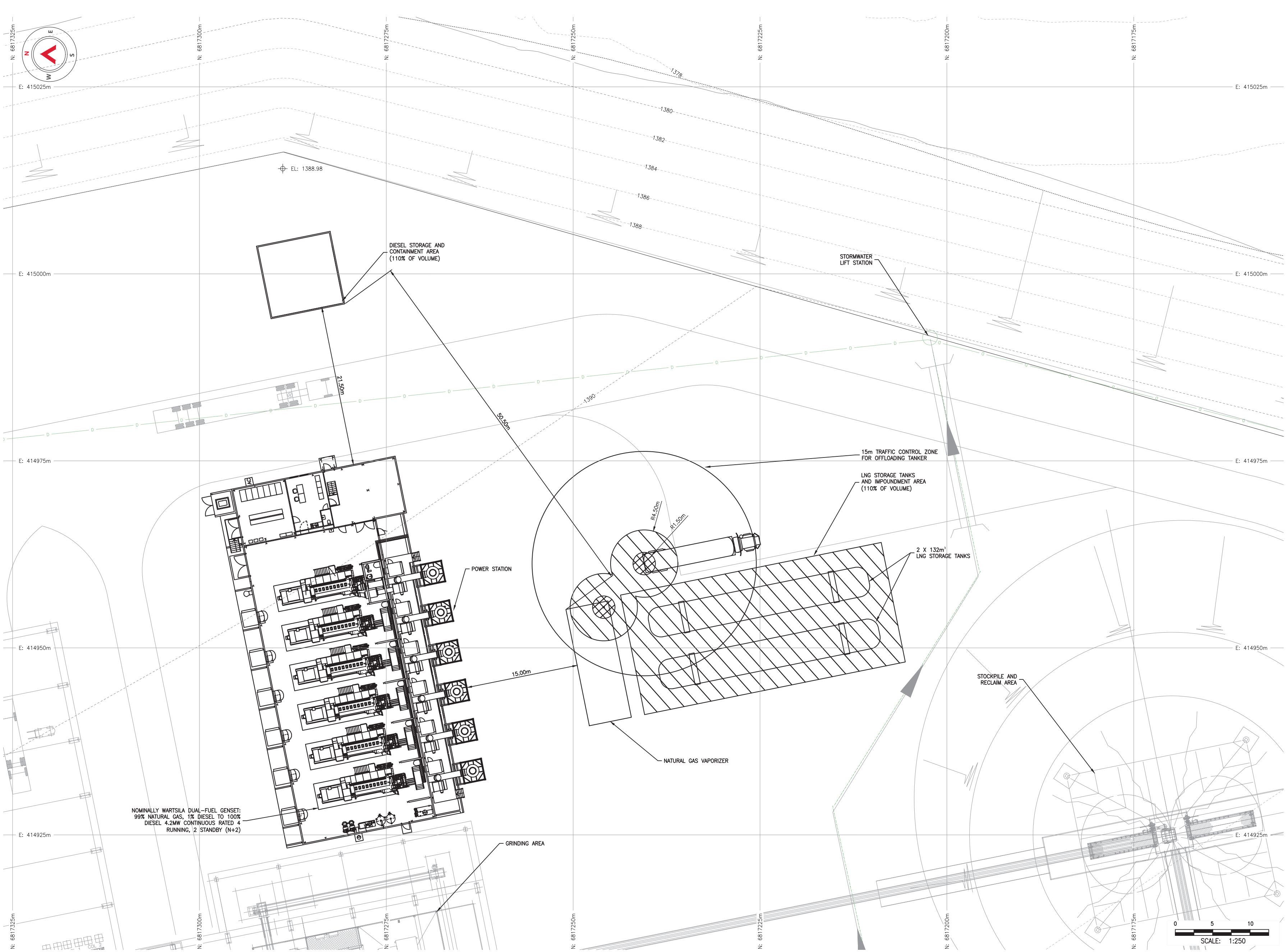
"Provide a map of the power plant showing the equipment layout and LNG storage area."

A map of the power plant showing the equipment layout and LNG storage area has been included in R284.

R284

"Provide the proposed positioning of the LNG storage tanks and LNG containment in relation to the buildings, diesel tanks and other activities which may impact the overall site layout."

The proposed positioning of the LNG storage tanks and LNG containment in relation to surrounding infrastructure is shown in Figure 20-2 below. The layout and location will be refined as more detailed design work progresses to support the application of licences from the Department of Energy, Mines and Resources.



REFERENCE DRAWINGS

DRAWING NO	DRAWING DESCRIPTION/TITLE	REF
-	-	1

HAZARDOUS AREA LEGEND:

ZONE 1

ZONE 2

REV	YY/MM/DD	DESCRIPTION	DRWN	APVD
A	17/06/15	PRE-FEASIBILITY REVIEW	JLC	SK

CLIENT:

BMC MINERALS

Allnorth

CLIENT NO:	4-14	DRWN:	JLC	DATE:	17/06/15
PROJECT NO:	16VA0054	DSGN:	JLC	DATE:	17/06/15
DRAWING SIZE:	22 X 34	CHKD:	JRG	DATE:	17/06/15
SCALE:	1:250	APVD:	DP	DATE:	17/06/15

PROJECT:

KUDZ ZE KAYAH

TITLE:

FIGURE 20-2 PROPOSED POWER GENERATION LAYOUT PLAN

DWG NO: 16VA0054-001-1900-105

REV: A

Date: 2017/06/15 | User: Jessica Currie | File: P:\VA\2016\16VA0054 BMC - KZK PFS update\1000-Drawings\1011-Civil\01-Production\16VA0054-001-1900 | Layout: 105 | Paper Size: 863.6mm x 558.8mm

R285

"Provide an analysis of potential risks and their implications of LNG operations onsite and during transportation."

As with any fuel, the use of LNG poses a number of potential risks both onsite and during transportation; however, these risks are well understood and successfully managed by many industries that utilise LNG in their day to day operations. BMC, in consultation with their selected LNG provider, will develop and implement LNG management practices as part of the various management plans required for the Quartz Mining Licence application to the Department of Energy, Mines and Resources. These plans include (but are not limited to) a Hazardous Materials Management Plan, Spill Contingency Plan and Traffic and Access Management Plan. These conceptual plans are presented in Section 18 of the Project Proposal.

The design and operation of the LNG facilities will be conducted in accordance with the *Oil and Gas Act* and *Gas Processing Plant Regulations*.

Risks from using LNG onsite include:

- Tank or piping failure due to impact;
- Tank or piping failure due to material failure;
- Operator error;
- Accident, operator error, or equipment malfunction during fuel delivery and unloading; and
- Mechanical failure in tank, tanker offloading pumps, or refueling equipment leading to vapour leak or LNG spill.

Many of these risks are similar to that of diesel as a fuel, with the key differences being that LNG is stored under pressure and at a cryogenic temperature and that spillage will result in natural gas evaporation as a gas lighter than air, while a spillage of diesel will create a flammable liquid contaminant. As noted in Section 17.3.3 of the Project Proposal, all LNG storage tanks will be located within concrete bunding capable of containing 110% of the storage volume. Should an LNG spill occur, the liquid will absorb heat from the environment and dissipate over time as it returns to a gaseous state. Natural ventilation is expected to adequately disperse the resulting vapour.

The risks and management of the transportation of LNG are similar to that listed above. Transportation by truck of natural gas will be in the form of LNG which is controlled and licensed by Territory and Provincial governments. All haulage will be in accordance with government standards and requirements.

YESAB ISSUE

Transportation Aviation Branch reviewed the section on the proposed upgrades to the Finlayson Lake Airstrip and have provided the following comments. The proponent has not indicated whether or not *the proposed improvements for the airstrip will be done in compliance with Transport Canada's document TP312 Aerodrome Standards and Recommended Practices, 5th Edition.*

R286

"Describe how proposed upgrades to the Finlayson Lake Airstrip will be done in compliance with Transport Canada's TP312 Aerodrome Standards and Recommended Practices, 5th Edition."

BMC proposes to extend the length of the Finlayson Lake airstrip by more than 10% of its existing length, therefore it will require authorization from Transport Canada. An application under the *Canadian Aviation Regulations* is required, and this application will be supported by engineering design that will be prepared in consultation with Yukon Government, Aviation Branch of the Departments or Highway and Public Works. The design will meet standards set out in 5th Edition, Aerodrome Standards and Recommended Practices (TP312).

The application under the *Canadian Aviation Regulations* involves conducting and reporting on stakeholder consultations with affected parties such as bordering land owners (in this case Yukon Government and Kaska First Nations who have unsurrendered rights and title to the land surrounding the aerodrome), air navigation service providers, other aerodrome owners/administrators, other land users such as Yukon Big Game Outfitters, trappers, etc.

YESAB ISSUE

Transportation Engineering Branch also reviewed the information provided on the proposed upgrades to the airstrip and has identified that further, more detailed information on the proposed design, and how it relates to the surrounding terrain, is required. As indicated in the project proposal, HPW previously considered options for upgrading this airstrip. From this exercise HPW is aware that the surrounding terrain (e.g. close proximity to the lake), the location of the road, and the availability of materials for upgrading present challenges to the design, cost and feasibility of potential upgrades.

R287

"Provide more detailed design information and discussion in relation to the upgrades of the Finlayson Lake airstrip. Specifically:

a) consider how the proposed design will address/service multiple users, vehicle parking, plane parking and equipment and materials storage to support servicing of the airstrip;

b) given the surrounding terrain challenges, the detailed design information needs to demonstrate how the upgrades can be completed in the proposed location; and

c) identify any necessary mitigations or changes that may be required to the surrounding environment."

As stated in the Project Proposal (Section 4.12.2), BMC is only aware at a high level of Department of Highways and Public Works (HPW's) previous work on the Finlayson Lake airstrip, with regard to terrain challenges. Detailed designs have not been completed, however all designs will follow applicable Federal and Territorial regulations for airstrips.

The upgrading of the Finlayson Lake airstrip will involve lengthening, and widening as required, to a standard as specified in the Aerodrome Standards and Recommended Practices TP 312 (5th Edition). The upgrade is required to bring the airstrip up to a standard suitable for a nominally sized 18 passenger aircraft to land and takeoff. There is not expected to be any requirements for passengers, or aircraft to wait at the airstrip other than for passenger loading and unloading. Supplies for the aircraft, in the event that they are required, will be provided by transporting from the KZK Project site and maintenance of the airstrip will be on an "as required" basis, and will be fulfilled by equipment mobilised from the KZK Project site.

Current usage of the Finlayson Lake airstrip is minimal and even with the extension of the airstrip it is not expected to increase substantially. The airstrip is relatively isolated and the nearest area with land transport is Ross River thus incentive to land at Finlayson Lake, rather than at Ross River, is minimal. However, the Finlayson Lake airstrip could be used as an emergency alternative to Ross River airstrip if required due to bad weather, distance, or other factors.

Final designs have not been completed but initial construction designs will be discussed with the Transport Engineering Branch and the Aviation division prior to any design submissions and will require approval under relevant Federal and Territorial regulations before moving forward.

YESAB ISSUE

Mineral Resources Branch is of the opinion that the method of co-mingling waste should be determined in the early stages of facility design, as this will have an impact on both the geochemical and physical stability of the facility. Without knowledge of how the facility is being constructed, the proponent cannot be certain that the kinetic tests being performed will be reflective of site conditions in the operational period as well as facility performance in post-closure.

R288

"Confirm the disposal methodology for the Class A facility. This could be done by: initiating a representative kinetic test to predict acid generation and metal leaching from the facility; or conducting a sensitivity analysis on cell C-10 to determine the scaling factors that should be used based upon ultimate disposal determinations."

As noted in Section 4.9.4.4 of the Project Proposal, the specific comingling method for Class A waste rock and tailings had not been defined at the time of submission of the Project Proposal, and will be determined during the final design phase. Feasible comingling methods could include one or more of the following options:

- Waste rock and tailings placed in lifts;
- Waste rock placed in cells and surrounded by tailings; and
- Waste rock mixed with tailings and placed in lifts.

Geotechnical analysis of the three different methods of comingling will be undertaken as part of the final design phase to assess the characteristics of each method. The geotechnical analysis will be considered in conjunction with geochemical sensitivity analysis work to select the preferred method(s) of comingling waste rock with tailings. The preferred method(s) will be tested in the field during project commissioning and revised where appropriate to reflect experience gained from operating within the site-specific conditions.

The COPI scaled loading rates for the kinetic tests composed of Class A material are presented in Table 20-2. Column C-7 comprises Class A waste rock, humidity cell HC-3 is composed of tailings material, and column C-10 comprises comingled tailings and Class A waste rock (constructed as layers of tailings and crushed waste rock). The scaled loading rates shown in Table 20-2 are based on the average of the last two months of data (circumneutral pH) with the exception of column C-7, which is based on the average of average of cycles 2 to 10 (pH 6.8 to 7.2) in order to produce a loading rate at circumneutral pH for comparison with the similarly circumneutral pH conditions of tests C-10 and HC-3. These tests provide "end-member" data with respect to Class A waste rock (column C-7) and tailings (HC-3) such that if more water-rock interaction is anticipated with tailings or waste rock then the resulting drainage chemistry can be calculated with a combination of the C-7 and HC-3 tests. Furthermore, the Class A waste rock and comingled tailings in column-10 presents a scenario similar to the first and third bullet point indicated above.

A comparison of the Class A waste rock (C-7) and tailings humidity cell (HC-3) scaled loading rates indicates that the scaled loading rates from the majority of COPIs are considerably higher (typically by an order of magnitude) from the tailings than the Class A waste rock, suggesting that the tailings component will likely drive the leachate chemistry from the Class A Waste Storage Facility. The scaled loading rates developed from column C-10 (comingled tailings and waste rock) are comparable to those calculated from a 60:40 mix of tailings (i.e., HC-3) and Class A waste rock (i.e., C-7) as presented in the final column in Table 20-2 Only the loading rate for selenium was significantly higher (13 fold higher) in the C-7/HC-3 combination compared to C-10; however, substitution of this higher loading rate in the water quality model did not result in exceedances of the selenium water quality objective in the receiving environment.

Table 20-2: Comparison of Circumneutral COPI Loading Rates from Kinetic Tests Bearing Class A Material

	Class A Waste Rock (C-7)	Tailings (HC-3)	Comingled Class A Waste Rock and Tailings (C-10)	Class A (C-7 + HC-3) [a]
	mg/kg/wk			
Sulphate	0.098	9.3	1.7	5.6
Antimony	0.00012	0.000027	0.000017	0.000064
Arsenic	0.0000059	0.0000052	0.000012	0.0000055
Cadmium	0.0000070	0.000090	0.000019	0.000057
Copper	0.0000018	0.000017	0.0000072	0.000011
Iron	0.0000020	0.000030	0.000046	0.000019

	Class A Waste Rock (C-7)	Tailings (HC-3)	Comingled Class A Waste Rock and Tailings (C-10)	Class A (C-7 + HC-3) [a]
	mg/kg/wk			
Lead	0.0000062	0.0000092	0.000010	0.0000080
Manganese	0.0023	0.0070	0.0064	0.0051
Nickel	0.000032	0.000079	0.00031	0.000060
Selenium	0.000025	0.0015	0.000073	0.00094
Uranium	0.0000051	0.0000053	0.000014	0.0000052
Zinc	0.00020	0.0032	0.0061	0.0020

[a] Calculated based on 60% tailings (i.e. HC-3) and 40% Class A waste rock (i.e. C-7).

It is expected that these kinetic tests will inform the final design of the Class A Waste Storage Facility and the specific method for comingling Class A waste rock and tailings.

YESAB ISSUE

The Class A facility is predicted to be net acid generating within the mine life, while the Class B facility is expected to be net acid generating during the closure period. As such, seepage collection from these facilities is required to ensure protection of both surface and ground water resources. It is unclear however how the proponent has tested the proposed liner system to ensure that all seepage from the facility will be collected.

R289

"Provide additional information to demonstrate that the proposed liner system will be sufficient to direct seepage from the Class A and Class B facilities to the seepage collection ponds for treatment. This should be demonstrated for both the operational and closure facilities."

The Class A and B Waste Storage Facilities are designed for geochemical and geotechnical stability in perpetuity.

The Class A Waste Storage Facility includes a progressively constructed low permeability cover system above the filtered tailings and waste rock to limit surface runoff and infiltration into the facility. A seepage collection system will be constructed above a low permeability foundation liner. Seepage that migrates through the material within the Class A Waste Storage Facility will be routed through the underdrain system to a sump and pumped to the Class A Collection Pond. The underdrain system of waste rock is a preferential pathway for seepage above the low permeability liner.

The Class B Waste Storage Facility includes a progressively constructed low permeability cover system above the waste rock material, as well as a low permeability foundation liner. Infiltration of water within the Class B waste rock will be routed through the foundation of the facility to a sump and pumped to the Class B Collection Pond. Water will be routed preferentially through the free draining Class B waste rock material, above the low permeability foundation liner.

The foundation liner systems for the Class A and Class B Waste Storage Facilities will be refined as part of the detailed design phase.

YESAB ISSUE

Section 12 and Appendix E of the project proposal both discuss timber values that will be impacted by this project but do not provide specific detail on how much timber volume will be removed incidentally to project activities or discuss the management of incidentally harvested timber. Timber is a valuable resource to Yukon communities and the Forest Management Branch prefers timber to be salvaged whenever practical and economically feasible.

R290

"Provide details on how incidentally harvested timber will be managed. Specifically address the following:

a) details on the total amount of incidental timber volume to be harvested;

b) whether timber will be utilized by the proponent during project activities, made available for public salvage, or disposed of with a rationale for this decision; and

c) if timber is proposed to be made available for public use, identify the proposed storage location, salvage volume, and method of harvesting."

The amount of incidental lumber harvested during upgrading of the Access Road and Project facilities is expected to be low. There will be limited opportunity for the use of this lumber harvested for construction purposes, on the Project site, and it is proposed that any lumber harvested will be made available for public salvage. The lumber would be harvested directly by felling with chainsaws, limbing, bucking to manageable lengths, and then stockpiled by the gatehouse for public access. Some lumber may be salvaged after trees are uprooted with earthmoving equipment with larger pieces being separated and similarly prepared for public salvage.

YESAB ISSUE

While the proposal provides an effects characterization on Transportation Infrastructure – Roads and Airports (Section 15.8.2), it only considers traffic volumes; it does not provide information on or discuss the current condition of the Robert Campbell Highway. No details are provided about the configuration and types of project related vehicles that will be using the highway, and there is limited discussion as to how or whether or not the current conditions and state of the highway, and how it can vary seasonally, could affect or alter the project schedule and use of the highway. Additionally, there is limited discussion about potential mitigations or adjustments that the proponent could implement or propose to accommodate highway conditions and other highway users. The discussion provided is focused on limits to legal axle loads that could be imposed during spring thaw and break up. And while the project proposal does have a Traffic and Access Management Plan component (Section 18.12), it appears only *to apply to the proposed tote road and site/haul roads in the project area and not to the proposed use of the Robert Campbell Highway.*

R291

"Provide information on the following in relation to the Robert Campbell Highway:

a) current conditions with respect to expected road standards;

b) configuration and types of project related vehicles that will be using the highway;

c) discussion on how or whether the current conditions and state of the highway, and expected seasonal variances and effects of the environments, may affect or alter the project schedule and proposed use of the highway;

d) traffic management plan for proposed use of the Robert Campbell Highway including consideration for the varying physical state and condition of the road and with respect to other users; and

e) mitigations and alternatives that could be implemented."

It is acknowledged that there have been upgrades to the Robert Campbell Highway and more are planned by the Department of Highways and Public Works (HPW). The recent upgrades have concentrated on the section between Watson Lake and the Tuchitua Highway Maintenance Camp over the last years.

While the current road conditions on the highway between KZK and the Wolverine Mine (approximately 50 km) are not ideal they are acceptable for all expected Project traffic and are not expected to affect or delay the Projects timeline or proposed use of the highway. However, any highway improvements that are made to this section of the road will benefit all users of the road including those directly involved with the Project. The existing highway from Wolverine mine to the port of Stewart has been upgraded by HPW to allow concentrate haulage.

Project related traffic on the Robert Campbell Highway has been described at a high level in Section 4.12.4 (Transportation Volumes) of the Project Proposal. There will be a variety of configuration of trucks and light vehicles dependent on the material being transported to, or from, the site. These will vary from light vehicles carrying passengers to oversize wide load haulers for the larger pieces of equipment during the construction phase. During the operations phase the majority of the traffic will entail concentrate haulers consisting of a combination of conventional bulk concentrate carriers (tridem tractor with Super B train Convey Ore style concentrate trailers) and specialized super B flat deck trailers outfitted to transport containerized bulk carriers. Supplies will be transported using conventional trucking fleets provided by appropriately licenced contractors and suppliers.

The current condition of the road and seasonal variances have been taken into account with the construction schedule, the projected concentrate trucking schedule, and the supply schedule with redundancy and excess warehouse space to mitigate for seasonal, and unanticipated road closures and less than ideal driving conditions.

The Traffic and Access Management Plan only applies to the access road from Robert Campbell Highway to the Kudz Ze Kayah site. It would be presumptuous for BMC to create a traffic management plan for a public highway such as the Robert Campbell Highway as any such plan may involve restrictions on other users. It is anticipated that a traffic management plan would be created for the Robert Campbell Highway by the HPW, with input from BMC regarding Project related traffic use. The condition of the Robert Campbell Highway would inform any restrictions required and the plan would be updated as roads were improved or conditions deteriorated. Restrictions, such as the speed limits enforced for the concentrate trucks from Wolverine, may be required on project specific equipment and possibly on all traffic, an example of this would be extended “No Passing” zones. The decisions for these are the responsibility of the HPW although it is hoped that they would liaise with BMC when making adjustments to traffic use requirements.

YESAB ISSUE

The proponent's Conceptual Waste Management Plan (Section 18.2) has limited details regarding destination for certain waste streams. For example, Table 18 -2 in the Waste Management Plan notes that tires will be taken for "off site disposal" and Special Waste such as batteries, antifreeze and solvents will be "Shipped to licensed recycle or disposal facility on regular basis."

Small community and unincorporated waste management facilities and transfer stations are not appropriate destinations for waste produced at industrial/mining operations.

R292

“Provide additional information related to the destination for all potential waste types.”

BMC will develop a fully equipped and properly designed Solid Waste Management Facility on site, in accordance with appropriate regulations under the *Environment Act*. In addition, KZK will have a hydrocarbon-contaminated soil remediation facility on site; this facility will also be designed, built and operated in accordance with *Environment Act Regulations*.

Any special Waste as defined by the *Environment Act Regulations* would be shipped off site and out of Yukon to authorized sites in Southern Canada. Collection and shipping of wastes will be handled by an authorized contractor, who will be responsible for sourcing these outside facilities.

YESAB ISSUE

Appendix A-6 – Occupational Health and Safety Policy (links to Health, Safety and Emergency Response Plan (HSERP)) These comments are related to HSS values of Health and Safety of Individuals.

The BMC Health and Safety Management System is noted as a component of the Occupational Health and Safety Policy, but primarily the process for developing this system is described in the proposal here (with suggestions for planned components but many details 'to be determined').

R293

"Provide additional information on the Health and Safety Management System and the risks it is designed to address. Specifically describe the potential risks and the responses."

The BMC health & safety management system (SMS) referenced within the Proposal is simply a tool that assists the mine operators (i.e. line managers, employees and contractors) to systematically achieve and maintain standards for managing safety and health. It brings together the policies and procedures required to effectively mitigate (i.e. lessen) the risks associated with the mining and associated operations. The SMS is shown in Figure 20-3 below.

The SMS is also designed to assist mine management to demonstrate the effective management of health and safety on site to:

- Employees, contractors and others working at the mine site;
- The regulator and other external stakeholders;
- Management when assessing the mine systems against recognised industry standards.

To maximise its effectiveness, the SMS needs to be:

- A documented system;
- Be easily understood;
- Accessible.

The risks managed at all mining operations are dynamic and varied. The SMS is used to ensure these risks are considered and strategies are documented so adequate controls are implemented for the life of the mine.

While all mines have safety- and risk-related policies, plans and procedures in place, the SMS ties these elements in a single integrated system.

The BMC SMS referenced in the Proposal will be designed around the following elements;

1. **Management framework**

- health and safety systems framework
- sustainability
- corporate policies

2. Leadership and accountability

- roles and accountabilities
- procedural requirements
- statutory appointments and positions

3. Planning and performance

- health and safety objectives and targets
- performance measurement
- monitoring and review

4. Implementation

- licenses and permits
- document and record control

5. Compliance and document control

- maintaining documents such as standard operating procedures (SOPs), safe work instructions (SWIs) or safe work method statements (SWMSs)

6. Operational risk management

- safety in design
- change management
- risk assessment tools
- workplace inspections

7. Communication and consultation

- safety and health communication
- safety and health committees

8. Behavioural safety, awareness and competence

- training plan and matrix

- fitness for work
- inductions

9. Systems of work

- SOP, SWI or SWMS development and use
- Job safety analysis (JSA) or job hazard analysis (JHA)
- contractor management

10. Incident investigation

- incident reporting
- investigation tools
- corrective action management

11. Emergency management

- emergency response plan
- injury management
- crisis management

12. Quality assurance, measurement and evaluation

- continuous improvement process
- audit criteria
- audit and review timeframes

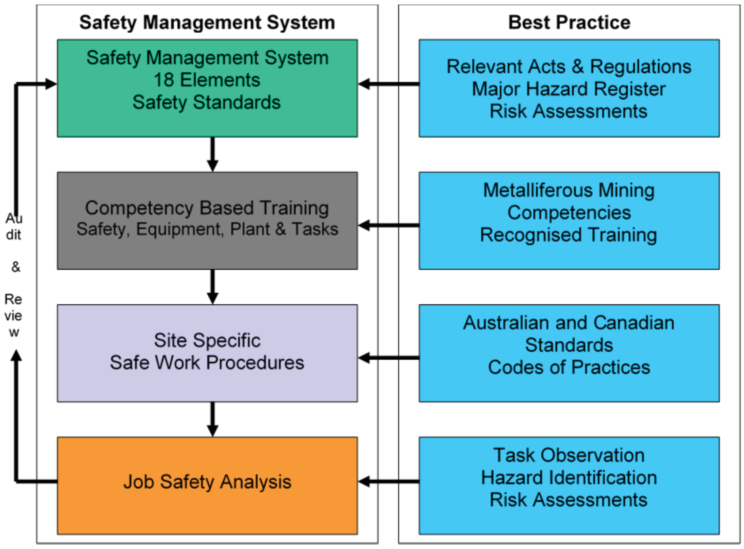


Figure 20-3: Safety Management System

With reference to the second part of the question (specific risks and proposed responses) it should be stated that risk assessment and mitigation strategies are only one part of a holistic SMS. In addition, BMC notes that this question is one that is more normally addressed by the decision body at the time of permit issue and by the regulatory body once construction and operations are underway. A full risk assessment for the project will be provided to the relevant regulatory body as part of the permitting process however in the interim please note the following.

The risk assessment/response process is designed to identify potential hazards, assess the likely risk and then to generate an appropriate response and implement controls designed to remove the potential hazard or to reduce the risk or both.

A hazard is a source or a situation with the potential for harm in terms of human injury or ill-health, damage to property, damage to the environment, or a combination of these. Hazards at work may include noisy machinery, a moving forklift, chemicals, electricity, working at heights, a repetitive job, or inappropriate behaviour that adversely affects a worker's safety and health.

A risk is the chance of something happening that will have a negative effect. The level of risk reflects:

- The likelihood of the unwanted event; and
- The potential consequences of the unwanted event.

Controls are the measures put in place to decrease the likelihood or consequences from an unwanted event. They can:

- Prevent the unwanted event or reduce the loss of control of the hazard (e.g. reduce or contain energy release); and

- Reduce the effects (e.g. provide shield from hazard; event has happened but emergency response and medical treatment reduce the severity and duration of consequences).

The assessment of risk and the implementation of appropriate controls involves the application of a Hierarchy of Control according to the system described below. The following elements should be utilised in the order presented and where appropriate used in conjunction with one another.

1. Elimination – eliminate the task and thereby the risk e.g. Use a forklift instead of manually handling heavy objects.
2. Substitution – substitute the task with another that has a lower risk e.g. The replacement of one chemical with a safer one
3. Isolation – isolate the risk from those at risk e.g. use of electrical compounds or noise barriers between people and the noise
4. Engineering – engineer a solution that reduces or eliminates the risk e.g. Install a safety rail or machinery guards
5. Administration – manage the risk e.g. Develop a safe procedure
6. Personal Protective Equipment (PPE) – use safety equipment e.g. gloves

The BMC hazard and risk assessment processes will be applied to the following areas of the proposed project;

1. Exploration activities
2. Underground mining
3. Open Pit mining
4. Access road
5. Mineral processing plant
6. Administration offices and activities including employee transport
7. Camp
8. Offsite trucking of concentrate including the port handling facility
9. Reclamation activities
10. Any other area requested by the regulator

YESAB ISSUE

More information on the 'levels' of emergency is required in order to assess impacts/ effectiveness of mitigations (given potential connection to public health and safety, health and safety of individuals and quality health care service delivery).

While the type of 'control measures' to be defined have been listed, many of the details are left for later in the planning stage. In order to assess the potential impacts and mitigations on health and safety risks to employees, the public and service providers, more information is needed at this stage on these control measures.

The medical evacuation flowchart is provided as an example but lacks details.

R294

"Provide the following information related to levels of emergency:

- ***a) type of incidents that will be manageable with onsite personnel;***
- ***b) type of health professionals and health services that will be available on-site;***
- ***c) type of incidents that will require Government of Yukon services;***
- ***d) plans for each 'level' developed with Government of Yukon; and***
- ***e) defined roles and responsibilities related to emergency response."***

The Health & Safety Emergency Response Plan "HSERP" will detail the type and number of health professionals available on site and this will dictate what type of incident will be manageable. However, each incident will have different complexities and as such consultation with off-site health professionals both commercial and YG will be required. The requirement for YG services cannot be quantified until the available non-YG resources are evaluated and incorporated into the HSERP. The HSERP will be developed after consultation with YG service providers and input from other service providers, which will be provided during permitting.

R295

"Provide the following in relation to control measures:

- ***a) details on the personnel training plan & emergency response/rescue team;***
- ***b) how many personnel will be trained and to what level; and***
- ***c) the level of emergency medical care that will be available on site and in what quantity."***

The roles and responsibilities related to emergency response will be developed as the HSERP is developed in conjunction with the other required management plans to support the QML permit application.

The personnel training plan and emergency response team details will be part of the HSERP which will be developed prior to submission of the QML permit application. Conceptual levels and quantities of emergency medical care have been developed, however these will be refined before inclusion in the HSERP.

R296

"Confirm that the medical evacuation flowchart is the anticipated flow of evacuation and whether it was informed by emergency response providers."

The medical evacuation flowchart (Figure 18-10 of the Project Proposal) was developed as a decision making tool for the current operations. This flow chart will be evaluated and refined after further consultation with service providers (both YG and private) and included as part of the HSERP that will be prepared to support the licence applications.

YESAB ISSUE

In Section 18.11.2, the proponent describes a number of dust suppression measures that will be used (e.g. watering unpaved roads, exposed surfaces and stockpiles) during all phases of the project. However, it is not clear when these measures will be implemented.

R297

"Describe how you will determine when dust suppression (e.g. watering unpaved roads, exposed surfaces and stockpiles) is needed."

Unpaved roads and exposed surfaces watering will be carried out on a regular basis, with frequency increased during dry and/or wind windy weather conditions, if visibility is reduced or if comments are received from road users.

R298

"Describe the thresholds or triggers for the application of dust control measures."

The dust control measures outlined in the conceptual Air Quality Management Plan (Section 18.11 of the Project Proposal), such as enclosures, progressive reclamation, watering of roads and exposed surfaces and various operating practices will be applied on a regular basis, while triggers for additional contingency dust control measures, in addition to dry or windy weather conditions, may include complaints or reduced visibility, and will be based on professional judgement.

The Project will not use numeric thresholds from any quantitative monitoring program to guide dust suppression activities. These measures will be implemented at the discretion and judgement of site supervisors and managers and will be based on visual evaluations of dust generation on an exception basis. Climatic controls will be observed and lack of precipitation and potential for wind will provide indications that increased preventative dust suppression measures will occur.

YESAB ISSUE

In Section 18.11.3.3 ambient monitoring results above Yukon Ambient Air Quality Standards (YAAQS) are noted as triggers for the application of contingency measures in the case of specific weather conditions. However, in Section 6.6.1 (Air Quality Monitoring) of the proposal, the proponent suggests that no air quality monitoring is proposed.

R299

"Describe the source for the monitoring results that would trigger dust suppression and other mitigations."

No monitoring is proposed. Triggers for contingency dust suppression or other mitigations, in addition to dry or windy weather conditions, may include complaints or reduced visibility, and will be based on professional judgement.

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APPENDIX 1.
Thermistor Data Report

Knight Piésold
CONSULTING

www.knightpiesold.com

MEMORANDUM

To:	[Name Redacted]	Date:	June 22, 2017
		File No.:	VA101-00640/05-A.01
From:	[Name Redacted]	Cont. No.:	VA17-01001

Re: KZK Project – 2015 and 2016 Geotechnical Site Investigations – Thermistor Data

1 – INTRODUCTION

Knight Piésold Ltd. completed geotechnical site investigations in 2015 and 2016 for the Kudz Ze Kayah (KZK) Project in Yukon, Canada. The objective of the site investigation programs was to characterize geotechnical and hydrogeological conditions across the project site to support on-going project development.

The 2015 and 2016 geotechnical site investigation programs included installation of multi-node thermistor cables in drillholes across the project area to monitor ground temperature conditions. Discontinuous permafrost has been historically identified across the project site, therefore thermistors collecting consistent and continuous ground temperature data will help in further characterizing the absence or presence of permafrost conditions.

A total of thirteen 10-node thermistor cables manufactured by RST Instruments Ltd. (RST) were installed in 2015 and 2016 in select drillholes to establish ground temperature profiles. Six of the thermistor installations were completed during the drilling programs, and seven were completed after the drilling programs were finished, as the thermistors were not available at the time of drilling.

The thermistor cables installed during the drilling programs were attached to PVC pipe and lowered downhole. The cable and pipe were then grouted in place from the bottom up by pumping a cement and bentonite powder mixture down through the PVC. A DT2055B ten-channel data logger was installed at each thermistor location to collect and record temperature measurements at regular time intervals. A plastic protective casing was installed over the data logger at each site. The seven thermistors installed following the site investigation program were inserted and lowered into an empty PVC housing that was installed during the site investigation. Silicone oil was poured into the PVC pipe to surround the entire thermistor cable. The silicon oil reduces air temperature effects on the downhole instruments and has a freezing temperature of -50°C. A DT2055B ten-channel data logger was installed at each location and covered with a plastic protective casing.

A summary of all thermistors installed during the 2015 and 2016 site investigation programs is provided in Table 1 and 2. Locations of all drillholes with thermistor installations are shown on Figure 1.

Table 1 Summary of 2015 Thermistor Installations

Drillhole ID		K15-330	K15-331	K15-335	K15-336
Thermistor Node and Depth Below Ground Surface (m)	1	1.0	1.6	1.5	1.3
	2	2.0	2.6	2.5	2.3
	3	3.0	3.6	3.5	3.3
	4	4.5	5.1	5.0	4.8
	5	6.5	7.1	7.0	6.8
	6	9.5	10.1	10.0	9.8
	7	13.5	14.1	14.0	13.8
	8	20.5	19.1	19.0	20.8
	9	33.5	24.1	24.0	33.8
	10	48.5	29.1	29.0	48.8

Table 2 Summary of 2016 Thermistor Installations

Thermistor Node and Depth Below Ground Surface (m)	Drillhole ID	K16-387	K16-389	K16-390	K16-392	K16-395	K16-402	K16-410	K16-411	K16-412
	1	2.1	3.0	3.0	2.4	3.0	2.5	1.0	2.0	2.0
	2	4.1	5.0	5.0	4.4	5.0	3.5	2.0	3.0	3.0
	3	6.1	7.0	7.0	6.4	7.0	5.0	3.0	4.0	4.0
	4	8.1	9.0	9.0	8.4	9.0	7.0	4.0	5.0	5.0
	5	10.1	11.0	11.0	10.4	11.0	10.0	6.0	7.0	7.0
	6	14.1	15.0	15.0	14.4	15.0	15.0	9.0	10.0	10.0
	7	18.1	20.0	20.0	19.4	20.0	20.0	14.0	15.0	15.0
	8	22.1	25.0	25.0	24.4	25.0	30.0	19.0	20.0	20.0
	9	26.1	30.0	30.0	29.4	30.0	50.0	24.0	25.0	25.0
	10	33.1	40.0	37.6	39.4	40.0	70.0	29.0	30.0	30.0

2 – RESULTS OF 2015 AND 2016 SITE INVESTIGATION THERMISTOR DATA MONITORING

The recorded thermistor data collected as of May 2017 is presented in Appendix A, as data plots. Table 3 summarizes the results of the thermistor data collected to date.

Table 3 Summary of Thermistor Data Collected from February 2016 to May 2017

Drillhole	Depth of 1st Node (mbgs)	Coldest Month (1st Node)	Coldest Temp (°C)	Warmest Month (1st Node)	Warmest Temp (°C)	Slope Aspect	Slope Elevation (m)	Installation
K15-330	1.0	March	-0.1	September	1.7	W	1,347	Silicon Oil
K15-331	1.6	June	0.2	September	4.8	NW	1,387	Silicon Oil
K15-335	1.5	May	0	August	0.9	E	1,421	Silicon Oil
K15-336	1.3	May	0.4	September	1.1	W	1,318	Silicon Oil
K16-387	2.1	May	0.1	August	6.3	E	1,411	Grout
K16-389	3.0	May	0.2	September	4.5	E	1,421	Grout
K16-390	3.0	May	0.1	September	3.9	E	1,409	Grout
K16-392	2.4	May	0.7	September	4.3	E	1,390	Grout
K16-395	3.0	May	0.6	October	2	E	1,406	Grout
K16-402	2.5	May	0.4	September	3.7	SW	1,443	Grout
K16-410	1.0	March	-1.4	September	1.3	S	1,473	Silicon Oil
K16-411	2.0	May	0.3	September	4.3	N	1,446	Silicon Oil
K16-412	2.0	April/ May	-0.1	September	4.5	N	1,464	Silicon Oil

A summary of the key observations of the thermistor monitoring data collected to date is as follows:

- The thermistors installed in silicon oil appear to be functioning similarly to the thermistors installed in a grout mixture.
- The coldest recorded temperatures occur earlier on south facing sites (March, K16-410), and later on north facing sites (June, K15-331).
- Most of the sites are coldest in May (possibly due to snow cover persisting into May and melting into June).
- Most of the sites are warmest in September.

2.1 EFFECTS OF SNOW COVER

The effect of snow cover on ground temperature can be significant. Snow cover has an insulating effect on ground temperatures, which can cause a reduction and lag in ground freezing in areas of high snow cover. This effect varies with rate of snow accumulation, depth and density of snow, and duration of snow cover. The duration of snow cover is dependent on the aspect of the site. South facing sites will lose snow cover earlier than north facing sites, so ground warming will occur sooner on south aspects. While the coldest air temperatures will occur from December through February, the heat transfer from the ground to the air will lag due to the insulation of the soil above the first thermistor node and the snow pack on the surface. The warming effect of more direct sunlight in the spring will also be dampened by the snow because of the high albedo of snow.

2.2 THERMISTORS INSTALLED BENEATH MINE SITE INFRASTRUCTURE

Below is a summary of the instrumentation installed beneath each of the proposed mine site infrastructure areas:

Table 4 Mine Site Infrastructure

Mine Site Areas	Thermistors
Class A Storage Facility	K16-387, K16-389 and K16-390
Class B Storage Facility	None
Class C Storage Facility	K16-410, K16-411, K16-412 and K16-402
Overburden Storage Facility	None
Lower Water Management Pond	K15-336
Upper Water Management Pond	None
Mill Site	K15-335, K16-392 and K16-395

The 2017 geotechnical site investigation, scheduled to begin in June 2017, includes proposed thermistor installations beneath the Class B, Overburden and Upper Water Management Pond. The 2017 geotechnical site investigation also includes additional proposed thermistors to be installed in the Class A Storage Facility.

3 – CONCLUSIONS

None of the thermistors installed in 2015 or 2016 have identified permafrost conditions below the seasonal active layer, however discontinuous permafrost is anticipated to be present based on previous site investigation results. The thermistors installed in 2015/16 indicate the seasonal active layer is in the order of 1 to 4 mbgs based on the record of information collected. Although less than one full year of data has been recorded in the 2016 thermistors at the time of this letter, it is expected that frozen ground conditions associated with permafrost would have been identified by the thermistor data.

The thermistors were primarily installed in areas of potential mine infrastructure development. The thermistor data therefore does not provide a complete coverage of the entire mine site and it is possible permafrost conditions exist in areas not investigated. The 2015 and 2016 thermistors will continue to be monitored as part of the site wide permafrost characterization. Detailed geotechnical characterization, including terrain hazard mapping and permafrost characterization, will be carried out as required as part of the detailed design phase of project development.

PROFESSIONAL
YUKON
[Name Redacted]
TERRITORY

[Name Redacted]
Prepared: ______________________

[Name Redacted]
Project Engineer

[Name Redacted]
Reviewed: Jun 22/17

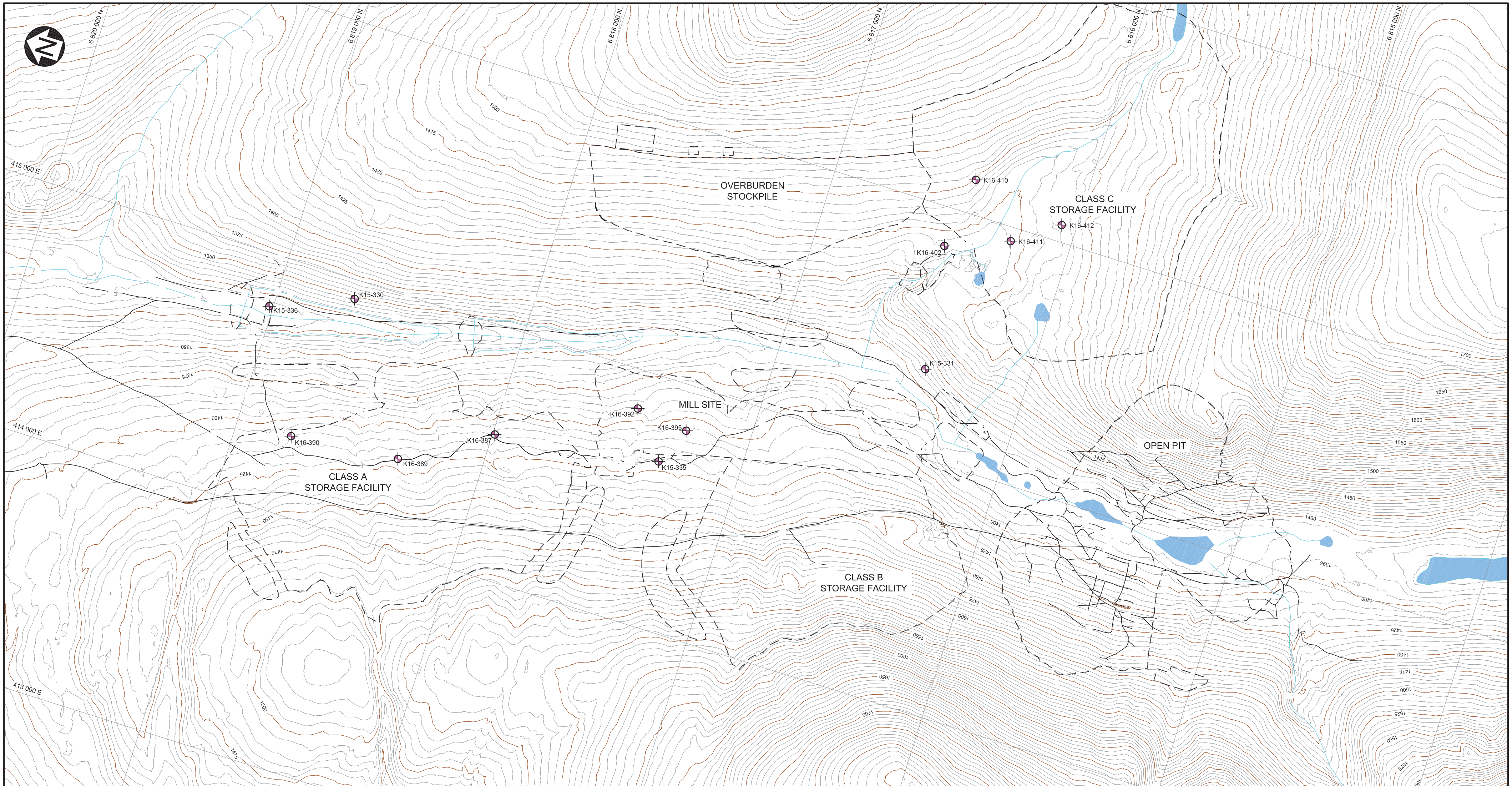
Specialist Engineer | Associate

[Name Redacted]

Approval that this document adheres to Knight Piésold Quality Systems:

Attachments:

Figure 1 Rev A 2015/2016 Geotechnical Site Investigation Thermistor Locations



PLAN

SCALE A

150 75 0 250 500 750 m

SCALE A

NOTES:

1. COORDINATE GRID IS UTM NAD 83 ZONE 9N.
2. TOPOGRAPHIC DETAIL BASED ON INFORMATION PROVIDED BY BMC MINERALS (NO.1) LTD. FEBRUARY 2, 2016.
3. PIT SHELLS PROVIDED BY BMC MINERALS (NO.1) LTD. APRIL 8, 2016.
4. CONTOUR INTERVAL IS 5 METRES.
5. ALL ELEVATIONS ARE IN METRES, UNLESS NOTED OTHERWISE.

LEGEND:

- GEOTECHNICAL DRILLHOLE
- FACILITY OUTLINE
- RIVER/STREAM/DRAINAGE
- EXISTING ACCESS ROAD / TRAIL

REV	DATE	DESCRIPTION	DESIGNED	DRAWN	REVIEWED
A	15JUN'17	ISSUED WITH TRANSMITTAL VA17-01001	MAP	MAP	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

2015/2016 GEOTECHNICAL SITE INVESTIGATION THERMISTOR LOCATIONS

Knight Piésold CONSULTING

P/A NO.	REF NO.
VA101-640/5	VA17-01001

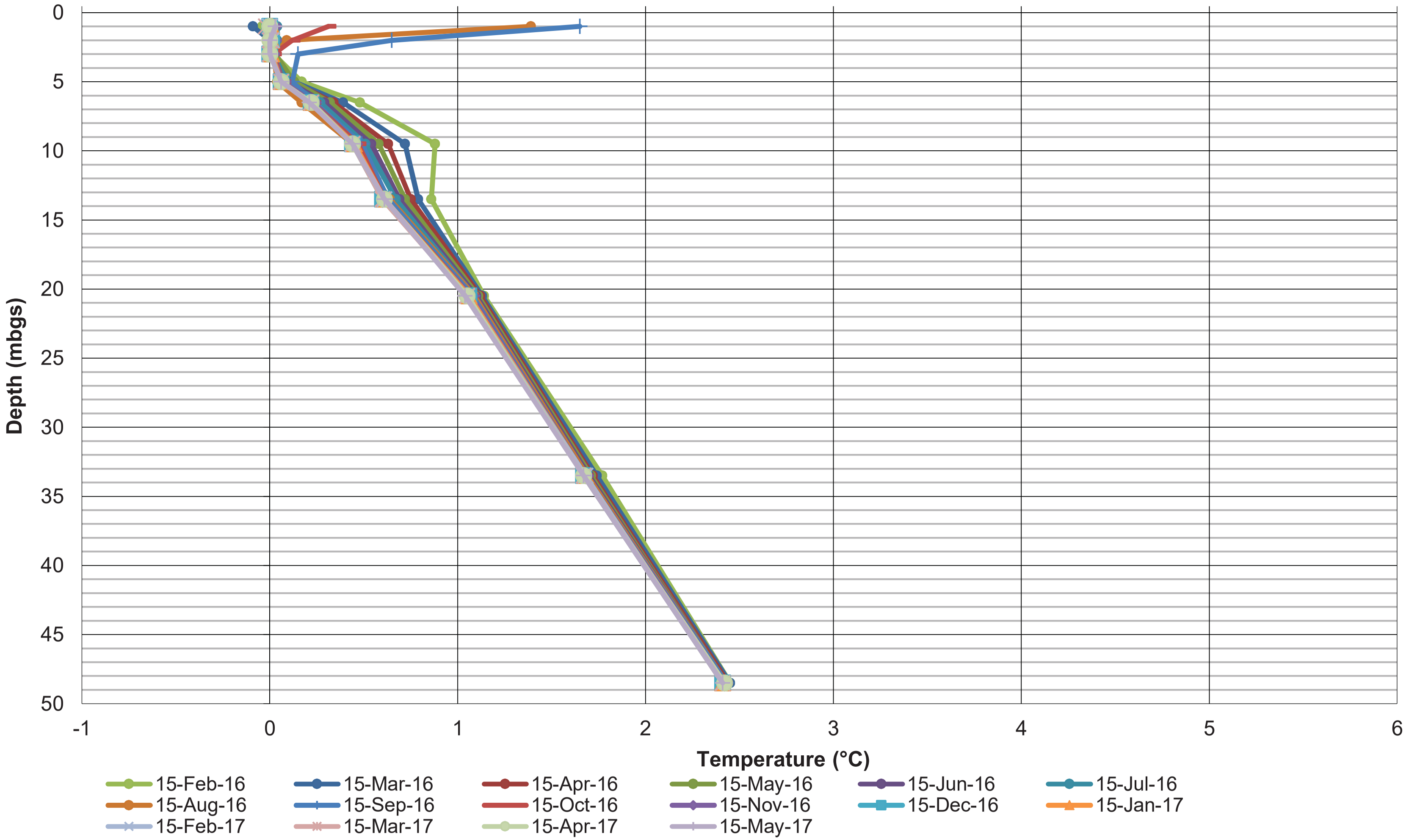
FIGURE 1 REV A

Knight Piésold
CONSULTING

APPENDIX A

THERMISTOR DATA PLOTS

(Pages A-1 to A-26)



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K15-330 TRUMPET CURVE

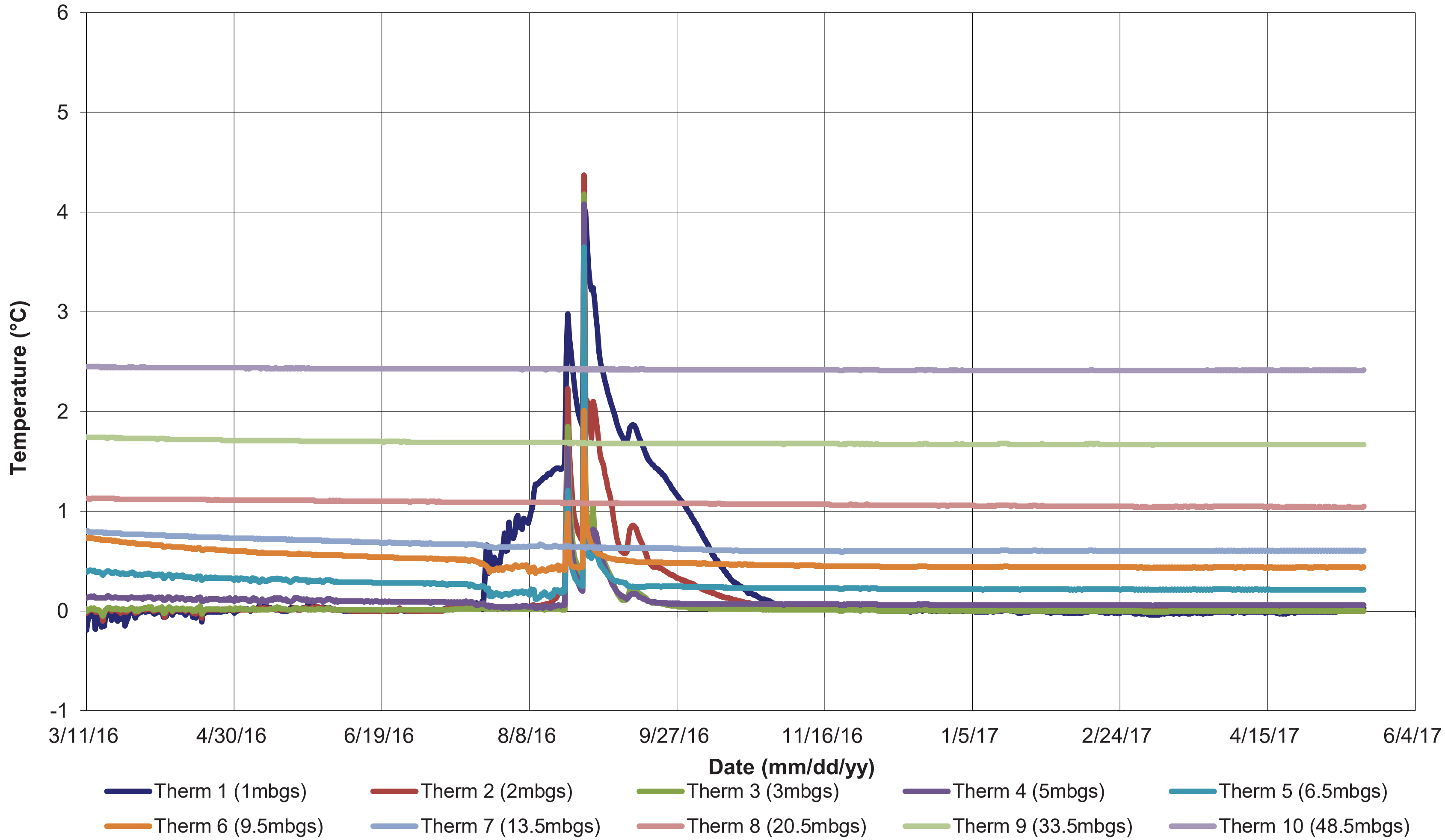
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-1

REV A



NOTES:

1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

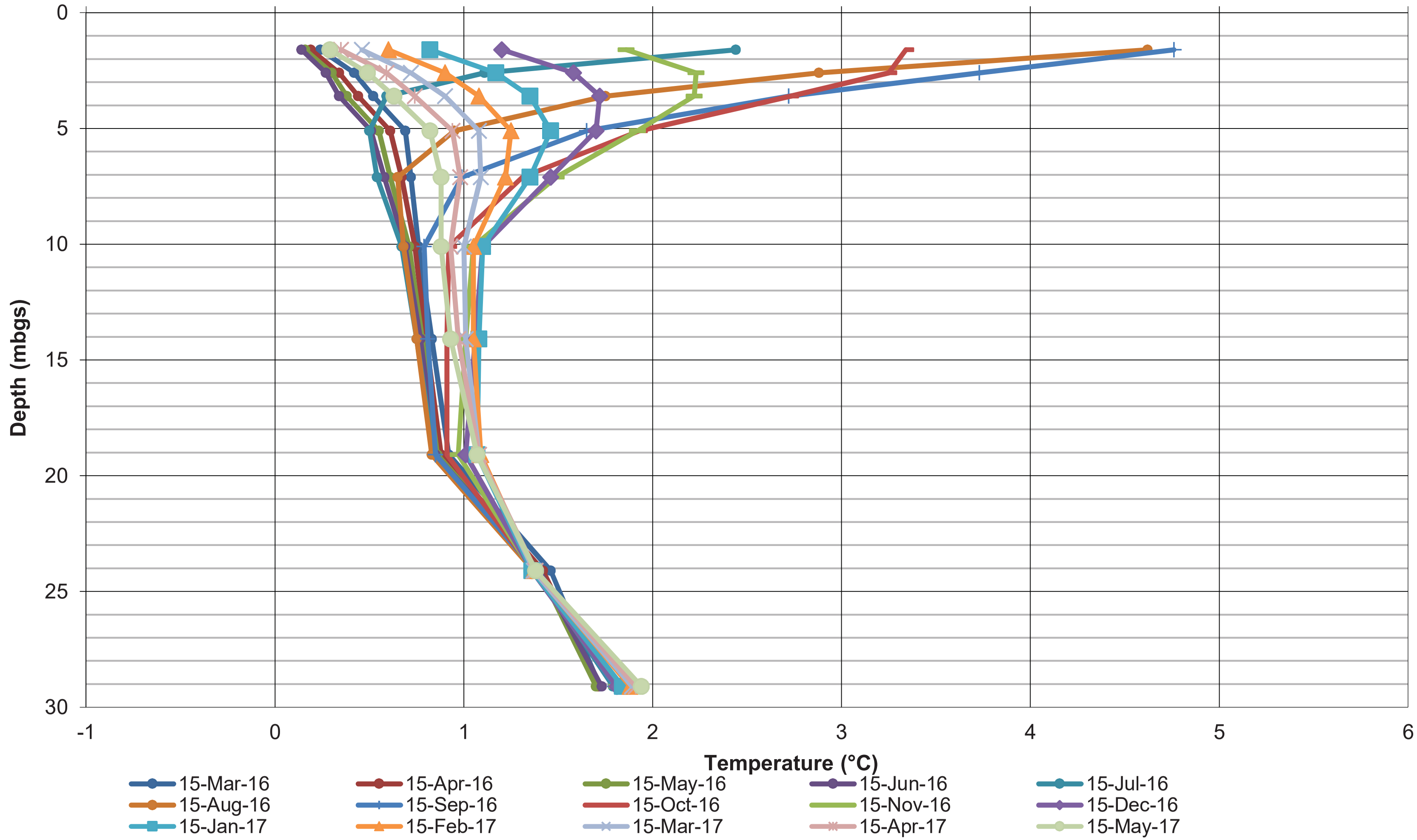
K15-330 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-640/05	VA17-01001

FIGURE A-2 REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

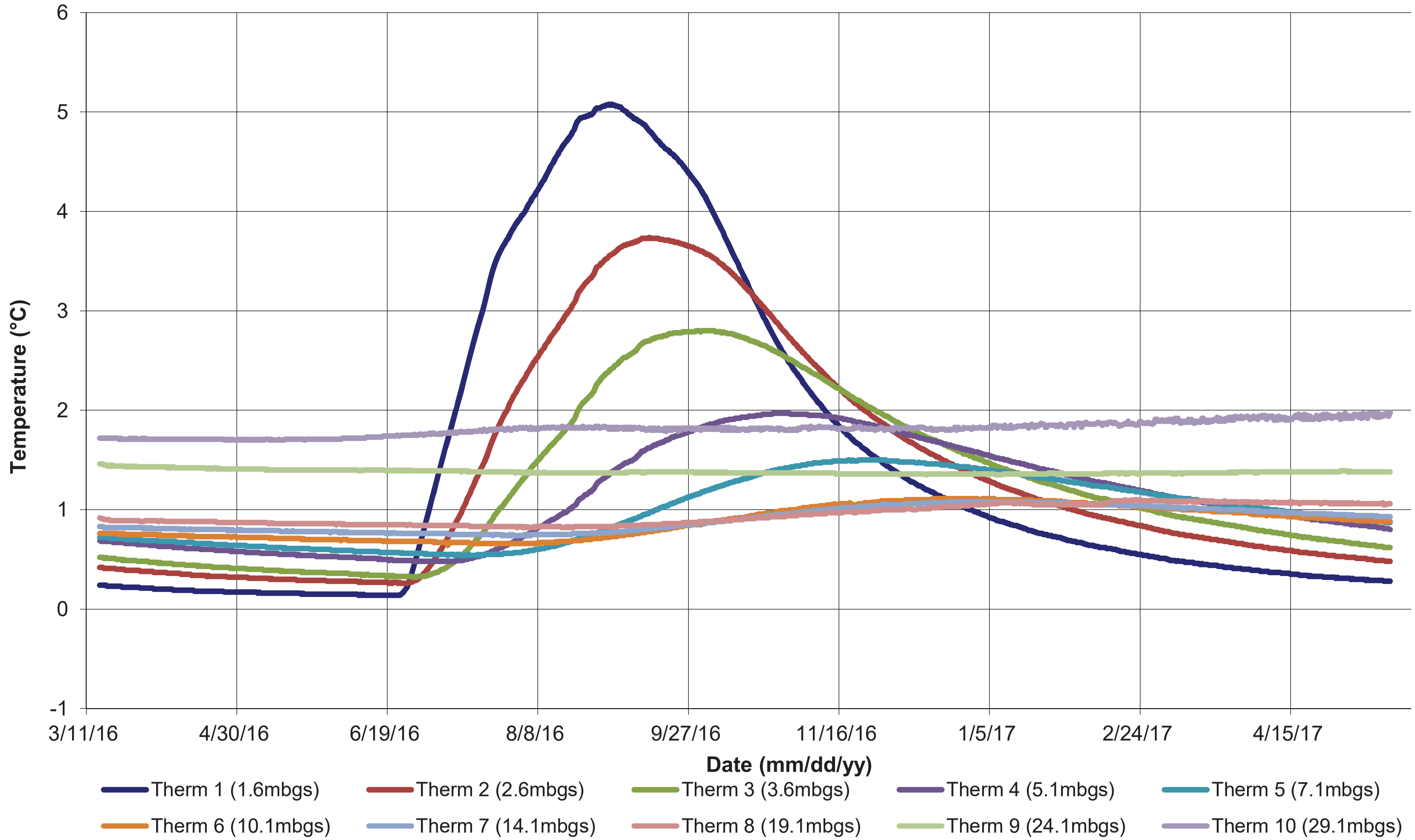
BMC MINERALS (NO.1) LTD.
KUDZ ZE KAYAH PROJECT

K15-331 TRUMPET CURVE

Knight Piésold CONSULTING

P/A NO. VA101-640/05
REF. NO. VA17-01001

FIGURE A-3
REV A



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

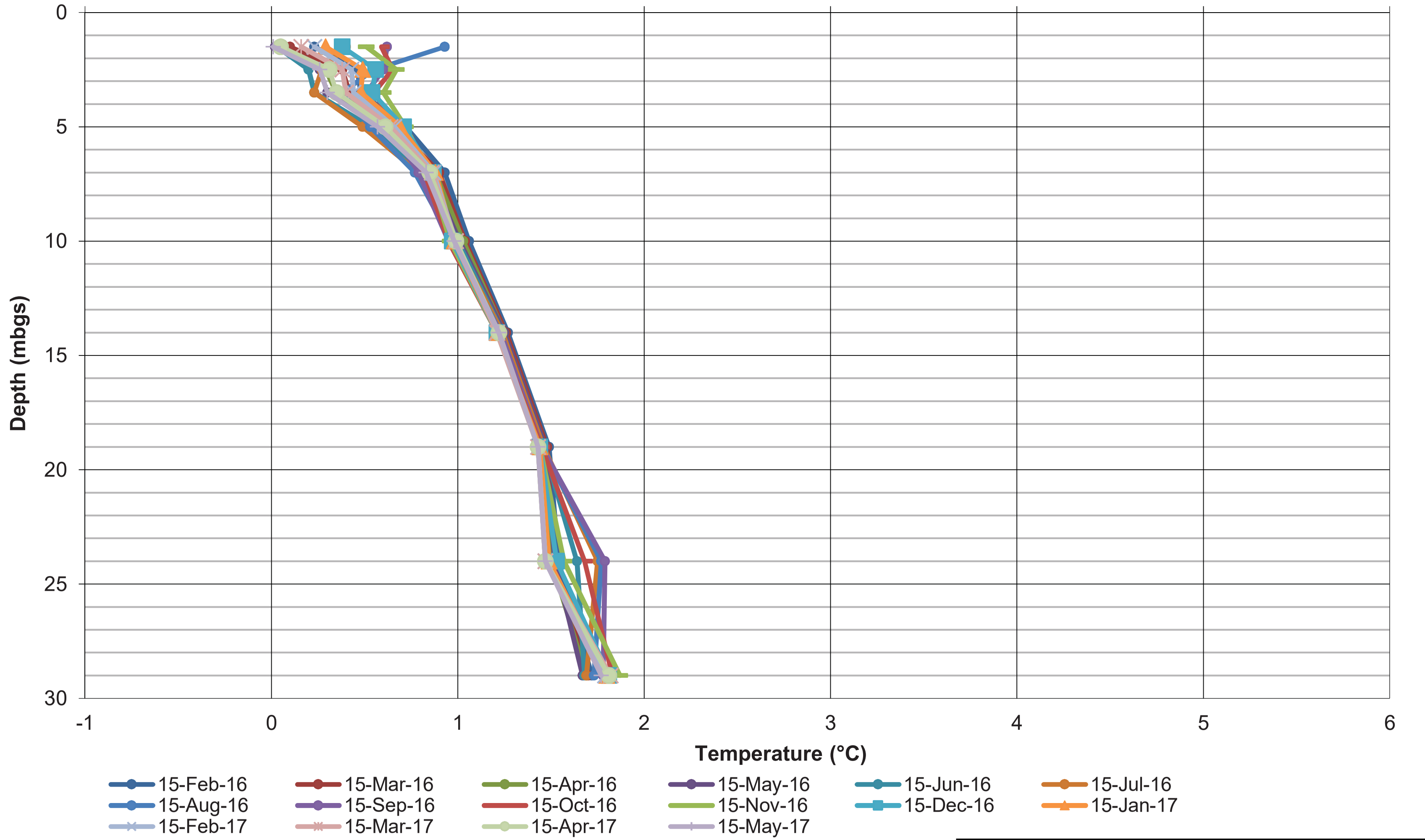
REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

BMC MINERALS (NO.1) LTD.
KUDZ ZE KAYAH PROJECT

K15-331 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO. VA101-640/05
REF. NO. VA17-01001
FIGURE A-4
REV A



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

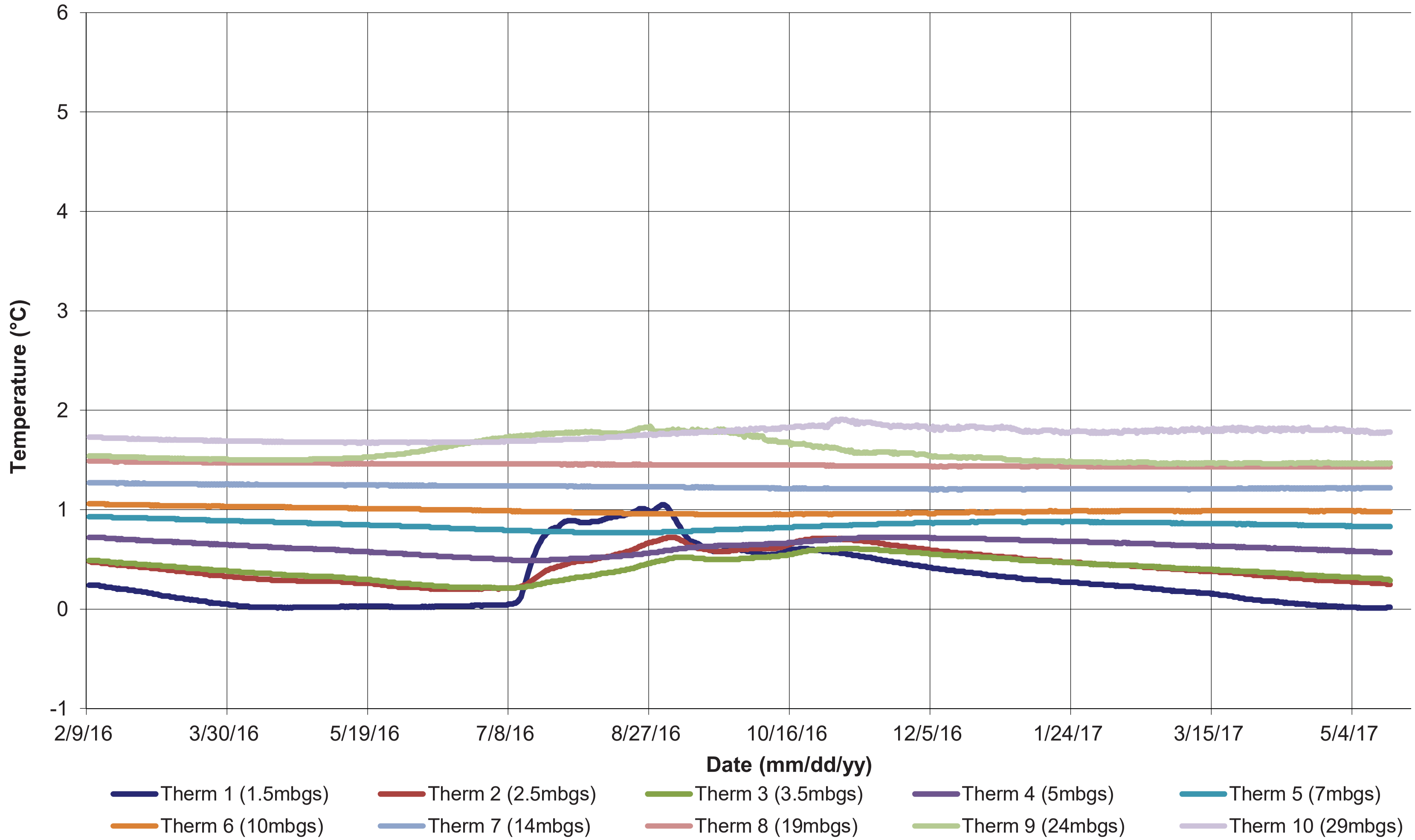
BMC MINERALS (NO.1) LTD.
KUDZ ZE KAYAH PROJECT

K15-335 TRUMPET CURVE

Knight Piésold CONSULTING

P/A NO. VA101-640/05 | REF. NO. VA17-01001

FIGURE A-5 | REV A



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

BMC MINERALS (NO.1) LTD.
KUDZ ZE KAYAH PROJECT

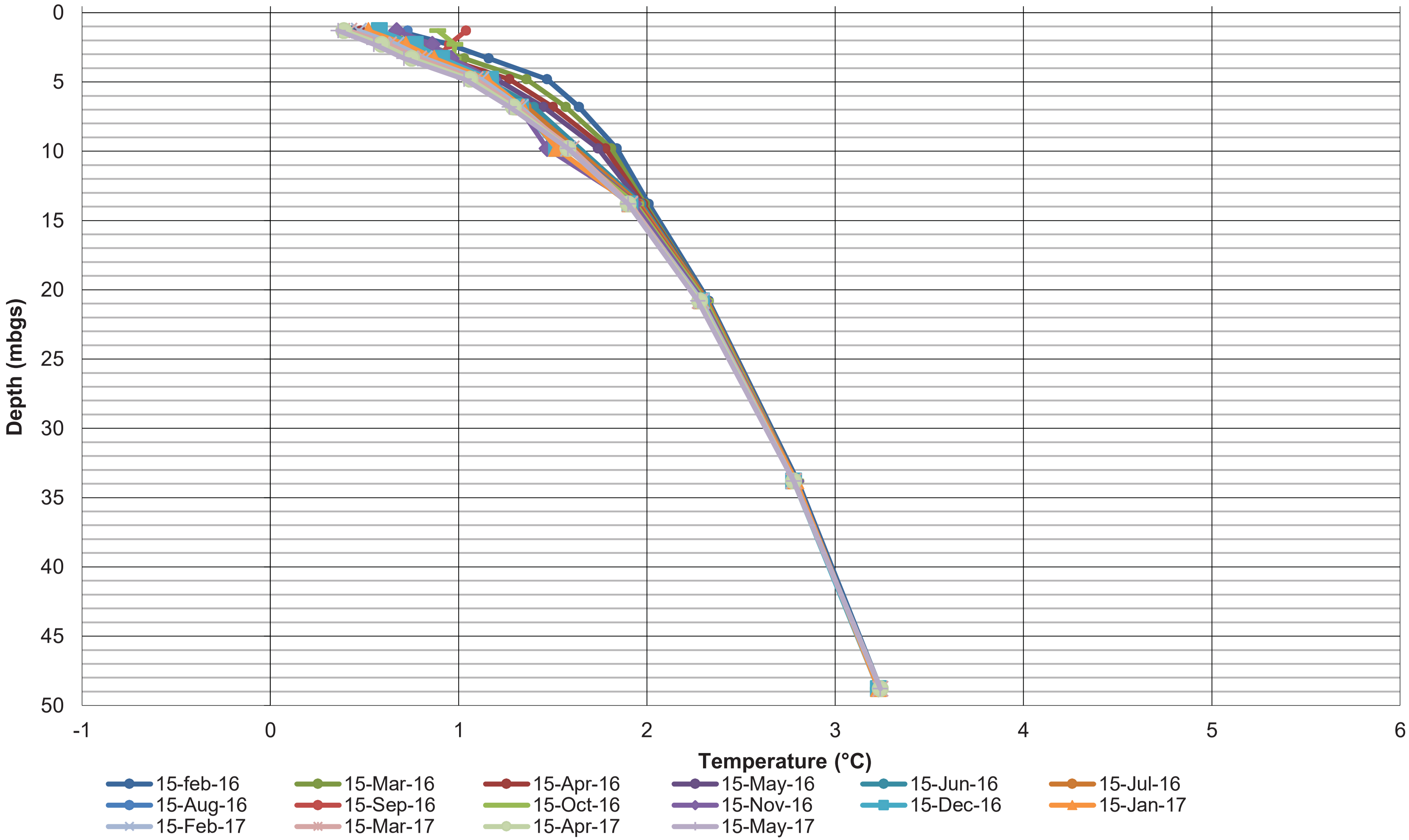
K15-335 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO. VA101-640/05
REF. NO. VA17-01001

FIGURE A-6
REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG



NOTES:

1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K15-336 TRUMPET CURVE

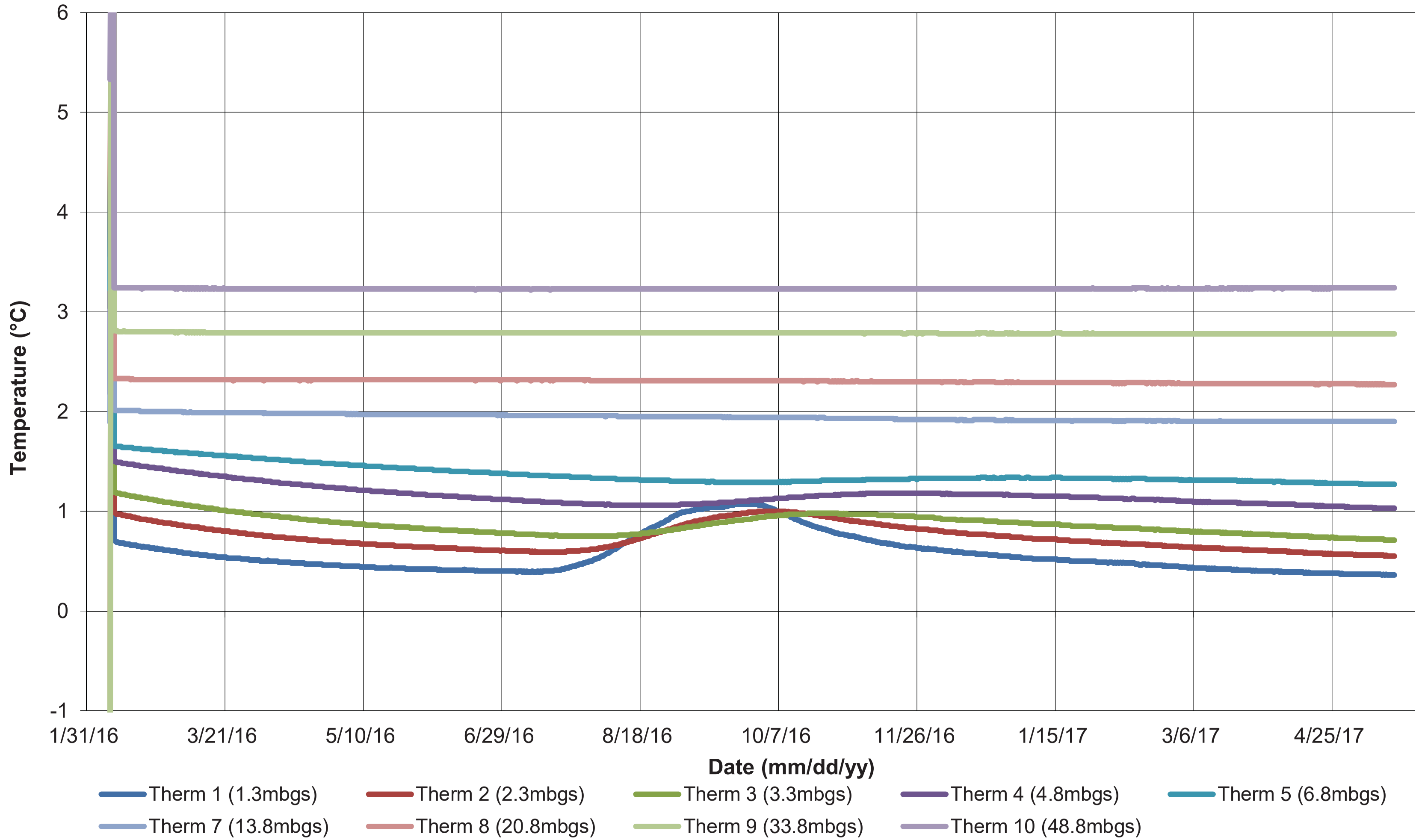
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-7

REV A



NOTES:
1. THERMISTOR INSTALLED IN FEBRUARY 2016 AFTER THE DRILLING PROGRAM WAS COMPLETE.

BMC MINERALS (NO.1) LTD.
KUDZ ZE KAYAH PROJECT

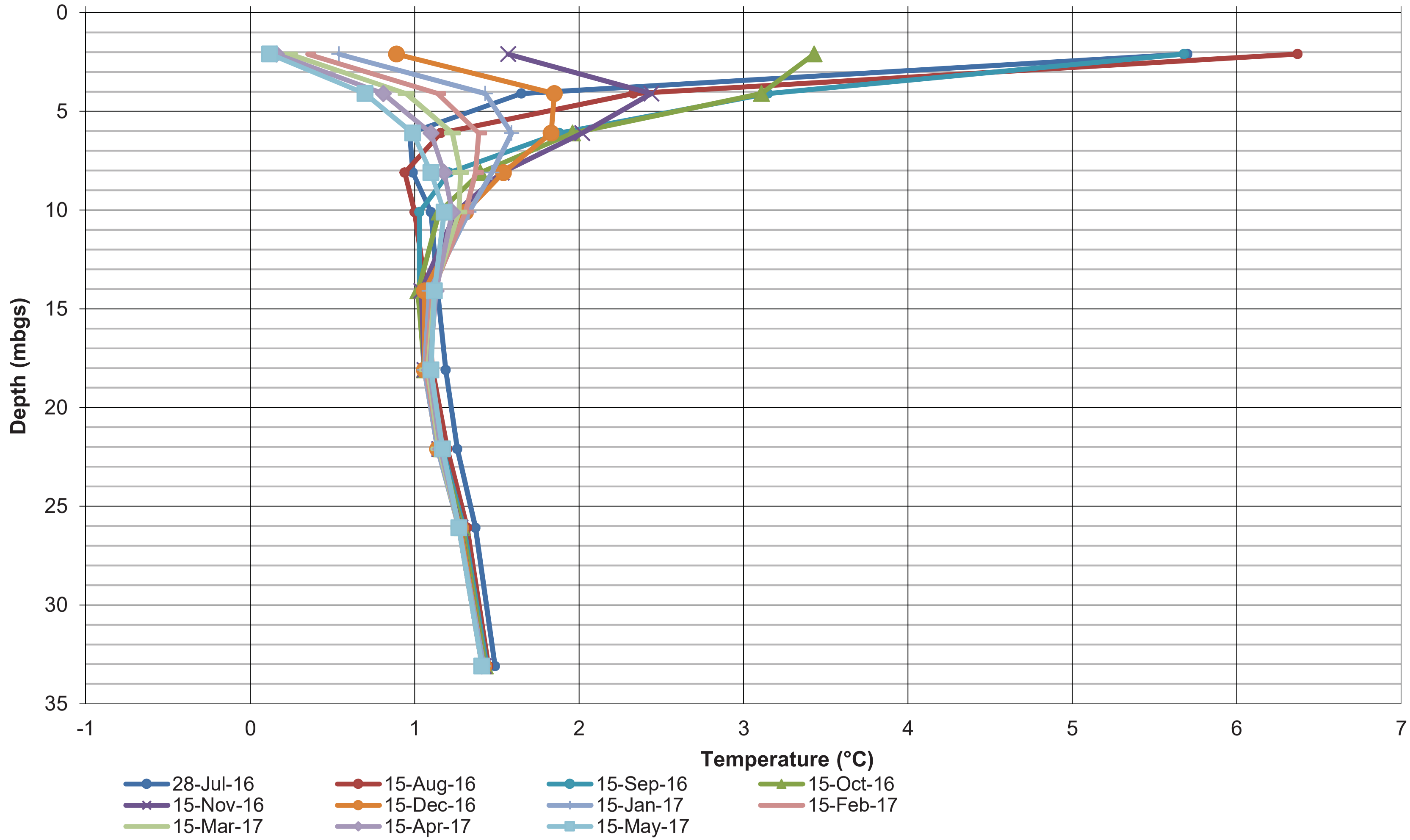
K15-336 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-640/05	VA17-01001

FIGURE A-8 REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG



BMC MINERALS (NO.1) LTD.

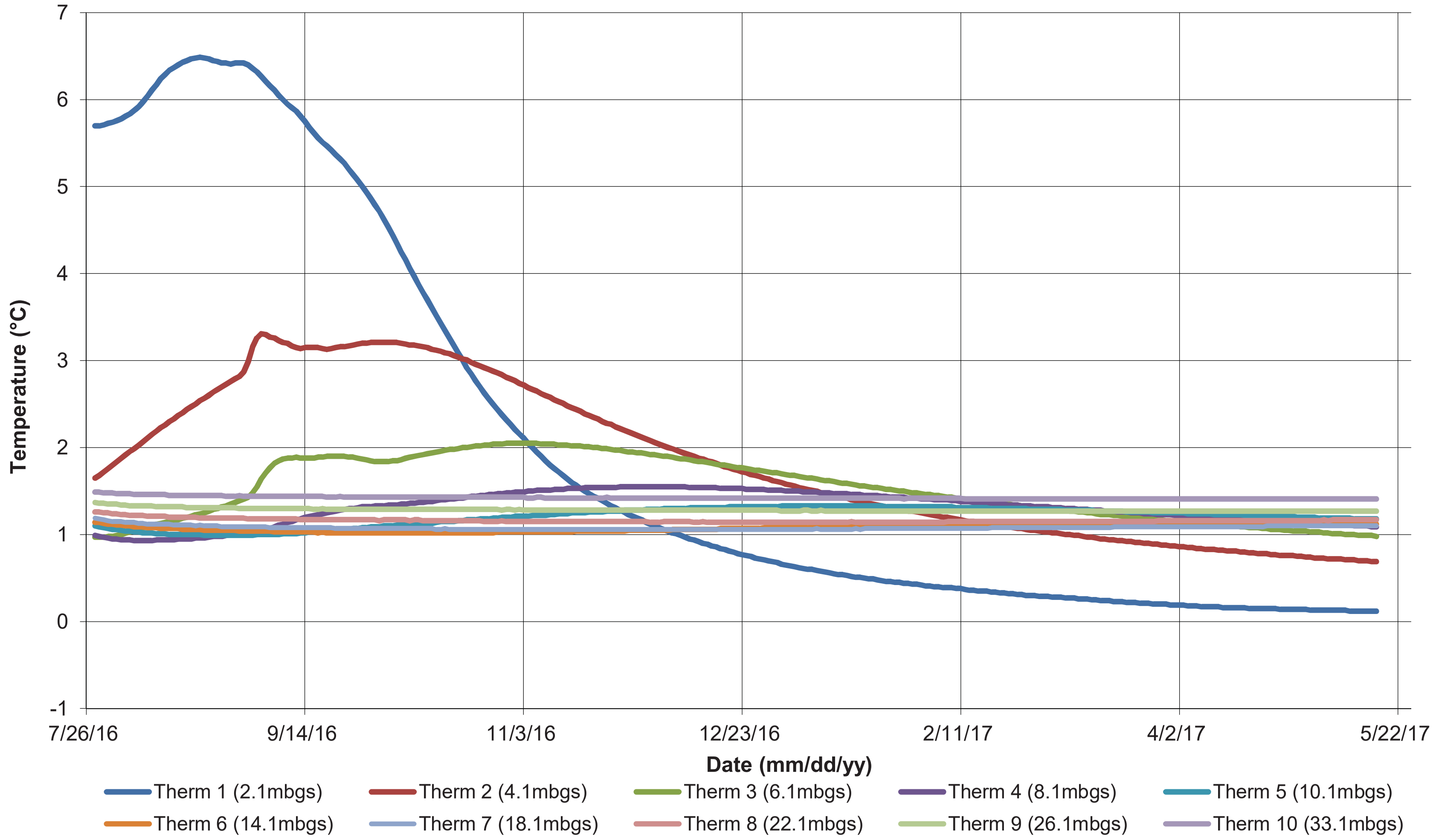
KUDZ ZE KAYAH PROJECT

K16-387 TRUMPET CURVE

Knight Piésold CONSULTING

P/A NO.	REF. NO.	
VA101-640/05	VA17-01001	
FIGURE A-9		REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG



BMC MINERALS (NO.1) LTD.

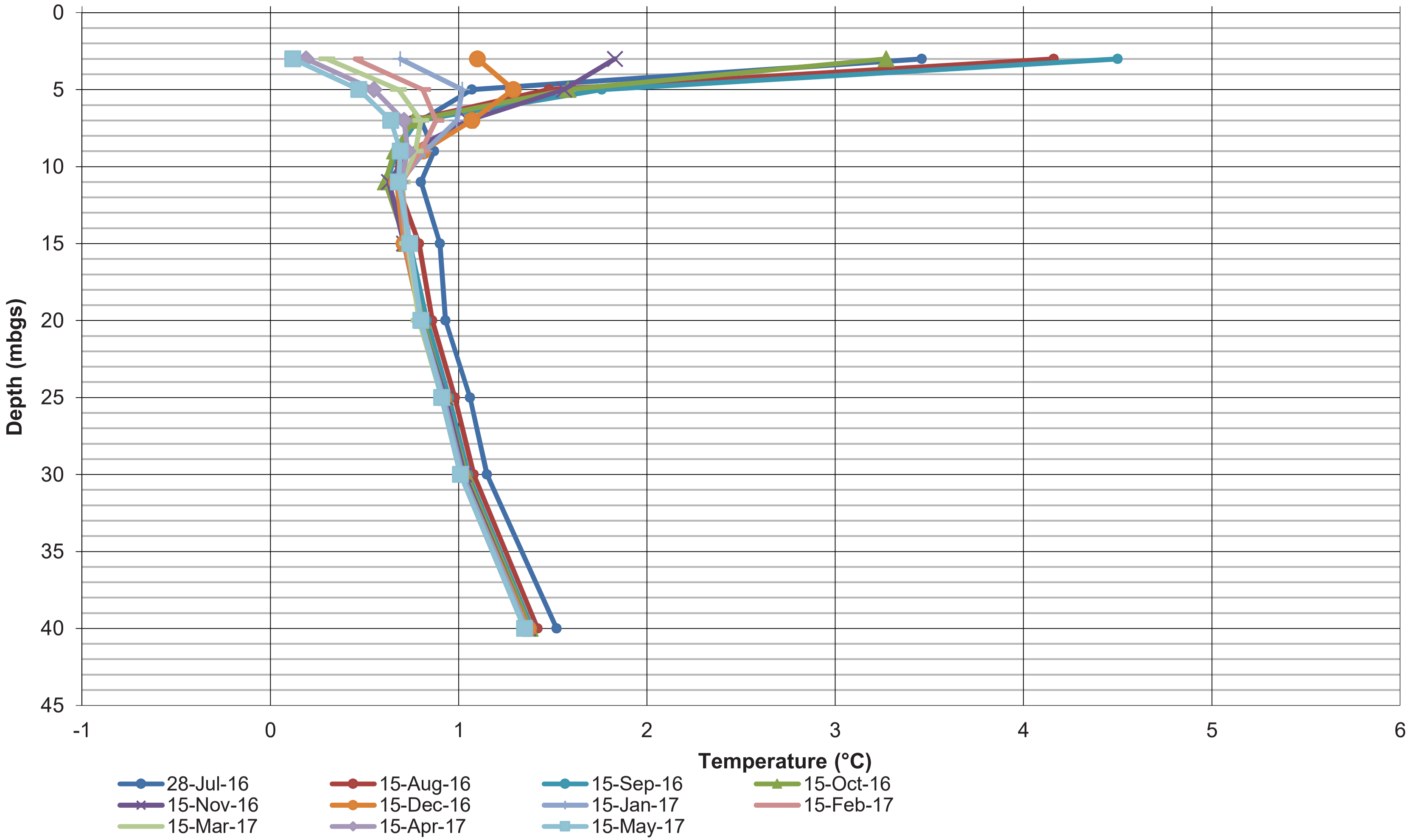
KUDZ ZE KAYAH PROJECT

K16-387 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.	
VA101-640/05	VA17-01001	
FIGURE A-10		REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-389 TRUMPET CURVE

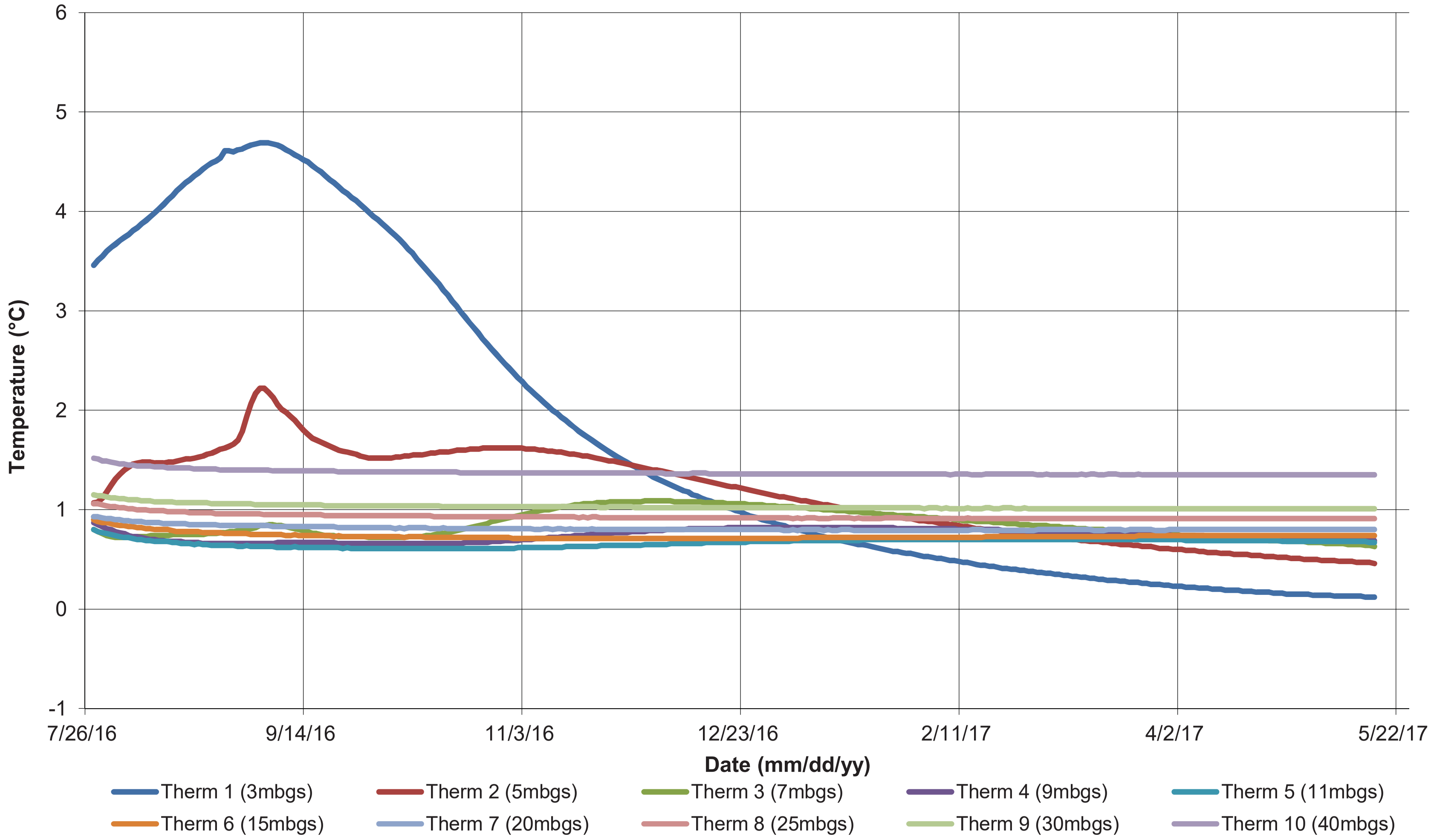
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-11

REV A



BMC MINERALS (NO.1) LTD.

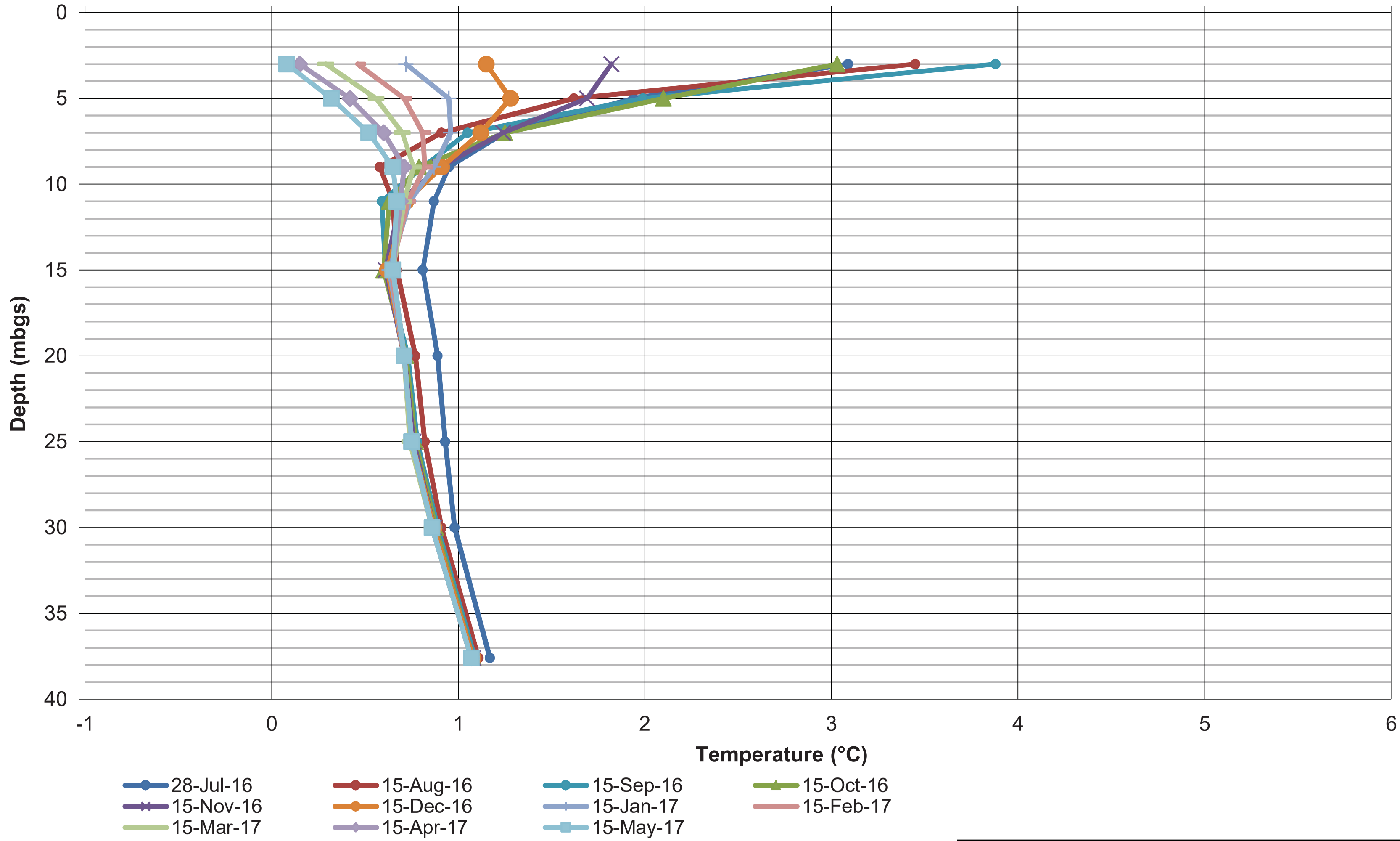
KUDZ ZE KAYAH PROJECT

K16-389 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO. VA101-640/05	REF. NO. VA17-01001
FIGURE A-12	REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



REV	DATE	DESCRIPTION	PREP'D	RVW'D
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BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-390 TRUMPET CURVE

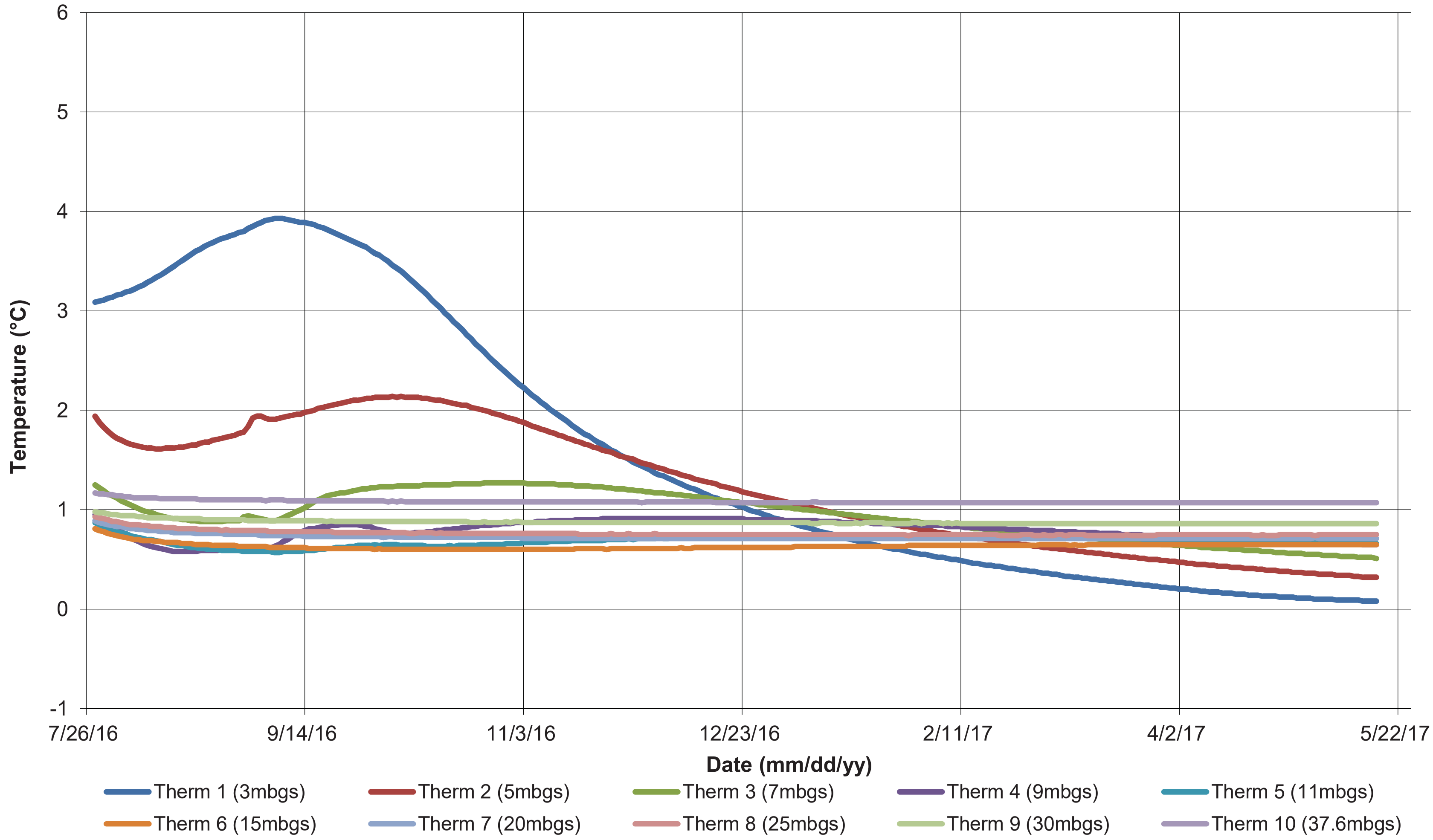
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-13

REV A



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-390 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.	
VA101-640/05	VA17-01001	
FIGURE A-14		REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
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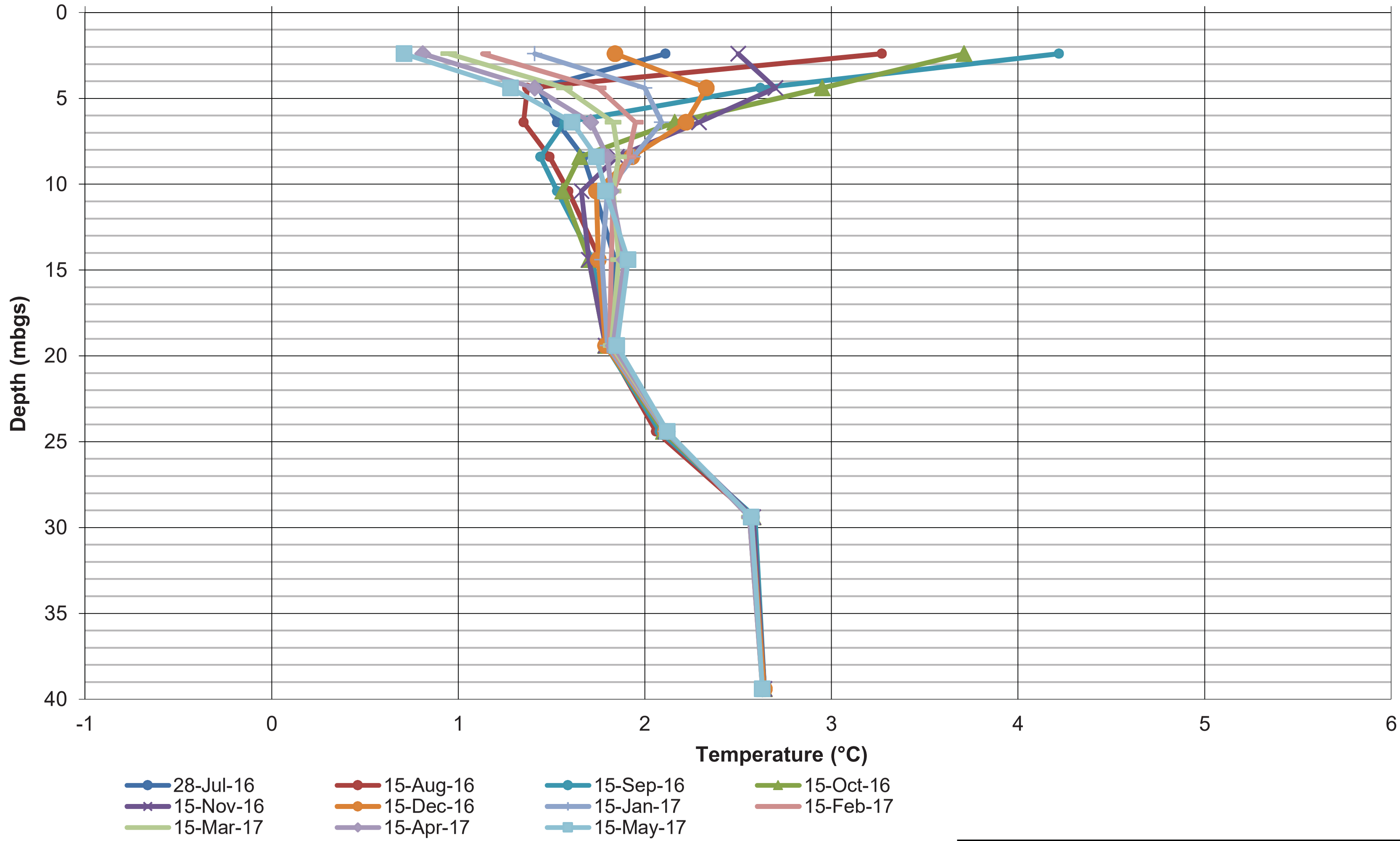


A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-392 TRUMPET CURVE

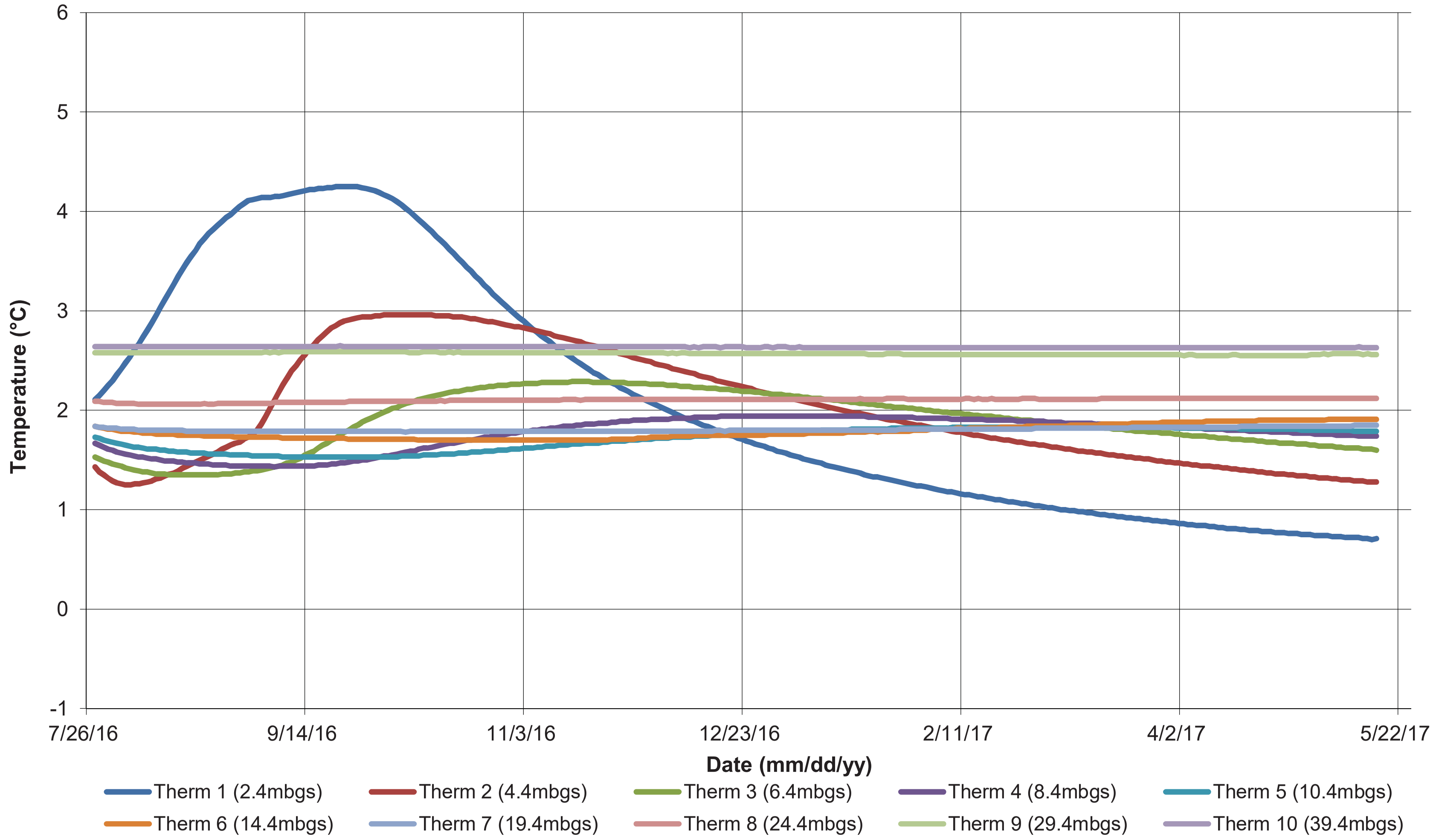
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-15

REV A



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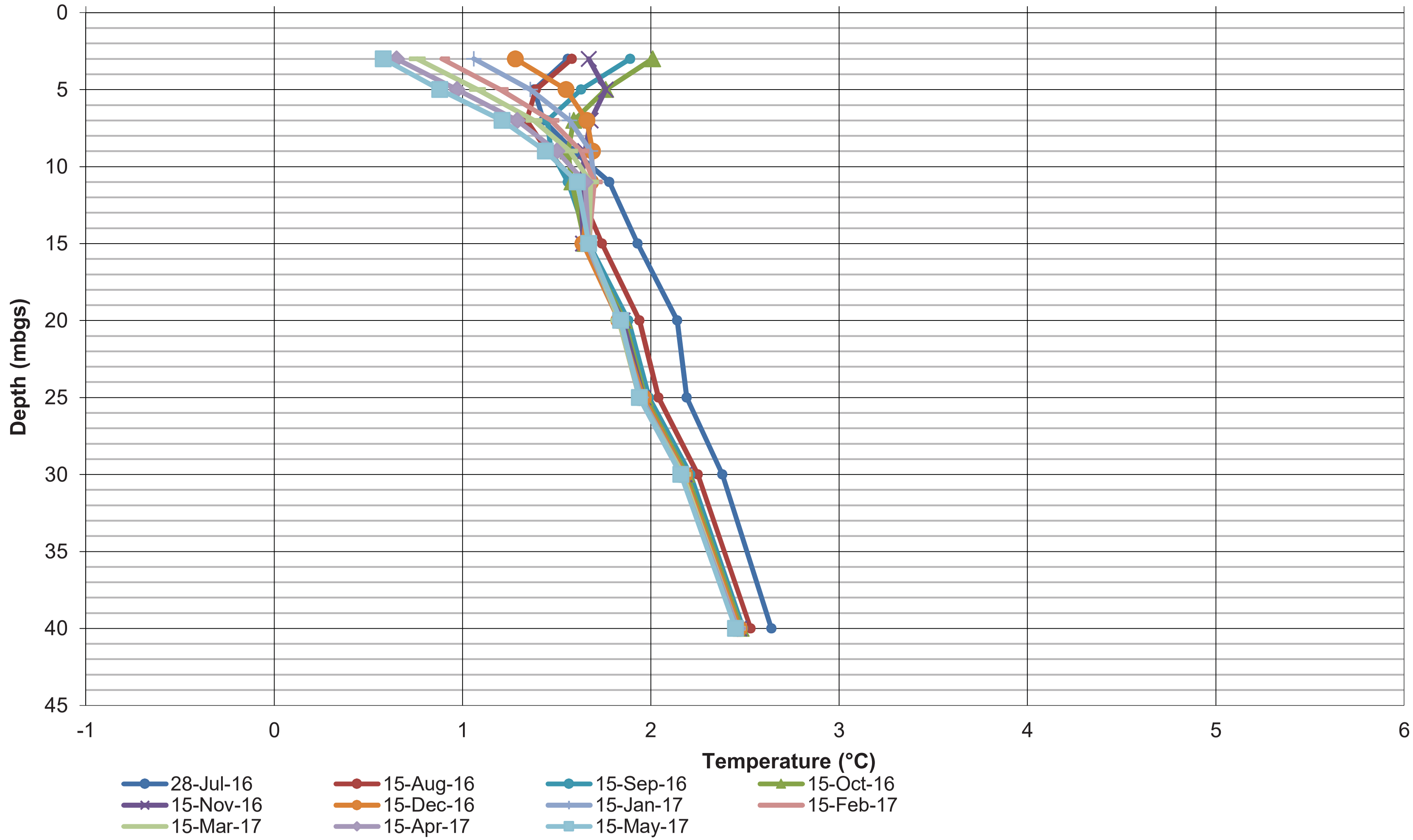
KUDZ ZE KAYAH PROJECT

K16-392 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.	
VA101-640/05	VA17-01001	
FIGURE A-16		REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-395 TRUMPET CURVE

Knight Piésold CONSULTING

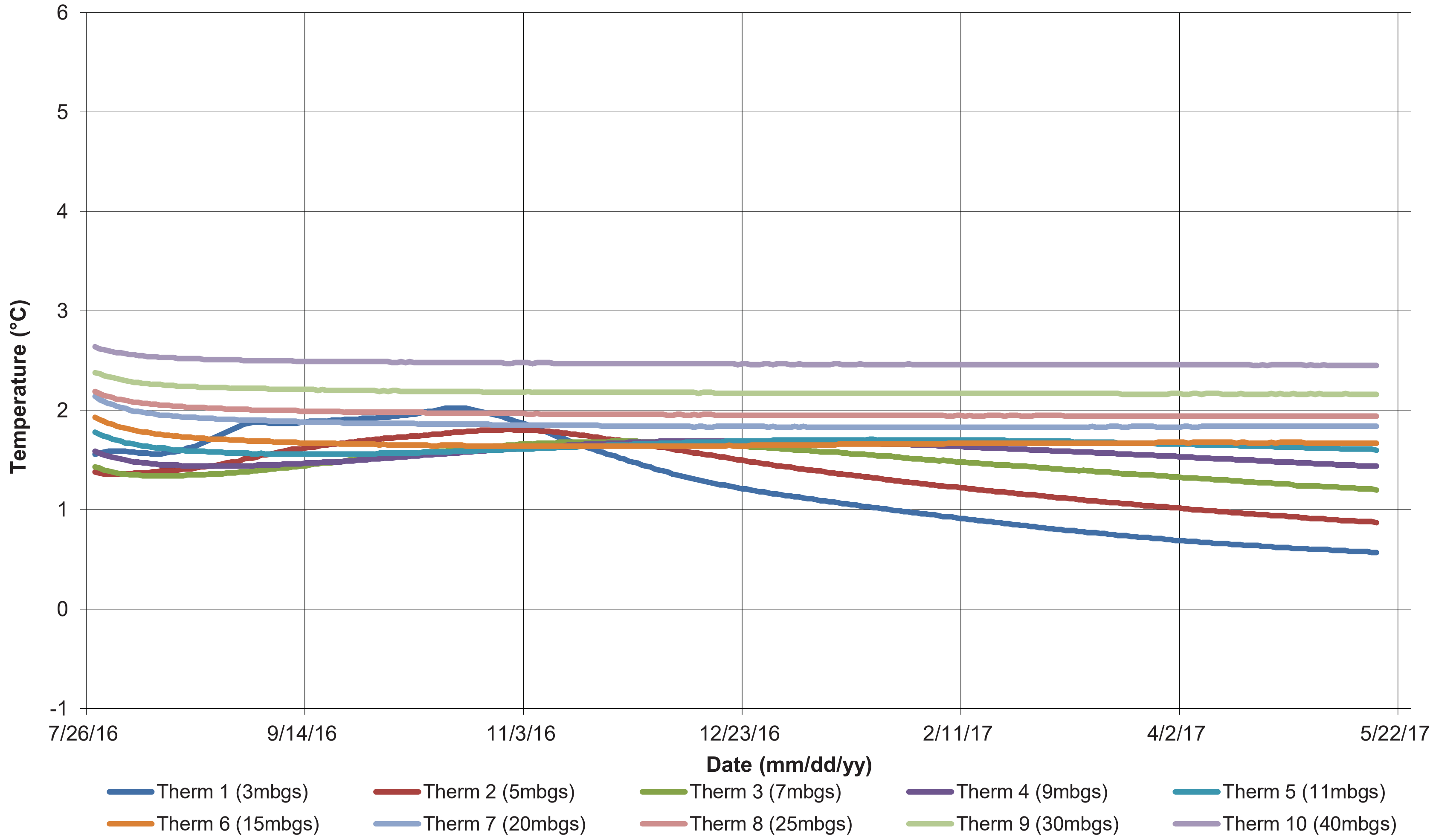
P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-17

REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-395 THERMISTOR DATA

Knight Piésold CONSULTING

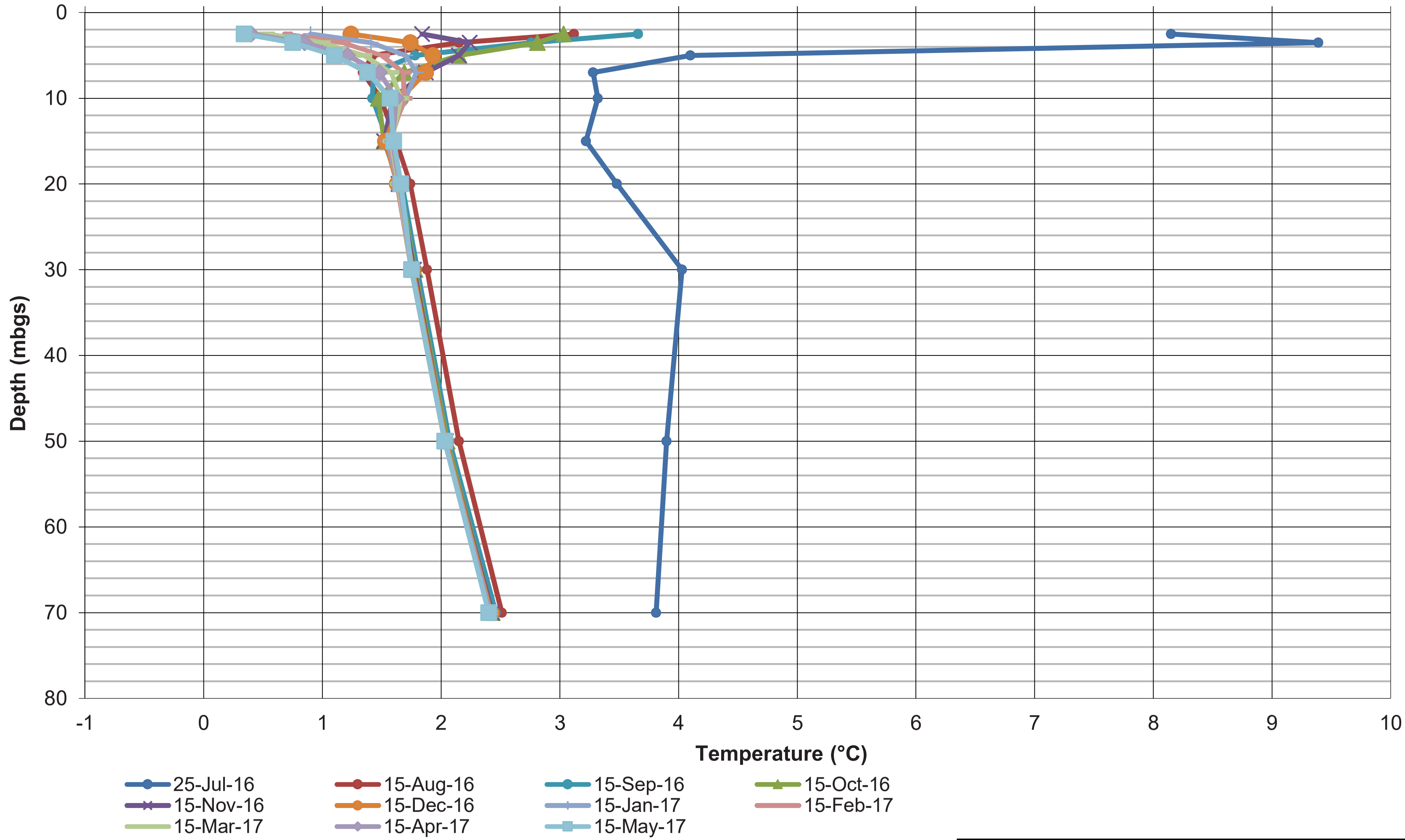
P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-18

REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG



A	13MAY'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-402 TRUMPET CURVE

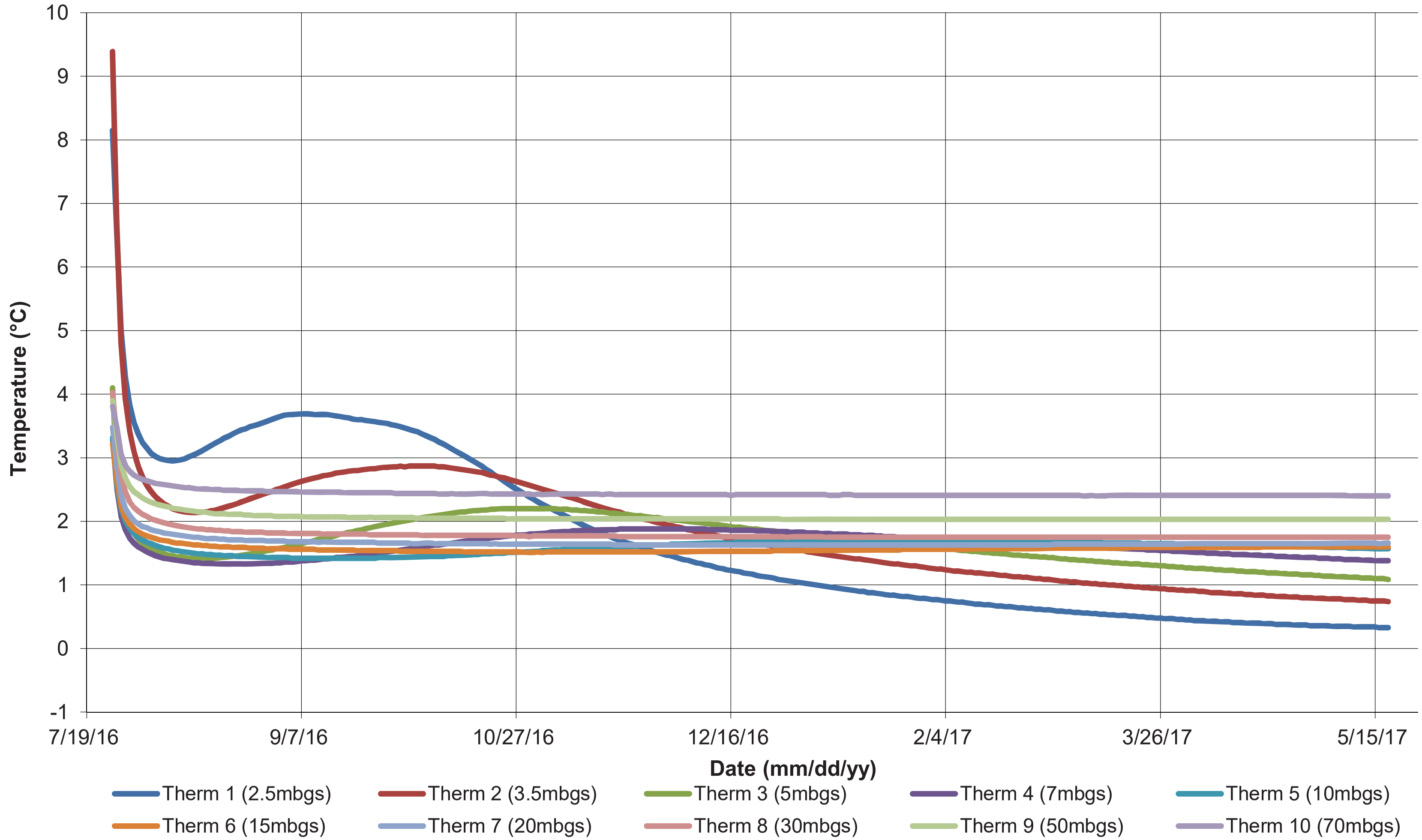
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-19

REV A



BMC MINERALS (NO.1) LTD.

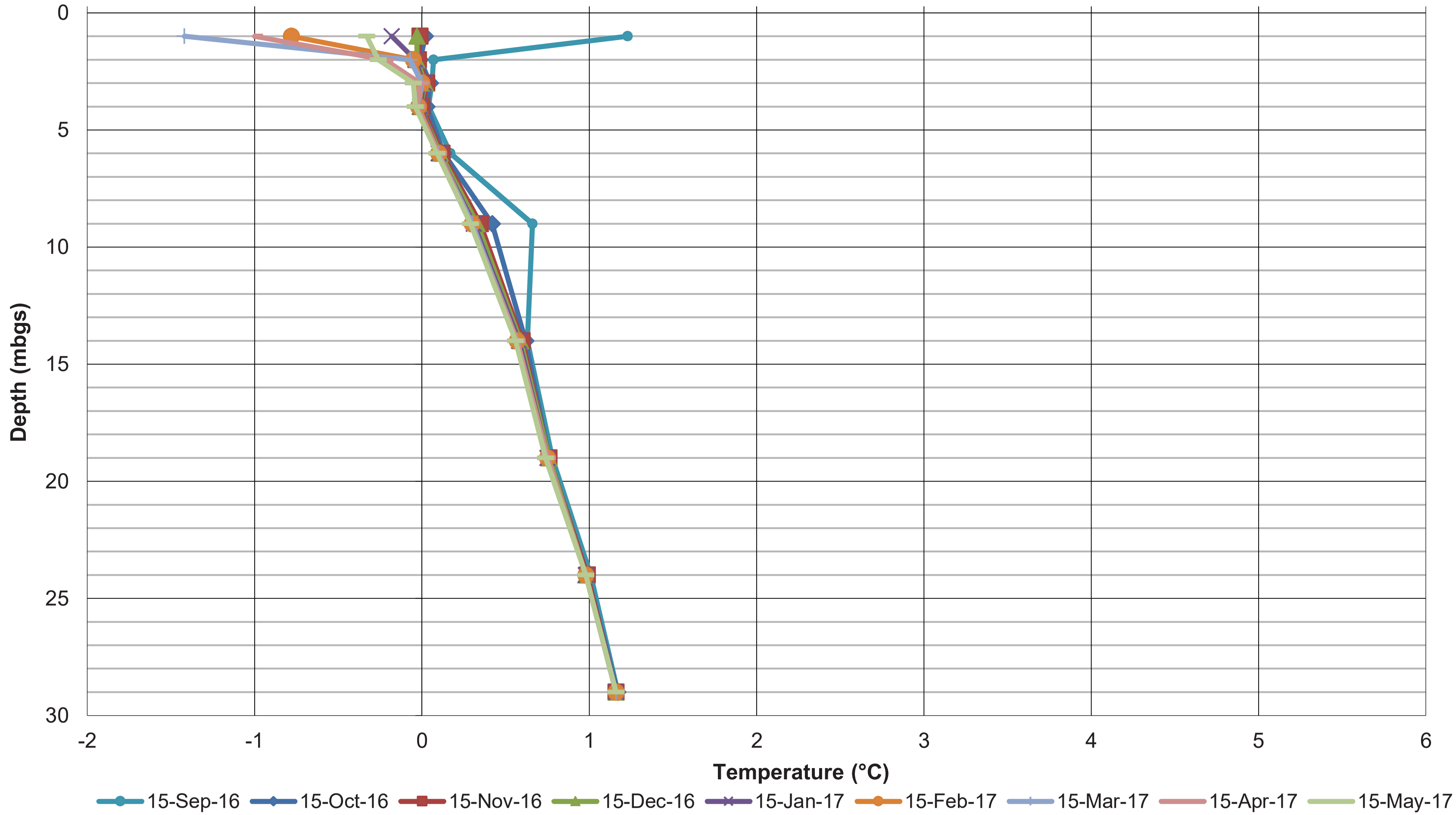
KUDZ ZE KAYAH PROJECT

K16-402 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO. VA101-640/05	REF. NO. VA17-01001
FIGURE A-20	REV A

A	13MAY'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-410 TRUMPET CURVE

Knight Piésold CONSULTING

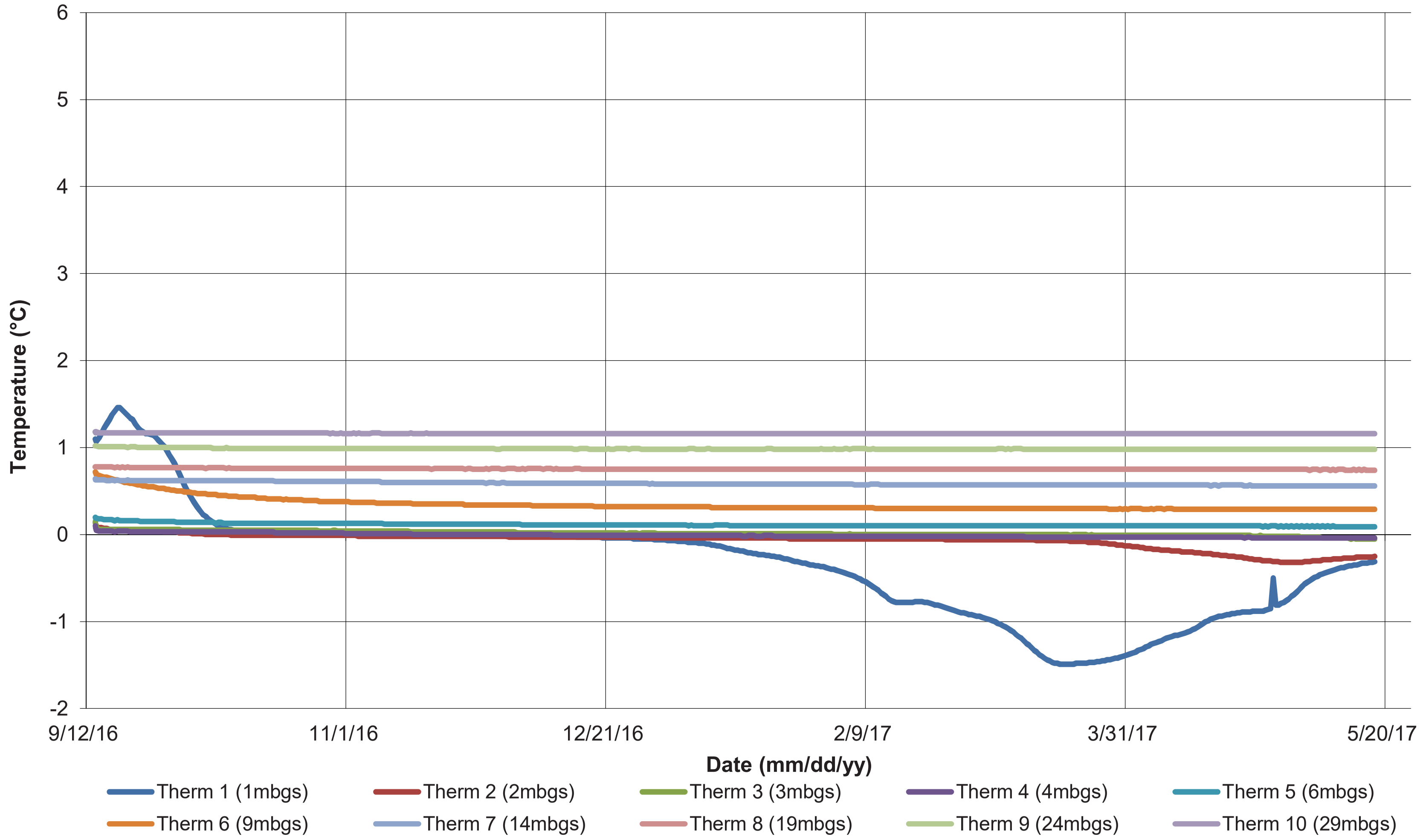
P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-21

REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



BMC MINERALS (NO.1) LTD.

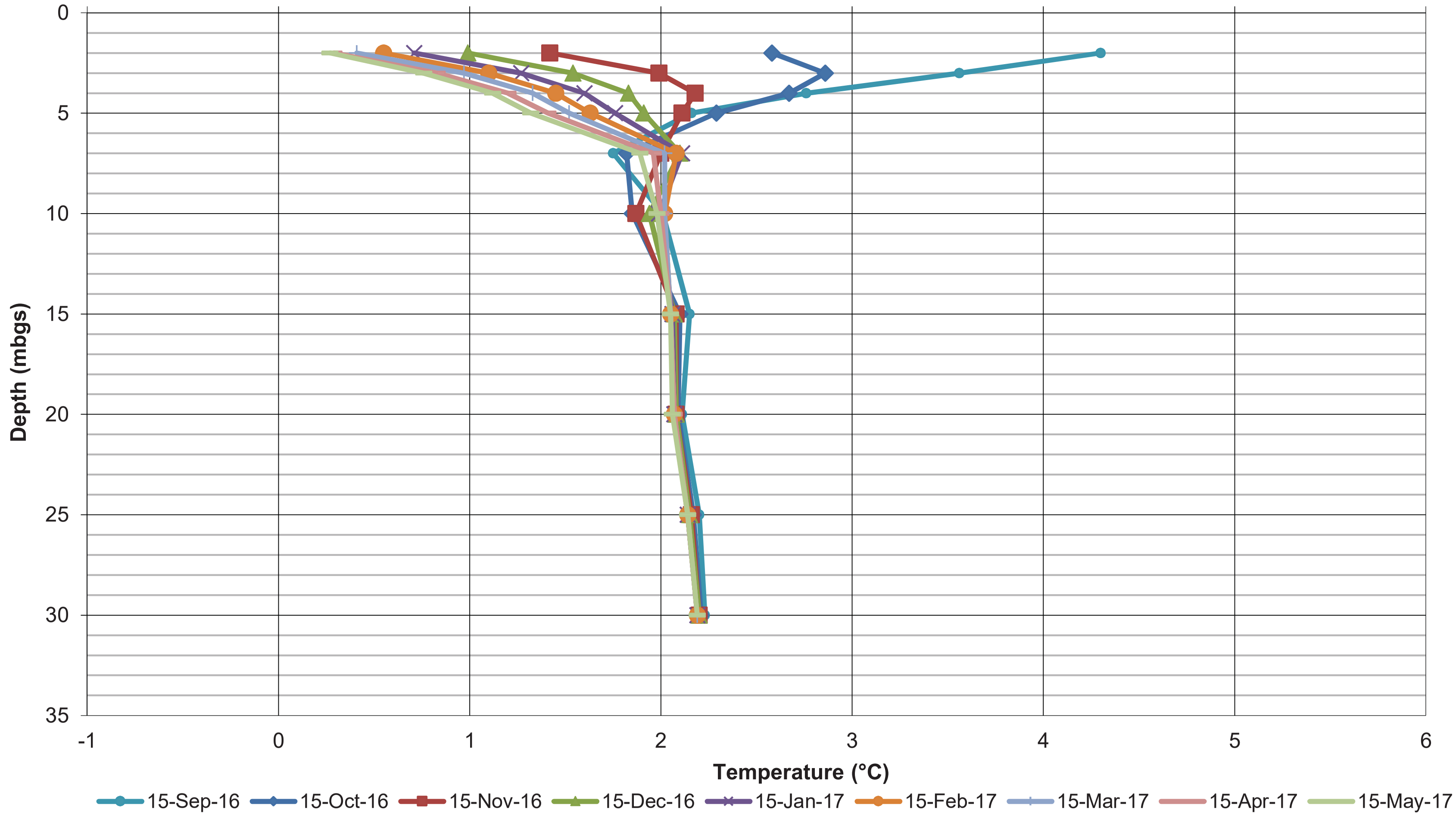
KUDZ ZE KAYAH PROJECT

K16-410 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.	
VA101-640/05	VA17-01001	
FIGURE A-22		REV A

A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG
REV	DATE	DESCRIPTION	PREP'D	RVW'D



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-411 TRUMPET CURVE

Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-23

REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
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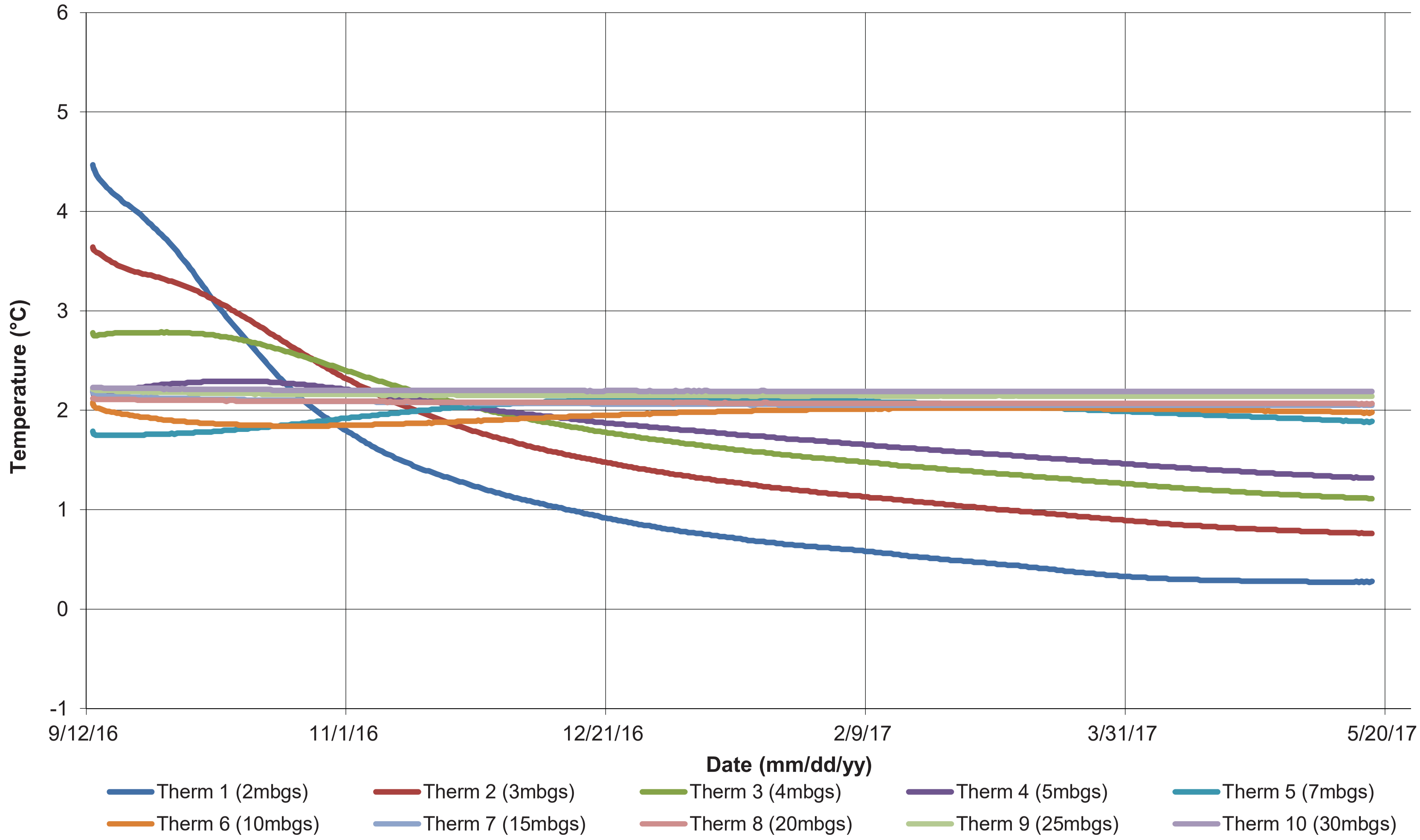


REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-411 THERMISTOR DATA

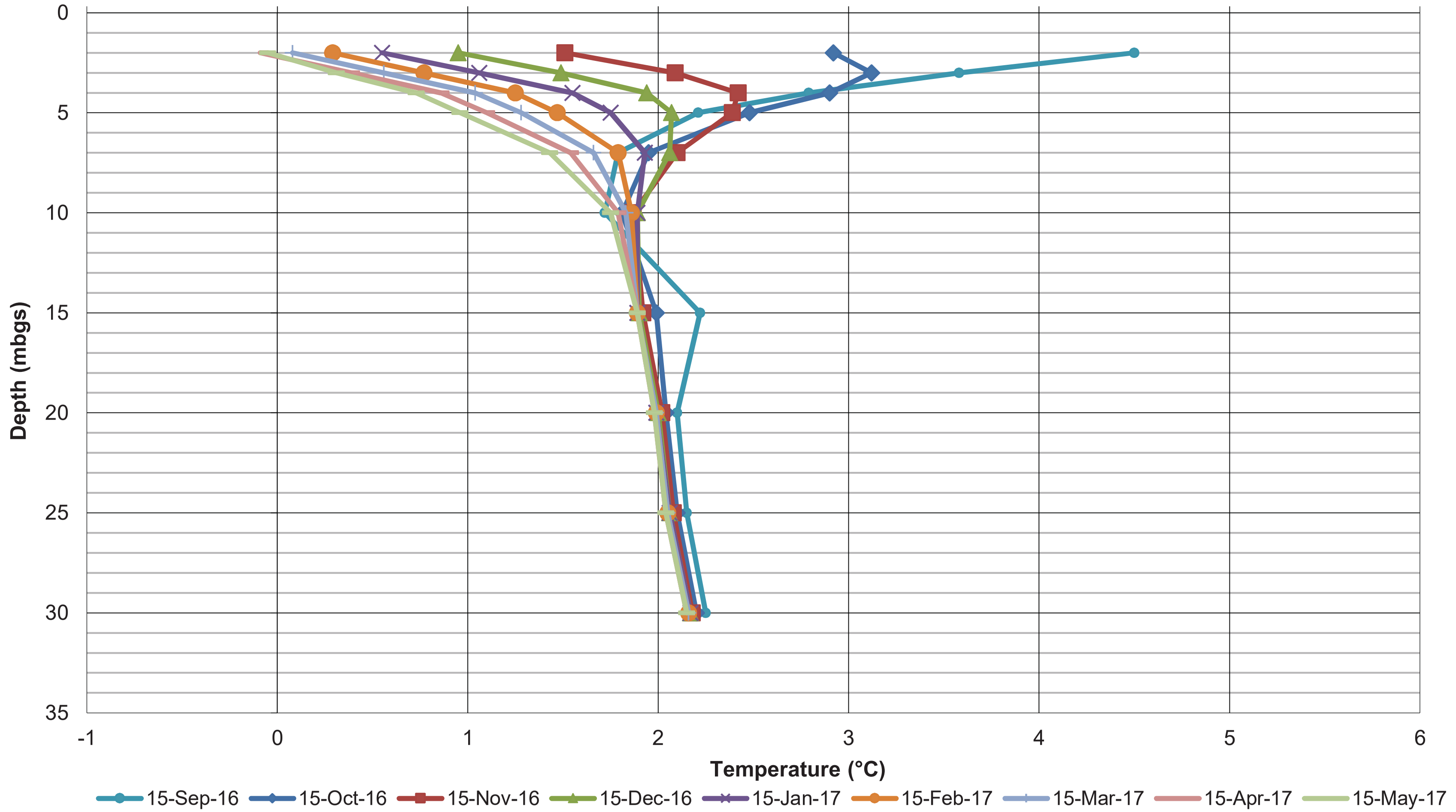
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-24

REV A



REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-412 TRUMPET CURVE

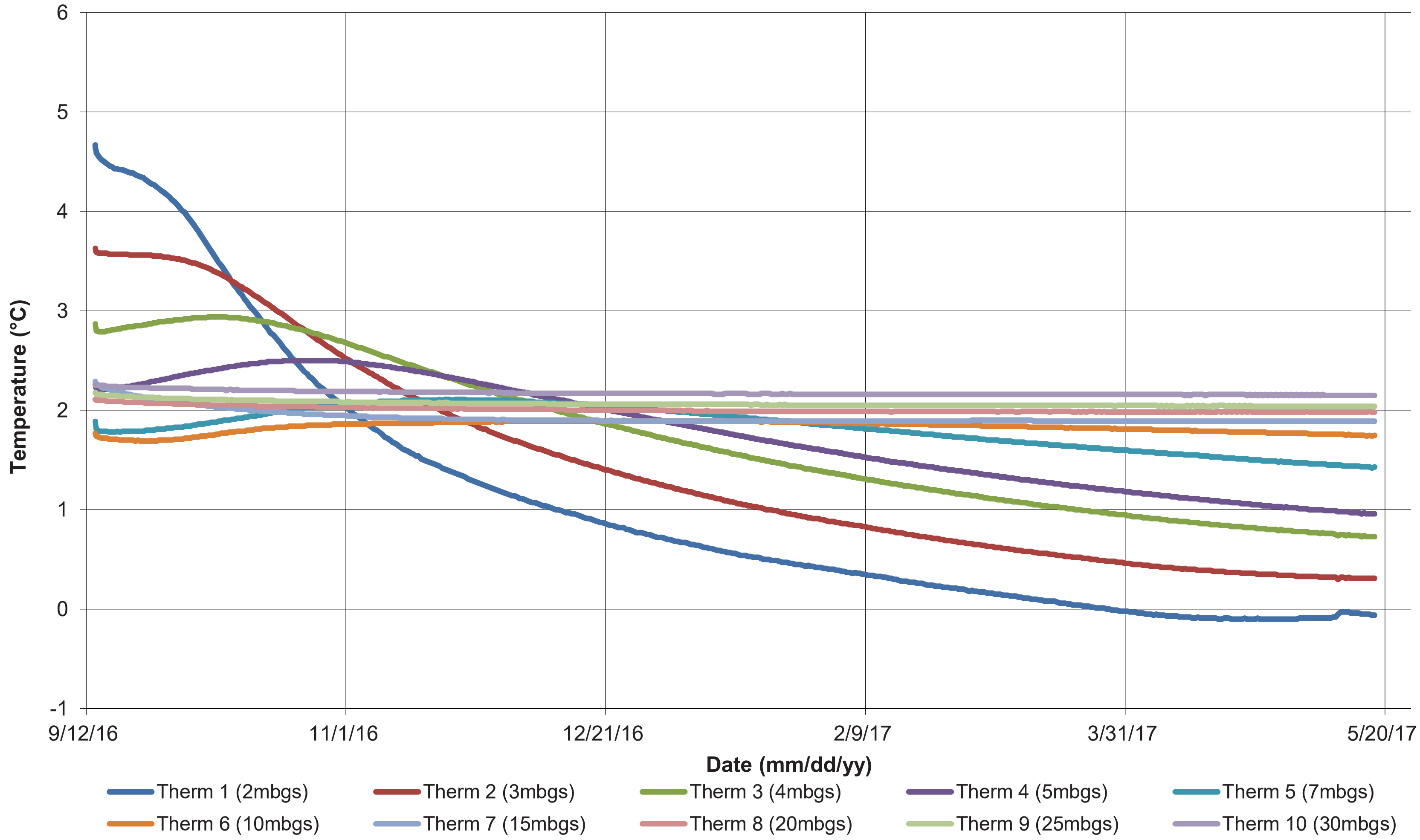
Knight Piésold CONSULTING

P/A NO. VA101-640/05

REF. NO. VA17-01001

FIGURE A-25

REV A



BMC MINERALS (NO.1) LTD.

KUDZ ZE KAYAH PROJECT

K16-412 THERMISTOR DATA

Knight Piésold CONSULTING

P/A NO.	REF. NO.
VA101-640/05	VA17-01001

FIGURE A-26 REV A

REV	DATE	DESCRIPTION	PREP'D	RVW'D
A	13JUN'17	ISSUED WITH TRANSMITTAL	DJR	LJG

APPENDIX 2.
Rockland Geotech Report

ROCKLAND LTD.

Rock Engineering and Mine Backfill Specialist

November 23, 2016

BMC Minerals Ltd.
530 - 1130 West Pender St.,
Vancouver, BC,
V6E 4A4

Attn.: [Name Redacted]
Chief Mine Engineer

Dear Sir,

RE: GEOTECHNICAL PRE-FEASIBILITY STUDY OF THE UNDERGROUND MINE DESIGN FOR THE KRAKATOA ZONE – BMC MINERALS LTD.

Please find attached a copy of the above referenced report. This report presents the analyses and results of geomechanical investigations for the underground mine design of the Krakatoa Zone.

I trust that this report meets with your present requirements. Should you have any questions with regard to the content of this report, please do not hesitate to contact me.

Yours truly
ROCKLAND LTD.
[Name Redacted] *Ph. D., P. Eng.*
Principal
Attachment

GEOTECHNICAL PRE-FEASIBILITY STUDY OF THE UNDERGROUND MINE DESIGN FOR THE KRAKATOA ZONE

Report Prepared for:

BMC MINERALS LTD.

November 23, 2016

ROCKLAND LTD.

Rock Engineering and Mine Backfill Specialist

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LIST OF ABBREVIATIONS

Abbreviation	Description
FWD	Footwall Domain
GSI	Geological Strength Index
HWD	Hangingwall Domain
$I_{s\ (50)}$	Point Load Strength Index
NGI	Norwegian Geotechnical Institute
OD	Ore Domain
PLT	Point Load Test
RMR	Rock Mass Rating
RQD	Rock Quality Designation
UCS	Unconfined Compression Strength

EXECUTIVE SUMMARY

The BMC Minerals Ltd. is conducting the Pre-feasibility Study on the Krakatoa Zone. As part of the study, geomechanical mine design inputs are required. In particular, geomechanical mine design recommendations are necessary for the rock quality evaluation, mining method assessment, ground support recommendations and crown pillar determination.

A mine design geomechanical program, including geotechnical drilling, field data collection and analyses was carried out. The field data collection program consisted of geotechnical drilling and logging, Point Load test and commercial laboratory test on representative core samples.

The unconfined compressive test was carried out in a commercial laboratory on representative core samples. Two rock mass classifications of RMR_{76} and Q were implemented for geotechnical logging and rock quality determination. The rock was evaluated based on four domains; Immediate Hangingwall Domain, Ore Domain, Immediate Footwall Domain and Footwall Domain. For comparison purposes, both commercial laboratory and Point Load Strength Index values were employed. The main objectives were to establish the ranges of rock mass quality for various domains for the purpose of stability assessment and ground support recommendations.

The Cut and Fill mining method, using a footwall ramp and central access drive, have been proposed for Krakatoa Zone. The main deposit at Krakatoa is aim to be fully extracted, using the primary and secondary drifting method to maximise productivity. The geomechanical aspects of the proposed mining method were evaluated.

The ground support recommendations for Krakatoa were prepared based on empirical methods and the Q-support guidelines. The recommendations provided length and spacing of ground support for various geomechanical domains and intersections.

The crown pillar dimension was evaluated based on the Scaled Crown Span method for crown pillar assessment which uses a guideline for risk exposure and probability of failure. In the absence of information at the crown pillar area, assumptions were made and crown pillar thickness was recommended.

This report presents the results of various geomechanical mine design investigations carried out and contains a number of recommendations for the next stage of assessment or as the project proceeds to the feasibility level study.

1.0 INTRODUCTION

The BMC Minerals Ltd. (BMC) is currently conducting the Pre-Feasibility Study (PFS) of the Krakatoa Zone (Krakatoa) about 120 km south of Ross River, Yukon. As part of PFS, a mine design study should be prepared. Dr. Khosrow Aref, P. Eng. of Rockland Ltd (Rockland) was retained to provide geotechnical inputs to the mine design. This report presents the results of geomechanical mine design assessments carried out for Krakatoa.

The geomechanical mine design assessments consisted of a number of investigations including site visits, geotechnical site investigations, rock mass quality assessment, mining method evaluations, ground support recommendations and crown pillar assessments. The report provides the results of these investigations and contains recommendations for the next stage of assessment.

2.0 SITE INVESTIGATION

2.1 Visit

Two site visits were carried out by Dr. Khosrow Aref, P. Eng. of Rockland to Krakatoa. The first was planned from May 23 to May 27, 2016. During the visit, a tour of various parts of the deposit was conducted and typical drill cores were inspected. The main objective of the visit was training of BMC’s geological and geotechnical staff for geotechnical data collection program. The second visit was carried out from June 20 to June 24. The objective of the second visit was to collect detailed geotechnical data from several drill holes. The collected information during these site visits was analysed and the results are included in relevant sections of this report.

2.2 Available Information

The following information was made available for geomechanical analyses in this report:

- Report entitled "Hangingwall Stability of Kudz Ze Kayah Project", August 22, 1995 by Golder Associates Ltd.
- Report entitled "Geotechnical Review of Kudz Ze Kayah Project" dated March 31, 2016 by SRK Consulting

Selected information employed for geomechanical analyses is referenced in relevant sections of this report.

2.3 Units

The S.I. unit system was adopted for all data presented in this report. Since some data are commonly expressed in other unit systems, both S.I. and the equivalent unit are included.

3.0 SITE CHARACTERISATION

The site characterisations, including geometry, geology and rock types, are required for the underground geomechanical assessment. This information is summarized in the following sections based on geological notes provided by BMC (2016). A copy of these notes is included in the Appendix I.

3.1 Geometry

The ABM deposit is divided between the ABM and Krakatoa Zones, which are separated from each other by the East Fault as illustrated in Figure 1.

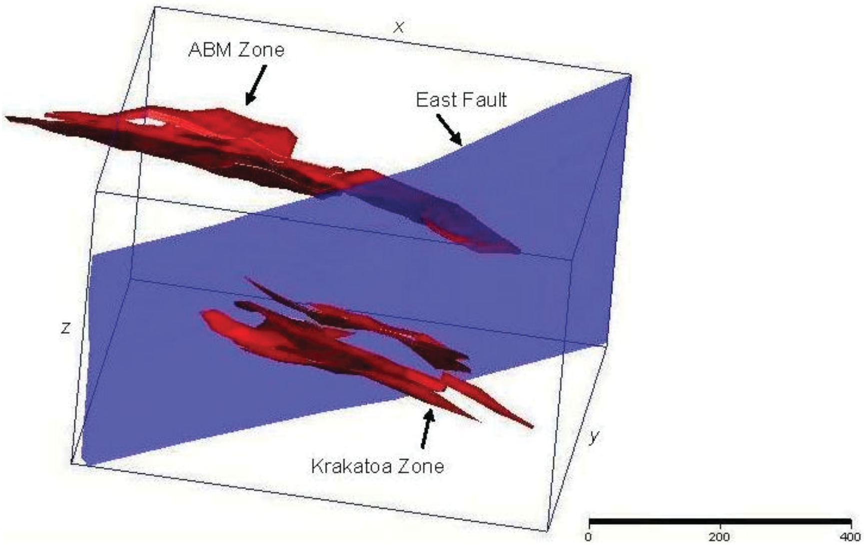

Figure 1: Wire frame model for the ABM Deposit, showing the ABM and Krakatoa Zones as well as the East Fault. Cube shows the X, Y and Z directions.

The ABM deposit comprises 20.1 Mt of ore that are divided between the ABM (15.0 Mt) and Krakatoa (5.1 Mt) zones, which are separated from each other by the East Fault (See Figure 1). Key geometric features of the ABM Zone include:

- Architecture comprising a sub-parallel pair of stacked lenses that coalesce into a single lens at the eastern and western extremities of the deposit;
- Generally tabular form with average true thickness of 20 m and maximum of 39 m, as well as continuity of up to 700 m along strike and 400 m in the down-dip direction;
- Strike of 290° and dip of -35° to the NNE that flattens to between -10° to -15° at 200 m down-dip depth;
- All lenses lie above the mafic footwall intrusion (as opposed to Krakatoa Zone - see below).

Essential geometric features for the Krakatoa Zone include:

- Architecture comprising a series of stacked lenses and pods, the largest of which comprise the main and upper lenses;
- A main lens with a more elongate tabular form relative to ABM, with average thickness of 15 m and maximum of 22 m, in addition to 220 m of strike length and up to 350 m of down-dip extent;
- Strike of 300° and dip of -35° to the NNE;
- Most lenses lie within the mafic footwall intrusion or at its upper and/or lower contacts.

3.2 Geology

3.2.1 Reginal and Local Geology

The KZK Property is underlain by polydeformed meta-sedimentary, -volcanic and -plutonic rocks of the Yukon-Tanana terrane, which extends from central British Columbia into eastern Alaska. The Finlayson Lake belt, a 300 km long by 50 km wide geographic subdivision of the Yukon Tanana and Slide Mountain terranes, is notable for hosting several syngenetic VMS deposits in both Yukon-Tanana (e.g. Wolverine, ABM, GP4F, Fyre Lake) and Slide Mountain (e.g. Ice) rocks, as well as in the adjacent platform rocks of ancestral North America (e.g. Wolf).

Subdivisions of the Yukon-Tanana terrane that occur on the KZK Property, as shown in Table 1, include the Grass Lakes group and the Grass Lakes plutonic suite. The Grass Lakes group is subdivided into, from oldest to youngest, the Fire Lake, Kudz Ze Kayah (KZK) and Wind Lake formations. The KZK formation occurs extensively within the southern half of the Property and hosts both the ABM and GP4F deposits. It passes upwards from a basal sub-unit of calcareous and carbonaceous metasedimentary rocks into a distinctive feldspar-muscovite-quartz schist and phyllite. The overlying Wind Lake formation is similar to the basal KZK, comprising mostly carbonaceous phyllite and quartzite that is intercalated with chloritic phyllite.

Table 1: Stratigraphic units on the KZK Property

<table>
<tr><th>Epoch</th><th>Suite or succession</th><th>Formation</th><th>Sub-unit</th></tr>
<tr><td rowspan="2">Early Mississippian</td><td rowspan="2">Grass Lakes plutonic suite</td><td rowspan="2"></td><td>Equigranular metagranitoids</td></tr>
<tr><td>Augen metagranitoids</td></tr>
<tr><td rowspan="8">Late Devonian to Early Mississippian</td><td rowspan="8">Grass Lakes group</td><td rowspan="4">Wind Lake</td><td>Quartzite</td></tr>
<tr><td>Chloritic phyllite</td></tr>
<tr><td>Carbonaceous phyllite/schist</td></tr>
<tr><td>Metaconglomerate</td></tr>
<tr><td rowspan="3">Kudz Ze Kayah</td><td>Fsp-ms-qtz schist and phyllite</td></tr>
<tr><td>Carbonaceous phyllite/schist</td></tr>
<tr><td>Calcareous metasandstone</td></tr>
<tr><td>Fire Lake</td><td>Pl-chl phyllite/schist; carbonaceous phyllite</td></tr>
</table>

3.2.2 Rock Types and Mineralization

Most drilling on the Property, including geotechnical drillings, has focussed on VMS deposits hosted within the KZK Formation and, so, are mostly collared within KZK rocks or the overlying Wind Lake Formation. The lithological codes used for logging these rocks are included in Table 2 and discussed below.

Table 2: Rock types for Krakatoa Zone

Group	Description	Lithological codes	Associated deposits
Grass Lakes plutonic suite: Granitoids			
INT	Undifferentiated intrusive rocks	INT	
DIOf	Feldspar augen diorite intrusion	DIOf	
KZK Formation: Felsic volcanic			
RHY	Undifferentiated rhyolite (usually altered)	RHY	
RHYc	Coherent (or partially siliceous?) rhyolite	RHYc, RHYcw	ABM
RHYx	Crystal-bearing rhyolite, porphyry	RHYcf, RHYcq, RHYif, RHYvx	GP4F
RHYi	Aphanitic (or siliceous?) rhyolite	RHYi	Krakatoa Zone
RHYv	Volcaniclastic rhyolite	RHYv, RHYva, RHYvl	
KZK Formation: Sedimentary rocks			
MDU	Carbonaceous mudstone (Wind Lake Fm)	MDU, MDUc	
MDS	Mud- to silt-stone, carbonaceous mudstone (KZK Fm)	MDS, MDSc, MDSt, MDSw	
PEL	Pelite	PEL	
SED	Undifferentiated sedimentary rock	SED, SEDc, ARK, SLT, WCK	
CHT	Chert	CHT	
KZK Formation: Mafic intrusive and volcanic			
MAFi	Mafic intrusive	MAFi	ABM
MAFt	Mafic volcanic	MAFt, MAFta, MAFw	
KZK Formation: Massive and disseminated sulphide			
Massive	Massive sulphide (>50% sulphide)	OA, OB, OC, OD, OF, OG, OH, OL	ABM, GP4F
Disseminated	Disseminated to semi-massive sulphide (25-50% sulphide)	OI, OJ, OK	ABM, GP4F
Other codes			
OVBN	Overburden, casing	OVBN, CASN	
FLZ	Fault zone	FLZ	
No core	Interval with 0% recovery	No core	

The predominant lithology within most drill holes is feldspar-muscovite-quartz phyllite and schist formed from felsic volcanic protoliths and coded as “RHY” in the geological and geotechnical logs (Table 2). There are five main types of RHY, as shown in Table 2. The most abundant of these is felsic volcaniclastic (RHYv), which includes the volcaniclastic rhyolite (RHYva), coarse-grained to ash tuff (RHYva) and lapilli tuff (RHYvl) lithologies. Next most abundant is coherent felsic volcanic (RHYc). The crystal-bearing felsic volcanic group (RHYx) include both crystal tuff (RHYvx) and feldspar- and/or quartz-porphyritic units (RHYcf, RHYcq, RHYif). Aphanitic rhyolite (RHYi) is marked by very hard and fine-grained silica.

Sedimentary rocks are split into five main types as shown in Table 2. Carbonaceous mudstone is coded as MDU where it occurs in the Wind Lake formation and MDS when it forms part of the KZK stratigraphy. The MDS grouping furthermore includes carbonaceous dominant mudstone (MDSc), rhyolite tuff dominant mudstone (MDSt) and coherent rhyolite with carbonaceous content (MDSw). Pelitic rocks (PEL) are biotite-rich schists. Undifferentiated sedimentary rocks (SED) include non-calcareous (SED) and calcareous (SEDc) lithologies, and also sparsely used codes like wacke (WCK) and siltstone (SLT). Chert (CHT) is marked by finely banded and amorphous silica.

Mafic rocks are split into mafic intrusive (MAFi) and mafic volcanic (MAFt) types. The mafic intrusive group includes only rocks logged as MAFi, whereas the MAFt group includes mafic volcaniclastic (MAFt), coarse-grained to ash tuff (MAFta) and mafic volcanic flows (MAFw).

Massive and semi-massive sulphide can be split into predominately massive and disseminated types (Table2). The massive sulphide types are described / logged with a series of O-codes (OA, OB, OC, OD, OF, OG, OH and OL). Disseminated sulphide includes schist-hosted (OI) and proximal alteration-hosted (OJ) types, as well as heavily disseminated sulphide associated with barite (OK).

The ABM Zone occurs mostly within RHYc host rocks and is directly underlain by the mafic footwall intrusion (MAFi). The Krakatoa Zone occurs within the mafic footwall intrusion (MAFi) or at its upper and/or lower contacts, and occurs on the same horizon as an aphanitic rhyolite unit (RHYi). These relations are summarized based on Hangingwall Domain (HWD), Ore Domain (OD) and Footwall Domain (FWD) in Table 3.

Table 3: Generalized description for the HWD, OD and FWD

Zone	Domain	Rock Type	Geology Description
ABM	HWD	Rhyolite	Mostly coherent rhyolite schist (RHYc) comprising bands of qtz-ser and amorphous silica
	OD	Rhyolite	Pyrite-rich massive sulphide with lesser amounts of stringer/disseminated mineralization
	FWD	Mafic intrusive	Chlorite + calcite altered mafic intrusive
Krakatoa	HWD	Rhyolite or mafic intrusive	Coherent and volcaniclastic rhyolite; chlorite + calcite altered mafic intrusive
	OD	Massive sulphide	Pyrite-rich massive sulphide with lesser amounts of stringer/disseminated mineralization
	FWD	Rhyolite	Volcaniclastic rhyolite formed by quartz-sericite schist

3.3 Rock Strength

The rock strength was established through both commercial laboratory and field point load tests during the geotechnical core logging. The results of these tests are summarized in the following sections.

For the purpose of geomechanical analyses the rock strength are normally discussed based on HWD, OD and FWD. However, at Krakatoa, the ore zone could consist of two or more lenses and a rock type could be present in both HWD and FWD. Therefore, the results of laboratory and point load tests are initially discussed based on the rock types rather than domains and then, as required, grouped into Ore and Waste Domains.

3.3.1 Laboratory Test Results

A commercial laboratory test program was carried out on representative core samples of the Waste, Ore Stringer and OD. The results of the commercial laboratory test are included in Appendix II and a summary is provided in Table 4.

Table 4: Summary of laboratory test results

Domain	Rock Types	No of Test	Dry Density (Kg / m^3)			UCS (MPa)		
			Range	Mean	Std. Dev.	Range	Mean	Std. Dev.
Ore	OA, OB, OI	5	3197-4701	4249.6	482.3	35-138.4	99.35	28.6
Ore Stringer	OJ, OI (stinger)	14	2593-3262	2873.2	309.6	15.1-64.2	40.9	17.6
Waste	RHY_c	6	2642-2907	2774.8	84.9	5.1-51.8	25.2	17.7
	RHY	3	2645-2745	2731.7	81.9	32.1-94	56.1	27.1
	RHY_i	7	2600-2734	2643.9	49.0	51.6-147.4	104.6	34.7
	MAFi	8	2786-3103	2947.3	100.7	13.4-76.5	45.5	21.3
	RHY_v	7	2701-2776	2743.6	26.5	34.4-103.5	65.8	27.5

Also, a limited number of laboratory tests were carried out on Mudstone by BMC. The results are also included in Appendix II. The results on three tests had an average UCS of 29.8 MPa, however, further tests are required to establish a representative UCS value for Mudstone.

The grade and estimated range of UCS according to the International Society of Rock Mechanics, ISRM (1981) for various rock types are presented in Table 5.

Table 5: Field estimates of uniaxial compressive strength (ISRM, 1981)

Grade*	Term	Uniaxial Compressive Strength (MPa)	Point Load Index (MPa)	Field Estimate of Strength	Examples
R6	Extremely Strong	>250	> 10	Specimen can only be chipped with a geological hammer	Fresh basalt, chert, diabase, gneiss, granite, quartzite
R5	Very Strong	100 -250	4 – 10	Specimen requires many blows of a geological hammer to fracture it	Amphibolite, sandstone, basalt, gabbro, gneiss, granodiorite, peridotite, rhyolite, tuff
R4	Strong	50 – 100	2 – 4	Specimen requires more than one blow of geological hammer to fracture it	Limestone, marble, sandstone, schist
R3	Medium Strong	25 – 50	1 – 2	Cannot be scraped or peeled with a pocket knife, specimen can be fractured with a single blow from a geological hammer	Concrete, phyllite, schist, siltstone
R2	Weak	5 – 25	**	Can be peeled with a pocket knife with difficulty, shallow indentation made by firm blow with point of geological hammer	Chalk, claystone, potash, marl, siltstone, shale, rock salt
R1	Very Weak	1 – 5	**	Crumbles under firm blows with point of geological hammer, can be peeled with pocket knife	Highly weathered or altered rock, shale
R0	Extremely Weak	0.25 -1	**	Indented by thumbnail	Stiff fault gouge

*Grade according to Brown (1981).
**Point load tests on rocks with a uniaxial compressive strength below 25MPa are likely to yield highly ambiguous results.

Using the classification presented in Table 5, grade and terms of range and average UCS values are summarized in Table 6.

Table 6: Average UCS values, grades and terms for ore and waste domains

Domain	Rock Types	Average MPa	Grade and Term
Waste	RHY_c and MAF_i	25.2-45.5	R3 "Medium Strong"
	RHY and RHY_v	56.1-65.7	R4 "Strong"
	RHY_i	104.6	R5 "Very Strong"
Ore Stringer	OJ (Stringer), OI (Stringer)	40.9	R3 "Medium Strong"
Ore	OA, OB, OI	99.35	R4 "Strong"

Therefore, as shown in Table 6, RHY_i and Ore samples have the highest average UCS at Krakatoa and strongest rock types. The weakest rock types, as shown in Table 6, are RHY_c, MAF_i and Ore Stringer. It should be noted that the examination of RHY_c core samples indicated that low average values were associated with presence of weak features in the core samples.

The review of dry density measurements in Table 4 shows that ore has the highest average dry density (4.2 tonne/m^3) and the rest have a close average range of dry density (2.6-29 tonnes/m^3).

The Krakatoa's laboratory results provided UCS excluding Young's Modulus and Poisson's Ratio. In the next stage of assessment, a series of laboratory of tests should be carried out to establish Young's Modulus and Poisson's ratio for the main Krakatoa's rock types. This information will be required to characterise various domains, stability assessment and ground support recommendations.

3.3.2 Point Load Test

The Point Load Test (PLT) provides quantitative estimates of rock compressive strength through a simple field test. These tests are typically completed with a higher frequency than UCS test, as to allow closer tracking of compressive strength for mine design purposes. The following sections initially discuss the PLT results and then the correlation of results with UCS.

3.3.2.1 Krakatoa's Point Load Index

A PLT program was carried out during core logging using PIL-7 test machine. The tests were conducted according to International Society for Rock Mechanics (ISRM, 1985) procedures. Both axial (parallel to the long axis of the core) and diametral (perpendicular to the long axis of the core) loading tests were conducted. Axial point load test was performed as core samples suitable for testing in an axial orientation were obtained from coring or were produced by breaking long pieces of cores.

PLT was conducted on cores of several drill holes. These drill holes included K16-351, K16-353, K16-358, K16-360, K16-352, K16-367, K16-370, K16-357, K16-359, K16-363, K16-355, K16-354 and K16-356. Point Load Strength Index ($I_{s\,(50)}$) was calculated from the field PLT using the ISRM (1985) suggested method. A summary of PLT results for diametral and axial tests are presented in Tables 7 and 8.

Table 7: Summary of diametral Point Load Test results

Rock Type	No. of Valid Test	$I_{s(50)}$ (MPa)			
		Min	Max	Mean	Std. Dev.
Ore	25	1.06	6.03	3.68	1.27
Ore Stringer	5	1.57	3.51	2.52	0.17
RHY_c	19	1.09	5.17	2.28	0.90
RHY	4	1.22	2.49	1.70	0.67
RHY_i	41	1.02	8.56	3.17	1.47
MAF_i	74	1.08	6.45	2.76	1.18
RHY_v	78	1.01	4.17	1.82	0.68

Table 8: Summary of Axial Point Load Test results

Rock Type	No. of Valid Test	$I_{s(50)}$ (MPa)			
		Min	Max	Mean	Std. Dev.
Ore	12	1.73	8.53	4.61	2.20
Ore Stringer	6	1.92	4.47	3.06	0.87
RHY_c	19	1.56	9.11	2.87	0.99
RHY	9	1.05	6.48	2.89	1.99
RHY_i	17	1.38	11.02	6.15	2.98
MAFi	69	1.07	11.51	5.10	2.28
RHY_v	99	1.0	10.04	3.86	1.93

Using the ISRM (1985) recommended procedure, the average $I_{s\ (50)}$ was calculated and the corresponding "Grade and Terms" were assigned. The results are included in Table 9.

Table 9: Summary of Point Load test results

Rock Type	Average $I_{s(50)}$ (MPa)	Grade and Term for Point Load Test
Ore	4.14	R5 – Very Strong
Ore Stringer	2.79	R4 - Strong
RHY_c	2.57	R4- Strong
RHY	2.29	R4 - Strong
RHY_i	4.66	R5 – Very Strong
MAF_i	3.93	R4 - Strong
RHY_v	2.84	R4 - Strong

According to the PLT results, Ore and RHY_i are the strongest rocks at Krakatoa. Within the waste domain, RHY_i / MAF_i are the strongest rock followed by RHY_v / RHY_c / RHY with similar average $I_{s(50)}$

3.3.2.2 Correlation of UCS and Point Load Test Data

The use of $I_{s(50)}$ to estimate UCS requires the following conversion:

$UCS = CF \times I_{s(50)}$

CF = Correlation Factor

CF can be affected by characteristics such as rock type, alteration, and geologic structure. On average, UCS is 20-25 times point load strength, however, the ratio can vary between 15 and 50 especially for anisotropic rocks. This is particularly important for Krakatoa, as foliation and joints are present within the rock mass.

During the PFS, in addition to PLT tests, PLT was also performed adjacent to some of the UCS sample obtained for laboratory test. The reason for the paired PLT and UCS samples was for estimation of CF. The results of UCS test and PLT were compared in Table 10 to establish CF between these two sources of data.

Table 10: Krakatoa's UCS and PLT test results at equivalent depth

Rock Type	Drill Hole	Depth (m)	UCS (MPa)	$I_{s(50)}$ equivalent Depth (m)	$I_{(s)50}$ MPa		CF ($UCS/I_{s(50)}$)	
					Diam.	Ax	Diam.	Ax
RHYv	K16-353	50.12-50.46	68.1	n/a	n/a	n/a	n/a	n/a
	K16-353	50.12-50.46	40.5	n/a	n/a	n/a	n/a	n/a
	K16-357	48-48.25	62.7	45	n/a	0.39	n/a	n/a
				54	n/a	3.33	n/a	18.83
	K16-357	74.3-74.6	50.4	73.66	0.69	n/a	n/a	n/a
	K16-376	14.84-15.2	34.4	12.45	1.28	3.77	26.88	9.11
	K16-371	88.50-88.79 & 88.50-88.79	103.5 & 100.8	86.25-86.8	5.85	1.83	17.46	55.8
				87.6	2.98	10.25	34.28	9.97
				83.6	0.34	0.74	n/a	n/a
				84.33	3.77	8.23	27.1	12.41
MAFi	K16-353	27.13-27.33 & 33.0-33.27	54.0 & 51.5	27	n/a	0.77	n/a	n/a
				27	2.83	n/a	18.64	n/a
				24	4.20	n/a	12.56	n/a
				31.3	3.52	n/a	14.98	n/a
	K16-356	12.5-12.8	76.5	13.7	3.05	5.20	25.1	14.7
	K16-357	309-309.28	64.7	308.9	2.98	5.25	21.7	12.3
	K16-357	315.38-315.76	47.5	317.6	3.7	n/a	12.8	n/a
	K16-357	61.48-61.81	13.4	0.63	n/a	n/a	n/a	n/a
	K16-357	68.94-69.29	35.8	0.69	n/a	n/a	n/a	n/a
	K16-357	68.94-69.29	20.8	n/a	n/a	n/a	n/a	n/a
RHYi	K16-354	33.0-33.27	94.5	n/a	n/a	n/a	n/a	n/a
	K16-357	90.6-90.85	51.6	84.6	2.36	1.38	21.86	37.94
	K16-377	24.92-25.12	122.6	28.48	8.32	n/a	14.74	n/a
				30.57	6.14	7.87	19.97	15.58
	K16-371	58.95-59.22	67.6	58.72-58.75	5.42	7.53	12.47	8.98
	K16-371	59.91-60.13	123.4	60.13-60.15	4.69	5.73	26.31	21.53
	K16-371	66-66.35	125.1	66.7-66.68	3.25	10.16	38.49	12.3
	K16-371	66-66.35	147.4	67.9 - 69.69	5.96	6.71	24.73	21.96
RHY$_c$	K16-350	204-204.135	5.1	n/a	n/a	n/a	n/a	n/a
	K16-357	104.4-104.65	51.8	n/a	n/a	n/a	n/a	n/a
	K16-357	192.5-192.85	19.7	188.85	0.44	2.25	n/a	8.76
	K16-357	192.5-192.85	8.4	n/a	n/a	n/a	n/a	n/a
	K16-357	195.35-195.70	30.2	199.47	n/a	0.58	n/a	n/a
	K16-357	195.35-195.70	36.2	n/a	n/a	n/a	n/a	n/a
RHY	K16-358	64.15-64.46	32.1	64.7	2.42	n/a	13.3	n/a
	K16-358	64.15-64.46	42.1			n/a	17.4	n/a
	K16-353	82.08-82.31	94	82.75	2.72	n/a	34.6	n/a

n/a: not available

The results of $I_{s(50)}$ for diametral test are plotted vs UCS values of corresponding rock types in Figure 2.

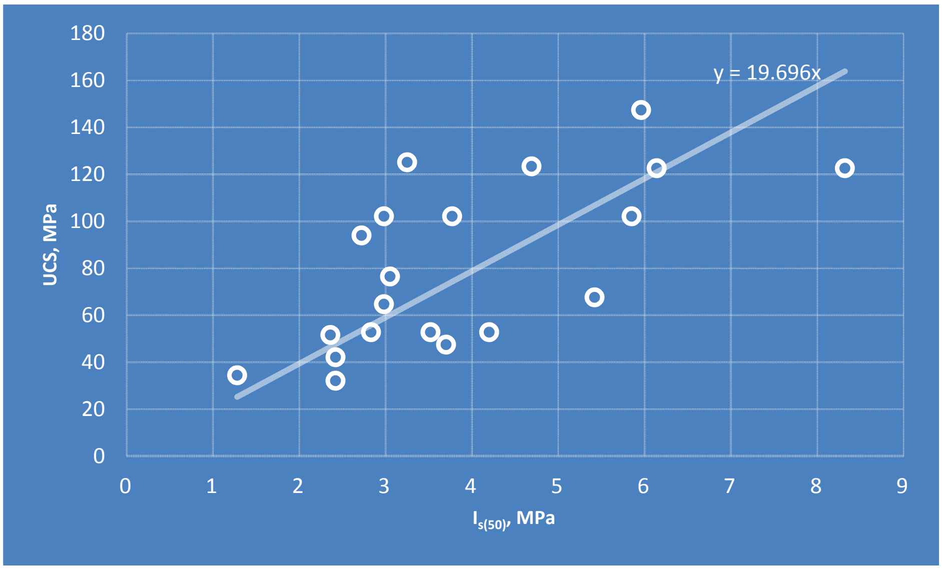

Figure 2: Correlation factor for diametral PLT vs UCS for all data

According to these results, CF of 20 is suggested for diametral tests. Similarly, CF was evaluated for axial tests. The examination of results, as shown in Table 10, indicated lower number of tests with scattered results. In the next stage of study, a minimum of two PLT (two valid axial and two diametral tests) should be conducted where UCS samples are collected.

Finally, the average UCS value of each rock type (Table 11) was compared with corresponding average $I_{s\ (50)}$ and the results are plotted in Figure 3.

Table 11: Summary of Point Load test results

Rock Type	Average $I_{s(50)}$	Grade and Term UCS Test	Average UCS	Grade and Term UCS Test
Ore	4.14	R5 Very Strong	99.35	R4 Strong
Ore Stringer	2.79	R4 Strong	40.9	R3 Medium Strong
RHY_c	2.57	R4 Strong	25.2	R3 Medium Strong
RHY	2.29	R4 Strong	56	R4 Strong
RHY_i	4.66	R5 Very Strong	104.6	R5 Very Strong
MAF_i	3.93	R4 Strong	45.5	R3 Medium Strong
RHY_v	2.84	R4 Strong	65.7	R4 Strong

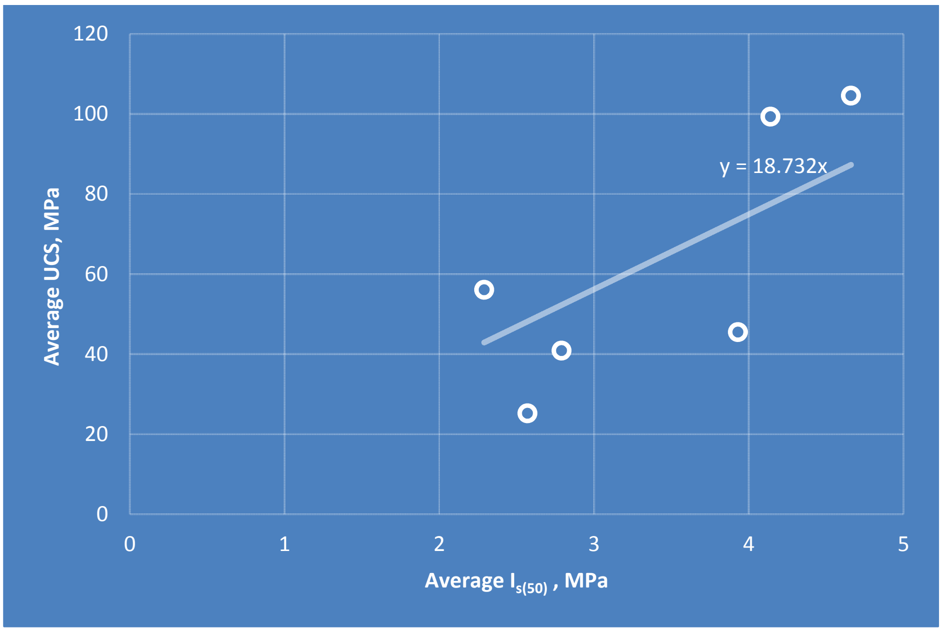

Figure 3: Correlation factor for Point Load Strength Index vs UCS for all data

As indicated previously, the examination of UCS results showed a low average value for RHY_c due to presence of weak planes / foliation. Eliminating this low value and also ore, the average UCS vs. $I_{s(50)}$ values are plotted in Figure 4.

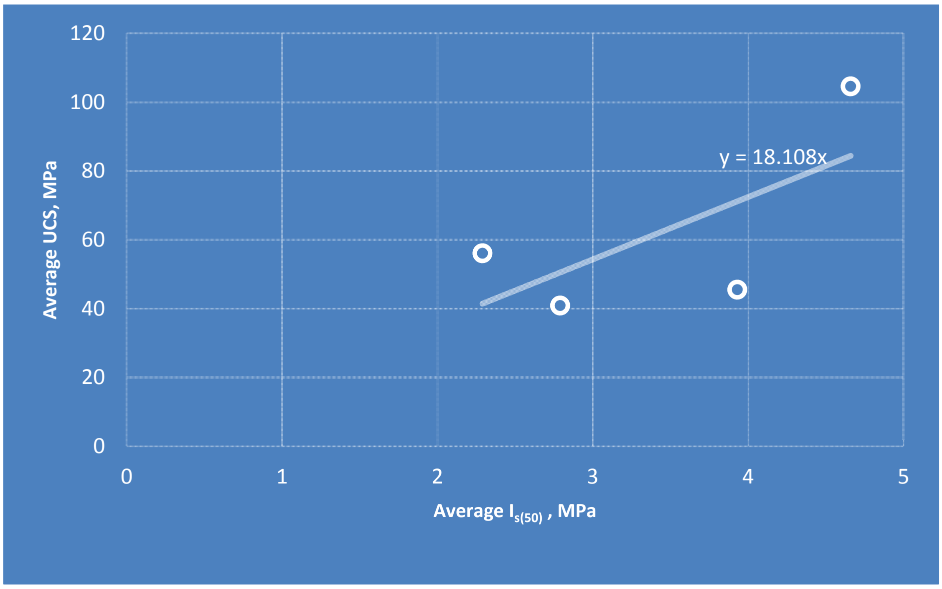

Figure 4: Correlation factor for Point Load Strength Index vs UCS (excluding Ore and RHY_c)

There are additional data including UCS tests that are required to support the relationship shown in Figure 4, however, this relationship suggests preliminary CF value of 18.

3.4 In-Situ Stress

The magnitude and orientation of in-situ stress, influences ground behavior. Based on available information, there has been no in-situ stress measurement conducted at Krakatoa or vicinity. Therefore, an estimate of in-situ stress based upon previous experiences and published data was made.

Typically, vertical stress may be equated, approximately to the overburden load (Hoek and Brown, 1980), while horizontal stresses have been found to range from about half of the overburden load to more than three times the overburden load, depending upon depth, topography and tectonic history. These can be expressed as:

$$\sigma_3 = \Upsilon * z$$

$$\sigma_h = k\,\sigma_V$$

Where: σ_3 = Vertical Stress, MPa

σ_1 and σ_2 = Horizontal stress, MPa

Υ = unit weight of the rock, MPa/m

z = the depth at which the stress is required, m

k = ratio of the average horizontal stress to the vertical stress

Assuming an average unit weight of 0.027 MPa/m, the far field vertical stress could be calculated for any depth. For the purpose of underground mining at Krakatoa, the major (σ_1) and intermediate (σ_2) stresses are assumed to be 2.5 and 1.5 times the vertical stress respectively (Martin et. al, 2003). Assuming 300 m as the deepest elevation for underground mining, this will result in far field major and intermediate stress values of 20.25 MPa and 12.15 MPa respectively. The major principal stress direction, using the regional stress direction, is approximately northeast / southwest direction and the minor principal stress is vertical.

3.5 Rock Mass Quality

The rock quality is required to evaluate the mining method, specify stope dimension and recommend ground support system. The methodology employed for the rock quality determination was based on establishing empirical analyses and geotechnical domains. The rock quality was established based on two rock mass classification system. Following a brief description of the rock mass classification systems, the Krakatoa's rock mass quality is discussed in the following sections.

3.5.1 Rock Mass Classification System

Two rock mass classification systems should ideally be implemented in any rock quality determination exercise. Two widely used rock mass classifications are Bieniawski's RMR (1976) and the rock tunnelling index, Q, of Barton et al, (1974). A detailed description of these classification systems are given in the standard rock mechanics books and only a brief description is provided in this report. For the geomechanical investigation, both RMR_{76} and Q classification systems were used.

The Rock Mass Rating, RMR, also known as the Geomechanics Classification, was developed by Bieniawski in 1972-1973 and subsequently modified as more case histories became available and to conform with international standard and procedures. The system has gained wide acceptance in the design of tunnels, chambers, mines, slopes and foundations. The following six parameters are used in the RMR system:

Table 12: Rock mass parameters

Factors	Factors	Range
uniaxial compressive strength of intact rock	A1	0-15
Rock quality designation, RQD	A2	3-20
spacing of discontinuities	A3	5-30
Condition of discontinuities	A4	0-25
Ground water conditions	A5	0-10

A rating guide for various parameters to calculate RMR is provided in Appendix III. Further descriptions of each parameter are available in the standard rock engineering books. A numerical value is selected for each parameter, and the sum of the ratings, yields the Rock Mass Rating, RMR:

$$RMR = A1 + A2 + A3 + A4 + A5$$

Based on this relationship, Bieniawski proposed the following rock mass classifications:

Table 13: Classification of Rock Mass Rating.

Rock Mass Class	Description	RMR
I	Very Good Rock	81 – 100
II	Good Rock	61 – 80
III	Fair rock	41 – 60
IV	Poor Rock	21 – 40
V	Very Poor Rock	0 –21

On the basis of an evaluation of a large number of case histories of underground excavations, Barton et al. (1974) proposed a Tunnelling Quality Index (Q) for the determination of rock mass characteristics and tunnel support requirement. The Q index is established through the following relations:

$$Q = (RQD/J_n) \times (J_r/J_a) \times (J_w/SRF)$$

Where RQD = rock quality designation

J_n = joint set number

J_r = joint roughness number

J_a = joint alteration number

J_w = joint water reduction factor

SRF =stress reduction factor

A rating guide for various parameters to calculate Q is provided in Appendix III. The parameters RQD, J_n, J_r and J_a are normally measured during geotechnical core logging or underground geotechnical mapping. J_w is estimated from previous site experience and drilling reports of water levels. SRF is determined by empirical methods, which relate the estimated in situ stress and rock strength.

The rock mass rating based on the Q classification is shown in Table 14.

Table 14: Rock mass description based upon the Tunnelling Quality Index

Tunnelling Quality Index, Q	Rock Mass Description
0.001 – 0.01	Exceptionally Poor
0.01 – 0.1	Extremely Poor
0.1 – 1	Very Poor
1 – 4	Poor
4 – 10	Fair
10 – 40	Good
40 – 100	Very Good
100 – 400	Extremely Good
400 – 1000	Exceptionally Good

3.5.2 Krakatoa's Rock Mass Quality

A field data collection program was implemented in 2016 to collect information for geomechanical assessment. No dedicated underground drilling was carried for this PFS study and geotechnical data collection was conducted based on available exploration holes. The locations of these drill holes are illustrated in Figure 5 and their details are provided in Table 15.

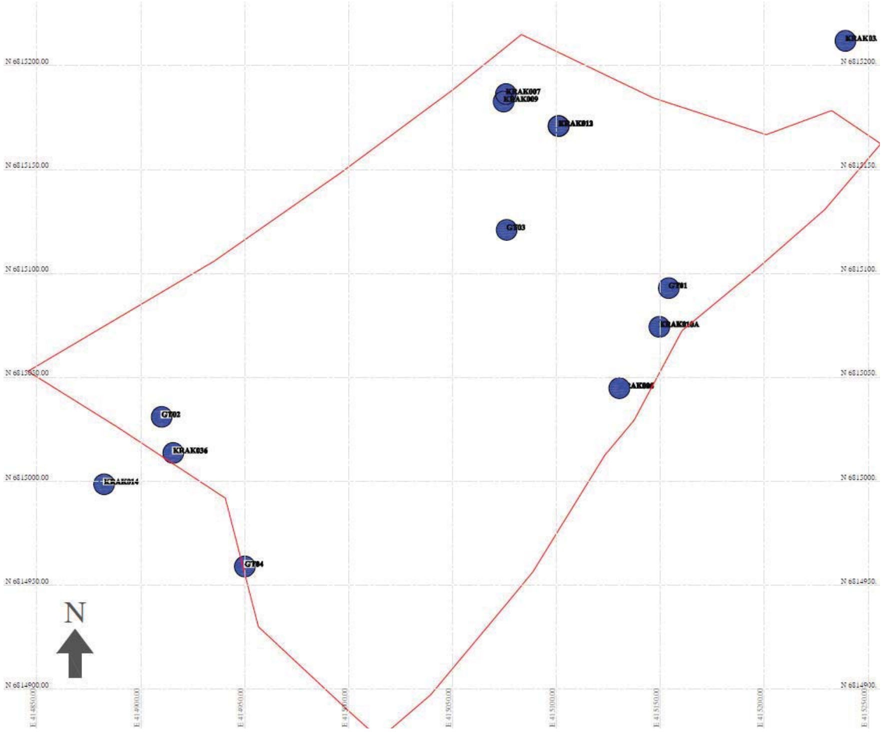

Figure 5: Location of drill holes on the Krakatoa main lens

Table 15: Geotechnical drill holes used for underground geotechnical design assessments and ground support recommendations

Hole ID	Prop _ID	Easting	Northing	Elevation	Azimuth (^{0})	Dip (^{0})	Length (m)	Core Size
K16-351	KRAK025	415130.2	6815044.8	1399.4	214.0	-59.0	200.0	NQ3
K16-353	KRAK014	414882.3	6814998.6	1390.4	210.0	-77.0	160.0	HQ3
K16-358	KRAK012	415101.0	6815171.0	1396.0	73.0	-86.0	325.0	HQ3
K16-360	KRAK013	415101.0	6815171.0	1396.0	20.0	-77.0	325.0	HQ3
K16-352	KRAK006	415130.2	6815044.8	1399.4	224.0	-83.0	200.0	HQ3
K16-367	KRAK007	415075.7	6815186.4	1388.5	215.0	-65.0	275.0	HQ3
K16-370	KRAK009	415074.6	6815182.8	1388.0	215.0	-80.0	275.0	HQ3
K16-357	KRAK019A	415207.0	6815283.0	1425.0	211.0	-72.0	350.4	HQ3
K16-359	KRAK030	415207.0	6815283.0	1425.0	180.0	-73.0	380.0	HQ3
K16-363	KRAK033	415239.0	6815212.0	1440.0	16.5	-78.5	415.0	HQ3
K16-355	KRAK010A	415149.5	6815074.3	1407.2	36	-80.0	300.0	HQ3
K16-354	KRAK010	415149.5	6815074.3	1407.2	38.0	-80.0	300.0	HQ3
K16-356	KRAK019	415207.0	6815283.0	1425.0	211.0	-72.0	350.4	HQ3

The information collected during the field data program is included in Appendix IV. The objective was to gather essential data to establish rock quality based on the RMR_{76} and Q rock mass classification systems. As shown in Figure 5, the majority of these holes, which were drilled to extend the resources, are located around the periphery of the main lens. In the next stage of assessment, a dedicated geotechnical drilling program should be carried out to obtain representative geotechnical information across the main lens and where other important infrastructures such as ramp which will be located underground.

Detailed geotechnical data collection including joint mapping was carried out on two underground drill holes of K16-367 and K16-370. Though good orientation data was collected from holes drilled for pit wall design purposes, orientation data from these underground holes were inconsistent. Even in the good rock quality that can be pieced together for successive runs, the orientations did not line up. In addition, only every 2 or 3rd run are oriented which means that oriented data could not be established in poor rock quality zones. These holes were drilled prior to our arrival to the project site. It was evident that either the drillers did not have sufficient experience or proper orientation procedure was not implemented. In the next stage of assessment, during the geotechnical drilling of the main lens, the structural data should also be collected.

As stated in Section 3.4, no stress measurement has been carried out at Krakatoa site or vicinity. According to the current mining plan, the deepest stopes are located at approximately 300 m below the surface and low stress / favourable stress condition is expected.

No hydrological study has been conducted for underground Krakatoa. This PFS assumes that underground Krakatoa will use systems of sumps and pumps to collect water and transfer to the surface. Further, the geomechanical assessment assumed little water inflow or dry condition underground. In the next stage of assessment, a hydrogeological study should be carried out to provide information on water inflow as mining progresses at Krakatoa. Therefore, the analyses in this report should be reviewed and adjusted as information on the ground water inflow becomes available.

The rock mass ratings (RMR_{76}) along with the Modified Rock Quality Index (Q') for drill holes are presented in Table 16. The rock quality was established based on domains; Immediate HWD, OD, Immediate FWD and FWD. The main objectives were to establish ranges of rock mass quality for these domains for the purpose of stability assessment and ground support recommendations.

For the purpose of this PFS, two rock strength values, the results of commercial laboratory and field test ($I_{s(50)}$) results, were examined for the rock quality determination. The results are included in Tables 16 and 17.

Table 16: Rock Quality of Various Domains Based on RMR_{76} and Q' (Using UCS Laboratory Results)

Drill Hole	RMR 76				Q'			
	Immediate HWD	OD	Immediate FWD	FWD	Immediate HWD	OD	Immediate FWD	FWD
K16-351	44	57	47	18	6	14.5	7.5	0.07
K16-353	42	49	47	52	0.05	23	7	34
K16-358	32	66	71	56	0.5	7.7	6.3	2.2
	62	79	47		3.7	31	2.6	
K16-360	32	69	47	47	0.8	12	5.1	5.3
K16-352	38	51	27	18	1.9	7.3	1.5	0.07
	35	47	40		0.23	2	2.3	
K16-367	63	65	47	52	10.13	22.3	0.47	2.9
	47	57	47		0.47	6.17	7.4	
K16-370	47	73	47	52	6.8	75	14.2	2.8
	47	51	67		15.5	1.6	35.6	
K16-357	44	57	44	44	7	19.3	2.3	3.7
	31	65	49		0.07	5.3	1.2	
K16-359	31	65	41	36	0.6	2.7	3.25	0.8
	18	51	47		0.05	1	7.3	
	61	65	41		32	48	5.7	
K16-363	36	70	31	47	0.07	7.7	0.09	1.67
	26	74	56		0.07	42	7.8	
K16-355	NA	NA	NA	18	NA	NA	NA	0.07
	NA	NA	NA	28	NA	NA	NA	0.2

Table 17: Rock Quality of Various Domains Based on RMR_{76} and Q' (Using average $I_{s(50)}$ values)

Drill Hole	RMR_{76}				Q'			
	Immediate HWD	OD	Immediate FWD	FWD	Immediate HWD	OD	Immediate FWD	FWD
K16-351	47	60	47	18	6	14.5	7.5	0.07
K16-353	42	52	47	52	0.05	23	7	34
K16-358	35	69	74	56	0.5	7.7	6.3	2.2
	65	79	50		3.7	31	2.6	
K16-360	35	69	50	50	0.8	12	5.1	5.3
K16-352	41	51	30	18	1.9	7.3	1.5	0.07
	35	47	40		0.23	2	2.3	
K16-367	66	65	47	52	10.13	22.3	0.47	2.9
	47	52	50		0.47	6.17	7.4	
K16-370	50	73	50	52	6.8	75	14.2	2.8
	50	51	70		15.5	1.6	35.6	
K16-357	47	57	47	44	7	19.3	2.3	
	31	65	52		0.07	5.3	1.2	3.7
K16-359	31	65	41	36	0.6	2.7	3.25	0.8
	18	51	50		0.05	1	7.3	
	64	65	41		32	48	5.7	
K16-363	36	70	31	47	0.07	7.7	0.09	1.67
	26	74	56		0.07	42	7.8	
K16-355	NA	NA	NA	18	NA	NA	NA	0.07
	NA	NA	NA	28	NA	NA	NA	0.2

A wide range of rock quality present within various domains and the representative ranges were selected and summarized in Table 18.

Table 18: Representative Ranges of Rock Quality of Various Domains

UCS	Drill Hole	RMR_{76}				Q'			
		Immediate HWD	OD	Immediate FWD	FWD	Immediate HWD	OD	Immediate FWD	FWD
Laboratory UCS values	All Drill Holes	26 - 62	49 - 74	31 - 67	18 - 52	0.05 – 15.5	1.6 - 48	0.47 - 14.2	0.07 - 5.3
	Range of Rock Quality	Poor - Good	Fair-Good	Poor-Good	Very Poor - Fair	Extremely Poor- Good	Poor-Very Good	Very Poor-Good	Extremely Poor- Fair
Average $I_{s(50)}$	All Drill Holes	26-65	51-74	31-70	18-52	0.05 – 15.5	1.6 - 48	0.47 - 14.2	0.07 - 5.3
	Range of Rock Quality	Poor - Good	Fair-Good	Poor-Good	Very Poor - Fair	Extremely Poor- Good	Poor-Very Good	Very Poor-Good	Extremely Poor- Fair

The comparison of these results indicates a similar range. Therefore, according to available information and analyses carried out, the rock mass quality ranges from “Very Poor to Good” and “Extremely Poor to Good” based on RMR_{76} and Q rock mass classifications respectively. Further, the OD has a higher rock quality compared to other domains. Also, according to the Q’ results, immediate HWD is poorer in rock quality than immediate FWD. In the FWD, rock quality ranges from “Poor to Fair” and “Extremely Poor to Fair” based on RMR_{76} and Q classifications respectively. It should be mentioned that localized zones of higher and lower rock qualities should also be expected.

4.0 EVALUATION OF MINING METHOD

The Cut and Fill mining method has been proposed for Krakatoa. Following a brief description of the method, the geomechanical aspects of the proposed method are evaluated in the following section.

4.1 Cut and Fill Mining Method

Cut and Fill mining method uses a central access drive with perpendicular ore drives coming off the access (Entech, 2016). Profiles of these drives are square drives with a width of 5.0 m and a height of 5.0 m. Shanty back drives are used in the hangingwall of the deposit to reduce dilution from development activities. Panels were designed to be a maximum of 5 lifts, benched downwards for two lifts and upwards for two lifts, for a total mined panel height of 25 m. The extraction sequence for the proposed method is illustrated below in Figure 6.

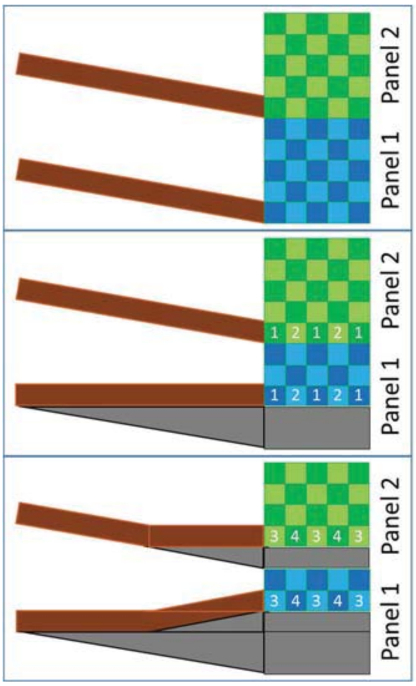

Figure 6: Cut and Fill Mining method and sequence of mining

At the completion of the first lift, fill with a higher cement content is planned to allow full drive exposure from underneath. The main deposit at Krakatoa is aimed to be fully extracted, using primary and secondary drifting to maximise productivity. As shown in Figure 6, the blue and green coloured checkerboards represent different drifts that can be mined simultaneously, with each level within each panel, being mined sequentially bottom up. The high strength cemented pillar will allow mining in each panel to occur concurrently, increasing the productivity of the method.

The geomechanical aspects of the proposed Cut and Fill mining method were evaluated. The stability of unsupported span was investigated using critical span curve for man-entry excavation (Ouchi, 2004). The representative ranges of rock quality for HWD and OD has been established in Section 3.5.2. These ranges are plotted in Figure 7.

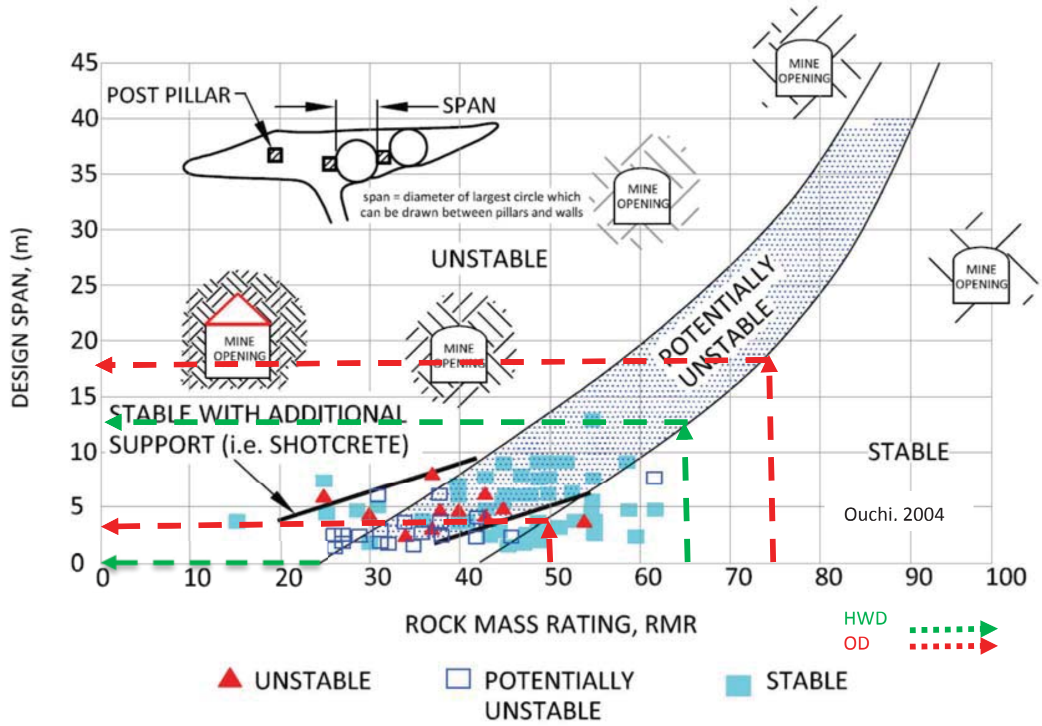

Figure 7: Critical span curve for man-entry excavation

The stable span ranges from 0 (immediate collapse) – 12 m and 3 m – 17 m for HWD and OD respectively. It should also be mentioned that these ranges are valid where domains are defined without structural features such as faults, damage zone, microdefect zone and shears. However, as observed during core logging, structural features are present within various domains. Therefore, pattern bolting is required to ensure stability for OD and HWD. The required ground support for each geotechnical domains is discussed in Section 5.

According to description of the mining plan, at the completion of the first lift, backfill with a higher cement content is planned to allow full drive exposure from underneath. In other words, the high cemented backfill should be stable while mining progresses below and above the first lift. In the next stage of assessment, the stability of this lift and in particular the required cement content or other type of reinforcement should be investigated.

Further, the mining method requires primary and secondary drifting to maximise productivity. This is an entry type of mining method and therefore pillars (while the primary drifting in progress) and backfill (while the secondary drifting is in progress) should be stable. In the next stage of assessment, once representative rock quality data becomes available, an investigation should be carried out to ensure stability during the primary and secondary drifting.

5.0 GROUND SUPPORT

Several design approaches are available for recommendation of ground support including "permanent or temporary", "active or passive" and "primary and secondary". In the absence of detailed geomechanical information at Krakatoa, the ground support requirements are recommended based on their required service life:

i. Permanent headings: This refers to excavations with the service life of greater than 6 months
ii. Temporary headings: This refers to excavations with service life of less than 6 months

The ground support of headings was determined by two empirical designs and subsequently compared with a rock mass classification system.

The bolt length and spacing are the function of a number of parameters including rock quality, presence of shears / faults, joint spacing, state of stress, etc. In moderately jointed rock, an empirical equation, developed by Schach et al (1979), could be employed for determination of length and spacing of bolt of an excavation:

$$L = 1.4 + 0.184\ W$$

$$L / S = 2$$

Where, L = length of bolt (m),

W = excavation width (m)

S = bolt spacing (m)

This equation was developed based on the stress arch concept and mainly used in hard rock mining. Using the empirical relation, the suggested bolt length and spacing for a 5 m span are given in Table 19.

Table 19: Bolt length and spacing for permanent headings

Span or Height m	Length m	Spacing m
5	2.4	1.2

The second empirical relation, shown in Figure 8, has been developed by U. S. Army Corps of Engineers (1980) for blocky and fractured ground. The minimum bolt spacing should be 0.5 times the bolt length. The required length of ground support for 5 m span is plotted in Figure 8.

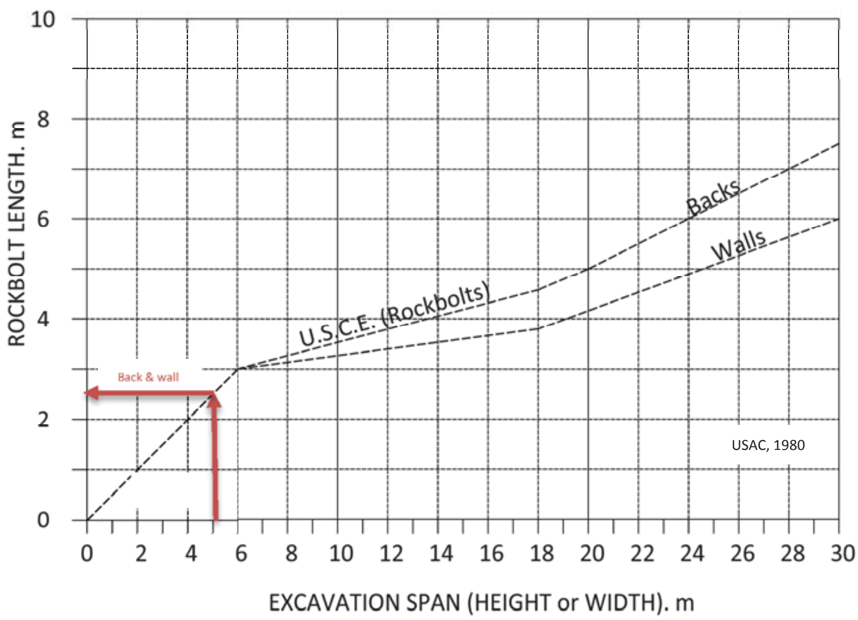

Figure 8: Rockbolt Length

Therefore, based on both empirical methods, bolt lengths should be 2.4 m (8’) long with bolt spacing of 1.2 m for back and walls.

These length and spacing were compared with recommended bolt and spacing based on the Q rock mass classification system. Barton (1980) recommended the length of bolt based on the following equation

$L = 2 + (0.15\ W/ESR)$

Where, L = length of bolt (in m),

W = excavation width (in m),

ESR = excavation support ratio which relate the intended use of the excavation and degree of safety / security

Using ESR=1.6 for permanent headings, the bolt length of 2.5 m is recommended for the back and wall respectively. The bolt spacing should be established based on the Q support guidelines as discussed below.

Barton (1974) has developed a relationship between rock mass quality, opening size and support requirements. This relationship is used as the basis for assessing the support needs in different mine openings. Inputs include a range of opening dimensions; and the predicted effects of mining induced-stress. Support recommendations based on the Q-system have evolved over the years as more and more case histories have been added to the database. Grimstad and Barton (1993) proposed a summary graph, presented in Figure 9, based on these recommendations.

Assuming Equivalent Support Ratios (ESR) of 3 and 1.6 for temporary and permanent headings respectively, the typical ranges of Q' values for 5 m span excavation are plotted in Figure 9.

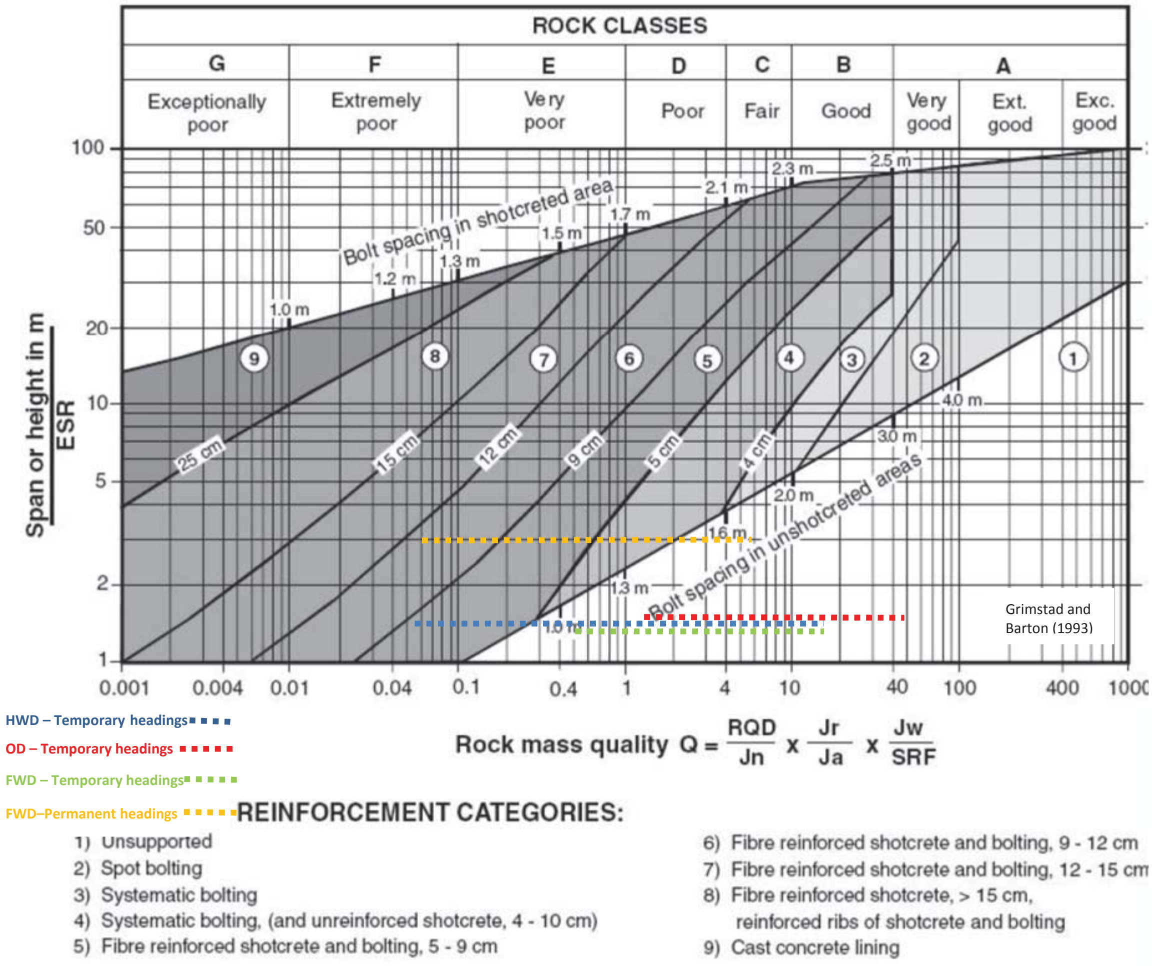

Figure 9: Ground Support Requirements for the Permanent and Temporary Headings

Using the above ground support guidelines and empirical rules, the following length and spacing of ground support, as shown in Table 20, are recommended for permanent and temporary headings at Krakatoa.

Table 20: Preliminary Ground Support Recommendations for 5 m Span and 5 m Height

Type of Excavation	Domain	Bolt (a, b ,c , d)				Shotcrete
		Location	Type	Length m (ft.)	Pattern m x m (ft. x ft.)	Thickness cm (in)
Permanent headings (life of the mine, Ramp and Permanent Accesses)	FWD	Back	Resin Rebar	2.4(8’)	1.2x 1.2 (4’x4’)	
		Walls		2.4 (8’)	1.5x1.5 (5’x5’)	
	FWD with Very weak rock quality (e.g. faults, damaged and microdefect zones)	Back and Walls	Swellex bolt or similar	2.4 (8’)	1.0x1.0 (3’x3’)	7.5cm (3”)
Temporary headings (Production Stopes, Sill Drifts and Haulages)	Immediate HWD	Back	Resin Rebar	2.4 (8’)	1.2x1.2 (4’x4’)	
		Walls	Split Sets	2.4 (8’)	1.5x1.5 (5’x5’)	
	Immediate HWD with very weak rock quality (e.g. faults, damaged and microdefect zones)	Back and Walls	Swellex bolt or similar	2.4 (8’)	1x1 (3’x3’)	7.5 (3”)
	OD	Back	Resin Rebar	2.4 (8’)	1.5x1.5 (5’x5’)	
		Walls	Split Set	2.4 (8’)	1.5x1.5 (5’x5’)	
	Immediate FWD	Back	Resin Rebar	2.4(8’)	1.2x1.2 (4’x4’)	
		Walls	Split Sets	2.4 (8’)	1.5x1.5 (5’x5’)	

(a) Use Resin Rebar #7 (22 mm) for permanent and temporary excavations.
(b) Use Split Set 39 mm for temporary excavations
(c) All walls and back: Use Welded Wire Mesh or equivalent for permanent and temporary excavations respectively. Install to 1.5m (5’) and down to the sill for permanent and temporary excavation respectively. Use 1 m (3’) Split Sets to secure Welded Wire Mesh.
(d) For very weak domain such as fault / damage zones and broken zones, apply shotcrete and implement tighter bolting pattern. Spot bolt visible wedges and slabs as required.

The recommended ground support assumes non-acid generating environment underground with generally dry condition. Additional ground support should be installed at intersections and, where possible, four-way intersections should be avoided / minimized. The ground support for intersections is included in Table 21.

Table 21: Ground support standard for intersections

Type of Excavation	Maximum Span or Height m (a)	Secondary Support (b) (c) (d)	
		Length m	Pattern m x m (ft. x ft.)
All Intersections (Permanent and Temporary)	up to 7	3.7 (12’)	1.8 x 1.8 (6’x6’)
	up to 10	6	1.8x1.8 (6’ x 6’)

(a) Span measured as inscribed circle
(b) Secondary support installed in addition to minimum support recommended for the permanent headings
(c) Use Super Swellex or Omega Bolts or Dywidag #7 (fully grouted) or equivalent
(d) Extended one span diameter beyond intersections in all directions

Where extremely poor rock, such as fault zone or associated damaged zone, is encountered, the ground support should be adjusted. In poorer rock quality, such as fault and broken zones, shotcrete and tighter bolting pattern should be implemented.

Any empirical rules, however, give only a preliminary configuration of rock reinforcement, which must be checked, analyzed and, as necessary, modified to meet the requirements of a specific ground support recommendations. Similarly, the ground support recommendation in this report should further be updated with representative data as project progresses to the next stage of study. Further, an instrumentation and monitoring program, as described in Section 7, should be planned to optimize the recommended ground support system.

6.0 CROWN PILLAR DESIGN

Several mechanisms have been observed in failure of surface crown pillars. These include “Plug Failures”, “Chimneying, Caving”, “Unravelling” and “Delamination” Failures. It is also likely that more than one failure mechanism may operate in any given failure.

As a result, several methods have been developed to evaluate stability of crown pillars and recommend crown pillar dimensions. These methods use different parameters including rock quality, state of stress, excavation geometry, etc. Each parameter has a different influence on the stability and, in most cases, due to its complexity, no single method is available for the stability assessment and crown pillar determination. Ideally, empirical, analytical and numerical techniques should be used for the stability assessment.

In general, for surface crown pillar design, two methods of Empirical Assessment and Limit Equilibrium analysis are required. However, irrespective of whichever methodology is chosen as appropriate, some key information is always required on geometry and rock quality of the crown pillar. Where such details on crown pillar are unavailable, the empirical assessment is used to provide the "*first pass*" design approach. Once the information on geometry and rock quality becomes available, other methods of assessments are essential.

Similarly, this approach was adopted for Krakatoa's crown pillar design. The following section provides the design based on an empirical method and as further information becomes available more detailed analyses involving numerical modelling and risk assessment are required in the next stage of assessment.

6.1 Empirical Methodology - Scaled Crown Span Method

The Scaled Crown Span method (Carter, 2014) is an empirical method for the assessment of the surface crown pillar. It is based on an assessment of numerous crown pillar case studies and designed to evaluate the stability of a given crown pillar. The technique involves the stability assessment of the Scaled Crown Span (C_S) as the function of the rock mass quality. This relation is illustrated in Figure 10.

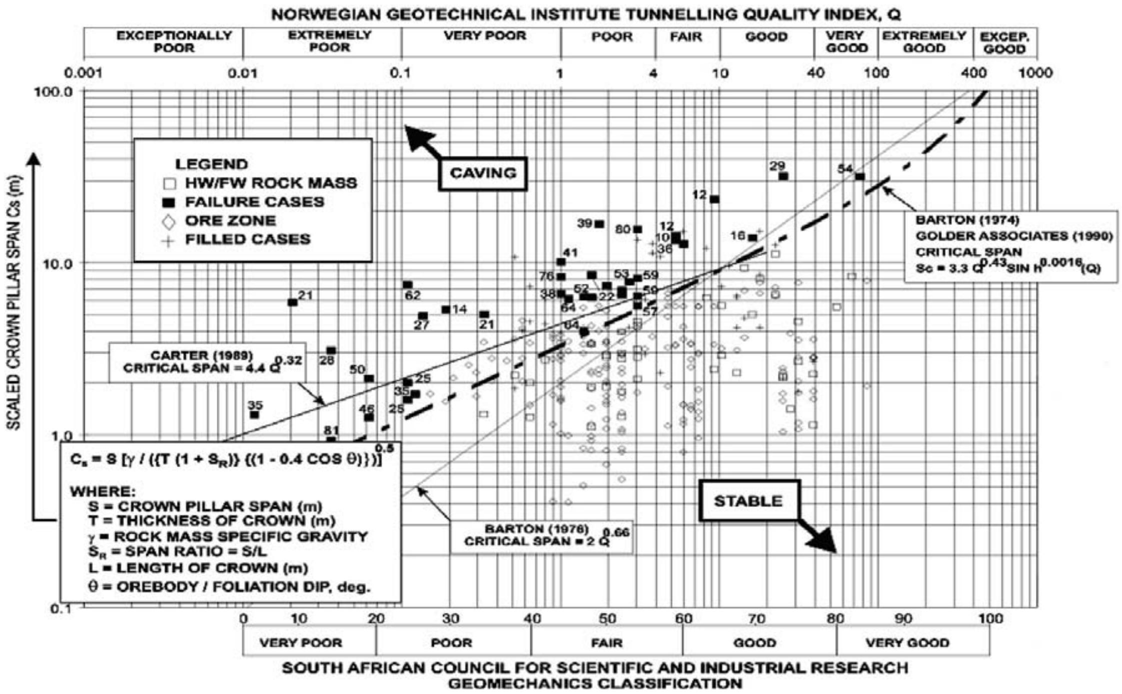

Figure 10: The original Scaled Crown Span Chart, showing stable and failed case records plotted as Scaled Crown Spans versus Rock Quality

The Scaled Crown Span is calculated based on the following formula.

$C_S = S\,[\gamma / (T\,\{1+S_R\}\{1-0.4\cos\theta\})]^{0.5}$

Where:

- S= crown pillar span, (m);
- γ= specific gravity of the rock mass;
- T= thickness of crown pillar, (m);
- θ= orebody/foliation dip, and;
- S_R= span ratio
  - = S/L (crown pillar span/crown pillar strike length).

This approach provides a basic means of crown pillar stability assessment by allowing the scaling of crown geometries for different rock mass conditions. Further, because it is based on a fairly extensive database of crown pillar case records, it does provide a ready base for sensitivity evaluation when used in conjunction with more sophisticated techniques of numerical analysis.

In Figure 10, each of the individual failure cases have been plotted as best as possible with respect to what could logically be defined as the "controlling rock quality" reflecting the condition thought most likely characterized the failure case behavior. For cases where dislocation occurred on a footwall or hangingwall contact, the contact rock quality was taken as representative. For crown which raveled due to a weak ore zone rock mass, the ore quality was assumed as representative. Similarly for stable cases, the geometry and the most likely failure mechanism were both assessed and then the most likely and representative (i.e. "controlling rock quality") Q value was signed. Therefore, in use of the Scaled Crown Span method, it is essential to identify and characterize the "controlling rock quality" to evaluate the crown pillar.

6.2 Krakatoa's Crown Pillar Dimension

In design of any crown pillar, the "Acceptable Risk Exposure" or "Expectancy" should initially be established. The guideline for risk exposure and probability of failure for crown pillar design are provided in Table 22 and Figure 11. Once the risk exposure is established for a crown pillar, the maximum Scaled Crown Span value could be determined based on the rock quality data. Then, it possible to examine the crown pillar thickness based on Scaled Crown Span formula.

In the absence of detailed information at Krakatoa, several assumptions were made for determination of the crown pillar thickness. As concluded in Section 5.3.2, the ore domain has a higher rock quality compared to other domains. Also, these results indicated that immediate HWD is poorer in rock quality than immediate FWD. Therefore, HWD is expected to be the "controlling rock quality" of the crown pillar areas. The average value of rock quality for HWD was assumed for the crown pillar area.

At Krakatoa, the service life of the pillar was assumed to be "Short Term; 5-10 years" and Maximum Scaled Crown Span was calculated and also plotted in Figure 11. According to the final pit wire frame, the final bench is approximately 22 m wide and 50 m long (Hansen, 2016). Using this information, the crown pillar thickness was calculated for orebody dip of 35^0. The results are provided in Table 23.

Table 22: Acceptable risk exposure guidelines – Comparative significance of crown pillar failure

Class	Probability of Failure %	Minimum Factor of Safety	Maximum Scaled Span, Cs (= Sc)	ESR (Barton et al. 1974)	Design Guidelines for Pillar Acceptability/Serviceable Life of Crown Pillar				
					Expectancy	Years	Public Access	Regulatory position on closure	Operating Surveillance Required
A	50 – 100	<1	$11.31Q^{0.44}$	>5	Effectively zero	< 0.5	Forbidden	Totally unacceptable	Ineffective
B	20 – 50	1.0	$3.58Q^{0.44}$	3	Very, very short-term (temporary mining purposes only ; unacceptable risk of failure for temporary civil tunnel portals	1.0	Forcibly Prevented	Not acceptable	Continuous sophisticated monitoring
C	10 – 20	1.2	$2.74Q^{0.44}$	1.6	Very short-term (quasi-temporary stope crowns ; undesirable risk of failure for temporary civil works)	2 – 5	Actively prevented	High level of concern	Continuous monitoring with instruments
D	5 – 10	1.5	$2.33Q^{0.44}$	1.4	Short-term (semi-temporary crowns, e.g.under non-sensitive mine infrastructure)	5 – 10	Prevented	Moderate level of concern	Continuous simple monitoring
E	1.5 – 5	1.8	$1.84Q^{0.44}$	1.3	Medium-term (semi-permanent crowns, possibly under structures)	15–20	Discouraged	Low to moderate level of concern	Conscious superficial monitoring
F	0.5 – 1.5	2	$1.12Q^{0.44}$	1	Long-term (quasi-permanent crowns, civil portals, near-surface sewer tunnels)	50–100	Allowed	Of limited concern	Incidental superficial monitoring
G	<0.5	>>2	$0.69\ Q^{0.44}$	0.8	Very long-term (permanent crowns over civil tunnels)	>100	Free	Of no concern	None required

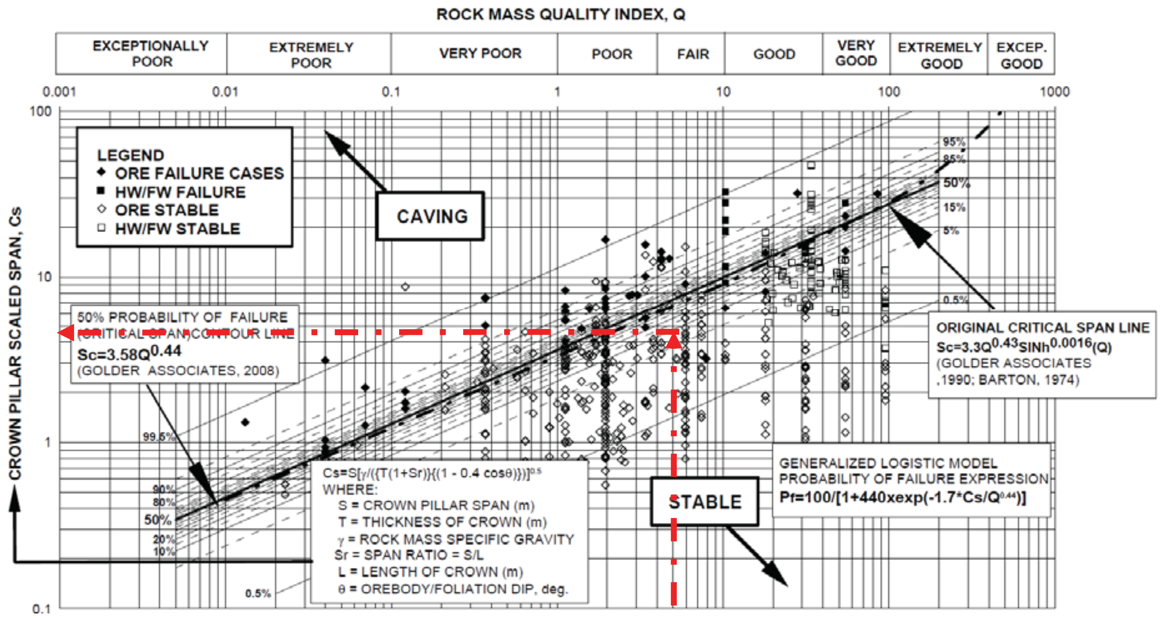

Figure 11: Updated Scaled Crown Span Chart with probability of failure contour intervals

Table 23: Variations of crown pillar thickness with orebody dip

Average rock quality (Q)	Orebody dip (⁰)	Scaled Crown Span (C_s)	Specific Gravity (γ)	Span (m)	Crown Pillar Strike Length	Thickness (T) (m)
4.5	35	4.63	2.7	22	50	63

Therefore, a crown pillar thickness of 63 m is recommended for this PFS. It should be noted that crown pillar calculation assumes that no faults and damage zone are present in the area. Further, the crown pillar calculation assumes that mining activity will occur below the crown pillar and no underground mining or excavations will take place around the crown pillar.

6.3 Discussion

The original Scaled Crown Span method has been adopted in this PFS for the Krakatoa crown pillar evaluation. However, this method has been mainly derived from steeply dipping case studies (i.e. with excavation / foliation dips, $\theta > 40^0$). This may not be representative of orebody at Krakatoa's crown pillar area. Where the ore body dip ranges between 40^0 -50^0, the competency of the rock mass, comprising the ore zone and hangingwall, becomes the controlling factor. If the ore zone is weaker than host rock mass, then stability seems to always be controlled by crown failure through ravelling of the ore or by shear on the ore contact margins, as such in defining the controlling span, use should be made of the original uncorrected true stope span. If, however, hangingwall rock mass quality is adverse, hangingwall failure might be more likely, and in this case other criteria and evaluation methods should be adopted.

Further, based upon the past experiences, a common thread in the collapse of crown pillars is that invariably some combination of adverse geology existed which lead to the cave-in. However, only infrequently, geology is seen as the sole cause of failure. Rather, most of failures are recorded to have occurred because of a combination of factors. For example, water could lead to loss of strength or washing out of critical binding material or keying materials. Water can also wash away joint infill, causing the flow to become severe and allowing free block movement, which could reduce stability. The flowing groundwater cause rapid deterioration in the geotechnical properties of weak rock owing to its susceptibility to weathering - that is, reduces its shear strength and precipitate failure. Any of these factors may provide the trigger for the collapse that ultimately results in crown pillar failures.

Therefore, limited information is currently available for crown pillar evaluation. In the next stage of Krakatoa's study, a drilling program should be carried out to define the geometry, geology / structural geology, hydrogeology and geotechnical characteristics of the crown pillar area. Once this information becomes available, the recommended crown pillar dimensions in this report could be updated.

7.0 INSTRUMENTATION, MONITORING AND QUALITY CONTROL PROGRAM

The empirical gives relative rather than absolute answers and requires calibration against existing excavations behaviour. Therefore, an instrumentation and monitoring program should be implemented during the development and production at Krakatoa. The main goal of the program is to monitor stability of underground excavations, optimize the ground support guidelines and ensure safety.

The following quality control, instrumentation and monitoring program should be implemented during the Krakatoa development:

I. Pull test; and,
II. Multi Point Borehole Extensometer (MPBX);

The pull test is the method which is commonly used to determine the effectiveness of ground support element. Initially, a pull test equipment should be purchased and pull test should be carried out on various bolts during the ramp and mine development at Krakatoa. Then, a pull test program on a regular basis should be implemented to ensure that bolts are effective in different domains / parts of the mines.

An instrumentation program, consisting of Multiple Point Borehole Extensometers (MPBX), should be planned. Using MPBX, major underground openings, any large size spans, critical excavations and underground infrastructures should be monitored. Further, the suitability of the ground support guidelines should be verified by MPBX. The ultimate goal of the program is to optimize the ground support system and reduce cost. Further, the instrumentation and monitoring results should be compared with empirical and / or numerical model predicted displacement and stresses. Then, the calibrated model could be used to optimize the mine layouts and ground support recommendations of future mining blocks with similar geomechanical characteristics. In addition, Instrumentation installed to monitor a local safety concern, is highly valuable. Typical examples are very short MPBX and Ground Movement Monitor (GMM) which could easily be installed in various parts of the mine. Such instruments however, do not necessarily assist in gaining any overall understanding of ground response to increase extraction in given stoping block or on a mine wide basis.

8.0 RECOMMENDATIONS

As with any mining operation, the design guideline evolves over time to reflect refinement in the geological models and mining methods. Similarly at Krakatoa, the evolution of the geomechanical mine design guidelines must also take place to reflect an increase in the understanding of underground geology, structural geology, rock quality and stress conditions as mining progresses. To further refine the recommended geomechanical mine design guidelines provided in this PFS, it is important to increase the geotechnical database and quantitative data. The following geotechnical program is therefore recommended:

I. No dedicated drilling for underground geotechnical data collection was carried out in this PFS. The data collection was conducted based on available exploration holes which were drilled to extend the resources located at the periphery of the main lens. In the next stage of assessment, a dedicated geotechnical drilling should be planned to obtain representative geotechnical information across the main lens and where other important infrastructures such as ramp will be located underground.

II. The review of drill holes indicated the presence of foliation, faults, structures, damage zone and microdefect zone. Orientation data was made available from two holes. Though good orientation data was collected from holes drilled for pit wall design purposes, orientation data from underground holes were inconsistent. In the next stage of assessment, during the geotechnical drilling of the main lens, the structural data should also be collected.

III. It is important to develop the three dimensional lithological and fault / structure model(s) of the Krakatoa Zone. The objective is to divide the rock mass / ore domain into geologically or geomechanically distinct zones. These zones permit adaption of design to local conditions and provide opportunity to other type of mining method including bulk mining methods where rock quality permits.

IV. The Krakatoa's UCS laboratory results did not include Young's Modulus and Poisson's Ratio. In the next UCS laboratory investigation, Young's Modulus and Poisson's ratio should also be included for the main Krakatoa's rock types. This information will be required to characterise various domains, stability assessment and ground support recommendations.

V. The examination of axial results for Point Load Test indicated a lower number of tests (compared to the diametral test) with scattered results for various rock types. In the next stage of drilling and Point Load Test, additional axial tests should be conducted to improve the correlation factor. Further, a minimum of two Point Load Test (two valid axial and two diametral tests) should be conducted where samples are collected for Unconfined Compressive Strength tests.

VI. Major fault zones and intersecting structural features (broken zones, gouges, contact zone, shears, dykes, etc.) should be identified with dip and dip direction, and included in geological sections and / or geological model. The extent of poor rock quality zones including damaged zones / microdefect zones, from one mining level to the next, and close and within the Ore Zone should be defined.

VII. A hydrogeological study should be carried out to provide information on water inflow as mining progresses at Krakatoa. Further, the rock quality calculations in this report assumed "dry condition" underground. The ground water inflow (through main faults, joints, lakes, river or others) should be monitored to provide an estimate on water inflow, permeability, joints' water pressure. Subsequently, the analyses in this report should be reviewed and adjusted as information on the ground water inflow becomes available.

VIII. According to description of the mining plan, at the completion of the first lift, fill with a higher cement content is planned to allow full drive exposure from underneath. In other words, the high cemented fill should be stable while mining progresses below and above the first lift. In the next stage of assessment, the stability of this cemented lift and in particular the required cement content or other required type of reinforcement should be investigated.

IX. The Cut and Fill mining method uses the primary and secondary drifting to maximise productivity. This is an entry type of mining method and therefore pillars (while the primary drifting is in progress) and backfill (while the secondary drifting is in progress) should be stable. In the next stage of assessment, once representative rock quality data becomes available, an investigation should be carried out to ensure stability while the primary and secondary drifting is in progress.

X. The crown dimension was evaluated based on limited geological and geotechnical information. In the next stage of Krakatoa's study, a drilling program should be carried out to define the geometry, geology, structural geology, hydrogeology and geotechnical characteristics of the crown pillar area. Once this information becomes available, the recommended crown pillar dimensions in this report could be updated.

9.0 CONCLUSIONS

A geomechanical mine design assessment for the Krakatoa Zone was carried out. Based on the results of various investigations, a number of conclusions were reached. These are as follows:

- According to the unconfined compressive strength test results, RHY_i and Ore samples have the highest average UCS at Krakatoa and the strongest rock types. RHY_c, MAF_i and Ore Stringer are the weakest rock type. Further, ore has the highest average dry density and the remainders have a close average range of dry density;
- According to the Point Load Test results, Ore and RHY_i are the strongest rocks at Krakatoa. Within the waste domain, RHY_i / MAF_i are the strongest rocks followed by RHY_v / RHY_c / RHY with similar Point Load Strength Index values;
- A Correlation Factor of 20 is recommended for Point Load diametral tests. Additional test is required to establish the Correlation Factor for Point Load axial tests;
- The rock quality of various domains was established based on RMR_{76} and Q rock mass classification systems. The rock quality was evaluated for Immediate Hangingwall Domain, Ore Domain, Immediate Footwall Domain and Footwall Domain. For comparison purposes, both commercial laboratory and field Point Load Strength Index

strength values were employed. The comparison of these results indicates a similar and wide range from "Very Poor to Good" and "Extremely Poor to Good" rock based on RMR_{76} and Q rock mass classifications respectively. The Ore Domain has a higher rock quality compared to other domains. Also, according to the Q' results, the immediate Hangingwall Domain is poorer in rock quality than immediate Footwall Domain. Further, localized zones of higher and lower rock qualities should be expected for all domains;

- In the Footwall Domain, rock quality ranges from "Poor to Fair" and "Extremely Poor to Fair" based on RMR_{76} and Q classifications respectively;
- The proposed Cut and Fill mining method at Krakatoa will use the primary and secondary drifting with a width and height of 5.0 m by 5.0 m. The stability evaluation reveals that pattern bolting are required for these excavations;
- The ground support standard was prepared based on the required service life and span and height of excavations for Immediate Hangingwall Domain, Ore Domain, Immediate Footwall Domain and Footwall Domain. For permanent headings (Ramp and Permanent Accesses) the ground support system, consisting of resin rebars and welded wire meshes on the back and walls, are recommended. For Temporary headings (Production Stopes, Sill Drifts and Haulages) resin rebars and Split Sets on the back and walls respectively with wire meshes are specified. In very weak ground (Fault / damage zone / micro defect zone) Swellex or similar bolts with welded wire meshes (or equivalents) are required. Secondary ground support were specified for intersections;
- The empirical Scaled Crown Span method along with risk exposure guidelines and probability of failure was employed to evaluate the crown pillar thickness. A pillar thickness of 63m is recommended for this PFS; and,
- To further refine the recommended geomechanical mine design guidelines provided in this PFS, it is essential to increase information available in the geotechnical database and quantitative data as recommended in Section 8.

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APPENDIX I

KZK GEOLOGICAL NOTES

SITE CHARACTERIZATION

The site characteristics, including geometry, geology, rock properties and rock mass quality are required for the purpose of geomechnical assessment, and are discussed in the following sections.

Geometry

The KZK Property hosts two known volcanogenic massive sulphide (VMS) deposits; ABM and GP4F. The ABM deposit is the larger and more accessible of these two, and is thereby the cornerstone of the KZK Project. The significantly smaller GP4F deposit lies 5 km southeast of the ABM deposit and is accessible only by helicopter.

The ABM deposit comprises 20.1 Mt of ore that are divided between the ABM (15.0 Mt) and Krakatoa (5.1 Mt) zones (Green et al., 2016), which are separated from each other by the East Fault (Figure 1). Key geometric features of the ABM Zone include:

- Architecture comprising a sub-parallel pair of stacked lenses that coalesce into a single lens at the eastern and western extremities of the deposit;
- Generally tabular form with average true thickness of 20 m and maximum of 39 m, as well as continuity of up to 700 m along strike and 400 m in the down-dip direction;
- Strike of 290° and dip of -35° to the NNE that flattens to between -10° to -15° at 200 m down-dip depth. The origin of this flattening is unconstrained but is most likely due to open folding or minor normal offset along an east-west trending fault;
- All lenses lie above the mafic footwall intrusion (as opposed to Krakatoa Zone - see below).

Essential geometric features for the Krakatoa Zone include:

- Architecture comprising a series of stacked lenses and pods, the largest of which comprise the main and upper lenses;
- A main lens with a more elongate tabular form relative to ABM, with average thickness of 15 m and maximum of 22 m, in addition to 220 m of strike length and up to 350 m of down-dip extent;
- Strike of 300° and dip of -35° to the NNE;
- Most lenses lie within the mafic footwall intrusion or at its upper and/or lower contacts.

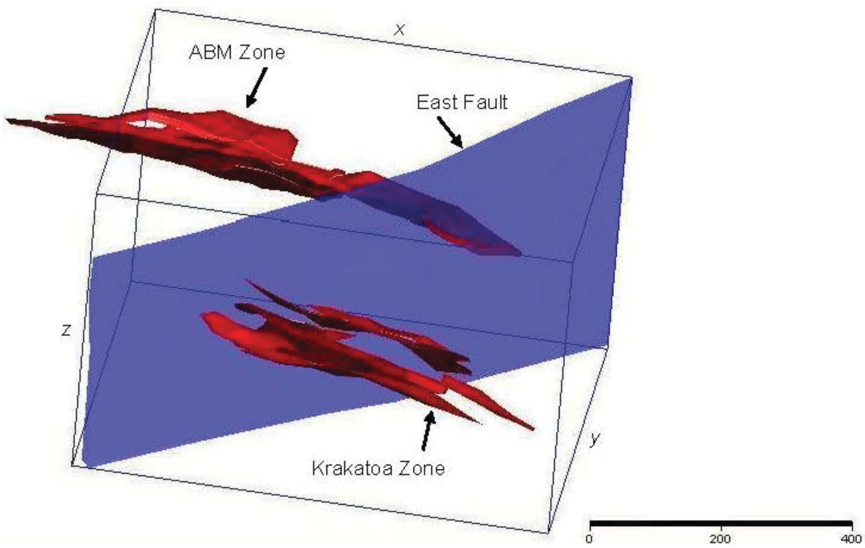

Figure 1: Wire frame model for the ABM deposit, showing the ABM and Krakatoa zones as well as the East Fault. Cube shows the X, Y and Z directions.

The GP4F deposit comprises 1.7 Mt of ore (Green, 2015) that is hosted within a series of stacked lenses that, like the ABM and Krakatoa zones, comprises a "main" lens over- and underlain by subsidiary lenses and pods (Figure 2). Key geometric features of the GP4F deposit include:

- Architecture comprising two stacked lenses (main, lower) overlain and underlain by small and widely spaced pods, with the main lens hosting the bulk of the resource;
- Main lens with tabular form, typical thickness of 10 m and maximum thickness of 20 m, as well as continuity along 300 m of strike length and 350 m of down-dip extent;
- Strike of 300° and dip of -30° to the NNE.

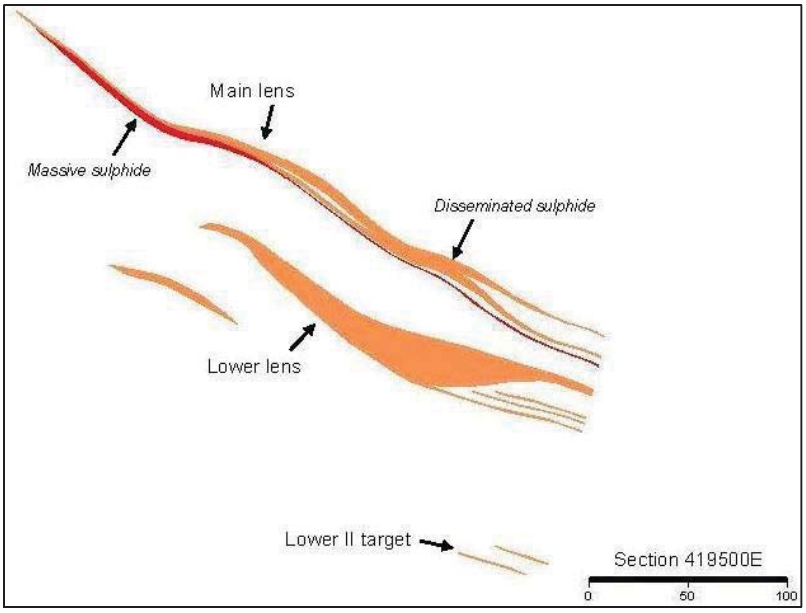

Figure 2: Cross-sectional view through the GP4F deposit, showing the main and lower lenses as well as the lower II target. Note that the deposit is open at depth.

Geology

The geology of the ABM and GP4F deposits has been most recently summarized in a series of internal technical (Duncan and Baker, 2015; Hughes and Baknes, 2015; Jones, 2016; Voordouw, 2016), internal resource (Green, 2015; Green et al., 2016) and public assessment (Hughes et al., 2016) reports. An additional summary is provided below.

Regional and local geology

The KZK Property is underlain by polydeformed meta-sedimentary, -volcanic and -plutonic rocks of the Yukon-Tanana terrane, which extends from central British Columbia into eastern Alaska. These rocks were formed in a peri-cratonic continental arc separated from ancestral North America by a back-arc rift basin. In Central Yukon, the Yukon-Tanana terrane occurs, together with back arc-related units of the Slide Mountain terrane (Nelson et al., 2013), in the Finlayson Lake belt, a crescent-shaped area approximately 300 km long and 50 km wide that extends from Ross River in the north to Watson Lake in the south. The Finlayson Lake belt is notable for hosting several syngenetic VMS deposits in both Yukon-Tanana (e.g. Wolverine, ABM, GP4F, Fyre Lake) and Slide Mountain (e.g. Ice) rocks, as well as in the adjacent platform rocks of ancestral North America (e.g. Wolf).

Subdivisions of the Yukon-Tanana terrane that occur on the KZK Property include the Grass Lakes group and the Grass Lakes plutonic suite (Table 1). The Grass Lakes group is subdivided into, from oldest to youngest, the Fire Lake, Kudz Ze Kayah (KZK) and Wind Lake formations (Murphy et al., 2001; Piercey et al., 2008). The Fire Lake formation consists of undifferentiated plagioclase-chlorite phyllite and schist, carbonaceous phyllite and muscovite-quartz phyllite (***DF***) that occurs only in the southwestern part of the Property. The KZK formation occurs extensively within the southern half of the Property and hosts both the ABM and GP4F deposits. It passes upwards from a basal sub-unit of calcareous (***DKcs***) and carbonaceous (***DKcp***) metasedimentary rocks into a distinctive feldspar-muscovite-quartz schist and phyllite (***DK***) that are likely derived from felsic volcanic protoliths. The overlying Wind Lake formation is similar to the basal KZK, comprising mostly carbonaceous phyllite (***DMcp***) and quartzite (***DMq***) that is intercalated with chloritic phyllite (***DMm***). A Wind Lake meta-conglomerate unit (***DMcg***) occurs within the western part of the Property. Meta-granitic to monzonitic rocks of the Grass Lakes plutonic suite are generally younger than the Grass Lakes groups, and are regionally sub-divided into equigranular (***MGg***) and augen-textured (***MGag***) types.

Table 1: Stratigraphic units on the KZK Property (after Murphy et al., 2001; Piercey et al., 2008)

Epoch	Age (Ma)	Suite or succession	Formation	Sub-unit
Early Mississippian	347-359	Grass Lakes plutonic suite		MGg: Equigranular metagranitoids
				MGag: Augen metagranitoids
Late Devonian to Early Mississippian	347-383	Grass Lakes group	Wind Lake	DMq: Quartzite
				DMm: Chloritic phyllite
				DMcp: Carbonaceous phyllite/schist
				DMcg: Metaconglomerate
			Kudz Ze Kayah	DK: Fsp-ms-qtz schist and phyllite
				DKcp: Carbonaceous phyllite/schist
				DKcs: Calcareous metasandstone
			Fire Lake	DF: Pl-chl phyllite/schist; carbonaceous phyllite

Structural geology

The Yukon-Tanana terrane is pervasively foliated and lineated, and also imbricated by Permian thrust faulting into at least three structurally bound sheets (Cleaver Lake, Money, Big Campbell), some of which record at least 35 km of northeast-directed displacement (Murphy, 2004). Thrusting culminated in the Late Triassic-Early Jurassic with emplacement of the Yukon-Tanana terrane onto North America along the Big Campbell and Inconnu thrusts. The KZK Property lies entirely within the Big Campbell thrust sheet in what is the structurally deepest part of the Yukon-Tanana terrane. Regional-scale thrust faults are generally northwest trending and dip moderately to either the northeast or southwest.

The GP4F deposit is underlain by what appears to be a layer-parallel fault striking 300° and dipping 30° to the northeast ("Lower fault" in Voordouw, 2016), broadly subparallel to the regional-scale thrusts. There are, however, no constraints on the magnitude or the direction of displacement on this structure.

The regional map of Murphy et al (2001) also shows a prominent northeast to southwest trending normal fault cutting the Grass Lakes group just southeast of the ABM deposit. Normal displacement is southeast-side down. At the deposit-scale, this regional-scale structure is manifested by the East and Fault Creek fault zones, both of which are 20 and 50 m wide (respectively) damage zones formed by braided networks of fault gouge and panels. The East Fault trends 050°, dips 85° to the southeast and bounds the eastern side of the ABM deposit, separating it from the Krakatoa zone to the southeast. The Fault Creek Fault bounds the other side of the Krakatoa Zone and is oriented at 060°/60° NW. Both faults record 200+ m of apparent dextral offset manifested through either dextral strike-slip or SE-down dip-slip displacement (Baker, 2016), or a combination of both. The East and Fault Creek faults may be linked together through the Sunda Fault (or the A-FLT of Baker, 2016), which strikes 070° and dips at 85° to the SSE.

Baker (2016) also modeled two syngenetic growth faults based on the idea that the emplacement of aphanitic rhyolite (RHYi) and mafic footwall intrusive units (see “Rock types”) was structurally-controlled by early faulting. The orientation of these structures appears to be 090°/65° S for the mafic growth fault and 095°/85° N for the RHYi fault.

The Yukon-Tanana rocks on the KZK Property are strongly structurally transposed, polydeformed and overprinted by mid-greenschist to lower amphibolite grade metamorphism. Up to five phases of deformation have been recognized (see Hughes et al., 2016), the first three (D1, D2, D3) of which involved regionally penetrative ductile shearing, faulting and folding. The oldest of these fabrics (S1) range from weak, bedding-parallel schistosity to mylonite, and are transposed into a strong, shallow dipping, crenulation cleavage (S2) that was formed during the development of south- to southeast-verging F2 folds. North- to northeast-dipping S3 cleavage and shear bands offset S2 fabrics in a top-to-the-south/southeast shear sense.

The last two phases of deformation (D4, D5) were developed through non-penetrative compression and extension. D4 deformation is characterized by broad open folds whereas D5 deformation is typified by late-stage, commonly north- and northeast-striking, brittle-style normal faults. In addition, several older thrust faults were likely re-activated during D5 extension.

Rock types

Most drilling on the Property has focussed on VMS deposits hosted within the KZK Formation and, so, are mostly collared within KZK rocks or the overlying Wind Lake Formation. The lithological codes used to log these rocks are described in Hughes and Baknes (2015) and in Hughes et al (2016), and are here lumped into groups to facilitate their description (Table 2).

The predominant lithology within most drill holes is feldspar-muscovite-quartz phyllite and schist formed from felsic volcanic protoliths, equivalent to the DK unit of Murphy et al (2001) and coded as “RHY” in BMC’s database. There are five main types of RHY. The most abundant of these is felsic volcaniclastic (***RHYv***), which includes the volcaniclastic rhyolite (*RHYva*), coarse-grained to ash tuff (*RHYva*) and lapilli tuff (*RHYvl*) lithologies. Next most abundant is coherent felsic volcanic (***RHYc***) consisting of laminar (*RHYc*) and curdy (*RHYcw*) flow-banded units. Coherent lithologies typically comprise mm- to cm-scale layers of amorphous silica in quartz-sericite/muscovite schist, and could therefore also be interpreted as silicified. The crystal-bearing felsic volcanic group (***RHYx***) include both crystal tuff (*RHYvx*) and feldspar- and/or quartz-porphyritic units (*RHYcf*, *RHYcq*, *RHYif*). Aphanitic rhyolite (***RHYi***) is marked by very hard and fine-grained silica. Undifferentiated rhyolite (***RHY***) cannot be split into any of the aforementioned sub-types, typically because it is strongly altered and/or deformed.

Sedimentary rocks are split into five main types (Table 2). Carbonaceous mudstone is coded as ***MDU*** where it occurs in the Wind Lake formation and ***MDS*** when it forms part of the KZK stratigraphy. The ***MDS*** grouping furthermore includes carbonaceous dominant mudstone (*MDSc*), rhyolite tuff dominant mudstone (*MDSt*) and coherent rhyolite with carbonaceous content (*MDSw*). Pelitic rocks (***PEL***) are biotite-rich schists. Undifferentiated sedimentary rocks (***SED***) include non-calcareous (*SED*) and calcareous (*SEDc*) lithologies, and also sparsely used codes like wacke (*WCK*) and siltstone (*SLT*). Chert (***CHT***) is marked by finely banded and amorphous silica.

Mafic rocks are split into mafic intrusive (***MAFi***) and mafic volcanic (***MAFt***) types. The mafic intrusive group includes only rocks logged as MAFi, whereas the ***MAFt*** group includes mafic volcaniclastic (*MAFt*), coarse-grained to ash tuff (*MAFta*) and mafic volcanic flows (*MAFw*).

Massive and semi-massive sulphide are described with a series of O-codes that can be split into predominantly massive and disseminated types (Table 2). ***Massive sulphide*** includes magnetite-bearing massive (*OA*), magnetite-poor massive (*OB*), ccp + po net-textured (*OC*), brecciated (*OD*), po-rich (*OF*), ccp-rich (*OG*), fine-grained homogeneous (*OH*) and buckshot pyrite in sp ± po + mag + gn + ccp (*OL*) lithologies. ***Disseminated sulphide*** includes schist-hosted (*OI*) and proximal alteration-hosted (*OJ*) types, as well as heavily disseminated sulphide associated with barite (*OK*).

Codes that refer to Grass Lakes plutonic suite include undifferentiated (most granitic) intrusive (*INT*) and feldspar augen meta-diorite (*DIOf*). Other codes include overburden (*OVBN*), fault zones (*FLZ*) and no core.

Table 2: Groupings used for the sectional interpretation of ABM and GP4F deposits (from Voordouw et al., 2016)

Group	Description	Lithological codes	Associated deposits
Grass Lakes plutonic suite: Granitoids			
INT	Undifferentiated intrusive rocks	INT	
DIOf	Feldspar augen diorite intrusion	DIOf	
KZK Formation: Felsic volcanic			
RHY	Undifferentiated rhyolite (usually altered)	RHY	
RHYc	Coherent (or partially siliceous?) rhyolite	RHYc, RHYcw	ABM
RHYx	Crystal-bearing rhyolite, porphyry	RHYcf, RHYcq, RHYif, RHYvx	GP4F
RHYi	Aphanitic (or siliceous?) rhyolite	RHYi	Krakatoa Zone

RHYv	Volcaniclastic rhyolite	RHYv, RHYva, RHYvl	
KZK Formation: Sedimentary rocks			
MDU	Carbonaceous mudstone (Wind Lake Fm)	MDU, MDUc	
MDS	Mud- to silt-stone, carbonaceous mudstone (KZK Fm)	MDS, MDSc, MDSt, MDSw	
PEL	Pelite	PEL	
SED	Undifferentiated sedimentary rock	SED, SEDc, ARK, SLT, WCK	
CHT	Chert	CHT	
KZK Formation: Mafic intrusive and volcanic			
MAFi	Mafic intrusive	MAFi	ABM
MAFt	Mafic volcanic	MAFt, MAFta, MAFw	
KZK Formation: Massive and disseminated sulphide			
Massive	Massive sulphide (>50% sulphide)	OA, OB, OC, OD, OF, OG, OH, OL	ABM, GP4F
Disseminated	Disseminated to semi-massive sulphide (25-50% sulphide)	OI, OJ, OK	ABM, GP4F
Other codes			
OVBN	Overburden, casing	OVBN, CASN	
FLZ	Fault zone	FLZ	
No core	Interval with 0% recovery	No core	

Some of the rock types show an intimate relationship with VMS mineralization (Table 3). The ABM Zone occurs mostly within ***RHYc*** host rocks and is directly underlain by the mafic footwall intrusion (***MAFi***). The Krakatoa Zone occurs within the mafic footwall intrusion (***MAFi***) or at its upper and/or lower contacts, and occurs on the same horizon as an aphanitic rhyolite unit (***RHYi***). The GP4F main lens occurs within a crystal-bearing felsic volcanic unit (***RHYx***). These relations are summarized in table 3.

Table 3: Generalized descriptions for the hanging wall (HW), footwall (FW) and ore zone of each mineralized zone

Zone	Component	Rock type	Geological description
ABM	HW	Rhyolite	Mostly coherent rhyolite schist (RHYc) comprising bands of qtz-ser and amorphous silica
	Ore	Massive sulphide	Pyrite-rich massive sulphide with lesser amounts of stringer/disseminated mineralization
	FW	Mafic intrusive	Chl + cal altered mafic intrusive
Krakatoa	HW	Rhyolite or mafic intrusive	Coherent and volcaniclastic rhyolite; chl + cal altered mafic intrusive
	Ore	Massive sulphide	Pyrite-rich massive sulphide with lesser amounts of stringer/disseminated mineralization
	FW	Rhyolite	Volcaniclastic rhyolite formed by qtz-ser schist
GP4F	HW	Rhyolite	Quartz phyric rhyolite (RHYx) with lesser amounts of volcaniclastic and pelite
	Ore	Disseminated to massive sulphide	Disseminated sulphide with minor amounts of massive mineralization
	FW	Rhyolite	Quartz phyric rhyolite (RHYx) with lesser amounts of volcaniclastic and pelite

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APPENDIX II

LABORATORY TEST RESULTS

UNCONFINED COMPRESSIVE TEST

Laboratory Determination of Uniaxial Compressive Strength of Intact Rock Core Specimens.

Summary of Test Results

ASTM D7012 Method C

Project No.: 1658755
Project: KZK
Location: Not provided
Client: BMC Minerals Ltd.
Lab ID No: 219

Failure Modes
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Note: (deg) measured from core axis
Wet density based on as received moisture

No.	Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	Area (cm²)	Volume (cm³)	Mass (g)	Wet Density (kg/m³)	Moisture (%)	Dry Density (kg/m³)	Maximum Load (kN)	Stress σ_u (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
1	K16-353	0190409-A	129.77-130.68	62.00	122.19	30.19	368.90	1003.20	2719	1.26	2686	115.70	38.3	Stringer (OJ)	5	19
2	K16-353	0190409-B	129.77-130.68	62.06	123.02	30.25	372.13	1005.10	2701	1.09	2672	45.70	15.1	Stringer (OJ)	5	34
3	K16-353	0190409-C	129.77-130.68	62.07	120.50	30.26	364.62	951.90	2611	0.70	2593	137.20	45.3	Stringer (OJ)	5	25
4	K16-357	0190419-A	223.55-224.10	61.09	126.92	29.31	372.01	1174.00	3156	0.09	3153	122.20	41.7	OI (Stringer)	5*	59
5	K16-357	0190419-B	223.55-224.10	61.07	121.85	29.29	356.92	1166.10	3267	0.15	3262	188.00	64.2	OI (Stringer)	5*	35
6	K16-357	0190420-A	253.90-254.60	60.59	124.06	28.83	357.70	1555.20	4348	0.07	4345	293.70	101.9	OB (Ore)	2*	
7	K16-357	0190420-B	253.90-254.60	60.81	121.84	29.04	353.86	1133.90	3204	0.23	3197	101.60	35.0	OB (Ore)	5	23
8	K16-358	0190427-A	165.80-166.40	61.53	125.56	29.73	373.35	1742.10	4666	0.14	4660	284.10	95.5	OA	5/2	12
9	K16-358	0190427-B	165.80-166.40	61.48	126.62	29.69	375.89	1769.50	4708	0.14	4701	276.80	93.2	OA	5	20
10	K16-358	0190427-C	165.80-166.40	61.57	124.07	29.77	369.40	1725.40	4671	0.17	4663	394.50	132.5	OA	2	
11	K16-358	0190428-A	169.90-170.40	61.54	123.93	29.74	368.62	1200.40	3256	0.29	3247	272.60	91.6	OI	5/6	15
12	K16-358	0190429-A	217.60-218.60	61.86	122.74	30.05	368.89	1548.60	4198	0.05	4196	410.90	136.7	OB	5	26
13	K16-358	0190429-B	217.60-218.60	61.95	125.67	30.14	378.79	1516.90	4005	0.04	4003	417.10	138.4	OB	2	
14	K16-358	0190430-A	219.45-220.44	61.90	124.28	30.09	374.00	1649.70	4411	0.06	4408	388.70	129.2	OB	5/6	29
15	K16-358	0190430-B	219.45-220.44	61.82	125.95	30.02	378.05	1584.80	4192	0.06	4190	287.70	95.8	OB	6	
16	K16-358	0190431-A	245.46-246.46	62.01	123.35	30.20	372.52	1704.20	4575	0.06	4572	214.40	71.0	OB	1	
17	K16-358	0190431-B	245.46-246.46	62.00	125.61	30.19	379.23	1755.30	4629	0.10	4624	241.10	79.9	OB	5	13
18	K16-358	0190431-C	245.46-246.46	62.01	122.81	30.20	370.89	1596.10	4303	0.07	4300	244.50	81.0	OB	2	

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacte	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Laboratory Determination of Uniaxial Compressive Strength of Intact Rock Core Specimens.

Summary of Test Results

ASTM D7012 Method C

Project No.: 1658755
Project: KZK
Location: Not provided
Client: BMC Minerals Ltd.
Lab ID No: 219

Failure Modes
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Note: (deg) measured from core axis
Wet density based on as received moisture

No.	Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	Area (cm²)	Volume (cm³)	Mass (g)	Wet Density (kg/m³)	Moisture (%)	Dry Density (kg/m³)	Maximum Load (kN)	Stress σ_u (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
19	K16-358	0190431-D	245.46-246.46	62.04	120.65	30.23	364.72	1603.00	4395	0.17	4388	330.20	109.2	OB	2	

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacte	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	0190409-A
Location:	Not provided	**Depth (m):**	129.77-130.68
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**115.70**	Diameter	(mm)	62.00
		Height	(mm)	122.19
Stress σ_u (MPa)	**38.3**	Area	(cm²)	30.19
		Volume	(cm³)	368.90
Pace Rate (kN/s)	0.50	Mass	(g)	1003.20
		Moisture Content (%)		1.26
Lithology	Stringer (OJ)	Wet Density	(kg/m³)	2719
		Dry Density	(kg/m³)	2686

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **19**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	0190409-B
Location:	Not provided	**Depth (m):**	129.77-130.68
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**45.70**	Diameter (mm)	62.06
		Height (mm)	123.02
Stress σ_u (MPa)	**15.1**	Area (cm²)	30.25
		Volume (cm³)	372.13
Pace Rate (kN/s)	0.50	Mass (g)	1005.10
		Moisture Content (%)	1.09
Lithology	Stringer (OJ)	Wet Density (kg/m³)	2701
		Dry Density (kg/m³)	2672

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **34**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	0190409-C
Location:	Not provided	**Depth (m):**	129.77-130.68
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results

Max Load (kN)	**137.20**
Stress σ_u (MPa)	**45.3**
Pace Rate (kN/s)	0.50
Lithology	Stringer (OJ)

Sample Measurements

Diameter	(mm)	62.07
Height	(mm)	120.50
Area	(cm²)	30.26
Volume	(cm³)	364.62
Mass	(g)	951.90
Moisture Content (%)		0.70
Wet Density	(kg/m³)	2611
Dry Density	(kg/m³)	2593

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **25**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

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Golder Associates

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	0190419-A
Location:	Not provided	**Depth (m):**	223.55-224.10
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**122.20**	Diameter	(mm)	61.09
		Height	(mm)	126.92
Stress σ_u (MPa)	**41.7**	Area	(cm²)	29.31
		Volume	(cm³)	372.01
Pace Rate (kN/s)	0.50	Mass	(g)	1174.00
		Moisture Content (%)		0.09
Lithology	OI (Stringer)	Wet Density	(kg/m³)	3156
		Dry Density	(kg/m³)	3153

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	**5***	**Mode:**
		(1) Simple Extension
Degrees:*	**59**	(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

* - shear along foliation

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	0190419-B
Location:	Not provided	**Depth (m):**	223.55-224.10
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**188.00**	Diameter	(mm)	61.07
		Height	(mm)	121.85
Stress σ_u (MPa)	**64.2**	Area	(cm²)	29.29
		Volume	(cm³)	356.92
Pace Rate (kN/s)	0.50	Mass	(g)	1166.10
		Moisture Content (%)		0.15
Lithology	OI (Stringer)	Wet Density	(kg/m³)	3267
		Dry Density	(kg/m³)	3262

BEFORE TEST

Failure Mode

Type: **5***

Degrees:* **35**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

* - shear along foliation

Sample size does not meet standard requirements

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[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	0190420-A
Location:	Not provided	**Depth (m):**	253.90-254.60
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**293.70**	Diameter	(mm)	60.59
		Height	(mm)	124.06
Stress σ_u (MPa)	**101.9**	Area	(cm²)	28.83
		Volume	(cm³)	357.70
Pace Rate (kN/s)	0.50	Mass	(g)	1555.20
		Moisture Content (%)		0.07
Lithology	OB (Ore)	Wet Density	(kg/m³)	4348
		Dry Density	(kg/m³)	4345

BEFORE TEST

Failure Mode	Notes
	- Water content as received
	- Wet density based on as received moisture
Type: **2***	**Mode:**
	(1) Simple Extension
Degrees:* ______	(2) Multiple Extension
	(3) Multiple Fracturing
* Degrees measured with respect to core axis.	(4) Multiple Shear
	(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.	(6) Spalling
	(7) Other

AFTER TEST

Comments

* - vertical conical extension

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	0190420-B
Location:	Not provided	**Depth (m):**	253.90-254.60
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**101.60**	Diameter (mm)	60.81
		Height (mm)	121.84
Stress σ_u (MPa)	**35.0**	Area (cm^2)	29.04
		Volume (cm^3)	353.86
Pace Rate (kN/s)	0.50	Mass (g)	1133.90
		Moisture Content (%)	0.23
Lithology	OB (Ore)	Wet Density (kg/m^3)	3204
		Dry Density (kg/m^3)	3197

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **23**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190427-A
Location:	Not provided	**Depth (m):**	165.80-166.40
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**284.10**	Diameter	(mm)	61.53
		Height	(mm)	125.56
Stress σ_u (MPa)	**95.5**	Area	(cm^2)	29.73
		Volume	(cm^3)	373.35
Pace Rate (kN/s)	0.50	Mass	(g)	1742.10
		Moisture Content (%)		0.14
Lithology	OA	Wet Density	(kg/m^3)	4666
		Dry Density	(kg/m^3)	4660

BEFORE TEST

Failure Mode

Type: **5/2**

Degrees:* **12**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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TESTED BY	DATE	CHECKED BY	DATE
[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190427-B
Location:	Not provided	**Depth (m):**	165.80-166.40
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results

Max Load (kN)	**276.80**
Stress σ_u (MPa)	**93.2**
Pace Rate (kN/s)	0.50
Lithology	OA

Sample Measurements

Diameter	(mm)	61.48
Height	(mm)	126.62
Area	(cm^2)	29.69
Volume	(cm^3)	375.89
Mass	(g)	1769.50
Moisture Content (%)		0.14
Wet Density	(kg/m^3)	4708
Dry Density	(kg/m^3)	4701

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **20**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments

AFTER TEST

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[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190427-C
Location:	Not provided	**Depth (m):**	165.80-166.40
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**394.50**	Diameter (mm)	61.57
		Height (mm)	124.07
Stress σ_u (MPa)	**132.5**	Area (cm²)	29.77
		Volume (cm³)	369.40
Pace Rate (kN/s)	0.50	Mass (g)	1725.40
		Moisture Content (%)	0.17
Lithology	OA	Wet Density (kg/m³)	4671
		Dry Density (kg/m³)	4663

BEFORE TEST

Failure Mode

Type: **2**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190428-A
Location:	Not provided	**Depth (m):**	169.90-170.40
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**272.60**	Diameter	(mm)	61.54
		Height	(mm)	123.93
Stress σ_u (MPa)	**91.6**	Area	(cm²)	29.74
		Volume	(cm³)	368.62
Pace Rate (kN/s)	0.50	Mass	(g)	1200.40
		Moisture Content (%)		0.29
Lithology	OI	Wet Density	(kg/m³)	3256
		Dry Density	(kg/m³)	3247

BEFORE TEST

Failure Mode

Type: **5/6**

Degrees:* **15**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)
ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190429-A
Location:	Not provided	**Depth (m):**	217.60-218.60
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results	
Max Load (kN)	**410.90**
Stress σ_u (MPa)	**136.7**
Pace Rate (kN/s)	0.50
Lithology	OB

Sample Measurements		
Diameter	(mm)	61.86
Height	(mm)	122.74
Area	(cm^2)	30.05
Volume	(cm^3)	368.89
Mass	(g)	1548.60
Moisture Content (%)		0.05
Wet Density	(kg/m^3)	4198
Dry Density	(kg/m^3)	4196

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **26**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

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[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190429-B
Location:	Not provided	**Depth (m):**	217.60-218.60
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**417.10**	Diameter (mm)	61.95
		Height (mm)	125.67
Stress σ_u (MPa)	**138.4**	Area (cm²)	30.14
		Volume (cm³)	378.79
Pace Rate (kN/s)	0.50	Mass (g)	1516.90
		Moisture Content (%)	0.04
Lithology	OB	Wet Density (kg/m³)	4005
		Dry Density (kg/m³)	4003

BEFORE TEST

Failure Mode

Type: **2**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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TESTED BY	DATE	CHECKED BY	DATE
[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190430-A
Location:	Not provided	**Depth (m):**	219.45-220.44
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**388.70**	Diameter (mm)	61.90
		Height (mm)	124.28
Stress σ_u (MPa)	**129.2**	Area (cm²)	30.09
		Volume (cm³)	374.00
Pace Rate (kN/s)	0.50	Mass (g)	1649.70
		Moisture Content (%)	0.06
Lithology	OB	Wet Density (kg/m³)	4411
		Dry Density (kg/m³)	4408

BEFORE TEST

Failure Mode

Type: **5/6**

Degrees:* **29**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190430-B
Location:	Not provided	**Depth (m):**	219.45-220.44
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**287.70**	Diameter	(mm)	61.82
		Height	(mm)	125.95
Stress σ_u (MPa)	**95.8**	Area	(cm²)	30.02
		Volume	(cm³)	378.05
Pace Rate (kN/s)	0.50	Mass	(g)	1584.80
		Moisture Content (%)		0.06
Lithology	OB	Wet Density	(kg/m³)	4192
		Dry Density	(kg/m³)	4190

BEFORE TEST

Failure Mode

Type: **6**

Degrees:* ______

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190431-A
Location:	Not provided	**Depth (m):**	245.46-246.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**214.40**	Diameter (mm)	62.01
		Height (mm)	123.35
Stress σ_u (MPa)	**71.0**	Area (cm²)	30.20
		Volume (cm³)	372.52
Pace Rate (kN/s)	0.50	Mass (g)	1704.20
		Moisture Content (%)	0.06
Lithology	OB	Wet Density (kg/m³)	4575
		Dry Density (kg/m³)	4572

BEFORE TEST

Failure Mode

Type: **1**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190431-B
Location:	Not provided	**Depth (m):**	245.46-246.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements		
Max Load (kN)	**241.10**	Diameter	(mm)	62.00
		Height	(mm)	125.61
Stress σ_u (MPa)	**79.9**	Area	(cm²)	30.19
		Volume	(cm³)	379.23
Pace Rate (kN/s)	0.50	Mass	(g)	1755.30
		Moisture Content (%)		0.10
Lithology	OB	Wet Density	(kg/m³)	4629
		Dry Density	(kg/m³)	4624

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **13**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190431-C
Location:	Not provided	**Depth (m):**	245.46-246.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**244.50**	Diameter (mm)	62.01
		Height (mm)	122.81
Stress σ_u (MPa)	**81.0**	Area (cm^2)	30.20
		Volume (cm^3)	370.89
Pace Rate (kN/s)	0.50	Mass (g)	1596.10
		Moisture Content (%)	0.07
Lithology	OB	Wet Density (kg/m^3)	4303
		Dry Density (kg/m^3)	4300

BEFORE TEST

Failure Mode

Type: **2**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	0190431-D
Location:	Not provided	**Depth (m):**	245.46-246.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	219

Testing Results		Sample Measurements	
Max Load (kN)	**330.20**	Diameter (mm)	62.04
		Height (mm)	120.65
Stress σ_u (MPa)	**109.2**	Area (cm²)	30.23
		Volume (cm³)	364.72
Pace Rate (kN/s)	0.50	Mass (g)	1603.00
		Moisture Content (%)	0.17
Lithology	OB	Wet Density (kg/m³)	4395
		Dry Density (kg/m³)	4388

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	**2**	**Mode:**
		(1) Simple Extension
Degrees:*		(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

Sample size does not meet standard requirements

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	June 14, 2016	[Name Redacted]	June 15,2016
TESTED BY	DATE	CHECKED BY	DATE

Laboratory Determination of Uniaxial Compressive Strength of Intact Rock Core Specimens.

Summary of Test Results

ASTM D7012 Method C

Project No.: 1658755
Project: KZK
Location: Not provided
Client: BMC Minerals Ltd.
Lab ID No: 270

Failure Modes
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Note: (deg) measured from core axis
Wet density based on as received moisture

No.	Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	Area (cm²)	Volume (cm³)	Mass (g)	Wet Density (kg/m³)	Moisture (%)	Dry Density (kg/m³)	Maximum Load (kN)	Stress σ_u (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
1	K16-350	190401	204.0-204.135	61.07	140.12	29.29	410.44	1194.40	2910	0.09	2907	14.80	5.1	RHYc	5	45
2	K16-353	190404	27.13-27.33	61.01	124.92	29.23	365.19	1101.50	3016	0.10	3013	157.80	54.0	MAFi	5	27
3	K16-353	190405	33.0-33.27	61.11	125.16	29.33	367.10	1105.40	3011	0.14	3007	151.00	51.5	MAFi	5	25
4	K16-353	190406-A	50.12-50.46	61.30	128.43	29.51	379.03	1036.40	2734	0.14	2731	200.90	68.1	RHYv	5	34
5	K16-353	190406-B	50.12-50.46	61.29	126.16	29.50	372.21	1018.50	2736	0.12	2733	119.40	40.5	RHYv	5	38
6	K16-353	190407	82.08-82.31	61.68	129.43	29.88	386.74	1024.90	2650	0.20	2645	280.90	94.0	RHY	5	18
7	K16-354	190410	33.0-33.27	60.99	122.45	29.22	357.74	937.80	2621	0.33	2613	276.00	94.5	RHYi	4	
8	K16-356	190411	12.5-12.8	60.78	128.56	29.01	373.01	1040.50	2789	0.14	2786	221.90	76.5	MAFi	5	15
9	K16-357	190412	48.0-48.25	61.11	131.13	29.33	384.61	1070.50	2783	0.26	2776	183.80	62.7	RHYv	5/6	40
10	K16-357	190413	74.3-74.6	61.37	128.82	29.58	381.05	1057.80	2776	0.17	2771	149.20	50.4	RHYv	5	33
11	K16-357	190414	90.6-90.85	61.32	130.06	29.53	384.09	1000.80	2606	0.23	2600	152.50	51.6	RHYi	1*	
12	K16-357	190415	104.4-104.65	61.36	128.70	29.57	380.57	1008.40	2650	0.29	2642	153.10	51.8	RHYc	5	19
13	K16-357	190416-A	192.5-192.85	61.10	131.16	29.32	384.57	1061.00	2759	0.29	2751	57.70	19.7	RHYc	5	55
14	K16-357	190416-B	192.5-192.85	61.07	125.78	29.29	368.43	1027.10	2788	0.22	2782	24.60	8.4	RHYc	5	54
15	K16-357	190417-A	195.35-195.70	61.13	129.70	29.35	380.66	1057.10	2777	0.11	2774	88.50	30.2	RHYc	5	57
16	K16-357	190417-B	195.35-195.70	61.04	113.04	29.26	330.79	925.00	2796	0.13	2793	105.90	36.2	RHYc	5	67
17	K16-358	190421-A	64.15-64.46	61.12	125.59	29.34	368.48	1037.70	2816	0.29	2808	94.30	32.1	RHY	5	37
18	K16-358	190421-B	64.15-64.46	61.15	128.11	29.37	376.24	1034.80	2750	0.32	2742	123.50	42.1	RHY	5	39

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[Name Redacted]	July 22, 2016	[Name Redact	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Laboratory Determination of Uniaxial Compressive Strength of Intact Rock Core Specimens.

Summary of Test Results

ASTM D7012 Method C

Project No.: 1658755
Project: KZK
Location: Not provided
Client: BMC Minerals Ltd.
Lab ID No: 270

Failure Modes
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Note: (deg) measured from core axis
Wet density based on as received moisture

No.	Borehole #	Sample #	Depth (m)	Dia (mm)	Ht (mm)	Area (cm²)	Volume (cm³)	Mass (g)	Wet Density (kg/m³)	Moisture (%)	Dry Density (kg/m³)	Maximum Load (kN)	Stress σ_u (MPa)	Rock Type	Failure Mode Type	Failure Mode (deg)
19	K16-357	190422	309.0-309.28	60.85	131.81	29.08	383.32	1140.40	2975	0.18	2970	188.30	64.7	MAFi	5	29
20	K16-357	190423	315.38-315.76	60.73	127.05	28.97	368.02	1076.40	2925	0.32	2916	137.70	47.5	MAFi	6/5	77
21	K16-378	190434	151.76-151.90	60.85	120.98	29.08	351.82	934.40	2656	Sample is too weak to test						
22	K16-377	190435	24.92-25.12	61.09	126.18	29.31	369.85	975.70	2638	0.23	2632	359.30	122.6	RHYi	1	
23	K16-371	190436	59.91-60.13	61.11	125.21	29.33	367.24	961.90	2619	0.19	2614	361.80	123.4	RHYi	1	
24	K16-371	190437	58.95-59.22	61.09	126.33	29.31	370.29	974.30	2631	0.23	2625	198.00	67.6	RHYi	5	14
25	K16-376	190438	14.84-15.20	61.27	127.12	29.48	374.80	1034.80	2761	0.08	2759	101.30	34.4	RHYv	5	21
26	K16-373	190439-A	61.48-61.81	60.62	127.17	28.86	367.03	1098.10	2992	0.28	2983	38.60	13.4	MAFi	5	25
27	K16-373	190439-B	61.48-61.81	60.70	128.28	28.94	371.22	1108.90	2987	0.22	2981	103.70	35.8	MAFi	5	28
28	K16-373	190441	68.94-69.29	60.75	129.27	28.99	374.70	1063.30	2838	0.22	2832	60.40	20.8	MAFi	5	33
29	K16-371	190442-A	66.0-66.35	60.13	129.16	28.40	366.78	1004.30	2738	0.15	2734	355.20	125.1	RHYi	6	
30	K16-371	190442-B	66.0-66.35	61.08	125.29	29.30	367.12	988.70	2693	0.15	2689	432.00	147.4	RHYi	6	
31	K16-371	190445-A	88.50-88.79	61.12	126.22	29.34	370.33	1001.90	2705	0.16	2701	303.70	103.5	RHYv	5	15
32	K16-371	190445-B	88.50-88.79	61.15	129.29	29.37	379.71	1039.50	2738	0.13	2734	295.90	100.8	RHYv	5	14

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[Name Redacted]	July 22, 2016	[Name Redact	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-350
Project:	KZK	**Sample Number:**	190401
Location:	Not provided	**Depth (m):**	204.0-204.135
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**14.80**	Diameter (mm)	61.07
		Height (mm)	140.12
Stress σ_u (MPa)	**5.1**	Area (cm^2)	29.29
		Volume (cm^3)	410.44
Pace Rate (kN/s)	1.25	Mass (g)	1194.40
		Moisture Content (%)	0.09
Lithology	RHYc	Wet Density (kg/m^3)	2910
		Dry Density (kg/m^3)	2907

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **45**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Height and mass measurements include sulfur cap.

Shear along foliation.

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	190404
Location:	Not provided	**Depth (m):**	27.13-27.33
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**157.80**	Diameter (mm)	61.01
		Height (mm)	124.92
Stress σ_u (MPa)	**54.0**	Area (cm^2)	29.23
		Volume (cm^3)	365.19
Pace Rate (kN/s)	1.25	Mass (g)	1101.50
		Moisture Content (%)	0.10
Lithology	MAFi	Wet Density (kg/m^3)	3016
		Dry Density (kg/m^3)	3013

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **27**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	190405
Location:	Not provided	**Depth (m):**	33.0-33.27
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements		
Max Load (kN)	**151.00**	Diameter	(mm)	61.11
		Height	(mm)	125.16
Stress σ_u (MPa)	**51.5**	Area	(cm²)	29.33
		Volume	(cm³)	367.10
Pace Rate (kN/s)	1.25	Mass	(g)	1105.40
		Moisture Content (%)		0.14
Lithology	MAFi	Wet Density	(kg/m³)	3011
		Dry Density	(kg/m³)	3007

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	**5**	**Mode:**
		(1) Simple Extension
Degrees:*	**25**	(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	190406-A
Location:	Not provided	**Depth (m):**	50.12-50.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**200.90**	Diameter (mm)	61.30
		Height (mm)	128.43
Stress σ_u (MPa)	**68.1**	Area (cm²)	29.51
		Volume (cm³)	379.03
Pace Rate (kN/s)	1.25	Mass (g)	1036.40
		Moisture Content (%)	0.14
Lithology	RHYv	Wet Density (kg/m³)	2734
		Dry Density (kg/m³)	2731

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **34**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	190406-B
Location:	Not provided	**Depth (m):**	50.12-50.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**119.40**	Diameter (mm)	61.29
		Height (mm)	126.16
Stress σ_u (MPa)	**40.5**	Area (cm²)	29.50
		Volume (cm³)	372.21
Pace Rate (kN/s)	1.25	Mass (g)	1018.50
		Moisture Content (%)	0.12
Lithology	RHYv	Wet Density (kg/m³)	2736
		Dry Density (kg/m³)	2733

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	5	**Mode:**
		(1) Simple Extension
Degrees:*	38	(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-353
Project:	KZK	**Sample Number:**	190407
Location:	Not provided	**Depth (m):**	82.08-82.31
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements		
Max Load (kN)	**280.90**	Diameter	(mm)	61.68
		Height	(mm)	129.43
Stress σ_u (MPa)	**94.0**	Area	(cm²)	29.88
		Volume	(cm³)	386.74
Pace Rate (kN/s)	1.25	Mass	(g)	1024.90
		Moisture Content (%)		0.20
Lithology	RHY	Wet Density	(kg/m³)	2650
		Dry Density	(kg/m³)	2645

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	**5**	**Mode:**
		(1) Simple Extension
Degrees:*	**18**	(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-354
Project:	KZK	**Sample Number:**	190410
Location:	Not provided	**Depth (m):**	33.0-33.27
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results

Max Load (kN)	**276.00**
Stress σ_u (MPa)	**94.5**
Pace Rate (kN/s)	1.25
Lithology	RHYi

Sample Measurements

Diameter	(mm)	60.99
Height	(mm)	122.45
Area	(cm^2)	29.22
Volume	(cm^3)	357.74
Mass	(g)	937.80
Moisture Content (%)		0.33
Wet Density	(kg/m^3)	2621
Dry Density	(kg/m^3)	2613

BEFORE TEST

Failure Mode

Type: **4**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-356
Project:	KZK	**Sample Number:**	190411
Location:	Not provided	**Depth (m):**	12.5-12.8
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**221.90**	Diameter (mm)	60.78
		Height (mm)	128.56
Stress σ_u (MPa)	**76.5**	Area (cm²)	29.01
		Volume (cm³)	373.01
Pace Rate (kN/s)	1.25	Mass (g)	1040.50
		Moisture Content (%)	0.14
Lithology	MAFi	Wet Density (kg/m³)	2789
		Dry Density (kg/m³)	2786

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **15**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190412
Location:	Not provided	**Depth (m):**	48.0-48.25
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**183.80**	Diameter (mm)	61.11
		Height (mm)	131.13
Stress σ_u (MPa)	**62.7**	Area (cm²)	29.33
		Volume (cm³)	384.61
Pace Rate (kN/s)	1.25	Mass (g)	1070.50
		Moisture Content (%)	0.26
Lithology	RHYv	Wet Density (kg/m³)	2783
		Dry Density (kg/m³)	2776

BEFORE TEST

Failure Mode

Type: **5/6**

Degrees:* **40**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments

AFTER TEST

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190413
Location:	Not provided	**Depth (m):**	74.3-74.6
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements		
Max Load (kN)	**149.20**	Diameter	(mm)	61.37
		Height	(mm)	128.82
Stress σ_u (MPa)	**50.4**	Area	(cm^2)	29.58
		Volume	(cm^3)	381.05
Pace Rate (kN/s)	1.25	Mass	(g)	1057.80
		Moisture Content (%)		0.17
Lithology	RHYv	Wet Density	(kg/m^3)	2776
		Dry Density	(kg/m^3)	2771

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **33**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190414
Location:	Not provided	**Depth (m):**	90.6-90.85
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results	
Max Load (kN)	**152.50**
Stress σ_u (MPa)	**51.6**
Pace Rate (kN/s)	1.25
Lithology	RHYi

Sample Measurements		
Diameter	(mm)	61.32
Height	(mm)	130.06
Area	(cm²)	29.53
Volume	(cm³)	384.09
Mass	(g)	1000.80
Moisture Content (%)		0.23
Wet Density	(kg/m³)	2606
Dry Density	(kg/m³)	2600

BEFORE TEST

Failure Mode

Type: **1***

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Sample broke along healed discontinuity.

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190415
Location:	Not provided	**Depth (m):**	104.4-104.65
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**153.10**	Diameter (mm)	61.36
		Height (mm)	128.70
Stress σ_u (MPa)	**51.8**	Area (cm^2)	29.57
		Volume (cm^3)	380.57
Pace Rate (kN/s)	1.25	Mass (g)	1008.40
		Moisture Content (%)	0.29
Lithology	RHYc	Wet Density (kg/m^3)	2650
		Dry Density (kg/m^3)	2642

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **19**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190416-A
Location:	Not provided	**Depth (m):**	192.5-192.85
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**57.70**	Diameter (mm)	61.10
		Height (mm)	131.16
Stress σ_u (MPa)	**19.7**	Area (cm²)	29.32
		Volume (cm³)	384.57
Pace Rate (kN/s)	1.25	Mass (g)	1061.00
		Moisture Content (%)	0.29
Lithology	RHYc	Wet Density (kg/m³)	2759
		Dry Density (kg/m³)	2751

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **55**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments

Shear along foliation.

AFTER TEST

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190416-B
Location:	Not provided	**Depth (m):**	192.5-192.85
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**24.60**	Diameter (mm)	61.07
		Height (mm)	125.78
Stress σ_u (MPa)	**8.4**	Area (cm²)	29.29
		Volume (cm³)	368.43
Pace Rate (kN/s)	1.25	Mass (g)	1027.10
		Moisture Content (%)	0.22
Lithology	RHYc	Wet Density (kg/m³)	2788
		Dry Density (kg/m³)	2782

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **54**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190417-A
Location:	Not provided	**Depth (m):**	195.35-195.70
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**88.50**	Diameter (mm)	61.13
		Height (mm)	129.70
Stress σ_u (MPa)	**30.2**	Area (cm^2)	29.35
		Volume (cm^3)	380.66
Pace Rate (kN/s)	1.25	Mass (g)	1057.10
		Moisture Content (%)	0.11
Lithology	RHYc	Wet Density (kg/m^3)	2777
		Dry Density (kg/m^3)	2774

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **57**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190417-B
Location:	Not provided	**Depth (m):**	195.35-195.70
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results	
Max Load (kN)	**105.90**
Stress σ_u (MPa)	**36.2**
Pace Rate (kN/s)	1.25
Lithology	RHYc

Sample Measurements		
Diameter	(mm)	61.04
Height	(mm)	113.04
Area	(cm²)	29.26
Volume	(cm³)	330.79
Mass	(g)	925.00
Moisture Content (%)		0.13
Wet Density	(kg/m³)	2796
Dry Density	(kg/m³)	2793

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **67**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments

Sample size does not meet standard requirements.

Shear along folation with rock bridges.

AFTER TEST

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	190421-A
Location:	Not provided	**Depth (m):**	64.15-64.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**94.30**	Diameter (mm)	61.12
		Height (mm)	125.59
Stress σ_u (MPa)	**32.1**	Area (cm²)	29.34
		Volume (cm³)	368.48
Pace Rate (kN/s)	1.25	Mass (g)	1037.70
		Moisture Content (%)	0.29
Lithology	RHY	Wet Density (kg/m³)	2816
		Dry Density (kg/m³)	2808

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **37**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Shear along foliation with rock bridges.

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-358
Project:	KZK	**Sample Number:**	190421-B
Location:	Not provided	**Depth (m):**	64.15-64.46
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements		
Max Load (kN)	**123.50**	Diameter	(mm)	61.15
		Height	(mm)	128.11
Stress σ_u (MPa)	**42.1**	Area	(cm²)	29.37
		Volume	(cm³)	376.24
Pace Rate (kN/s)	1.25	Mass	(g)	1034.80
		Moisture Content (%)		0.32
Lithology	RHY	Wet Density	(kg/m³)	2750
		Dry Density	(kg/m³)	2742

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **39**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Single shear along foliation with rock bridges

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190422
Location:	Not provided	**Depth (m):**	309.0-309.28
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements		
Max Load (kN)	**188.30**	Diameter	(mm)	60.85
		Height	(mm)	131.81
Stress σ_u (MPa)	**64.7**	Area	(cm²)	29.08
		Volume	(cm³)	383.32
Pace Rate (kN/s)	1.25	Mass	(g)	1140.40
		Moisture Content (%)		0.18
Lithology	MAFi	Wet Density	(kg/m³)	2975
		Dry Density	(kg/m³)	2970

BEFORE TEST

Failure Mode		Notes
		- Water content as received
		- Wet density based on as received moisture
Type:	**5**	**Mode:**
		(1) Simple Extension
Degrees:*	**29**	(2) Multiple Extension
		(3) Multiple Fracturing
* Degrees measured with respect to core axis.		(4) Multiple Shear
		(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.		(6) Spalling
		(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-357
Project:	KZK	**Sample Number:**	190423
Location:	Not provided	**Depth (m):**	315.38-315.76
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**137.70**	Diameter (mm)	60.73
		Height (mm)	127.05
Stress σ_u (MPa)	**47.5**	Area (cm²)	28.97
		Volume (cm³)	368.02
Pace Rate (kN/s)	1.25	Mass (g)	1076.40
		Moisture Content (%)	0.32
Lithology	MAFi	Wet Density (kg/m³)	2925
		Dry Density (kg/m³)	2916

BEFORE TEST

Failure Mode		Notes
Type:	**6/5**	- Water content as received
Degrees:*	**77**	- Wet density based on as received moisture

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Mode:
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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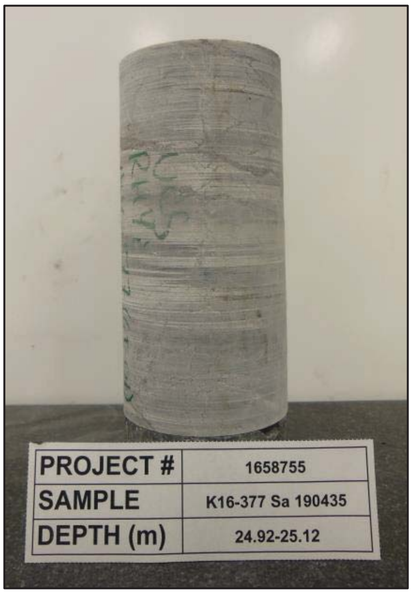
Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-377
Project:	KZK	**Sample Number:**	190435
Location:	Not provided	**Depth (m):**	24.92-25.12
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results	
Max Load (kN)	**359.30**
Stress σ_u (MPa)	**122.6**
Pace Rate (kN/s)	1.25
Lithology	RHYi

Sample Measurements		
Diameter	(mm)	61.09
Height	(mm)	126.18
Area	(cm^2)	29.31
Volume	(cm^3)	369.85
Mass	(g)	975.70
Moisture Content (%)		0.23
Wet Density	(kg/m^3)	2638
Dry Density	(kg/m^3)	2632



BEFORE TEST

Failure Mode

Type: **1**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190436
Location:	Not provided	**Depth (m):**	59.91-60.13
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**361.80**	Diameter (mm)	61.11
		Height (mm)	125.21
Stress σ_u (MPa)	**123.4**	Area (cm²)	29.33
		Volume (cm³)	367.24
Pace Rate (kN/s)	1.25	Mass (g)	961.90
		Moisture Content (%)	0.19
Lithology	RHYi	Wet Density (kg/m³)	2619
		Dry Density (kg/m³)	2614

BEFORE TEST

Failure Mode

Type: **1**

Degrees:* ______

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190437
Location:	Not provided	**Depth (m):**	58.95-59.22
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**198.00**	Diameter (mm)	61.09
		Height (mm)	126.33
Stress σ_u (MPa)	**67.6**	Area (cm^2)	29.31
		Volume (cm^3)	370.29
Pace Rate (kN/s)	1.25	Mass (g)	974.30
		Moisture Content (%)	0.23
Lithology	RHYi	Wet Density (kg/m^3)	2631
		Dry Density (kg/m^3)	2625

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **14**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

The test data given herein pertain to the sample provided only. This report constitutes a testing service only.

[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

Golder Associates Ltd.
300, 3811 North Fraser Way, Burnaby, British Columbia, Canada V5J 5J2
Tel: 604-412-6899 Fax: 604-412-6816 www.golder.com

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-376
Project:	KZK	**Sample Number:**	190438
Location:	Not provided	**Depth (m):**	14.84-15.20
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**101.30**	Diameter (mm)	61.27
		Height (mm)	127.12
Stress σ_u (MPa)	**34.4**	Area (cm²)	29.48
		Volume (cm³)	374.80
Pace Rate (kN/s)	1.25	Mass (g)	1034.80
		Moisture Content (%)	0.08
Lithology	RHYv	Wet Density (kg/m³)	2761
		Dry Density (kg/m³)	2759

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **21**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Shear along foliation.

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Golder Associates

Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-373
Project:	KZK	**Sample Number:**	190439-A
Location:	Not provided	**Depth (m):**	61.48-61.81
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**38.60**	Diameter (mm)	60.62
		Height (mm)	127.17
Stress σ_u (MPa)	**13.4**	Area (cm^2)	28.86
		Volume (cm^3)	367.03
Pace Rate (kN/s)	1.25	Mass (g)	1098.10
		Moisture Content (%)	0.28
Lithology	MAFi	Wet Density (kg/m^3)	2992
		Dry Density (kg/m^3)	2983

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **25**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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TESTED BY	DATE	CHECKED BY	DATE
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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)
ASTM D7012

Project No.:	1658755	**Borehole:**	K16-373
Project:	KZK	**Sample Number:**	190439-B
Location:	Not provided	**Depth (m):**	61.48-61.81
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**103.70**	Diameter (mm)	60.70
		Height (mm)	128.28
Stress σ_u (MPa)	**35.8**	Area (cm²)	28.94
		Volume (cm³)	371.22
Pace Rate (kN/s)	1.25	Mass (g)	1108.90
		Moisture Content (%)	0.22
Lithology	MAFi	Wet Density (kg/m³)	2987
		Dry Density (kg/m³)	2981

BEFORE TEST

Failure Mode	Notes
	- Water content as received
	- Wet density based on as received moisture
Type: **5**	**Mode:**
	(1) Simple Extension
Degrees:* **28**	(2) Multiple Extension
	(3) Multiple Fracturing
* Degrees measured with respect to core axis.	(4) Multiple Shear
	(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.	(6) Spalling
	(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
TESTED BY	DATE	CHECKED BY	DATE

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-373
Project:	KZK	**Sample Number:**	190441
Location:	Not provided	**Depth (m):**	68.94-69.29
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results	
Max Load (kN)	**60.40**
Stress σ_u (MPa)	**20.8**
Pace Rate (kN/s)	1.25
Lithology	MAFi

Sample Measurements		
Diameter	(mm)	60.75
Height	(mm)	129.27
Area	(cm^2)	28.99
Volume	(cm^3)	374.70
Mass	(g)	1063.30
Moisture Content (%)		0.22
Wet Density	(kg/m^3)	2838
Dry Density	(kg/m^3)	2832

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **33**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

Shear along foliation with rock bridges.

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
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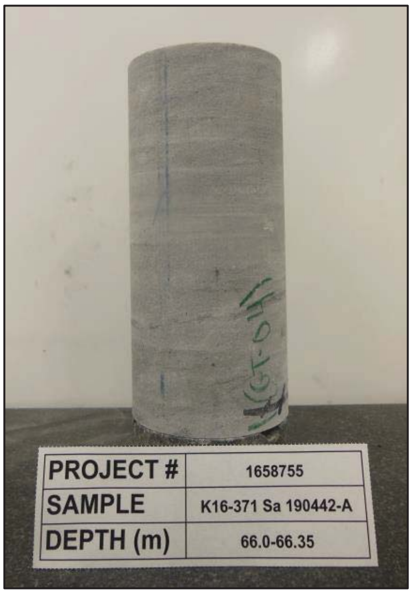
Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)
ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190442-A
Location:	Not provided	**Depth (m):**	66.0-66.35
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**355.20**	Diameter (mm)	60.13
		Height (mm)	129.16
Stress σ_u (MPa)	**125.1**	Area (cm²)	28.40
		Volume (cm³)	366.78
Pace Rate (kN/s)	1.25	Mass (g)	1004.30
		Moisture Content (%)	0.15
Lithology	RHYi	Wet Density (kg/m³)	2738
		Dry Density (kg/m³)	2734



BEFORE TEST

Failure Mode

Type: **6**

Degrees:*

* Degrees measured with respect to core axis.

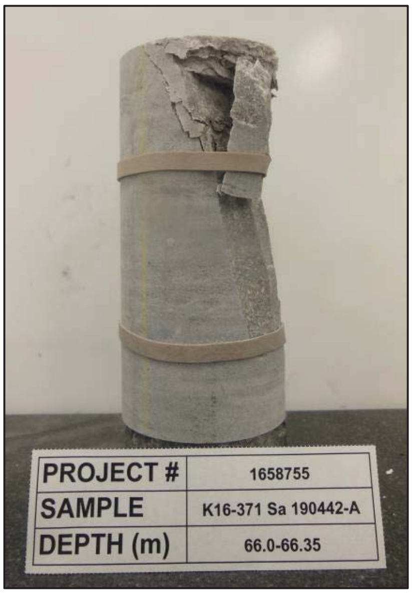
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

Comments



AFTER TEST

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190442-B
Location:	Not provided	**Depth (m):**	66.0-66.35
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**432.00**	Diameter (mm)	61.08
		Height (mm)	125.29
Stress σ_u (MPa)	**147.4**	Area (cm²)	29.30
		Volume (cm³)	367.12
Pace Rate (kN/s)	1.25	Mass (g)	988.70
		Moisture Content (%)	0.15
Lithology	RHYi	Wet Density (kg/m³)	2693
		Dry Density (kg/m³)	2689

BEFORE TEST

Failure Mode

Type: **6**

Degrees:*

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:

(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)

ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190445-A
Location:	Not provided	**Depth (m):**	88.50-88.79
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results		Sample Measurements	
Max Load (kN)	**303.70**	Diameter (mm)	61.12
		Height (mm)	126.22
Stress σ_u (MPa)	**103.5**	Area (cm²)	29.34
		Volume (cm³)	370.33
Pace Rate (kN/s)	1.25	Mass (g)	1001.90
		Moisture Content (%)	0.16
Lithology	RHYv	Wet Density (kg/m³)	2705
		Dry Density (kg/m³)	2701

BEFORE TEST

Failure Mode	Notes
	- Water content as received
	- Wet density based on as received moisture
Type: **5**	**Mode:**
	(1) Simple Extension
Degrees:* **15**	(2) Multiple Extension
	(3) Multiple Fracturing
* Degrees measured with respect to core axis.	(4) Multiple Shear
	(5) Single Shear
The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.	(6) Spalling
	(7) Other

AFTER TEST

Comments

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Uniaxial Compressive Strength of Intact Rock Core Specimens (Method C)
ASTM D7012

Project No.:	1658755	**Borehole:**	K16-371
Project:	KZK	**Sample Number:**	190445-B
Location:	Not provided	**Depth (m):**	88.50-88.79
Client:	BMC Minerals Ltd.	**Lab ID No:**	270

Testing Results

Max Load (kN)	**295.90**
Stress σ_u (MPa)	**100.8**
Pace Rate (kN/s)	1.25
Lithology	RHYv

Sample Measurements

Diameter	(mm)	61.15
Height	(mm)	129.29
Area	(cm²)	29.37
Volume	(cm³)	379.71
Mass	(g)	1039.50
Moisture Content (%)		0.13
Wet Density	(kg/m³)	2738
Dry Density	(kg/m³)	2734

BEFORE TEST

Failure Mode

Type: **5**

Degrees:* **14**

* Degrees measured with respect to core axis.

The impact of any pre-existing feature on the test results will be noted in the comments, if applicable.

Notes

- Water content as received
- Wet density based on as received moisture

Mode:
(1) Simple Extension
(2) Multiple Extension
(3) Multiple Fracturing
(4) Multiple Shear
(5) Single Shear
(6) Spalling
(7) Other

AFTER TEST

Comments

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[Name Redacted]	July 22, 2016	[Name Redacted]	July 27,2016
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UCS TEST RESULTS - MDU

August 23, 2016

Imran Haque, EIT

SUMMARY

A total of six samples were gathered for testing where a total of seven tests were possible given the length and diameter ratios as per ASTM standards. One sample was broken upon arrival whereas two samples broke when attempting to sulfur cap. Therefore, a total of four UCS tests were completed successfully.

Due to the weak nature of the sedimentary rock, a wet weight was excluded for measurement due to excessive handling required which may cause further damage to the sample. Preparation of the sample included an average measurement of the length and diameter, dry weight, and sulfur capping or saw cutting, if possible.

Before testing, a pace rate of 2.4 kN/s was applied. Core length and diameter were input on to the machine before testing. All tests required plates on the base due to the sample length and any debris or material was wiped off before each test.

Out of the four samples, Q190446 was the most carbonaceous weakly foliated sample which was the best representation of KZK's mudstone unit. The UCS strength of said sample was 9 MPa with a Type 4 failure breaking along foliation at 62°.

The remaining three samples, Q190450-A, Q190450-B, and Q930551, were noted as an MDU unit but did consist of biotite and calcite veining and was not as carbonaceous as Q190446. The three samples collected were a gradational contact between the MDU and MAFt units. The UCS results were 24.9 MPa, 29.3 MPa, 35.3 MPa. This results in an average strength of 29.8 MPa and a standard deviation of +/- 5.2 MPa.

Given the results above and due to the lacking number of MDU unit samples that meet the standard length and diameter ratio, as well as weak engineering and strength properties, it is fair to assume a carbonaceous MDU unit is <25 MPa.

Sample ID:	Q930551	**σ (MPa):**	35.3
Length (mm):	130	**α (°):**	55
Diameter (mm):	61.1	**Type:**	2
Dry Weight (kg):	1.0661	**Preparation:**	Sulfur Cap

Comments: Broke along weak plane of foliation as well as vertical cracks observed from both ends of cap.

Sample ID:	Q190448	**σ (MPa):**	-
Length (mm):	-	**α (°):**	-
Diameter (mm):	-	**Type:**	-
Dry Weight (kg):	-	**Preparation:**	Broken

Comments: Sample broken upon arrival.

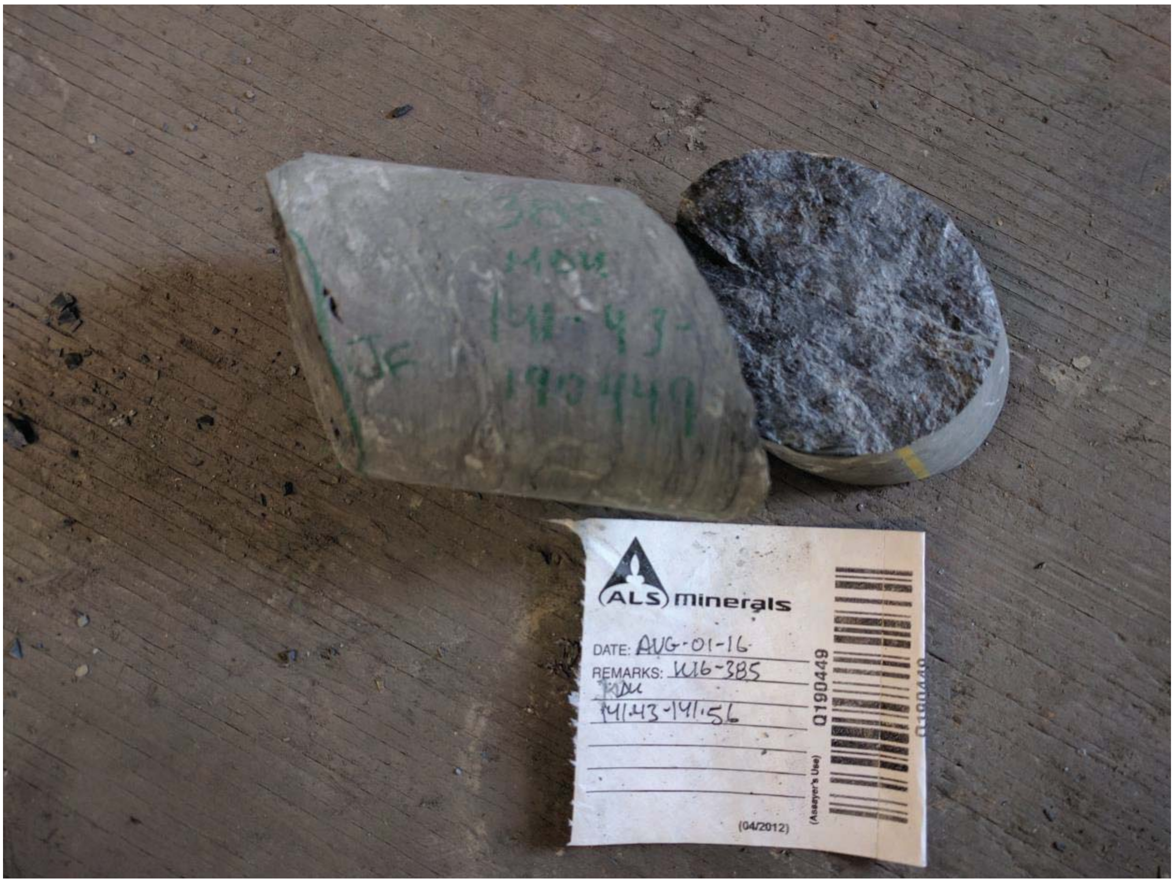
Sample ID:	Q190448	**σ (MPa):**	9.0
Length (mm):	99	**α (°):**	62
Diameter (mm):	61.1	**Type:**	4
Dry Weight (kg):	1.0254	**Preparation:**	Sulfur Cap

Comments: Best representation of MDU unit due to amount of carbonaceous material and weak planes of foliation. Sample does not meet L/D ratio. Fresh diagonal cut failure which may be the cause of unbonded sulfur cap.

Sample ID:	Q190447	σ (MPa):	-
Length (mm):	-	α (°):	-
Diameter (mm):	-	Type:	-
Dry Weight (kg):	-	Preparation:	Broke

Comments: Broke when attempting to sulfur cap.

Sample ID:	Q190449	**σ (MPa):**	-
Length (mm):	-	**α (°):**	-
Diameter (mm):	-	**Type:**	-
Dry Weight (kg):	-	**Preparation:**	Broke



Comments: Broke when attempting to sulfur cap.

Sample ID:	Q190450-A	**σ (MPa):**	24.9
Length (mm):	142	**α (°):**	38
Diameter (mm):	61.1	**Type:**	2
Dry Weight (kg):	1.1723	**Preparation:**	Saw

Comments: Well defined cone at bottom with vertical cracks on top end of cone.

Sample ID:	Q190450-B	**σ (MPa):**	29.3
Length (mm):	145	**α (°):**	85
Diameter (mm):	61.1	**Type:**	3
Dry Weight (kg):	1.2061	**Preparation:**	Saw

Comments: Vertical cracking on both ends of cone.

APPENDIX III

Guide for Rock Mass Classification Systems

Rock Mass Rating (RMR$_{76}$) System

	Parameter		Ranges of Values						
1	Strength of intact rock material	Point load strength index	> 8 MPa	4-8 MPa	2-4 MPa	1-2 MPa	For this low range uniaxial		
		Uniaxial compressive strength	> 200 MPa	100-200 MPa	50-100 MPa	25-50 MPa	10-25 MPa	3-10 MPa	1-3 MPa
	Rating		15	12	7	4	2	1	0
2	Drill core quality RQD		90% - 100%	75% - 90%	50% - 75%	25% - 50%	<25%		
	Rating		20	17	13	8	3		
3	Spacing of joints		>3 m	1-3 m	0.3 – 1 m	50 – 300 mm	<50 mm		
	Rating		30	25	20	10	5		
4	Condition of joints		Very rough surfaces Not continuous No Separation Hard joint wall rock	Slightly rough surfaces Separation <1 mm Hard joint wall rock	Slightly rough surfaces Separation <1 mm Soft joint wall rock	Slickensided surfaces OR Gouge <5 mm thick OR joint	Soft gouge >5 mm thick OR Joints open >5 mm continuous joints		
	Rating		25	20	12	6	0		
5	Groundwater	Inflow per 10 m per tunnel length	None		<25 litres / min	25-125 litres / min	>125 litres / min		
		Raito joint water pressure / major principal stress	0		0.0 – 0.2	0.2 – 0.5	>0.5		
		General conditions	Completely dry		Moist only (interstitial water)	Water under moderate pressure	Server water problems		
	Rating		10		7	4	0		

Tunneling Quality Index (Q) Classification System

1	RQD (Rock Quality Designation)		RQD
A	Very poor	(> 27 joints per m³)	0-25
B	Poor	(20-27 joints per m³)	25-50
C	Fair	(13-19 joints per m³)	50-75
D	Good	(8-12 joints per m³)	75-90
E	Excellent	(0-7 joints per m³)	90-100

Note: i) Where RQD is reported or measured as ≤ 10 (including 0) the value 10 is used to evaluate the Q-value

ii) RQD-intervals of 5, i.e. 100, 95, 90, etc., are sufficiently accurate

2	Joint set number	J_n
A	Massive, no or few joints	0.5-1.0
B	One joint set	2
C	One joint set plus random joints	3
D	Two joint sets	4
E	Two joint sets plus random joints	6
F	Three joint sets	9
G	Three joint sets plus random joints	12
H	Four or more joint sets, random heavily jointed "sugar cube", etc	15
J	Crushed rock, earth like	20

Note: i) For tunnel intersections, use 3 x J_n

ii) For portals, use 2 x J_n

3	Joint Roughness Number	J_r
	a) Rock-wall contact, and *b) Rock-wall contact before 10 cm of shear movement*	
A	Discontinuous joints	4
B	Rough or irregular, undulating	3
C	Smooth, undulating	2
D	Slickensided, undulating	1.5
E	Rough, irregular, planar	1.5
F	Smooth, planar	1
G	Slickensided, planar	0.5

Note: i) Description refers to small scale features and intermediate scale features, in that order

	c) No rock-wall contact when sheared	
H	Zone containing clay minerals thick enough to prevent rock-wall contact when sheared	1

Note: ii) Add 1 if the mean spacing of the relevant joint set is greater than 3 m (dependent on the size of the underground opening)

iii) J_r = 0.5 can be used for planar slickensided joints having lineations, provided the lineations are oriented in the estimated sliding direction

4	Joint Alteration Number	Φ_r approx.	J_a
	a) Rock-wall contact (no mineral fillings, only coatings)		
A	Tightly healed, hard, non-softening, impermeable filling, i.e., quartz or epidote.		0.75
B	Unaltered joint walls, surface staining only.	25-35°	1
C	Slightly altered joint walls. Non-softening mineral coatings; sandy particles, clay-free disintegrated rock, etc.	25-30°	2
D	Silty or sandy clay coatings, small clay fraction (non-softening).	20-25°	3
E	Softening or low friction clay mineral coatings, i.e., kaolinite or mica. Also chlorite, talc gypsum, graphite, etc., and small quantities of swelling clays.	8-16°	4
	b) Rock-wall contact before 10 cm shear (thin mineral fillings)		
F	Sandy particles, clay-free disintegrated rock, etc.	25-30°	4
G	Strongly over-consolidated, non-softening, clay mineral fillings (continuous, but <5mm thickness).	16-24°	6
H	Medium or low over-consolidation, softening, clay mineral fillings (continuous, but <5mm thickness).	12-16°	8
J	Swelling-clay fillings, i.e., montmorillonite (continuous, but <5mm thickness). Value of J_a depends on percent of swelling clay-size particles.	6-12°	8-12
	c) No rock-wall contact when sheared (thick mineral fillings)		
K	Zones or bands of disintegrated or crushed rock. Strongly over-consolidated.	16-24°	6
L	Zones or bands of clay, disintegrated or crushed rock. Medium or low over-consolidation or softening fillings.	12-16°	8
M	Zones or bands of clay, disintegrated or crushed rock. Swelling clay. J_a depends on percent of swelling clay-size particles.	6-12°	8-12
N	Thick continuous zones or bands of clay. Strongly over-consolidated.	16-24°	10
O	Thick, continuous zones or bands of clay. Medium to low over-consolidation.	12-16°	13
P	Thick, continuous zones or bands with clay. Swelling clay. J_a depends on percent of swelling clay-size particles.	6-12°	13-20

5	Joint Water Reduction Factor	J_w
A	Dry excavations or minor inflow (humid or a few drips)	1.0
B	Medium inflow, occasional outwash of joint fillings (many drips/"rain")	0.66
C	Jet inflow or high pressure in competent rock with unfilled joints	0.5
D	Large inflow or high pressure, considerable outwash of joint fillings	0.33
E	Exceptionally high inflow or water pressure decaying with time. Causes outwash of material and perhaps cave in	0.2-0.1
F	Exceptionally high inflow or water pressure continuing without noticeable decay. Causes outwash of material and perhaps cave in	0.1-0.05

Note: i) Factors C to F are crude estimates. Increase J_w if the rock is drained or grouting is carried out

ii) Special problems caused by ice formation are not considered

6	Stress Reduction Factor	SRF
	a) Weak zones intersecting the underground opening, which may cause loosening of rock mass	
A	Multiple occurrences of weak zones within a short section containing clay or chemically disintegrated, very loose surrounding rock (any depth), or long sections with incompetent (weak) rock (any depth). For squeezing, see 6L and 6M	10
B	Multiple shear zones within a short section in competent clay-free rock with loose surrounding rock (any depth)	7.5
C	Single weak zones with or without clay or chemical disintegrated rock (depth ≤ 50m)	5
D	Loose, open joints, heavily jointed or "sugar cube", etc. (any depth)	5
E	Single weak zones with or without clay or chemical disintegrated rock (depth > 50m)	2.5

Note: i) Reduce these values of SRF by 25-50% if the weak zones only influence but do not intersect the underground opening

	b) Competent, mainly massive rock, stress problems	σ_c/σ_1	σ_θ/σ_c	SRF
F	Low stress, near surface, open joints	>200	<0.01	2.5
G	Medium stress, favourable stress condition	200-10	0.01-0.3	1
H	High stress, very tight structure. Usually favourable to stability. May also be unfavourable to stability dependent on the orientation of stresses compared to jointing/weakness planes*	10-5	0.3-0.4	0.5-2 2-5*
J	Moderate spalling and/or slabbing after > 1 hour in massive rock	5-3	0.5-0.65	5-50
K	Spalling or rock burst after a few minutes in massive rock	3-2	0.65-1	50-200
L	Heavy rock burst and immediate dynamic deformation in massive rock	<2	>1	200-400

Note: ii) For strongly anisotropic virgin stress field (if measured): when $5 \le \sigma_1/\sigma_3 \le 10$, reduce σ_c to $0.75\,\sigma_c$. When $\sigma_1/\sigma_3 > 10$, reduce σ_c to $0.5\,\sigma_c$, where σ_c = unconfined compression strength, σ_1 and σ_3 are the major and minor principal stresses, and σ_θ = maximum tangential stress (estimated from elastic theory)

iii) When the depth of the crown below the surface is less than the span; suggest SRF increase from 2.5 to 5 for such cases (see F)

	c) Squeezing rock: plastic deformation in incompetent rock under the influence of high pressure	σ_θ/σ_c	SRF
M	Mild squeezing rock pressure	1-5	5-10
N	Heavy squeezing rock pressure	>5	10-20

Note: iv) Determination of squeezing rock conditions must be made according to relevant literature (i.e. Singh et al., 1992 and Bhasin and Grimstad, 1996)

	d) Swelling rock: chemical swelling activity depending on the presence of water	SRF
O	Mild swelling rock pressure	5-10
P	Heavy swelling rock pressure	10-15

Note:
The values for J_r and J_a should be chosen based on the orientation and shear strength, τ, (where $\tau \approx \sigma \tan^{-1}(J_r/J_a)$) of the joint or discontinuity that gives the most unfavourable stability for the rock mass, and along which failure most likely will occur.

APPENDIX IV

GEOTECHNICAL DRILL HOLES

AND

POINT LOAD TEST

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-351	Krakatoa (in-pit)	All	KRAK025	415130	6815045	1399.4	198	-59	NQ3	214	24-May-16	25-May-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	DH		
Geotech Log	HM	IH	01-Jun-16
PLT	IH	IH	01-Jun-16
UCS	N/A	N/A	N/A

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-351	0.00	9.30	Overburden (OVBN)
K16-351	9.30	9.90	Coherent rhyolite (RHYc)
K16-351	9.90	14.50	Pelite (PEL)
K16-351	14.50	17.30	Volcaniclastic rhyolite (RHYv)
K16-351	17.30	19.80	Volcaniclastic rhyolite (RHYv)
K16-351	19.80	32.10	Aphanitic rhyolite (RHYi)
K16-351	32.10	34.40	Volcaniclastic rhyolite (RHYv)
K16-351	34.40	36.30	Pelite (PEL)
K16-351	36.30	37.00	Volcaniclastic rhyolite (RHYv)
K16-351	37.00	37.50	Pelite (PEL)
K16-351	37.50	38.90	Coherent rhyolite (RHYc)
K16-351	38.90	53.60	Volcaniclastic rhyolite (RHYv)
K16-351	53.60	54.80	No Core
K16-351	54.80	68.00	Volcaniclastic rhyolite (RHYv)
K16-351	68.00	93.00	Coherent rhyolite (RHYc)
K16-351	93.00	94.60	Rhyolite (RHY)
K16-351	94.60	95.60	Mafic intrusion (MAFi)
K16-351	95.60	101.90	Volcaniclastic rhyolite (RHYv)
K16-351	101.90	103.00	Mafic intrusion (MAFi)
K16-351	103.00	110.90	Volcaniclastic rhyolite (RHYv)
K16-351	110.90	131.80	Mafic intrusion (MAFi)
K16-351	131.80	133.40	Semi-massive sulphide (OI, OJ)
K16-351	133.40	135.60	Massive sulphide (OA, OB, OC, OF, OK)
K16-351	135.60	140.20	Massive sulphide (OA, OB, OC, OF, OK)
K16-351	140.20	146.90	Volcaniclastic rhyolite (RHYv)
K16-351	146.90	147.50	Aphanitic rhyolite (RHYi)
K16-351	147.50	149.60	Volcaniclastic rhyolite (RHYv)
K16-351	149.60	152.00	Aphanitic rhyolite (RHYi)
K16-351	152.00	153.40	Rhyolite (RHY)
K16-351	153.40	155.10	Aphanitic rhyolite (RHYi)
K16-351	155.10	156.90	Rhyolite (RHY)
K16-351	156.90	161.10	Aphanitic rhyolite (RHYi)
K16-351	161.10	163.20	Rhyolite (RHY)
K16-351	163.20	198.00	Fault Zone (FLZ)
		EOH	

Geotechnical Log

Hole ID	Zone	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	Discontinuity parameters: 0-29 Count	Type	Jr	Ja	30-59 Count	Type	Jr	Ja	60-90 Count	Type	Jr	Ja	Alpha	Beta	Type	Confidence		Fault and Broken Zones					Comment
K16-351	HW	RHYc	9.3	9.9	0.6	0.6	100%	9	0.0	0%	W2	R3	2									6	J	2	4	70.0		J	1	12	0%	0%	0%	0%	0%	
K16-351	HW	PEL	9.9	14.5	4.6	3.2	70%	57	2.0	43%	W2	R2	2	1	J	4	1	4	J	2	2	52	J, Fol	2	4				1	12	0%	0%	0%	5%	0%	
K16-351	HW	RHYv	14.5	19.8	5.3	4.6	86%	75	2.0	37%	W3	R3	3					5	J	2	4	57	J, Fol	2	4	60.0	240.0	J	2	12	0%	0%	0%	5%	0%	
K16-351	HW	RHYi	19.8	22.8	3.0	2.8	93%	17	1.9	63%	W2	R3/R4	3	3	J	2	4	0				14	J	2	4	65.0	270.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYi	22.8	25.8	3.0	2.6	87%	13	2.4	80%	W2	R3/R4	3	1	J	2	4	0				12	J	2	4	65.0	250.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYi	25.8	28.8	3.0	1.9	63%	6	1.9	63%	W2	R3/R4	3	1	J	2	4	0				5	J	2	4	60.0	80.0	J	1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYi	28.8	32.1	3.3	2.8	85%	21	1.9	58%	W3	R3/R4	3	4	J	2	4	0				17	J	2	4	25.0	170.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	32.1	34.4	2.3	2.3	100%	12	1.8	78%	W2	R3	3	1	J	2	4	1	J	2	4	10	J	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	PEL	34.4	36.3	1.9	1.8	95%	3	1.7	89%	W1	R3	2					1	J	3	3	2	J	2	4	80.0	280.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	36.3	37.0	0.7	0.7	100%	5	0.4	57%	W2	R3	3	2	J	2	4					3	J	2	4	80.0	90.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYc	37.0	38.9	1.9	1.5	79%	5	1.3	68%	W2	R3	3	1	J	2	4					4	J	2	4	20.0	75.0	J	2	12	0%	0%	0%	0%	0%	0.5m of PEL lumped into it
K16-351	HW	RHYv	38.9	41.9	3.0	2.7	90%	31	1.8	60%	W2	R3	3	1	J	2	4					30	J	2	4	85.0	290.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	41.9	44.9	3.0	2.6	87%	37	0.8	27%	W3	R2/R3	4	3	J	2	4					34	J	2	4	70.0	320.0	J	2	12	0%	0%	10%	0%	0%	
K16-351	HW	RHYv	44.9	47.9	3.0	2.7	90%	19	1.5	50%	W2	R3	3	1	J	2	4	1	J	2	4	17	J	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	47.9	50.9	3.0	2.6	87%	31	1.1	37%	W2	R3	3	2	J	3	3					29	J	2	4				1	12	0%	0%	10%	0%	10%	
K16-351	HW	RHYv	50.9	53.9	3.0	2.2	73%	30	1.2	40%	W2	R3	3									30	J	2	4				1	12	0%	0%	5%	0%	15%	
K16-351	HW	RHYv	53.9	56.9	3.0	2.9	97%	27	0.6	20%	W3	R3	3	1	J	3	3					26	J	2	4				1	12	40%	0%	0%	0%	0%	Fault Gouge
K16-351	HW	RHYv	56.9	59.9	3.0	2.8	93%	44	1.1	37%	W2	R3	3	1	J	3	4					43	J	2	3	70.0	90.0	J	2	12	0%	0%	0%	5%	0%	
K16-351	HW	RHYv	59.9	62.9	3.0	1.8	60%	30	0.5	17%	W2	R3	2									30	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	1m wash away
K16-351	HW	RHYv	62.9	65.9	3.0	2.7	90%	41	1.2	40%	W2	R3	3									41	J, Fol	3	4	75.0	250.0	J	2	12	0%	0%	0%	5%	0%	
K16-351	HW	RHYv	65.9	68.9	3.0	2.1	70%	52	0.8	27%	W3	R2	3	1	J	2	4					51	J, Fol	2	4	70.0	270.0	J	2	12	0%	0%	0%	0%	30%	0.9m of RHYc
K16-351	HW	RHYc	68.9	71.9	3.0	1.9	63%	36	0.2	7%	W3	R2	3	1	J	3	4					35	J, Fol	2	4				1	12	0%	0%	0%	5%	5%	1m wash away
K16-351	HW	RHYc	71.9	74.9	3.0	2.0	67%	36	0.3	10%	W3	R2	2									36	J, Fol	2	4				1	12	0%	0%	0%	2%	0%	0.5 m wash away
K16-351	HW	RHYc	74.9	77.9	3.0	1.8	60%	38	0.4	13%	W3	R2	2									38	J, Fol	2	4				1	12	0%	0%	0%	10%	0%	1.5m wash away
K16-351	HW	RHYc	77.9	80.9	3.0	2.7	90%	35	1.1	37%	W3	R3	2									35	J, Fol	2	4	75.0	280.0	Fol	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYc	80.9	83.9	3.0	2.7	90%	25	1.8	60%	W3	R3	2									25	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	0.2m wash away
K16-351	HW	RHYc	83.9	86.9	3.0	2.6	87%	29	1.7	57%	W2	R3	2									29	J, Fol	2	4	70.0	330.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYc	86.9	89.9	3.0	2.6	87%	30	1.9	63%	W2	R3	3					1	J	3	3	29	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYc	89.9	93.0	3.1	2.5	81%	33	1.3	42%	W3	R2	2									33	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	0.3m wash out
K16-351	HW	RHY	93.0	95.6	2.6	2.1	81%	53	0.2	8%	W4	R2	3					2	J	3	4	51	J, Fol	2	4				1	12	0%	0%	0%	5%	20%	1m MAFi
K16-351	HW	RHYv	95.6	98.6	3.0	1.9	63%	38	0.5	17%	W3	R3	3					1	J	3	4	37	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	98.6	102.0	3.4	3.2	94%	58	1.3	38%	W3	R2	2									58	J, Fol	2	4				1	12	0%	0%	0%	0%	0%	0.1m MAFi
K16-351	HW	MAFi	102.0	103.0	1.0	0.9	90%	17	0.5	50%	W4	R2	3					1	J	3	3	16	Fol	3	3				1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	103.0	106.0	3.0	2.7	90%	58	0.5	17%	W2	R3	3	1		2	4					57	Fol	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	RHYv	106.0	110.4	4.4	1.1	25%	64	0.1	2%	W3	R3	2									64	Fol	2	4				1	12	0%	0%	10%	0%	10%	1.3m wash away
K16-351	HW	MAFi	110.4	113.4	3.0	1.6	53%	42	0.6	20%	W3	R2	3					1	J	3	3	41	Fol	3	3				1	12	0%	0%	0%	20%	0%	1.2m wash away
K16-351	HW	MAFi	113.4	116.4	3.0	2.9	97%	25	2.0	67%	W3	R2	2									25	Fol	3	3				1	12	0%	0%	0%	0%	0%	
K16-351	HW	MAFi	116.4	119.0	2.6	2.5	96%	28	1.0	38%	W3	R2	3					5	J	3	3	23	J, Fol	3	3				1	12	0%	0%	0%	0%	0%	
K16-351	HW	MAFi	119.0	122.0	3.0	2.8	93%	18	2.5	83%	W3	R2	3					16	Foil	3	4	2	J	3	4				1	12	0%	0%	0%	0%	0%	
K16-351	HW	MAFi	122.0	125.0	3.0	2.7	90%	27	1.3	43%	W3	R2	3					23	J, Fol	3	4	4	J	3	4	40.0	230.0	J	2	12	0%	0%	0%	0%	0%	
K16-351	HW	MAFi	125.0	128.0	3.0	2.6	87%	47	0.9	30%	W3	R2	3					25	J, Fol	3	4	22	J	2	4				1	12	0%	0%	10%	0%	10%	
K16-351	HW	MAFi	128.0	131.8	3.8	3.3	87%	27	1.4	37%	W3	R2	3					11	SHR	2	4	16	Foil	2	4				1	12	0%	0%	10%	0%	5%	
K16-351	Ore	Stringer/diss. sulphid	131.8	133.4	1.6	1.3	81%	25	0.1	6%	W3	R3/R4	2									25	Foil	2	4	70.0	250.0	Foil	2	12	0%	0%	10%	5%	0%	
K16-351	Ore	Mass. Sulphides	133.4	135.6	2.2	2.0	91%	11	1.4	64%	W1	R4	2					11	J	1.5	2					55.0	110.0	J	2	20	0%	0%	0%	0%	0%	
K16-351	Ore	Stringer	135.6	138.6	3.0	2.8	93%	9	2.4	80%	W1	R3/R4	2					9	J	1.5	2					55.0	140.0	J	2	20	0%	0%	0%	0%	0%	
K16-351	Ore	Stringer	138.6	140.2	1.6	1.5	94%	7	1.3	81%	W1	R4	2					7	J	2	2					30.0	140.0	J	2	20	0%	0%	0%	0%	0%	
K16-351	FW	RHY	140.2	143.2	3.0	2.9	97%	43	0.9	30%	W3	R3	2									43	Fol, J	2	4				1	12	0%	0%	0%	0%	0%	
K16-351	FW	RHY	143.2	146.9	3.7	3.1	84%	74	0.3	8%	W4	R3	2									74	Fol, J	2	4				1	12	0%	0%	60%	5%	5%	
K16-351	FW	RHYi	146.9	150.0	3.1	2.8	90%	39	1.2	39%	W3	R3	3					1	J	2	6	38	Foil	2	4	80.0	90.0		2	12	0%	0%	5%	0%	0%	
K16-351	FW	RHYi	150.0	153.0	3.0	2.7	90%	34	1.3	43%	W2	R3	3	1	J	4	6					33	Fol, J	2	4	30.0	340.0	J	1	12	0%	0%	10%	0%	0%	
K16-351	FW	RHYi	153.0	156.0	3.0	2.4	80%	40	0.9	30%	W3	R3	2									40	Fol, J	2	4				1	12	0%	0%	0%	10%	0%	0.9m of RHY
K16-351	FW	RHYi	156.0	159.0	3.0	2.5	83%	38	1.1	37%	W4	R3	3					1	J	4	4								1	12	0%	0%	0%	10%	5%	0.9m of RHY
K16-351	FW	RHYi	159.0	162.0	3.0	2.1	70%	39	1.1	37%	W4	R2	2					3	J	4	4	36	Fol, J	2	4	50.0	90.0	J	2	12	0%	0%	0%	5%	30%	0.9m of RHY
K16-351	FW	RHYi																								60.0	80.0	J	2							
K16-351	FW	RHY	162.0	163.2	1.2	1.0	83%	23	0.3	25%	W4	R2	3					2	J	4	4	21	Fol, J	4	6				1	12	0%	0%	10%	0%	10%	
K16-351	FW	Fault zone	163.2	166.0	2.8	2.3	82%	32	0.8	29%	W5	R0	6																1	12	0%	0%	0%	0%	90%	
K16-351	FW	Fault zone	166.0	169.0	3.0	3.0	100%	18	1.8	60%	W5	R0	6																1	6	30%	40%	0%	0%	30%	Fault clast in gouge, folded highly altered RHY
K16-351	FW	Fault zone	169.0	172.0	3.0	2.9	97%	120	0.7	23%	W5	R0	20																1	0	70%	30%	0%	0%	0%	argillitic clast in fault gouge
K16-351	FW	Fault zone	172.0	175.0	3.0	2.5	83%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	only evidence of rock structure preserved
K16-351	FW	Fault zone	175.0	178.0	3.0	2.5	83%	120	0.0	0%	W5	R0	20																1	0	90%	0%	0%	10%	0%	few heavily altered rock fragments, rubble
K16-351	FW	Fault zone	178.0	181.0	3.0	2.7	90%	54	1.2	40%	W5	R0	20																1	0	30%	0%	0%	5%	65%	gouge and heavily altered rock
K16-351	FW	Fault zone	181.0	184.0	3.0	1.8	60%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	gouge
K16-351	FW	Fault zone	184.0	187.0	3.0	2.7	90%	120	0.0	0%	W5	R0	20																1	0	90%	0%	10%	0%	0%	heavily altered rock (broken zone) within gouge
K16-351	FW	Fault zone	187.0	190.0	3.0	2.6	87%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	completely gouge
K16-351	FW	Fault zone	190.0	193.0	3.0	2.8	93%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	completely gouge
K16-351	FW	Fault zone	193.0	196.0	3.0	2.7	90%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	completely gouge
K16-351	FW	Fault zone	196.0	198.0	2.0	1.9	95%	120	0.0	0%	W5	R0	20																1	0	100%	0%	0%	0%	0%	completely gouge, End of hole

UCS Sample Summay

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
								0	#DIV/0!		
								0	#DIV/0!		
									#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7

Load Correction Factor = 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-351	PLT-001	58.80	HW	RHYv	7.9	L	a	fresh break II to fol. Valid	55.00	45	55.00	79	7.49	3151.27	0.002376567	0.9537	2.27	
K16-351	PLT-002	65.96	HW	RHYv	7.3	L	a	fresh break II to fol. Valid	45.00	45	45.00	73	6.92	2578.31	0.002684084	0.9537	2.56	
K16-351	PLT-003	68.00	HW	RHYv	10.1	L	a	fresh break II to fol. Valid	47.00	45	47.00	101	9.57	2692.90	0.00355557	0.9537	3.39	
K16-351	PLT-004	79.85	HW	RHYc	2.44	II	d	fresh break II valid	45.00	45	45.00	24.4	2.31	2025.00	0.001142281	0.9537	1.09	
K16-351	PLT-005	93.00	HW	RHY	1.18	II	d	natural break along fol. Valid	45.00	45	45.00	11.8	1.12	2025.00	0.000552415	0.9537	0.53	
K16-351	PLT-006	93.00	HW	RHY	3.96	L	a	fresh break L to fol. Valid	40.00	45	40.00	39.6	3.75	2291.83	0.001638026	0.9537	1.56	
K16-351	PLT-007	95.20	HW	MAFi	3.14	L	a	natural break along fol. Valid	35.00	45	35.00	31.4	2.98	2005.35	0.001484388	0.9537	1.42	
K16-351	PLT-008	114	HW	MAFi	6.06	L	a	natural break along fol. valid	45	45	45.00	60.6	5.74	2578.31	0.002228157	0.9537	2.12	
K16-351	PLT-009	133.2	Ore	string	5.88	II	d	fresh break valid	45	45	45.00	58.8	5.57	2025.00	0.002752711	0.9537	2.63	
K16-351	PLT-010	135.6	Ore	MXSX	10.1	II	d	fresh break valid	45	45	45.00	101	9.57	2025.00	0.004728296	0.9537	4.51	
K16-351	PLT-011	140.2	Ore	string	0.96	II	d	fresh break valid	45	45	45.00	9.6	0.91	2025.00	0.000449422	0.9537	0.43	
K16-351	PLT-012	157.1	FW	RHYi	3.28	II	d	fresh break valid	45	45	45.00	32.8	3.11	2025.00	0.001535526	0.9537	1.46	
K16-351	PLT-013	161.8	FW	RHYi	4.96	L	a	fresh break L to fol valid	29	45	29.00	49.6	4.70	1661.58	0.002829889	0.9537	2.70	
K16-351	PLT-014	171.8	FW	MDS	1.54	II	d	natural break along fol valid	45	45	45.00	15.4	1.46	2025.00	0.000720948	0.9537	0.69	
											0.00	0	0.00	0.00		0.0000		

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-352	Krakatoa	All	KRAK006	415130	6815045	1399.4	192	-83	HQ3	224	25-May-16	28-May-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	DH		
Geotechnical	ON	IH	3/Jun/16
PLT	IH	IH	3/Jun/16
UCS	N/A	N/A	

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-352	0	1.5	Overburden (OVBN)
K16-352	1.5	10.4	Coherent rhyolite (RHYc)
K16-352	10.4	12.7	Pelite (PEL)
K16-352	12.7	20.1	Volcaniclastic rhyolite (RHYv)
K16-352	20.1	33.3	Aphanitic rhyolite (RHYi)
K16-352	33.3	34	Volcaniclastic rhyolite (RHYv)
K16-352	34	37.4	Pelite (PEL)
K16-352	37.4	38.5	Coherent rhyolite (RHYc)
K16-352	38.5	38.8	Pelite (PEL)
K16-352	38.8	40.3	Coherent rhyolite (RHYc)
K16-352	40.3	65.8	Volcaniclastic rhyolite (RHYv)
K16-352	65.8	66.2	Mafic intrusion (MAFi)
K16-352	66.2	73	Volcaniclastic rhyolite (RHYv)
K16-352	73	75.3	Mudstone (MDS)
K16-352	75.3	77.5	Mudstone (MDS)
K16-352	77.5	107.9	Coherent rhyolite (RHYc)
K16-352	107.9	121.8	Volcaniclastic rhyolite (RHYv)
K16-352	121.8	124	Coherent rhyolite (RHYc)
K16-352	124	147.5	Mafic intrusion (MAFi)
K16-352	147.5	149.3	Semi-massive sulphide (OI, OJ)
K16-352	149.3	152.9	Mafic intrusion (MAFi)
K16-352	152.9	155.1	Rhyolite (RHY)
K16-352	155.1	156	Semi-massive sulphide (OI, OJ)
K16-352	156	164.7	Rhyolite (RHY)
K16-352	164.7	173.5	Aphanitic rhyolite (RHYi)
K16-352	173.5	187.2	Fault Zone (FLZ)
K16-352	187.2	188.9	Semi-massive sulphide (OI, OJ)
K16-352	188.9	192	Fault Zone (FLZ)

Geotechnical Log

Hole ID	Zone	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)
			Core Recovery Data				
K16-352	HW	RHYc	1.50	3.00	1.5		0%
K16-352	HW	RHYc	3.00	6.00	3.0	1.91	64%
K16-352	HW	RHYc	6.00	9.00	3.0	2.47	82%
K16-352	HW	RHYc	9.00	10.40	1.4	1.37	98%
K16-352	HW	PEL	10.40	12.70	2.3	2.14	93%
K16-352	HW	RHYv	12.70	15.00	2.3	2.10	91%
K16-352	HW	RHYv	15.00	18.00	3.0	2.23	74%
K16-352	HW	RHYv	18.00	20.10	2.1	2.04	97%
K16-352	HW	RHYi	20.10	25.00	4.9	4.37	89%
K16-352	HW	RHYi	25.00	27.00	2.0	1.64	82%
K16-352	HW	RHYi	27.00	30.10	3.1	2.82	91%
K16-352	HW	RHYi	30.10	33.30	3.2	2.57	80%
K16-352	HW	RHYv	33.30	34.61	1.3	1.30	99%
K16-352	HW	PEL	34.60	37.40	2.8	2.65	95%
K16-352	HW	RHYc	37.40	40.40	3.0	2.74	91%
K16-352	HW	RHYv	40.40	45.00	4.6	3.61	78%
K16-352	HW	RHYv	45.00	48.00	3.0	2.93	98%
K16-352	HW	RHYv	48.00	51.00	3.0	2.75	92%
K16-352	HW	RHYv	51.00	54.00	3.0	2.92	97%
K16-352	HW	RHYv	54.00	57.00	3.0	2.97	99%
K16-352	HW	RHYv	60.00	63.00	3.0	2.31	77%
K16-352	HW	RHYv	63.00	66.00	3.0	2.87	96%
K16-352	HW	RHYv	66.00	69.00	3.0	1.61	54%
K16-352	HW	RHYv	69.00	75.00	6.0	1.91	32%
K16-352	HW	RHYc	75.00	77.50	2.5	0.22	9%
K16-352	HW	RHYc	77.50	81.00	3.5	2.81	80%
K16-352	HW	RHYc	81.00	84.00	3.0	2.65	88%
K16-352	HW	RHYc	84.00	87.00	3.0	2.65	88%
K16-352	HW	RHYc	87.00	90.00	3.0	1.81	60%
K16-352	HW	RHYc	90.00	93.00	3.0	2.70	90%
K16-352	HW	RHYc	93.00	96.00	3.0	2.96	99%
K16-352	HW	RHYc	96.00	99.00	3.0	2.58	86%
K16-352	HW	RHYc	99.00	102.00	3.0	2.99	100%
K16-352	HW	RHYc	102.00	105.00	3.0	2.66	89%
K16-352	HW	RHYc	105.00	107.90	2.9	2.69	93%
K16-352	HW	RHYv	107.90	111.00	3.1	2.65	85%
K16-352	HW	RHYv	111.00	114.00	3.0	2.95	98%
K16-352	HW	RHYv	114.00	117.00	3.0	2.96	99%
K16-352	HW	RHYv	117.00	120.00	3.0	2.63	88%
K16-352	HW	RHY	120.00	121.80	1.8	1.78	99%
K16-352	HW	RHY	121.80	124.35	2.6	2.51	98%
K16-352	HW	MAF	124.35	129.00	4.7	4.29	92%
K16-352	HW	MAF	129.00	132.00	3.0	2.97	99%
K16-352	HW	MAF	132.00	135.00	3.0	2.52	84%
K16-352	HW	MAF	135.00	138.00	3.0	2.41	80%
K16-352	HW	MAF	138.00	141.00	3.0	2.86	95%
K16-352	HW	MAF	141.00	144.00	3.0	2.78	93%
K16-352	HW	MAF	144.00	147.43	3.4	2.91	85%
K16-352	Ore	OI	147.43	149.30	1.9	1.55	83%
K16-352	FW	MAF	149.30	152.90	3.6	2.26	63%
K16-352	FW	RHY	152.90	155.05	2.2	1.16	54%
K16-352	Ore	OI	155.05	156.00	0.9	0.81	85%
K16-352	Waste	RHY	156.00	159.00	3.0	2.80	93%
K16-352	Waste	RHY	159.00	162.00	3.0	2.92	97%
K16-352	Waste	RHY	162.00	164.70	2.7	2.55	94%
K16-352	Waste	RHYi	164.70	168.00	3.3	3.03	92%
K16-352	Waste	RHYi	168.00	171.00	3.0	1.70	57%
K16-352	Waste	RHYi	171.00	173.50	2.5	2.27	91%
K16-352	Waste	FLZ	173.50	177.00	3.5	3.17	91%
K16-352	Waste	FLZ	177.00	180.00	3.0	2.67	89%
K16-352	Waste	FLZ	180.00	183.00	3.0	1.64	55%
K16-352	Waste	FLZ	183.00	186.00	3.0	1.30	43%
K16-352	Waste	FLZ	186.00	189.00	3.0	1.78	59%
K16-352	Waste	FLZ	189.00	192.00	3.0	2.90	97%
					0.0		#DIV/0!

From (m)	Confidence (3,2,1)	Joint Condition Rating	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
		RMR76	Fault and Broken Zones					
1.50								Null
3.00		20			15%	65%		No orientation line, broken zone due to poor ground conditions,
6.00		20				20%		No orientation line, some lost core in blocky/broken zone, Jointing both follows and cuts discontinuous muscovite layers
9.00		20						Short interval due to lithology change, no orientation line, Jointing both follows and cuts discontinuous muscovite
10.40		12-20	5%					No orientation line, Interval length due to small unit, Rare high angle TCA clay filled joints (fault?)
12.70		12-20	5%					No orientation line, interval length due to short unit, Rare high angle gouge filled fractures/joints
15.00	3.0	12-20	5%					interval length due to short unit, Rare high angle gouge filled fractures/joints
18.00	3.0	6-12	1%					Rare high angle TCA gouge zones parallel to the primary joint set, short interval due to lithology change
20.10		20				8%	10%	Long interval due to driller blocking, no orientation line, microdefects following muscovite rich flow bands in the rhyolite
25.00	2.0	20				8%		Short interval due to blocking, lost core in broken/blocky zone
27.00	3.0	20				4%		Interval length due to driller blocking
30.10	3.0	20				10%		Joints exploit pyrite veinlets and muscovite rick flow banding discontinuities. Length due to lithology change
33.30	3.0	12-20						Short run due to lith change, joints developed along and cutting foliation
34.60		6-12	1%					Run length for lith, no ori line, high angle to joints follow dominant foliation
37.40		6	5%			5%		no ori line, small lenses of PEL within RHYc, Run length due lithology change
40.40	3.0	0-6	7%		10%			lost core in broken/gouge zone,
45.00	2.0	0-6	5%					Small gouge faults following the foliation
48.00	2.0	0-6	1%					Small gouge faults following the foliation
51.00	3.0	6	1%	1%				Small gouge faults following the foliation
54.00		0	15%	15%	10%			No Ori line, Fault zones exploiting foliation fabric are 1-25cm wide
60.00		0-6	5%	10%				No Ori line, Fault zones exploiting foliation fabric are 1-5cm wide
63.00	3.0	6		3%			3%	Some spun core, early alternating light and dark foliation bands (bedding?) transposed into the dominant foliation at alpha 60-70 beta
66.00		0-6		50%			5%	No ori line, poor recovery in fault zone (wash away)
69.00		0-6		68%		26%		No ori line, lost core due to rubble/gouge faults, long interval due to very poor recovery
75.00		0		91%		9%		Run lost due to poor ground/fault, no ori line, short due to lithology change
77.50		0		12%			5%	Some core loss due to poor ground, no ori line, long interval due to lith change
81.00		6-12				5%		Minor core loss due to rubbly ground? No ori line where joints are
84.00	3.0	6-12	3%					Core lost to grinding/spun core, fault breccia well preserved
87.00		12				20%		Core lost to grinding, spun core PR
90.00	3.0	6						Core lost to spun core,
93.00	2.0	6						Joints are exploiting variable foliation developed along micaceous partings
96.00	3.0	6						Joints are exploiting variable foliation developed along micaceous partings
99.00	2.0	6						Joints are exploiting variable foliation developed along micaceous partings
102.00	2.0	6		20%				Joints are exploiting variable foliation developed along micaceous partings
105.00		6-12						Short interval due to lithology change, no ori line, some core blocks were spun and ground PR
107.90		12						Long interval due to lith change, Joints are exploiting variable foliation developed along micaceous partings, no ori line
111.00		6-12						Joints are exploiting variable foliation developed along micaceous partings, no ori line
114.00		6-12						Joints are exploiting variable foliation developed along micaceous partings, no ori line
117.00		6		20%				Joints are exploiting variable foliation developed along micaceous partings, no ori line
120.00		6						Joints are exploiting variable foliation developed along micaceous partings, no ori line, short interval for lith change
121.80		6				30%	30%	Joints are exploiting variable foliation developed along micaceous partings, no ori line, short interval for lith change
124.35	3.0	0		8%			10%	Joints are exploiting variable foliation developed along micaceous partings, long interval for lith change
129.00	3.0	20						Slickensided joint surfaces (chlorite)
132.00	3.0	6					3%	Slickensided joint surface with chlorite and hematite, no ori line
135.00	2.0	6				3%		Slickensided joint surface with chlorite, no ori line
138.00		6					5%	Slickensided joint surface with chlorite, no ori line
141.00		6-12						chloritic joint surface with clay, no ori line
144.00		6		3%				chloritic joint surface with minor clay, no ori line, poor recovery due to bad ground, long interval due to lith change
147.43	2.0	6-12		15%				Chloritic partings commonly make joints, poor recovery due to fault rubble, short interval due to lith change, poor recovery due to fau
149.30		0-6		10%				Foliation partings commonly make joints, poor recovery due to fault rubble, short interval due to lith change, no ori line
152.90		0						Foliation partings commonly make joints, poor recovery due to fault rubble, short interval due to lith change no ori line
155.05		12						Foliation partings commonly make joints, short interval due to lith change no ori line
156.00		0-6				30%	20%	Foliation partings make joint surfaces and fault planes, poor recovery due to fault breccia no ori line
159.00	3.0	0-6		6%			75%	Foliation partings make joint surfaces and fault planes,
162.00		6-12					10%	Foliation partings make joint surfaces and fault planes, short interval due to lith change
164.70	3.0	6-12		10%			80%	Well consolidated fault breccia and with zones of more competent rock. microdefects are widespread
168.00		0-6			45%		25%	Poor recovery due to blocky ground, no ori line
171.00		0-6			10%		85%	No ori line, poor ground,
173.50				100%				No ori line, fault zone
177.00				100%				No ori line, fault zone
180.00				100%				No ori line, fault zone
183.00				100%				No ori line, fault zone
186.00				100%				No ori line, fault zone
189.00				100%				No ori line, fault zone

No UCS

POINT LOAD TEST RESULTS

Load Correction Factor = 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-352	PLT-01	8.21	HW	RHYc	17.12	II	d	Valid test	61.10	61.1	61.10	171.2	16.23	3733.21	0.004347401	1.0944	4.76	
K16-352	PLT-02	8.21	HW	RHYc	13.62	II	d	Valid test	61.10	61.1	61.10	136.2	12.91	3733.21	0.003458621	1.0944	3.79	
K16-352	PLT-03	8.21	HW	RHYc	17.82	L	a	Valid test	46.00	61.1	46.00	178.2	16.89	3578.57	0.004720705	1.0944	5.17	
K16-352	PLT-04	12.05	HW	PEL	2.76	II	d	Valid test	61.10	61.1	61.10	27.6	2.62	3733.21	0.000700866	1.0944	0.77	
K16-352	PLT-05	15.04	HW	RHYv	3.8	II	d	Valid test	61.10	61.1	61.10	38	3.60	3733.21	0.00096496	1.0944	1.06	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-353	Krakatoa (in-pit)	All	KRAK014	414882	6814999	1390	159	-77	HQ3	210	27-May-16	30-May-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	JDP		
Geotechnical	IH	IH	1/Jun/16
PLT	IH	IH	1/Jun/16
UCS	IH	IH	1/Jun/16

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-353	0.00	11.40	Overburden (OVBN)
K16-353	11.40	12.80	Massive sulphide (OA, OB, OC, OF, OK)
K16-353	12.80	21.10	Volcaniclastic rhyolite (RHYv)
K16-353	21.10	34.10	Mafic intrusion (MAFi)
K16-353	34.10	40.30	Volcaniclastic rhyolite (RHYv)
K16-353	40.30	43.35	Aphanitic rhyolite (RHYi)
K16-353	43.35	45.00	Volcaniclastic rhyolite (RHYv)
K16-353	45.00	48.95	Aphanitic rhyolite (RHYi)
K16-353	48.95	52.14	Volcaniclastic rhyolite (RHYv)
K16-353	52.14	75.10	Aphanitic rhyolite (RHYi)
K16-353	75.10	78.00	Rhyolite (RHY)
K16-353	78.00	78.70	Aphanitic rhyolite (RHYi)
K16-353	78.70	79.95	Rhyolite (RHY)
K16-353	79.95	81.36	Aphanitic rhyolite (RHYi)
K16-353	81.36	85.60	Rhyolite (RHY)
K16-353	85.60	86.07	Aphanitic rhyolite (RHYi)
K16-353	86.07	87.21	Rhyolite (RHY)
K16-353	87.21	87.60	Aphanitic rhyolite (RHYi)
K16-353	87.60	88.95	Volcaniclastic rhyolite (RHYv)
K16-353	88.95	91.00	Aphanitic rhyolite (RHYi)
K16-353	91.00	97.90	Volcaniclastic rhyolite (RHYv)
K16-353	97.90	98.08	Aphanitic rhyolite (RHYi)
K16-353	98.08	100.90	Rhyolite (RHY)
K16-353	100.90	101.80	Aphanitic rhyolite (RHYi)
K16-353	101.80	105.70	Rhyolite (RHY)
K16-353	105.70	106.95	Rhyolite (RHY)
K16-353	106.95	108.43	Mafic intrusion (MAFi)
K16-353	108.43	121.10	Volcaniclastic rhyolite (RHYv)
K16-353	121.10	122.40	Rhyolite (RHY)
K16-353	122.40	129.77	Volcaniclastic rhyolite (RHYv)
K16-353	129.77	132.77	Semi-massive sulphide (OI, OJ)
K16-353	132.77	138.51	Volcaniclastic rhyolite (RHYv)
K16-353	138.51	139.60	Rhyolite (RHY)
K16-353	139.60	143.94	Volcaniclastic rhyolite (RHYv)
K16-353	143.94	149.95	Volcaniclastic rhyolite (RHYv)
K16-353	149.95	152.82	Volcaniclastic rhyolite (RHYv)
K16-353	152.82	154.70	Volcaniclastic rhyolite (RHYv)
K16-353	154.70	159.00	Volcaniclastic rhyolite (RHYv)
		EOH	

Geotechnical Log

			From	To	Run	Rec	TCR %			RQD %				ALPHA0-29 Count	ALPHA0-29 TYPE	ALPHA0-29 Jr	ALPHA0-29 Ja	ALPHA30-59 Count	ALPHA30-59 TYPE	ALPHA30-59 Jr	ALPHA30-59 Ja	ALPHA60-90 Count	ALPHA60-90 TYPE	ALPHA60-90 Jr	ALPHA60-90 Ja	Oriented Core Log Alpha	Beta	Type	Confidence (3,2,1)	RMR76 Jnt Condition Rating	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
[illegible]	HW	OVBN	8.0	11.3	3.3	2.4	73%	85	0	4%	W4	R1	20																		10%		20%	60%	30%	Considered as OVBN by GEO w/.17m of MSDX broken with remaining run vary in crushed to microdefected/gouged run and no ORIENT line
[illegible]	Ore	MXSX	11.3	13.2	1.9	0.9	46%	29	0	0%	W3	R4	15					14	JF	3.0	2.0									20	5%		80%			Ore broken up heavily no orient line due to broken zone difficult to measure or identify joints
[illegible]	Waste	RHHv	13.2	15.0	1.8	1.4	80%	21	0	21%	W2	R3	6					21	JF	2.0	3.0	1	J	2.0	4.0					12	5%		30%		15%	Change in lith with small scale clay coatings with one dominate fol.j no orient line
[illegible]	Waste	RHHv	15.0	18.0	3.0	1.3	43%	24	1	23%	W2	R3	6					12	JF	2.0	3.0	2	J	2.0	3.0					12	20%		10%	10%	20%	No orient line available highly silicified at end of run gouge to clay like material crushed up.
[illegible]	Waste	RHHv	18.0	21.2	3.2	2.3	73%	71	0	12%	W2	R2	6					18	JF	2.0	3.0	6	J	2.0	3.0					12			30%	30%	5%	Difference in FF as counted more for R2 and B2 areas but two distinctive joints can be seen. No orient line available mostly poker chip to rubble/broken areas through run with soft coatings
[illegible]	Waste	MAFi	21.2	24.0	2.9	2.9	103%	20	3	89%	W2	R4	6					7	J	2.0	3.0	12	JF	3.0	2 to 3	69.0	320.0	JF	3.0	20			5%			Good run with distinctive joint sets no more gouge or b/r zones. Surface of J a little more rougher now planar in some areas no signs of weathering. Took two blows to break rock
[illegible]	Waste	MAFi	24.0	27.0	3.0	3.2	105%	18	2	83%	W2	R4	6					4	J	3.0	3.0	14	JF	3.0	3.0	45.0	332.0	J	3.0	20			5%			Minor broken zone but similar condition as last run. Joint surface seems to be more sandy like as before and hard seems like change in dominate foliation joint with it now >60deg.
[illegible]	Waste	MAFi	27.0	30.0	3.0	2.5	84%	14	2	74%	W2	R4	3									13	JF	3.0	3.0	67.0	296.0	JF	2.0	20			5%			Similar as last run
[illegible]	Waste	MAFi	30.0	33.0	3.0	2.9	96%	20	2	67%	W2	R4	6					8	J	3.0	3.0	12	JF	3.0	3.0	49.0	324.0	J	2.0	20						Similar as last run but other joint set able to detect and more mechanical breaks this run
[illegible]	Waste	MAFi	33.0	35.7	2.7	2.2	82%	13	2	56%	W2	R3	6					2	J	3.0	3.0	9	JF	3.0	3.0	57.0	324.0	J	2.0	20			10%			Broken zone within run but minor similar joint conditions but end of run clayey due to change in lith
[illegible]	Waste	RHY	35.7	39.0	3.3	3.0	91%	120	0	0%	W3	R1	15 to 20																	6			30%	50%	70%	After change in lith very broken up almost crushed rock in most portions of run and in most areas microdefects where picking up sample breaks no orient line due to poor ground
[illegible]	Waste	RHY	39.0	40.3	1.3	0.8	63%	27	0	9%	W3	R1	15																	6			10%	40%	50%	Small run due to lith change on next run.
[illegible]	Waste	RHS	40.3	42.0	1.7	1.6	95%	44	0	0%	W3	R1	15									19	JF	2.0	4.0					6				30%	60%	Small run due to lith change. Majority of run very silicified with veining and microdefects visible throughout. In areas where there is jointing it is very closely spaced. Clay coatings muscovite to sericitic on joint surfaces.
[illegible]	Waste	RHS	42.0	45.0	3.0	1.7	56%	41	0	14%	W3/W4	R1	15									23	JF	1.0	4.0					6	10%			50%	70%	Poor recovery due to washing out of material (gouge?). All joints have clay to gouge filling approx. 2-5mm thick where joints are very closely spaced.
[illegible]	Waste	RHS	45.0	48.3	3.3	2.0	60%	45	0	10%	W4	R1/R2	15-20																	6				80%	90%	Unable to make joint measurements as very crushed up fractured rock. Large QTZ veining through run with clay infillings. Albite present within vein as well. Poor recovery again due to washing of material possible gouge?Lith change.
[illegible]	Waste	RHHv	48.3	52.1	3.9	3.2	81%	35	2	63%	W2	R3	6					2	J	2.0	4.0	28	JF	2.0	3.0	70.0	345.0	JF	3.0	6					30%	A lot better run with minimal thick gouge or QTZ veining in comparison to last few runs. Consistent dominate fol. Throughout with multiple mechanical breaks. Lith change.
[illegible]	Waste	RHS	52.1	54.0	1.9	1.8	96%	72	0	0%	W3/W4	R2	15-20																	12				80%	40%	Back to QTZ veining with in albite and muscovite/sericitic coatings on surfaces of most fractures. Very rubble zone like no orientation line available. Longer run due to change in lith.
[illegible]	Waste	RHS	54.0	57.0	3.0	2.9	97%	90	0	5%	W3/W4	R2/R3	15-20																	12				90%	75%	Similar as last run where all run is rubble with multiple fractures due to high content in silica and albite where in some cases infilling of 1-5mm coatings on surface of fracture/joint areas. Unable to mark orientation due to no line
[illegible]	Waste	RHS	57.0	60.0	3.0	2.1	69%	85	0	5%	W3	R3	15-20																					80%	50%	Similar as previous run very rubble like to broken rock throughout with microdefects. Again no orientation line due to poor rock. Poor recovery as noted in block got washed out.
[illegible]	Waste	RHS	60.0	63.0	3.0	2.6	86%	60	0	13%	W3	R2-R3	15-20																					60%	40%	Similar as previous run.
[illegible]	Waste	RHS	63.0	66.0	3.0	2.9	97%	110	0	8%	W3	R2	15-20																					90%	60%	Similar as previous run. No orient poor ground cannot measure any joints as too broken just like last runs.
[illegible]	Waste	RHS	66.0	69.0	3.0	2.7	89%	105	0	4%	W3	R2	15-20																					90%	75%	Similar as previous run. No orient poor ground cannot measure any joints as too broken just like last runs.
[illegible]	Waste	RHS	69.0	72.0	3.0	3.1	105%	120	0	0%	W3	R2	15-20																					90%	60%	No drillers block for the 72m mark so had use our own meter mark therefore rec or RQD not too accurate. Similar to last run very broken up and rubble throughout run very muscovite rich and in areas silicified.
[illegible]	Waste	RHS	72.0	75.0	3.0	2.6	88%	42	2	54%	W3	R3	6									8	JF	3.0	2 to 3					12			30%		40%	Change in FF and J as I counted rubble zones as 4/10cm. Very silicified with QTZ veining with albite with multiple microdefects and fractures but earlier in the run dominate fol present with random jointing and another secondary jointing difficult to measure. No orient line.
[illegible]	Waste	RHS	75.0	78.0	3.0	3.1	103%	21	2	65%	W2/W3	R3	3									9	JF	3.0	2.0					6/12			10%		20%	No orient line. One dominate joint visible with some random jointing but jointing very far spaced. Initial run with QTZ veining then into conventional RHY/RHS with multiple mechanical sharp breaks throughout. GEO has this zone has RHY/RHS but I have continued with the same lith as RHS for simplicity due to small run.
[illegible]	Waste	RHS	78.0	81.9	3.9	3.8	97%	72	2	46%	W3	R3	6	7	J	1.5	3.0					5	JF	2.0	3.0					6			20%	10%	25%	Longer run due to lith change next run. <0.7m RHY in this run but combined it with RHS as useless to combine the two with such small length of lith. Clay coated infills with some joint surfaces. Noticed a joint set almost parallel to core axis with a rougher surface then the dominate fol(J). Also some random jointing. No orient line available.
[illegible]	Waste	RHY	81.9	84.0	2.1	2.2	106%	27	1	53%	W2/W3	R3	12	3	J	3.0	2.0	3	J	3.0	2.0	6	JF	2.0	4.0					6/12			20%			Short run due end of block and lith change. Three joints spotted with random jointing this run but dominate fol has to have weaker joint surface condition.
[illegible]	Waste	RHY	84.0	85.6	1.6	1.6	100%	27	1	59%	W2/W3	R3	3									6	JF	2.0	4.0					12			25%			Short run due to lith change again. FF do not match due to broken zone natural. One J set seen with some random. No orient line available.
[illegible]	Waste	RHS	85.6	87.6	2.0	1.7	87%	31	1	32%	W3	R3	3									10	JF	2.0	4.0					12			20%		30%	Again short run due to lith change. One dominate joint visible with lots of random jointing throughout run. Some areas there is fracturing right parallel to core axis. No orient line.
[illegible]	Waste	RHY	87.6	89.0	1.4	1.1	78%	35	0	17%	W4	R3	15-20																	6	25%			50%	25%	Short run due to lith change Mostly gouged up material and rubble zones. No orient line available.
[illegible]	Waste	RHS	89.0	91.0	2.1	0.8	41%	85	0	0%	W4	R2	20																	6	25%			60%	25%	Short run again due to lith change. Majority of run gouged to rubble like zone. Unable to make any measurements a no orient line due to poor rock.
[illegible]	Waste	RHY	91.0	93.0	2.0	1.8	90%	43	0	18%	W3	R3	3									31	JF	3.0	3.0					12				15%	10%	Change in lith due to run change again. More competent rock this portion of lith with the dominate fol with some random jointing apparent. Minor rubble zones at initial of run due to the different in FF and J reading count.
[illegible]	Waste	RHY	93.0	96.0	3.0	2.6	87%	41	1	48%	W3	R3	3									4	JF	3.0	3.0	68.0	330.0	JF	3.0	12	15%			25%		Most noted were mechanical breaks. High number between FF and joints due to R2 and gouged areas. Random jointing present as well.
[illegible]	Waste	RHY	96.0	99.0	3.0	2.9	96%	62	0	12%	W2/W3	R2	15									11	JF	3.0	3.0					6/12			65%	20%	10%	Close spacing of random jointing with dominate fol present throughout. No orient line. Crumbled rock in some areas as B2 or R2.
[illegible]	Waste	RHY	99.0	102.0	3.0	2.9	96%	120	0	0%	W3	R2	15																	6			80%	20%	75%	Microdefected throughout with B2 very poor run.
[illegible]	Waste	RHY	102.0	105.0	3.0	1.8	60%	120	0	0%	W4	R2	15-20																	6	20%		80%		50%	Similar as previous run. Poor recovery due to poor ground. Gouged in one portion of run ~20cm long
[illegible]	Waste	RHY	105.0	108.0	3.0	2.9	98%	69	1	27%	W4	R1/R2	15																	6		35%			50%	No orientation line, fault breccia zone run at a low angle to the core axis,
[illegible]	Waste	RHY	108.0	111.0	3.0	3.0	100%	38	2	63%	W3	R2	3									12	JF	2.0	4.0					6	15%		10%		40%	No orientation line, gouge zones are at a high angle to the core axis,
[illegible]	Waste	RHY	111.0	114.0	3.0	3.1	103%	19	2	60%	W3	R3	6									19	JF	2.0	4.0	69.0	18.0	J	2.0	12					10%	Decent run with fairly competent rock with visible jointing some random in areas but dominate fol visible.
[illegible]	Waste	RHY	114.0	117.0	3.0	2.2	73%	18	2	63%	W2/W3	R3	3									12	JF	2.0	4.0	66.0	330.0	JF	3.0	12	15%				15%	Similar as previous run with minor gouge sericitic
[illegible]	Waste	RHY	117.0	120.0	3.0	3.1	103%	27	1	28%	W3	R2/R3	3									24	JF	2.0	4.0					12	20%				10%	No meter block for 120 used meter mark for assumption. Joints filled with clay fill sericitic coating mostly undulated.
[illegible]	Waste	RHY	120.0	123.0	3.0	2.5	82%	46	1	35%	W3	R2/R3	3									23	JF	2.0	4.0					12			40%	10%	25%	Several broken zones throughout run. No orientation line available. Similar to last run where surface of joint very clay like coating.
[illegible]	Waste	RHY	123.0	126.0	3.0	2.4	80%	32	1	48%	W3/W4	R2/R3	3									15	JF	2.0	4.0					12	20%			20%	30%	Minor gouge zone within run as well as a rubble zone natural no orientation line available. Similar joint surface conditions as previous run.
[illegible]	Waste	RHY	126.0	129.8	3.8	3.2	85%	120	0	7%	W4	R2/R3	15																	12	40%			20%	70%	Gouged material throughout run with microdefects high intensity no orientation line available. Longer run due to lith change next run.
[illegible]	Ore	Stringer	129.8	132.8	3.0	2.8	94%	32	2	69%	W4	R3	3									7	J	3.0	3.0					12	20%				25%	Highly chloritic altered stringer zone with pyrite majority. No orientation line minor gouged areas with sharp contact.
[illegible]	Waste	RHHv	132.8	135.0	2.2	2.0	91%	25	1	32%	W3	R3	3									12	JF	2.0	3.0					12				20%	40%	Minor broken zones run small due change in lith.
[illegible]	Waste	RHHv	135.0	138.0	3.0	2.7	90%	58	1	47%	W3/W4	R3	3									11	JF	2.0	3.0					12			30%	10%	50%	Difference in FF due to broken and rubble areas which is microdefected. No orientation line.
[illegible]	Waste	RHHv	138.0	141.0	3.0	2.8	93%	29	2	68%	W3	R3	3									20	JF	2.0	3.0					12	5%			25%	30%	Proximal alteration for half of run but mostly RHHv unit. No orient line.
[illegible]	Waste	RHHv	141.0	144.0	3.0	2.9	96%	17	2	82%	W2/W3	R3	3									11	JF	3.0	3.0					12			10%	10%		Competent run with larger spacing of discont. No orient line.
[illegible]	Waste	RHHv	144.0	147.0	3.0	3.0	98%	30	2	61%	W3	R3	3									20	JF	3.0	2.0					12				10%	10%	Competent run breaks through parallel to core axis but dominate J still visible no orient mark.
[illegible]	Waste	RHHv	147.0	150.0	3.0	2.8	92%	45	1	38%	W3	R3	3									30	JF	3.0	2.0					12	25%		10%		10%	~30cm gouge within run but mostly competent rock but close spacing of discont.
[illegible]	Waste	RHHv	150.0	153.0	3.0	2.6	87%	34	2	55%	W3	R3	3									13	JF	3.0	2.0	70.0	330.0	JF	3.0	12	30%			10%		~0.5m gouge within run but competent rock with dominate fol present.
[illegible]	Waste	RHHv	153.0	156.0	3.0	2.8	93%	36	2	68%	W3	R3	3									18	JF	3.0	2.0					12			10%	20%		Higher FF versus JF due to R2 and B2 areas. No orient line.
[illegible]	Waste	RHHv	156.0	159.0	3.0	2.3	77%	42	1	34%	W3/W4	R3	3									15	JF	2.0	3.0					12			25%	25%	30%	Higher alteration within this run in comparison to before with broken and rubble ones. No orient line. EOH
					0.0		#DIV/0!			#DIV/0!																										

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-353	MAFi	Waste	22.34	22.62	0190403		61.1	280	4.58265139116205 Valid	29-May-16	
K16-353	MAFi	Waste	27.13	27.33	0190404		61.1	200	3.27332242225858 Valid	29-May-16	
K16-353	MAFi	Waste	33	33.27	0190405		61.1	270	4.41898527004915 Valid	29-May-16	
K16-353	RHYv	Waste	50.12	50.46	0190406		61.1	340	5.56464811783966 Valid	29-May-16	
K16-353	RHY	Waste	82.08	82.31	0190407		61.1	230	3.76432078559745 Valid	31-May-16	
K16-353	RHYv	Waste	150.52	150.68	0190408		61.1	160	2.61865793780682 Valid	31-May-16	
K16-353	Stringer (OJ)	Ore	129.77	130.68	0190409	B00291512	61.1	910	14.8936170212765 Valid	31-May-16	Stringer - Chloritic altered
								0	#DIV/0!	29-May-16	

POINT LOAD TEST RESULTS

Equipment: PIL-7

Load Correction Factor = 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	F=$(D_e/50)^{0.45}$	$Is_{(50)}$ = F x I_s (MPa)	UCS Sample Match
K16-353	PLT-01	16.17	Waste	RHYv	4.94	II	d	fresh cut valid test silicified	61.10	61.10	61.10	49.4	4.68	3733.21	0.001254449	1.0944	1.37	
K16-353	PLT-02	24.00	Waste	MAFi	15.12	II	d	fresh cut valid test	61.10	61.10	61.10	151.2	14.33	3733.21	0.003839527	1.0944	4.20	
K16-353	PLT-03	27.00	Waste	MAFi	10.18	II	d	fresh cut valid test	61.10	61.10	61.10	101.8	9.65	3733.21	0.002585078	1.0944	2.83	
K16-353	PLT-04	27.00	Waste	MAFi	3.26	L	a	fresh cut valid break L to fol but very low number	56.30	61.10	56.30	32.6	3.09	4379.85	0.000705612	1.0944	0.77	
K16-353	PLT-05	31.30	Waste	MAFi	12.66	II	d	fresh cut break along fol valid	61.10	61.10	61.10	126.6	12.00	3733.21	0.003214842	1.0944	3.52	
K16-353	PLT-06	40.40	Waste	RHYi	4.86	II	d	break along fol	61.10	61.10	61.10	48.6	4.61	3733.21	0.001234134	1.0944	1.35	
K16-353	PLT-07	47.50	Waste	RHYi	1.64	II	d	break L to fol fresh cut	61.10	61.10	61.10	16.4	1.55	3733.21	0.000416457	1.0944	0.46	
K16-353	PLT-08	63	Waste	RHYi	10.1	II	d	fresh cut along fol valid	61.10	61.10	61.10	101	9.57	3733.21	0.002564763	1.0944	2.81	
K16-353	PLT-09	82.75	Waste	RHY	9.8	II	d	fresh cut along fol valid	61.1	61.1	61.10	98	9.29	3733.21	0.002488582	1.0944	2.72	
K16-353	PLT-10	91.2	Waste	RHYv	0.34	II	d	natural break along fol valid	61.1	61.1	61.10	3.4	0.32	3733.21	8.63386E-05	1.0944	0.09	
K16-353	PLT-11	91.2	Waste	RHYv	0.96	L	a	natural break (2) along fol valid	39	61.1	39.00	9.6	0.91	3034.00	0.00029996	1.0944	0.33	
K16-353	PLT-12	111	Waste	RHY	1.62	II	d	discontinuous cut parallel to fol valid	61.1	61.1	61.10	16.2	1.54	3733.21	0.000411378	1.0944	0.45	
K16-353	PLT-13	130.95	Ore	Stringer	9.4	II	d	fresh cut perpendicular to core axis, valid	61.1	61.1	61.10	94	8.91	3733.21	0.002387007	1.0944	2.61	
K16-353	PLT-14	137.16	Waste	RHYv	0.32	II	d	natural break along fol valid	61.1	61.1	61.10	3.2	0.30	3733.21	8.12598E-05	1.0944	0.09	
K16-353	PLT-15	151.86	Waste	RHYv	0.5	II	d	natural break along fol valid	61.1	61.1	61.10	5	0.47	3733.21	0.000126968	1.0944	0.14	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-354	Krakatoa	HW	KRAK010	415150	6815074	1407.2	39	-80	HQ3	38	28-May-16	29-May-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	DH		
Geotechnical	IH	IH	01-Jun-16
PLT	KF	IH	

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-354	0.00	3.50	Overburden (OVBN)
K16-354	3.50	11.70	Volcaniclastic rhyolite (RHYv)
K16-354	11.70	12.30	Coherent rhyolite (RHYc)
K16-354	12.30	12.60	Volcaniclastic rhyolite (RHYv)
K16-354	12.60	14.00	Pelite (PEL)
K16-354	14.00	28.10	Coherent rhyolite (RHYc)
K16-354	28.10	32.50	Pelite (PEL)
K16-354	32.50	39.00	Aphanitic rhyolite (RHYi)
		EOH	

Geotechnical Log

Hole ID	Zone	Lithology	Core Recovery Data								Strength Data			Discontinuity parameters for Q System												[illegible]				[illegible]	[illegible]					Comment
														ALPHA/0-30				ALPHA/30-60				ALPHA/60-90														
			From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	Count	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	% Mkr defects	
K16-354	HW	RHW	3.5	6.0	2.5	2.1	82%	82	0	12%	W4/W5	R1/R2	20																	[illegible]			[illegible]	[illegible]		Note that there are no driller blocks per 3 m so using approx. meter marks for every 3 meter run. This specific run is a combination of RHW according to GEO but some OVBN within this run due to the low rating system.
K16-354	HW	RHW	6.0	9.0	3.0	1.3	44%	72	0	10%	W4/W5	R1/R2	20																	[illegible]			[illegible]	[illegible]		Similar as previous run in conditions.
K16-354	HW	RHW	9.0	12.6	3.6	3.3	91%	48	1	29%	W4	R2	6					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]	[illegible]			[illegible]		Heavily altered as previous run in the surface of core as well as the surface of joints. I would say the βfol is <30 seeing the overall foliation although the open and clay filled joints within that alpha range is lower then >60. Change in lith
K16-354	HW	PEL	12.6	14.0	1.4	1.4	98%	10	1	70%	W3/W4	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					[illegible]			[illegible]			Change in lith change due to run length. Competent domain but highly weather joint surfaces but surface of core is good. Two joint sets visible. No orient line.
K16-354	HW	RHC	14.0	18.0	4.0	3.8	95%	14	3	71%	W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		Longer run as trying to stay in a 3m sequence. Two distinctive joints visible through run fairly competent but joint surfaces still weathered. Core surface not weathered.
K16-354	HW	RHC	18.0	21.0	3.0	2.8	92%	34	2	72%	W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]		30%	Highly silicified through run with QTZ veining minor broken zone areas. Veining microdefected with low intensity
K16-354	HW	RHC	21.0	24.0	3.0	2.7	90%	18	2	78%	W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					10%	Highly silicified with QTZ veining as las run with distinctive two joint sets
K16-354	HW	RHC	24.0	28.1	4.1	4.1	100%	15	3	80%	W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						Competent run far spacing of discount. visible joint sets highly silicified veining.
K16-354	HW	PEL	28.1	32.5	4.4	4.2	95%	42	3	63%	W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]			[illegible]	[illegible]		range in lith due to run length. Minor R2 and R2 within run but fairly competent rock with far spaced discount..
K16-354	HW	RHY	32.5	36.0	3.5	3.4	96%	17	3	72%	W2/W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					25%	Similar as previous run.
K16-354	HW	RHY	36.0	39.0	3.0	3.0	98%	13	2	83%	W2/W3	R3	4					[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					10%	Competent run as last run with far spacing of discont... mostly mechanical breaks.
					0.0																															

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-354	RHYi	Waste	33	33.27	0190410		61.1	270	4.41898527004915 Valid	31-May-16	From abandoned hole
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7

Load Correction Factor = 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$ For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$(MPa)	UCS Sample Match
K16-354	PLT-001	3.50	HW	RHYV	2.68	II	d	Valid test	61.10	61.1	61.10	26.8	2.54	3733.21	0.000680551	1.0944	0.74	
K16-354	PLT-002	3.50	HW	RHYV	5.42	II	d	Valid test	61.10	61.1	61.10	54.2	5.14	3733.21	0.001376338	1.0944	1.51	
K16-354	PLT-003	3.50	HW	RHYV	14.34	L	a	Invalid test jumped off	47.50	61.1	47.50	143.4	13.59	3695.26	0.003678854	1.0944	4.03	
K16-354	PLT-004	10.81	HW	RHYV	5.86	II	d	Valid test	61.10	61.1	61.10	58.6	5.56	3733.21	0.001488071	1.0944	1.63	
K16-354	PLT-005	10.81	HW	RHYV	13.4	L	a	Invalid test jumped off	55.00	61.1	55.00	134	12.70	4278.72	0.002968924	1.0944	3.25	
K16-354	PLT-006	17.70	HW	RHYC	1.38	II	d	Valid test	61.10	61.1	61.10	13.8	1.31	3733.21	0.000350433	1.0944	0.38	
K16-354	PLT-007	17.70	HW	RHYC	10.62	II	d	Valid test	61.10	61.1	61.10	106.2	10.07	3733.21	0.002696811	1.0944	2.95	
K16-354	PLT-008	17.7	HW	RHYC	9.44	II	d	Valid test	61.1	61.1	61.10	94.4	8.95	3733.21	0.002397165	1.0944	2.62	
K16-354	PLT-009	17.7	HW	RHYC	12.36	L	a	Valid test	29	61.1	29.00	123.6	11.72	2256.05	0.005193707	1.0944	5.68	
K16-354	PLT-010	24	HW	RHYC	8.68	II	d	Valid test	61.1	61.1	61.10	86.8	8.23	3733.21	0.002204173	1.0944	2.41	
K16-354	PLT-011	24	HW	RHYC	6.2	L	a	Valid test	46	61.1	46.00	62	5.88	3578.57	0.001642445	1.0944	1.80	
											0.00	0	0.00	0.00		0.0000	0.00	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-355	KRAKATOA	All	KRAK010A	415150	6815074	1425	329.7	-80	HQ3	36	29-May-16	2-Jun-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	DH		
Geotech Log	O Nielsen	IH	6/Jun/16
PLT	KF	IH	6/Jun/16
UCS	N/A	N/A	N/A

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-355	0.00	4.50	Overburden (OVBN)
K16-355	4.50	12.00	Volcaniclastic rhyolite (RHYv)
K16-355	12.00	12.40	Coherent rhyolite (RHYc)
K16-355	12.40	12.60	Volcaniclastic rhyolite (RHYv)
K16-355	12.60	14.30	Pelite (PEL)
K16-355	14.30	27.80	Coherent rhyolite (RHYc)
K16-355	27.80	32.50	Pelite (PEL)
K16-355	32.50	66.60	Aphanitic rhyolite (RHYi)
K16-355	66.60	70.50	Coherent rhyolite (RHYc)
K16-355	70.50	77.20	Pelite (PEL)
K16-355	77.20	81.30	Coherent rhyolite (RHYc)
K16-355	81.30	81.90	Greywacke (WCK)
K16-355	81.90	87.20	Volcaniclastic rhyolite (RHYv)
K16-355	87.20	105.20	Volcaniclastic rhyolite (RHYv)
K16-355	105.20	123.20	Volcaniclastic rhyolite (RHYv)
K16-355	123.20	126.40	Volcaniclastic rhyolite (RHYv)
K16-355	126.40	133.80	Volcaniclastic rhyolite (RHYv)
K16-355	133.80	138.10	Rhyolite (RHY)
K16-355	138.10	140.10	Fault Zone (FLZ)
K16-355	140.10	155.60	Rhyolite (RHY)
K16-355	155.60	157.30	Fault Zone (FLZ)
K16-355	157.30	181.40	Rhyolite (RHY)
K16-355	181.40	185.30	Coherent rhyolite (RHYc)
K16-355	185.30	247.50	Mafic intrusion (MAFi)
K16-355	247.50	275.90	Volcaniclastic rhyolite (RHYv)
K16-355	275.90	283.50	Fault Zone (FLZ)
K16-355	283.50	285.20	Volcaniclastic rhyolite (RHYv)
K16-355	285.20	292.70	Undifferentiated sedimentary rock (SED)
K16-355	292.70	296.30	Volcaniclastic rhyolite (RHYv)
K16-355	296.30	298.00	Undifferentiated sedimentary rock (SED)
K16-355	298.00	312.40	Volcaniclastic rhyolite (RHYv)
K16-355	312.40	329.70	Fault Zone (FLZ)

Geotechnical Log

Hole ID	Zone	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	ALPHA 0-29 Count	ALPHA 0-29 TYPE	ALPHA 0-29 Jr	ALPHA 0-29 Ja	ALPHA 30-59 Count	ALPHA 30-59 TYPE	ALPHA 30-59 Jr	ALPHA 30-59 Ja	ALPHA 60-90 Count	ALPHA 60-90 TYPE	ALPHA 60-90 Jr	ALPHA 60-90 Ja	Alpha	Beta	Type	Confidence (1,2,3)	Joint Condition Rating	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
[illegible]	HW	OVBN	4.30	8.50	4.2		0%			0%																										Overburden
[illegible]	HW	RHYv	8.50	12.60	4.1	2.74	67%	42	1.09	27%	W4/A4	R3/4	6					11	J	1	4-8	4	J/F	1.5	4-8					0-6			15%			No ori line, interval length due to lith change, poor recovery due to broken ground
[illegible]	HW	PEL	12.60	14.30	1.7	1.36	80%	13	1.00	59%	W3/A3	R3/4	6					3	J	3	2	5	J/F	1	4					6-12		15%	10%			Poor recovery in fault zone? No ori line, Length due to lith change
[illegible]	HW	RHYc	14.30	18.00	3.7	3.50	95%	9	3.30	89%	W1/A1	R4	1									1	J/F	3	2					12-20			5%			No ori line, interval length due to lith change,
[illegible]	HW	RHYc	18.00	21.00	3.0	2.70	90%	8	2.50	83%	W1/A1	R4	2									5	J/F	3	1								5%			No ori line, poor recovery due to spun core, ground
[illegible]	HW	RHYc	21.00	24.00	3.0	2.93	98%	4	2.93	98%	W1/A1	R4	2					3	J	3	1	1	J	1	8	20.0	0.0	FOL	3.0	12						Good recovery,
[illegible]	HW	RHYc	24.00	27.80	3.8	3.65	96%	10	3.50	92%	W1/A1	R4	4					5	J	1-3	1	4	J	1-3	4	25.0	170.0	FOL	2.0	20						Good recovery, length due to light change
[illegible]	HW	PEL	27.80	32.50	4.7	4.19	89%	18	3.94	84%	W1/A1	R4	6	1	J	3	1	5	J/F	1	4	4	J/F	1	4	45.0	175.0	FOL	3.0	6		3%	5%			Foliation changes (folded) within the run, poor recovery due to spun core, joints parting along micaceous foliation planes,
[illegible]	HW	RHYi	32.50	36.00	3.5	3.04	87%	7	3.01	86%	W1/A1	R3	3	4	J	4	1					3	J	3	2	18.0	26.0	J	3.0	20						Spun core,
[illegible]	HW	RHYi	36.00	39.00	3.0	2.74	91%	7	2.74	91%	W1/A1	R4	3					1	J	1	3	6	J	1	4-6					6-20						Good recovery, no ori line
[illegible]	HW	RHYi	39.00	42.00	3.0	2.63	88%	11	2.08	69%	W1/A1	R3	3	2	J	3.0	1.0					9	J	1-3	1-4					12-20						No ori line, spun core
[illegible]	HW	RHYi	42.00	45.00	3.0	2.75	92%	6	2.68	89%	W1/A1	R4	3					4	J	1.5	1	2	J	1.5	1					20-25						Spun core, no ori line,
[illegible]	HW	RHYi	45.00	48.00	3.0	1.80	60%	8	1.69	56%	W1/A1	R4	4					2	J	1.5	1	6	J	1.5	1	50.0	205.0	J	3.0	20						Poor recovery PR no reason,
[illegible]	HW	RHYi	48.00	51.00	3.0	2.82	94%	9	2.78	93%	W1/A1	R5	4	3	J	3.0	1.0	2	J	1.5	1	4	J	1-1.5	1-4					12-20						No ori line, good recovery
[illegible]	HW	RHYi	51.00	54.00	3.0	2.97	99%	8	2.97	99%	W1/A1	R3	3					5	J	1.5	1-4	3	J	1	4	60.0	124.0	J	3.0	6-12						Good recovery
[illegible]	HW	RHYi	54.00	57.00	3.0	3.05	102%	12	2.87	96%	W1/A1	R4	3					2	J	1	4	6	J	1	1-4	75.0	136.0	J	3.0	12-20				3%		Good recovery
[illegible]	HW	RHYi	57.00	60.00	3.0	2.54	85%	15	2.18	73%	W1/A1	R4	3	1	J	3.0	1.0	10	J	1	4	4	J	1	1-4	50.0	340.0	J	2.0	12-20						Good recovery

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
								0	#DIV/0!		
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7

Load Correction Factor = 0.09 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$ For diam. test $D_e^2 = D^2$ (mm)	Is $(kN/mm^2) = P/D_e^2$	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-355	PLT-01	44.10	HW	RHYi	18.1	II	d	valid	61.10	61.10	61.10	181	17.16	3733.21	0.004596259	1.0944	5.03	
K16-355	PLT-02	44.10	HW	RHYi	17.74	L	a	valid	23.00	61.10	23.00	177.4	16.82	1789.28	0.009399025	1.0944	10.29	
K16-355	PLT-03	69.90	HW	PEL	11.72	II	d	valid	61.10	61.10	61.10	117.2	11.11	3733.21	0.002976141	1.0944	3.26	
K16-355	PLT-04	77.80	HW	RHYc	9.36	II	d	valid	61.10	61.10	61.10	93.6	8.87	3733.21	0.00237685	1.0944	2.60	
K16-355	PLT-05	115.80	HW	RHYv	4.66	II	d	valid	61.10	61.10	61.10	46.6	4.42	3733.21	0.001183346	1.0944	1.30	
K16-355	PLT-06	115.80	HW	RHYv	11.4	L	a	valid	42.50	61.10	42.50	114	10.81	3306.28	0.003268684	1.0944	3.58	
K16-355	PLT-07	190.10	WASTE	MAFi	8.08	II	d	valid	61.10	61.10	61.10	80.8	7.66	3733.21	0.002051811	1.0944	2.25	
K16-355	PLT-08	210.9	WASTE	MAFi	10.8	II	d	valid	61.10	61.10	61.10	108	10.24	3733.21	0.002742519	1.0944	3.00	
K16-355	PLT-09	229.1	WASTE	MAFi	6.04	II	d	valid	61.1	61.10	61.10	60.4	5.73	3733.21	0.001533779	1.0944	1.68	
K16-355	PLT-10	229.1	WASTE	MAFi	5.54	L	a	valid	34	61.10	34.00	55.4	5.25	2645.03	0.001985582	1.0944	2.17	
K16-355	PLT-11	242.3	WASTE	MAFi	1.1	II	d	valid	61.1	61.10	61.10	11	1.04	3733.21	0.000279331	1.0944	0.31	
K16-355	PLT-12	242.3	WASTE	MAFi	9.44	L	a	valid	28	61.10	28.00	94.4	8.95	2178.26	0.004108383	1.0944	4.50	
K16-355	PLT-13	297.5	FW	SED	1.9	II	d	valid	61.1	61.10	61.10	19	1.80	3733.21	0.00048248	1.0944	0.53	
K16-355	PLT-14	298.5	FW	SED	4.44	L	a	valid	25.5	61.10	25.50	44.4	4.21	1983.77	0.002121777	1.0944	2.32	
											0.00	0	0.00	0.00	#DIV/0!	0.0000	#DIV/0!	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-356	Krakatoa	HW	KRAK019	415207	6815283	1425	19	-72	HQ3	211	30-May-16	31-May-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	JDP		
Geotechnical	IH		
PLT	IH		
UCS			

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-356	0	12	Overburden (OVBN)
K16-356	12	14.5	Mafic tuff (MAFt)
K16-356	14.5	15.5	Graphitic mudstone (MDU)
K16-356	15.5	15.9	Mafic tuff (MAFt)
K16-356	15.9	19	Graphitic mudstone (MDU)

Geotechnical Log

Hole ID	Zone	Lithology	Core Recovery Data: From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Strength Data: Weathering/Alteration	Strength	Joint Set Number (Jn)	Discontinuity parameters for Q System: ALPHA=0-29: Count	TYPE	Jr	Ja	ALPHA=30-59: Count	TYPE	Jr	Ja	ALPHA=60-90: Count	TYPE	Jr	Ja	Oriented Core Log: Alpha	Beta	Type	Confidence (3,2,1)	RMR76: Joint Condition Rating	Fault and Broken Zones: % Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
K16-356	HW	OVBN	11.0	12.0	1.0	0.6	59%	40	0	0%	W4	R2/R3	20																	0				100%		Weathered OVBN material low run due to lith change next.
K16-356	HW	MAFI	12.0	14.5	2.5	1.5	58%	28	1	36%	W4	R3	3									9	J	2.0	2.0					6				30%		Weathered on surface of core and joints. Still some rubble zone in this run but competent Mafi
K16-356	HW	MDS	14.5	18.0	3.5	2.0	56%	61	0	3%	W4	R2	15-20																				20%	50%		Mudstone closely spacing of discont. weathered with R2 and R2 throughout run incompetent rock.
K16-356	HW	MDS	18.0	19.0	1.0	0.6	57%	40	0	0%	W4	R2	15-20																					90%		Similar as last run rubble zone throughout. EOH abandoned due to deviation in drilling.
					0.0		#DIV/0!			#DIV/0!																										

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-356	MAFi	Waste	12.5	12.8	0190411		61.1	300	4.9099836333879 Valid	01-Jun-16	From abandoned hole
								0	#DIV/0!		
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7 **Load Correction Factor =** 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$; For diam. test $D_e^2 = D^2$ (mm)	Is $(kN/mm^2) = P/D_e^2$	$F = (D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-356	PLT-01	13.70	HW	MAFi	10.98	II	d	valid fresh break perp to core axis	61.10	61.10	61.10	109.8	10.41	3733.21	0.002788228	1.0944	3.05	
K16-356	PLT-02	13.70	HW	MAFi	16.46	L	a	fresh break along core axis valid	42.20	61.10	42.20	164.6	15.60	3282.95	0.004753072	1.0944	5.20	
K16-356	PLT-03	17.93	HW	MDS	4.52	II	d	natural break along fol	61.10	61.10	61.10	45.2	4.28	3733.21	0.001147795	1.0944	1.26	
K16-356	PLT-04	17.93	HW	MDS	5.8	L	a	natural break along fol w/chloritic alteration	26.90	61.10	26.90	58	5.50	2092.68	0.002627439	1.0944	2.88	
K16-356	PLT-05	18.30	HW	MDS	1.78	L	a	II to core axis valid break	41.60	61.10	41.60	17.8	1.69	3236.27	0.000521415	1.0944	0.57	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-357	Krakatoa	All	KRAK019A	415207	6815283	1425	381	-72	HQ3	211	1-Jun-16	6-Jun-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	JDP		
Geotechnical	IH	IH	06-Jun-16
PLT	JF/RN/IH	IH	06-Jun-16
UCS	IH	IH	06-Jun-16

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-357	0	12	Overburden (OVBN)
K16-357	12	12.84	Mafic tuff (MAFt)
K16-357	12.84	21.2	Graphitic mudstone (MDU)
K16-357	21.2	22.44	Mafic tuff (MAFt)
K16-357	22.44	25.65	Graphitic mudstone (MDU)
K16-357	25.65	27.52	Mafic tuff (MAFt)
K16-357	27.52	33.47	Graphitic mudstone (MDU)
K16-357	33.47	37.6	Mafic tuff (MAFt)
K16-357	37.6	42.82	Graphitic mudstone (MDU)
K16-357	42.82	43.48	Undifferentiated sedimentary rock (SED)
K16-357	43.48	69	Volcaniclastic rhyolite (RHYv)
K16-357	69	69.69	Coherent rhyolite (RHYc)
K16-357	69.69	75.22	Volcaniclastic rhyolite (RHYv)
K16-357	75.22	81.81	Volcaniclastic rhyolite (RHYv)
K16-357	81.81	93.29	Aphanitic rhyolite (RHYi)
K16-357	93.29	97.46	Volcaniclastic rhyolite (RHYv)
K16-357	97.46	99.2	Coherent rhyolite (RHYc)
K16-357	99.2	103	Volcaniclastic rhyolite (RHYv)
K16-357	103	106.78	Coherent rhyolite (RHYc)
K16-357	106.78	108.08	Volcaniclastic rhyolite (RHYv)
K16-357	108.08	109.27	Coherent rhyolite (RHYc)
K16-357	109.27	114.12	Volcaniclastic rhyolite (RHYv)
K16-357	114.12	118.89	Pelite (PEL)
K16-357	118.89	120.72	Volcaniclastic rhyolite (RHYv)
K16-357	120.72	138	Volcaniclastic rhyolite (RHYv)
K16-357	138	141.24	Volcaniclastic rhyolite (RHYv)
K16-357	141.24	141.48	Volcaniclastic rhyolite (RHYv)
K16-357	141.48	144.48	Volcaniclastic rhyolite (RHYv)
K16-357	144.48	147.44	Coherent rhyolite (RHYc)
K16-357	147.44	148.93	Mafic intrusion (MAFi)
K16-357	148.93	150.56	Coherent rhyolite (RHYc)
K16-357	150.56	155.3	Aphanitic rhyolite (RHYi)
K16-357	155.3	161.81	Volcaniclastic rhyolite (RHYv)
K16-357	161.81	163.78	Volcaniclastic rhyolite (RHYv)
K16-357	163.78	164.65	Volcaniclastic rhyolite (RHYv)
K16-357	164.65	167.14	Volcaniclastic rhyolite (RHYv)
K16-357	167.14	179.41	Volcaniclastic rhyolite (RHYv)
K16-357	179.41	184.42	Coherent rhyolite (RHYc)
K16-357	184.42	185.9	Volcaniclastic rhyolite (RHYv)
K16-357	185.9	186.65	Greywacke (WCK)
K16-357	186.65	189.73	Volcaniclastic rhyolite (RHYv)
K16-357	189.73	190.4	Undifferentiated sedimentary rock (SED)
K16-357	190.4	191.82	Volcaniclastic rhyolite (RHYv)
K16-357	191.82	205.43	Coherent rhyolite (RHYc)
K16-357	205.43	216.8	Volcaniclastic rhyolite (RHYv)
K16-357	216.8	221.26	Coherent rhyolite (RHYc)
K16-357	221.26	225.26	Semi-massive sulphide (OI, OJ)
K16-357	225.26	230.61	Coherent rhyolite (RHYc)
K16-357	230.61	231.6	Rhyolite (RHY)
K16-357	231.6	240.35	Rhyolite (RHY)
K16-357	240.35	243	Coherent rhyolite (RHYc)
K16-357	243	246	Rhyolite (RHY)
K16-357	246	252.24	Rhyolite (RHY)
K16-357	252.24	252.74	Massive sulphide (OA, OB, OC, OF, OK)
K16-357	252.74	253.26	Volcaniclastic rhyolite (RHYv)
K16-357	253.26	254.6	Massive sulphide (OA, OB, OC, OF, OK)
K16-357	254.6	256.6	Volcaniclastic rhyolite (RHYv)
K16-357	256.6	257.27	Massive sulphide (OA, OB, OC, OF, OK)
K16-357	257.27	259.37	Semi-massive sulphide (OI, OJ)
K16-357	259.37	304.44	Mafic intrusion (MAFi)
K16-357	304.44	306.24	Mafic intrusion (MAFi)
K16-357	306.24	331	Mafic intrusion (MAFi)
K16-357	331	332.23	Mafic intrusion (MAFi)
K16-357	332.23	340.27	Volcaniclastic rhyolite (RHYv)
K16-357	340.27	347.12	Volcaniclastic rhyolite (RHYv)
K16-357	347.12	369.94	Volcaniclastic rhyolite (RHYv)
K16-357	369.94	371.58	Volcaniclastic rhyolite (RHYv)
K16-357	371.58	377.69	Volcaniclastic rhyolite (RHYv)
K16-357	377.69	381	Volcaniclastic rhyolite (RHYv)

Geotechnical Log

			Core Recovery Data								Strength Data			Discontinuity parameters for Q System																RMR76						
														ALPHA/0-29				ALPHA/30-59				ALPHA/60-90				Oriented Core Log					Fault and Broken Zones					
Hole ID	Zone	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	Count	TYPE	Jr	Ja	Count	TYPE	Jr	Ja	Count	TYPE	Jr	Ja	Alpha	Beta	Type	Confidence (3,2,1)	Joint Condition Rating	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-357	RHYv	Waste	48	48.25	0190412		61.1	250	4.09165302782324 Valid	02-Jun-16	
K16-357	RHYv	Waste	74.3	74.6	0190413		61.1	300	4.90998363338784 Valid	02-Jun-16	
K16-357	RHYi	Waste	90.6	90.85	0190414		61.1	250	4.09165302782324 Valid	02-Jun-16	
K16-357	RHYc	Waste	104.4	104.65	0190415		61.1	250	4.09165302782324 Valid	02-Jun-16	
K16-357	RHYc	Waste	192.5	192.85	0190416		61.1	350	5.72831423895244 Valid	04-Jun-16	
K16-357	RHYc	Waste	195.35	195.7	0190417		61.1	350	5.72831423895244 Valid	04-Jun-16	
K16-357	RHYi	Waste	216	216.3	0190418		61.1	300	4.90998363338807 Valid	04-Jun-16	
K16-357	OI (Stringer)	Ore	223.55	224.1	0190419	B00291557	61.1	550	9.00163666121085 Valid	04-Jun-16	Should be able to test 2
K16-357	OB (Ore)	Ore	253.9	254.6	190420	B00291585	61.1	700	11.4566284779049 Valid	05-Jun-16	Should be able to test 2
K16-357	MAFi	Waste	309	309.28	190422		61.1	280	4.58265139116158 Valid	06-Jun-16	
K16-357	MAFi	Waste	315.38	315.76	190423		61.1	380	6.21931260229125 Valid	06-Jun-16	
K16-357	RHYv	Waste	366.73	367.03	190424		61.1	300	4.90998363338714 Valid	06-Jun-16	
								0	#DIV/0!		
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7

Load Correctio 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$ For diam. test $D_e^2 = D^2$ (mm)	Is $(kN/mm^2) = P/D_e^2$	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-377	PLT-01	12.84	HW	MDS	2.52	II	d	valid test	61.10	61.1	61.10	25.2	2.39	3733.21	0.000639921	1.0944	0.70	
K16-357	PLT-02	17.25	HW	MDS	2.48	II	d	valid test	61.10	61.1	61.10	24.8	2.35	3733.21	0.000629764	1.0944	0.69	
K16-357	PLT-03	17.25	HW	MDS	9.68	L	a	invalid test jump off	49.90	61.1	49.90	96.8	9.18	3881.97	0.002363915	1.0944	2.59	
K16-357	PLT-04	22.59	HW	MDS	0.98	II	d	valid test	61.10	61.1	61.10	9.8	0.93	3733.21	0.000248858	1.0944	0.27	
K16-357	PLT-05	24.90	HW	MDS	0.96	II	d	valid test	61.10	61.1	61.10	9.6	0.91	3733.21	0.000243779	1.0944	0.27	
K16-357	PLT-06	24.90	HW	MDS	0.96	L	a	invalid test jump off	54.00	61.1	54.00	9.6	0.91	4200.93	0.000216638	1.0944	0.24	
K16-357	PLT-07	27.42	HW	MDS	2.14	II	d	valid test	61.10	61.1	61.10	21.4	2.03	3733.21	0.000543425	1.0944	0.59	
K16-357	PLT-08	45	HW	RHYV	0	II	d	invalid test fell apart	61.1	61.1	61.10	0	0.00	3733.21	0	1.0944	0.00	
K16-357	PLT-09	45	HW	RHYV	1.64	L	a	valid test	56	61.1	56.00	16.4	1.55	4356.52	0.000356872	1.0944	0.39	
K16-357	PLT-10	54	HW	RHYV	0	II	d	invalid test jump off	61.1	61.1	61.10	0	0.00	3733.21	0	1.0944	0.00	
K16-357	PLT-11	54	HW	RHYV	9.48	L	a	valid test	38	61.1	38.00	94.8	8.99	2956.21	0.003040057	1.0944	3.33	
K16-357	PLT-12	63.9	HW	RHYV	2.28	II	d	valid test	61.1	61.1	61.10	22.8	2.16	3733.21	0.000578976	1.0944	0.63	
K16-357	PLT-13	73.66	HW	RHYV	2.5	II	d	valid test	61.1	61.1	61.10	25	2.37	3733.21	0.000634842	1.0944	0.69	
K16-357	PLT-14	84.6	HW	RHYI	8.48	II	d	valid test	61.1	61.1	61.10	84.8	8.04	3733.21	0.002153385	1.0944	2.36	
K16-357	PLT-15	84.6	HW	RHYI	3.94	L	a	valid test	38	61.1	38.00	39.4	3.74	2956.21	0.001263484	1.0944	1.38	
K16-357	PLT-16	130.05	HW	RHYV	3.12	II	d	valid test	61.10	61.1	61.10	31.2	2.96	3733.21	0.000792283	1.0944	0.87	
K16-357	PLT-17	130.05	HW	RHYV	8.94	L	a	valid test	44.00	61.1	44.00	89.4	8.48	3422.98	0.00247595	1.0944	2.71	
K16-357	PLT-18	141.85	HW	RHYV	3.3	II	d	valid test	61.10	61.1	61.10	33	3.13	3733.21	0.000837992	1.0944	0.92	
K16-357	PLT-19	146.52	HW	RHYC	4.2	II	d	valid test	61.10	61.1	61.10	42	3.98	3733.21	0.001066535	1.0944	1.17	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-358	Krakatoa	All	KRAK012	415101	6815171	1396	325	-86.3	HQ3	73.4	2-Jun-06	6-Jun-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	Dillon		
Geotechnical	Oscar	IH	15/Jun/16
PLT	Kellin		
UCS	Oscar/Imran	IH	15/Jun/16

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-358	0	6.3	Overburden (OVBN)
K16-358	6.3	10	Volcaniclastic rhyolite (RHYv)
K16-358	10	11.9	Volcaniclastic rhyolite (RHYv)
K16-358	11.9	13.5	Volcaniclastic rhyolite (RHYv)
K16-358	13.5	14.6	Volcaniclastic rhyolite (RHYv)
K16-358	14.6	33.5	Volcaniclastic rhyolite (RHYv)
K16-358	33.5	54.6	Volcaniclastic rhyolite (RHYv)
K16-358	54.6	63.8	Aphanitic rhyolite (RHYi)
K16-358	63.8	65.5	Rhyolite (RHY)
K16-358	65.5	78	Aphanitic rhyolite (RHYi)
K16-358	78	78.6	Pelite (PEL)
K16-358	78.6	81.9	Volcaniclastic rhyolite (RHYv)
K16-358	81.9	86.3	Aphanitic rhyolite (RHYi)
K16-358	86.3	91	Volcaniclastic rhyolite (RHYv)
K16-358	91	96.5	Volcaniclastic rhyolite (RHYv)
K16-358	96.5	100.1	Volcaniclastic rhyolite (RHYv)
K16-358	100.1	100.5	Pelite (PEL)
K16-358	100.5	125.6	Volcaniclastic rhyolite (RHYv)
K16-358	125.6	135.4	Volcaniclastic rhyolite (RHYv)
K16-358	135.4	136.7	Semi-massive sulphide (OI, OJ)
K16-358	136.7	148.9	Volcaniclastic rhyolite (RHYv)
K16-358	148.9	150.1	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	150.1	151.4	Coherent rhyolite (RHYc)
K16-358	151.4	152	Semi-massive sulphide (OI, OJ)
K16-358	152	156.4	Mafic intrusion (MAFi)
K16-358	156.4	165.8	Coherent rhyolite (RHYc)
K16-358	165.8	167.3	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	167.3	168.2	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	168.2	169.3	Semi-massive sulphide (OI, OJ)
K16-358	169.3	169.9	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	169.9	170.4	Semi-massive sulphide (OI, OJ)
K16-358	170.4	217.6	Mafic intrusion (MAFi)
K16-358	217.6	224.3	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	224.3	224.98	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	224.98	225.72	Semi-massive sulphide (OI, OJ)
K16-358	225.72	245.46	Mafic intrusion (MAFi)
K16-358	245.46	246.46	Massive sulphide (OA, OB, OC, OF, OK)
K16-358	246.46	247.16	Semi-massive sulphide (OI, OJ)
K16-358	247.16	250.51	Rhyolite (RHY)
K16-358	250.51	266.71	Volcaniclastic rhyolite (RHYv)
K16-358	266.71	274.49	Volcaniclastic rhyolite (RHYv)
K16-358	274.49	286.39	Volcaniclastic rhyolite (RHYv)
K16-358	286.39	290.66	Coherent rhyolite (RHYc)
K16-358	290.66	303.72	Volcaniclastic rhyolite (RHYv)
K16-358	303.72	305.92	Volcaniclastic rhyolite (RHYv)
K16-358	305.92	320.88	Volcaniclastic rhyolite (RHYv)
K16-358	320.88	348	Volcaniclastic rhyolite (RHYv)

Geotechnical Log

[illegible]

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-358	RHY	Waste	64.15	64.46	0190421		61.1	310	5.07364975450062 Valid	June 6 2016	Two tests may be possible
K16-358	OA	ORE	165.8	166.4	0190427	B00292344	61.1	600	9.81996726677568 Valid	June 8 2016	
K16-358	OI	ORE	169.9	170.4	0190428	B00292349	61.1	500	8.18330605564648 Valid	June 8 2016	
K16-358	OB	ORE	217.6	218.6	0190429	B00292368	61.1	1000	16.366612111293 Valid	June 8 2016	
K16-358	OB	ORE	219.45	220.44	0190430	B00292372	61.1	990	16.2029459901802 Valid	June 8 2016	
K16-358	OB	ORE	245.46	246.46	0190431	B00292397	61.1	1000	16.366612111293 Valid	June 9 2016	
								0	#DIV/0!		
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7 **Load Correction Factor =** 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	(mm) only for axial te	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	F=$(D_e/50)^{0.45}$	$Is_{(50)}$ = F x I_s (MPa)	UCS Sample Match
K16-358	PLT-01	13.90	HW	RHYV	8.28	II	d	Valid test	61.10	61.1	61.10	82.8	7.85	3733.21	0.002102598	1.0944	2.30	
K16-358	PLT-02	26.30	HW	RHYV	5.08	II	d	Valid test	61.10	61.1	61.10	50.8	4.82	3733.21	0.00129	1.0944	1.41	
K16-358	PLT-03	26.30	HW	RHYV	14.22	L	a	Valid test	46.50	61.1	46.50	142.2	13.48	3617.46	0.003726522	1.0944	4.08	
K16-358	PLT-04	37.00	HW	RHYV	2.84	II	d	Valid test	61.10	61.1	61.10	28.4	2.69	3733.21	0.000721181	1.0944	0.79	
K16-358	PLT-05	48.00	HW	RHYV	4.82	II	d	Valid test	61.10	61.1	61.10	48.2	4.57	3733.21	0.001223976	1.0944	1.34	
K16-358	PLT-06	55.90	HW	RHYI	4.8	II	d	Valid test	61.10	61.1	61.10	48	4.55	3733.21	0.001218897	1.0944	1.33	
K16-358	PLT-07	60.10	HW	RHYI	11.9	II	d	Valid test	61.10	61.1	61.10	119	11.28	3733.21	0.00302185	1.0944	3.31	
K16-358	PLT-08	64.7	HW	RHY	8.7	II	d	Valid test	61.1	61.1	61.10	87	8.25	3733.21	0.002209252	1.0944	2.42	
K16-358	PLT-09	74.5	HW	RHYI	10.86	II	d	Valid test	61.1	61.1	61.10	108.6	10.30	3733.21	0.002757755	1.0944	3.02	
K16-358	PLT-10	74.5	HW	RHYI	31.32	L	a	invalid test jump off	60	61.1	60.00	313.2	29.69	4667.70	0.006361031	1.0944	6.96	
K16-358	PLT-11	79.1	HW	RHYV	3.62	II	d	Valid test	61.1	61.1	61.10	36.2	3.43	3733.21	0.000919252	1.0944	1.01	
K16-358	PLT-12	94.2	HW	RHYV	2.44	II	d	Valid test	61.1	61.1	61.10	24.4	2.31	3733.21	0.000619606	1.0944	0.68	
K16-358	PLT-13	94.2	HW	RHYV	12.78	L	a	Valid test	30	61.1	30.00	127.8	12.12	2333.85	0.005191186	1.0944	5.68	
K16-358	PLT-14	100.1	HW	PEL	12.6	II	d	Valid test	61.1	61.1	61.10	126	11.94	3733.21	0.003199606	1.0944	3.50	
K16-358	PLT-15	111.9	HW	RHYV	3.58	II	d	Valid test	61.1	61.1	61.10	35.8	3.39	3733.21	0.000909094	1.0944	0.99	
K16-358	PLT-16	111.9	HW	RHYV	11.14	L	a	Valid test	52	61.1	52.00	111.4	10.56	4045.34	0.002610591	1.0944	2.86	
K16-358	PLT-17	123.3	HW	RHYV	0.62	II	d	Valid test	61.1	61.1	61.10	6.2	0.59	3733.21	0.000157441	1.0944	0.17	
K16-358	PLT-18	123.3	HW	RHYV	10.42	L	a	Valid test	29	61.1	29.00	104.2	9.88	2256.05	0.004378514	1.0944	4.79	
K16-358	PLT-19	127.6	HW	RHYV	2.58	II	d	Valid test	61.1	61.1	61.10	25.8	2.45	3733.21	0.000655157	1.0944	0.72	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-359	Krakatoa	All	KRAK030	415207.0	6815283.0	1425.0	380.0	-73.0	HQ3	180.0	7-Jun-20	12-Jun-20

Drill Hole Collection Program

Discipline	Personnel	Checked by	Date
Geologist	JDP		
Geotech Log	HM/IH		
PLT	HM/IH		
UCS	IH/HM	IH	

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-359	0	12	Overburden (OVBN)
K16-359	12	21.1	Graphitic mudstone (MDU)
K16-359	21.1	22.12	Mafic tuff (MAFt)
K16-359	22.12	24.34	Graphitic mudstone (MDU)
K16-359	24.34	27.03	Mafic tuff (MAFt)
K16-359	27.03	34	Graphitic mudstone (MDU)
K16-359	34	36.23	Chert (CHT)
K16-359	36.23	41.64	Graphitic mudstone (MDU)
K16-359	41.64	42.87	Undifferentiated sedimentary rock (SED)
K16-359	42.87	43.67	Graphitic mudstone (MDU)
K16-359	43.67	48.4	Mafic tuff (MAFt)
K16-359	48.4	57.9	Volcaniclastic rhyolite (RHYv)
K16-359	57.9	78.11	Volcaniclastic rhyolite (RHYv)
K16-359	78.11	80.7	Volcaniclastic rhyolite (RHYv)
K16-359	80.7	93.07	Aphanitic rhyolite (RHYi)
K16-359	93.07	99.17	Volcaniclastic rhyolite (RHYv)
K16-359	99.17	103.28	Rhyolite (RHY)
K16-359	103.28	103.75	Mafic intrusion (MAFi)
K16-359	103.75	107.02	Volcaniclastic rhyolite (RHYv)
K16-359	107.02	108.68	Pelite (PEL)
K16-359	108.68	111.45	Volcaniclastic rhyolite (RHYv)
K16-359	111.45	113	Pelite (PEL)
K16-359	113	113.68	Volcaniclastic rhyolite (RHYv)
K16-359	113.68	118.03	Pelite (PEL)
K16-359	118.03	120.49	Pelite (PEL)
K16-359	120.49	124.85	Volcaniclastic rhyolite (RHYv)
K16-359	124.85	128.49	Volcaniclastic rhyolite (RHYv)
K16-359	128.49	134.11	Coherent rhyolite (RHYc)
K16-359	134.11	141.43	Coherent rhyolite (RHYc)
K16-359	141.43	142.98	Mafic intrusion (MAFi)
K16-359	142.98	146.9	Coherent rhyolite (RHYc)
K16-359	146.9	149.69	Coherent rhyolite (RHYc)
K16-359	149.69	153.92	Coherent rhyolite (RHYc)
K16-359	153.92	160.54	Volcaniclastic rhyolite (RHYv)
K16-359	160.54	164.24	Volcaniclastic rhyolite (RHYv)
K16-359	164.24	173.1	Volcaniclastic rhyolite (RHYv)
K16-359	173.1	174.53	Volcaniclastic rhyolite (RHYv)
K16-359	174.53	178.76	Volcaniclastic rhyolite (RHYv)
K16-359	178.76	181.15	Volcaniclastic rhyolite (RHYv)
K16-359	181.15	184.77	Volcaniclastic rhyolite (RHYv)
K16-359	184.77	185.88	Volcaniclastic rhyolite (RHYv)
K16-359	185.88	188.7	Coherent rhyolite (RHYc)
K16-359	188.7	190.1	Fault Zone (FLZ)
K16-359	190.1	191.92	Volcaniclastic rhyolite (RHYv)
K16-359	191.92	193.3	Rhyolite (RHY)
K16-359	193.3	213.75	Volcaniclastic rhyolite (RHYv)
K16-359	213.75	221.14	Volcaniclastic rhyolite (RHYv)
K16-359	221.14	227.25	Volcaniclastic rhyolite (RHYv)
K16-359	227.25	229.34	Rhyolite (RHY)
K16-359	229.34	231.83	Coherent rhyolite (RHYc)
K16-359	231.83	236.65	Volcaniclastic rhyolite (RHYv)
K16-359	236.65	239.69	Coherent rhyolite (RHYc)
K16-359	239.69	249.1	Coherent rhyolite (RHYc)
K16-359	249.1	252.75	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	252.75	255	Coherent rhyolite (RHYc)
K16-359	255	258	Rhyolite (RHY)
K16-359	258	258.5	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	258.5	260.37	Semi-massive sulphide (OI, OJ)
K16-359	260.37	261.41	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	261.41	264.25	Coherent rhyolite (RHYc)
K16-359	264.25	264.75	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	264.75	266.9	Semi-massive sulphide (OI, OJ)
K16-359	266.9	267.86	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	267.86	338.13	Mafic intrusion (MAFi)
K16-359	338.13	338.7	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	338.7	339.4	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	339.4	339.9	Massive sulphide (OA, OB, OC, OF, OK)
K16-359	339.9	352	Volcaniclastic rhyolite (RHYv)
K16-359	352	374.51	Volcaniclastic rhyolite (RHYv)
K16-359	374.51	382.38	Rhyolite (RHY)
K16-359	382.38	390	Undifferentiated sedimentary rock (SED)

Geotechnical Log

Hole ID	Zone	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/m	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	ALPHA 0-29 Count	ALPHA 0-29 TYPE	ALPHA 0-29 Jr	ALPHA 0-29 Ja	ALPHA 30-59 Count	ALPHA 30-59 TYPE	ALPHA 30-59 Jr	ALPHA 30-59 Ja	ALPHA 60-90 Count	ALPHA 60-90 TYPE	ALPHA 60-90 Jr	ALPHA 60-90 Ja	Oriented Core Log Alpha	Beta	Type	Confidence (3,2,1)	RMR76 Joint Condition Rating	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
K16-359	HW	OVBN	12.00	15.00	3.0	0.75	25%	120	0.00	0%	W5	R1	15																					100%		Overburden - lost core
K16-359	HW	MDU	15.00	18.00	3.0	1.54	51%	37	0.32	11%	W4	R3	12									16	J	1.50	4					6			30%	20%		Mudstone unit weathered on surface of core and joints hard to determine fairly competent may have chlorite
K16-359		MDU	18.00	21.10	3.1	1.31	42%	39	0.14	5%	W3/W4	R3	12									5	J	1.5	4					6	10%		40%	20%		Similar as prev run with minor gouge zone - change in lith
K16-359		MAR	21.10	22.12	1.0	1.06	100%	9	0.78	76%	W3	R3	6									4	J	3	3					12			20%			Change in lith short competent run with fracture thru core seals at end of run
K16-359		MDU	22.12	24.34	2.2	2.07	93%	36	0.86	39%	W3	R3	6									15	J	1	4					12	15%		30%			Close spacing of discont - planar smooth joint surfaces one blow of hammer to break
K16-359		MAR	24.34	27.03	2.7	2.26	84%	34	0.99	37%	W3	R3	6									11	J	1.5	4	72.0	20.0	JF	1.0	12			25%	10%		Change in lith
K16-359		MDU	27.03	30.00	3.0	1.47	49%	120	0.00	0%	W2	R2/R3	15																	6	10%		50%	40%		Major BZ and RZ with minor gouge within MDU unit
K16-359		MDU	30.00	33.00	3.0	1.38	46%	120	0.59	20%	W2	R2	15										no data, core already cut							6	25%		40%	10%		Similar as prev. run
K16-359		MDU	33.00	34.00	1.0	0.90	90%	120	0.25	25%	W2	R3	15																	12	0%	0%	20%			folded
K16-359		MAR	34.00	36.23	2.2	1.17	52%	120	0.33	15%	W3	R3	3									17	J	3	4.00											cherty mafic
K16-359		MDU	36.23	39.00	2.8	2.44	88%	23	1.80	65%	W2	R4	2									15	Fol,J	2.00	4.00	65.0	350.0		2.0	12	0%	0%	0%	0%	0%	competent rock, but folded
K16-359		MDU	39.00	41.64	2.6	2.46	93%	25	1.10	42%	W2/W3	R4	3					2	J	2	4	23	[illegible]	2.00	4.00					12	0%	0%	10%	10%	0%	competent rock with quartz veining and altered portions
K16-359		MDU	41.64	43.67	2.0	1.95	96%	20	1.17	58%	W2/W3	R3	4									20	Fol,J	2.00	4.00					12	0%	0%	0%	10%	0%	folded, 1.2 m MD and 0.8m in MDU
K16-359		MAR	43.67	47.00	3.3	2.04	61%	48	0.45	14%	W3	R2	3									23	F,J	2.00	4.00					12	0%	0%	0%	40%	0%	joints follow foliation mainly
K16-359		MAR	47.00	48.40	1.4	1.30	93%	23	0.77	55%	W2	R3	3									8	F,J	2.00	4.00					6	0%	0%	20%	0%	0%	

UCS Sample Summary

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
K16-359	MDS	Waste	23.4	23.58	01904026		61.1	180	2.94599018003273 Valid	07-Jun-16	
								0	#DIV/0!		

POINT LOAD TEST

Equipment: PIL-7

Load Correction Factor = 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	F=$(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$(MPa)	UCS Sample Match
K16-359	PLT-01	22.39	HW	MDS	5.40	II	d	valid	61.10	61.10	61.10	54	5.12	3733.21	0.00137126	1.0944	1.50	
K16-359	PLT-02	22.39	HW	MDS	2.84	II	d	valid	61.10	61.10	61.10	28.4	2.69	3733.21	0.000721181	1.0944	0.79	
K16-359	PLT-03	22.39	HW	MDS	1.06	L	a	valid	26.00	61.10	26.00	10.6	1.00	2022.67	0.000496809	1.0944	0.54	
K16-359	PLT-04	22.39	HW	MDS	0.64	L	a	valid	29.00	61.10	29.00	6.4	0.61	2256.05	0.00026893	1.0944	0.29	
K16-359	PLT-05	28.26	HW	MDS	1.40	L	a	valid	39.00	61.10	39.00	14	1.33	3034.00	0.000437442	1.0944	0.48	
K16-359	PLT-06	31.61	HW	Mafi	9.86	II	d	valid	61.10	61.10	61.10	98.6	9.35	3733.21	0.002503818	1.0944	2.74	
K16-359	PLT-07	32.61	HW	Mafi	8.08	L	a	valid	37.50	61.10	37.50	80.8	7.66	2917.31	0.002625652	1.0944	2.87	
K16-359	PLT-08	44.29	HW	MDU	1.38	ii	d	valid	61.10	61.10	61.10	13.8	1.31	3733.21	0.000350433	1.0944	0.38	
K16-359	PLT-09	44.29	HW	MDU	2.22	L	a	valid	26.50	61.10	26.50	22.2	2.10	2061.57	0.001020855	1.0944	1.12	
K16-359	PLT-10	52.97	HW	RHYv	3.98	ii	d	valid	61.10	61.10	61.10	39.8	3.77	3733.21	0.001010669	1.0944	1.11	
K16-359	PLT-11	52.97	HW	RHYv	15.16	L	a	invalid	40.00	61.10	40.00	151.6	14.37	3111.80	0.00461845	1.0944	5.05	
K16-359	PLT-12	74.91	HW	RHYv	8.78	ii	d	valid	61.10	61.10	61.10	87.8	8.32	3733.21	0.002229567	1.0944	2.44	
K16-359	PLT-13	75.91	HW	RHYv	18.58	L	a	valid	31.60	61.10	31.60	185.8	17.61	2458.32	0.007164991	1.0944	7.84	
K16-359	PLT-14	87.32	HW	RHYi	7.08	ii	d	valid	61.10	61.10	61.10	70.8	6.71	3733.21	0.001797874	1.0944	1.97	
K16-359	PLT-15	88.32	HW	RHYi	13.80	L	a	valid	45.50	61.10	45.50	138	13.08	3539.67	0.003695938	1.0944	4.04	
K16-359	PLT-16	94.07	HW	RHYv	5.38	ii	d	valid	61.10	61.10	61.10	53.8	5.10	3733.21	0.001366181	1.0944	1.50	
K16-359	PLT-17	95.07	HW	RHYv	8.10	L	a	valid	47.50	61.10	47.50	81	7.68	3695.26	0.002078014	1.0944	2.27	
K16-359	PLT-18	103.92	HW	RHY	8.96	ii	d	valid	61.10	61.10	61.10	89.6	8.49	3733.21	0.002275275	1.0944	2.49	
K16-359	PLT-19	104.92	HW	RHY	19.40	L	a	valid	40.00	61.10	40.00	194	18.39	3111.80	0.005910153	1.0944	6.47	
K16-359	PLT-20	107.23	HW	PEL	2.02	ii	d	valid	61.10	61.10	61.10	20.2	1.91	3733.21	0.000512953	1.0944	0.56	
K16-359	PLT-21	108.23	HW	PEL	14.00	L	a	invalid	40.00	61.10	40.00	140	13.27	3111.80	0.004265059	1.0944	4.67	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-360	Krakatoa		KRAK013	415101.0	6815171.0	1396.0	325.0	-77	HQ3	20	6-Jun-16	9-Jun-16

Drill Hole Collection Program

Discipline	Personnel	Checked by	Date
Geologist	RH		
Geotech Log	IH/ON	IH	19/Jul/16
PLT	IH/ON	IH	19/Jul/16

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-360	0	7.5	Overburden (OVBN)
K16-360	7.5	10.4	Volcaniclastic rhyolite (RHYv)
K16-360	10.4	14.65	Mafic tuff (MAFt)
K16-360	14.65	22.36	Volcaniclastic rhyolite (RHYv)
K16-360	22.36	23.02	Coherent rhyolite (RHYc)
K16-360	23.02	28.38	Volcaniclastic rhyolite (RHYv)
K16-360	28.38	29.5	Rhyolite (RHY)
K16-360	29.5	30.55	Volcaniclastic rhyolite (RHYv)
K16-360	30.55	31.38	Coherent rhyolite (RHYc)
K16-360	31.38	35	Volcaniclastic rhyolite (RHYv)
K16-360	35	37.87	Volcaniclastic rhyolite (RHYv)
K16-360	37.87	43.68	Volcaniclastic rhyolite (RHYv)
K16-360	43.68	44.67	Coherent rhyolite (RHYc)
K16-360	44.67	47.06	Volcaniclastic rhyolite (RHYv)
K16-360	47.06	48.09	Volcaniclastic rhyolite (RHYv)
K16-360	48.09	49.8	Volcaniclastic rhyolite (RHYv)
K16-360	49.8	62	Coherent rhyolite (RHYc)
K16-360	62	64.65	Aphanitic rhyolite (RHYi)
K16-360	64.65	82.6	Coherent rhyolite (RHYc)
K16-360	82.6	83.33	Mafic intrusion (MAFi)
K16-360	83.33	89.12	Coherent rhyolite (RHYc)
K16-360	89.12	89.97	Mafic intrusion (MAFi)
K16-360	89.97	93.55	Volcaniclastic rhyolite (RHYv)
K16-360	93.55	96	Aphanitic rhyolite (RHYi)
K16-360	96	110.16	Volcaniclastic rhyolite (RHYv)
K16-360	110.16	114.34	Volcaniclastic rhyolite (RHYv)
K16-360	114.34	118.16	Coherent rhyolite (RHYc)
K16-360	118.16	123.95	Volcaniclastic rhyolite (RHYv)
K16-360	123.95	129.2	Volcaniclastic rhyolite (RHYv)
K16-360	129.2	130.7	Volcaniclastic rhyolite (RHYv)
K16-360	130.7	132.2	Volcaniclastic rhyolite (RHYv)
K16-360	132.2	133.47	Volcaniclastic rhyolite (RHYv)
K16-360	133.47	139.69	Volcaniclastic rhyolite (RHYv)
K16-360	139.69	150.2	Volcaniclastic rhyolite (RHYv)
K16-360	150.2	151.65	Rhyolite (RHY)
K16-360	151.65	163	Volcaniclastic rhyolite (RHYv)
K16-360	163	169.07	Volcaniclastic rhyolite (RHYv)
K16-360	169.07	176.64	Coherent rhyolite (RHYc)
K16-360	176.64	177.15	Massive sulphide (OA, OB, OC, OF, OK)
K16-360	177.15	178.26	Rhyolite (RHY)
K16-360	178.26	179.51	Massive sulphide (OA, OB, OC, OF, OK)
K16-360	179.51	180.03	Semi-massive sulphide (OI, OJ)
K16-360	180.03	181.04	Massive sulphide (OA, OB, OC, OF, OK)
K16-360	181.04	182.66	Semi-massive sulphide (OI, OJ)
K16-360	182.66	273.12	Mafic intrusion (MAFi)
K16-360	273.12	274.4	Massive sulphide (OA, OB, OC, OF, OK)
K16-360	274.4	275.6	Rhyolite (RHY)
K16-360	275.6	276.59	Rhyolite (RHY)
K16-360	276.59	330	Volcaniclastic rhyolite (RHYv)

Geotechnical Log

Hole ID	Zone	Lithology	Core Recovery Data: From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Strength Data: Weathering/Alteration	Strength	Joint Set Number (Jn)	Discontinuity parameters for Q System: ALPHA=0-29 Count	TYPE	Jr	Ja	ALPHA=30-59 Count	TYPE	Jr	Ja	ALPHA=60-90 Count	TYPE	Jr	Ja	Oriented Core Log: Alpha	Beta	Type	Confidence (3,2,1)	RMR76: Joint Condition Rating	Fault and Broken Zones: % Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	0				100%		OVBN
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									4	J	1.5	4					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3	3	4	J	3	3					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3	3	2	J	3	3	6	J	3	4	70.0	140.0	J	3.0	12	5%			5%		Change in lith.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	2	3	11	J	1	4					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5	2	3	J	2	3	8	J	2	3					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					1	J	2	3	2	J	2	3					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									5	J	2	4					12	20%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					5	J	2	3	7	J	2	3	50.0	180.0	JF	3.0	6	20%		20%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									3	J	3	3					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	0		75%		25%		[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					4	J	1.5	4	12	J	2	4					6			5%	15%	50%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	0				60%	70%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	2	4	12	J	2	4					6				50%	40%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	3	1	J	2	4	11	J	1	4	50.0	180.0	J	3.0	12			20%		25%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]													65.0	175.0	J	3.0	0-6				75%	40%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3	3	9	J	2	3	32.0	10.0	J	3.0	12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									3	J	1.5	3					20						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									6	J	3.0	3.0	72.0	18.0	J	3.0	20						Similar as prev run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					9	J	3.0	3.0					50.0	290.0	J	2.0	20						Similar as prev run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									6	J	3.0	3.0	60.0	280.0	V	3.0	20						Similar as prev run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									7	J	3.0	3.0	55.0	0.0	SHR	3.0	12	5%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	20						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	3	4	J	3.0	3.0	10	J	3.0	3.0	70.0	175.0	J	3.0	12			30%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									5	J	3.0	3.0	62.0	150.0	J	3.0	12			5%			Minor BZ
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					3	J	3.0	3.0	6	J	3.0	3.0	74.0	180.0	J	3.0	12						Similar as prev run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					4	J	3.0	3.0	14	J	3.0	3.0					12			20%			Minor BZ
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3.0	3.0	7	J	3.0	3.0					12			40%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									8	J	3.0	3.0					12			20%			Change in lith.
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					1	J	3.0	3.0	3	J	3.0	3.0					12			5%			Shark contact
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									4	J	2.0	3.0	67.0	180.0	J	3.0	12		30%			10%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]									9	J	3.0	3.0					12		40%			30%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					3	J	3.0	3.0	4	J	3.0	3.0					12		20%			30%	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3.0	4.0	2	J	3.0	4.0	46.0	290.0	SHR	3.0	12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3.0	4.0	10	J	3.0	4.0					12	5%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					3	J	3.0	3.0	7	J	3.0	3.0	68.0	140.0	J	3.0	12			10%			Minor BZ
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3	3	3	J	3	3					12			5%			Minor BZ
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	6		25%		30%	40%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					5	J	3	4	9	J	3	4	46.0	330.0	J	3.0	12	5%		20%		10%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					8	J	3	4	2	J	3	4	49.0	230.0	JF	3.0	12						Competent run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					3	J	3	4	9	J	3	4					12			10%			Similar as last run
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					5	J	3	4	8	J	3	4					6-12				30%	40%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2.0	2	8	J	3	4-8	3	J	1-3	2-8					0-6	6%		2%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5	1	7	JF	1-1.5	4-8									6	1%		5%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					9	JF	1-2	4-12					45.0	260.0	SHR	3.0	0-6		4%	3%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					3	JF	1	2-4	4	JF	1-2	2-8	45.0	153.0	JF	3.0	6-12			7%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					13	JF	1-2	2-12	6	J	1-2	4	55.0	165.0	JF	3.0	6-12		5%				[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					8	JF	1-2	4	1	JF	1	4					12	9%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					10	JF	1	4-6	2	J	1.5	2					12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					12	JF	1-3	1-4	1	J	2	2	55.0	160.0	JF	3.0	12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					7	JF	1-2	2	1	JF	2	2	50.0	165.0	JF	3.0	12	1%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					9	JF	1-2	2					60.0	148.0	JF	3.0	12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.5	1	7	JF	1-2	2-4	1	J	3	2					6-12					3%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					15	JF	1-2	2-4	1	J	1	8	70.0	186.0	J	3.0	6-12	1%					[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]													42.0	300.0	FAU	3.0	0		47%			53%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	0		25%			75%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]																	0		8%			92%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					19	JF	1-2	2					45.0	210.0	J	3.0	6-12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					9	JF	2-3	1-2	2	J	2	2	50.0	150.0	JF	3.0	12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					5	JF	1-2	2-12									0-6		5%			33%	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					1	JF	2	2									12						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					5	JF	1-2	2-4									12			10%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	JF	1	4									0		67%	10%			[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					2	J	3	1					50.0	65.0	J	3.0	20						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]					4	JF	1	4					52.0	170.0	JF	3.0	6						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	1	1	JF	3	1									20						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	3.0	1	1	JF	2	1									12-20						[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	1.0	1	1	JF	1	1									20						[illegible]
K16-360	ORE	Vein and Disse	181.04	182.66	1.62	1.45	90%	0	1.45	90%	W1	R5	0.5																							Foliated sulphide with sulphides defining the foliation plane. No natural breaks
K16-360	WASTE	MAFi	182.66	186.00	3.34	2.98	89%	13	2.74	82%	W2	R3/4	6	1	J	3.0	2	8	JF	1-2	1-4	1	JF	1.5	4					6-20			3%			Mixed interval. MAFi and a thick quartz vein. Quartz vein has a well developed fracture network. MAFi parts along chloritic foliation planes.
K16-360	WASTE	MAFi	186.00	189.00	3.00	2.87	96%	2	2.87	96%	W2	R3	2					2	JF	0.5	4					70.0	94.0	JF	2.0	6						Slickensided chloritic partings in the chlorite defined foliation.
K16-360	WASTE	MAFi	189.00	192.00	3.00	3.00	100%	3	3.00	100%	W2	R3	3	1	J	3.0	1	2	JF	0.5	4									6/20						Slickensided chloritic partings in the chlorite defined foliation. One discontinuity defined by a calcite healed joint
K16-360	WASTE	MAFi	192.00	195.00	3.00	2.96	99%	2	2.96	99%	W2	R4	2					2	JF	0.5	4					70.0	150.0	JF	3.0	6						Slickensided chloritic partings in the chlorite defined foliation.
K16-360	WASTE	MAFi	195.00	198.00	3.00	2.98	99%	4	2.93	98%	W2	R4	2					4	JF	0.5-1	4					60.0	195.0	JF	3.0	6						slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	198.00	201.00	3.00	2.93	98%	4	2.91	97%	W2	R4	4	2	J	3.0	6					2	JF	1.5	4	25.0	60.0	J	3.0	6-12						Joints comprise high angle to gouge faults and soft chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	201.00	204.00	3.00	2.97	99%	3	2.97	99%	W2	R3	3	1	J	2.0	1	8	JF	0.5	4	1	JF	0.5	4	75.0	144.0	JF	3.0	6-12						Joints comprise high angle to gouge faults and soft chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	204.00	207.00	3.00	2.97	99%	8	2.93	98%	W2	R3	2					8	JF	0.5-1.5	2-4					35.0	125.0	JF	3.0	6-12						Joints comprise soft chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	207.00	210.00	3.00	2.86	95%	3	2.83	94%	W2	R3	3	1	J	2.0	2	2	JF	0.5-1.5	4					40.0	140.0	JF	3.0	6-12						Joints comprise soft chloritic partings along the chlorite defined foliation and a high angle to chloritic parting.
K16-360	WASTE	MAFi	210.00	213.00	3.00	2.92	97%	12	2.76	92%	W2	R3	3	1	J	2.0	2	9	JF	0.5-2	2-4	2	J	0.5-1	2-4	70.0	180.0	J	3.0	6-12						Joints comprise soft chloritic partings both along and cutting the chlorite defined foliation and a high angle to chloritic parting.
K16-360	WASTE	MAFi	213.00	216.00	3.00	2.88	96%	3	2.88	96%	W2	R3	3					2	JF	0.5-1.5	4.0	1	J	0.5	4					6-12						Joints comprise soft chloritic partings both along and cutting the chlorite defined foliation
K16-360	WASTE	MAFi	216.00	219.00	3.00	2.80	93%	18	2.35	78%	W3	R3	6	1	J	3.0	3	5	JF	0.5-1.5	4	2	J	1.5	6					6-12					13%	Joints comprise soft chloritic partings both along and cutting the chlorite defined foliation. Two zones of microdefects where low angle to joints have cut
K16-360	WASTE	MAFi	219.00	222.00	3.00	2.95	98%	6	2.95	98%	W2	R4	3					6	J	0.5-3	1-4					55.0	152.0	JF	3.0	6-12						Joints comprise soft and slickensided chloritic partings both along and cutting the chlorite defined foliation.
K16-360	WASTE	MAFi	222.00	225.00	3.00	2.94	98%	4	2.94	98%	W2	R4	2					4	JF	0.5-3	2-4					55.0	154.0	JF	3.0	6-12						Joints comprise soft and slickensided chloritic partings both along and cutting the chlorite defined foliation.
K16-360	WASTE	MAFi	225.00	228.00	3.00	2.82	94%	5	2.82	94%	W2	R4	3					3	JF	1	4-6	2	JF	0.5	4					6						Joints comprise soft and slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	228.00	231.00	3.00	2.86	95%	3	2.78	93%	W2	R4	1					3	JF	2	2-4					55.0	90.0	J	3.0	12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	231.00	234.00	3.00	3.00	100%	8	2.79	93%	W2	R3	2									2	JF	1.5	4	75.0	150.0	JF	3.0	6-12			5%			Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	234.00	237.00	3.00	2.84	95%	8	2.68	89%	W3	R3	3					8	JF	0.5-2	2-4					62.0	240.0	J	3.0	12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	237.00	240.00	3.00	2.91	97%	5	2.78	93%	W2	R4	3					4	JF	0.51	2-4	1	JF	1	6	75.0	186.0	JF	3.0	6						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	240.00	243.00	3.00	2.90	97%	5	2.90	97%	W2	R4	2					5	JF	0.5-1	4					65.0	118.0	JF	3.0	6						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	243.00	246.00	3.00	3.07	102%	1	3.00	100%	W2	R4	0.5					1	JF	0.5	4					55.0	108.0	JF	3.0	6						Joint comprises soft a slickensided chloritic parting along the chlorite defined foliation.
K16-360	WASTE	MAFi	246.00	249.00	3.00	2.99	100%	2	2.99	100%	W2	R4	1					2	JF	1.5	4					65.0	90.0	JF	3.0	6						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	249.00	252.00	3.00	2.91	97%	7	2.81	94%	W2	R3	6	1	J	3.0	2	5	JF	1.5-2	2-4	1	JF	0.5	4	50.0	140.0	JF	3.0	6-12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	252.00	255.00	3.00	2.98	99%	5	2.90	97%	W2	R4	3	1	J	3.0	2	4	JF	0.5-2	2-4					55.0	82.0	JF	3.0	6-12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	255.00	258.00	3.00	2.96	99%	2	2.96	99%	W2	R5	1	2	J	3.0	1-2									250.0	5.0	J	1.0	12						
K16-360	WASTE	MAFi	258.00	261.00	3.00	3.00	100%	1	3.00	100%	W2	R4	0.5					1	J	1.5	1					0.0	50.0	J	3.0	20						
K16-360	WASTE	MAFi	261.00	264.00	3.00	2.97	99%	3	2.97	99%	W2	R4	3	2	J	3.0	1	1	J	1.5	4					55.0	106.0	J	3.0	12						Spray quartz crystals on the joint surface of the high to angle joints
K16-360	WASTE	MAFi	264.00	267.00	3.00	2.86	95%	12	2.78	93%	W3	R3	4	2	J	1.5	4	2	JF	1.5-2	4									6		3%				Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	267.00	270.00	3.00	2.89	96%	4	2.89	96%	W3	R4	2					4	JF	0.5-1.5	4					45.0	82.0	JF	3.0	6-12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	WASTE	MAFi	270.00	273.12	3.12	2.94	94%	15	2.79	89%	W3	R3	4					3	JF	0.5	4	5	JF	0.5-1	2-4					6-12						Joints comprise soft and/or slickensided chloritic partings along the chlorite defined foliation.
K16-360	ORE	MXSX	273.12	274.40	1.28	1.28	100%	4	1.12	88%	W3	R5	2					4	J	1.5	4									6						Chloritic material on the OJ ore has formed undulating slickenside surfaces.
K16-360	FW	RHY	274.40	276.59	2.19	1.79	82%	120	0.00	0%	W5	R0/2	12																	0						Veins or extremely well developed alteration mica/sericite (paste) have formed in the RHY, rendering it extremely incompetent
K16-360	FW	RHYv	276.59	279.00	2.41	2.23	93%	64	0.60	25%	W3	R0/2	12					2	JF	1	4									0		7%	45%			Micaceous partings in the RHYv, cut by a fault zone and two broken zones flanking it.
K16-360		RHYv	279.00	282.00	3.00	3.00	100%	17	2.70	90%	W3	R0/3	15					5	J	1.5	4-6									12		10%				Joints predominantly cut the micaceous foliation, and have developed discontinuous gouge. Two 15cm fault zones cut the interval
K16-360		RHYv	282.00	285.00	3.00	2.85	95%	8	2.79	93%	W2	R3	6	1	J	2.0	4	5	J	1-2	2	2	JF	1	4					12						High angle to joints are foliation parallel (micaceous partings). Other joints cut the foliation. Low angle TCA joint has a discontinuous chloritic slickenside surface.
K16-360		RHYv	285.00	288.00	3.00	2.80	93%	30	2.00	67%	W3	R1/3	3					8	JF	1	2-6									12		7%			5%	Joints predominantly cut the micaceous foliation, and have developed discontinuous gouge. one 20cm fault zones cuts the interval
K16-360		RHYv	288.00	291.00	3.00	2.79	93%	62	1.28	43%	W4	R0-3	3					8	JF	1	4-8									6	1%				48%	Joints predominantly follow the micaceous partings that define the dominant foliation, as do the defects in the microdefect zone
K16-360		RHYv	291.00	294.00	3.00	2.75	92%	41	1.94	65%	W3	R0-3	3					10	JF	1-2	4-12									0-6		2%			27%	Joints predominantly follow the micaceous partings that define the dominant foliation, as do the defects in the microdefect zone
K16-360		RHYv	294.00	297.00	3.00	3.00	100%	18	2.60	87%	W3	R2/3	3	1	J	0.5	4	2	JF	1-2	4-12					23.0	318.0	J	3.0	0-6	1%				14%	Joints predominantly follow the micaceous partings that define the dominant foliation, as do the defects in the microdefect zone
K16-360		RHYv	297.00	300.00	3.00	2.97	99%	9	2.71	90%	W2	R2	3					9	JF	1	4-8									6						Joints predominantly follow the micaceous partings that define the dominant foliation
K16-360		RHYv	300.00	303.00	3.00	2.70	90%	120	0.00	0%	W4	R1	3													55.0	72.0	JF	3.0	6						Rock is weak along the micaceous partings that define the dominant foliation, highly altered
K16-360		RHYv	303.00	306.00	3.00	3.00	100%	11	2.87	96%	W2	R3	4					5	JF	1-2	2-4	2	J	2	2					12			3%			Joints predominantly follow the micaceous partings that define the dominant foliation, as do the breaks in the broken zone
K16-360		RHYv	306.00	309.00	3.00	2.87	96%	5	2.83	94%	W2	R3	6	1	J	1.0	2	2	JF	0.5-2	4-6	2	JF	1	8	68.0	70.0	JF	3.0	6						Joints predominantly follow the micaceous partings that define the dominant foliation, zone of gouge developed along the foliation plane.
K16-360		RHYv	309.00	312.00	3.00	2.93	98%	7	2.82	94%	W3	R3	4					2	JF	1-2	4	5	J	1-2	4-8	70.0	92.0	JF	3.0	6-12						Joints predominantly follow the micaceous partings that define the dominant foliation, small zone of gouge developed along the foliation plane.
K16-360		RHYv	312.00	315.00	3.00	2.98	99%	5	2.98	99%	W2	R4	2					5	J	1-2	4-6					55.0	80.0	JF	3.0	6-12						Joints predominantly follow the micaceous partings that define the dominant foliation however some cut it, and have developed gouge
K16-360		RHYv	315.00	318.00	3.00	2.85	95%	6	2.85	95%	W2	R3	2									6	JF	1-2	4-6					6-12						Joints predominantly follow the micaceous partings that define the dominant foliation. Some have developed slickensides comprising calcite
K16-360		RHYv	318.00	321.00	3.00	2.96	99%	18	2.70	90%	W3	R2/3	3					3	JF	1	6	1	JF	1	6					6		2%			10%	Joints predominantly follow the micaceous partings that define the dominant foliation. Some have developed weak gouge/breccia along their surfaces
K16-360		RHYv	321.00	324.00	3.00	2.94	98%	6	2.84	95%	W2	R3	3	1	J	2.0	2	1	J	3	2	4	JF	1	4-6	70.0	86.0	JF	3.0	6-12						Foliation is less well developed in this run
K16-360		RHYv	324.00	327.00	3.00	2.89	96%	6	2.81	94%	W2	R4	3	1	J	1.5	1	5	JF	1-2	2-4									12						Foliation is less well developed in this run
K16-360		RHYv	327.00	330.00	3.00	2.90	97%	6	2.79	93%	W2	R3	3					5	JF	1-2	2-4	1	JF	1	4					12						Foliation is less well developed in this run
			#REF!		#REF!		#REF!			#REF!																										

POINT LOAD TEST RESULTS

Equipment: PIL-7 **Load Correction Factor =** 0.094971 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test D_e^2 =4(WD)/pi For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	F=$(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)
K16-360	PLT-01	20.91	HW	RHYv	3.36	II	d	fresh break along silicified core axis broke into three pieces	61.10	61.10	61.10	33.6	3.19	3733.21	0.000854767	1.0944	0.94
K16-360	PLT-02	20.91	HW	RHYv	14.48	L	a	Broke into four pieces fresh break	37.00	61.10	37.00	144.8	13.75	2878.41	0.004777564	1.0944	5.23
K16-360	PLT-03	38.91	HW	RHYv	14.86	L	a	fresh break silicified	41.50	61.10	41.50	148.6	14.11	3228.49	0.004371298	1.0944	4.78
K16-360	PLT-04	54.00	HW	RHYi	19.86	II	d	fresh break perp to core axis	61.10	61.10	61.10	198.6	18.86	3733.21	0.005052285	1.0944	5.53
K16-360	PLT-05	87.75	HW	RHYc	6.56	II	d	fresh break perp to core axis	61.10	61.10	61.10	65.6	6.23	3733.21	0.001668831	1.0944	1.83
K16-360	PLT-06	108.00	HW	RHYv	5.94	II	d	fresh break	61.10	61.10	61.10	59.4	5.64	3733.21	0.001511106	1.0944	1.65
K16-360	PLT-07	117.00	HW	RHYc	3.9	II	d	fresh break along foliation pane	61.10	61.10	61.10	39	3.70	3733.21	0.000992141	1.0944	1.09
K16-360	PLT-08	196.4	WASTE	MAFi	7.96	II	d	clean break	61.10	61.10	61.10	79.6	7.56	3733.21	0.002024984	1.0944	2.22
K16-360	PLT-09	196.4	WASTE	MAFi	9.58	II	d	clean break	61.10	61.10	61.10	95.8	9.10	3733.21	0.002437104	1.0944	2.67
K16-360	PLT-10	196.4	WASTE	MAFi	18.6	L	a	clean break	27.50	61.10	27.50	186	17.66	2139.36	0.008256955	1.0944	9.04
K16-360	PLT-11	204.9	WASTE	MAFi	1.94	II	d	clean break	61.1	61.10	61.10	19.4	1.84	3733.21	0.000493526	1.0944	0.54
K16-360	PLT-12	217.8	WASTE	MAFi	5.2	II	d	clean break	61.1	61.10	61.10	52	4.94	3733.21	0.001322854	1.0944	1.45
K16-360	PLT-13	186.2	WASTE	MAFi	1.24	II	d	clean break	61.1	61.10	61.10	12.4	1.18	3733.21	0.00031545	1.0944	0.35
K16-360	PLT-14	186.2	WASTE	MAFi	1.68	II	d	clean break	61.1	61.10	61.10	16.8	1.60	3733.21	0.000427384	1.0944	0.47
K16-360	PLT-15	186.2	WASTE	MAFi	3.5	L	a	clean break	26	61.10	26.00	35	3.32	2022.67	0.001643366	1.0944	1.80
K16-360	PLT-16	186.2	WASTE	MAFi	4.58	L	a	clean break	30	61.10	30.00	45.8	4.35	2333.85	0.001863734	1.0944	2.04
K16-360	PLT-17	164.7	HW	RHYv	1.8	II	d	clean break	61.1	61.1	61.10	18	1.71	3733.21	0.000457911	1.0944	0.50
K16-360	PLT-18	142.6	HW	RHYv	1.66	II	d	fresh break along foliation pane	61.1	61.1	61.10	16.6	1.58	3733.21	0.000422296	1.0944	0.46
K16-360	PLT-19	142.6	HW	RHYv	10.84	L	a	clean break	29.5	61.1	29.50	108.4	10.29	2294.95	0.004485873	1.0944	4.91
K16-360	PLT-20	227.1	WASTE	MAFi	3.96	II	d	clean break	61.1	61.1	61.10	39.6	3.76	3733.21	0.001007404	1.0944	1.10
K16-360	PLT-21	133.4	HW	RHYv	4.24	II	d	fresh break along foliation pane	61.1	61.1	61.10	42.4	4.03	3733.21	0.001078635	1.0944	1.18

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-363	Krakatoa	All	KRAK033	415239	6815212	1440	415.0	-78.5	HQ3	16.5	12-Jul-16	17-Jul-16

Drill Hole Collection Program

Discipline	Personnel	Checked by	Date
Geologist	RH		
Geotech Log	HM/IH	IH	19/Jul/16
PLT	HM/IH	IH	19/Jul/16
UCS	N/A	N/A	N/A

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology & Lithology Code
K16-363	0	4.5	Overburden (OVBN)
K16-363	4.5	10.7	Mafic tuff (MAFt)
K16-363	10.7	16.07	Graphitic mudstone (MDU)
K16-363	16.07	23.9	Mafic tuff (MAFt)
K16-363	23.9	31.9	Graphitic mudstone (MDU)
K16-363	31.9	57.8	Volcaniclastic rhyolite (RHYv)
K16-363	57.8	71.82	Volcaniclastic rhyolite (RHYv)
K16-363	71.82	85.81	Aphanitic rhyolite (RHYi)
K16-363	85.81	88.6	Volcaniclastic rhyolite (RHYv)
K16-363	88.6	91	Aphanitic rhyolite (RHYi)
K16-363	91	105.05	Volcaniclastic rhyolite (RHYv)
K16-363	105.05	107.9	Pelite (PEL)
K16-363	107.9	109.41	Volcaniclastic rhyolite (RHYv)
K16-363	109.41	113.6	Coherent rhyolite (RHYc)
K16-363	113.6	115.74	Volcaniclastic rhyolite (RHYv)
K16-363	115.74	118.45	Coherent rhyolite (RHYc)
K16-363	118.45	129.3	Volcaniclastic rhyolite (RHYv)
K16-363	129.3	131.2	Coherent rhyolite (RHYc)
K16-363	131.2	133.41	Pelite (PEL)
K16-363	133.41	134.96	Volcaniclastic rhyolite (RHYv)
K16-363	134.96	137.47	Volcaniclastic rhyolite (RHYv)
K16-363	137.47	140.9	Coherent rhyolite (RHYc)
K16-363	140.9	141.8	Volcaniclastic rhyolite (RHYv)
K16-363	141.8	143.33	Coherent rhyolite (RHYc)
K16-363	143.33	150.96	Coherent rhyolite (RHYc)
K16-363	150.96	152.09	Volcaniclastic rhyolite (RHYv)
K16-363	152.09	153.18	Coherent rhyolite (RHYc)
K16-363	153.18	157	Coherent rhyolite (RHYc)
K16-363	157	158	Volcaniclastic rhyolite (RHYv)
K16-363	158	161.63	Coherent rhyolite (RHYc)
K16-363	161.63	167.52	Volcaniclastic rhyolite (RHYv)
K16-363	167.52	172.27	Coherent rhyolite (RHYc)
K16-363	172.27	176.25	Volcaniclastic rhyolite (RHYv)
K16-363	176.25	181.98	Volcaniclastic rhyolite (RHYv)
K16-363	181.98	182.56	Pelite (PEL)
K16-363	182.56	196.71	Volcaniclastic rhyolite (RHYv)
K16-363	196.71	197.78	Pelite (PEL)
K16-363	197.78	203.65	Aphanitic rhyolite (RHYi)
K16-363	203.65	234.09	Volcaniclastic rhyolite (RHYv)
K16-363	234.09	234.83	Mudstone (MDS)
K16-363	234.83	239.6	Volcaniclastic rhyolite (RHYv)
K16-363	239.6	253.8	Volcaniclastic rhyolite (RHYv)
K16-363	253.8	260.82	Coherent rhyolite (RHYc)
K16-363	260.82	261.65	Mudstone (MDS)
K16-363	261.65	269.55	Volcaniclastic rhyolite (RHYv)
K16-363	269.55	285.58	Volcaniclastic rhyolite (RHYv)
K16-363	285.58	288.45	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	288.45	317.58	Coherent rhyolite (RHYc)
K16-363	317.58	323.17	Coherent rhyolite (RHYc)
K16-363	323.17	332.35	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	332.35	335.95	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	335.95	337.82	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	337.82	339.63	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	339.63	341.86	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	341.86	344	Massive sulphide (OA, OB, OC, OF, OK)
K16-363	344	345.74	Rhyolite (RHY)
K16-363	345.74	346.65	Semi-massive sulphide (OI, OJ)
K16-363	346.65	354.6	Volcaniclastic rhyolite (RHYv)
K16-363	354.6	355.5	Pelite (PEL)
K16-363	355.5	358.3	Volcaniclastic rhyolite (RHYv)
K16-363	358.3	359	Pelite (PEL)
K16-363	359	364.46	Volcaniclastic rhyolite (RHYv)
K16-363	364.46	372.07	Volcaniclastic rhyolite (RHYv)
K16-363	372.07	375.64	Volcaniclastic rhyolite (RHYv)
K16-363	375.64	379.75	Volcaniclastic rhyolite (RHYv)
K16-363	379.75	380.5	Mafic intrusion (MAFi)
K16-363	380.5	382.12	Volcaniclastic rhyolite (RHYv)
K16-363	382.12	384.26	Mafic intrusion (MAFi)
K16-363	384.26	395.1	Volcaniclastic rhyolite (RHYv)
K16-363	395.1	405.31	Volcaniclastic rhyolite (RHYv)
K16-363	405.31	412.28	Volcaniclastic rhyolite (RHYv)
K16-363	412.28	420.32	Volcaniclastic rhyolite (RHYv)
K16-363	420.32	423.94	Volcaniclastic rhyolite (RHYv)
K16-363	423.94	425	Volcaniclastic rhyolite (RHYv)
K16-363	425	432	Volcaniclastic rhyolite (RHYv)
K16-363	432	432.2	Pelite (PEL)
K16-363	432.2	433.12	Volcaniclastic rhyolite (RHYv)
K16-363	433.12	433.27	Pelite (PEL)
K16-363	433.27	435	Volcaniclastic rhyolite (RHYv)

Geotechnical Log

Hole ID	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Weathering/Alteration	Strength	Joint Set Number (Jn)	Count
K16-363	MAFi	4.4	7.4	3.0	2.0	67%	120	0.14	5%	W5	R3-R1	3	
K16-363	MAFi	7.4	10.8	3.4	2.5	72%	120	0.76	22%	W4	R3-R1	3	
K16-363	MDU	10.8	13.8	3.0	2.1	70%	120	0.13	4%	W5	R2-R0	3	
K16-363	MDU	13.8	16.1	2.3	1.3	58%	53	0.22	10%	W4	R1	6	
K16-363	Qtz-vein	16.1	18.9	2.8	2.0	71%	27	1.10	39%	W3	R4	9	
K16-363	MDU	18.9	22.0	3.1	2.3	73%	46	1.27	41%	W3	R2	12	
K16-363	MDU	22.0	23.9	1.9	1.1	60%	120	0.10	5%	W4	R3-R1	12	no dominant discontinuity orientation
K16-363	MDU	23.9	26.0	2.1	1.4	66%	120	0.26	13%	W4	R2-R0	12	no dominant discontinuity orientation
K16-363	Fault zone	26.0	29.0	3.1	1.9	62%	120	0.00	0%	W5	S4-R1	20	no dominant discontinuity orientation
K16-363	Fault zone	29.0	31.9	2.9	0.7	24%	120	0.00	0%	W5	S4-R1	20	no dominant discontinuity orientation
K16-363	RHYv	31.9	35.0	3.1	2.0	65%	72	0.40	13%	W3	R2-S4	12	
K16-363	RHYv	35.0	38.0	3.0	2.1	71%	50	1.08	36%	W4	R2	12	
K16-363	RHYv	38.0	41.0	3.0	1.9	62%	58	0.36	12%	W3	R3-R1	12	
K16-363	RHYv	41.0	44.0	3.0	2.0	66%	59	0.60	20%	W3	R2	12	
K16-363	RHYv	44.0	47.0	3.0	2.5	82%	43	1.08	36%	W2	R2	6	
K16-363	RHYv	47.0	50.0	3.0	2.1	70%	63	0.45	15%	W2	R2	6	
K16-363	RHYv	50.0	53.0	3.0	2.4	79%	46	0.70	23%	W2/W3	R2	6	3
K16-363	RHYv	53.0	56.0	3.0	1.9	63%	37	1.01	34%	W2	R2	6	
K16-363	RHYv	56.0	59.0	3.0	2.4	80%	36	1.03	34%	W2	R2	6	3
K16-363	RHYv	59.0	62.0	3.0	2.0	68%	49	1.08	36%	W3	R2	3	
K16-363													
K16-363	RHYv	62.0	65.0	3.0	2.0	67%	39	1.00	33%	W3/W4	R2	6	3
K16-363	RHYv	65.0	68.0	3.0	2.5	84%	30	1.65	55%	W3	R2/R3	6	
K16-363													
K16-363													
K16-363	RHYv	68.0	71.0	3.0	2.7	90%	21	2.34	78%	W2/W3	R2	4	
K16-363													
K16-363	RHYi	71.0	74.0	3.0	2.4	78%	27	0.92	31%	W2	R3/R2	6	4
K16-363	RHYi	74.0	77.0	3.0	2.3	78%	40	0.76	25%	W2	R3	6	4
K16-363	RHYi	77.0	80.0	3.0	2.8	93%	26	1.94	65%	W2	R3	3	
K16-363	RHYi	80.0	83.0	3.0	2.8	92%	32	1.68	56%	W2	R3/R4	6	6
K16-363	RHYi	83.0	85.8	2.8	2.4	84%	32	1.27	45%	W3	R3	6	5
K16-363	RHY	85.8	88.7	2.8	2.5	86%	33	1.40	49%	W3	R2/R3	4	
K16-363	RHYi	88.7	91.0	2.3	2.1	88%	26	1.42	60%	W2	R3	3	
K16-363	RHYv	91.0	94.0	3.0	2.6	85%	35	1.45	48%	W2/W3	R2	3	
K16-363													
K16-363	RHYv	94.0	97.0	3.0	2.7	90%	45	1.45	48%	W2	R2	6	
K16-363	RHYv	97.0	100.0	3.0	2.6	86%	16	2.15	72%	W2	R2	4	4
K16-363	RHYv	100.0	103.0	3.0	2.6	86%	46	1.17	39%	W3/W2	R2/R1	12	
K16-363	RHYv	103.0	105.1	2.1	1.6	80%	22	1.35	66%	W3	R2/R1	3	
K16-363	PEL	105.1	107.9	2.9	2.3	82%	37	1.63	57%	W2	R2	6	
K16-363	RHYv	107.9	109.4	1.5	1.4	95%	14	0.60	40%	W2	R2	9	2
K16-363	RHYc	109.4	113.6	4.2	3.5	82%	27	2.59	62%	W2/W3	R2	12	2
K16-363	RHYv	113.6	115.7	2.1	1.9	90%	29	1.10	51%	W3	R2	3	
K16-363													
K16-363	RHYc	115.7	118.5	2.7	2.5	93%	15	2.30	85%	W2		6	
K16-363	RHYv	118.5	121.0	2.6	2.2	86%	28	1.30	51%	W2/W3	R2	6	
K16-363	RHYv	121.0	124.0	3.0	2.8	92%	31	1.25	42%	W2	R2	6	
K16-363	RHYv	124.0	127.0	3.0	2.4	79%	39	1.12	37%	W2/W3	R2-R1	9	4
K16-363	RHYv	127.0	129.3	2.3	2.0	85%	37	0.83	36%	W3	R2	3	
K16-363	RHYc	129.3	131.2	1.9	1.3	66%	53	0.11	6%	W4	R3/R1	12	
K16-363	RHYv	131.2	133.4	2.2	1.7	76%	35	0.88	40%	W2	R2	3	2
K16-363	RHYv	133.4	136.0	2.6	2.4	91%	31	1.17	45%	W3	R2	4	3
K16-363													
K16-363	RHYv	136.0	137.5	1.5	1.2	84%	30	0.67	46%	W3	R2	9	2
K16-363	RHYc	137.5	141.8	4.3	3.5	82%	72	1.14	26%	W4	R2	12	2
K16-363	Fault zone	141.8	145.0	3.2	2.6	82%	32	1.13	35%	W4/W5	R1	9	

UCS Sample Summay

Hole ID	Lithology	Ore/Waste	From	To	ALS Sample Tag #	SGS Sample Tag #	Diameter (mm)	Length (mm)	L/D Ratio	Date Prepped	Comments
								0	#DIV/0!		
								0	#DIV/0!		

POINT LOAD TEST RESULTS

Equipment: PIL-7 **Load Correction Factor =** 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Zone (e.g. HW/Ore/FW)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$ For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm^2)= P/D_e^2	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-363	PLT-01	21.00	HW	MDU	1.70	II	d	valid	61.10	61.10	61.10	17	1.61	3733.21	0.000431693	1.0944	0.47	
K16-363	PLT-02	21.00	HW	MDU	7.10	L	a	nonvalue, shearing	46.50	61.10	46.50	71	6.73	3617.46	0.00186064	1.0944	2.04	
K16-363	PLT-03	28.40	HW	MDU	2.16	II	d	valid	61.10	61.10	61.10	21.6	2.05	3733.21	0.000548504	1.0944	0.60	
K16-363	PLT-04	28.40	HW	MDU	0.36	L	a	valid	26.20	61.10	26.20	3.6	0.34	2038.23	0.00016744	1.0944	0.18	
K16-363	PLT-05	35.10	HW	RHYv	7.48	II	d	valid	61.10	61.10	61.10	74.8	7.09	3733.21	0.001899448	1.0944	2.08	
K16-363	PLT-06	35.10	HW	RHYv	6.38	L	a	valid	46.70	61.10	46.70	63.8	6.05	3633.02	0.001664795	1.0944	1.82	
K16-363	PLT-07	45.90	HW	RHYv	3.90	II	d	valid	61.10	61.10	61.10	39	3.70	3733.21	0.000990354	1.0944	1.08	
K16-363	PLT-08	45.90	HW	RHYv	9.12	L	a	valid	40.80	61.10	40.80	91.2	8.65	3174.03	0.002723903	1.0944	2.98	
K16-363	PLT-09	51.91	HW	RHYv	8.58	II	d	valid	61.10	61.10	61.10	85.8	8.13	3733.21	0.002178779	1.0944	2.38	
K16-363	PLT-10	51.91	HW	RHYv	7.06	L	a	valid	54.60	61.10	54.60	70.6	6.69	4247.60	0.001575684	1.0944	1.72	
K16-363	PLT-11	65.88	HW	RHYv	9.00	II	d	valid	61.10	61.10	61.10	90	8.53	3733.21	0.002285433	1.0944	2.50	
K16-363	PLT-12	65.88	HW	RHYv	17.32	L	a	valid	23.00	61.10	23.00	173.2	16.42	1789.28	0.0091765	1.0944	10.04	
K16-363	PLT-13	73.10	HW	RHYi	12.88	II	d	valid	61.10	61.10	61.10	128.8	12.21	3733.21	0.003270708	1.0944	3.58	
K16-363	PLT-14	73.10	HW	RHYi	6.22	L	a	valid	55.20	61.10	55.20	62.2	5.90	4294.28	0.001373119	1.0944	1.50	
K16-363	PLT-15	84.48	HW	RHYi	8.62	II	d	valid	61.10	61.10	61.10	86.2	8.17	3733.21	0.002188937	1.0944	2.40	
K16-363	PLT-16	84.48	HW	RHYv		L	a	not available due fracturing		61.10	0.00	0	0.00	0.00	#DIV/0!	1.0944	#DIV/0!	
K16-363	PLT-17	89.72	HW	RHYi	7.44	II	d	valid	61.10	61.10	61.10	74.4	7.05	3733.21	0.001889291	1.0944	2.07	
K16-363	PLT-18	89.72	HW	RHYi	22.48	L	a	not valid, shearing	47.80	61.10	47.80	224.8	21.31	3718.60	0.005730934	1.0944	6.27	
K16-363	PLT-19	90.00	HW	RHYi	0.30	II	d	valid	61.10	61.10	61.10	3	0.28	3733.21	7.61811E-05	1.0944	0.08	
K16-363	PLT-20	90.00	HW	RHYi	8.64	L	a	valid	35.00	61.10	35.00	86.4	8.19	2722.82	0.003008172	1.0944	3.29	
K16-363	PLT-21	95.12	HW	RHYv	8.54	II	d	valid	61.10	61.10	61.10	85.4	8.10	3733.21	0.002168622	1.0944	2.37	
K16-363	PLT-22	95.12	HW	RHYv	23.00	L	a	not valid, shearing	54.50	61.10	54.50	230	21.80	4239.82	0.005142666	1.0944	5.63	
K16-363	PLT-23	104.04	HW	RHYv	7.46	II	d	valid	61.10	61.10	61.10	74.6	7.07	3733.21	0.00189437	1.0944	2.07	
K16-363	PLT-24	104.04	HW	RHYv	16.00	L	a	valid	41.20	61.10	41.20	160	15.17	3205.15	0.004732382	1.0944	5.18	
K16-363	PLT-25	121.24	HW	RHYv	10.76	II	d	valid	61.10	61.10	61.10	107.6	10.20	3733.21	0.002732362	1.0944	2.99	
K16-363	PLT-26	121.24	HW	RHYv	27.92	L	a	valid	58.20	61.10	58.20	279.2	26.47	4527.67	0.005845874	1.0944	6.40	
K16-363	PLT-27	132.70	HW	PEL	10.24	II	d	valid	61.10	61.10	61.10	102.4	9.71	3733.21	0.002600314	1.0944	2.85	
K16-363	PLT-28	132.70	HW	PEL	22.84	L	a	valid	45.00	61.10	45.00	228.4	21.65	3500.77	0.006185013	1.0944	6.77	
K16-363	PLT-29	139.86	HW	RHYc	0.26	II	d	valid	61.10	61.10	61.10	2.6	0.25	3733.21	6.60236E-05	1.0944	0.07	
K16-363	PLT-30	139.86	HW	RHYc	1.42	L	a	valid	46.50	61.10	46.50	14.2	1.35	#REF!	#REF!	1.0944	#REF!	
K16-363	PLT-31	149.83	HW	RHYc	2.58	II	d	valid	61.10	61.10	61.10	25.8	2.45	4753.27	0.000514559	1.0944	0.56	
K16-363	PLT-32	149.83	HW	RHYc	4.72	L	a	valid	21.00	61.10	21.00	47.2	4.47	1633.69	0.002738922	1.0944	3.00	
K16-363	PLT-33	159.07	HW	RHYc	1.24	II	d	valid	61.10	61.10	61.10	12.4	1.18	3733.21	0.000314882	1.0944	0.34	
K16-363	PLT-34	159.07	HW	RHYc	10.66	L	a	not valid, shearing	47.00	61.10	47.00	106.6	10.11	3656.36	0.002763862	1.0944	3.02	
K16-363	PLT-35	158.48	HW	RHYc	5.20	II	d	valid	61.10	61.10	61.10	52	4.93	3733.21	0.001320472	1.0944	1.45	
K16-363	PLT-36	158.48	HW	RHYc	14.16	L	a	valid	36.20	61.10	36.20	141.6	13.42	2816.18	0.004766633	1.0944	5.22	
K16-363	PLT-37	162.25	HW	RHYv	2.16	II	d	valid	61.10	61.10	61.10	21.6	2.05	3733.21	0.000548504	1.0944	0.60	
K16-363	PLT-38	162.25	HW	RHYv	14.14	L	a	valid	50.00	61.10	50.00	141.4	13.40	3889.75	0.003446168	1.0944	3.77	
K16-363	PLT-39	247.82	HW	RHYv	11.54	II	d	valid fresh cut silicified	61.10	61.10	61.10	115.4	10.94	3733.21	0.002930433	1.0944	3.21	
K16-363	PLT-40	247.82	HW	RHYv	7.10	L	a	valid fresh cut silicified	24.00	61.10	24.00	71	6.73	1867.08	0.00360499	1.0944	3.95	
K16-363	PLT-41	255.20	HW	RHYc	0.30	II	d	multiple breaks valid	61.10	61.10	61.10	3	0.28	3733.21	7.61811E-05	1.0944	0.08	
K16-363	PLT-42	255.20	HW	RHYc	1.34	L	a	multiple breaks valid	32.50	61.1	32.50	13.4	1.27	2528.34	0.000502433	1.0944	0.55	
K16-363	PLT-43	261.00	HW	MDS	0.24	II	d	easily broken along foliation valid	61.10	61.1	61.10	2.4	0.23	3733.21	6.09449E-05	1.0944	0.07	
K16-363	PLT-44	261.00	HW	MDS	0.36	L	a	easily broken along foliation valid	43.00	61.1	43.00	3.6	0.34	3345.18	0.000102021	1.0944	0.11	
K16-363	PLT-45	281.82	HW	RHYv	2.26	II	d	break along fol valid	61.10	61.1	61.10	22.6	2.14	3733.21	0.000573898	1.0944	0.63	
K16-363	PLT-46	281.82	HW	RHYv	8.84	L	a	multiple breaks along fol valid	38.50	61.1	38.50	88.4	8.38	2995.11	0.002798005	1.0944	3.06	
K16-363	PLT-47	287.91	Ore	MXSX	8.64	II	d	fresh cut valid	61.10	61.1	61.10	86.4	8.19	3733.21	0.002194015	1.0944	2.40	
K16-363	PLT-48	303.00	Waste	RHYc	0.46	II	d	easily break along fol valid	61.10	61.1	61.10	4.6	0.44	3733.21	0.000116811	1.0944	0.13	
K16-363	PLT-49	303.00	Waste	RHYc	4.92	L	a	multiple breaks valid	34.00	61.1	34.00	49.2	4.66	2645.03	0.001763369	1.0944	1.93	
K16-363	PLT-50	319.31	Waste	RHYc	0.60	L	a	multiple breaks valid	27.50	61.1	27.50	6	0.57	2139.36	0.000265874	1.0944	0.29	
K16-363	PLT-51	323.92	Ore	MXSX	15.44	II	d	fresh break valid	61.10	61.1	61.10	154.4	14.64	3733.21	0.003920787	1.0944	4.29	
K16-363	PLT-52	373.80	Waste	RHYv	6.74	II	d	fresh break valid	61.10	61.1	61.10	67.4	6.39	3733.21	0.001711535	1.0944	1.87	
K16-363	PLT-53	392.30	Waste	RHYv	4.80	II	d	fresh break valid	61.10	61.1	61.10	48	4.55	3733.21	0.001218897	1.0944	1.33	
K16-363	PLT-54	409.37	Waste	RHYv	4.82	II	d	fresh break valid	61.10	61.1	61.10	48.2	4.57	3733.21	0.001223976	1.0944	1.34	
K16-363	PLT-55	409.37	Waste	RHYv	12.40	L	a	multiple breaks	45.00	61.1	45.00	124	11.76	3500.77	0.003357888	1.0944	3.67	
K16-363	PLT-56	425.97	Waste	RHYv	9.44	L	a	multiple breaks	36.00	61.1	36.00	94.4	8.95	2800.62	0.003195409	1.0944	3.50	
											0.00	0	0.00	0.00	#DIV/0!	0.0000	#DIV/0!	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-367	Krakatoa (in-pit)	All	KRAK007 (UG Hole 1)	415075.7	6815186.4	1388.5	282	-65	HQ3	215	15-Jun-16	18-Jun-18

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	ON		
Geotechnical	JM/IH	JRM	
PLT	IH/JRM/ON	JRM	Jun 26 - July 6

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology and Lithology Code
K16-367 (UG Hole 1)	0	8.7	OVBN
K16-367 (UG Hole 1)	8.7	16.3	Aphanitic Rhyolite (RHYi)
K16-367 (UG Hole 1)	16.3	19.4	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	19.4	29	Aphanitic Rhyolite (RHYi)
K16-367 (UG Hole 1)	29	29.8	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	29.8	48.3	Aphanitic Rhyolite (RHYi)
K16-367 (UG Hole 1)	48.3	49.55	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	49.55	52.7	Coherent Rhyolite (RHYc)
K16-367 (UG Hole 1)	52.7	56.6	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	56.6	57.35	Coherent Rhyolite (RHYc)
K16-367 (UG Hole 1)	57.35	83.85	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	83.85	86.9	Sediment (SED)
K16-367 (UG Hole 1)	86.9	107.8	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	107.8	111.5	Stringer Sulfide (OJ)
K16-367 (UG Hole 1)	111.5	118.2	Coherent Rhyolite (RHYc)
K16-367 (UG Hole 1)	118.2	147.5	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	147.5	148.2	Stringer Sulfide (OJ)
K16-367 (UG Hole 1)	148.2	151.9	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	151.9	152.5	Stringer Sulfide (OJ)
K16-367 (UG Hole 1)	152.5	152.8	Massive Sulfide (OB)
K16-367 (UG Hole 1)	152.8	155.1	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	155.1	156.1	Massive Sulfide (OK)
K16-367 (UG Hole 1)	156.1	173.1	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	173.1	177.1	Massive Sulfide (OK)
K16-367 (UG Hole 1)	177.1	178.8	Undifferentiated Rhyolite (RHY)
K16-367 (UG Hole 1)	178.8	180	Massive Sulfide (OK)
K16-367 (UG Hole 1)	180	184.3	Undifferentiated Rhyolite (RHY)
K16-367 (UG Hole 1)	184.3	188.8	Massive Sulfide (OB)
K16-367 (UG Hole 1)	188.8	207.6	Mafic Sill (MAFi)
K16-367 (UG Hole 1)	207.6	207.9	Stringer Sulfide (OJ)
K16-367 (UG Hole 1)	207.9	210.3	Coherent Rhyolite (RHYc)
K16-367 (UG Hole 1)	210.3	211.1	Mudstone (MDSt)
K16-367 (UG Hole 1)	211.1	223.1	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	223.1	223.5	Disseminated Sulfide (OI)
K16-367 (UG Hole 1)	223.5	273.1	Volcaniclastic Rhyolite (RHYv)
K16-367 (UG Hole 1)	273.1	278.7	Sediment (SED)
K16-367 (UG Hole 1)	278.7	282	Fault Zone (FLZ)

Geotechnical Log

Hole ID	Lithology	From (m)	To (m)	Run (m)	TCR (m)	TCR (%)	FF/run	RQD (m)	RQD (%)	Betadiff. between runs	Weathering/Alteration	Strength	Joint Set Number (Jn)	ALPHA=0-29 Count	ALPHA=0-29 TYPE	ALPHA=0-29 Jr	ALPHA=0-29 Ja	ALPHA=30-59 Count	ALPHA=30-59 TYPE	ALPHA=30-59 Jr	ALPHA=30-59 Ja	ALPHA=60-90 Count	ALPHA=60-90 TYPE	ALPHA=60-90 Jr	ALPHA=60-90 Ja	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
K16-367 (UG Hole 1)	Overburden (OVBN)	0.00	9.00																												
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	9.00	10.50	1.50	1.50	100%	18	0.96	64%	NEW	W2	R4	4	1	JN	2.0	1.0					17	JN	1.0	1.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	10.50	12.00	1.50	1.50	100%	3	1.50	100%	0	W1	R4	4					1	JN	2.0	1.0	2	JN	1.5	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	12.00	13.50	1.50	1.50	100%	3	1.50	100%	0	W1	R4	4					1	JN	1.0	4.0	3	JN	1.5-3	1-2						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	13.50	15.00	1.50	1.50	100%	3	1.50	100%	0	W1	R4	3	1	JN	1.5	2.0	1	JN	1.5	2.0	1	JN	1.5	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	15.00	16.30	1.30	1.30	100%	2	1.30	100%	0	W1	R4	3	1	JN	3.0	2.0					1	JN	1.5	1.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	16.30	18.00	1.70	1.70	100%	9	1.50	88%	0	W1	R4	6	1	JN	3.0	2.0	3	JN	1.5	2-4	4	JF	1.0	2.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	18.00	19.40	1.40	1.40	100%	5	1.20	86%	NEW	W2	R3	2									5	JF	1.0	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	19.40	21.00	1.60	1.60	100%	1	1.60	100%	0	W1	R4	2									1	JF	1.0	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	21.00	22.50	1.50	1.50	100%	2	1.50	100%	0	W1	R3	3					1	JF	2.0	2.0	1	JN	1.0	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	22.50	24.00	1.50	1.50	100%	2	1.50	100%	0	W1	R3	2									2	JF	1.0	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	24.00	25.50	1.50	1.50	100%	1	1.50	100%	0	W1	R4	2									1	JF	1.0	1.0					10%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	25.50	27.00	1.50	1.50	100%	7	1.44	96%	0	W1	R4	3					1	JN	1.0	2.0	6	JF	1.0	2.0					10%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	27.00	28.50	1.50	1.50	100%	4	1.43	95%	0	W1	R3	3									4	JF	1.5	1-2					15%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	28.50	29.70	1.20	1.20	100%	4	0.83	69%	-	W2	R2	3	1	JN	3.0	2.0					3	JF	1.0	2-6	5%		15%			[illegible]
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	29.70	31.25	1.55	1.16	75%	36	0.36	23%	-	W3/W4	R2	15									1	FLT	1.0	8.0	5%	10%	65%		60%	[illegible]
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	31.25	33.00	1.75	1.75	100%	4	1.75	100%	NEW	W2	R3	4					1	HJN	2.0	0.8	3	JN	2-3	2.0						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	33.00	34.50	1.50	1.50	100%	6	1.50	100%	NEW	W1	R3	6	1	JN	2.0	2.0	3	JN	2.0	2.0	2	JN	1-2	1-2						
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	34.50	36.00	1.50	1.50	100%	7	1.31	87%	-	W2	R4	6					5	JN/HJN	1.5	1-2	2	HJN/HFLT	1-1.5	0.8						[illegible]
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	36.00	37.50	1.50	1.50	100%	8	1.05	70%	NEW	W2	R3	4					8	JN	1.5-3	1-2									15%	[illegible]
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	37.50	39.00	1.50	1.37	91%	28	0.45	30%	-	W3	R3	4					1	JN	4.0	4.0	4	JN	1.0	2-4						[illegible]
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	39.00	40.50	1.50	1.50	100%	5	1.31	87%	NEW	W2	R3	3									5	JF	1.5	2.0					10%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	40.50	42.00	1.50	1.50	100%	5	1.29	86%	0	W2	R3	3					2	JN	1.5	1.0	3	JN/JF	1.5	2.0					15%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	42.00	43.50	1.50	1.50	100%	2	1.50	100%	0	W2	R3	3																		
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	43.50	45.00	1.50	1.50	100%	5	1.44	96%	0	W2	R3	4	2	JN	1.5	2.0					3	JF	1.5	4.0					20%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	45.00	46.50	1.50	1.50	100%	4	1.50	100%	0	W2	R3	6	2	JN	1.5	2.0					2	JF/JN	1.5	2.0					10%	
K16-367 (UG Hole 1)	Aphanitic Rhyolite (RHYi)	46.50	48.00	1.50	1.50	100%	2	1.50	100%	0	W2	R3	4	1	JN	3.0	2.0					1	JF	1.5	2.0					50%	
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	48.00	49.50	1.50	1.50	100%	2	1.41	94%	NEW	W2	R2	3					1	JN	2.0	4.0	1	JF	2.0	4.0						[illegible]
K16-367 (UG Hole 1)	Coherent Rhyolite (RHYc)	49.50	51.00	1.50	1.50	100%	4	1.50	100%	0	W2	R2/R3	3	1	JN	1.5	2.0					2	JF	1.0	4.0						
K16-367 (UG Hole 1)	Coherent Rhyolite (RHYc)	51.00	52.50	1.50	1.50	100%	5	1.37	91%	0	W2	R3	4	2	JN	1.5	2.0					2	JF	1.0	4.0					5%	
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	52.50	54.00	1.50	1.50	100%	7	1.28	85%	NEW	W2	R2	3									5	JF	1.0	4.0						[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	54.00	55.50	1.50	1.50	100%	5	1.35	90%	NEW	W2	R3	6					5	JN/JF	1.5	4.0							2%			[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	55.50	56.50	1.00	1.00	100%	4	0.89	89%	-	W2	R3	3					1	JN	3.0	2.0	3	JN	1.0	4.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	56.50	58.50	2.00	2.00	100%	5	1.85	93%	NEW	W2	R4	3									4	JF	1.5	2.0			5%		2%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	58.50	60.00	1.50	1.50	100%	4	1.43	95%	-	W2	R4	3					1	JN	1.5	2.0	3	JF	1.5	4.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	60.00	61.50	1.50	1.50	100%	2	1.50	100%	0	W2	R4	3	1	JN	1.5	2.0					1	JF	1.0	2.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	61.50	63.00	1.50	1.50	100%	2	1.50	100%	0	W2	R4	2					2	JF	1.5	2.0									5%	
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	63.00	64.50	1.50	1.50	100%	3	1.50	100%	0	W2	R3	3									2	JF/JN	1.5	2.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	64.50	66.00	1.50	1.50	100%	1	1.50	100%	0	W2	R4	2									1	JF	1.5	2.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	66.00	67.50	1.50	1.50	100%	0	1.50	100%	-	W2	R4	1																	2%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	67.50	69.00	1.50	1.50	100%	2	1.50	100%	0	W2	R4	2					2	JN	1.5	1.0										
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	69.00	69.75	0.75	0.75	100%	0	0.75	100%	-	W2	R4	2																		[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	69.75	72.00	2.25	2.15	96%	15	1.58	70%	NEW	W2/W3	R2	3					1	JN	3.0	2.0	12	JF	2.0	4.0			5%			[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	72.00	73.50	1.50	1.50	100%	12	1.06	71%	NEW	W2/W3	R2	3	1	JN	3.0	2.0					8	JN	2.0	4.0			1%	1%		[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	73.50	75.00	1.50	1.50	100%	9	1.25	83%	NEW	W2	R2/R3	3					3	JN	2.0	4.0	1	JF	2.0	4.0			18%			[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	75.00	76.50	1.50	1.50	100%	7	1.39	93%	NEW	W2	R3	3	2	JN	3.0	2.0					1	JN	2.0	4.0			2%	2%		[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	76.50	78.00	1.50	1.50	100%	4	1.50	100%	335	W2	R3	3					1	JN	3.0	2.0	3	JF/JN	2.0	4.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	78.00	79.50	1.50	1.50	100%	16	1.24	83%	NEW	W2	R3	3					1	JN	3.0	2.0	4	JF/JN	2.0	4.0			20%		5%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	79.50	81.00	1.50	1.29	86%	23	0.81	54%	NEW	W2/W3	R3	3					1	JN	3.0	2.0	3	JF	2.0	4.0	30%			5%	15%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	81.00	82.50	1.50	1.50	100%	6	1.49	99%	NEW	W2	R3	6					3	JN	3.0		2	JF	1.0	4.0						
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	82.50	84.00	1.50	1.50	100%	5	1.37	91%	270	W2	R3	6					3	JN	3.0	2.0	2	JF	1.0	4.0						
K16-367 (UG Hole 1)	Sediment (SED)	84.00	85.50	1.50	1.50	100%	7	1.33	89%	180	W2	R3	3					3	JN	3.0	2.0	3	JF	2.0	4.0	1%				5%	[illegible]
K16-367 (UG Hole 1)	Sediment (SED)	85.50	87.00	1.50	1.50	100%	2	1.50	100%	-	W2	R3	3	1	HJN	3.0	2.0					2	JF	1.0	4.0			1%			[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	87.00	88.50	1.50	1.50	100%	4	1.50	100%	NEW	W2/23	R2/R3	3									4	JF/JN	1.0	4.0					10%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	88.50	90.48	1.98	1.98	100%	10	1.56	79%	NEW	W2	R2	3									6	JF/FLT	2.0	4.0	1%		1%		2%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	90.48	91.50	1.02	1.02	100%	1	1.02	100%	NEW	W2	R3	1	1	JN	3.0	2.0														
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	91.50	93.00	1.50	1.50	100%	3	1.50	100%	-	W2	R4	1					3	JN	1.5	2.0									2%	
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	93.00	94.50	1.50	1.50	100%	15	1.03	69%	-	W2/W3	R2	3													2%			3%		[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	94.50	96.00	1.50	1.40	93%	26	0.10	7%	-	W2/W3	R2	3													10%			5%	15%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	96.00	97.50	1.50	1.50	100%	6	1.28	85%	NEW	W2/W3	R2	3					2	JN	3.0	4.0	4	JN/JF	1.0	4.0	1%				8%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	97.50	99.00	1.50	1.50	100%	9	1.08	72%	NEW	W2	R3	6	3	JN	3.0	2.0					3	JN/JF	1.0	4.0					5%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	99.00	100.50	1.50	1.50	100%	5	1.38	92%	NEW	W2	R3	6	1	JN	3.0	2.0	3	JN	3.0	2.0	1	JF	1.0	4.0					2%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	100.50	102.11	1.61	1.61	100%	4	1.55	96%	-	W2	R3	3									4	JF	1.0	4.0					15%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	102.11	104.38	2.27	2.27	100%	9	1.74	77%	NEW	W2	R1-R3	3					3	JN	2.0	2.0	6	JN/JF	2.0	2.0			5%		10%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	104.38	105.00	0.62	0.62	100%	5	0.41	66%	0	W2/W3	R1	3					6	JN	2.0	4.0	7	JN/JF	1.0	4.0			5%		20%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	105.00	106.40	1.40	1.40	100%	44	0.10	7%	NEW	W3/W4	R1	20					1	JN	3.0	4.0	2	JN/JF	2.0	4-8		50%			80%	[illegible]
K16-367 (UG Hole 1)	Volcaniclastic Rhyolite (RHYv)	106.40	108.00	1.60	1.60	100%	8	1.28	80%	0	W2/W3	R1/R2	3					2	FLT	3.0	4.0	4	JN/JF	2.0	2.0					30%	[illegible]
K16-367 (UG Hole 1)	Stringer Sulfide (OJ)	108.00	109.50	1.50	1.50	100%	3	1.45	97%	0	W2	R3	3									3	JN/JF	1.0	2.0					30%	
K16-367 (UG Hole 1)	Stringer Sulfide (OJ)	109.50	111.26	1.76	1.76	100%	1	1.76	100%	0	W2	R4	1									1	JF	2.0	4.0					40%	[illegible]
K16-367 (UG Hole 1)	Coherent Rhyolite (RHYc)	111.26	112.85	1.59	1.59	100%	31	0.20	13%	NEW	W3	R1	3					2	JN	3.0	2.0	21	JF	2.0	4.0			25%		90%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Coherent Rhyolite (RHYc)	112.85	114.60	1.75	1.75	100%	26	0.11	6%	-	W3/W4	R1	20														90%			100%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Coherent Rhyolite (RHYc)	114.60	115.50	0.90	0.90	100%	7	0.40	44%	NEW	W3	R2	15					2	JN/FLT	2.0	2.0	3	JF/JN	2.0	4.0		100%			100%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Coherent Rhyolite (RHYc)	115.50	117.00	1.50	1.50	100%	9	1.01	67%	-	W3	R2	15	1	JN	2.0	4.0	7	JN/FLT	2.0	4.0	1	JN.	3.0	4.0		100%			100%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Coherent Rhyolite (RHYc)	117.00	117.71	0.71	0.71	100%	28	0.00	0%	-	W3/W4	R1	20														100%			100%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Coherent Rhyolite (RHYc)	117.71	118.50	0.79	0.79	100%	13	0.11	14%	-	W2	R3	6					9	JN/JF	2.0	4.0	1	JN	2.0	4.0	5%				30%	
K16-367 (UG Hole 1)	Fault Breccia - Mafic Sill (MAFi)	118.50	120.00	1.50	1.17	78%	27	0.00	0%	NEW	W3	R2	15	2	JN	1.0	4.0	7	JN/JF	2.0	4.0	4	JN	2.0	4.0		100%			100%	[illegible]
K16-367 (UG Hole 1)	Fault Breccia - Mafic Sill (MAFi)	120.00	121.50	1.50	1.50	100%	49	0.00	0%	275	W3/W4	R1	20	2	JN	1.0	4.0	3	JN	3.0	4.0						100%			100%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	121.50	121.88	0.38	0.38	100%	6	0.00	0%	-	W2/W3	R2	4	4	JF	1.5	4.0	2	JF	2.0	4.0									100%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	121.88	123.00	1.12	1.12	100%	8.00	0.53	47%	-	W2	R2	4.00					2.00	FLT	1.00	2-6	6.00	JF	1.00	2-4		1%		15%		
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	123.00	124.50	1.50	1.43	95%	5.00	0.79	53%	-	W3	R2	6.00					3.00	FLT	1-2	2-6	2.00	JF	1.00	2.00		3%				
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	124.50	126.00	1.50	1.50	100%	12.00	1.24	83%	335	W2	R2	9.00					6.00	JN	1-2	2-4	6.00	JF	1-2	2.00						
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	126.00	127.50	1.50	1.50	100%	9.00	0.92	61%	-	W2	R2	9.00					4.00	JN	1.50	2-4	5.00	JF	1-2	2.00						
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	127.50	129.00	1.50	1.45	97%	7.00	1.15	77%	New	W2	R2	9.00					2.00	JN	1.5-3	2-4	5.00	JF	0.5-1	2-4						
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	129.00	130.50	1.50	1.50	100%	5.00	1.41	94%	New	W2	R2	9.00					2.00	JN	1.50	4.00	3.00	JF	0.5-1.5	2-4						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	130.50	132.00	1.50	1.44	96%	4.00	1.15	77%	-	W2	R2	6.00	1.00	JN	2.00	4.00	1.00	JN	1.00	2.00	2.00	JF	0.5-1	2-4						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	132.00	133.50	1.50	1.50	100%	5.00	1.42	95%	New	W2	R2	4.00					1.00	JN	1.50	2.00	4.00	JF	0.50	4.00						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	133.50	135.00	1.50	1.20	80%	8.00	0.80	53%	-	W2	R2	6.00					1.00	JN	1.50	4.00	7.00	JF	1-1.5	2-4						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	135.00	136.50	1.50	1.35	90%	13.00	1.19	79%	-	W2	R2	4.00									10.00	JF/FLT	0.5-1.5	2-6						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	136.50	137.82	1.32	1.32	100%	9	1.07	81%	NEW	W2	R3	3									9	JF/JN	1.0	4.0			2%		15%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	137.82	139.50	1.68	1.68	100%	3	1.68	100%	80	W2	R4	3									2	JF/JN	1.0	4.0					50%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	139.50	140.83	1.33	1.33	100%	5	1.26	95%		W2	R3/R4	3					2	JN	1.0	4.0	3	JF/JN	2.0	4.0					5%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	140.83	142.50	1.67	1.67	100%	13	1.17	70%		W2/W3	R2	6					4	JN	1.0	4-8	5	JF/JN	1.0	4-8			2%		5%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	142.50	144.00	1.50	1.50	100%	16	1.01	67%		W3	R2	3					1	JN	2.0	4.0	8	JF	0.5	4-8	3%	3%				[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	144.00	145.50	1.50	1.50	100%	10	1.10	73%		W2	R2	6					2	JN	2.0	4.0	7	JF	1.0	4.0			2%			[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	145.50	147.00	1.50	1.50	100%	13	0.88	59%		W2	R3	6					3	JN	2.0	4.0	9	JF	1.0	4.0	2%		2%			[illegible]
K16-367 (UG Hole 1)	Stringer Sulfide (OJ)	147.00	148.50	1.50	1.50	100%	8	1.16	77%		W2	R3	6					4	JN	1.5	2.0	4	JF	1.0	2.0						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	148.50	150.00	1.50	1.50	100%	6	1.37	91%		W2	R3	6					2	JN	1.5	4.0	4	JF	1.0	4.0					5%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	150.00	151.50	1.50	1.50	100%	6	1.30	87%	New	W2/W3	R1/R2	6					3	JN	1.5	4.0	3	JF	1.0	2.0			2%		15%	[illegible]
K16-367 (UG Hole 1)	Stringer Sulfide (OJ)	151.50	153.00	1.50	1.50	100%	9	1.25	83%	0	W2/W3	R1/R2	3					1	JN	3.0	2.0	8	JF	0.5	4.0					10%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	153.00	154.08	1.08	1.08	100%	5	0.96	89%	-	W2	R3	3					3	JN	1.0	4.0	2	JF	1.0	4.0						
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	154.08	154.65	0.57	0.57	100%	22	0.16	28%	-	W2	R1/R2	3					1	JN	1.0	2.0	14	JF	0.5	4.0			10%			[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	154.65	155.10	0.45	0.45	100%	1	0.45	100%	0	W2	R3	3					1	JN	1.0	4.0										[illegible]
K16-367 (UG Hole 1)	Massive Sulfide (OK)	155.10	156.10	1.00	1.00	100%	0	1.00	100%	-	W2	R5	1																		[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	156.10	157.50	1.40	1.40	100%	4	1.37	98%	0	W2	R3	3					2	JN	1.5	2.0	2	JF	1.0	2.0					5%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	157.50	159.00	1.50	1.50	100%	2	1.50	100%	0	W2	R4	3									1	JF	1.0	2.0					5%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	159.00	160.50	1.50	1.50	100%	1	1.50	100%	0	W2	R4	3									1	JF	1.0	2.0						[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	160.50	162.00	1.50	1.50	100%	3	1.50	100%	0	W2	R4	3					1	JN	3.0	2.0	1	JF	1.0	2.0					30%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	162.00	163.50	1.50	1.50	100%	1	1.50	100%	0	W2	R4	1																	15%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	163.50	165.00	1.50	1.50	100%	1	1.50	100%	0	W2	R4	1																	2%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	165.00	166.50	1.50	1.50	100%	0	1.50	100%	0	W2	R4	2																		[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	166.50	168.00	1.50	1.50	100%	3	1.43	95%	0	W2	R4	3									1	JF	1.5	2.0					20%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	168.00	169.50	1.50	1.50	100%	0	1.50	100%	0	W2	R4	1																	3%	[illegible]
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	169.50	171.00	1.50	1.50	100%	2	1.42	95%	0	W2	R4	3									1	JF	1.5	2.0					10%	
K16-367 (UG Hole 1)	Mafic Sill (MAFi)	171.00	173.15	2.15	2.15	100%	13	1.74	81%	0	W2/W3	R1/R2	6					3	JN	1.5	2.0	6	JF/JN	2.0	2.0		15%			10%	[illegible]
K16-367 (UG Hole 1)	Massive Sulfide (OK)	173.15	174.00	0.85	0.85	100%	0	0.85	100%		W1	R6	1																		[illegible]
K16-367 (UG Hole 1)	Massive Sulfide (OK)	174.00	175.50	1.50	1.47	98%	3	1.47	98%	NEW	W1	R3	1	1	JN	4.0	0.8	1	JN	4.0	2.0	1	JN	1.5	1.0						
K16-367 (UG Hole 1)	Massive Sulfide (OK)	175.50	177.10	1.60	1.60	100%	5	1.60	100%	0	W1	R4	1	2.0	JN	3.0	0.75-1	1	JN	1.5	2.0	2	JF	1.5	1.0						
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Detailed Log

Hole ID	Zone	Depth (m)	Lithology	Oriented Core Log				Infill Material	RMR76	Comment
				Alpha	Beta	Type	Confidence (3,2,1)		Joint Condition Rating	
K16-367 (UG Hole 1)		9.75	Aphanitic Rhyolite (RHYi)	90	0	JN	2	CL/LI	12	
K16-367 (UG Hole 1)		9.98	Aphanitic Rhyolite (RHYi)	86	20	JN	2	CL/LI	12	
K16-367 (UG Hole 1)		10.28	Aphanitic Rhyolite (RHYi)	11	55	JN	2	LI	16	
K16-367 (UG Hole 1)		12.73	Aphanitic Rhyolite (RHYi)	69	200	JN	2	SE	16	
K16-367 (UG Hole 1)		12.33	Aphanitic Rhyolite (RHYi)	61	205	JN	2	SE	16	
K16-367 (UG Hole 1)		12.53	Aphanitic Rhyolite (RHYi)	43	290	JN	2	CL	12	
K16-367 (UG Hole 1)		13.02	Aphanitic Rhyolite (RHYi)	66	195	JN	2		20	
K16-367 (UG Hole 1)		14.30	Aphanitic Rhyolite (RHYi)	47	250	JN	2	SE	20	
K16-367 (UG Hole 1)		14.53	Aphanitic Rhyolite (RHYi)	79	345	JN	2		20	
K16-367 (UG Hole 1)		14.79	Aphanitic Rhyolite (RHYi)	16	50	JN	2	CL	16	
K16-367 (UG Hole 1)		15.66	Aphanitic Rhyolite (RHYi)	22	30	JN	2		22	
K16-367 (UG Hole 1)		16.14	Aphanitic Rhyolite (RHYi)	74	230	JN	2		20	
K16-367 (UG Hole 1)		16.66	Volcaniclastic Rhyolite (RHYv	74	10	JF	2	CL	16	
K16-367 (UG Hole 1)		16.69	Volcaniclastic Rhyolite (RHYv	76	240	JN	2	CL	12	
K16-367 (UG Hole 1)		16.81	Volcaniclastic Rhyolite (RHYv	59	320	JN	2	CL	16	
K16-367 (UG Hole 1)		16.93	Volcaniclastic Rhyolite (RHYv	77	225	JF	2	CL	12	
K16-367 (UG Hole 1)		17.46	Volcaniclastic Rhyolite (RHYv	65	230	JN	2	CL	12	
K16-367 (UG Hole 1)		17.57	Volcaniclastic Rhyolite (RHYv	27	70	JN	2	CL	12	
K16-367 (UG Hole 1)		17.88	Volcaniclastic Rhyolite (RHYv	10	5	JN	2	CA	22	
K16-367 (UG Hole 1)		17.87	Volcaniclastic Rhyolite (RHYv	76	270	JF	2	CL	12	
K16-367 (UG Hole 1)		17.93	Volcaniclastic Rhyolite (RHYv	70	240	JF	2	CL	12	
K16-367 (UG Hole 1)		18.13	Volcaniclastic Rhyolite (RHYv	73	200	JF	2	CL	12	
K16-367 (UG Hole 1)		18.25	Volcaniclastic Rhyolite (RHYv	75	200	JF	2		16	
K16-367 (UG Hole 1)		18.32	Volcaniclastic Rhyolite (RHYv	70	180	JF	2	CL	12	
K16-367 (UG Hole 1)		18.42	Volcaniclastic Rhyolite (RHYv	68	235	JF	2	CL	12	
K16-367 (UG Hole 1)		18.59	Volcaniclastic Rhyolite (RHYv	74	200	JF	2	CL	6	
K16-367 (UG Hole 1)		18.94	Volcaniclastic Rhyolite (RHYv	76	225	JF	2	CL	12	
K16-367 (UG Hole 1)		19.16	Volcaniclastic Rhyolite (RHYv	77	240	JF	2	CL	6	
K16-367 (UG Hole 1)		19.51	Aphanitic Rhyolite (RHYi)	67	255	JF	2	CL	12	
K16-367 (UG Hole 1)		21.63	Aphanitic Rhyolite (RHYi)	58	215	JF	2	CL	16	
K16-367 (UG Hole 1)		21.93	Aphanitic Rhyolite (RHYi)	82	160	JN	2	CL	12	
K16-367 (UG Hole 1)		23.55	Aphanitic Rhyolite (RHYi)	76	225	JF	2	CL	16	
K16-367 (UG Hole 1)		23.89	Aphanitic Rhyolite (RHYi)	76	235	JF	2	CL	12	
K16-367 (UG Hole 1)		24.89	Aphanitic Rhyolite (RHYi)	71	200	JF	2		16	
K16-367 (UG Hole 1)		25.61	Aphanitic Rhyolite (RHYi)	61	10	FLT	2	CL	0	
K16-367 (UG Hole 1)		26.04	Aphanitic Rhyolite (RHYi)	64	160	JF	2	CL	12	
K16-367 (UG Hole 1)		26.30	Aphanitic Rhyolite (RHYi)	53	185	JN	2	CL	12	
K16-367 (UG Hole 1)		26.59	Aphanitic Rhyolite (RHYi)	72	175	JF	2	CL	12	
K16-367 (UG Hole 1)		26.82	Aphanitic Rhyolite (RHYi)	64	190	JF	2	CL	16	
K16-367 (UG Hole 1)		26.85	Aphanitic Rhyolite (RHYi)	75	175	JF	2	CL	12	
K16-367 (UG Hole 1)		26.88	Aphanitic Rhyolite (RHYi)	71	175	JF	2	CL	16	
K16-367 (UG Hole 1)		27.45	Aphanitic Rhyolite (RHYi)	71	165	JF	2	MI	16	
K16-367 (UG Hole 1)		27.52	Aphanitic Rhyolite (RHYi)	63	230	JF	2	MI	16	
K16-367 (UG Hole 1)		27.73	Aphanitic Rhyolite (RHYi)	70	190	JF	2	CL	12	
K16-367 (UG Hole 1)		27.97	Aphanitic Rhyolite (RHYi)	69	200	JF	2	CL	12	
K16-367 (UG Hole 1)		28.97	Aphanitic Rhyolite (RHYi)	28	190	JN	2	CL	20	
K16-367 (UG Hole 1)		29.07	Mafic Sill (MAFi)	79	215	FLT	2	CL	0	
K16-367 (UG Hole 1)		29.11	Mafic Sill (MAFi)	77	170	JF	2	CL	12	
K16-367 (UG Hole 1)		29.14	Mafic Sill (MAFi)	73	170	JF	2	CL	6	
K16-367 (UG Hole 1)		31.15	Aphanitic Rhyolite (RHYi)	61	180	FLT	1	CL/CR	0	
K16-367 (UG Hole 1)		31.83	Aphanitic Rhyolite (RHYi)	60	260	HJN	1	CL	25	
K16-367 (UG Hole 1)		31.90	Aphanitic Rhyolite (RHYi)	50	180	JN	1	CL	12	
K16-367 (UG Hole 1)		32.69	Aphanitic Rhyolite (RHYi)	40	320	JN	1	CL	20	
K16-367 (UG Hole 1)		32.94	Aphanitic Rhyolite (RHYi)	70	220	JN	1	CL	6	
K16-367 (UG Hole 1)		33.58	Aphanitic Rhyolite (RHYi)	57	270	JN	1	CL	16	
K16-367 (UG Hole 1)		33.33	Aphanitic Rhyolite (RHYi)	60	190	JN	1	CL	6	
K16-367 (UG Hole 1)		33.54	Aphanitic Rhyolite (RHYi)	47	155	JN	1	CL	12	
K16-367 (UG Hole 1)		34.02	Aphanitic Rhyolite (RHYi)	60	230	JN	1	CL	12	
K16-367 (UG Hole 1)		34.21	Aphanitic Rhyolite (RHYi)	28	220	JN	1	CL	16	
K16-367 (UG Hole 1)		34.37	Aphanitic Rhyolite (RHYi)	46	275	JN	1	-	22	
K16-367 (UG Hole 1)		34.81	Aphanitic Rhyolite (RHYi)	46	255	JN	1	-	22	
K16-367 (UG Hole 1)		34.99	Aphanitic Rhyolite (RHYi)	37	90	HJN	1	-	25	
K16-367 (UG Hole 1)		35.03	Aphanitic Rhyolite (RHYi)	46	240	JN	1	-	25	
K16-367 (UG Hole 1)		35.07	Aphanitic Rhyolite (RHYi)	55	100	JN	1	CA	20	
K16-367 (UG Hole 1)		35.14	Aphanitic Rhyolite (RHYi)	56	225	JN	1	CA	20	
K16-367 (UG Hole 1)		35.63	Aphanitic Rhyolite (RHYi)	70	30	HFLT	1	CL	25	
K16-367 (UG Hole 1)		35.80	Aphanitic Rhyolite (RHYi)	65	20	HJN	1	CL	25	
K16-367 (UG Hole 1)		35.90	Aphanitic Rhyolite (RHYi)	37	20	JN	1		20	
K16-367 (UG Hole 1)		37.25	Aphanitic Rhyolite (RHYi)	55	20	JN	1		20	
K16-367 (UG Hole 1)		37.70	Aphanitic Rhyolite (RHYi)	57	190	JN	1	CL	16	
K16-367 (UG Hole 1)		37.73	Aphanitic Rhyolite (RHYi)	23	220	HJN	1	CL	25	
K16-367 (UG Hole 1)		37.81	Aphanitic Rhyolite (RHYi)	62	70	JN	1	CL	12	
K16-367 (UG Hole 1)		39.05	Aphanitic Rhyolite (RHYi)	68	210	JF	3	CL	16	
K16-367 (UG Hole 1)		39.80	Aphanitic Rhyolite (RHYi)	66	205	JF	3	CL	12	
K16-367 (UG Hole 1)		39.89	Aphanitic Rhyolite (RHYi)	69	215	JF	3	CL	12	
K16-367 (UG Hole 1)		40.03	Aphanitic Rhyolite (RHYi)	72	215	JF	3	CL	12	
K16-367 (UG Hole 1)		40.28	Aphanitic Rhyolite (RHYi)	63	230	JF	3	CL	12	
K16-367 (UG Hole 1)		40.58	Aphanitic Rhyolite (RHYi)	49	200	JF	3	CL	16	
K16-367 (UG Hole 1)		40.98	Aphanitic Rhyolite (RHYi)	62	185	JF	3	CL/MI	20	
K16-367 (UG Hole 1)		41.09	Aphanitic Rhyolite (RHYi)	78	290	JN	3	CL	12	
K16-367 (UG Hole 1)		41.38	Aphanitic Rhyolite (RHYi)	47	170	JN	3	CA	12	
K16-367 (UG Hole 1)		41.80	Aphanitic Rhyolite (RHYi)	45	120	JN	3	CL	6	
K16-367 (UG Hole 1)		42.29	Aphanitic Rhyolite (RHYi)	55	210	JF	3	CL	20	
K16-367 (UG Hole 1)		43.11	Aphanitic Rhyolite (RHYi)	75	205	JN	3	CL	6	
K16-367 (UG Hole 1)		43.53	Aphanitic Rhyolite (RHYi)	72	180	JF	2	CA	16	
K16-367 (UG Hole 1)		43.80	Aphanitic Rhyolite (RHYi)	66	200	JF	2	MI	12	
K16-367 (UG Hole 1)		43.85	Aphanitic Rhyolite (RHYi)	65	195	JF	2	CL	6	
K16-367 (UG Hole 1)		43.91	Aphanitic Rhyolite (RHYi)	13	190	JN	2	SE	16	
K16-367 (UG Hole 1)		44.82	Aphanitic Rhyolite (RHYi)	12	200	JN	2	SE	12	
K16-367 (UG Hole 1)		45.35	Aphanitic Rhyolite (RHYi)	17	200	JN	2	SE	16	
K16-367 (UG Hole 1)		45.57	Aphanitic Rhyolite (RHYi)	20	185	JN	2	CA	12	
K16-367 (UG Hole 1)		45.82	Aphanitic Rhyolite (RHYi)	65	190	JF	2	MI	16	
K16-367 (UG Hole 1)		46.31	Aphanitic Rhyolite (RHYi)	65	315	JN	2	MI	16	
K16-367 (UG Hole 1)		46.81	Aphanitic Rhyolite (RHYi)	59	220	JF	2	CA	16	
K16-367 (UG Hole 1)		47.84	Aphanitic Rhyolite (RHYi)	29	210	JN	2	CL	20	
K16-367 (UG Hole 1)		49.41	Volcaniclastic Rhyolite (RHYv	72	325	JF	2	MI	12	
K16-367 (UG Hole 1)		49.45	Volcaniclastic Rhyolite (RHYv	52	320	JN	2	CL	12	
K16-367 (UG Hole 1)		50.14	Coherent Rhyolite (RHYc)	27	340	JN	2	CL	16	
K16-367 (UG Hole 1)		50.22	Coherent Rhyolite (RHYc)	72	205	JF	2	MI/CL	12	
K16-367 (UG Hole 1)		50.78	Coherent Rhyolite (RHYc)	42	330	JN	2	CL	12	
K16-367 (UG Hole 1)		50.91	Coherent Rhyolite (RHYc)	74	275	JF	2	MI	12	
K16-367 (UG Hole 1)		51.31	Coherent Rhyolite (RHYc)	63	210	JF	2	CL	12	
K16-367 (UG Hole 1)		51.32	Coherent Rhyolite (RHYc)	11	350	JN	2	CL	16	
K16-367 (UG Hole 1)		52.05	Coherent Rhyolite (RHYc)	60	250	JF	2	CL	6	
K16-367 (UG Hole 1)		52.45	Coherent Rhyolite (RHYc)	76	255	JF	2	MI/CL	12	
K16-367 (UG Hole 1)		52.47	Coherent Rhyolite (RHYc)	26	355	JN	2	CL	6	
K16-367 (UG Hole 1)		54.17	Volcaniclastic Rhyolite (RHYv	45	330	JN	1	CL	20	
K16-367 (UG Hole 1)		54.26	Volcaniclastic Rhyolite (RHYv	55	90	JN	1	CL/SU	20	
K16-367 (UG Hole 1)		54.81	Volcaniclastic Rhyolite (RHYv	82	70	JF	1	-	20	
K16-367 (UG Hole 1)		54.82	Volcaniclastic Rhyolite (RHYv	22	155	JN	1	-	16	
K16-367 (UG Hole 1)		54.97	Volcaniclastic Rhyolite (RHYv	53	40	JF	1	CL	12	
K16-367 (UG Hole 1)		56.13	Volcaniclastic Rhyolite (RHYv	71	45	JN	1	CL	16	
K16-367 (UG Hole 1)		56.21	Volcaniclastic Rhyolite (RHYv	75	35	JN	1	CL	12	
K16-367 (UG Hole 1)		56.24	Volcaniclastic Rhyolite (RHYv	59	255	JN	1	CL	6	
K16-367 (UG Hole 1)		57.30	Coherent Rhyolite (RHYc)	77	275	JF	2	CL	16	
K16-367 (UG Hole 1)		57.63	Volcaniclastic Rhyolite (RHYv	72	305	JF	2	CL/MI	16	
K16-367 (UG Hole 1)		58.75	Volcaniclastic Rhyolite (RHYv	57	310	JF	2	-	20	
K16-367 (UG Hole 1)		59.23	Volcaniclastic Rhyolite (RHYv	64	15	JF	2	CL	12	
K16-367 (UG Hole 1)		59.30	Volcaniclastic Rhyolite (RHYv	59	0	JN	2	-	20	
K16-367 (UG Hole 1)		59.77	Volcaniclastic Rhyolite (RHYv	76	40	JN	2	CL	6	
K16-367 (UG Hole 1)		60.17	Volcaniclastic Rhyolite (RHYv	64	285	JF	2	CL	12	
K16-367 (UG Hole 1)		61.05	Volcaniclastic Rhyolite (RHYv	9	185	JN	2	CL	16	
K16-367 (UG Hole 1)		62.24	Volcaniclastic Rhyolite (RHYv	55	265	JF	3	CL	12	
K16-367 (UG Hole 1)		62.67	Volcaniclastic Rhyolite (RHYv	61	275	JF	3	MI	12	
K16-367 (UG Hole 1)		63.71	Volcaniclastic Rhyolite (RHYv	60	270	JN	3	-	20	
K16-367 (UG Hole 1)		63.97	Volcaniclastic Rhyolite (RHYv	66	285	JF	3	MI/SE	16	
K16-367 (UG Hole 1)		64.30	Volcaniclastic Rhyolite (RHYv	65	290	JF	3	MI	16	
K16-367 (UG Hole 1)		65.31	Volcaniclastic Rhyolite (RHYv	68	260	JF	3	CL	12	
K16-367 (UG Hole 1)		68.35	Volcaniclastic Rhyolite (RHYv	36	135	JN	3	-	20	
K16-367 (UG Hole 1)		68.66	Volcaniclastic Rhyolite (RHYv	43	135	JN	3	MI	16	
K16-367 (UG Hole 1)		70.55	Volcaniclastic Rhyolite (RHYv	67	150	JF	1	MI	12	
K16-367 (UG Hole 1)		71.21	Volcaniclastic Rhyolite (RHYv	81	60	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		71.34	Volcaniclastic Rhyolite (RHYv	81	60	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		71.48	Volcaniclastic Rhyolite (RHYv	61	295	JN	1	CL	20	
K16-367 (UG Hole 1)		72.28	Volcaniclastic Rhyolite (RHYv	76	270	JN	1	CL	16	
K16-367 (UG Hole 1)		72.73	Volcaniclastic Rhyolite (RHYv	77	275	JN	1	CL	12	
K16-367 (UG Hole 1)		72.81	Volcaniclastic Rhyolite (RHYv	15	290	JN	1	CL	20	
K16-367 (UG Hole 1)		72.99	Volcaniclastic Rhyolite (RHYv	68	280	JN	1	CL	16	
K16-367 (UG Hole 1)		73.17	Volcaniclastic Rhyolite (RHYv	77	5	JN	1	MI	16	
K16-367 (UG Hole 1)		73.37	Volcaniclastic Rhyolite (RHYv	59	315	JN	1	CL	16	
K16-367 (UG Hole 1)		73.50	Volcaniclastic Rhyolite (RHYv	46	315	JN	1	CL	12	
K16-367 (UG Hole 1)		74.16	Volcaniclastic Rhyolite (RHYv	82	80	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		74.60	Volcaniclastic Rhyolite (RHYv	40	70	JN	1	CL	12	
K16-367 (UG Hole 1)		74.84	Volcaniclastic Rhyolite (RHYv	79	250	JN	1	MI/CL	12	
K16-367 (UG Hole 1)		75.23	Volcaniclastic Rhyolite (RHYv	5	170	JN	2	CL	20	
K16-367 (UG Hole 1)		75.25	Volcaniclastic Rhyolite (RHYv	68	165	JN	2	CL	16	
K16-367 (UG Hole 1)		76.00	Volcaniclastic Rhyolite (RHYv	53	240	JN	2	CL	20	
K16-367 (UG Hole 1)		76.18	Volcaniclastic Rhyolite (RHYv	75	330	JN	2	CL	0	
K16-367 (UG Hole 1)		76.27	Volcaniclastic Rhyolite (RHYv	19	40	JN	2	CL	20	
K16-367 (UG Hole 1)		76.60	Volcaniclastic Rhyolite (RHYv	73	300	JF	2	CL	6	
K16-367 (UG Hole 1)		76.88	Volcaniclastic Rhyolite (RHYv	34	285	JN	2	CL	16	
K16-367 (UG Hole 1)		77.47	Volcaniclastic Rhyolite (RHYv	72	300	JF	2	CL/CH	6	
K16-367 (UG Hole 1)		77.79	Volcaniclastic Rhyolite (RHYv	71	325	JN	2	CL/CH	6	
K16-367 (UG Hole 1)		78.12	Volcaniclastic Rhyolite (RHYv	48	140	JN	2	CA	20	
K16-367 (UG Hole 1)		78.39	Volcaniclastic Rhyolite (RHYv	78	320	JN	2	MI	12	
K16-367 (UG Hole 1)		79.48	Volcaniclastic Rhyolite (RHYv	35	310	JN	1	CL	20	
K16-367 (UG Hole 1)		80.95	Volcaniclastic Rhyolite (RHYv	80	60	JF	1	CL/MI	6	
K16-367 (UG Hole 1)		81.20	Volcaniclastic Rhyolite (RHYv	82	210	JF	1	CH	6	
K16-367 (UG Hole 1)		81.41	Volcaniclastic Rhyolite (RHYv	42	180	JN	1	-	22	
K16-367 (UG Hole 1)		81.58	Volcaniclastic Rhyolite (RHYv	79	300	JF	1	CL	12	
K16-367 (UG Hole 1)		82.03	Volcaniclastic Rhyolite (RHYv	21	150	JN	1	CL	20	
K16-367 (UG Hole 1)		82.32	Volcaniclastic Rhyolite (RHYv	5	310	JN	1	CL	22	
K16-367 (UG Hole 1)		82.50	Volcaniclastic Rhyolite (RHYv	41	255	JN	1	CA	20	
K16-367 (UG Hole 1)		82.57	Volcaniclastic Rhyolite (RHYv	37	265	JN	1	SE	22	
K16-367 (UG Hole 1)		83.00	Volcaniclastic Rhyolite (RHYv	41	175	JN	1	-	22	
K16-367 (UG Hole 1)		83.51	Volcaniclastic Rhyolite (RHYv	41	165	JN	1	SE	20	
K16-367 (UG Hole 1)		83.83	Volcaniclastic Rhyolite (RHYv	76	285	JF	1	CH	12	
K16-367 (UG Hole 1)		83.89	Sediment (SED)	77	310	JF	1	CL	6	

K16-367 (UG Hole 1)		97.83	Volcaniclastic Rhyolite (RHYv	66	345	JF	1	CL	6	
K16-367 (UG Hole 1)		98.56	Volcaniclastic Rhyolite (RHYv	62	350	JN	1	CL/MI	6	
K16-367 (UG Hole 1)		98.84	Volcaniclastic Rhyolite (RHYv	14	135	JN	1	CL	16	
K16-367 (UG Hole 1)		98.87	Volcaniclastic Rhyolite (RHYv	18	135	JN	1	CL	16	
K16-367 (UG Hole 1)		98.96	Volcaniclastic Rhyolite (RHYv	36	215	JN	1	-	22	
K16-367 (UG Hole 1)		99.15	Volcaniclastic Rhyolite (RHYv	55	240	JN	1	-	22	
K16-367 (UG Hole 1)		99.24	Volcaniclastic Rhyolite (RHYv	44	210	JN	1	-	22	
K16-367 (UG Hole 1)		99.84	Volcaniclastic Rhyolite (RHYv	12	150	JN	1	CL	20	
K16-367 (UG Hole 1)		99.99	Volcaniclastic Rhyolite (RHYv	68	65	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		100.37	Volcaniclastic Rhyolite (RHYv	57	245	JN	1	CL	16	
K16-367 (UG Hole 1)		100.79	Volcaniclastic Rhyolite (RHYv	73	50	JF	1	MI	12	
K16-367 (UG Hole 1)		101.89	Volcaniclastic Rhyolite (RHYv	78	95	JF	1	CL	12	
K16-367 (UG Hole 1)		102.75	Volcaniclastic Rhyolite (RHYv	69	105	JN	2	CA	16	
K16-367 (UG Hole 1)		102.94	Volcaniclastic Rhyolite (RHYv	65	70	JN	2	CH	12	
K16-367 (UG Hole 1)		103.26	Volcaniclastic Rhyolite (RHYv	65	340	JF	2	CA	20	
K16-367 (UG Hole 1)		103.27	Volcaniclastic Rhyolite (RHYv	66	180	JN	2	-	20	
K16-367 (UG Hole 1)		103.39	Volcaniclastic Rhyolite (RHYv	56	25	JF	2	CH	0	
K16-367 (UG Hole 1)		103.44	Volcaniclastic Rhyolite (RHYv	69	5	JF	2	CH/MI	12	
K16-367 (UG Hole 1)		103.76	Volcaniclastic Rhyolite (RHYv	70	340	JF	2	CL	16	
K16-367 (UG Hole 1)		104.08	Volcaniclastic Rhyolite (RHYv	68	170	JN	2	CL	20	
K16-367 (UG Hole 1)		104.17	Volcaniclastic Rhyolite (RHYv	77	325	JF	2	MI	12	
K16-367 (UG Hole 1)		104.28	Volcaniclastic Rhyolite (RHYv	81	200	JN	2	CA	12	
K16-367 (UG Hole 1)		104.57	Volcaniclastic Rhyolite (RHYv	71	75	JN	2	MI	12	
K16-367 (UG Hole 1)		104.70	Volcaniclastic Rhyolite (RHYv	69	35	JN	2	MI	16	
K16-367 (UG Hole 1)		104.73	Volcaniclastic Rhyolite (RHYv	62	280	JN	2	CL	12	
K16-367 (UG Hole 1)		104.77	Volcaniclastic Rhyolite (RHYv	49	85	JF	2	CL	12	
K16-367 (UG Hole 1)		104.96	Volcaniclastic Rhyolite (RHYv	82	260	JN	2	MI	12	
K16-367 (UG Hole 1)		105.09	Volcaniclastic Rhyolite (RHYv	50	10	JN	2	MI	12	
K16-367 (UG Hole 1)		105.81	Volcaniclastic Rhyolite (RHYv	71	230	JN	1	CL	0	
K16-367 (UG Hole 1)		105.82	Volcaniclastic Rhyolite (RHYv	65	90	JN	1	CL	12	
K16-367 (UG Hole 1)		106.45	Volcaniclastic Rhyolite (RHYv	77	315	JF	1	CL	12	
K16-367 (UG Hole 1)		106.67	Volcaniclastic Rhyolite (RHYv	45	35	FLT	3	CL	6	
K16-367 (UG Hole 1)		107.30	Volcaniclastic Rhyolite (RHYv	34	270	JN	3	CA	20	
K16-367 (UG Hole 1)		107.39	Volcaniclastic Rhyolite (RHYv	73	50	JF	3	MI	12	
K16-367 (UG Hole 1)		107.43	Volcaniclastic Rhyolite (RHYv	69	75	FLT	3	CL	12	
K16-367 (UG Hole 1)		107.53	Volcaniclastic Rhyolite (RHYv	71	265	FLT	3	CH	12	
K16-367 (UG Hole 1)		107.73	Volcaniclastic Rhyolite (RHYv	73	205	JN	3	CH	12	
K16-367 (UG Hole 1)		107.83	Stringer Sulfide (OJ)	80	270	JF	3	MI	12	
K16-367 (UG Hole 1)		109.36	Stringer Sulfide (OJ)	80	5	JF	3	MI	12	
K16-367 (UG Hole 1)		109.41	Stringer Sulfide (OJ)	85	355	JF	3	CH	6	
K16-367 (UG Hole 1)		110.28	Stringer Sulfide (OJ)	85	15	JF	3	MI	12	
K16-367 (UG Hole 1)		111.29	Stringer Sulfide (OJ)	75	70	JF	3	CH	12	
K16-367 (UG Hole 1)		111.42	Stringer Sulfide (OJ)	69	75	JF	3	CH	12	
K16-367 (UG Hole 1)		111.84	Coherent Rhyolite (RHYc)	76	75	JN	1	MI	12	
K16-367 (UG Hole 1)		111.88	Coherent Rhyolite (RHYc)	62	225	JN	1	MI	12	
K16-367 (UG Hole 1)		111.92	Coherent Rhyolite (RHYc)	70	220	JF	1	MI	16	
K16-367 (UG Hole 1)		111.96	Coherent Rhyolite (RHYc)	71	185	JF	1	CH/MI	12	
K16-367 (UG Hole 1)		111.98	Coherent Rhyolite (RHYc)	68	215	JF	1	MI	12	
K16-367 (UG Hole 1)		112.04	Coherent Rhyolite (RHYc)	82	315	JF	1	MI	12	
K16-367 (UG Hole 1)		112.09	Coherent Rhyolite (RHYc)	74	195	JF	1	MI	12	
K16-367 (UG Hole 1)		112.24	Coherent Rhyolite (RHYc)	70	205	JF	1	MI	6	
K16-367 (UG Hole 1)		112.27	Coherent Rhyolite (RHYc)	70	200	JF	1	CH	6	
K16-367 (UG Hole 1)		112.38	Coherent Rhyolite (RHYc)	74	150	JF	1	MI	6	
K16-367 (UG Hole 1)		112.65	Coherent Rhyolite (RHYc)	74	180	JF	1	MI	6	
K16-367 (UG Hole 1)		112.75	Coherent Rhyolite (RHYc)	77	145	JF	1	MI	6	
K16-367 (UG Hole 1)		112.79	Coherent Rhyolite (RHYc)	75	125	JF	1	MI	6	
K16-367 (UG Hole 1)		112.84	Coherent Rhyolite (RHYc)	76	110	JF	1	MI	6	
K16-367 (UG Hole 1)		114.85	Coherent Rhyolite (RHYc)	77	240	JF	1	MI	6	
K16-367 (UG Hole 1)		115.08	Coherent Rhyolite (RHYc)	65	245	JN	1	MI	6	
K16-367 (UG Hole 1)		115.16	Coherent Rhyolite (RHYc)	40	270	FLT	1	MI	6	
K16-367 (UG Hole 1)		115.46	Coherent Rhyolite (RHYc)	56	310	JN	1	MI	12	
K16-367 (UG Hole 1)		115.52	Coherent Rhyolite (RHYc)	65	45	JN	1	MI	12	
K16-367 (UG Hole 1)		116.02	Coherent Rhyolite (RHYc)	55	180	JN	1	CH	20	
K16-367 (UG Hole 1)		116.25	Coherent Rhyolite (RHYc)	75	240	JN	1	MI	12	
K16-367 (UG Hole 1)		116.27	Coherent Rhyolite (RHYc)	73	75	JN	1	MI	6	
K16-367 (UG Hole 1)		116.32	Coherent Rhyolite (RHYc)	27	175	JN	1	MI/CL	0	
K16-367 (UG Hole 1)		116.42	Coherent Rhyolite (RHYc)	51	70	JN	1	MI/CL	12	
K16-367 (UG Hole 1)		116.47	Coherent Rhyolite (RHYc)	49	150	JN	1	MI/CL	6	
K16-367 (UG Hole 1)		116.53	Coherent Rhyolite (RHYc)	50	120	JF	1	MI	16	
K16-367 (UG Hole 1)		116.58	Coherent Rhyolite (RHYc)	39	90	FLT	1	MI/CH	6	
K16-367 (UG Hole 1)		116.85	Coherent Rhyolite (RHYc)	40	85	JN	1	MI	12	
K16-367 (UG Hole 1)		116.93	Coherent Rhyolite (RHYc)	49	60	JF	1	MI	6	
K16-367 (UG Hole 1)		119.56	Mafic Sill (MAfi)	68	120	JF	1	CH/CL	0	
K16-367 (UG Hole 1)		119.59	Mafic Sill (MAfi)	66	100	JF	1	MI	16	
K16-367 (UG Hole 1)		119.61	Mafic Sill (MAfi)	22	180	JN	1	CL	20	
K16-367 (UG Hole 1)		119.62	Mafic Sill (MAfi)	55	225	JN	1	MI	16	
K16-367 (UG Hole 1)		119.68	Mafic Sill (MAfi)	30	180	JN	1	MI/CL	12	
K16-367 (UG Hole 1)		119.80	Mafic Sill (MAfi)	27	165	JN	1	MI/CL	12	
K16-367 (UG Hole 1)		119.89	Mafic Sill (MAfi)	36	0	JN	1	MI	16	
K16-367 (UG Hole 1)		120.26	Mafic Sill (MAfi)	55	50	JF	1	CL	6	
K16-367 (UG Hole 1)		120.56	Mafic Sill (MAfi)	22	210	JN	1	CL/CA	12	
K16-367 (UG Hole 1)		120.74	Mafic Sill (MAfi)	25	225	FLT	1	CH	6	
K16-367 (UG Hole 1)		121.11	Mafic Sill (MAfi)	36	325	JN	1	CH	12	
K16-367 (UG Hole 1)		121.18	Mafic Sill (MAfi)	41	300	JN	1	CH	12	
K16-367 (UG Hole 1)		121.57	Mafic Sill (MAfi)	15	150	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		121.70	Mafic Sill (MAfi)	25	145	JF	1	MI/CL	12	
K16-367 (UG Hole 1)		121.77	Mafic Sill (MAfi)	29	135	JF	1	MI/CH	12	
K16-367 (UG Hole 1)		121.84	Mafic Sill (MAfi)	42	120	JF	1	MI/CH	12	
K16-367 (UG Hole 1)		121.88	Mafic Sill (MAfi)	39	130	JF	1	MI/CH	12	
K16-367 (UG Hole 1)		124.74	Mafic Sill (MAfi)	78	110	JF	1	CH	12	
K16-367 (UG Hole 1)		124.89	Mafic Sill (MAfi)	29	270	JN	1	CH/CL	6	
K16-367 (UG Hole 1)		124.92	Mafic Sill (MAfi)	79	270	JN	1	CH/CL	6	
K16-367 (UG Hole 1)		124.94	Mafic Sill (MAfi)	76	270	JN	1	CH/CL	6	
K16-367 (UG Hole 1)		125.07	Mafic Sill (MAfi)	78	150	JF	1	CH/CL	12	
K16-367 (UG Hole 1)		125.14	Mafic Sill (MAfi)	51	120	JN	1	CH/CL	12	

K16-367 (UG Hole 1)	HW	141.91	Mafic Sill (MAFI)	43	95	JN	1	CH/HE	12	
K16-367 (UG Hole 1)	HW	142.05	Mafic Sill (MAFI)	74	0	JN	1	CH/HE	6	
K16-367 (UG Hole 1)	HW	142.08	Mafic Sill (MAFI)	59	180	JN	1	CH	12	
K16-367 (UG Hole 1)	HW	142.30	Mafic Sill (MAFI)	71	40	JN	1	CH	0	
K16-367 (UG Hole 1)	HW	142.96	Mafic Sill (MAFI)	65	325	JN	1	CL/CH	12	
K16-367 (UG Hole 1)	HW	143.06	Mafic Sill (MAFI)	70	30	JF	1	CH/HE	6	
K16-367 (UG Hole 1)	HW	143.37	Mafic Sill (MAFI)	62	75	FLT	1	CH	0	
K16-367 (UG Hole 1)	HW	143.46	Mafic Sill (MAFI)	59	75	FLT	1	CH	0	
K16-367 (UG Hole 1)	HW	143.52	Mafic Sill (MAFI)	65	60	JF	1	CH	6	
K16-367 (UG Hole 1)	HW	143.62	Mafic Sill (MAFI)	68	50	JF	1	CH	0	
K16-367 (UG Hole 1)	HW	143.70	Mafic Sill (MAFI)	66	75	JN	1	CH	6	
K16-367 (UG Hole 1)	HW	143.91	Mafic Sill (MAFI)	79	5	JN	1	CH	12	
K16-367 (UG Hole 1)	HW	143.94	Mafic Sill (MAFI)	75	250	JN	1	CH	12	
K16-367 (UG Hole 1)	HW	144.14	Mafic Sill (MAFI)	52	5	JN	1	CH	16	
K16-367 (UG Hole 1)	HW	144.21	Mafic Sill (MAFI)	29	150	JN	1	CA	16	
K16-367 (UG Hole 1)	HW	144.25	Mafic Sill (MAFI)	72	250	JN	1	CH	12	
K16-367 (UG Hole 1)	HW	144.38	Mafic Sill (MAFI)	73	245	JN	1	CH	12	
K16-367 (UG Hole 1)	HW	144.42	Mafic Sill (MAFI)	40	235	JN	1	CH	20	
K16-367 (UG Hole 1)	HW	144.53	Mafic Sill (MAFI)	73	335	JN	2	CH	12	
K16-367 (UG Hole 1)	HW	144.73	Mafic Sill (MAFI)	77	260	JN	2	CH	16	
K16-367 (UG Hole 1)	HW	144.95	Mafic Sill (MAFI)	70	0	JF	2	CH	6	
K16-367 (UG Hole 1)	HW	145.13	Mafic Sill (MAFI)	73	0	JF	2	CH	6	
K16-367 (UG Hole 1)	HW	145.23	Mafic Sill (MAFI)	70	15	JF	2	CH	6	
K16-367 (UG Hole 1)	HW	145.60	Mafic Sill (MAFI)	67	335	JN	2	CH	12	
K16-367 (UG Hole 1)	HW	145.67	Mafic Sill (MAFI)	65	60	JN	2	CA/CH	6	
K16-367 (UG Hole 1)	HW	145.76	Mafic Sill (MAFI)	86	35	JN	2	CL/CH	0	
K16-367 (UG Hole 1)	HW	145.85	Mafic Sill (MAFI)	72	25	JF	2	SE/CH	6	
K16-367 (UG Hole 1)	HW	146.06	Mafic Sill (MAFI)	59	285	JN	2	CA	12	
K16-367 (UG Hole 1)	HW	146.25	Mafic Sill (MAFI)	70	255	JN	2	CH	12	
K16-367 (UG Hole 1)	HW	146.31	Mafic Sill (MAFI)	58	40	JF	2	CH	6	
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	
K16-367 (UG Hole 1)	Waste	161.76	Mafic Sill (MAFI)	33	115	JN	3	CA	16	
K16-367 (UG Hole 1)	Waste	162.85	Mafic Sill (MAFI)	27	270	FLT	3	CL/CA	12	
K16-367 (UG Hole 1)	Waste	163.61	Mafic Sill (MAFI)	76	80	JN	3	CA	12	
K16-367 (UG Hole 1)	Waste	166.90	Mafic Sill (MAFI)	70	135	JF	3	SE	16	
K16-367 (UG Hole 1)	Waste	167.20	Mafic Sill (MAFI)	47	235	JN	3	CH	20	
K16-367 (UG Hole 1)	Waste	167.27	Mafic Sill (MAFI)	63	150	JN	3	CH	16	
K16-367 (UG Hole 1)	Waste	170.13	Mafic Sill (MAFI)	26	345	JN	3	CH	16	
K16-367 (UG Hole 1)	Waste	170.21	Mafic Sill (MAFI)	75	150	JF	3	CH	12	
K16-367 (UG Hole 1)	Waste	171.05	Mafic Sill (MAFI)	35	5	JN	3	SE	16	
K16-367 (UG Hole 1)	Waste	171.19	Mafic Sill (MAFI)	33	320	JN	3	CH	0	
K16-367 (UG Hole 1)	Waste	171.58	Mafic Sill (MAFI)	63	110	JF	3	SE/MI	6	
K16-367 (UG Hole 1)	Waste	171.86	Mafic Sill (MAFI)	65	125	JF	3	SE/CH	12	
K16-367 (UG Hole 1)	Waste	172.04	Mafic Sill (MAFI)	57	25	JN	3	CA	16	
K16-367 (UG Hole 1)	Waste	172.55	Mafic Sill (MAFI)	46	135	JN	3	CA	16	
K16-367 (UG Hole 1)	Waste	172.57	Mafic Sill (MAFI)	55	150	JF	3	CA	16	
K16-367 (UG Hole 1)	Waste	172.77	Mafic Sill (MAFI)	62	175	JN	3	CH/CA	12	
K16-367 (UG Hole 1)		172.86	Mafic Sill (MAFI)	84	45	VN	3	CA/CH	16	
K16-367 (UG Hole 1)	Ore	174.57	Massive Sulfide (OK)	76	190	JN	1		20	
K16-367 (UG Hole 1)	Ore	175.00	Massive Sulfide (OK)	30	110	JN	1	SU	22	
K16-367 (UG Hole 1)	Ore	175.33	Massive Sulfide (OK)	45	120	JN	1	SU	25	
K16-367 (UG Hole 1)	Ore	175.64	Massive Sulfide (OK)	65	280	JN	1	SU/CL	20	
K16-367 (UG Hole 1)	Ore	175.77	Massive Sulfide (OK)	10	170	JN	1	SU/CL	25	
K16-367 (UG Hole 1)	Ore	175.99	Massive Sulfide (OK)	20	150	JN	1	SU/CL	20	
K16-367 (UG Hole 1)	Ore	176.09	Massive Sulfide (OK)	45	110	JN	1	SU/CL	16	
K16-367 (UG Hole 1)	Ore	176.97	Massive Sulfide (OK)	60	20	JF	1	SU	20	
K16-367 (UG Hole 1)	Ore	177.00	Massive Sulfide (OK)	74	80	JF	1	CL	12	
K16-367 (UG Hole 1)	Ore	177.07	Massive Sulfide (OK)	70	50	JN	1	CL/SU	16	
K16-367 (UG Hole 1)	Ore	177.23	Undifferentiated Rhyolite (RH'	46	30	JN	1	SU	22	
K16-367 (UG Hole 1)	Ore	177.46	Undifferentiated Rhyolite (RH'	61	20	JN	1	SU	22	
K16-367 (UG Hole 1)	Ore	177.48	Undifferentiated Rhyolite (RH'	54	10	JN	1	SU	22	
K16-367 (UG Hole 1)	Ore	177.53	Undifferentiated Rhyolite (RH'	73	335	JN	1	SU/CL	20	
K16-367 (UG Hole 1)	Ore	177.67	Undifferentiated Rhyolite (RH'	49	145	JN	1	SU/CL	16	
K16-367 (UG Hole 1)	Ore	177.84	Undifferentiated Rhyolite (RH'	6	180	JN	1		25	
K16-367 (UG Hole 1)	Ore	177.80	Undifferentiated Rhyolite (RH'	74	310	JN	1		20	
K16-367 (UG Hole 1)	Waste	178.66	Undifferentiated Rhyolite (RH'	64	320	JF	1	CL	12	
K16-367 (UG Hole 1)	Waste	178.70	Undifferentiated Rhyolite (RH'	64	310	JF	1	CL	12	
K16-367 (UG Hole 1)	Waste	180.19	Undifferentiated Rhyolite (RH'	56	350	JN	1	CH	16	
K16-367 (UG Hole 1)	Waste	180.23	Undifferentiated Rhyolite (RH'	46	30	JF	1	CL	12	
K16-367 (UG Hole 1)	Waste	180.25	Undifferentiated Rhyolite (RH'	35	0	JN	1	CL	12	
K16-367 (UG Hole 1)	Waste	180.28	Undifferentiated Rhyolite (RH'	61	20	JF	1	MI	12	
K16-367 (UG Hole 1)	Waste	180.33	Undifferentiated Rhyolite (RH'	66	0	JF	1	MI/CL	12	
K16-367 (UG Hole 1)	Waste	180.41	Undifferentiated Rhyolite (RH'	63	320	JF	1	MI/CL	12	
K16-367 (UG Hole 1)	Waste	180.43	Undifferentiated Rhyolite (RH'	69	330	JF	1	MI/CL	12	
K16-367 (UG Hole 1)	Waste	180.56	Undifferentiated Rhyolite (RH'	77	335	JN	1	CA	12	
K16-367 (UG Hole 1)	Waste	180.61	Undifferentiated Rhyolite (RH'	6	210	JN	1	MI	16	
K16-367 (UG Hole 1)	Waste	180.67	Undifferentiated Rhyolite (RH'	76	330	JN	1	CH	12	
K16-367 (UG Hole 1)	Waste	180.72	Undifferentiated Rhyolite (RH'	73	315	JF	1	MI	12	
K16-367 (UG Hole 1)	Waste	180.76	Undifferentiated Rhyolite (RH'	76	310	JF	1	MI	12	
K16-367 (UG Hole 1)	Waste	180.86	Undifferentiated Rhyolite (RH'	73	350	JN	1	CA	12	
K16-367 (UG Hole 1)	Waste	181.01	Undifferentiated Rhyolite (RH'	79	310	JF	1	CA	12	
K16-367 (UG Hole 1)	Waste	181.32	Undifferentiated Rhyolite (RH'	70	215	JF	1	MI	6	
K16-367 (UG Hole 1)	Waste	181.36	Undifferentiated Rhyolite (RH'	45	220	FLT	1	MI/CL	0	
K16-367 (UG Hole 1)	Ore	186.04	Massive Sulfide (OB)	30	305	VN	1	CA	20	
K16-367 (UG Hole 1)	Ore	186.28	Massive Sulfide (OB)	24	300	JN	1	-	20	
K16-367 (UG Hole 1)	Ore	186.68	Massive Sulfide (OB)	25	280	JN	1	SU	12	
K16-367 (UG Hole 1)	Ore	186.74	Massive Sulfide (OB)	16	330	JN	1	CA	16	
K16-367 (UG Hole 1)	Ore	186.85	Massive Sulfide (OB)	23	260	JN	1	SU	12	
K16-367 (UG Hole 1)	Ore	186.94	Massive Sulfide (OB)	12	135	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	187.14	Massive Sulfide (OB)	43	125	JN	1	SU	20	
K16-367 (UG Hole 1)	Ore	187.23	Massive Sulfide (OB)	5	240	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	187.34	Massive Sulfide (OB)	75	0	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	187.44	Massive Sulfide (OB)	4	225	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	187.60	Massive Sulfide (OB)	70	325	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	187.68	Massive Sulfide (OB)	12	235	JN	1	SU	16	
K16-367 (UG Hole 1)	Ore	188.37	Massive Sulfide (OB)	81	35	JF	1	SU	16	
K16-367 (UG Hole 1)	Ore	188.74	Massive Sulfide (OB)	37	300	JN	1	QZ	20	
K16-367 (UG Hole 1)	Waste	188.85	Mafic Sill (MAFI)	42	260	JN	1	CA	12	
K16-367 (UG Hole 1)	Waste	189.66	Mafic Sill (MAFI)	52	10	JN	2	CH/CL	12	
K16-367 (UG Hole 1)	Waste	189.76	Mafic Sill (MAFI)	51	95	JN	2	CH	16	
K16-367 (UG Hole 1)	Waste	190.00	Mafic Sill (MAFI)	70	315	JF	2	CH	12	
K16-367 (UG Hole 1)	Waste	190.72	Mafic Sill (MAFI)	64	295	JF	2	MI/CH	12	
K16-367 (UG Hole 1)	Waste	190.80	Mafic Sill (MAFI)	60	315	JF	2	MI/CH	12	
K16-367 (UG Hole 1)	Waste	190.85	Mafic Sill (MAFI)	70	335	JF	2	CH	6	
K16-367 (UG Hole 1)	Waste	191.47	Mafic Sill (MAFI)	65	300	JF	2	CH	12	
K16-367 (UG Hole 1)	Waste	192.74	Mafic Sill (MAFI)	60	315	JF	2	CA	12	
K16-367 (UG Hole 1)	Waste	192.87	Mafic Sill (MAFI)	56	315	JF	2	CA	16	
K16-367 (UG Hole 1)	Waste	193.27	Mafic Sill (MAFI)	60	275	JF	2	SE	16	
K16-367 (UG Hole 1)	Waste	194.47	Mafic Sill (MAFI)	55	330	JN	2	CL	20	
K16-367 (UG Hole 1)	Waste	194.79	Mafic Sill (MAFI)	77	300	JF	2	CL	16	
K16-367 (UG Hole 1)	Waste	195.74	Mafic Sill (MAFI)	71	220	JN	2	CL/CH	12	
K16-367 (UG Hole 1)	Waste	196.88	Mafic Sill (MAFI)	75	190	JF	2	CL/CH	12	
K16-367 (UG Hole 1)	Waste	197.55	Mafic Sill (MAFI)	79	130	JN	2	CL/CH	16	
K16-367 (UG Hole 1)	Waste	197.66	Mafic Sill (MAFI)	60	245	FLT	2	CL/CH	0	
K16-367 (UG Hole 1)		198.50	Mafic Sill (MAFI)	71	170	JN	2	CL/CH	12	
K16-367 (UG Hole 1)		198.69	Mafic Sill (MAFI)	69	140	JN	2	CL/CH	16	

K16-367 (UG Hole 1)		198.79	Mafic Sill (MAR)	77	70	JF	2	CL/CH	16	
K16-367 (UG Hole 1)		198.74	Mafic Sill (MAR)	67	150	JN	2	CH	12	
K16-367 (UG Hole 1)		198.90	Mafic Sill (MAR)	45	320	JN	2	CH	16	
K16-367 (UG Hole 1)		198.93	Mafic Sill (MAR)	35	335	JN	2	CH	16	
K16-367 (UG Hole 1)		199.79	Mafic Sill (MAR)	76	270	JN	2	CH	12	
K16-367 (UG Hole 1)		199.99	Mafic Sill (MAR)	57	270	JN	2	CL/CH	12	
K16-367 (UG Hole 1)		200.31	Mafic Sill (MAR)	56	90	JN	2	CH/CL	16	
K16-367 (UG Hole 1)		200.84	Mafic Sill (MAR)	56	0	JN	2	CH	16	
K16-367 (UG Hole 1)		202.10	Mafic Sill (MAR)	73	0	JN	2	CH	20	
K16-367 (UG Hole 1)		202.90	Mafic Sill (MAR)	76	310	JF	2	CL/CH	12	
K16-367 (UG Hole 1)		203.70	Mafic Sill (MAR)	63	50	JN	2	CH	20	
K16-367 (UG Hole 1)		203.44	Mafic Sill (MAR)	78	20	JF	2	CH	6	
K16-367 (UG Hole 1)		203.60	Mafic Sill (MAR)	83	110	JN	2	CH	12	
K16-367 (UG Hole 1)		203.81	Mafic Sill (MAR)	78	270	JN	2	CL/CH	12	
K16-367 (UG Hole 1)		203.87	Mafic Sill (MAR)	78	230	JF	2	CH	12	
K16-367 (UG Hole 1)		203.92	Mafic Sill (MAR)	61	280	JN	2	CH	12	
K16-367 (UG Hole 1)		204.53	Mafic Sill (MAR)	77	235	JN	2	CH	12	
K16-367 (UG Hole 1)		204.66	Mafic Sill (MAR)	69	295	JF	2	CH	16	
K16-367 (UG Hole 1)		205.06	Mafic Sill (MAR)	63	275	JF	2	CH	16	
K16-367 (UG Hole 1)		205.35	Mafic Sill (MAR)	57	285	JN	2	CL/CH	12	
K16-367 (UG Hole 1)		205.49	Mafic Sill (MAR)	64	280	JF	2	CL/CH	6	
K16-367 (UG Hole 1)		207.59	Mafic Sill (MAR)	61	315	JF	2	CH	6	
K16-367 (UG Hole 1)		207.72	Stringer Sulfide (OJ)	60	290	JF	2	CH	6	
K16-367 (UG Hole 1)		207.89	Stringer Sulfide (OJ)	56	150	FLT	2	CL	0	
K16-367 (UG Hole 1)		207.93	Coherent Rhyolite (RHYc)	90	0	JN	2	CL	12	
K16-367 (UG Hole 1)		207.99	Coherent Rhyolite (RHYc)	68	340	JF	2	CL/MI	12	
K16-367 (UG Hole 1)		208.04	Coherent Rhyolite (RHYc)	72	320	JF	2	CL/MI	12	
K16-367 (UG Hole 1)		208.12	Coherent Rhyolite (RHYc)	62	330	JN	2	CL/MI	6	
K16-367 (UG Hole 1)		208.20	Coherent Rhyolite (RHYc)	71	310	JF	2	MI	12	
K16-367 (UG Hole 1)		208.37	Coherent Rhyolite (RHYc)	78	335	JN	2	MI	12	
K16-367 (UG Hole 1)		208.42	Coherent Rhyolite (RHYc)	72	320	JN	2	MI	12	
K16-367 (UG Hole 1)		208.79	Coherent Rhyolite (RHYc)	67	290	JF	2	MI	12	
K16-367 (UG Hole 1)		208.91	Coherent Rhyolite (RHYc)	69	300	FLT	2	CL/MI	6	
K16-367 (UG Hole 1)		209.05	Coherent Rhyolite (RHYc)	71	290	JF	2	MI	12	
K16-367 (UG Hole 1)		209.13	Coherent Rhyolite (RHYc)	66	120	JN	2	MI	16	
K16-367 (UG Hole 1)		209.18	Coherent Rhyolite (RHYc)	61	290	JF	2	MI	12	
K16-367 (UG Hole 1)		209.48	Coherent Rhyolite (RHYc)	62	70	JN	2	MI	16	
K16-367 (UG Hole 1)		209.52	Coherent Rhyolite (RHYc)	60	270	JF	2	CL/MI	12	
K16-367 (UG Hole 1)		209.56	Coherent Rhyolite (RHYc)	64	280	JF	2	CL/MI	12	
K16-367 (UG Hole 1)		209.60	Coherent Rhyolite (RHYc)	74	90	JN	2	CL	6	
K16-367 (UG Hole 1)		209.70	Coherent Rhyolite (RHYc)	70	260	JF	2	MI	12	
K16-367 (UG Hole 1)		209.79	Coherent Rhyolite (RHYc)	70	260	JF	2	CL/MI	6	
K16-367 (UG Hole 1)		209.87	Coherent Rhyolite (RHYc)	74	270	JF	2	MI	12	
K16-367 (UG Hole 1)		210.60	Mudstone (MDSI)	56	350	FLT	1		0	
K16-367 (UG Hole 1)		211.15	Volcaniclastic Rhyolite (RHYv	65	190	JN	1	MI	12	
K16-367 (UG Hole 1)		211.18	Volcaniclastic Rhyolite (RHYv	64	190	JN	1	CH/MI	12	
K16-367 (UG Hole 1)		211.22	Volcaniclastic Rhyolite (RHYv	81	190	JF	1	MI/SU	12	
K16-367 (UG Hole 1)		211.38	Volcaniclastic Rhyolite (RHYv	61	50	FLT	1	CH/CL	0	
K16-367 (UG Hole 1)		211.64	Volcaniclastic Rhyolite (RHYv	61	195	JN	1	MI	16	
K16-367 (UG Hole 1)		211.75	Volcaniclastic Rhyolite (RHYv	65	10	JN	1	CH	12	
K16-367 (UG Hole 1)		211.86	Volcaniclastic Rhyolite (RHYv	71	10	FLT	1	MI	12	
K16-367 (UG Hole 1)		212.22	Volcaniclastic Rhyolite (RHYv	76	220	JF	1	MI	12	
K16-367 (UG Hole 1)		212.43	Volcaniclastic Rhyolite (RHYv	70	270	FLT	1	CH/SU	6	
K16-367 (UG Hole 1)		214.57	Volcaniclastic Rhyolite (RHYv	82	60	HFLT	1	CL	25	
K16-367 (UG Hole 1)		215.00	Volcaniclastic Rhyolite (RHYv	70	30	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.02	Volcaniclastic Rhyolite (RHYv	80	180	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.05	Volcaniclastic Rhyolite (RHYv	69	40	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.13	Volcaniclastic Rhyolite (RHYv	70	20	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.15	Volcaniclastic Rhyolite (RHYv	80	120	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.18	Volcaniclastic Rhyolite (RHYv	70	30	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.25	Volcaniclastic Rhyolite (RHYv	90	0	JN	1	CL/MI	12	
K16-367 (UG Hole 1)		215.43	Volcaniclastic Rhyolite (RHYv	77	30	JN	1	CL/MI/CH	6	
K16-367 (UG Hole 1)		215.60	Volcaniclastic Rhyolite (RHYv	27	220	JN	1	CL	12	
K16-367 (UG Hole 1)		217.38	Volcaniclastic Rhyolite (RHYv	70	65	FLT	1	CL/CH	0	
K16-367 (UG Hole 1)		217.45	Volcaniclastic Rhyolite (RHYv	43	60	HJN	1	CL	25	
K16-367 (UG Hole 1)		216.28	Volcaniclastic Rhyolite (RHYv	60	140	JN	1	CL	12	
K16-367 (UG Hole 1)		216.40	Volcaniclastic Rhyolite (RHYv	65	330	FLT	1	CL/CH	6	
K16-367 (UG Hole 1)		217.60	Volcaniclastic Rhyolite (RHYv	80	290	FLT	1	CL/CH	6	
K16-367 (UG Hole 1)		218.06	Volcaniclastic Rhyolite (RHYv	54	80	JN	1	CL/CH	12	
K16-367 (UG Hole 1)		218.34	Volcaniclastic Rhyolite (RHYv	77	70	JF	1	CL/CH	6	
K16-367 (UG Hole 1)		218.43	Volcaniclastic Rhyolite (RHYv	81	90	JF	1	CL/CH	6	
K16-367 (UG Hole 1)		218.67	Volcaniclastic Rhyolite (RHYv	73	90	JF	1	CH	12	
K16-367 (UG Hole 1)		218.84	Volcaniclastic Rhyolite (RHYv	85	90	JF	1	CL/CH	6	
K16-367 (UG Hole 1)		219.05	Volcaniclastic Rhyolite (RHYv	70	100	JF	1	MI/CH	12	
K16-367 (UG Hole 1)		230.22	Volcaniclastic Rhyolite (RHYv	85	215	JN	1	CL	0	
K16-367 (UG Hole 1)		230.55	Volcaniclastic Rhyolite (RHYv	75	285	JN	1	MI/CL	12	
K16-367 (UG Hole 1)		230.62	Volcaniclastic Rhyolite (RHYv	72	110	FLT	1	MI/CL	0	
K16-367 (UG Hole 1)		230.73	Volcaniclastic Rhyolite (RHYv	55	330	JN	1	CA	16	
K16-367 (UG Hole 1)		230.93	Volcaniclastic Rhyolite (RHYv	53	330	JN	1	CH	16	
K16-367 (UG Hole 1)		233.96	Volcaniclastic Rhyolite (RHYv	75	320	JF	1	CL	12	
K16-367 (UG Hole 1)		236.89	Volcaniclastic Rhyolite (RHYv	74	0	JF	1	CL	6	
K16-367 (UG Hole 1)		236.93	Volcaniclastic Rhyolite (RHYv	82	330	JF	1	CL	0	
K16-367 (UG Hole 1)		248.03	Volcaniclastic Rhyolite (RHYv	65	335	JN	1	CL	16	
K16-367 (UG Hole 1)		248.37	Volcaniclastic Rhyolite (RHYv	88	195	JF	1	MI	12	
K16-367 (UG Hole 1)		248.73	Volcaniclastic Rhyolite (RHYv	56	80	JN	1	CA	20	
K16-367 (UG Hole 1)		256.60	Volcaniclastic Rhyolite (RHYv	65	130	JN	1	CL	6	
K16-367 (UG Hole 1)		256.88	Volcaniclastic Rhyolite (RHYv	56	305	JN	1	CA	20	
K16-367 (UG Hole 1)		257.03	Volcaniclastic Rhyolite (RHYv	82	175	VN	1	CH/CL	0	
K16-367 (UG Hole 1)		257.06	Volcaniclastic Rhyolite (RHYv	63	135	JF	1	CH/CL	6	
K16-367 (UG Hole 1)		257.71	Volcaniclastic Rhyolite (RHYv	70	355	JN	1	MI	16	
K16-367 (UG Hole 1)		257.91	Volcaniclastic Rhyolite (RHYv	87	140	JF	1	CL/MI	16	
K16-367 (UG Hole 1)		270.88	Volcaniclastic Rhyolite (RHYv	78	70	JF	2	CL/MI	12	
K16-367 (UG Hole 1)		270.92	Volcaniclastic Rhyolite (RHYv	49	195	JF	2	CL	25	
K16-367 (UG Hole 1)		270.93	Volcaniclastic Rhyolite (RHYv	75	60	HJN	2	CL/MI	12	
K16-367 (UG Hole 1)		271.02	Volcaniclastic Rhyolite (RHYv	54	190	JN	2	CL	16	
K16-367 (UG Hole 1)		271.28	Volcaniclastic Rhyolite (RHYv	75	220	JN	2	CL	6	
K16-367 (UG Hole 1)		271.39	Volcaniclastic Rhyolite (RHYv	79	90	JF	2	CH	12	
K16-367 (UG Hole 1)		271.63	Volcaniclastic Rhyolite (RHYv	42	270	JN	2	CL	12	
K16-367 (UG Hole 1)		271.71	Volcaniclastic Rhyolite (RHYv	71	200	JF	2	CL	6	
K16-367 (UG Hole 1)		271.87	Volcaniclastic Rhyolite (RHYv	79	70	JN	2	MI/CH	12	
K16-367 (UG Hole 1)		271.89	Volcaniclastic Rhyolite (RHYv	66	200	FLT	2	CL/CH	6	
K16-367 (UG Hole 1)		272.22	Volcaniclastic Rhyolite (RHYv	64	175	JF	2	MI/CL	6	
K16-367 (UG Hole 1)		272.25	Volcaniclastic Rhyolite (RHYv	72	115	JN	2	MI/CL	6	
K16-367 (UG Hole 1)		272.30	Volcaniclastic Rhyolite (RHYv	64	175	JF	2	MI/CL	12	
K16-367 (UG Hole 1)		272.48	Volcaniclastic Rhyolite (RHYv	72	95	JN	2	CH/CL	12	
K16-367 (UG Hole 1)		272.80	Volcaniclastic Rhyolite (RHYv	74	160	JF	2	CH/CL	12	
K16-367 (UG Hole 1)		281.95	Fault Zone (FLZ)	55	290	FLT	1	-	25	

POINT LOAD TEST RESULTS

Equipment: PIL-7 **Load Correction Factor =** 0.0948

Hole ID	Test No.	Depth of Top of Sample (m)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For axial test $D_e^2 = 4(WD)/pi$; For diam. test $D_e^2 = D^2$ (mm)	Is (kN/mm²)= P/D_e^2	$F=(D_e/50)^{0.45}$	$Is_{(50)} = F \times I_s$ (MPa)	UCS Sample Match
K16-367 (UG Hole 1)		10.5	Aphanitic Rhyolite (RHYi)	8.92	II	D	Valid Test	168	61.1	168.00	89.2	8.46	3733.21	0.002265118	1.0944	2.48	
K16-367 (UG Hole 1)		10.5	Aphanitic Rhyolite (RHYi)	19.72	-	a	Valid Test	42	61.1	42.00	197.2	18.69					
K16-367 (UG Hole 1)		12.33	Aphanitic Rhyolite (RHYi)	11.54	II	D	Valid Test	186	61.1	186.00	115.4	10.94	3733.21	0.002930433	1.0944	3.21	
K16-367 (UG Hole 1)		12.33	Aphanitic Rhyolite (RHYi)	35.18	L	A	Valid Test	46	61.1	46.00	351.8	33.35	3578.57	0.009319551			
K16-367 (UG Hole 1)		16	Aphanitic Rhyolite (RHYi)	5.86	II	D	Valid Test	146	61.1	146.00	58.6	5.56	3733.21	0.001488071	1.0944	1.63	
K16-367 (UG Hole 1)		16	Aphanitic Rhyolite (RHYi)	16.96	L	A	Valid Test	41	61.1	41.00	169.6	16.08	3189.59	0.005040795			
K16-367 (UG Hole 1)		16.32	Volcaniclastic Rhyolite (RHYv	7.76	II	D	Valid Test	179	61.1	179.00	77.6	7.36	3733.21	0.001970551	1.0944	2.16	
K16-367 (UG Hole 1)		16.32	Volcaniclastic Rhyolite (RHYv	21.76	L	A	Valid Test	44	61.1	44.00	217.6	20.63	3422.98	0.006026473			
K16-367 (UG Hole 1)		20.64	Aphanitic Rhyolite (RHYi)	11.14	II	D	Valid Test	177	61.1	177.00	111.4	10.56	3733.21	0.002828858	1.0944	3.10	
K16-367 (UG Hole 1)		20.64	Aphanitic Rhyolite (RHYi)	43.26	L	A	Valid Test	45	61.1	45.00	432.6	41.01	3500.77	0.011714696			
K16-367 (UG Hole 1)		23.55	Aphanitic Rhyolite (RHYi)	14.02	II	D	Valid Test	170	61.1	170.00	140.2	13.29	3733.21	0.003560196	1.0944	3.90	
K16-367 (UG Hole 1)		23.55	Aphanitic Rhyolite (RHYi)	32.8	L	A	Valid Test	38	61.1	38.00	328	31.09	2956.21	0.010518341			
K16-367 (UG Hole 1)		27.3	Aphanitic Rhyolite (RHYi)	4.66	II	D	Valid Test	149	61.1	149.00	46.6	4.42	3733.21	0.001183346	1.0944	1.30	
K16-367 (UG Hole 1)		27.3	Aphanitic Rhyolite (RHYi)	21.68	-	A	Failed Test	51	61.1	51.00	216.8	20.55	3967.54	0.005180195			
K16-367 (UG Hole 1)		29.3	Mafic Sill (MAFi)	11.4	II	D	Valid Test - Failure along fabric	170	61.1	170.00	114	10.81	3733.21	0.002894881	1.0944	3.17	
K16-367 (UG Hole 1)		29.3	Mafic Sill (MAFi)	33.5	L	a	Valid Test	41	61.1	41.00	335	31.76	3189.59	0.009956758			
K16-367 (UG Hole 1)		30.85	Aphanitic Rhyolite (RHYi)	12.28	L	A	Valid Test	30	61.1	30.00	122.8	11.64	2333.85	0.004988088	1.0944	5.46	
K16-367 (UG Hole 1)		31.34	Aphanitic Rhyolite (RHYi)	4.64	II	D	Valid Test - Failure along fabric	146	61.1	146.00	46.4	4.40	3733.21	0.001178267	1.0944	1.29	
K16-367 (UG Hole 1)		32.1	Aphanitic Rhyolite (RHYi)	24.28	L	A	Valid Test	40	61.1	40.00	242.8	23.02	3111.80	0.007396831	1.0944	8.10	
K16-367 (UG Hole 1)		37.27	Aphanitic Rhyolite (RHYi)	24.92	-	D	Valid Test	193	61.1	193.00	249.2	23.62	3733.21	0.006328109	1.0944	6.93	
K16-367 (UG Hole 1)		37.81	Aphanitic Rhyolite (RHYi)	25.48	L	A	Valid Test	41	61.1	41.00	254.8	24.16	3189.59	0.007573081	1.0944	8.29	
K16-367 (UG Hole 1)		39.48	Aphanitic Rhyolite (RHYi)	10.98	II	D	Valid Test - Failure along fabric	131	61.1	131.00	109.8	10.41	3733.21	0.002788228	1.0944	3.05	
K16-367 (UG Hole 1)		39.48	Aphanitic Rhyolite (RHYi)	12.28	L	A	Valid Test - Failure along joint or	57	61.1	57.00	122.8	11.64	4434.31	0.00262531	1.0944	2.87	
K16-367 (UG Hole 1)		41.15	Aphanitic Rhyolite (RHYi)	34.70	L	A	Valid Test	42	61.1	42.00	347	32.90	3267.39	0.010067861	1.0944	11.02	
K16-367 (UG Hole 1)		42	Aphanitic Rhyolite (RHYi)	13.86	-	D	Valid Test	166	61.1	166.00	138.6	13.14	3733.21	0.003519566	1.0944	3.85	
K16-367 (UG Hole 1)		44.52	Aphanitic Rhyolite (RHYi)	12.88	-	D	Valid Test - Failure along joint or	134	61.1	134.00	128.8	12.21	3733.21	0.003270708	1.0944	3.58	
K16-367 (UG Hole 1)		45.82	Aphanitic Rhyolite (RHYi)	17.18	II	D	Valid Test	215	61.1	215.00	171.8	16.29	3733.21	0.004362637	1.0944	4.77	
K16-367 (UG Hole 1)		45.52	Aphanitic Rhyolite (RHYi)	31.96	-	A	Valid Test	40	61.1	40.00	319.6	30.30	3111.80	0.009736521	1.0944	10.66	
K16-367 (UG Hole 1)		48	Aphanitic Rhyolite (RHYi)	2.38	II	D	Valid Test - Failure along fabric	124	61.1	124.00	23.8	2.26	3733.21	0.00060437	1.0944	0.66	
K16-367 (UG Hole 1)		48	Aphanitic Rhyolite (RHYi)	10.78	L	A	Valid Test	36	61.1	36.00	107.8	10.22	2800.62	0.003648995	1.0944	3.99	
K16-367 (UG Hole 1)		49.6	Coherent Rhyolite (RHYc)	5.46	-	A	Valid Test	46	61.1	46.00	54.6	5.18	3578.57	0.001446411	1.0944	1.58	
K16-367 (UG Hole 1)		50.22	Coherent Rhyolite (RHYc)	8.74	II	D	Valid Test - Failure along fabric	167	61.1	167.00	87.4	8.29	3733.21	0.002219409	1.0944	2.43	
K16-367 (UG Hole 1)		50.22	Coherent Rhyolite (RHYc)	21.86	L	A	Valid Test	32	61.1	32.00	218.6	20.72	2489.44	0.008324481	1.0944	9.11	
K16-367 (UG Hole 1)		53.73	Volcaniclastic Rhyolite (RHYv	15.84	L	A	Valid Test	29	61.1	29.00	158.4	15.02	2256.05	0.006656013	1.0944	7.28	
K16-367 (UG Hole 1)		54.97	Volcaniclastic Rhyolite (RHYv	9.64	II	D	Valid Test - Failure along fabric	189	61.1	189.00	96.4	9.14	3733.21	0.002447952	1.0944	2.68	
K16-367 (UG Hole 1)		54.97	Volcaniclastic Rhyolite (RHYv	25.82	L	A	Valid Test	45	61.1	45.00	258.2	24.48	3500.77	0.006991989	1.0944	7.65	
K16-367 (UG Hole 1)		59.35	Volcaniclastic Rhyolite (RHYv	13.26	-	D	Valid Test	130	61.1	130.00	132.6	12.57	3733.21	0.003367204	1.0944	3.69	
K16-367 (UG Hole 1)		59.35	Volcaniclastic Rhyolite (RHYv	23.40	-	A	Failed Test	50	61.1	50.00	234	22.18	3889.75	0.005702993	1.0944	6.24	
K16-367 (UG Hole 1)		62.2	Volcaniclastic Rhyolite (RHYv	7.02	II	D	Valid Test - Failure along fabric	151	61.1	151.00	70.2	6.65	3733.21	0.001782637	1.0944	1.95	
K16-367 (UG Hole 1)		62.2	Volcaniclastic Rhyolite (RHYv	16.06	L	A	Valid Test	35	61.1	35.00	160.6	15.22	2722.82	0.00559158	1.0944	6.12	
K16-367 (UG Hole 1)		65.4	Volcaniclastic Rhyolite (RHYv	8.50	II	D	Valid Test - Failure along fabric	164	61.1	164.00	85	8.06	3733.21	0.002158464	1.0944	2.36	
K16-367 (UG Hole 1)		65.4	Volcaniclastic Rhyolite (RHYv	21.88	L	A	Valid Test	36	61.1	36.00	218.8	20.74	2800.62	0.007406309	1.0944	8.11	
K16-367 (UG Hole 1)		68.9	Volcaniclastic Rhyolite (RHYv	15.02	-	D	Valid Test	134	61.1	134.00	150.2	14.24	3733.21	0.003814133	1.0944	4.17	
K16-367 (UG Hole 1)		68.9	Volcaniclastic Rhyolite (RHYv	25.44	-	A	Failed Test	36	61.1	36.00	254.4	24.12	2800.62	0.008611357	1.0944	9.42	
K16-367 (UG Hole 1)		72.65	Volcaniclastic Rhyolite (RHYv	4.68	II	D	Valid Test - Failure along fabric	95	61.1	95.00	46.8	4.44	3733.21	0.001188425	1.0944	1.30	
K16-367 (UG Hole 1)		72.65	Volcaniclastic Rhyolite (RHYv	15.94	L	A	Valid Test	45	61.1	45.00	159.4	15.11	3500.77	0.004316511	1.0944	4.72	
K16-367 (UG Hole 1)		75.85	Volcaniclastic Rhyolite (RHYv	3.56	II	D	Valid Test - Failure along fabric	126	61.1	126.00	35.6	3.37	3733.21	0.000904016	1.0944	0.99	
K16-367 (UG Hole 1)		75.85	Volcaniclastic Rhyolite (RHYv	11.90	L	A	Valid Test	51	61.1	51.00	119	11.28	3967.54	0.002843373	1.0944	3.11	
K16-367 (UG Hole 1)		77.65	Volcaniclastic Rhyolite (RHYv	4.80	II	D	Valid Test - Failure along fabric	190	61.1	190.00	48	4.55	3733.21	0.001218897	1.0944	1.33	
K16-367 (UG Hole 1)		77.65	Volcaniclastic Rhyolite (RHYv	18.58	L	A	Valid Test	46	61.1	46.00	185.8	17.61	3578.57	0.004922037	1.0944	5.39	
K16-367 (UG Hole 1)		80.15	Volcaniclastic Rhyolite (RHYv	4.54	II	D	Valid Test - Failure along fabric	127	61.1	127.00	45.4	4.30	3733.21	0.001152874	1.0944	1.26	
K16-367 (UG Hole 1)		80.15	Volcaniclastic Rhyolite (RHYv	12.36	L	A	Valid Test - Failure along joint or	51	61.1	51.00	123.6	11.72	3967.54	0.002953285	1.0944	3.23	
K16-367 (UG Hole 1)		83.15	Volcaniclastic Rhyolite (RHYv	6.26	-	D	Valid Test	118	61.1	118.00	62.6	5.93	3733.21	0.001589645	1.0944	1.74	
K16-367 (UG Hole 1)		83.15	Volcaniclastic Rhyolite (RHYv	18.24	-	A	Valid Test	35	61.1	35.00	182.4	17.29	2722.82	0.006350586	1.0944	6.95	
K16-367 (UG Hole 1)		85.2	Sediment (SED)	4.50	ii	D	Valid Test - Failure along fabric	166	61.1	166.00	45	4.27	3733.21	0.001142716	1.0944	1.25	
K16-367 (UG Hole 1)		85.2	Sediment (SED)	17.64	L	A	Valid Test	30	61.1	30.00	176.4	16.72	2333.85	0.007165299	1.0944	7.84	
K16-367 (UG Hole 1)		87.95	Volcaniclastic Rhyolite (RHYv	1.02	ii	D	Valid Test - Failure along fabric	86	61.1	86.00	10.2	0.97	3733.21	0.000259016	1.0944	0.28	
K16-367 (UG Hole 1)		87.95	Volcaniclastic Rhyolite (RHYv	11.88	L	A	Valid Test	45	61.1	45.00	118.8	11.26	3500.77	0.003217073	1.0944	3.52	
K16-367 (UG Hole 1)		91.15	Volcaniclastic Rhyolite (RHYv	4.12	II	D	Valid Test - Failure along fabric	136	61.1	136.00	41.2	3.91	3733.21	0.00104622	1.0944	1.14	
K16-367 (UG Hole 1)		91.15	Volcaniclastic Rhyolite (RHYv	8.98	L	A	Valid Test	20	61.1	20.00	89.8	8.51	1555.90	0.005471462	1.0944	5.99	
K16-367 (UG Hole 1)		94.25	Volcaniclastic Rhyolite (RHYv	1.48	II	D	Valid Test - Failure along fabric	123	61.1	123.00	14.8	1.40	3733.21	0.000375827	1.0944	0.41	
K16-367 (UG Hole 1)		94.25	Volcaniclastic Rhyolite (RHYv	6.60	L	A	Valid Test	47	61.1	47.00	66	6.26	3656.36	0.001711209	1.0944	1.87	
K16-367 (UG Hole 1)		96.9	Volcaniclastic Rhyolite (RHYv	1.72	II	D	Valid Test - Failure along fabric	112	61.1	112.00	17.2	1.63	3733.21	0.000436772	1.0944	0.48	
K16-367 (UG Hole 1)		96.9	Volcaniclastic Rhyolite (RHYv	10.78	L	A	Valid Test	45	61.1	45.00	107.8	10.22	3500.77	0.002919196	1.0944	3.19	
K16-367 (UG Hole 1)		99.3	Volcaniclastic Rhyolite (RHYv	1.52	II	D	Valid Test - Failure along fabric	98	61.1	98.00	15.2	1.44	3733.21	0.000385984	1.0944	0.42	
K16-367 (UG Hole 1)		99.3	Volcaniclastic Rhyolite (RHYv	9.04	L	A	Valid Test	48	61.1	48.00	90.4	8.57	3734.16	0.002295008	1.0944	2.51	
K16-367 (UG Hole 1)		101	Volcaniclastic Rhyolite (RHYv	1.50	II	D	Valid Test - Failure along fabric	132	61.1	132.00	15	1.42	3733.21	0.000380905	1.0944	0.42	
K16-367 (UG Hole 1)		101	Volcaniclastic Rhyolite (RHYv	11.90	L	A	Valid Test	47	61.1	47.00	119	11.28	3656.36	0.003085362	1.0944	3.38	
K16-367 (UG Hole 1)		104.05	Volcaniclastic Rhyolite (RHYv	3.40	II	D	Valid Test - Failure along fabric	93	61.1	93.00	34	3.22	3733.21	0.000863386	1.0944	0.94	
K16-367 (UG Hole 1)		104.07	Volcaniclastic Rhyolite (RHYv	13.44	L	A	Valid Test	41	61.1	41.00	134.4	12.74	3189.59	0.003994592	1.0944	4.37	
K16-367 (UG Hole 1)		107.05	Volcaniclastic Rhyolite (RHYv	4.42	II	D	Valid Test - Failure along fabric	105	61.1	105.00	44.2	4.19	3733.21	0.001122401	1.0944	1.23	
K16-367 (UG Hole 1)		107.08	Volcaniclastic Rhyolite (RHYv	10.36	L	A	Valid Test	46	61.1	46.00	103.6	9.82	3578.57	0.002744473	1.0944	3.00	
K16-367 (UG Hole 1)		110.1	Stringer Sulfide (OJ)	8.36	-	D	Valid Test	130	61.1	130.00	83.6	7.93	3733.21	0.002122913	1.0944	2.32	
K16-367 (UG Hole 1)		110.07	Stringer Sulfide (OJ)	17.74	-	A	Valid Test	57	61.1	57.00	177.4	16.82	4434.31	0.003792589	1.0944	4.15	
K16-367 (UG Hole 1)		112.61	Coherent Rhyolite (RHYc)	1.32	II	D	Valid Test - Failure along fabric	71	61.1	71.00	13.2	1.25	3733.21	0.000335197	1.0944	0.37	
K16-367 (UG Hole 1)		112.63	Coherent Rhyolite (RHYc)	5.22	L	A	Valid Test	36	61.1	36.00	52.2	4.95	2800.62	0.001766953	1.0944	1.93	
K16-367 (UG Hole 1)		114.2	Coherent Rhyolite (RHYc)	1.42	L	A	Valid Test	42	61.1	42.00	14.2	1.35	3267.39	0.000411999	1.0944	0.45	
K16-367 (UG Hole 1)		117.85	Coherent Rhyolite (RHYc)	5.02	L	A	Valid Test	43	61.1	43.00	50.2	4.76	3345.18	0.001422631	1.0944	1.56	
K16-367 (UG Hole 1)		120.45	Mafic Sill (MAFi)	0.94	-	D	Valid Test	110	61.1	110.00	9.4	0.89	3733.21	0.000238701	1.0944	0.26	
K16-367 (UG Hole 1)		120.48	Mafic Sill (MAFi)	0.60	-	A	Valid Test - Failure along joint or	55	61.1	55.00	6	0.57	4278.72	0.000132937	1.0944	0.15	
K16-367 (UG Hole 1)		121.86	Mafic Sill (MAFi)	1.20	L	A	Valid Test	39	61.1	39.00	12	1.14	3034.00	0.00037495	1.0944	0.41	
K16-367 (UG Hole 1)		123.3	Mafic Sill (MAFi)	4.92	II	D	Valid Test - Failure along fabric	130	61.1	130.00	49.2	4.66	3733.21	0.00124937	1.0944	1.37	
K16-367 (UG Hole 1)		123.3	Mafic Sill (MAFi)	8.72	L	A	Valid Test	32	61.1	32.00	87.2	8.27	2489.44	0.003320653	1.0944	3.63	
K16-367 (UG Hole 1)		127.06	Mafic Sill (MAFi)	7.16	II	D	Valid Test	125	61.1	125.00	71.6	6.79	3733.21	0.001818189	1.0944	1.99	
K16-367 (UG Hole 1)		127.06	Mafic Sill (MAFi)	11.40	L	A	Valid Test	35.5	61.1	35.50	114	10.81	2761.72	0.003913213	1.0944	4.28	
K16-367 (UG Hole 1)		129.9	Mafic Sill (MAFi)	7.34	II	D	Valid Test	180	61.1	180.00	73.4	6.96	3733.21	0.001863897	1.0944	2.04	
K16-367 (UG Hole 1)		129.9	Mafic Sill (MAFi)	15.70	L	A	Valid Test	44.5	61.1	44.50	157	14.88	3461.87	0.004299289	1.0944	4.71	
K16-367 (UG Hole 1)		131.71	Mafic Sill (MAFi)	9.48	II	D	Valid Test	210	61.1	210.00	94.8	8.99	3733.21	0.002407322	1.0944	2.63	
K16-367 (UG Hole 1)		131.71	Mafic Sill (MAFi)	19.46	L	A	Valid Test	44	61.1	44.00	194.6	18.45	3422.98	0.005389484	1.0944	5.90	
K16-367 (UG Hole 1)		137.90	Mafic Sill (MAFi)	4.90	-	D	Valid Test	118.00	61.10	118.00	49	4.65	3733.21	0.001244291	1.0944	1.36	
K16-367 (UG Hole 1)		137.93	Mafic Sill (MAFi)	4.10	-	A	Valid Test	51.00	61.10	51.00	41	3.89	3967.54	0.000979649	1.0944	1.07	
K16-367 (UG Hole 1)		139.56	Mafic Sill (MAFi)	21.12	II	D	Valid Test	168.00	61.10	168.00	211.2	20.02	3733.21	0.005363149	1.0944	5.87	
K16-367 (UG Hole 1)		139.63	Mafic Sill (MAFi)	25.26	L	A	Valid Test	31.00	61.10	31.00	252.6	23.95	2411.64	0.009929529	1.0944	10.87	
K16-367 (UG Hole 1)		141.72	Mafic Sill (MAFi)	4.08	II	D	Valid Test	91.00	61.10	91.00	40.8	3.87	3733.21	0.001036063	1.0944	1.13	
K16-367 (UG Hole 1)		141.72	Mafic Sill (MAFi)	19.58	L	A	Valid Test	30.00	61.10	30.00	195.8	18.56	2333.85	0.00795332	1.0944	8.70	
K16-367 (UG Hole 1)		143.50	Mafic Sill (MAFi)	1.70	L	A	Valid Test	41.00	61.10	41.00	17	1.61	3189.59	0.000505268	1.0944	0.55	
K16-367 (UG Hole 1)		145.3	Mafic Sill (MAFi)	2.46	II	D	Valid Test	129.00	61.10	129.00	24.6	2.33	3733.21	0.000624685	1.0944	0.68	
K16-367 (UG Hole 1)		145.33	Mafic Sill (MAFi)	2.92	L	A	Valid Test	33	61.1	33.00	29.2	2.77	2567.23	0.001078266	1.0944	1.18	
K16-367 (UG Hole 1)		146.95	Mafic Sill (MAFi)	2.50	II	D	Valid Test	146	61.1	146.00	25	2.37	3733.21	0.000634842	1.0944	0.69	
K16-367 (UG Hole 1)		146.98	Mafic Sill (MAFi)	10.72	L	A	Valid Test	21	61.1	21.00	107.2	10.16	1633.69	0.006220603	1.0944	6.81	
K16-367 (UG Hole 1)		148	Stringer Sulfide (OJ)	12.64	-	D	Valid Test	99	61.1	99.00	126.4	11.98	3733.21	0.003209763	1.0944	3.51	
K16-367 (UG Hole 1)		147.96	Stringer Sulfide (OJ)	18.42	-	A	Valid Test	55	61.1	55.00	184.2	17.46	4278.72	0.004081163	1.0944	4.47	
K16-367 (UG Hole 1)		149.28	Mafic Sill (MAFi)	1.20	II	D	Valid Test	96	61.1	96.00	12	1.14	3733.21	0.000304724	1.0944	0.33	
K16-367 (UG Hole 1)		149.28	Mafic Sill (MAFi)	7.58	L	A	Valid Test	45	61.1	45.00	75.8	7.19	3500.77	0.002052644	1.0944	2.25	
K16-367 (UG Hole 1)		151.82	Mafic Sill (MAFi)	5.78	II	D	Valid Test	170	61.1	170.00	57.8	5.48	3733.21	0.001467756	1.0944	1.61	
K16-367 (UG Hole 1)		151.82	Mafic Sill (MAFi)	9.30	L	A	Valid Test	47	61.1	47.00	93	8.82	3656.36	0.002411249	1.0944	2.64	
K16-367 (UG Hole 1)		154.2	Mafic Sill (MAFi)	0.98	II	D	Valid Test	87	61.1	87.00	9.8	0.93	3733.21	0.000248858	1.0944	0.27	
K16-367 (UG Hole 1)		154.22	Mafic Sill (MAFi)	9.36	L	A	Valid Test	32	61.1	32.00	93.6	8.87	2489.44	0.003564371	1.0944	3.90	

Drill Hole Information

Hole ID	Location	Zone HW/Ore/FW	Planned ID	Planned							Date	
				X	Y	Z	Length (m)	Dip (°)	Diameter	AZ (°)	Start	End
K16-370	Krakatoa Underground	Ore/Waste	KRAK009 (UG Hole 2)	415074.6	6815182.8	1388.0	280.5	-80	HQ3	215	18-Jun-16	20-Jun-16

Data Collection Program

Discipline	Personnel	Checked by	Date
Geology	DH		
Geotechnical	IH	JRM	
PLT	IH/JRM	JRM	Jun 28 - July 7

Geology Quick Log

Hole ID	From (m)	To (m)	Lithology and Lithology Code
K16-370 (UG Hole 2)	0	6.8	OVBN
K16-370 (UG Hole 2)	6.8	16.6	Aphanitic Rhyolite (RHYi)
K16-370 (UG Hole 2)	16.6	18.9	Pelite (PEL)
K16-370 (UG Hole 2)	18.9	30.2	Aphanitic Rhyolite (RHYi)
K16-370 (UG Hole 2)	30.2	30.75	Pelite (PEL)
K16-370 (UG Hole 2)	30.75	53.1	Aphanitic Rhyolite (RHYi)
K16-370 (UG Hole 2)	53.1	55.5	Coherent Rhyolite (RHYc)
K16-370 (UG Hole 2)	55.5	57.6	Pelite (PEL)
K16-370 (UG Hole 2)	57.6	70.3	Volcaniclastic Rhyolite (RHYv)
K16-370 (UG Hole 2)	70.3	71.5	Pelite (PEL)
K16-370 (UG Hole 2)	71.5	124.3	Volcaniclastic Rhyolite (RHYv)
K16-370 (UG Hole 2)	124.3	130	Coherent Rhyolite (RHYc)
K16-370 (UG Hole 2)	130	139.1	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	139.1	140.6	Stringer Sulfide (OJ)
K16-370 (UG Hole 2)	140.6	141.7	Undifferentiated Rhyolite (RHY)
K16-370 (UG Hole 2)	141.7	142.3	Disseminated Sulfide (OI)
K16-370 (UG Hole 2)	142.3	145.7	Undifferentiated Rhyolite (RHY)
K16-370 (UG Hole 2)	145.7	146.9	Massive Sulfide (OA)
K16-370 (UG Hole 2)	146.9	148.4	Undifferentiated Rhyolite (RHY)
K16-370 (UG Hole 2)	148.4	150.7	Massive Sulfide (OB)
K16-370 (UG Hole 2)	150.7	174.6	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	174.6	175.1	Stringer Sulfide (OJ)
K16-370 (UG Hole 2)	175.1	180.8	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	180.8	181.7	Massive Sulfide (OF)
K16-370 (UG Hole 2)	181.7	198.1	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	198.1	199.4	Massive Sulfide (OB)
K16-370 (UG Hole 2)	199.4	200.1	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	200.1	200.45	Massive Sulfide (OB)
K16-370 (UG Hole 2)	200.45	224.2	Mafic Sill (MAFi)
K16-370 (UG Hole 2)	224.2	224.6	Massive Sulfide (OB)
K16-370 (UG Hole 2)	224.6	232.4	Coherent Rhyolite (RHYc)
K16-370 (UG Hole 2)	232.4	280.5	Volcaniclastic Rhyolite (RHYv)

Geotechnical Log

Hole ID	Lithology	From(m)	To(m)	Run(m)	TCR(m)	TCR(%)	FF/run	RQD(m)	RQD(%)	Difference in data between runs	Weathering/Alteration	Strength	Joint Set Number (Jn)	ALPHA=0-29 Count	TYPE	Jr	Ja	ALPHA=30-59 Count	TYPE	Jr	Ja	ALPHA=60-90 Count	TYPE	Jr	Ja	% Fault Gouge	% Fault Breccia	% Broken zone	% Rubble zone	% Microdefects	Comment
K16-370 (UG Hole 2)	Overburden (OVBN)	0.0	6.8																												
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	6.8	9.7	2.85				0.00	0%	-	W3	R3	15																		Core stones
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	9.7	10.5	0.85	0.85	100%	10	0.64	75%	-	W3	R3	3					3	JN	3	1	3	JN	3	1				13%		Weather joint surfaces top of OVBN=9.65
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	10.5	12.0	1.50	1.50	100%	10	1.34	89%	-	W3	R3	3	2	JN	3	1					5	JN	3	1				6%		Weather joint surfaces unable to ori beginning of run since no ori line marked had to use ori from the 12-13.5 run to carry over ori
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	12.0	13.5	1.50	1.50	100%	9	1.24	83%	New	W2	R4	3	1	JN	3	1					8	JN	3	1						Similar ori condition as prev run
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	13.5	15.0	1.50	1.40	93%	15	0.81	54%	-	W2	R3	6	1	JN	3	1					6	JN	3	1				14%		Had to use prev run ori line since RZ at end of run unable to use ori
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	15.0	16.6	1.60	1.60	100%	5	1.60	100%	New	W2	R3	3	1	JN	3	1					4	JN	3	1						Far spacing of discont. New ori but lost at initial of run and could not match with prev since last run broken
K16-370 (UG Hole 2)	Pelite (PEL)	16.6	18.9	2.30	2.10	91%	16	1.48	64%	-	W2/W3	R3	6									13	JN/FLT	1-3	1-6						lost ori at 16.6-17.72 and had to carry ori form the next run - new lith change/minor FLT at 17.7-17.75
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	18.9	21.0	2.10	2.10	100%	8	1.87	89%	New	W2	R3	3									8	JN	3	1						Many of the breaks are right thru the core axis which isn't considered as FF or joints since completely parallel to CA
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	21.0	22.5	1.50	1.50	100%	18	1.20	80%	-	W2	R3	3									10	JN	3	1				10%	20%	Ori from 21 to 21.42 had to carry from prev run due to RZ area and gain as mentioned before a lot of breaks thru CA not considered as fractures
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	22.5	24.0	1.50	1.50	100%	9	0.80	53%	-	W2	R3	3	1	JN	3	1					5	JN	3	1				3%		No ori line broken on both ends and do not match
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	24.0	25.5	1.50	1.50	100%	18	0.96	64%	New	W2	R3	6									14	JN/FLT	1-3	1-6	3%				10%	close spacing of fractures this run
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	25.5	27.0	1.50	1.42	95%	21	0.97	65%	-	W2	R3	6					3	JN	3	1	6	JN	3	1-2				25%	10%	No ori line due to RZ
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	27.0	29.2	2.21	2.21	100%	19	1.75	79%	New	W2	R3	6									13	JN	3	1-2				10%		RZ at 28.3-28.35 ori line broke off after RZ also no ori marked for this run from driller so had to use prev run ori to carry over... New eng domain coming
K16-370 (UG Hole 2)	Pelite (PEL)	29.2	30.8	1.54	1.07	69%	63	0.00	0%	-	W3	R2	12									12	JN	1-2	3-4				17%	90%	Weak ENG domain PEL lith with initial of RHYi domain but highly microdefected hence FF max with multiple RZ within run with weaker strength able to ori 30.45 to 30.75 only
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	30.8	33.0	2.25	2.25	100%	18	1.47	65%	New	W2	R3	6									16	JN/HJN/FLT	1-3	1-4					15%	Minor FLT at 31.1 back into RHYi ori line used from the next run carried over since no ori marked by driller for this run
K16-370 (UG Hole 2)	Aphanitic Rhyolite (RHYi)	33.0	34.5	1.50	1.50	100%	6	1.31	87%	New	W2	R3	3					1	JN	3	1	5	JN	3	1					10%	Had to use prev run ori to carry over

Detailed Log

Hole ID	Depth (m)	Lithology	Oriented Core Log					RMR76	Comment
			Alpha	Beta	Type	Confidence (3,2,1)	Infill material	Joint Condition Rating	
K16-370 (UG Hole 2)	11.13	Aphanitic Rhyolite (RHYi)	65	270	JN	1		22	
K16-370 (UG Hole 2)	11.28	Aphanitic Rhyolite (RHYi)	65	270	JN	1		22	
K16-370 (UG Hole 2)	11.38	Aphanitic Rhyolite (RHYi)	70	300	JN	1		22	
K16-370 (UG Hole 2)	11.72	Aphanitic Rhyolite (RHYi)	70	300	JN	1		22	
K16-370 (UG Hole 2)	12.20	Aphanitic Rhyolite (RHYi)	75	0	JN	1		16	
K16-370 (UG Hole 2)	12.30	Aphanitic Rhyolite (RHYi)	73	30	JN	1		20	
K16-370 (UG Hole 2)	12.41	Aphanitic Rhyolite (RHYi)	71	30	JN	1		22	
K16-370 (UG Hole 2)	12.49	Aphanitic Rhyolite (RHYi)	73	60	JN	1		16	
K16-370 (UG Hole 2)	12.53	Aphanitic Rhyolite (RHYi)	70	30	JN	1		16	
K16-370 (UG Hole 2)	12.74	Aphanitic Rhyolite (RHYi)	78	60	JN	1		16	
K16-370 (UG Hole 2)	12.79	Aphanitic Rhyolite (RHYi)	73	30	JN	1		16	
K16-370 (UG Hole 2)	13.12	Aphanitic Rhyolite (RHYi)	68	30	JN	1		20	
K16-370 (UG Hole 2)	13.20	Aphanitic Rhyolite (RHYi)	40	60	JN	1		20	
K16-370 (UG Hole 2)	13.57	Aphanitic Rhyolite (RHYi)	59	30	JN	1		12	
K16-370 (UG Hole 2)	13.82	Aphanitic Rhyolite (RHYi)	68	30	JN	1		22	
K16-370 (UG Hole 2)	13.88	Aphanitic Rhyolite (RHYi)	70	120	JN	1		16	
K16-370 (UG Hole 2)	13.94	Aphanitic Rhyolite (RHYi)	50	120	JN	1		20	
K16-370 (UG Hole 2)	14.23	Aphanitic Rhyolite (RHYi)	30	120	JN	1		22	
K16-370 (UG Hole 2)	14.31	Aphanitic Rhyolite (RHYi)	75	30	JN	1		20	
K16-370 (UG Hole 2)	14.61	Aphanitic Rhyolite (RHYi)	65	60	JN	1		22	
K16-370 (UG Hole 2)	15.60	Aphanitic Rhyolite (RHYi)	75	120	JN	1		20	
K16-370 (UG Hole 2)	15.68	Aphanitic Rhyolite (RHYi)	24	150	JN	1		20	
K16-370 (UG Hole 2)	16.18	Aphanitic Rhyolite (RHYi)	71	330	JN	1		22	
K16-370 (UG Hole 2)	17.72	Pelite (PEL)	67	220	JN	1	CL	12	
K16-370 (UG Hole 2)	18.10	Pelite (PEL)	75	330	JN	1	CL	12	
K16-370 (UG Hole 2)	18.15	Pelite (PEL)	70	330	JN	1		16	
K16-370 (UG Hole 2)	18.20	Pelite (PEL)	70	300	JN	1		16	
K16-370 (UG Hole 2)	18.40	Pelite (PEL)	74	60	JN	1		20	
K16-370 (UG Hole 2)	18.75	Pelite (PEL)	70	300	FLT	1	CL	0	
K16-370 (UG Hole 2)	18.80	Pelite (PEL)	73	30	JN	1		16	
K16-370 (UG Hole 2)	18.82	Pelite (PEL)	65	30	JN	1		16	
K16-370 (UG Hole 2)	19.01	Aphanitic Rhyolite (RHYi)	55	120	JN	1		16	
K16-370 (UG Hole 2)	19.17	Aphanitic Rhyolite (RHYi)	40	60	JN	1		16	
K16-370 (UG Hole 2)	19.33	Aphanitic Rhyolite (RHYi)	72	0	JN	1		16	
K16-370 (UG Hole 2)	20.00	Aphanitic Rhyolite (RHYi)	83	0	JN	1		20	
K16-370 (UG Hole 2)	20.05	Aphanitic Rhyolite (RHYi)	86	0	JN	1	CL	12	
K16-370 (UG Hole 2)	20.28	Aphanitic Rhyolite (RHYi)	79	0	JN	1		20	
K16-370 (UG Hole 2)	20.35	Aphanitic Rhyolite (RHYi)	70	300	JN	1		16	
K16-370 (UG Hole 2)	20.72	Aphanitic Rhyolite (RHYi)	81	0	JN	1		16	
K16-370 (UG Hole 2)	21.03	Aphanitic Rhyolite (RHYi)	83	0	JN	1		16	
K16-370 (UG Hole 2)	21.05	Aphanitic Rhyolite (RHYi)	82	30	JN	1		20	
K16-370 (UG Hole 2)	21.11	Aphanitic Rhyolite (RHYi)	85	30	JN	1		20	
K16-370 (UG Hole 2)	21.28	Aphanitic Rhyolite (RHYi)	78	0	JN	1		20	
K16-370 (UG Hole 2)	21.42	Aphanitic Rhyolite (RHYi)	73	300	JN	1		20	
K16-370 (UG Hole 2)	24.05	Aphanitic Rhyolite (RHYi)	68	300	JN	1		20	
K16-370 (UG Hole 2)	24.15	Aphanitic Rhyolite (RHYi)	72	270	JN	1		16	
K16-370 (UG Hole 2)	24.30	Aphanitic Rhyolite (RHYi)	74	270	JN	1		20	
K16-370 (UG Hole 2)	24.34	Aphanitic Rhyolite (RHYi)	74	300	JN	1		16	
K16-370 (UG Hole 2)	24.52	Aphanitic Rhyolite (RHYi)	75	300	JN	1		16	
K16-370 (UG Hole 2)	24.62	Aphanitic Rhyolite (RHYi)	72	300	JN	1		16	
K16-370 (UG Hole 2)	24.68	Aphanitic Rhyolite (RHYi)	68	270	JN	1		16	
K16-370 (UG Hole 2)	24.77	Aphanitic Rhyolite (RHYi)	74	300	JN	1		20	
K16-370 (UG Hole 2)	24.90	Aphanitic Rhyolite (RHYi)	79	300	JN	1		16	
K16-370 (UG Hole 2)	25.04	Aphanitic Rhyolite (RHYi)	55	120	JN	1	CL	0	
K16-370 (UG Hole 2)	25.19	Aphanitic Rhyolite (RHYi)	72	270	JN	1		16	
K16-370 (UG Hole 2)	25.21	Aphanitic Rhyolite (RHYi)	65	240	JN	1		16	
K16-370 (UG Hole 2)	25.24	Aphanitic Rhyolite (RHYi)	70	270	JN	1		16	
K16-370 (UG Hole 2)	25.28	Aphanitic Rhyolite (RHYi)	63	270	JN	1		16	
K16-370 (UG Hole 2)	25.30	Aphanitic Rhyolite (RHYi)	73	270	JN	1		16	
K16-370 (UG Hole 2)	25.33	Aphanitic Rhyolite (RHYi)	76	240	JN	1		20	
K16-370 (UG Hole 2)	27.05	Aphanitic Rhyolite (RHYi)	78	300	JN	1		20	
K16-370 (UG Hole 2)	27.25	Aphanitic Rhyolite (RHYi)	86	300	JN	1		20	
K16-370 (UG Hole 2)	27.32	Aphanitic Rhyolite (RHYi)	65	270	JN	1		16	
K16-370 (UG Hole 2)	27.49	Aphanitic Rhyolite (RHYi)	65	300	JN	1		20	
K16-370 (UG Hole 2)	27.55	Aphanitic Rhyolite (RHYi)	63	300	JN	1		16	
K16-370 (UG Hole 2)	27.76	Aphanitic Rhyolite (RHYi)	70	300	JN	1		20	
K16-370 (UG Hole 2)	28.01	Aphanitic Rhyolite (RHYi)	72	270	JN	1		20	
K16-370 (UG Hole 2)	28.13	Aphanitic Rhyolite (RHYi)	76	270	JN	1		20	
K16-370 (UG Hole 2)	30.47	Pelite (PEL)	56	180	JN	1		12	
K16-370 (UG Hole 2)	30.52	Pelite (PEL)	79	30	JN	1		12	
K16-370 (UG Hole 2)	30.56	Pelite (PEL)	75	60	JN	1		12	
K16-370 (UG Hole 2)	30.60	Pelite (PEL)	78	60	JN	1		12	
K16-370 (UG Hole 2)	30.64	Pelite (PEL)	80	30	JN	1		12	
K16-370 (UG Hole 2)	30.69	Pelite (PEL)	79	90	JN	1		12	
K16-370 (UG Hole 2)	30.89	Aphanitic Rhyolite (RHYi)	73	90	JN	1		16	
K16-370 (UG Hole 2)	30.99	Aphanitic Rhyolite (RHYi)	74	90	JN	1		16	
K16-370 (UG Hole 2)	31.10	Aphanitic Rhyolite (RHYi)	70	60	FLT	1		0	
K16-370 (UG Hole 2)	31.14	Aphanitic Rhyolite (RHYi)	80	60	HJN	1		12	
K16-370 (UG Hole 2)	31.26	Aphanitic Rhyolite (RHYi)	61	60	JN	1		12	
K16-370 (UG Hole 2)	31.35	Aphanitic Rhyolite (RHYi)	71	60	JN	1		12	
K16-370 (UG Hole 2)	31.48	Aphanitic Rhyolite (RHYi)	57	270	JN	1		22	
K16-370 (UG Hole 2)	31.58	Aphanitic Rhyolite (RHYi)	77	60	JN	1		20	
K16-370 (UG Hole 2)	31.84	Aphanitic Rhyolite (RHYi)	82	90	JN	1		16	
K16-370 (UG Hole 2)	31.90	Aphanitic Rhyolite (RHYi)	69	90	JN	1		16	
K16-370 (UG Hole 2)	32.04	Aphanitic Rhyolite (RHYi)	73	90	JN	1		20	
K16-370 (UG Hole 2)	32.17	Aphanitic Rhyolite (RHYi)	65	90	JN	1		12	
K16-370 (UG Hole 2)	32.23	Aphanitic Rhyolite (RHYi)	62	90	JN	1		16	
K16-370 (UG Hole 2)	32.35	Aphanitic Rhyolite (RHYi)	61	90	JN	1		16	
K16-370 (UG Hole 2)	32.80	Aphanitic Rhyolite (RHYi)	52	90	JN	1		20	
K16-370 (UG Hole 2)	32.83	Aphanitic Rhyolite (RHYi)	68	90	JN	1		16	
K16-370 (UG Hole 2)	32.90	Aphanitic Rhyolite (RHYi)	76	90	JN	1		16	
K16-370 (UG Hole 2)	33.08	Aphanitic Rhyolite (RHYi)	63	90	JN	1		16	
K16-370 (UG Hole 2)	33.33	Aphanitic Rhyolite (RHYi)	44	300	JN	1		16	
K16-370 (UG Hole 2)	33.78	Aphanitic Rhyolite (RHYi)	73	90	JN	1		16	
K16-370 (UG Hole 2)	33.82	Aphanitic Rhyolite (RHYi)	69	60	JN	1		16	
K16-370 (UG Hole 2)	34.02	Aphanitic Rhyolite (RHYi)	68	60	JN	1		16	
K16-370 (UG Hole 2)	34.17	Aphanitic Rhyolite (RHYi)	83	90	JN	1		16	
K16-370 (UG Hole 2)	37.29	Aphanitic Rhyolite (RHYi)	70	90	JN	1		16	
K16-370 (UG Hole 2)	37.83	Aphanitic Rhyolite (RHYi)	72	330	JN	1		16	
K16-370 (UG Hole 2)	38.20	Aphanitic Rhyolite (RHYi)	64	30	JN	1		16	
K16-370 (UG Hole 2)	38.44	Aphanitic Rhyolite (RHYi)	66	150	JN	1		16	
K16-370 (UG Hole 2)	38.82	Aphanitic Rhyolite (RHYi)	69	180	JN	1		16	
K16-370 (UG Hole 2)	39.24	Aphanitic Rhyolite (RHYi)	69	150	JN	1		20	
K16-370 (UG Hole 2)	39.80	Aphanitic Rhyolite (RHYi)	65	0	JN	1		20	
K16-370 (UG Hole 2)	40.73	Aphanitic Rhyolite (RHYi)	73	180	JN	1		20	
K16-370 (UG Hole 2)	43.82	Aphanitic Rhyolite (RHYi)	33	330	JN	1		20	
K16-370 (UG Hole 2)	44.02	Aphanitic Rhyolite (RHYi)	25	330	JN	1		20	
K16-370 (UG Hole 2)	45.15	Aphanitic Rhyolite (RHYi)	24	240	JN	1		20	
K16-370 (UG Hole 2)	47.02	Aphanitic Rhyolite (RHYi)	76	120	JN	2		12	
K16-370 (UG Hole 2)	47.23	Aphanitic Rhyolite (RHYi)	85	180	JN	2		12	
K16-370 (UG Hole 2)	47.45	Aphanitic Rhyolite (RHYi)	77	270	JN	2		20	
K16-370 (UG Hole 2)	49.16	Aphanitic Rhyolite (RHYi)	70	300	JN	2		16	
K16-370 (UG Hole 2)	51.99	Aphanitic Rhyolite (RHYi)	70	270	JN	2		20	
K16-370 (UG Hole 2)	53.79	Coherent Rhyolite (RHYc)	47	90	JN	2		22	
K16-370 (UG Hole 2)	54.07	Coherent Rhyolite (RHYc)	47	90	JN	2		22	
K16-370 (UG Hole 2)	54.79	Coherent Rhyolite (RHYc)	71	300	JN	2		16	
K16-370 (UG Hole 2)	57.22	Pelite (PEL)	70	180	JN	1		16	
K16-370 (UG Hole 2)	57.69	Volcaniclastic Rhyolite (RHYv)	63	150	JN	1	CL	12	
K16-370 (UG Hole 2)	58.89	Volcaniclastic Rhyolite (RHYv)	77	330	JN	1		20	
K16-370 (UG Hole 2)	59.88	Volcaniclastic Rhyolite (RHYv)	75	330	JN	1		20	
K16-370 (UG Hole 2)	60.70	Volcaniclastic Rhyolite (RHYv)	63	270	JN	1		20	
K16-370 (UG Hole 2)	61.64	Volcaniclastic Rhyolite (RHYv)	67	270	JN	1		20	
K16-370 (UG Hole 2)	62.25	Volcaniclastic Rhyolite (RHYv)	58	300	JN	1		22	
K16-370 (UG Hole 2)	63.30	Volcaniclastic Rhyolite (RHYv)	56	270	JN	1		20	
K16-370 (UG Hole 2)	64.45	Volcaniclastic Rhyolite (RHYv)	55	330	JN	1		20	
K16-370 (UG Hole 2)	65.25	Volcaniclastic Rhyolite (RHYv)	57	0	JN	1		20	
K16-370 (UG Hole 2)	65.89	Volcaniclastic Rhyolite (RHYv)	64	0	JN	1		20	
K16-370 (UG Hole 2)	66.38	Volcaniclastic Rhyolite (RHYv)	67	330	JN	1		20	
K16-370 (UG Hole 2)	67.66	Volcaniclastic Rhyolite (RHYv)	64	90	JN	1		6	
K16-370 (UG Hole 2)	67.84	Volcaniclastic Rhyolite (RHYv)	66	330	FLT	1		0	
K16-370 (UG Hole 2)	68.20	Volcaniclastic Rhyolite (RHYv)	76	60	JN	1		20	
K16-370 (UG Hole 2)	68.26	Volcaniclastic Rhyolite (RHYv)	57	0	JN	1		16	
K16-370 (UG Hole 2)	68.54	Volcaniclastic Rhyolite (RHYv)	75	30	JN	1		16	
K16-370 (UG Hole 2)	68.65	Volcaniclastic Rhyolite (RHYv)	65	0	JN	1		16	
K16-370 (UG Hole 2)	69.25	Volcaniclastic Rhyolite (RHYv)	60	0	JN	1		6	Slickenside
K16-370 (UG Hole 2)	69.54	Volcaniclastic Rhyolite (RHYv)	78	90	JN	1		20	
K16-370 (UG Hole 2)	69.64	Volcaniclastic Rhyolite (RHYv)	28	180	JN	1		20	
K16-370 (UG Hole 2)	69.76	Volcaniclastic Rhyolite (RHYv)	63	0	JN	1		20	
K16-370 (UG Hole 2)	69.88	Volcaniclastic Rhyolite (RHYv)	69	0	JN	1		20	
K16-370 (UG Hole 2)	70.17	Volcaniclastic Rhyolite (RHYv)	55	0	JN	1		20	
K16-370 (UG Hole 2)	70.26	Volcaniclastic Rhyolite (RHYv)	60	90	JN	1		20	
K16-370 (UG Hole 2)	73.60	Volcaniclastic Rhyolite (RHYv)	85	180	FLT	1		6	
K16-370 (UG Hole 2)	73.74	Volcaniclastic Rhyolite (RHYv)	58	0	JN	1		12	
K16-370 (UG Hole 2)	73.88	Volcaniclastic Rhyolite (RHYv)	65	30	FLT	1		6	
K16-370 (UG Hole 2)	74.04	Volcaniclastic Rhyolite (RHYv)	65	0	FLT	1		6	
K16-370 (UG Hole 2)	74.17	Volcaniclastic Rhyolite (RHYv)	65	180	JN	1		12	
K16-370 (UG Hole 2)	76.67	Volcaniclastic Rhyolite (RHYv)	70	240	JF	1		12	
K16-370 (UG Hole 2)	76.70	Volcaniclastic Rhyolite (RHYv)	76	180	JF	1		12	
K16-370 (UG Hole 2)	76.96	Volcaniclastic Rhyolite (RHYv)	75	210	HJF	1		12	
K16-370 (UG Hole 2)	77.21	Volcaniclastic Rhyolite (RHYv)	40	210	JF	1		22	
K16-370 (UG Hole 2)	90.63	Volcaniclastic Rhyolite (RHYv)	45	90	FLT	1		6	
K16-370 (UG Hole 2)	90.86	Volcaniclastic Rhyolite (RHYv)	76	330	JN	1		20	
K16-370 (UG Hole 2)	91.15	Volcaniclastic Rhyolite (RHYv)	55	330	JN	1		16	
K16-370 (UG Hole 2)	91.60	Volcaniclastic Rhyolite (RHYv)	49	300	JN	1		12	
K16-370 (UG Hole 2)	91.80	Volcaniclastic Rhyolite (RHYv)	53	60	JN	1		12	
K16-370 (UG Hole 2)	91.95	Volcaniclastic Rhyolite (RHYv)	69	300	JN	1		12	
K16-370 (UG Hole 2)	92.30	Volcaniclastic Rhyolite (RHYv)	60	300	JN	1		6	
K16-370 (UG Hole 2)	92.84	Volcaniclastic Rhyolite (RHYv)	51	270	JN	1		12	
K16-370 (UG Hole 2)	93.30	Volcaniclastic Rhyolite (RHYv)	45	270	JN	1		12	
K16-370 (UG Hole 2)	99.05	Volcaniclastic Rhyolite (RHYv)	83	180	JN	1		20	
K16-370 (UG Hole 2)	99.15	Volcaniclastic Rhyolite (RHYv)	78	330	JN	1		16	
K16-370 (UG Hole 2)	99.42	Volcaniclastic Rhyolite (RHYv)	50	0	JF	1		16	
K16-370 (UG Hole 2)	99.55	Volcaniclastic Rhyolite (RHYv)	68	0	JN	1		16	
K16-370 (UG Hole 2)	99.58	Volcaniclastic Rhyolite (RHYv)	75	330	JN	1		16	
K16-370 (UG Hole 2)	99.68	Volcaniclastic Rhyolite (RHYv)	80	240	HJN	1	CL	12	
K16-370 (UG Hole 2)	99.83	Volcaniclastic Rhyolite (RHYv)	63	240	JN	1		16	
K16-370 (UG Hole 2)	100.07	Volcaniclastic Rhyolite (RHYv)	66	300	JN	1		16	
K16-370 (UG Hole 2)	100.45	Volcaniclastic Rhyolite (RHYv)	54	330	JN	1	CL	6	
K16-370 (UG Hole 2)	102.25	Volcaniclastic Rhyolite (RHYv)	60	300	JN	1		16	
K16-370 (UG Hole 2)	102.39	Volcaniclastic Rhyolite (RHYv)	62	270	JN	1		16	
K16-370 (UG Hole 2)	102.41	Volcaniclastic Rhyolite (RHYv)	56	270	JN	1		16	
K16-370 (UG Hole 2)	103.03	Volcaniclastic Rhyolite (RHYv)	56	300	JN	1	MU	12	
K16-370 (UG Hole 2)	103.05	Volcaniclastic Rhyolite (RHYv)	72	330	JN	1	MU	12	
K16-370 (UG Hole 2)	103.21	Volcaniclastic Rhyolite (RHYv)	39	300	JN	1		16	
K16-370 (UG Hole 2)	103.24	Volcaniclastic Rhyolite (RHYv)	49	300	JN	1		16	
K16-370 (UG Hole 2)	103.30	Volcaniclastic Rhyolite (RHYv)	45	300	JN	1	MU	12	
K16-370 (UG Hole 2)	103.35	Volcaniclastic Rhyolite (RHYv)	73	300	JN	1		16	
K16-370 (UG Hole 2)	103.38	Volcaniclastic Rhyolite (RHYv)	63	270	JN	1		16	
K16-370 (UG Hole 2)	103.42	Volcaniclastic Rhyolite (RHYv)	59	270	JN	1		16	
K16-370 (UG Hole 2)	106.60	Volcaniclastic Rhyolite (RHYv)	73	60	JN	1	CL	12	
K16-370 (UG Hole 2)	106.72	Volcaniclastic Rhyolite (RHYv)	53	30	JN	1	CL	6	Slickenside
K16-370 (UG Hole 2)	106.80	Volcaniclastic Rhyolite (RHYv)	39	30	JN	1	CL	12	
K16-370 (UG Hole 2)	106.96	Volcaniclastic Rhyolite (RHYv)	35	30	HJN	1	CL	6	
K16-370 (UG Hole 2)	111.05	Volcaniclastic Rhyolite (RHYv)	80	0	JN	1	CL	12	
K16-370 (UG Hole 2)	111.23	Volcaniclastic Rhyolite (RHYv)	69	330	JN	1		16	
K16-370 (UG Hole 2)	111.35	Volcaniclastic Rhyolite (RHYv)	73	0	JN	1		16	
K16-370 (UG Hole 2)	111.58	Volcaniclastic Rhyolite (RHYv)	63	0	JN	1		20	
K16-370 (UG Hole 2)	111.65	Volcaniclastic Rhyolite (RHYv)	59	0	JN	1		20	
K16-370 (UG Hole 2)	111.67	Volcaniclastic Rhyolite (RHYv)	53	0	JN	1		20	
K16-370 (UG Hole 2)	111.80	Volcaniclastic Rhyolite (RHYv)	65	30	JN	1		22	
K16-370 (UG Hole 2)	112.20	Volcaniclastic Rhyolite (RHYv)	39	240	JN	1		16	
K16-370 (UG Hole 2)	112.27	Volcaniclastic Rhyolite (RHYv)	86	240	JN	1		22	
K16-370 (UG Hole 2)	112.30	Volcaniclastic Rhyolite (RHYv)	89	0	JN	1		22	
K16-370 (UG Hole 2)	112.60	Volcaniclastic Rhyolite (RHYv)	30	30	JN	1		22	
K16-370 (UG Hole 2)	112.87	Volcaniclastic Rhyolite (RHYv)	74	300	JN	1		20	
K16-370 (UG Hole 2)	113.26	Volcaniclastic Rhyolite (RHYv)	47	30	JN	1		20	
K16-370 (UG Hole 2)	113.45	Volcaniclastic Rhyolite (RHYv)	55	30	JN	1		20	
K16-370 (UG Hole 2)	113.80	Volcaniclastic Rhyolite (RHYv)	68	30	JN	1		20	
K16-370 (UG Hole 2)	113.90	Volcaniclastic Rhyolite (RHYv)	51	0	JN	1		20	
K16-370 (UG Hole 2)	117.07	Volcaniclastic Rhyolite (RHYv)	64	60	JN	1		16	
K16-370 (UG Hole 2)	117.18	Volcaniclastic Rhyolite (RHYv)	69	60	JN	1		16	
K16-370 (UG Hole 2)	117.72	Volcaniclastic Rhyolite (RHYv)	28	270	JN	1		20	
K16-370 (UG Hole 2)	117.85	Volcaniclastic Rhyolite (RHYv)	76	30	JN	1		16	
K16-370 (UG Hole 2)	117.89	Volcaniclastic Rhyolite (RHYv)	53	90	JN	1		20	
K16-370 (UG Hole 2)	117.96	Volcaniclastic Rhyolite (RHYv)	84	90	JN	1		20	
K16-370 (UG Hole 2)	118.16	Volcaniclastic Rhyolite (RHYv)	60	270	JN	1		20	
K16-370 (UG Hole 2)	118.26	Volcaniclastic Rhyolite (RHYv)	60	330	JN	1		16	
K16-370 (UG Hole 2)	124.30	Coherent Rhyolite (RHYc)	64	270	JF	1		16	
K16-370 (UG Hole 2)	124.35	Coherent Rhyolite (RHYc)	65	240	JN	1		16	
K16-370 (UG Hole 2)	125.15	Coherent Rhyolite (RHYc)	89	30	JN	1		12	
K16-370 (UG Hole 2)	125.55	Coherent Rhyolite (RHYc)	81	240	JN	1		16	
K16-370 (UG Hole 2)	125.88	Coherent Rhyolite (RHYc)	70	180	JN	1		16	
K16-370 (UG Hole 2)	126.64	Coherent Rhyolite (RHYc)	70	30	JN	1		6	Slickenside
K16-370 (UG Hole 2)	126.65	Coherent Rhyolite (RHYc)	69	0	JN	1		6	Slickenside
K16-370 (UG Hole 2)	126.80	Coherent Rhyolite (RHYc)	65	0	JN	1		16	
K16-370 (UG Hole 2)	127.06	Coherent Rhyolite (RHYc)	86	60	JN	1		6	Slickenside
K16-370 (UG Hole 2)	127.84	Coherent Rhyolite (RHYc)	70	120	JN	1		6	Slickenside
K16-370 (UG Hole 2)	128.00	Coherent Rhyolite (RHYc)	74	120	JN	1	MU	12	
K16-370 (UG Hole 2)	128.15	Coherent Rhyolite (RHYc)	78	120	JN	1	MU	12	
K16-370 (UG Hole 2)	128.18	Coherent Rhyolite (RHYc)	85	90	JN	1	MU	12	
K16-370 (UG Hole 2)	128.30	Coherent Rhyolite (RHYc)	69	0	JF	1	MU	12	
K16-370 (UG Hole 2)	128.38	Coherent Rhyolite (RHYc)	60	0	JF	1	MU	12	
K16-370 (UG Hole 2)	128.40	Coherent Rhyolite (RHYc)	73	0	JF	1	MU	12	
K16-370 (UG Hole 2)	128.43	Coherent Rhyolite (RHYc)	65	0	JF	1	MU	12	
K16-370 (UG Hole 2)	128.47	Coherent Rhyolite (RHYc)	57	0	JF	1	MU	12	
K16-370 (UG Hole 2)	129.12	Coherent Rhyolite (RHYc)	66	0	JF	1	MU	12	
K16-370 (UG Hole 2)	129.22	Coherent Rhyolite (RHYc)	72	0	JF	1	MU	12	
K16-370 (UG Hole 2)	129.29	Coherent Rhyolite (RHYc)	60	90	JF	1	MU	12	
K16-370 (UG Hole 2)	129.34	Coherent Rhyolite (RHYc)	59	0	JF	1	MU	12	
K16-370 (UG Hole 2)	129.44	Coherent Rhyolite (RHYc)	69	150	JN	1	MU	12	
K16-370 (UG Hole 2)	129.58	Coherent Rhyolite (RHYc)	70	240	FLT	1	CL	0	
K16-370 (UG Hole 2)	130.95	Mafic Sill (MAFi)	65	270	JN	1	CH	12	
K16-370 (UG Hole 2)	131.06	Mafic Sill (MAFi)	73	300	JF	1	CH	6	
K16-370 (UG Hole 2)	131.10	Mafic Sill (MAFi)	76	300	JF	1	CH	6	
K16-370 (UG Hole 2)	131.19	Mafic Sill (MAFi)	48	210	JN	1	CH	12	
K16-370 (UG Hole 2)	131.23	Mafic Sill (MAFi)	58	240	JN	1	CH	16	

K16-370 (UG Hole 2)	131.39	Mafic Sill (MAFI)	66	300	JN	1	CH	12	
K16-370 (UG Hole 2)	131.48	Mafic Sill (MAFI)	54	300	JN	1	CL	6	
K16-370 (UG Hole 2)	131.72	Mafic Sill (MAFI)	51	300	JN	1	CL	12	
K16-370 (UG Hole 2)	131.85	Mafic Sill (MAFI)	46	270	SHR	1	CL	6	
K16-370 (UG Hole 2)	132.02	Mafic Sill (MAFI)	61	210	JF	1	CL	12	
K16-370 (UG Hole 2)	132.03	Mafic Sill (MAFI)	66	190	JF	1	CL	12	
K16-370 (UG Hole 2)	132.05	Mafic Sill (MAFI)	69	170	JF	1	CL	12	
K16-370 (UG Hole 2)	132.10	Mafic Sill (MAFI)	69	180	JF	1	CL	12	
K16-370 (UG Hole 2)	132.20	Mafic Sill (MAFI)	68	150	JF	1	CL	12	
K16-370 (UG Hole 2)	132.27	Mafic Sill (MAFI)	68	170	JF	1	CL	12	
K16-370 (UG Hole 2)	132.30	Mafic Sill (MAFI)	31	90	HJN	1	CL	6	
K16-370 (UG Hole 2)	132.40	Mafic Sill (MAFI)	54	80	JN	1	CH	20	
K16-370 (UG Hole 2)	132.50	Mafic Sill (MAFI)	54	90	JN	1	CH	6	Slickenside
K16-370 (UG Hole 2)	132.59	Mafic Sill (MAFI)	29	90	JN	1	CH	20	
K16-370 (UG Hole 2)	133.05	Mafic Sill (MAFI)	59	90	JN	1	CH	20	
K16-370 (UG Hole 2)	133.60	Mafic Sill (MAFI)	62	180	JN	1	CH	20	
K16-370 (UG Hole 2)	134.02	Mafic Sill (MAFI)	36	150	JN	1	CH	20	
K16-370 (UG Hole 2)	134.07	Mafic Sill (MAFI)	37	150	JN	1	CH	20	
K16-370 (UG Hole 2)	134.24	Mafic Sill (MAFI)	37	150	JN	1	CH	20	
K16-370 (UG Hole 2)	134.40	Mafic Sill (MAFI)	40	150	JN	1	CH	20	
K16-370 (UG Hole 2)	134.66	Mafic Sill (MAFI)	56	120	JN	1	CH	20	
K16-370 (UG Hole 2)	134.71	Mafic Sill (MAFI)	60	280	JN	1	CH	20	
K16-370 (UG Hole 2)	134.97	Mafic Sill (MAFI)	81	240	JN	1	CH	20	
K16-370 (UG Hole 2)	135.21	Mafic Sill (MAFI)	33	150	JN	1	CH	20	
K16-370 (UG Hole 2)	135.72	Mafic Sill (MAFI)	71	80	JN	1	CH	16	
K16-370 (UG Hole 2)	136.05	Mafic Sill (MAFI)	78	240	JF	1	CH	12	
K16-370 (UG Hole 2)	136.14	Mafic Sill (MAFI)	53	270	JN	1	CH	12	
K16-370 (UG Hole 2)	136.33	Mafic Sill (MAFI)	75	270	JN	1	CH	12	
K16-370 (UG Hole 2)	136.70	Mafic Sill (MAFI)	71	270	JF	1	CH	12	
K16-370 (UG Hole 2)	137.08	Mafic Sill (MAFI)	77	270	JF	1	CH	12	
K16-370 (UG Hole 2)	137.16	Mafic Sill (MAFI)	75	300	HJN	1	CL	6	
K16-370 (UG Hole 2)	137.47	Mafic Sill (MAFI)	80	270	JF	1	CH	12	
K16-370 (UG Hole 2)	137.54	Mafic Sill (MAFI)	55	210	HJF	1	CL	6	
K16-370 (UG Hole 2)	137.57	Mafic Sill (MAFI)	81	210	JF	1	CH	12	
K16-370 (UG Hole 2)	137.75	Mafic Sill (MAFI)	83	270	JN	1	CH	12	
K16-370 (UG Hole 2)	137.88	Mafic Sill (MAFI)	78	240	JF	1	CH	12	
K16-370 (UG Hole 2)	137.93	Mafic Sill (MAFI)	83	240	JF	1	CH	12	
K16-370 (UG Hole 2)	137.96	Mafic Sill (MAFI)	83	240	JF	1	CH	12	
K16-370 (UG Hole 2)	137.99	Mafic Sill (MAFI)	80	270	JF	1	CH	12	
K16-370 (UG Hole 2)	138.05	Mafic Sill (MAFI)	80	270	JF	1	CH	12	
K16-370 (UG Hole 2)	138.08	Mafic Sill (MAFI)	80	270	JF	1	CH	12	
K16-370 (UG Hole 2)	138.75	Mafic Sill (MAFI)	71	30	JN	1	CL	12	
K16-370 (UG Hole 2)	138.81	Mafic Sill (MAFI)	63	90	JN	1	CL	12	
K16-370 (UG Hole 2)	138.83	Mafic Sill (MAFI)	70	150	JN	1	CL	12	
K16-370 (UG Hole 2)	138.86	Mafic Sill (MAFI)	68	150	JN	1	CL	12	
K16-370 (UG Hole 2)	138.98	Mafic Sill (MAFI)	74	180	JN	1	CL	12	
K16-370 (UG Hole 2)	139.05	Mafic Sill (MAFI)	55	150	JN	1	CL	12	
K16-370 (UG Hole 2)	139.16	Stringer Sulfide (OJ)	70	90	JF	1	CL	6	Slickenside
K16-370 (UG Hole 2)	139.21	Stringer Sulfide (OJ)	75	90	JF	1	CL	12	
K16-370 (UG Hole 2)	139.33	Stringer Sulfide (OJ)	76	120	JF	1	CH	12	
K16-370 (UG Hole 2)	139.41	Stringer Sulfide (OJ)	69	300	JN	1	CL	20	
K16-370 (UG Hole 2)	139.52	Stringer Sulfide (OJ)	80	110	JF	1	CH	12	
K16-370 (UG Hole 2)	139.68	Stringer Sulfide (OJ)	76	90	JF	1	CH	12	
K16-370 (UG Hole 2)	140.05	Stringer Sulfide (OJ)	70	240	JN	1	CL	12	
K16-370 (UG Hole 2)	140.24	Stringer Sulfide (OJ)	88	180	JN	1	CH	16	
K16-370 (UG Hole 2)	142.79	Undifferentiated Rhyolite (RHY)	79	270	JN	1	CL	12	
K16-370 (UG Hole 2)	142.82	Undifferentiated Rhyolite (RHY)	73	270	JN	1	CL	12	
K16-370 (UG Hole 2)	143.05	Undifferentiated Rhyolite (RHY)	74	270	JN	1	CL	12	
K16-370 (UG Hole 2)	143.06	Undifferentiated Rhyolite (RHY)	63	180	JN	1	CL	12	
K16-370 (UG Hole 2)	143.19	Undifferentiated Rhyolite (RHY)	68	200	JN	1	CL	12	
K16-370 (UG Hole 2)	143.21	Undifferentiated Rhyolite (RHY)	68	280	JN	1	CL	12	
K16-370 (UG Hole 2)	143.43	Undifferentiated Rhyolite (RHY)	73	240	JN	1	CL	12	
K16-370 (UG Hole 2)	143.71	Undifferentiated Rhyolite (RHY)	77	240	JN	1	CL	12	
K16-370 (UG Hole 2)	143.93	Undifferentiated Rhyolite (RHY)	79	180	JN	1	CL	12	
K16-370 (UG Hole 2)	143.97	Undifferentiated Rhyolite (RHY)	53	120	JN	1	CL	12	
K16-370 (UG Hole 2)	148.83	Massive Sulfide (OB)	44	120	JN	1		25	
K16-370 (UG Hole 2)	149.23	Massive Sulfide (OB)	72	90	JN	1		25	
K16-370 (UG Hole 2)	149.33	Massive Sulfide (OB)	61	330	JN	1		25	
K16-370 (UG Hole 2)	149.61	Massive Sulfide (OB)	61	300	JN	1		25	
K16-370 (UG Hole 2)	149.92	Massive Sulfide (OB)	78	300	JN	1		25	
K16-370 (UG Hole 2)	150.14	Massive Sulfide (OB)	27	150	JN	1		25	
K16-370 (UG Hole 2)	150.32	Massive Sulfide (OB)	36	90	JN	1		25	
K16-370 (UG Hole 2)	150.50	Massive Sulfide (OB)	53	300	JN	1		25	
K16-370 (UG Hole 2)	154.17	Mafic Sill (MAFI)	66	240	JF	1		20	
K16-370 (UG Hole 2)	154.27	Mafic Sill (MAFI)	69	180	JF	1		20	
K16-370 (UG Hole 2)	154.40	Mafic Sill (MAFI)	84	200	JN	1		20	
K16-370 (UG Hole 2)	154.72	Mafic Sill (MAFI)	45	60	JN	1		20	
K16-370 (UG Hole 2)	155.19	Mafic Sill (MAFI)	48	60	JN	1		20	
K16-370 (UG Hole 2)	155.38	Mafic Sill (MAFI)	83	30	JN	1		20	
K16-370 (UG Hole 2)	155.56	Mafic Sill (MAFI)	80	300	JN	1		20	
K16-370 (UG Hole 2)	155.88	Mafic Sill (MAFI)	86	300	JN	1		20	
K16-370 (UG Hole 2)	156.34	Mafic Sill (MAFI)	37	60	JN	1		20	
K16-370 (UG Hole 2)	156.69	Mafic Sill (MAFI)	73	90	JN	1		20	
K16-370 (UG Hole 2)	157.40	Mafic Sill (MAFI)	86	90	JN	1		20	
K16-370 (UG Hole 2)	157.80	Mafic Sill (MAFI)	86	270	JN	1		20	
K16-370 (UG Hole 2)	158.03	Mafic Sill (MAFI)	79	210	JN	1		20	
K16-370 (UG Hole 2)	158.35	Mafic Sill (MAFI)	49	100	JN	1		20	
K16-370 (UG Hole 2)	158.50	Mafic Sill (MAFI)	84	300	JN	1		20	
K16-370 (UG Hole 2)	158.84	Mafic Sill (MAFI)	84	300	JN	1		20	
K16-370 (UG Hole 2)	158.94	Mafic Sill (MAFI)	75	300	JN	1		20	
K16-370 (UG Hole 2)	159.20	Mafic Sill (MAFI)	73	275	JN	1		20	
K16-370 (UG Hole 2)	159.30	Mafic Sill (MAFI)	34	185	JN	1		20	
K16-370 (UG Hole 2)	159.54	Mafic Sill (MAFI)	83	305	JN	1		20	
K16-370 (UG Hole 2)	159.59	Mafic Sill (MAFI)	45	305	JN	1		20	
K16-370 (UG Hole 2)	159.83	Mafic Sill (MAFI)	79	5	JN	1		20	
K16-370 (UG Hole 2)	160.21	Mafic Sill (MAFI)	55	310	JN	1		16	
K16-370 (UG Hole 2)	160.27	Mafic Sill (MAFI)	73	345	JN	1		6	Slickenside
K16-370 (UG Hole 2)	160.37	Mafic Sill (MAFI)	67	355	JN	1		16	
K16-370 (UG Hole 2)	160.82	Mafic Sill (MAFI)	50	10	JN	1		20	
K16-370 (UG Hole 2)	161.30	Mafic Sill (MAFI)	48	340	JN	1		20	
K16-370 (UG Hole 2)	161.50	Mafic Sill (MAFI)	47	340	JN	1		16	
K16-370 (UG Hole 2)	161.60	Mafic Sill (MAFI)	68	160	JN	1		20	
K16-370 (UG Hole 2)	161.80	Mafic Sill (MAFI)	56	10	JN	1		20	
K16-370 (UG Hole 2)	163.72	Mafic Sill (MAFI)	47	355	JN	1	CL	12	
K16-370 (UG Hole 2)	163.85	Mafic Sill (MAFI)	48	0	JN	1	-	22	
K16-370 (UG Hole 2)	164.04	Mafic Sill (MAFI)	20	220	JN	1	-	22	
K16-370 (UG Hole 2)	164.73	Mafic Sill (MAFI)	56	275	JN	1	CL	20	
K16-370 (UG Hole 2)	164.85	Mafic Sill (MAFI)	37	340	JN	1	CH	20	
K16-370 (UG Hole 2)	165.31	Mafic Sill (MAFI)	72	140	JN	2	CH	16	
K16-370 (UG Hole 2)	165.79	Mafic Sill (MAFI)	29	45	JN	2	CL	16	
K16-370 (UG Hole 2)	166.13	Mafic Sill (MAFI)	31	150	JN	2	CL	16	
K16-370 (UG Hole 2)	166.30	Mafic Sill (MAFI)	10	30	JN	2	CH	20	
K16-370 (UG Hole 2)	167.91	Mafic Sill (MAFI)	34	355	JN	2	-	22	
K16-370 (UG Hole 2)	168.28	Mafic Sill (MAFI)	34	60	JN	2	CH	16	
K16-370 (UG Hole 2)	168.91	Mafic Sill (MAFI)	72	105	JN	2	CH	16	
K16-370 (UG Hole 2)	169.00	Mafic Sill (MAFI)	63	320	JN	2	CA	12	
K16-370 (UG Hole 2)	169.08	Mafic Sill (MAFI)	55	300	JN	2	CH	12	
K16-370 (UG Hole 2)	169.50	Mafic Sill (MAFI)	51	100	JN	2	CH	20	
K16-370 (UG Hole 2)	170.12	Mafic Sill (MAFI)	41	300	JN	2	-	22	
K16-370 (UG Hole 2)	170.23	Mafic Sill (MAFI)	71	275	JF	2	MI	6	
K16-370 (UG Hole 2)	170.27	Mafic Sill (MAFI)	80	290	JF	2	MI	6	
K16-370 (UG Hole 2)	170.39	Mafic Sill (MAFI)	60	165	JN	2	SE	16	
K16-370 (UG Hole 2)	170.80	Mafic Sill (MAFI)	33	90	JN	2	-	22	
K16-370 (UG Hole 2)	171.27	Mafic Sill (MAFI)	71	175	JN	2	CH	16	
K16-370 (UG Hole 2)	171.59	Mafic Sill (MAFI)	45	355	JN	2	-	20	
K16-370 (UG Hole 2)	172.02	Mafic Sill (MAFI)	61	0	JN	2	CH	16	
K16-370 (UG Hole 2)	172.14	Mafic Sill (MAFI)	75	185	JF	2	MI	12	
K16-370 (UG Hole 2)	172.26	Mafic Sill (MAFI)	80	300	JF	2	MI	12	
K16-370 (UG Hole 2)	173.61	Mafic Sill (MAFI)	65	0	JF	2	MI/CH	6	
K16-370 (UG Hole 2)	174.11	Mafic Sill (MAFI)	74	330	JF	2	CL/CH	0	
K16-370 (UG Hole 2)	174.15	Mafic Sill (MAFI)	56	230	JN	2	MI	12	
K16-370 (UG Hole 2)	174.42	Mafic Sill (MAFI)	63	350	JN	2	CH	16	
K16-370 (UG Hole 2)	174.45	Mafic Sill (MAFI)	60	245	JN	2	CA	16	
K16-370 (UG Hole 2)	174.67	Stringer Sulfide (OJ)	69	235	JN	2	CL	16	
K16-370 (UG Hole 2)	174.85	Stringer Sulfide (OJ)	78	75	JN	2	MI	12	
K16-370 (UG Hole 2)	174.86	Stringer Sulfide (OJ)	65	280	JN	2	CL	12	
K16-370 (UG Hole 2)	175.17	Mafic Sill (MAFI)	68	270	JF	2	MI	16	
K16-370 (UG Hole 2)	175.32	Mafic Sill (MAFI)	52	220	JN	2	CH	16	
K16-370 (UG Hole 2)	175.45	Mafic Sill (MAFI)	71	270	JF	2	CH	6	
K16-370 (UG Hole 2)	175.61	Mafic Sill (MAFI)	63	205	JN	2	MI	16	
K16-370 (UG Hole 2)	175.71	Mafic Sill (MAFI)	49	215	JN	2	CH/CL	12	
K16-370 (UG Hole 2)	175.92	Mafic Sill (MAFI)	60	220	JN	2	CH	16	
K16-370 (UG Hole 2)	176.10	Mafic Sill (MAFI)	70	285	JF	2	CH	12	
K16-370 (UG Hole 2)	176.11	Mafic Sill (MAFI)	66	210	JN	2	CH	12	
K16-370 (UG Hole 2)	176.13	Mafic Sill (MAFI)	75	290	JF	2	CH	12	
K16-370 (UG Hole 2)	176.15	Mafic Sill (MAFI)	71	5	JN	2	CH	16	
K16-370 (UG Hole 2)	176.30	Mafic Sill (MAFI)	70	280	JF	2	MI	6	
K16-370 (UG Hole 2)	176.81	Mafic Sill (MAFI)	70	330	JN	2	CH	12	
K16-370 (UG Hole 2)	176.83	Mafic Sill (MAFI)	73	270	JF	2	CH/CA	6	
K16-370 (UG Hole 2)	176.85	Mafic Sill (MAFI)	75	265	JF	2	CH/CA	6	
K16-370 (UG Hole 2)	177.44	Mafic Sill (MAFI)	70	270	JF	2	CH	6	
K16-370 (UG Hole 2)	177.74	Mafic Sill (MAFI)	45	210	JN	2	CH/CL	6	
K16-370 (UG Hole 2)	177.82	Mafic Sill (MAFI)	46	180	JN	2	MI	16	
K16-370 (UG Hole 2)	177.83	Mafic Sill (MAFI)	35	0	JN	2	CH	20	
K16-370 (UG Hole 2)	177.94	Mafic Sill (MAFI)	47	200	JN	2	CA	20	
K16-370 (UG Hole 2)	178.02	Mafic Sill (MAFI)	60	315	JF	2	CH	12	
K16-370 (UG Hole 2)	178.08	Mafic Sill (MAFI)	53	340	JF	2	CH/CA	6	
K16-370 (UG Hole 2)	178.63	Mafic Sill (MAFI)	57	300	JN	1	CH	12	
K16-370 (UG Hole 2)	178.67	Mafic Sill (MAFI)	64	310	JF	1	CH/MI	12	
K16-370 (UG Hole 2)	178.83	Mafic Sill (MAFI)	52	300	JN	1	CH/MI	6	
K16-370 (UG Hole 2)	179.39	Mafic Sill (MAFI)	67	330	JF	1	CH/CL	12	
K16-370 (UG Hole 2)	179.47	Mafic Sill (MAFI)	67	5	JF	1	CH/CL	12	
K16-370 (UG Hole 2)	179.55	Mafic Sill (MAFI)	65	15	JF	1	CH/CL	6	
K16-370 (UG Hole 2)	179.71	Mafic Sill (MAFI)	46	30	JN	1	CH	16	
K16-370 (UG Hole 2)	179.73	Mafic Sill (MAFI)	51	335	JF	1	CH/CL	12	
K16-370 (UG Hole 2)	179.81	Mafic Sill (MAFI)	66	20	JF	1	CH/SE	12	
K16-370 (UG Hole 2)	179.86	Mafic Sill (MAFI)	62	15	JF	1	CH/SE	12	
K16-370 (UG Hole 2)	179.97	Mafic Sill (MAFI)	58	340	JF	1	CH	12	
K16-370 (UG Hole 2)	180.19	Mafic Sill (MAFI)	67	5	JF	1	CH/CL	6	
K16-370 (UG Hole 2)	180.26	Mafic Sill (MAFI)	45	295	JN	1	CH	12	
K16-370 (UG Hole 2)	180.42	Mafic Sill (MAFI)	64	15	JF	1	CH	12	
K16-370 (UG Hole 2)	180.58	Mafic Sill (MAFI)	62	15	JF	1	CH	6	
K16-370 (UG Hole 2)	180.66	Mafic Sill (MAFI)	60	15	JF	1	SE	20	
K16-370 (UG Hole 2)	180.87	Massive Sulfide (OF)	66	310	JN	1	CH	16	
K16-370 (UG Hole 2)	181.24	Massive Sulfide (OF)	63	285	JF	1	CH	16	
K16-370 (UG Hole 2)	181.71	Mafic Sill (MAFI)	62	290	JN	3	CL	16	
K16-370 (UG Hole 2)	181.81	Mafic Sill (MAFI)	61	290	JF	3	CL	12	
K16-370 (UG Hole 2)	181.84	Mafic Sill (MAFI)	68	275	JF	3	CL	12	
K16-370 (UG Hole 2)	181.88	Mafic Sill (MAFI)	73	305	JF	3	CL	6	
K16-370 (UG Hole 2)	182.05	Mafic Sill (MAFI)	63	305	JF	3	MI	6	
K16-370 (UG Hole 2)	182.21	Mafic Sill (MAFI)	65	320	JF	3	CL	6	
K16-370 (UG Hole 2)	183.21	Mafic Sill (MAFI)	70	340	JN	3	-	20	
K16-370 (UG Hole 2)	183.80	Mafic Sill (MAFI)	59	325	JF	3	CH	12	
K16-370 (UG Hole 2)	183.83	Mafic Sill (MAFI)	40	50	JF	3	CH	12	
K16-370 (UG Hole 2)	184.17	Mafic Sill (MAFI)	54	300	JF	3	CH	6	
K16-370 (UG Hole 2)	184.26	Mafic Sill (MAFI)	59	315	JF	3	MI	20	
K16-370 (UG Hole 2)	184.30	Mafic Sill (MAFI)	62	290	JF	3	CH/CL	6	
K16-370 (UG Hole 2)	184.32	Mafic Sill (MAFI)	31	255	JN	3	CL	20	
K16-370 (UG Hole 2)	184.55	Mafic Sill (MAFI)	21	240	JN	3	-	22	
K16-370 (UG Hole 2)	184.66	Mafic Sill (MAFI)	72	305	JF	3	SE	12	
K16-370 (UG Hole 2)	185.27	Mafic Sill (MAFI)	58	325	JF	3	CH	12	
K16-370 (UG Hole 2)	185.46	Mafic Sill (MAFI)	60	300	JF	3	CH/CA	12	
K16-370 (UG Hole 2)	185.67	Mafic Sill (MAFI)	57	350	JF	3	CH	20	
K16-370 (UG Hole 2)	185.91	Mafic Sill (MAFI)	76	70	JN	3	CA	12	
K16-370 (UG Hole 2)	186.21	Mafic Sill (MAFI)	57	0	JF	3	CH	16	
K16-370 (UG Hole 2)	186.46	Mafic Sill (MAFI)	57	335	JF	3	CH	16	
K16-370 (UG Hole 2)	186.95	Mafic Sill (MAFI)	47	140	JN	3	CH	20	
K16-370 (UG Hole 2)	187.42	Mafic Sill (MAFI)	55	325	JF	3	CH	12	
K16-370 (UG Hole 2)	187.58	Mafic Sill (MAFI)	62	305	JN	3	CH	16	
K16-370 (UG Hole 2)	188.43	Mafic Sill (MAFI)	61	355	JF	3	-	16	
K16-370 (UG Hole 2)	189.06	Mafic Sill (MAFI)	57	330	JF	3	CH	12	
K16-370 (UG Hole 2)	189.24	Mafic Sill (MAFI)	50	300	JN	3	CH	12	
K16-370 (UG Hole 2)	189.53	Mafic Sill (MAFI)	66	310	JN	3	CH	12	
K16-370 (UG Hole 2)	190.17	Mafic Sill (MAFI)	30	300	JF	3	CH	16	
K16-370 (UG Hole 2)	190.24	Mafic Sill (MAFI)	45	325	JF	3	CH	16	
K16-370 (UG Hole 2)	190.30	Mafic Sill (MAFI)	54	340	JF	3	CH	12	
K16-370 (UG Hole 2)	190.33	Mafic Sill (MAFI)	65	0	JF	3	CH	16	
K16-370 (UG Hole 2)	190.53	Mafic Sill (MAFI)	32	330	JN	3	CH	20	
K16-370 (UG Hole 2)	190.64	Mafic Sill (MAFI)	65	355	JF	3	CH	16	
K16-370 (UG Hole 2)	190.74	Mafic Sill (MAFI)	70	325	JF	3	CH	16	
K16-370 (UG Hole 2)	191.05	Mafic Sill (MAFI)	66	30	JF	3	CA	16	
K16-370 (UG Hole 2)	191.31	Mafic Sill (MAFI)	50	275	JF	3	CA	16	
K16-370 (UG Hole 2)	191.48	Mafic Sill (MAFI)	25	340	JN	3	CA	20	
K16-370 (UG Hole 2)	191.52	Mafic Sill (MAFI)	70	105	JN	3	-	22	
K16-370 (UG Hole 2)	192.11	Mafic Sill (MAFI)	65	345	JF	3	CH	12	
K16-370 (UG Hole 2)	192.21	Mafic Sill (MAFI)	45	330	JN	3	CH	16	
K16-370 (UG Hole 2)	192.50	Mafic Sill (MAFI)	57	0	JF	3	CH	16	
K16-370 (UG Hole 2)	192.52	Mafic Sill (MAFI)	80	30	JN	3	CH	16	
K16-370 (UG Hole 2)	193.02	Mafic Sill (MAFI)	71	315	JF	3	CH	12	
K16-370 (UG Hole 2)	193.15	Mafic Sill (MAFI)	50	290	JN	3	CH	12	
K16-370 (UG Hole 2)	193.18	Mafic Sill (MAFI)	52	295	JN	3	CH	12	
K16-370 (UG Hole 2)	193.98	Mafic Sill (MAFI)	60	0	JF	3	CH	12	
K16-370 (UG Hole 2)	194.25	Mafic Sill (MAFI)	64	345	JF	3	CH	16	
K16-370 (UG Hole 2)	194.32	Mafic Sill (MAFI)	54	355	JN	3	CA	16	
K16-370 (UG Hole 2)	194.35	Mafic Sill (MAFI)	61	330	JF	3	CH	16	
K16-370 (UG Hole 2)	194.72	Mafic Sill (MAFI)	73	35	JN	3	CH	16	
K16-370 (UG Hole 2)	194.74	Mafic Sill (MAFI)	76	0	JN	3	CH	12	
K16-370 (UG Hole 2)	194.78	Mafic Sill (MAFI)	65	345	JN	3	CH	12	
K16-370 (UG Hole 2)	194.85	Mafic Sill (MAFI)	52	350	JF	3	CH	12	
K16-370 (UG Hole 2)	194.91	Mafic Sill (MAFI)	50	120	JN	3	CH	6	
K16-370 (UG Hole 2)	195.05	Mafic Sill (MAFI)	59	190	JN	1	-	22	
K16-370 (UG Hole 2)	195.43	Mafic Sill (MAFI)	64	300	JF	1	CH	12	
K16-370 (UG Hole 2)	195.69	Mafic Sill (MAFI)	62	305	JF	1	CH	12	
K16-370 (UG Hole 2)	196.07	Mafic Sill (MAFI)	57	305	JF	1	CH	12	
K16-370 (UG Hole 2)	196.22	Mafic Sill (MAFI)	37	240	JN	1	CL	16	
K16-370 (UG Hole 2)	197.80	Mafic Sill (MAFI)	58	350	JF	1	CL/MI	0	
K16-370 (UG Hole 2)	197.83	Mafic Sill (MAFI)	60	340	JF	1	CH	6	
K16-370 (UG Hole 2)	197.85	Mafic Sill (MAFI)	52	330	JN	1	CH	16	
K16-370 (UG Hole 2)	198.14	Massive Sulfide (OB)	66	320	JN	1	CL	0	
K16-370 (UG Hole 2)	198.36	Massive Sulfide (OB)	7	120	JN	1	SU	16	
K16-370 (UG Hole 2)	199.54	Mafic Sill (MAFI)	50	320	JN	1	CL	0	
K16-370 (UG Hole 2)	199.66	Mafic Sill (MAFI)	61	340	JN	1	CL	0	
K16-370 (UG Hole 2)	199.90	Mafic Sill (MAFI)	33	330	JN	1	CH	6	
K16-370 (UG Hole 2)	200.10	Massive Sulfide (OB)	49	315	JN	1	MI	12	

K16-370 (UG Hole 2)	200.16	Massive Sulfide (OB)	33	345	JN	1	CH/CL	6	
K16-370 (UG Hole 2)	200.21	Massive Sulfide (OB)	32	330	JN	1	SU	20	
K16-370 (UG Hole 2)	200.36	Massive Sulfide (OB)	44	150	JN	1	CH	16	
K16-370 (UG Hole 2)	200.53	Mafic Sill (MAFi)	41	325	JF	1	CL	12	
K16-370 (UG Hole 2)	200.56	Mafic Sill (MAFi)	40	330	JN	1	CL/CH	6	
K16-370 (UG Hole 2)	200.63	Mafic Sill (MAFi)	31	165	JF	1	CL	6	
K16-370 (UG Hole 2)	200.84	Mafic Sill (MAFi)	24	165	JF	1	CL/CH	6	
K16-370 (UG Hole 2)	200.88	Mafic Sill (MAFi)	25	170	JF	1	CL	12	
K16-370 (UG Hole 2)	200.98	Mafic Sill (MAFi)	37	330	JN	1	CL	12	
K16-370 (UG Hole 2)	201.02	Mafic Sill (MAFi)	24	150	JF	1	CL	12	
K16-370 (UG Hole 2)	201.08	Mafic Sill (MAFi)	37	170	JF	1	CH	12	
K16-370 (UG Hole 2)	201.15	Mafic Sill (MAFi)	36	300	JF	3	CH/CL	12	
K16-370 (UG Hole 2)	201.38	Mafic Sill (MAFi)	29	295	JF	3	SE/CH	12	
K16-370 (UG Hole 2)	201.51	Mafic Sill (MAFi)	28	290	JF	3	MI	12	
K16-370 (UG Hole 2)	201.84	Mafic Sill (MAFi)	41	305	JF	3	CH/CL	12	
K16-370 (UG Hole 2)	201.95	Mafic Sill (MAFi)	31	30	JF	3	CH/CA	12	
K16-370 (UG Hole 2)	202.06	Mafic Sill (MAFi)	36	310	JF	3	CL/CH	6	
K16-370 (UG Hole 2)	202.38	Mafic Sill (MAFi)	33	305	JF	3	CH	0	
K16-370 (UG Hole 2)	202.44	Mafic Sill (MAFi)	36	315	JF	3	CH/CL	12	
K16-370 (UG Hole 2)	202.65	Mafic Sill (MAFi)	32	335	JF	3	SE/CH	16	
K16-370 (UG Hole 2)	202.78	Mafic Sill (MAFi)	33	325	JF	3	CH	12	
K16-370 (UG Hole 2)	203.24	Mafic Sill (MAFi)	31	325	JF	3	CH	12	
K16-370 (UG Hole 2)	203.48	Mafic Sill (MAFi)	32	310	JF	3	CH	12	
K16-370 (UG Hole 2)	204.16	Mafic Sill (MAFi)	36	330	JF	3	CH	12	
K16-370 (UG Hole 2)	204.28	Mafic Sill (MAFi)	28	315	JF	3	CH	12	
K16-370 (UG Hole 2)	204.54	Mafic Sill (MAFi)	25	330	JF	3	CA	16	
K16-370 (UG Hole 2)	205.75	Mafic Sill (MAFi)	47	335	JF	3	CH	12	
K16-370 (UG Hole 2)	205.87	Mafic Sill (MAFi)	18	125	JN	3	-	22	
K16-370 (UG Hole 2)	206.78	Mafic Sill (MAFi)	62	340	JF	3	CH	12	
K16-370 (UG Hole 2)	206.81	Mafic Sill (MAFi)	50	320	JF	3	CL	12	
K16-370 (UG Hole 2)	206.96	Mafic Sill (MAFi)	35	290	JN	3	CH	12	
K16-370 (UG Hole 2)	207.36	Mafic Sill (MAFi)	36	300	JF	3	CA	16	
K16-370 (UG Hole 2)	207.43	Mafic Sill (MAFi)	41	325	JF	3	CH	6	
K16-370 (UG Hole 2)	208.45	Mafic Sill (MAFi)	50	315	JF	3	CH	12	
K16-370 (UG Hole 2)	209.57	Mafic Sill (MAFi)	39	355	JF	3	CH	12	
K16-370 (UG Hole 2)	209.87	Mafic Sill (MAFi)	37	325	JF	3	CH/CL	6	
K16-370 (UG Hole 2)	211.93	Mafic Sill (MAFi)	46	355	JF	3	CH	12	
K16-370 (UG Hole 2)	212.51	Mafic Sill (MAFi)	41	325	JF	3	CH/CL	6	
K16-370 (UG Hole 2)	213.98	Mafic Sill (MAFi)	54	340	JF	3	CH	12	
K16-370 (UG Hole 2)	215.47	Mafic Sill (MAFi)	55	30	JF	3	CH	12	
K16-370 (UG Hole 2)	215.49	Mafic Sill (MAFi)	49	45	JN	3	CH	12	
K16-370 (UG Hole 2)	215.76	Mafic Sill (MAFi)	65	15	JN	3	SE/CH	16	
K16-370 (UG Hole 2)	216.09	Mafic Sill (MAFi)	49	350	JF	3	SE	16	
K16-370 (UG Hole 2)	216.38	Mafic Sill (MAFi)	41	355	JF	3	CH/CL	6	
K16-370 (UG Hole 2)	216.97	Mafic Sill (MAFi)	45	355	JF	3	CH	16	
K16-370 (UG Hole 2)	218.35	Mafic Sill (MAFi)	47	340	JF	3	CH	16	
K16-370 (UG Hole 2)	218.46	Mafic Sill (MAFi)	65	335	JF	3	CH	16	
K16-370 (UG Hole 2)	218.87	Mafic Sill (MAFi)	60	345	JF	3	CH	16	
K16-370 (UG Hole 2)	218.90	Mafic Sill (MAFi)	54	330	JF	3	CH	16	
K16-370 (UG Hole 2)	220.27	Mafic Sill (MAFi)	49	330	JF	3	CH	16	
K16-370 (UG Hole 2)	220.39	Mafic Sill (MAFi)	44	330	JF	3	CH	12	
K16-370 (UG Hole 2)	220.62	Mafic Sill (MAFi)	23	340	JN	3	MI	20	
K16-370 (UG Hole 2)	222.05	Mafic Sill (MAFi)	45	330	JF	3	CH/HE	12	
K16-370 (UG Hole 2)	222.32	Mafic Sill (MAFi)	53	355	JF	3	MI	12	
K16-370 (UG Hole 2)	222.89	Mafic Sill (MAFi)	60	355	JF	3	CH	16	
K16-370 (UG Hole 2)	223.08	Mafic Sill (MAFi)	46	305	JN	3	CH	12	
K16-370 (UG Hole 2)	223.22	Mafic Sill (MAFi)	37	300	JN	3	CH	16	
K16-370 (UG Hole 2)	223.38	Mafic Sill (MAFi)	54	350	JF	3	CH	6	
K16-370 (UG Hole 2)	223.64	Mafic Sill (MAFi)	54	15	JF	3	CH	12	
K16-370 (UG Hole 2)	223.81	Mafic Sill (MAFi)	65	345	JN	3	CH	12	
K16-370 (UG Hole 2)	224.05	Mafic Sill (MAFi)	35	335	JN	3	CH/CL	6	
K16-370 (UG Hole 2)	224.17	Mafic Sill (MAFi)	62	10	JF	3	CL	12	
K16-370 (UG Hole 2)	224.78	Coherent Rhyolite (RHYc)	62	345	JF	3	MI	6	
K16-370 (UG Hole 2)	224.85	Coherent Rhyolite (RHYc)	60	335	JF	3	MI	6	
K16-370 (UG Hole 2)	224.87	Coherent Rhyolite (RHYc)	62	0	JF	3	MI	6	
K16-370 (UG Hole 2)	225.39	Coherent Rhyolite (RHYc)	72	5	FLT	3	MI/CL	0	
K16-370 (UG Hole 2)	225.55	Coherent Rhyolite (RHYc)	63	345	JF	3	MI	12	
K16-370 (UG Hole 2)	225.73	Coherent Rhyolite (RHYc)	43	170	JN	3	CL	16	
K16-370 (UG Hole 2)	226.25	Coherent Rhyolite (RHYc)	65	55	JN	3	MI/CL	6	
K16-370 (UG Hole 2)	232.37	Coherent Rhyolite (RHYc)	74	270	JF	1	MI/SE	16	
K16-370 (UG Hole 2)	232.43	Volcaniclastic Rhyolite (RHYv)	52	90	JN	1	CH	12	
K16-370 (UG Hole 2)	233.10	Volcaniclastic Rhyolite (RHYv)	55	330	JF	1	MI	6	
K16-370 (UG Hole 2)	233.13	Volcaniclastic Rhyolite (RHYv)	66	310	JF	1	CL/MI	6	
K16-370 (UG Hole 2)	233.40	Volcaniclastic Rhyolite (RHYv)	70	340	JF	1	CL/MI	6	
K16-370 (UG Hole 2)	233.51	Volcaniclastic Rhyolite (RHYv)	65	320	JF	1	MI	6	
K16-370 (UG Hole 2)	233.68	Volcaniclastic Rhyolite (RHYv)	67	345	FLT	1	CR/CL	0	
K16-370 (UG Hole 2)	233.97	Volcaniclastic Rhyolite (RHYv)	38	30	JN	1	CL	16	
K16-370 (UG Hole 2)	234.13	Volcaniclastic Rhyolite (RHYv)	59	30	JF	1	CL	6	
K16-370 (UG Hole 2)	234.29	Volcaniclastic Rhyolite (RHYv)	62	25	JF	1	CL/MI	6	
K16-370 (UG Hole 2)	234.35	Volcaniclastic Rhyolite (RHYv)	66	15	JF	1	CL/MI	12	
K16-370 (UG Hole 2)	234.38	Volcaniclastic Rhyolite (RHYv)	65	110	FLT	1	CL/CH	0	
K16-370 (UG Hole 2)	234.54	Volcaniclastic Rhyolite (RHYv)	70	40	JF	1	MI	12	
K16-370 (UG Hole 2)	234.83	Volcaniclastic Rhyolite (RHYv)	70	30	JF	1	CL	6	
K16-370 (UG Hole 2)	234.98	Volcaniclastic Rhyolite (RHYv)	66	30	JF	1	CL/MI	6	
K16-370 (UG Hole 2)	235.14	Volcaniclastic Rhyolite (RHYv)	76	50	FLT	1	CL/MI	6	
K16-370 (UG Hole 2)	235.39	Volcaniclastic Rhyolite (RHYv)	60	60	JN	1	CA	16	
K16-370 (UG Hole 2)	235.58	Volcaniclastic Rhyolite (RHYv)	73	40	JF	1	CL/MI	12	
K16-370 (UG Hole 2)	235.63	Volcaniclastic Rhyolite (RHYv)	56	50	JN	1	CA/CL	16	
K16-370 (UG Hole 2)	236.51	Volcaniclastic Rhyolite (RHYv)	70	330	JF	1	CL/CH	12	
K16-370 (UG Hole 2)	236.71	Volcaniclastic Rhyolite (RHYv)	71	340	JF	1	CL/CH	12	
K16-370 (UG Hole 2)	237.16	Volcaniclastic Rhyolite (RHYv)	74	270	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	237.61	Volcaniclastic Rhyolite (RHYv)	64	270	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	237.77	Volcaniclastic Rhyolite (RHYv)	70	300	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	237.88	Volcaniclastic Rhyolite (RHYv)	68	290	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	237.90	Volcaniclastic Rhyolite (RHYv)	66	280	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	238.70	Volcaniclastic Rhyolite (RHYv)	66	330	JF	2	CL/CH	12	
K16-370 (UG Hole 2)	238.72	Volcaniclastic Rhyolite (RHYv)	65	315	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	239.13	Volcaniclastic Rhyolite (RHYv)	63	330	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	239.16	Volcaniclastic Rhyolite (RHYv)	66	320	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	239.26	Volcaniclastic Rhyolite (RHYv)	67	320	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	239.44	Volcaniclastic Rhyolite (RHYv)	61	315	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	239.70	Volcaniclastic Rhyolite (RHYv)	38	70	JN	2	CL	16	
K16-370 (UG Hole 2)	239.93	Volcaniclastic Rhyolite (RHYv)	67	320	JF	2	CL	12	
K16-370 (UG Hole 2)	240.20	Volcaniclastic Rhyolite (RHYv)	65	290	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	240.39	Volcaniclastic Rhyolite (RHYv)	32	280	JN	2	CL	16	
K16-370 (UG Hole 2)	240.56	Volcaniclastic Rhyolite (RHYv)	66	290	JF	2	CL/MI	12	
K16-370 (UG Hole 2)	240.79	Volcaniclastic Rhyolite (RHYv)	60	120	JN	2	CL/MI	16	
K16-370 (UG Hole 2)	240.96	Volcaniclastic Rhyolite (RHYv)	23	250	JN	2	CL/MI	12	
K16-370 (UG Hole 2)	241.09	Volcaniclastic Rhyolite (RHYv)	64	310	JF	2	CL/MI	12	
K16-370 (UG Hole 2)	241.20	Volcaniclastic Rhyolite (RHYv)	28	290	JN	2	CL	16	
K16-370 (UG Hole 2)	241.35	Volcaniclastic Rhyolite (RHYv)	65	310	JF	2	CL	12	
K16-370 (UG Hole 2)	241.41	Volcaniclastic Rhyolite (RHYv)	73	71	JF	2	CL	12	
K16-370 (UG Hole 2)	241.71	Volcaniclastic Rhyolite (RHYv)	65	33	FLT	2	CL	0	
K16-370 (UG Hole 2)	242.16	Volcaniclastic Rhyolite (RHYv)	63	325	JF	2	CL	12	
K16-370 (UG Hole 2)	242.35	Volcaniclastic Rhyolite (RHYv)	22	260	JN	2	CL	12	
K16-370 (UG Hole 2)	242.67	Volcaniclastic Rhyolite (RHYv)	40	320	JN	2	CL	12	
K16-370 (UG Hole 2)	242.78	Volcaniclastic Rhyolite (RHYv)	58	310	JN	2	CL	12	
K16-370 (UG Hole 2)	242.84	Volcaniclastic Rhyolite (RHYv)	58	110	JN	2	CL	16	
K16-370 (UG Hole 2)	243.32	Volcaniclastic Rhyolite (RHYv)	34	330	JN	2	CL	12	
K16-370 (UG Hole 2)	243.44	Volcaniclastic Rhyolite (RHYv)	57	290	JN	2	CL	12	
K16-370 (UG Hole 2)	243.47	Volcaniclastic Rhyolite (RHYv)	70	320	JF	2	CL	12	
K16-370 (UG Hole 2)	243.24	Volcaniclastic Rhyolite (RHYv)	63	310	JF	2	CL	12	
K16-370 (UG Hole 2)	243.91	Volcaniclastic Rhyolite (RHYv)	58	310	JF	2	CL	12	
K16-370 (UG Hole 2)	244.02	Volcaniclastic Rhyolite (RHYv)	64	320	JF	2	CL	12	
K16-370 (UG Hole 2)	244.74	Volcaniclastic Rhyolite (RHYv)	60	70	JN	2	CH/SE	12	
K16-370 (UG Hole 2)	244.76	Volcaniclastic Rhyolite (RHYv)	73	50	JN	2	CH	12	
K16-370 (UG Hole 2)	244.92	Volcaniclastic Rhyolite (RHYv)	51	80	JN	2	CH/CL	12	
K16-370 (UG Hole 2)	245.14	Volcaniclastic Rhyolite (RHYv)	72	310	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	245.57	Volcaniclastic Rhyolite (RHYv)	63	320	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	245.69	Volcaniclastic Rhyolite (RHYv)	61	320	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	245.87	Volcaniclastic Rhyolite (RHYv)	64	310	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	246.00	Volcaniclastic Rhyolite (RHYv)	63	320	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	246.25	Volcaniclastic Rhyolite (RHYv)	62	320	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	246.31	Volcaniclastic Rhyolite (RHYv)	64	315	JF	2	CL/MI	12	
K16-370 (UG Hole 2)	246.59	Volcaniclastic Rhyolite (RHYv)	33	320	JN	2	CL	12	
K16-370 (UG Hole 2)	246.66	Volcaniclastic Rhyolite (RHYv)	46	100	JN	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	246.69	Volcaniclastic Rhyolite (RHYv)	65	310	JN	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	246.72	Volcaniclastic Rhyolite (RHYv)	63	320	JN	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	246.74	Volcaniclastic Rhyolite (RHYv)	34	140	JN	2	CL	12	
K16-370 (UG Hole 2)	247.17	Volcaniclastic Rhyolite (RHYv)	58	290	JN	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	247.21	Volcaniclastic Rhyolite (RHYv)	58	310	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	247.61	Volcaniclastic Rhyolite (RHYv)	65	300	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	247.70	Volcaniclastic Rhyolite (RHYv)	12	235	JN	2	CH/CL	16	
K16-370 (UG Hole 2)	248.24	Volcaniclastic Rhyolite (RHYv)	64	240	JN	2	CL	16	
K16-370 (UG Hole 2)	248.30	Volcaniclastic Rhyolite (RHYv)	60	315	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	248.59	Volcaniclastic Rhyolite (RHYv)	66	340	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	248.61	Volcaniclastic Rhyolite (RHYv)	67	340	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	249.13	Volcaniclastic Rhyolite (RHYv)	42	290	JN	2	CL	12	
K16-370 (UG Hole 2)	249.25	Volcaniclastic Rhyolite (RHYv)	70	310	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	249.86	Volcaniclastic Rhyolite (RHYv)	67	325	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	249.88	Volcaniclastic Rhyolite (RHYv)	61	330	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	249.98	Volcaniclastic Rhyolite (RHYv)	62	320	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	250.90	Volcaniclastic Rhyolite (RHYv)	68	340	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	251.58	Volcaniclastic Rhyolite (RHYv)	70	340	JF	2	CL/SE/MI	6	
K16-370 (UG Hole 2)	251.66	Volcaniclastic Rhyolite (RHYv)	65	320	JF	2	CH/CL	12	
K16-370 (UG Hole 2)	251.87	Volcaniclastic Rhyolite (RHYv)	75	320	JF	2	CL/SE/MI	12	
K16-370 (UG Hole 2)	252.73	Volcaniclastic Rhyolite (RHYv)	62	80	JN	2	CL	6	
K16-370 (UG Hole 2)	253.42	Volcaniclastic Rhyolite (RHYv)	57	290	JF	2	CL	12	
K16-370 (UG Hole 2)	254.23	Volcaniclastic Rhyolite (RHYv)	68	310	JN	2	CL	12	
K16-370 (UG Hole 2)	254.54	Volcaniclastic Rhyolite (RHYv)	67	320	JN	2	CL	12	
K16-370 (UG Hole 2)	254.75	Volcaniclastic Rhyolite (RHYv)	72	340	JN	2	CL	12	
K16-370 (UG Hole 2)	255.01	Volcaniclastic Rhyolite (RHYv)	60	120	JN	2	CA	20	
K16-370 (UG Hole 2)	255.10	Volcaniclastic Rhyolite (RHYv)	36	100	JN	2	CA	20	
K16-370 (UG Hole 2)	255.30	Volcaniclastic Rhyolite (RHYv)	75	0	JN	2	MI/CL	12	
K16-370 (UG Hole 2)	257.07	Volcaniclastic Rhyolite (RHYv)	56	345	JF	1	MI/CL	12	
K16-370 (UG Hole 2)	257.29	Volcaniclastic Rhyolite (RHYv)	77	305	JF	1	MI	12	
K16-370 (UG Hole 2)	257.37	Volcaniclastic Rhyolite (RHYv)	74	240	JN	1	CL	12	
K16-370 (UG Hole 2)	257.57	Volcaniclastic Rhyolite (RHYv)	61	330	JF	1	CL	12	
K16-370 (UG Hole 2)	257.63	Volcaniclastic Rhyolite (RHYv)	68	320	JF	1	CL/CH	6	
K16-370 (UG Hole 2)	258.48	Volcaniclastic Rhyolite (RHYv)	76	300	JF	3	MI	6	
K16-370 (UG Hole 2)	258.69	Volcaniclastic Rhyolite (RHYv)	72	305	JF	3	MI	6	
K16-370 (UG Hole 2)	258.79	Volcaniclastic Rhyolite (RHYv)	55	325	JN	3	CL	6	
K16-370 (UG Hole 2)	259.96	Volcaniclastic Rhyolite (RHYv)	65	275	JF	3	CL	12	
K16-370 (UG Hole 2)	260.50	Volcaniclastic Rhyolite (RHYv)	74	270	JF	3	CA	16	
K16-370 (UG Hole 2)	260.62	Volcaniclastic Rhyolite (RHYv)	63	285	JF	3	MI/CL	6	
K16-370 (UG Hole 2)	261.24	Volcaniclastic Rhyolite (RHYv)	66	290	JF	3	MI/CL	6	
K16-370 (UG Hole 2)	261.37	Volcaniclastic Rhyolite (RHYv)	78	280	JF	3	MI/CL	6	
K16-370 (UG Hole 2)	261.57	Volcaniclastic Rhyolite (RHYv)	75	330	JN	1	MU	6	
K16-370 (UG Hole 2)	261.68	Volcaniclastic Rhyolite (RHYv)	78	300	JN	1	MU	12	
K16-370 (UG Hole 2)	261.77	Volcaniclastic Rhyolite (RHYv)	69	270	JN	1	MU	12	
K16-370 (UG Hole 2)	261.98	Volcaniclastic Rhyolite (RHYv)	66	270	JN	1	MU	12	
K16-370 (UG Hole 2)	262.66	Volcaniclastic Rhyolite (RHYv)	73	180	JN	1	CL	12	
K16-370 (UG Hole 2)	262.73	Volcaniclastic Rhyolite (RHYv)	70	180	JN	1	MU	12	
K16-370 (UG Hole 2)	262.76	Volcaniclastic Rhyolite (RHYv)	81	180	JN	1	MU	6	Slickenside
K16-370 (UG Hole 2)	262.80	Volcaniclastic Rhyolite (RHYv)	46	180	JN	1	MU	12	
K16-370 (UG Hole 2)	262.86	Volcaniclastic Rhyolite (RHYv)	61	180	JN	1	MU	12	
K16-370 (UG Hole 2)	262.93	Volcaniclastic Rhyolite (RHYv)	47	120	JN	1	MU	12	
K16-370 (UG Hole 2)	263.06	Volcaniclastic Rhyolite (RHYv)	76	60	JN	1	MU	12	
K16-370 (UG Hole 2)	263.12	Volcaniclastic Rhyolite (RHYv)	67	60	JN	1	MU	12	
K16-370 (UG Hole 2)	263.13	Volcaniclastic Rhyolite (RHYv)	73	60	JN	1	MU	6	Slickenside
K16-370 (UG Hole 2)	263.16	Volcaniclastic Rhyolite (RHYv)	70	60	JN	1	MU	6	Slickenside
K16-370 (UG Hole 2)	264.04	Volcaniclastic Rhyolite (RHYv)	63	30	JN	1	MU	6	Slickenside
K16-370 (UG Hole 2)	264.06	Volcaniclastic Rhyolite (RHYv)	72	30	JN	1	MU	12	
K16-370 (UG Hole 2)	264.20	Volcaniclastic Rhyolite (RHYv)	74	30	JN	1	MU	12	
K16-370 (UG Hole 2)	264.25	Volcaniclastic Rhyolite (RHYv)	49	120	JN	1	CL	6	
K16-370 (UG Hole 2)	264.33	Volcaniclastic Rhyolite (RHYv)	70	30	JN	1	MU	12	
K16-370 (UG Hole 2)	270.08	Volcaniclastic Rhyolite (RHYv)	56	0	JN	1	CL	12	
K16-370 (UG Hole 2)	270.18	Volcaniclastic Rhyolite (RHYv)	59	0	JN	1	MU	16	
K16-370 (UG Hole 2)	270.21	Volcaniclastic Rhyolite (RHYv)	75	330	JN	1	MU	12	
K16-370 (UG Hole 2)	270.28	Volcaniclastic Rhyolite (RHYv)	60	330	JN	1	CL	12	
K16-370 (UG Hole 2)	270.39	Volcaniclastic Rhyolite (RHYv)	63	330	JN	1	CL	12	
K16-370 (UG Hole 2)	270.49	Volcaniclastic Rhyolite (RHYv)	60	330	JN	1	CL	12	
K16-370 (UG Hole 2)	270.54	Volcaniclastic Rhyolite (RHYv)	66	330	JN	1	CL	12	
K16-370 (UG Hole 2)	270.60	Volcaniclastic Rhyolite (RHYv)	60	330	JN	1	MU	16	
K16-370 (UG Hole 2)	270.75	Volcaniclastic Rhyolite (RHYv)	49	330	JN	1	MU	16	
K16-370 (UG Hole 2)	270.78	Volcaniclastic Rhyolite (RHYv)	59	300	JN	1	MU	6	Slickenside
K16-370 (UG Hole 2)	271.00	Volcaniclastic Rhyolite (RHYv)	52	120	JN	1	CL	12	
K16-370 (UG Hole 2)	271.04	Volcaniclastic Rhyolite (RHYv)	63	300	JN	1	CL	12	
K16-370 (UG Hole 2)	271.27	Volcaniclastic Rhyolite (RHYv)	73	150	JN	1	CL	12	
K16-370 (UG Hole 2)	271.29	Volcaniclastic Rhyolite (RHYv)	65	30	JN	1	CL	12	
K16-370 (UG Hole 2)	271.30	Volcaniclastic Rhyolite (RHYv)	73	150	JN	1	CL	12	
K16-370 (UG Hole 2)	271.44	Volcaniclastic Rhyolite (RHYv)	60	180	JN	1	CL	12	
K16-370 (UG Hole 2)	271.54	Volcaniclastic Rhyolite (RHYv)	53	330	JN	1	CL	12	
K16-370 (UG Hole 2)	271.59	Volcaniclastic Rhyolite (RHYv)	73	330	JN	1	CL	12	
K16-370 (UG Hole 2)	271.92	Volcaniclastic Rhyolite (RHYv)	56	330	JN	1	CL	12	
K16-370 (UG Hole 2)	272.03	Volcaniclastic Rhyolite (RHYv)	50	330	HJN	1	CL	12	
K16-370 (UG Hole 2)	272.14	Volcaniclastic Rhyolite (RHYv)	53	330	JN	1	CL	12	
K16-370 (UG Hole 2)	272.19	Volcaniclastic Rhyolite (RHYv)	55	330	JN	1	MU	16	
K16-370 (UG Hole 2)	272.71	Volcaniclastic Rhyolite (RHYv)	63	0	JN	1	MU	16	
K16-370 (UG Hole 2)	272.72	Volcaniclastic Rhyolite (RHYv)	67	0	JN	1	MU	16	
K16-370 (UG Hole 2)	272.75	Volcaniclastic Rhyolite (RHYv)	74	330	HJN	1	CL	6	
K16-370 (UG Hole 2)	272.85	Volcaniclastic Rhyolite (RHYv)	60	0	JN	1	CL	12	
K16-370 (UG Hole 2)	273.04	Volcaniclastic Rhyolite (RHYv)	64	180	JN	1		20	
K16-370 (UG Hole 2)	273.24	Volcaniclastic Rhyolite (RHYv)	65	30	JN	1		20	
K16-370 (UG Hole 2)	273.36	Volcaniclastic Rhyolite (RHYv)	82	60	JN	1		16	
K16-370 (UG Hole 2)	273.41	Volcaniclastic Rhyolite (RHYv)	75	60	JN	1		20	
K16-370 (UG Hole 2)	273.48	Volcaniclastic Rhyolite (RHYv)	88	180	JN	1		20	
K16-370 (UG Hole 2)	273.50	Volcaniclastic Rhyolite (RHYv)	77	180	JN	1		20	
K16-370 (UG Hole 2)	273.58	Volcaniclastic Rhyolite (RHYv)	83	180	JN	1		16	
K16-370 (UG Hole 2)	273.71	Volcaniclastic Rhyolite (RHYv)	68	30	JN	1		22	
K16-370 (UG Hole 2)	273.93	Volcaniclastic Rhyolite (RHYv)	57	210	JN	1		16	
K16-370 (UG Hole 2)	274.03	Volcaniclastic Rhyolite (RHYv)	73	210	JN	1		16	
K16-370 (UG Hole 2)	274.05	Volcaniclastic Rhyolite (RHYv)	63	180	JN	1		16	
K16-370 (UG Hole 2)	274.21	Volcaniclastic Rhyolite (RHYv)	53	210	JN	1		16	
K16-370 (UG Hole 2)	274.25	Volcaniclastic Rhyolite (RHYv)	55	180	JN	1		20	
K16-370 (UG Hole 2)	274.36	Volcaniclastic Rhyolite (RHYv)	79	0	JN	1		20	
K16-370 (UG Hole 2)	279.30	Volcaniclastic Rhyolite (RHYv)	72	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.33	Volcaniclastic Rhyolite (RHYv)	48	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.45	Volcaniclastic Rhyolite (RHYv)	62	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.49	Volcaniclastic Rhyolite (RHYv)	72	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.59	Volcaniclastic Rhyolite (RHYv)	60	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.68	Volcaniclastic Rhyolite (RHYv)	65	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.75	Volcaniclastic Rhyolite (RHYv)	63	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.83	Volcaniclastic Rhyolite (RHYv)	63	330	JF	1	MU	12	

K16-370 (UG Hole 2)	279.88	Volcaniclastic Rhyolite (RHYv)	52	330	JF	1		20	
K16-370 (UG Hole 2)	279.95	Volcaniclastic Rhyolite (RHYv)	50	0	JF	1	MU	12	
K16-370 (UG Hole 2)	279.16	Volcaniclastic Rhyolite (RHYv)	53	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.23	Volcaniclastic Rhyolite (RHYv)	55	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.27	Volcaniclastic Rhyolite (RHYv)	58	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.31	Volcaniclastic Rhyolite (RHYv)	40	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.35	Volcaniclastic Rhyolite (RHYv)	60	330	JF	1	MU	12	
K16-370 (UG Hole 2)	279.40	Volcaniclastic Rhyolite (RHYv)	45	330	JF	1		16	

POINT LOAD TEST RESULTS

Equipment: **PIL-7** **Load Correction Factor =** 0.0948 kN/bar

Hole ID	Test No.	Depth of Top of Sample (m)	Lithology	Reading on gauge (MPa)	II or L to weak planes, if applicable	Test Type (d or a)	Comment and test quality	Distance Between Platens Before Test (mm)	Core diameter D (mm)	W (mm) only for axial tests	Pressure (bar)	Corrected Load L_c (kN)	For diam. test $D_e^2 = D^2$ (mm) / For axial test $D_e^2 = 4(WD)/pi$	Is (kN/mm^2)= P/D_e^2	F=$(D_e/50)^{0.45}$	$Is_{(50)}$ = F x I_s (MPa)	UCS Sample Match
K16-370 (UG Hole 2)	PLT-01	8.10	Aphanitic Rhyolite (RHYi)	14.84	II	d	Valid Test	61.10	61.10	61.10	148.4	14.07	3733.21	0.003768424	1.0944	4.12	
K16-370 (UG Hole 2)	PLT-02	10.80	Aphanitic Rhyolite (RHYi)	3.66	II	d	Valid Test - Failure along fabric	61.10	61.10	61.10	36.6	3.47	3733.21	0.000929409	1.0944	1.02	
K16-370 (UG Hole 2)	PLT-03	12.53	Aphanitic Rhyolite (RHYi)	14.06	II	d	Valid Test	61.10	61.10	61.10	140.6	13.33	3733.21	0.003570354	1.0944	3.91	
K16-370 (UG Hole 2)	PLT-04	13.08	Aphanitic Rhyolite (RHYi)	33.84	L	a	Valid Test	42.00	61.10	42.00	338.4	32.08	3267.39	0.00981834	1.0944	10.75	
K16-370 (UG Hole 2)	PLT-05	14.35	Aphanitic Rhyolite (RHYi)	4.3	II	d	Valid Test	61.10	61.10	61.10	43	4.08	3733.21	0.001091929	1.0944	1.20	
K16-370 (UG Hole 2)	PLT-06	16.18	Aphanitic Rhyolite (RHYi)	7.16	II	d	Valid Test	61.10	61.10	61.10	71.6	6.79	3733.21	0.001818189	1.0944	1.99	
K16-370 (UG Hole 2)	PLT-07	18.10	Pelite (PEL)	13.76	L	a	Failed Test	45.00	61.10	45.00	137.6	13.04	3500.77	0.003726172	1.0944	4.08	
K16-370 (UG Hole 2)	PLT-08	20.8	Aphanitic Rhyolite (RHYi)	4.88	II	d	Valid Test	61.10	61.10	61.10	48.8	4.63	3733.21	0.001239212	1.0944	1.36	
K16-370 (UG Hole 2)	PLT-09	24.3	Aphanitic Rhyolite (RHYi)	12.02	L	a	Valid Test	35	61.1	35.00	120.2	11.39	2722.82	0.00418498	1.0944	4.58	
K16-370 (UG Hole 2)	PLT-10	25.78	Aphanitic Rhyolite (RHYi)	11.24	II	d	Valid Test	61.1	61.1	61.10	112.4	10.66	3733.21	0.002854251	1.0944	3.12	
K16-370 (UG Hole 2)	PLT-11	27.32	Aphanitic Rhyolite (RHYi)	3.14	II	d	Failed Test	61.1	61.1	61.10	31.4	2.98	3733.21	0.000797362	1.0944	0.87	
K16-370 (UG Hole 2)	PLT-12	28.89	Aphanitic Rhyolite (RHYi)	5.09	II	d	Valid Test	61.1	61.1	61.10	50.9	4.83	3733.21	0.001292539	1.0944	1.41	
K16-370 (UG Hole 2)	PLT-13	30.69	Pelite (PEL)	5.06	II	d	Valid Test	61.1	61.1	61.10	50.6	4.80	3733.21	0.001284921	1.0944	1.41	
K16-370 (UG Hole 2)	PLT-14	32.17	Aphanitic Rhyolite (RHYi)	18.7	L	a	Valid Test	47	61.1	47.00	187	17.73	3656.36	0.004848426	1.0944	5.31	
K16-370 (UG Hole 2)	PLT-15	34.02	Aphanitic Rhyolite (RHYi)	12.72	II	d	Valid Test	61.1	61.1	61.10	127.2	12.06	3733.21	0.003230078	1.0944	3.54	
K16-370 (UG Hole 2)	PLT-16	35.85	Aphanitic Rhyolite (RHYi)	14.32	II	d	Valid Test	61.1	61.1	61.10	143.2	13.58	3733.21	0.003636377	1.0944	3.98	
K16-370 (UG Hole 2)	PLT-17	37.61	Aphanitic Rhyolite (RHYi)	11.04	II	d	Failed Test	61.1	61.1	61.10	110.4	10.47	3733.21	0.002803464	1.0944	3.07	
K16-370 (UG Hole 2)	PLT-18	39.56	Aphanitic Rhyolite (RHYi)	30.8	II	d	Valid Test	61.1	61.1	61.10	308	29.20	3733.21	0.007821258	1.0944	8.56	
K16-370 (UG Hole 2)	PLT-19	41.54	Aphanitic Rhyolite (RHYi)	24.4	II	d	Valid Test	61.1	61.1	61.10	244	23.13	3733.21	0.006196062	1.0944	6.78	
K16-370 (UG Hole 2)	PLT-20	42.67	Aphanitic Rhyolite (RHYi)	30.96	L	a	Valid Test	40	61.1	40.00	309.6	29.35	3111.80	0.009431874	1.0944	10.32	
K16-370 (UG Hole 2)	PLT-21	44.23	Aphanitic Rhyolite (RHYi)	27.86	II	d	Valid Test	61.1	61.1	61.10	278.6	26.41	3733.21	0.007074684	1.0944	7.74	
K16-370 (UG Hole 2)	PLT-22	46.77	Aphanitic Rhyolite (RHYi)	3.42	II	d	Valid Test	61.1	61.1	61.10	34.2	3.24	3733.21	0.000868464	1.0944	0.95	
K16-370 (UG Hole 2)	PLT-23	47.88	Aphanitic Rhyolite (RHYi)	12.56	II	d	Failed Test	43	61.1	43.00	125.6	11.91	3733.21	0.003189448	1.0944	3.49	
K16-370 (UG Hole 2)	PLT-24	50.13	Aphanitic Rhyolite (RHYi)	18.16	II	d	Valid Test	61.1	61.1	61.10	181.6	17.22	3733.21	0.004611495	1.0944	5.05	
K16-370 (UG Hole 2)	PLT-25	51.99	Aphanitic Rhyolite (RHYi)	31.86	L	a	Failed Test	55	61.1	55.00	318.6	30.20	4278.72	0.00705895	1.0944	7.73	
K16-370 (UG Hole 2)	PLT-26	52.34	Aphanitic Rhyolite (RHYi)	12.3	II	d	Valid Test	61.1	61.1	61.10	123	11.66	3733.21	0.003123425	1.0944	3.42	
K16-370 (UG Hole 2)	PLT-27	54.07	Coherent Rhyolite (RHYc)	15.34	II	d	Valid Test	61.1	61.1	61.10	153.4	14.54	3733.21	0.003895393	1.0944	4.26	
K16-370 (UG Hole 2)	PLT-28	55.5	Pelite (PEL)	4.14	II	d	Valid Test - Failure along fabric	82	61.1	82.00	41.4	3.92	3733.21	0.001051299	1.0944	1.15	
K16-370 (UG Hole 2)	PLT-29	58.35	Volcaniclastic Rhyolite (RHYv)	7.38	II	d	Valid Test	101	61.1	101.00	73.8	7.00	3733.21	0.001874055	1.0944	2.05	
K16-370 (UG Hole 2)	PLT-30	60.65	Volcaniclastic Rhyolite (RHYv)	13.62	II	d	Valid Test	190	61.1	190.00	136.2	12.91	3733.21	0.003458621	1.0944	3.79	
K16-370 (UG Hole 2)	PLT-31	60.65	Volcaniclastic Rhyolite (RHYv)	34.9	L	a	Valid Test	52	61.1	52.00	349	33.09	4045.34	0.008178602	1.0944	8.95	
K16-370 (UG Hole 2)	PLT-32	62.84	Volcaniclastic Rhyolite (RHYv)	11.26	II	d	Valid Test	160	61.1	160.00	112.6	10.67	3733.21	0.00285933	1.0944	3.13	
K16-370 (UG Hole 2)	PLT-33	65.8	Volcaniclastic Rhyolite (RHYv)	3	II	d	Valid Test	91	61.1	91.00	30	2.84	3733.21	0.000761811	1.0944	0.83	
K16-370 (UG Hole 2)	PLT-34	67.5	Volcaniclastic Rhyolite (RHYv)	6.8	II	d	Valid Test	165	61.1	165.00	68	6.45	3733.21	0.001726771	1.0944	1.89	
K16-370 (UG Hole 2)	PLT-35	68.8	Volcaniclastic Rhyolite (RHYv)	6.04	II	d	Valid Test	127	61.1	127.00	60.4	5.73	3733.21	0.001533779	1.0944	1.68	
K16-370 (UG Hole 2)	PLT-36	68.8	Volcaniclastic Rhyolite (RHYv)	15.82	L	a	Valid Test	39	61.1	39.00	158.2	15.00	3034.00	0.004943094	1.0944	5.41	
K16-370 (UG Hole 2)	PLT-37	69.88	Volcaniclastic Rhyolite (RHYv)	3.85	L	a	Valid Test	55	61.1	55.00	38.5	3.65	4278.72	0.000853012	1.0944	0.93	
K16-370 (UG Hole 2)	PLT-38	72	Volcaniclastic Rhyolite (RHYv)	5.7	II	d	Valid Test	141	61.1	141.00	57	5.40	3733.21	0.001447441	1.0944	1.58	
K16-370 (UG Hole 2)	PLT-39	73.5	Volcaniclastic Rhyolite (RHYv)	5.1	L	a	Valid Test	43	61.1	43.00	51	4.83	3345.18	0.001445302	1.0944	1.58	
K16-370 (UG Hole 2)	PLT-40	79.36	Volcaniclastic Rhyolite (RHYv)	1.6	II	d	Valid Test	140	61.1	140.00	16	1.52	3733.21	0.000406299	1.0944	0.44	
K16-370 (UG Hole 2)	PLT-41	80.44	Volcaniclastic Rhyolite (RHYv)	2.42	L	a	Valid Test	44	61.1	44.00	24.2	2.29	3422.98	0.000670224	1.0944	0.73	
K16-370 (UG Hole 2)	PLT-42	82.02	Volcaniclastic Rhyolite (RHYv)	4.08	II	d	Valid Test	161	61.1	161.00	40.8	3.87	3733.21	0.001036063	1.0944	1.13	
K16-370 (UG Hole 2)	PLT-43	85.4	Volcaniclastic Rhyolite (RHYv)	7.14	II	d	Valid Test	101	61.1	101.00	71.4	6.77	3733.21	0.00181311	1.0944	1.98	
K16-370 (UG Hole 2)	PLT-44	88.5	Volcaniclastic Rhyolite (RHYv)	21.06	L	a	Valid Test	60	61.1	60.00	210.6	19.96	4667.70	0.004277245	1.0944	4.68	
K16-370 (UG Hole 2)	PLT-45	91.47	Volcaniclastic Rhyolite (RHYv)	20.3	L	a	Valid Test	33	61.1	33.00	203	19.24	2567.23	0.007496164	1.0944	8.20	
K16-370 (UG Hole 2)	PLT-46	94	Volcaniclastic Rhyolite (RHYv)	3.88	II	d	Valid Test	112	61.1	112.00	38.8	3.68	3733.21	0.000985275	1.0944	1.08	
K16-370 (UG Hole 2)	PLT-47	96.83	Volcaniclastic Rhyolite (RHYv)	1.22	II	d	Valid Test - Failure along fabric	173	61.1	173.00	12.2	1.16	3733.21	0.000309803	1.0944	0.34	
K16-370 (UG Hole 2)	PLT-48	98.99	Volcaniclastic Rhyolite (RHYv)	2.34	II	d	Valid Test	125	61.1	125.00	23.4	2.22	3733.21	0.000594212	1.0944	0.65	
K16-370 (UG Hole 2)	PLT-49	102	Volcaniclastic Rhyolite (RHYv)	6.04	II	d	Valid Test	169	61.1	169.00	60.4	5.73	3733.21	0.001533779	1.0944	1.68	
K16-370 (UG Hole 2)	PLT-50	106.88	Volcaniclastic Rhyolite (RHYv)	2.16	L	a	Valid Test - Failure along fabric	50	61.1	50.00	21.6	2.05	3889.75	0.00052643	1.0944	0.58	
K16-370 (UG Hole 2)	PLT-51	107.6	Volcaniclastic Rhyolite (RHYv)	1.96	L	a	Valid Test - Failure along fabric	39	61.1	39.00	19.6	1.86	3034.00	0.000612419	1.0944	0.67	
K16-370 (UG Hole 2)	PLT-52	111	Volcaniclastic Rhyolite (RHYv)	7.8	L	a	Valid Test - Failure along fabric	52	61.1	52.00	78	7.39	4045.34	0.001827882	1.0944	2.00	
K16-370 (UG Hole 2)	PLT-53	112.87	Volcaniclastic Rhyolite (RHYv)	4.68	II	d	Valid Test	173	61.1	173.00	46.8	4.44	3733.21	0.001188425	1.0944	1.30	
K16-370 (UG Hole 2)	PLT-54	116.54	Volcaniclastic Rhyolite (RHYv)	4.2	II	d	Valid Test	145	61.1	145.00	42	3.98	3733.21	0.001066535	1.0944	1.17	
K16-370 (UG Hole 2)	PLT-55	117.47	Volcaniclastic Rhyolite (RHYv)	11.3	L	a	Valid Test	55	61.1	55.00	113	10.71	4278.72	0.002503645	1.0944	2.74	
K16-370 (UG Hole 2)	PLT-56	123.07	Volcaniclastic Rhyolite (RHYv)	2.88	II	d	Valid Test	190	61.1	190.00	28.8	2.73	3733.21	0.000731338	1.0944	0.80	
K16-370 (UG Hole 2)	PLT-57	124.99	Coherent Rhyolite (RHYc)	8	II	d	Valid Test	122	61.1	122.00	80	7.58	3733.21	0.002031496	1.0944	2.22	
K16-370 (UG Hole 2)	PLT-58	125.95	Coherent Rhyolite (RHYc)	10.36	L	a	Valid Test	56	61.1	56.00	103.6	9.82	4356.52	0.002254388	1.0944	2.47	
K16-370 (UG Hole 2)	PLT-59	127.79	Coherent Rhyolite (RHYc)	10.48	L	a	Failed Test	51	61.1	51.00	104.8	9.94	3967.54	0.00250408	1.0944	2.74	
K16-370 (UG Hole 2)	PLT-60	128.86	Coherent Rhyolite (RHYc)	4.16	II	d	Valid Test	141	61.1	141.00	41.6	3.94	3733.21	0.001056378	1.0944	1.16	
K16-370 (UG Hole 2)	PLT-61	131.00	Mafic Sill (MAFi)	5.76	II	d	Valid Test - Failure along fabric	110.00	61.10	110.00	57.6	5.46	3733.21	0.001462677	1.0944	1.60	
K16-370 (UG Hole 2)	PLT-62	131.05	Mafic Sill (MAFi)	5.96	L	a	Valid Test	35.00	61.10	35.00	59.6	5.65	2722.82	0.002075082	1.0944	2.27	
K16-370 (UG Hole 2)	PLT-63	132.30	Mafic Sill (MAFi)	0.16	II	d	Valid Test - Failure along fabric	108.00	61.10	108.00	1.6	0.15	3733.21	4.06299E-05	1.0944	0.04	
K16-370 (UG Hole 2)	PLT-64	132.25	Mafic Sill (MAFi)	8.68	L	a	Valid Test	31.00	61.10	31.00	86.8	8.23	2411.64	0.003412047	1.0944	3.73	
K16-370 (UG Hole 2)	PLT-65	134.75	Mafic Sill (MAFi)	6.86	-	d	Valid Test	97.00	61.10	97.00	68.6	6.50	3733.21	0.001742008	1.0944	1.91	
K16-370 (UG Hole 2)	PLT-66	134.75	Mafic Sill (MAFi)	13.16	-	a	Valid Test	45.00	61.10	45.00	131.6	12.48	3500.77	0.003563694	1.0944	3.90	
K16-370 (UG Hole 2)	PLT-67	136.40	Mafic Sill (MAFi)	3.04	II	d	Valid Test - Failure along fabric	105.00	61.10	105.00	30.4	2.88	3733.21	0.000771968	1.0944	0.84	
K16-370 (UG Hole 2)	PLT-68	136.4	Mafic Sill (MAFi)	10.32	L	a	Valid Test	53.00	61.10	53.00	103.2	9.78	4123.13	0.002372798	1.0944	2.60	
K16-370 (UG Hole 2)	PLT-69	139.25	Stringer Sulfide (OJ)	6.78	L	a	Valid Test	47	61.1	47.00	67.8	6.43	3656.36	0.001757878	1.0944	1.92	
K16-370 (UG Hole 2)	PLT-70	140.35	Stringer Sulfide (OJ)	3.52	II	d	Valid Test - Failure along fabric	111	61.1	111.00	35.2	3.34	3733.21	0.000893858	1.0944	0.98	
K16-370 (UG Hole 2)	PLT-71	140.35	Stringer Sulfide (OJ)	9.88	L	a	Valid Test	51	61.1	51.00	98.8	9.37	3967.54	0.002360716	1.0944	2.58	
K16-370 (UG Hole 2)	PLT-72	143.25	Undifferentiated Rhyolite (RHY)	4.42	-	d	Valid Test	155	61.1	155.00	44.2	4.19	3733.21	0.001122401	1.0944	1.23	
K16-370 (UG Hole 2)	PLT-73	143.25	Undifferentiated Rhyolite (RHY)	11.82	L	a	Valid Test	40	61.1	40.00	118.2	11.21	3111.80	0.003600928	1.0944	3.94	
K16-370 (UG Hole 2)	PLT-74	145.3	Undifferentiated Rhyolite (RHY)	0.50	II	d	Valid Test - Failure along fabric	95	61.1	95.00	5	0.47	3733.21	0.000126968	1.0944	0.14	
K16-370 (UG Hole 2)	PLT-75	145.3	Undifferentiated Rhyolite (RHY)	1.56	L	a	Valid Test	29	61.1	29.00	15.6	1.48	2256.05	0.000655516	1.0944	0.72	
K16-370 (UG Hole 2)	PLT-76	146.4	Massive Sulfide (OA)	14.34	II	d	Valid Test - Failure along fabric	146	61.1	146.00	143.4	13.59	3733.21	0.003641456	1.0944	3.99	
K16-370 (UG Hole 2)	PLT-77	146.4	Massive Sulfide (OA)	15.22	L	a	Valid Test	31	61.1	31.00	152.2	14.43	2411.64	0.005982876	1.0944	6.55	
K16-370 (UG Hole 2)	PLT-78	147.95	Undifferentiated Rhyolite (RHY)	3.34	II	d	Valid Test - Failure along fabric	175	61.1	175.00	33.4	3.17	3733.21	0.000848149	1.0944	0.93	
K16-370 (UG Hole 2)	PLT-79	147.95	Undifferentiated Rhyolite (RHY)	2.98	L	a	Valid Test	28	61.1	28.00	29.8	2.83	2178.26	0.001296926	1.0944	1.42	

APPENDIX 3.
Preliminary Qualitative Risk Assessment

BMC MINERALS (NO.1) LTD

KUDZ ZE KAYAH PROJECT

PRELIMINARY QUANTITATIVE RISK ASSESSMENT

June 2017

EXECUTIVE SUMMARY

At the request of the Yukon Environmental and Socio-economic Assessment Board, BMC Minerals (No.1) Ltd. (BMC) has completed a human health risk assessment (HHRA) of environmental conditions of at the proposed Kudz Ze Kayah Mine Project (the Project). The objective of the HHRA was to determine if there are acceptable risks to human health from Contaminants of Potential Concern (COPCs) under the various Project Phases.

The HHRA was completed using Health Canada risk assessment guidance, environmental concentrations predicted by other disciplines and the assumption that the Mitigation and Management Measures (as outlined in BMC's Project Proposal for Executive Committee Screening) will be followed. Briefly, Health Canada Preliminary Quantitative Risk Assessment (PQRA) was used as the key basis of the risk assessment methods. Although not specifically developed by Health Canada for use in environmental assessment, Health Canada PQRA guidance was applied to provide upper bound estimates of human health risks.

Applying the Health Canada PQRA guidance, it was found that risks will be acceptable provided the key elements of the Mitigation and Management Measures are followed. For all COPCs other than fluoride and uranium, it was found that environmental concentrations will remain within the same range of current background concentrations and/or will not exceed existing environmental guidelines or criteria. Since guidelines for protection of human health are generally developed for protection of a Hazard Quotient of 0.2 and an Incremental Lifetime Cancer Risk of 1 x 10-5, no unacceptable risks are predicted as there will be no pathways for exposures to media exceeding guidelines that are protective of such risks.

In the case of fluoride and uranium, the Mitigation and Management Measures will adequately address these substances. Although it was not possible to quantitatively estimate risks from these metals, there is high confidence that risks will not exceed Hazard Quotient values of 0.2. Since neither of these substances are considered to be carcinogens, Incremental Lifetime Cancer Risk estimates are not estimated.

Overall, the HHRA has indicated acceptable risks when the RMP is implemented and maintained.

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1. INTRODUCTION

BMC Minerals (No.1) Ltd. (BMC) has completed a human health risk assessment (HHRA) of environmental conditions at the proposed Kudz Ze Kayah Mine Project (the Project). The objective of the HHRA was to determine if there are acceptable risks to human health from metals and other Contaminants of Potential Concern (COPC) under during the various Project phases (i.e., construction, operations and closure).

The HHRA was completed using Health Canada risk assessment guidance, environmental concentrations predicted by other disciplines and the assumption that the Mitigation and Management Measures as described in the Kudz Ze Kayah Project Proposal (Project Proposal) (BMC, 2017) will be followed. Briefly, Health Canada Preliminary Quantitative Risk Assessment (PQRA) guidance was used as the key basis of the risk assessment methods. Although not specifically developed by Health Canada for use in environmental assessment, Health Canada PQRA guidance was applied to provide upper bound estimates of human health risks as requested by Yukon Environmental and Socio-economic Assessment Board (YESAB) during their Adequacy Review of the Project Proposal.

This report outlines the methods, results, conclusions and recommendations of the HHRA and is organized as follows:

- Section 2 summarizes the site setting and relevant documents that provide information cited in the HHRA;
- Section 3 provides methods used to complete the HHRA;
- Section 4 provides the results of the HHRA;
- Section 5 provides the uncertainty analysis for the HHRA;
- Section 6 provides the conclusions of the HHRA;
- Section 7 provides the statement of limitations;
- Section 8 provides the references.

1.1 SCOPE OF WORK

The HHRA was based on the measured and predicted concentrations various of substances that have been reported by other disciplines. The measured and predicted concentration data (where available) are presented in the Project Proposal as follows: air quality (Chapter 6). Water quality (Chapter 8), Soil (Chapter 11) and Vegetation (Chapter 12). Noise has also been included in the HHRA. Baseline and predicted noise levels are presented in Chapter 7 of the Project Proposal. The HHRA was also based on the proposed Mitigation and Management measures and that are presented throughout the Project Proposal chapters (which are summarized in Chapter 18).

The methods used are based on guidance provided by Health Canada and the World Health Organization; however, the HHRA also incorporates the scientific literature to the maximum extent reasonable.

2. SUMMARY OF SITE SETTING AND BACKGROUND INFORMATION

BMC proposes the development of the KZK Project in southeast Yukon and within the Kaska traditional territory. The Project is a proposed open pit/underground copper, lead, and zinc mine located approximately 115 km southeast of Ross River, Yukon.

The Project lies within the Pelly River and Pelly Mountain ecoregions and is within the northern foothills of the Pelly Mountains of the Yukon Plateau. The elevations around Project area generally vary 800 to 1,800 metres above sea level. The Project is located on the east side of the divide between the Pelly River and the Liard River drainage basin, in the Upper Liard Drainage. The Project is located in the Geona Creek watershed which drains to Finlayson Creek. Finlayson Creek meets the outflow of Finlayson Lake north of the Robert Campbell Highway and flows east to eventually join the Frances River, and ultimately, the Mackenzie River.

The Project encompasses the A.B. Mawer (ABM) Deposit (named in recognition of geologist A.B. Mawer), of which there are two zones; the ABM Zone and the Krakatoa Zone. The ABM Deposit is a polymetallic volcanogenic massive sulphide deposit containing economic concentrations of copper, lead, zinc, gold, and silver. Mining is planned to be conducted via both open pit and underground mining methods, with ore processed into separate copper, lead, and zinc concentrates via sequential flotation through a nominal 2 million tonnes per year processing plant. Dry stack tailings will be deposited in the Class A Storage Facility on the western slope of the Geona Creek Valley while waste rock will be stored according to acid generation and metal leaching potential. Strongly acid generating material will be co-disposed within tailings or alternatively stored in mined out areas of the open pit and underground workings. Other waste rock material will be placed on the surface in managed facilities.

The mine is planned to operate for ten years, producing up to 180,000 tonne (t) zinc, 60,000 t copper, and 35,000 t lead concentrates annually. Concentrate will be transported to the port of Stewart for sale to market via Highway 4 south (Robert Campbell Highway) to Watson Lake and Highway 37 south to Stewart, British Columbia (a distance of 911 km).

The scope of the Project includes developing on site and off site surface infrastructure to support open pit and underground mining activities required to extract mineral reserves from the ABM Deposit. The Project will have a nominal 5,500 tonne per day throughput over an approximate 10-year mine life.

More detailed information on the proposed Project (including the environmental setting) is presented in the Project Proposal (BMC, 2017).

3. METHODS

3.1 INTRODUCTION

This section of the report presents the methods used to complete the HHRA. As noted earlier, the HHRA was completed using Health Canada risk assessment guidance, environmental concentrations predicted by other disciplines and the assumption that Mitigation and Management Measures as described in the Kudz Ze Kayah Project Proposal (Project Proposal) (BMC, 2017) will be followed. Briefly, Health Canada Preliminary Quantitative Risk Assessment (PQRA) was used as the key basis of the risk assessment methods. Although not specifically developed by Health Canada for use in environmental assessment, Health Canada PQRA guidance was applied to provide upper bound estimates of human health risks.

Important documents that were used to estimate risks include the following:

- Health Canada (2012): Federal Contaminated Site Risk Assessment in Canada – Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA); and
- Health Canada (2010a): Federal Contaminated Site Risk Assessment in Canada –Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors.

The details on the methods are provided in the sections below.

3.2 PROBLEM FORMULATION

In order for a potential risk to occur, there must be an interaction between all three of the following components:

- Contaminants of Potential Concern (COPC) that might pose a toxicological hazard;
- The presence of a human receptor who might come into contact with the COPC; and
- A pathway by which the person may be exposed to the COPC (i.e. inhalation, ingestion, skin contact, etc.).

Without the presence of all three components there is no potential for a risk to occur. Therefore, the first step in the HHRA was to develop a problem formulation and conceptual model for the risk assessment. The problem formulation is presented in the following sections for air quality, noise, water quality, and other environmental media.

3.2.1 Air Quality

An air quality effects assessment is presented in Chapter 6 of the Project Proposal. The air quality model predicted changes to air quality based on two study areas:

- The local study area (5 km by 5 km, centred on the mine footprint).
- The regional study area (40 km by 40 km and encompasses the mine footprint and the entire Tote Road/Proposed Access Road).

The closest receptors to the mine site in the modelling domains are the mine employees living in the camp. Employees on shift will be protected from any health effects as BMC will be required to meet the WCB regulations for air quality at an industrial site. However, there may be exposure to off-shift works staying at the camp during their rotation. The potential exposure pathway would be inhalation. However, the modelled air quality generally meets the air quality objectives at the camp (for construction, operations and closure). As discussed in Chapter 6 of the Project Proposal, a few exceedances are predicted under the worst case meteorological conditions, which if they occurred would be less than 1% of the time over a 24-hour period (based on conservative modelling assumptions). Therefore, all three components required for a risk assessment are not met as the modelled COPCs do not pose a toxicological hazard. Subsequently, no further risk assessment is required. Since the closest receptor is not at risk, it follows that there would be no risk from incidental exposure due to Project related changes in air quality (i.e., to people using the regional areas for hunting, fishing or trapping at farther distances from the site).

Mitigation measures to minimize air emissions are presented in Section 6.4.2 of the Project Proposal and the conceptual Air Quality Management Plan is presented in Section 18.11 of the Project Proposal.

3.2.2 Noise

A noise levels effects assessment is presented in Chapter 7 of the Project Proposal. The noise model predicted changes in noise over the following study areas:

- The local study area (4.6 km by 6.0 km, centred on the Project Footprint, and includes camp as a sensitive receptor).
- The regional study area (32 km by 36 km and encompasses the Project Footprint and the entire Tote Road/proposed Access Road).

The closest receptor to the mine site in the modelling domain are the mine employees living in the camp. Employees on shift would be protected from any health effects as BMC will be required to meet the WCB regulations for noise at an industrial site. However, there may be exposure to off-shift works staying at the camp during their rotation. The potential exposure pathway would be acoustic. However, the noise model meets the noise objectives at the camp (for construction, operations and closure). Therefore, all three components required for quantitative risk assessment are not met as the modelled changes in noise levels do not pose a human health hazard. Subsequently a no further risk assessment is required. Since the closest receptor is not at risk then there would be no risk from incidental exposure due to Project related changes in noise (i.e. to people using the regional areas for hunting, fishing or trapping at farther distances from the site).

Mitigation measures to reduce noise presented in Section 7.4.2 of the Project Proposal. Due to the low levels of noise predicted at the camp receptor, no specific monitoring is proposed. However, if off-shift workers were to complain about noise at the camp, then additional mitigation measures would be applied.

3.2.3 Water Quality

A water quality effects assessment is presented in Chapter 8 of the Project Proposal. This assessment did consider potential impacts on human health. However, for clarity the results are summarized in the following paragraphs. Appendix A of this HHRA presents the modelled COPC concentrations compared to the drinking water guidelines.

The assessment included waterbodies in the local study area (Geona Creek, South Creek and upper Finlayson Creek) and the regional study area (Lower Finlayson Creek and North River). The only creek in the Project area that was specifically identified by First Nations as being used for drinking water purposes is Fault Creek. However, other creeks in the study areas may also be used for drinking water purposes when people are hunting or fishing in the area. It is unlikely that Geona Creek is used for drinking water purposes as it is a low flowing stream that visibly does not look potable. The water quality in Fault Creek is not predicted to change as it is upgradient of the Project activities. Therefore, a further risk assessment of Fault Creek is not warranted as there are no Project related "COPCs that might pose a toxicological hazard".

During the construction, operations, and decommissioning, reclamation and closure phases, there will be no public access to the creeks in the local study area (i.e., Fault Creek, Geona Creek, and upper Finlayson Creek). As per the requirements of the Tote Road license, the road will be gated and will be manned 24 hours a day 365 days per year. Therefore, there will be no "presence of a human receptor who might come into contact with a COPC" during these Project phases. Thus, further human health risk assessment is not required. The only spatial overlap in these creeks would be during the post-closure scenario. Therefore, the water quality model results during post closure in Geona Creek and Upper Finlayson Creek were compared to the maximum acceptable concentration drinking water guidelines (as provided by Health Canada, 2014). No COPCs were estimated to exceed the drinking water quality guidelines during the post closure period. Therefore, there are no "COPCs that might pose a toxicological hazard" and thus no further risk assessment is required. The model results for all Project phases have been included in the following section (although only the post closure phase applies).

During all Project phases, people could access the creeks in the regional study area (i.e. lower Finlayson Creek, South Creek and North River). Therefore, the water quality model results were compared to the maximum acceptable concentration guidelines (Health Canada, 2014) during each of these Project phases.

No COPCs assessed were estimated to exceed Canadian drinking water guidelines in the publicly accessible lower Finlayson Creek during the construction, operations or closure/post closure phases. Similarly, no COPCs were estimated to exceed drinking water guidelines in South Creek during all

Project phases. Since South Creek ultimately flows in the North River, North River would also not exceed the applicable guidelines.

3.2.4 Other Environmental Media

Country foods are animals, plants, or fungi used by people for medicinal or nutritional purposes that are harvested through hunting, gathering, or fishing. Country foods take up chemicals from the environmental media (i.e., water, soil, and vegetation). Thus, their concentrations (i.e., quality of the food) are directly related to the concentrations in the environmental media. Subsequently, any Project activity that could affect the quality of water, soil, and vegetation could also affect the quality of country foods. To determine the potential effects to country foods, predicted changes to the environmental media were reviewed from other relevant sections of the Project Proposal.

Soil

During construction, operations and closure, soil quality could be affected by minor fuel spills. These minor spills will be remediated as per the Spill Contingency Plan (Section 18.5 of the Project Proposal). Because the spills and all associated affected soils will be cleaned up, there is no potential for such spills to affect the quality of country foods (i.e., vegetation or wildlife) during all Project phases.

During construction, operations and closure, soil quality could be affected by dust containing metals. Potential sources of atmospheric metals are from residual ore dust from blasting, open haul trucks going to the crusher, the live ore stockpile, tailings dust from the Class A Storage Facility where the material has dried but is not yet covered, and earthmoving activities in an area with naturally higher mineralization. However, given the low levels of particulate that are predicted in the Air Quality Model (Chapter 6 of the Project Proposal). It is unlikely that concentrations in soils (from dust from the Project facilities) will increase. As such, there is low potential for changes in soil quality to affect the quality of country foods (i.e. vegetation or wildlife) during all Project phases.

In order to confirm this prediction, a monitoring program will initially collect soil samples at exposure and control sites. The sampling program will be conducted prior to construction, after development, and once every three years through to closure with data tracked over time to determine if there are any changes in metal concentrations resulting from the Project. An adaptive management plan will be developed during permitting, which will identify trigger values for additional mitigation or monitoring. If the soil concentrations are approaching the trigger values, additional mitigation measures would be implemented and a more intrusive monitoring program would be implemented (i.e., vegetation monitoring program).

Vegetation

Potential sources of COPC uptake into plants are from either air, soil or water.

Since the soil is not predicted to be impacted, then there would be no subsequent change to the vegetation concentrations. In order to confirm this prediction a monitoring program will initially collect soil samples at exposure and control sites. The sampling program will be conducted prior to construction, after development and once every three years through to closure with data tracked over time to determine if there are any changes in metal concentrations resulting from the Project. An adaptive management plan will be developed during permitting, which will identify trigger values for additional mitigation or monitoring. If the soil concentrations are approaching the trigger values, then additional mitigation measures would be implemented and a more intrusive monitoring program would be implemented (i.e. vegetation monitoring program).

Potential sources of COPCs in vegetation from water sources are limited to the closure period for constructed wetlands. The water management program will control and treat any contact water prior to release to the environment during operations and closure. A soil and vegetation metal monitoring program will commence with installation of constructed wetlands in order to monitor the efficacy of the constructed wetland at treating water as well as to ensure that metals are not accumulating to any significant degree in vegetative matter of any species. For wetlands, soils will be tested for nutrients, metals, and microbes. The wetlands are designed to create metal compounds in the soil and root systems that are not bioavailable. The monitoring program will be used to ensure that metals are not accumulating significantly in the vegetative matter. If there is significant increase in vegetation metal concentrations beyond background, then the wetland system will be modified to minimize wildlife access.

Based on the above, the quality of edible vegetation (by people and wildlife) in the vicinity of the Project is not predicted to be affected during any of the Project phases. In addition, the general public will not be permitted to access the Project area during construction, operations and active closure, as per the Tote Road licence requirements.

Water

An effects assessment for water quality was presented in Chapter 8 of the Project Proposal. The following presents a summary of the water quality predictions during each of the Project phases as they relate to potential changes in the quality of country foods (i.e., fish and wildlife that may drink the water). This summary is qualitative, rather than quantitative due to the lack of reliable models for predicting fish tissue concentrations for the COPCs.

Construction

During construction, no COPCs were estimated to exceed their respective water quality objectives. The exception is concentrations of fluoride (during March under the mean scenario and February and March under the wet scenario) in Genoa Creek. Since these concentrations are only predicted to be reached intermittently throughout operations the likelihood of fluoride and uranium concentrations increasing in country foods (i.e., fish or wildlife from drinking the water) is low.

It is noted that the only fish in this system that could be harvested for consumption is arctic grayling. However, the abundance of arctic grayling in this system is extremely low (this is likely due to the fish barrier at the culverts where Finlayson Creek crosses the Robert Campbell Highway) and subsequently is not major source of fish for consumption. In addition, during construction, the general public will not be permitted to use Geona Creek for fishing due to the Tote Road licence requirements. Therefore, there will be no exposure to people from eating the fish from Geona Creek.

Operations

During operations, COPC concentrations were estimated to be higher than baseline but lower than preliminary Water Quality Objectives (pWQO) for the majority of COPCs. The exception was fluoride which was estimated to marginally exceed its pWQO in Geona Creeks and Finlayson Creeks for some months of the calendar year during operations. Uranium was also estimated to exhibit marginal pWQO exceedances under the 1/10 dry year scenario in Geona Creek in October only. Since these concentrations are only predicted to be reached intermittently throughout operations the likelihood of fluoride and uranium concentrations increasing in country foods (i.e. arctic grayling or wildlife from drinking the water) is low. Currently, the abundance of arctic grayling in these systems is extremely low and subsequently these creeks are not major sources of fish for consumption. In addition, during operations there will be no public access to the site for fishing purposes, as per the requirements of the Tote Road Licence.

No changes in COPC concentrations are expected in South Creek, and although COPC concentrations are anticipated to be higher than baseline in South Creek due to the diversion of Fault Creek, no pWQO exceedances were modelled.

Closure

During post-closure, no COPCs were estimated to exceed their respective water quality objectives in Geona or Lower Finlayson Creeks under the mean precipitation scenario. Only fluoride was estimated to exceed its water quality objective in upper Finlayson Creek, but the exceedance was marginal (<10% higher than the pWQO) and only occurred in April of each year. Under the 1/10 dry year scenario, fluoride was estimated to exceed its water quality objective in Geona Creek. The modelled fluoride excursion was marginal for all three sites and occurred only in March or April. Since these concentrations are only predicted to be reached intermittently the likelihood of fluoride and uranium concentrations increasing in country foods (i.e. arctic grayling or wildlife from drinking the water) is low.

Summary of Potential Risks from Fluoride and Uranium

Due to the lack of reliable models for predicting fish tissue concentrations, it was not possible to quantify human health risks from fluoride or uranium because of fish consumption in a manner that would meet Health Canada risk assessment guidance. No water quality guideline in Canada or elsewhere has been identified that reliably predicts the movement of fluoride or uranium from water into fish tissue and so there is no value for comparison. In particular, the federal guidelines and objectives do not address this pathway and, thus, an exceedance should not be considered to be an indicator of potential health risks. In addition, there is no generally accepted manner identified to predict fish tissue concentrations for these substances. Consequently, there is little likelihood of completing a scientifically rigorous quantitative human health risk assessment of these substances.

Notwithstanding the above, there is a high degree of certainty that no unacceptable risks would occur from fish consumption and that people will be adequately protected for a variety qualitative reasons discussed in part above and in more detail below. Firstly, a key principle of risk assessment guidance is that in order for risk to occur, there must first be exposure. Exceedances of the CCME water quality objective that are predicted to occur during construction, operations and active closure, access to the creeks would not be permitted (via the Tote Road). Thus, there will essentially be no exposure and, therefore, no risks during the period that the elevations in fluoride and uranium concentrations could occur.

A second factor that suggests low likelihood of unacceptable risks is that exceedance is acute in nature whereas most of the health concerns regarding fluoride and uranium are chronic. Specifically, the exceedance is expected to only occur for one month of a 10 year operation period and, thus, exposure would be characterized as acute or subchronic. A review of the toxicological literature has identified chronic tolerable daily intakes for both fluoride and uranium were used by Health Canada in development of its drinking water quality guidelines (Health Canada, 2001, 2010b); however, acute and subchronic toxicity reference values were not provided nor the basis of the guidelines. Consequently, even if tissue concentrations were available and even if people were consuming such fish, it would be difficult to quantify risks from such short duration exposure.

The most important consideration that suggests low likelihood of unacceptable risks is the rigorous fish tissue monitoring plan that will be in place. Due to the lack of reliable models for predicting fish tissue concentrations, the most accurate method of assessment of risks is monitoring of fish tissue concentrations. A very substantial database of baseline fish concentrations has been collected that will be used to compare against the monitoring that will take place during the mine operation and post-closure periods (which will be required under MMER and the Type A Water Licence). This baseline data set includes fish tissue sampling every other year since 2000. If fish concentrations do not appreciably change from baseline concentrations, it will be clear that no incremental human health risks from fish consumption will be associated with the Project. In the event that fish tissue concentrations start to trend higher, there will be ample time to complete a human health risk assessment to evaluate any concern during the period that fish consumption from the lake is not occurring. Consequently, there will be essentially no opportunity for persons to consume fish with elevated concentrations of fluoride or uranium without a human health risk assessment having first been completed.

Overall, there is no information that suggests the fluoride and uranium will result in an unacceptable human health risks from fish consumption. Although it is possible that there could be a minor exceedance of environmental objectives for fluoride and uranium, these water quality objectives were not developed for protection of the fish consumption pathway and, thus, do not actually indicate concern levels. Although there are no suitable models to accurately predict fish tissue concentrations, other factors are suggestive of low likelihood of risks. Most importantly, a rigorous monitoring plan will be in place that will detect any increases in fish tissues concentrations well in advance of any opportunity for persons to fish at the lake.

Wildlife Exposure to Mine Site Water

Potential exposure pathways to terrestrial wildlife include ingesting water from the Operations Water Management Ponds, treatment ponds, or ABM Lake at closure, or from ingesting plants that may have increased metal concentrations from accumulation or deposition. The likelihood for metals to transfer water will be limited due to wildlife access barriers and water control and treatment programs. Wildlife is unlikely to access the water collection ponds or water management ponds as they will be fenced. In addition, the water quality of the ponds is predicted to meet the livestock drinking water guidelines with the exception of the Class A and Class B Storage Facilities collection ponds, which may have some elevated metals. But with limited access this is not a concern. The ABM lake will be batch treated if necessary after closure to maintain water quality within acceptable guidelines for wildlife protection.

Based on the above, the quality of country foods (i.e. terrestrial wildlife) is not predicted to be effects due to on-site water storage and management facilities.

Summary

To determine the potential effects to country foods, predicted changes to environmental media were reviewed from other relevant sections of the Project Proposal. Based on this review, changes in air, soil, water and vegetation are not likely to result in a change in the quality of country foods. Therefore, it is concluded that a quantitative risk assessment on country foods is not required as there are no "COPCs that might pose a toxicological hazard". Monitoring programs for the environmental media will confirm this and an adaptive management program will be implemented (trigger values will be developed during permitting).

3.2.5 Receptors of Concern

Under PQRA guidance, the key receptors of concern were considered to be toddlers for non-carcinogens and adult/composite receptor for carcinogens. For these age groups, two receptors of primary concern were:

- Nearest residents: The closest permanent residents to the Project Site are the residents of Ross River (approximately 115 km from the site).
- Nearest recreational receptors: Kaska citizens (Ross River Dena Council and Liard First Nations) are known to conduct traditional activities (i.e. hunt, trap, fish, gather plants) in the regional area. In addition, Yukon Big Game Outfitters guides and outfits in the regional area on a seasonal basis.

Workers on-shift at the site were not addressed in the PQRA since they will be protected by a separate worker health and safety plan. However, workers off-shift staying in the camp were considered in the PQRA.

3.2.6 Conceptual Model

Based on the information provided in the previous sections and application of guidance from Health Canada, conceptual models were developed to illustrate the receptors and exposure pathways identified for evaluation of risks to nearest residential receptors (see Table 3-1) and nearest recreational receptors. These conceptual models assume that the Mitigation and Management Measures presented in the Project Proposal will be in place.

Table 3-1: Conceptual Model for Nearest Residents

Critical receptor		Exposure pathways	
	Infant	NPC	Soil Ingestion
√	Toddler	NPC	Soil dermal absorption
	Child	NPC	Particulate inhalation
	Teen	NPC	Vapour inhalation
√	Adult	NPC	Water dermal exposure
		NPC	Water ingestion
		NPC	Berry ingestion
		NPC	Fish ingestion
		NPC	Wild game ingestion

√ – Requires evaluation in the human health risk assessment
NPC - No pathway due to the lack of predicted contamination

Table 3-2: Conceptual Model for Nearest Recreational Receptor

Critical receptor		Exposure pathways	
	Infant	NPC	Soil Ingestion
√	Toddler	NPC	Soil dermal absorption
	Child	NPC	Particulate inhalation
	Teen	NPC	Vapour inhalation
√	Adult	NPC	Water dermal exposure
		NPC	Water ingestion
		NPC	Berry ingestion
		NPC	Fish ingestion
		NPC	Wild game ingestion

X – Requires evaluation in the human health risk assessment
NPC - No pathway due to the lack of predicted contamination

Based on these tables it is clear that there are no risks to further evaluate in this PQRA.

4. RESULTS

Applying the Health Canada PQRA guidance, it was found that risks will be acceptable provided the Mitigation and Management measures presented in the Project Proposal are followed. For all COPCs other than fluoride and uranium, it was found that environmental concentrations will remain within the same range of current background concentrations and/or will not exceed existing environmental guidelines or criteria. Since guidelines for protection of human health are generally developed for protection of a Hazard Quotient of 0.2 and an Incremental Lifetime Cancer Risk of 1×10^{-5}, no unacceptable risks are predicted as there will be no pathways for exposures to media exceeding guidelines that are protective of such risks.

In the case of fluoride and uranium, mitigation and management measures in the Project Proposal will adequately address these substances. Although it was not possible to quantitatively estimate risks from these metals, there is high confidence that risks will not exceed Hazard Quotient values of 0.2. Since neither of these substances are considered to be carcinogens, Incremental Lifetime Cancer Risk estimates are not estimated.

5. DISCUSSION AND UNCERTAINTY ANALYSIS

The HHRA was completed using a series of upper-bound assumptions intended to over-estimate actual health risks and thereby ensure a conservative assessment. Given the conservative assumptions used in this assessment, it is quite possible that actual risks may be substantially lower than estimated herein. Nevertheless, certain assumptions were key determinants in the acceptability of risks. The following sensitivity analysis discusses some of the most important assumptions that had key influences on the results and conclusions of the HHRA.

Chemical Concentrations in the Environment

One source of uncertainty is the predicted change in concentrations in environmental media during each of the Project Phases (which is the case with all models). However, the HHRA was based on upper bound estimates of concentrations and, thus, it is likely that concentrations will be even lower than assumed in the HHRA.

Implementation of the RMP

The HHRA was based on the Mitigation and Management measures presented in the Project Proposal as being implemented to ensure the key elements remain in place. If certain elements are not in place, it is possible that greater risks will exists than estimated in the current HHRA. Consequently, it is considered extremely important that the Mitigation and Management measures are implemented and monitored throughout the life of the Project (as per the permit requirements that will be in place prior to construction and operations).

Overall Uncertainty in the Risk Assessment

Overall, it is unlikely that human health risks have been underestimated in the risk assessment and it is quite possible that risks have been overestimated.

With the above noted, it is still possible (but not likely) that risks may have been underestimated for certain receptors in some cases. The two main conditions where risks may have been underestimated would include:

- Any situation where environmental modelling has underestimated concentrations; and
- Any situation where people are not accurately represented by the assumed receptor assumptions.

Monitoring will be undertaken to ensure that neither of the conditions described above occur. If such conditions do occur, additional risk analysis would be recommended to address potential increases in human health risks.

6. CONCLUSIONS

Overall, the HHRA has indicated acceptable risks when the Mitigation and Management measures are implemented and maintained. The Mitigation and Management measures that will be protective of human health are summarized in Chapter 18 (Conceptual Management Plans) of the Project Proposal and include the following plans (but are not limited to):

- Waste Management Plan;
- Hazardous Materials Management Plan;
- Surface Water Management Plan;
- Spill Contingency Plan;
- Sediment and Erosion Control Plan;
- Wildlife Protection Plan;
- Vegetation Management Plan;
- Fish and Aquatic Habitat Management Plan;
- Noise Management Plan;
- Air Quality Management Plan; and
- Health, Safety and Emergency Response Plan.

When these plans are implemented (along the with the adaptive management and monitoring program that will be finalized during permitting), acceptable human health risks are estimated.

7. STATEMENT OF LIMITATIONS

This report has been prepared for the sole benefit of BMC Minerals (No.1) Ltd (BMC). Any use that a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties. BMC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

The information and conclusions contained in this report are based upon work undertaken by trained professional staff in accordance with generally accepted scientific practices current at the time the work was performed.

Conclusions presented in this report should not be construed as legal advice.

This risk assessment was undertaken exclusively for the purpose outlined herein and was limited to those contaminants, exposure pathways, receptors, and related uncertainties specifically referenced in the report. This work was specific to the site conditions and land use considerations described in the report. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations.

This report describes only the applicable risks associated with the identified environmental hazards, and is not intended to imply a risk-free site. Should any conditions at the site be observed or discovered that differ from those at the sample locations, or should the land use surrounding the identified hazards change significantly, Wilson Scientific requests to be notified immediately to reassess the conclusions provided herein.

8. REFERENCES

BMC Minerals (No.1) Ltd., 2017. Kudz Ze Kayah Project, Project Proposal for YESAB Executive Committee Screening. March 2017.

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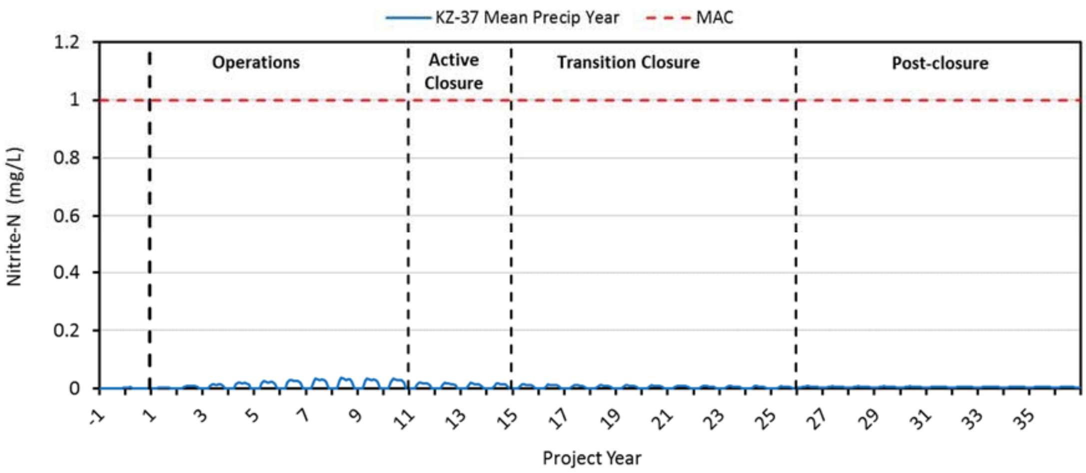
Health Canada, 2012. Federal Contaminated Site Risk Assessment in Canada – Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA). Environmental Health Assessment Services, Safe Environments Programme, Health Canada, Ottawa, Ontario.

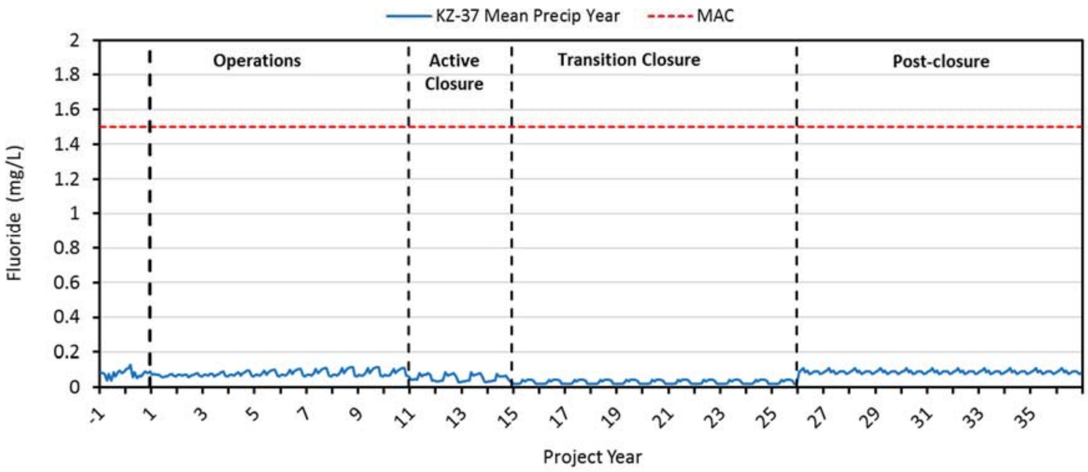
APPENDIX A.
Summary of Model Results Compared to Drinking Water Guidelines

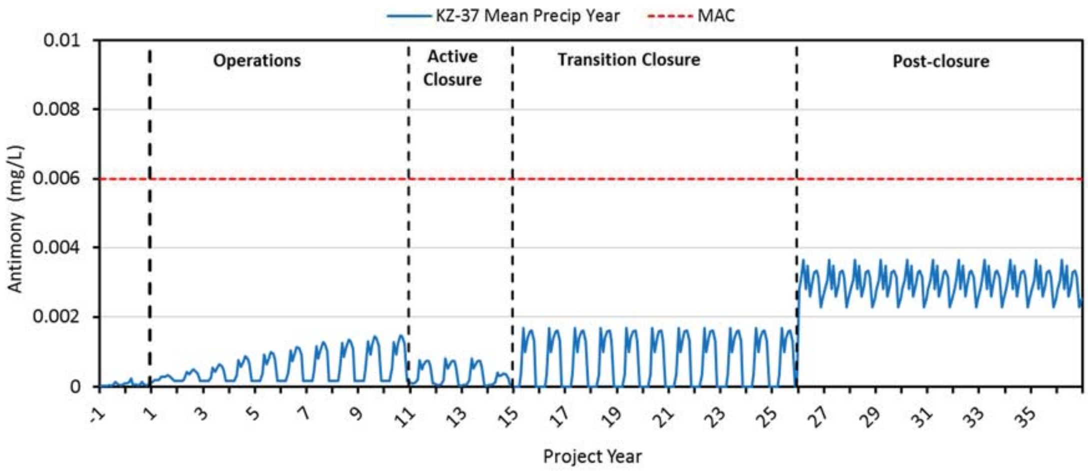
Summary of Model Results for COPCs Compared to Drinking Water Guidelines

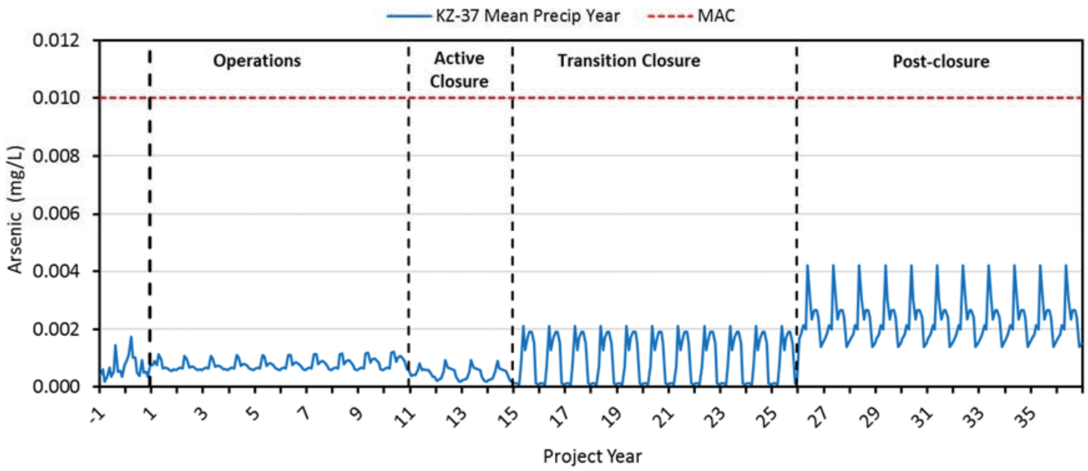
COPC	Guidelines for Canadian Drinking Water Quality Maximum Acceptable Concentration (MAC) (mg/L)
Nitrite (as N)	1
Fluoride	1.5
Antimony	0.006
Arsenic	0.01
Cadmium	0.005
Selenium	0.05
Uranium	0.02

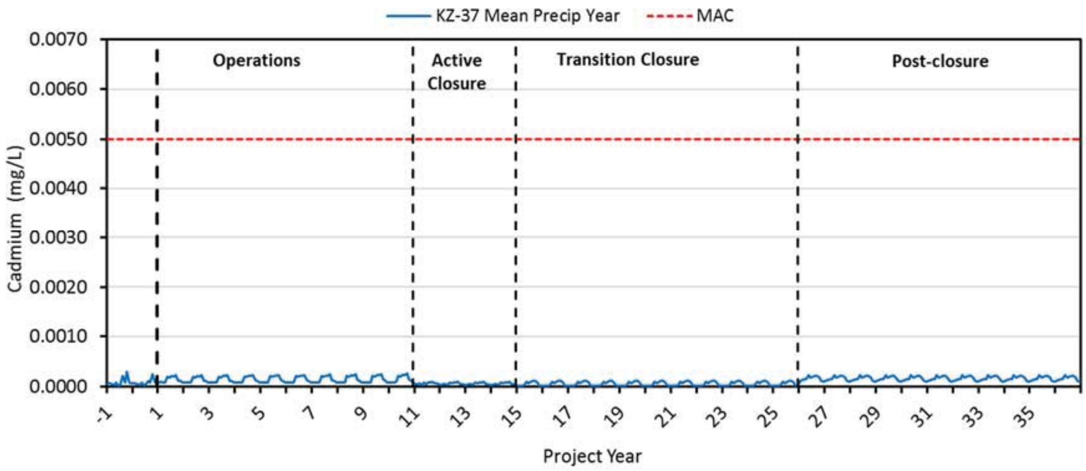
Model Results for Geona Creek




KZ-37 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Fluoride (mg/L)
Project Year


KZ-37 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Antimony (mg/L)
Project Year


KZ-37 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Arsenic (mg/L)
Project Year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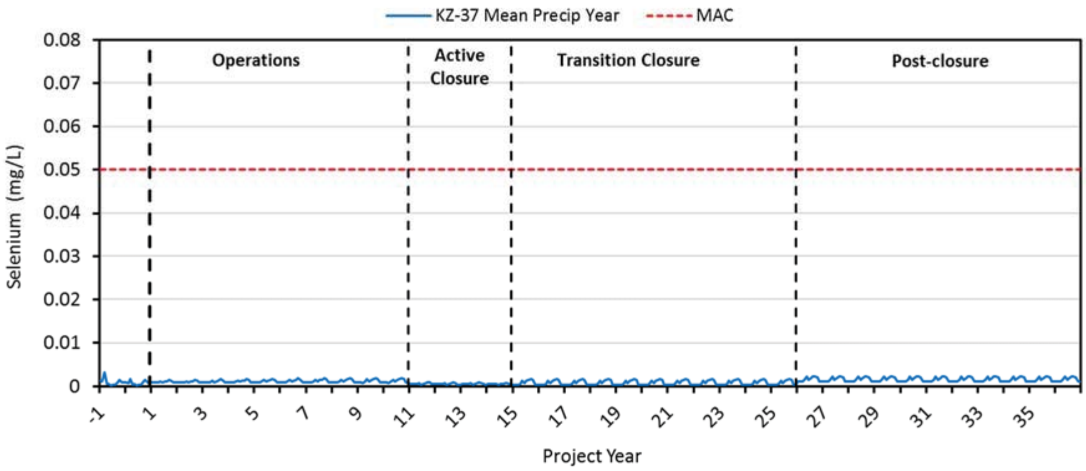
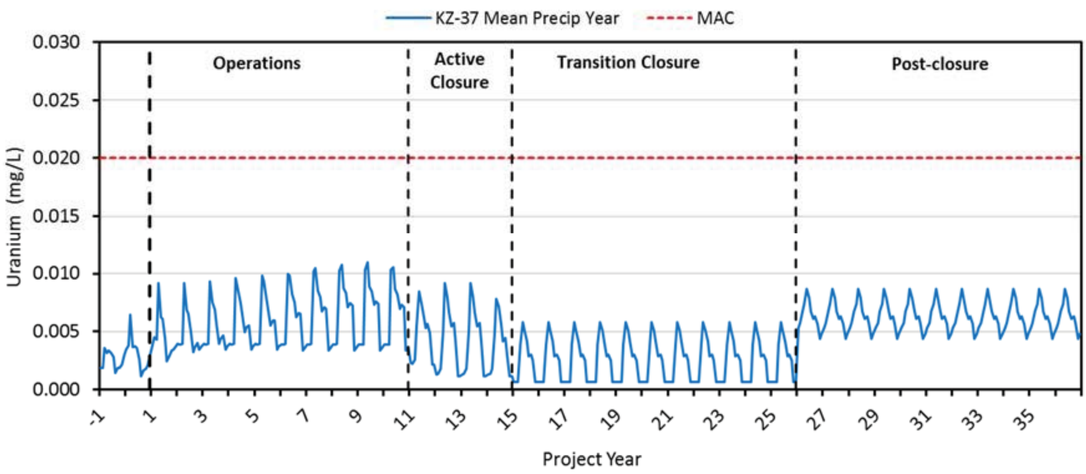
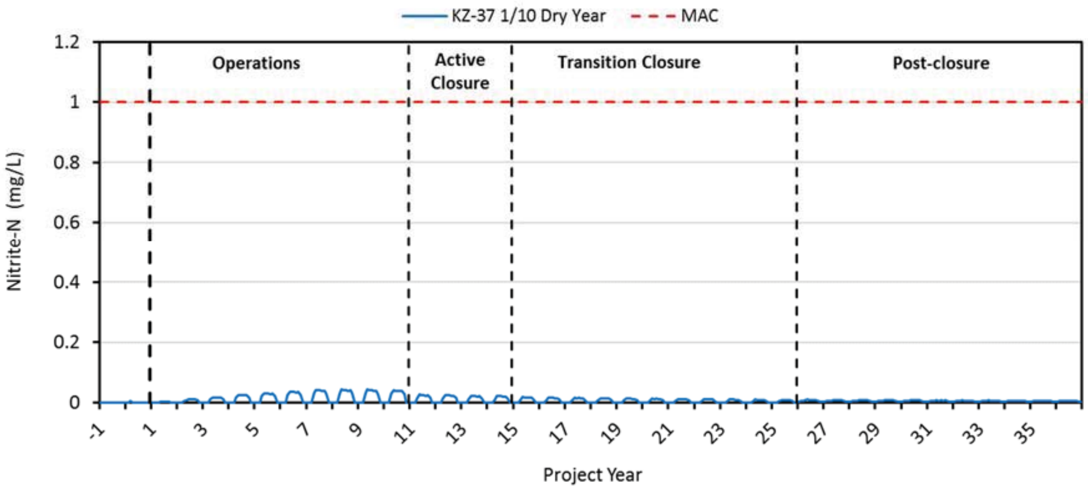
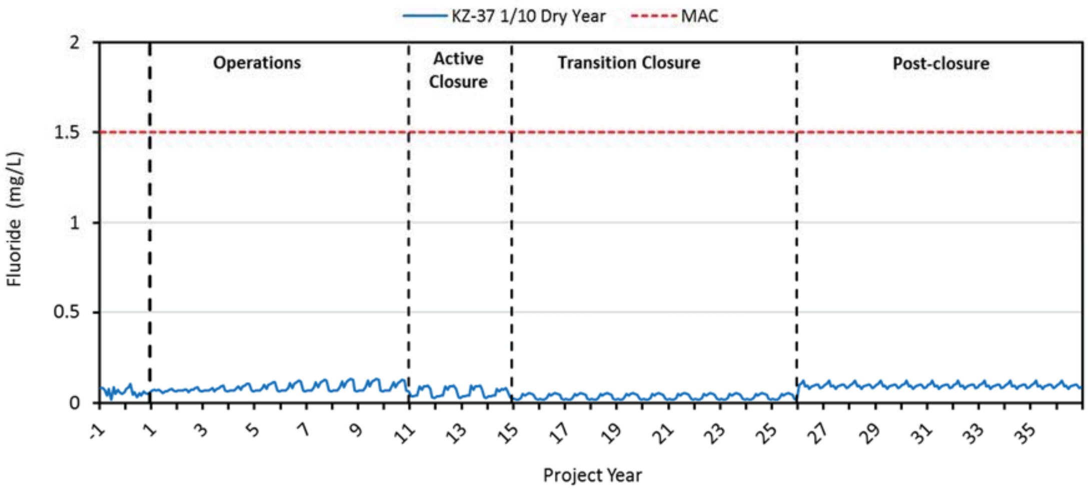
MAC
Operations
Active Closure
Transition Closure
Post-closure
Cadmium (mg/L)
Project Year


KZ-37 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
Project Year


KZ-37 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
Project Year


KZ-37 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Nitrite-N (mg/L)
Project Year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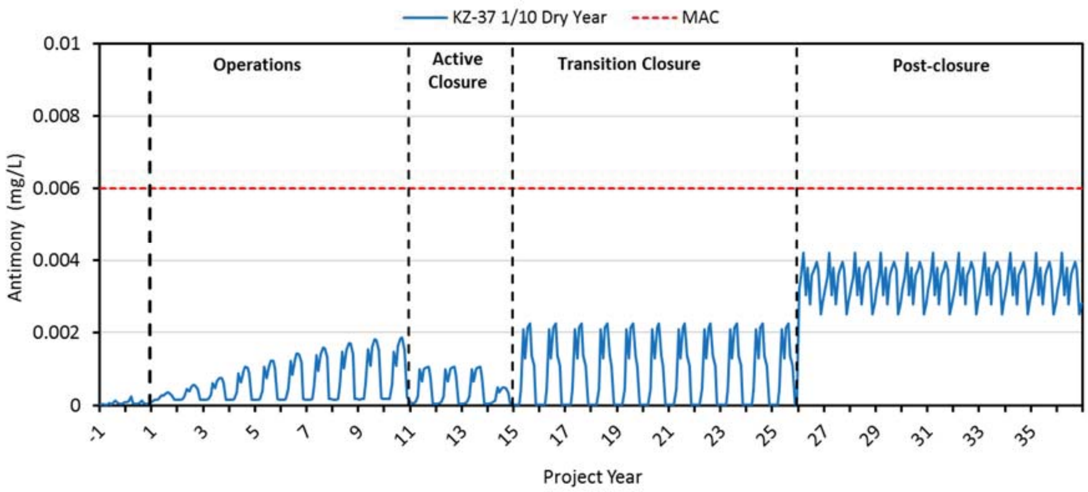
MAC
Operations
Active Closure
Transition Closure
Post-closure
Fluoride (mg/L)
Project Year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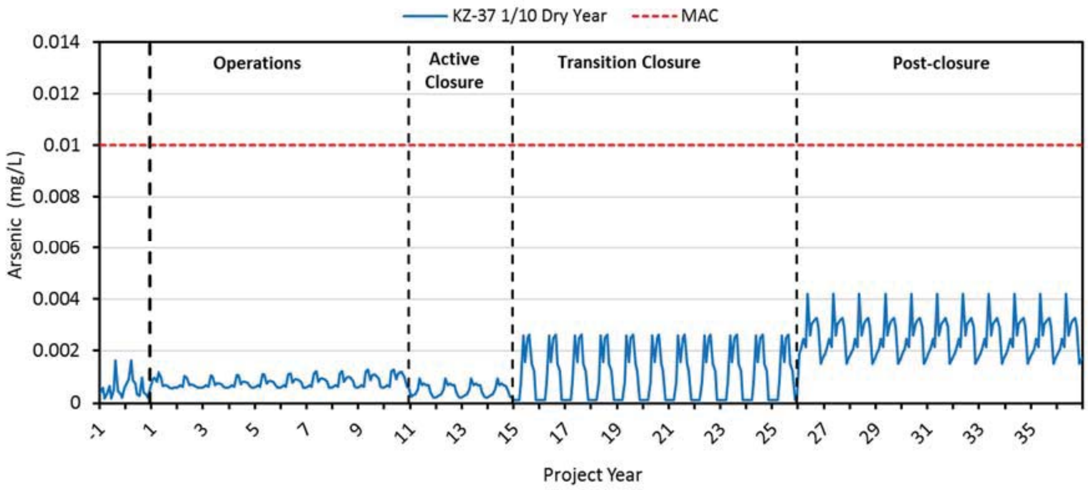
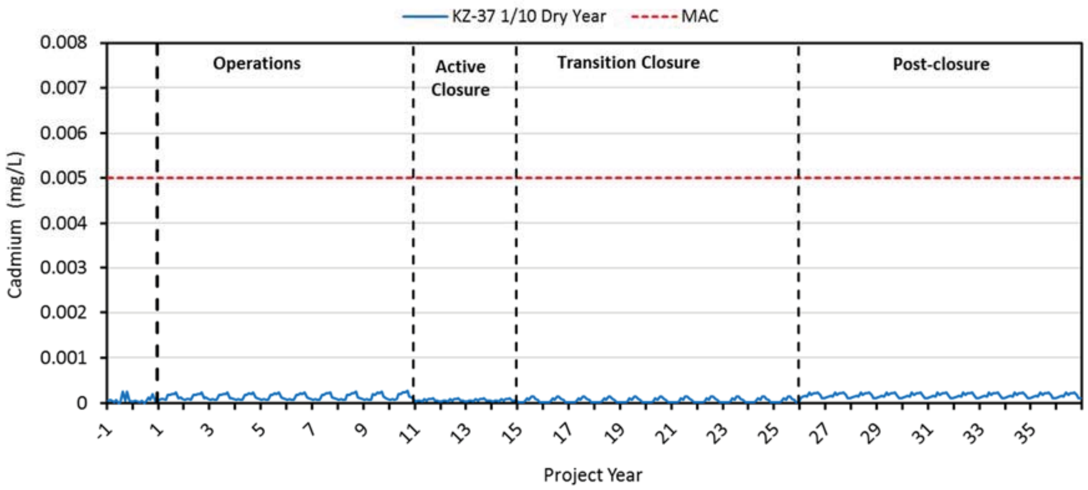
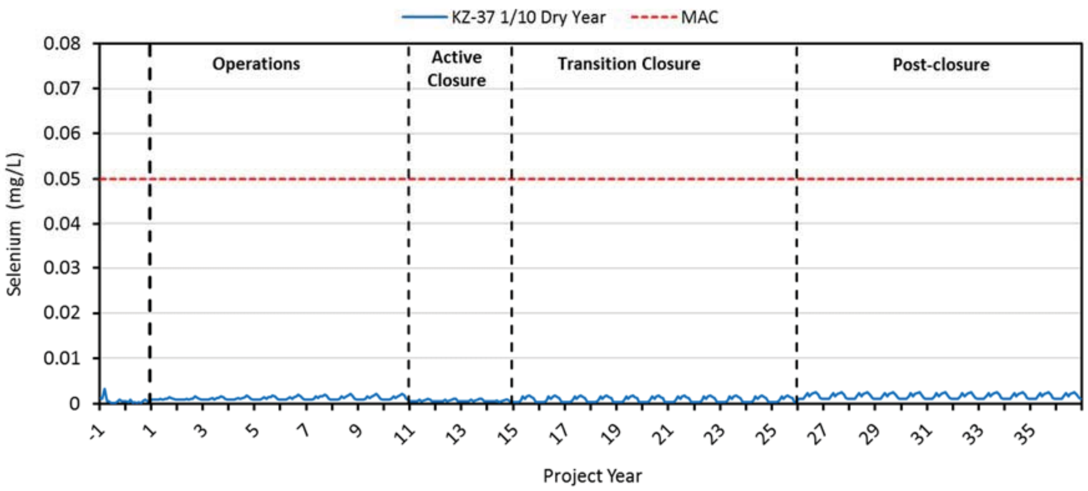
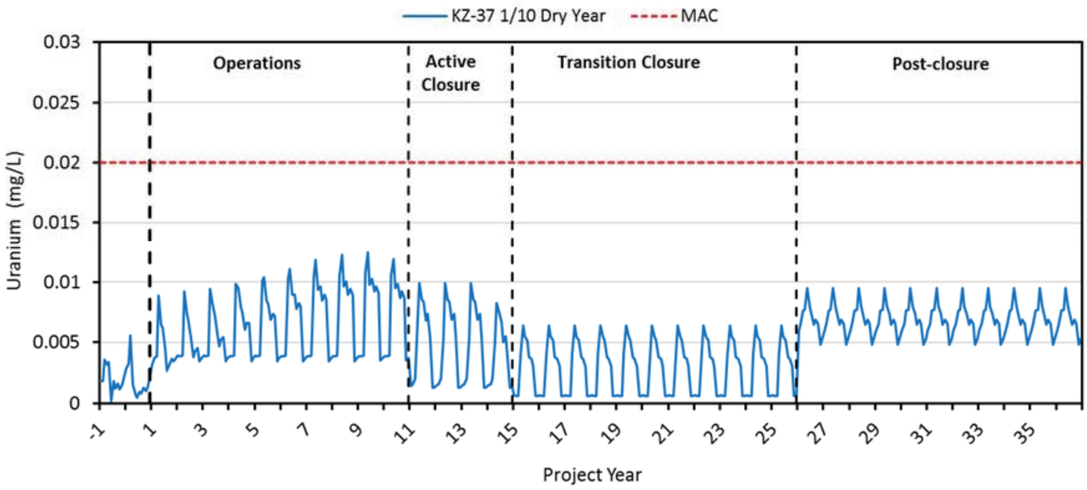
Operations
Active Closure
Transition Closure
Post-closure
Antimony (mg/L)
Project Year

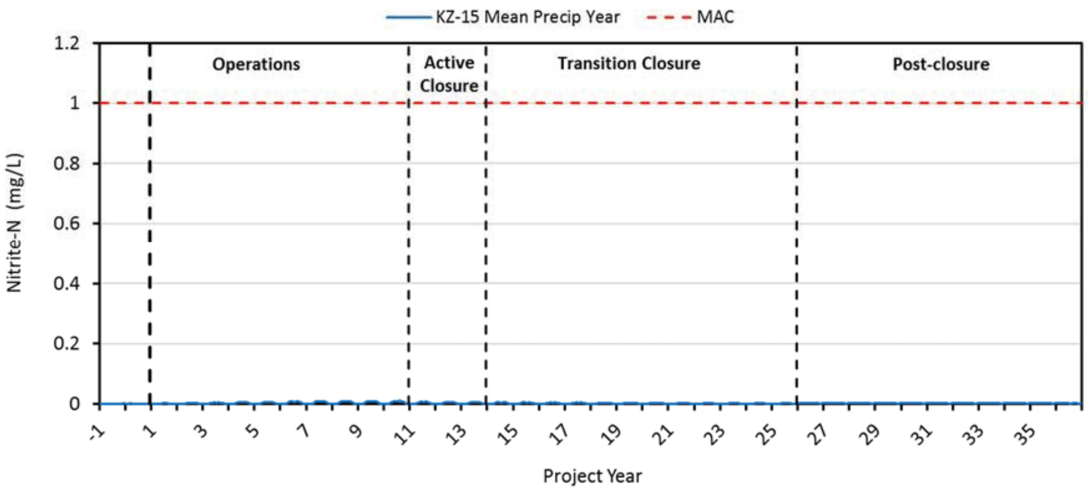

KZ-37 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Arsenic (mg/L)
0.014
0.012
0.01
0.008
0.006
0.004
0.002
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year

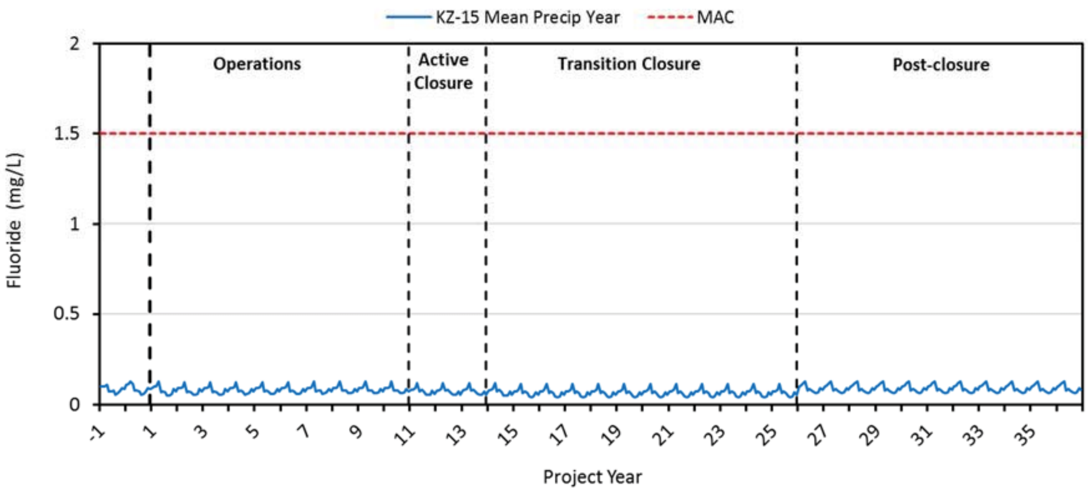

KZ-37 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Cadmium (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year

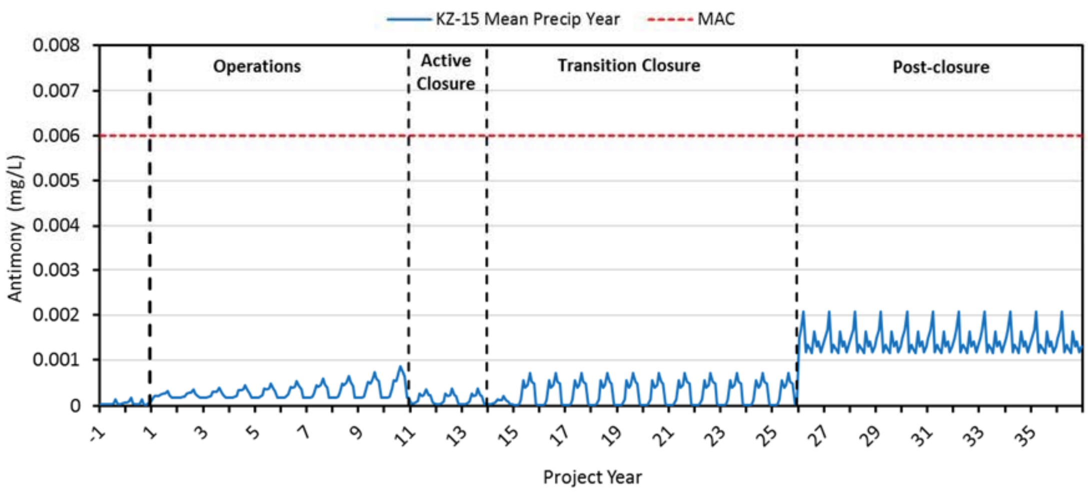

KZ-37 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year

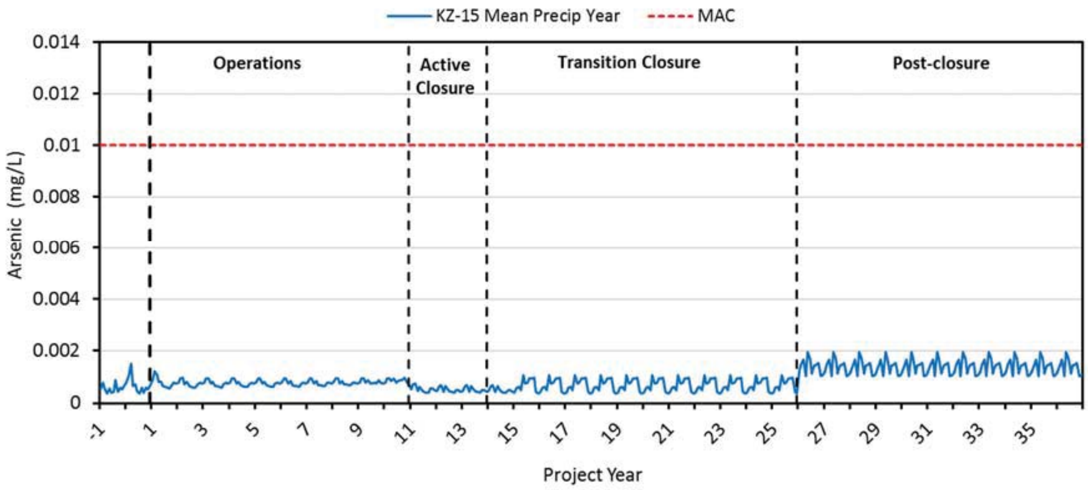

KZ-37 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
0.03
0.025
0.02
0.015
0.01
0.005
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year

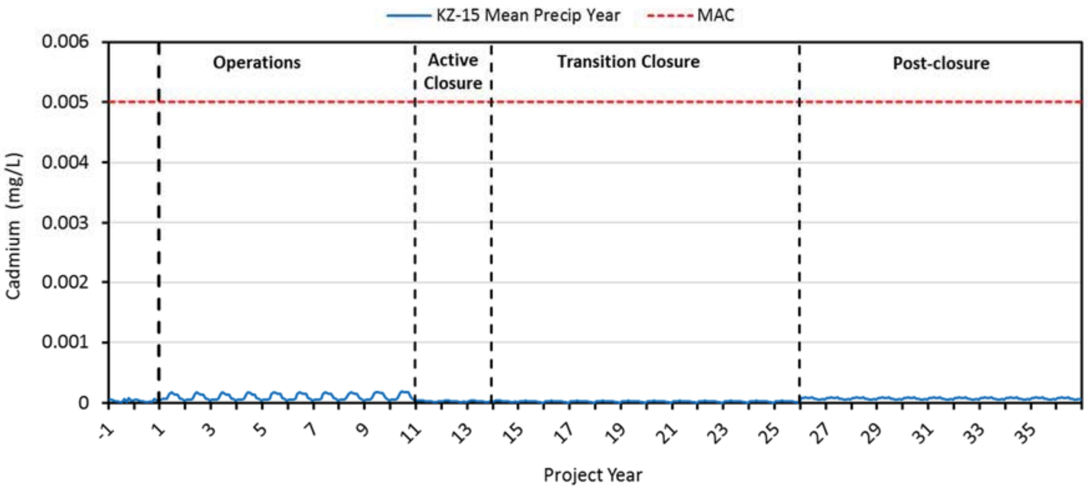
Model Results for Finlayson Creek

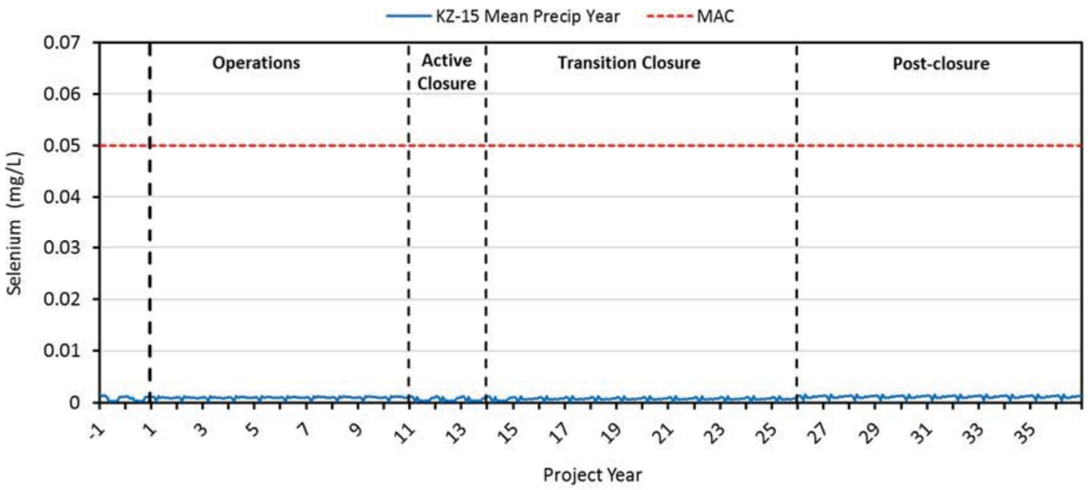


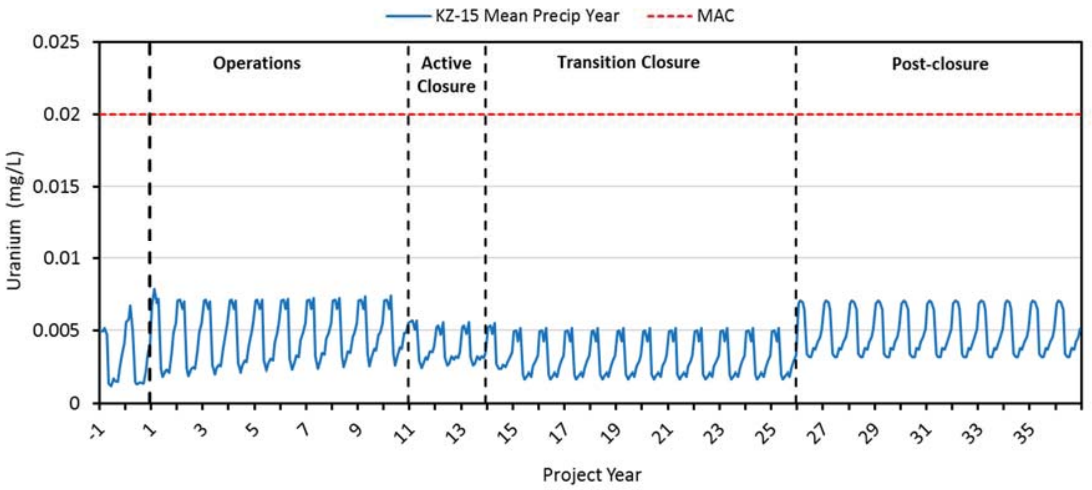


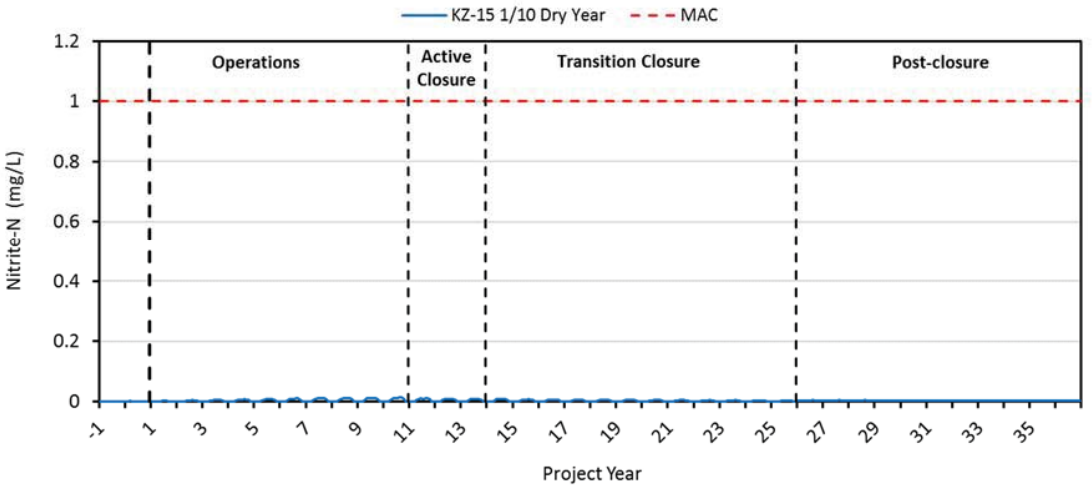


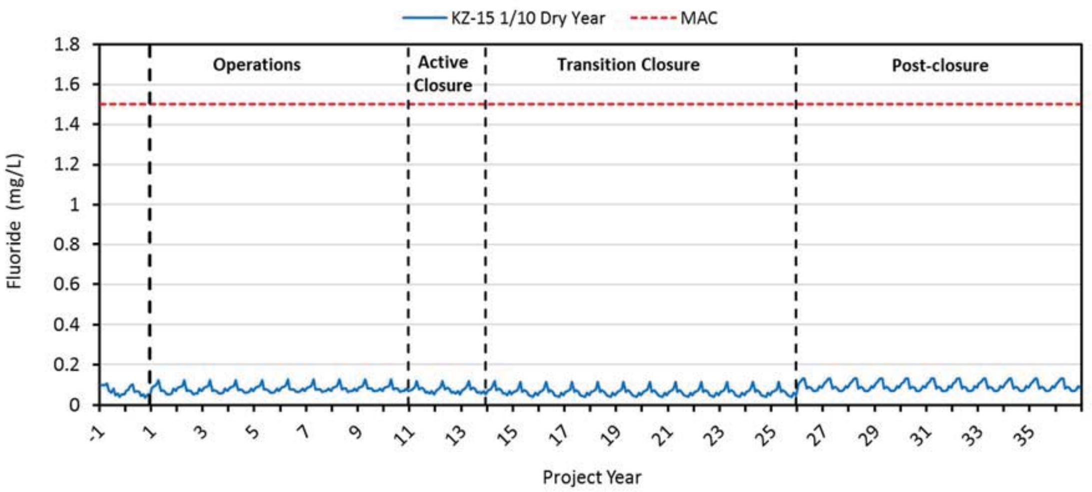

KZ-15 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Arsenic (mg/L)
Project Year

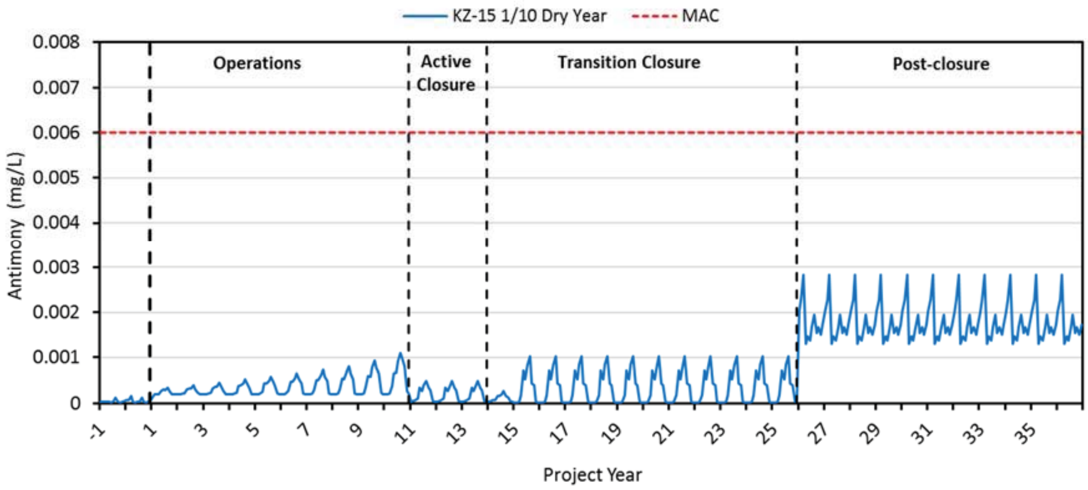

KZ-15 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Cadmium (mg/L)
Project Year

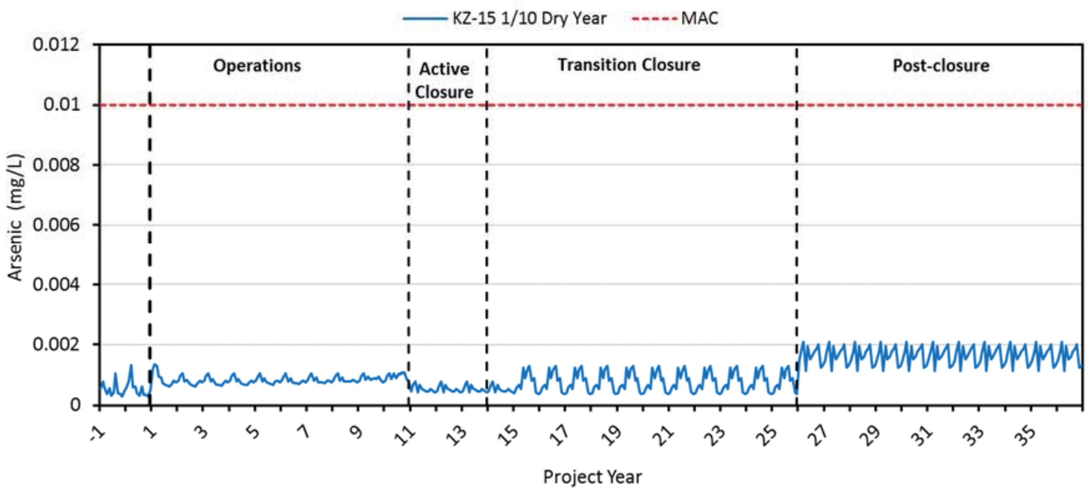

KZ-15 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
Project Year

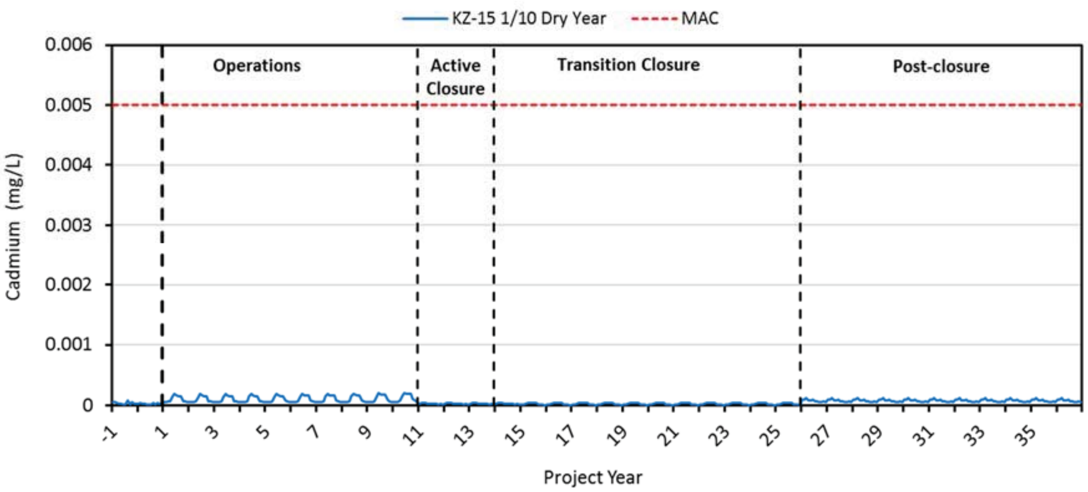

KZ-15 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
Project Year

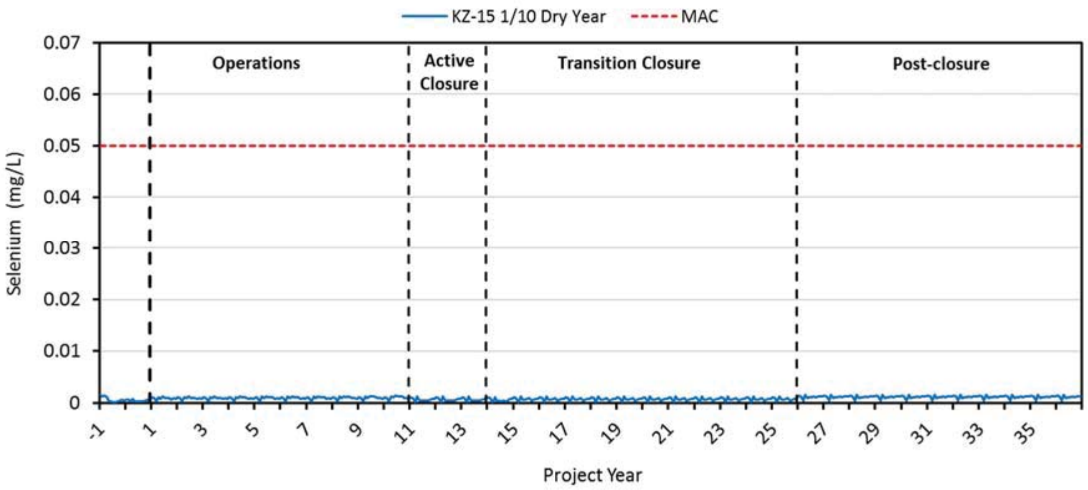

KZ-15 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Nitrite-N (mg/L)
Project Year

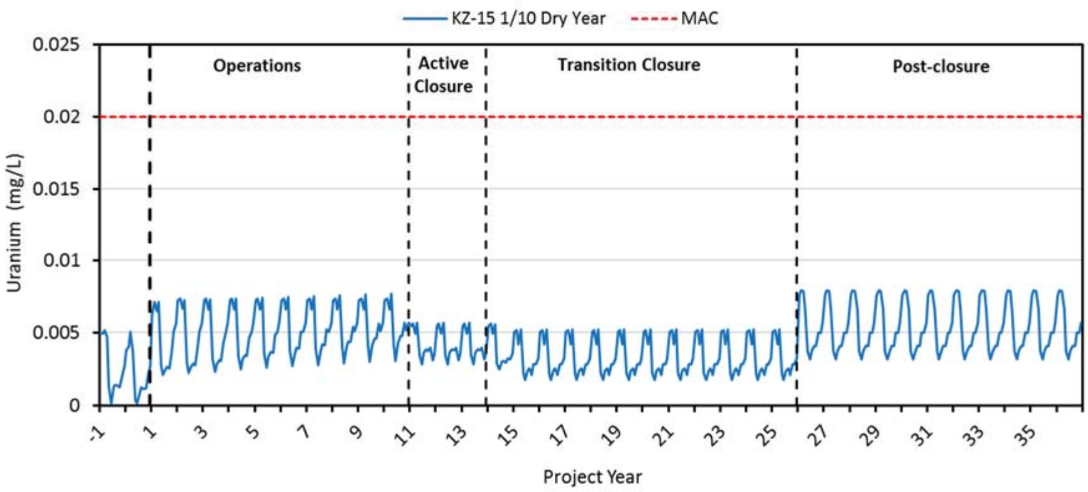

KZ-15 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Fluoride (mg/L)
Project Year

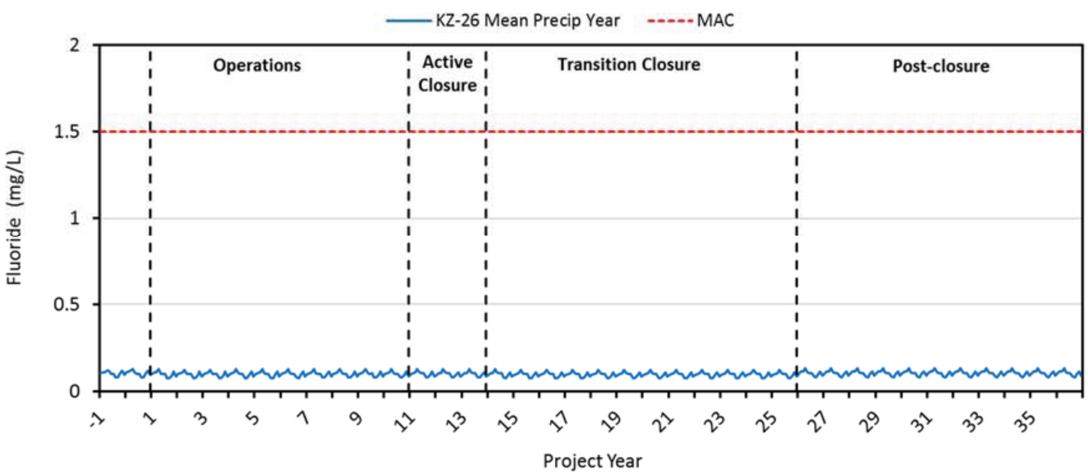

KZ-15 1/10 Dry Year
MAC
Antimony (mg/L)
Operations
Active Closure
Transition Closure
Post-closure
Project Year

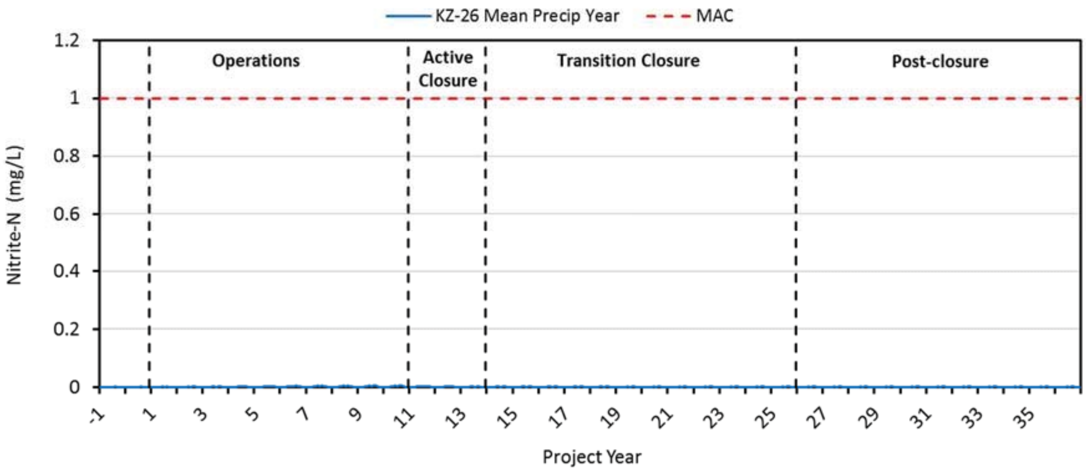

KZ-15 1/10 Dry Year
MAC
Arsenic (mg/L)
Operations
Active Closure
Transition Closure
Post-closure
Project Year

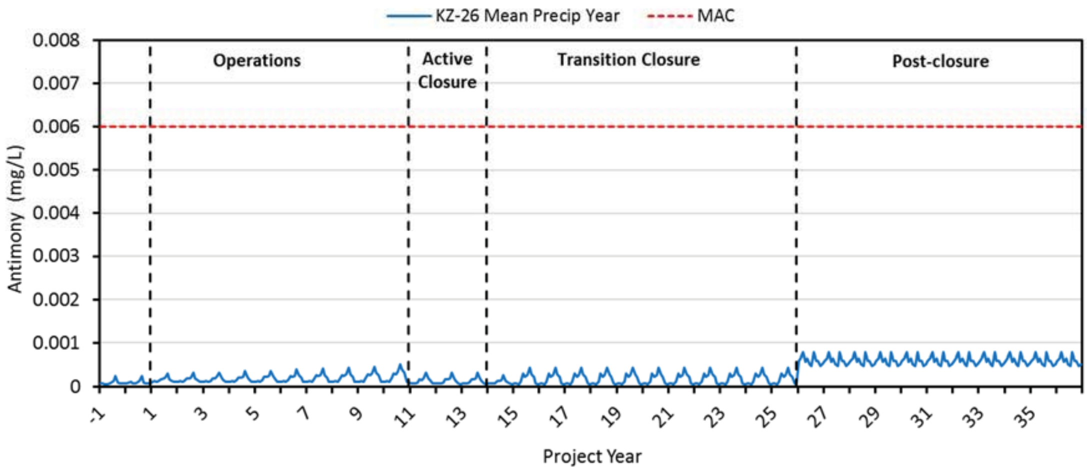

KZ-15 1/10 Dry Year
MAC
Cadmium (mg/L)
Operations
Active Closure
Transition Closure
Post-closure
Project Year


KZ-15 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
Project Year


KZ-15 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
Project Year


KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Fluoride (mg/L)
Project Year


KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Nitrite-N (mg/L)
1.2
1
0.8
0.6
0.4
0.2
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year


KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Antimony (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-1
1
3
5
7
9
11
13
15
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19
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23
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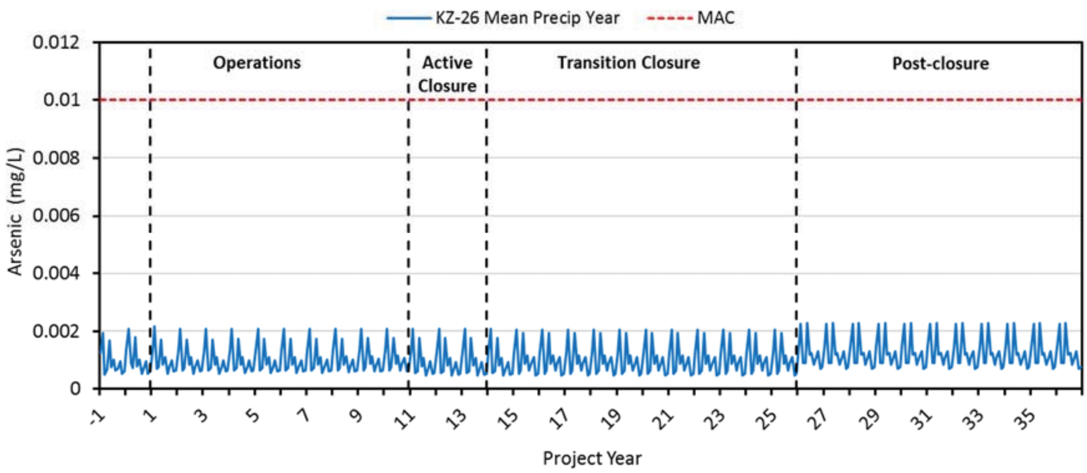
31
33
35
Project Year


KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Arsenic (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
-1
1
3
5
7
9
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15
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19
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23
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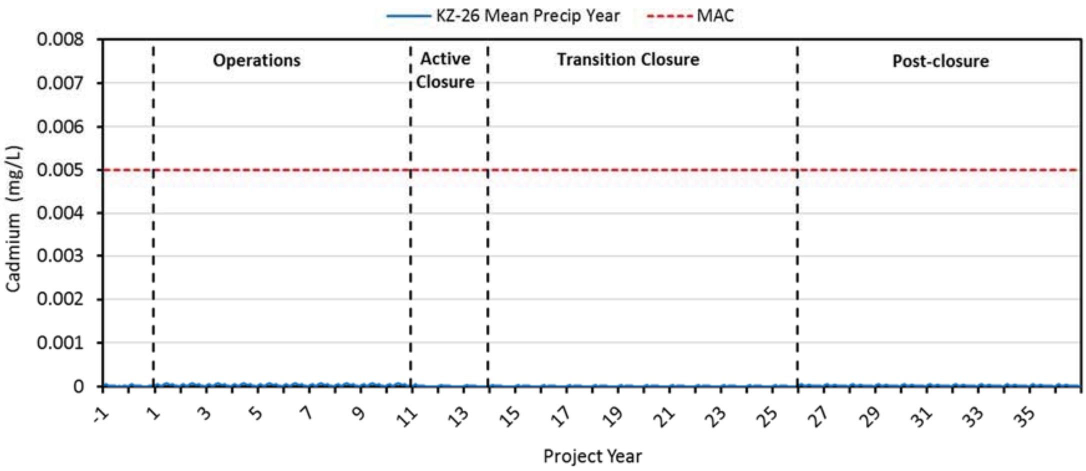
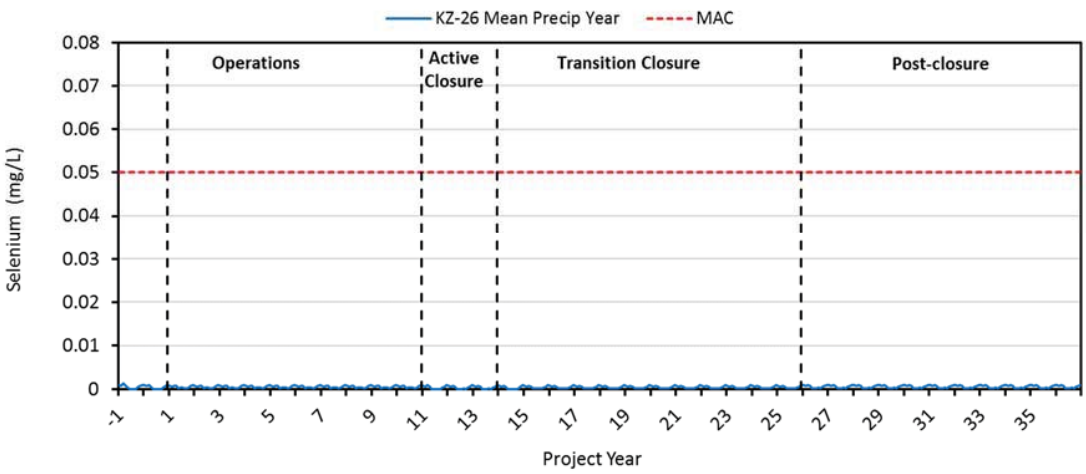
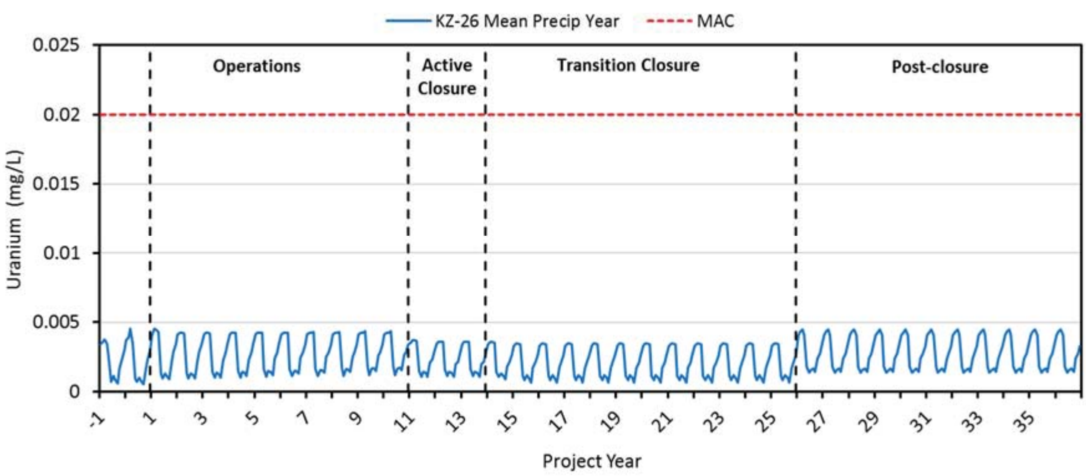
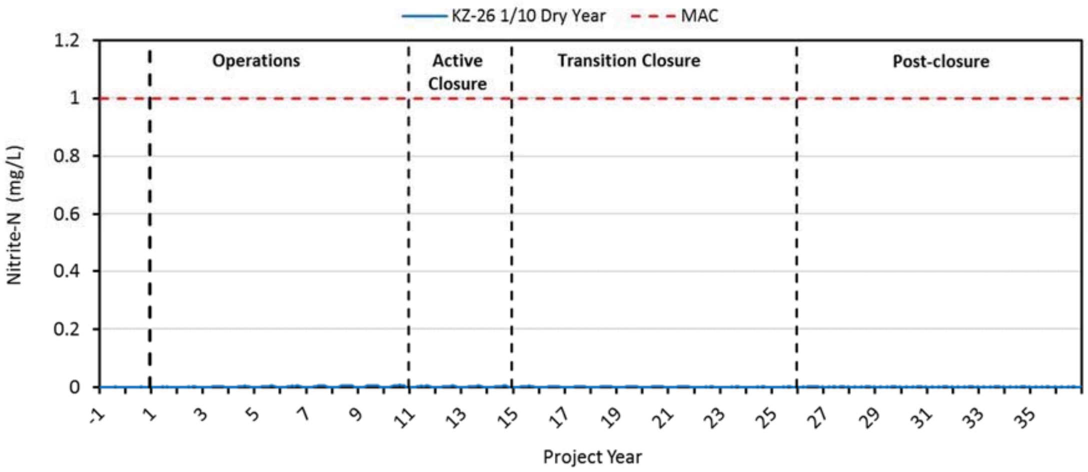
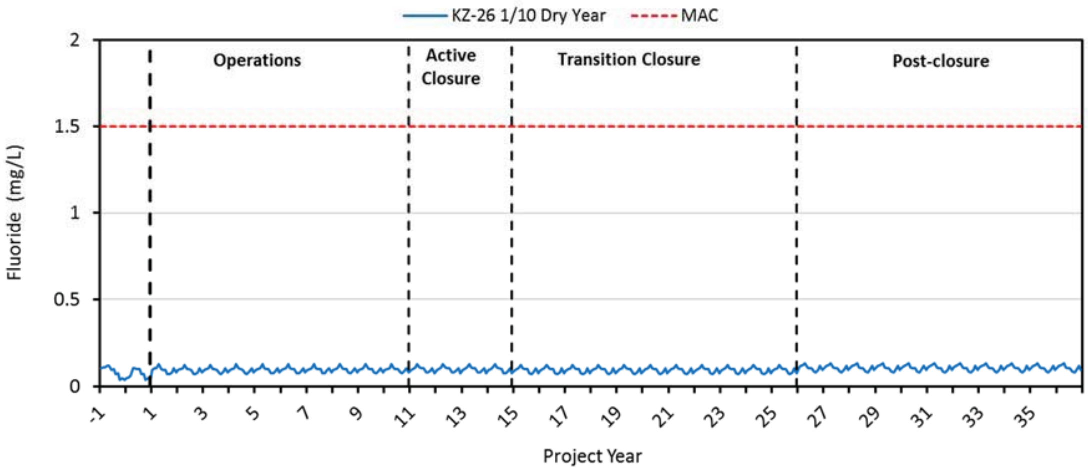
31
33
35
Project Year

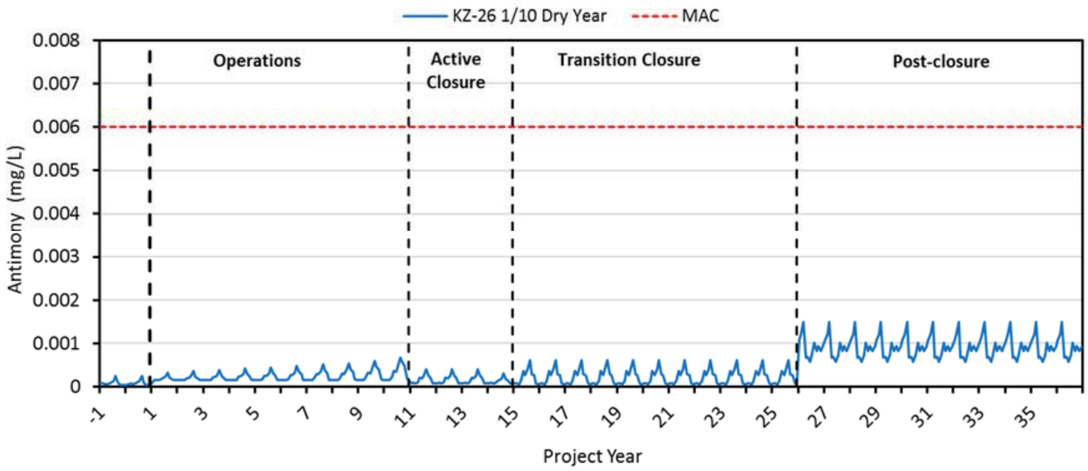

KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Cadmium (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

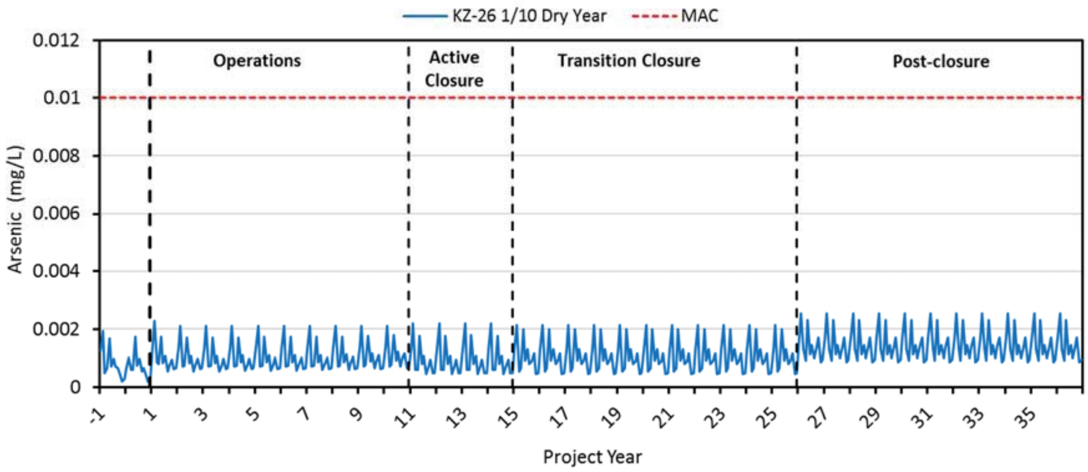

KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

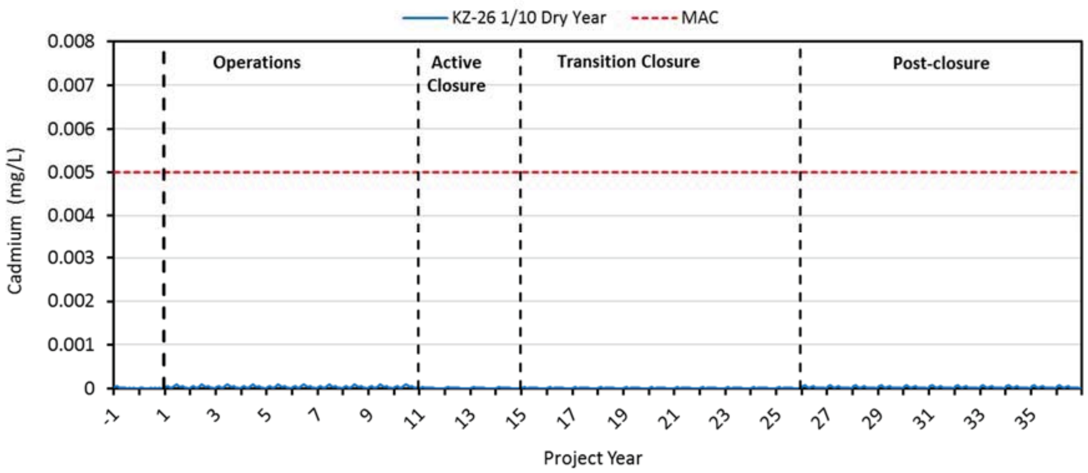

KZ-26 Mean Precip Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
0.025
0.02
0.015
0.01
0.005
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

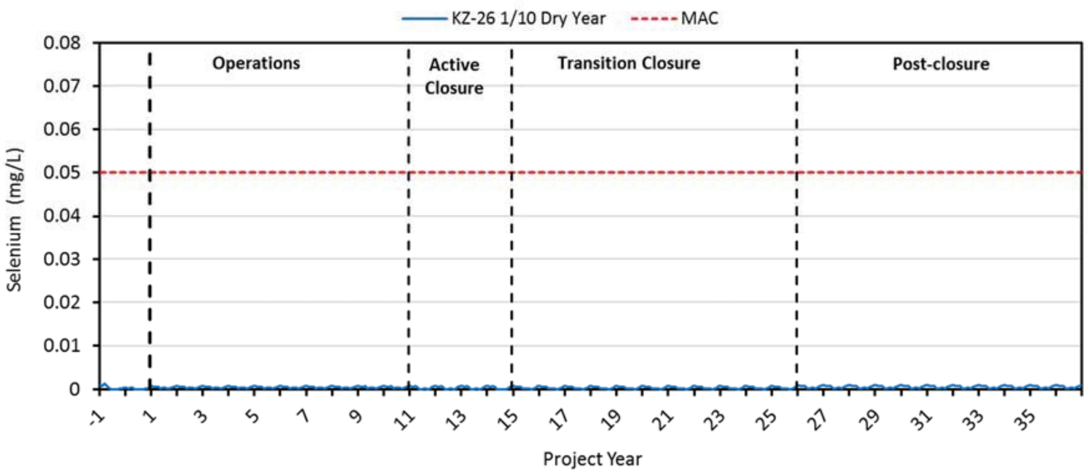

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Nitrite-N (mg/L)
Project Year

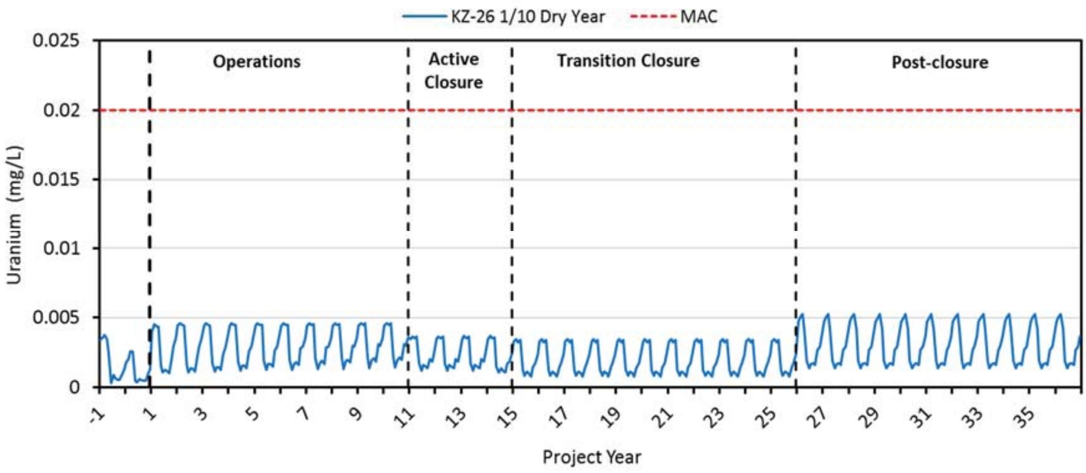

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Fluoride (mg/L)
Project Year


KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Antimony (mg/L)
Project Year

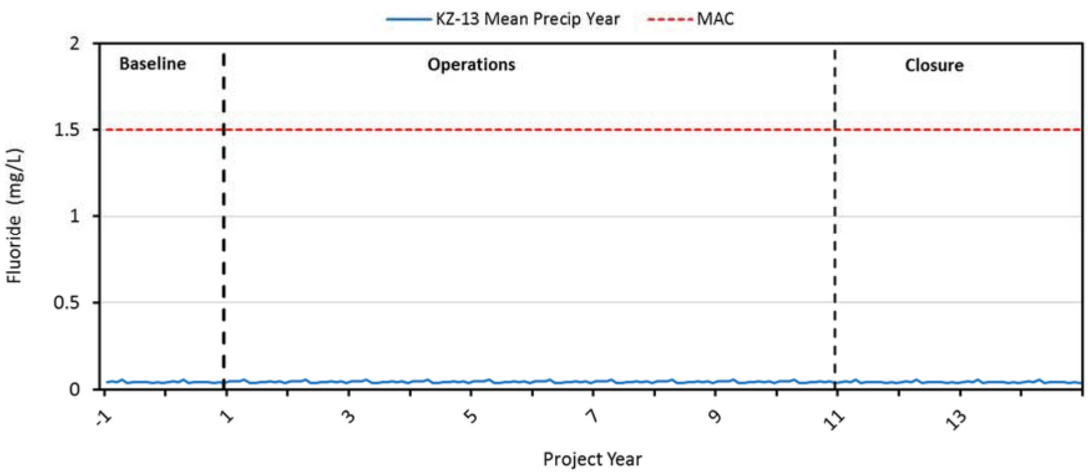

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Arsenic (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

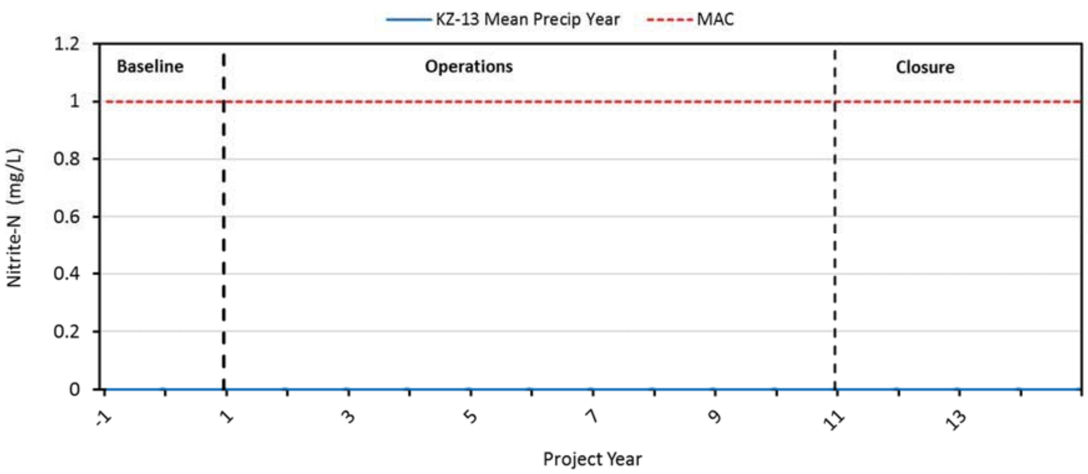

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Cadmium (mg/L)
0.008
0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

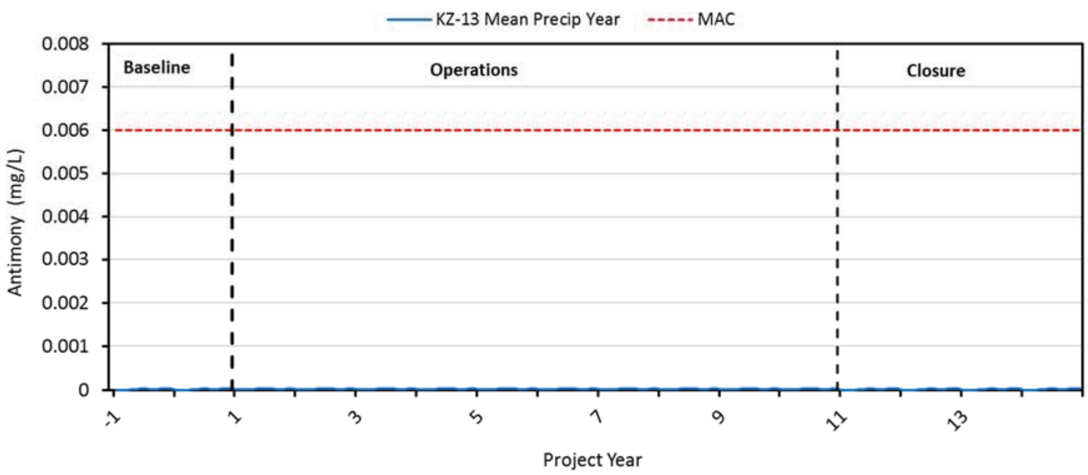

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Selenium (mg/L)
0.08
0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1 1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35
Project Year

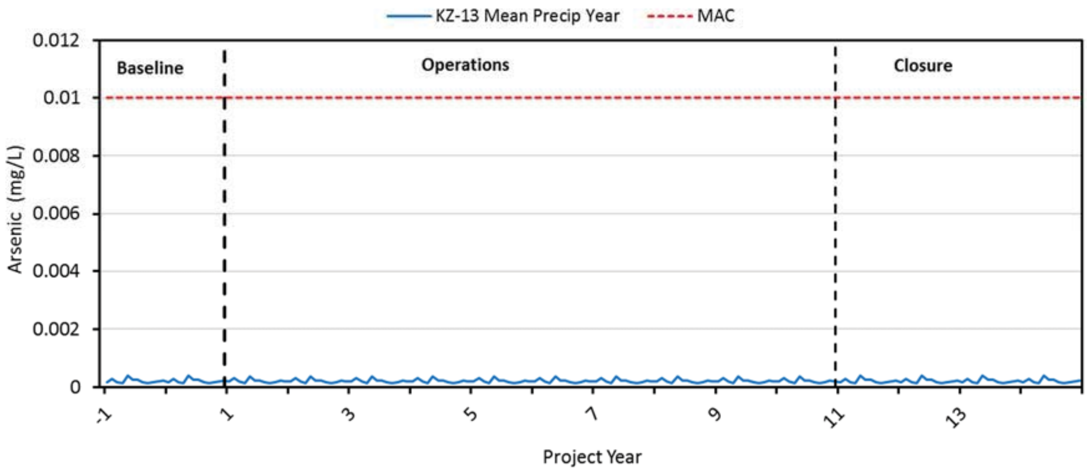

KZ-26 1/10 Dry Year
MAC
Operations
Active Closure
Transition Closure
Post-closure
Uranium (mg/L)
0.025
0.02
0.015
0.01
0.005
0
-1
1
3
5
7
9
11
13
15
17
19
21
23
25
27
29
31
33
35
Project Year

Model Results for South Creek








KZ-13 Mean Precip Year
MAC
Baseline
Operations
Closure
Arsenic (mg/L)
0.012
0.01
0.008
0.006
0.004
0.002
0
-1
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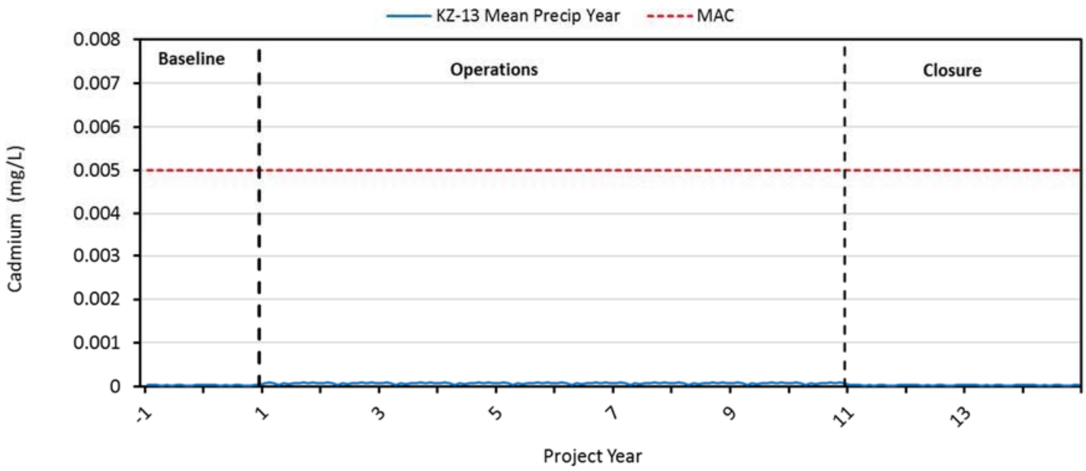
Project Year


KZ-13 Mean Precip Year
MAC
Baseline
Operations
Closure
Cadmium (mg/L)
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0.007
0.006
0.005
0.004
0.003
0.002
0.001
0
-1
1
3
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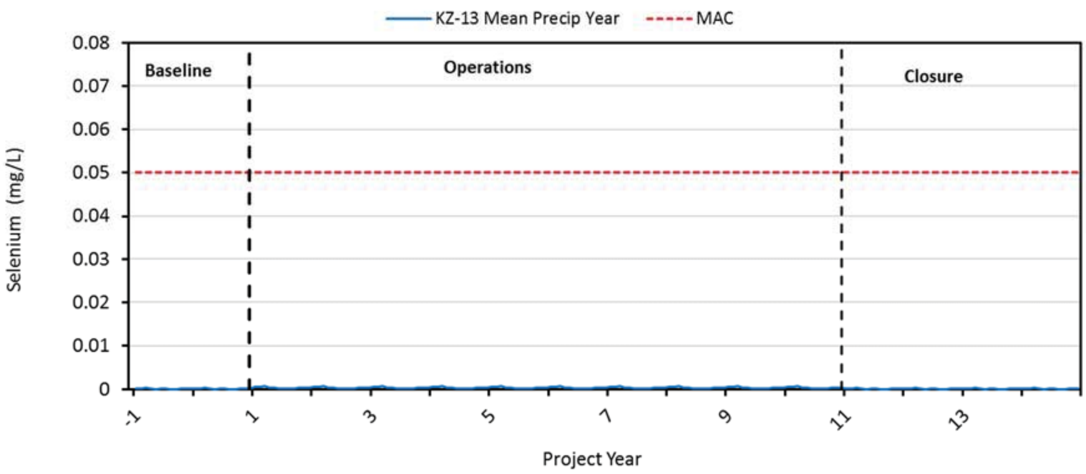
9
11
13
Project Year


KZ-13 Mean Precip Year
MAC
Baseline
Operations
Closure
Selenium (mg/L)
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0.07
0.06
0.05
0.04
0.03
0.02
0.01
0
-1
1
3
5
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13
Project Year

APPENDIX 4.
Water Treatment Summary

INTEGRATED SUSTAINABILITY

Memo

To:	[Name Redacted]
Cc:	[Name Redacted]
From:	[Name Redacted]
Date:	June 30, 2017
Project #:	VP17-BMC-01-00
Priority:	Normal
Subject:	Water Treatment Summary Outline - Draft

1 INTRODUCTION

BMC Minerals (BMC) has retained Integrated Sustainability Consultants Ltd. (Integrated Sustainability) to develop a technical outline for water treatment at the Kudz Ze Kayah mine project east of Whitehorse, Yukon.

In support of the Kudz Ze Kayah water treatment work, this memorandum is intended to summarize the process selection and modelling work that has been completed to advance water treatment plant (WTP) design and inform key stakeholders.

1.1 Water Treatment Basis

The water treatment plant will be designed to treat:

- All class A and class B contact water from the class A and B storage facility collection ponds
- Runoff from the process plant facility site collected in the perimeter sumps, including low grade ore (LGO) and run of mine (ROM) contact water

The intent is to treat all class A and B water classes of contact water in the WTP prior to discharge to the environment. The species requiring treatment/removal are expected to be fluoride, cadmium, selenium, and zinc.

Treatment of the class A and B contact water is expected to meet discharge objectives when blended with untreated pit rim pond water.

2 BACKGROUND

The following reports have been commissioned by BMC Minerals, and provide the basis for site water management:

- BMC-15-02-2351_019_Preliminary Water Quality Objectives_Rev3_161212
- BMC-15-02-2352_027_Receiving Environment Water Balance_Rev0_170113
- BMC-15-02-2353_038_KZK WQ Model_Rev0_170226

Further to the above reports, Integrated Sustainability have reviewed associated field and lab work provided.

2.1 Water Treatment for Project Water Management Phases

The candidate technologies consider the following project phases of the Kudz Ze Kayah project:

- Operations Phase
- Active Closure Water Management Phase
- Transition Closure Phase
- Post-Closure Phase

3 PREDICTED WATER QUANTITY AND QUALITY

The volume of water expected to be delivered to the treatment system is summarized in Table A.

Table A. Predicted Water Quantity

Parameter	Units	Flow
January	m^3/d	387
February	m^3/d	318
March	m^3/d	290
April	m^3/d	2,134
May	m^3/d	17,290
June	m^3/d	19,233
July	m^3/d	8,774
August	m^3/d	7,485
September	m^3/d	7,534
October	m^3/d	2,000
November	m^3/d	734
December	m^3/d	451
Total	m^3/yr	66,630
Daily Average	m^3/d	5907

The flow rates in Table A correspond to treating all of the class A and B contact water and runoff water. These flow estimates are preliminary, and may change as WTP influent flow and chemistry estimates are refined in subsequent phases of the project.

The opportunity for flow equalization is somewhat limited by the available space for water containment. Opportunities for flow equalization will be considered during engineering in order to reduce the size, capital cost and required turn-down of the WTP infrastructure.

3.1 Water Quality

Predicted WTP inflow data compiled from flow and concentration information is summarized in Table B.

Table B. Predicted Water Quality

Parameter	Units	Predicted WTP Influent	WTP Effluent Objectives
Hardness	mg/L	2338	N/A
Sulphate, dissolved	mg/L	2057	N/A
Nitrate (N)	mg/L	4.92	N/A
Nitrite (N)	mg/L	0.11	N/A
Ammonia (N)	mg/L	0.62	N/A
Phosphorus (P)	mg/L	0.037	N/A
Fluoride (F)	mg/L	0.72	0.058
Chloride	mg/L	64	N/A

Aluminum (Al), total	mg/L	0.053	N/A
Antimony (Sb), total	mg/L	0.035	N/A
Arsenic (As), total	mg/L	0.033	N/A
Cadmium (Cd), total	mg/L	0.048	0.00042
Copper (Cu), total	mg/L	0.0073	N/A
Iron (Fe), total	mg/L	0.0076	N/A
Lead (Pb), total	mg/L	0.024	N/A
Manganese (Mn), total	mg/L	4.80	N/A
Nickel (Ni), total	mg/L	0.089	N/A
Silver (Ag), total	mg/L	0.000076	N/A
Selenium (Se), total	mg/L	0.65	0.0022
Uranium (U), total	mg/L	0.014	N/A
Zinc (Zn), total	mg/L	2.81	0.09

The concentrations in Table B correspond to the 1/10 dry season concentrations of class A and B contact water.

Key water quality considerations include:

- High concentration of sulphate, which may inhibit the removal of selenium
- Total dissolved solids (TDS) concentration is not included in the analysis. Elevated concentration of TDS (including salinity) may reduce the effectiveness of specific ion removal, depending on membrane selection.
- The pH is not indicated, but impacts the oxidation state of the selenium and thus the mechanisms for removal (treatment processes). The mine water is assumed to have a circumneutral pH, given the natural buffering capacity of the local geology.

4 PROPOSED TREATMENT METHODS

Based on the site-specific requirements, we recommend a staged effluent treatment system that is designed to focus on bulk removal of dissolved and suspended species, as well as provisional unit processes that can provide polishing to achieve the required discharge standards.

The proposed active water treatment systems include the unit processes precipitation, chemical addition, media and/or membrane filtration, and ion exchange to meet the discharge water quality requirements. Provisions have been made to develop a treatment approach that can be adapted as more data becomes available and engineering work progresses.

4.1 Proposed Treatment

Preliminary candidate technologies include precipitation (via lime, sulphide or ferric addition), multimedia filtration, membrane filtration by nanofiltration (NF) or reverse osmosis (RO), and ion exchange (IX).

This approach assumes that the speciation of selenium may include elemental selenium and other oxidation states that produce oxygenated anions, e.g. selenite (HSeO4-;

oxidation state +IV) and selenate (SeO42-; oxidation state +VI). Permutations of the proposed processes could be configured to accommodate the requirement for targeting a variety of oxidation states of selenium with downstream polishing (e.g. an advanced reactive media ion exchange and/or reverse osmosis). The requirements for selenium removal will be confirmed pending a speciation of selenium, however preliminary thermodynamic modelling has been conducted to predict selenium speciation at the expected pH and reduction-oxidation potential ranges.

The high density sludge (HDS) and standard IX treatment option is suitable option for removal of selenium (in the elemental form), heavy metals and metalloids as well as other organic and inorganic parameters. Other species of selenium may be targeted with specialized ion exchange resins, or polishing with membrane filtration.

The treatment process is detailed in Figure A.

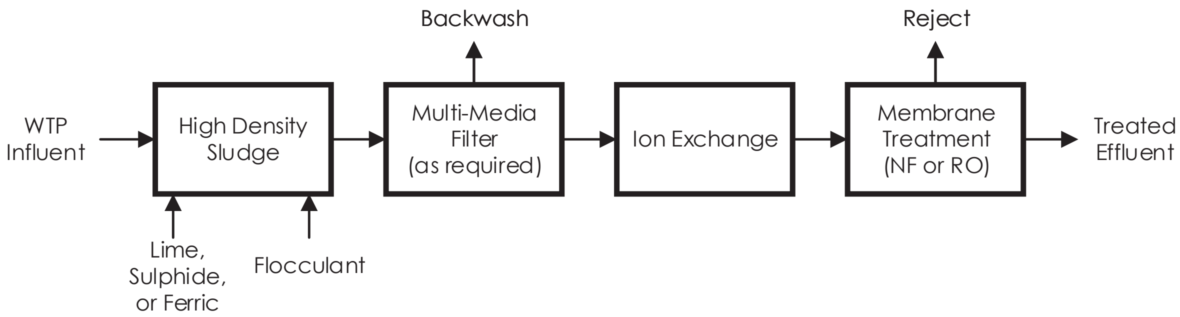

Figure A. Block flow Diagram of Treatment

Treatment consists of the following treatment processes:

- High density sludge – addition of lime, sulphide and/or ferric to encourage precipitiation of metals, and flocculation to improve separation of metals and metalloids. Ballast may be included to increase the settling rate of the particles to reduce the footprint of the clarifier
- Multi-media filtration – Filtration to prevent carryover of precipitated metallic and non-metallic solids from the HDS and flocculation clarification system to the ion exchange and/or membrane systems. This improves the removal of precipitated species and protects the ion exchange system.
- Ion exchange – Achieves removal of selenium and other trace metals via exchange of target species within a fluidized resin bed
- Membrane filtration – ultrafiltration, nanofiltration or reverse osmosis may be included to achieve a high degree of removal of trace elements including fluoride and selenium in oxy-anionic forms.

Filter backwash from the multi-media filter will be returned to the front-end of the process to reduce the volume of waste generated from this process.

Further evaluation will be conducted to determine the efficacy of different precipitation processes and any additional pre-treatment for ion exchange, as well as requirements for downstream membrane treatment.

The treatment process will generate waste streams such as HDS sludge, ion exchange regenerant and membrane reject that may require further treatment, stabilization and disposal. Disposal of the waste stream may be achieved through conveyance to an acceptable storage location (e.g. lined contaminated pond), with or without concentration via a sludge thickening/dewatering process (e.g. filter press), volume reduction via thermal processes (e.g. evaporator), or additional processing (e.g. electroreduction for ion exchange spent regenerant).

4.1.1 Precipitation via High Density Sludge Process

A High Density Sludge (HDS) process is a solids-separation technology that utilizes lime, sulphide and/or ferric addition to precipitate solids and produce a concentrated sludge that minimizes storage requirements and maximizes the sludge stability. Lime addition is the more conventional process, although metal sulphides have lower solubility than hydroxide species, so there can be significant advantages in effluent quality and sludge generation where the water chemistry supports sulphide precipitation. Ferric co-precipitation is also effective at removing elemental selenium and other heavy metals and may be employed to optimize the downstream process. Another benefit of ferric precipitation is that it may also be effective at removing uranium, which has been identified in water balance and geochemistry work. It is not expected to exceed the receiving water proposed limit but may become a treatment objective if elevated levels are developed in subsequent modelling or sampling.

A HDS process consists of the following components:

- Clarifier/thickener
- Lime, sulphide and/or ferricdosing
- HDS reactor tank (including aeration and agitation)
- Flocculant dosing
- Flocculant tank

Performance

Modelling for HDS performance using lime was undertaken using a specialized thermodynamic model to estimate removal rates from the influent, with the model focusing on metallic species. Results are summarized in Table C, and provided in detail in the Appendix. In order to support prelimary process selection with respect to polishing with advanced reactive ion exchange resin and/or reverse osmosis, selenium speciation was estimated by considering the generation of selenate from selenite as alkalinity increased while considering the effects of sulphate in maintaining a portion as selenite.

Modelling for sulphate and/or ferric addition will be completed during preliminary engineering process selection to optimize the HDS process.

The following assumptions were incorporated into the model:

- WTP influent is slightly acidic (pH 6.5 used to assume oxidation states of elements for chemical modelling)
- Selenium speciation is 60% selenate, 40% selenite
- HDS process will be run at pH of 10
- Assumes equilibrium is reached

Table C. HDS System (Lime) – Influent and Effluent Water Qualities

Parameter (units)	Units	Influent Water Quality	Predicted Effluent Water Quality
Cadmium (Cd), total	mg/L	0.048	Feed
Copper (Cu), total	mg/L	0.0073	0.00040
Iron (Fe), total	mg/L	0.0076	0.00070
Lead (Pb), total	mg/L	0.0237	Feed
Manganese (Mn), total	mg/L	4.8	Feed
Nickel (Ni), total	mg/L	0.089	0.019
Silver (Ag), total	mg/L	0.000076	Feed
Selenium (Se), total	mg/L	0.65	Feed
Uranium (U), total	mg/L	0.01351	0.0021
Zinc (Zn), total	mg/L	2.81	Feed[1]

[1]Zinc is expected to transition from Zn^{2+} to $Zn(OH)_2$ at a pH of 10, however, model results suggest zinc hydroxide will remain soluble. Additional optimization and sensitivity testing if the model is planned to further examine zinc removal in HDS

Advantages and Disadvantages of High Density Sludge Systems

- Produces high quality effluent
- Simple operation
- Many system components required
- Chemical dosing and optimization is necessary

4.1.2 Multi-media Filtration

Overflow from the HDS system will be filtered through a multimedia filter, which will remove suspended solids as well as dissolved metals that can be precipitated by oxidation (e.g. iron, manganese). The feed water from the HDS will be dosed with flocculant to aid in the agglomeration and retention of suspended solids. Filtered water will then flow to a dedicated filtered water tank.

The filter will periodically perform an automated backwash based on pressure differential or total filter throughput. During filter backwash, water from the Filtered Water Tank is pumped up through the filter. After backwash, the filter is rinsed to return the filtrate to acceptable quality. The backwash stream is sent to a storage location (e.g. surge pond or tank) for solids removal and water recovery.

The multimedia filter consists of an specialized coarse and fine media that provides effective pre-treatment for the downstream processes which may include ion exchange and/or membrane filtration processes. Effective pre-treatment will protect the ion exchange resin beds and/or membranes from fouling and will increase the operational run-time and life span of the systems, thus reducing operating costs.

Performance

The multimedia filter performance was assessed using benchmark performance data from leading manufacturers. The filter is anticipated to remove total suspended solids from the HDS effluent down to a concentration of 4 mg/L, with manganese and un-oxidized iron being oxidized and removed in the filtration process simultaneously.

4.1.3 Sludge Thickener

A sludge thickener will be implemented to dewater the HDS system sludge, multimedia filter backwash and potentially the membrane filtration concentrate (pending further evaluation). The filter backwash will contain suspended solids and other contaminants. The sludge thickener will dewater the suspended solids within the filter backwash and membrane system concentrate.

The water recovered from the sludge thickener will be returned to the influent line upstream of the HDS.

4.1.4 Ion Exchange

Ion exchange is included to target elemental selenium and can be configured to remove other selenium oxidation states and compounds (e.g. selenite, selenate) from the influent. A key design criteria for ion exchange is selection of a suitable resin to selectively remove target parameters. During operation, the resin will become saturated with the target parameters and is periodically regenerated using a brine solution that reverses the ion exchange process. In some cases, where downstream membrane filtration is employed, there can be a comingling of membrane reject and regenerant to reduce overall waste volume. Some plants are also designed to futher concentrate and precipitate the dissolved components of the waste regenerant to produce a solid waste product, which can be dewatered and stockpiled or trucked away.

During engineering, modelling will be undertaken to optimize resin selection, waste management as well as consider whether a multi-stage ion exchange process will be employed. An upfront sacrificial column set may be required to prevent fluoride interference with selenium, and a downstream polishing column set may be required to target other oxidation states of selenium.

4.1.5 Membrane Treatment

Membrane filtration is a pressure-membrane technology that can filter out suspended particles, and other dissolved and non-soluble contaminants, such as oil, bacteria, metals, suspended and dissolved solids. A succession of membranes of increasingly discriminating pore sizes may be used at successively higher feed pressures. For example, ultrafiltration (UF), when used as a pre-treatment system for an RO, helps reduce fouling of the RO membranes.

Membrane treatment may include UF pretreatment, nanofiltration (likely without UF pre-treatment), or reverse osmosis (with UF pretreatment).

4.1.6 Ultrafiltration

The UF unit operation includes multiple treatment trains in parallel to accommodate variable flow requirements. UF permeate is expected to consistently produce a high-quality permeate with turbidity less than 0.2 NTU, regardless of feed water quality. The high quality permeate will be free of suspended solids, and will provide pre-treatment that will improve efficiency of the RO membranes.

The UF concentrate waste stream that will flow to the sludge thickener for dewatering, or to the HDS for an additional pass through the metals removal circuit. The UF concentrate waste stream will consist mostly of suspended solids that are too large to pass through the membrane pores. The permeate water quality will be characterized by dissolved parameters such as calcium ions, and chloride, which will be removed in the RO process, respectively.

Advantages and Disadvantages of Ultrafiltration Systems

- Small footprint
- Longer operational service life than RO membranes
- High tolerance to feed water quality upsets
- Does not require pre-treatment chemicals
- When operated as a pre-treatment, UF improves the performance and reduces maintenance costs of the RO system
- Cannot separate low molecular weight or dissolved contaminants

Table D. Ultrafiltration – Influent and Effluent Water Qualities

Parameter (units)	Units	Influent Water Quality	Predicted Effluent Water Quality
Turbidity	NTU	2	<0.2
Total Suspended Solids (TSS)	mg/L	4	<0.5
Silt Density Index (SDI)[1]	N/A	N/A	3

[1]The silt density index is used to indicate the quantity of particulate matter in water and is applicable to relatively low (<1.0 NTU) turbidity waters such as well water, filtered water, or clarified effluent samples (ASTM D4189-07, 2014).

Performance

The UF unit is projected to recover 96% of the influent as a high-quality permeate, with the remaining 4% as a reject stream. This was determined via industry UF modelling software, assuming four racks of HYDRAcap MAX 80 modules, with 105 m^2 of membrane area per module. UF model results have been included in Appendix 1.

4.1.7 Nanofiltration and Reverse Osmosis

Nanofiltration and reverse osmosis are used to remove microorganisms and multivalent ions from influent water. Nanofiltration has a larger pore size and better tolerance to suspended solids, but is only marginally effective at removing small multivalent ions and monovalent ions. Because of the sensitivity of RO to suspended solids, UF is often used upstream. In this application, some modelling has been done to evaluate a UF/RO system, although further evaluation will be conducted to determine the optimal membrane system which may contain UF/RO or NF.

A two-stage fully automatic RO system was modelled for purposes of removing the dissolved fraction of target parameters such as sulphate, chlorides and remaining heavy metals as required by the environmental discharge requirements. The proposed RO system is configured in two stages and is expected to provide 79 % recovery. Subsequent process modelling may include additional stages of RO to optimize higher recovery rate (and, consequently, lower waste generation) vs capital and operaring cost (including power and chemical consumption). The RO system will produce high-purity water that is suitable for discharge to the environment.

The model for RO conservatively assumed little to no reduction of selenium in the HDS process. Software sensitivity limited evaluation of selenium removal over less than 0.005 mg/L, but is supported by full scale applications in which selenium was reduced to 0.002 mg/L at the Barrick Richmond Hill Mine, and to less than 0.005 mg/L at a former gold mine in California (U.S. Environmental Protection Agency, 2014). Additional modelling to improve sensitivity to low effluent concentration and incorporate upstream ion exchange will be conducted to establish consistent removal to below 0.002 mg/L

The 2nd stage RO system will increase the throughput by treating the concentrate waste stream from the first stage. Concentrate from the first-stage membrane module will be sent to the second stage RO membrane module for treatment, and the concentrate from the second RO stage will be sent to the evaporator for solids recovery.

The RO equipment will be furnished with a fully automatic Clean in Place (CIP) and permeate flush system.

Further evaluation of whether the ammonia entering the WTP is ionized or un-ionized is required, as pH adjustment may be required prior to the RO to meet target removal rates.

Additional RO stages may decrease the volume of brine generated, however, increased anti-scalant usage may be required to prvent fouling in successive stages.

Advantages and Disadvantages of Reverse Osmosis Systems

- Risk of fouling and scaling membranes
- Membranes are sensitive to process upset (e.g. chemical or suspended solids breakthrough)
- Modularized system
- Demonstrated at full scale to remove selenium (selenite or selenate) to less than 5 µg/L

Table E. Reverse Osmosis – Influent and Effluent Water Qualities

Parameter (units)	Units	Influent Water Quality	Predicted Effluent Water Quality
Hardness	mg/L	2110	6.39
Sulphate, dissolved	mg/L	2057	5.52
Cadmium (Cd), total	mg/L	0.048	0.00042
Nitrate (N)	mg/L	4.92	0.27
Ammonia (N)	mg/L	0.62	0.011
Fluoride (F)	mg/L	0.72	0.015
Chloride	mg/L	64	0.69
Lead (Pb), total	mg/L	0.0237	0.0012
Manganese (Mn), total	mg/L	0.05	<0.001
Selenium (Se), total	mg/L	0.65	<0.005
Silver (Ag), total	mg/L	0.000076	<0.00001
Zinc (Zn), total	mg/L	2.81	0.009

Performance

The RO unit is predicted to remove the remainder of dissolved solids to target effluent objectives at a 79% overall permeate recovery (i.e. 21% reject stream). The effluent quality was determined with industry RO modelling software, assuming four trains using CPA5-LD RO membrane elements. RO model results have been included in Appendix 1.

5 PROCESS SELECTION – RATIONALE

Based on the treatment requirements identified, it is expected that the treatment requirements can be achieved using the treatment approach shown in Figure A.

The polishing processes (membrane filtration or advanced ion exchange) are included as provisional process steps, but may be excluded if the base case ion exchange effluent meets the target criteria for discharge.

Reverse osmosis was selected as the preferred provisional polishing unit process as it was deemed the most reliable to achieve the effluent objectives required. While the process steps upstream of the RO system will reduce the concentration of a large number of these species, the RO (if required) will provide a polishing step to reach target concentrations and provide treatment for any species not removed in earlier steps, such as ammonia.

Ion exchange is a common process and capable of removing various species of inorganic contaminants, heavy metals and selenium in different valence states. To account for variable selenium species, this process may include specialized, advanced reactive media. Multi-stage ion exchange would require highly skilled operators and may require targeted pilot testing due to the sensitivity to site specific water quality.

Other candidate technologies capable of treating water to the requirements include:

- Thermal processes
    - Evaporation and/or crystallization for bulk removal of the key contaminants is expected to have extensive pre-treatment requirements
    - The capital and operating costs associated with this treatment method may be significantly higher than the membrane treatment (i.e. the ultrafiltration and RO system proposed)
    - Thermal process may be useful to treat membrane reject as a waste-reduction process
- Electrodeionization
    - Electrodeionization is used for very challenging wastewater and has precedent in ultra-pure water treatment applications
    - Suitable for low TDS water (~150-200 ppm)
    - It is often used as an alternative to mixed bed deionization, since it does not require chemical addition for regeneration
    - Often used as a replacement for Reverse Osmosis, if the chemistry of the water suits the technology (most are affected by the presence of dissolved gasses)
    - The capital and operating costs associated with this treatment method may be significantly higher than membrane treatment (i.e. the ultrafiltration, nanofiltration and RO systems)
- Biological treatment
    - Various biological methods exist for treatment of selenium, which reduce the oxyanion species to elemental selenium, including:
        - Fixed film bacterial attenuation
        - Algal volatilization
        - Constructed wetlands
        - Phytoremediation
    - Extensive piloting would likely be required and long-term operational information on the performance and optimization of biological systems (particularly in cold-weather) is not readily available

5.1 Similar Applications

The process selection employed to date has referenced vaious other mining applications in which similar influent flow and chemistry has been targeted to meet similar effluent objectives. Examples of operating projects, successful pilots or projects in advanced engineering include:

- JDS Silver Silvertip mine – To target Cd, Zn, Cu the SilverTip mine uses sulphide precipitation followed by media filtration. Ferric addition for co-precipitation is included to target selenium, but is not used full-time.
- AuRico Gold Kemess Underground Mine – Current plans for the Kemess underground mine include ferric co-precipitation, sulphide precipitation followed by ion exchange to remove total selenium to 0.002 mg/L.[1] The treatment plant is currently in the detailed engineering and permitting phase, and succesful piloting of the treatment process took place in 2015 and 2017.
- IDM Mining Red Mountain – Current plans for the Red Mountain mine include lime and ferric co-precipitation for metals removal. The mine is currently in feasibility-level engineering
- Wolverine mine - Two treatment methods for removal of selenium and dissolved metals from tailings storage facility water at the Wolverine mine were evaluated at a scoping level:
  - In-situ biological reduction combined with ferric/lime treatment, and
  - Zero-valent iron treatment combined with ferric/lime treatment. [2]

5.2 Residuals Management

The ion exchange system and membrane filtration systems will ultimately generate a waste streams.

Based on experience with similar projects, the ion exchange waste stream is expected to be approximately 5% of the inlet flow, assuming that lean "shoulder" regenerant may be recovered and recycled.

For the RO system, preliminary modeling estimates that up to 21% of the inlet flow will be retained as reject. Further analysis of an NF system is required to estimate reject stream volumes.

Incorporating further RO passes will decrease the volume of reject, however additional chemical dosage will be required to prevent scaling (for example, due to $CaSO_4$ saturation occurring at the RO membrane surface).

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[1] Feasibility Study Update Kemess Underground Project British Columbia, Canada, SRK Consulting

[2] Wolverine Mine Reclamation and Closure Plan Version 2016-07, Yukon Zinc Corporation

The management of this reject stream has been carefully considered in the planning work to date on WTP design and process selection.

The understanding is that the Kudz Ze Kayah mill will be able to effectively manage up to 7.5 m^3/hr (180 m^3/d) of reject, whereas preliminary modelling indicates that the RO reject stream is likely to exceed this amount in a two pass configuration. Additional treatment of the waste stream such as a thermal process (e.g. by evaporator/crystallizer or humidification/dehumidification process) may be considered to further reduce the volume of the waste stream.

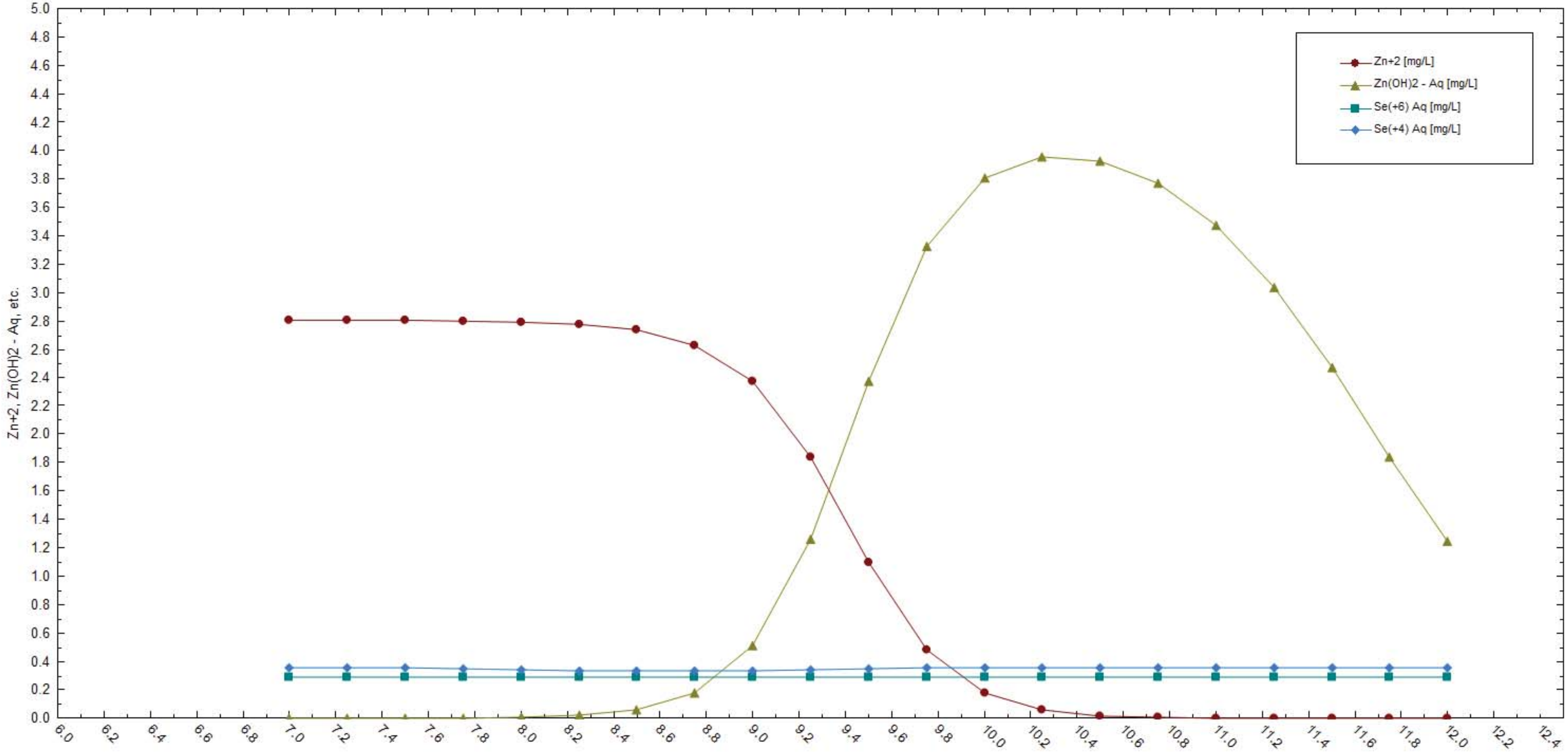
To most economically manage the reject volume while achieving discharge objectives, consideration should be made for a chemical optimization program, in which the capital expenditures and operating expenses of increased RO passes and increased anti-scalant dosage would be compared against a thermal process.

6 BIBLIOGRAPHY

U.S. Environmental Protection Agency. (2014). *Reference Guide to Treatment Technologies for Mining-Influenced Waters.* US EPA.

Appendix 1 – Technical Documentation

HDS Modelling Results – Selenium and Zinc Species vs pH



HDS Modelling Results – Select Species in Aqueous Phase vs pH

	Target pH	Zn+2	Zn(OH)2 - Aq	U(+6) Aq	Se(+6) Aq	Se(+4) Aq	Pb(+2) Aq	Ni(+2) Aq	Mn(+2) Aq	Fe(+3) Aq	Cu(+2) Aq	Cd(+2) Aq	Ag(+1) Aq
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
1	7.00000	2.80684	6.06521e-5	0.0135077	0.291152	0.358749	0.0236960	0.0889850	4.79919	5.38768e-4	7.29877e-3	0.0479919	7.59872e-5
2	7.25000	2.80586	1.91730e-4	0.0135077	0.291152	0.358750	0.0236960	0.0889850	4.79919	5.31694e-4	7.29877e-3	0.0479919	7.59872e-5
3	7.50000	2.80401	6.05902e-4	0.0135077	0.291151	0.355955	0.0236960	0.0869088	4.79919	5.28147e-4	7.29876e-3	0.0479919	7.59872e-5
4	7.75000	2.80035	1.91353e-3	0.0135077	0.291151	0.345513	0.0236960	0.0791498	4.79919	5.26510e-4	7.29876e-3	0.0479919	7.59872e-5
5	8.00000	2.79267	6.03452e-3	0.0135077	0.291151	0.339580	0.0236960	0.0747411	4.79919	5.26115e-4	7.29875e-3	0.0479919	7.59872e-5
6	8.25000	2.77544	0.0189651	0.0105358	0.291151	0.336454	0.0236960	0.0724183	4.79919	5.26797e-4	7.29874e-3	0.0479919	7.59872e-5
7	8.50000	2.73393	0.0590769	6.75583e-3	0.291151	0.335180	0.0236960	0.0714716	4.79919	5.28781e-4	5.28027e-3	0.0479919	7.59872e-5
8	8.75000	2.62950	0.179688	4.63836e-3	0.291151	0.335354	0.0236960	0.0716011	4.79919	5.32739e-4	2.35916e-3	0.0479919	7.59872e-5
9	9.00000	2.37340	0.512918	3.45019e-3	0.291151	0.337027	0.0236960	0.0728442	4.79919	5.40021e-4	1.15100e-3	0.0479919	7.59872e-5
10	9.25000	1.84307	1.25975	2.78285e-3	0.291152	0.340714	0.0236960	0.0755837	4.79919	5.53106e-4	6.23407e-4	0.0479919	7.59873e-5
11	9.50000	1.09678	2.37114	2.40785e-3	0.291152	0.347518	0.0236960	0.0806393	4.79920	5.76448e-4	3.99782e-4	0.0479920	7.59873e-5
12	9.75000	0.485611	3.32063	2.19706e-3	0.291152	0.358750	0.0236960	0.0491059	4.79920	6.17995e-4	3.40455e-4	0.0479920	7.59873e-5
13	10.0000	0.176008	3.80652	2.07856e-3	0.291152	0.358750	0.0236961	0.0190909	4.79920	6.91898e-4	4.02948e-4	0.0479920	7.59873e-5
14	10.2500	0.0578401	3.95619	2.01193e-3	0.291152	0.358751	0.0236961	8.03476e-3	4.79920	8.23329e-4	5.98426e-4	0.0479920	7.59874e-5
15	10.5000	0.0169277	3.92744	1.97676e-3	0.291178	0.358783	0.0236982	3.50319e-3	4.63563	1.04841e-3	9.70277e-4	0.0479964	7.59942e-5
16	10.7500	4.95110e-3	3.76580	1.95724e-3	0.291191	0.358798	0.0236992	1.70195e-3	1.52140	1.44853e-3	1.65294e-3	0.0479984	7.59975e-5
17	11.0000	1.42866e-3	3.47277	1.94603e-3	0.291199	0.358799	0.0236995	8.91428e-4	0.542836	2.16361e-3	2.88215e-3	0.0479991	6.42392e-5
18	11.2500	3.93991e-4	3.03633	1.93959e-3	0.291211	0.358791	0.0236997	4.97814e-4	0.210337	3.43766e-3	5.07736e-3	0.0417026	3.62555e-5
19	11.5000	1.01443e-4	2.47094	1.93583e-3	0.291219	0.358787	0.0236998	3.07857e-4	0.0897529	5.70614e-3	7.29995e-3	0.0311700	2.04832e-5
20	11.7500	2.39752e-5	1.84205	1.93352e-3	0.291224	0.358787	0.0237000	2.33457e-4	0.0427411	7.60001e-3	7.30001e-3	0.0271946	1.16101e-5
21	12.0000	5.16322e-6	1.24813	1.93186e-3	0.291230	0.358790	0.0237004	2.42401e-4	0.0229475	7.60012e-3	7.30011e-3	0.0258239	6.63141e-6

Basic Design

Project name	H2OI Mining WTP RO		
Calculated by	UDY	Permeate flow/train	1800.0 m3/d
HP Pump flow	94.93 m3/h	Total product flow	7200.00 m3/d
Feed pressure	14.3 bar	Number of trains	4
Feed temperature	4.0 °C(39.2°F)	Raw water flow/train	2278.5 m3/d
Feed water pH	7.50	Permeate recovery	79.00 %
Chem dose, mg/l, -	H2SO4	Element age	0.0 years
Specific energy	0.66 kwh/m3	Flux decline %, first year	12.0
Pass NDP	11.9 bar	Fouling factor	1.00
Average flux rate	16.8 lmh	SP increase, per year	10.0 %
		Inter-stage pipe loss	0.2 bar
		Feed type	Waste MF/UF

Pass - Stage	Perm. Flow m3/h	Flow / Vessel Feed m3/h	Flow / Vessel Conc m3/h	Flux lmh	DP bar	Flux Max lmh	Beta	Stagewise Pressure Perm. bar	Stagewise Pressure Boost bar	Stagewise Pressure Conc bar	Perm. TDS mg/l	Element Type	Element Quantity	PV# x Elem #
1-1	52.5	7.3	3.3	18.2	0.4	19	1.17	0	0	13.9	9.2	CPA5-LD	78	13 x 6M
1-2	22.5	6.1	2.8	14.4	0.3	16.1	1.15	0	0	13.3	28.6	CPA5-LD	42	7 x 6M

Ion (mg/l)	Raw Water	Feed Water	Permeate Water	Concentrate 1	Concentrate 2
Hardness, as CaCO3	2110.62	2110.62	6.388	4719.9	10060.1
Ca	559.00	559.00	1.692	1250.1	2664.4
Mg	174.00	174.00	0.527	389.1	829.4
Na	117.38	117.38	1.696	261.5	554.4
K	16.05	16.05	0.289	35.7	75.6
NH4	0.62	0.62	0.011	1.4	2.9
Ba	0.000	0.000	0.000	0.0	0.0
Sr	0.000	0.000	0.000	0.0	0.0
Mn	0.050	0.050	0.000	0.1	0.2
Pb	0.020	0.020	0.000	0.0	0.1
Zn	2.810	2.810	0.009	6.3	13.4
H	0.00	0.00	0.001	0.0	0.0
CO3	0.41	0.41	0.000	2.5	13.6
HCO3	186.66	186.66	4.289	410.0	854.7
SO4	2057.00	2057.00	5.522	4600.5	9807.2
Cl	64.00	64.00	0.685	142.7	303.2
F	0.72	0.72	0.015	1.6	3.4
NO3	4.92	4.92	0.268	10.8	22.5
PO4	0.00	0.00	0.000	0.0	0.0
OH	0.00	0.00	0.000	0.0	0.0
SiO2	2.73	2.73	0.028	6.1	12.9
B	0.00	0.00	0.000	0.0	0.0
CO2	11.30	11.30	11.30	11.30	11.30
TDS	**3186.37**	**3186.37**	**15.03**	**7118.41**	**15158.02**
pH	**7.50**	**7.50**	**5.96**	**7.81**	**8.10**

Saturations	**Raw Water**	**Feed Water**	**Concentrate**	**Limits**
CaSO4 / ksp * 100, %	133	133	936	400
SrSO4 / ksp * 100, %	0	0	0	1200
BaSO4 / ksp * 100, %	0	0	0	10000
SiO2 saturation, %	3	3	13	140
CaF2 / ksp * 100, %	20	20	1266	50000
Ca3(PO4)2 saturation index	0.0	0.0	0.0	2.4
CCPP, mg/l	51.87	51.87	564.01	
Langelier saturation index	0.46	0.46	2.33	2.5
Ionic strength	0.09	0.09	0.43	
Osmotic pressure, bar	1.0	1.0	4.7	

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Basic Design

Project name	H2OI Mining WTP RO		
Calculated by	UDY	Permeate flow/train	1800.0 m3/d
HP Pump flow	94.93 m3/h	Total product flow	7200.00 m3/d
Feed pressure	14.3 bar	Number of trains	4
Feed temperature	4.0 °C(39.2°F)	Raw water flow/train	2278.5 m3/d
Feed water pH	7.50	Permeate recovery	79.00 %
Chem dose, mg/l, -	H2SO4	Element age	0.0 years
Specific energy	0.66 kwh/m3	Flux decline %, first year	12.0
Pass NDP	11.9 bar	Fouling factor	1.00
Average flux rate	16.8 lmh	SP increase, per year	10.0 %
		Inter-stage pipe loss	0.2 bar
		Feed type	Waste MF/UF

Pass - Stage	Perm. Flow m3/h	Flow / Vessel Feed m3/h	Conc m3/h	Flux lmh	DP bar	Flux Max lmh	Beta	Stagewise Pressure Perm. bar	Boost bar	Conc bar	Perm. TDS mg/l	Element Type	Element Quantity	PV# x Elem #
1-1	52.5	7.3	3.3	18.2	0.4	19	1.17	0	0	13.9	9.2	CPA5-LD	78	13 x 6M
1-2	22.5	6.1	2.8	14.4	0.3	16.1	1.15	0	0	13.3	28.6	CPA5-LD	42	7 x 6M

Pass - Stage	Element no.	Feed Pressure bar	Pressure Drop bar	Conc Osmo. bar	NDP bar	Permeate Water Flow m3/h	Permeate Water Flux lmh	Beta	Permeate (Passwise cumulative) TDS	Ca	Mg	Na	Cl
1-1	1	14.3	0.1	1.1	13.2	0.7	19	1.1	5.1	0.573	0.178	0.577	0.232
1-1	2	14.2	0.09	1.2	13	0.7	18.7	1.11	5.6	0.63	0.196	0.634	0.256
1-1	3	14.1	0.07	1.4	12.7	0.7	18.3	1.12	6.2	0.7	0.218	0.705	0.284
1-1	4	14	0.06	1.6	12.5	0.7	18	1.13	7	0.789	0.245	0.794	0.32
1-1	5	14	0.05	1.9	12.2	0.7	17.5	1.15	8	0.903	0.281	0.908	0.366
1-1	6	13.9	0.04	2.2	11.8	0.6	17	1.17	9.2	1.031	0.321	1.037	0.418
1-2	1	13.7	0.08	2.5	11.3	0.6	16.1	1.1	9.9	1.11	0.346	1.116	0.45
1-2	2	13.6	0.07	2.8	10.9	0.6	15.6	1.11	10.7	1.198	0.373	1.203	0.485
1-2	3	13.5	0.06	3.1	10.6	0.6	14.9	1.11	11.5	1.295	0.403	1.301	0.525
1-2	4	13.5	0.05	3.5	10.1	0.5	14.3	1.12	12.5	1.407	0.438	1.412	0.57
1-2	5	13.4	0.04	4.1	9.6	0.5	13.4	1.13	13.7	1.537	0.478	1.542	0.622
1-2	6	13.4	0.03	4.7	9	0.5	12.4	1.15	15	1.69	0.526	1.695	0.684

Basic Design

Project name	H2OI Mining WTP RO			Page : 3/4
Calculated by	UDY		Permeate flow/train	1800.0 m3/d
HP Pump flow	94.93 m3/h		Total product flow	7200.00 m3/d
Feed pressure	14.3 bar		Number of trains	4
Feed temperature	4.0 °C(39.2°F)		Raw water flow/train	2278.5 m3/d
Feed water pH	7.50		Permeate recovery	79.00 %
Chem dose, mg/l, -	H2SO4		Element age	0.0 years
Specific energy	0.66 kwh/m3		Flux decline %, first year	12.0
Pass NDP	11.9 bar		Fouling factor	1.00
Average flux rate	16.8 lmh		SP increase, per year	10.0 %
			Inter-stage pipe loss	0.2 bar
			Feed type	Waste MF/UF

THE FOLLOWING PARAMETERS EXCEED RECOMMENDED DESIGN LIMITS

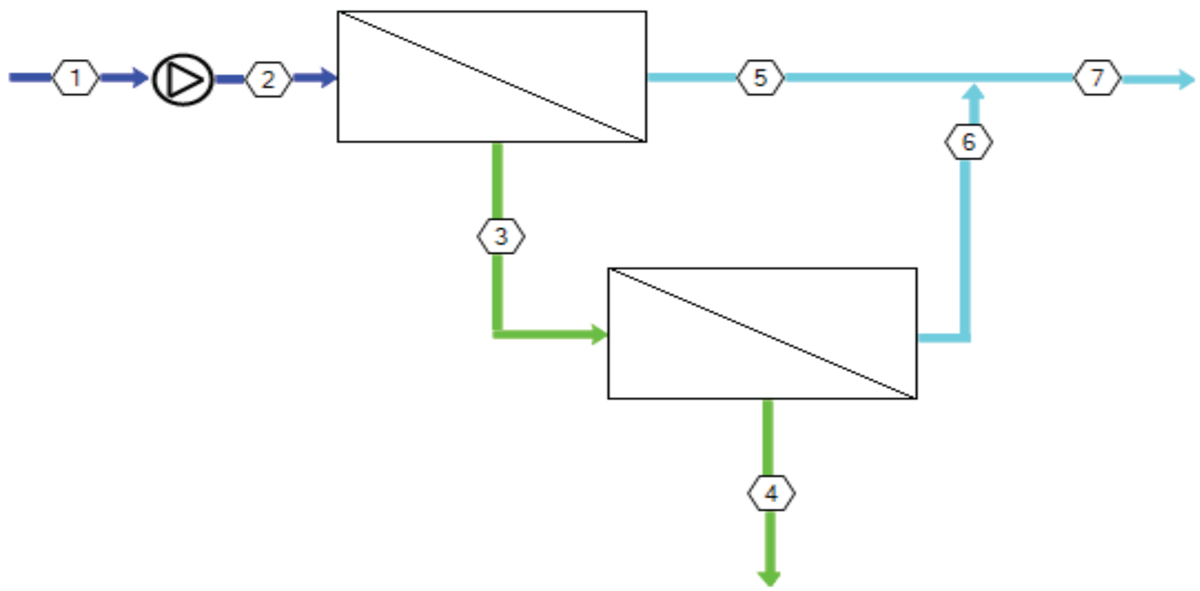
Concentrate saturation of $CaSO_4$ (936.49 %) is higher than limit 400 %.

The above saturations limits only apply when using effective scale inhibitor or dispersant. Without scale inhibitor or dispersant, the saturation and precipitation limit of the contaminant should not exceed its solubility in solution.

Basic Design

Project name H2OI Mining WTP RO

Temperature : 4.0 °C Element age, P1 : 0.0 years



Stream No.	Flow (m3/h)	Pressure (bar)	TDS (mg/l)	pH	Econd (μs/cm)
1	94.9	0	3186	7.50	5438
2	94.9	14.3	3186	7.50	5438
3	42.4	13.9	7118	7.81	11351
4	19.9	13.3	15158	8.10	22896
5	52.5	0	9.18	5.75	16.4
6	22.5	0	28.6	6.23	49.3
7	75.0	0	15.0	5.96	26.2

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HYDRAcap MAX 80 Summary

Project Details	
Project Title	Mining WWTP
Application	RO Pretreatment
Client Name	H2O Innovation
Prepared By	uyagnik@hydranautics.com

1. Feed water quality		
Source	**Waste Water - Industrial (Chemical)**	
Minimum Temperature	4	°C
Turbidity	**2**	**NTU**
Total suspended solids	4	ppm
Total dissolved solids	3000	ppm
COD	200	ppm
BOD5	20	ppm
TOC	10	ppm
pH	7.5	
Fe	0.2	mg/L as Fe
Mn	0.02	mg/L as Mn
Al	0.05	mg/L as Al
Alkalinity	100	mg/L as CaCO3
Ca	559	mg/L as CaCO3
Total Hardness	2338	mg/L as CaCO3
LSI*	-0.205	

** If LSI is negative, there is little to no potential for scale in the form of CaCO3; if LSI is positive, there is potential for scale in the form of CaCO3.*

1 A. Expected permeate water quality		
Turbidity	< 0.2	NTU
TSS	< 0.5	ppm
SDI	3	

** These values are general values based on any feed water characteristics.*

2. Main Operating Parameters		
Filtration time	**26**	**min**
Air Scour Sequence Duration	4.602	min
Cycle Duration	30.6	min
Number of cycles per day	47.06	#
Number of cycles per day without MC	35.06	#
Number of cycles per day with MC	12	#
Design Basis	**Constant Flux**	
Enhanced Solids Removal	☐	
Accelerated Drain	☑	
Use of concentrate?	☐	
Concentrate %	0.00	%
Concentrate Bleed %	0.00	%
Maintenance Clean Solution Make Up Water	Filtrate Water	
Chemical for MC1 and RC1	NaOCl	
Chemical for MC3 and RC3	Sulfuric Acid and Citric Acid	
MC1 frequency	0	#/rack/day
MC2 frequency	0	#/rack/day
MC3 frequency	1	#/rack/day
MC1 + 2 Frequency	2	#/rack/day
RC1 frequency	0.017	#/rack/day
RC2 frequency	0.017	#/rack/day
RC3 frequency	0.017	#/rack/day
MIT frequency	0.0333	#/rack/day

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3. System Design Overview		
Number of modules per rack	**30**	
Number of duty racks	4	
Number of standby racks	0	
Total number of racks	4	
Total Rack footprint size*	65.56	m^2
Single Rack Length	4.3	m
Single Rack Width	1.8	m
Single Rack footprint size*	7.714	m^2
Number of valves/rack**	8	
Total number of valves***	35	
Module type	**HYDRAcap MAX 80**	
Membrane material	PVDF	
Membrane area per module	105	m^2
Total number of duty modules	120	
Total number of standby modules	0	
Total number of modules	120	
Number of duty feed pumps	2	
Number of duty air scour blowers	2	
Number of duty chemical dosing systems	1	
Daily Total Feed Volume	10000	m^3/d
Daily Net Filtrate Volume	9602	m^3/d
Daily Gross Filtrate Volume	9635	m^3/d
Total Waste water volume	398.5	m^3/d
Total Chemical-free Waste water volume	336.5	m^3/d
Total Chemical Waste water volume	61.71	m^3/d
Total concentrate volume	0	m^3/d
Total concentrate volume	0	m^3/h
Total concentrate bleed volume	0	m^3/d
Total concentrate bleed volume	0	m^3/h
Average Recovery	**96.02**	**%**
Operation Time	24	h/24
System production time with n racks in service	7.361	h
System production time with n-1 racks in service	13.88	h
System production time with n-2 racks in service	2.761	h
System production time with n-3 racks in service	0	h
Per rack production time with n-1 racks in service	10.41	h
Per rack production time with n-2 racks in service	1.381	h
Per rack production time with n-3 racks in service	0	h

** Total rack footprint sizes assumes a gap between each rack of 2 m (~7 ft). **Assumes there are automatic and manual valves for all major valves (i.e. feed, filtrate, concentrate, etc.). Also, includes either feed chemical injection points for chlorine, caustic, and acid if required by design. ***Assumes three extra valves for common chemical injection points for RC's.*

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N RACKS IN SERVICE		
Instantaneous total feed flow	501.4	m^3/h
Instantaneous individual rack feed flow	125.3	m^3/h
Instantaneous total filtrate flow	501.4	m^3/h
Instantaneous individual rack filtrate flow	125.3	m^3/h
Instantaneous total concentrate	0	m^3/h
Instantaneous individual rack concentrate	0	m^3/h
Instantaneous total concentrate bleed flow	0	m^3/h
Instantaneous individual rack concentrate bleed flow	0	m^3/h
Instantaneous rack flux	39.79	LMH
Temperature corrected instantaneous flux	50.99	LMH

N-1 RACKS IN SERVICE		
Instantaneous total feed flow	376	m^3/h
Instantaneous individual rack feed flow	125.3	m^3/h
Instantaneous total filtrate flow	376	m^3/h
Instantaneous individual rack filtrate flow	125.3	m^3/h
Instantaneous total concentrate	0	m^3/h
Instantaneous individual rack concentrate	0	m^3/h
Instantaneous total concentrate bleed flow	0	m^3/h
Instantaneous individual rack concentrate bleed flow	0	m^3/h
Instantaneous rack flux	39.79	LMH
Temperature corrected instantaneous flux	50.99	LMH

N-2 RACKS IN SERVICE		
Instantaneous total feed flow	250.7	m^3/h
Instantaneous individual rack feed flow	125.3	m^3/h
Instantaneous total filtrate flow	250.7	m^3/h
Instantaneous individual rack filtrate flow	125.3	m^3/h
Instantaneous total concentrate	0	m^3/h
Instantaneous individual rack concentrate	0	m^3/h
Instantaneous total concentrate bleed flow	0	m^3/h
Instantaneous individual rack concentrate bleed flow	0	m^3/h
Instantaneous rack flux	39.79	LMH
Temperature corrected instantaneous flux	50.99	LMH

N-3 RACKS IN SERVICE		
Instantaneous total feed flow	0	m^3/h
Instantaneous individual rack feed flow	0	m^3/h
Instantaneous total filtrate flow	0	m^3/h
Instantaneous individual rack filtrate flow	0	m^3/h
Instantaneous total concentrate	0	m^3/h
Instantaneous individual rack concentrate	0	m^3/h
Instantaneous total concentrate bleed flow	0	m^3/h
Instantaneous individual rack concentrate bleed flow	0	m^3/h
Instantaneous rack flux	0	LMH
Temperature corrected instantaneous flux	0	LMH

Average gross flux	**39.79**	**LMH**
Temperature correction factor	1.281	
Temperature corrected average gross flux	**50.99**	**LMH**

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4. Cleaning Occurrence and Time Consumption

Sequence	Duration (min)	Total Plant Occurrence / day	Total Plant Time Consumed for Cleaning per Day (min)
AS	4.602	176.2	811
MC1	29.41	0	0
MC2	0	0	0
MC3	29.41	4	117.7
MC1 + 2	29.41	8	235.3
MIT	11.84	0.133	1.577
RC1	121.9	0.067	8.127
RC2	121.9	0.067	8.127
RC3	121.9	0.067	8.127
Total per day (min)			1166
Non production time per rack (min)			291.4

5. Waste water production

Sequence	Chemical-free waste water volume / sequence (m^3)	Chemical waste water volume / sequence (m^3)	Occurrence / day	Total waste water volume / day (m^3)	Waste water %
Concentrate Bleed		0.0		0	0
AS	1.785	~	176.2	314.5	78.92
MC1	0	0	0	0	0
MC2	0	0	0	0	0
MC3	1.838	5.142	4	27.92	7.006
MC1 + 2	1.838	5.142	8	55.84	14.01
MIT	1.785	0	0.133	0.238	0.071
RC1	7.155				
RC2	7.155				
RC3	7.155				
Total per day				398.5	
Chemical-free wastewater total per day				336.5	
Chemical wastewater total per day				61.71	

6. Major Equipment Specification Summary

Equipment	Detail	Units	Value	Notes
Feed pump(s)	Number of duty pumps		2	Feed pumps must be equipped with VFDs
	Average feed flow rate per pump	m^3/h	208.3	
	Average feed pressure	kPa	182.5	
	Assumed average filtrate pressure	kPa	35	
	Maximum feed flow rate per pump	m^3/h	250.7	
	Maximum feed pressure*	kPa	281.4	
	Estimated average total feed pump energy consumption	kWh/m^3	0.081	
Air scour & Blower(s)	Number of duty blowers		2	
	Average aeration rate per rack/blower	m^3/h	365	
	Maximum aeration rate per rack/blower	m^3/h	456.3	
	Average Air Scour Pressure	kPa	53.06	
	Maximum Air Scour Pressure	kPa	70	
	Estimated average total blower energy consumption	kWh/m^3	0.008	

**Does not include piping losses outside of rack. i.e. The piping to and from the rack. **Chemical for RCs can be poured and mixed directly into RC tank. In which case, no RC dosing pump is required.*

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7. Chlorine Maintenance Clean (MC1) summary

General		
Makeup water for MC1s	N/A	
Number of MC1 per rack per day	0	
Duration	29.41	minutes
Target chlorine concentration per MC	0	ppm
MC1 Chlorine Consumption Data		
Assumed chemical stock concentration	0	g/L
Assumed chemical stock concentration	12	%
Volume of chlorine to be used per MC	0	L
Volume of chlorine to be used per day	0	L
MC1 Chemical Filling		
Pump used for chemical solution filling	N/A	
MC1 chemical solution filling flowrate	0	m^3/h
Chlorine dosing pump flowrate	0	L/h
Chlorine dosing pump run time	0	s
MC1 Chemical Rinsing		
Pump used for chemical rinsing	N/A	
MC1 rinsing flow	0	m^3/h
MC1 Dosing Pump Specifications		
Chemical dosed into	N/A	
Maximum dosing pump flow rate	0	L/h
Maximum dosing pump pressure	0	kPa

8. Chlorine Recovery Clean (RC1) summary

General		
Makeup water for RC1s	Filtrate	
Number of days between RC1 per rack	59.99	days
Duration	121.9	minutes
Target chlorine concentration per RC	1000	ppm
Target temperature of solution	40	°C
RC1 Chlorine Consumption Data		
Solution concentration	133.1429	g/L
Stock Solution concentration (weight percent)	12	%
Volume of chlorine to be used per RC	20.31	L
Volume of chlorine to be used per day	1.354	L
RC1 Chemical Filling		
Pump used for chemical solution filling	RC Pump	
RC1 filling flow	126.4	m^3/h
RC1 Chemical Rinsing		
Pump used for chemical rinsing	Feed Pump	
RC1 rinsing flow	125.3	m^3/h

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9. Caustic Maintenance Clean (MC2) summary

General		
Makeup water for MC2s	N/A	
Number of MC2 per rack per day	0	
Duration	0	minutes
Target caustic solution concentration	0	ppm
MC2 Caustic Consumption Data		
Stock chemical density	0	g/mL
Stock chemical %	50	%
Volume of caustic to be used per MC	0	L
Volume of caustic to be used per day	0	L
MC2 Chemical Filling		
Pump used for chemical solution filling	N/A	
Filling flow	0	m^3/h
Caustic flow during filling	0	L/h
Caustic dosing pump running time	0	s
MC2 Chemical Rinsing		
Pump used for chemical rinsing	N/A	
MC2 Rinsing flux	0	LMH
MC2 Rinsing flow	0	m^3/h
MC2 Dosing Pump Specifications		
Chemical dosed into	N/A	
Maximum dosing pump flow rate	0	L/h
Maximum dosing pump pressure	0	kPa

10. Caustic Recovery Clean (RC2) summary

General		
Makeup water for RC2s	Filtrate	
Number of days between RC2 per rack	59.99	days
Duration	121.9	minutes
Target caustic concentration	3500	ppm
Target temperature of solution	40	°C
RC2 Caustic Consumption		
Density	1.52	g/ML
% commercial solution	50	%
Volume of caustic to be used per RC	12.45	L
Volume of caustic to be used per day	0.83	L
RC2 Chemical Filling		
Pump used for chemical solution filling	RC Pump	
Filling flow	126.4	m^3/h
RC2 Chemical Rinsing		
Pump used for chemical rinsing	Feed Pump	
RC2 Rinsing flow	125.3	m^3/h

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11. Acid Maintenance Clean (MC3) summary

General		
Makeup water for MC3s	Filtrate	
Number of MC3 per rack per day	1	
Duration	29.41	minutes
Type of acid	Sulfuric Acid	
Target acid solution concentration	1470	ppm
MC3 Acid Consumption Data		
Stock chemical density	1.86	g/mL
Stock chemical %	96	%
Volume of acid to be used per MC	2.226	L
Volume of acid to be used per day	8.905	L
MC3 Chemical Filling		
Pump used for chemical solution filling	RC Pump	
Filling flow	126.4	m^3/h
Acid flow during filling	104.1	L/h
Acid dosing pump running time	77	s
MC3 Chemical Rinsing		
Pump used for chemical rinsing	Feed Pump	
MC3 Rinsing flux	39.66	LMH
MC3 Rinsing flow	125.3	m^3/h
MC3 Dosing Pump Specifications		
Chemical dosed into	Filtrate Line	
Maximum dosing pump flow rate	104.1	L/h
Maximum dosing pump pressure	230	kPa

12. Acid Recovery Clean (RC3) summary

General		
Makeup water for RC3s	Filtrate	
Number of days between RC3 per rack	59.99	days
Type of acid	Citric Acid	
Duration	121.9	minutes
Target acid concentration	20000	ppm
Target temperature of solution	40	°C
RC3 Acid Consumption		
Density	1.24	g/l
% commercial solution	50	%
Volume of acid to be used per RC	87.23	L
Volume of acid to be used per day	5.817	L
RC3 Chemical Filling		
Pump used for chemical solution filling	RC Pump	
Filling flow	126.4	m^3/h
RC3 Chemical Rinsing		
Pump used for chemical rinsing	Feed Pump	
RC3 Rinsing flow	125.3	m^3/h

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13. Chlorine + Caustic Maintenance Clean (MC1 + 2) summary		
General		
Makeup water for MC1+2s	Filtrate	
Number of MC1+2 per rack per day	2	
Duration	29.41	minutes
Target chlorine solution concentration	200	ppm
Target caustic solution concentration	1200	ppm
MC1+2 Chlorine & Caustic Consumption Data		
Chlorine stock chemical concentration	133.1429	g/L
Caustic stock chemical density	1.52	g/mL
Chlorine stock chemical %	12	%
Caustic stock chemical %	50	%
Volume of chlorine to be used per MC	4.062	L
Volume of caustic to be used per MC	4.27	L
Volume of chlorine to be used per day	32.5	L
Volume of caustic to be used per day	34.16	L
MC1+2 Chemical Filling		
Pump used for chemical solution filling	RC Pump	
Filling flow	126.4	m^3/h
Chlorine dosing pump flowrate	189.9	L/h
Chlorine dosing pump run time	77	s
Caustic dosing pump flowrate	199.6	L/h
Caustic dosing pump run time	77	s
MC1+2 Chemical Rinsing		
Pump used for chemical rinsing	Feed Pump	
MC1+2 Rinsing flux	39.66	Lmh
MC1+2 Rinsing flow	125.3	m^3/h
MC1+2 Dosing Pump Specifications		
Chemical dosed into	Filtrate Line	
Maximum dosing pump flow rate (chlorine)	189.9	L/h
Maximum dosing pump flow rate (caustic)	199.6	L/h
Maximum dosing pump pressure	230	kPa

14. Chemical Consumption Summary		
12% SODIUM HYPOCHLORITE		
Sodium Hypochlorite Consumption due to MC1	0.000000	L/m^3 filtrate
Sodium Hypochlorite Consumption due to MC1 + 2	0.003384	L/m^3 filtrate
Sodium Hypochlorite Consumption due to RC1	0.000141	L/m^3 filtrate
Total Sodium Hypochlorite Consumption	0.003526	L/m^3 filtrate
Total Daily Sodium Hypochlorite Consumption	33.85	L/day
Total Annual Sodium Hypochlorite Consumption	12355	L/year
50% SODIUM HYDROXIDE		
Sodium Hydroxide Consumption due to MC2	0.000000	L/m^3 filtrate
Sodium Hydroxide Consumption due to MC1 + 2	0.003558	L/m^3 filtrate
Sodium Hydroxide Consumption due to RC2	0.000086	L/m^3 filtrate
Total Sodium Hydroxide Consumption	0.003644	L/m^3 filtrate
Total Daily Sodium Hydroxide Consumption	34.99	L/day
Total Annual Sodium Hydroxide Consumption	12771	L/year
96% SULFURIC ACID & 50% CITRIC ACID		
Sulfuric Acid Consumption due to MC3	0.000927	L/m^3 filtrate
Citric Acid Consumption due to RC3	0.000606	L/m^3 filtrate
Total Acid Consumption	0.001533	L/m^3 filtrate
Total Daily Acid Consumption	14.72	L/day
Total Annual Acid Consumption	5373	L/year

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15. Auxiliary Equipment Recommendations

RECOMMENDATION*		
Number of RC pumps	1	
RC maximum pump flow	126.4	m^3/h
RC maximum pump pressure	230	kPa
RC Tank Size	5.639	m^3
Number of Compressors/Air Receivers/Dryers	1	
Compressed Air Receiver Size**	0.162	m^3
Air Volume required to do a Pressurized Drain and MIT***	0.757	m^3
Compressor Rating****	10.21	m^3/h
Dryer Rating*****	10	m^3/h

All sizes expressed in this table depend upon site requirements
All sizes expressed correspond to working volume capacities not including piping from tank to racks or safety factors
***Assumes air in receiver is at 6 bar.Only considers volume required for air assisted chemical drain and integrity testing, which is delivered to the rack at ~1.4 bar. Does not consider requirements of any other equipment requiring compressed air for operation.*
****Assumes pressure required for the modules (no piping) and a 50% safety factor.*
*****Assumes a 50% safety factor and that the air will be delivered within the first third air scour and chemical drain step.*
******Assumes dryer is only used for pneumatic valve operations.*

16. Automatic Valves

# Valves/ Rack	Total # of Valves	Valve Description	Pipe Velocity (m/s)	Size (mm)	Notes
1	4	Feed valve	≤2.7	150	
1	4	Filtrate valve	<2.7	150	Size of common filtrate pipe section*
1	4	Concentrate valve	≤8.6	100	
0	0	Concentrate return valve			
1	4	Drain valve	≤1.2	150	
1	4	Air scouring inlet valve	≤0.75 kPa ΔP/30.5m of pipe	150	
1	4	Filtrate to drain valve	≤2.7	100	
1	4	RC feed valve	≤2.7	150	
1	4	Membrane integrity test valve	≤97 kPa ΔP/100m of pipe	37	
0	0	Feed chlorine injection valve			
1	1	Filtrate chlorine injection valve			
0	0	Feed caustic injection valve			
1	1	Filtrate caustic injection valve			
0	0	Feed acid injection valve			
1	1	Filtrate acid injection valve			

**Top and Bottom Header size is 100 mm*

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Calculation Summary				
Post-HDS Stream				
Stream Inflows				
Row Filter Applied: Only Non Zero Values				
Species	mg/L			
H2O	1.00E+06			
CaO	958.291			
NaCl	0.118085			
NH3	0.59304			
As	0.0246054			
N2O5	4.08572			
SO3	1187.76			
CdSe	0.0779119			
PbSe	0.0312077			
ZnSe	1.0505			
MnCl2	8.23371			
P2O5	6.25E-06			
HCl	657.486			
Al2O3	0.0271351			
Al(NO2)3	0.128801			
FeO	9.32E-03			
MgO	275.106			
NiO	0.0163138			
ZnCl2.5ZnO	3.05073			
O2	0.0562737			
Na2O	7.59E-06			
Ag2Se	9.90E-05			
As2O3	8.89E-03			
Cu2Se	0.0112843			
H2	1.99E-04			
UO2	0.0146126			
CaSO4.2H2O	960.855			
Sb2O3	0.0387651			
Al(OH)3	0.0442306			
Ca5(PO4)3F	0.193017			
MnF2	1.66124			
Ni(OH)2	0.113803			
As2O5	4.82E-05			

FeAsO4	2.71E-07			
Sb	7.94E-04			
Stream Parameters				
Row Filter Applied: Only Non Zero Values				
column Filter Applied: Only Non Zero Values				
Mixture Properties				
Stream Amount	1048.83	L		
Temperature	10	ÁC		
Pressure	1	atm		
Aqueous Properties				
pH	9.9276			
Ionic Strength (x-based)	1.46E-03	mol/mol		
Ionic Strength (m-based)	0.0809153	mol/kg		
ORP	0.600745	V (SHE)		
Osmotic Pressure	1.19754	atm		
Specific Electrical Conductivity	2580.34	µmho/cm		
Electrical Conductivity, molar	4.12E-03	m2/ohm-mol		
Viscosity, absolute	1.32234	cP		
Viscosity, relative	1.01279			
Standard Liquid Volume	1052.51	L		
Volume, Std. Conditions	1051.98	L		
Solid Properties				
Standard Liquid Volume	0.489904	L		
Thermodynamic Properties				
	Unit	Total	Aqueous	Solid
Density	g/ml	1.0036	1.00301	2.59098
Enthalpy	cal	-4.00E+09	-4.00E+09	-2.84E+06
Species Output (True Species)				
Row Filter Applied: Only Non Zero Values				
column Filter Applied: Only Non Zero Values				
	Total	Aqueous	Solid	
	mg/L	mg/L	mg/L	
H2O	1.00E+06	1.00E+06	0	

SO4-2	1282.96	1283.43	0	
CaSO4.2H2O (Gypsum)	960.849	0	961.206	
Cl-1	644.364	644.604	0	
Ca+2	643.975	644.214	0	
Mg+2	154.849	154.907	0	
CaSO4 (Anhydrite)	138.418	138.47	0	
MgSO4	53.3157	53.3355	0	
NO3-1	4.61663	4.61834	0	
Mn+2	3.17932	3.1805	0	
Zn(OH)2	2.99435	2.99546	0	
MnSO4	2.90638	2.90746	0	
ZnSe (Stilleite)	1.0505	0	1.05089	
F-1	0.679083	0.679335	0	
OH-1	0.554745	0.554951	0	
MgOH+1	0.482501	0.48268	0	
NH3	0.320713	0.320832	0	
NH4+1	0.272352	0.272453	0	
Mn(OH)+1	0.259849	0.259945	0	
Ca5(PO4)3F (Fluorapatite)	0.193017	0	0.193089	
CaOH+1	0.15977	0.159829	0	
MnCl+1	0.138027	0.138079	0	
Ca(NO3)+1	0.12169	0.121736	0	
Al(OH)4-1	0.117	0.117044	0	
Ni(OH)2 (Theophrastite)	0.111716	1.00E-10	0.111758	
Zn(OH)3-1	0.110172	0.110213	0	
NO2-1	0.107739	0.107779	0	
Zn+2	0.102637	0.102675	0	
NH4SO4-1	0.100604	0.100642	0	
ZnOH+1	0.0857961	0.0858279	0	
CdSe (Cadmoselite)	0.0779119	0	0.0779408	
MnO4-1	0.069933	0.069959	0	
HAsO4-2	0.0585841	0.0586059	0	
MnO4-2	0.0528695	0.0528892	0	
Al(OH)3 (Bayerite)	0.0505837	5.49E-05	0.0505477	
Sb(OH)3	0.0468295	0.0468469	0	
Na+1	0.0444627	0.0444792	0	
PbSe (Clausthalite)	0.0312077	0	0.0312193	
UO2(OH)2	0.0163133	3.47E-03	0.0128501	
Fe(OH)3 (Bernalite)	0.0131645	1.30E-03	0.01187	
Cu2Se (Bellidoite)	0.011283	0	0.0112872	
NaSO4-1	0.0103242	0.010328	0	
NiOH+1	8.12E-03	8.12E-03	0	

Ni+2	6.14E-03	6.14E-03	0	
NiSO4	4.27E-03	4.27E-03	0	
Mn(OH)2 (Pyrochroite)	9.28E-04	9.29E-04	0	
Fe(OH)4-1	8.13E-04	8.14E-04	0	
ZnCl+1	7.34E-04	7.35E-04	0	
ZnNH3+2	5.00E-04	5.01E-04	0	
MnNO3+1	3.67E-04	3.67E-04	0	
CaF+1	3.34E-04	3.34E-04	0	
O2	3.18E-04	3.18E-04	0	
Sb(OH)4-1	2.74E-04	2.74E-04	0	
NH4NO3 (Gwihabaite)	2.34E-04	2.34E-04	0	
Zn(OH)4-2	1.23E-04	1.23E-04	0	
(UO2)3(OH)5+1	1.04E-04	1.04E-04	0	
NiNH3+2	1.04E-04	1.04E-04	0	
Ag2Se (Naumannite)	9.90E-05	0	9.90E-05	
CaCl+1	5.93E-05	5.94E-05	0	
UO2OH+1	3.17E-05	3.17E-05	0	
MgF+1	2.99E-05	2.99E-05	0	
ZnNO3+1	2.02E-05	2.02E-05	0	
ZnCl2	1.64E-05	1.64E-05	0	
CaPO4-1	7.39E-06	7.39E-06	0	
NiCl+1	5.90E-06	5.90E-06	0	
ZnF+1	5.72E-06	5.72E-06	0	
Ni(OH)3-1	5.14E-06	5.14E-06	0	
HSO4-1	4.36E-06	4.36E-06	0	
MgPO4-1	3.32E-06	3.32E-06	0	
Zn(NH3)2+2	2.88E-06	2.88E-06	0	
NaF (Villiaumite)	1.48E-06	1.48E-06	0	
NiNO3+1	1.30E-06	1.30E-06	0	
Mn(OH)3-1	1.28E-06	1.28E-06	0	
Cu(OH)3-1	1.09E-06	1.09E-06	0	
AsO4-3	6.22E-07	6.22E-07	0	
NaNO3 (Nitratine)	5.76E-07	5.76E-07	0	
Ni(NH3)2+2	4.95E-07	4.96E-07	0	
CaHPO4 (Monetite)	2.74E-07	2.75E-07	0	
HPO4-2	2.54E-07	2.54E-07	0	
NiF+1	2.25E-07	2.25E-07	0	
Cu(OH)2 (Spertiniite)	2.12E-07	2.12E-07	0	
ZnCl3-1	1.65E-07	1.65E-07	0	
H+1	1.52E-07	1.53E-07	0	
MgHPO4	1.40E-07	1.40E-07	0	
HF	1.01E-07	1.01E-07	0	

Mn(NO3)2	8.13E-08	8.13E-08	0	
CuNH3+2	7.82E-08	7.82E-08	0	
Fe(OH)2+1	3.41E-08	3.41E-08	0	
HNO2	2.33E-08	2.33E-08	0	
Zn(NH3)3+2	1.98E-08	1.98E-08	0	
CuOH+1	1.23E-08	1.23E-08	0	
Cu(NH3)2+2	7.45E-09	7.45E-09	0	
UO2SO4	5.74E-09	5.74E-09	0	
UO2F+1	4.73E-09	4.73E-09	0	
Cu+2	4.27E-09	4.27E-09	0	
Al(OH)2+1	3.49E-09	3.49E-09	0	
UO2+2	3.15E-09	3.15E-09	0	
PO4-3	2.61E-09	2.61E-09	0	
(UO2)2(OH)2+2	1.88E-09	1.89E-09	0	
Ni(NH3)3+2	6.90E-10	6.90E-10	0	
UO2(SO4)2-2	5.83E-10	5.84E-10	0	
Ni2OH+3	4.47E-10	4.47E-10	0	
Mn(OH)4-2	4.23E-10	4.23E-10	0	
Zn(NO3)2	3.36E-10	3.36E-10	0	
UO2F2	3.35E-10	3.35E-10	0	
H2AsO4-1	2.93E-10	2.93E-10	0	
Ni(OH)4-2	2.60E-10	2.60E-10	0	
H2PO4-1	2.59E-10	2.59E-10	0	
HSe-1	2.27E-10	2.27E-10	0	
CuCl+1	2.18E-10	2.18E-10	0	
Cu(NH3)3+2	1.68E-10	1.68E-10	0	
Sb(OH)2+1	1.62E-10	1.62E-10	0	
ZnHPO4	1.49E-10	1.49E-10	0	
Cu(OH)4-2	1.49E-10	1.49E-10	0	
Zn(NH3)4+2	6.77E-11	6.77E-11	0	
UO2Cl+1	3.01E-11	3.01E-11	0	
Ni(NH3)4+2	2.69E-11	2.69E-11	0	
CaH2PO4+1	1.79E-11	1.80E-11	0	
Ni(OH)3(H2PO4)-2	4.35E-12	4.35E-12	0	
UO2F3-1	2.24E-12	2.24E-12	0	
CuCl2 (Tolbachite)	1.95E-12	1.95E-12	0	
HF2-1	1.72E-12	1.72E-12	0	
CuNO3+1	1.03E-12	1.03E-12	0	
CuNO2+1	9.14E-13	9.14E-13	0	
FeOH+2	8.60E-13	8.60E-13	0	
Cu(NH3)4+2	6.20E-13	6.20E-13	0	
Ni4(OH)4+4	6.03E-13	6.04E-13	0	

AlOH+2	3.88E-13	3.88E-13	0	
MgH2PO4+1	5.59E-14	5.59E-14	0	
Na2F+1	3.93E-14	3.93E-14	0	
AlF2+1	2.61E-14	2.61E-14	0	
AlOHCl+1	1.77E-14	1.77E-14	0	
UO2Cl2	1.58E-14	1.58E-14	0	
HCl	1.38E-14	1.38E-14	0	
ZnH2PO4+1	1.25E-14	1.25E-14	0	
AlF3	7.02E-15	7.03E-15	0	
AlF+2	3.77E-15	3.77E-15	0	
Se-2	1.57E-15	1.57E-15	0	
HNO3	1.53E-15	1.53E-15	0	
UO2F4-2	8.59E-16	8.60E-16	0	
H3AsO4	2.58E-16	2.58E-16	0	
H2Se	1.30E-16	1.30E-16	0	
CuCl3-1	1.13E-16	1.13E-16	0	
AlF4-1	8.03E-17	8.04E-17	0	
AlSO4+1	7.91E-17	7.91E-17	0	
Al(SO4)2-1	5.27E-17	5.27E-17	0	
Al+3	2.80E-17	2.80E-17	0	
Cu(NO2)2	2.40E-17	2.40E-17	0	
Cu+1	1.29E-17	1.29E-17	0	
CuCl	1.15E-17	1.15E-17	0	
Cu(NO3)2	1.02E-17	1.02E-17	0	
Fe+2	9.82E-18	9.83E-18	0	
Ni(OH)2(HPO4)-2	9.31E-18	9.31E-18	0	
FeOH+1	8.42E-18	8.42E-18	0	
PbOH+1	6.93E-18	6.93E-18	0	
Cu(NH3)5+2	5.40E-18	5.41E-18	0	
AgCl2-1	3.30E-18	3.30E-18	0	
H3PO4	3.11E-18	3.11E-18	0	
CuCl2-1	2.51E-18	2.51E-18	0	
MgP2O7-2	1.86E-18	1.86E-18	0	
Ni(NH3)5+2	8.04E-19	8.05E-19	0	
UO2+1	6.82E-19	6.82E-19	0	
AgCl	6.71E-19	6.71E-19	0	
CdSO4	3.72E-19	3.72E-19	0	
Cd+2	3.42E-19	3.42E-19	0	
CdCl+1	2.76E-19	2.76E-19	0	
AlF5-2	1.19E-19	1.19E-19	0	
FeO	1.14E-19	1.14E-19	0	
Fe+3	1.03E-19	1.03E-19	0	

CdCl2	8.77E-20	8.78E-20	0	
CdOH+1	3.57E-20	3.57E-20	0	
PbO (Massicot)	3.52E-20	3.52E-20	0	
Ag+1	1.73E-20	1.73E-20	0	
FeSO4+1	8.72E-21	8.72E-21	0	
HPbO2-1	7.64E-21	7.64E-21	0	
Cd(OH)2	7.45E-21	7.45E-21	0	
Fe(NH3)+2	4.81E-21	4.82E-21	0	
PbSO4 (Anglesite)	3.80E-21	3.81E-21	0	
AgSO4-1	3.76E-21	3.76E-21	0	
CdNH3+2	3.59E-21	3.60E-21	0	
Pb+2	3.47E-21	3.47E-21	0	
FeF+2	1.20E-21	1.20E-21	0	
HFeO2-1	1.05E-21	1.05E-21	0	
CdNO2+1	9.21E-22	9.21E-22	0	
PbCl+1	7.59E-22	7.59E-22	0	
P2O7-4	7.56E-22	7.56E-22	0	
CaCl2 (Hydrophilite)	4.84E-22	4.84E-22	0	
Ag(NH3)2+1	4.43E-22	4.43E-22	0	
FeF2+1	1.26E-22	1.27E-22	0	
CdCl3-1	8.35E-23	8.35E-23	0	
FeCl+1	7.34E-23	7.34E-23	0	
FeCl+2	5.77E-23	5.77E-23	0	
AlF6-3	4.46E-23	4.46E-23	0	
CdNO3+1	4.30E-23	4.31E-23	0	
AgOH	4.12E-23	4.12E-23	0	
HP2O7-3	3.66E-23	3.66E-23	0	
PbNO2+1	3.42E-23	3.42E-23	0	
PbCl2 (Cotunnite)	3.40E-23	3.41E-23	0	
FeHPO4+1	2.93E-23	2.93E-23	0	
Ni(NH3)6+2	2.14E-23	2.14E-23	0	
(HF)2	1.63E-23	1.63E-23	0	
CdF+1	1.38E-23	1.39E-23	0	
Cd(NH3)2+2	1.05E-23	1.05E-23	0	
AgNO2	9.87E-24	9.88E-24	0	
Fe(NH3)2+2	9.51E-24	9.51E-24	0	
CdCl4-2	7.09E-24	7.09E-24	0	
FeCl2+1	6.01E-24	6.01E-24	0	
Cd(OH)3-1	4.82E-24	4.82E-24	0	
PbNO3+1	2.25E-24	2.26E-24	0	
AgCl3-2	1.43E-24	1.43E-24	0	
FeF3	1.31E-24	1.31E-24	0	

AgNO3	9.88E-25	9.89E-25	0	
AgF	9.35E-25	9.35E-25	0	
PbF+1	7.29E-25	7.29E-25	0	
FeNO3+2	6.41E-25	6.41E-25	0	
PbCl3-1	3.61E-25	3.62E-25	0	
Cd(NO2)2	2.09E-25	2.09E-25	0	
Fe(HAsO4)+1	1.94E-25	1.94E-25	0	
Ag(OH)2-1	1.80E-25	1.81E-25	0	
U(OH)4	2.25E-26	2.25E-26	0	
H2SO4	1.83E-26	1.83E-26	0	
Al(OH)2Cl	1.53E-26	1.53E-26	0	
PbCl4-2	1.16E-26	1.16E-26	0	
FeCl3 (Molysite)	8.01E-27	8.02E-27	0	
Cd(NH3)3+2	6.46E-27	6.47E-27	0	
H2P2O7-2	5.23E-27	5.23E-27	0	
Fe(NH3)3+2	4.11E-27	4.11E-27	0	
FeCl2 (Lawrencite)	3.98E-27	3.98E-27	0	
U(OH)5-1	3.66E-27	3.66E-27	0	
Ag(NO2)2-1	2.82E-27	2.82E-27	0	
Pb(NO2)2	2.69E-27	2.69E-27	0	
FeHPO4	1.75E-28	1.75E-28	0	
PbF2	1.60E-28	1.60E-28	0	
CdF2	1.24E-28	1.24E-28	0	
Pb(NO3)2	9.58E-29	9.59E-29	0	
Cd(OH)4-2	9.07E-29	9.07E-29	0	
Cd(NO2)3-1	1.16E-29	1.16E-29	0	
FeCl4-1	3.76E-30	3.76E-30	0	
PbHPO4	2.39E-30	2.39E-30	0	
FeAsO4	1.78E-30	1.78E-30	0	
SO3	1.67E-30	1.67E-30	0	
Cd(NH3)4+2	1.04E-30	1.04E-30	0	
FeH2PO4+2	5.41E-31	5.41E-31	0	
Fe2(OH)2+4	3.57E-31	3.57E-31	0	
Pb(NO2)3-1	1.44E-31	1.44E-31	0	
FeH2PO4+1	9.81E-32	9.82E-32	0	
PbF3-1	9.31E-32	9.31E-32	0	
Pb(NO3)3-1	2.66E-33	2.66E-33	0	
Fe(NH3)4+2	1.37E-33	1.37E-33	0	
PbH2PO4+1	2.08E-34	2.08E-34	0	
H3P2O7-1	6.27E-35	6.27E-35	0	
U(OH)3+1	4.06E-35	4.06E-35	0	
Cd(NH3)5+2	1.22E-35	1.22E-35	0	

PbF4-2	2.67E-36	2.67E-36	0	
AsO2-1	1.78E-37	1.78E-37	0	
HAsO2	5.00E-38	5.00E-38	0	
Fe(NH3)5+2	4.46E-40	4.46E-40	0	
HAsO3-2	7.93E-42	7.93E-42	0	
Cd(NH3)6+2	5.47E-42	5.47E-42	0	
H2	4.39E-42	4.39E-42	0	
H4P2O7	1.79E-43	1.79E-43	0	
U(OH)2+2	1.22E-43	1.22E-43	0	
AsO3-3	6.37E-46	6.37E-46	0	
Fe(NH3)6+2	1.43E-46	1.44E-46	0	
AsO+1	9.18E-48	9.19E-48	0	
UOH+3	9.73E-51	9.73E-51	0	
UF3+1	5.09E-53	5.10E-53	0	
UF2+2	3.06E-53	3.06E-53	0	
UF4	2.58E-53	2.58E-53	0	
UF+3	3.62E-55	3.62E-55	0	
U(SO4)2	3.08E-55	3.08E-55	0	
USO4+2	3.08E-56	3.08E-56	0	
As(OH)2Cl3	1.53E-58	1.53E-58	0	
U+4	3.34E-59	3.34E-59	0	
UCl+3	9.58E-60	9.58E-60	0	
U+3	2.57E-80	2.57E-80	0	
Total (by phase)	1.00E+06	1.00E+06	962.758	
Element Balance				
Row Filter Applied: Only Non Zero Values				
column Filter Applied: Only Non Zero Values				
	Total	Aqueous	Solid	
	mg/L	mg/L	mg/L	
H(+1)	1.12E+05	1.12E+05	22.5141	
Na(+1)	0.0464573	0.0464745	0	
N(-3)	0.487741	0.487923	0	
Ca(+2)	908.625	685.138	223.825	
Zn(+2)	2.67917	2.20411	0.47605	
Cu(+2)	8.25E-07	8.26E-07	0	
Fe(+2)	1.64E-17	1.64E-17	0	
Mg(+2)	165.899	165.96	0	
Pb(+2)	0.0225965	6.45E-18	0.0226049	
Al(+3)	0.050723	0.0332574	0.0174845	

Mn(+2)	4.51979	4.52147	0	
Fe(+3)	7.25E-03	1.05E-03	6.20E-03	
Ni(+2)	0.0848562	0.0141443	0.0707435	
F(-1)	0.686477	0.679458	7.27E-03	
O(-2)	8.89E+05	8.89E+05	536.081	
Cl(-1)	644.419	644.658	0	
P(+5)	0.0355676	2.74E-06	0.035578	
S(+6)	654.658	475.882	179.019	
N(+3)	0.0328019	0.0328141	0	
N(+5)	1.05967	1.06006	0	
H	4.39E-42	4.39E-42	0	
O(0)	3.18E-04	3.18E-04	0	
As(+5)	0.0313682	0.0313799	0	
As(+3)	1.60E-37	1.60E-37	0	
Se(-2)	0.619736	2.24E-10	0.619967	
Cu(+1)	6.96E-03	2.14E-17	6.96E-03	
Mn(+7)	0.032303	0.032315	0	
Mn(+6)	0.0244212	0.0244302	0	
Cd(+2)	0.0457651	8.47E-19	0.0457822	
Ag(+1)	7.25E-05	2.51E-18	7.25E-05	
U(+4)	2.02E-26	2.02E-26	0	
U(+6)	0.012881	2.83E-03	0.0100601	
Sb(+3)	0.033176	0.0331883	0	
U(+3)	2.57E-80	2.57E-80	0	
U(+5)	6.01E-19	6.01E-19	0	
Element Distribution				
	Total	Total	Aqueous	Solid
	mol	mole %	% of Total	% of Total
H(+1)	1.16E+05	66.6065	99.9799	0.020114
Na(+1)	2.12E-03	1.21E-06	100	0
N(-3)	0.0365225	2.09E-05	100	0
Ca(+2)	23.7785	0.0136034	75.3758	24.6242
Zn(+2)	0.0429729	2.46E-05	82.238	17.762
Cu(+2)	1.36E-08	7.79E-12	100	0
Fe(+2)	3.07E-19	1.76E-22	100	0
Mg(+2)	7.15902	4.10E-03	100	0
Pb(+2)	1.14E-04	6.54E-08	2.85E-14	100
Al(+3)	1.97E-03	1.13E-06	65.5423	34.4577
Mn(+2)	0.0862883	4.94E-05	100	0

Fe(+3)	1.36E-04	7.79E-08	14.4285	85.5715
Ni(+2)	1.52E-03	8.68E-07	16.6623	83.3377
F(-1)	0.0378979	2.17E-05	98.9408	1.05924
O(-2)	58299.3	33.3524	99.9397	0.0602572
Cl(-1)	19.0643	0.0109065	100	0
P(+5)	1.20E-03	6.89E-07	7.70E-03	99.9923
S(+6)	21.4129	0.0122501	72.6648	27.3352
N(+3)	2.46E-03	1.41E-06	100	0
N(+5)	0.0793486	4.54E-05	100	0
H	4.57E-42	2.61E-45	100	0
O(0)	2.09E-05	1.19E-08	100	0
As(+5)	4.39E-04	2.51E-07	100	0
As(+3)	2.24E-39	1.28E-42	100	0
Se(-2)	8.23E-03	4.71E-06	3.62E-08	100
Cu(+1)	1.15E-04	6.57E-08	3.08E-13	100
Mn(+7)	6.17E-04	3.53E-07	100	0
Mn(+6)	4.66E-04	2.67E-07	100	0
Cd(+2)	4.27E-04	2.44E-07	1.85E-15	100
Ag(+1)	7.05E-07	4.03E-10	3.47E-12	100
U(+4)	8.90E-29	5.09E-32	100	0
U(+6)	5.68E-05	3.25E-08	21.9286	78.0714
Sb(+3)	2.86E-04	1.64E-07	100	0
U(+3)	1.13E-82	6.49E-86	100	0
U(+5)	2.65E-21	1.51E-24	100	0

APPENDIX 5.
Bird Survey Data

APPENDIX 5 - 2016 Bird Survey Data

Table A5-1: 2016 Bird Survey Results - Riparian and Subalpine

Site name	BB_1	BB_2	BB_4	BB_7	Riparian TOTAL Individuals	BB_6	BB_9	BB_12	BB_8	BB-5	Mixed open Sub-alpine forest TOTAL
Habitat	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian		Subalpine near road	Subalpine near road	Subalpine wetland	Subalpine	Subalpine near treeline	
Date	15-Jun-16	15-Jun-16	15-Jun-16	15-Jun-16		15-Jun-16	15-Jun-16	15-Jun-16	16-Jun-16	16-Jun-16	
Time	9:30 AM	10:00 AM	7:40 AM	7:15 AM		4:45 AM	5:00 AM	5:15 AM	6:00 AM	4:45 AM	
Scaup sp.					0			3			3
Bufflehead					0						0
Barrow's Goldeneye					0						0
Goldeneye sp.					0						0
Green-winged Teal					0						0
Mallard					0						0
Red-breasted Merganser					0						0
Willow Ptarmigan			1		1						0
Common Loon					0						0
Northern Harrier					0						0
Golden Eagle					0						0
Eagle species					0						0
raptor species			1		1						0
Solitary Sandpiper					0						0
Spotted Sandpiper					0			1			1
Semi-palmated plover					0						0
Red-necked Phalarope					0						0
Lesser Yellowlegs					0						0
Bonaparte's Gull					0						0
Olive-sided Flycatcher	1				1	1					1
Alder Flycatcher	1		1		2						0
Northern Flicker					0						0
Say's Phoebe					0						0
Northern Shrike					0						0
Gray Jay	1				1	1			1		2

Site name	BB_1	BB_2	BB_4	BB_7	Riparian TOTAL Individuals	BB_6	BB_9	BB_12	BB_8	BB-5	Mixed open Sub-alpine forest TOTAL
Habitat	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian		Subalpine near road	Subalpine near road	Subalpine wetland	Subalpine	Subalpine near treeline	
Date	15-Jun-16	15-Jun-16	15-Jun-16	15-Jun-16		15-Jun-16	15-Jun-16	15-Jun-16	16-Jun-16	16-Jun-16	
Time	9:30 AM	10:00 AM	7:40 AM	7:15 AM		4:45 AM	5:00 AM	5:15 AM	6:00 AM	4:45 AM	
Common Raven					0						0
Horned Lark					0						0
Bank Swallow					0						0
Tree Swallow					0						0
Boreal Chickadee					0						0
Ruby-crowned Kinglet		1			1						0
Townsend's Solitaire					0						0
American Robin		1	1		2	1					1
Gray-cheeked Thrush			1		1	2			2		4
Hermit Thrush					0						0
Swainson's Thrush					0						0
Bohemian Waxwing					0						0
Yellow Warbler			1		1						0
Yellow-rumped Warbler					0						0
Blackpoll Warbler		1			1	2		1	2	1	6
Common Yellowthroat		1	1		2				1		1
Orange-crowned Warbler			1	1	2					1	1
Wilson's Warbler	1	1	1	3	6	3	1	1	1		6
American Tree Sparrow			1	2	3	2	1	3	1	1	8
Chipping Sparrow					0						0
Savannah Sparrow					0						0
Fox Sparrow					0						0
Lincoln's Sparrow			2		2						0
White-crowned Sparrow	1	1	3	2	7	1	1	2	1	3	8
Golden-crown Sparrow					0					1	1

Site name	BB_1	BB_2	BB_4	BB_7	Riparian TOTAL Individuals	BB_6	BB_9	BB_12	BB_8	BB-5	Mixed open Sub-alpine forest TOTAL
Habitat	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian	Subalpine/ Riparian		Subalpine near road	Subalpine near road	Subalpine wetland	Subalpine	Subalpine near treeline	
Date	15-Jun-16	15-Jun-16	15-Jun-16	15-Jun-16		15-Jun-16	15-Jun-16	15-Jun-16	16-Jun-16	16-Jun-16	
Time	9:30 AM	10:00 AM	7:40 AM	7:15 AM		4:45 AM	5:00 AM	5:15 AM	6:00 AM	4:45 AM	
Dark-eyed Junco	1				1	1				1	2
Common Redpoll					0						0
Pine Grosbeak					0					2	2
TOTAL SPECIES	6	6	12	4	17	9	3	6	7	7	15

Table A5-2: 2016 Bird Survey Results - Alpine and Wetlands

Site name	BB_3	BB-10	BB_11	BB_17	BB_17	BB_18	Alpine TOTAL Ind	Footprint TOTAL Ind
Habitat	Alpine	Alpine	Alpine	Alpine	Alpine	Alpine		
Date	15-Jun-16	15-Jun-16	16-Jun-16	13-Jun-16	13-Jun-16	14-Jun-16		
Time	11:30 AM	6:15 AM	5:30 AM	1:00 PM	1:15 PM	2:00 PM		
Scaup sp.							0	3
Bufflehead							0	0
Barrow's Goldeneye							0	0
Goldeneye sp.							0	0
Green-winged Teal							0	0
Mallard							0	0
Red-breasted Merganser							0	0
Willow Ptarmigan	2						2	3
Common Loon							0	0
Northern Harrier							0	0
Golden Eagle					1		1	1
Eagle species							0	0
raptor species							0	1
Solitary Sandpiper							0	0
Spotted Sandpiper							0	1
Semi-palmated plover							0	0
Red-necked Phalarope							0	0
Lesser Yellowlegs							0	0
Bonaparte's Gull							0	0
Olive-sided Flycatcher							0	2
Alder Flycatcher							0	2
Northern Flicker							0	0
Say's Phoebe							0	0
Northern Shrike							0	0
Gray Jay				2			2	5
Common Raven				1			1	1
Horned Lark	1						1	1
Bank Swallow							0	0
Tree Swallow							0	0

Site name	BB_3	BB-10	BB_11	BB_17	BB_17	BB_18	Alpine TOTAL Ind	Footprint TOTAL Ind
Habitat	Alpine	Alpine	Alpine	Alpine	Alpine	Alpine		
Date	15-Jun-16	15-Jun-16	16-Jun-16	13-Jun-16	13-Jun-16	14-Jun-16		
Time	11:30 AM	6:15 AM	5:30 AM	1:00 PM	1:15 PM	2:00 PM		
Boreal Chickadee							0	0
Ruby-crowned Kinglet							0	1
Townsend's Solitaire					2		2	2
American Robin	5	1				1	7	10
Gray-cheeked Thrush			1				1	6
Hermit Thrush							0	0
Swainson's Thrush							0	0
Bohemian Waxwing							0	0
Yellow Warbler							0	1
Yellow-rumped Warbler							0	0
Blackpoll Warbler							0	7
Common Yellowthroat							0	3
Orange-crowned Warbler							0	3
Wilson's Warbler			2				2	14
American Tree Sparrow	2	4	1			1	8	19
Chipping Sparrow							0	0
Savannah Sparrow	1	2				1	4	4
Fox Sparrow							0	0
Lincoln's Sparrow							0	2
White-crowned Sparrow			1				1	16
Golden-crown Sparrow		1					1	2
Slate-colour Junco							0	3
Common Redpoll							0	0
Pine Grosbeak							0	2
TOTAL SPECIES	5	4	4	2	2	3	13	26

Table A5-3: 2016 Bird Survey Results - Wetlands

Site name	ABR-1	ABR-1	ABR-2	ABR-2	ABR-2	ABR-3	ABR-4	Wetland TOTAL Ind	Footprint + Wetland TOTAL Ind
Habitat	Subalpine wet & uplands	Subalpine	Middle pond	Upper pond	Wetland	Subalpine wetland/	North Lake Wetland/		
	-								
Date	15-Jun-16	14-Jun-16	13-Jun-16	13-Jun-16	13-Jun-16	16-Jun-16	16-Jun-16		
Time	5:30 AM	2:30 PM	1:50 PM	2:30 PM	5:50 AM	6:30 AM	7:00 AM		
Scaup sp.				2		33		35	38
Bufflehead								0	0
Barrow's Goldeneye		3						3	3
Goldeneye sp.				1				1	1
Green-winged Teal		1	1	1	2		5	10	10
Mallard								0	0
Red-breasted Merganser				1				1	1
Willow Ptarmigan			2				1	3	6
Common Loon								0	0
Northern Harrier						1		1	1
Golden Eagle								0	1
Eagle species								0	0
raptor species								0	1
Solitary Sandpiper			1					1	1
Spotted Sandpiper		1	2	2	2	1		8	9
Semi-palmated plover			1			1		2	2
Red-necked Phalarope				1				1	1
Lesser Yellowlegs		2			1		1	4	4
Bonaparte's Gull								0	0
Olive-sided Flycatcher		2						2	4
Alder Flycatcher	1							1	3
Northern Flicker								0	0
Say's Phoebe			1					1	1
Northern Shrike	2							2	2
Gray Jay								0	5
Common Raven								0	1
Horned Lark								0	1
Bank Swallow								0	0
Tree Swallow							4	4	4
Boreal Chickadee								0	0
Ruby-crowned Kinglet								0	1

Site name	ABR-1	ABR-1	ABR-2	ABR-2	ABR-2	ABR-3	ABR-4	Wetland TOTAL Ind	Footprint + Wetland TOTAL Ind
Habitat	Subalpine wet & uplands	Subalpine	Middle pond	Upper pond	Wetland	Subalpine wetland/	North Lake Wetland/		
	-								
Date	15-Jun-16	14-Jun-16	13-Jun-16	13-Jun-16	13-Jun-16	16-Jun-16	16-Jun-16		
Time	5:30 AM	2:30 PM	1:50 PM	2:30 PM	5:50 AM	6:30 AM	7:00 AM		
Townsend's Solitaire								0	2
American Robin		1	1					2	12
Gray-cheeked Thrush								0	6
Hermit Thrush								0	0
Swainson's Thrush								0	0
Bohemian Waxwing								0	0
Yellow Warbler								0	1
Yellow-rumped Warbler								0	0
Blackpoll Warbler								0	7
Common Yellowthroat	2					1	1	4	7
Orange-crowned Warbler								0	3
Wilson's Warbler		1				1		2	16
American Tree Sparrow	2			1		2	1	6	25
Chipping Sparrow								0	0
Savannah Sparrow						1	1	2	6
Fox Sparrow								0	0
Lincoln's Sparrow	1							1	3
White-crowned Sparrow	1					2	1	4	20
Golden-crown Sparrow								0	2
Slate-colour Junco								0	3
Common Redpoll								0	0
Pine Grosbeak								0	2
TOTAL SPECIES	6	7	7	7	3	9	8	24	38

Table A5-4: 2016 Bird Survey Results - Boreal

Site name	RS_3	RS_5	RS_4	RS_1	RS_6	RS_7	RS_2	RS_8	RS_9	RS_10	RS_11	RS_12	RS_13	RS_14	Boreal TOTAL Ind	Footprint + Wetland + Boreal Sites TOTAL Ind
Habitat	Boreal	Boreal	Boreal	Boreal and Pond	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal		
Date	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16		
Time	7:20 AM	6:30 AM	7:00 AM	8:40 AM	8:20 AM	8:00 AM	7:40 AM	9:00 AM	9:20 AM	9:40 AM	10:00 AM	10:20 AM	10:35 AM	10:45 AM		
Scaup sp.															0	38
Bufflehead															0	0
Barrow's Goldeneye				1											1	4
Goldeneye sp.															0	1
Green-winged Teal															0	10
Mallard				9											9	9
Red-breasted Merganser															0	1
Willow Ptarmigan															0	6
Common Loon	1														1	1
Northern Harrier															0	1
Golden Eagle															0	1
Eagle species															0	0
raptor species															0	1
Solitary Sandpiper															0	1
Spotted Sandpiper															0	9
Semi-palmated plover															0	2
Red-necked Phalarope															0	1
Lesser Yellowlegs	1														1	5
Bonaparte's Gull															0	0
Olive-sided Flycatcher		1		1							1			1	4	8
Alder Flycatcher	1														1	4
Northern Flicker								1			1				2	2
Say's Phoebe															0	1
Northern Shrike															0	2
Gray Jay				2		1		2						1	6	11

Site name	RS_3	RS_5	RS_4	RS_1	RS_6	RS_7	RS_2	RS_8	RS_9	RS_10	RS_11	RS_12	RS_13	RS_14	Boreal TOTAL Ind	Footprint + Wetland + Boreal Sites TOTAL Ind
Habitat	Boreal	Boreal	Boreal	Boreal and Pond	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal		
Date	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16		
Time	7:20 AM	6:30 AM	7:00 AM	8:40 AM	8:20 AM	8:00 AM	7:40 AM	9:00 AM	9:20 AM	9:40 AM	10:00 AM	10:20 AM	10:35 AM	10:45 AM		
Common Raven															0	1
Horned Lark															0	1
Bank Swallow			2												2	2
Tree Swallow															0	4
Boreal Chickadee			1		2					1				1	5	5
Ruby-crowned Kinglet	1			1	1	1	1	1		1	1				8	9
Townsend's Solitaire															0	2
American Robin	1	1		2				1			1		1		7	19
Gray-cheeked Thrush			1						3	2	1	1	2		10	16
Hermit Thrush														1	1	1
Swainson's Thrush				1	1										2	2
Bohemian Waxwing			4												4	4
Yellow Warbler															0	1
Yellow-rumped Warbler					1		2		1	1	1				6	6
Blackpoll Warbler		1	1						1			1			4	11
Common Yellowthroat															0	7
Orange-crowned Warbler															0	3
Wilson's Warbler						1									1	17
American Tree Sparrow		1													1	26
Chipping Sparrow				1	1										2	2
Savannah Sparrow															0	6
Fox Sparrow				1		1	2			1		1			6	6
Lincoln's Sparrow	1														1	4

Site name	RS_3	RS_5	RS_4	RS_1	RS_6	RS_7	RS_2	RS_8	RS_9	RS_10	RS_11	RS_12	RS_13	RS_14	Boreal TOTAL Ind	Footprint + Wetland + Boreal Sites TOTAL Ind
Habitat	Boreal	Boreal	Boreal	Boreal and Pond	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal	Boreal		
Date	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16	14-Jun-16		
Time	7:20 AM	6:30 AM	7:00 AM	8:40 AM	8:20 AM	8:00 AM	7:40 AM	9:00 AM	9:20 AM	9:40 AM	10:00 AM	10:20 AM	10:35 AM	10:45 AM		
White-crowned Sparrow	1	2	1								1	1	2		8	28
Golden-crown Sparrow															0	2
Dark-eyed Junco	1	3	1	1	2	1	1	1	1	1		1		3	17	20
Common Redpoll	1					8	1								10	10
Pine Grosbeak															0	2
TOTAL SPECIES	9	6	7	10	6	6	5	5	4	6	7	5	3	5	26	50

Table A5-5: 2016 Bird Survey Results - Reference Sites

Site name	REF-1	REF-2	REF-3	REF-4	REF-5		
Habitat	Subalpine wetland	Subalpine wetland	Subalpine wetland	Alpine	Alpine		
Date	16-Jun-16	16-Jun-16	16-Jun-16	16-Jun-16	16-Jun-16		
Time	8:00 AM	7:30 AM	9:00 AM	9:30 AM	9:45 AM	Reference TOTAL Ind	ALL SITES TOTAL Ind
Scaup sp.		15	7			22	60
Bufflehead		1				1	1
Barrow's Goldeneye						0	4
Goldeneye sp.	2	5	2			9	10
Green-winged Teal			1			1	11
Mallard						0	9
Red-breasted Merganser						0	1
Willow Ptarmigan		1				1	7
Common Loon						0	1
Northern Harrier						0	1
Golden Eagle			1			1	2
Eagle species						0	0
raptor species						0	1
Solitary Sandpiper						0	1
Spotted Sandpiper						0	9
Semi-palmated plover	1	3				4	6
Red-necked Phalarope		9				9	10
Lesser Yellowlegs		2				2	7
Bonaparte's Gull			1			1	1
Olive-sided Flycatcher						0	8
Alder Flycatcher			1			1	5
Northern Flicker						0	2
Say's Phoebe						0	1
Northern Shrike						0	2
Gray Jay						0	11
Common Raven						0	1
Horned Lark						0	1
Bank Swallow						0	2
Tree Swallow						0	4
Boreal Chickadee						0	5
Ruby-crowned Kinglet						0	9
Townsend's Solitaire						0	2

Site name	REF-1	REF-2	REF-3	REF-4	REF-5		
Habitat	Subalpine wetland	Subalpine wetland	Subalpine wetland	Alpine	Alpine		
Date	16-Jun-16	16-Jun-16	16-Jun-16	16-Jun-16	16-Jun-16		
Time	8:00 AM	7:30 AM	9:00 AM	9:30 AM	9:45 AM	Reference TOTAL Ind	ALL SITES TOTAL Ind
American Robin						0	19
Gray-cheeked Thrush						0	16
Hermit Thrush						0	1
Swainson's Thrush						0	2
Bohemian Waxwing						0	4
Yellow Warbler						0	1
Yellow-rumped Warbler						0	6
Blackpoll Warbler						0	11
Common Yellowthroat						0	7
Orange-crowned Warbler						0	3
Wilson’s Warbler	1					1	18
American Tree Sparrow	1		2	1		4	30
Chipping Sparrow						0	2
Savannah Sparrow	1	2	2	1	1	7	13
Fox Sparrow						0	6
Lincoln’s Sparrow						0	4
White-crowned Sparrow	1		1		1	3	31
Golden-crown Sparrow						0	2
Dark-eyed Junco						0	20
Common Redpoll						0	10
Pine Grosbeak						0	2
TOTAL SPECIES	6	8	9	2	2	15	52

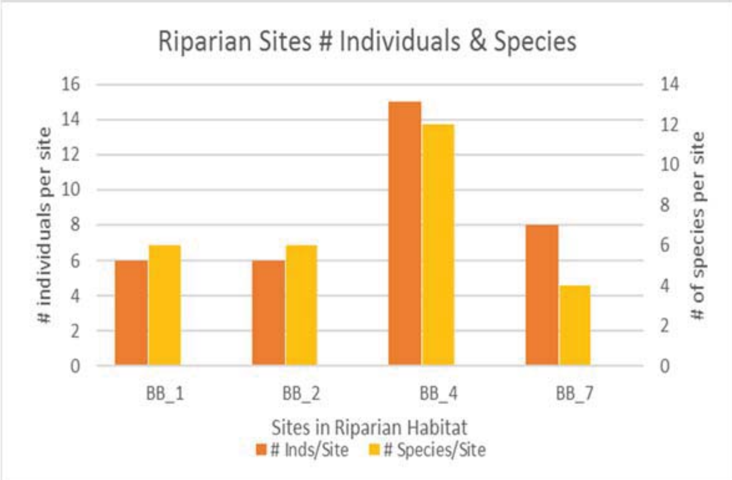


Figure A5-1: Relative Abundance & Richness (Riparian)

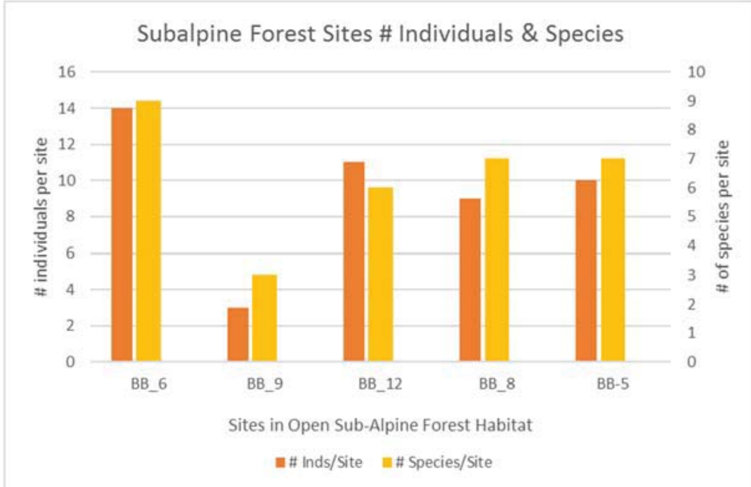


Figure A5-2: Relative Abundance & Richness (Subalpine)

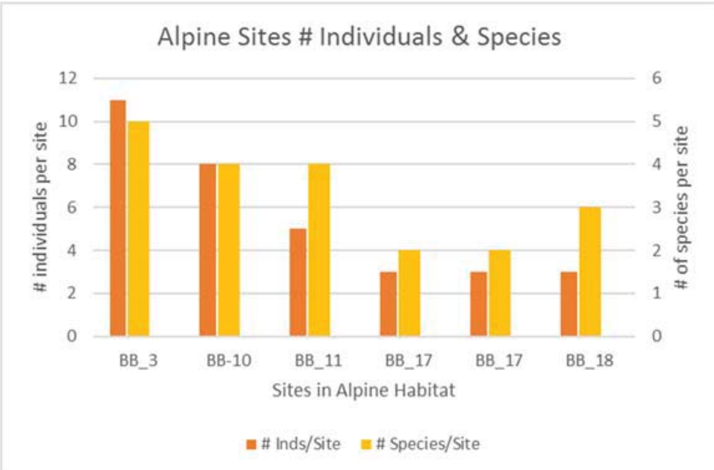


Figure A5-3: Relative Abundance & Richness (Alpine)

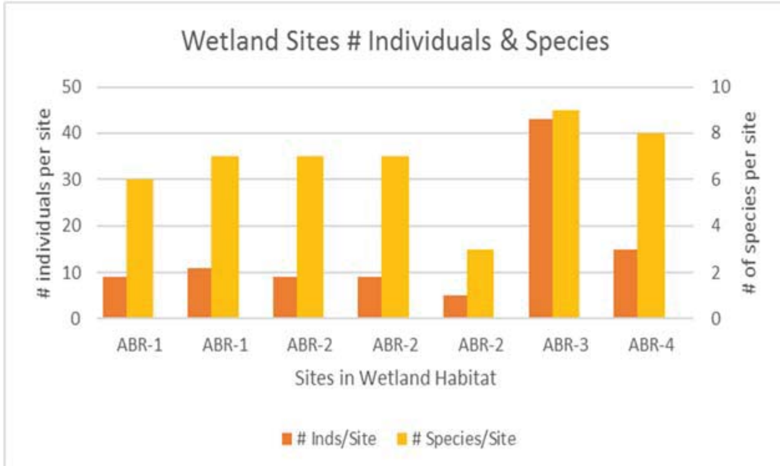


Figure A5-4: Relative Abundance & Richness (Wetland)

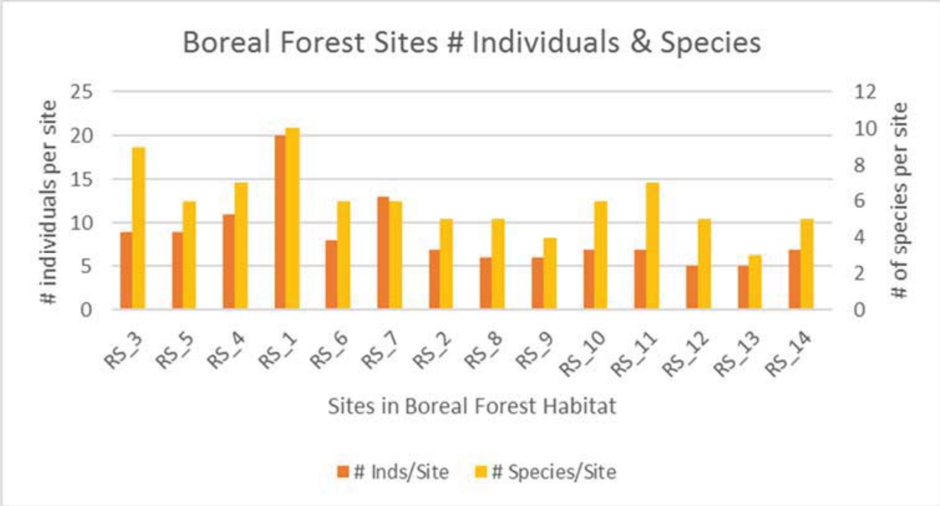
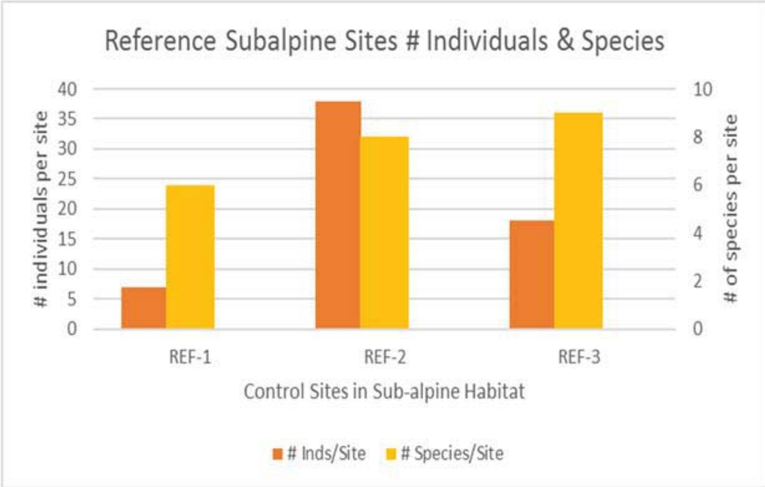


Figure A5-5: Relative Abundance & Richness (Boreal)



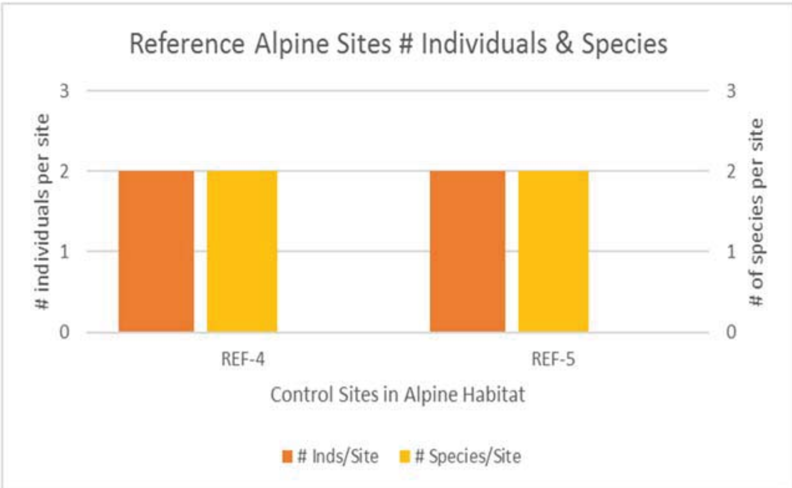


Figure A5-6: Relative Abundance & Richness (Reference Subalpine)

Figure A5-7 Relative Abundance & Richness (Reference Alpine)

APPENDIX 6.
Heritage Report

ECOFOR
natural and cultural resource consultants

Heritage Resource Impact Assessment: Proposed BMC Minerals Kude Ze Kayah Mine

(To Be Included in YESAB Materials – All Sensitive Site Data Removed)

Permit 15-10ASR

Prepared for:

[Name Redacted]

BMC Minerals (No. 1) Ltd.
530 – 1130 West Pender
Vancouver, BC
V6E 4A4

By:

[Name Redacted]

Ecofor Consulting Ltd.
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Whitehorse, YK
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March 23, 2016

Heritage Resource Impact Assessment: Proposed BMC Minerals Kude Ze Kayah Mine

Prepared By:

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Heritage Resources Unit
Department of Tourism and Culture
Government of Yukon
PO Box 2703
Whitehorse, YT Y1A-2C6
Phone: (867) 667-5983

Report also submitted to:

Ross River Dena Council
Liard First Nation

EXECUTIVE SUMMARY

At the request of BMC Minerals (No. 1) Ltd. (BMC), Ecofor Consulting Ltd. conducted a Heritage Resource Impact Assessment (HRIA) for the proposed BMC Minerals Kude Ze Kayah Mine. This HRIA assessed the potential mine site and associated developments, including the proposed pit, western waste rock storage, main waste rock storage, organic storage areas, mill site, accommodations area, explosive area, 2015 exploration targets, and reviewed the existing tote road for likely road improvement areas. **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this YESAB ready version of this report so that it can be issued publicly while protecting sensitive site data.**

Eight landforms were identified as possessing elevated potential for buried cultural materials and were shovel tested. Two of these landforms were found to contain prehistoric lithic sites: JiTp-1 (the Alistair Site) and JjTp-1 (the Fat Lip Site). In addition to subsurface testing at the eight landforms discussed above, surficial survey was conducted at high elevation exploration zones, resulting in the recovery/documentation of heritage resources at three localities (Ice Patch #1, #2, and #3).

Additional data recovery work is recommended for JiTp-1. BMC Minerals has agreed to conduct additional work at this site in 2016. This work will consist of additional shovel testing and test unit excavation. Additional work should include approximately 30 to 40 additional shovel tests and approximately 6 to 8 test units to further sample and mitigate the proposed impacts to the site.

Avoidance is recommended for JjTp-1. At this time there are no specific proposed impacts to the site area. However, if the site will be impacted in the future due to changes in the proposed development plan then it is recommended that 10 to 15 additional shovel tests and 3 to 5 test units be excavated to further sample and mitigate the impacts to the site.

No further work is recommended in relation to the Ice Patch #1, #2, and #3 finds associated with the 2015 high elevation exploration targets. If any additional high elevation exploration targets are proposed they should be assessed before ground disturbing activities are allowed to commence.

No built structures, cambium stripped trees, or additional buried cultural materials were identified within the survey footprint, including along the existing tote road where future road improvements might be made. As such, **no further work is recommended in relation to known tote road improvements. However, if any cultural materials are identified during activities related to road improvements, or any other development activities at the BMC Minerals Kude**

Ze Kayah Mine, then work in the area should stop, the materials should be protected from further disturbance, and the BMC chance finds protocol should be implemented.

CREDITS

Permit Holder:	[Name Redacted]
Report Authors:	[Name Redacted]
Report Editing:	[Name Redacted]
Field Crew	[Name Redacted]
	(Ross River Dena Council)
Graphics/GIS Technicians:	[Name Redacted]

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1. INTRODUCTION

At the request of BMC Minerals (No. 1) Ltd. (BMC), Ecofor Consulting Ltd. conducted a Heritage Resource Impact Assessment (HRIA) for the proposed BMC Minerals Kude Ze Kayah Mine (Figure 1). The Kudz Ze Kayah (KZK) project is located approximately 260 km northwest of Watson Lake, 110 km southeast of Ross River and 24 km south west of the Robert Campbell Highway near Finlayson Lake. The project components are located within NTS mapsheets 105G/07, 105G/08, 105G/09 and 105G/10, and are located within the traditional territory of the Ross River Dena Council (RRDC) and the Liard First Nation (LFN) which are both members of the Kaska Nation. The north end of the tote road, represents the lowest elevation, while exploration drilling represents the highest elevation in the south. The study area covers approximately 325 ha. **Note: All specific geographic references to heritage site locations, photographs, and some site details have been removed from this YESAB ready version of this report so that it can be issued publicly while protecting sensitive site data.**

1.1 Project Overview

This HRIA assessed the proposed mine site and associated developments, including the proposed pit, western waste rock storage area, main waste rock dump, organic storage areas, mill site, accommodations area, explosive area, 2015 exploration targets, and reviewed the existing tote road for likely road improvement areas. In particular, attention was focused on possible high elevation exploration targets that might have the potential to impact ice patch related heritage resources. Previous heritage impact assessment studies were conducted in relation to an earlier but similar project in 1995 and 1996 and no cultural materials were identified. The rationale for the current assessment was based on differences in past assessed areas and current project components including the high elevation drill targets.

Eight landforms were evaluated in the field as containing potential for heritage resources. The eight landforms were tested with hand excavated subsurface shovel testing. The amount of subsurface testing at these eight shovel test locations (STLs) ranged from five shovel tests up to 240 shovel tests, for a total of 346 tests. Two of these STLs were found to contain prehistoric lithic materials, resulting in the recording of two new archaeological sites: JiTp-1 (the Alistair Site) and JjTp-1 (the Fat Lip Site). In addition, wooden artifacts were identified on the surface at three high elevation ice patch edge locations. These sites have not been assigned Borden numbers and are reported here as Ice Patch 1, 2, and 3.

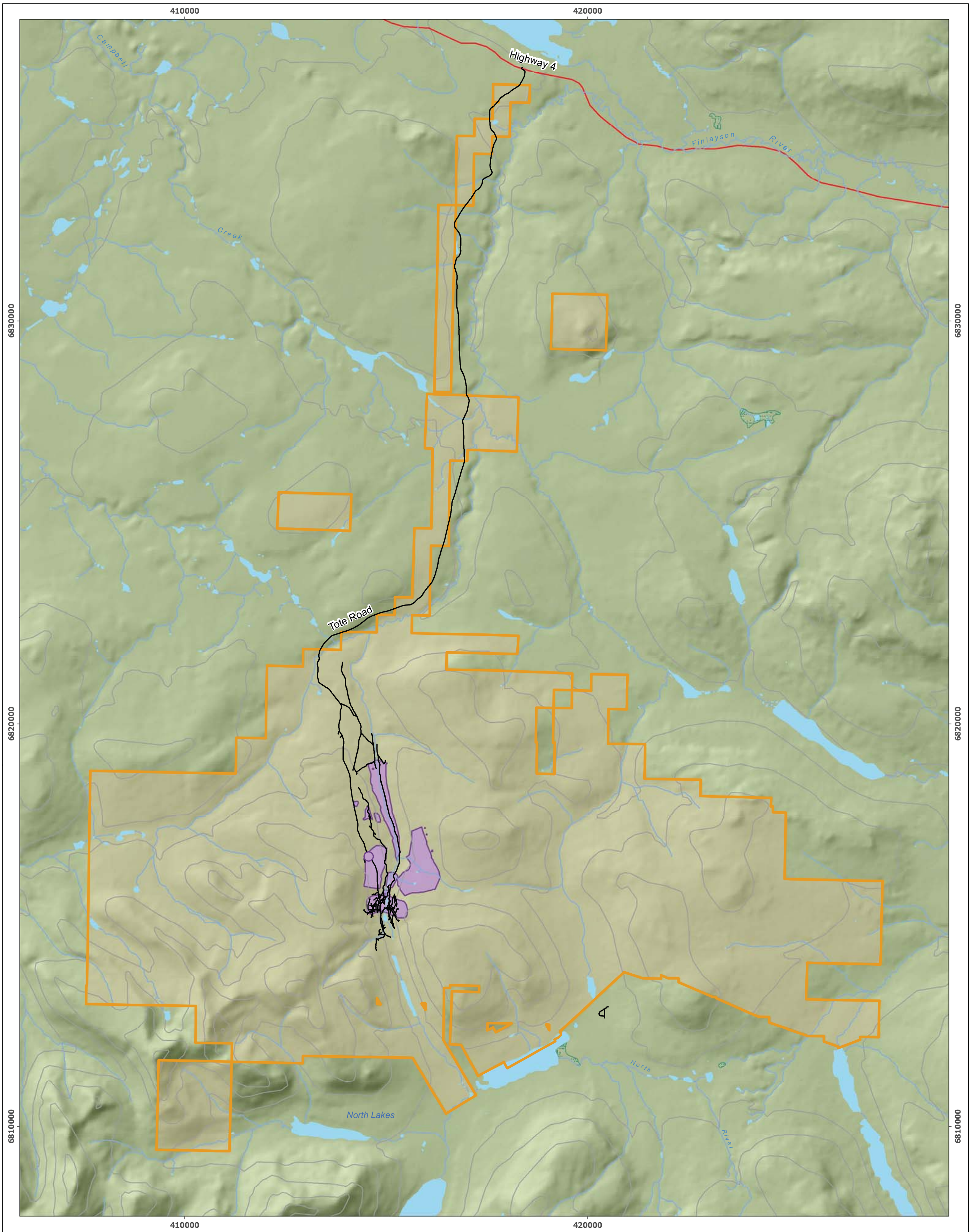


FIGURE 1
KUDE ZE KAYAH PROPERTY OVERVIEW MAP

BMC MINERALS

ECOFOR natural and cultural resource consultants

Ecofor Consulting Ltd. February-26-16 (MM)

Base Features

- Contour (500 ft)
- Watercourse
- Waterbody
- Wetland

Access

- Highway
- Tote Road

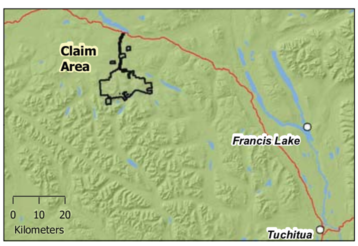
Assessment Features

- Kude Ze Kayah Claim Area
- Potential Mine Infrastructure

1:90,000

0 2,000 4,000 6,000 m

NAD 1983 UTM Zone 9N



Disclaimer:
This product is for informational purposes only and may not have been prepared for or be suitable for legal, engineering, or surveying purposes. The base data layers have been obtained from the National Topographic Database (NTDB), and GeoYukon.

1.2 Personnel

In August of 2015, Ecofor staff consisting of [Name Redacted] and [Name Redacted] and one RRDC participant, [Name Redacted] completed these HRIA field efforts.

1.3 Report Format

Following this introduction in Section 1.0, Section 2.0 provides a discussion of the environmental setting that the study area is located within, Section 3.0 discusses the culture history of the area in which the proposed development is located, Section 4.0 details the methodologies employed in completing this work; Section 5.0 presents the results of this HRIA and the recommendations that stemmed from them, Section 6.0 provides a summary and offers concluding remarks, and Section 7.0 closes the report with a listing of references cited.

Five appendices are included at the end of this report[1]. Appendix A shows project mapping; Appendix B provides project photographs; Appendix C contains the site form for newly recorded archaeological sites JiTp-1 and JjTp-1; Appendix D contains the artifact catalogues from JiTp-1 and JjTp-1; and Appendix E contains a copy of the field notes.

[1] Note: These appendices have been removed from this YESAB ready version of this report so that it can be issued publicly while protecting sensitive site data.

2. ENVIRONMENTAL SETTING

The study area fall within the Yukon Plateau – North Ecoregion which is part of the Boreal Cordillera Ecozone (Smith et al. 2004).

2.1 The Yukon Plateau – North Ecoregion

The Yukon Plateau – North Ecoregion is the largest ecoregion entirely inside the Yukon and contains a large portion of the Tintina Trench. The ecoregion generally consists of relatively rolling highlands with an east-west orientation.

The mean annual temperature in the Yukon Plateau – North Ecoregion is near -5°C. Mean temperatures for January range from below -30°C in the lower valleys to above -20°C in higher terrain. This is drastically different by July as mean temperatures in the lower valleys are 15°C and close to 8°C in higher terrain. Frost can occur at any time of the year, but is less likely from mid-June to late July.

Precipitation is moderate with an increase in higher elevation sections in the eastern part of the ecozone. Annual precipitation ranges from approximately 300 to 600 mm. The winter months have mean precipitation of 20 to 30 mm while the summer months can expect 40 to 80 mm of rainfall (Smith et al. 2004). Winds are generally light, however they may increase to moderate/high during unusually active weather systems or thunderstorms.

The vegetation of the Yukon Plateau – North ranges from boreal to alpine. Northern boreal forest exists at elevations up to 1500 m (Smith et al. 2004). Open black spruce with a moist moss, or drier lichen understory is the dominant forest type in the boreal zone. Shrub and lichen tundra dominate the higher elevations. The alpine vegetation is characterized by low ericaceous shrubs, prostrate willows, and lichens. In the subalpine areas, shrub birch, with scattered pine, white spruce, subalpine fir and a lichen understory, is extensive. Extensive shrub lands exist at mid-elevations and on valley bottoms that are subject to cold air drainage. Black spruce is the dominate tree type in the ecoregion, however white spruce, occasionally with aspen or lodgepole pine, occur in warmer, better-drained areas and in forest fire burn areas.

The Yukon Plateau–North Ecoregion supports wildlife populations typical of Yukon's boreal forest. Moose, woodland caribou, Stone sheep, Dall sheep, grizzly bear, black bear, wolverine, and marten are all abundant. This ecoregion supports the greatest proportion of brown-coloured black bears in the Yukon, occurring between the Stewart and Pelly rivers. Lynx, beaver, chestnut cheeked vole, mule deer, coyotes, and red fox are also present in some sections of the Yukon

Plateau – North (Smith et al. 2004). Of interest in the larger area are the Tay River Caribou herd, and an overlap of Stone and Dall Sheep, while Mountain goats are uncommon. The local project area overlaps with the Finlayson Caribou herd but does not overlap with either species of sheep.

The glacial history of the Yukon Plateau – North Ecoregion was dominated by the actions of the Cordilleran ice sheet and local glaciers. More recent glaciations were less extensive. Most current glacial features are remnants from the McConnell glaciation (Smith et al. 2004), however some older features and glacial erratics are present from the older Reid and pre-Reid glaciations. Some uplands and valley floors were extensively eroded into "whalebacks" or rock drumlins by the glacial flow. The western edge of the ecoregion was approximately the terminus for the ice sheet of the McConnell glaciation. As the ice retreated through regional stagnation and wasting it left behind kame and kettle topography and glacial lake deposits in many valleys (Smith et al. 2004).

Soils in the valleys of this ecoregion tend to be underlain by glacial parent materials. Soil development also reflects the presence of extensive discontinuous permafrost and a strong continental climate (Smith et al. 2004). Of interest is the presence of the Wounded Moose and the Diversion Creek palaeosols. These two palaeosols are buried soils formed a great deal of time before the current environmental conditions and may reflect past stable ground surfaces. The Wounded Moose palaeosol developed on glacial surfaces of pre-Reid age and the Diversion Creek palaeosol developed between the Reid and the McConnell glaciations. Both of these palaeosols would predate the known cultural history in the Yukon.

The bedrock geology of this ecoregion includes sections of two geological provinces of metamorphosed sedimentary rock. In the northern half of the ecoregion, variably deformed sedimentary rocks have been deposited on the outer continental shelf of ancestral North America, the Selwyn Basin. The bedrock geology in the southeast part of the ecoregion includes siliceous sedimentary and volcanic rocks of the Yukon-Tanana terrane and metabasaltic flows of the Slide Mountain terrane. The origin of these materials is not well-known due to deformation before and during transportation onto the Selwyn Basin strata (Smith et al. 2004). The southeast section of the ecoregion between Faro and Ross River also includes exposed river and stream cut banks along the Tintina Trench (a 450 km fault) that contains rhyolite and olivine basalt which may have provided materials for prehistoric stone tool making. Also of interest in the northern Anvil Range are jet-black or gun steel-blue weathering siliceous siltstone and conglomerate containing chert pebbles. These materials may also have been used for making stone tools.

3. CULTURAL HISTORY

The following is an overview of the culture history for the broader region surrounding the study area including south-central and southwestern Yukon, and northern BC. Many researchers have reviewed the cultural history of this broader area and have presented the information using a variety of terms and temporal ranges (Clark 1981; West 1996; Workman 1978; Wright 1995, 1999). Temporal ranges begin with years before present abbreviated BP.

3.1 Prehistoric Period (>11000 BP to ca. AD 1700s)

The earliest prehistoric occupation, which dates to early post-glacial times, is known as the Northern Cordilleran tradition (Clark 1983; Hare 1995). The earliest Northern Cordilleran tradition occupation known at present is a site located near Beaver Creek, dated to 10670 radiocarbon years before present (BP)(Heffner 2002). The majority of sites in this period appear to date older than 7000 to 8000 BP. The Northern Cordilleran tradition, with some overlap, predates the introduction of microlithic technology from Alaska into the interior of the central and southern Yukon (Clark 1983; Hare 1995).

The Little Arm phase dates from 7000 to approximately 4500 BP (Clark and Gotthardt 1999; Workman 1978) and can be defined by the use of microlithic technologies. After about 4500 BP, there is less evidence of microblade use in the Yukon, and an increase in the use of notched projectile points and a variety of scraping and carving tools. This is labeled the Taye Lake phase in southwest Yukon, or more broadly in Yukon and Alaska, the Northern Archaic tradition (Hare 1995; Workman 1978). The most recent archaeological culture of southern Yukon is that of the Aishihik phase (Workman 1978). This phase is thought to be a cultural development from the earlier Taye Lake culture, although there are some significant differences in technology. The most notable is the introduction of the bow and arrow, replacing a type of throwing spear known as an atlatl (Hare et al. 2004). These Aishihik phase sites are found above the White River Volcanic ash layer (also known as Tephra) that is dated to about 1250 BP (Clague et al. 1995).

3.2 Athabaskan Period (ca AD 500 to AD 1840s)

In the Athabaskan Period, the project area is thought to have been populated by ancestors of the current Ross River Dena Council which may have been comprised of the Shu-tah Dene, Northern Tuchone, and Kaska. A great deal of information concerning the Northern Tutchone people was recorded in oral traditions passed on through generations and recorded by various researchers (Dobrowolsky 1987, Gotthardt 1987, Legros 1999; McClellan 1981, McClellan et al. 1987). More information regarding the Kaska is presented below.

From a tool kit perspective, the Athabaskan period has been identified as a shift to stemmed projectile points, the increased use of bone and antler projectile points, and the use of the bow and arrow.

This late prehistoric period is defined by those archaeological components dating after the fall of the White River Tephra (WRT). The Aishihik phase has been evaluated as ranging from approximately AD 750 to AD 1750 and also include the use of native copper tools, stemmed projectile points, and gorges. Also indicative of the Aishihik phase are small stemmed Kavik points, end and side scrapers, and ground adzes (Hare 1995). The poor preservation of organic materials makes the task of diet reconstruction more difficult than at coastal sites, but there is evidence of continued use of a variety of large and small mammals, fish, and birds. In the high elevations of the southern Yukon ice patches, examples of the transition from the older atlatl technology to the bow and arrow use has been clearly documented by recent finds (Hare et al. 2004). The shift to the new technology was a rather abrupt one at roughly AD 750 based on a good sample of dated atlatl dart shafts and bow and arrow remains.

3.3 Proto-historic Period (AD 1700s to ca AD 1840s)

The proto-historic period, as presented here, also overlaps with the late Athabaskan Period and can be defined by the appearance of non-native goods, other early trade items, and foreign (western or eastern) influences, but not the documented accounts of westerners themselves. Other indicators of the proto-historic period are the arrival of the first non-native diseases and oral traditions concerning non-natives. This period spans the time between the first introduction of non-native influences or artifacts, and the recording of first hand or primary written accounts. Unlike other cultural periods with more specific temporal ranges it is difficult and perhaps impossible to determine when the first ‘outside’ influences of Russian, Asian, European, or other cultures began to impact First Nations people in the Yukon interior.

Some of these far reaching effects may have been passed along from Russian exploration in the early and mid-1700s (Veniaminov 1984) and other Asian and European (Andreev 1944, Quimby 1985) exploration and contact with coastal communities. The Chilkat Tlingit from the Northwest Coast travelled and traded with many interior First Nation peoples throughout this proto-historic period, including the Kaska and the Northern Tutchone from the Dawson and Mayo areas, and occasionally the Mountain Dene people from as far away as Fort Norman on the Mackenzie River. The Tlingit protected and controlled the trading routes into the interior and fiercely defended those routes when they were threatened. News of early non-native explorers and traders would have travelled inland along with foreign items such as metals, cloths, glass beads, and later tobacco and other goods.

In some of the earliest cases, the impacts of these foreign cultures could have had significant impacts even without the presence of the foreigners themselves. Such is the case for what is called 'drift-iron' whereby metals and other materials from Asian or European shipwreck wash ashore. Historical accounts of shipwrecks were reported in the mid-1700s, but much earlier wrecks were possible. Metals and other foreign trade items have been derived from ship wrecks off what is now British Columbia, southwest Alaska, and perhaps the northwest Alaska as well.

3.4 Historic Period (post AD 1840s)

During the early years of this period the Russians were expanding their exploration and trade network along the Pacific coast and up the major rivers of the Alaskan interior, while the British were exploring eastward into what would become Canada's Northwest and Yukon Territories, as well as Alaska. In the 1840s, representatives of the Hudson's Bay Company (HBC) established trading posts near the study area. Frances Lake Post was established by the narrows of Frances Lake in 1840 while Fort Pelly Banks was constructed in the winter of 1842-43 on the Pelly River at the mouth of Campbell Creek. Fort Yukon was established by John Bell at the confluence of the Yukon and the Porcupine Rivers in 1847. The next year Robert Campbell established Fort Selkirk on the upper Yukon River and then relocated to an improved location in 1851. The Frances Lake post functioned primarily as a meat post and then as a staging post enroute to Fort Selkirk. These posts were plagued by starvation, poor supply and poor trade due to hostilities and feuding.

The location of Fort Selkirk was known to upset the Chilkat Tlingit who controlled the trade routes from the coast to the central Yukon. In 1852, a Chilkat Tlingit raiding party travelled inland and forced Robert Campbell and his crew to leave the trading post, which was consequently burned by the Northern Tutchone (Castillo 2012). The posts at Frances Lake and the Fort at Pelly Banks were abandoned by the Hudson's Bay Company by 1851-1852, while Fort Halkett, on the Upper Liard River near what would become the BC-Yukon border, remained open until 1865.

In 1867, US Secretary of State William Seward was able to focus increasing American interests, and he convinced the United States Senate to purchase Alaska from Russia. Soon after the purchase, the US Army sent Captain Raymond up the Yukon River on the first stern-wheel steamer to reach Fort Yukon (Grauman 1977). Raymond surveyed the location of Fort Yukon and proved that it was within US territory. The British sold the Fort to the US Government and relocated east across the 141st Meridian.

The inland fur industry continued to drive exploration and settlement into the late 1800s, but mining would shift the focus to the placer gold found in streams and alluvial deposits. Mining in the second half of the 19th century was a risky but often very lucrative enterprise. The impacts of mining would spread quickly and drastically change the larger regional area.

Mineral prospecting and mining efforts in the second half of the 19th century were in some ways very dependent on the existing infrastructure of the fur trading and missionary efforts. As the competition for the inland fur trade grew, so would the number of stern-wheelers on the Yukon River. These steamers could better supply the small number of trading posts along the Yukon and its tributaries and reduce the risk of prospectors running short of supplies. Therefore, more of the fur traders and other explorers turned their attention to search for gold and other minerals. Three key prospectors in the north were L.S. (Jack) McQueston, Al Mayo, and Arthur Harper. They wrote to miners in the United States to encourage them to come north. They also established outposts along the Yukon River, including Fort Reliance, established in 1874 near the confluence of the Klondike River (what would become Dawson City) (Wright 1976).

Harper and another man may have been the first to travel up the Fortymile River in search of gold in 1881 (Buzzell 2003). They collected a very rich sample, but were unable to relocate the exact location of their original find. In 1886, McQueston, Harper, and Mayo built a post on the confluence of the Stewart and Yukon Rivers which provided supplies for additional prospectors. Also in 1886, Howard Franklin made a richer find on the Fortymile River. Others rushed in and these claims along the Fortymile River attracted miners from across central and eastern Alaska, and even southeast Alaska. Forty Mile was the first town to grow to over a thousand people by the mid-1890s (Buzzell 2003), and in 1887 the Stewart River post was deserted. Some prospectors that did not find easy success in Fortymile returned to the Stewart River and continued work in the area. In 1890, Harper re-established a trading post at the site of the old HBC post at Selkirk as interest in the area grew. This was followed by Jack Dalton who developed a series of existing First Nation trails beginning at tide water at Haines Alaska, into Fort Selkirk.

On August 16, 1896, George Carmack, Skookum Jim, and Tagish Charlie discovered a very rich claim on Bonanza Creek, a tributary to the Klondike River near Dawson. This discovery sparked one of the largest gold rushes in history.

It would take almost a year for the news of the Klondike gold fields to spread south, even to places relatively close by in southeast Alaska. Most of the prospectors and traders in the Alaskan and Yukon interior had already converged on the Dawson area during the winter and spring, and supplies ran dangerously low. That would quickly change in the summer of 1897 and spring of 1898 as new towns and supply posts sprang up along the Gold Rush routes to cash in on the increased demand.

The population of Dawson City grew very fast and in 1898 reached a peak of over 30000. However, the boom period did not last long and the vast majority of the population moved on very quickly with the news of other discoveries. The Gold Rush period saw greatly increased steamer traffic on the entire Yukon River drainage basin and across the interior. Just prior to the Gold Rush there were only a few steamers, while at its peak there were hundreds of vessels working the rivers. These shallow draft steamers were supported by a network of wood camps, shipyards, and a large workforce which kept the river traffic moving. This network provided the infrastructure backbone for trading posts, fish camps, missionaries, and mail routes, while meeting the needs of the growing number of prospectors and traders.

As the world's attention was drawn to growing concerns in Europe in 1939, the Canadian Government began building a chain of airfields across the northwest under the Northwest Staging Route Program. Following the bombing of Pearl Harbor there was no doubt that Alaska and the Yukon would play a key role in the war, and a road was required to link Alaska to the contiguous United States. It was quickly decided that the "Prairie Route" would be used, whereby key airfields would be linked from Great Falls, Montana to Fairbanks, Alaska. As part of the agreement Canada agreed to build and improve airstrips along the way, including Watson Lake. In February 1942, the US War Department issued the directive to begin construction. These actions spurred on the building of approximately 2446 km of new road through British Columbia and the Yukon Territory. Following the completion of the Alaska Highway the Canol Pipeline and Canol Road (North and South) were completed to allow the flow of oil from Norman Wells, NWT to Whitehorse in 1944. These two events increased access to the traditional territory of the Ross River Dena Council and were largely responsible for commercial and mining/industrial activities in recent decades, including construction of the Robert Campbell Highway (Tungsten Road) in 1961.

3.5 The Kaska Nation

The project falls within the traditional territories of the Ross River Dena Council (RRDC) and the Liard First Nation (LFN). Both First Nations are part of the Kaska Nation. The Kaska Nation's traditional territory covers a large area of northwestern BC, southeastern Yukon, and southern NWT. Within the Kaska traditional territory there are five First Nations communities: the Dease River First Nation, the Kwadacha Nation, the Ross River Dena Council, the Liard First Nation and the Daylu Dena Council. Each Kaska First Nation is represented by an elected Chief and Council as well as a Hereditary Chief.

Prior to European contact, traditional subsistence activities typically featured a seasonal round of winter hunting and summer fishing covering vast areas. In summer, families congregated at lakes and rivers, where fish and plants were collected, dried and stored. In late summer, small groups dispersed throughout the uplands and higher valley systems to hunt in clan-owned territories. Temporary camp sites, situated within a variety of ecological zones, were often reoccupied year after year in order to exploit seasonally available resources (Honingmann 1981).

Contact with neighbouring Nations was vital to First Nations' economies. Interior bands traded hides, furs and obsidian to coastal groups for fish oil, dentalium, woodwork and blankets. Trails were an intrinsic part of this economy and traditional subsistence as a whole. The principal ethnographic descriptions of the Kaska Dena are available in Black (1955), Jenness (1937), and Morice (1893, 1903, 1905). Additional information on past lifeways can be found in Honigmann (1981).

Ross River, near the confluence of the Ross and Pelly Rivers, is the modern focal point of the Ross River Dena Council. Originally, First Nations people used the area as a seasonal camp and gathering place. By 1903, a trading post was established nearby and later when the American army completed the Canol Pipeline and Canol Road in 1944, they connected Ross River by road to the rest of the Yukon (Cohen 1992). In 1962, Ross River was relocated to its current site close to the Campbell Highway (Yukon Community Profiles 2012).

Watson Lake, Upper Liard and the adjoining settlements are home to the Liard First Nation. The amount of activity near Watson Lake was greatly increased when its airfield was established in 1939. This was part of the Canadian government's construction of a chain of airports across northeastern British Columbia and the Yukon as part of the lend-lease program. The new community was soon after used as a supply centre for the construction of the Alaska Highway in 1942.

3.6 Previous Heritage Investigations

In 1995, a heritage impact study was conducted in collaboration with the RRDC as part of the Initial Environmental Evaluation of the proposed KZK Mine. The study identified no cultural materials or features (Rutherford 1995a); however, a review of the oral history provided by Kaska members indicates that the project area was used for subsistence hunting, trapping and fishing, and as an access route to the North Lakes (Rutherford 1995b). In 1996, an additional study for cultural materials was undertaken at a proposed airstrip location near the Robert Campbell Highway (Rutherford 1996). No cultural materials were identified in this follow-up study. No archaeological sites were known for this area prior to the current 2015 heritage study.

4. METHODOLOGY

Field efforts were separated into two main tasks consisting of pedestrian transect survey to assess in-field potential and subsurface testing where potential for buried heritage resources was determined to be moderate to high.

Due to the relatively small size of the assessment areas, each proposed target area was walked in relatively tight transect intervals of approximately 5 to 15 m apart. When areas or landforms were assessed in the field to possess moderate to high potential, shovel tests were excavated. Shovel tests were located approximately 5 to 10 m apart. Shovel tests were a minimum of approximately 35 by 35 cm and were excavated with shovel and trowel as needed into sterile sub soils. All soil matrix were screened through ¼” mesh. Artifacts identified were collected and bagged according to the shovel test unit and stratum, or arbitrary 5 cm vertical interval. The profile of positive shovel tests were recorded by depth below surface and natural and cultural soil strata. All shovel tests were backfilled and returned to as close to natural conditions as possible. If surface finds or subsurface cultural materials were identified additional shovel testing was conducted to assess the vertical and horizontal limits of the site, and to recover a sample of the cultural material to assist in the assessment of the site use and cultural affiliation. All sites, isolates, and heritage resources were photographed and the site location recorded using a hand-held GPS unit. Sketch maps were prepared in the field for all sites. Additional site data included setting, access, vegetation, water system information, elevation, soils data including number of cultural strata, features present, and other comments. This information was submitted to Yukon Heritage Branch for site inventory and return of Borden Site number. The condition of sites was also assessed based on the amount of disturbance, ranging from relatively intact to destroyed. Historic and prehistoric sites were flagged in the field as needed. A buffer area of 30 m around known historic and prehistoric sites was flagged with yellow “no work zone” ribbon as well as flagging at the centre of the site. Field work was completed by crews of three to four individuals (principal investigator, archaeological field technician, and First Nation Participant).

Interim and final reports, site forms, and artifact curation preparations met the Yukon Archaeological Sites Regulations Guidelines for Permit Holders.

If mummified or skeletal palaeontological remains were exposed, Yukon Palaeontology would have been contacted before disturbing them further.

If human remains were identified during operations, all work would have ceased in the area immediately and the R.C.M.P, First Nations, and Yukon Heritage Resources would have been notified.

4.1 Curation of Materials Collected

The Yukon Heritage Resources Unit will serve as the repository for the materials collected. Contact information of the Heritage Resources Unit is provided below.

Heritage Resources Unit
Department of Tourism and Culture
Government of Yukon
P.O. Box 2703, Whitehorse, YT Y1A 2C6

Contact: Ruth Gotthardt
Phone: (867) 667-5983
Fax: (867) 667-5377
Ruth.Gotthardt@gov.yk.ca

4.2 Resource Definitions

A Site is an area, place or parcel of land which contains heritage resources or objects.

Historic Sites contain heritage resources that are greater than 45 years in age and possess significant heritage value. By convention, historic sites date to the period for which written records are available; in this case, the historic period commences with the arrival of the Hudson's Bay Company in the early to mid-19th century. Historic sites may include cabins, caches, camps, brush camps, and any other man-made structures, features or objects that date between the 1830s to 1850s and the 1960s.

Proto-historic Sites can be viewed as prehistoric sites from a time period which includes the effects of foreign historic cultures but lacks the first hand written descriptions of that area. For example, in the Yukon the proto-historic period ends with the appearance of the first hand written descriptions in the mid-1800s. However the proto-historic time period extends back through time when foreign materials such as "drift-iron" from ship wrecks on the west coast, or foreign trade items, were carried into the Yukon. Examples of foreign historic materials which predate the mid-1800s found in prehistoric contexts usually represent this proto-historic period.

Archaeological or Prehistoric Sites generally represent use before European contact and are found on or under the ground surface, and may consist of the remains of ancient camps, including hearths, animal bone and stone tools and debris. In this usage, an Archaeological Site equates to a Prehistoric Site (a site that dates to the period before written history). Note, however, that in heritage resource management usage, archaeological resources are viewed as resources that are in subsurface context (buried) and may also include historic period objects and features.

5.0 RESULTS

Field assessment during this HRIA focused on potential locations of the mine pit, main waste rock storage area, western waste rock storage area, organic storage areas, mill site, accommodations area, explosive area, and 2015 exploration targets. The tote road ROW was also reviewed for likely road improvement areas. Special attention was focused on possible high elevation exploration targets that might have the potential to impact ice patch related resources.

As a result of this assessment, eight landforms were identified as having high potential for heritage resources (see Appendix A). Subsurface testing was conducted at all eight high potential areas. The amount of subsurface testing at these eight shovel test locations (STLs) ranged from five shovel tests up to 240 shovel tests, for a total of 346 tests (see Table 1). Two of these STLs were found to contain prehistoric lithic materials, resulting in the recording of two new archaeological sites: JiTp-1 (the Alistair Site) and JjTp-1 (the Fat Lip Site). In addition, wooden artifacts were recovered from the surface at three high elevation ice patch edge locations. These ice patch sites have not been assigned Borden numbers and are reported here as Ice Patch #1, #2, and #3.

Locality	Borden # and Common Name	Total (+) Tests	Total (-) Tests	Landform	Lanform Size (m)	Site Type & Recommendation	Overall Site Size (m)
STL-J1	JiTp-1/Alistair Site	8	232	Large bench	190 x 70	lithic scatter, avoidance or further testing	35 x 55
STL-J2	n/a	0	16	Small terrace	50 x 5	n/a	n/a
STL-J3	n/a	0	14	Two benches	15 x 5; 30 x 5	n/a	n/a
STL-J4	n/a	0	13	Ridge	25 x 8	n/a	n/a
STL-J5	n/a	0	5	Knoll	5 x 8	n/a	n/a
STL-J6	n/a	0	18	Terrace	50 x 5	n/a	n/a
STL-J7	JjTp-1/Fat Lip Site	2	27	Break in slope	30 x 15	lithic scatter, avoidance or further testing	20 x 5
STL-J8	n/a	0	11	Break in slope	25 x 5	n/a	n/a
Ice Patch 1	n/a	na	na	Ice patch edge	n/a	wood isolate, no further work	5 x 5
Ice Patch 2	n/a	na	na	Ice patch edge	n/a	wood isolate, no further work	5 x 5
Ice Patch 3	n/a	na	na	Ice patch edge	n/a	wood & wire isolate, avoidance or collection	5 x 5

Table 1: Subsurface and ice patch test locations.

No built structures, cambium stripped, or culturally modified trees (CMTs) were identified during this HRIA.

Details of these newly recorded sites are presented below.

5.1 JiTp-1 – the Alistair Site

JiTp-1 (Appendix A-D) is a large low density lithic scatter site located on a large gently sloping north to south oriented "whale's back" landform. This landform is south of the exploration camp near km 23, and rises above the west side of the valley floor providing good vistas in 360 degrees. The best views are to the north, east, and south, overlooking the valley lakes and streams. Vegetation includes scrub birch, grasses, and berries growing in thin soils. The landform is roughly battleship shaped, and measures approximately 190 m north to south and 70 m at the widest in the mid-section. The north and east sides of the landform are cut on the side slope by the exploration camp road and the north end has a vertical cobble cairn marker on the east side of the road adjacent to a small borrow area. The north end of the landform has been partially impacted by the borrow pit operations.

In total, 240 shovel tests were excavated at JiTp-1, eight of which were positive for heritage resources in the form of lithic artifacts. Sediment profiles encountered consisted of black organic duff from 0-5 cm, followed by black organic silty loam from 5-10 cm, a grey E-horizon (possibly White River Tephra; WRT) from 10-15 cm, reddish brown silty loam with ~25% gravel and cobbles from 15-25 cm, then light olive brown silty loan with ~40% cobbles and gravel from 25-30 cm below surface (see Appendix B). Minor bioturbation was noted in some shovel tests. In addition to shovel testing, a 1 x 1 m test unit was opened over the richest shovel test (stp 1). This test unit was excavated in arbitrary 10 cm levels, with stp 1 located in its northeastern corner. Sediment profiles for this unit are illustrated in Appendix B.

The lithic scatter was identified in the central and southern part of the landform. The lithic scatter measures approximately 35 m east to west and roughly 7 m north to south. An isolated tested chert cobble was also recovered from a shovel test excavated approximately 50 m south of the main scatter. In total, 77 lithic artifacts were recovered, with 45 being recovered from the 1 x 1 m test unit (see Appendix D). Details of the artifact types recovered are presented in Table 2. Artifacts were recovered from throughout the first 20 cm below surface; above, below, and within the possible WRT layer. No culturally/temporally diagnostic artifacts or formed tools were recovered, however some temporal inferences can possibly be made if the observed E-horizon is in fact WRT. Of particular interest in this assemblage is the proportionately large percentage of obsidian (n=52; 67.5%) recovered (see Table 3). A representative sample of these obsidian artifacts has been submitted for sourcing analysis (results pending).

JiTp-1 was flagged in the field with a 30 m diameter buffer of 1" wide yellow flagging tape, with the words "No Work Zone" printed in black. **It is recommended that JiTp-1, be the subject of additional testing and excavation to mitigate development related impacts to heritage resources at JiTp-1. Further work at this site is planned to be conducted in 2016.**

Lithic Type	n=
Debitage	28
Flake Fragment	1
Interior Flake	23
Interior Flake Fragment	15
Primary Flake	1
Retouched Flake	1
Secondary Flake	2
Shatter	5
Utilized Shatter	1
Grand Total	**77**

Table 2: Lithic artifact types at JiTp-1.

Raw Material	n=
Chert	16
Obsidian	52
Obsidian/Chert	3
Quartz	6
Grand Total	**77**

Table 3: Lithic raw materials at JiTp-1.

5.2 JjTp-1 – the Fat Lip Site

JjTp-1 (Appendix A-D) is a small low density lithic scatter site located on a southeast facing break in slope, above the west side of Finlayson Creek. It is located roughly 10 km south of the Robert Campbell Highway on the KZK tote road. The existing tote road cuts through the west side of this raised landform, but no cultural materials were identified in exposed soils along the road cut. The landform overlooks the larger valley to the northeast, east, and southeast. Vegetation includes scattered spruce, scrub birch, grasses, and mosses. The level area in the centre of the landform between the road cut and break in slope has been disturbed by cat tracks and what appears to be a 1990s heavy equipment test pit approximately 2.5 m x 6 m. The entire break in slope edge is approximately 35 m long running in a southwest to northeast direction.

In total, 28 shovel tests were excavated at JjTp-1, two of which were positive for heritage resources in the form of lithic artifacts (see Appendix A). Sediment profiles encountered consisted of dark brown organic leaf litter/moss from 0-9 cm, followed by a grey E-horizon (possible WRT) from 9-14 cm, fine grey sandy loam from 14-18 cm, fine reddish brown sandy loam from 18-21 cm, coarse brown sandy loam from 21-30 cm, then coarse olive brown sands with ~25% cobles and gravel to 40 cm below surface (see Appendix B).

Two artifacts were recovered from separate shovel tests, including one utilized/retouched basalt flake and one piece of multi-coloured chert shatter (see Appendix D). No culturally/temporally diagnostic artifacts or formed tools were recovered, however both artifacts were recovered from below the possible WRT E-horizon, some temporal inferences can be made if the observed strata is indeed WRT.

JjTp-1 was flagged in the field with a 30 m diameter buffer of 1” wide yellow flagging tape, with the words “No Work Zone” printed in black. **It is recommended that JjTp-1, and its buffer zone, be avoided during development to prevent any impacts to the site. If avoidance is not feasible, then further testing and excavation are recommended to mitigate development related impacts to heritage resources at JjTp-1.**

5.3 Ice Patch Sites

High elevation mineral exploration target areas were inspected for ice patch related heritage resources (see Appendix A and B) as required in BMC Minerals exploration permit. This high elevation inspection of existing ice patch edges and remnant ice patch scars, revealed two wood fragments above the tree line that appear to have be modified and/or carried into the alpine by people. These two wood fragments were recorded as ice patch (IP) #1 and #2, and submitted to the Yukon Heritage Resources Unit for care and curation. A third ice patch related wood item (IP #3) was found with an attached wire segment, similar to a snare pole, and was left in place as it was not threatened by any proposed impacts. **No further work is recommended for the ice patch edges and remnant scars associated with the 2015 high elevation exploration targets.**

6.0 SUMMARY AND RECOMMENDATIONS

At the request of BMC Minerals (No. 1) Ltd. (BMC), Ecofor Consulting Ltd. conducted a Heritage Resource Impact Assessment (HRIA) for the proposed BMC Minerals Kude Ze Kayah Mine. This HRIA assessed the potential mine site and associated developments, including the proposed pit, western waste rock dump, main waste rock dump, organic storage areas, mill site, accommodations area, explosive area, 2015 exploration targets, and reviewed the existing tote road for likely road improvement areas. In particular, attention was focused on possible high elevation exploration targets that might have the potential to impact ice patch related heritage resources.

Eight landforms were identified as possessing elevated potential for buried cultural materials and were shovel tested. Two of these landforms were found to contain prehistoric lithic sites: JiTp-1 (the Alistair Site) and JjTp-1 (the Fat Lip Site). Both sites were flagged in the field with a 30 m diameter buffer of 1" wide yellow flagging tape, with the words "No Work Zone" printed in black. In addition to subsurface testing at the eight landforms discussed above, surficial survey was conducted at high elevation exploration zones. This high elevation inspection resulted in the recovery/ documentation of heritage resources at three localities (Ice Patch #1, #2, and #3).

Avoidance is recommended for JiTp-1. However, the site is located on a large landform which will be impacted by a waste rock storage area under the current development plan. As such additional shovel testing and test unit excavation will be completed in 2016. Additional work is recommended to include 30 to 40 additional shovel tests and approximately 6 to 8 test units to further sample and mitigate the proposed impacts to the site.

Avoidance is also recommended for JjTp-1. At this time there are no specific proposed impacts to the site area. However, if the site will be impacted in the future due to changes in the proposed development plan then it is recommended that 10 to 15 additional shovels and 3 to 5 test units be excavated to further sample and mitigate the impacts to the site.

No further work is recommended in relation to the Ice Patch #1, #2, and #3 finds associated with the 2015 high elevation exploration targets. If any additional high elevation exploration targets are proposed they should be assessed before ground disturbing activities are allowed to commence.

No built structures, cambium stripped trees, or additional buried cultural materials were identified within the survey footprint, including along the existing tote road where future road improvements might be made. As such, **no further work is recommended in relation to known**

tote road improvements. However, if any cultural materials are identified during activities related to road improvements, or any other development activities at the BMC Minerals Kude Ze Kayah Mine, then work in the area should stop, the materials should be protected from further disturbance, and the BMC chance finds protocol should be implemented.

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APPENDIX A: Project Mapping – NOT INCLUDED IN YESSB READY/PUBLIC VERSION OF REPORT

APPENDIX B: Photographs – NOT INCLUDED IN YESSB READY/PUBLIC VERSION OF REPORT

APPENDIX C: Site Forms – NOT INCLUDED IN YESSB READY/PUBLIC VERSION OF REPORT

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APPENDIX E: Field Notes – NOT INCLUDED IN YESSB READY/PUBLIC VERSION OF REPORT

APPENDIX 7.
Tailings Embankment Design

105 G - 07 KUDZ ZE KAYAH

3100 Property Pre Feasibility
30 Pre-Feasibility Internal & External Reports

TAILINGS EMBANKMENT DESIGN REPORT
KUDZ ZE KAYAH PROJECT

Golder Associates

Golder Associates Ltd.

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Burnaby, British Columbia, Canada V5C 6C6
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Golder Associates

REPORT ON

TAILINGS EMBANKMENT DESIGN REPORT
KUDZ ZE KAYAH PROJECT

Submitted to:

Cominco Ltd.
#500 - 200 Burrard Street
Vancouver, B.C.
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October 17, 1996 952-1523I

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Golder Associates

October 17, 1996

952-1523I

Cominco Ltd.
500 - 200 Burrard Street
Vancouver, B.C.
V6C 3L7

Attention: [Name Redacted]
Project Manager

RE: TAILINGS EMBANKMENT DESIGN REPORT

Dear [Name Redacted]:

Attached please find a copy of our report presenting the design for the tailings embankment at the Kudz Ze Kayah Project. This report incorporates the modifications made to the draft version after the review by the regulatory authorities.

We trust that this report meets your current requirements. If you have any questions or require clarification of any points, please do not hesitate to contact me.

Yours very truly,

GOLDER ASSOCIATES LTD.

[Name Redacted]

Principal

PFS/pfs/gc
952-1523I

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EXECUTIVE SUMMARY

This report presents the revised design for the tailings impoundment for the proposed Kudz Ze Kayah (KZK) mine, which is located in southeastern Yukon.

The design of the dam has been revised from that presented in the "Initial Environmental Evaluation (I.E.E.) - Kudz Ze Kayah Project - Yukon Territory", dated February 1996. A number of concerns had been identified with respect to the original design and operation of the dam and impoundment. As a result of that review and the collection of additional site data, the design has been modified.

Mining of the Kudz Ze Kayah deposit will require the proper management of potentially acid generating mill tailings and mine waste rock. All of the tailings and the more reactive waste rock will be managed through permanent underwater disposal in the tailings impoundment.

In recognition of the requirement for the dam to provide secure storage of the tailings and waste rock in perpetuity, the design philosophy has been to use conservative engineering parameters for all aspects of the dam. It is Cominco Ltd.'s objective that there be a high degree of confidence in the proposed design with respect to the long-term containment of mine waste.

Geotechnical studies were conducted in 1995 and 1996. The main findings of these are:

- The surficial geology consists of interlayered glaciofluvial, glaciolacustrine and till sediments, up to 19 m thick, overlying bedrock at the proposed site. These sediments are thickest in the valley bottom and, in general, become thinner up the sides of the valley.

- Site characterization studies, including drilling programs, geophysical surveys and remote sensing have led to the conclusion that a major or through-going fault does not underlie Geona valley.

- The site is characterized by low seismic activity and the 8000 year event is estimated to produce firm ground acceleration of 0.12 times gravity.

- Some of the soils within the footprint of the dam are potentially liquefiable under the Maximum Credible Earthquake (MCE), if they are saturated. If left in place, these soils have the potential to adversely affect the performance of the dam.

- Where permafrost is present, the temperature is in the range of 0 to -1°C. On the west slope of Geona Creek, permafrost exists in unsaturated soils above about

1370 m elevation. On the east slope of Geona Creek, permafrost appears to be present above about 1345 m elevation. Zones of frozen ground may exist near the creek on the east slope. Visible ice contents in frozen soils are generally less than 10%.

The design criteria for the tailings impoundment are summarized below.

- The impoundment is designed to store 8.6 million m^3 of tailings and strongly potentially acid generating (SPAG) waste rock;
- The total tailings production is estimated as 7.9 million tonnes, with an estimated total volume of 6.32 million m^3;
- The quantity of SPAG waste rock is estimated to be 3.5 million tonnes, with an estimated total volume of 1.84 million m^3; and
- The volume of potentially acid consuming (PAC) waste rock used in construction of the SPAG dumps is estimated to be 0.47 million m^3, resulting in a total volume of waste rock (SPAG & PAC) of 2.31 million m^3.

The proposed tailings embankment will consist of a compacted, low permeability, earth-fill core with supporting rockfill shell both upstream and downstream. At the ultimate height, the crest of the dam will be approximately 450 m long and 50 m above the current valley floor. A multi-layer filter zone of select sand and gravel will be placed between the core and the downstream shell. PAC rock will be used in the downstream shell of the embankment and weakly potentially acid generating (WPAG) mine rock will be used in the upstream shell of the embankment below the final water elevation. The embankment will be constructed with upstream and downstream slopes of two horizontal to one vertical (2H:1V).

The core of the dam will be extended to bedrock by excavating the overburden soils. This will require an excavation up to 19 m deep and up to 37 m wide at its base.

The ultimate crest of the embankment will be 10 m wide at 1370 m elevation. Above this elevation a frost protection cap will be placed to prevent frost penetration into the saturated sections of the core of the dam. A temporary frost protection cap will also be incorporated onto each raise. The effect of the frost protection cap will be to increase the apparent crest of the dam to 1373 m elevation.

The ultimate dam will have a fill volume of 1, 855,000 m^3 of soil and rock.

Seepage analyses showed that the most likely total flow through the dam is 250 m^3/d.

Slope stability has been assessed for two sections through the dam. The calculated factor of safety for static conditions was found to be 1.63 and for seismic conditions to be 1.20. These values exceed the minimum recommended factor of safety for these cases of 1.5 and 1.0, respectively.

An evaluation of liquefaction potential of the loose sands at the dam site has been completed and it was concluded that if saturated, some of the loose soils in the foundation of the dam could adversely affect the performance of the dam during seismic events. These materials will be removed or densified during construction unless these soils are shown not to be of concern.

In addition, frozen soils and low strength soils that may affect the performance of the dam will be removed.

The Kudz Ze Kayah tailings dam will be raised in three stages. The 3.0 m frost protection cap will provide 5.0 m insulation over the phreatic surface.

Foundation excavation and preparation for the starter dam will involve three tasks. These are: grouting of bedrock, excavation down to bedrock, and removal of poor soils from the footprint of the downstream shell.

A permanent spillway will be constructed on the east side of Geona Creek. This spillway will be designed to pass the peak discharge of the probable maximum flood (PMF) after attenuation in the impoundment. The PMF volume of water has been determined for the entire watershed, including all of the Fault Creek catchment. The spillway will consist of a curved channel located on the east abutment. The invert will be at 1367.5 m elevation and will be located 10 m east of the crest of the dam.

For the operating period of the mine, a design flood of 50% of the PMF has been selected. Flood management will be provided by siphon discharge of about half of this event and storage of the balance by the stage raises of the dam and the additional capacity provided by the frost protection cap.

1.0 INTRODUCTION

This report presents the revised design for the tailings impoundment for the proposed Kudz Ze Kayah mine. The mine is located in southeastern Yukon, as shown on Figure 1, approximately 500 kilometers by road east of Whitehorse and 235 kilometers by road north of Watson Lake. A general arrangement of the project components is shown in Figure 2.

The design has been revised from that presented in the Cominco Ltd. report, "Initial Environmental Evaluation (I.E.E.) - Kudz Ze Kayah Project - Yukon Territory", dated February 1996. During the review of that report, the Regional Environmental Review Committee (RERC) identified a number of concerns with respect to the design and operation of the proposed dam and impoundment. As a result of that review and the collection of additional site data the design has been modified. This report contains all elements of the proposed design and addresses the comments by the RERC on the earlier report regarding the tailings impoundment.

This report contains the following:

- Section 2 presents the design philosophy.
- Section 3 is a summary of the site selection study.
- Section 4 is a summary of the 1995 and 1996 site characterization studies.
- Section 5 presents the design objectives.
- Sections 6 through 10 describe the dam design, construction method, QA/QC and materials of construction.
- Section 11 describes the impoundment operation, water management and water balance.
- Section 12 presents the closure and post-closure activities.

2.0 DESIGN PHILOSOPHY

Mining of the Kudz Ze Kayah deposit will require the proper management of the mill tailings and portions of mine waste rock which are potentially acid generating. All of the tailings and the more reactive waste rock will be managed through permanent underwater disposal in the tailings impoundment. Long-term environmental protection will be achieved if two conditions are met:

- The embankment must be stable and resistant to deterioration from extreme natural events (floods and earthquakes) and progressive erosion; and,
- The water balance of the impoundment must be such that the materials are always saturated under water.

In recognition of the requirement for the dam to provide secure storage of the tailings and waste rock in perpetuity, the design philosophy has been to use conservative engineering parameters for all aspects of the dam. It is Cominco Ltd.'s objective that there be a high degree of confidence in the proposed design with respect to the long-term containment of mine waste. A monitoring and maintenance program is proposed to ensure the long term performance of the dam.

The embankment will be designed to be stable with minimal maintenance. The tailings dam will be raised in stages to meet the needs of tailings and waste rock storage and water management. This approach allows monitoring of the performance of the dam during operation and the opportunity to incorporate design modifications as may be required. The final dam elevation and configuration will be adjusted to suit the actual requirements of the operation. Excess storage capacity is provided in the current design criteria to ensure that the project requirements will be met.

3.0 SITE SELECTION STUDY

The site selection study was carried out in several phases; 1) initial screening, 2) site evaluation and selection, 3) detailed geotechnical evaluation and 4) feasibility design and final recommendation. The results of the initial screening and the site evaluation and selection processes are presented in Appendix 2.5c of the I.E.E. report. Following is a summary of that appendix.

An initial site selection was carried out in November 1994, based solely on aerial photography. This study identified ten potential sites, five of which were considered to have insufficient storage capacity based on the waste management plan. The remaining sites were prioritized and further evaluation of the prime sites commenced.

Field investigations carried out during 1995 included geophysical surveys, site reconnaissance, overburden and bedrock evaluations by test-pitting and geotechnical drilling, and hydrogeological and permafrost evaluations by instrumentation of drill holes.

Concurrent with the geotechnical investigation program, the mining and waste management plans were being developed for the project. The results of the detailed ARD evaluations permitted the classification of waste rock into three categories; strongly potentially acid generating, (SPAG); weakly potentially acid generating (WPAG); and potentially acid consuming (PAC). The waste management plan was modified to include separate storage of the three waste types with the SPAG waste rock going to the tailings area.

The revised waste management plan with only 5% of the waste rock plus the tailings going to the tailings area, permitted the re-evaluation of several sites originally considered too small. The following table is a list of the sites considered during the final site evaluation and the concerns associated with each site.

TABLE 1
SUMMARY OF SITE SELECTION STUDY

SITE	CONCERN
Geona Creek - Site A	> 40 m of permeable sands and gravel
Geona Creek - Site B	~ 40 m of permeable sands and gravel
Geona Creek - Site C	~ 30 m of permeable sands and gravel
Geona Creek - Site D	**Recommended site,** up to 19 m of permeable sands and gravel
Upper Finlayson Creek	> 40 m permeable overburden
East Tributary to Geona Creek	Insufficient volume, 90 m high dam
East Creek	~ 30 m of permeable overburden, caribou rutting area
South Creek	~ 25 m of overburden, two dams, heritage significance
North Lakes	Heritage significance for Ross River Dena

Based on the site selection studies and geotechnical evaluations, Geona Creek Site D was selected as the basis for feasibility design and economic evaluation. Dam Site D is located in the Geona Creek Valley at approximately 6,819,000 N and 414,750 E.

4.0 SITE CHARACTERIZATION - DAM SITE D

4.1 1995 and 1996 Site Investigations

Two geotechnical site investigations have been conducted for the Kudz Ze Kayah project. The first, conducted in 1995 included a geophysical survey, surficial examination, bore holes and test pits and instrumentation of the bore holes. A series of six test pits and seven bore holes were put down and twelve standpipe piezometers installed along the proposed dam alignment.

The second geotechnical study was conducted in 1996 to add to the data base of 1995 information and to address the following specific areas:

- characterize and delineate suitable material for the core of the dam,
- characterize the soils in the foundation of the dam with respect to liquefaction potential, and

- investigate the ground temperature regime in the dam foundation and along the eastern impoundment slope.

The results of both investigations are presented in the following documents. These documents contain all of the field and laboratory data:

- Feasibility Level Geotechnical and Hydrogeological Site Investigation, ABM Deposit, Kudz Ze Kayah Project, 1995 (Appendix 2.5b); and
- 1996 Geotechnical Site Investigations for the ABM Deposit, Kudz Ze Kayah Project (Addendum to Appendix 2.5b).

Figures 3, 4 and 5 present the locations of the 1995 site investigation boreholes and test pits. Figures 6 and 7 present the locations of the 1996 site investigation and borrow source investigation test pits. Figure 8 presents the locations of the 1996 test pits and 1995 boreholes at the tailing Dam Site D.

A summary of the site characterization work from both of these studies is presented below.

4.2 Surficial Geology

Within Geona valley, the surficial geology consists of interlayered glaciofluvial, glaciolacustrine and till sediments overlying bedrock. At Dam Site D, these deposits are thickest, up to 19 m, in the valley bottom and, in general, becoming thinner up the sides of the valley. The valley bottom soils increase in thickness moving downstream.

The surficial geology along the axis of the dam interpreted from the results of the geotechnical investigations is presented on Figure 9. Within the valley bottom, the overburden consists of interlayered glaciofluvial, glaciolacustrine and till sediments with a thickness ranging from 14 to 19 m.

On the west side of the valley the overburden ranges from 10 to 20 m thick. The uppermost soil unit consists of loose to compact silty, sand and gravel. Near the center of the valley, this material overlies compact gravel and above about 1320 m elevation this material overlies a sequence up to 15 m thick of compact to dense silty gravel and silty, sand and gravel with occasional cobbles and boulders. A 3 to 5 m thick layer of compact fine sandy silt occurs near the center of this silty sand and gravel sequence.

Along the east valley slope, the overburden ranges from 4 to 7 m thick and consists of loose to compact silty sand and gravel overlying compact gravel below about 1330 m elevation. Above 1330 m elevation the surficial silty sand and gravel overlies compact silt sand and gravel.

Soil density, ground temperature and the distribution of permafrost at the site are discussed in the sections 4.5 - 4.7 below.

4.3 Bedrock Geology

Bedrock geology in the vicinity of the proposed dam has been investigated by several methods including: geotechnical drilling, remote sensing, exploration drilling, airborne geophysical surveys, and ground-based geophysical surveys. The results of these investigations are described as follows.

The footprint of the proposed dam is underlain by surficially weathered and strongly fractured mafic tuffs, chlorite-calcite schists and phyllites, and argillite to argillaceous metasediments. Weathering has resulted in a high degree of fracturing of the rock surface. The zone of fractured rock varies from 6 to 8 m thick across the dam alignment.

No evidence of major through-going structures coincident with Geona Creek were identified in the geotechnical investigations.

Fractured rock was encountered in the west abutment bedrock in all drill holes. The I.E.E. report described this area of fractured rock as a fault zone, although the only consistent orientation of fractures was due to the foliation surfaces. The more intense fracturing in this area may be associated with several transcurrent faults trending in an easterly to northeasterly direction. These structures are visible along the western flanks of Geona Valley. The fractured rock on the west abutment is not believed to be associated with any major through-going structures coincident with Geona Creek.

A remote sensing project using satellite imagery analysis was completed in June, 1995. The remote sensing imagery indicated several transcurrent faults trending in an easterly to northeasterly direction. These structures are visible along the western flanks of the Geona Creek Valley. However, the imagery does not indicate the presence of a through-going structure forming the base of Geona Creek.

Exploration drill holes KZK-95-162, -163, and -164 were drilled vertically along the axis of the Geona Creek Valley at approximate northings of 6818925N, 6818675N, and 6818375N, respectively. Drill hole KZK-95-162, the northernmost and closest hole to Dam Site D (approximately 6819000N), encountered argillite, mafic to intermediate tuff, and related mafic units to a final depth of 75.3 metres. The hole encountered no significant indications of regional scale, through-going faulting coincident with the base of Geona Creek. Drill holes 95-163 and 95-164, approximately 300 and 600 metres south of the proposed dam footprint, encountered faulting at depths of around 40 to 50 metres. The apparent width intersected in drill hole 95-164 was 3.5 metres. It is likely that these are discrete fault zones related to the easterly trending faults observed on the ridge west of Geona Creek.

A component of Cominco's exploration work leading to discovery of the Kudz Ze Kayah ore deposit was airborne geophysical surveys. These surveys included airborne magnetic and electrical resistivity characterization of Geona valley and the surrounding area. Although features such as the ore zone and Fault Creek were clearly revealed, there was no indication of any tectonic or lithologic features which are sub-parallel to Geona Creek.

Ground based geophysical surveys were conducted during 1995 at potential dam sites in Geona Valley. These surveys included electrical conductivity to identify bedrock faulting, ground penetrating radar to identify massive ground ice, and seismic reflection for determination of the depth to bedrock. Due to site conditions including discontinuous permafrost and highly variable depth to bedrock, the results of the ground penetrating radar and seismic reflection work were inconclusive and of little value in the ongoing studies. A resistivity traverse was conducted across Geona Valley near Dam Site D. While some locally anomalous resistivities were encountered, no broad zones of significant resistivity contrast were encountered to indicate a major or regional through-going fault structure coincident with Geona Creek.

In summary, all methods of site characterization have led to the conclusion that a major or through-going fault does not underlie Geona valley.

4.4 Siesmicity

Data has been obtained from the Geological Survey of Canada regarding the predicted seismic characteristics of the site. The predicted horizontal accelerations are tabulated below.

TABLE 2
KUDZ ZE KAYAH PROJECT
SEISMIC RISK CALCULATION RESULTS
By Geological Survey of Canada

Probability of exceedance per annum	0.010	0.005	0.0021	0.001
Peak horizontal ground acceleration (gravity)	0.034	0.042	0.056	0.072
Peak horizontal ground velocity (m/s)	0.077	0.094	0.121	0.149

The reciprocal of the annual probability of exceedance is often referred to as the event return period (i.e.: 0.001 probability becomes the 1000 year return period event). Although this is not exactly correct it serves to provide an indication of how often a specific event may occur. Detailed design of the tailings dam will be based on determination of the maximum credible earthquake (MCE), which is estimated to have a return period between 5000 and 10,000 years. For the purpose of this study, the ground accelerations associated with the MCE have been estimated by extrapolating the Geological Survey of Canada data to an 8000 year event, as shown on Figure 10. The 8000 year event is estimated to cause peak horizontal ground acceleration of 0.12 times gravity (0.12 g), and has been used in the stability analyses presented below. This acceleration is estimated to be caused by a magnitude M6.5 event with five (5) cycles of loading.

4.5 Insitu Soil Density

Some low density soils were identified in the foundation of the dam during the 1995 site investigation. Concern for the potential of these soils to be liquefied during a severe seismic event lead to the need for additional characterization of these materials. This work was conducted during the 1996 investigation. The approach taken was to determine the soils density index (I_d, %) and to estimate the soil density above which liquefaction would not be expected to occur for the soil.

The I_d of the soil is used to express the relationship between the actual void ratio (or density) and the minimum and maximum bounds for that material. The actual or insitu density was measured with a nuclear densometer, a standard engineering tool used to measure soil density in field conditions. Test pits were excavated within the footprint of the dam. In each test pit where potentially low density soils were encountered, the insitu soil density was measured at four to six points in the pit. A sample of soil was then taken to the laboratory where the maximum and minimum density was determined using ASTM methods.

Determination of the liquefaction criteria density index for these soils was determined using the Seed simplified procedure (Seed et al, 1971). It was assumed that the peak horizontal acceleration for firm ground would be amplified by 1.3 to 1.5 times as a result of propagation of seismic waves through the overburden soils. As discussed above, the design earthquake loading (MCE) has been taken as producing a horizontal acceleration for firm ground of 0.12 g.

The liquefaction potential from the Seed simplified procedure indicates that equivalent cyclic stress ratios (CSRs) of 0.16 to 0.19 will be induced in the foundation soils for the saturated case under the design seismic event. This would require an equivalent SPT (N1)60 blow count value in the range of 14 to 18 blows per foot in the soils to prevent liquefaction. This blow count range was converted to a range of density index value of 50 to 60%, which is shown on the Figure 11 along with the average in-situ I_d from the field data.

Applying these criteria to the average density index as measured in the field indicates that the materials in TP-96-D1 and D4 were found to be liquefiable, TP96-D3 and D7 are potentially liquefiable and TP96-D2 and D5 are not liquefiable.

However, the material in TP96-D4 is a well graded coarse sand and gravel and is therefore not expected to be susceptible to liquefaction. Also, the field calculated I_d may be in error due to the laboratory determined minimum and maximum densities not being as accurate for coarse grained material as they are for sand size material.

Based on the field density measurements, the materials in the upper 1 to 4 m of TP96-D1, D3 and D7 are expected to liquefy under the MCE if they are saturated. Although saturated conditions were not observed in these test pits, it is believed that similar soils exist in the valley bottom where saturated conditions are expected under the dam. If left in place, these soils in the valley bottom have the potential to adversely affect the performance of the dam. Removal of these materials is described further in Sections 9.1 and 9.4.

4.6 Ground Temperature

The Kudz Ze Kayah project is located in an area of discontinuous permafrost. Frozen soils have the potential to adversely affect the performance of engineered structures when they thaw by causing reduction in both strength and volume. Ground temperature measurements and observations were made as part of the 1995 field investigation. Records of ice content and distribution were made during test pit excavations. Temperature was measured in drill holes by lowering a temperature probe down the piezometer pipes. Unfortunately, instrument problems rendered the 1995 data suspect.

Additional ground temperature data was collected during the 1996 field investigation. This consisted of additional observations of ice in test pits and temperature measurements using an improved temperature probe which was lowered into the piezometers installed in 1995. The detailed results are presented in the 1996 field investigation report.

Test pits excavated in June of 1996 were examined in detail for the presence of ice. Ice was encountered within the upper 2.0 m of most, but not all, of the 14 test pits excavated within the immediate vicinity of the dam (test pits 96-D 1 to 10, B1, and S1 to 3). On the west abutment the depth of ice ranged from 0.9 m below ground surface to as low as 2.9 m deep. On the east abutment ice was not observed in some test pits and to extend beyond the 5.0 m reach of the excavator in other pits.

The depth of ice and recorded minimum temperatures are shown in plan view on Figure 12. Frozen conditions can only occur above the regional ground water table. At Site D, the ground water table is at or above the ground surface in the valley bottom. The groundwater table becomes increasingly depressed below the ground surface higher up the valley sides.

Temperature readings were taken from boreholes along the dam in August of 1996. Typical plots of ground temperature in the area of the dam are shown in Figures 13 to 15. The warmest ground temperature recorded was near the center of the valley and the temperature gradually decreased up the valley sides.

At 96G-19, located near the western edge of the ultimate crest of the dam, sub-zero ground temperatures were observed between 3 and 14 m depth with a minimum temperature of -0.5 deg. C at 8 m depth. Bedrock at this location is located at a depth of 14.5 m.

On the east abutment, ground temperature readings were only taken in 95G-21 where non-frozen conditions were observed. Ground temperature readings were not obtained higher on the slope. Test pit records show frozen conditions down near to bedrock. Borehole records (95G-17 and 18) indicate no groundwater as deep as 17 m below ground surface. Consequently, it is believed that frozen conditions may exist as deep as 17 m below ground surface above about 1345 m elevation; roughly half way up the abutment.

Based on the field data, the Kudz Ze Kayah project area is characterized by discontinuous permafrost. Where permafrost is present, the temperature is in the range of 0 to -1°C. Observations of the effect of exploration activities carried out over the last 2 years indicate that, in general, the terrain is tolerant to disturbances to the ground cover and thermal regime. Disruption of the vegetation by roads and passage of track-mounted equipment has not caused thaw-induced instability. Even the road cuts across 3H:1V slopes west of the ore zone, which encountered ice lenses up to 10 cm thick, have remained stable over 2 years.

In summary, the distribution of frozen ground at the Kudz Ze Kayah dam site is variable and appears to depend upon a number of factors. These include elevation of the ground water table, aspect, elevation, soil type and type of ground cover. In general, seasonal frost appears to extend to about 2.5 m. On the west slope, permafrost exists in unsaturated soils above about 1370 m elevation. Ice contents in frozen soils are generally less than 10% except in the fine sandy silt horizon where ice contents may exceed 30%.

On the east slope, permafrost appears to be present above about 1345 m elevation and zones of frozen ground may exist near the creek on the east slope. The depth of frozen ground is unknown but probably extends 10 m or more into bedrock. Ice contents in the soils vary between 10 and 15%.

5.0 DESIGN OBJECTIVES

The design criteria for the tailings impoundment are summarized below.

- The impoundment is designed to store 8.6 million m^3 of tailings and strongly potentially acid generating (SPAG) waste rock;
- The total tailings production is estimated as 7.9 million tonnes;
- The in-situ density of the tailings is estimated to be 1.25 tonnes/m^3, resulting in a total volume of tailings of 6.32 million m^3;
- The quantity of SPAG waste rock is estimated to be 3.5 million tonnes;
- The broken density of the SPAG waste rock is estimated to be 1.9 tonnes/m^3, resulting in a volume of SPAG waste rock of 1.84 million m^3;
- The volume of PAC waste rock used in construction of the SPAG dumps is estimated to be 0.47 million m^3, resulting in a total volume of waste rock (SPAG & PAC) of 2.31 million m^3; and
- Tailings will be deposited at an average rate of 905,200 tonnes per year.

A number of conservative assumptions have been made in the tailings dam design, likely resulting in an over estimation of the required storage volume. Conservative estimates of the settled density of the tailings and the waste rock have been used and no allowance has been made for the beneficial effect of tailings filling the void space in the waste rock during co-disposal. Industry experience indicates that lead-zinc tailings will attain an in-situ density in the range of 1.25 to 1.65 tonnes/m^3. The lowest end of this range was used to determine the storage requirements for tailings thus any greater density will reduce the volume required.

Mine rock typically swells by 35 to 40% upon blasting. In determining the storage requirements for the SPAG rock, the pre-blasted density was assumed to be 2.65 tonnes/m^3 although the actual density may range from 2.8 to 4.0 t/m^3. If a density of 3.0 t/m^3 is used rather than 2.65, the broken density will increase to 2.2 t/m^3 and the storage requirement will decrease to 1.6 million m^3. In addition, the amount of SPAG rock has been conservatively estimated by Cominco Ltd. to allow for misclassified WPAG and PAC waste rock reaching the tailings area.

The impoundment general arrangement is shown in Figure 16. The impoundment height-storage volume curve is shown in Figure 17.

6.0 EMBANKMENT DESIGN

6.1 Geometry

The proposed tailings embankment will consist of a compacted, low permeability, earth-fill core with supporting rock fill shell both upstream and downstream, as shown in section in Figure 18 and plan view in Figure 19. At the ultimate height, the crest of the dam will be approximately 450 m long and 50 m above the current valley floor. A multi-layer filter zone of select sand and gravel will be placed between the core and the downstream shell to protect the core from piping failure. PAC rock will be used in the downstream shell of the embankment and WPAG mine rock will be used in the upstream shell of the embankment below the final water elevation. The embankment will be constructed with upstream and downstream slopes of two horizontal to one vertical (2H:1V). Rock fill slopes of 2H:1V were selected to provide good performance with respect to slope stability, resistance to erosion, and performance under seismic events. Dam stability is discussed further in Section 8.0.

In order to control seepage under the embankment, the core and filter zone will be extended through the overburden soils to bedrock. The uppermost 2 m of bedrock will be removed and the bedrock between 2 and 8 m from the top of existing bedrock will be pressure grouted. The core trench excavation will have 2H:1V slopes and a footprint for the core and filter zones which is up to 37 m wide.

The core will have a minimum thickness of 5 m at the crest, and at any depth the thickness will not be less than 0.4 times the maximum hydraulic head at that depth. This geometry, with a core thickness to head ratio of 0.4, lies in the middle of the range (0.3 to 0.5) of conventional engineering practice for earth fill dams. It provides good control of seepage in consideration of seepage stability and project water management objectives.

The 10 m wide crest of the dam allows practical placement of the various zones within the dam when nearing the ultimate crest elevation, provides some flexibility for further raising of the dam should this become necessary, and minimizes the risk that the dam could be breached should there be any erosion of the dam slopes.

6.2 Frost Protection Cap

The crest of the embankment will be 10 m wide at the 1370 m elevation. Above this elevation, a frost protection cap will be placed to prevent frost penetration into the saturated section of the core of the dam. A temporary frost protection cap will also be incorporated onto each raise. The cap will consist of silty sand and gravel; the same material as used in the core of the dam. Preliminary design of the proposed frost protection cap for the ultimate dam is shown in Figure 20.

Test pit records indicate that the depth of seasonal frost penetration is in the range of 2.5 m. Permafrost occurs at higher elevations in the vicinity of the dam. The depth of frost penetration is estimated to be 3.5 m using the method from the Canadian Foundation Engineering Manual, 2nd Edition. The actual depth of seasonal frost penetration on the crest of the dam may be different from this value due to warming from the adjacent tailings and impoundment supernatant. Temperature measurements and observations of depth of ice formation will be made on the cap placed on the starter and first raise of the dam.

Unpublished data on the performance of dams in the Yukon indicate that the depth of frost penetration may exceed the predicted depth and that 5.0 m of insulation may be required. The frost protection cap on the starter and first raise will be 5.0 m thick, from the top of the cap to the top of the water table. It will be placed over the core of the dam only. The thickness of the frost protection cap for the ultimate dam will be based on observations of the frost penetration on the starter dam and first raise, and further examination of the performance of other dams in the Yukon. At this time, provision is made for the insulating layer over the phreatic surface (water table) to be 5.0 m thick on the ultimate dam. This will raise the apparent crest of the dam to 1373 m elevation.

6.3 Materials & Fill Volumes

The volumes of material in the core trench excavation and embankment fill are tabulated below.

TABLE 3
SITE D
VOLUMES OF EXCAVATION AND DAM FILL

MATERIAL	VOLUME, m^3
foundation excavation, rock	31,000
foundation excavation, soil	411,000
rock to be grouted	35,000
embankment core	303,000
filter zone 1	86,000
filter zone 2	86,000
rock fill shells	1,347,000
frost protection cap	28,000
Total Embankment	**1,855,000**

The foundation conditions consist of loose sand and gravel overlying dense sand and gravel and fractured bedrock, as shown in Figure 9. There is discontinuous permafrost in the foundation area on the west abutment just west of the crest of the dam and on the east abutment at about mid-height of the dam. Ice rich and/or potentially liquefiable soils which have the potential to adversely affect the performance of the dam will be removed during construction. The criteria for soil removal is described further in the foundation excavation and QA/QC sections.

The foundation excavation volume includes provision for removal of an average of 4 m depth of frozen or low density and potentially liquefiable soils over the area of the downstream shell beyond the limits of the core trench excavation. Testing during construction will determine the need to remove these materials.

The core of the dam will consist of select silty sand and gravel to be taken from the borrow area on the west side of the impoundment. This material has a silt content of about 30% and when compacted has a very low hydraulic conductivity, in the range of 4 x 10^{-8} m/s, as described in the seepage analysis section and in the 1996 Site Investigation Report. Typical gradations of this material are shown in Figure 21.

Two filter zones will be incorporated into the dam to prevent piping failure of the core of the dam. Preliminary filter zone gradations are shown in Figure 22. If the mine rock to be used in the downstream shell proves to be too coarse then a third filter zone may be added to the dam. This filter zone would consist of mine rock which is processed to remove the coarsest fraction.

Mine rock used in the upstream and downstream shells will consist of coarse, durable waste rock. PAC rock will be placed in the downstream shell and WPAG rock will be placed in the upstream shell below the final water elevation. Highly fractured or weathered rock will not be used in the dam. During final design, consideration will be given to using some of the excavated core trench material in the upstream shell of the dam.

Additional information on material selection and placement is provided in the QA/QC section.

7.0 SEEPAGE ANALYSES

Seepage analyses were carried out using the finite element program SEEP/W produced by GEOSLOPE of Calgary. Seepage simulations were done with a variety of parameters, including range of hydraulic conductivity for core, foundation materials and grouted bedrock below the core of the dam. The seepage analyses were carried out for the ultimate dam; lesser seepage is expected for the starter and first raise dams when the hydraulic head is lower.

Results of the hydraulic conductivity tests on the core material are presented in Table 4. The results of seepage modeling of the proposed dam structure are presented in detail in Tables 5 to 7 and representative results in Figures 23 and 24.

A borrow area containing approximately 500,000 m^3 of silty sand and gravel suitable for use as core material has been delineated on the west side of the impoundment. Three samples of this material, two from test pits at the north and south ends of the borrow area, and the third a blend from test pits in the center of the borrow area, were tested using the falling head method with the samples compacted to 95% of modified Proctor Density. Hydraulic conductivity results are shown in Table 4:

TABLE 4
HYDRAULIC CONDUCTIVITY DATA
PROPOSED MATERIAL FOR CORE OF DAM

SAMPLE	HYDRAULIC CONDUCTIVITY (based on laboratory tests)
TP96-B11	9.3×10^{-9} m/s
TP96-B18	3.8×10^{-8} m/s
TP96-B4, 5, 6 (blend)	5.6×10^{-8} m/s
AVERAGE	**3.4×10^{-8} m/s**

Table 5 shows the base case hydraulic conductivity values used in the seepage analysis and Table 6 shows the range of hydraulic conductivities which were considered for the key materials in the dam and foundation.

TABLE 5
SUMMARY OF HYDRAULIC CONDUCTIVITY VALUES FOR SEEPAGE ANALYSIS - BASE CASE

MATERIAL	HYDRAULIC CONDUCTIVITY, m/s
Consolidated tailings	5×10^{-8}
Core	1×10^{-7}
Filters	1×10^{-4}
Rock fill	1×10^{-1}
Foundation soils	1×10^{-3}
Fractured bedrock	1×10^{-5}
Grouted bedrock	1×10^{-7}

TABLE 6
SEEPAGE ANALYSIS SENSITIVITY STUDY
HYDRAULIC CONDUCTIVITY RANGE FOR KEY MATERIALS IN DAM

Case	Bedrock	Grouted Bedrock	Fractured Bedrock	Core	Lower Foundation	Upper Foundation	Seepage, Q
	m/s	m/s	m/s	m/s	m/s	m/s	m3/day
Base	1×10^{-07}	1×10^{-07}	1×10^{-05}	5×10^{-08}	1×10^{-03}	1×10^{-03}	250
Grouted Bedrock, high	**1×10^{-06}**	**1×10^{-06}**	1×10^{-05}	1×10^{-07}	1×10^{-03}	1×10^{-03}	1150
Core, high	1×10^{-07}	1×10^{-07}	1×10^{-05}	**5×10^{-07}**	1×10^{-03}	1×10^{-03}	1200
Core	1×10^{-07}	1×10^{-07}	1×10^{-05}	**1×10^{-07}**	1×10^{-03}	1×10^{-03}	400

The analyses showed that the most important variable in controlling seepage past the dam is the hydraulic conductivity of the core material. The effectiveness of bedrock grouting below the dam is the next most important factor in controlling seepage past the dam.

Table 7 is a summary of the expected seepage through the ultimate dam for a range of hydraulic conductivity of the core material. Considering the average tested hydraulic conductivity of the core material (which is less than the value used in the base case), the "most likely" total flow through the dam is estimated to be in the range of 250 to 400 m^3/d.

TABLE 7
ESTIMATED RANGE OF SEEPAGE THROUGH DAM

HYDRAULIC CONDUCTIVITY OF CORE MATERIAL	ESTIMATED SEEPAGE THROUGH DAM
5×10^{-7} m/s	1200 m^3/d
1×10^{-7} m/s	400 m^3/d
5×10^{-8} m/s (base case)	250 m^3/d

8.0 STABILITY ANALYSES

Limit equilibrium stability analyses were carried out using the program XSTABL, and the simplified Janbu method for static and pseudo-static conditions. The pseudo-static mode was run to assess the performance of the dam during an earthquake.

The seismic coefficients for the site were provided by the Geological Survey of Canada. As described above in Section 4.4, the MCE is estimated to produce firm ground acceleration of 0.12 times gravity. This value has been used in the pseudo-static stability analyses. The results of the analyses and the details of the modeling are summarized below and in Figures 25 to 30.

8.1 Slopes

Slope stability has been assessed for two sections through the dam. The first section is through the centerline of the dam and addresses the highest dam section. The second section addresses the stability of the downstream slope where it overlies the silty fine sand on the west abutment. These sections are shown in plan on Figure 18.

Shear strength parameters for the materials in the dam and foundation used in the analyses are as follows:

TABLE 8
SUMMARY OF STRENGTH PARAMETERS

MATERIAL	STRENGTH PARAMETERS	
	Cohesion, (kPa)	Friction Angle, (deg.)
Consolidated tailings	0	28
Core	0	33
Rock fill	0	38
Foundation, upper, sand and gravel	0	34
upper, silts	0	28
lower, sand and gravel	0	35
lower, gravel	0	37
Bedrock	500	45

The calculated factors of safety for static conditions and seismic conditions evaluated by pseudo-static methods, are summarized below in comparison to the minimum values recommended by CANMET, Pit Slope Manual - Chapter 9 - Waste Embankments, 1977.

TABLE 9
STABILITY ANALYSIS RESULTS

STABILITY ANALYSIS	MINIMUM RECOMMENDED FACTOR OF SAFETY*	CALCULATED FACTOR OF SAFETY	
		Centerline section	West abutment section
Using peak shear strength parameters	1.5	1.66	1.63
Including loading for the 100 year earthquake	1.2	1.52	1.48
Including loading for the maximum credible earthquake (MCE)	1.0	1.25	1.20

* Factor of safety values for cases where it is anticipated that severe damage would occur as a result of embankment failure.

Figure 25 to 27 shows stability analysis results for the main section, for static, seismic (MCE) and seismic (1/100 yr. return) cases, respectively. Figure 28 to 30 shows stability analysis for the west abutment section for static, seismic (MCE) and seismic (1/100 yr. return) cases, respectively.

8.2 Liquefaction Potential

An evaluation of liquefaction potential of the loose sands at the dam site has been completed as part of the 1996 investigation, as described in Section 4.5, above. It was concluded that if saturated, some of the loose soils in the foundation of the dam could adversely affect the performance of the dam during seismic events. Construction of the dam will require removal of most of these materials during the excavation for the core trench. However, some of these loose soils occur beyond the limit of the excavation but within the footprint of the downstream shell. These loose soils will be removed or densified during construction unless these soils are shown not to be of concern. The criteria for not removing foundation materials are described further in Sections 9.1 and 9.4.

9.0 CONSTRUCTION SEQUENCE

9.1 General

The Kudz Ze Kayah tailings dam will be raised in three stages; a starter dam which will have a crest at 1347 m elevation, the first raise which will bring the crest up to 1360 m elevation, and the final raise which will bring the crest up to 1370 m elevation. A frost protection cap will provide 5.0 m insulation above the phreatic surface, resulting in an apparent increase in dam height of 3.0 m and is not included in these elevations. Figure 19 shows the cross section of the dam with the elevation of the starter and first raise indicated again without the frost protection cap indicated. The frost protection cap will be removed from the dam before each of the raises commence.

Foundation excavation and preparation for the starter dam will involve three tasks: grouting of bedrock; excavation down to bedrock; and removal of poor soils from the footprint of the downstream shell.

9.2 Bedrock Grouting

Grouting details will be developed during detailed design. A conceptual approach to the grouting program is provided as follows. Bedrock grouting will be conducted prior to excavation of the overburden. This will allow the grouting to be conducted with the benefit of the confining pressure of the overburden and higher grouting pressures can be used. Grout holes, approximately 50 mm in diameter, will be drilled a minimum of 8 m into bedrock. The holes will be located on 5 m centers in three lines of grout holes along the axis of the dam. Grouting will be conducted in the outer two rows of holes, followed by grouting in the center row of holes. Packer testing may be carried out in the centre line of holes to determine if grouting of this line of holes is required.

Frozen bedrock, where present on the east abutment of the dam, will hamper grouting, if not thawed. Thawing of this bedrock will precede grouting by injecting steam or hot water into the outer two lines of grout holes. The middle row will be monitored with thermistors to determine when the rock has thawed and grouting may proceed.

Grouting of the bedrock will be conducted in two phases. In the first phase, grouting of the footprint of the starter dam will be conducted. Overburden will be stripped off the remainder of the east abutment upon completion of the starter dam to promote thawing of the bedrock. The balance of the bedrock grouting will be conducted prior to the first raise of the dam in year 2. At that time grouting up to the 1370 m elevation in bedrock will be completed. Any remaining frozen bedrock will be thawed before grouting. During this grouting phase the bedrock under the spillway invert will also be grouted in order to strengthen the rock and reduce the potential for frost degradation in the spillway once it is in service.

Grouting pressures and quantity injected will be monitored in each hole. Additional holes will be drilled and grouted in areas where the grouting record indicates that not all of the fractures are sealed. If heavily fractured areas are encountered, the depth of grouting will be increased to ensure that all of the fracture zone is sealed.

9.3 Foundation Excavation

Once bedrock grouting is complete, excavation of the overburden down to bedrock will commence. The excavation sequence will be finalized in detailed design phase, however, the conceptual approach will be to divert Geona Creek along the west abutment at about the 1325 m elevation and excavate the eastern portion of the foundation first. Excavated soil may be used in the upstream shell of the dam or disposed of within the impoundment area.

Final foundation preparation will consist of stripping loose rock with excavators followed by cleaning with high pressure air blasting. Any areas where depressions or abrupt edges exist will be repaired with concrete. The core, filter zones and the sub-grade sections of the rockfill shells will then be constructed up to the level of the existing topography. Once this is complete, Geona Creek will be re-diverted to the east abutment to allow the above process to be carried out on the west side of the dam.

The excavation will have slopes at 2H:1V or flatter as required to maintain stable slopes. Most of the soils which will be exposed in the core trench excavation are not expected to loose significant strength upon thawing due to their low moisture content (typically less than 10%) and their granular nature. However, some soils which are unstable upon thawing may be encountered during the excavation to bedrock and could cause minor instability of the excavation slopes. These include the silty fine sand on the west abutment and some of the silty sand and gravel on the east abutment. An insulating layer may also be placed over some of the slopes to prevent thawing while the excavation is open.

Within the footprint of the downstream shell of the dam and beyond the limit of the core trench excavation there are some soils which could adversely affect the performance of the dam. These soils include ice rich materials which may loose strength or cause settlement of the dam upon thawing, and some low density soils which are potentially liquefiable during an earthquake. Any such soils will be removed. In addition, it is proposed to align the access road into the excavation so that the silty fine sand on the west abutment is removed. Separate criteria for each material of concern will be used in the field to determine which soils must removed.

The criteria for frozen soils will require the removal of all soils with segregated ice lenses or with the potential to cause more than 0.01 m of settlement of the overlying dam material upon thawing. Settlement less than this amount is considered unlikely to affect the integrity of the rock-fill shell of the dam. Frozen fine grained soils such as the silty fine sand on the west abutment could loose strength upon thawing and will be removed prior to placement of the downstream shell of the dam. Frozen fine grained soils with a moisture content which is higher than the liquid limit for the material will also be removed. Additional criteria for field determination of which material must be removed is described in the QA/QC section

The criteria for low density soils will require the removal of all soils with an I_D of 60% or less which could be saturated after the dam is constructed. Soils more dense than this, or which will not be saturated after construction of the dam, are not expected to liquefy under the MCE and can be left in place. During the construction phase, the density of the soils within the footprint of the downstream shell will be determined in test pits and drill holes. The N-value or standard penetration resistance will be used as the primary method to determine insitu density and assess the liquefaction potential.

Additional criteria for field determination of low density soils which must be removed is described in the QA/QC section. Allowance has been made in the excavation and fill volumes for removal of an average of 4 m depth of soil under the downstream shell beyond the limit of the core trench excavation.

9.4 Embankment Construction

The embankment will consist of three primary zones: a low permeability core, a sand and gravel filter, and rock shells. The embankment will be constructed in a series of lifts commencing with placement and compaction of the core, followed by the filter zone and finally the rock shells.

The low permeability core material will be excavated from borrow pits developed on the west side of the impoundment as described in Section 9.6. The core material will be selected based on grain size distribution and moisture content. Drying or wetting of the core material may be required to reach the proper moisture content for compaction. The core material will be placed in lifts of approximately 150 mm and compacted to 95% of maximum modified Proctor Density. Field verification of material suitability and compacted density will be conducted as described in the QA/QC Section.

The filter zone will consist of select sand and gravel with a size distribution to satisfy the filter criterion and prevent piping of the dam. The filter zone will consist of 2 or 3 layers, with the finest material adjacent to the core and progressing to coarser material against the rock shell. The filter zone will be placed in lifts of approximately 150 mm and compacted to 95% of maximum Modified Proctor Density.

The rock material to be used in the upstream and downstream shells will be durable coarse PAC and WPAG waste rock from the open pit. This material will be placed in lifts not more than 5 m in thickness and compacted by the movement of the trucks and dozers involved in the placement of the material.

9.5 Construction Water Management

Water management objectives during construction of the tailings dam will include:

- diversion of Geona Creek around the core trench excavation
- dewatering for slope stability in the core trench excavation
- control of sediment release from the borrow areas

Geona Creek will be diverted around the core trench excavation as described above in the construction sequence section. The coffer dam will consist of a sand and gravel embankment with an upstream liner composed of a geosynthetic-clay liner (GCL). The dam will be about 5 m high. The GCL will be keyed into the local soils to reduce seepage under the dam. Geona Creek will be routed into a diversion channel located along the 1325 m contour to a point downstream of the core trench excavation, as shown in Figure 31. A sump will be constructed downstream of the coffer dam to intercept any water that by passes the diversion.

Dewatering of the core trench excavation will be required in order to maintain the slopes in a stable condition. Dewatering will be carried out with wells installed upstream of the core trench. These wells will discharge into the diversion channel. Supplemental dewatering will consist of a sump in the bottom of the trench.

Sediment control from the borrow areas is described in the following section on borrow materials.

9.6 Borrow Source for Dam Core Material

9.6.1 Borrow Material

The 1996 field investigation program included testing of potential borrow sources for dam core material. A total of 19 test pits, TP96-B1 to B19, were excavated along the western slope of the Geona Creek valley over a linear distance of 1600 m. This latest series of test pits was required to confirm the results of the earlier test pits (TP95B-12 through 20, TPON-1 through 9 and TP95-6 through -10). These were excavated along the west valley wall to the south of the dam site D in 1995.

Based on the information obtained from the test pits, an approximate volume of between 400,000 m^3 and 500,000 m^3 of suitable dam core material has been delineated along the western slope of the Geona Creek (Figure 32). This material is contained within inter-layered alluvial, glaciofluvial and glaciolacustrine sediments. The material is typically a silty gravelly sand, with a composition of approximately 40% to 50% sand, 20% to 40% silt and 15% to 25% gravel. Although the silt content for this material ranges between 20% to 40%, four of the five grain size analyses on this material had a silt content of 28% or higher. This material will satisfy the gradation and permeability requirements for the dam core material.

The borrow material is generally overlain by a thin layer of between 0.1 m to 0.3 m of loose, organic silt containing root material. This layer of organic material will be stripped and stockpiled prior to development of the borrow sources. The approximate foot print areas for the proposed borrow pits are shown on Figure 32. The silty gravelly sand varies in thickness from 0.8 to 5 m. The volume of potential borrow material, and the limits of the borrow areas is based on the extent of the material with a minimum thickness of 2 m.

9.6.2 Borrow Pits

The location of the proposed borrow pits are shown in plan on Figure 32 and in section on Figure 33.

Borrow Pit 1

The proposed pit is located between 6,817,410 N and 6,817,800 N, extending approximately 375 m north-south and 380 m east-west. The required depth of stripping is expected to be limited to 0.4 m. Below this depth, a thick layer of compact silty sand to sandy silt is expected to a depth of approximately 5 m.

Borrow Pit 2

The proposed pit is located between 6,817,800 N and 6,818,050 N, extending approximately 320 m east-west and 225 m north-south. The required depth of stripping should be limited to 0.4 m in most areas. The expected resource of dam core material may reach a maximum depth of 3 m. This will be underlain by silt with sand and gravel, or bedrock.

Borrow Pit 3

The proposed pit is located between 6,818,900 N and 6,818,750 N, extending approximately 315 m north-south and 320 m east-west. The required depth of stripping varies between 0.4 m to the east and 0.7 m to the west. The expected resource of dam core material is believed to extend to a maximum depth of 3 m and is underlain by a layer of silt with sand and gravel, or bedrock.

9.6.3 Borrow Pit Construction

The excavation would proceed in sequence commencing at Borrow Pit 1. Once excavated, Pit 1 will be used to hold the stripped organic material, spoil and any oversized material from Pit 2. This procedure will reduce the end-hauling distance, will partially reclaim the pits, and will reduce sedimentation. Once excavation of the Borrow Pit 2 has been completed and all its spoil and oversized material deposited in Borrow Pit

1, final reclamation of Borrow Pit 1 may commence. The same procedure will be used to develop Pit 3, using Borrow Pit 2 to deposit the stripped organic and over sized material.

Material excavated from Borrow Pits 1 and 2 will be used as construction material for the proposed starter dam. It is anticipated that the remaining material in Borrow Pit 2 will be sufficient for raising of the dam crest in year 2. Borrow pit 3 will be developed in year 5.

The total volume of potential borrow material is about 60% greater than the required volume. In the event that the total volume is required then the lower portion of Borrow Pit 3 will be developed at year 2 so that it is not submerged as the pond level rises.

The slope angles for all borrow pit walls are not to exceed a 2H: 1V grade. All borrow pits are to have diversion ditches around the perimeter to minimize water problems within the borrow areas. Any water in the borrow areas will be routed to settlement ponds before release to the tailings pond. The minimum set back distance for the collection ditches will be 10 m from the borrow pit crests. The settlement ponds will extend in the order of 50 m north-south and 25 m east-west. The actual sizes for these containment features will be constructed to suit topography and surface runoff.

9.7 Construction Quality Control

Described below are the methods and procedures which will provide guidance in the proper construction and monitoring of the geotechnical and material testing aspects of the project. This work shall be carried out to conform to the engineering plans and specifications.

Quality Control, (QC), is defined as a planned system of inspections, carried out to accepted standard specifications, that are used to directly monitor and control the quality of a construction project. Construction quality control is required to ensure that the work is carried out in compliance with the specifications outlined in the contract documents.

Quality Assurance, (QA), is defined as a planned system of activities that provide the owner, (Cominco Ltd.), lending institutions and permitting agencies assurance that the dam is constructed as specified in the design.

Core Trench Excavation & Sub-Grade Preparation

Prior to construction of the dam, the sub-grade of the dam foot-print will be inspected to ensure suitability for construction. Areas of unacceptable sub-grade will include permafrost soil with ice lenses, loose sand and gravel which is potentially liquefiable (as determined by standard penetration testing), and any other areas deemed unacceptable to the inspector. All unacceptable materials will be either removed and disposed of in the impoundment area or worked so as to make them acceptable.

The following criteria will be applied for identification of frozen soils which must be removed:

- presence of massive segregated ice
- ice content sufficient to cause settlement of 0.1 m
- moisture content greater than the liquid limit

The ice content will be visually monitored in cut slopes as excavation of the core trench proceeds. Representative soil samples will be taken from each layer of frozen materials for moisture content and index testing analysis.

The following criteria will be applied for identification of low density soils which must be removed:

- standard penetration testing will be used to develop profiles of insitu density;
- standard penetration testing to be conducted in ten holes using split spoon or Becker hammer method; and
- equivalent SPT $(N_1)_{60}$ blow count value less than 14 to 18 blows per foot, depending on soil type, will be threshold level below which the soil must be removed or densified in place.

Final proof rolling of all unfrozen sub-grade surfaces will be conducted to identify any additional zones of loose material that will require removal or densification.

9.8 Bedrock Grouting

Grouting of fractured bedrock below the core of the dam will be required to control seepage. Grouting will consist of injecting a cement mixture into the rock in a series of holes forming three parallel lines under the dam. The depth of grouting will be from 2 m below bedrock surface down to 8 m below the bedrock surface. Control of seepage through the upper 2 m of the fractured bedrock will be provided by excavation of this rock. Grouting pressures and quantity injected will be monitored in each hole. Additional holes will be drilled and grouted in areas where the grouting record indicates that not all of the fractures are sealed. If heavily fractured areas are encountered then the depth of grouting will be increased to ensure that all of the fracture zone is sealed.

9.9 Construction Materials

Proposed borrow sources are described above. If other potential sources are identified prior to construction, sampling and testing of these potential borrow sources will be carried out by a geotechnical laboratory. The testing shall be performed for the parameters and frequencies specified in Table 10 to determine whether the material(s) conform to the project specifications. Acceptability of the material(s) shall be based on test results, and the available volume of material as compared to that required.

TABLE 10
Preconstruction Evaluation Testing of Potential Borrow Sources

TEST	METHOD	MINIMUM FREQUENCY
Natural Moisture Content	ASTM D 2216	1 per 20,000 m^3
Grain Size Distribution	ASTM D 422	1 per 20,000 m^3
Moisture Density Relationship	ASTM D 1557	1 per 20,000 m^3

The following presents a general description of the materials and the tests required to confirm that the borrow materials meet project specifications prior to construction.

Category 1 Rock Fill

Shall consist of durable, unweathered rock excavated from the open pit, free of organic material, and with a maximum of 3 percent fine mineral particles passing the No.200

(75 μm) sieve and a maximum size of 1.5 m. All rock shall be tested for acid generation potential. Only non-PAG rock will be placed in the downstream shell of the dam. WPAG rock may be placed in the upstream shell below the level of permanent inundation.

Category 2 Core Zone

Core zone material will be well-graded silty-sandy gravel with not less than 25% passing 75 μm (200 mesh) and with 100% passing 100 mm. Material will be tested for size distribution and compaction characteristics to assess compliance with design permeability criteria. A grain size range for the core zone material is shown in Figure 21.

Category 3 Filter Zone

Filter zone materials will be select sand and gravel with size distributions to satisfy the filter criterion and prevent piping in the dam. Gradations for filter zone materials will be determined during the final design. A preliminary grain size range for the filter zone materials is shown in Figure 22.

9.10 Borrow Source Evaluation

Construction evaluation shall consist of monitoring the daily construction activities for compliance with the project specifications. Test pits and grade control will be used to identify the lower limit of the core material and to ensure that none of the underlying unacceptable material is incorporated into the core of the dam.

The inspector shall observe and document that all compacted soil material is obtained from an approved borrow source. Ice lenses will be removed if encountered in any borrow area. Soil with interstitial ice may be worked to promote thawing or removed and disposed of in the tailings impoundment area.

9.11 Field Testing - Core & Filter Zone Material

Unless soil characteristics preclude its use, direct or backscatter nuclear densometer test methods shall be used to determine the in-place moisture/density of the placed soils. The moisture content may be checked using either the oven dry (ASTM D 2216) or the microwave (ASTM D 4643) method.

If field testing results indicate densities or moisture contents not in accordance with the project specifications, the failing areas shall be reworked to meet project specifications. Rework may consist of one or more of the following based upon the conditions:

- Correct density, high or low moisture content: Moisture conditioning of the soil;
- Low density, correct moisture content: Continued compactive effort;
- Low density, low moisture content: Scarification and addition of moisture and recompaction; and
- Low density, high moisture content: Repeated scarification or disc harrowing, air drying for a sufficient length of time to correct for high moisture content and recompaction. Alternatively, the material may be removed and stockpiled in a separate area to be dried and utilized at a later date.

Should test results indicate unacceptable density despite one of the above corrective actions being implemented, the compaction characteristics of the borrow material shall be re-evaluated by performing a modified Proctor test (ASTM D 1557), on the failing material. Alternatively, the soils may be removed and replaced with acceptable material. In all cases, the failing areas shall be reworked to the satisfaction of the project specifications.

9.12 Quality Assurance Testing

The term "lift" is defined as follows:

A "lift" is a segment of a soil layer compacted in general to a nominal thickness not exceeding 150 mm, or a segment of a rock layer compacted to a nominal thickness of 5 m.

Increased testing frequencies shall be instituted if observations by the quality assurance contractor (QAC) of normal testing frequency results indicate potential problems. Additional testing may be warranted when:

- The material repeatedly fails to meet specifications;
- The degree of compaction is doubtful;
- The materials appear to differ from those specified;
- Less than the required number of compaction equipment passes are made;
- The material moisture contents differ from those specified;
- Adverse weather conditions occur; or
- Directed by the Owner.

9.12.1 Monitoring of the Work

The following construction activities shall be monitored and the results reviewed by the QAC:

- Field testing as described in the detailed QA/QC procedures;
- Visual examination of the subgrade for unacceptable areas;
- Method of subgrade preparation;
- Loose lift thicknesses prior to compaction;
- Volume of soils placed and compacted from each borrow source and corresponding soil sampling frequencies;
- Identification of borrow source location, soil description, and specific borrow area maximum dry density and optimum moisture content;
- Compaction equipment (type and weight) and method;
- Removal of organic material, large boulders, and other materials which do not meet the specifications;
- General observation of the equipment passes during compaction of each lift;

- Areas or units of work being tested, identifying lift, or elevation and location. Test locations shall be designated by increasing chronological order and co-ordinates;
- Failed test areas, identified by co-ordinate boundaries, the corrective action taken in these areas and results of retests. Retests shall cross-reference the numbers and dates of failed tests;
- Action of the compaction and heavy equipment on the compacted layer (i.e., pumping, rutting, cracking, etc.);
- Effectiveness of corrective actions for deficient work; and
- Methods of adjusting soil moisture and controlling desiccation cracking.

10.0 GEOTECHNICAL MONITORING

In addition to the construction QA/QC, geotechnical monitoring will be conducted during the construction to ascertain that actual conditions are in general compliance with the design assumptions. Monitoring will be conducted during operation of the tailings dam to ensure that the dam is performing as expected and to assess the need to modify the design before the first and final raises are constructed. The monitoring will be focused on pore pressure distribution in the core, establishment of the thermal regime in the dam, and monitoring any settlement which may occur.

Geotechnical monitoring will be conducted at three sections along the crest of the dam. One at the centerline or maximum height of dam, and the other two approximately 150 m to either side. Pore pressure transducers will be installed at three elevations in the core of the dam on each section. Also, there will be three settlement plates on the face of the dam and a fourth on the crest. Temperature monitoring will consist of a 10 point thermistor string installed in the core on each of the three sections. The spacing of the thermistors will be biased towards monitoring the temperature in the upper most portion of the core and the frost protection cap.

Normally, seepage monitoring would be conducted on a dam such as this; however, due to the significant depth of overburden at the site it will not be possible to directly measure seepage. Inferred seepage rates will be determined by sampling the groundwater downstream of the dam and analyzing the seepage for the chemical constituents found in the tailings water. The concentration of these parameters will be used to estimate the volume of tailings water which is seeping past the dam. It is recognized that this approach will provide only a very rough indication of seepage past the dam.

Regular inspections will also be conducted on the dam to detect any erosion, slope movement or deterioration which may occur. The inspection and instrumentation monitoring records will form part of the permanent record of the dam construction and operation.

All monitoring and maintenance will be conducted to meet the Canadian Dam Safety Guidelines and DIAND Water Resources standards for abandonment of tailings dams, which may be in effect at the time of closure. Complete design, as-built, operations and closure manuals will be compiled to form the permanent documentation record of the dam.

11.0 IMPOUNDMENT OPERATION

11.1 Tailings Disposal

It is planned that all tailings will be discharged underwater, avoiding the creation of beaches and maintaining permanent underwater disposal. A minimum of 2 m of water cover over the upper surface of the deposited material will be provided during the operation and after closure. In order to assure a permanent water cover, the embankment must be water retaining and the impoundment must have a positive annual water balance. Any tailings pond supernatant not required for process water will be discharged to the environment during operations via a controlled discharge system. The discharge will be stepped to roughly match the natural runoff cycle and thus minimize the impact on the receiving waters.

The tailings will be discharged directly underwater throughout the operation. This will satisfy the design objective of preventing the formation of beaches which could result in acid generation. Underwater discharge will involve the use of a barge or floating tailings line. During winter months the barge will be situated over a deep portion of the impoundment to reduce the need to move the barge. During the summer months the barge will be moved to fill the shallow areas around the perimeter of the impoundment.

11.2 SPAG Rock Dump

Several objectives must be satisfied in developing a method for placement of the SPAG rock into the impoundment. These include:

- Construction of a causeway or route into the impoundment;
- Placement of the SPAG rock such that it remains under the water level; and
- The method should not result in upsetting the tailings impoundment water balance.

Three options were considered for placement of the mine rock in the impoundment. The first two involved maintaining separate areas in the impoundment for the tailings and waste rock, and the third involved mixing of the materials.

The first option involved placing the rock in layers which were thin enough to be submerged by the rising pond level in a short period of time, nominally less than six months. This was considered to be impractical because towards the end of the mine life the pond level would rise at a rate of less than 2 m per year which would require placing the rock in layers less than 1 m thick. Consequently, this approach was rejected.

The second option involved allowing the pond level to rise to form a pond at least 5 m deep over the previously placed material. This would allow placing the rock in lifts of similar height by dumping into the water. The result of this approach would be to displace water from the pond at a rate equal to the rate of rock addition. Due to the requirement for additional height on the embankment during the early years of the mine life, this approach was rejected.

The third approach involved co-disposal of the rock and tailings. A series of four rock peninsulas will be developed into the tailings area from which the rock can be dumped. The rock would be either dumped directly into the tailings or pushed in by dozer. The working surface of these peninsulas, which would be maintained about 2 m above the pond level, would be constructed of WPAG rock. This approach has been selected as the most practical way of disposing of the rock while addressing water management objectives.

The layout of the SPAG dumping arrangements are shown in plan on Figure 35. Co-disposing of the waste rock and the tailings has the added advantage of the tailings infilling the waste rock voids thus increasing the overall density of the deposit and reducing the permeability, although this benefit has not been considered in the storage requirements of the impoundment.

Provision for 4 SPAG dumping berms has been made. It is expected that all of the material could be contained in the two berms closest to the dam. However, instability around the crest of the dumps and the potential for rock buildup over ice in the winter suggest the need for flexibility in dump management.

11.3 East Slope Permafrost

Permafrost conditions exist along part of the east side of the impoundment. Potentially thaw unstable material was encountered in TP96D-13, which is located about 1500 m south of the tailings dam. Test pits TP-96-6,7 and 8, and TP95G-5, 6 and 7, which are located 700 to 1200 m further south of TP96D-13 all encountered sand and gravel with interstitial ice. Based on these observations, a zone of potentially thaw unstable material exists only in the vicinity of TP96D-13. During operations this material will be buttressed, if required, as the impoundment water level rises to control any thaw induced slope failure which may occur. The buttress material will be PAC rock which was destined for the nearby PAC waste dump.

11.4 Water Management

Baseline hydrology data for design of the water management facilities and the impoundment water balance has been provided by Hay & Company Consultants Inc. This included the meteorlogic data and estimation of the probable maximum flood (PMF).

11.4.1 Water Balance

Water inflows into the tailings impoundment include the tailings stream, surface runoff (including discharge from the mine water treatment plant and runoff from the WPAG waste dump), and miscellaneous inputs (sewage). The water losses include the water reclaimed to the mill, water retained in tailings, the seepage and evaporation losses and the decant. The reclaim water will be pumped back to the mill by barge mounted pumps. The barge will be located to assure sufficient water depth at the pump intakes.

The decant will be through two siphons; one designed to discharge 0.4 m^3/sec (1440 m^3/hr) and the other designed to discharge 0.2 m^3/sec (720 m^3/hr). The siphons will be located near the west abutment. The siphons will be operated together or independently to provide three different discharge rates.

The tailings impoundment water balance is presented in Table 11 Parts A and B (which follow the body of this report). The water balance has been computed using Golder Associates WATBAL© spreadsheet. Table 11-A shows the input parameters consisting of the water inputs and outputs of the impoundment. Meteorological parameters and mill production are from the I.E.E. report. The miscellaneous inflows are based on sewage from the accommodation complex at a discharge rate of 72 m^3 per day (3 m^3 per hour). Seepage losses are based on 250 m^3 per day through and under the dam, which is the "most likely" seepage quantity as described in Section 7.0. The initial pond volume is the amount of water in excess of the amount required to maintain the 2 m water cover over the tailings and waste rock. The decant strategy is based on a staged discharge schedule which has been determined by modeling to minimize the environmental impact.

The initial pond volume is somewhat arbitrary but must meet the following criteria:

- Sufficient water to provide recycle water throughout the low runoff winter months;
- Sufficient water to maintain the minimum 2 m water cover;
- Sufficient water depth to float the water reclaim barge and eliminate complete freezing; and
- Sufficient retention time to permit clarification of the supernatant water before recycle or discharge.

Maintaining more than the minimum quantity of water to meet the above criteria, is not advantageous, as it may result in having to raise the dam earlier than necessary to maintain adequate freeboard to minimize the potential for uncontrolled discharge.

Table 11-B presents the calculation of the water balance on a monthly basis. All of the inflows and outflows of the system are computed and totalled. The accumulation column shows the net inflow to the impoundment and the decant volume was developed to accommodate the schedule determined by the environmental impact modeling. The total decant volume has been adjusted to equal the net inflow volume thus there will be no net accumulation of water in the tailings impoundment. This water balance is based on the average year precipitation. Higher and lower precipitation years can be accommodated by adjusting the discharge rate and schedule to suit.

Water Balance Sensitivity Study

Sensitivity studies of the impoundment water balance have been conducted and are shown as Tables 12 to 19 (which follow the body of this report). A number of input parameters have been examined relative to the base case including: lower or higher seepage rates, lower or higher recirculation rate to the mill, moderate and high settled density of tailings, and one in ten year low and high runoff cases. A low settled density case was not examined because the base case is for a conservatively estimated density at the lower end of the range for lead/zinc tailings. Table 20 presents the results of the sensitivity analyses in terms of the effect on the annual total volume of decant from the impoundment and the peak decant rate in June, at which the highest rate of decant occurs.

TABLE 20
Water Balance Sensitivity Study

CASE	ANNUAL TOTAL DECANT m³	CHANGE RELATIVE TO BASE CASE	JUNE DECANT	CHANGE RELATIVE TO BASE CASE	MAXIMUM EXCESS OF STORED WATER m³
BASE	4,470,000	-	1,567,000	-	120,000
Low seepage	4,696,000	+ 1%	1,550,000	+1%	142,000
High seepage	4,408,000	-2%	1,454,000	-2%	35,000
Low recirculation	4,830,000	+2%	1,594,000	+2%	187,000
High recirculation	4,670,000	-2%	1,541,000	-2%	134,000
Moderate settled density	4,784,000	+1%	1,579,000	+1%	172,000
High settled density	4,819,000	+2%	1,590,000	+2%	184,000
10 year low flow	3,775,000	-20%	1,246,000	-21%	132,000
10 year high flow	5,718,000	+21%	1,887,000	+21%	189,000

With the exception of the 10 year low and high flow cases, all of the changes in input parameters result in a change of only a few percent or less in the impoundment water balance and volume of discharge. This is due to the large volume of inputs (7.1 million m^3/year) versus the relatively small volume of water retained in the tailings (350,000 m^3/year), lost to seepage and evaporation (240,000 m^3/year) and in recirculation to the mill (1.76 million m^3/year).

Timing of the peak decant rate from the impoundment to coincide with the onset of the spring freshet results in a very small accumulation of excess water in the impoundment. An accumulation of 200,000 m^3 would cause less than a 0.5 m rise in water level.

Significant changes in the volume of decant and the peak decant volume occur in the month of June in the one in ten year low and high flow cases. The annual runoff in these cases is approximately 20% lower or higher than the mean year runoff, and the change in impoundment decant is in direct proportion to the change in runoff. A 21% increase in peak discharge would require that one additional siphon pipe be added to the decant system. Local monitoring of the snowpack will be conducted to predict when a high runoff year may occur. The operational flood control provisions, as described in Section 11.4.5, allow sufficient time to install any additional siphons than may be required.

11.4.2 Polishing Pond

Project water quality objectives require that the tailings pond water be treated for removal of metals prior to discharge. The treatment system is described in Addendum 2.6.1 in the supplemental information provided by Cominco Ltd. in response to comments by the RERC. A component of this system will be a polishing pond to allow chemical reaction time and settling of precipitates.

An empirically established rule for sizing this type of pond is to provide one square foot of surface area for each one third of a gallon per minute of flow (1 m^2 per 1 m^3/hr) (ref. Cominco Ltd.). Applying this criteria to the average monthly flow to be discharged in the month of June (2,160 m^3/hr) gives a pond area of 2,200 m^3. The pond, shown in Figures 36 and 37, will consist of a 3.5 m high rock fill dam with a geo-synthetic clay liner (GCL) on its upstream face and extended into the polishing pond basin. Areas of bouldery sub-grade, as may occur in the Geona Creek channel, will be removed or covered with local sand and gravel. A 300 mm protective layer of select sand and gravel will be placed over the GCL to protect it from damage.

Due the disturbance from construction of the tailings dam it is expected that the local topography in the area of the polishing pond may be altered. Therefore, final design and layout of the pond will be conducted upon completion of the starter tailings dam.

11.4.3 West Diversion Ditch

A diversion ditch will be constructed on the west side of the impoundment to direct surface runoff around the tailings impoundment. It will be located at about 1425 m elevation, as shown on Figure 16 The catchment for this ditch is 2.51 km^2 and it is designed for the 100 year 24 hour storm event, which is estimated to have a peak instantaneous flow of 2.26 m^3/s. This ditch will be required during operations only. It will be an unlined ditch and losses to groundwater are expected to occur. The tailings impoundment water balance, described above, has assumed that only 50% of the runoff from above the ditch is routed around the impoundment.

The ditch will generally parallel the main access and tailings access roads. The final location of the ditch will be determined in the field. The ditch will have a bed width of 3 m, a depth of 1 m and the side slopes will be 3H:1V. At its discharge end the ditch will be routed diagonally down the slope at a gradient of about 16% to intercept Geona Creek about 250 m downstream of the polishing pond. Rip rap up to 0.5 m diameter will be required on the steeper section of the ditch. Rip rap will also be placed to stabilize the side slope if ice rich or thaw unstable soils are identified during construction.

11.4.4 Spillway

A major component of the tailings dam closure is the installation of a permanent spillway which will allow unrestricted discharge of water to Geona Creek below the dam. The permanent spillway will be constructed on the east side of Geona Creek. This spillway will be designed to pass the probable maximum flood (PMF) of the entire watershed, including all of the Fault Creek catchment. The spillway design incorporates an allowance for attenuation of the flood event in the impoundment, thus reducing the peak discharge through the spillway.

The spillway will consist of a curved channel located on the east abutment, as shown on Figure 37. The invert will be at 1367.5 m elevation and will be located 10 m east of the crest of the dam. The spillway profile will involve three sections, as shown on Figure 38. From the edge of the impoundment to the invert the channel will be essentially flat. This section will be excavated through overburden and then through rock closer to the invert. It will be excavated with a base width of 16 m and armored with rip rap.

A cross-section of the spillway at the invert is shown in Figure 38. It will have a base width of 8 m. The invert location is off-set 10 m from the edge of the dam to ensure that it is located in competent rock. This rock will be grouted during the final stage of bedrock grouting (at the time of the first raise on the dam) to ensure that it is competent and resistant to frost degradation. The rock slope above the invert will be excavated at a 2H:1V slope to the top of the bedrock surface. Soil slopes above the spillway will be trimmed to 3H:1V.

The spillway slope will be -2% from the invert location to a point which is downstream of the toe of the dam. At this point the spillway channel will be turned to direct the flow straight down the slope at a gradient of approximately -25%. This section will consist of a channel excavated 4.5 m into the natural soils. The channel will be lined with a 1.5 m bedding layer of sand and gravel and a 3 m thick layer of rip rap with a nominal diameter (D_{50}) of 1.0 m. At the end of the channel, a rock buttress will be constructed to dissipate the flow before it enters Geona Creek.

Above the spillway excavation, all overburden will be stripped to expose a bare bedrock surface for about 100 m up slope, to about elevation 1400 m. This will minimize the potential for solifluction processes to block the spillway with overburden debris. Above 1400 m elevation the slope decreases and the potential for solifluction movement of surficial soil is reduced. Final determination of the extent of overburden stripping will be made in the field. Overburden thickness, ice content and slope will be considered in determining the limit of stripping.

At closure, the following elevations are planned:

• Top of frost protection cap	1373.0 m
• Functional crest of the dam with 1 m freeboard	1370.0 m
• Maximum water level with storage of ½ PMF	1369.0 m
• Normal water level with 2 m water cover	1367.5 m
• Top of the tailings and SPAG waste rock	1365.5 m
• Invert of the permanent spillway	1367.5 m

11.4.5 Operational Flood Control

Three approaches to flood management were considered for the tailings impoundment; provide capacity to store an entire flood event, pass the entire flood event through an emergency spillway, or attenuate the flood and pass the water over an extended period of time.

The 500 year return period flood event is estimated to be approximately one half of the PMF or about 1.2 x 10^6 m^3. This event would result from a combination of precipitation and rapid snowmelt, which has been assumed to occur over a 14 day period. A flood event of 1.2 x 10^6 m^3 reporting to the tailings impoundment is an over estimation of the 500 year flood volume during operations because it includes the catchment of the open pit and Fault Creek, which amount to 29% of the impoundment catchment. However, during operations any major flood would result in filling of the pit, and the water would not report to the tailings impoundment. It has also been assumed that the west diversion ditch fails and does not divert any water around the impoundment during the extreme event.

During operations the dam will be raised in stages such that at most times the dam will be capable of storing all of the 500 year event without any discharge of water. Only at the end of years 2 and 5, just before the dam is raised, will there be insufficient freeboard to store the entire flood event.

The tailings pond water management plan includes a siphon system with a maximum capacity of 0.6 m^3/s. Based on 90% availability of the siphon system, a total of 653,000 m^3 of water could be discharged during a 14 day flood event. It is proposed that the remaining flood water, some 546,000 m^3, would be stored. This would require the dam to be about 3.1 m higher at the end of year 2 and 1.5 m higher at the end of year 5, while still maintaining the 1 m minimum freeboard.

The extra capacity to store the water from such an extraordinary event will be provided by the frost protection cap which increases the apparent height of the dam by 3 m. This cap will be constructed of the same fine grained material that will compose the core of the dam, and it will be placed and compacted in the same manner in order to provide maximum frost protection. It will be placed over the full width of the core; 12.5 m wide at year 2 and 9 m wide at year 5. In the unlikely event that the 500 year flood occurs during year 2 or 5, then the frost protection cap would be subjected to a head of 2.5 m of water, resulting in a hydraulic gradient of about one tenth of the design gradient for the core of the dam.

This design provides a very conservative approach to flood management. The design flood is much more severe than the 100 to 200 year flood event which is typically used for the operating period for tailings dams in North America. Only at years 2 and 5 is there any risk of the water level rising against the frost protection cap during the design event. Even if the water level were to overtop the dam, the risk of a breach is very low because the crest width of the dam is 68 m at year 2 and 39 m at year 5, and most of the dam section is erosion resistant rockfill.

12.0 CLOSURE

Closure activities for the tailings dam will consist of: construction of the permanent spillway; placement of the frost protection cap; and installation of instrumentation for post-closure monitoring. The tailings dam for the Kudz Ze Kayah project has been designed such that all requirements for closure will have been addressed in the construction of the dam. In addition, the dam has been designed to resist the effects of progressive erosion and to withstand the forces associated with the maximum credible earthquake (MCE) and the probable maximum flood (PMF). It will be constructed of durable materials such that post-closure care and maintenance is reduced the lowest practical level.

Construction of the permanent spillway can be conducted anytime after year 6, one year after the final raise on the dam is completed. Details of the spillway design and construction are described in Section 11.4.4, above.

At the time of completion of the frost protection cap on the final raise of the dam, the instrumentation for operating and post-closure monitoring of the dam will be installed. Details of the instrumentation and monitoring program are described in Section 10, above. Completion of the dam and instrumentation at year 5 will allow 4 years of monitoring of the dam's performance while operations are ongoing. If any modifications are required they can be made during this period.

Post-closure care and maintenance will consist of: monitoring of the dam's condition through continued reading of the instrumentation, conducting an annual inspection of the spillway for ice and blockage by debris, and conducting an inspection after major floods or earthquakes.

The annual spillway inspection would be conducted before the spring freshet. If necessary, removal of ice and snow, debris or beaver dams would be conducted prior to spring thawing. Equipment access would be via a winter road after the mine access road has been reclaimed.

Following a major flood or earthquake an inspection will be conducted to verify that the dam is continuing to function as designed and to identify any remedial work which may be required. No adverse effects are expected to occur as a result of the MCE and post-earthquake maintenance is not expected to be necessary.

A flood event producing a discharge through the spillway which is greater than 30 m^3/s is expected to result in damage to the spillway rip rap in the - 25% section of the spillway. Replacement of some rip rap will be required. In order to facilitate this work, a stockpile of select PAC waste rock will be constructed beyond the toe of the dam to provide the materials for repair of the spillway.

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TABLE 11
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A
INPUT PARAMETERS BASE CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	25682	7500	0	115831	149013	48247	0	48247	1048247
Feb	123084	16016	31566	170666	23197	7500	0	104621	135318	35348	0	35348	1083595
Mar	136272	17732	31566	185569	25682	7500	0	115831	149013	36556	0	36556	1120152
Apr	131876	17160	36242	185278	24854	7500	0	112094	144448	40830	0	40830	1160982
May	136272	17732	873318	1027321	25682	7500	20250	115831	169263	858058	1092457	-234398	926583
Jun	131876	17160	1636740	1785776	24854	7500	45000	112094	189448	1596328	1567438	28890	955473
Jul	136272	17732	839414	993417	25682	7500	45000	115831	194013	799405	1092457	-293052	662421
Aug	136272	17732	509728	663731	25682	7500	24750	115831	173763	489968	569977	-80009	582412
Sep	131876	17160	451273	600308	24854	7500	13500	112094	157948	442360	427483	14877	597289
Oct	136272	17732	197578	351581	25682	7500	0	115831	149013	202569	0	202569	799858
Nov	131876	17160	109895	258931	24854	7500	0	112094	144448	114483	0	114483	914341
Dec	136272	17732	80668	234671	25682	7500	0	115831	149013	85659	0	85659	1000000
TOTAL	1604488	208780	4841243	6654511	302384	90000	148500	1363815	1904699	4749812	4749812	0	1000000

TABLE 12
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A
INPUT PARAMETERS UPPER LIMIT OF EXPECTED SEEPAGE CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	12000													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B
COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	25682	12000	0	115831	153513	43747	0	43747	1043747
Feb	123084	16016	31566	170666	23197	12000	0	104621	139818	30848	0	30848	1074595
Mar	136272	17732	31566	185569	25682	12000	0	115831	153513	32056	0	32056	1106652
Apr	131876	17160	36242	185278	24854	12000	0	112094	148948	36330	0	36330	1142982
May	136272	17732	873318	1027321	25682	12000	20250	115831	173763	853558	1080037	-226478	916503
Jun	131876	17160	1636740	1785776	24854	12000	45000	112094	193948	1591828	1549618	42210	958713
Jul	136272	17732	839414	993417	25682	12000	45000	115831	198513	794905	1080037	-285132	673581
Aug	136272	17732	509728	663731	25682	12000	24750	115831	178263	485468	563497	-78029	595552
Sep	131876	17160	451273	600308	24854	12000	13500	112094	162448	437860	422623	15237	610789
Oct	136272	17732	197578	351581	25682	12000	0	115831	153513	198069	0	198069	808858
Nov	131876	17160	109895	258931	24854	12000	0	112094	148948	109983	0	109983	918841
Dec	136272	17732	80668	234671	25682	12000	0	115831	153513	81159	0	81159	1000000
TOTAL	1604488	208780	4841243	6654511	302384	144000	148500	1363815	1958699	4695812	4695812	0	1000000

TABLE 13
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A
INPUT PARAMETERS WORST SEEPAGE CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	36000													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	25682	36000	0	115831	177513	19747	0	19747	1019747
Feb	123084	16016	31566	170666	23197	36000	0	104621	163818	6848	0	6848	1026595
Mar	136272	17732	31568	185569	25682	36000	0	115831	177513	8056	0	8056	1034652
Apr	131876	17160	36242	185278	24854	36000	0	112094	172948	12330	0	12330	1046982
May	136272	17732	873318	1027321	25682	36000	20250	115831	197763	829558	1013797	-184238	862743
Jun	131876	17160	1636740	1785776	24854	36000	45000	112094	217948	1567828	1454578	113250	975993
Jul	136272	17732	839414	993417	25682	36000	45000	115831	222513	770905	1013797	-242892	733101
Aug	136272	17732	509728	683731	25682	36000	24750	115831	202263	481468	528937	-67469	665632
Sep	131876	17160	451273	600308	24854	36000	13500	112094	186448	413860	396703	17157	682789
Oct	136272	17732	197578	351581	25682	36000	0	115831	177513	174069	0	174069	856858
Nov	131876	17160	109895	258931	24854	36000	0	112094	172948	85983	0	85983	942841
Dec	136272	17732	80668	234671	25682	36000	0	115831	177513	57159	0	57159	1000000
TOTAL	1604488	208780	4841243	6654511	302384	432000	148500	1363815	2246699	4407812	4407812	0	1000000

TABLE 14
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A

INPUT PARAMETERS — LOW RECIRCULATION TO MILL CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	80													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	25682	7500	0	109017	142199	55061	0	55061	1055061
Feb	123084	16016	31566	170666	23197	7500	0	98467	129164	41502	0	41502	1096563
Mar	136272	17732	31566	185569	25682	7500	0	109017	142199	43370	0	43370	1139933
Apr	131876	17160	36242	185278	24854	7500	0	105501	137854	47424	0	47424	1187357
May	136272	17732	873318	1027321	25682	7500	20250	109017	162449	864872	1110908	-246036	941320
Jun	131876	17160	1636740	1785776	24854	7500	45000	105501	182854	1602922	1593912	9010	950330
Jul	136272	17732	839414	993417	25682	7500	45000	109017	187199	806218	1110908	-304690	645640
Aug	136272	17732	509728	663731	25682	7500	24750	109017	166949	496782	579604	-82822	562817
Sep	131876	17160	451273	600308	24854	7500	13500	105501	151354	448954	434703	14251	577068
Oct	136272	17732	197578	351581	25682	7500	0	109017	142199	209382	0	209382	786451
Nov	131876	17160	109895	258931	24854	7500	0	105501	137854	121077	0	121077	907528
Dec	136272	17732	80668	234671	25682	7500	0	109017	142199	92472	0	92472	1000000
TOTAL	1604488	208780	4841243	6654511	302384	90000	148500	1283590	1824475	4830036	4830036	0	1000000

TABLE 15
KZK WATER BALANCE

TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A
INPUT PARAMETERS — HIGH RECIRCULATION TO MILL CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	90													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B
COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	25682	7500	0	122644	155826	41434	0	41434	1041434
Feb	123084	16016	31566	170666	23197	7500	0	110776	141472	29194	0	29194	1070627
Mar	136272	17732	31566	185569	25682	7500	0	122644	155826	29743	0	29743	1100370
Apr	131876	17160	36242	185278	24854	7500	0	118688	151042	34236	0	34236	1134606
May	136272	17732	873318	1027321	25682	7500	20250	122644	176076	851245	1074005	-222760	911846
Jun	131876	17160	1636740	1785776	24854	7500	45000	118688	196042	1589734	1540964	48770	960616
Jul	136272	17732	839414	993417	25682	7500	45000	122644	200826	792591	1074005	-281414	679202
Aug	136272	17732	509728	663731	25682	7500	24750	122644	180576	483155	560351	-77196	602007
Sep	131876	17160	451273	600308	24854	7500	13500	118688	164542	435767	420263	15504	617510
Oct	136272	17732	197578	351581	25682	7500	0	122644	155826	195755	0	195755	813265
Nov	131876	17160	109895	258931	24854	7500	0	118688	151042	107889	0	107889	921155
Dec	136272	17732	80668	234671	25682	7500	0	122644	155826	78845	0	78845	1000000
TOTAL	1604488	208780	4841243	6654511	302384	90000	148500	1444039	1984923	4669588	4669588	0	1000000

TABLE 16
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A
INPUT PARAMETERS MODERATE SETTLED DENSITY CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		31	31	31	31	31	31	31	31	31	31	31	31	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B
COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	22747	7500	0	115831	146078	51183	0	51183	1051183
Feb	123084	16016	31566	170666	20546	7500	0	104621	132667	37999	0	37999	1089181
Mar	136272	17732	31566	185569	22747	7500	0	115831	146078	39492	0	39492	1128673
Apr	131876	17160	36242	185278	22013	7500	0	112094	141607	43670	0	43670	1172343
May	136272	17732	873318	1027321	22747	7500	20250	115831	166328	860994	1100405	-239412	932932
Jun	131876	17160	1636740	1785776	22013	7500	45000	112094	186607	1599168	1578842	20326	953258
Jul	136272	17732	839414	993417	22747	7500	45000	115831	191078	802340	1100405	-298065	655192
Aug	136272	17732	509728	663731	22747	7500	24750	115831	170828	492903	574124	-81221	573971
Sep	131876	17160	451273	600308	22013	7500	13500	112094	155107	445201	430593	14608	588579
Oct	136272	17732	197578	351581	22747	7500	0	115831	146078	205504	0	205504	794083
Nov	131876	17160	109895	258931	22013	7500	0	112094	141607	117324	0	117324	911406
Dec	136272	17732	80668	234671	22747	7500	0	115831	146078	88594	0	88594	1000000
TOTAL	1604488	208780	4841243	6654511	267826	90000	148500	1363815	1870141	4784370	4784370	0	1000000

TABLE 17
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A

INPUT PARAMETERS HIGH SETTLED DENSITY CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		3.7	2.7	2.7	3.1	74.7	140	71.8	43.6	38.6	16.9	9.4	6.9	414.1
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		27	27	27	27	27	27	27	27	27	27	27	27	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	43257	197260	19812	7500	0	115831	143143	54118	0	54118	1054118
Feb	123084	16016	31566	170666	17895	7500	0	104621	130016	40650	0	40650	1094767
Mar	136272	17732	31566	185569	19812	7500	0	115831	143143	42427	0	42427	1137194
Apr	131876	17160	36242	185278	19173	7500	0	112094	138767	46511	0	46511	1183705
May	136272	17732	873318	1027321	19812	7500	20250	115831	163393	863929	1108354	-244425	939280
Jun	131876	17160	1636740	1785776	19173	7500	45000	112094	183767	1602009	1590246	11762	951042
Jul	136272	17732	839414	993417	19812	7500	45000	115831	188143	805275	1108354	-303079	647963
Aug	136272	17732	509728	663731	19812	7500	24750	115831	167893	495839	578271	-82433	565531
Sep	131876	17160	451273	600308	19173	7500	13500	112094	152267	448041	433704	14338	579868
Oct	136272	17732	197578	351581	19812	7500	0	115831	143143	208439	0	208439	788307
Nov	131876	17160	109895	258931	19173	7500	0	112094	138767	120164	0	120164	908471
Dec	136272	17732	80668	234671	19812	7500	0	115831	143143	91529	0	91529	1000000
TOTAL	1604488	208780	4841243	6654511	233268	90000	148500	1363815	1835583	4818928	4818928	0	1000000

TABLE 18
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A

INPUT PARAMETERS 1 IN 10 YEAR LOW FLOW CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		2.95	2.16	2.16	2.48	59.66	111.81	57.34	34.82	30.83	13.5	7.51	5.51	330.73
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	34488	188492	25682	7500	0	115831	149013	39479	0	39479	1039479
Feb	123084	16016	25253	164353	23197	7500	0	104621	135318	29035	0	29035	1068514
Mar	136272	17732	25253	179256	25682	7500	0	115831	149013	30243	0	30243	1098757
Apr	131876	17160	28994	178029	24854	7500	0	112094	144448	33582	0	33582	1132339
May	136272	17732	697485	851489	25682	7500	20250	115831	169263	682226	868281	-186055	946284
Jun	131876	17160	1307171	1456206	24854	7500	45000	112094	189448	1266759	1245794	20965	967248
Jul	136272	17732	670362	824366	25682	7500	45000	115831	194013	630353	868281	-237928	729320
Aug	136272	17732	407081	561084	25682	7500	24750	115831	173763	387321	453016	-65695	663626
Sep	131876	17160	360434	509469	24854	7500	13500	112094	157948	351521	339762	11759	675385
Oct	136272	17732	157829	311832	25682	7500	0	115831	149013	162819	0	162819	838205
Nov	131876	17160	87799	236835	24854	7500	0	112094	144448	92387	0	92387	930592
Dec	136272	17732	64417	218421	25682	7500	0	115831	149013	69408	0	69408	1000000
TOTAL	1604488	208780	3866564	5679832	302384	90000	148500	1363815	1904699	3775133	3775133	0	1000000

TABLE 19
KZK WATER BALANCE
TYPICAL YEAR - All mine water to tailings impoundment, & staged discharge schedule.

TABLE A

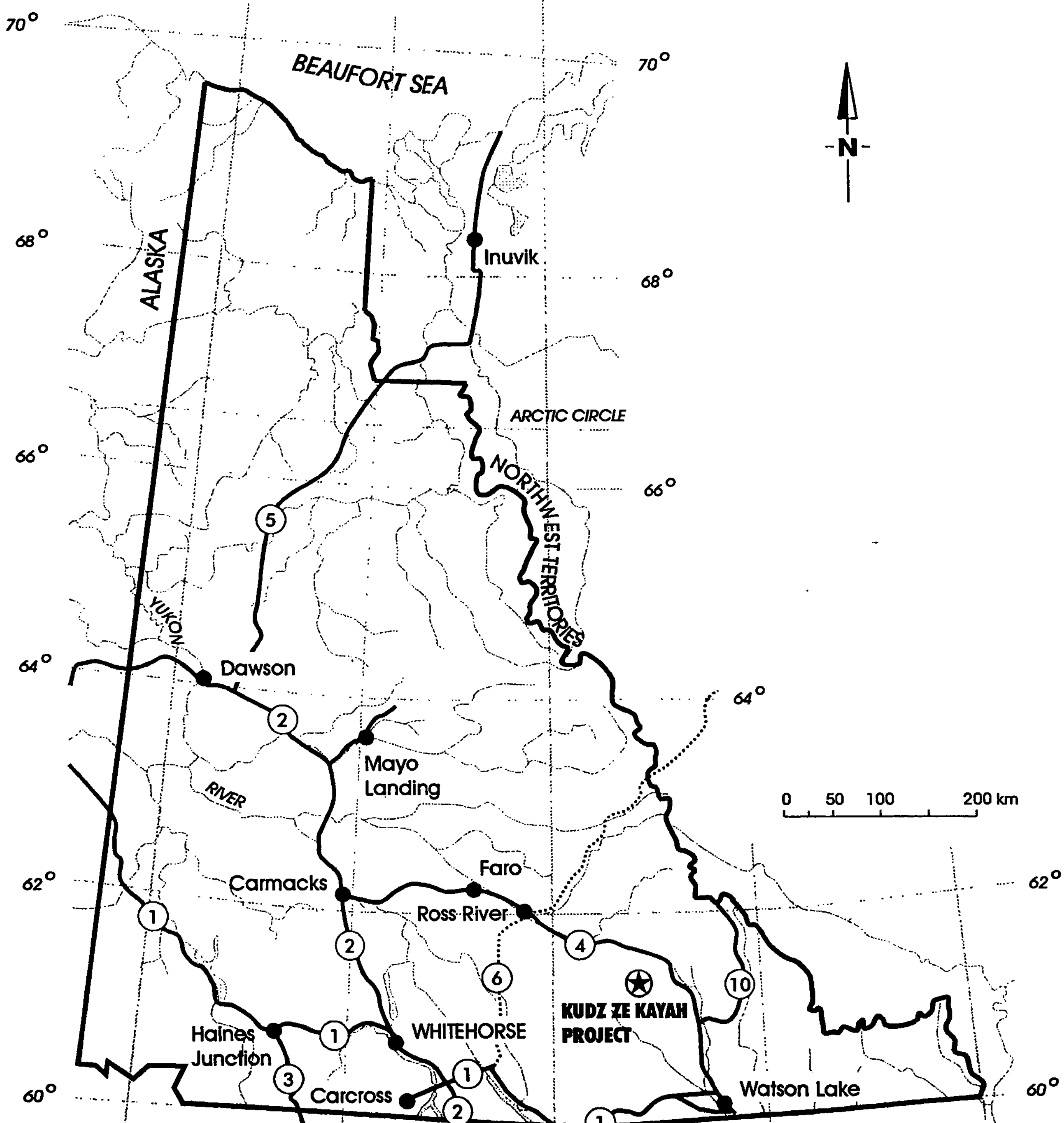
INPUT PARAMETERS 1 IN 10 YEAR HIGH FLOW CASE

	UNITS	VALUE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Starting Month	(no.)	1													
Mill Production	(t/day)	2367													863955
Operating Period	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Solids (by weight) in Discharge	(%)	35													
Miscellaneous Inflows	(m^3/day)	572	500 m3/d from south pit + 72 m3/d sewage												
Precipitation	(mm/mo.)		4.44	3.24	3.24	3.72	89.64	168	86.16	52.32	46.32	20.28	11.28	8.28	496.92
Area Virgin Land in Basin	(ha)	1098													
Runoff Factor	(%)	100													
Area of Tailings and Ponds	(ha)	45													
Runoff Factor	(%)	158													
Period of Runoff	logic		1	1	1	1	1	1	1	1	1	1	1	1	
Water retained in Tailings (water content)	(%)		35	35	35	35	35	35	35	35	35	35	35	35	
Estimated Seepage Losses	(m^3/mo.)	7500													
Evaporation	(mm/mo.)		0	0	0	0	45	100	100	55	30	0	0	0	330
Area of Ponds and Wetted Tailings	(ha)	45													
Recirculation	(%)	85													
Decant Strategy (portion of total net inflow)	(% / mo.)		0	0	0	0	23	33	23	12	9	0	0	0	100
Initial Water Volume in Ponds	(m^3)	1000000													

TABLE B

COMPUTATIONS

	INFLOWS (m^3/mo.)				LOSSES (m^3/mo.)					ACCUMULATION (m^3/mo.)			(m^3)
Month	Tailings Water	Misc. Inflows	Runoff	Total	Retained in Tailings	Seepage Losses	Pond Evap.	Recirc.	Total	Net Inflow	Decant	Net Change	Accum. Volume
1	2	3	4	5	6	7	8	9	10	11	12	13	14
INITIAL													1000000
Jan	136272	17732	51908	205912	25682	7500	0	115831	149013	56899	0	56899	1056899
Feb	123084	16016	37879	176979	23197	7500	0	104621	135318	41661	0	41661	1098560
Mar	136272	17732	37879	191882	25682	7500	0	115831	149013	42870	0	42870	1141429
Apr	131876	17160	43491	192526	24854	7500	0	112094	144448	48078	0	48078	1189508
May	136272	17732	1047981	1201985	25682	7500	20250	115831	169263	1032722	1315154	-282432	907076
Jun	131876	17160	1964088	2113124	24854	7500	45000	112094	189448	1923676	1886960	36716	943792
Jul	136272	17732	1007297	1161300	25682	7500	45000	115831	194013	967287	1315154	-347867	595925
Aug	136272	17732	611673	765677	25682	7500	24750	115831	173763	591914	686167	-94253	501672
Sep	131876	17160	541527	690563	24854	7500	13500	112094	157948	532615	514625	17990	519661
Oct	136272	17732	237093	391097	25682	7500	0	115831	149013	242084	0	242084	761745
Nov	131876	17160	131874	280910	24854	7500	0	112094	144448	136462	0	136462	898208
Dec	136272	17732	96801	250805	25682	7500	0	115831	149013	101792	0	101792	1000000
TOTAL	1604488	208780	5809492	7622760	302384	90000	148500	1363815	1904699	5718061	5718061	0	1000000



Note: Highway Route Numbers are referenced from Yukon Official Road Map

Reference : Norecol, Dames & Moore, Inc.

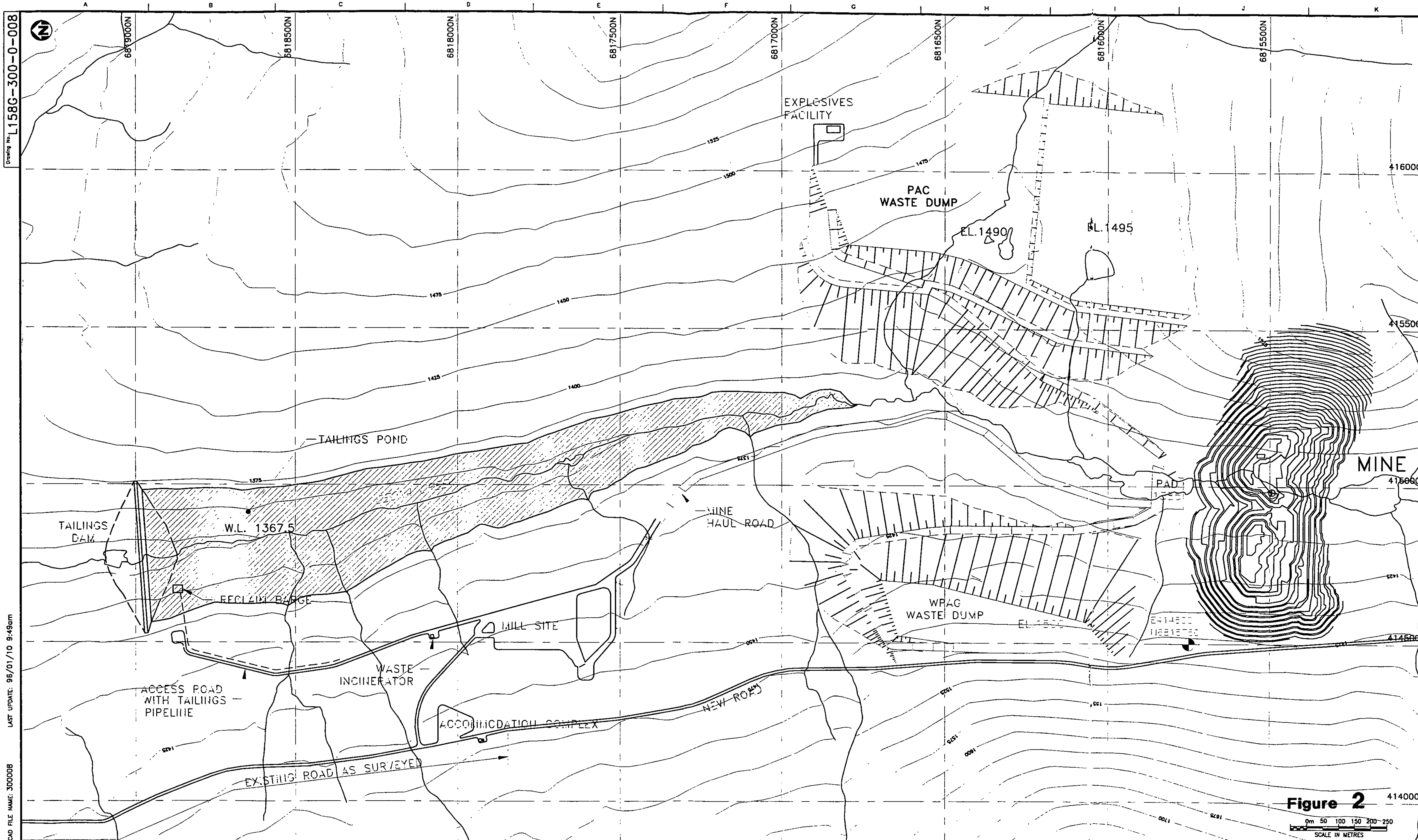
Project No. 952-1523 I Drawn ~ Reviewed J.C.C. Date Sept. '96

Golder Associates

GENERAL LOCATION

Figure 1

Drawing No. L158G-300-0-008



Rev.	Revision Description	Date	By	Chk'd	App'd
A	EAST DUMP LOCATION	98/10/16	Bb		

No.	Dwg. No.	Reference Drawings
1		
2		
3		
4		
5		
6		
7		
8		
9		

Print Record: Date / Issue To — For Tender; For Approval; For Checking

Engineering Review		
Approved By		
Checked By		
Drawn By	DC	SEPT/12/95
Designed By		

CLIENT APPROVAL — By / Date

Client Dwg. No.

Job. No. L158G — Scale NTS

SIMONS — H.A. SIMONS LTD. MINING GROUP VANCOUVER, CANADA

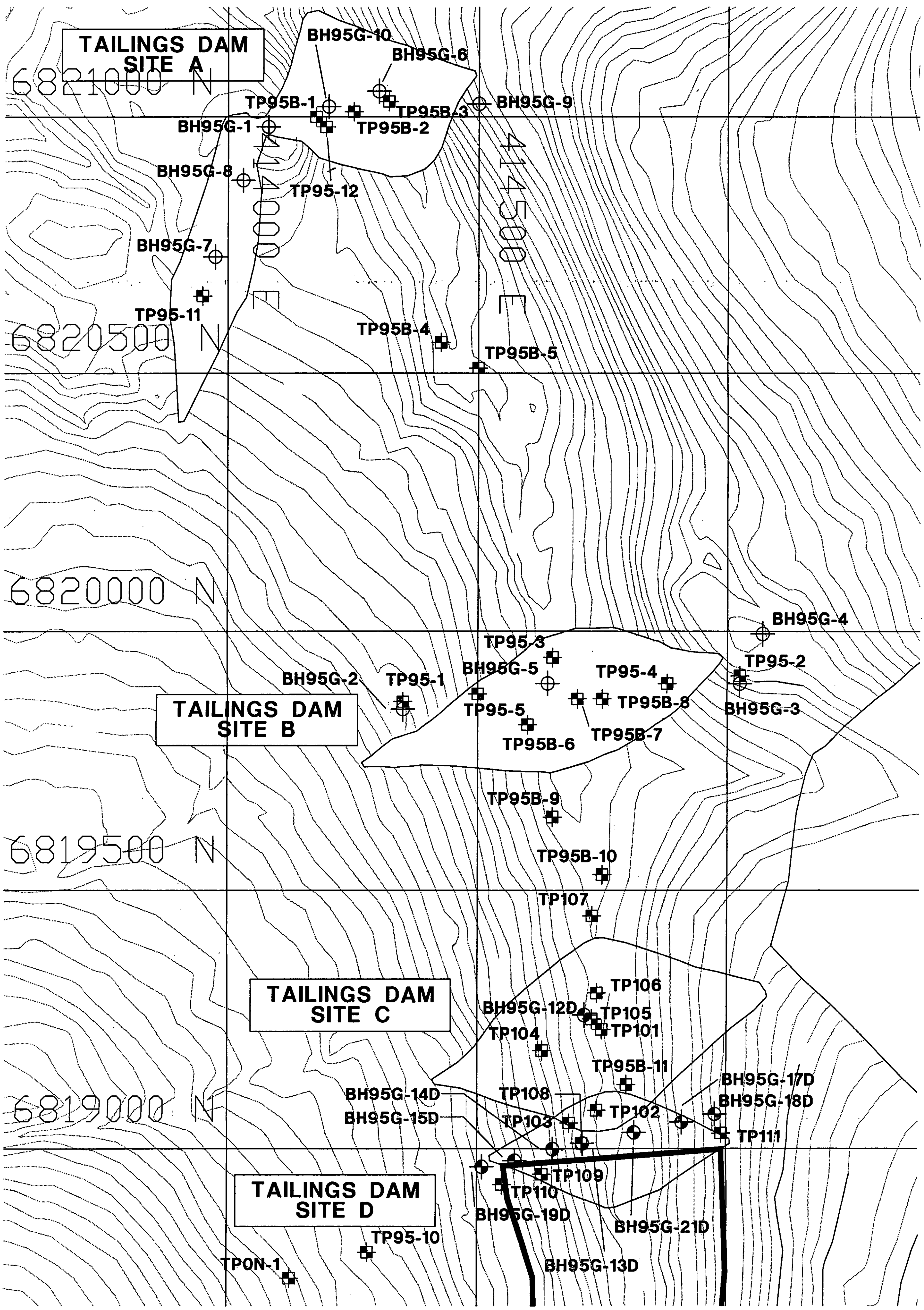
Title: COMINCO LTD.
KUDZ ZE KAYAH PROJECT
FEASIBILITY STUDY
MINE DEVELOPMENT - YEAR 8

Drawing No. L158G-300-0-008 Rev. E

LAST UPDATE: 96/01/10 9:49am

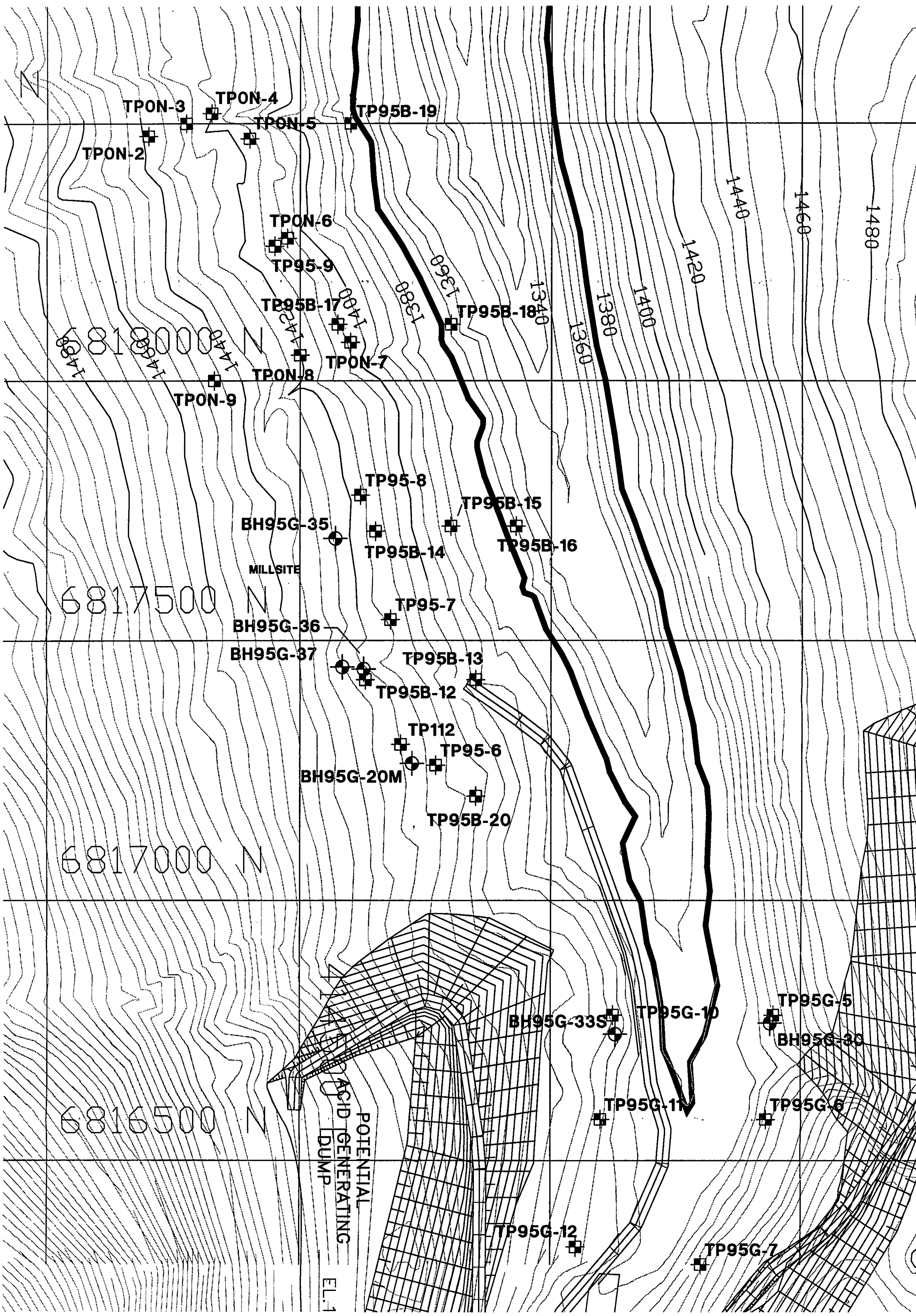
CAD FILE NAME: 300008

R:\MINING\95\952-1523\ACAD\P1523-04.DWG



Project No.: 952-1523I Drawn: GG Reviewed: LP Date: 18-OCT-96	Golder Associates	1995 BOREHOLE & TEST PIT LOCATION PLAN (RELATIVE TO ORIGINAL & REVISED DAM SITE LOCATIONS) KUDZ ZE KAYAH	Figure 3

R:\MINING\95\952-1523\ACAD\P1523-04.DWG



Project No.: 952-1523I Drawn: GG Reviewed: LP Date: 16-OCT-96	Golder Associates	**1995 BOREHOLE & TEST PIT LOCATION PLAN (RELATIVE TO ORIGINAL & REVISED DAM SITE LOCATIONS) KUDZ ZE KAYAH**	Figure **4**

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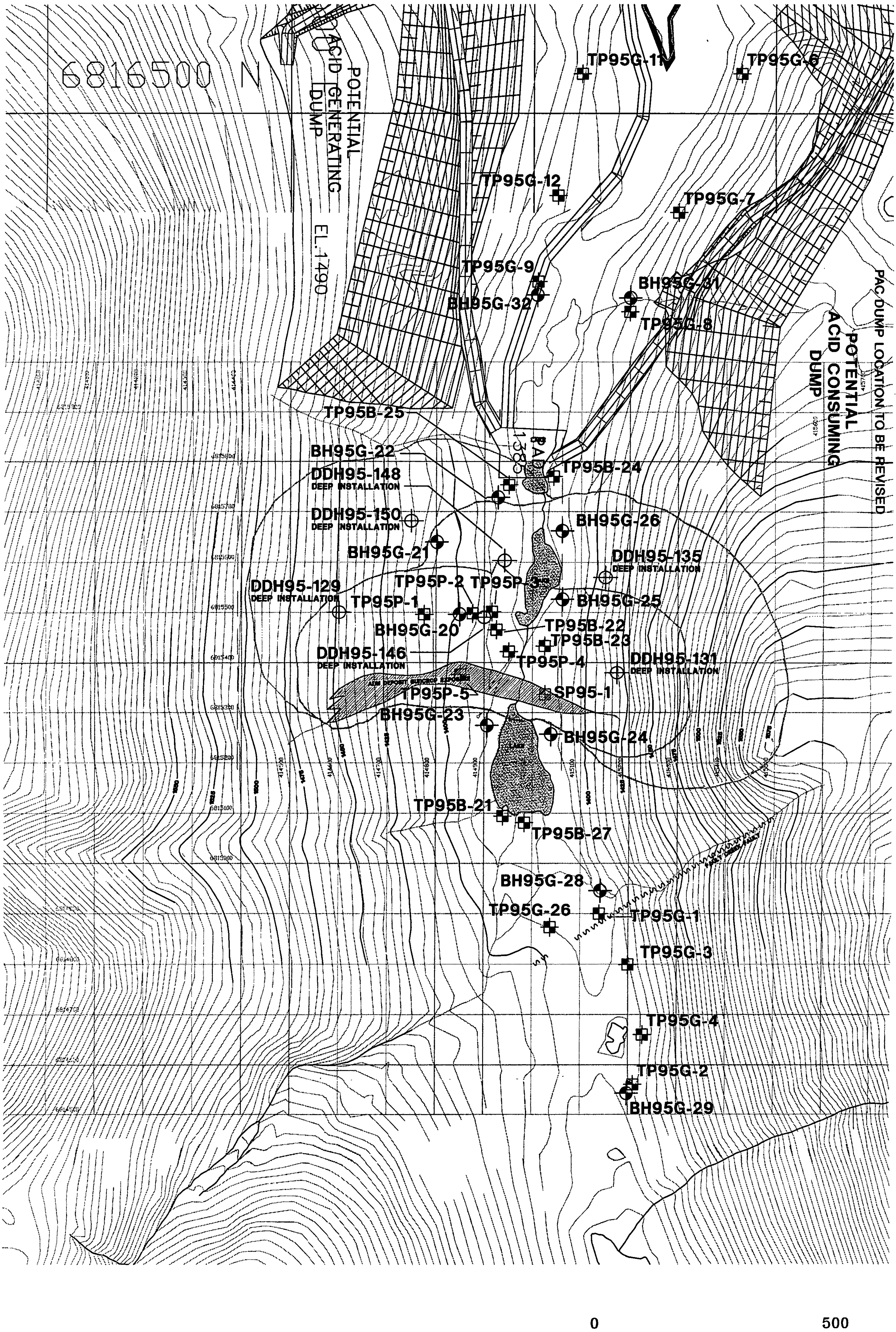


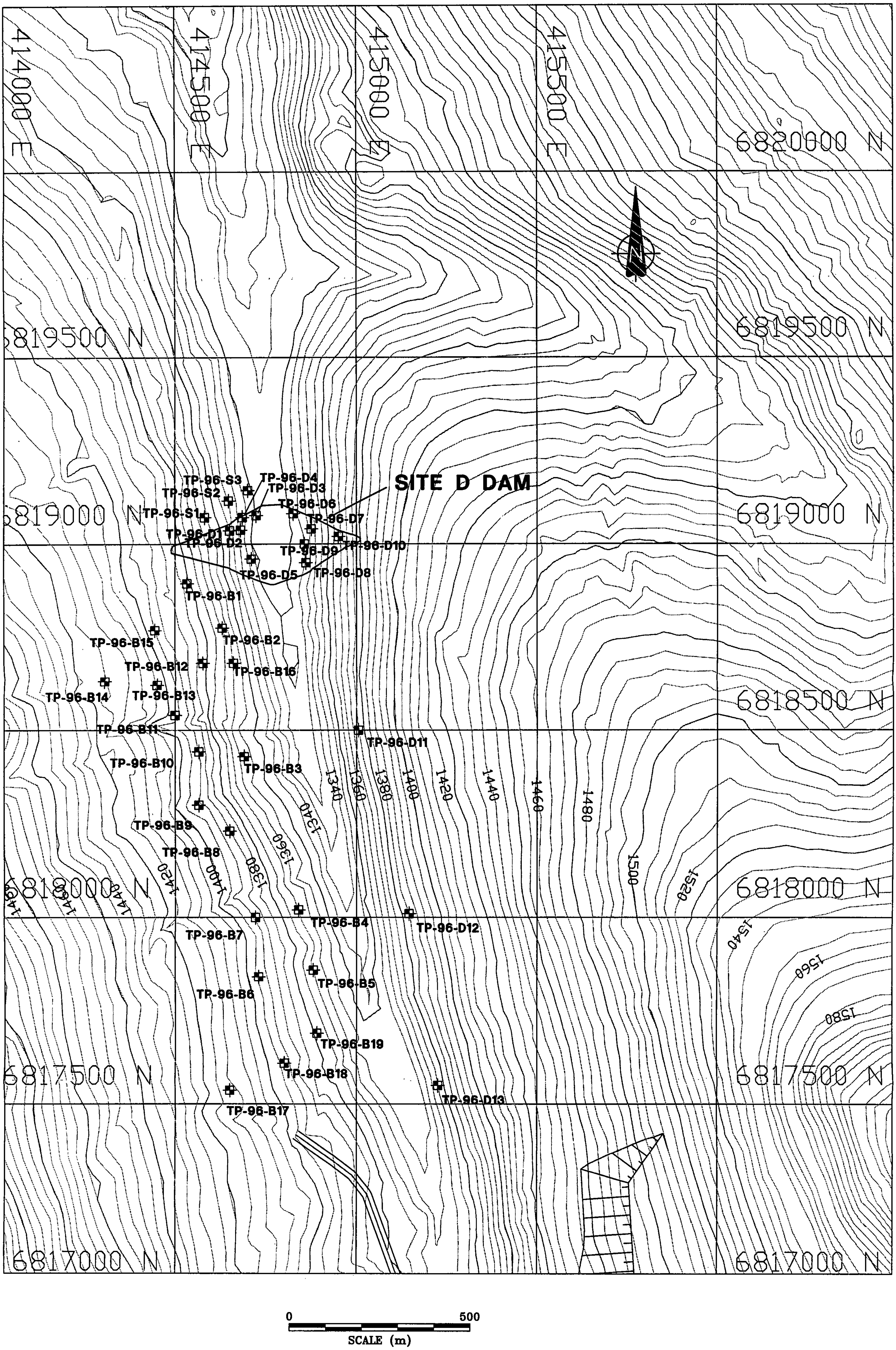
Project No.: 952-1523I
Drawn: GG
Reviewed: LP
Date: SEP-27-95

Golder Associates

1995 BOREHOLE & TEST PIT LOCATION PLAN (RELATIVE TO ORIGINAL & REVISED DAM SITE LOCATIONS) KUDZ ZE KAYAH

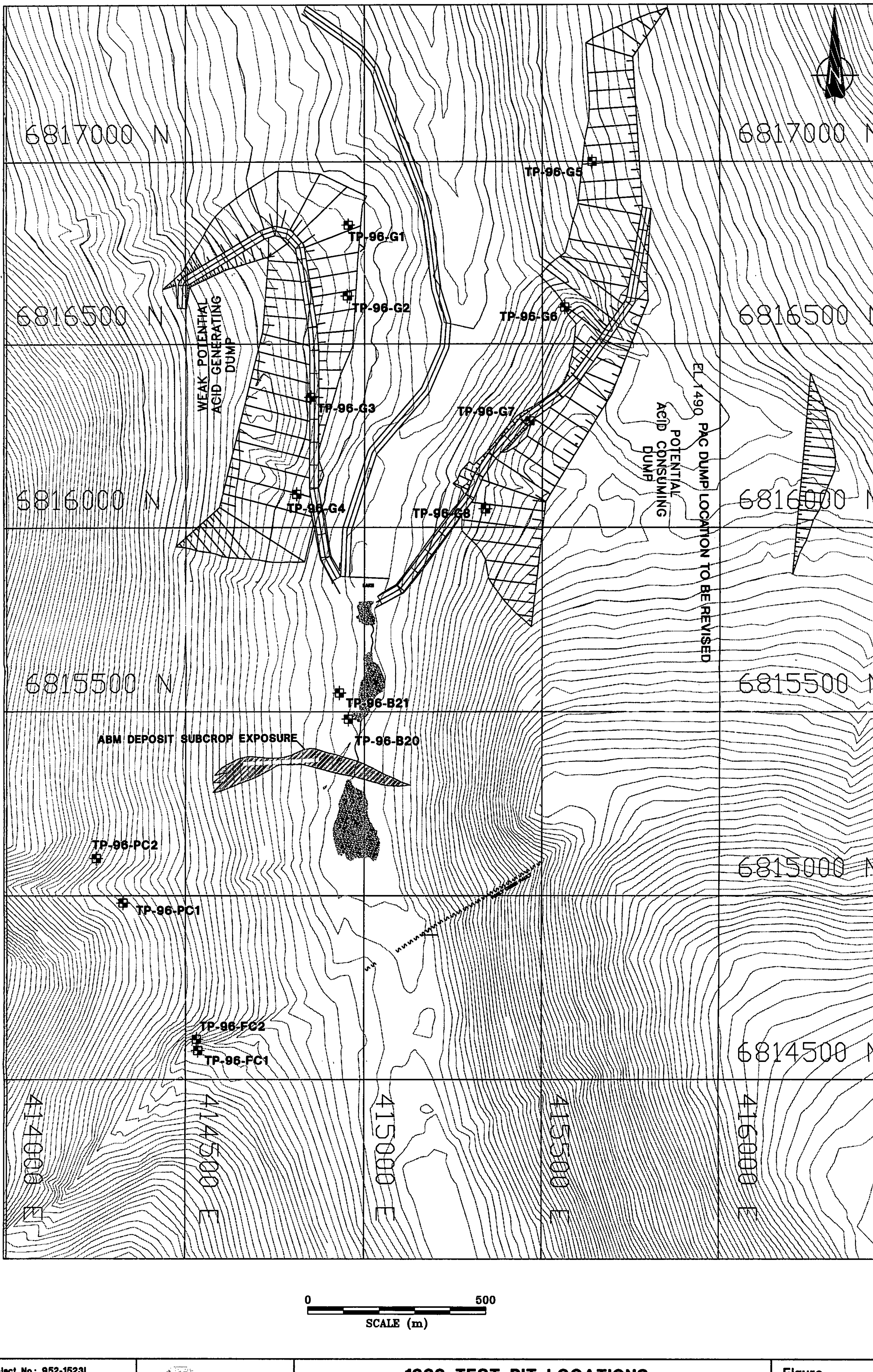
Figure 5

R:\MINING\95\952-1523\1996\ACAD\TOPO1.DWG

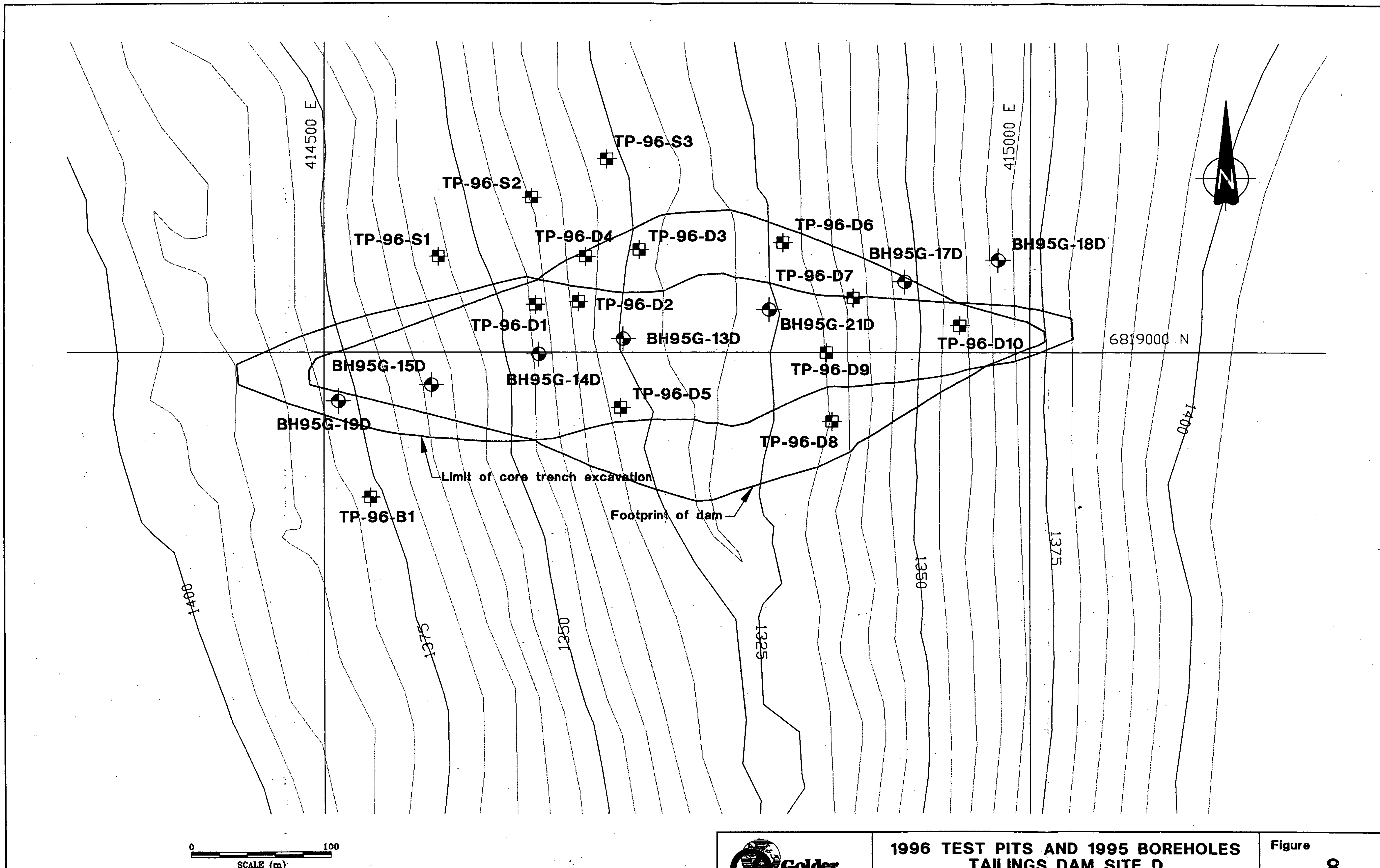


Project No.: 952-1523I Drawn: GG Reviewed: JCC Date: SEP-4-96	Golder Associates	**1996 TEST PIT LOCATIONS DAM AND BORROW AREAS KUDZ ZE KAYAH**	Figure **6**

R:\MINING\95\952-1523\1996\ACAD\TOPO1.DWG



Project No.: 952-1523I Drawn: GG Reviewed: JCC Date: SEP-4-96	Golder Associates	1996 TEST PIT LOCATIONS WASTE DUMPS, FAULT AND PIT CREEK AREAS KUDZ ZE KAYAH	Figure 7



Golder Associates

1996 TEST PITS AND 1995 BOREHOLES
TAILINGS DAM SITE D
KUDZ ZE KAYAH

Figure 8

Project: 952-1523I Drawn: JCC/GG Reviewed: JB Rev.: OCT-17-96 R:\MINING\95\952-1523\1996\ACAD\DAM-TP.dwg

LOOKING DOWNSTREAM

SCALE 1 : 1000

SPECIAL NOTE: *Data concerning th*
obtained at Borehole an
The Soil Stratigraphy be
Pits has been inferred f
and so may vary from th

Golder Associates

TAILINGS IMPOUN
LONGITUD

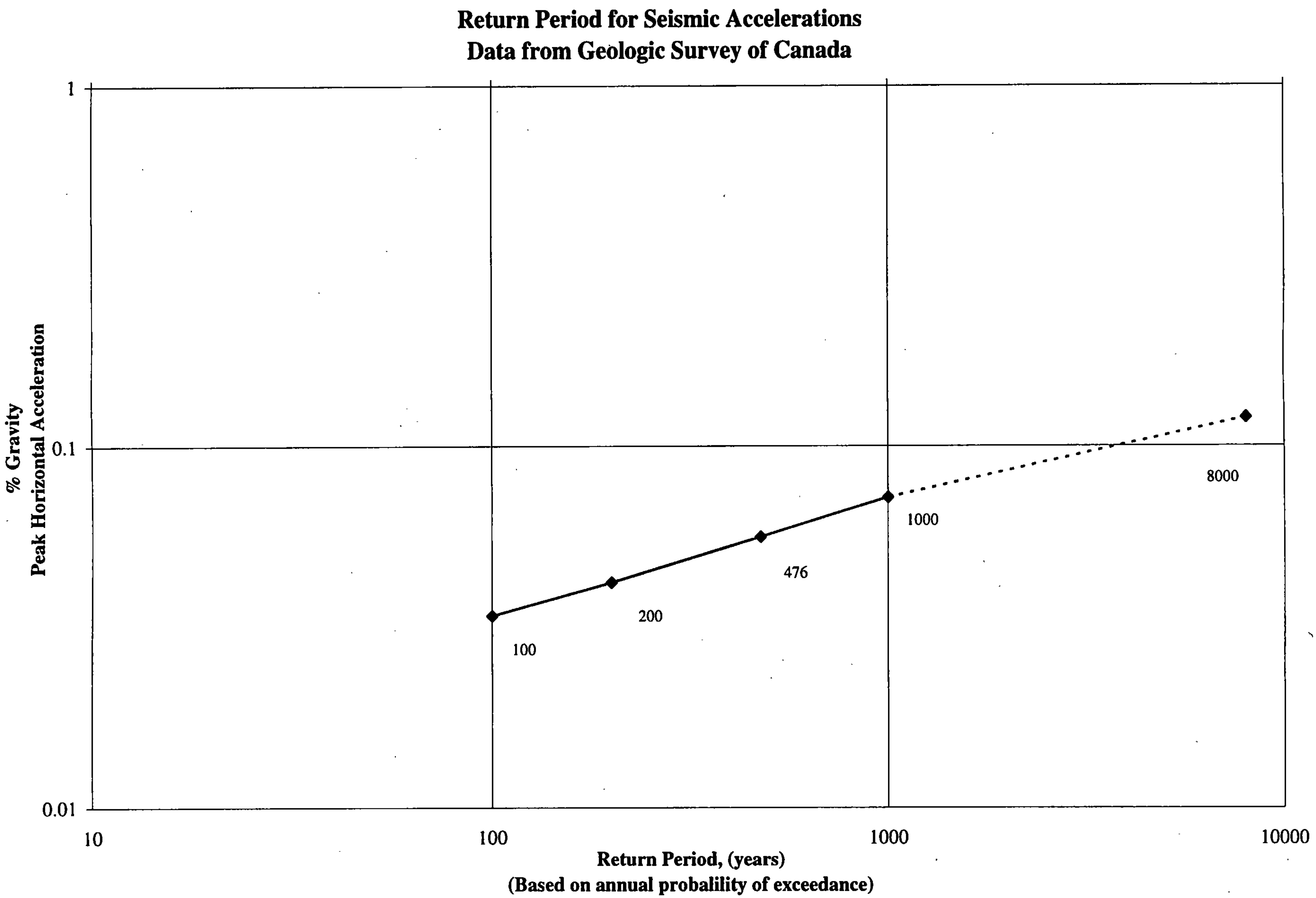
Project No. 952-1523 Drawn BAD Reviewed J.C. Date Sept. '96

LOOKING DOWNSTREAM

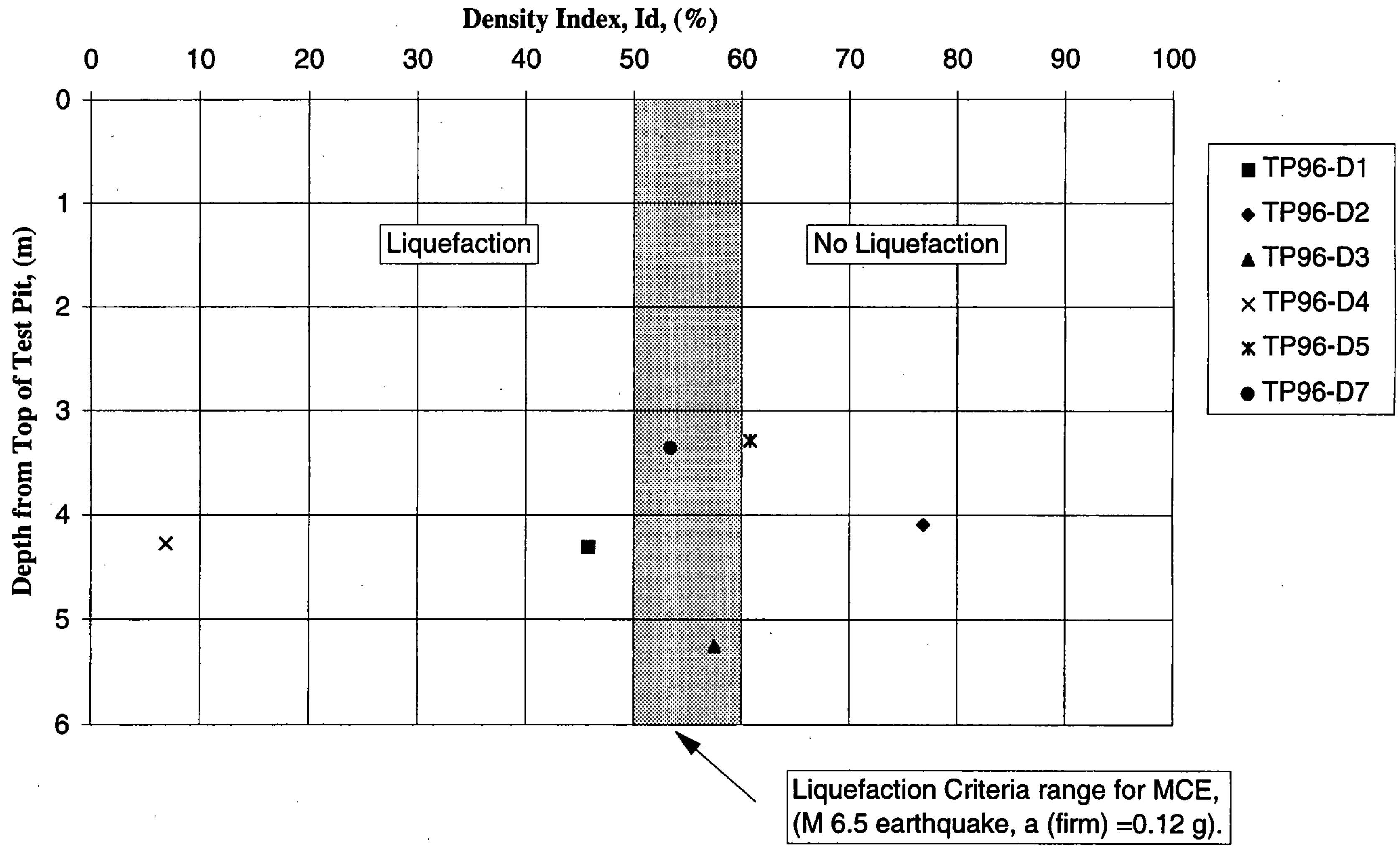
SCALE 1 : 1000

SPECIAL NOTE: Data concerning the various strata have been obtained at Borehole and Test Pit locations only. The Soil Stratigraphy between Boreholes and Test Pits has been inferred from Geological evidence and so may vary from that shown.

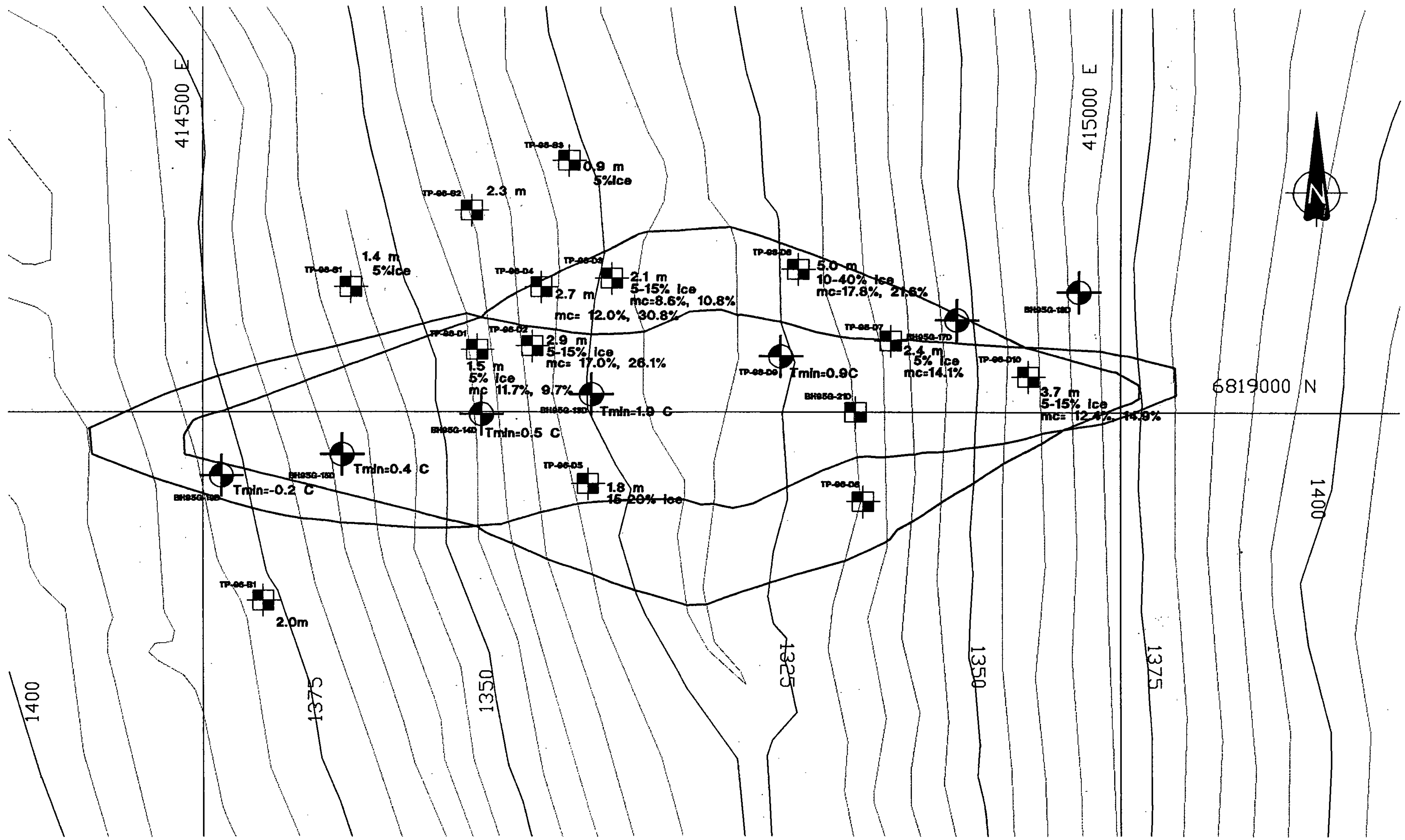
Golder Associates	TAILINGS IMPOUNDMENT – DAM SITE D LONGITUDINAL SECTION	Figure 9



Project No. 952-1523 I Drawn ~ Reviewed J.C.C. Date Oct '96	Golder Associates	**KUDZ ZE KAYAH** **RETURN PERIOD FOR SEISMIC ACCELERATIONS** **DATA FROM GEOLOGIC SURVEY OF CANADA**	Figure **10**



Project No. 952-15231 Drawn ~ Reviewed J.C.C. Date Oct '96	Golder Associates	**KUDZ ZE KAYAH** **DAM SITE D – TEST PIT AVERAGE IN-SITU DENSITY INDEX AND LIQUEFACTION CRITERIA**	Figure **11**



0 100
SCALE (m)

NOTES:

Test pits labeled with:

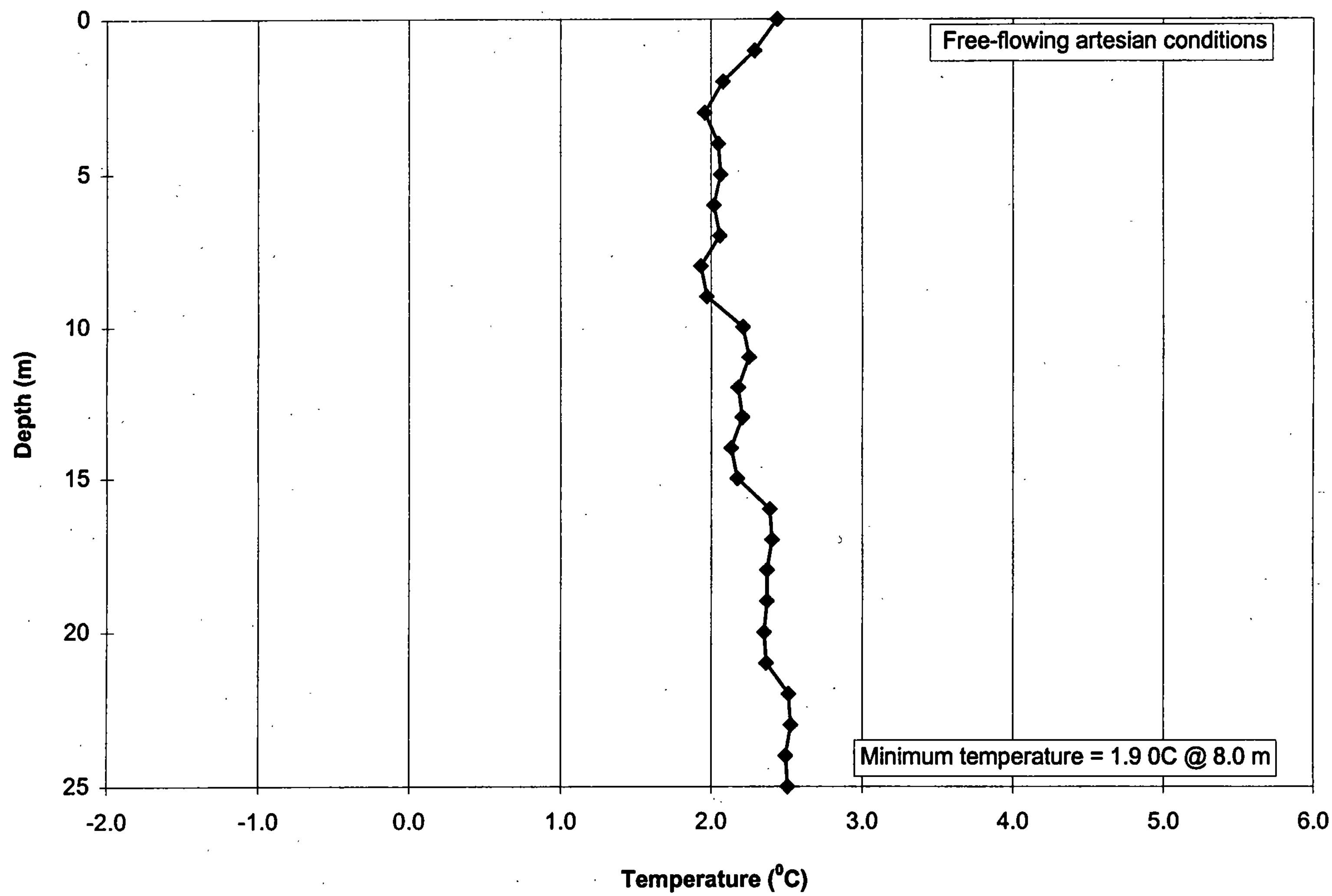
Depth of frozen ground (July 1996)
ice content in frozen ground
moisture content from samples in frozen ground

Boreholes labeled with:

Tmin = Minimum temperature from thermistor sounding in piezometer (August 1996)

Golder Associates	1996 TEST PIT AND 1995 BOREHOLE GROUND TEMPERATURE AND ICE CONDITIONS KUDZ ZE KAYAH	Figure 12

Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: OCT-17-96 R:\MINING\95\952-1523\1996\ACAD\DAM-TP1.DWG



Project No. 952-1523 I
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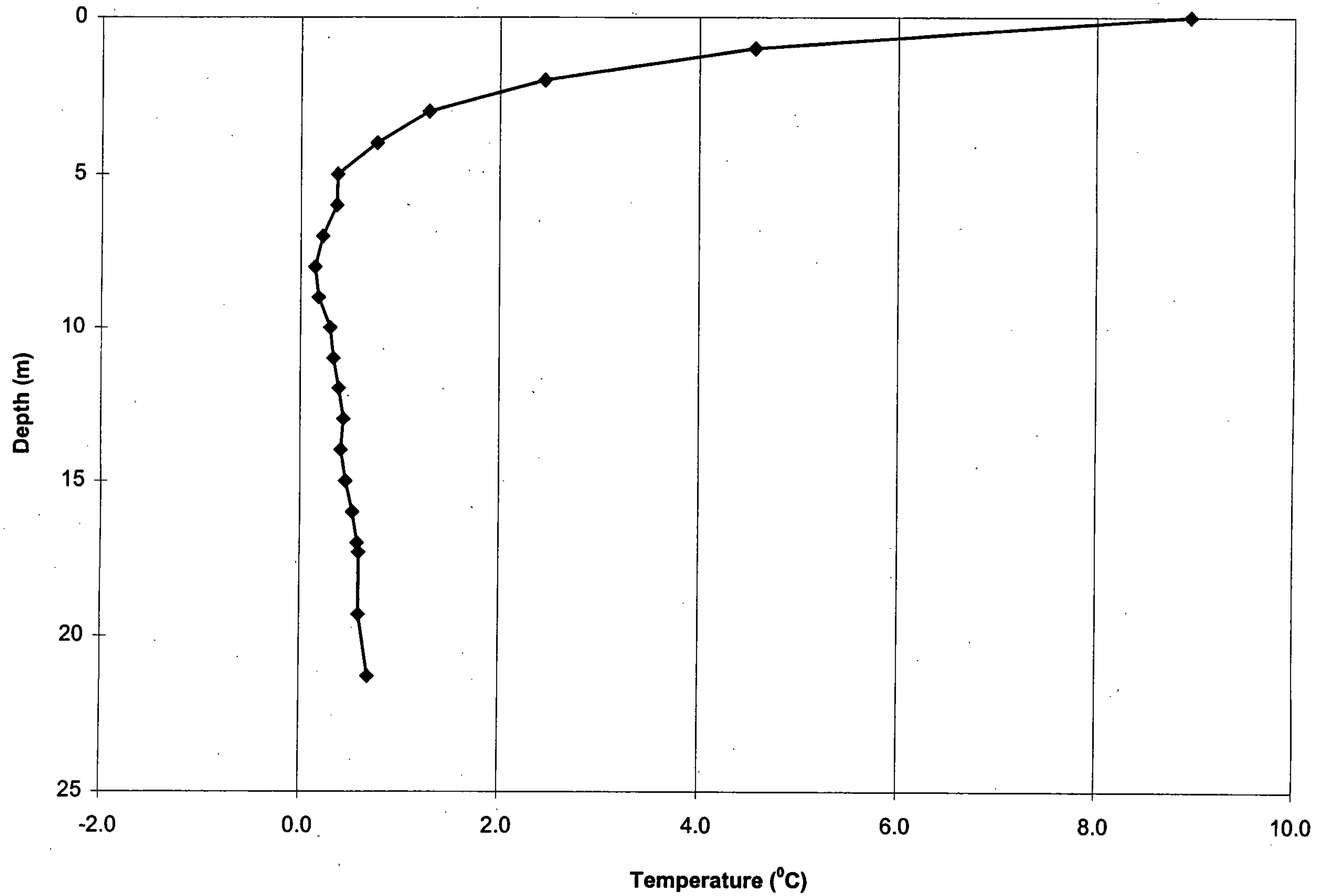
Date Oct '96

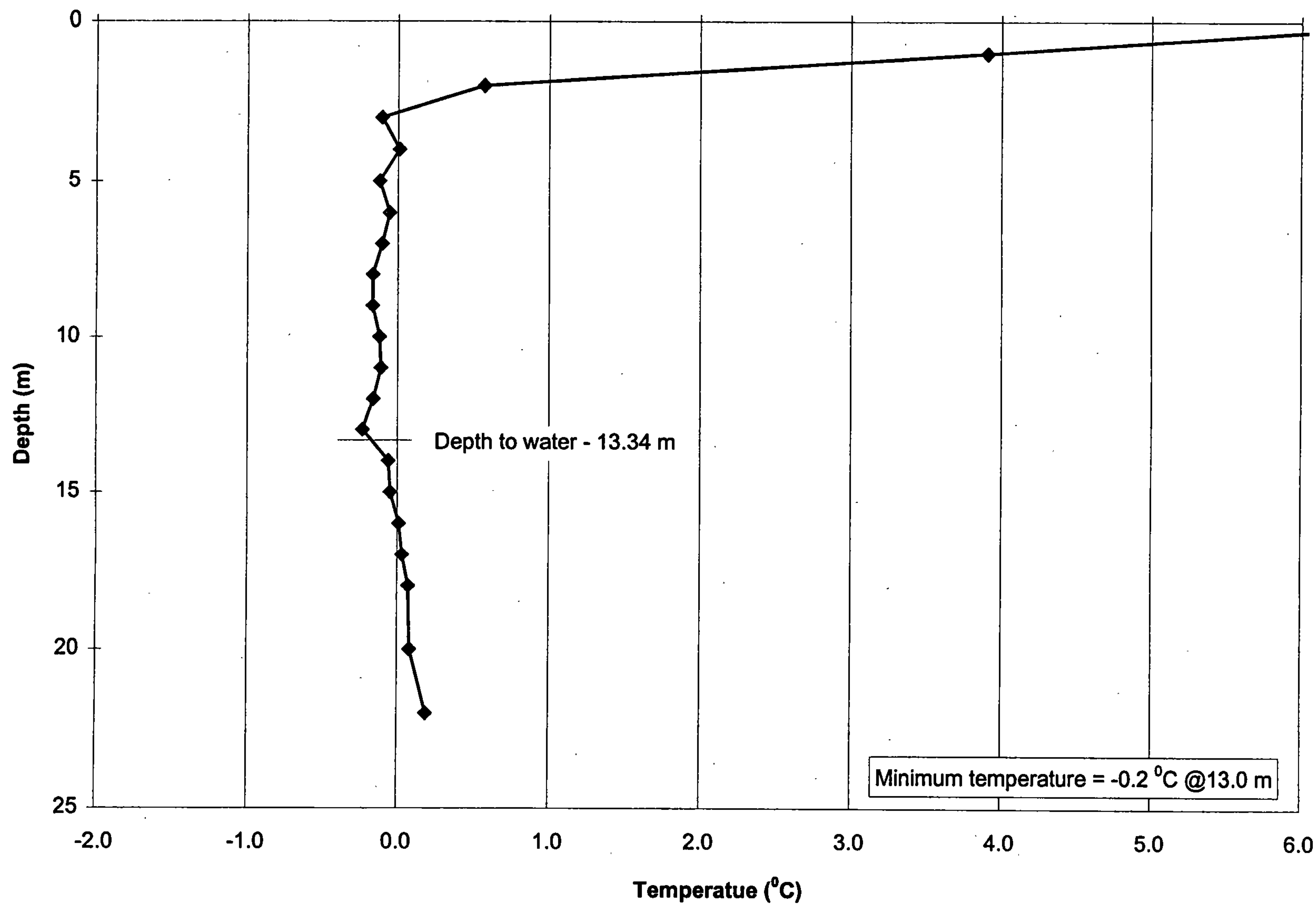
Golder Associates

TEMPERATURE PROFILE AT 95G-13D
(August 23, 1996)

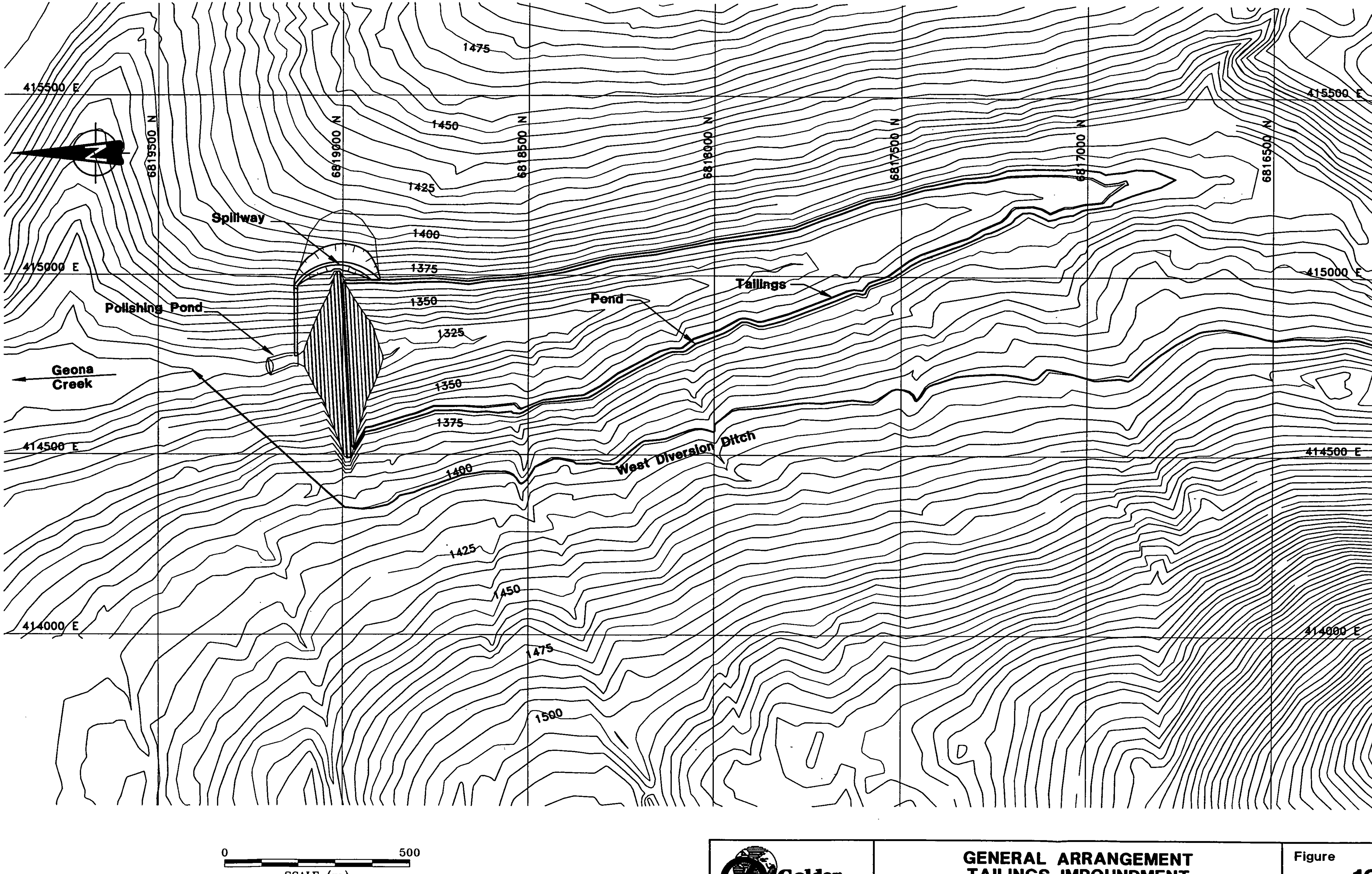
Figure **13**



Project No. 952-1523 I Drawn ~ Reviewed J. C. C. Date Oct '96	Golder Associates	**TEMPERATURE PROFILE AT 95G-15D** (August 18, 1996)	Figure **14**



Project No. 952-1523I Drawn ~ Reviewed J.C.C. Date Oct '96	Golder Associates	**TEMPERATURE PROFILE AT 95G-19** (August 18, 1996)	Figure **15**

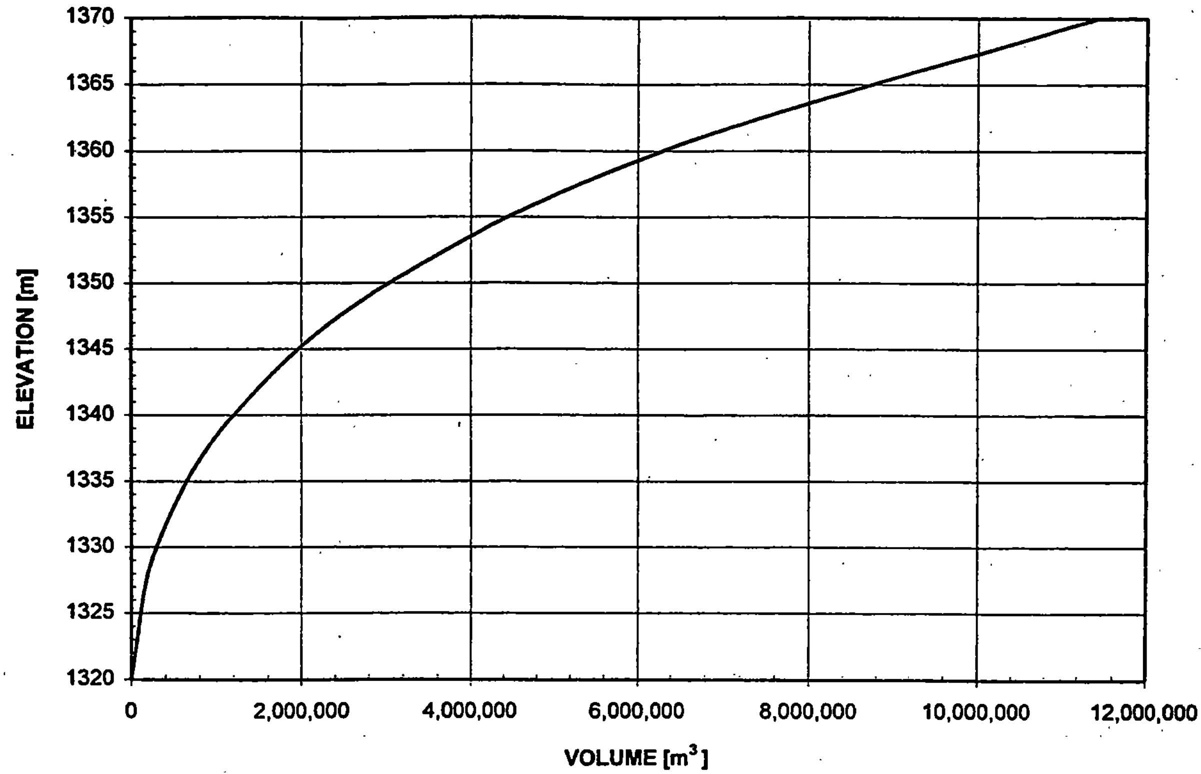


Golder Associates

GENERAL ARRANGEMENT
TAILINGS IMPOUNDMENT
KUDZ ZE KAYAH

Figure 16

Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: 10-OCT-96 R:\MINING\95\952-1523\1996\ACAD\EX1.DWG

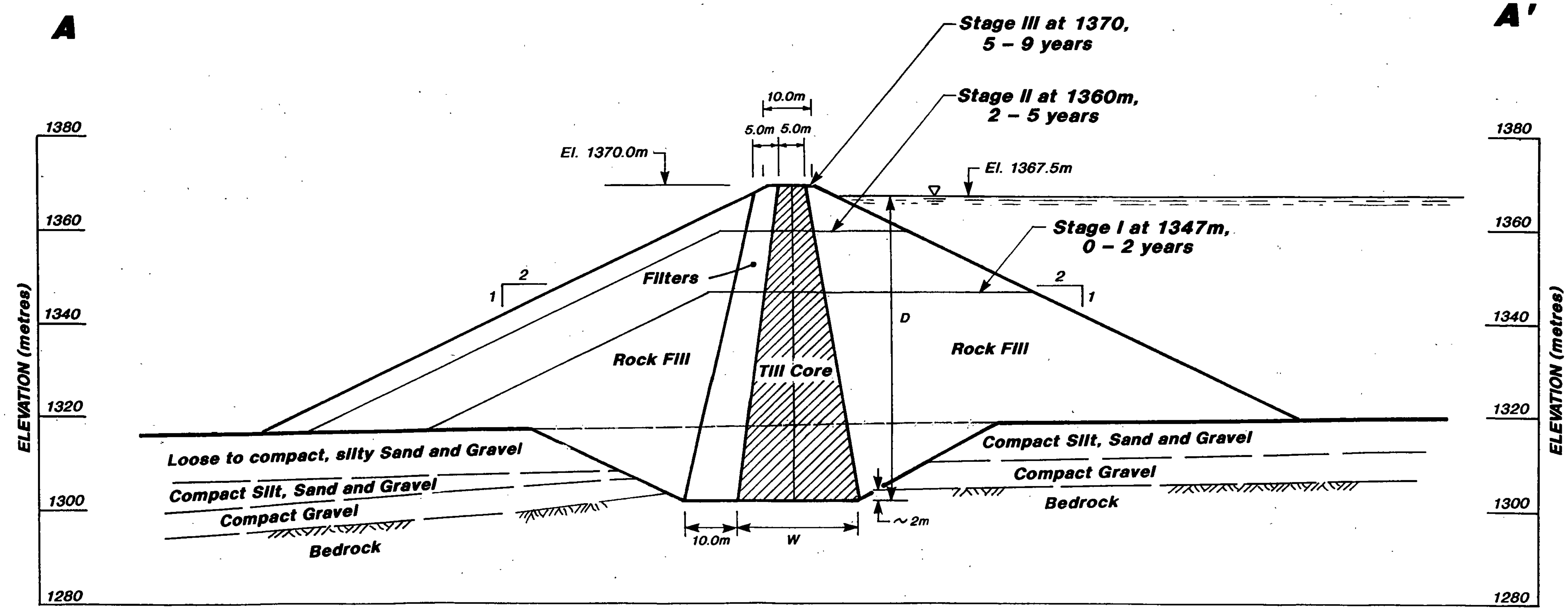


Project No. 952-1523 I Drawn ~ Reviewed J.C.C. Date Sept. '96

Golder Associates

TAILINGS DAM – SITE D
HEIGHT Vs VOLUME CURVE

Figure **17**



CROSS-SECTION A - A

SCALE 1 : 1000

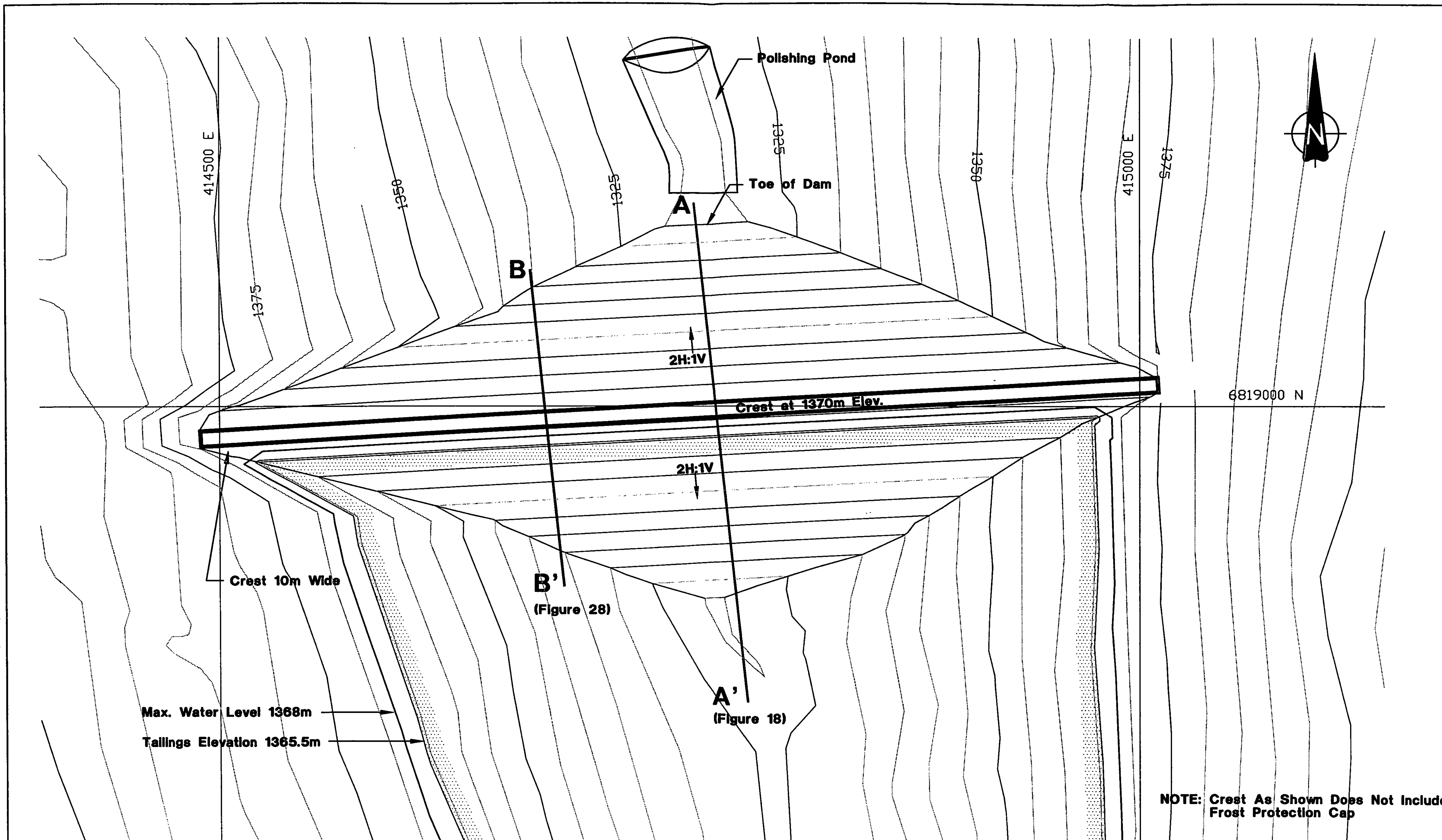
NOTE: 1) Crest of dam will incorporate 3m frost protection cap on each stage
2) W/D ≥ 0.4

Project No. 952-1523 Drawn ✓ Reviewed R.B. Date Sept./95

Golder Associates

TAILINGS IMPOUNDMENT - DAM SITE D CROSS SECTION

Figure 18



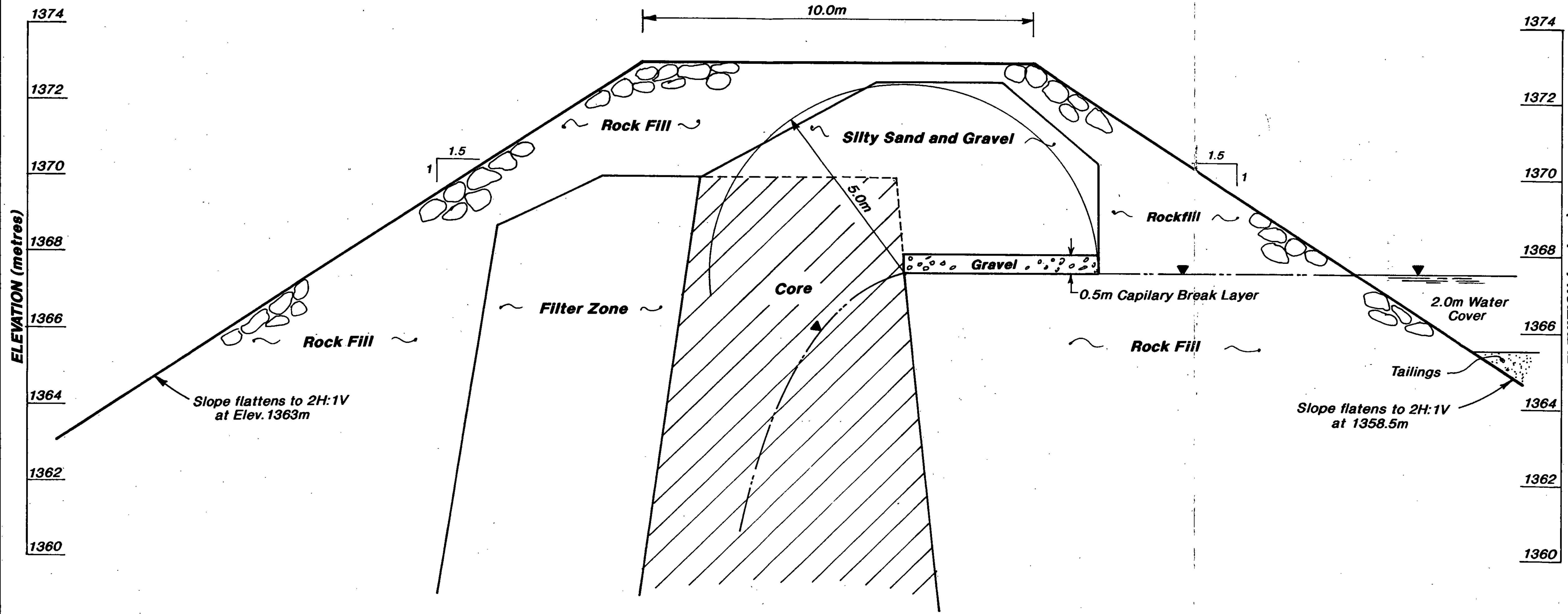
0 100
SCALE (m)

Golder Associates

TAILINGS DAM DETAILS
KUDZ ZE KAYAH

Figure 19

Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: 1 R:\MINING\95\952-1523\1998\ACAD\EX1.DWG



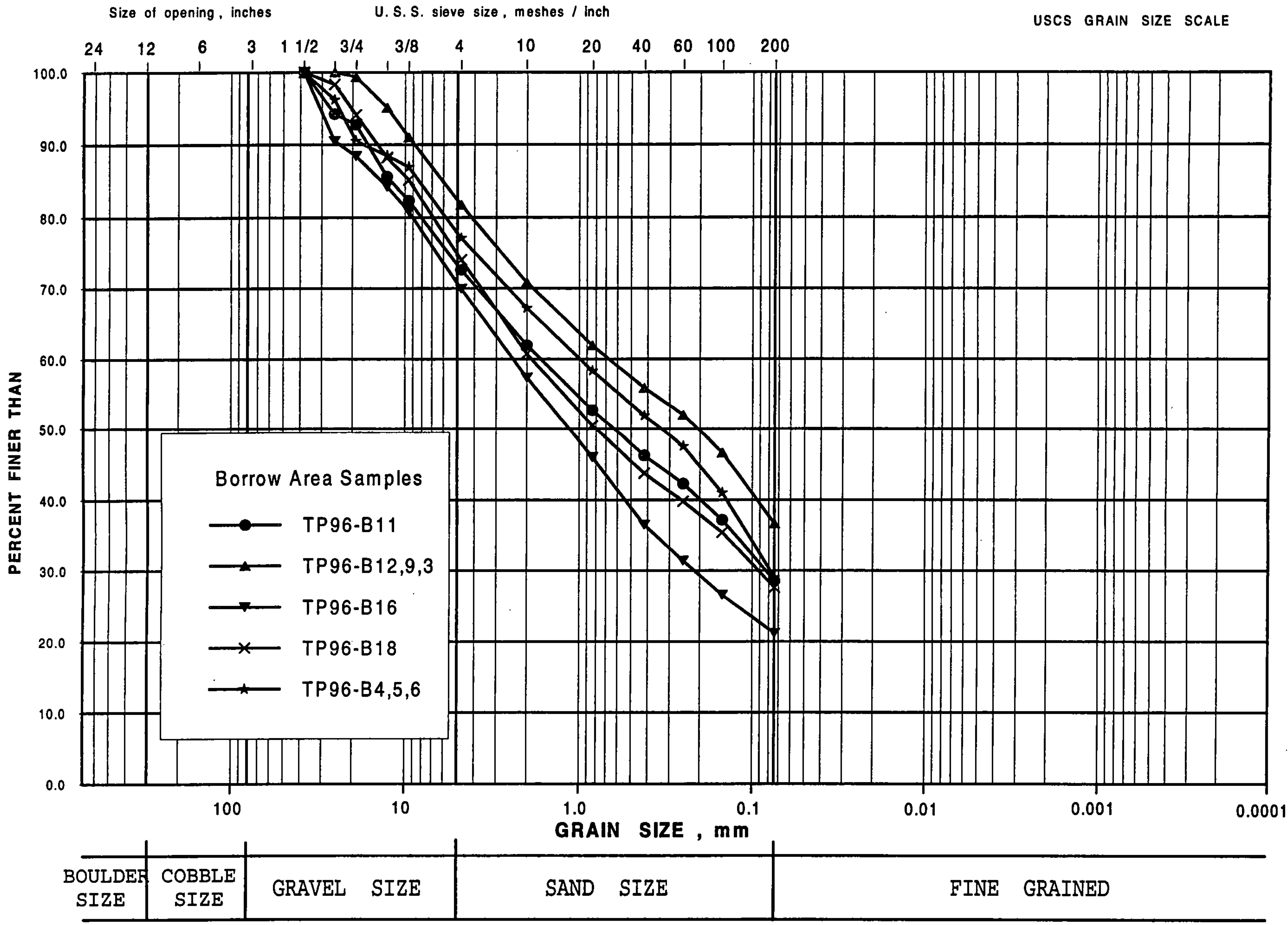
SCALE 1 : 100

Project No. 952-1523 Drawn J Reviewed J.C. Date Oct. '96

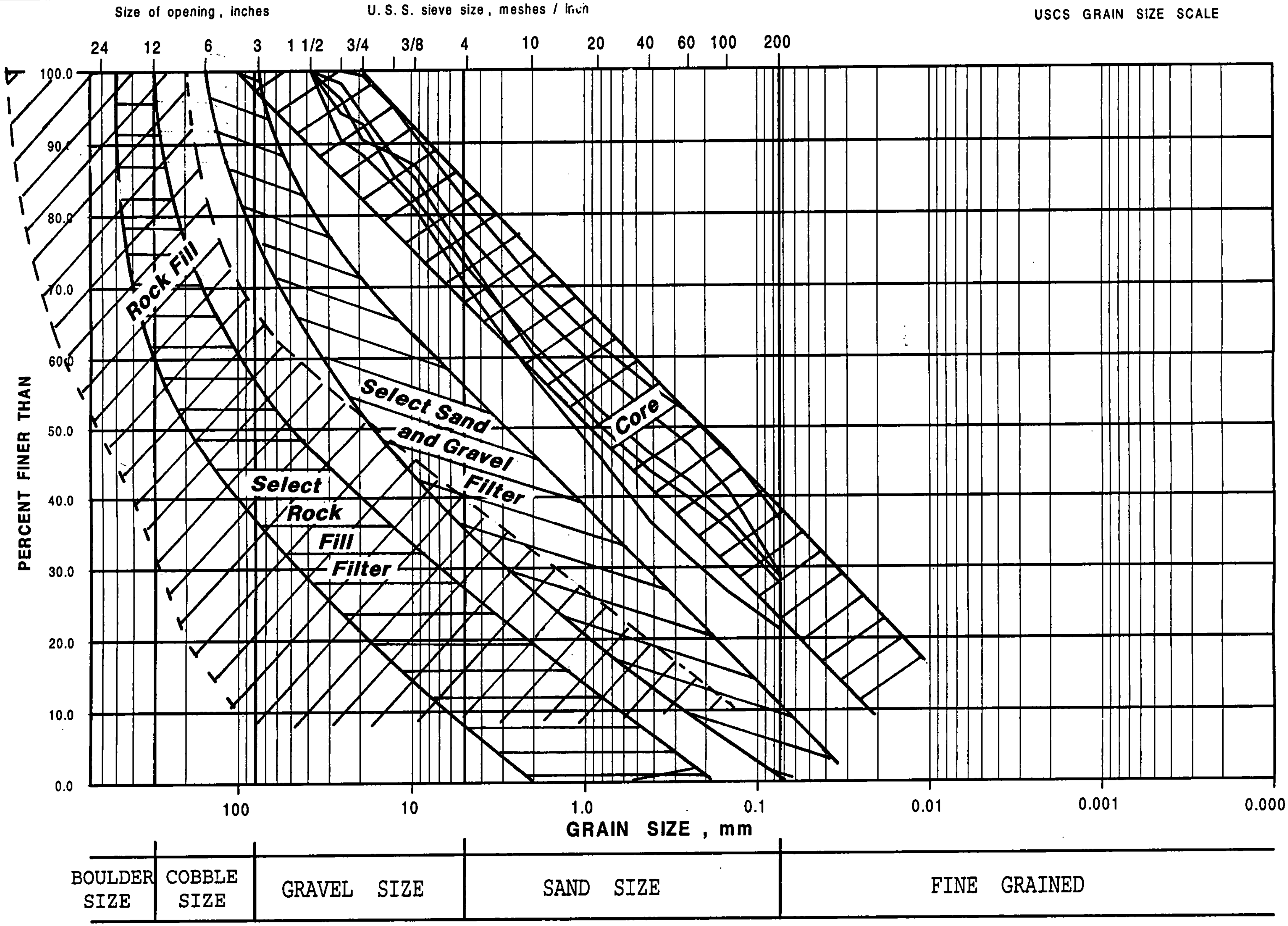
Golder Associates

DAM SITE D
PRELIMINARY CREST DETAIL SHOWING FROST PROTECTION CAP

Figure **20**



Project No.: ...952-1523I... Drawn: ....ANB........... Reviewed: .... Date: ...July 31, 1996.......	Golder Associates	**BORROW AREA TEST PIT SAMPLES GRAIN SIZE DISTRIBUTION KUDZ ZE KAYAH**	**Figure 21**



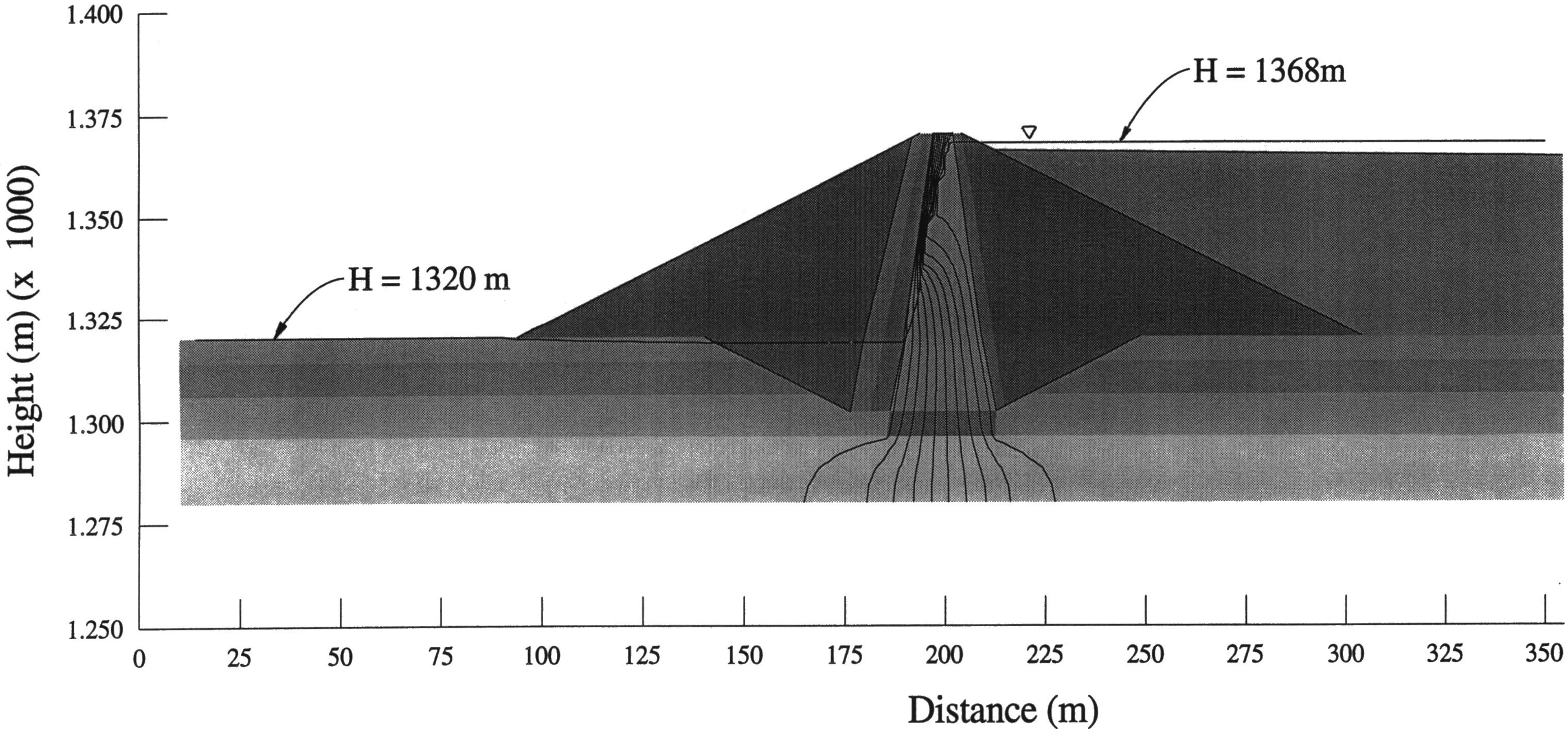
Project No.: ...952-1523I...
Drawn: ....JMS...........
Reviewed: ......JCC.............
Date: ...July 30, 1996.......

Golder Associates

BORROW AREA -GRAIN SIZE DISTRIBUTION RANGE
PRELIMINARY FILTER CRITERIA
KUDZ ZE KAYAH

Figure

22



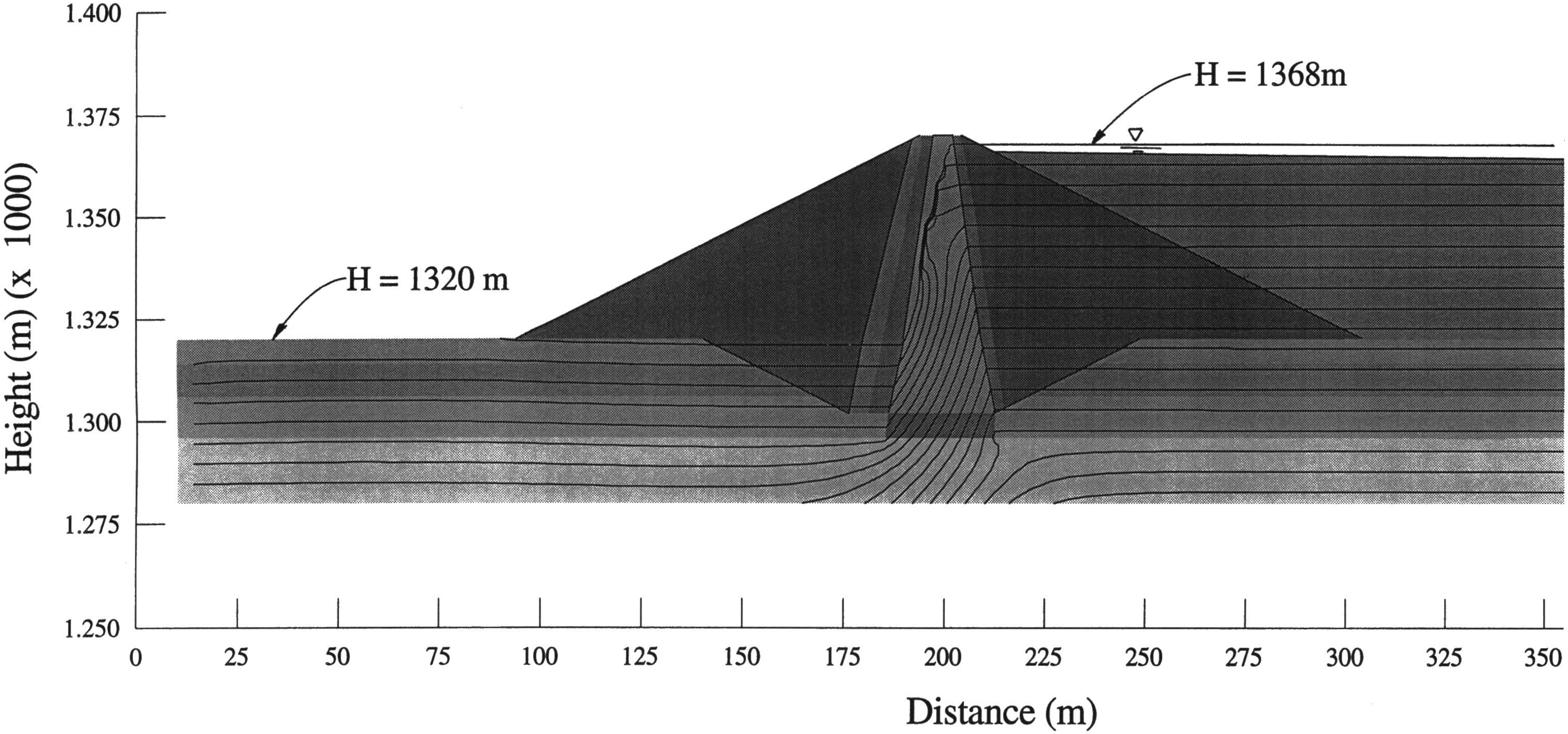
Project No. 952-15231
Drawn ~
Reviewed J.C.C.
Date Oct' 96

Golder Associates

KUDZ ZE KAYAH

TAILINGS DAM SEEPAGE ANALYSIS – BASE CASE
CONTOURS OF TOTAL HEAD, 5m INTERVAL

Figure **23**

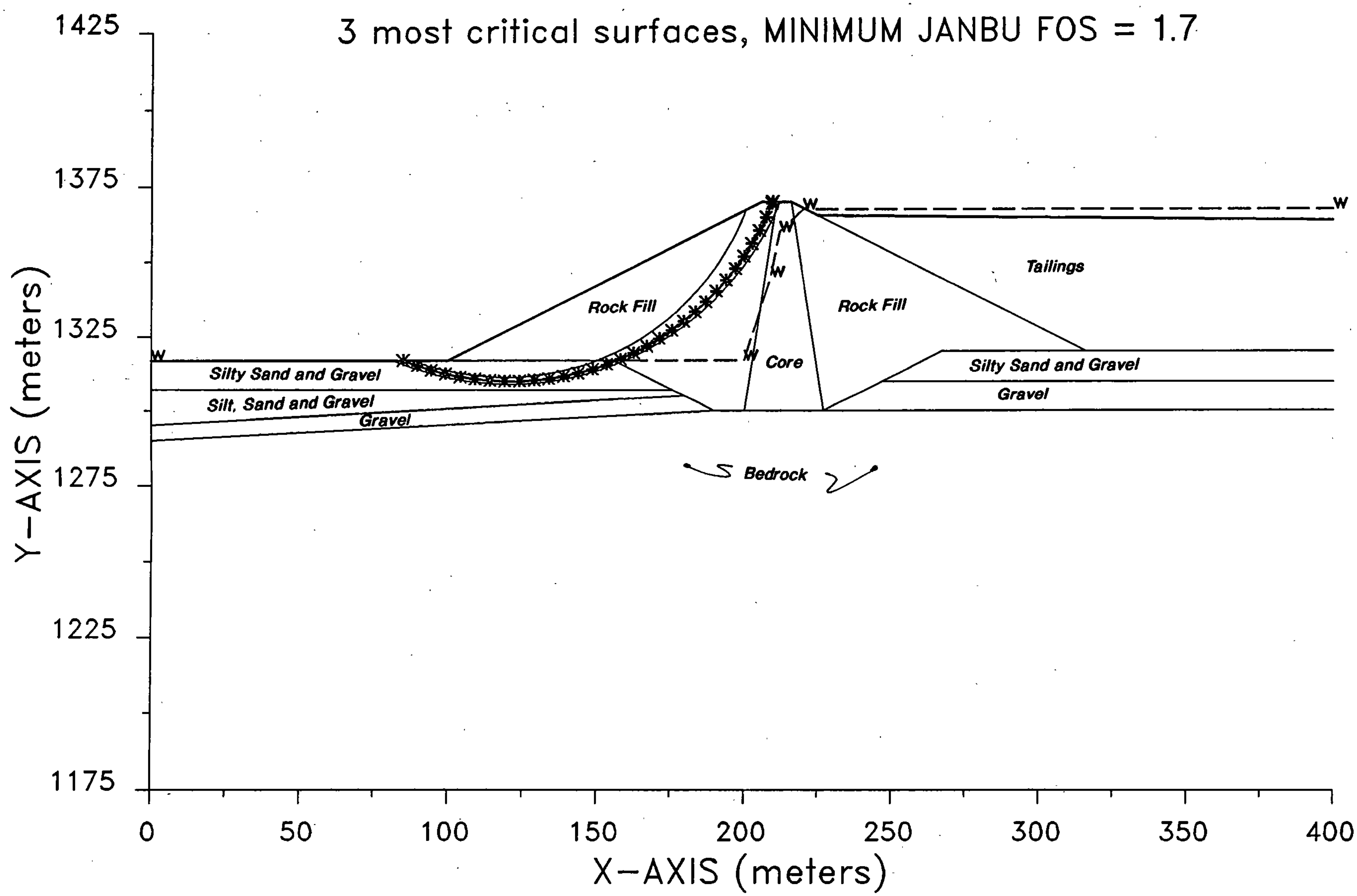


Project No. 952-15231
Drawn ~
Reviewed J.C.C.
Date Oct '96

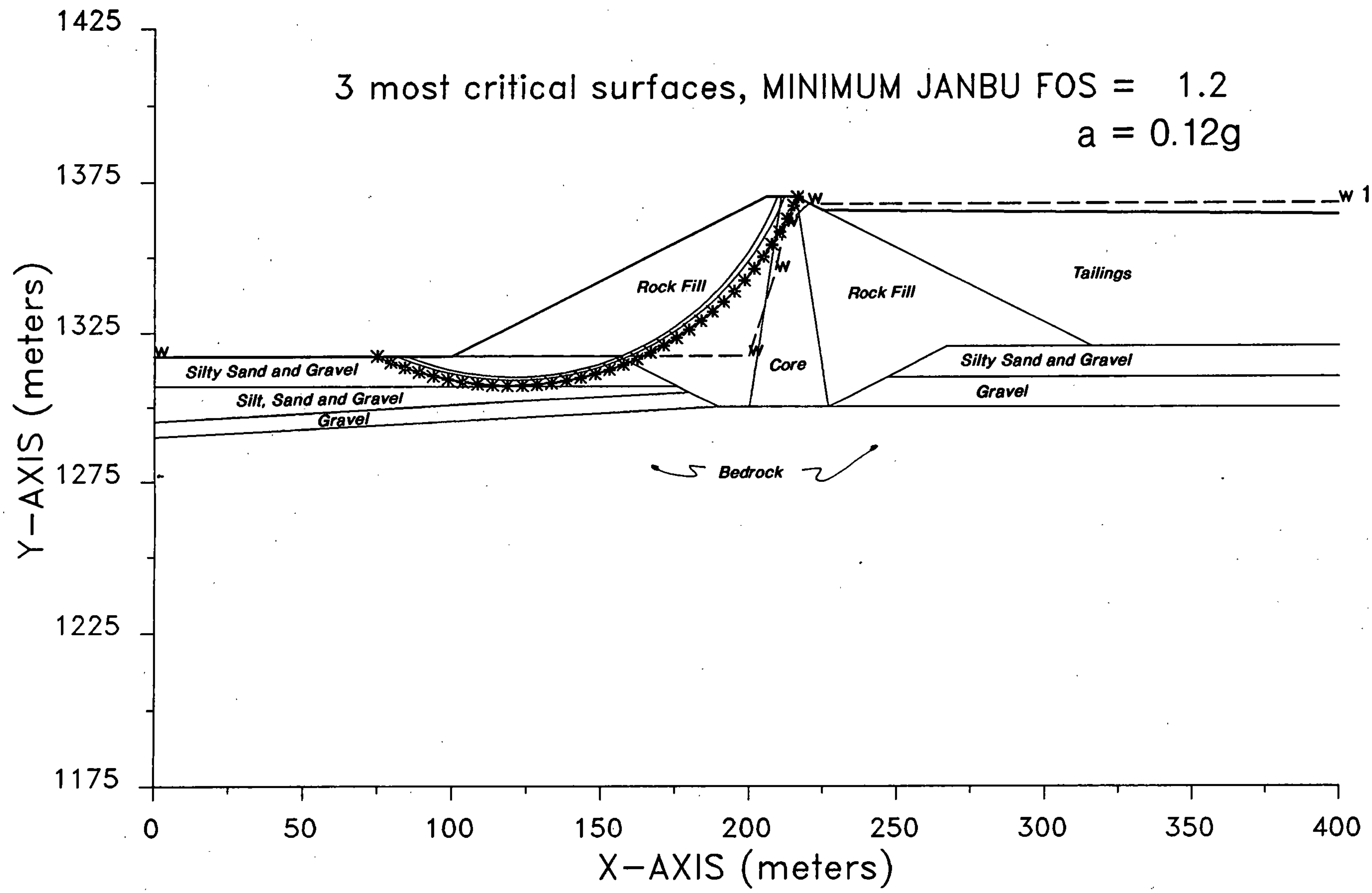
Golder Associates

KUDZ ZE KAYAH
TAILINGS DAM SEEPAGE ANALYSIS – BASE CASE
CONTOURS OF PRESSURE HEAD, 5m INTERVAL

Figure **24**



Project No. 952-1523.I Drawn — Reviewed J.C. Date Sept.'96	Golder Associates	**KUDZ ZE KAYAH** **TAILINGS DAM D – SECTION A – A'** **STATIC ANALYSIS**	Figure **25**

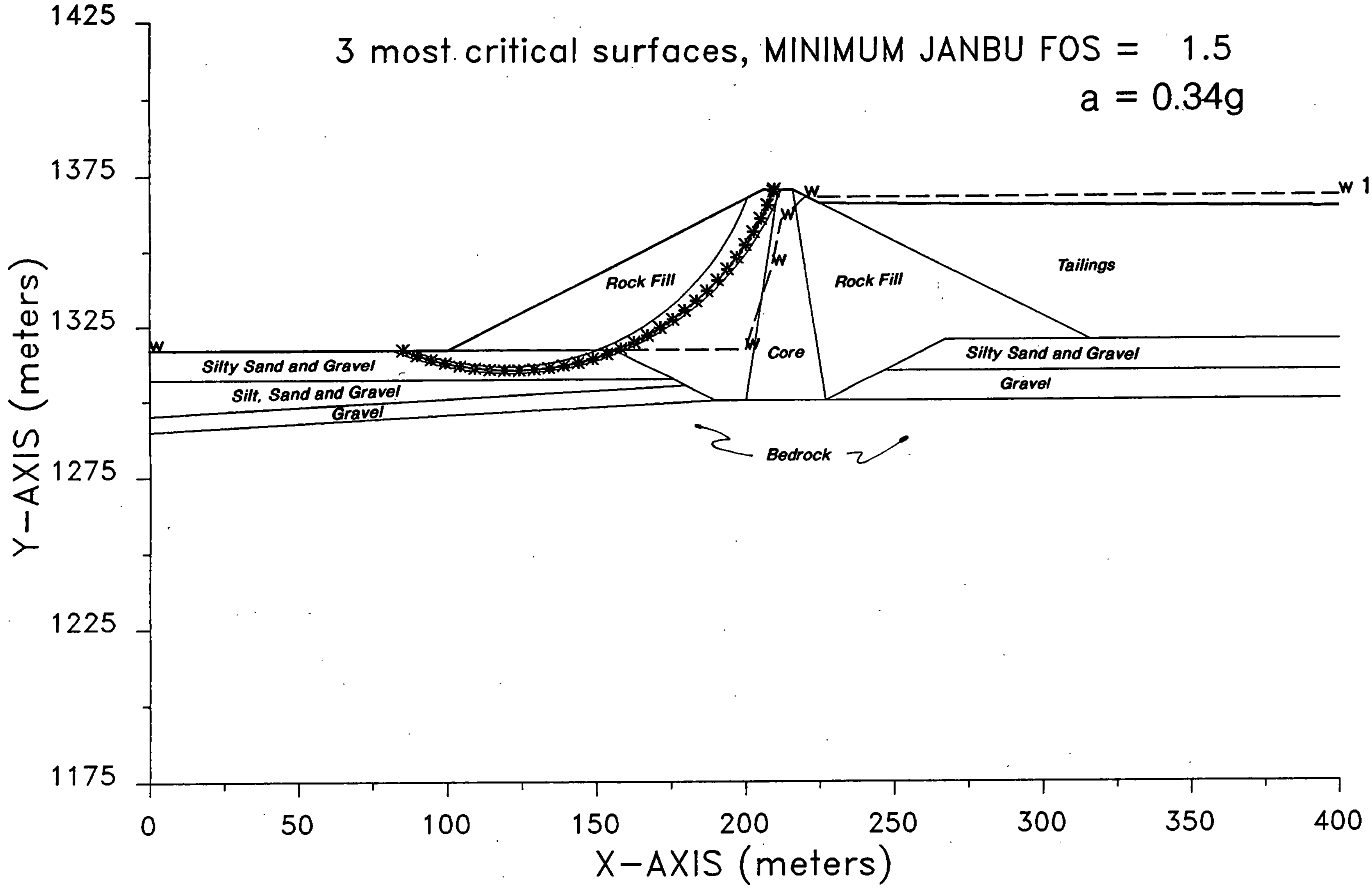


Project No. 952-1523 I
Drawn —
Reviewed J.C.
Date Sept.'96

Golder Associates

KUDZ ZE KAYAH
TAILINGS DAM D – WEST ABUTMENT SECTION A – A'
PSEUDO STATIC ANALYSIS – MCE EVENT

Figure **26**

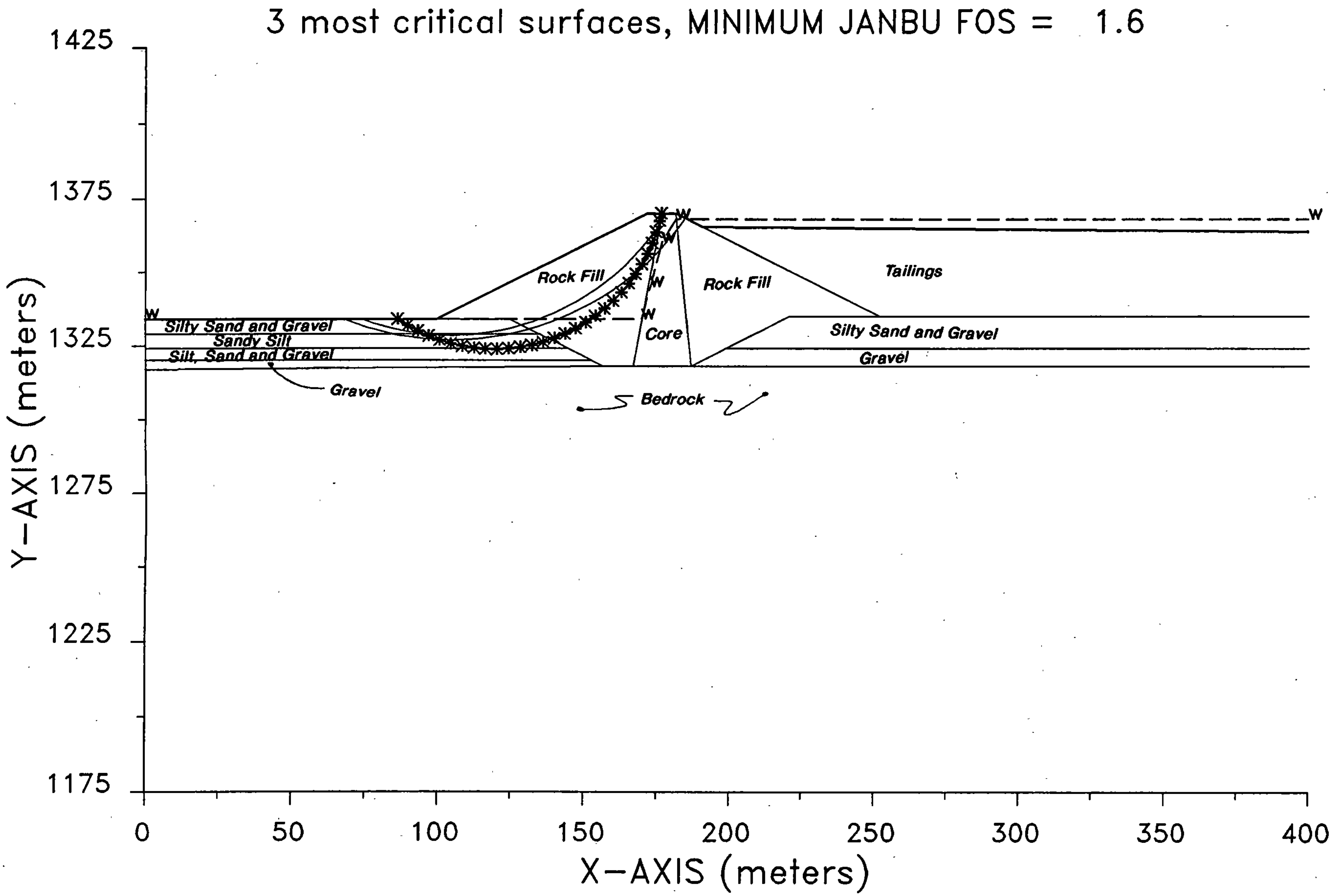


Project No. 952-1523 I
Drawn ~
Reviewed J.C.
Date Sept. '96

Golder Associates

KUDZ ZE KAYAH
TAILINGS DAM D – SECTION A – A'
PSEUDO STATIC ANALYSIS – 1/100 year EVENT

Figure **27**



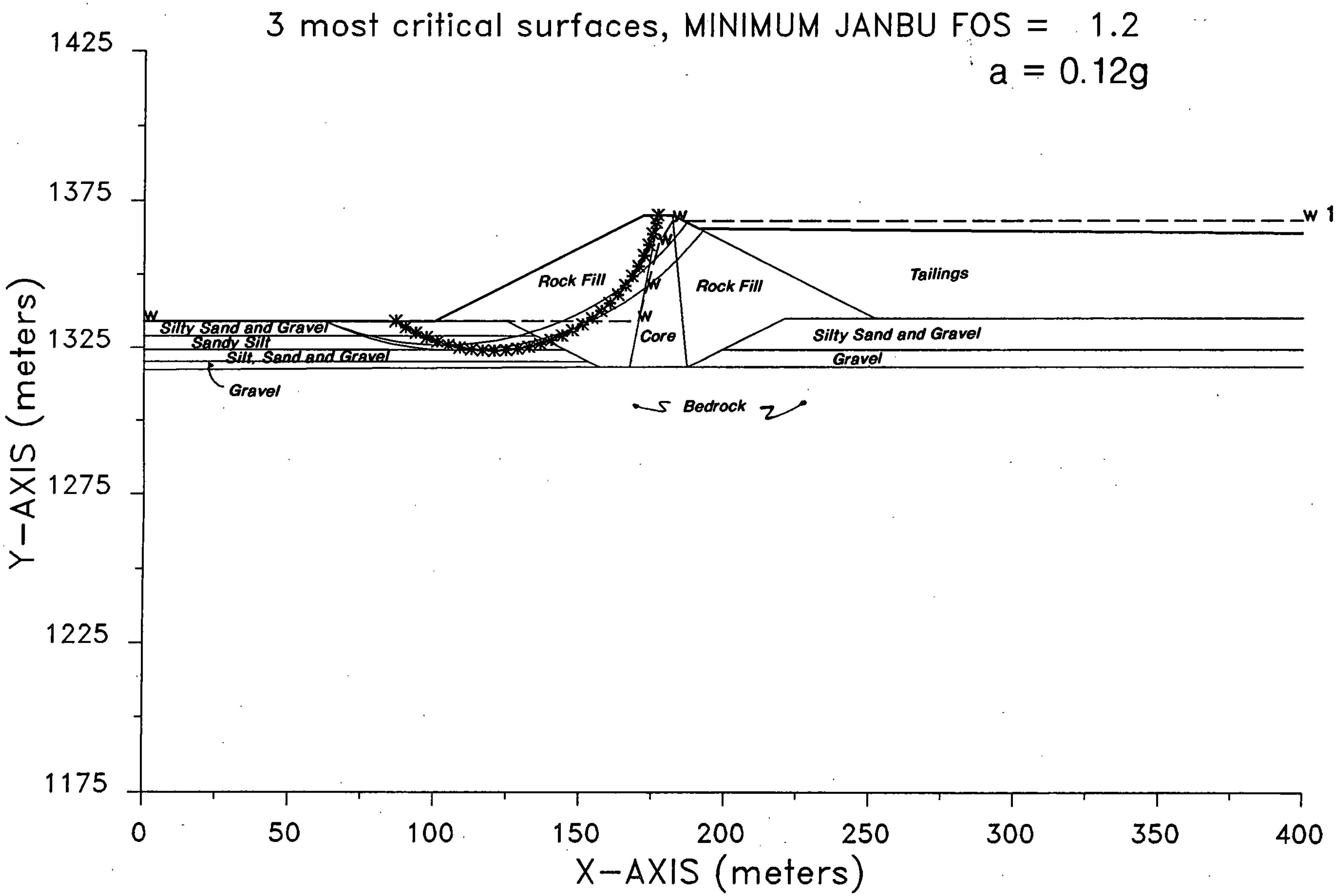
Project No. 952-1523.I
Drawn —
Reviewed J.C.
Date Sept. '96

Golder Associates

KUDZ ZE KAYAH

TAILINGS DAM D – WEST ABUTMENT SECTION B – B'
STATIC ANALYSIS

Figure **28**

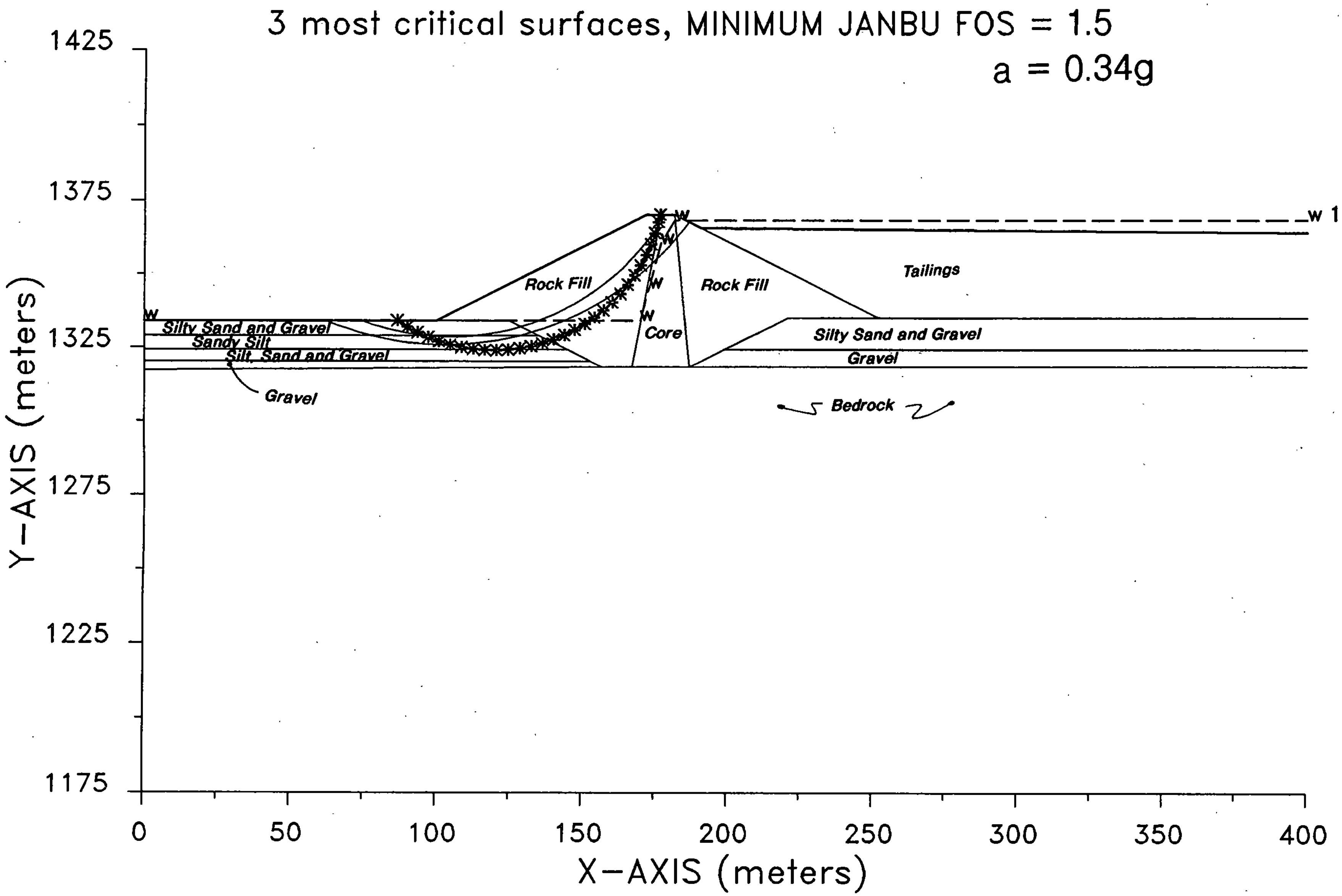


Project No. 952-1523 I
Drawn —
Reviewed J.C.
Date Sept.'96

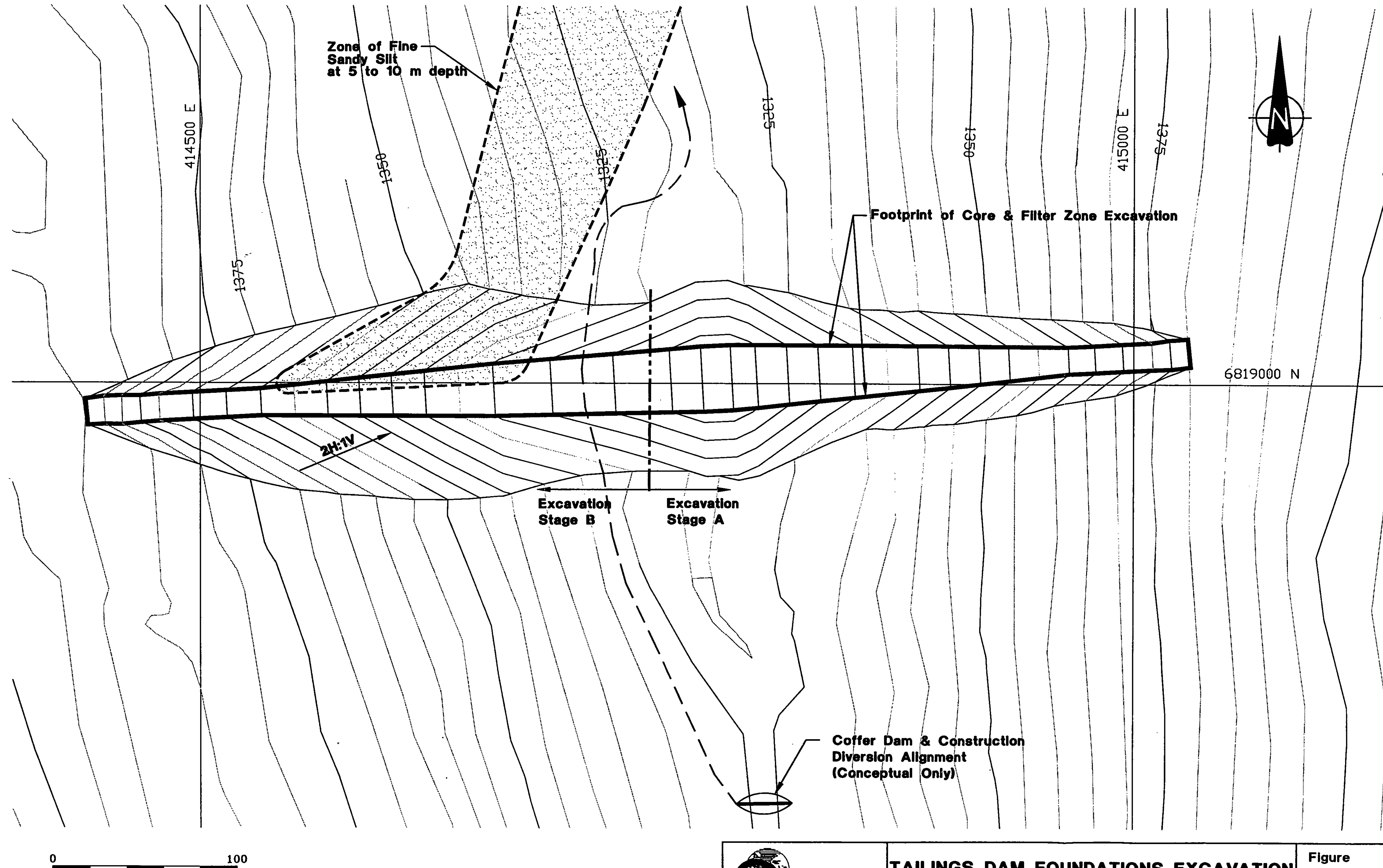
Golder Associates

KUDZ ZE KAYAH
TAILINGS DAM D – WEST ABUTMENT SECTION B – B'
PSEUDO STATIC ANALYSIS – MCE EVENT

Figure **29**



Project No. 952-1523 I Drawn — Reviewed J.C. Date Sept./96	Golder Associates	KUDZ ZE KAYAH TAILINGS DAM D – WEST ABUTMENT SECTION B – B' PSEUDO STATIC ANALYSIS – 1/100 year EVENT	Figure 30



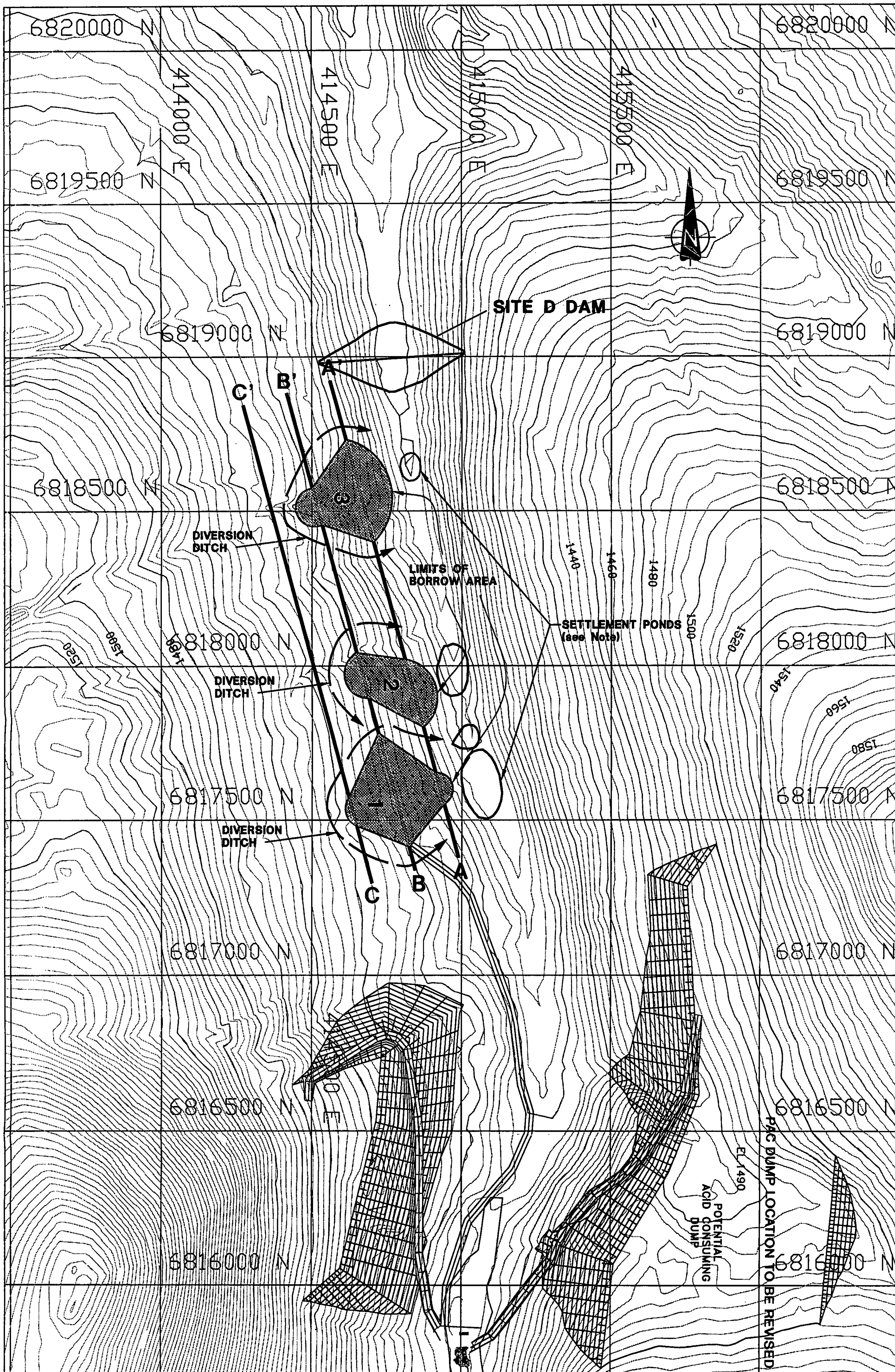
Golder Associates

TAILINGS DAM FOUNDATIONS EXCAVATION
KUDZ ZE KAYAH

Figure **31**

Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: 11-OCT-96 R:\MINING\95\952-1523\1996\ACAD\EX1.DWG

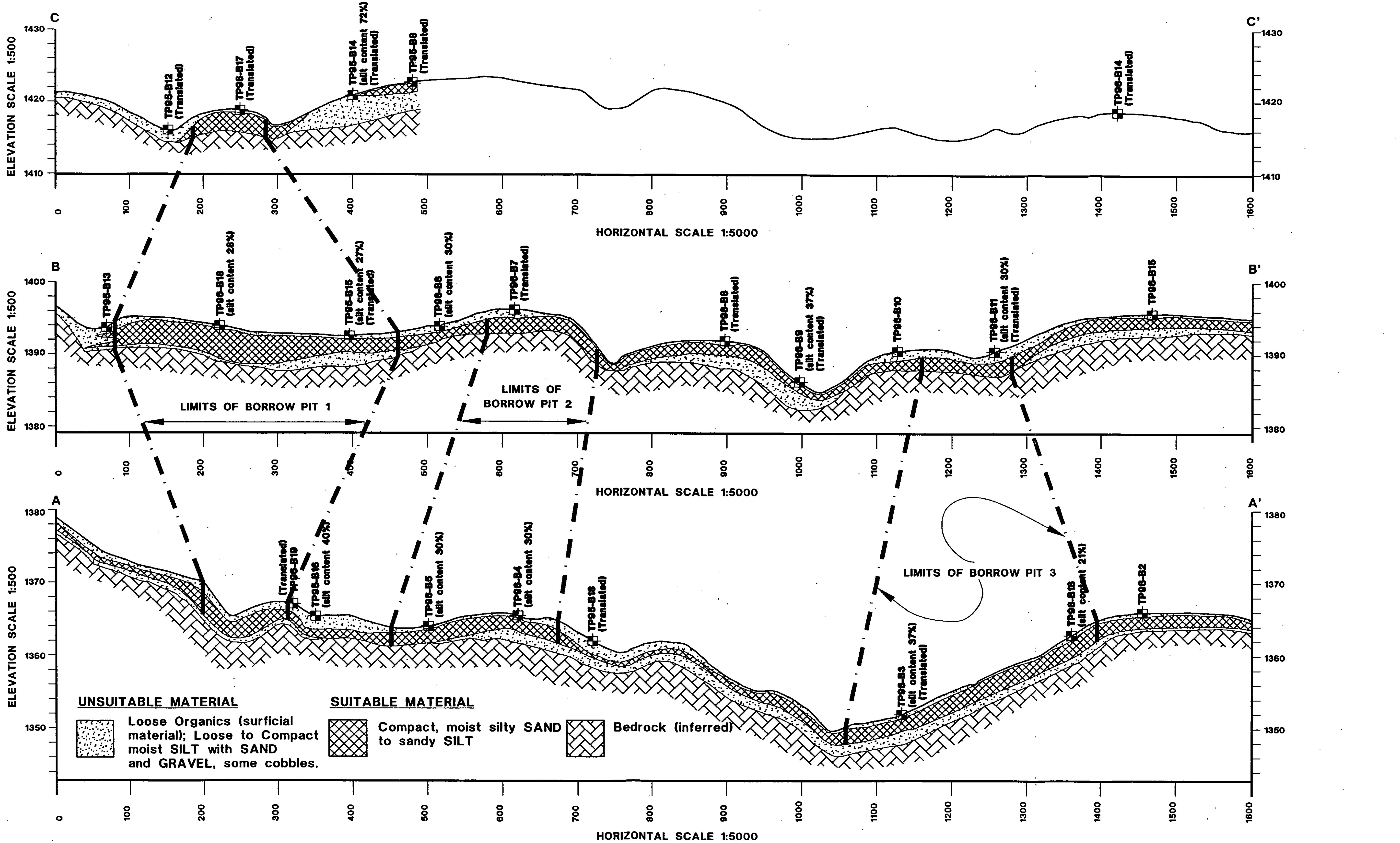
R:\MINING\95\952-1523\1996\ACAD\BORPLAN.DWG



0 500
SCALE (m)

NOTE:
Settlement Ponds not to scale.
Minimum limits of borrow area shown.
Final limits dependant on topography and actual soil thicknesses.

Project No.: 952-1523I Drawn: CJC Reviewed: Date: OCT-11-96	Golder Associates	BORROW SOURCE LOCATION KUDZ ZE KAYAH	Figure 32

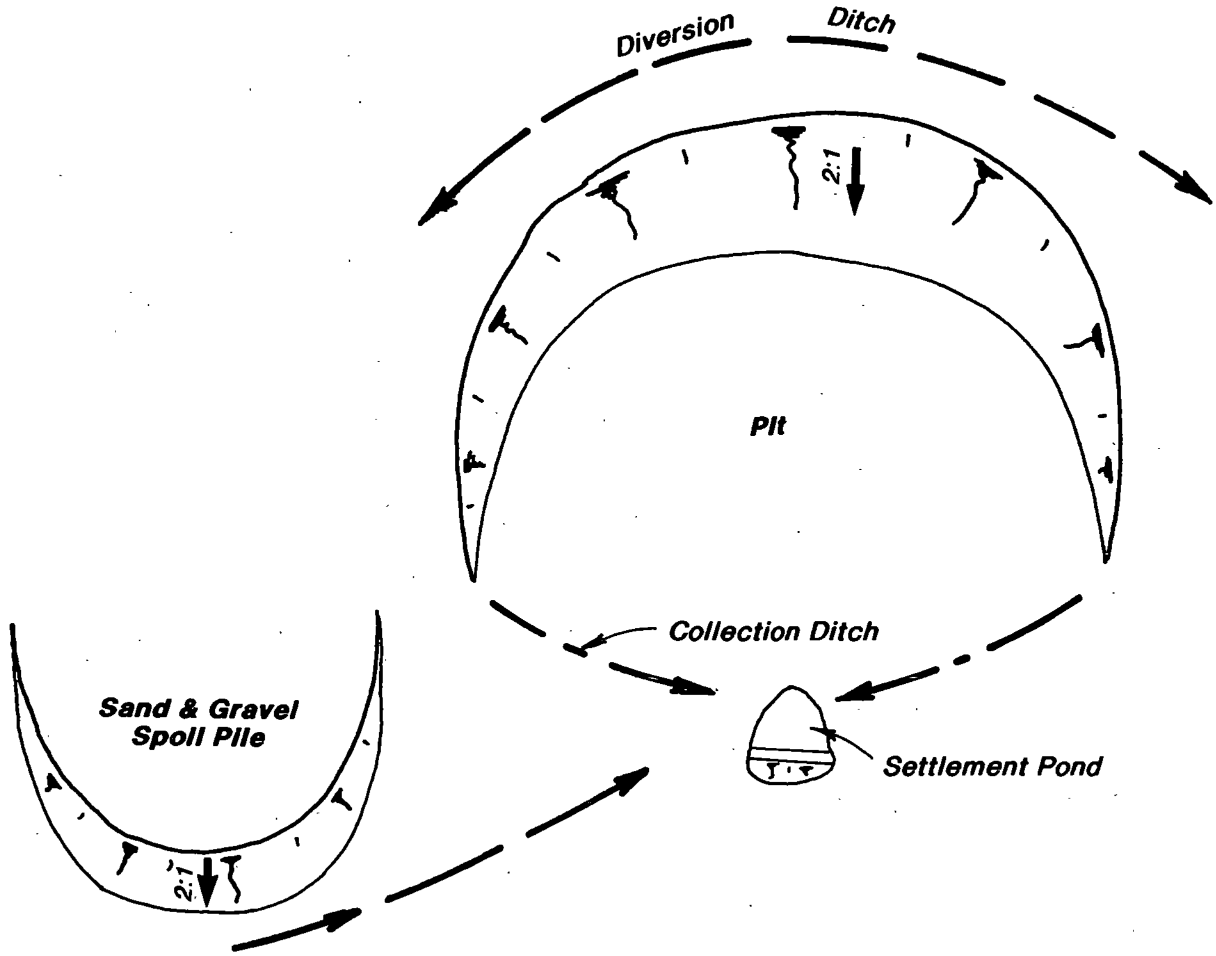


Golder Associates

SECTION SHOWING PROPOSED DAM CORE BORROW AREA KUDZ ZE KAYAH

Figure 33

Project: 952-1523I Drawn: CJC Reviewed: JCC Rev.: 10-OCT-96 R:\MINING\95\952-1523\1996\ACAD\BORROW1.DWG



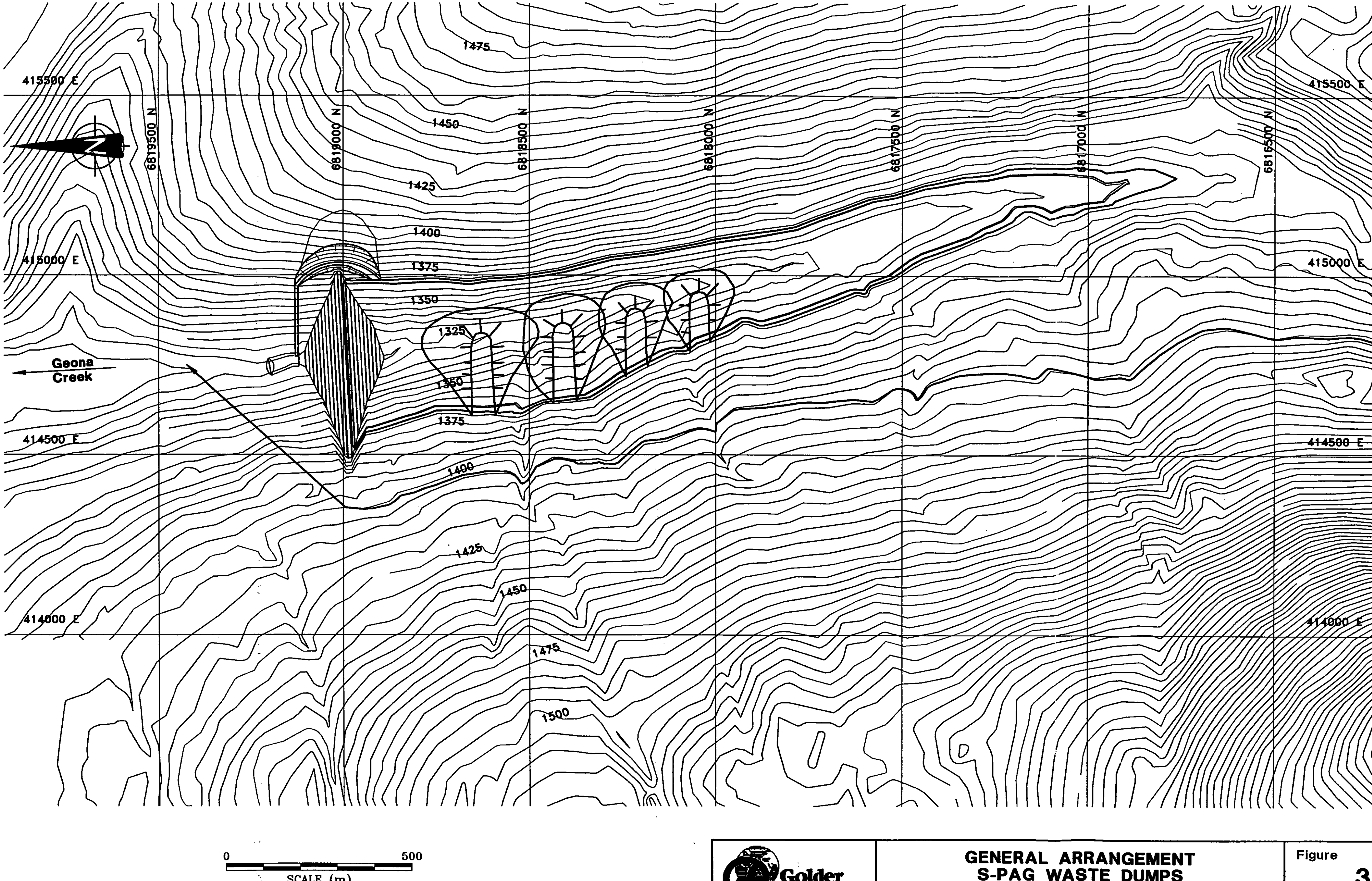
SCHEMATIC ONLY
Not to Scale

Project No. 952-15231 Drawn M.T. Reviewed .... Date Aug '96

Golder Associates

SCHEMATIC PLAN
BORROW PIT WATER MANAGEMENT

Figure 34



Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: 10-OCT-96 R:\MINING\95\952-1523\1996\ACAD\EX1.DWG

Golder Associates

GENERAL ARRANGEMENT
S-PAG WASTE DUMPS
KUDZ ZE KAYAH

Figure **35**

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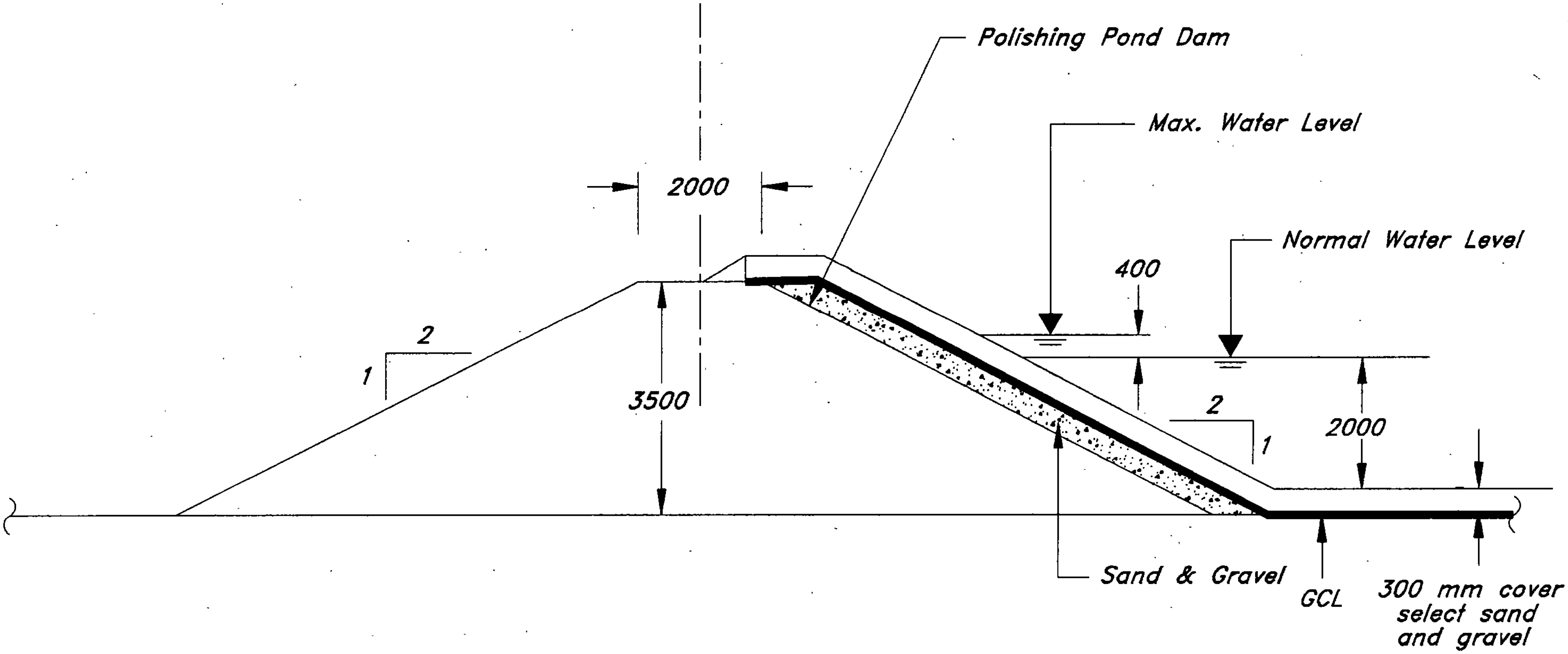
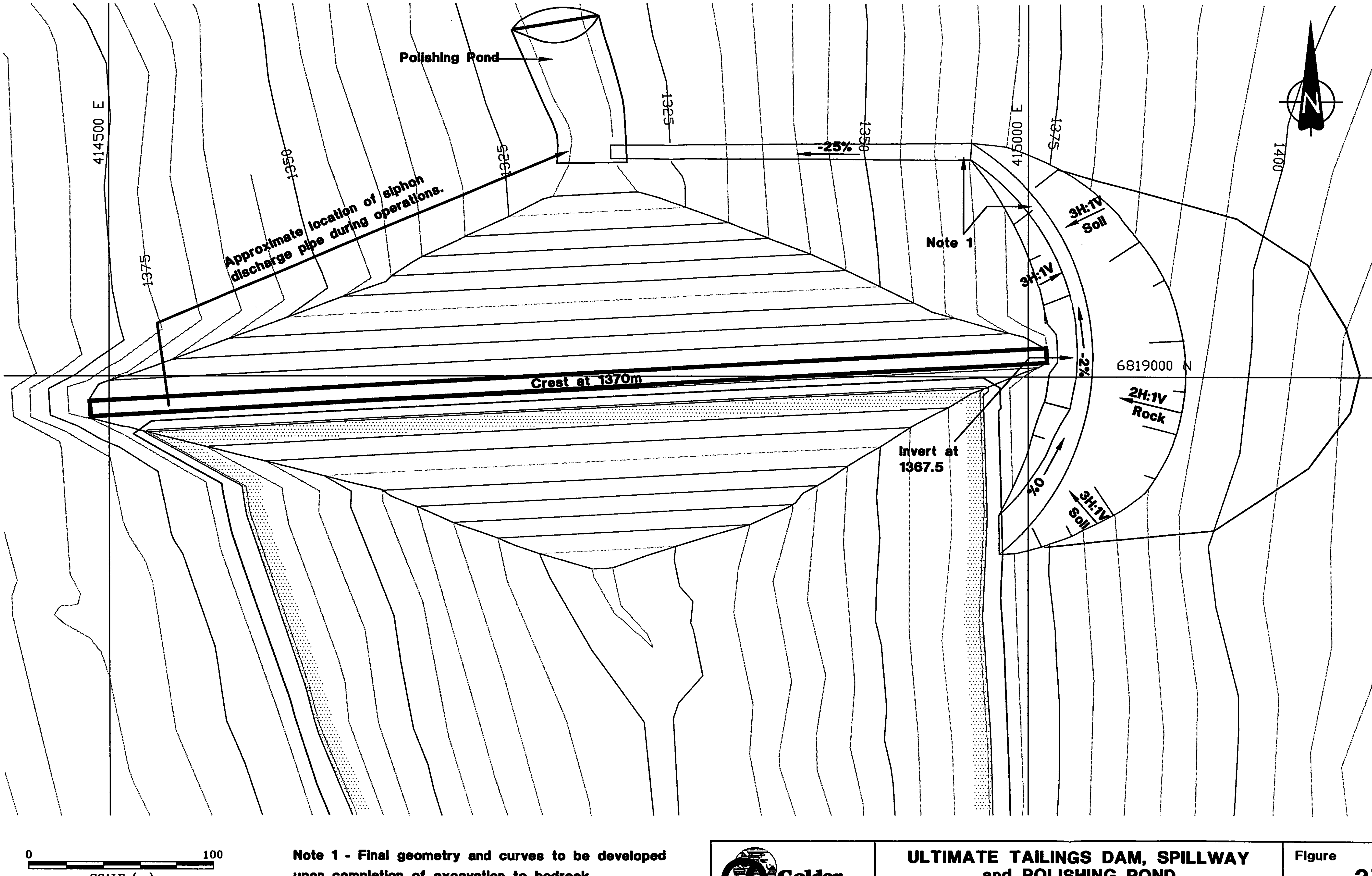


- G.C.L. = geosynthetic - clay liner
- Final geometry to be determined in the field after construction of main dam.

Project No.: 952-1523 Drawn: S.S.S Reviewed: J.C.C Rev.: 11-OCT-96	Golder Associates	**TYPICAL SECTION OF POLISHING POND DAM KUDZ ZE KAYAH**	Figure **36**



Note 1 - Final geometry and curves to be developed upon completion of excavation to bedrock.

Golder Associates

ULTIMATE TAILINGS DAM, SPILLWAY and POLISHING POND
SITE D KUDZ ZE KAYAH

Figure **37**

Project: 952-1523I Drawn: JCC Reviewed: JB Rev.: 11-OCT-96 R:\MINING\95\952-1523\1996\ACAD\EX1.DWG

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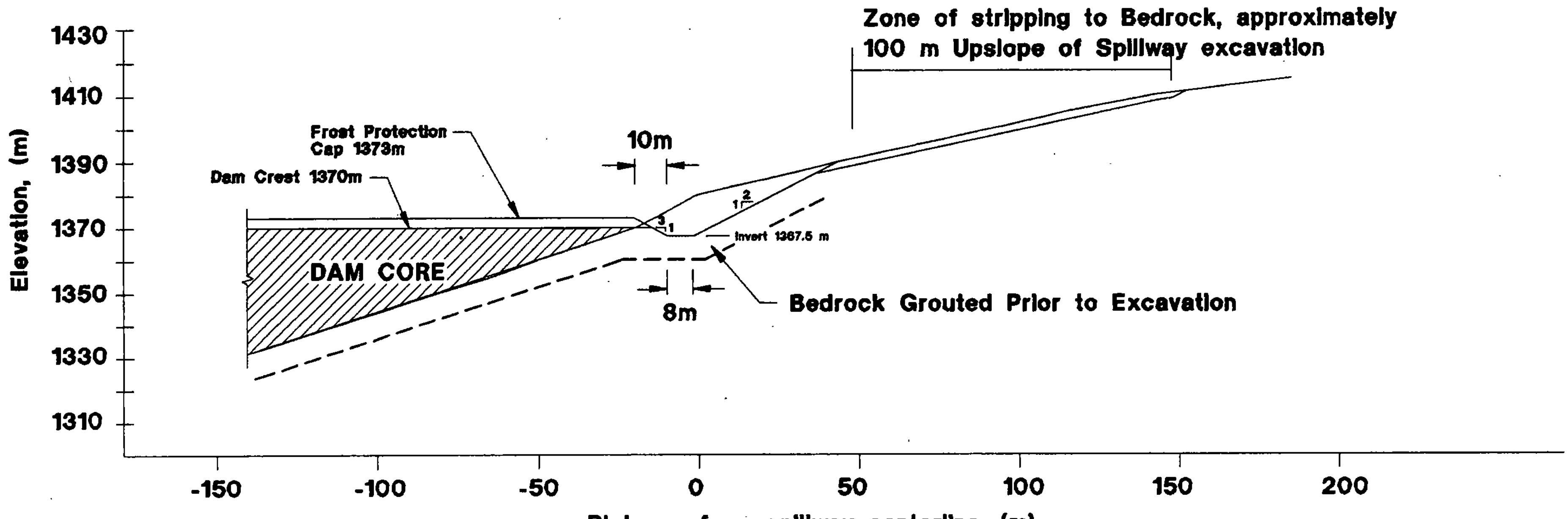
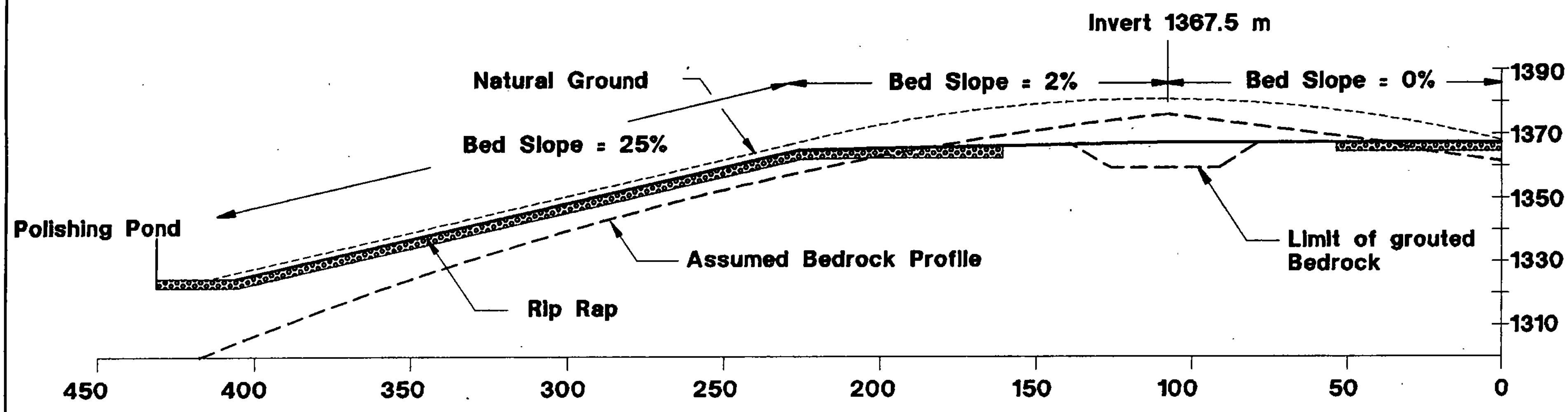


Section Along Dam Centerline



Section Along Spillway Centerline

Project No.: 952-1523!
Drawn: JCC
Reviewed: JB
Rev.: 09-OCT-96

Golder Associates

SPILLWAY DETAIL
TAILINGS DAM D
KUDZ ZE KAYAH

Figure 38

APPENDIX 8.
Assessment of Tailings

BMC MINERALS (NO. 1) LTD.
KUDZ ZE KAYAH PROJECT

TAILINGS MANAGEMENT ALTERNATIVES ASSESSMENT

PREPARED FOR:

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VA101-640/2-2
Rev 0
October 20, 2016

Knight Piésold
CONSULTING
www.knightpiesold.com

ISO 9001
ISO 14001
OHSAS 18001

FS 64925
EMS 550121
OHS 550122

BMC MINERALS (NO. 1) LTD.
KUDZ ZE KAYAH PROJECT

TAILINGS MANAGEMENT ALTERNATIVES ASSESSMENT
VA101-640/2-2

Rev	Description	Date
0	Issued in Final	October 20, 2016

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CONSULTING

EXECUTIVE SUMMARY

This alternatives assessment presents an evaluation of tailings storage concepts for the Kudz Ze Kayah Project, to support the 2016 Project Proposal and Prefeasibility Design. This report documents the process of characterization and selection of the most suitable tailings management location for the Project. The assessment includes environmental, technical, and project economic considerations.

Thirteen potential tailings storage sites were identified within approximately 10 km from the deposit. Two methods of tailings storage technology were considered: slurry and filtered tailings. The tailings technology for each candidate was selected based on site specific constraints.

Pre-screening criteria were developed to evaluate and eliminate candidates with evident shortcomings. Eight candidates were removed in the pre-screening process and four candidates were advanced to the next assessment phase. The four candidates remaining after the pre-screening were:

- **Candidate 1:** Slurry tailings facility located in Geona Creek
- **Candidate 7:** Slurry tailings facility located in the East Hanging Valley
- **Candidate 10:** Filtered tailings facility located near the current exploration camp, at the confluence of Geona and Finlayson Creeks, and
- **Candidate 12:** Filtered tailings facility located on the western hillside of Geona Creek.

Site specific information such as environmental considerations, embankment construction requirements, site water management plans, and closure objectives were then defined for each of the four candidates to provide a basis for comparison.

Environmental, technical and project economic effects were selected for consideration. Socioeconomic effects were not considered. Specific criteria within each of these categories were established; for example, within the environmental category, the criteria included waterbodies and/or wetlands affected, fish habitat affected, caribou habitat, and the potential long-term impacts of the facility.

Ratings were established to allow for a high-level ranking of the alternatives. Ratings of “preferred”, “acceptable” and “least preferred” were then assigned to the site specific criteria of each candidate to provide a means of comparison.

Candidate 12 received the preferred overall rating of the four alternatives, achieving “preferred” ratings in environmental and technical categories, and “acceptable” in project economics. This assessment indicates Candidate 12, a filtered tailings facility located on the western hillside of Geona Creek, is the preferred location for tailings and waste rock management.

Knight Piésold CONSULTING

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ABBREVIATIONS

Access	Access Consulting Group
ARD	acid rock drainage
BMC	BMC Minerals (No. 1) Ltd.
Cominco.	Cominco Ltd.
Golder	Golder Associates
KP	Knight Piésold Ltd.
KZK	Kudz Ze Kayah Project
PAC	potentially acid consuming
MAT	most appropriate technology
MMER	Metal Mining Effluent Regulations
PAG	potentially acid generating
PFS	Pre-Feasibility
SPAG	strongly potentially acid generating
Teck	Teck Resources Ltd.
tpd	tonnes per day
TSF	tailings storage facility
WPAG	weakly potentially acid generating

1 – INTRODUCTION

1.1 PROJECT DESCRIPTION

The Kudz Ze Kayah (KZK) Project is a proposed copper-zinc-lead-silver-gold mine in southeastern Yukon Territory, Canada. The project is located in the Saint Cyr Range area of the Pelly Mountains, approximately 250 km northeast of Whitehorse. The project location is shown on Figure 1.1.

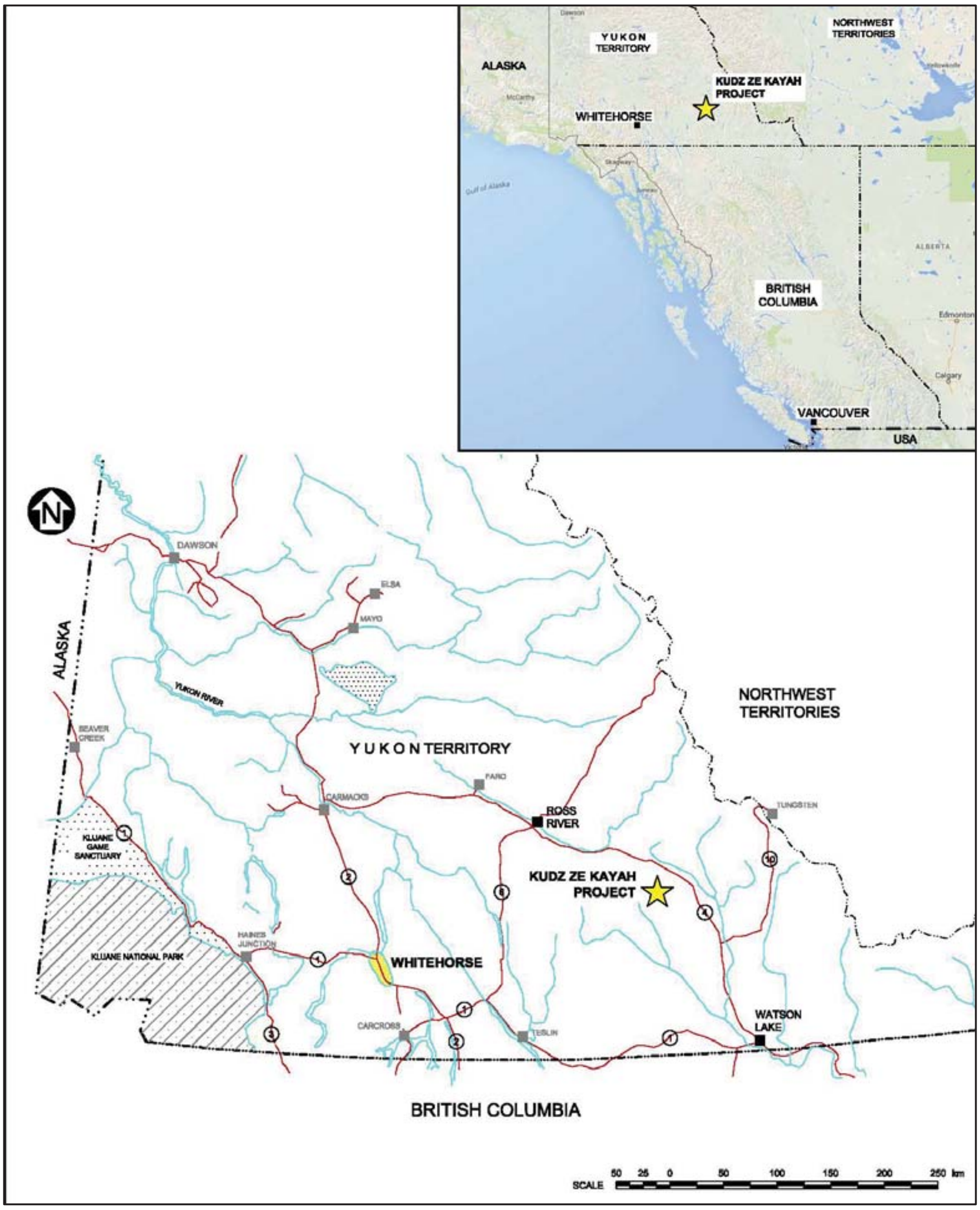

Figure 1.1 Project Location Map

BMC Minerals (No. 1) Ltd. (BMC) is currently advancing the KZK Project to a Pre-Feasibility (PFS) design stage. The resource will be extracted by open pit and underground mining methods with a milling rate of approximately 2 million tonnes per year over a 9.5 year mine life, and producing approximately 120 million tonnes of waste rock material. The topography of the KZK Project area consists of rolling hills with creeks and lakes in the valley bottoms. A small stream, Geona Creek, runs through the open pit and project area.

1.2 PREVIOUS STUDIES

The previous project owner, Cominco Ltd. (Cominco), conducted exploration work in 1994 and 1995 to delineate the ABM deposit, support engineering design and to begin baseline environmental studies. The Cominco mine plan included development of one open pit over a 9 year mine life, extraction of 9.4 million tonnes of ore, and storage of approximately 72 million tonnes of waste rock (Cominco, 1997).

A high level tailings management alternatives study was completed in 1994 by Norecol and Simons. Golder Associates (Golder) reviewed the study and prepared a high level ranking of the alternatives based on storage capacity, storage ratio, distance from the open pit, seepage, closure considerations, watersheds impacted, length of creek affected, and the lake areas affected (Golder, 1995). The areas are shown in Appendix A and summarized in Table 1.1. The desktop study ultimately recommended storing tailings in the Geona Creek valley, referred to as “Site 1D”.

Table 1.1 Historic Tailings Management Alternatives Assessment

Tailings Management Sites	
1a, 1b, 1c & 1d	Geona Creek Site A, B, C, and D ***(Recommended site)***
2	North Lakes Creek
3	East Creek
4	Lower Finlayson Creek
5	Upper Finlayson Creek
6	North Creek
7a & 7b	East Hanging Valley
8	Fault Creek
9 & 10	North Hanging Valley Upper and Lower

The proposed tailings and waste rock management strategy included the following:

- A Tailings Storage Facility (TSF) located in Geona Creek to contain strongly potentially acid generating (SPAG) slurry tailings material, as well as well as SPAG waste rock. The closure plan included permanently covering the tailings and waste rock with water.
- Weakly potentially acid generating (WPAG) waste rock was to be stored temporarily on surface and hauled to the open pit at closure and placed below the final water level in the flooded pit.
- Non-acid generating (NAG) waste rock was to be permanently stored on surface.

Cominco completed site investigation programs in 1995 and 1996 to support the mine design (Golder, 1996). The feasibility study for the KZK project was completed in 1998 and the project was approved under the Canadian Environmental Assessment Act (Screening Level Assessment) and received a Water Licence, however project development ceased after 1998 (Cominco, 1997).

BMC acquired the KZK Project in February 2015. BMC completed additional site investigations in 2015 to update the mineral resource estimation to support an updated mine plan. The updated mineral resource estimation and total waste rock produced includes 18.1 million tonnes of ore and 121 million tonnes of waste rock, which is greater than the previous Cominco mine plan of 9.4 million tonnes of ore and 72 million tonnes of waste rock.

1.3 SCOPE OF WORK

This report presents the preliminary assessment of tailings management concepts to support the KZK Project PFS design and Project Proposal. The objective of this alternatives assessment is to locate the most suitable project specific solution to manage the tailings material for the life of mine and post closure.

A total of thirteen alternatives were evaluated. Factors considered in this evaluation were environmental, technical and economic project impacts. Socio-economic considerations were not included in this assessment. This report is intended to present a preliminary technical recommendation based on the current project information.

2 – TAILINGS AND WATER MANAGEMENT

2.1 INTRODUCTION

This section summarizes project specific tailings, waste rock and water management details and design considerations. This information should be updated as the project develops and additional studies are completed.

Geotechnical and geochemical design considerations are required for long-term physical and geochemical stability. Consideration of these sometimes opposing design objectives is required to determine the most appropriate site specific tailings and water management strategy. The alternatives considered in this assessment incorporate the Most Appropriate Technologies (MAT) for tailings and water management that will reduce project specific physical, environmental, and economic risks.

2.2 TAILINGS

Tailings are defined as the fraction of processed ore produced at the mill that is not considered to be economically valuable. Tailings are managed as a waste material and require a geotechnically and geochemically stable storage option that will manage the tailings throughout the mine life and after closure.

The tailings throughput for the KZK Project is approximately 5,500 tonnes per day (tpd), over a 9.5 year mine life. The total tonnage of tailings material is approximately 15.3 million tonnes based on the current mineral resource estimate (18.1 million tonnes as ore). All the tailings material is considered to be SPAG. This alternatives assessment assumes all tailings produced during the life of mine will be stored on surface and produced in one tailings stream.

Tailings characteristics such as particle size, geochemistry, and rheology were not available at the time of this report; therefore this assessment assumes the tailings materials are amenable to filtration at a feasible cost. Tailings technology optimizations (such as splitting the tailings stream into PAG and NAG streams, or coarse and fine streams) were not considered for this report but may be considered in future studies.

2.3 TAILINGS TECHNOLOGIES AND MANAGEMENT STRATEGIES

The tailings continuum is shown on Figure 2.1. The continuum qualitatively describes the tailings solids content, the thickening/dewatering effort required, the method of conveyance, and segregation potential of the tailings.

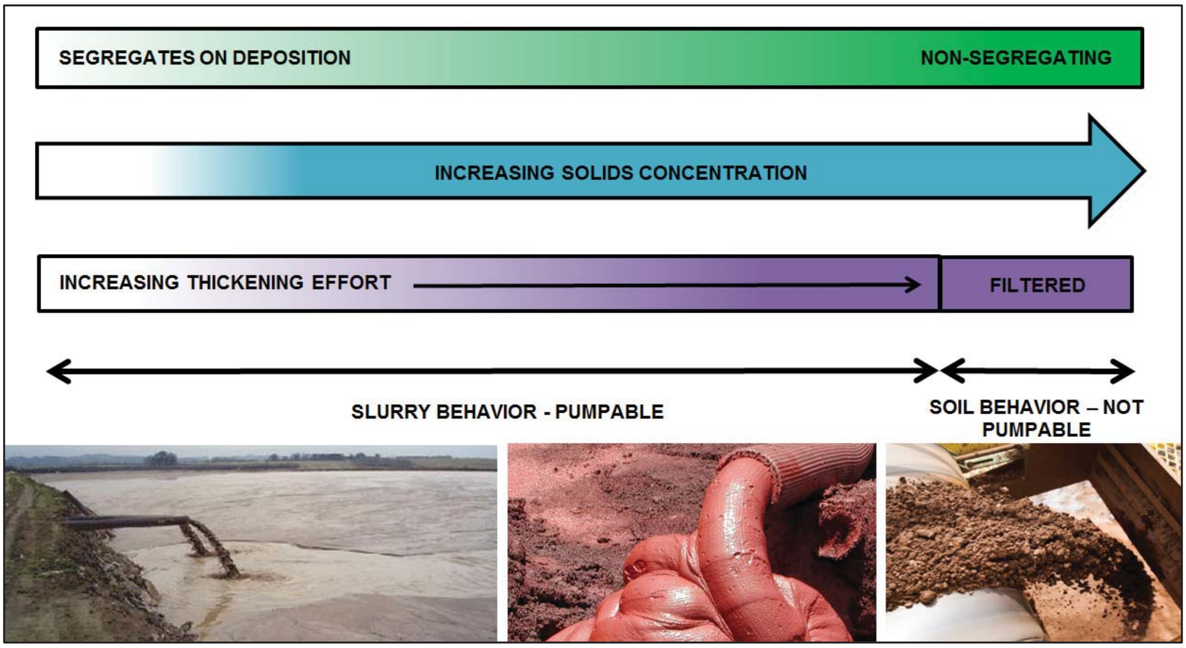

Figure 2.1 Tailings Continuum

The tailings solids content (i.e.: pumpable versus non-pumpable) is one aspect of the overall tailings management strategy, however, the tailings technology used will impact many other aspects of the project, therefore it should be considered when determining the mine development concept. The following section describes the tailings technologies considered in this assessment and reasoning for the inclusion or exclusion of certain technologies.

2.3.1 Slurry Tailings

Slurry tailings include the full range of pumpable tailings, as shown on Figure 2.1. Slurry tailings with a solids content of approximately 20 to 40% are typically referred to as conventional slurry tailings. This assessment assumes that slurry tailings are piped, using gravity and/or pumping, to a TSF. The average dry density of the tailings slurry was assumed to be 1.3 t/m^3 to estimate storage volume requirements.

Some advantages of conventional slurry tailings are that no additional processing is required following the milling process, and tailings can be pumped to a remote facility.

Slurry tailings can be thickened at the mill to extract additional water for re-use; however slurry tailings with any solids concentration will consolidate to a consistent density regardless of the moisture content at discharge. This assessment did not include considerations for thickening the tailings, since the KZK project is not anticipated to experience a water deficit; however, thickening could be examined in future studies.

Paste or “ultra-thickened” tailings offer maximum water recovery while maintaining the ability to pump the slurry tailings. Surface storage of paste tailings was not considered in this alternatives assessment but could be investigated in future studies if it is identified as an opportunity for optimization.

2.3.2 Non-Pumpable Tailings (Filtered)

Filtered tailings are mechanically dewatered to a point where they behave as a soil. Mechanical dewatering can be achieved through vacuum and pressure filtration processes. The alternatives assessment conducted by Norecol and Simons in 1994 did not consider filtered tailings as an option for tailing management.

This assessment assumes filtered tailings will be transported by truck to the TSF. The moisture content of the filtered tailings is assumed to be approximately 15 to 20% with an average dry density of 1.6 t/m^3 to estimate the storage volume requirements. The use of filtered tailings technology was selected for consideration in this assessment based on the benefits and disadvantages outlined below.

The benefits of filtered tailings, as they relate specifically to the KZK Project, are:

- Filtered tailings have been implemented successfully for low throughput operations of around 20,000 tpd or less, therefore there is a precedent for this technology to be successful at the KZK Project (5,500 tpd).
- Separation of tailings and water reduces the potential consequence in the event of a facility failure because tailings material cannot be mobilized by supernatant water.
- Filtered tailings can be progressively capped for reclamation, allowing for re-contouring, and resulting in a stable landform with a walk-away closure solution at the end of the mine life.

Disadvantages or risks associated with filtered tailings technology, as they relate specifically to the KZK Project, are:

- Filtration technology generally has a higher capital and operating costs associated with power consumption and the maintenance required. The KZK Project is located in a remote northern climate; therefore there will be an increased power generation demand, and standby filters may be required to prevent delays to production in the event the tailings filters are incapacitated.
- Desaturated PAG tailings may generate ARD and metal leaching when exposed to the environment. The design of the facility and water management plan will require long-term geochemical stability considerations.
- The physical properties and geochemistry of the tailings will determine the feasibility of filtration technology.
- Dust generation may add to operating costs.

2.4 WASTE ROCK

Waste rock material from the Open Pit and underground workings is classified into three categories, based on the ARD test results provided by BMC in April 2016:

- Class A material: strongly potentially acid generating (SPAG) – 8.4 M tonnes
- Class B material: weakly potentially acid generating (WPAG) – 35 M tonnes, and
- Class C material: potentially acid consuming (PAC) – 78 M tonnes.

Class A waste rock material will be encapsulated in the tailings mass for all slurry and filtered options. The total volume of Class A material is approximately 4 Mm^3, assuming a density of 1.9 t/m^3.

Class B waste rock material is to be stored on the surface of the western slopes, adjacent to the Open Pit. This location is similar to the location identified in the Cominco design (Golder, 1996). The location of the Class B storage facility was assumed to be the same for all the candidates considered. This material is assumed to be encapsulated at closure for permanent storage. The total volume of Class B material is approximately 18 Mm^3, assuming a density of 1.9 t/m^3.

Class C waste rock material will be stored on surface adjacent to the Open Pit in the East Hanging Valley area, in approximately the same location as proposed in the Cominco design (Golder, 1996). The location of the Class C storage facility was assumed to be the same for all alternatives considered in this report. The long term water quality from the Class C runoff and seepage is assumed to be acceptable for discharge to the environment without treatment. The material has been treated as a zero-cost construction rock fill material for this assessment. The total volume of Class C material is approximately 42 Mm^3, assuming a density of 1.9 t/m^3.

2.5 WATER MANAGEMENT

Water management is a critical component of the successful design, operation and closure of a tailings facility. Water management strategies include reducing contributing catchment areas, diversion of non-contact water, and effective capture and management of contact water. This section outlines the water management considerations included in this assessment. The KZK site is anticipated to be in an annual site water surplus for each alternative considered (Access, 2016a).

This assessment assumes slurry tailings options are covered with water at closure, in perpetuity, to prevent acid generation. Slurry facilities have been located in valleys and areas where the storage ratio of embankment material to tailings storage is preferable. Emergency site water storage is included in the design capacity of the tailing storage facility.

This assessment assumes filtered tailings material is encapsulated with a low permeability material and sealed from oxygen contact to prevent acid generation and seepage to the downstream environment in the long-term. Filtered tailings facilities have been located in topographically flatter areas to minimize water ponding on the facility surface and allow diversion of non-contact water away from the facility. Filtered tailings alternatives require additional water management ponds to store site water. It is presumed the water management pond will be located in Geona Creek during the life of mine and decommissioned at closure. Emergency site water storage is included in the design capacity of the water management pond(s).

3 – ALTERNATIVES ASSESSMENT METHODOLOGY

This section outlines the methodology and assumptions used in this alternatives assessment.

3.1 INTRODUCTION

Environment Canada published the *Guidelines for the Assessment of Alternatives for Mine Waste Disposal* in September 2011. These guidelines are intended to be used by project proponents to evaluate of mine waste and water management alternatives. The guidelines are recommended if a project proponent is considering using a natural water body frequented by fish as a tailings and waste management facility, which would require a Schedule 2 amendment to the Metal Mining Effluent Regulations (MMER) of the Fisheries Act of Canada. The guidelines were used as a general framework for this alternatives assessment.

3.2 PRELIMINARY CANDIDATES

The first step in determining the preferred mine waste and water management strategy was to define preliminary tailings facility locations based on threshold criteria.

The threshold criteria established for the KZK Project included:

- To locate the facility within a 10 km radius of the Open Pit
- To locate the facility in an area of practical topography and with access to the Open Pit
- To not use subaqueous storage of tailings in existing lakes, and
- To use a single facility for tailings management.

The locations from the historic Cominco tailings management alternatives assessment were included in this assessment due to their relative proximity and favourable topography for slurry tailings impoundments (Candidates 1 to 9). These locations were re-developed for the 2016 mine plan waste quantities. Four new TSF alternatives were developed for filtered tailings management (Candidates 10 to 13) based on the threshold criteria.

The candidates are summarized below in Table 3.1 and shown on Figure 3.1.

Table 3.1 Preliminary Candidates

Slurry Tailings Candidates (Adapted from 1994 Assessment)		Filtered Tailings Candidates (2016 Assessment)	
1	Geona Creek	10	Exploration Camp
2	North Lakes Creek	11	Long Haul
3	East Creek	12	Western Hillside
4	Lower Finlayson	13	Adjacent to Open Pit
5	Upper Finlayson		
6	North Creek		
7	East Hanging Valley		
8	Fault Creek		
9	North Hanging Valley		

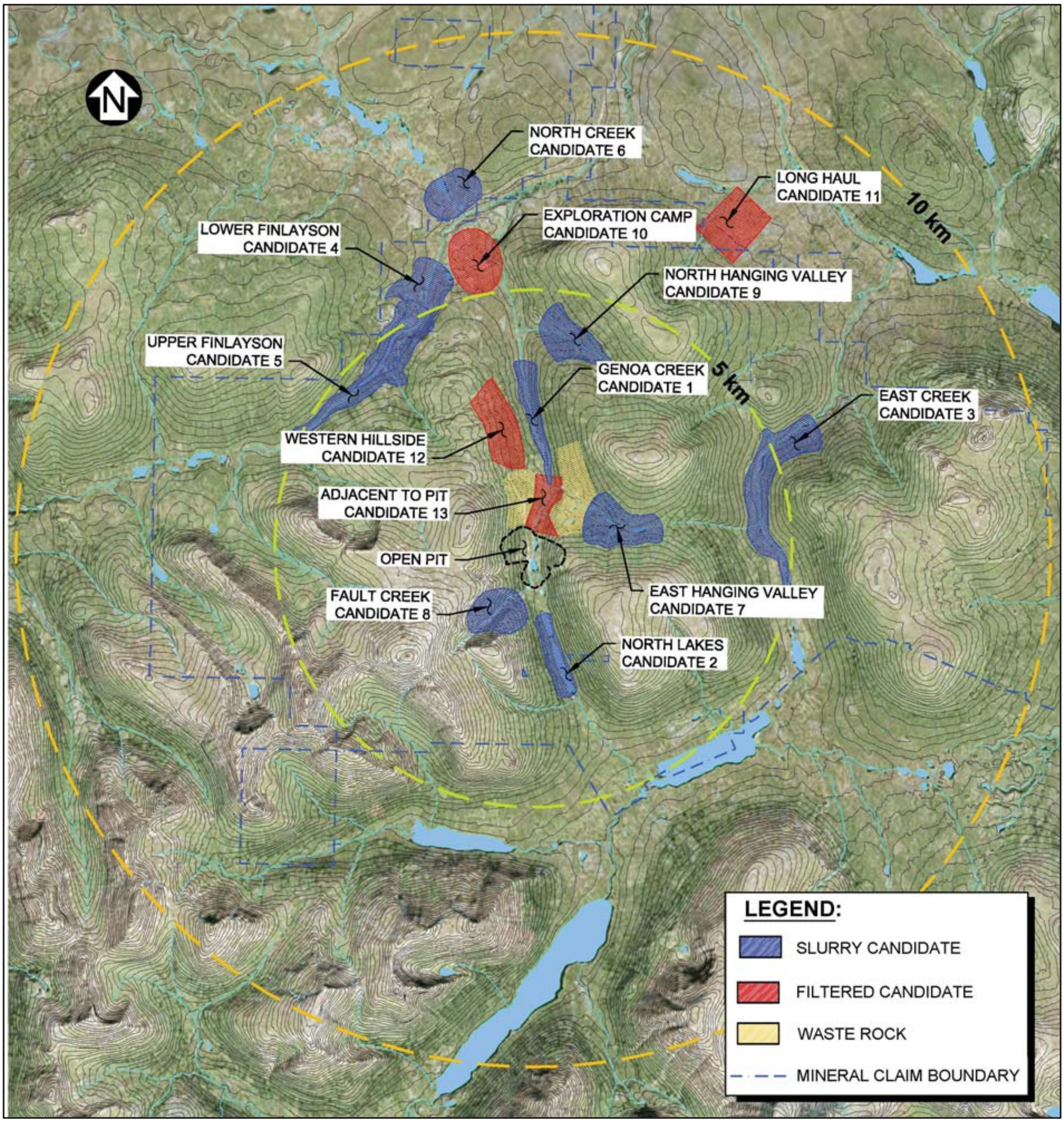

Figure 3.1 Preliminary Candidates

3.3 PRE-SCREENING ASSESSMENT

The second stage of the assessment was to apply pre-screening criteria to each of the candidates, with the goal of eliminating candidates with perceived fatal flaws and carrying the remaining candidates forward for further analysis. Pre-screening questions were developed with input from BMC. The pre-screening criteria and the results of the assessment are summarized in Table 3.2.

Table 3.2 Pre-Screening Assessment

Pre-Screening Criteria	Candidates												
	1	2	3	4	5	6	7	8	9	10	11	12	13
The facility is unable to reasonably contain the required volume of tailings and Class A material (very poor storage ratio of tailings to embankment material)						✓		✓	✓				
The facility is located outside the BMC mineral claim boundary						✓					✓		
There are significant water management issues associated with this option		✓											
The facility is located in a catchment area outside of Geona Creek, increasing the environmental footprint of project		✓	✓	✓	✓	✓					✓		
Starter dam material requirement is in excess of the initial material availability						✓		✓	✓				
The facility prevents re-establishment of flow of Geona Creek at closure													✓
The alternative passes the pre-screening criteria and should be carried forward for further assessment	✓						✓			✓		✓	

Candidates 2–6, 8, 9, 11, 13 were precluded from further assessment based on the pre-screening criteria, and Candidates 1, 7, 10, 12 were carried forward for further assessment.

3.4 CHARACTERIZATION OF THE PRE-SCREENED CANDIDATES

The candidates remaining after the pre-screening process were then characterized in detail. The purpose of the characterization was to provide details that could be used to compare the candidates. The four remaining candidates for tailings management are shown in Figure 3.2:

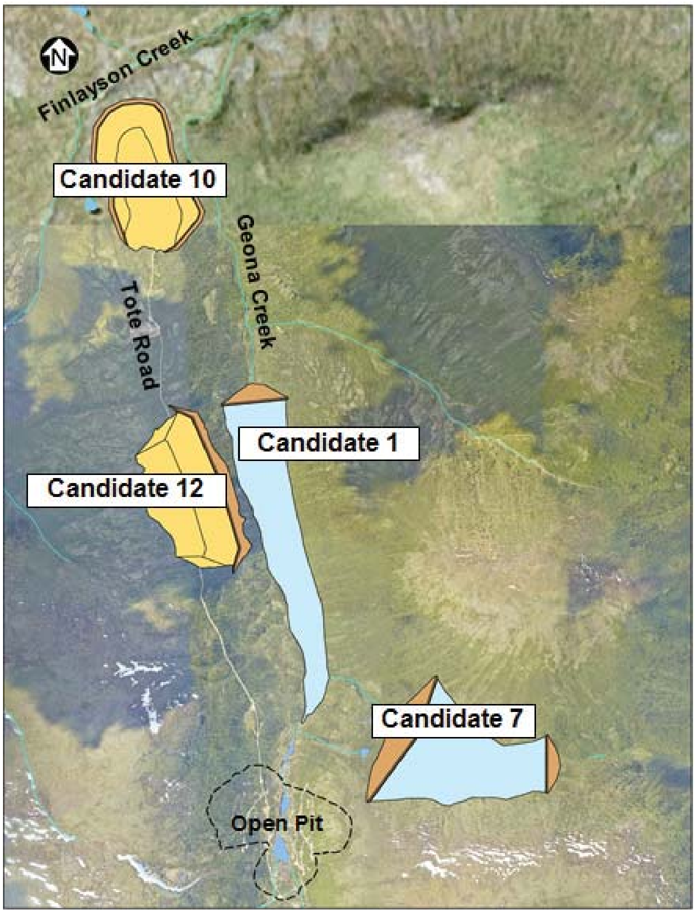

Figure 3.2 Pre-screened Candidates

3.4.1 Candidate 1

Candidate 1 (previously referred to as Geona Creek "Site D") was the preferred tailings facility location for the Cominco mine plan. The previous design was updated to include the increased tailings and waste rock tonnages from the 2016 BMC mine plan. Candidate 1 is shown in Figure 3.3.

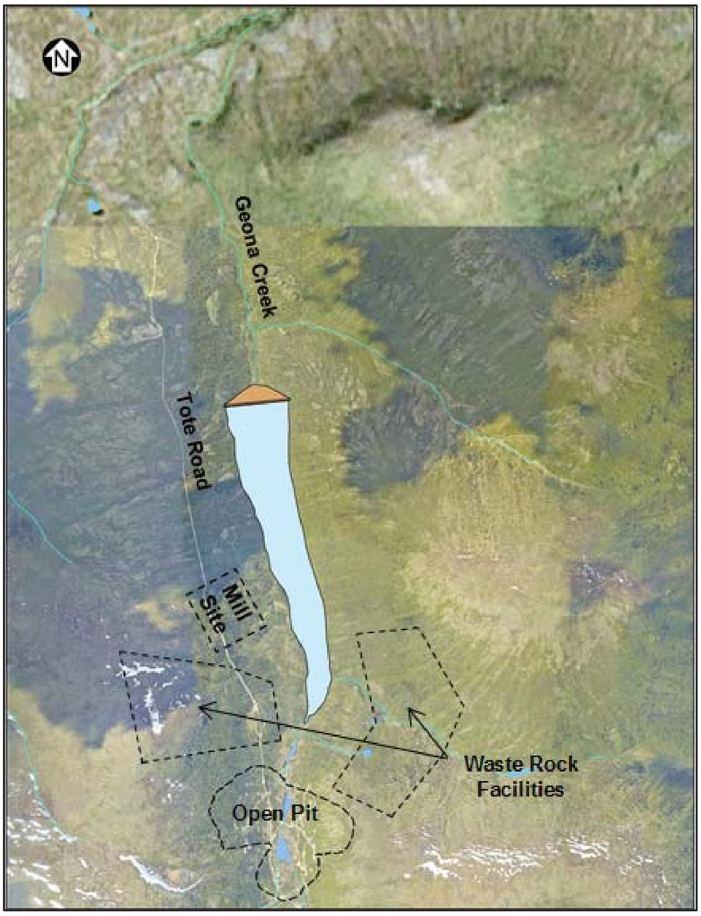

Figure 3.3 Candidate 1

The Geona Creek site is approximately 3 km from the Open Pit. Candidate 1 is a conventional slurry tailings facility with a water cover over the entire facility to prevent ARD. Slurry tailings discharged to a TSF located close to the Open Pit and Mill is cost efficient since no additional processing is required after the milling process, and the tailings can be gravity discharged from the Mill to the facility.

Candidate 1 requires one dam to contain the tailings material in Geona Creek valley. The embankment height is approximately 50 m and the total estimated volume of material required to construct the embankment is 2.3 Mm^3 (a 140,000 m^3 starter dam is required). The total footprint of the facility is approximately 60 ha.

The construction of the facility would permanently alter approximately 3.4 km of Geona Creek, from the Open Pit area to the downstream toe of the tailings embankment. Grayling do not overwinter in Geona Creek, however there is seasonal migration from the downstream environment and spawning in Geona Creek (Access, 2016).

Tailings and waste rock will be co-disposed in the TSF. Placing tailings and waste rock in Geona Creek may require a Schedule 2 amendment to the Fisheries Act of Canada. The tailings and waste rock will be permanently submerged, and at closure the creek will be re-established over the facility, and pass over the embankment through a spillway. This alternative is considered a permanent removal of the creek, however flow will be returned to Geona Creek at the end of the mine life.

The tailings facility embankment would be constructed from Class C rockfill and includes a low permeability core. There is opportunity to buttress the embankment with additional material to increase the overall stability of the facility due to the abundance of Class C construction material. There are potential opportunities for optimization of this alternative, such as separating tailings streams into PAG and non PAG material so large non PAG beaches could be developed, reducing the extent of the water cover on the facility.

The area is anticipated to have discontinuous permafrost (KP, 2016). Permafrost conditions would require investigation, design considerations and monitoring. Long-term closure objectives will require consideration of changing permafrost conditions due to climate change.

The geotechnical and hydrogeological conditions beneath the tailings facility in Geona Creek were investigated by Golder in 1995 and 1996, Tetra Tech and KP in 2015. Overburden thickness in the area ranges from 10 to 20 m and generally consists of glaciofluvial deposits (KP, 2015). Bedrock in the Geona Creek area generally consists of weathered to slightly weathered, highly fractured sedimentary mudstone schist and mafic ash tuff and fresh bedrock is found at approximately 50 m in depth and generally consists of highly fractured sedimentary mudstone schist (KP, 2015).

Bedrock hydraulic conductivity in the Geona Creek area ranges from 2E-05 cm/s to 3E-03 cm/s, with artesian conditions (KP, 2015). The hydraulic conductivity values could indicate additional seepage control measures may be required. The Cominco design included grouting the bedrock beneath the embankment as a seepage control measure. An advantage of Candidate 1 is the seepage path from the facility is contained in the valley bottom and the direction of seepage is predictable, so seepage can be monitored and managed downstream.

The closure plan for Candidate 1 is unchanged from the Cominco design. The Open Pit will gradually fill with groundwater after closure. The closure of the facility includes a water cover flowing from the Open Pit area over the facility and through a spillway. The facility and downstream environment will be re-vegetated and will remain saturated long-term and water quality will mimic pre-mining conditions.

3.4.2 Candidate 7

Candidate 7 is located in the East Hanging Valley, east of the Open Pit and near the location of the proposed Class C Storage Facility. Candidate 7 is shown in Figure 3.4:

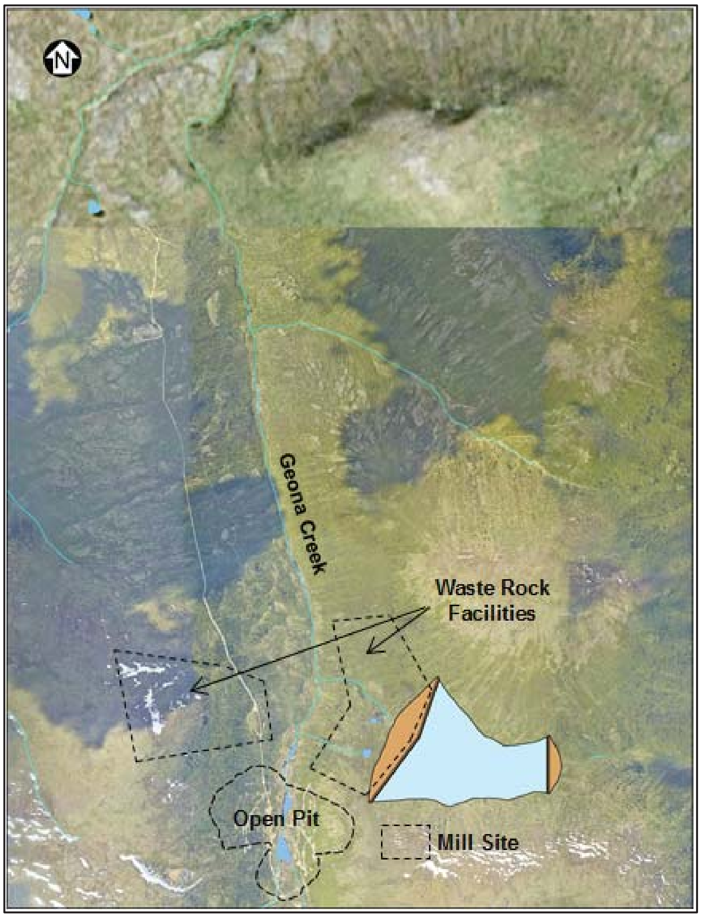

Figure 3.4 Candidate 7

Candidate 7 is a conventional slurry tailings facility with a water cover. Two embankments are required to contain the slurry tailings and waste rock material in the valley. The embankments would be constructed from Class C rockfill and includes a low permeability core. The Class C waste rock storage facility will be constructed downstream of the main embankment, creating a massive buttress and increasing the stability of the facility.

The East Hanging Valley site is approximately 1.5 km from the Open Pit. The Mill Site shown in Figure 3.4 has been re-located to the hillside above the facility for this option. Slurry tailings located in a facility close to the Open Pit and Mill area is cost efficient. The ore haul from the Open Pit will require an elevation gain of approximately 150 m, which will increase the cost of tailings management, however, no additional processing is required after the milling process and tailings could be gravity discharged from the Mill to the TSF.

The estimated embankment height is 75 m and the total estimated volume of material required to construct the embankment is 9 Mm^3 (a 540,000 m^3 starter dam is required). The total footprint of the facility is approximately 130 ha.

The East Hanging Valley contains a small tributary stream to Geona Creek, however no fish have been identified in this area and it is not considered fish habitat (Access, 2016). Constructing a tailings facility in this location would not directly impact fish habitat but may reduce the flows in Geona Creek.

Minimal exploration, geotechnical or hydrogeological site investigations have been completed in this area. Tetra Tech completed one monitoring well installation in 2015 in this area (Tetra Tech, 2015). Geotechnical and hydrogeological site investigations will be required in the area to investigate seepage potential. The facility straddles two catchment areas, increasing the water management requirements, and complicating seepage monitoring and control because PAG seepage from the tailings facility could potentially report in multiple directions. Detailed hydrogeological investigation, groundwater modelling and monitoring may be required to predict and mitigate seepage.

The facility includes a permanent water cover to prevent acid generation in the tailings and waste rock materials. There are potential opportunities for optimization of this alternative, such as separating tailings streams into PAG and non PAG material so large non PAG beaches could be developed, reducing the extent of the water cover on the facility.

The area is anticipated to have discontinuous permafrost (KP, 2016). Permafrost conditions would require investigation, design considerations and monitoring. Long-term closure objectives will require consideration of changing permafrost conditions due to climate change.

3.4.3 Candidate 10

Candidate 10 is a filtered tailings facility located in the approximate area of the current exploration camp, near to the confluence of Finlayson and Geona Creek. Candidate 10 is shown in Figure 3.5:

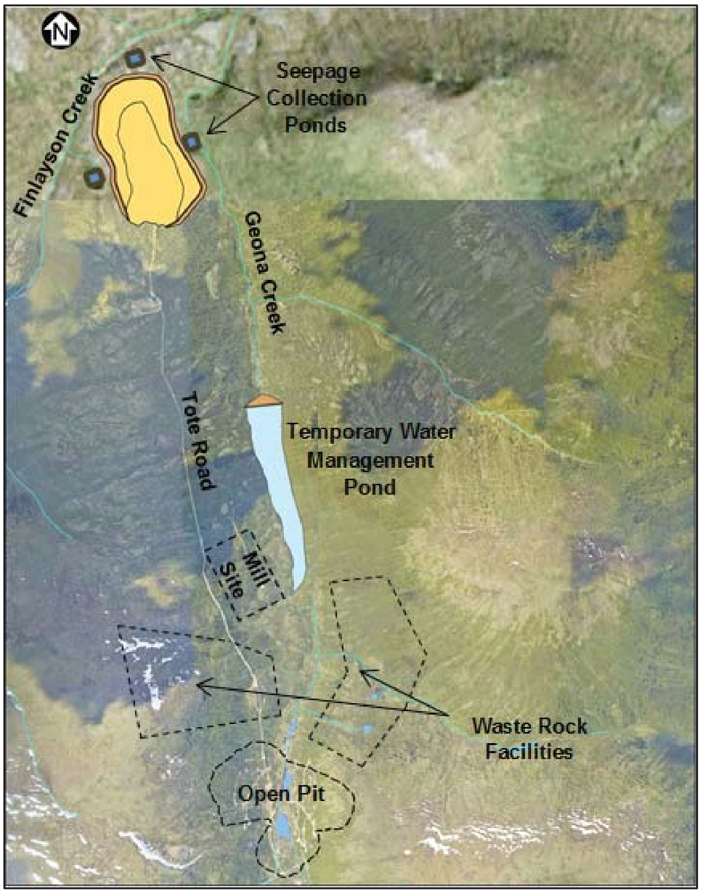

Figure 3.5 Candidate 10

Candidate 10 is located approximately 7 km from the Open Pit. The facility would be constructed from filtered tailings and waste rock material hauled by truck and placed and compacted. A water management pond is required to store site surplus water, and will be removed at closure. The water management pond is assumed to be located in Geona Creek, close to the Open Pit and Mill Site.

The estimated buttress height to contain the filtered tailings is approximately 15 m and the total estimated volume of material required to construct the buttress is 2.7 Mm^3. The footprint of the facility is approximately 100 ha. Hauling filtered tailings from the Mill Site to the Candidate 10 area is a negligible elevation change, but is a moderate haul distance therefore it will increase the tailings management costs.

No exploration, geotechnical or hydrogeological site investigations have been conducted in this area. Geotechnical and hydrogeological site investigations will be required. Seepage could theoretically report to two drainages (Finlayson and Geona Creek) since the facility is located on a catchment divide.

The area does not contain any water bodies and is therefore not considered to be fish habitat, however constructing the facility in this area may temporarily alter the seasonal flows to Finlayson and Geona Creeks during the mine life.

Foundation preparation beneath the facility would include a low permeability foundation, with drains to convey and collect seepage. Seepage collection ponds are located around the facility. The buttress would be constructed with a Class C material.

The area is anticipated to have discontinuous permafrost conditions (KP, 2016). Permafrost conditions would require investigation, design considerations and monitoring. Long-term closure objectives will require consideration of changing permafrost conditions due to climate change.

The closure plan for the facility includes progressive reclamation with a low permeability cover. The cover would limit water and oxygen infiltration into the tailings and Class A waste rock material. The facility would be covered with Class C waste rock as frost protection for the low permeability material, and re-vegetated.

3.4.4 Candidate 12

Candidate 12 is a filtered tailings facility located on the western slope of Geona Creek valley. Candidate 12 is shown on Figure 3.6.

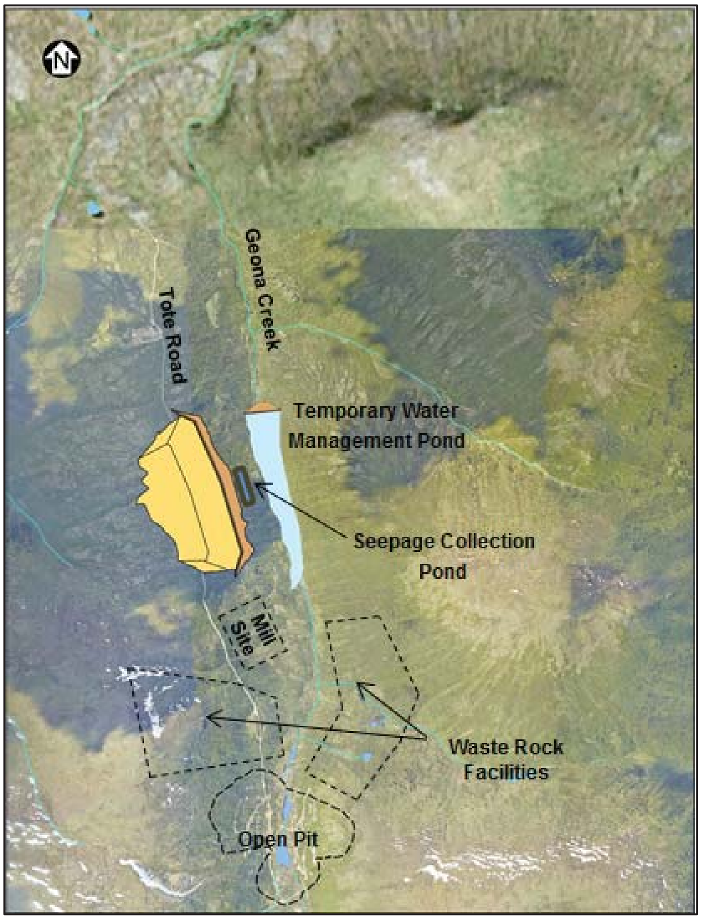

Figure 3.6 Candidate 12

Candidate 12 is located approximately 3 km from the Open Pit. The estimated buttress height is 30 m and the total estimated volume of material required to construct the buttress is 1.4 Mm^3. The buttress would be constructed with Class C material. Class C material is considered to be low cost, readily available construction material.

The total footprint of the facility is approximately 100 ha. Hauling filtered tailings from the Mill Site to the facility requires an elevation gain of 50 m, but short haul distance of 0.3 km, reducing the cost to manage tailings and challenge of handling the material in the winter.

The area does not contain any water bodies and is not considered fish habitat however constructing the facility in this area may temporarily alter the seasonal flows to Finlayson and Geona Creeks during the mine life.

Minimal exploration, geotechnical or hydrogeological site investigations have been completed in this area. Test pit were completed by Golder in 1995 and 1996 in the area of the facility buttress (Golder, 1997). The seepage path from the facility is towards Geona Creek, which simplifies collection and mitigation measures. Foundation preparation for the facility would include a low foundation, with drains to convey and collect seepage.

The area is anticipated to have discontinuous permafrost conditions (KP, 2016). Permafrost conditions would require investigation, design considerations and monitoring. Long-term closure objectives will require consideration of changing permafrost conditions due to climate change.

The closure plan includes progressive reclamation with a low permeability cover. The cover would limit water and oxygen infiltration into the tailings and Class A waste rock material. The facility would be covered with Class C waste rock as frost protection for the low permeability cover, and re-vegetated.

4 – RATING AND RANKING OF ALTERNATIVES

Site specific characterization criteria were developed to compare the candidates. The criteria are grouped into three categories: environmental, technical, and project economics. The criteria are summarized below:

- **Environmental**
  - Waterbodies and/or wetlands affected
  - Fish habitat affected
  - Caribou habitat
  - Long-term impact of facility
- **Technical**
  - Tailings technology
  - Geochemical stability (ARD mitigation)
  - Geotechnical characterization
  - Hydrogeological characterization
  - Dam requirements
  - Water management
- **Project Economics**
  - Tailings technology
  - Short-term closure requirements
  - Long-term closure requirements

Ratings were developed to compare the criteria. Ratings are “preferred”, “acceptable” and “least preferred”. Table 3.4 summarizes the ratings and their descriptions.

Table 4.1 Ratings and Descriptions

Rating	Environmental	Technical	Project Economics
Preferred	Negligible impact to the environment	Conditions are thoroughly understood, design objectives are feasible	Negligible impact to project costs
Acceptable	Impact to the environment with feasible mitigation	Conditions are unknown or known to be challenging, however design objectives are feasible	Cost to implement is anticipated to be within project budget, however may be a risk to the project in different market conditions
Least preferred	Impact to the environment with challenging mitigation	Design objectives or requirements add potential risks to the project	Cost to implement is anticipated to be a risk to the project

The ratings were then applied to the criteria of each candidate. The resulting ratings and their specific justifications are summarized in Tables 3.4, 3.5 and 3.6.

Table 4.2 Environmental Impacts

Criteria	Candidate 1		Candidate 7		Candidate 10		Candidate 12	
	Details	Rating	Details	Rating	Details	Rating	Details	Rating
Waterbodies and/or wetlands affected	Geona Creek is permanently altered, but flow is re-established at end of mine life. Wetland areas of Geona Creek are permanently altered, but habitat compensation is possible	Acceptable	East Hanging Creek is a tributary of Geona Creek. Wetland/marsh areas in the East Hanging Valley are permanently altered, but habitat compensation is possible	Acceptable	Water pond constructed in Geona Creek, but removed at closure. No permanent impacts	Preferred	Water pond constructed in Geona Creek, but removed at closure. No permanent impacts	Preferred
Fish habitat	Geona Creek is habitat to Artic Grayling	Acceptable	None	Preferred	None	Preferred	None	Preferred
Caribou habitat	Facility covered with water will be permanent reduction in caribou habitat	Least preferred	Facility covered with water will be permanent reduction in caribou habitat	Least preferred	Re-contoured and revegetated facility is not considered permanent reduction to caribou habitat	Acceptable	Re-contoured and revegetated facility is not considered permanent reduction to caribou habitat	Acceptable
Long-term impact of facility	Permanent dam located in creek	Least preferred	Permanent dam located in valley	Least preferred	No permanent structures	Preferred	No permanent structures	Preferred
Result	***Least preferred***		***Least preferred***		***Preferred***		***Preferred***	

NOTES:
1. Results were determined by ranking candidates that achieving no “least preferred” scores and the most “preferred” scores.

Table 4.3 Technical Impacts

Criteria	Candidate 1		Candidate 7		Candidate 10		Candidate 12	
	Details	Rating	Details	Rating	Details	Rating	Details	Rating
Tailings Technology	Slurry tailings are well understood technology, requiring no additional processing	Preferred	Slurry tailings are well understood technology, requiring no additional processing	Preferred	Filtered tailings are more challenging to produce and manage than slurry tailings	Acceptable	Filtered tailings are more challenging to produce and manage than slurry tailings	Acceptable
Geochemical stability (ARD mitigation)	Water cover	Acceptable	Water cover	Acceptable	Encapsulation with low permeability material	Acceptable	Encapsulation with low permeability material	Acceptable
Geotechnical conditions	Historic and recent site investigations	Acceptable	Recent site investigations	Acceptable	No historic or recent site investigations.	Acceptable	Recent site investigations	Acceptable
Hydrogeological conditions	Seepage reporting through facility in one direction can be monitored and managed	Acceptable	Seepage could potentially report in two directions to different catchments	Least preferred	Seepage could potentially report to Finlayson and Geona Creek	Least preferred	Seepage would be constrained to the Geona Creek valley, and can be monitored and managed	Acceptable
Dam requirements	Dam required in perpetuity	Acceptable	Dam required in perpetuity	Acceptable	No dam	Preferred	No dam	Preferred
Water management	Site water managed within the tailings facility with pond required in perpetuity for ARD management	Acceptable	Site water managed within the tailings facility with pond required in perpetuity for ARD management	Acceptable	Separate water management pond required (no pond on tailings facility)	Preferred	Separate water management pond required (no pond on tailings facility)	Preferred
Result	***Acceptable***		***Least preferred***		***Least preferred***		***Preferred***	

NOTES:

1. Results were determined by ranking candidates that achieving no “least preferred” scores and the most “preferred” scores.

Table 4.4 Project Economic Impacts

Criteria	Candidate 1		Candidate 7		Candidate 10		Candidate 12	
	Details	Rating	Details	Rating	Details	Rating	Details	Rating
Tailings technology	No additional processing after mineral extraction, slurry pumped to nearby facility	Preferred	No additional processing after mineral extraction, slurry pumped to nearby facility	Preferred	Tailings filtered, hauled 7 km, placed and compacted	Acceptable	Tailings filtered, hauled 0.3 km, placed and compacted	Acceptable
Short-term closure requirements	Monitoring required until water quality meets discharge requirements	Acceptable	Monitoring required until water quality meets discharge requirements	Acceptable	Monitoring required until water quality meets discharge requirements	Acceptable	Monitoring required until water quality meets discharge requirements	Acceptable
Long-term closure requirements	Dam safety inspections required in perpetuity	Acceptable	Dam safety inspections required in perpetuity	Acceptable	None	Preferred	None	Preferred
Result	***Acceptable***		***Acceptable***		***Acceptable***		***Acceptable***	

NOTES:

1. Results were determined by ranking candidates that achieving no “least preferred” scores and the most “preferred” scores.

5 – CONCLUSIONS

This preliminary tailings management alternatives assessment began with thirteen candidates, which were developed using threshold criteria. The thirteen candidates were then reduced to four final candidates based on pre-screening criteria. The final four candidates included two slurry tailings options located in valleys, and two filtered tailings options located on hillsides. The assessment indicates Candidate 12 is the preferred option for tailings management, as it received the best overall rating of the four remaining alternatives.

Table 5.1 summarizes the results of the environmental, technical and economic ratings:

Table 5.1 Results of Alternatives Assessment

Category	**Candidate 1** Slurry Tailings Geona Creek	**Candidate 7** Slurry Tailings East Valley	**Candidate 10** Filtered Tailings Exploration Camp	**Candidate 12** Filtered Tailings Western Hillside
Environmental	Least preferred	Least preferred	Preferred	Preferred
Technical	Acceptable	Least preferred	Least preferred	Preferred
Project Economics	Acceptable	Acceptable	Acceptable	Acceptable
Result				***Preferred***

Candidates 10 and 12 (filtered tailings options) do not include any permanent structures in Geona Creek, do not cause long-term impact to fish habitat, and allow for complete re-establishment of Geona Creek at closure, therefore both candidates received “preferred” ratings in the environmental category. Candidates 1 and 7 received “least preferred” ratings due to their requirement for permanent water retaining dams.

Candidate 1 achieved “acceptable” scores for all the technical criteria. Candidates 7 and 10 received “least preferred” ratings in the technical category due to the potential risk of seepage reporting in multiple directions. Candidate 12 does not require construction and maintenance of a tailings and water retaining dam in perpetuity and is not anticipated to have challenging seepage conditions, therefore this option received the “preferred” rating overall in the technical category.

All the candidates received “acceptable” ratings in the project economics category.

Overall, after achieving “preferred” rankings in the environmental and technical categories, this assessment indicates Candidate 12 is considered to be the preferred location for tailings and waste rock management based on this preliminary assessment.

6 – REFERENCES

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7 – CERTIFICATION

This report was prepared and reviewed by the undersigned.

[Name Redacted]

Prepared:

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Staff Engineer

PROFESSIONAL
YUKON
[Name Redacted]
TERRITORY
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Oct 20/16

Reviewed:

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Specialist Engineer

[Name Redacted]

Approval that this document adheres to Knight Piésold Quality Systems:

APPENDIX A

COMINCO ALTERNATIVES ASSESSMENT FIGURES

(Pages A-1 to A-3)

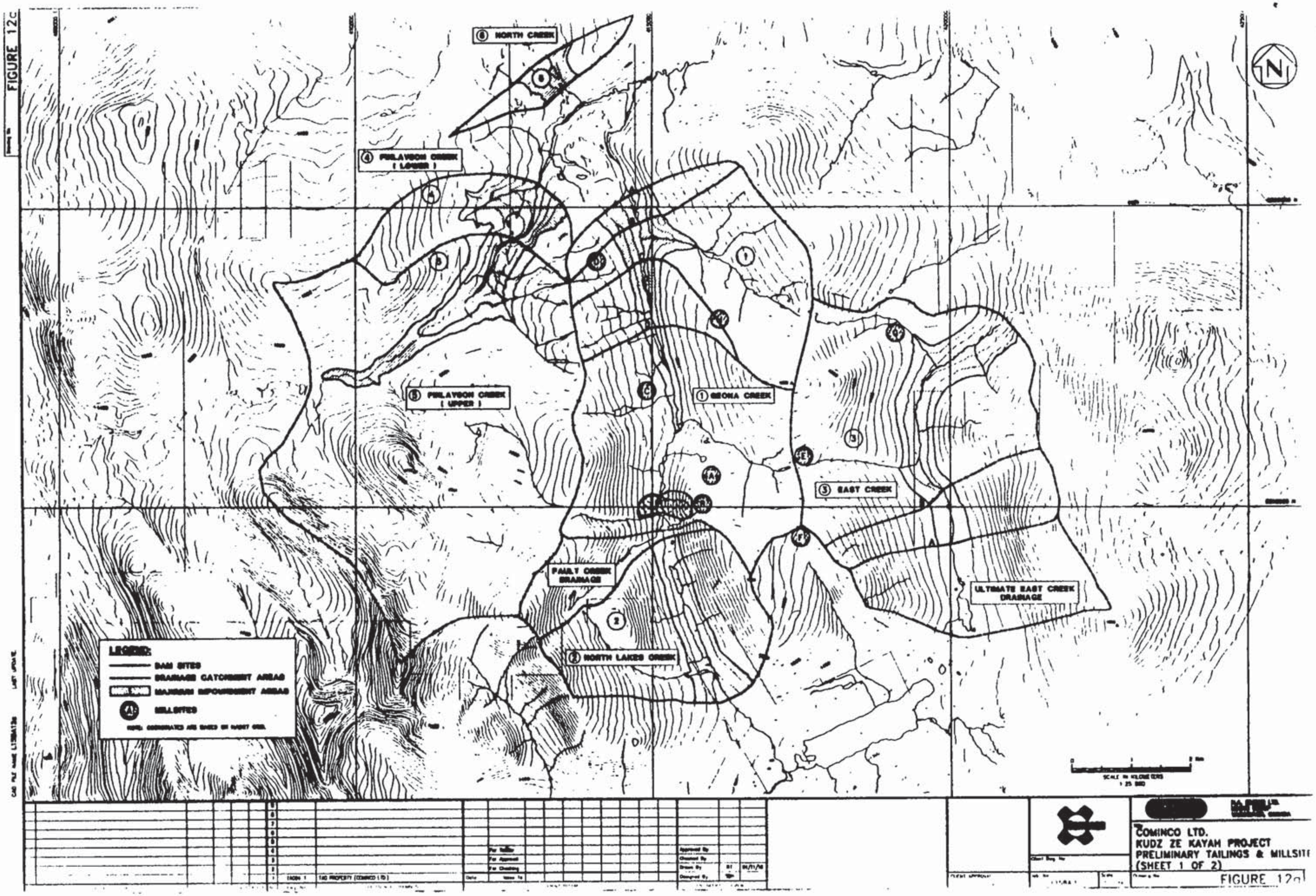
FIGURE 12c
6 NORTH CREEK
4 FINLAYSON CREEK (LOWER)
5 FINLAYSON CREEK (UPPER)
1 GEONA CREEK
3 EAST CREEK
FAULT CREEK DRAINAGE
2 NORTH LAKES CREEK
ULTIMATE EAST CREEK DRAINAGE
LEGEND:
DAM SITES
DRAINAGE CATCHMENT AREAS
MAXIMUM IMPOUNDMENT AREAS
MILLSITES
SCALE IN KILOMETERS
1:25 000
COMINCO LTD.
KUDZ ZE KAYAH PROJECT
PRELIMINARY TAILINGS & MILLSITE
(SHEET 1 OF 2)
FIGURE 12a

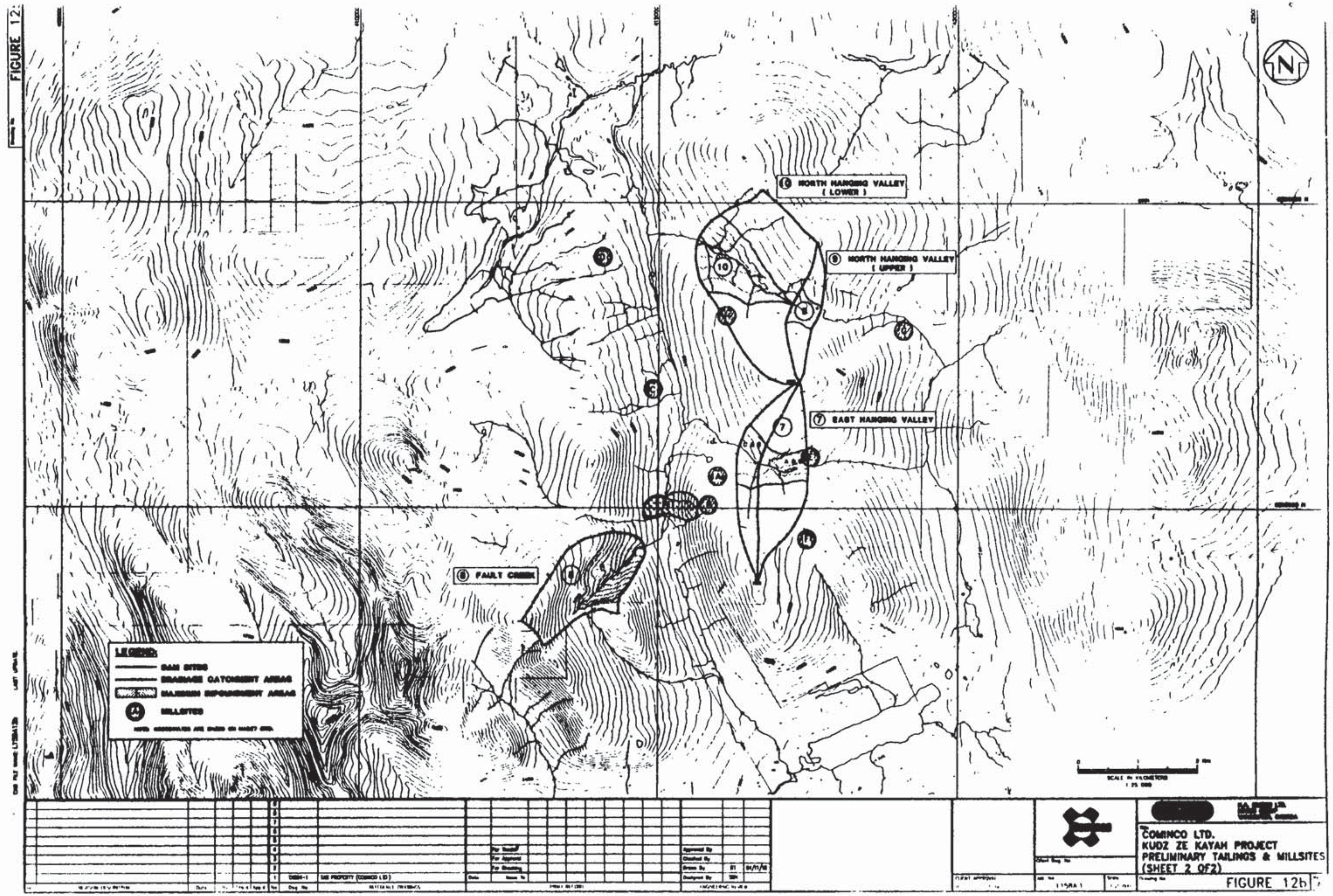

FIGURE 12
N
NORTH HANGING VALLEY (LOWER)
NORTH HANGING VALLEY (UPPER)
10
7
EAST HANGING VALLEY
FAULT CREEK
LEGEND:
DAM SITES
DRAINAGE CATCHMENT AREAS
MAXIMUM IMPOUNDMENT AREAS
MILLSITES
SCALE IN KILOMETERS
1:25 000
COMINCO LTD.
KUDZ ZE KAYAH PROJECT
PRELIMINARY TAILINGS & MILLSITES
(SHEET 2 OF2)
FIGURE 12b

TABLE 2.1

IMPOUNDMENT SITE STATISTICS

Site	Catchment Area (ha)	5 million m³ Storage				33 million m³ Storage			
		Dam Height (m)	Dam Volume million (m³)	Ratio	Rank	Dam Height (m)	Dam Volume million (m³)	Ratio	Rank
1a	2,404	37	1.0	5.0	4	73	8.7	3.8	4
1b	2,262	35	0.7	7.1	1	71	7.0	4.7	2
1c	1,593	40	0.9	5.6	3				
1d	1,360	40	1.0	5.0	4				
2	766	31	1.0	5.0	4	63	7.5	4.4	3
3	2,134	32	0.7	7.1	1	64	4.5	7.3	1
4	3,061	40	1.5	3.3	7	77	10.5	3.1	6
5	2,685	44	1.6	3.1	8	83	10.0	3.3	5
6	141	27	2.4	2.1	9				
7a&7b	160	46	4.0	1.3	12				
7c&7d	256	42	3.5	1.4	11				
8	194								
9	69								
10	384	50	3.0	1.7	10	104	27.0	1.2	7

Notes:
- Preliminary volumes were based on 25 m contour intervals.
- Sites 8 & 9 were excluded due to extremely low storage ratios.
- Sites were excluded from the 33 million m³ case due to insufficient volume.
- Ranking based on storage ratio only.