Yukon Government

Mt. Nansen Closure Alternatives Characterization

Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives

Hydrogeological Characterization of the Mt. Nansen Mine Site

Development of a Mount Nansen Precipitation, Temperature and Evaporation Data Record and Pit Tailings Pond Inflow Volume Estimation

Report Number:
60159089

Date:
November 2010

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Dear Mr. Patch:

Project No: 60159089 (402.19.2)

Regarding: Mount Nansen
Geotechnical, Hydrogeology, Hydrology Reports

AECOM is pleased to submit our reports regarding the above noted project. These documents have been provided to Lorax for incorporation in the overall report but we thought it appropriate that they also be provided directly to you and your department as this is who has contracted this work. The relationship with Lorax has been productive and we have worked through many questions and suggestions in the course of progressing from the draft stage to final reports. We look forward to the review meeting on this work.

Please feel free to contact the undersigned if you have any questions.

Sincerely,
AECOM Canada Ltd.

Tom Wingrove, P.Eng.
Executive Vice-President
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TW:dh
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Assessment and Abandoned Mines Branch

Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives

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Table of Contents

Statement of Qualifications and Limitations
Letter of Transmittal
Distribution List

page

1. Introduction 1
   1.1 Current Condition 1
      1.1.1 2009 Drilling and Instrumentation Program 1
      1.1.2 Monitoring Pins 3
   1.2 Mine Closure Options 3
2. Geotechnical Considerations 4
   2.1 Status Quo 4
   2.2 Option 1: Tailings Dam Upgrade with Water Cover, and Option 2: Tailings Dam Upgrade with Saturated Soil Cover 5
      2.2.1 Existing Tailings Dam Classification (Options 1 and 2) 5
      2.2.2 Dam Stability (Options 1 and 2) 6
         2.2.2.1 Failure Modes 6
         2.2.2.2 Development of Slope Stability Models 7
         2.2.2.3 Existing Stability 9
         2.2.2.4 Dam Upgrading 10
         2.2.2.5 Thermal Analysis 12
      2.2.3 Spillway Upgrading (Options 1 and 2) 13
         2.2.3.1 Hydraulic Analysis 13
      2.2.4 Diversion Channel Upgrading downstream of the Spillway (Options 1 and 2) 16
      2.2.5 Interceptor Ditch (Options 1 and 2) 17
      2.2.6 Water Diversion From Dome Creek (Options 1 and 2) 17
      2.2.7 Cover Design 18
         2.2.7.1 Water Cover (Option1) 18
         2.2.7.2 Saturated Soil Cover (Option 2) 18
      2.2.8 Seepage Control 20
      2.2.9 Waste Rock In Place (Option 1 and Option 2) 20
         2.2.9.1 Waste Rock Piles 21
         2.2.9.2 Condition of Brown-McDade Pit 21
      2.2.10 Alternative B: Waste Rock Backfill into Pit (Option 1B and Option 2B) 23
      2.2.11 Operations and Maintenance 23
   2.3 Option 3: Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place 24
      2.3.1 High Infiltration Cover 24
      2.3.2 Spillway and Pony Creek Diversion 26
      2.3.3 Transportation of Tailings 26
         2.3.3.1 Consolidation Settlement of Relocated Tailings – Saturated Environment 28
      2.3.4 Pony Creek Adit (Options 1B, 2B, 3 and 4) 28
      2.3.5 Valley Restoration (Option 3 and 4) 28
      2.3.6 Operations and Maintenance 28
   2.4 Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover 29
      2.4.1 Co-Disposal of Tailings and Waste Rock in Open Pit 29
      2.4.2 Consolidation of Tailings and Waste Rock in Open Pit – Unsaturated Environment 30
      2.4.3 Low Infiltration Soil Cover 30
      2.4.4 Tailings Relocation 31

2.4.5 Operations and Maintenance 31
3. Areas of Uncertainty and Risk 32
3.1 Areas of Uncertainty 32
3.1.1 Existing Tailings Dam (Option 1 and 2) 32
3.1.2 Cover Systems 32
3.1.3 Water Diversion Structures (Options 1, 2, and 3) 33
3.1.4 New Tailings Dam (Option 3) 33
3.1.5 Diversion Channels (Options 1, 2 and 3) 33
3.1.6 Waste Rock (All Options) 33
3.1.7 Existing Tailings Management Area (Options 3 and 4) 34
3.2 Risk 34
4. Summary of Costs 36
4.1 Capital Construction Costs 36
4.1.1 Inspection and Maintenance 37
5. References 38

List of Figures

Figure 1 Cross Section for Slope stability Analysis 8
Figure 2. 1000-year, 10000-year, IDF, and PMF Event Hydrographs 15
Figure 3. Grain Size Distribution from Victoria Creek Borrow Source 20
Figure 4. Brown McDade pit a) looking toward south entrance and b) from north end. 22
Figure 5. Approximate Location of West Abutment of Proposed Tailings Dam in Open Pit 25
Figure 6. Approximate Location of East Abutment for Tailings Dam in Open Pit 25

List of Tables

Table 1. Suggested Design Flood and Earthquake Levels (CDA, 2007) 6
Table 2. Loading Cases for Slope Stability Analysis (CDA, 2007) 8
Table 3. Summary of Soil Properties 9
Table 4. Factors of Safety for Existing Stability 10
Table 5. Factors of Safety for Existing Stability with Increased Depth of Thaw 10
Table 6. Factors of Safety for Upgraded Dam 12
Table 7. Summer PMP Estimate for Adjusted Environment Canada Carmacks Records 14
Table 8. Peak Flow and Volume Estimates for 1000-Year and 10000-Year Events 15
Table 9. Tailings Pond Spillway Peak Outflow and Maximum Water Level Rise 16
Table 10. Summary of Geotechnical Risks 35
Table 11. Capital Cost Estimates 36
Table 12. Annual Operations and Maintenance Cost Estimates (in 2010 $) 37

Appendices

Drawings
Appendix A Test Hole Logs
Appendix B Geotechnical
Appendix B-1 Monitoring Data
Appendix B-2 Geotechnical Summary Table
Appendix C Additional Reports
Appendix C-1 Seepage Analysis for Existing Dam
Appendix C-2 Thermal Analysis of Toe-Berm
Appendix D Cost Estimate

1. Introduction

This section presents a geotechnical assessment of the closure options for the Mt. Nansen Mine. The geotechnical aspects of the four proposed closure options are discussed as well as a brief overview of the existing conditions of the tailings facility. The estimated costs of the closure alternatives are compared.

This section is an update to the report submitted by AECOM (dated May 2010), reflecting the concept development, ongoing assessments and the 2010 site investigations. The current geotechnical assessment supersedes previous draft reports.

1.1 Current Condition

This section summarizes the evaluation of the existing tailings impoundment conducted by AECOM in 2008 (AECOM, 2009), supplemented by the results of drilling and further monitoring of geotechnical instrumentation conducted in the summers of 2009 and 2010. No significant changes in the overall condition of the tailings dam and associated works were observed during the inspections (compared to the AECOM (2008)) assessment. Specific observations and monitoring results will be presented in the following sections.

Overall, the tailings dam and seepage dyke are considered to be in reasonably good condition. Seepage water is collected at the toe of the rock fill in the seepage pond where it is pumped over the seepage dam, having met discharge criteria. The seepage water appears clean although there is considerable sediment visible in the pond. The spillway is in good condition although the constriction from widening the road approaching the south side of the bridge remains.

The interceptor ditch and diversion channel are functioning although the banks upstream of the emergency spillway are typically over-steepened with active erosion and sloughing. It appears that excavation of the accumulated sediment along flatter grades was undertaken after the 2008 inspection. Evidence of erosion and sedimentation was observed along the diversion channel and interceptor ditch. The diversion channel downstream of the emergency spillway remains in good condition with only minor loss of bank armouring material in the downstream half of this portion of the channel.

1.1.1 2009 Drilling and Instrumentation Program

In the summer of 2009 five test holes were drilled (GT09-01 to 05) to determine the stratigraphy, characterize the soil, collect samples, and install thermistor strings. Additional test holes were drilled for the additional purpose of installing monitoring wells (MW09-01 to MW09-23). The test hole logs are included in Appendix A. The groundwater conditions have been discussed in other sections of this report.

Geotechnical investigations were conducted at the existing tailings facility using air rotary drilling techniques combined with the ODEX casing system. Boreholes were completed to evaluate soil and groundwater conditions at key locations and to supplement data from previous investigations. Thermistor strings were installed in selected boreholes to measure ground temperatures. Standpipe piezometers were installed to facilitate groundwater level monitoring and sample collection. Standard penetration tests were conducted at regular intervals and split spoon samples were collected for further testing and classification. Approximate soil temperatures were measured at the ground surface on split spoon samples using a digital temperature probe. All geologic materials were then classified according to the Unified Soil Classification System and photographs of each sample were taken. Results from the geotechnical program have been used in subsequent assessments of existing slope stability, seepage and the feasibility of dam upgrading alternatives.

AECOM Test Hole GT09-01 was drilled adjacent to EBA TH 12861-03 where the depth of fill and the zero degree isotherm (permafrost contact) was undetermined. The hole was advanced to a depth of 30 m and a thermistor string was installed. The depth of fill was confirmed to be at about 16 m below the crest, terminating at about elevation 1083.4 m. It appears that the organic layer was stripped before fill placement, an observation that is consistent with previous observations by EBA. Permafrost was encountered at a depth of 21.5 m below ground surface during drilling. Based on one reading, permafrost is suspected to be at a depth of about 22 m (elevation 1077.9 m) which corresponds well with the field observation. This information suggests the depth of thaw into the foundation soil below the dam at this location is approximately 5 m which is significantly greater than observed at the closest adjacent borehole with a full depth thermistor string (EBA TH 12861-02). In EBA TH 12861-02, the top of the permafrost is at approximately 1079.79 m, which is 0.6 m below the interface of the fill and native foundation soil.

AECOM Test Hole GT-09-02 was drilled on the road to the stabilizing berm from the south abutment where significant settlement of the dam crest and downstream face has historically been observed (AECOM, 2009). Previous remedial works have been carried out in this area to address seepage (Klohn-Crippen, 1999). The depth of fill was determined to be about 4.3 m and permafrost, as evidenced by field observations and subsequent monitoring, was at a depth of about 6 m or elevation 1082.3 m. It appears that the organic layer was stripped prior to fill placement. The depth of thaw is therefore estimated to be in the order of 1.7 m (assuming the permafrost was immediately below the organic layer before construction).

AECOM Test Hole GT-09-03 was drilled on the north terrace in the vicinity of EBA TH 12861-07 where progressive thawing of the permafrost is apparent (EBA, 1999 & 2002). The zero degree isotherm in TH 12861-07 was believed to be below the lowest bead or greater than 9.4 m below grade. TH GT-09-03 was drilled to a depth of 19.9 m and a thermistor string for the full depth was installed. Frozen ground was logged at a depth of 16.5 m below ground surface. Thermistor monitoring indicates the permafrost is at about the same depth or at elevation 1072.4 m. Even at and below this depth, the ground temperatures are only just below zero, at about -0.05 degrees C. Based on a depth of fill of just over 1 m at this location, and an assumed depth to permafrost of 2 m before construction (Klohn, 1995) the depth of thaw is now estimated to be in the order of 13.5 m. This observation confirms previous interpretations that the presence of the dam on the south facing slope has lead to lateral as well as vertical thawing at this location (EBA, 1999). Seepage from the diversion ditch may be a contributing factor in the warmer ground temperatures.

AECOM Test Hole GT-09-04 was drilled to a depth of 16.2 m on the upstream edge of the seepage dyke crest in the vicinity of the former EBA TH 12861-10. A thermistor string was installed to the full depth of the hole and a piezometer was installed immediately adjacent (MW 09-20). Fill was encountered to a depth of 4 m. Based on thermistor readings, frozen ground is estimated to be within the fill at a depth of about 3.2 m or at elevation 1075.5 m. These readings suggest there may be a continuation of the decrease in thawed depth that extended to a depth of 4.8 m in 1998 and 4.2 m in 1999. This thermistor installation is in the vicinity of the thermosyphon loops installed in the seepage dyke.

AECOM Test Hole GT-09-05 was drilled to a depth of 19.8 m on the north terrace above the seepage pond in the vicinity of EBA TH 12861-09. There was no historical instrumentation data in this area and therefore a full depth thermistor string and piezometer (MW 09-24) were installed. Monitoring well MW 09-24 was installed in an adjacent borehole. Frozen ground was reported at a depth of 7.6 m when drilling TH 12861-09 in 1998. Frozen ground was encountered at a depth of 11.3 m during drilling of Test Hole GT 09-05. Thermistor monitoring confirms that permafrost is located at about the same depth (approximately 12 m or elevation 1075.6 m). Similar to TH-GT-09-03, the permafrost is warm with a minimum temperature of -0.1 degrees C. The groundwater level was at about 3 m or elevation 1084.5 m.

Plots of the ground temperatures measured in GT09-01 to 05 are included in Appendix B-1.

1.1.2 Monitoring Pins

Additional survey work was conducted at the Mt. Nansen mine site during the summer of 2010. The survey included:

- Cross-section through the centerline of the dam and seepage dyke, and continuing a short distance along the bottom of the valley below the seepage dyke.
- Monitoring pins on the tailings dam.
- Fill material placed in the north end of the pit.
- Low-grade ore placed in the area of the south entrance to the pit.

Drawings 1 to 4 have been updated with the new survey data where applicable. Deformations of the dam have been monitored since 1999. The horizontal displacements measured at the monitoring pins are shown on the figures in Appendix B-1. Over the two year period since 2008, the averaged horizontal displacements from all monitoring pins are 4 mm south and 4.5 mm east. It should be noted that the average horizontal displacement is less than the accuracy of the survey equipment.

The crest of the dam towards the south abutment has settled approximately 4 cm since 2008 based on monitoring pin surveys. The measured vertical displacements are listed in Drawing 9. These deformations may be caused by a combination of internal erosion, consolidation and creep movements.

1.2 Mine Closure Options

Closure alternatives described in this report are variations of the previously defined "Alternative 3" and "Alternative 4". For this report, 4 closure options are considered. Options 1 and 2 involve upgrading the existing tailings dam, while Options 3 and 4 involve decommissioning the tailings dam and associated works and relocating the tailings into the open pit. Inherent with both alternatives are geotechnical considerations necessary to maintain long term closure objectives in particular dam stability, water management and geochemical stability. Brief descriptions of the options are provided below with reference to the appropriate Drawings. Geotechnical considerations as they relate to these Options are discussed in subsequent report sections and in the Summary Table in Appendix B-2

The options are:

- Option 1 - Tailings Dam Upgrade with Water Cover, Waste Rock in Place (Drawing 1)
- Option 2 - Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place (Drawing 2)
- Option 3 - Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place (Drawing 3)
- Option 4 - Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover (Drawing 4)

Options 1B and 2B are the same as Options 1 and 2 but with as much waste rock as possible added to infill the open pit. (Drawing 5)

The cover options for Option1, 2 and 3 are similar in that each involves some thickness of inert saturated soil and/or water cover to prevent exposure of the tailings to oxygen. The purpose of the cover for Option 4 is different in that its purpose is to prevent infiltration to keep the tailings as dry as possible, thus reducing the potential for contaminant transport by groundwater.

2. Geotechnical Considerations

There are several geotechnical considerations associated with each of the mine closure alternatives under consideration. These considerations can be broadly characterized for the options as follows:

Option 1 – Tailings Dam Upgrade with Water Cover
and Option 2 - Tailings Dam Upgrade with Saturated Soil Cover

- Stability and upgrading of the existing tailings dam and associated works;
- Upgrading and sizing of water diversion structures associated with the existing TMA;
- Design and construction of a soil cover;
- Design and construction of a spillway to maintain the desired water level;
- Seepage control through the tailings by replacing coarse tailings with fine tailings;
- Designing to address the effects of liquefiable soils on the stability of the dam.
- Assessing the stability and contouring the remaining waste rock piles (Option 1A and 2A)
- Assessment of existing pit wall conditions (Option 1A and 2A)
- Placing and contouring waste rock in open pit (Option 1B and 2B)

Option 3 – Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place

- Transportation, placement and consolidation of tailings in the open pit;
- Design and construction of a tailings dam at the south end of the open pit;
- Design of high infiltration cover;
- Design and construction of a spillway to maintain the desired water level;
- Assessing the stability and contouring the remaining waste rock piles;
- Decommissioning of the existing tailings dam;
- Restoration of the Dome Creek valley within the TMA.

Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover

- Transportation, placement and consolidation of tailings in the open pit;
- Design and placement of waste rock reservoir (below tailings) and waste rock cover over tailings;
- Design low permeability cover;
- Decommissioning of the existing tailings dam;
- Restoration of the Dome Creek valley within the TMA.

Technical memos addressing specific geotechnical considerations in the context of the various closure alternatives under consideration were prepared and included in the initial draft report (January 2010) submitted to the Yukon Government. Further discussion and elaboration is provided in the following sections of this report.

2.1 Status Quo

The current state of the Mt. Nansen tailings facility was described in detail in the 2008 Geotechnical Inspections Report (AECOM 2008). Inspections in 2009 and 2010, have confirmed that there has been little change in general site conditions.

The AECOM (2008) report included a risk assessment of the current facility. The assessment identified the tailings dam and the diversion channel as items at *Risk Level II* (defined in AECOM 2008). Based on the assessed risk level, the following action items were recommended:

- Implementation of a comprehensive monitoring program;
- An emergency preparedness plan;
- An action plan for remedial works;
- Consideration of remedial works to reduce risk.

The most significant issue with the current tailings management facility (from a geotechnical perspective) is that the tailings dam did not meet the requirements of the 2007 Canadian Dam Association Guidelines. Based on the CDA Guidelines, the current facility was found to be inadequate with respect to:

- stability under earthquake loading scenarios
- the capacity and condition of the spillway.

The performance of the diversion channel, interceptor ditch, and seepage through the dam were secondary issues which also needed to be addressed by maintenance or remediation. Settlement of the dam crest has been ongoing (especially near the South Abutment), and this is attributed to thawing of the permafrost beneath the dam, and internal erosion of the dam. This also requires a long term solution.

2.2 Option 1: Tailings Dam Upgrade with Water Cover, and Option 2: Tailings Dam Upgrade with Saturated Soil Cover

Options 1 and 2 are very similar in concept, except with respect to the cover function and design. They will be discussed together in the following sections, except where otherwise noted.

2.2.1 Existing Tailings Dam Classification (Options 1 and 2)

Upgrading the existing tailings dam in association with Options 1 and 2 requires the classification of the structure (dam) in accordance with the Canadian Dam Association's, (CDA) *Dam Safety Guidelines.* This classification system is based on the consequences of a failure which may include loss of life, injury, property and environmental damage. In general, the consequences of a failure of the tailings dam would involve the release of water cover (which may be contaminated) and the release of tailings. The severity of a failure (in terms of consequences) will therefore depend on the alternative under consideration. For example, the downstream impacts could be greater for the alternative where a failure of the dam resulted in the release of a large volume of water and liquefied tailings over a long run-out distance. In the event of a soil cover, the impacted area could be considerably less as a result of a shorter run-out associated with slumped tailings.

A Dam Safety review carried out by EBA Engineering in 2002 considered the existing facility to be a *high* to *very-high* consequence facility, upgraded from the design consequence ranking of *high.* It should be recognized that these classifications were based on the 1999 CDA Guidelines which had four classifications (ranging from very low to very high) compared with the 2007 Guidelines which have five classifications ranging from low to extreme. The intent of AECOM's review is to establish preliminary dam classifications for the proposed closure scenarios using the most recent (2007) CDA *Dam Safety Guidelines* and based on our assumptions regarding incremental losses resultant from a hypothetical failure of the existing tailings dam.

Options 1 and 2 include a water cover of approximately 72,000 and 9,000 m^3 respectively. The potential for loss of life is remote and would only apply to persons temporarily in the vicinity of the dam. From a consequence perspective, the implications of loss of life can be considered "unspecified." However, a release of tailings pond water could result in significant environmental impacts. In this regard, we are of the opinion that Options 1 and 2 should be assigned a *High* classification (based on CDA 2007) until such time as more detailed assessments of the potential incremental impacts of dam failure demonstrate a lower classification is justifiable. For example, it may be

determined that a *Significant* classification is justifiable based on the reduced volume and temporal nature of the watercover for Option 2, in particular if the water quality is acceptable for direct discharge to the environment.

The dam classification has implications regarding design flows (spillway design), seismic loading factors for slope stability analysis and the frequency for dam safety reviews and maintenance and operations. In this regard, the suggested design flood and earthquake levels recommended in the 2007 CDA Guidelines for significant and high classification structures are summarized in Table 1.

Table 1. Suggested Design Flood and Earthquake Levels (CDA, 2007)

Classification	Annual Exceedance Probability for Inflow Design Flood	Annual Probability of Exceedance for Earthquake Design Ground Motion
Significant	Between 1/100 and 1/1,000	1/1000
High	1/3 between 1/1,000 and the Probable Maximum Flood (PMF)	1/2,500

In accordance with the CDA Guidelines, Dam safety reviews should be conducted at 7 and 10 year intervals for *High* and *Significant* consequence dams respectively. In any case, the frequency should also consider the presence or change of external hazards, the results of surveillance and the demonstrated performance. Maintenance and emergency response programs must be carried out while the dam remains in service (CDA 2007). It should be recognized that ongoing monitoring and inspections as part of the assessment of closure alternatives at the Mount Nansen Mine has significantly fulfilled the objectives of a dam safety review, in particular the completion of slope stability analysis.

2.2.2 Dam Stability (Options 1 and 2)

2.2.2.1 Failure Modes

The four most likely failure modes of the tailings dam are considered to be overtopping, internal erosion (piping), slope instabilities and liquefaction from an earthquake. The age of the tailings dam and repair work done to address previous instabilities has an influence on the potential for the identified failure modes. In general, many of the unknown defects in the Mount Nansen tailings dam have been tested throughout its life and therefore, there is a greater level of confidence in achieving satisfactory performance. The exception would be natural events, or operating strategies that create untested conditions, for example, an earthquake or increased tailings pond elevations. Each of the potential failure modes is discussed separately as follows:

Overtopping

Overtopping would occur as a result of flooding and therefore can be considered more of an issue with respect to water balance (hydrology) than geotechnical considerations e.g. the spillway must be designed to safely pass the design flood. The exception would be dam crest settlement which could cause a reduction in freeboard and an increased likelihood of overtopping. In this event, the failure mechanism would most likely be a breach of the dam and release of impounded water. Settlement of the south abutment has been observed in the past and is ongoing, based on the survey of the monitoring pins in 2010. It is possible that the settlement of the dam crest is a result of internal erosion and/or thawing of the permafrost foundation below the dam. *Continued monitoring of the crest is recommended to assess any ongoing settlement and determine the need to raise the dam to restore freeboard.*

Slope Instability

Large slope movements that would compromise the integrity of the tailings dam could lead to the release of tailings and water into the Dome Creek Valley. The dam has generally performed well from a static stability perspective (with the exception of some settlements and potentially some internal piping). Changes in loading, porewater pressures or ground conditions could lead to slope instability and potentially a catastrophic failure of the dam. The existing and upgraded stability assessments are discussed in more detail in the following sections. Regular assessment of stability conditions is required by the CDA guidelines (2007)

Seepage and Internal Erosion (Piping)

The most common failure mechanism for this mode is retrogressive internal erosion which may occur over a period of many years. At Mount Nansen, water from the tailings pond and natural groundwater pass through the dam fill material and foundation soils. The seepage water either enters the seepage collection pond or enters into the regional surface or groundwater system downstream of the dam. Excessive seepage on the downstream face of the dam resulted in the construction of the stabilizing berm in July 1997 (GLL, 2006). Seepage analysis by AECOM indicated a factor of safety of 3.5 exists against piping failure due to heave compared to a minimum value of 2.5 typically adopted. This theoretical determination however, does not agree with observations made previously with respect to evidence of piping conditions at the toe of the dam at the seepage pond which was attributed to possible thawing of frozen ground allowing for "roofing" and localized high gradients (EBA 2002). In this regard, the dam upgrading should incorporate a weighted filter layer at the downstream toe of the dam. The filter will extend into any buttressing required for the upgrading. While this filter is not intended to prevent seepage, it should be designed to control internal erosion and the development of quicking (heaving) conditions downstream of the dam. *Seepage losses (flow) should continue to be monitored on a regular basis to identify possible changes in the overall condition of the dam and any associated changes in seepage water quantity and quality.*

Liquefaction

Previous investigations (EBA 2002) have shown that soils which were previously frozen (permafrost) and thawed have a reduced strength that makes them susceptible to liquefaction under seismic loading conditions. Under an earthquake loading, the soil may experience a loss of shear strength resulting in slope failure, overtopping (from settlement) or internal erosion (from conduits opening). In this regard, the dam upgrading must be designed to provide adequate factors of safety against failure during an earthquake and after an earthquake when the liquefiable soils are at their critical (residual) state.

2.2.2.2 Development of Slope Stability Models

The stability of the existing tailings dam was assessed to determine the factor of safety (FS) against slope instabilities for both existing conditions and seismic loading conditions in accordance with the 2007 Canadian Dam Association (CDA) Dam Safety Guidelines. The analysis evaluated the sensitivity of the dam to seismic loads and groundwater levels and formed the basis for determining potential upgrading alternatives to conform to accepted practice for design of the closure of such structures. Numerical modeling was done with Geo-Studio 2007, (Geo-Slope Int. Ltd.) using the Slope/W and Seep/W modules. The loading cases analyzed and required factors of safety are summarized in Table 2.

Table 2. Loading Cases for Slope Stability Analysis (CDA, 2007)

Case	Loading Condition	Peak Ground Acceleration (annual probability of exceedance)	Dam Classification	Minimum Factor of Safety (note 1) Against Slope Instability
1 - Static	Steady state seepage	NA	NA	1.5
2 – Pseudo-static	Earthquake	0.27 (1/10,000)	Extreme	1.0
2a – Pseudo-static	Earthquake	0.11 (1/2,500)	High	1.1 (note 2)
3 - Static	Post-Earthquake	NA	NA	1.2

Note 1: The Factor of Safety is defined as the ratio of the resisting forces to the driving forces.
Note 2: 2007 CDA Guidelines allow a minimum FS of 1.0 for this loading case.

Section For Analysis

A typical stratigraphic profile was developed paying special attention to the depth to permafrost and the thickness of the thawed foundation zone based on borehole and monitoring data from all available sources (including those investigations by AECOM in 2009). The cross section chosen for the slope stability analysis (Section A) is shown in plan view on Drawing 01. A typical output from the slope stability model showing the cross section is illustrated on Figure 1. The results of the stability analysis for the three loading cases for existing and upgraded dam configurations are summarized on Drawings 06 and 07.

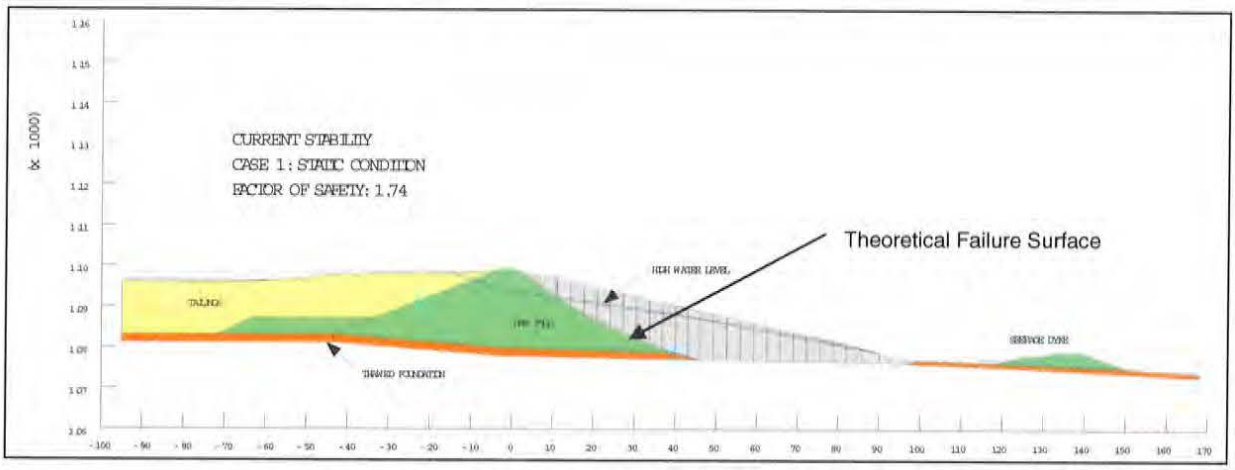

Figure 1 Cross Section for Slope stability Analysis

Piezometric Levels

Piezometric (groundwater) levels were based on historical monitoring and represent a range from low to high to bracket expected levels and evaluate the sensitivity of slope stability to piezometric conditions. The low piezometric level is consistent with that observed through monitoring during 2008 when pond levels were drawn down. This level is also considered to approximate what would be expected during normal operating conditions for an upgraded dam where the edge of the water is maintained at least 50 m from the dam crest (as per the design). The high piezometric level represents the highest levels recorded historically which would be associated with high pond levels (as occurred on occasion during the operation of the tailings facility) or high infiltration events. Because of the

history of seepage through the dam, it is considered prudent to evaluate upgrading alternatives using the high piezometric levels.

Soil Properties

The engineering properties of the soil units were adopted from the EBA Dam Safety Assessment (2002) (which we are in concurrence with). These values are based on engineering judgement and the results if in situ testing. Based on the results of previous cone penetrometer and standard penetration testing, any thawed foundation soils beneath the dam were considered to be liquefiable. Residual soil strengths were assigned for the liquefiable soil units for post earthquake analysis in accordance with recommendations in the 2007 CDA guidelines which cross-reference the methodology outlined in the Canadian Foundation manual (CFM, 200). In this case, the critical soil strengths are input into the stability model as residual cohesive strengths. The material properties assumed for the analysis are summarized in Table 3.

Table 3. Summary of Soil Properties

Soil Unit	Unit Weight (kN/m^3)	Friction Angle (deg)	Cohesion c' (kPa)
Tailings	18.6	28	0
Tailings (Post Earthquake)	18.6	0	9
Compacted Dam Fill	19.5	34	0
Native Foundation Soil (thawed)	19	28	0
Native Foundation Soil (Post Earthquake)	19	0	14.4
Rock Fill	21	45	0

Seismic Conditions

A detailed probabilistic seismic hazard assessment was not considered necessary to carry out preliminary assessments of slope stability. Rather, the current seismic hazard model and set of hazard maps developed by the Geological Survey of Canada for the 2005 Edition of the National Building Code of Canada were used to estimate peak ground accelerations (PGA) for the mine site. Peak (horizontal) ground accelerations of 0.11 and 0.27g representing predicted return periods of 1/2,500 and 1/10,000 respectively were considered. The selection of the appropriate PGA depends in part on the final dam classification. The higher value (PGA=0.27g) would be consistent with an *Extreme* classification while the lower value (0.11) would apply to a *High* classification based on the 2007 CDA Guidelines. Both values have been used in the analysis in order to bracket the range of factors of safety under earthquake loading recognizing that more detailed seismic analysis would be required for detailed design. For conceptual design purposes and in consideration that a classification of extreme is considered unlikely, we have established a target of 1.0 for a PGA of 0.27 and 1.1 for a PGA of 0.11.

2.2.2.3 Existing Stability

The existing factor of safety for the loading cases was calculated with the results summarized in Table 4. The tailings dam has an adequate factor of safety (>1.5) under both low and high piezometric levels. Under seismic (pseudo-static) loading conditions, the factors of safety for an extreme earthquake event (1/10,000), the calculated factors of safety are 0.72 and 0.93 for low and high piezometric levels respectively, both of which fall below the minimum FS of 1.1. For a 1/2,500 return period, which is consistent with a *High* dam classification, the factors of

safety are 1.12 and 1.45 for high and low piezometric levels respectively, values which exceed the minimum FS of 1.1 (note: CDA allows a minimum FS of 1.0 for this loading case). The calculated factors of safety for post-earthquake loading conditions are 0.56 and 0.63 for high and low piezometric levels respectively. These values fall well short of the minimum FS of 1.2 and for this reason, represent the basis for which dam upgrading alternatives were evaluated.

Table 4. Factors of Safety for Existing Stability

Case	Loading Condition	Acceptable Minimum Factor of Safety	Calculated Factor of Safety	
			Low Piezometric Level	High Piezometric Level
1 – Static	Steady state seepage	1.50	2.23	1.74
2 – Pseudo-static (PGA=0.27)	Earthquake	1.0	0.93	0.72
2a – Pseudo-static (PGA=0.11)	Earthquake	1.10	1.45	1.12
3 - Static	Post-Earthquake	1.20	0.63	0.56

The impact of additional permafrost thawing beneath the dam was evaluated for Cases 1, 2 and 3 to help understand the importance of this variable in dam stability and provide some guidance as to appropriate upgrading scenarios e.g. determine how the depth of thaw affects the relative improvement from ground improvement techniques. The results of this sensitivity analysis are summarized in Table 5 for analysis where the permafrost elevation below the dam was dropped by an additional 2 m. In all cases, the high piezometric level was assumed. The results show very little difference in global stability in the event that additional permafrost degradation occurs beneath the dam under existing conditions.

Table 5. Factors of Safety for Existing Stability with Increased Depth of Thaw

Case	Loading Condition	Acceptable Minimum Factor of Safety	Calculated Factor of Safety	
			Existing Depth to Permafrost	Increased Depth of Thaw (+2m)
1 - Static	Steady state seepage	1.50	1.74	1.66
2a – Pseudo-static (PGA=0.11)	Earthquake	1.10	1.12	1.08
3 - Static	Post-Earthquake	1.20	0.56	.49

2.2.2.4 Dam Upgrading

A number of dam upgrading alternatives were evaluated with the objective of meeting or exceeding the acceptable minimum factors of safety for all loading cases considered. The alternatives all fall into the category of lowering the piezometric level across the dam in conjunction with altering the downstream geometry of the dam by construction of a toe berm (buttress). These measures are effective in improving the stability for static and pseudo-static loading conditions but are largely ineffective in improving the factor of safety for post earthquake conditions where the operating strength of the liquefiable soil layer does not behave as a frictional soil. In this case, the soil strength does not increase with higher overburden pressure. These conditions make it impractical to provide the resistance to

sliding necessary to achieve the desired level of improvement with respect to global dam stability for the post-earthquake loading condition.

Ground improvement techniques were therefore considered to provide the necessary resistance to slope movements under post-earthquake conditions. A variety of techniques were looked at but they all fall into the general category of replacing a portion of the thawed (liquefiable) soil with higher strength material, a technique referred to in this report as a shear key. In this regard, a shear key could theoretically consist of frozen foundation soil or high strength granular soil in a thawed state. Any theoretical failure (slip) surface must then pass through the shear key whereby the factor of safety increases. Enough material must be placed above the shear key to prevent a failure surface from exiting above (rather than passing through) it. The material above the shear key could consist of waste rock or other suitable granular material. A fundamental requirement of the shear key is that it be keyed into frozen soil and that the permafrost is protected against thawing to guard against the slip surface running below the bottom of the key.

Compacted granular material for a shear key could be placed into either a trench or large diameter casing drilled into the permafrost. The selection will depend in part, on the location of the shear key and the depth of installation. For the purposes of evaluating the feasibility of the concept, we have assumed that the key would be located immediately downstream of the seepage pond where the depth to permafrost is in the order of 2 m in Test Hole 14618-04 (EBA, 2008). Test pits excavated farther downstream in 2001 show that the permafrost within the valley bottom remains at a depth of about 1.5 m (e.g. 14618-TP01). It may be possible to shift the location of the shear key closer to the dam but the depth to permafrost beneath the seepage pond is likely to be greater than that measured just downstream of the seepage dyke. The width of the shear key and fill thickness above the key were varied until a combination that raised the FS to 1.2 (for Case 3) was achieved. For the shear key positioned immediately downstream of the seepage dyke, the required width is about 18 m assuming complete thawing of existing freeze-back beneath the existing seepage dyke. The piezometric level across the dam was left high as a conservatism to simulate the extreme condition associated with a flood event or a spillway blockage where pond water levels flooded the beach area. The piezometric level makes little difference for the critical case (Case 3 with post-earthquake liquefaction) because the liquefied soils do not behave as frictional materials.

Drainage is a key consideration for the shear key. The seepage rates are expected to continue at a similar rate as they have in the past (approximately 2-3 l/s). A filter would be placed against the downslope face of the dam to reduce the potential for internal erosion. A weighted granular or geosynthetic filter would be suitable. The bottom layer of rockfill in the shear key would be graded to provide a low resistance drainage path. Designing the drainage layer through the freeze-back zone (where the thermosyphons will be located) will require some consideration at the design stage to ensure that drainage is maintained without degrading the permafrost.

Measured ground settlements (from observations of monitoring pins) are greater than would be expected from permafrost degradation over this depth of thaw. It is therefore possible that the settlement is related to internal erosion, an observation that warrants close monitoring during subsequent condition assessments. This potential can be addressed during dam upgrading through the installation of a granular or geosynthetic filter that allows seepage to continue but retains fine grained soil particles that may be carried in the seepage water.

The results of the analysis are provided in Table 6. The results show that the factors of safety achieved by keying in a granular shear key into the frozen foundation soil are very similar to re-freezing the foundation soil upward into the toe berm. Both options would require ground freezing and/or insulation to ensure adequate performance. In satisfying the minimum factors of safety for post-earthquake conditions, the factors of safety for the other two loading cases (static and pseudo static) are raised well above the minimum values. This is primarily because the buttress increases overburden pressures and hence shear strength along theoretical failure surfaces passing through the thawed layer. Stability analysis along a section to the south of section A, orientated towards the south abutment,

indicates the toe berm should extend to higher ground on the south valley slope as shown on Drawing 1 and 2. This requirement is a consequence of liquefiable soils evident in the vicinity of the south abutment (EBA, 2002). Similar (liquefiable) conditions do not appear towards the north terrace and a similar elevated berm on the north side of the valley does not appear necessary.

Table 6. Factors of Safety for Upgraded Dam

Case	Loading Condition	Acceptable Minimum Factor of Safety	Calculated Factor of Safety	
			Toe Berm With Granular Shear Key (high piezometric level)	Toe Berm With Frozen Foundation (high piezometric level)
1 - Static	Steady state seepage	1.50	2.62	2.88
2 – Pseudo-static (PGA=0.27)	Earthquake	1.0	1.01	1.03
2a – Pseudo-static (PGA=0.11)	Earthquake	1.10	1.60	1.72
3 - Static	Post-Earthquake	1.20	1.26	1.25

The conceptual design assumes that the seepage pond will no longer be required since the water currently meets discharge criteria. Should the criteria become more restrictive or if the water quality deteriorates, it may be necessary to construct a new seepage collection pond downstream of the toe berm. Costs for a replacement seepage pond were not included in capital cost estimates. The crest of the tailings dam may need to be raised by up to 1.1 m (where it has settled) to accommodate the freeboard requirements for closure Options 1 and 2. It is not expected that this additional load will have any significant consequence on the overall stability or the feasibility of upgrading measures, but will need to be assessed in the design stage.

As part of the next design phase, some additional geotechnical investigations should be conducted. Currently the depth to bedrock and the depth of the bottom of the permafrost zone are unknown in the area of the tailings dam and proposed toe berm. These factors could influence the design options. For example, if bedrock was relatively shallow it may be practical to extend the shear key into the bedrock, thus eliminating the need for ground freezing.

2.2.2.5 Thermal Analysis

Thermal analysis has been conducted by Naviq Consulting in the summer of 2010 to assess the feasibility of developing and maintaining permafrost freeze-back in the thawed foundation and into the toe berm. A memo discussing the thermal analysis is included in Appendix C-2. The analysis demonstrated that thermosyphons would be able to freeze the currently thawed ground, and maintain a frozen condition. Global warming was considered with an assumed rate of temperature increase for the mean annual temperature of 0.08°C/year based on the temperature trend since the 1960's. The validity of extending this estimate into the future has not been considered. The analysis showed that if the thermosyphons were "turned off" after 25 years the ground would thaw over a period of several years.

The thermal analysis considered the benefits of insulating the ground, in combination with the installation of thermosyphons. The results showed that the insulation was beneficial in reducing the active layer and maintaining the permafrost after the thermosyphons were "turned off". However, thermosyhphons are required to maintain the permafrost in the long term.

The long-term effectiveness of thermosyphons under increasing temperatures was also considered. The temperature warming trends were continued for 150 years, with the thermosyphons "turned on," producing the following results:

- After 50 years of warming (equivalent to a 4.0°C cumulative increase in the mean annual temperature) the thermosyhpons were shown to still be largely effective, though the active layer had increased to approximately 2.5 m, and lateral extents of the frozen zone were decreasing.
- After 100 years of warming (equivalent to a 8.0°C cumulative increase in the mean annual temperature) the active layer extended to approximately 6 m and the thermosyphons were only able to maintain frozen conditions within a 1 m radius.
- After 100 years of warming (equivalent to a 12.0°C cumulative increase in the mean annual temperature) the thermosyphons were totally ineffective, and no permafrost remained.

In the event that climate changes melted the full depth of permafrost (some years into the future), some additional ground improvement techniques may become feasible such as: dynamic compaction, compaction grouting, jet grouting. vibro-compaction or soil mixing. These technologies would not be effective while the ground is frozen. Some of these ground improvement methods may be implemented adjacent to the ground frozen by thermosyphons before decommissioning the thermosyphons, thus maintaining the acceptable minimum factor of safety throughout. This has not been considered further at this stage, but should be investigated further as a contingency plan.

Based on this analysis, thermosyphons are effective and would provide the required freeze-back, but they would require ongoing monitoring, maintenance and replacement. Final design of the stabilization measures will require a more rigorous thermal analysis to evaluate the necessary means to maintain frozen ground or prevent degradation of the permafrost beneath the shear key. The results of the thermistor monitoring at the seepage dyke are also encouraging as it appears that the thermosyphons have been effective at agrading permafrost into the base of the seepage dyke. Additional measures such as insulating layers of organic material e.g. sawdust or woodchips within the toe buttress could also be considered. Based on the current thermal analysis, we are of the opinion that measures can be taken to prevent degradation of the permafrost even with the inclusion of the latest global warming predictions.

2.2.3 Spillway Upgrading (Options 1 and 2)

2.2.3.1 Hydraulic Analysis

Peak flow rate and volume estimates were computed for the tailings pond to evaluate the necessary spillway upgrading. The assumed 6 hour storm duration peak flow rate for the 1000-year (0.1% event), 10,000-year (0.01% event), Probable Maximum Flood (PMF), and Inflow Design Flood (IDF) have been estimated as 4.0 m^3/s, 4.8 m^3/s, 12.5 m^3/s, and 6.8 m^3/s, respectively. The assumed 6 hour storm duration volumes for the 1,000-year, 10,000-year PMF, and IDF have been estimated as 89,000 m^3, 107,000 m^3, 281,500 m^3, and 153,000 m^3, respectively. Spillway widths of 5, 7 and 10 m were analyzed for the tailings pond based on the estimated peak flow rates and volumes for the above noted events. The maximum water level rise in the tailings pond has been assumed as 1 m.

Based on a high classification and in accordance with the Canadian Dam Association 2007 guidelines, the IDF should be estimated as 1/3 between the 1,000-year event and the PMF. The catchment area draining to the site has been estimated in a previous AECOM hydrologic analysis as 3.3 km^2. The Tailings Pond catchment area is

based on the combined Dome Creek catchment areas for the diversion ditch north of the pond and the interceptor ditch south of the Pond. The precipitation records from the Environment Canada meteorological gauging station at Carmacks, Yukon were used to estimate the peak flow rate and volume for the 1,000-year, 10,000-year, IDF, and PMF events. The recorded rainfall records at the Carmacks gauge have been adjusted to estimate the rainfall depth at the Mount Nansen mine site based on a regression analysis performed in the previous AECOM hydrological analysis.

The 1000-year and 10,000-year rainfall intensities have been extrapolated from the Intensity-Duration-Frequency curves (IDF curve) at the Carmacks gauge provided by Environment Canada. The Environment Canada estimated 2, 5, 10, 25, 50, and 100 year rainfall intensities were plotted to obtain regression equations for various storm durations. The regression equations were used to approximate the 1,000-year and 10,000-year rainfall intensities for various storm durations. CDA discourages the extrapolation of flood statistics beyond the 1,000-year event. The 10,000-year has been provided for the sake of analysis.

The Probable Maximum Precipitation (PMP) was used to develop the PMF. The PMP was computed using the maximum annual 24 hour rainfall records adjusted from Carmacks gauge. The summer PMP event has been estimated using the Hershfield statistical analysis ("Manual for Estimation of Probable Maximum Precipitation" – WMO No. 332). The general frequency equation is:

$X_m = X_n + K_m S_n$

Where:

X_m = rainfall for maximum observed rainfall
X_n = mean of a series of n annual maxima
S_n = standard deviation of a series of n annual maxima
K_m = common statistical variable that varies with X_n for different rainfall durations

The calculated annual mean, standard deviation and the selected Km for the adjusted Carmacks precipitation series as well as the area adjusted PMP estimate using the Hershfield statistical method are summarized in Table 7.

Table 7. Summer PMP Estimate for Adjusted Environment Canada Carmacks Records

X_n	S_n	K_m	Fixed Observation Adjustment	Area Adjustment	Area Adjusted PMP (mm)
18.0	6.0	19	1.13	1	149

The 1,000-year, 10,000-year, and PMF peak flow and volume estimates have been computed using the classic Rational Method. The estimated peak flow based on the Rational Method is computed using a runoff coefficient, rainfall intensity, and catchment area. The runoff coefficient has been approximated as 0.7 for the Mount Nansen site, based on the previous AECOM hydrological analysis. The peak flow and volume estimates for the 1,000-year and 10,000-year events for various storm durations are provided in Table 8.

Table 8. Peak Flow and Volume Estimates for 1000-Year and 10000-Year Events

Duration	1000-year Event		10000-year Event	
	Peak Flow (m^3/s)	Volume (m^3)	Peak Flow (m^3/s)	Volume (m^3)
5 min	151.3	45,500	179.2	54,000
10 min	83.1	50,000	98.9	59,500
15 min	58.7	53,000	69.9	63,000
30 min	32.4	58,500	38.8	70,000
1 hr	18.0	65,000	21.5	77,500
2 hr	10.0	72,000	12.0	86,500
6 hr	4.0	89,000	4.8	107,000
12 hr	2.2	96,000	2.7	115,000
24 hr	1.2	108,000	1.5	128,500

A 6 hour storm duration has been assumed for this analysis. The computed 24 hour storm duration peak flow and volume estimates for the PMF event are 3.9 m^3/s and 338,000 m^3. The 6 hour storm duration PMF estimate has been computed by approximating the ratio of 6 hour to 24 hour calculated for the 1,000-year and 10,000-year events. The 6-hr/24-hr peak flow ratio is 3.2. The 6-hr/24-hr volume ratio is 1.25. The estimated 6 hour storm duration PMF peak flow and volume estimates are 12.5 m^3/s and 281,500 m^3.

The IDF is computed as 1/3 between the 1000-year event and the PMF. The peak flow and volume have therefore both been computed as 1/3 between the two events. The IDF peak flow and volume estimates are 6.8 m^3/s and 153,000 m^3. Hydrographs were developed for the 1000-year, 10000-year, IDF, and PMF events based on the computed peak flow rates and volume. A hydrograph was developed for each event using a dimensionless hydrograph approach. The 1,000-year, 10,000-year, IDF, and PMF event hydrographs are shown in Figure 2.

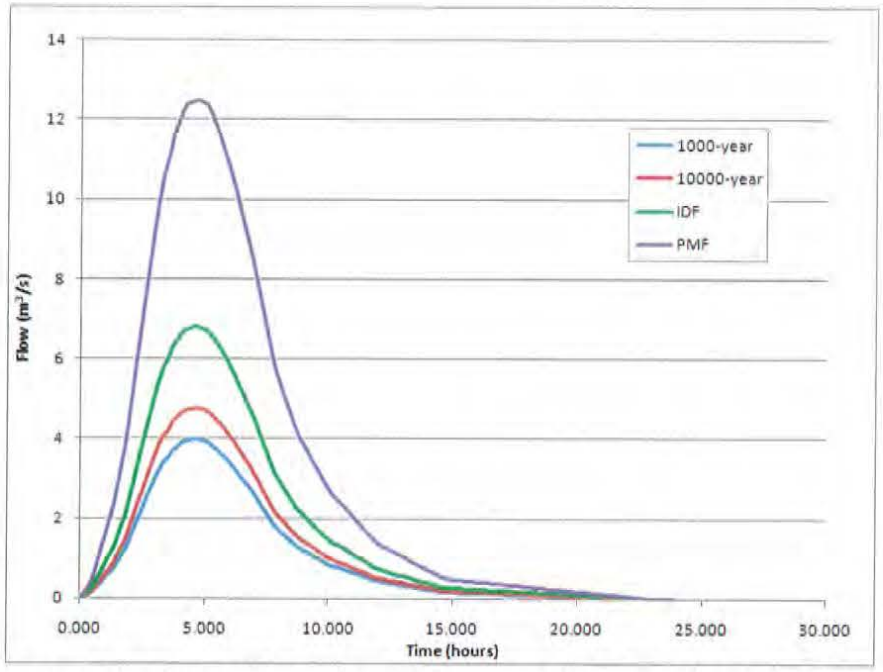

Figure 2. 1000-year, 10000-year, IDF, and PMF Event Hydrographs

The 1000-year, 10000-year, IDF, and PMF hydrographs were routed through the modelled tailings pond. A HEC-HMS model of the tailings pond was developed in the previous AECOM hydrologic analysis. A stage-storage curve was not available at the time the model was developed. A stage-storage curve was developed for the tailings pond assuming the pond has a 7 ha cylindrical storage area (i.e. area at the water cover elevation is the same at the dyke top: 7 ha). Spillway widths of 5 m, 7 m, and 10 m were analyzed for the 1000-year, 10000-year, IDF, and PMF events. The Tailings Pond spillway modelling results are shown in Table 9.

Table 9. Tailings Pond Spillway Peak Outflow and Maximum Water Level Rise

Event	Spillway Width (m)	Peak Inflow (m^3/s)	Inflow Volume (m^3)	Peak Spillway Outflow (m^3/s)	Maximum Water Level Rise (m)
1,000-year	5	4.0	89,000	2.8	0.5
1,000-year	7	4.0	89,000	3.1	0.4
1,000-year	10	4.0	89,000	3.4	0.3
10,000-year	5	4.8	107,000	3.5	0.6
10,000-year	7	4.8	107,000	3.8	0.5
10,000-year	10	4.8	107,000	4.1	0.4
IDF	5	6.8	153,000	5.2	0.7
IDF	7	6.8	153,000	5.6	0.6
IDF	10	6.8	153,000	6.0	0.5
PMF	5	12.5	281,500	10.3	1.1
PMF	7	12.5	281,500	11.0	0.9
PMF	10	12.5	281,500	11.5	0.8

For the purposes of conceptual design, we have selected a 5 m wide spillway as being required to pass the IDF. Assuming that a minimum of 0.5 m of remaining freeboard would be required at this flow, the spillway channel would have to be at least 1.2 m below the tailings dam crest. The spillway elevation will in turn be dependent on the final cover design. For example, a spillway elevation of 1098.75 is suitable for Option 1. A spillway elevation of 1098.9 for Option 2 would retain a small amount of water in drainage swales and in the cover. To maintain the desired remaining freeboard during the IDF, the dam crest would have to be either raised to elevation 1100.1 m (a raise of about 0.4 m) or alternatively, a wider spillway channel could be considered to almost eliminate the requirement for a dam raise. In any case, there is sufficient room on the north terrace at the existing spillway location to provide for the necessary spillway channel geometry although some modification to the existing road alignment may be required. Consideration will have to be given during detailed design to side slopes and channel armouring compatible with the anticipated velocities at peak flows. A conceptual cross section through the spillway channel is shown on Figure 9. Depending on the ultimate water management plan and associated flows over the spillway, a concrete spillway (overflow) structure may be preferred.

2.2.4 Diversion Channel Upgrading downstream of the Spillway (Options 1 and 2)

As established by the tailings pond water balance (GEEC 2010), it is necessary to open up the tailings pond diversion watershed into the proposed tailings pond. To accommodate this, the diversion ditch upstream of the spillway will be backfilled and graded to approximately fit the natural slope contours. Flows in the Dome Creek channel will be diverted over the tailings.

A conservative peak design flow of 10 m^3/sec was previously chosen for a conceptual channel design upstream of the emergency spillway (AECOM, 2009). While at less than 7 m^3/sec, the IDF is less than this assumed value, the results from our previous assessment of channel upgrading are considered representative for conceptual design purposes.

The diversion channel downstream of the emergency spillway appears to be close to the design cross section considering the design flows, and it should therefore be possible to maintain a flow depth of approximately 1 m or less. Based on the observations from our inspection, additional armouring and upgrading of some of the drop structures should be considered, in particular downstream of Drop Structure 6. *A more detailed hydraulic analysis is recommended to determine if the drop structures are sufficient to achieve velocities in the steeper channel section that are acceptable for the size and thickness of bedding and bank armouring material.* In lieu of this information, an allowance has been carried in our cost estimate for upgrading this section of the diversion channel. If the diversion channel is backfilled, the current bridge will no longer be required to access the tailings pond.

2.2.5 Interceptor Ditch (Options 1 and 2)

The interceptor ditch on the west side of the tailings pond was originally excavated to intercept runoff before it entered into the tailings pond. The water from the ditch is conveyed to the north where it enters the Dome Creek diversion channel as shown on Drawing 9. Maintenance of the channel has been problematic since it was constructed and we are of the opinion that it is no longer a necessary feature for closure alternatives under consideration. The final decision as to the requirement for the interceptor ditch will depend on the outcome of the detailed design of the water management system and cover. For the purposes of this report, we have assumed that the ditch will be backfilled and the perimeter road will be extended as shown on the section on Drawing 8.

2.2.6 Water Diversion From Dome Creek (Options 1 and 2)

Diversion of some or possibly all of the flow in Dome Creek into the tailings pond may be required for Options 1 and 2. Diverting water from the creek could be considered to maintain a constant water level and/or allow for replenishment with clean water, an operating strategy that may be preferred. In this case, the entire creek flow could be diverted through the tailings pond since the spillway is designed for the IDF. The attenuation in the pond will also help reduce the peak flow over the spillway for short duration but high flow events.

The elevation of the water cover for Option 2 is 1098.9 m, which is the highest water level of the options under consideration. In comparison, the elevation of the channel bottom of the diversion ditch at the confluence with Dome Creek is about elevation 1100 m, rendering it possible to divert water from the diversion channel into the tailings pond in this vicinity for any of the alternative cover designs.

If the entire creek flow is diverted into the pond, the spillway will be in service year round with the exception of freeze-up in the winter. Although this strategy eliminates the need for the diversion channel on the north edge of the pond during normal operation, it may be advisable to upgrade a portion of the diversion channel and have it remain as an emergency spillway in the event of a blockage of the spillway on the tailings dam. An overflow weir, likely a concrete structure, could be constructed to spill water into the diversion channel should water in the tailings pond reach a critical elevation. A decision can be made during detailed design once a more detailed water balance has been completed. In any case, it appears that sufficient water can be routed into the pond to satisfy all of the cover alternatives under consideration.

2.2.7 Cover Design

2.2.7.1 Water Cover (Option1)

A 0.7 m thick water is considered to be an efficient method for reducing oxidation of tailings. In terms of dam safety, the water cover could impose a more stringent classification because of the risk of overtopping and effects of wave action. A 0.3 m thick sand diffusion layer should be placed to minimize direct contact with the tailings. Even with this layer, potential contamination of the water cover must be considered, in particular if the water remains stagnant (zero discharge). There is a higher risk of not being able to maintain a water cover in dry years if the diversion is not implemented. The water management plan would involve routing flow in Dome Creek into the pond to provide dilution. In this case, the spillway would be used to discharge water and control the pond elevation.

The beach area would be constructed with the locally available sand. The sand beach material would serve to distribute porewater to the upper surface of the tailings the help maintain saturation. To the extent possible, vegetation would be established over the beach to reduce wind erosion. The optimal width of the beach would be determined in the detailed design stage, but a 50 m width is reasonable based on the current analysis.

2.2.7.2 Saturated Soil Cover (Option 2)

The objectives of a cover system are to

- control fugitive dust,
- inhibit the ingress of oxygen by maintaining saturated conditions within the cover,
- provide a medium for the establishment of vegetation.

Clearly, these objectives are very different in their intent as well as the methods of design and construction. Until such time as a preferred closure alternative has been selected, the cover system has only been considered in concept with recognition to existing hydrology and readily available construction materials. In this regard, a terrain mapping and materials search was carried out by EBA Engineering to locate suitable borrow sources of fine grained material potentially suitable for capping tailings or waste rock (EBA, 2009). The predominant soil types in the immediate vicinity of the mine consist of poorly graded glaciofluvial sand and gravel but a potentially suitable well graded material was identified near Victoria Creek. The potential Victoria Creek borrow source is discussed in the following section.

Soil covers are often utilized to minimize oxidation of tailings and surface water contamination. A soil cover prevents water infiltration from entering into direct contact with the tailings and consequently reduces the generation of contaminated runoff. Essentially, a blanket of saturated soil (tension saturated zone) is created within the cover which limits oxygen diffusion into the tailings. The soil cover therefore provides a water cover without the need for a continuous surface pond. This can be accomplished by either providing a low-permeability cover where water is stored near the surface and released as runoff or allowing water to infiltrate the cover where it can be subsequently released by evapo-transpiration. The cover should contain an optimum percentage of fines to retain some moisture under dry conditions.

The soil cover requires the placement of a minimum 1 m thick soil cover over the tailings and maintenance of an intermittent and discontinuous water cover approximately 0.15 m above the soil cover elevation to maintain the soil cover in a saturated condition. The surface of the cover would be constructed to be uneven, so that there would be areas where the cover is above the controlled water level while in other areas the soil would be below the typical water level. This would be conducive to establishing a vegetated wetland habitat on the cover. The intermittent water cover provides visual evidence that the cover is saturated, and serves as a temporary reservoir under dry conditions. Drainage swales with an invert elevation below the invert of the spillway would be used to direct excess

flows to the outlet, while also ensuring that surface water is distributed throughout the tailings management area under lower flow conditions. One advantage of the saturated soil cover approach is that it is possible to establish vegetation on the top of the cover in some areas.

The soil cover is considered a lower risk in terms maintaining saturated conditions since in dry years where the water cover cannot be maintained, soil would still cover the tailings. Since water is impounded, a spillway is required and would be set at elevation 1098.9 m Dam classification would likely be similar to the water cover scenario. Of significance is the potential that a locally available fine silty-sand may be suitable without amendments. The cover water is expected to be suitable for direct discharge if a minimum flow is maintained through the pond.

Victoria Creek Borrow Source

A potential source of borrow material, that may be suitable for the Option 2 soil cover, was identified approximately 5.5 km from the pit (along the mine access road near Victoria Creek). The "Victoria Creek borrow material" was well graded gravelly sand containing 16% silt and 6% clay, based on the grain size distribution shown in Figure 3. The silt and clay fractions of the Victoria Creek borrow material are great enough that the material exhibits some plastic behaviour when manipulated. This material is considered to have a lower hydraulic conductivity than the aeolianand glaciofluvial sands which are more common around the mine site. This material may be suitable as a cover material as it has some desirable characteristics not found in other local materials. The hydraulic conductivity of the material has been estimated to be between 2.5×10^{-7} and 3×10^{-5} m/s when calculated using the Hazen formula (Craig 2005):

$$k = CD_{10}^2 \quad (m/s)$$

where
C = a coefficient dependant on soil type.
k = hydraulic conductivity (m/s)
D_{10} = is the effective size (mm)

It should be noted that the Hazen formula is intended for sands. More advanced conductivity analysis of the material is recommended to develop a more reliable and accurate estimate.

Based on surficial observations of the deposit along the road cut, it appeared as if there was a large quantity of similar material available. Additional sampling and testing would be required to determine the available quantity and suitability of this material.

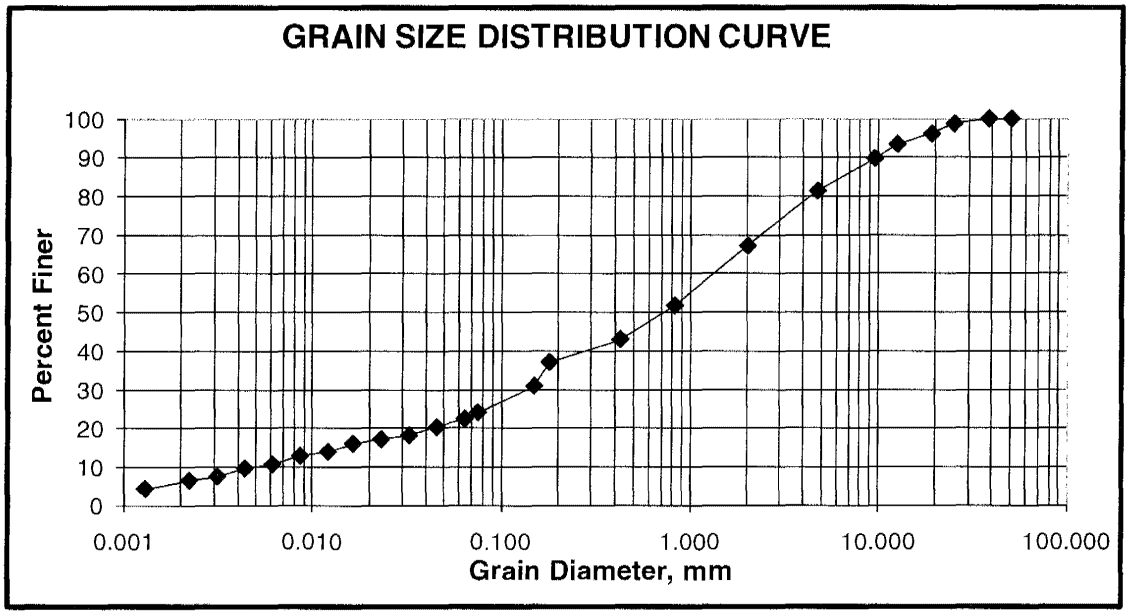

Figure 3. Grain Size Distribution from Victoria Creek Borrow Source

2.2.8 Seepage Control

An assessment of seepage through the tailings dam has been done by AECOM (Appendix C-1). The seepage analysis considered 2-D seepage through the tailings dam. It was demonstrated that seepage through the dam could be significantly decreased by either replacing the zone of coarse tailings (against the dam face) with finer tailings, or by installing a seepage barrier along the upslope face of the dam. Either of these improvements would require the excavation and replacement a volume of tailings. The seepage analysis showed that the tailings could be kept at or above 85% saturation by either of these means. It should be noted that several assumptions made in these models including hydraulic conductivities, geometry and boundary conditions that limit the reliability and accuracy of the results. These assumptions should be validated as part of future assessments based on measured or verified parameters where possible. The hydraulic conductivity of the coarse and fine tailings units had not been measured in a laboratory at the time of this analysis.

It is proposed that replacing some of the coarse tailings with fine tailings would be a practical solution because it does not rely on any manufactured or imported products. The lower conductivity fine tailings would reduce seepage through the dam, while maintaining saturation. An approximate volume of 35,000 m^3 would be replaced. The constructability of excavating and replacing the loose tailings should be considered in the design stage. Installing a grout curtain along the upslope face of the dam may also provide similar results, without requiring any excavation of the tailings. This option has not been considered further at this time.

2.2.9 Waste Rock In Place (Option 1 and Option 2)

The waste rock piles will remain in place and the pit will generally remain in its current state for the base cases of Option 1 and Option 2. The following sections discuss some of the considerations regarding the waste rock piles and the Brown-McDade pit for these closure options. This assessment only considers the physical condition of the waste-rock piles. A detailed discussion of the geo-chemical characteristics and considerations was provided by Altura (2009).

2.2.9.1 Waste Rock Piles

The bulk of the existing waste rock piles will remain in place for closure Options 1 and 2 (base cases) although some waste rock will be used for other construction activities (eg. constructing the toe-berm, and spillway armouring). Some additional grading may be required to improve the stability of the piles. The slopes of the waste rock piles are currently at the angle of repose, Φ_{repose}, which was reported as 32° (Altura 2009). The calculated factor of safety (FS) for a slope at the angle of repose is unity (1), under static conditions above the water table. For a frictional material above the water table, the calculated static FS can be estimated as:

$$FS = \frac{tan\phi_{repose}}{tan\beta}$$

where β is the slope angle. A reasonable design factor of safety for static conditions could be taken as 1.3, but this may be revised based on the history of good performance, and the relatively low level of risk associated with failure of a waste rock slope. The design criteria for the final grading of the waste rock piles should also consider the characteristics of the foundation material, stability under seismic conditions and the potential for erosion of the slope.

If the waste rock piles are left in their current state, erosional processes would decrease the slope angles and increase the pile footprint with time. Altura (2009) noted that no macro-scale erosional features were evident at the time of the inspections, but some sorting of materials was observed at the surface.

Where practical, the selection of waste rock for use in construction (toe berm, armouring, roads etc.) should be done with consideration for the stability of the waste rock piles, so as to minimize or eliminate additional re-grading of the waste rock piles. A system of compound berms and slopes could be considered for the final pile configuration. This geometry allows for interim construction access for removal of the waste rock, as well as developing a stable slope for closure. The re-grading of specific waste rock piles has not been considered for this report.

2.2.9.2 Condition of Brown-McDade Pit

The general condition of the Brown-McDade pit was assessed by AECOM during a site visit in 2008 and again briefly in 2010. The pit walls consist of weathered rock. The talus accumulated on the benches and at the base of the pit, shown in Figure 4, confirms that there has been ongoing spalling and erosion of the pit walls. No large-scale instability of the pit walls was noted but evidence such as tension cracks may have been obscured by overburden and weathered rock.

The condition of the pit walls should be considered in more detail during subsequent design stages. A program of scaling is recommended to remove the loose and marginally stable rock from the pit walls. Some blasting and re-grading may also be required to improve the stability conditions of the pit walls. Depending on the level of acceptable risk, the stability and condition of the pit walls should be assessed regularly as part of the ongoing maintenance plan.

Figure 4. Brown McDade pit a) looking toward south entrance and b) from north end.

The security measures for maintaining public safety at the pit site are currently inadequate. A ditch and berm system, possibly supplemented by fencing, should be constructed around the perimeter of the pit as a method of warning people of the hazard, and diverting traffic. The adequacy of the signage around the pit should be reviewed and improved as required.

2.2.10 Alternative B: Waste Rock Backfill into Pit (Option 1B and Option 2B)

For Options 1B and 2B the waste rock piles will be relocated into the pit. The placement of the waste rock will be subject to minimal sorting, placement and compaction criteria, except that the rock placed at the bottom of the pit, below the water table should be selected to ensure low metal mobility (Altura 2009). The surface of the waste rock should be contoured in such a way as to promote drainage of surface water out of the pit, and to minimize or eliminate the remaining high-wall. Vegetation should be established on the surface of the waste rock if possible. The newly exposed natural ground surface beneath the current waste rock piles should also be vegetated.

2.2.11 Operations and Maintenance

In the event that either Option 1 or 2 are implemented for the closure of the Mt. Nansen mine, there are a number of regular operations and maintenance items that must be considered. The specifics of these items will be developed during final design.

- Dam safety reviews: will be carried out at the minimum intervals as specified by the Canadian Dam Association Guidelines. This will provide a complete condition and performance assessment of the facility.
- Dam maintenance and toe-berm maintenance: Regular inspections will be required to identify maintenance issues.
- Spillway and diversion channel maintenance: The spillway and diversion channel will require regular maintenance to remove accumulated sediment, maintain the erosion protection and repair any damages. The drainage swales surrounding the tailings area, and through the tailings area may also require some maintenance.
- Cover maintenance: Some maintenance is anticipated for both cover options over several years following construction. An area of concern will be against the tailings dam where the coarse tails will be replaced with the fine tails. Some settlement would be expected in this area.
- Performance monitoring:
  - Deformations should be monitored at regular intervals (eg. Annually or bi-annually) after the construction of the remedial measured to identify changes in the performance of the dam, and determine the effectiveness of the stabilization work and seepage filters.
  - Thermistors should be monitored at regular intervals (seasonally or more regularly with a data logger) to determine the performance of the thermosyphons at the toe berm. Ongoing changes in the thermal regime at other locations are also of interest with respect to seepage and dam stability.
  - Water levels: Surface and groundwater levels are important indicators of the performance of the remedial works. Regular monitoring should be maintained until a *steady-state condition* develops (considering seasonal effects) and satisfactory performance is achieved.
- Environmental monitoring of groundwater and surface water: Monitoring for contaminants will be required for some period of time as specified by the stakeholders and regulators.
- Waste rock: The physical (ie. stability) condition of the waste rock piles should be considered as part of site inspections. The geo-chemical characteristics of the waste rock and the water quality of the seepage from the waste rock piles should be monitored as well.
- The pit should be inspected at regular intervals to assess the condition and stability of the pit walls. Some regular maintenance may be required if the pit walls are considered to pose a risk to the public. The perimeter safety barrier (ditch and berm) and signage should be maintained in good condition.

- Access to site: Access to the site should be maintained to accommodate maintenance, and monitoring programs.

2.3 Option 3: Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place

2.3.1 High Infiltration Cover

The principle of the design for Option 3 is that by maintaining the tailings at 85% saturation or greater, the diffusion of oxygen into the tailings is limited, and therefore the potential for the generation of Acid Rock Drainage (ARD) is greatly reduced (Golder 2010A). The cover serves some important functions as the available water is limited, and the efficient distribution of the available water to the surface of the tailings is critical to the success of Option 3.

The objectives of the high infiltration cover design for Option 3 are to:

- promote infiltration of precipitation, and available surface water through the cover and into the tailings
- limit evaporation
- control fugitive dust and limit erosion of the tailings and cover

The analysis conducted by Golder (2010A), considered a cover consisting of a 1 m thick layer of coarse waste rock to be suitable. The cover material should be inert so as not to not contaminate ground or surface water. It would not be beneficial to establish vegetation on this cover as this may result in an increase in water losses through evapotranspiration. Further assessment of cover options and cover design should be addressed in the final design. Tailings Dam at Open Pit

A dam at the south end of the open pit will be required to contain the tailings and water cover (Drawing 3) for Option 3. The dam is shown on Drawing 3 at the high point in the ramp into the pit, and although it could possibly be moved to the south (closer to the road), the height of the dam is expected to be in the order of 8 to 10 m. The west and east abutments are shown in Figures 5 and 6, respectively. The low grade ore can be seen along the base of the pit. A liner would likely be required to minimize seepage losses through the dam since these losses would report as surface water at the south end of the pit. The liner would extend into the bedrock foundation to minimize the potential for foundation seepage. A significant uncertainty at this time is the volume of seepage losses that can be expected around the perimeter of the pond, into fractured bedrock, and the possible requirement for seepage control measures in this regard.

The dam could be founded on bedrock, but this would require excavation of up to 6 m of the low grade ore that has been placed along the south entrance to the pit. Alternatively, it may be possible to construct the dam on top of the existing low grade ore, subject to future assessments. If the dam was built on bedrock, there would be no concerns with respect to liquefiable soils. The design of the dam should still follow the 2007 Canadian Dam Association guidelines, including the spillway which would be designed for the IDF associated with a high classification (to be confirmed during detailed design). The dam would be constructed using locally available materials, primarily inert waste rock and/or granular borrow materials. The same requirements for routine inspections, dam safety reviews and maintenance as exist for the existing tailings dam would apply to a tailings dam constructed to contain tailings at the open pit. In terms of risk, there would be very little difference between the existing and a new structure given that the consequences of a failure would be similar. It may be possible to demonstrate that the potential volume of tailings released in a failure would be less because of the natural bedrock barrier at elevation 1195 m but this would have to be quantified during detailed design.

Figure 5. Approximate Location of West Abutment of Proposed Tailings Dam in Open Pit

Figure 6. Approximate Location of East Abutment for Tailings Dam in Open Pit

2.3.2 Spillway and Pony Creek Diversion

It is understood that under normal operating conditions, the spillway would not be in use because the inflows are expected to be lower than the losses to infiltration, seepage and evaporation. However, as the tailings are contained by a dam, it necessary to provide some provision for the spilling of excess surface water to prevent overtopping of the dam. A spillway could be constructed either at the North end of the pit, or over the proposed tailings dam at the south end of the pit. Spilling water north, into Pony Creek, would require a shorter channel, but may require some excavation through bedrock.

Based on the current assessment, a water diversion from Pony Creek may not be necessary, A brief discussion of some of the geotechnical aspects of a diversion are still presented in the event that the diversion of some flow from Pony Creek is necessary. In order to divert water from Pony Creek, a side hill diversion channel would be required as shown on Drawing 3. Given the intermittent flow in the creek, it is anticipated that water would be re-routed entirely through the open pit and back into the creek via a spillway on the north end of the pit. A stop-log weir structure could accomplish this and would have the advantage of redirecting flow in the natural creek channel should water quality objectives not be met in the pond or if maintenance of the cover over the tailings is required.

A Pony Creek diversion channel and spillway channel would each have to cross the mine site access road at the north end of the open pit. Crossing options would include bridges, fords or culverts. A bridge crossing would be the most expensive option, and is likely not necessary considering the small volumes anticipated in the diverted flows. A culvert would be less expensive than a bridge, and would still provide an all-weather, dry crossing. The culvert would require ongoing maintenance and may be susceptible to plugging or constriction due to ice or debris. A ford crossing is the most economical option and requires the least maintenance, but would not provide all weather/all vehicle access. Some maintenance may be required depending on usage. Diverting water through a pipe or culvert would alleviate some of the challenges of building and maintaining a channel on a slope, but introduces other long term maintenance challenges of its own such as plugging or constriction with ice or debris, more difficulty inspecting and more costly and complex control structures

2.3.3 Transportation of Tailings

Options 3 and 4 require the relocation of approximately 300,000 m^3 of tailings and contaminated soil from the TMA Brown Mc-Dade Open Pit under various infill and cover scenarios. Tailings are commonly relocated using i) mechanical, ii) hydraulic and iii) dredging methods. The selection of the preferred method depends on tailings characteristics, climatic factors, distance and relief from tailings source, to name a few. The mechanical removal of tailings, namely by excavator and truck to a contained disposal site, has been shown to be successful for tailings deposits which are not submerged or are above the water table. For below water table deposits, mechanical removal may require dewatering (sump and pump) systems with water treatment. The key issue with this method is trafficability of equipment on top of saturated tailings. In cold weather climates, it has been found that frost penetration can be used to provide a working surface, allowing equipment to move over the saturated tailings.

Hydraulic removal utilizes high pressure sprays (water cannons) to liquefy the tailings deposit. Tailings are washed to sumps where slurry pumps and pipelines transport the tailings to the final destination (likely the open pit). Tailings gradation is a key consideration as it influences the ability to maintain a slurry during transport. In addition, the process is limited to summer operations, thereby limiting the time to remove and remediate the tailings area. The difference in elevation between the tailings pond and the open pit (approximately 105 m) and the distance (approximately 1 km) present significant challenges for this method.

Dredging has also been successfully used for relocating tailings. Key factors which influence the operation are the challenges of managing the volume of tailings, minimizing the water cover to achieve dredge flotation and maintaining sufficient freeboard in the tailings area to avoid unplanned release. Other forms of removal in this class are dumping the mechanically excavated tailings into a sump and transporting them as a slurry to the open pit, if economically justified.

Transportation of Tailings for Option 3

The design for Option 3 (wet cover) requires that the coarse and fine tailings be mixed to form a homogeneous blend of materials with a consistent hydraulic conductivity. Numerical analysis by Golder (2010A) indicated that 85% saturation could be maintained in the tailings if an average hydraulic conductivity of $5x10^{-9}$ m/s or less could be achieved for the tailings. Laboratory testing of blended tailings (Golder 2010A) demonstrated that the hydraulic conductivity of mixed tailings (blended in the laboratory) ranged from approximately $3x10^{-7}$ to $1.5x10^{-9}$ m/s depending on the gradient.

It is important to note the density of the samples in the laboratory (1850 kg/m^3) is greater than the density of the tailings in the current tailings management area (990 – 1785 kg/m^3) (Golder 2010A). Denser samples (under saturated conditions) will generally have a lower hydraulic conductivity than a looser sample. At the base of the pit, the tailings may consolidate somewhat, but it is not reasonable to assume that the tailings will consolidate naturally to a density of 1850 kg/m^3 over the full depth (based on the densities measured in the existing tailings management area). The density of the tailings will increase over time as they consolidate, with a corresponding decrease in hydraulic conductivity over time. It should be noted that the hydraulic conductivity measured in a laboratory typically varies by some amount from the hydraulic conductivity reasonably achieved in the field. Golder (2010A) blended the tailings in a laboratory conditions and it expected to be difficult to achieve this level of homogeneity under large-scale field conditions. If the tailings are placed in a slurry form some segregation of the coarse and fine fractions would be expected.

The ability to create a blend of tailings that achieves the required properties (ie. a homogeneous mixture with a hydraulic conductivity of less than of $5x10^{-9}$ m/s) is a significant uncertainty with respect to Option 3.

Based on conversations with an experienced contractor, the most economical way of blending and transporting the tailings would be by dredging the tailings and transporting them in a slurry form (ie by pipeline). Two dredging operations would be set up to collect materials from both fine and coarse tailings deposits simultaneously. The tailings would be mixed "in-line" by combining the flows from both dredgers into a single pipe. There would be some ability to further adjust the blend by controlling the flow rates from the individual sources. Segregation of the tailings upon placement into the pit would be a concern. Alternatively the tailings could be mixed by blending tailings in a hopper being fed by conveyors of coarse and fine tailings. This would not require slurrying of the tailings.

Approximately 300,000 -500,000m^3 of water would be required to slurry the tailings to allow hydraulic relocation to the open pit. Considering an average porosity of the tailings of 0.6 and saturated condition, it is estimated that the tailings contain approximately 180,000 m^3 of water in the pores. An additional 120,000 m^3 to 320,000 m^3 of water would therefore be required for the process, a portion of which would eventually end up in the open pit. Water for the dredging process would have to be stored in the tailings pond or in a different location prior to relocation of tailings and the re-use of process water would be considered. Potential environmental impacts associated with this method include spills along the pipe line system. Seepage of the process water out of the pit bottom and sides into the environment would be a concern during and following the tailings transportation.

2.3.3.1 Consolidation Settlement of Relocated Tailings – Saturated Environment

Some consolidation may occur due to the change in effective stresses (due to increased depth), transportation method chosen for the relocation of tailings to the open pit, due to load (cover) and/or due to potential fluctuations of the water table within the tailings layer (if any). The total consolidation amounts can be significantly reduced if the tailings are mechanically transported (without the addition of water). Potential consolidation will be an important consideration in establishing spillway control. For example, it may be necessary to provide the ability to lower the spillway elevation if maintaining a constant water depth is desired after consolidation takes place. Uneven differential settlements will also affect the surface water flows over the soil/rock cover.

2.3.4 Pony Creek Adit (Options 1B, 2B, 3 and 4)

The Pony Creek Adit daylights in the Brown McDade pit, with the portal approximately 160 m north-east of the pit, near Pony Creek. The Adit has a gradual downward slope from the pit to the portal. The Pony Creek Adit should be permanently plugged to prevent seepage of porewater, and erosion of backfill materials through the adit. There is currently a 50 cm thick reinforced concrete bulkhead installed approximately 30 m from the portal (SRK Consulting 2006). The performance of the bulkhead has not been tested, and because the surrounding rock was not grouted to seal fractures, the overall performance of the bulkhead system is uncertain. For the purpose of mine closure, it would be desirable to have a plug located closer to the pit face. A massive concrete bulkhead in the order of 32 m^3 (approximately 2.75 x 2.35 x 5m) combined with grouting radially around the circumference of the adit may provide a suitable plug. Alternatively, a plug constructed of select compacted soils, may provide good long term performance. A detailed design considering design criteria, closure option, location, bedrock conditions, porewater chemistry, porewater pressures, earth pressures, lifespan, and cost is required.

2.3.5 Valley Restoration (Option 3 and 4)

Once the tailings are removed from the existing TMA, it is expected that a series of staged and sequenced engineering, environmental and botanical solutions will be required to restore the affected tailings management area back to a natural setting. Some of these considerations will require a multi-disciplinary approach to the challenges of at least:

i. Removal and deposition of fill soils to original natural ground and groundwater conditions.
ii. Replacement with natural imported vegetative soil cover(s) with appropriate contouring and drainage improvement.
iii. Revegetation using native plant species and selected fertilizers.

At this stage of the study of closure options, and in consideration of the complexity of technical issues and related costs at this remote location, this report has only identified these requirements. The potential contamination of the in situ soils (beneath the tailings) and dam fill material has not been investigated and is a significant uncertainty. The suitability of these existing materials (in their current state) for use in the final restoration is unknown.

Further study will be required by appropriate expertise to define and design these measures, before more accurate cost estimates can be prepared. It is likely that locally available sands and gravel can be used for site restoration.

2.3.6 Operations and Maintenance

There are a number of operations and maintenance items to be considered for closure Option 3:

- Dam safety reviews: Reviews will be carried out at the minimum intervals as specified by the Canadian Dam Association Guidelines. This will provide a complete condition and performance assessment of the facility.

- Dam maintenance (in pit): Regular inspections will be required to identify maintenance issues.
- Spillway: The spillway will require maintenance to remove accumulated sediment, maintain the erosion protection and repair any damages.
- Cover maintenance: Some maintenance is anticipated for the cover options over several years following construction. It is anticipated that the tailings will be placed without any compaction, and therefore overall and differential settlements would be anticipated. The settlements may affect the performance of the cover by preventing the distribution of surface water across the tailings area.
- Performance monitoring:
  - Porewater pressures: The satisfactory performance of this option is dependent on the saturation (minimum 85%) of the tailings. To monitor performance, suction sensors, water content probes and piezometers should be installed and monitored.
- Water treatment: In the event that the tailings are transported in a slurry form, some water treatment may be required for the excess porewater that reports to the surface based on the results of monitoring. Some excess porewater will also report to the sides and bottom of the pit. This porewater water would be more difficult to capture and treat. Requirements for long term treatment of groundwater are not anticipated as the tailings should remain in a state of saturation based on the closure design.
- Environmental monitoring of groundwater and surface water: Monitoring for contaminants will be required for some period of time as specified by the stakeholders and regulators.
- Waste rock: The physical (ie. stability) condition of the waste rock piles should be considered as part of site inspections. The geo-chemical characteristics of the waste rock and the water quality of the seepage from the waste rock piles should be monitored as well.
- Access to site: Access to the site should be maintained to accommodate maintenance, and monitoring programs.

2.4 Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover

2.4.1 Co-Disposal of Tailings and Waste Rock in Open Pit

Option 4 requires that the tailings be placed above the water table on a layer of waste rock placed into the open pit to an elevation of 1190 m. We have estimated that approximately 44,000 m^3 of waste rock is required for the base layer which will contain coarse fractions of rock which acts as a reservoir. In this scenario, it will be necessary to seal the Pony Creek Adit as it is possibly submerged once water levels in the pit stabilize. Any water (flux) from the tailings will report to the waste rock reservoir where its release will be governed by the regional groundwater flow in the surrounding rock. A trench should be excavated between the two existing ponds in the open pit to allow for a pumping well to be installed in the lowest section of the pit at a later date should pumping and treatment be required.

A waste rock plug at the south end of the pit may or may not be required for containment of the tailings. Future assessments should consider in detail the stability of the tailings without the waste rock plug to determine whether the plug is required for stability purposes. Preliminary assessments have shown that if the tailings are placed with a gradual slope, the plug may not be required to maintain stability of the tailings. In either case the pit backfill will be designed with an adequate factor of safety for all loading cases. This is considered to be technically feasible, considering the pit geometry, and available materials. If the waste rock is required to act as a containment structure, the waste rock plug may have to be considered as a dam, and would be subject to the requirements outlined in the Canadian Dam Association Guidelines. The strength of the tailings is also expected to increase with time as consolidation occurs. Surface drainage would be to the south and north off the final cover of clean soil.

The gradation of the waste rock used for the base reservoir and the intermediate layers will be determined during detailed design. Preliminary inspections of the waste rock piles indicates a wide range of gradations are available although processing is likely required. It will be important to consider the appropriate filter layers at the interface

between the waste rock layers and fine grained tailings. If a natural filter layer is uneconomical to produce, geotextiles could be considered.

2.4.2 Consolidation of Tailings and Waste Rock in Open Pit – Unsaturated Environment

Consolidation and resulting settlement is expected to occur due to an increase in effective stress since the water table will be confined to the underlying waste rock. The time required for consolidation settlement to occur depends on the length of either vertical or horizontal drainage paths; the shorter the drainage path, the more rapidly the tailings will consolidate. Geotechnical properties of the tailings were determined based on laboratory testing results and published information. If the tailings are placed in one continuous layer (up to 25 m thick), the estimated time to reach 90% consolidation (end of primary consolidation) is estimated to be in the order of 20 years. The anticipated total vertical settlement from consolidation is expected to be in the order of 0.8 to 1.5 m. This settlement will not be uniform across the tailings surface due to differences in density, the presence of frozen material and the varying thickness. It should be recognized that considerably more settlement could occur if the tailings are placed in a frozen state with large void spaces and it may also take considerably longer for thaw induced settlement to occur. The soil cover design should consider the uneven settlement of the tailings with time and final regrading of the cover may have to be delayed by several years.

As the tailings consolidate, the contaminated porewater will report to the underlying waste rock reservoir. The volume of water released will be directly related to the volume change of the tailings mass. Depending on the assumed compression index for the tailings (0.08 vs 0.15), preliminary calculations indicate that this volume is in the order of 3,000 to 21,000 m^3. The final volume of water reporting to the waste rock reservoir will be a combination of the water expelled during consolidation and that which will drain by gravity from the tailings (in excess of that via consolidation) and seepage out through the pit walls. This volume will depend on the matric suction of the tailings (the force that binds water in the tailings matrix), the presence of capillary breaks e.g. sandy tailings, etc. In no case however, can the total volume of water be greater than the volume in the pore spaces at the time of placement. Without the addition of additional water e.g. to slurry the tailings, this is estimated to be about 180,000 m^3 based on a porosity of 0.6. A more realistic estimate of maximum seepage water from the tailings during construction is 50,000 to 100,000 m^3.

2.4.3 Low Infiltration Soil Cover

Golder Associates (September 13, 2010) conducted a conceptual assessment of low infiltration cover options for Option 4.

Five cover options were considered. In general, the designs tried to utilize locally available material, and limit the reliance on synthetic products. The options included:

- Single-layer vegetated store-and-release soil cover
- Vegetated store-release-divert soil cover
- Multi-layer vegetated store-release-divert soil cover
- Synthetic barrier
- Multi-layer capillary break cover system.

The report by Golder (2010B) indicated that a vegetated store-release-divert type cover would be a viable option. This preliminary design of this cover option includes:

- 0.3 m of topsoil, with vegetation established in it.
- 1 m of the well graded Victoria Creek soil to act as a barrier to infiltration
- 1 m coarse waste rock – to act as a capillary break

A conceptual model developed by Golder showed that fluxes through the bottom of the capillary break would be less than 1% of the total precipitation. This may be low based on other experiences (Golder 2010B). Further testing of materials and design concepts would be required before final cover selection.

2.4.4 Tailings Relocation

The relocation of tailings for Option 4 would be similar to that for Option 3 except that the coarse and fine tailings do not need to be blended. This would afford the contractor more options for optimizing the transportation method.

In consideration of the general site conditions and tailings characteristics within the conceptual scope of this study, it was concluded that tailings relocation by mechanical removal was the preferred method for Option 4; final selection should be based on a more detailed review of applicable case histories. Based on discussions with experienced contractors, the tailings could be excavated during the winter in layers (2 to 3 m thick) to allow the surface of the tailings to freeze to allow machinery access to the tailings pond. The use of conveyors to move the tailings was also discussed as a potential transportation means. With sufficient equipment and working 24 hours per day, it may be possible to relocate to the open pit in one season based on moving up to 10,000 m^3 of tailings/day. If work is carried out over more than one season, a plan to operate the tailings dam in the interim (summer) must be developed. Water treatment would be an anticipated requirement, either at the open pit, or water could be pumped to the mill site for treatment. In this regard, leaving one or more of the existing buildings at the mill site intact could provide a suitable location for interim water treatment facilities.

2.4.5 Operations and Maintenance

There are a number of operations and maintenance items to be considered for closure Option 4:

- Cover maintenance: Some maintenance is anticipated the cover options over several years following construction. It is anticipated that the tailings will be placed without any compaction, and therefore overall and differential settlements would be anticipated. The settlements may affect the performance of the cover if the cover is not able to drain surface water effectively.
- Environmental monitoring of groundwater and surface water: Monitoring for contaminants will be required for some period of time as specified by the stakeholders and regulators It is recommended that a pumping well be installed to the base of the pit (through the proposed tailings and waste rock backfill). The well could be used for sampling, and extraction (for treatment) of the seepage water reporting to the base of the pit.
- Water treatment: Treatment of the porewater (expelled during consolidation of the tailings) may be required for some period of time. The seepage rate due to consolidation decreases logarithmically with respect to time. The period of time that treatment would be required for would be dependent on the water quality and dilution.
    - Water quality is the primary measure of performance for this option. There will be some seepage through the tailings due to infiltration. The objective of the concept design is to limit this infiltration so that long term groundwater treatment is not required.
- Access to site: Access to the site should be maintained to accommodate maintenance, and monitoring programs as required. This access may not be required in the long term if satisfactory performance is achieved. Occasional inspections may be conducted by using helicopters for site access if necessary.

Assuming that the cover performs satisfactorily, and that the environmental criteria are met, this option would require minimal long term monitoring and maintenance.

3. Areas of Uncertainty and Risk

3.1 Areas of Uncertainty

There are several areas of uncertainty with respect to geotechnical considerations associated with the closure alternatives under consideration. These uncertainties are summarized as follows and also in the Summary Table in Appendix B-2:

3.1.1 Existing Tailings Dam (Option 1 and 2)

- Potential long term thermal conditions, including the potential consequences of global warming.
- Potential for thawing of permafrost may require design changes to improve stabilizing/insulating measures.
- Downstream consequences associated with a hypothetical dam failure (and hence dam classification).
- The consequence of additional permafrost thaw on the north terrace on stability and seepage.
- The extent of tailings run-out or consequences of a dam failure (dam break analysis has not been completed).
- Frequency and cost for routine or unexpected maintenance.
- Seepage rates and water quality trends in the seepage pond.
- Potential ongoing settlement of the south abutment.
- Performance of existing and/or proposed (replacement of coarse tailings with fine tailings against dam face) seepage controls along upslope face of the dam.

3.1.2 Cover Systems

Option 1- Water Cover

- The effectiveness of the cover, especially under drought conditions
- Replacing coarse tailings with fine tailings (the wedge against the dam face)
  - Extents and constructability of the replacement
  - Effectiveness at maintaining saturation
- Water management plans associated with cover design
- The need for additional freeboard
- Dilution of pond water and the reduction of treatment requirements
- The impact on performance of the cover due to freezing conditions
- Frequency and cost for routine or unexpected maintenance

Option 2- Saturated Soil Cover

- The effectiveness of the cover, especially under drought conditions
- Replacing coarse tailings with fine tailings (the wedge against the dam face)
  - Extents and constructability of the replacement
  - Effectiveness at maintaining saturation
- Water management plans associated with cover designs
- The need for additional freeboard
- The impact on performance of the cover due to freezing conditions
- Frequency and cost for routine or unexpected maintenance
- Ability to support vegetation

Option 3 – High Infiltration Cover

- The ability to maintain saturated tailings which itself is dependent on the following uncertainties:

  - ability create a homogeneous blend of tailings
  - the balance between coarse and fine tailings is unknown, and this introduces an uncertainty in the final blended grain size distribution and resultant hydraulic conductivity
  - the hydraulic conductivity of the blended tailings, in particular the change in hydraulic conductivity as the tailings densify with time.
  - hydraulic gradient through tailings
  - distribution of available water over the surface of the tailings
- Water management plan associated with the cover design
- The impact on performance of the cover due to freezing conditions
- Time and magnitude of consolidation settlement of relocated tailings (dependent on transportation and placement methods)
- Consequences of differential settlement with respect to cover integrity, surface drainage and spillway design
- Frequency and cost for routine or unexpected maintenance
- Surface water quality (as runoff) from open pit

Option 4 – Low Infiltration Cover

- The ability to limit seepage through the cover
- Water management plan associated with the cover design
- The impact on performance of the cover due to freezing conditions
- Time and magnitude of consolidation settlement of relocated tailings (dependent on transportation and placement methods)
- Consequences of differential settlement with respect to cover integrity, surface drainage and spillway design
- Frequency and cost for routine or unexpected maintenance

3.1.3 Water Diversion Structures (Options 1, 2, and 3)

- Water management plan based on selected cover design and determination of acceptable risks associated with routing creek flows through tailings ponds.
- Frequency and cost for routine or unexpected maintenance uncertain.
- Regulatory approval requirements.

3.1.4 New Tailings Dam (Option 3)

- Foundation and abutment conditions at dam location.
- Downstream consequences associated with a hypothetical dam failure (and hence dam classification).
- Seepage from tailings pond water cover into surrounding bedrock.
- Need for grouting or other measures to seal fractured rock (sidewalls, foundation and adit).

3.1.5 Diversion Channels (Options 1, 2 and 3)

- Conditions along side-hill channel from Pony Creek to open pit.
- Requirement for crossings of entrance and spillway channels from Pony Creek to open pit.
- Frequency and cost for routine or unexpected maintenance.

3.1.6 Waste Rock (All Options)

- The long term stability of the (remaining) waste rock piles. Note that Options 1B and 2B will involve relocating all of the waste rock back into the pit
- Water quality of seepage out of waste rock piles, and any changes in water quality with time.

3.1.7 Existing Tailings Management Area (Options 3 and 4)

- Environmental impacts in existing TMA once tailings have been relocated.

3.2 Risk

Risk can generally be defined as a chance of loss and can be measured in terms of the product of the probability of an event and its consequence. For the purposes of this study, which primarily addressed scenarios for closure of the Mt. Nansen project, a limited risk ranking of geotechnical considerations associated with mine closure was conducted. A comprehensive risk analysis at this stage is considered premature and not consistent with the assessment of closure options (present scope). Nevertheless, some identification of risk is warranted to make informed decisions and reflect a degree of confidence. Risk has been addressed as relative uncertainties regarding an acceptable degree of performance to achieve design objectives. In this regard, the classification of risk for each discipline within this preliminary risk assessment has been selected as low, medium and high. To reflect the preliminary nature and limitations of this risk assessment, residual risks have been identified to modify or mitigate risk. Residual risks are those that remain once the alternative under consideration has been implemented e.g. the waste rock piles may remain in place. The risks associated with the closure alternatives are summarized in Table 4.

Table 10. Summary of Geotechnical Risks

Alternative	Relative Risk Ranking	Identified Risks	Mitigation Options	Residual Risks
Option 1 – Tailings Dam Upgrade with Water Cover, Waste Rock in Place	Medium	• Spillway Failure	• Repair and upgrade spillway	• Waste rock piles remain • Pit walls and lake pose potential risk to public safety
		• Dam Failure	• Relocate tailings to pit or rebuild dam to increase stability. Remediate contaminated area.	
		• Thawing of permafrost/failure of thermosyphons	• Other ground improvement measures	
		• Seepage water volume and quality may change; might require a future collection pond and treatment	• Install grout curtain. • Collect and treat water	
Option 2 – Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place	Low to Medium	• Spillway failure	• Repair and upgrade spillway.	• Waste rock piles remain • Pit walls and lake pose potential risk to public safety
		• Dam failure	• Relocate tailings to pit or re-build dam. Remediate contaminated area.	
		• Thawing of permafrost/failure of thermosyphons	• Other ground improvement measures	
		• Seepage water volume and quality may change; might require a future collection pond and treatment	• Install grout curtain. • Collect and treat water	
Alternative B (For Options 1 and 2) – Waste Rock relocated to open pit (in conjunction with remediation of the tailings dam and associated works with Option 1 and Option 2.	1B = Medium 2B = Low to medium	• Risks are primarily geochemical	• Treat water reporting to bottom of pit	• Minimal waste rock piles remain • Soil contamination below existing waste rock piles
Option 3 – Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place	Low to medium	• Unable to achieve required blend of tailings, and therefore the required hydraulic conductivity to maintain saturation due to o Segregation, uneven mixing or uneven placement. o Inadequate blended grain size distribution based on available materials,	• Investigate remedial engineering solutions	• Waste rock piles remain • Pit walls and lake pose potential risk to public safety • Contamination of soil and water at existing TMA
		• Dam failure (in pit)	• Repair dam, and remediate the contaminated area.	
		• Spillway failure	• Repair and upgrade spillway	
		• De-saturation of tailings	• Divert water from Pony Creek (if this would be beneficial)	
Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover	Low	• Waste rock plug at south end of pit may be considered a dam	• Conduct dam safety assessments	• Some waste rock piles remain • Contamination of soil and water at existing TMA
		• Excessive seepage through cover	• Upgrade cover • Treat contaminated seepage water	

4. Summary of Costs

4.1 Capital Construction Costs

The estimated capital costs for the various closure alternatives are summarized in Table 11. These costs include a 30 percent contingency but do not carry any allowance for additional field investigations, instrumentation monitoring, design engineering, routine inspections, operations or maintenance. A breakdown of estimated cost of the individual options is included in Appendix D.

These estimates are based on conceptual designs for the purpose of comparing the various alternatives. These estimates are considered to be Class D estimates (or ASTM E2516-06 Class 5), with an accuracy of -25 +40 percent.

Table 11. Capital Cost Estimates

Option	Cover Type	Cover Details	Tailings	Pit	Waste Rock	Capital Cost Estimate
1A	Water	• 0.7 m thick water cover • Divert water from Dome Creek	Stabilize tailings dam with toe berm	No change	Minor re-grading	$8,800,000
2A	Soil	• 1 m thick soil cover on top of tailings • 0.15 m thick water cover on top of cover	Stabilize tailings dam with toe berm	No change	Minor re-grading	$10,000,000
1B	Water	• 0.7 m thick water cover • Divert water from Dome Creek	Stabilize tailings dam with toe berm	Filled with waste rock	Relocate 500,000 m^3	$12,900,000
2B	Soil	• 1 m thick soil cover on top of tailings • 0.15 m thick water cover on top of cover	Stabilize tailings dam with toe berm	Filled with waste rock	Relocate 500,000 m^3 into pit	$14,100,000
3	Soil	• Soil/Rock cover	Relocate 300,000 m3 to pit.	Partially filled with tailings. Build tailings dam.	Minor re-grading	$14,300,000
4	Soil	• Low infiltration cover	Place tailings in pit	Completely filled with tailings and waste rock	• Waste rock reservoir beneath tailings • Remaining space filled with available waste rock	$15,500,000

4.1.1 Inspection and Maintenance

The requirement for inspection and maintenance is dependent on the alternative under consideration. For example, alternatives where the tailings remain in place will require long term monitoring and maintenance of completed works. Alternatives where the tailings are relocated may have similar albeit reduced inspection and maintenance requirements. The alternative with the lowest anticipated inspection and maintenance costs would be dry storage of tailings with a waste rock plug, in particular if the tailings properties (drained) and design of the plug will allow movement away from classifying this structure (plug) as a dam.

For preliminary comparison of alternatives, we recommend that an annual allowance of $500,000 be carried for each of the first five years after construction is complete for inspection and maintenance (total $2.5 million). This would be sufficient for monitoring and inspection at least twice a year and any necessary major repairs to the completed works. If good performance of the structures is confirmed after the first five years, it is anticipated that the frequency of inspections and requirement for maintenance could be significantly reduced. Table 11 shows estimated costs for long term monitoring and maintenance. These estimates are preliminary, and will largely depend on the performance of the selected closure options. It may eventually be possible to reduce these annual allowances further for scenarios where water management is not a critical component e.g. Option 4, in particular if the waste rock plug is not considered to be a dam.

Table 12. Annual Operations and Maintenance Cost Estimates (in 2010 $)

	Option 1	Option 2	Option 3	Option 4
Dam Safety Assessments	$10,000	$10,000	$10,000	$0
Monitoring	$100,000	$100,000	$75,000	$50,000
Miscellaneous Maintenance	$200,000	$200,000	$100,000	$100,000
Total	$310,000	$310,000	$185,000	$125,000

5. References

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AECOM 2008:
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SRK Consulting, 2006:
Pony Creek Adit Bulkhead, Mt. Nansen, Yukon

AECOM

Drawings

CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT GRADED TO FIT NATURAL TOPOGRAPHY

PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET

DOME CREEK

ACCESS ROAD

ENTRANCE CHANNEL

APRON

BORROW AREA TO BE RE-VEGETATED

ARMOURED DRAINAGE SWALES

CREEK CHANNEL

DRY CHANNEL

CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT REMOVED TO FIT NATURAL TOPOGRAPHY

DRY CHANNEL

ARMOURED DRAINAGE SWALES

SEEPAGE

SEEPAGE

SEEPAGE

0+000 CREEK

REGRADED TAILINGS AREA:
TAILINGS ELEV. 1097.75m
SAND DIFFUSION ELEV. 1098.05m
WATER COVER ELEV. 1098.75m
SPILLWAY ELEV. 1098.75m
TAILINGS SURFACE AREA 6.0ha

SOIL COVER BEACH
AREA 1.26ha
ELEV. 1099.40m

TAILINGS DAM CREST

ROCK FILL TOE BERM 7% SLOPE

ROCK FILL TOE BERM 10% SLOPE

NORTH TERRACE

ACCESS ROAD

REMOVE BRIDGE

SPILLWAY CONTROL

Y4101

CP4001

ACCESS ROAD

FORD CROSSING

RECONSTRUCT EMERGENCY SPILLWAY

DIVERSION CHANNEL

DROP STRUCTURE (TYP)

PLACE ADDITIONAL ARMOURING AS REQUIRED

END OF DIVERSION CHANNEL

DOME CREEK

ZONE OF GROUND FREEZING WITH THERMOSYPHONS

DRAINAGE DITCH

N

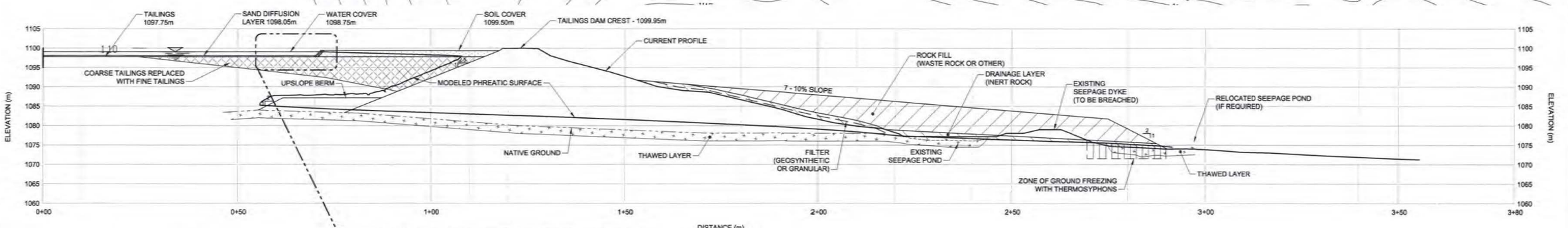
MOUNT NANSEN

0 12.5 25 37.5 m

LEGEND

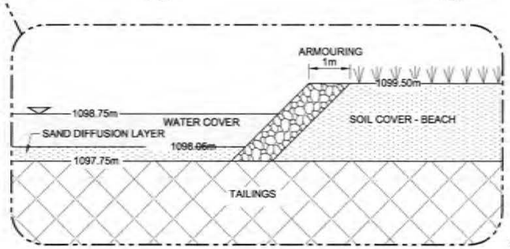
SURVEY BENCH MARK

NOTE
TO CONVERT ELEVATION SHOWN TO MINE DATUM ADD 51.81m.



PROFILE A

0 5 10 15 m

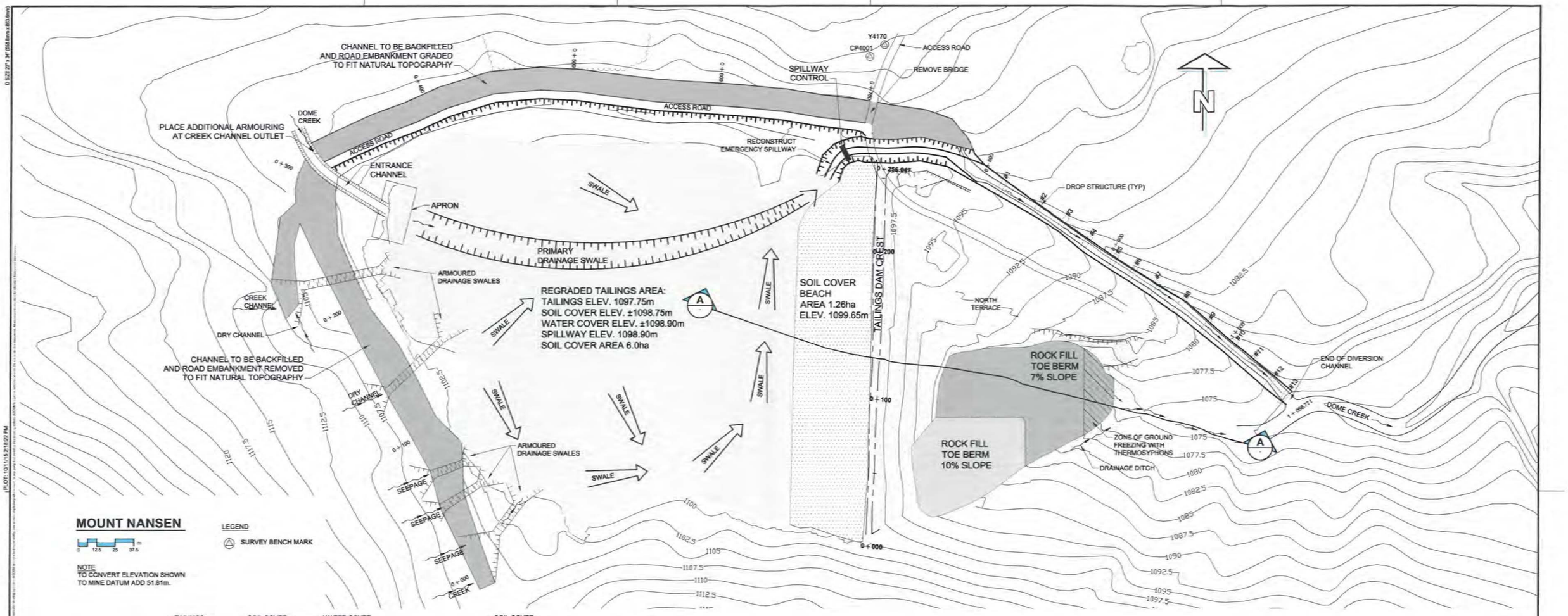


SCALE: NTS

AECOM

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 1
Site Plan & Profile
Drawing - 01



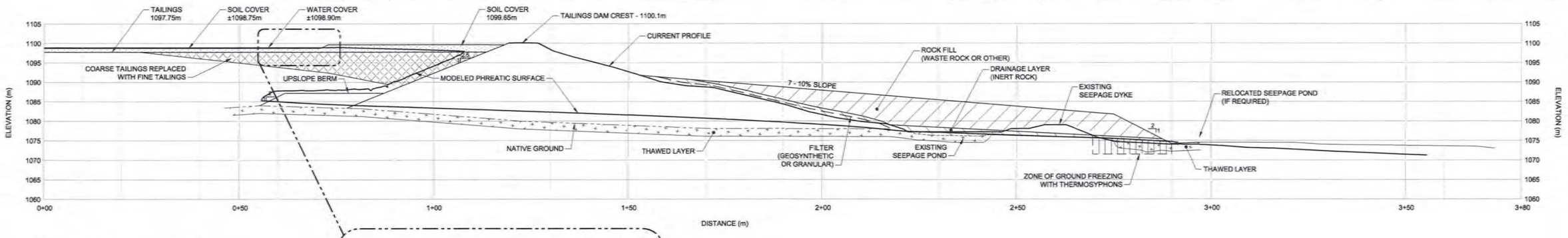
MOUNT NANSEN

0 12.5 25 37.5 m

LEGEND

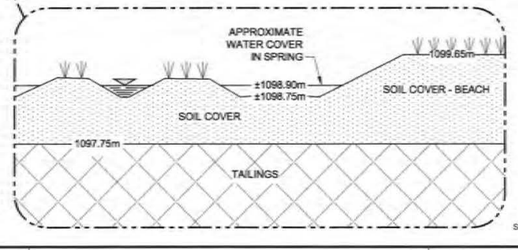
SURVEY BENCH MARK

NOTE
TO CONVERT ELEVATION SHOWN TO MINE DATUM ADD 51.81m.



PROFILE A

0 5 10 15 m

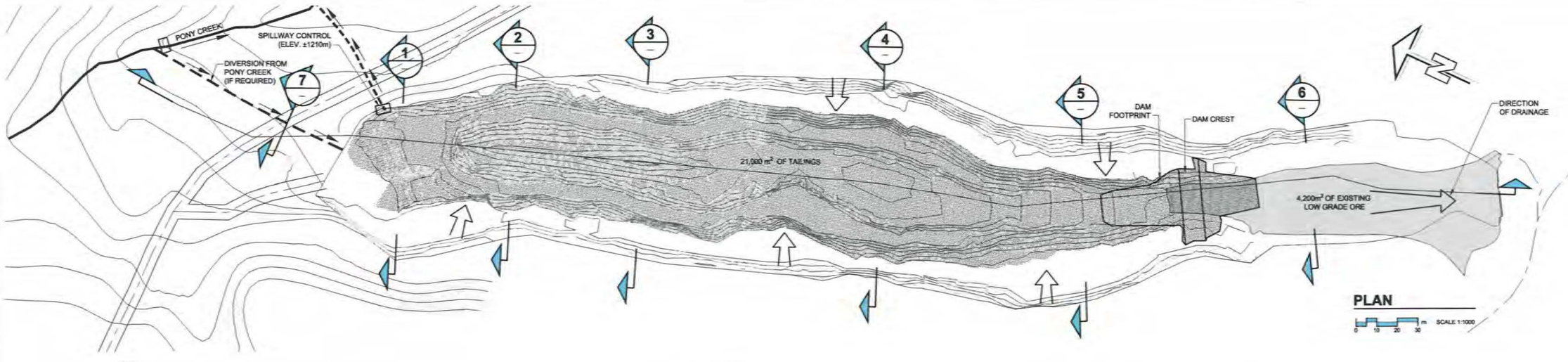


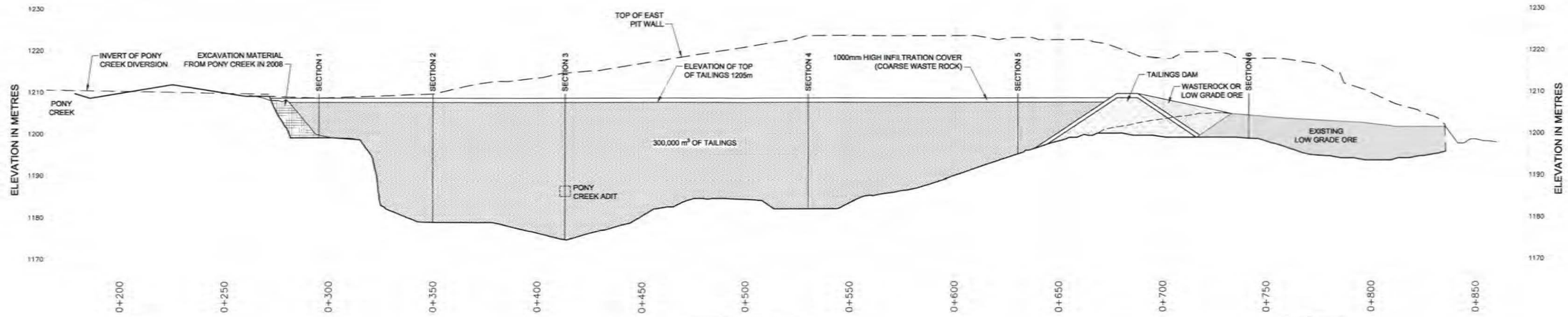
SCALE: NTS

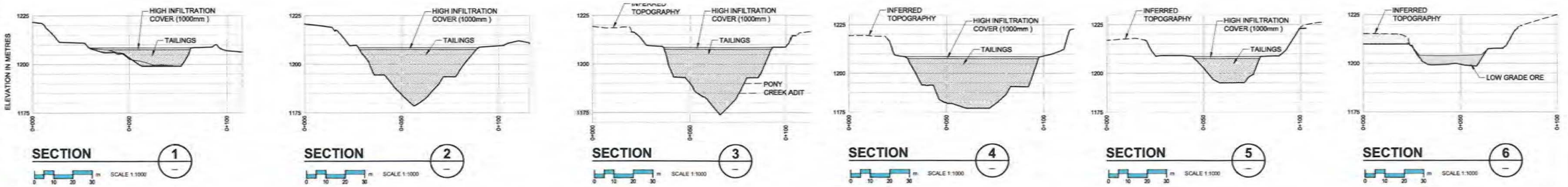
AECOM

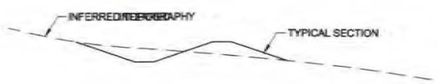
Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 2
Site Plan & Profile
Drawing 02









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Mt. Nansen Closure Alternatives Characterization

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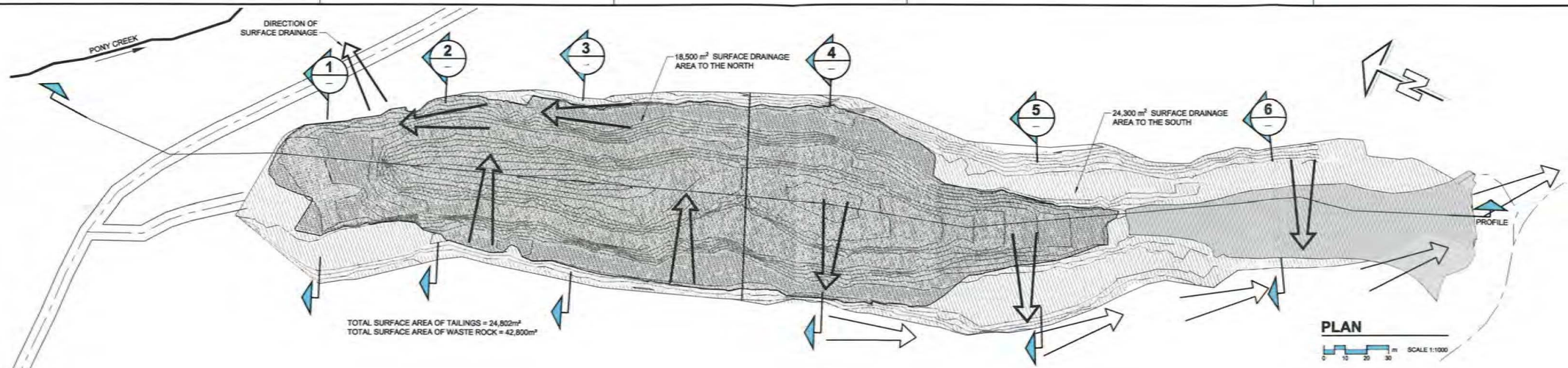
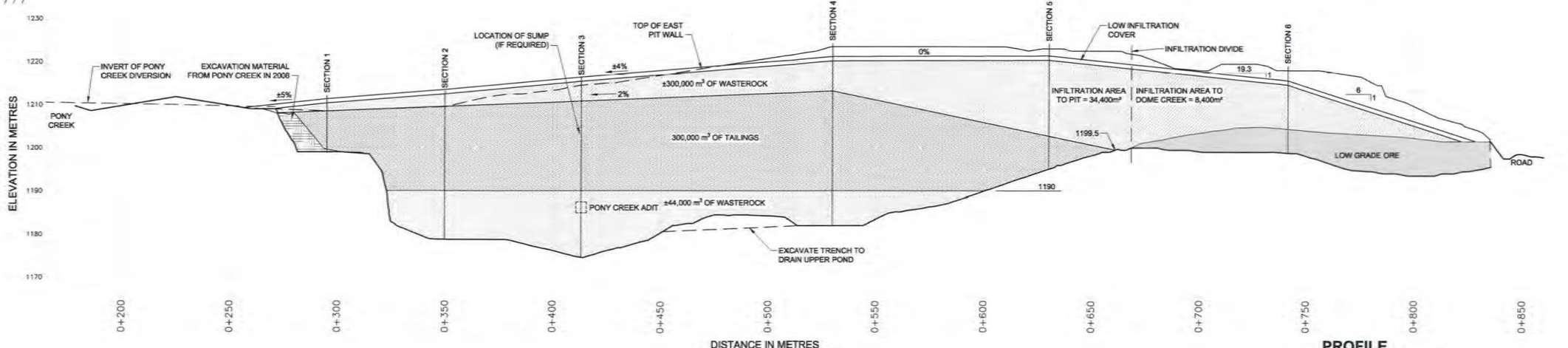
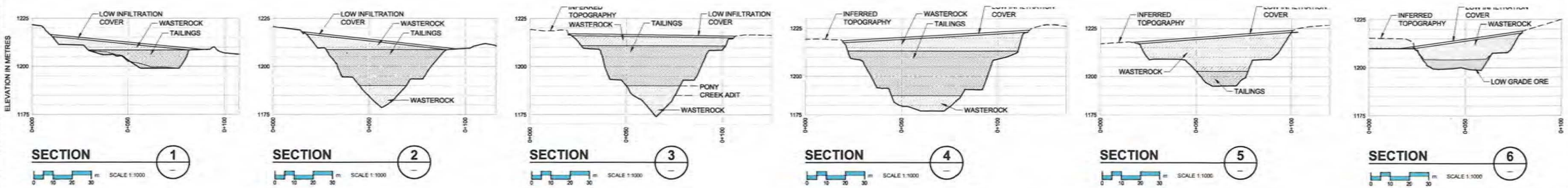
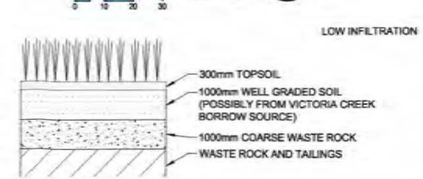
Option 3
Plan, Profile & Sections - Brown-McDade Open Pit
Drawing - 03









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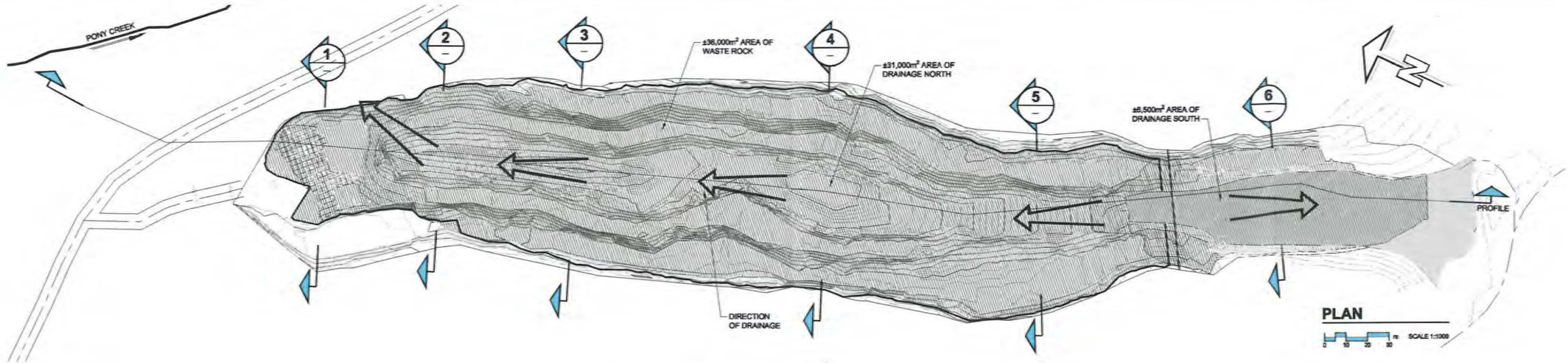
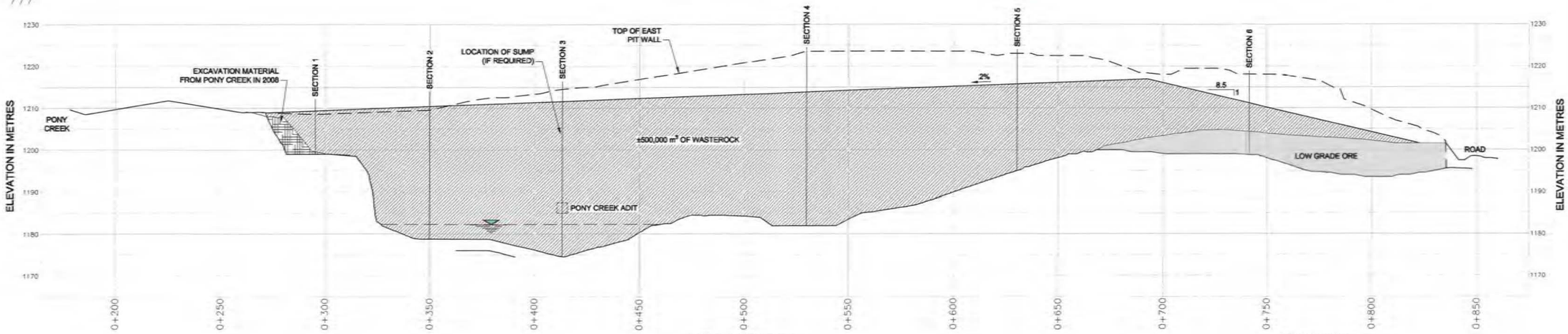
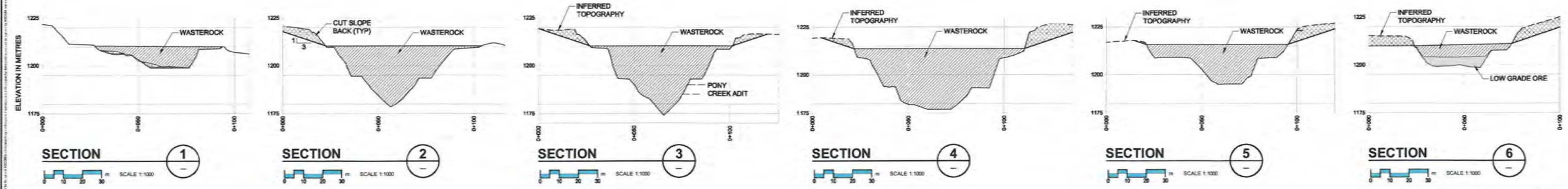
AECOM

Option 4
Plan, Profile & Sections - Brown-McDade Open Pit
Drawing - 04







NOTE: REFER TO DRAWING 01 AND 02 FOR DAM UPGRADING

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Mt. Nansen Closure Alternatives Characterization

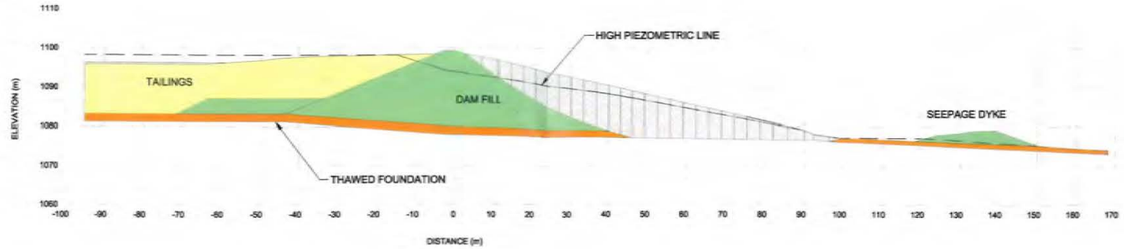
AECOM

Waste Rock Deposition for Option 1B and Option 2B
Plan, Profile & Sections - Brown-McDade Open Pit
Drawing - 05

CURRENT STABILITY

CASE 1: STATIC CONDITION

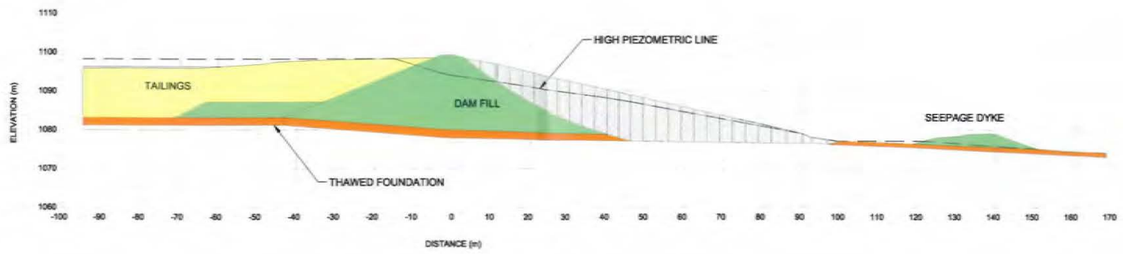
FACTOR OF SAFETY: 1.74



CURRENT STABILITY

CASE 2: PSEUDO-STATIC

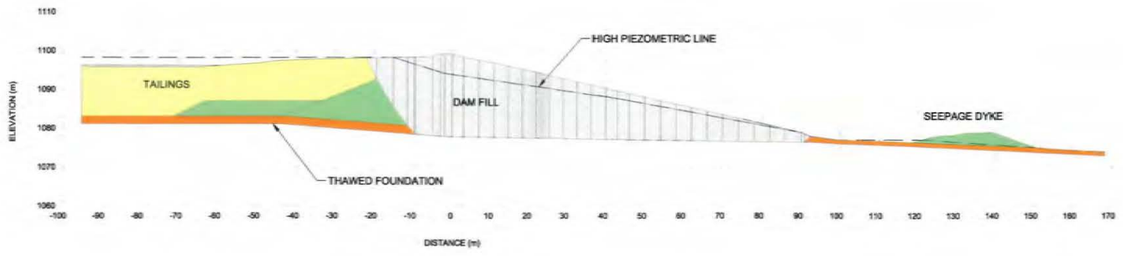
FACTOR OF SAFETY: 1.12



CURRENT STABILITY

CASE 3: POST EARTHQUAKE - RESIDUAL STRENGTH

FACTOR OF SAFETY: 0.56



SECTIONS

SCALE: NTS

AECOM

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

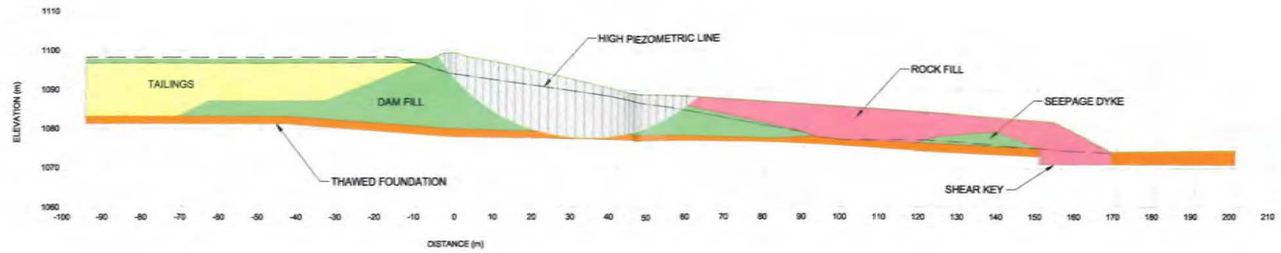
Option 1 & 2 - Stability Analysis

Drawing - 06

STABILIZED

CASE 1: STATIC CONDITION

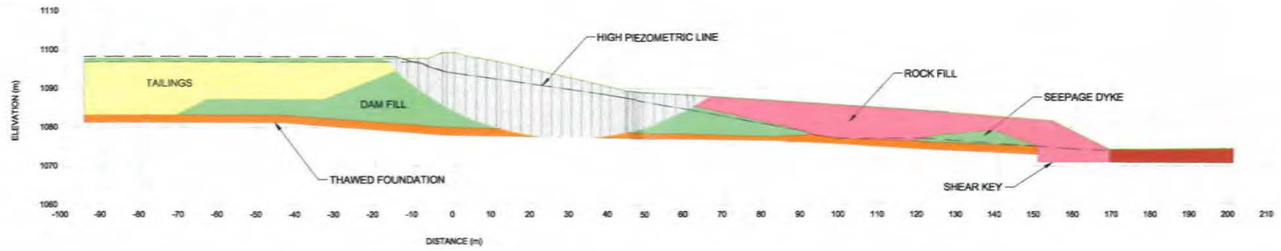
FACTOR OF SAFETY: 2.62



CURRENT STABILITY

CASE 2: PSEUDO-STATIC

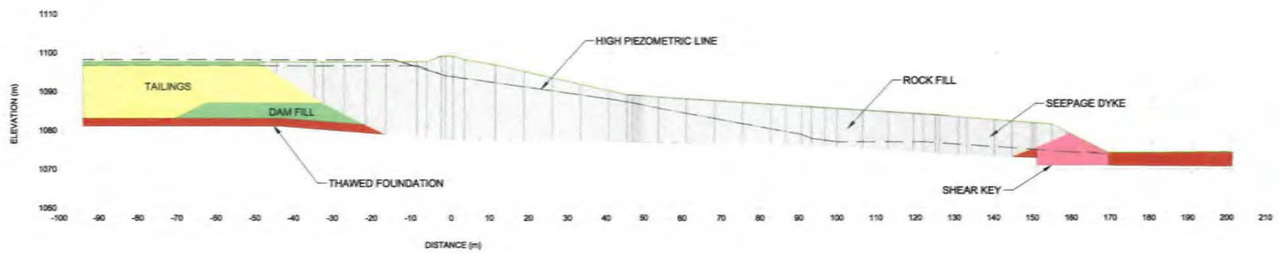
FACTOR OF SAFETY: 1.60



CURRENT STABILITY

CASE 3: POST EARTHQUAKE - RESIDUAL STRENGTH

FACTOR OF SAFETY: 1.26



SECTIONS

SCALE: NTS

PLOT: 10/11/15 2:24:20 PM
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Saved By: cloustonj
V: 0A
All FILE NAME: 60150069-05-B-F12-ROX.dwg

AECOM

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 1 & 2 - Stability Analysis

Drawing - 07

B SIZE 11" x 17" (279.4mm x 431.8mm)
PLOT: 10/11/15 2:25:11 PM
Saved By: cloustonc
ISS/REV: 0A
AECOM FILE NAME: 60159089-05-B-F11-R0X.dwg
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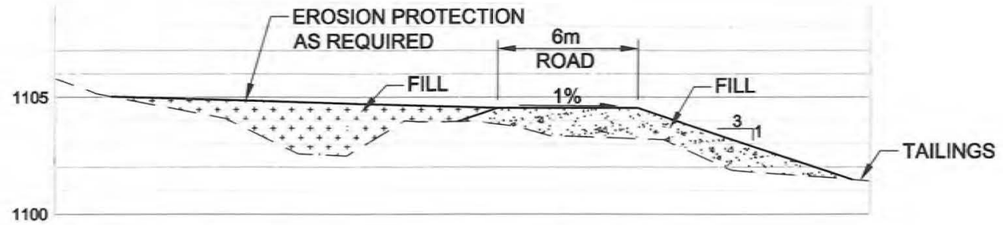
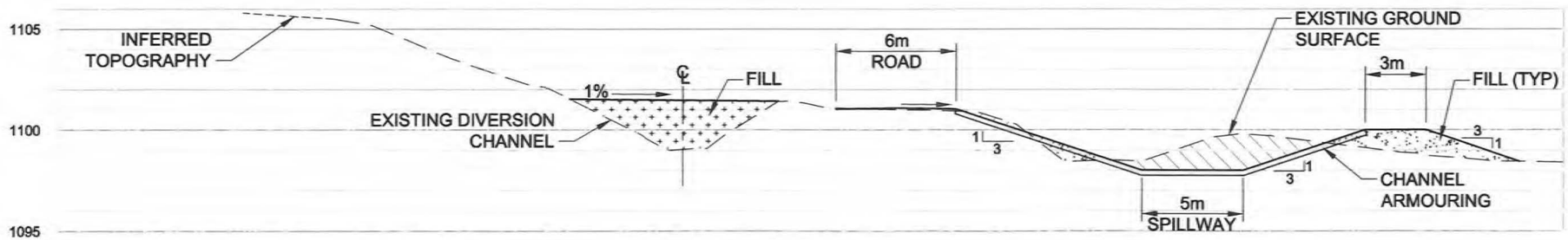


SECTION 0+105

0 2.5 5 m SCALE 1:250

INCEPTOR DITCH & DIVERSION CHANNEL



SECTION 0+715

0 2.5 5 m SCALE 1:250

SPILLWAY

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Tailings Management Area
Conceptual Diversion Channel & Spillway Cross Sections
Drawing - 08

AECOM

Pin #	Incremental Settlement 2008 to 2010 (mm)	Cummulatuve Settlement 1999 to
Y4150	-18	-38
Y4151	-9	3
Y4152	-9	-19
Y4153	-4	0
Y4154	-13	6
Y4155	24	105
Y4156	36	211
Y4157	37	233
Y4159	50	315
Y4161	-11	-13
Y4163	39	163
Y4172	20	81
Y4173	31	156
Y4175	31	99
Y4176	46	155
Y4177	53	239
Y4178	17	47
Y4179	24	67
Y4182	32	127
Y4183	7	8
Y4184	18	22
Y4185	16	-3
Y4187	4	2
Y7601	11	10
Y7603	28	149
Y7604	29	100
Y7614	-28	22

*Note: Negative numbers denotes increase in elevation.

EMERGENCY SPILLWAY
1104m
TAILINGS PILE (2008 SURVEY)
PUMP HOUSE
INTAKE STRUCTURE
PUMP HOUSE INTAKE LINE (1 - Ø50mm POLY)
TAILINGS POND
INTAKE STRUCTURE
RAMP
EROSION GULLY
DISCHARGE STRUCTURE
TAILINGS DAM CREST
APPROXIMATE EDGE OF WATER JULY 2008 (NOT SURVEYED)
TAILINGS PILE (2008 SURVEY)
1105m
0 + 200
0 + 100
DIVERSION CHANNEL
0 + 800
DROP STRUCTURE (TYP)
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
0 + 900
1 + 000
1 + 066.771
DOME CREEK
STOCK PILED ROCK FILL
NORTH TERRACE
SEEPAGE POND RETURN LINES
SEEPAGE POND
PUMP HOUSE
ROCK FILL
SEEPAGE DYKE CREST
APPROX. EDGE OF ROCK FILL
APPROX. UPSLOPE EDGE OF STABILIZING BERM
Y4150 Y4151 Y4152 Y4153 Y4154 Y4155 Y4156 Y4157 Y4159 Y4161 Y4163 Y4172 Y4173 Y4174 Y4175 Y4176 Y4177 Y4178 Y4179 Y4180 Y4181 Y4182 Y4183 Y4184 Y4185 Y4186 Y4187 Y7601 Y7602 Y7603 Y7604 Y7606 Y7614

LEGEND
- 1999 CONTROL POINT
- 2008 CONTROL POINT
- MOVEMENT DIRECTION 2001 TO 2008
- CUMULATIVE SETTLEMENT < 100mm
- CUMULATIVE SETTLEMENT > 100mm

MOUNT NANSEN
SCALE 1:500

NOTES
1) BASE PLAN GENERATED BASED ON 2000 TOPOGRAPHIC SURVEY PROVIDED BY GOY AND 2008 TOPOGRAPHIC SURVEY PROVIDED BY YES. COORDINATE SYSTEM IS UTM (NAD83) WITH GEODETIC ELEVATION.
2) TO CONVERT ELEVATION SHOWN TO MINE DATUM ADD 51.81m.

AECOM

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Tailings Dam Monitoring Pin Locations

Drawing - 09

Appendix A

Test Hole Logs

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01 / MW09**
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS (✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100)	COMMENTS	ELEVATION
0					SAND (fill), trace gravel, trace silt, trace organics - yellowish orange-brown - moist, compact to dense - medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - matrix supported - presence of roots until 3.05 m below ground surface						1099
1											1098
2											1097
3					- moist with dry lenses		S-1	10-14-15			1096
4											
	FILL										1095
5											1094
6											1093
7											1092
8											1091
9	FILL				- SAND and GRAVEL		S-2	7-14-15			1090
10					SAND (fill), trace to some gravel, trace silt - yellowish orange-brown - medium grained to fine grained sand (trace coarse sand), sub-rounded - sub-rounded gravel, >0.5 cm to <2 cm - matrix supported - moist, compact to dense						1089
11											
	FILL										1088
12											1087
13											1086
14					SAND and GRAVEL (fill), trace silt - brown - medium grained to fine grained sand, sub-rounded - sub-angular gravel, >0.5 cm to <2 cm - clast supported		S-3	43-57-48			
	FILL										1085
15											

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: GT09-01 / MW09
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15	FILL				- wet, dense to very dense - GRAVEL (fill), sandy						1084
16	SA				SAND (native soil), trace to some silt, trace organics - dark grey - medium grained to fine grained sand, sub-rounded - wet, loose to compact - silt content increases with depth		S-4	7-13-14			1083
17	GRSA				SAND and GRAVEL, trace silt - dark grey - medium grained sand (trace coarse sand), sub-rounded - sub-angular gravel, >0.5 cm to 5 cm - clast supported - wet, very loose		S-5	2-1-2			1082
18											1081
19	SA				SAND (native soil), trace to some silt, trace organics - dark grey - fine sand, sub-rounded - wet, very loose - sand coarsens with depth - some gravel						1080
20											1079
21	GRSA				SAND and GRAVEL, trace silt - dark grey-brown - medium sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - clast supported - permafrost at 21.5 m below ground surface, Nbn, 2.8C		S-6	4-20-47			1078
22											1077
23	SA				SAND, trace to some silt, trace gravel - dark grey - medium grained to fine grained sand, sub-rounded - sub-angular gravel, <1 cm - compact to dense - SAND and GRAVEL until approx. 27.4 m below ground surface						1076
24											1075
25											1074
26					- fine sand content decreases with depth		S-7	31-61-			1073
27											1072
28	GRSA				- some gravel SAND and GRAVEL - light grey-brown - fine grained to medium-coarse sand, sub-rounded - sub-angular gravel, <1 cm - coarsening downward sequences						1071
29							G-8				1
30											

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01 / MW09**
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
30					END OF DRILLING at 30.18 m in permafrost (refusal) - 10 cm of heaving at 17.53 m below ground surface MW09-23 install: - Screen interval: 13.41 m - 14.94 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 13.11 m - 14.94 m - Bentonite seal from ground surface to 13.11 m - WL: 13.409 mTPVC (21-Jul-09, 8:30:00 AM) Thermistor install: - 2" PVC pipe SCHED 40 - grout from 30.2 m below ground surface to ground surface - 1" PVC pipe SCHED 40 install inside the 2" PVC pipe SCHED 40 - grout inside the annulus space						1069
31											1068
32											1067
33											1066
34											1065
35											1064
36											1063
37											1062
38											1061
39											1060
40											1059
41											1058
42											1057
43											1056
44											1055
45											

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100

Total Unit Wt (kN/m³) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02 / MW09**
LOCATION: Tailings Dam, on Road from South Abutment UTM N 2,097,191.5 E 118,719.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1088.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0					SAND (fill), trace silt - medium brown - fine grained to medium grained sand, sub-rounded - moist, loose					1088
1										1087
2	FILL						S-1	5-7-10		1086
3					- some gravel below 2.13 m below ground surface		S-2	5-6-6		1085
4										1084
5	SA				SAND, trace silt, trace organics - wood debris, <2 cm - dark grey - sub-rounded - permafrost at 5.64 m below ground surface, Nbn, 1.6C - gravel content increases with depth to "gravelly"		S-3	1-1-1		1083
6							S-4	28-34-6		1082
7	GRSA				GRAVEL, sandy, trace silt - dark grey - medium to coarse sand, sub-angular - sub-angular gravel, >0.5 cm to 2 cm		S-5	25-42-35		1081
8					SAND, trace silt - dark grey - medium grained sand, sub-rounded					1080
9					- trace gravel (>0.5 cm) below 8.84 m below ground surface - fine grained to medium grained sand below 9.14 m below ground surface		S-6	27-42-34		1079
10										1078
11	SA				- medium grained sand below 10.36 m below ground surface - trace gravel (<2 cm) below 10.67 m below ground surface		S-7	37-38-46		1077
12										1076
13					- fine grained to medium grained sand below 12.19 m below ground surface		S-8	38-47-56		1075
14					- some gravel below 13.41 m below ground surface		S-9	37-45-47		1
15										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.77 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02 / MW09**
LOCATION: Tailings Dam, on Road from South Abutment UTM N 2,097,191.5 E 118,719.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1088.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
15	SA										1073
					GRAVEL, sandy, trace silt - yellowish orange - fine grained to medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - clast supported		S-10	38-49-60	>> ◆		
16	GRSA										1072
17					END OF DRILLING at 16.77 m in permafrost (refusal)						1071
18					MW09-22 install: - Screen interval: 1.22 m - 4.27 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 0.92 m - 4.27 m - Bentonite seal from ground surface to 0.92 m - WL: 4.845 mTPVC (22-Jul-09, 8:33:00 AM)						1070
19					Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.77 m below ground surface						1069
20											1068
21											1067
22											1066
23											1065
24											1064
25											1063
26											1062
27											1061
28											1060
29											1059
30											

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.77 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace UTM N 2,097,213.3 E 118,722.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1090.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: Becker / Dynamic Cone / SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0				SAND and GRAVEL(Fill), trace silt						1090
	FI			- dark brown						
				- moist, loose						
1				- medium grained sand, sub-angular						1089
				- sub-angular gravel, 0.5 cm to <1.5 cm						
				- clast supported						
				- staining on gravel						
				SAND (Aeolian), trace silt, trace gravel	X	S-1	4-5-4	◆		
2				- orange-brown						1088
				- moist with dry lenses, loose to compact						
				- fine grained to medium grained sand, sub-rounded						
				- sub-angular gravel, >0.5 cm to < 2.5 cm						
3				- matrix supported						1087
					X	S-2	4-5-5	◆		
4										1086
	SA									
					X	S-3	3-4-5	◆		
5										1085
				- some gravel below 5.33 m below ground surface						
6										1084
				- trace gravel below 6.10 m below ground surface	X	S-4	6-7-7	◆		
7										1083
				- some gravel below 7.32 m below ground surface						
					X	S-5	4-7-5	◆		
8	GRSA			SAND and GRAVEL, trace silt						1082
				- light brown-orange						
				- moist, compact						
				- medium grained sand, sub-rounded						
9	SA			- sub-angular gravel, >0.5 cm to 2 cm						1081
				- iron staining on gravel						
				SAND, trace gravel, trace silt (Aeolian)	X	S-6	3-7-9	◆		
				- orange-brown						
10	GRSA			- moist, compact						1080
				- medium grained sand, sub-rounded						
				- sub-rounded gravel, 1 cm to 1.5 cm						
				- matrix supported						
11				SAND and GRAVEL, trace silt	X	S-7	6-8-4	◆		1079
				SAND, trace gravel, trace silt						
12										1078
	SA									
				- some gravel below 12.19 m below ground surface	X	S-8	4-5-10	◆		
13										1077
				SAND and GRAVEL, trace silt	X	S-9	3-7-2	◆		
14				- coarsening downward sequence						
	GRSA									
15										

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace UTM N 2,097,213.3 E 118,722.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1090.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS (Becker / Dynamic Cone / SPT (Standard Pen Test) (Blows/300mm); Total Unit Wt (kN/m³); Plastic MC Liquid)	COMMENTS	ELEVATION
15	GRSA			GRAVEL, sandy, trace silt - coarsening downward sequence		S-10	5-24-16			1075
16	GRSA									1074
17				SAND, some silt, trace gravel - olive grey - very dense - fine grained to medium grained sand, sub-rounded - sub-angular, >0.5 cm to 1 cm - permafrost at 16.52 m below ground surface		S-11	25-52-34		1073
18	SA									1072
19										1071
20				END OF DRILLING at 19.87 m in permafrost (refusal) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 19.86 m below ground surface					1070
21										1069
22										1068
23										1067
24										1066
25										1065
26										1064
27										1063
28										1062
29										1061
30										

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04 / MW09**
LOCATION: Seepage Dam Crest UTM N 2,097,202.0 E 118,747.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1078.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0	FILL				SAND and GRAVEL (Fill), trace silt - light brown-orange - moist, very loose - medium grained sand, sub-rounded - gravel sub-angular, from 0.5 cm to >6 cm - matrix supported						1078
1											
2	FILL				SAND (Fill), trace to some silt, trace gravel - light brown-orange - mois, very dense - medium grained sand, sub-rounded - gravel sub-angular, from 2 cm to >4 cm - matrix supported		S-1	3-2-2			1077
3					- permafrost at 2.8 m below ground surface, -0.3C, Nbn		S-2	30-40-42			1076
4					SAND (Native soil), trace to some silt, trace to some organic - dark grey-brown - mediumgrained to coarse grained sand, sub-rounded						1075
5							S-3	14-19-20			1074
6	SA										
7	SA				- trace gravel below 6.5 m below ground surface - silt content increases with depth - sand becomes finer with depth		S-4	31-39-39			1072
8					SAND and GRAVEL, some silt - dark brown - coarse sand - sub-angular gravel - sub-angular sand		G-5				1071
9											1070
10	GRSA						G-6				1069
11							G-7				1068
12					- gravel content decreases to become SAND, gravelly, trace of silt						1067
13					SAND, trace to some silt, trace gravel - sub-angular gravel, 0.5 cm to < 2 cm - fine grained to medium grained sand, sub-rounded		G-8				1066
14	SA				- SAND, gravelly, trace of silt below 13.41 m below ground surface		S-9	41-71-51			1065
15											1064

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 16/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04 / MW09**
LOCATION: Seepage Dam Crest UTM N 2,097,202.0 E 118,747.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1078.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
15	SA										1063
16	GRSA				SAND and GRAVEL, trace of silt - dark grey-brown - medium sand, sub-rounded - gravel sub-angular, from 0.5 cm to > 4 cm - silt content increases with depth - permafrost temperature: 0.9°C description: Nbn		S-10	67--			1062
17					END OF DRILLING at16.23 m in permafrost (refusal)						1061
18					MW09-20 install: - Screen interval: 1.37 m - 2.90 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.10 m - 2.90 m - Bentonite seal from ground surface to1.10 m - WL: Dry (22-Jul-09, 8:25:00 AM)						1060
19											1059
20					Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.10 m below ground surface						1058
21											1057
22											1056
23											1055
24											1054
25											1053
26											1052
27											1051
28											1050
29											1049
30											

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 16/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-05 / MW09**
LOCATION: North terrace, near Seepage Dam UTM N 2,097,214.2 E 118,738.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1087.5

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0					SAND, trace silt, trace gravel (Aeolian) - Medium brown - moist, loose - fine grained to medium grained sand, sub-rounded - gravel sub-angular, >0.5 cm to 2 cm					1087
1										
2							S-1	1-3-3		1086
3					- fine sand content decreases with depth - coarsening downward sequence		S-2	3-4-4		1085
4										1084
5					- moist with dry lenses		S-3	4-9-8		1083
6					- coarsening downward sequence		S-4	5-8-10		1082
7										1081
8	SA				- some dark brown sand between 4.1 and 4.4 m below ground surface - moist, dense		S-5	10-18-18		1080
9					- some gravel below 8.38 m below ground surface - coarsening downward sequence - wet, loose		S-6	2-3-5		1079
10										1078
11							S-7	5-9-23		1077
12					- Permafrost at approximately 11.28 m below ground surface, Nbn		S-8	23-32-41		1076
13										1075
14	GRSA				SAND AND GRAVEL, trace silt (description from dill cuttings)					1074
15	SA				- SAND, some gravel, trace silt (description from dill cuttings)					1073

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 21/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-05 / MW09**
LOCATION: North terrace, near Seepage Dam UTM N 2,097,214.2 E 118,738.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1087.5

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
15	SASI				SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth					1072
16					SAND, trace to some silt, trace gravel - dark grey - dense					1071
17	SA				- fine grained to medium grained sand, sub-rounded - sub-angular gravel, < 1 cm - matrix supported - lenses of organic material, <2 cm		S-9	21-26-23		1070
18										1069
19	GRSA				SAND and GRAVEL, trace silt - gravel content increases with depth - sub-angular gravel, < 2 cm - coarse sand, sub-rounded					1068
20					END OF DRILLING at 19.87 m in permafrost (refusal) MW09-24 install: - Screen interval: 8.23 m - 11.28 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 7.82 m - 11.28 m - Bentonite seal from 0.61 m to 7.92 m - Drill cutting from ground surface - WL: 9.774 mTPVC (22-Jul-09, 8:06:00 AM) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 19.86 m below ground surface					1067
21										1066
22										1065
23										1064
24										1063
25										1062
26										1061
27										1060
28										1059
29										1058
30										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 21/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-01**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	FILL			SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded						1096
1										1095
2	SA			SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded						1094
3	SM			SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand		S-1				1093
4										1092
5	CI			CLAY TAILINGS - dark yellow brown - wet, medium stiff, cohesive, medium plasticity, slow dilatency - minor silt, fining downward and finely laminated						1091
6						S-2				1090
7										1089
8				- damp from 7.62 m to 9.14 m		S-3				1088
9	SM SA			SILTY SAND - brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, organic odour, twigs and organic matter embedded, sharp contact with overlying clay - encountered heaving sands at approx. 10 m; switched to cable tool drilling						1087
10	SA			SAND - brown - wet, very loose, non-cohesive, non-plastic - coarse subrounded sand with minor angular gravel inferred to be colluvium						1086
11										1085
12				SAND - brown grading to black below 10.21 m - wet, dense, non-cohesive, non-plastic - coarse sand with increasing silt content downhole, organic odour END OF DRILLING at 10.66 m						1084
13				MW09-01 installation: - Screen interval: 9.45 m - 9.75 m - Screen type: 10-Slot 1.25" PVC SCHED 40 - Filter pack interval: 9.14 m - 9.75 m - Bentonite seal: 8.53 m - 9.14 m - WL: 7.648 m bTOP (8-Jul-09, 8:00 AM)						1083
14										
15										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-02**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0	FILL			SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded						1096
1										1095
2	SA			SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded						1094
3				SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand						1093
4	SM					S-1				1092
5				END OF DRILLING at 4.57 m MW09-02 installation: - Screen interval: 3.05 m - 4.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 3.211 m bTOP (9-Jul-09, 11:35 AM)						1091
6										1090
7										1089
8										1088
9										1087
10										1086
11										1085
12										1084
13										1083
14										1082
15										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100

■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

AECOM	LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
	REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/7/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-03**
LOCATION: South side of tailings empoundment UTM N 2,097,195.3 E 118,691.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1096
1		SILTY SAND TAILINGS - dark yellowish orange - moist becoming wet at 2.31 m, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded		S-1			1095
2	SM						1094
3				S-2			1093
4	SASI SICL	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1092
5		SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency					1091
6	SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					1090
7	CL	CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, high plasticity, slow dilatency		S-3			1089
8	CB	COBBLES AND SAND AND SILT - brown - wet, dense, non-cohesive, non-plastic - loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam		S-4			1088
9	SA	SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill					1087
10		END OF DRILLING at 9.14 m MW09-03 installation: - Screen interval: 8.08 m - 9.14 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 7.93 m - 9.14 m - Bentonite seal: 7.32 m - 7.92 m - WL: 6.910 m bTOP (22-Jul-09)					1086
11							1085
12							1084
13							1083
14							
15							

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 9.14 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

AECOM

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-04**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.0

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL			SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					
1									1095
				SILTY SAND TAILINGS - dark yellowish orange - moist becoming wet at 2.31 m, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					
2	SM								1094
3						S-1			1093
				SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					
4	SASI SICL								1092
				SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency					
5						S-2			1091
	SM			SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					
6									1090
7				END OF DRILLING at 7.01 m					1089
				MW09-04 installation: - Screen interval: 5.49 m - 7.01 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 3.810 m bTOP (22-Jul-09)					
8									1088
9									1087
10									1086
11									1085
12									1084
13									1083
14									1082
15									

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 7.01 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-05**
LOCATION: North side of tailings empoundment UTM N 2,097,224.9 E 2,097,224.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0				SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency						1095
1	SICL									
				SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded						1094
2	SM									
				CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency						1093
3										
										1092
4	CL									
										1091
5										
	OR			ORGANICS - dark brown - wet - primarily moss						1090
6	SM									
	SA			SILTY SAND - dark brown - moist, dense, non cohesive, non plastic, slow dilatency - fine to medium sand, sub-rounded, occasional angular clast up to 10 mm inferred to be native aeolian sand						1089
7										1088
8				SAND - brown - moist, loose, non-cohesive, non-plastic, slow dilatency - medium sand with minor silt inferred to be native aeolian sand with developed soil horizon						1087
9				END OF DRILLING at 6.71 m						1086
10				MW09-05 installation: - Screen interval: 5.79 m - 6.70 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 5.49 m - 6.70 m - Bentonite seal: 5.18 m - 5.79 m - WL: Dry (22-Jul-09)						1085
11										1084
12										1083
13										1082
14										
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 6.71 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-06**
LOCATION: North side of tailings empoundment UTM N 2,097,224.9 E 2,097,224.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.3

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

BACKFILL TYPE: BENTONITE; GRAVEL; SLOUGH; GROUT; CUTTINGS; SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0	SICL			SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency						1095
1										
2	SM			SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded						1094
3	CL			CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency						1093
4										1092
5				END OF DRILLING at 4.57 m MW09-06 installation: - Screen interval: 1.52 m - 4.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 2.95 m bTOP (22-Jul-09)						1091
6										1090
7										1089
8										1088
9										1087
10										1086
11										1085
12										1084
13										1083
14										1082
15										1081

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100

■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 10/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-07**
LOCATION: North side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.8

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

BACKFILL TYPE: BENTONITE; GRAVEL; SLOUGH; GROUT; CUTTINGS; SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS (Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm); Total Unit Wt (kN/m³); Plastic MC Liquid)	COMMENTS	ELEVATION
0				SILTY SAND FILL - brown - dry, loose, non-cohesive, non-plastic - native fill used for drill pad construction						1095
1	SM									1094
2	SM OR SA CL			SILTY SAND TAILINGS - dark yellowish brown - moist, medium dense, non-cohesive, non-plastic - fine to medium grained sand, sub-rounded						1093
3				ORGANICS - dark brown to black - moist - fibrous roots and moss becoming more decomposed with depth						1092
4	SM			SAND - dark brown - moist, dense, non-cohesive, non-plastic - fine sand, sub-rounded, inferred to be developing soil horizon within native aeolian sand						1091
5				CLAY - light grey - moist, very dense, cohesive, non-plastic - clay sized volcanic ash sediments						1089
6				SILTY SAND - dark grey to black - moist, dense, cohesive, non-plastic - fine sand, sub-rounded, organic rich, grading coarser with depth						1088
7				END OF DRILLING at 4.57 m						1087
8				MW09-07 installation: - Screen interval: 2.31 m - 2.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: 2.00 m - 2.57 m - Bentonite seal: None - WL: Dry (22-Jul-09)						1086
9										1085
10										1084
11										1083
12										1082
13										1081
14										
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: MW09-08
LOCATION: Downstream of Seepage Dam UTM N 2,097,199.8 E 118,756.2		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1073.9

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

BACKFILL TYPE: BENTONITE; GRAVEL; SLOUGH; GROUT; CUTTINGS; SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0	GRSA			SAND and GRAVEL, trace silt - orange-brown - moist, loose - medium grained sand, sub-rounded - gravel sub-angular to sub-angular, 0.5 cm to 5 cm - clast supported - presence of organic (roots, grass)						
1										1073
2	SA			SAND, some silt, some organic - dark grey - moist to wet, loose - fine grained to medium grained sand - presence of roots						1072
3	GRSA			SAND and GRAVEL, trace silt - dark yellowish brown - medium grained sand, sub-rounded - sub-angular gravel, 0.5 cm to > 8 cm - clast supported - permafrost at 3.05 m below ground surface, Nbn						1071
4	SA									1070
5				SAND, trace silt - dark brown and grey - very dense - medium grained sand - presence of wood debris - permafrost, Nbn						1069
6				END OF DRILLING at 3.66 m in permafrost (refusal)						1068
7				MW09-08 install: - Screen interval: 1.52 m - 3.05 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.22 m - 3.58 m - Bentonite seal from ground surface to 1.22 m - WL: 1.028 mTPVC (22-Jul-09, 08:28:00 AM)						1067
8										1066
9										1065
10										1064
11										1063
12										1062
13										1061
14										1060
15										

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 3.66 m
REVIEWED BY: Ryan Mills	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-11**
LOCATION: South of Dome Creek and west of Diversion Channel UTM N 2,097,216.6 E 118,706.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1107.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	SA			SAND (Aeolian) - grey brown - dry, loose, non-cohesive - uniform fine to medium grained sand, sub-rounded, minor silt				✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100		1107
1										1106
2				- becoming moist at 1.37 m - medium dense (incresing density with depth), becoming wet at 1.92 m - increasing silt content with depth with medium sand interbeds, thinly bedded - non-cohesive, non-plastic, slow dilatency						1105
3				- saturated at 3.25 m, dense, sandy silt interbed <1 cm thick						1104
4				- occasional nugget of frozen sand between 3.66 m and 4.11 m		S-1				1103
5				- permafrost 4.11 m to 4.22 m, refusal at 4.22 m using direct push drilling method END OF DRILLING at 4.22 m in permafrost (refusal) MW09-11 install: - Screen interval: 2.69 m - 4.22 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 2.39 m - 4.22 m - Bentonite seal from 1.83 m to 2.39 m - Drill cutting from ground surface - WL: 4.27 m BTOP (22-Jul-09)					1102
6										1101
7										1100
8										1099
9										1098
10										1097
11										1096
12										1095
13										1094
14										1
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.22 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet		S-1				1208
1	CL									1207
2				DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet		S-2 S-3 S-4				1206
3										1205
4	BE					S-5 S-6				1204
5				- casing to 4.57 m		S-7 S-8				1203
6				- borehole producing approx. 1-2 L/min during air development		S-9 S-10				1202
7				GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11 S-12				1201
8						S-13				1200
9				- chips coarser from 8.53 m to 10.46 m		S-14				1199
10	BE					S-15 S-16				1198
11						S-17 S-18				1197
12						S-19				1196
13				DIORITE - light grey - dry, slightly weathered feldspars, quartz rich, low mafic content, massive structure - unreactive with HCl, overall less weathered and more competent than overlying rock		S-20 S-21				1195
14	BE					S-22 S-23				1194
15										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
15						S-24				1193
						S-25				
16						S-26				1192
						S-27				
17						S-28				1191
	BE									
18						S-29				1190
						S-30				
19						S-31				1189
						S-32				
20				HORNEBLENDE DIORITE - dark grey - dry, potassium feldspar and horneblende mildly weathered, chips fine		S-33				1188
21						S-34				1187
						S-35				
22						S-36				1186
						S-37				
23						S-38				1185
24						S-39				1184
						S-40				
25	BE					S-41				1183
						S-42				
26						S-43				1182
27						S-44				1181
						S-45				
28						S-46				1180
29						S-47				1
						S-48				
30										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
▩ Total Unit Wt ▩
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

AECOM

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
30	BE			QUARTZOLITE - white to light grey - primarily quartz with minor plagioclase feldspar and biotite - very hard (drilling at approx. 1.5 m/hour)		S-49				1178
31						S-50				1177
32	BE					S-51				1176
33						S-52				1175
34				GRANODIORITE - light grey - dry, high quartz content with minor amount of highly weathered potassium feldspar		S-53				1174
35	BE					S-54				1173
36						S-55				1172
37						S-56				1171
38						S-57				1170
39						S-58				1169
40				END OF DRILLING at 35.97 m MW09-13 install: - Screen interval: 29.87 m - 35.97 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 28.34 m - 35.97 m - Bentonite seal from 27.43 m to 28.34 m - Grouted to ground surface - WL: 33.24 m BTOP (22-Jul-09)						1168
41										1167
42										1166
43										1165
44										1164
45										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 — ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 — Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-14**
LOCATION: Northeast of Brown-McDade pit		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1207.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet		S-1		✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100		1207
1	CL									
2				DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet		S-2 S-3				1206
3						S-4				1205
4	BE					S-5 S-6				1204
5				- casing to 4.57 m		S-7 S-8				1203
6				- borehole producing approx. 1-2 L/min during air development		S-9 S-10				
7				GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11 S-12				1201
8						S-13				1200
9	BE			- chips coarser from 8.53 m to 10.46 m		S-14 S-15				1199
10						S-16				1198
11				END OF DRILLING at 10.67 m						1197
12				MW09-14 install: - Screen interval: 5.49 m - 8.53 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 5.18 m - 8.53 m - Bentonite seal from 0 m to 5.18 m - WL: Frozen at 8.13 m BTOP (22-Jul-09)						1196
13										1195
14										1194
15										1193

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0				CLAY (minor SAND and some GRAVEL) - brown - dry, loose, cohesive, non-plastic, rapid dilatency when wet						1206
1						S-1				
2	CL									1205
3						S-2				1204
4										1203
5	BE			DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - wet 4.88 m to 6.01 m		S-3 S-4 S-5 S-6 S-7				1202
6				HORNEBLENDE DIORITE - light grey - dry, slightly weathered, occasional iron staining, chips coarse - casing to 4.57 m; approx. 1 L of water in hole after changing bit		S-8 S-9				1201
7	BE									1200
8						S-10 S-11				1199
9				- highly weathered 8.53 m to 9.14 m - dry, absence of mafic minerals, high degree of iron staining - inferred conductive fracture zone when saturated - slightly weathered from 9.14 m to 14.63 m - dry, light grey		S-12 S-13				1198
10						S-14				1197
11				- quartz vein 10.97 m to 11.58 m		S-15 S-16				1196
12						S-17 S-18				1195
13						S-19				1194
14						S-20 S-21				1193
15	BE			GRANODIORITE						1192

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: .Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15				- grey-brown - moist from 14.63 m to 16.46 m and dry below, highly weathered and iron stained - rapid drilling rates - highly fractured bedrock 15.94 m to 16.92 m (rapid drilling) - zone of cave during well installation		S-22				
						S-23				
16						S-24				1191
	BE					S-25				1190
17						S-26				
						S-27				1189
18				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor potassium feldspar, chips fine		S-28				
						S-29				1188
19						S-30				
	BE					S-31				1187
20						S-32				
						S-33				
21				GRANODIORITE - grey-brown - moist, highly weathered, heavily fractured and iron stained, rapid drilling rates		S-34				1185
						S-35				
22	BE			DIORITE - light grey - dry, moderately weathered, trace feldspar		S-36				1184
						S-37				
23	BE			GRANODIORITE - orange-brown - moist, highly weathered with high clay mineral content inferred to be fault gouge - potentially conductive fracture zone		S-38				1183
						S-39				
24				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor iron staining, chips fine		S-40				1182
						S-41				
25						S-42				1181
	BE					S-43				
26						S-44				1180
						S-45				
27				- less than 1 m of water in borehole after sitting overnight without rods in hole		S-46				1179
28										1178
29										1177
30										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100

Total Unit Wt (kN/m³) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
30	BE			DIORITE - light grey - dry, soft, moderately weathered, minor iron staining		S-47				
						S-48				1176
31										
						S-49				
32						S-50				1175
						S-51				
33										1174
						S-52				
34	BE			- highly weathered from 34.14 m to end of hole at 38.10 m		S-53				1173
						S-54				
35										1172
						S-55				
				- moist from 35.36 m to 35.38 m		S-56				1171
36										
						S-57				
				- wet from 35.38 m to end of hole at 38.10 m						1170
37						S-58				
										1169
38						S-59				
						S-60				
				END OF DRILLING at 38.10 m						
				MW09-15 install: - Screen interval: 33.98 m - 37.03 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 33.22 m - 37.03 m - Bentonite seal from 32.00 m to 33.22 m - Grouted to ground surface - 0.5 L of WDS-120 polymer used to avoid loss of hole; re-drilled 7 times to remove cave and stabilize borehole - WL: 16.74 m BTOP (22-Jul-09)					1168
39										
										1167
40										
										1166
41										
										1165
42										
										1164
43										
										1163
44										
45										1162

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-16**
LOCATION: Downgradient of Mill		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1182.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				GRAVEL FILL with some SAND, SILT and CLAY - dark yellowish-brown - dry, dense, non-cohesive, non-plastic - gravel up to 3" diameter - inferred to be waste rock fill for staging area - becomes wet at 1.07 m						1182
1	GR									
2						S-1				1181
3	SASI			SANDY SILT - black-brown - wet, medium dense, cohesive, rapid dilatency - roots from 2.13 m to 3.66 m - increasing sand content with depth, sand fine to medium grained						1180
4										1179
	SM			SILTY SAND - brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand with very few organics - inferred to be aeolian sand						1178
5				END OF DRILLING at 4.57 m						
6				MW09-16 install: - Screen interval: 0.30 m - 1.83 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 0.15 m - 1.83 m - Bentonite seal from 0 m to 0.15 m - WL: 1.21 m BTOP (22-Jul-09)						1176
7										1175
8										1174
9										1173
10										1172
11										1171
12										1170
13										1169
14										1168
15										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM	LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
	REVIEWED BY: Marc Lavigne	COMPLETION DATE: 14/7/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-17**
LOCATION: Downgradient of Mill UTM N 2,097,319.7 E 118,286.2		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1178.0

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0				SILTY CLAY with some SAND and GRAVEL - orange - dry, dense, cohesive, low plasticity - inferred to be waste rock fill used for road bed construction						1178
1	SICL			- becomes moist at 1.37 m						1177
2	SASI			SANDY SILT - black - moist, medium dense, cohesive, medium plasticity - odour likely the result of organics in soil; does not smell like hydrocarbon		S-1				1176
3	GR			GRAVEL with some CLAY, SILT and SAND filling interstices - yellow-brown - wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered - gravel to 10 cm along long axis - inferred to be colluvium		S-2				1175
4										1174
5	BE			BEDROCK - dark grey - wet, very dense, fine texture, laminated, friable by hand, very cold - refusal at what is inferred to be frozen bedrock END OF DRILLING at 4.88 m						1173
6				MW09-17 install: - Screen interval: 3.35 m - 4.88 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 2.74 m - 4.88 m - Bentonite seal from 0 m to 2.74 m - WL: 3.88 m BTOP (22-Jul-09)						1172
7										1171
8										1170
9										1169
10										1168
11										1167
12										1166
13										1165
14										1164
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.88 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 14/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-18**
LOCATION: Downgradient of Mill UTM N 2,097,323.9 E 118,279.5		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1178.9

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0	SASI			SANDY SILT - brown with red staining - dry, loose, non-cohesive, non-plastic - organic rich with pervasive roots, mild unknown odour		S-1				1178
1				SILTY SAND - brown with yellow staining - dry, medium dense, non-cohesive, non-plastic - organics present, sand fine to medium - inferred to be waste rock fill - moist from 1.52 m to 3.81 m, becomes red-brown below 1.52 m, frequent gravel/boulders						1177
2										1176
3	SM									1175
4				- dry from 3.81 m to 4.88 m; loose						1174
5				SILTY SAND TAILINGS - yellow-orange - dry, medium dense, cohesive, low plasticity, rapid dilatency - minor subangular gravel		S-2				1173
6	SM									1172
7	GRSA			SAND and GRAVEL with minor CLAY - brown - wet, loose, non-cohesive, non-plastic - angular gravel sized clasts - inferred to be colluvium, potential bedrock contact at 6.70 m		S-3				1171
8				END OF DRILLING at 6.86 m MW09-18 install: - Screen interval: 6.70 m - 6.86 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 5.94 m - 6.86 m - Bentonite seal from 0 m to 5.94 m - WL: 4.40 m BTOP (22-Jul-09)						1170
9										1169
10										1168
11										1167
12										1166
13										1165
14										
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 6.86 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-19**
LOCATION: Downgradient of Mill		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1176.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0				No recovery					
	SM			SAND, silty - orange-brown - dry, loose - fine grained to medium grained sand					
1									1176
	GRSA			SAND and GRAVEL, trace silt - dark brown to orange - moist, dense - medium grained sand, sub-rounded - gravel sub-rounded to sub-angular, 0.5 cm to 7 cm (limited by core barrel)					
2						G-1			1175
	OR			- clast supported		G-2			
	SA			- presence of wood debris (waste rock?)		G-3			
3	OR			ORGANIC, some silt, trace sand - black - moist, loose - presence of roots					1174
	SA								
4				SAND, gravelly, trace of silt - orange-brown - moist, dense - fine grained sand, sub-rounded - volcanic ash marker					1173
5						G-4			1172
				ORGANIC, some silt, trace sand - dark brown - moist, loose - presence of roots					
6									1171
				SAND, some silt, trace gravel - dark grey - wet, loose - medium grained sand, sub-rounded - sub-angular gravel, 1 cm to >4 cm - matrix supported					
7									1170
				END OF DRILLING at 5.11 m in permafrost (refusal)					
8									1169
				MW09-19 install: - Screen interval: 3.58 m - 5.11 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 3.28 m - 5.11 m - Bentonite seal from ground surface to 3.28 m - WL: 2.614 mTPVC (22-Jul-09, 10:11:00 AM)					
9									1168
10									1167
11									1166
12									1165
13									1164
14									1163
15									1162

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 5.11 m
REVIEWED BY: Ryan Mills	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-21**
LOCATION: Tailings Dam UTM N 2,097,199.5 E 118,730.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1080.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	FILL			Ditch Armour on surface - cobbles and boulders up to 1 m - iron staining						1080
1	FILL			GRAVEL, sandy, trace silt - orange-brown - dry, very dense - fine grained to medium grained sand, sub-rounded - gravel/cobble sub-angular to angular, 0.5 cm to 8 cm (limited by core barrel) - clast supported		G-1				1079
2						S-1	19-32-50			
	FILL			SAND, gravelly, trace silt - orange-brown - medium/fine sand, sub-rounded						1078
3	SASI SA			- sub-angular gravel, from 0.5 cm to > 5 cm - clast supported, becomes matrix supported with depth - wet		S-2	41-50-			
4				SILT, sandy, trace organic - dark brown						1077
5				SAND, some silt, trace gravel - dark brown - medium sand, sub-rounded - sub-angular gravel, >0.5 cm to <1 cm - matrix supported						1076
6				SAND, some silt, trace to some organic (volcanic ash marker) - light grey END OF DRILLING at 3.20 m in permafrost (refusal)						1074
7				MW09-21 install: - Screen interval: 1.52 m - 3.05 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.22 m - 3.05 m - Bentonite seal from ground surface to 1.22 m - WL: 1.668 mTPVC (22-Jul-09, 8:31:00 AM)						1073
8										1072
9										1071
10										1070
11										1069
12										1068
13										1067
14										1066
15										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

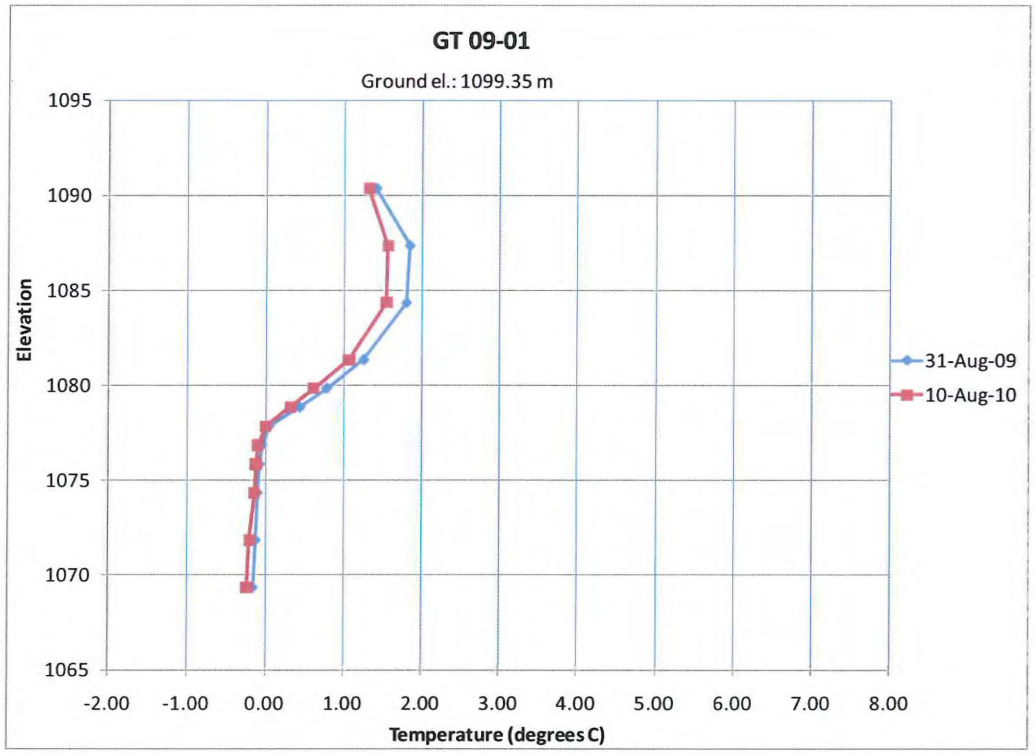
AECOM

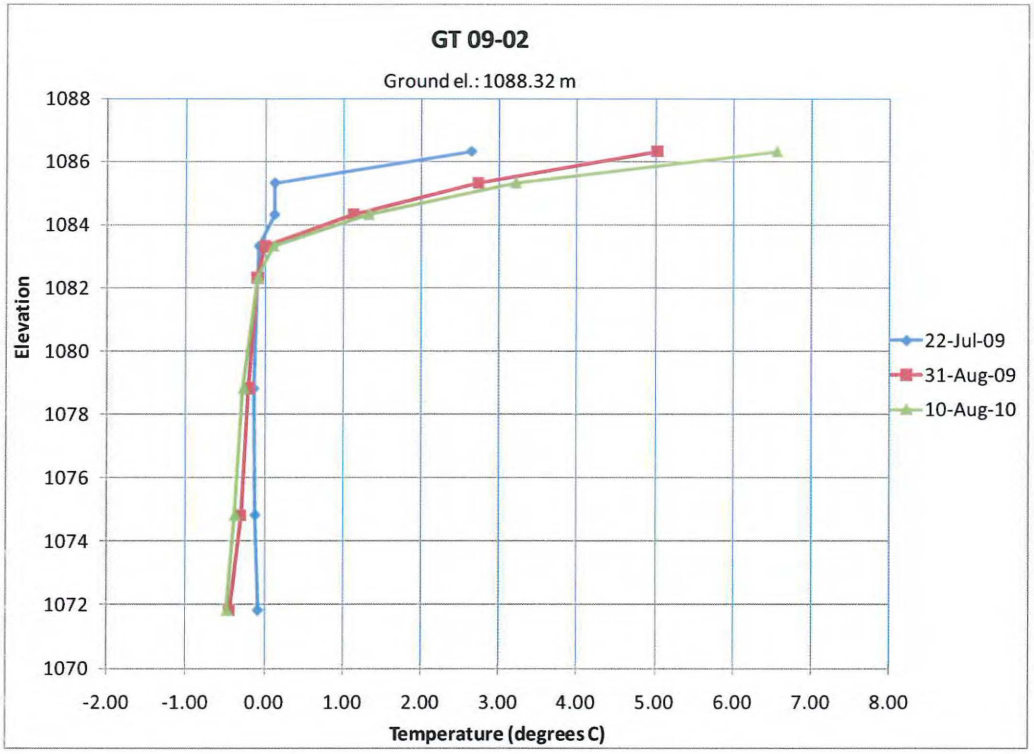
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 3.20 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

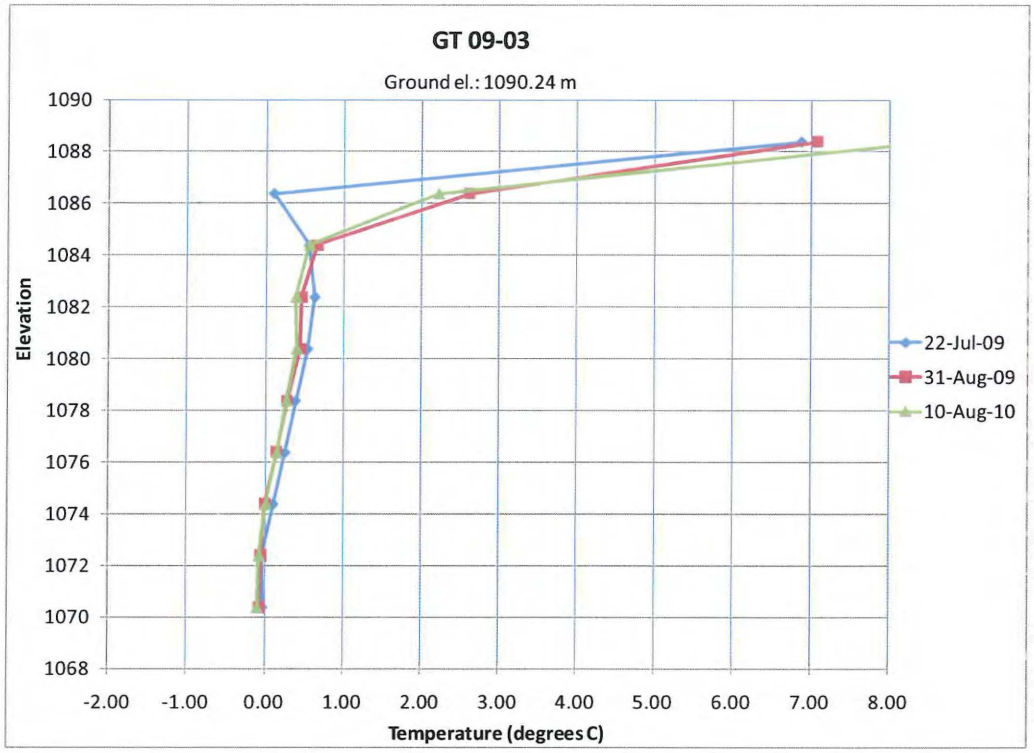
LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

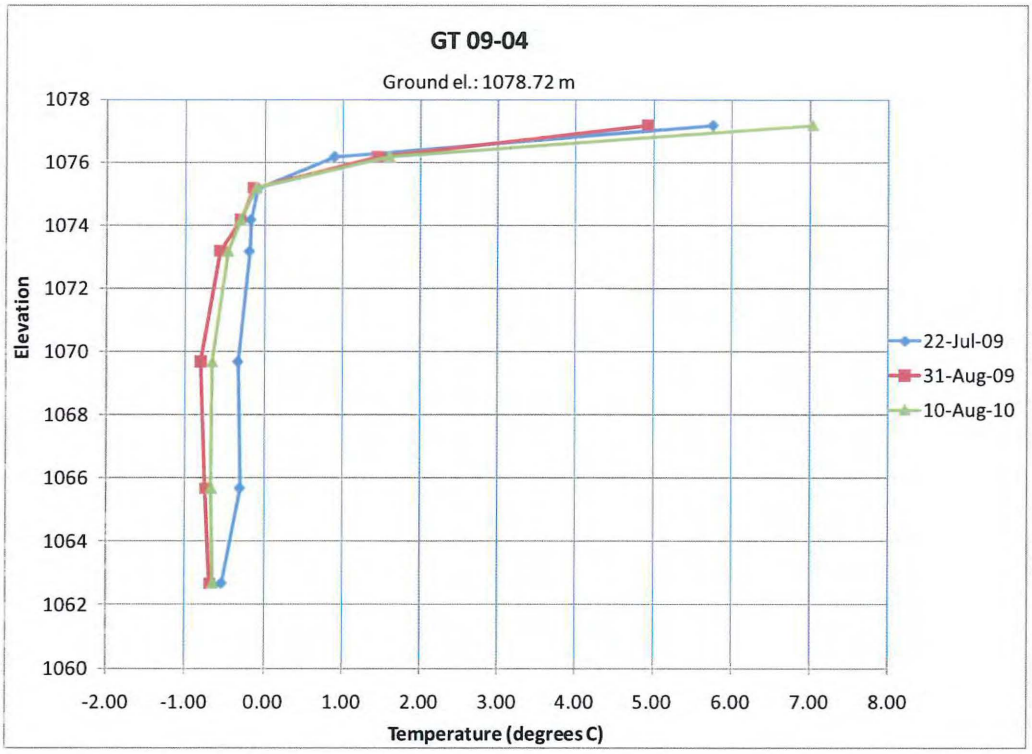
Appendix B
Geotechnical

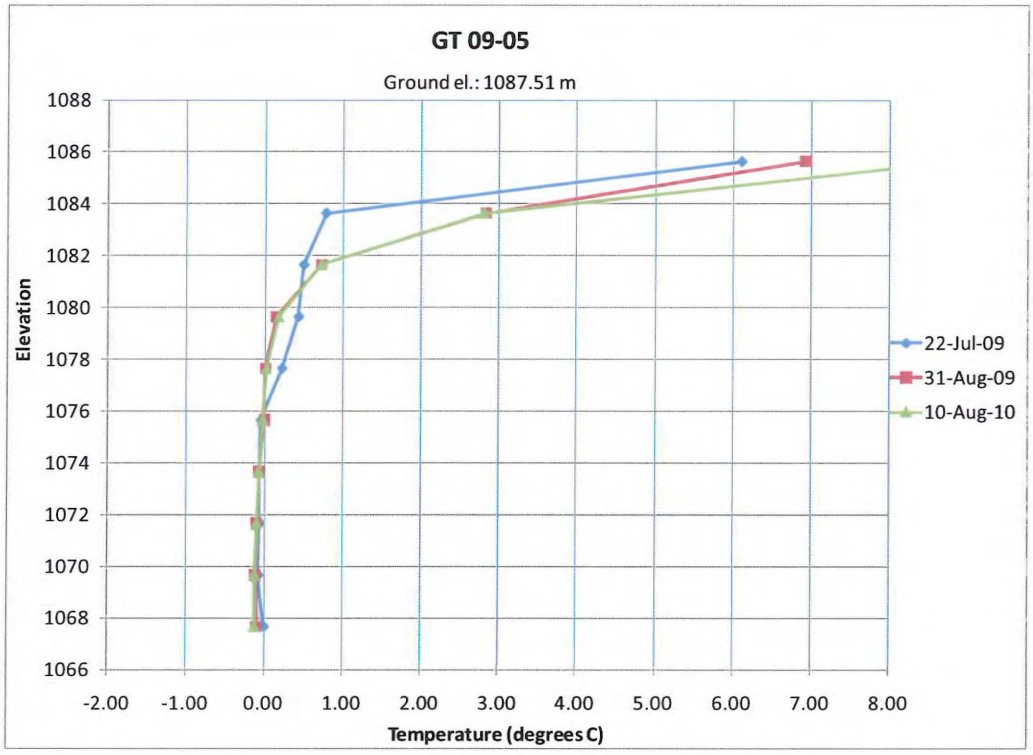
Appendix B-1
Monitoring Data


GT 09-01
Ground el.: 1099.35 m
Elevation
1095
1090
1085
1080
1075
1070
1065
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
31-Aug-09
10-Aug-10

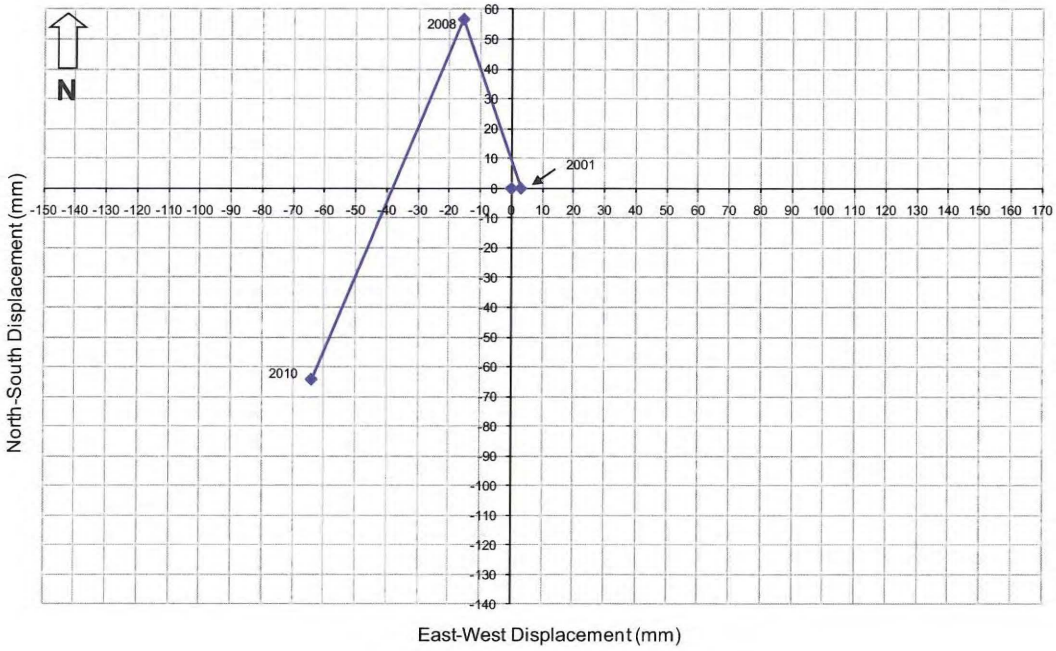

GT 09-02
Ground el.: 1088.32 m
Elevation
1088
1086
1084
1082
1080
1078
1076
1074
1072
1070
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10


GT 09-03
Ground el.: 1090.24 m
Elevation
1090
1088
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10


GT 09-04
Ground el.: 1078.72 m
Elevation
1078
1076
1074
1072
1070
1068
1066
1064
1062
1060
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10


GT 09-05
Ground el.: 1087.51 m
Elevation
1088
1086
1084
1082
1080
1078
1076
1074
1072
1070
1068
1066
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10

Mount Nansen - Deformation Survey
Pin Number Y4151



Mount Nansen - Deformation Survey
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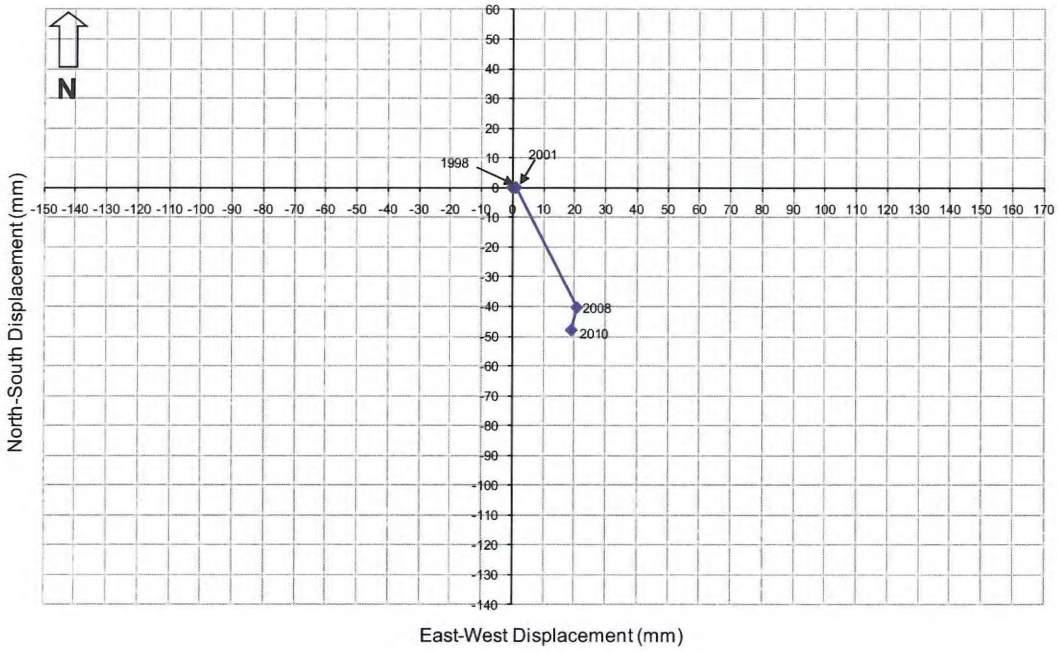

Mount Nansen - Deformation Survey
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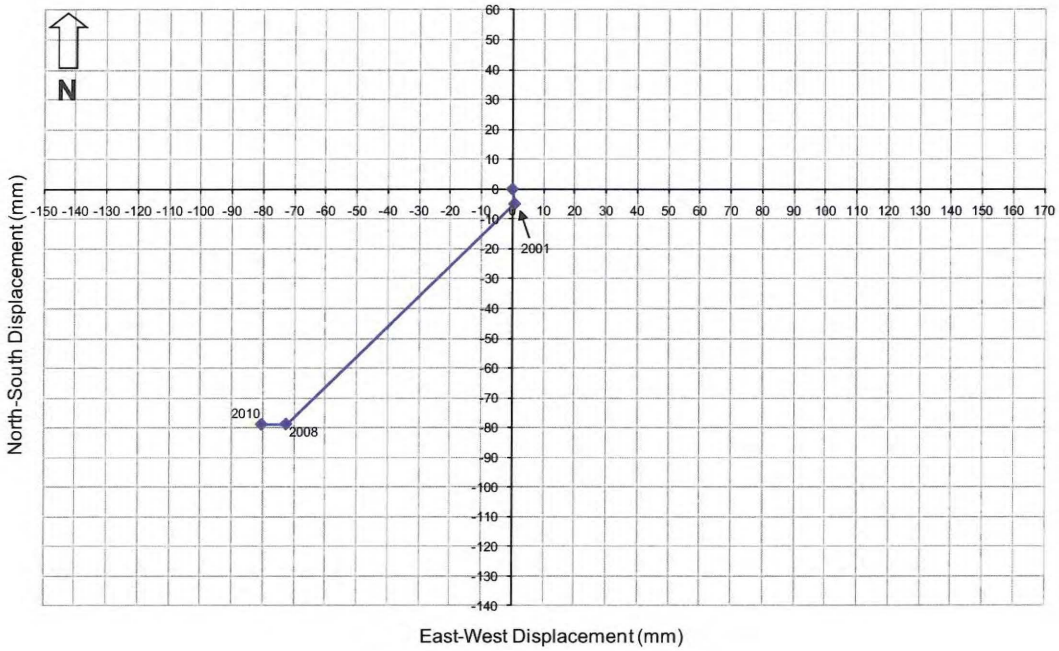

Mount Nansen - Deformation Survey
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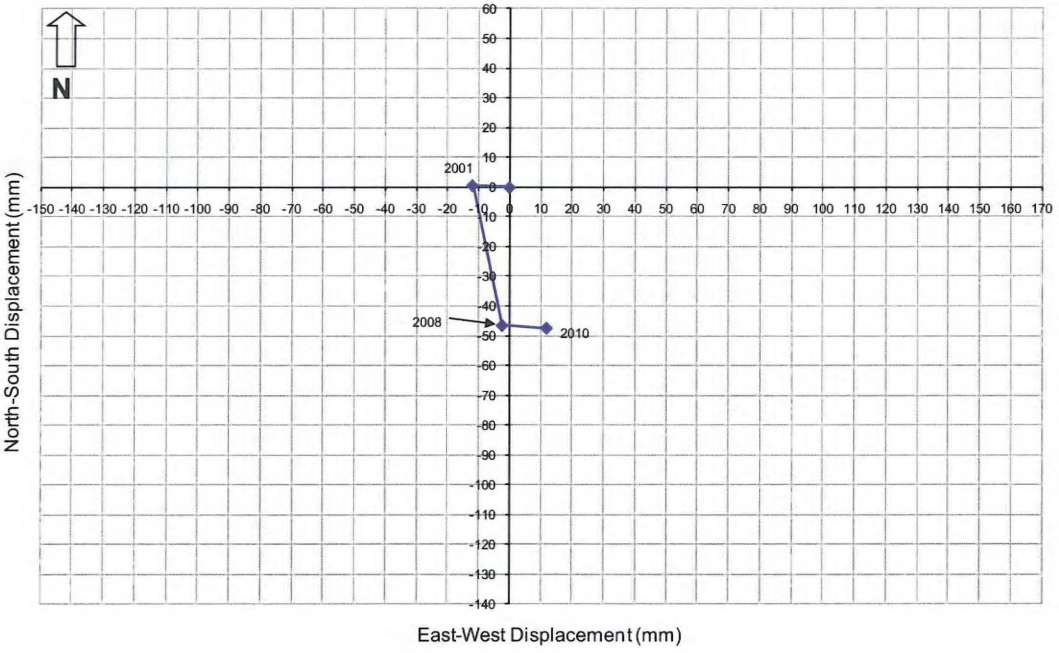

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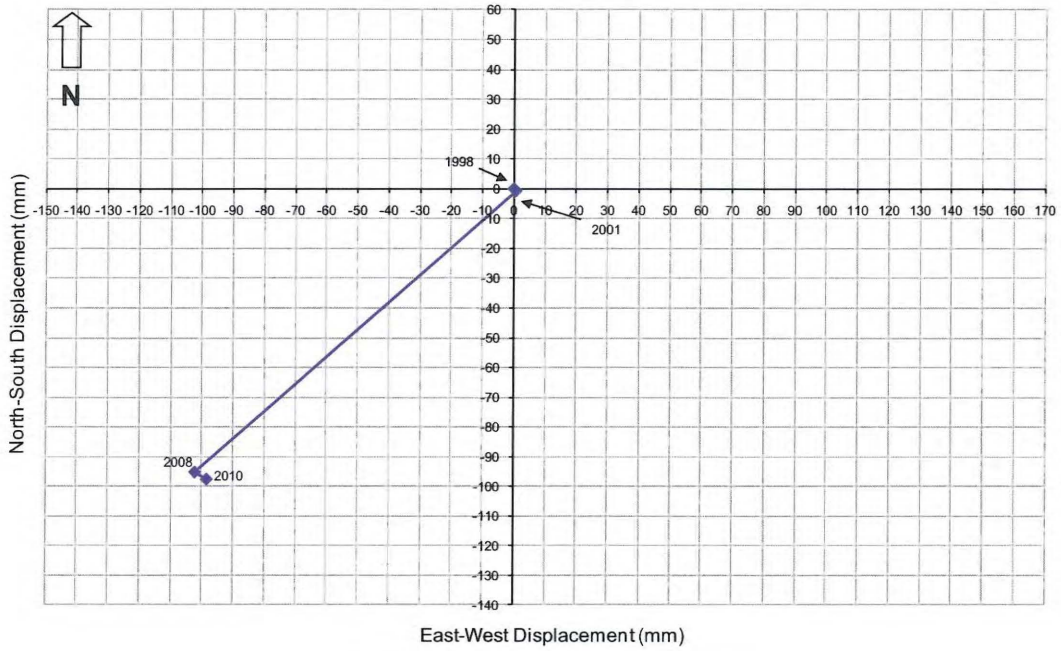

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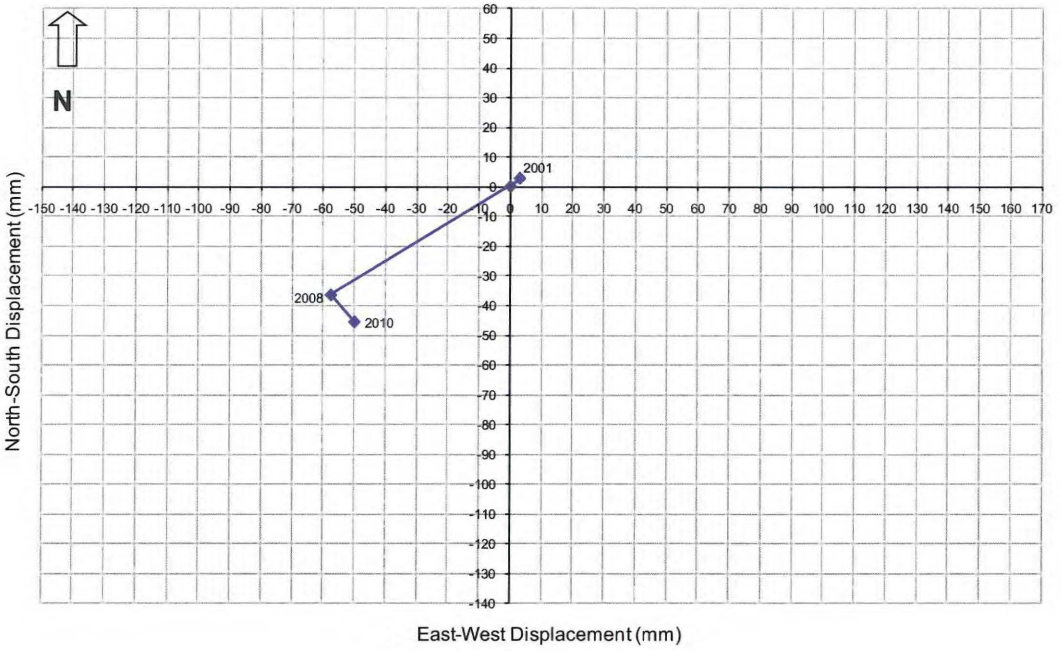

Mount Nansen - Deformation Survey
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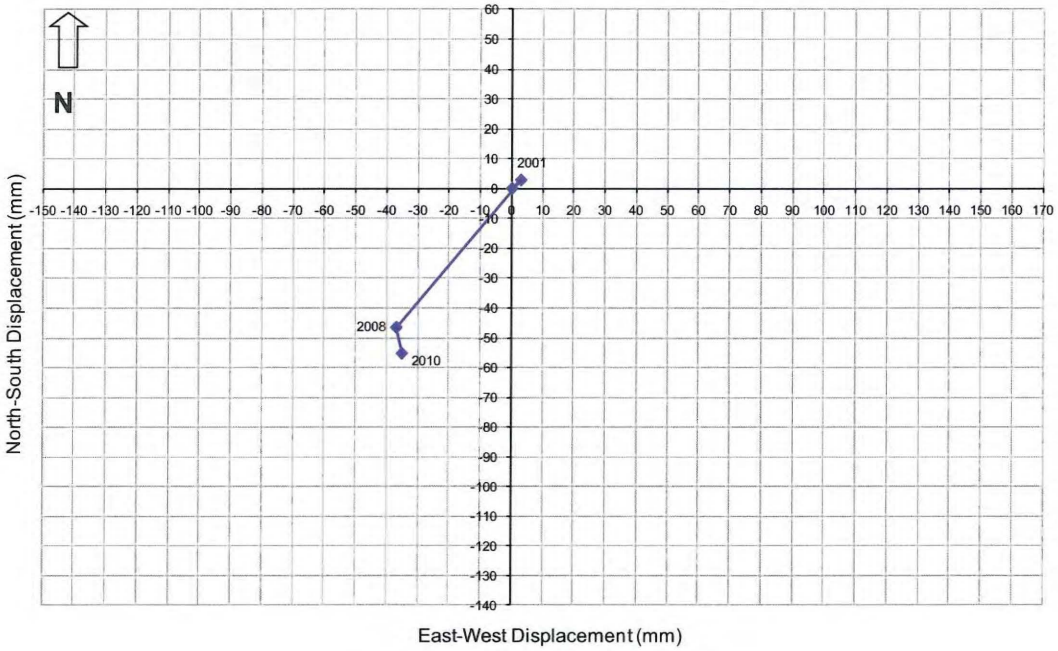

Mount Nansen - Deformation Survey
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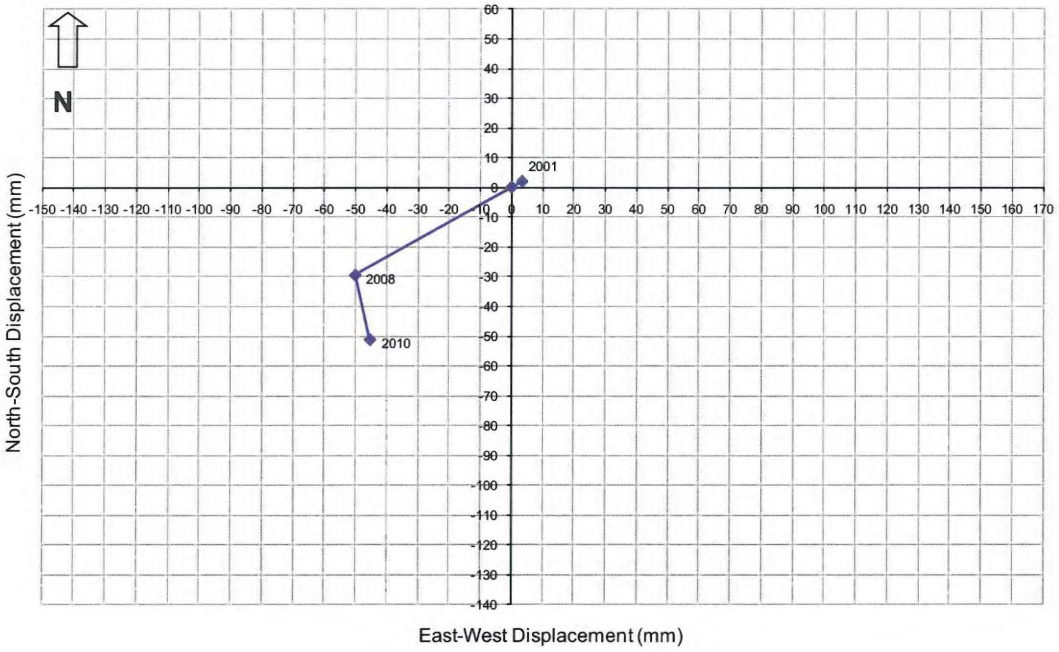

Mount Nansen - Deformation Survey
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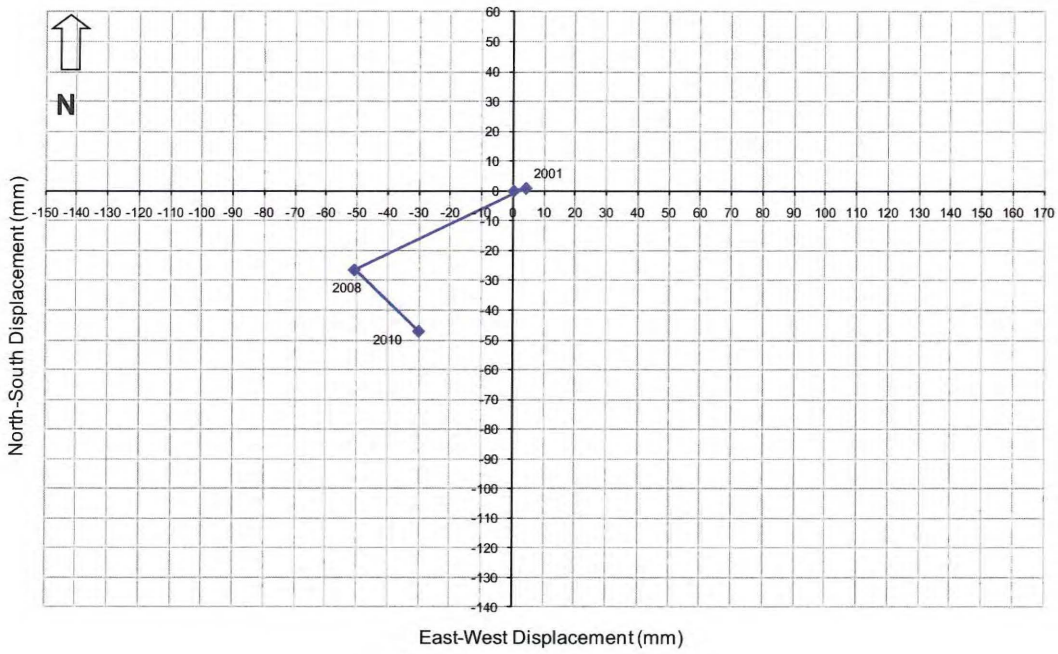

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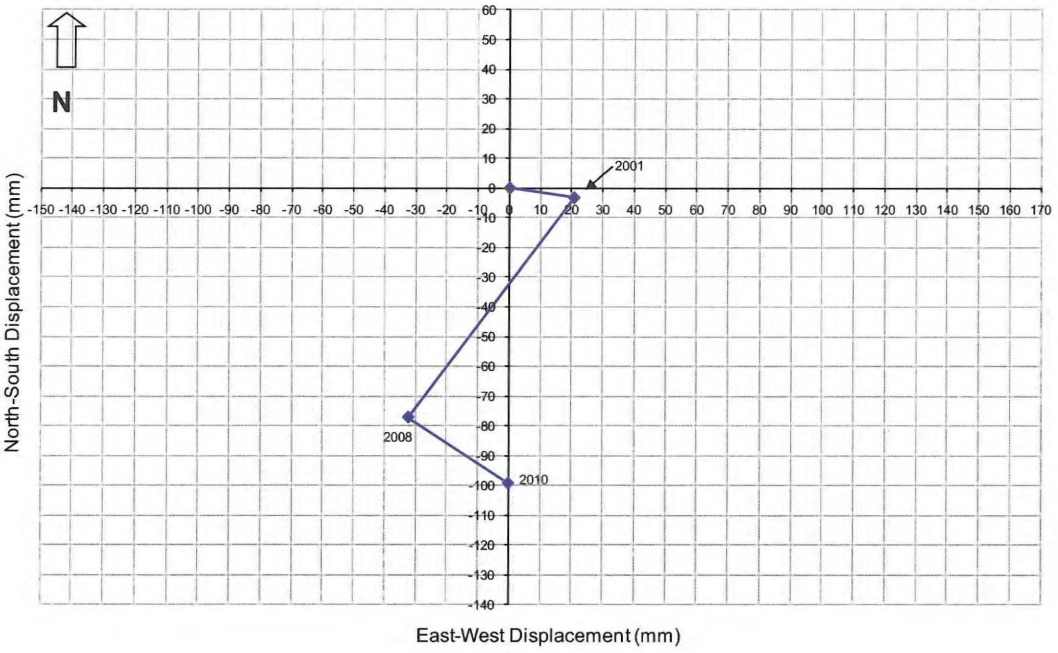

Mount Nansen - Deformation Survey
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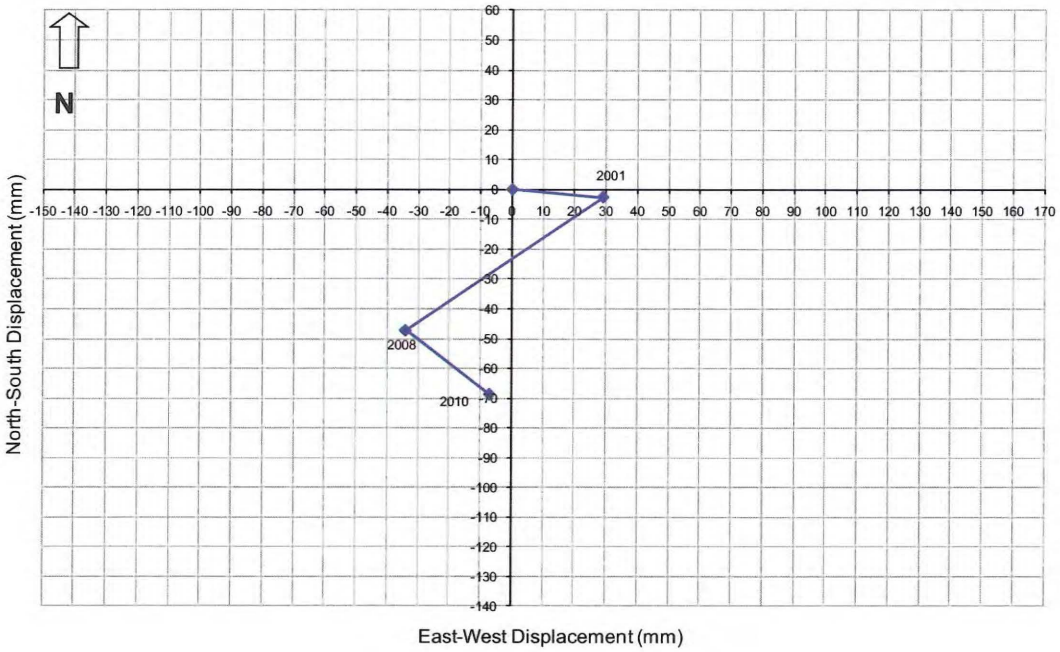

Mount Nansen - Deformation Survey
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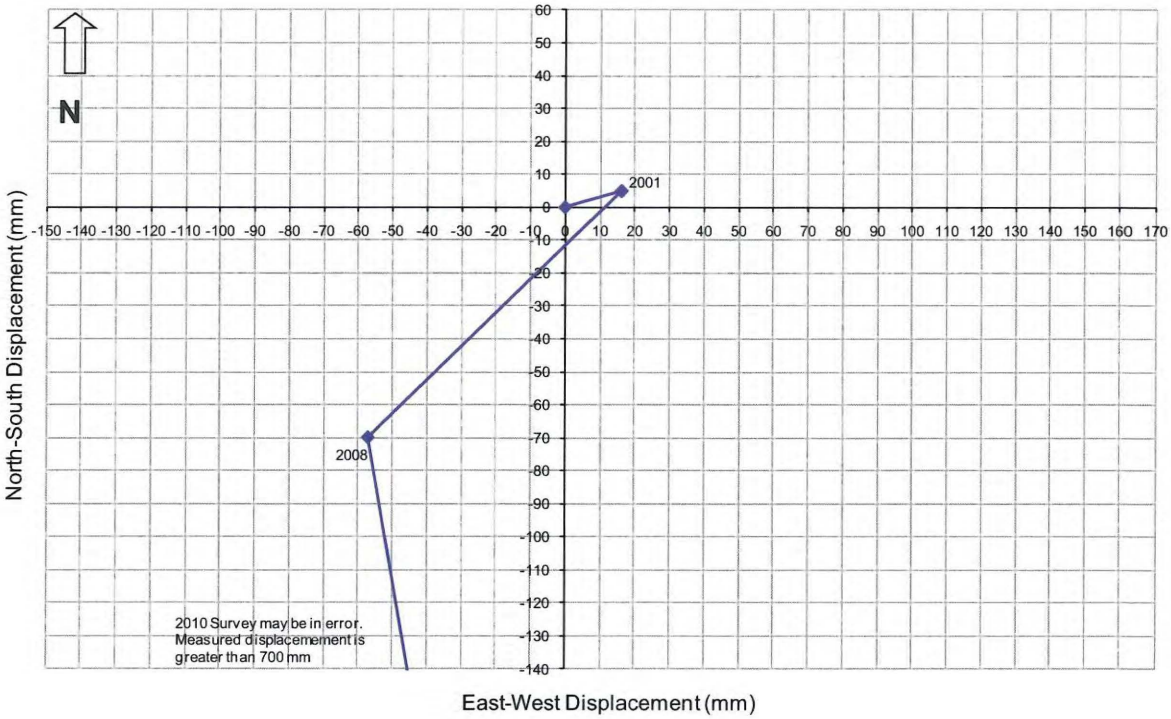

Mount Nansen - Deformation Survey
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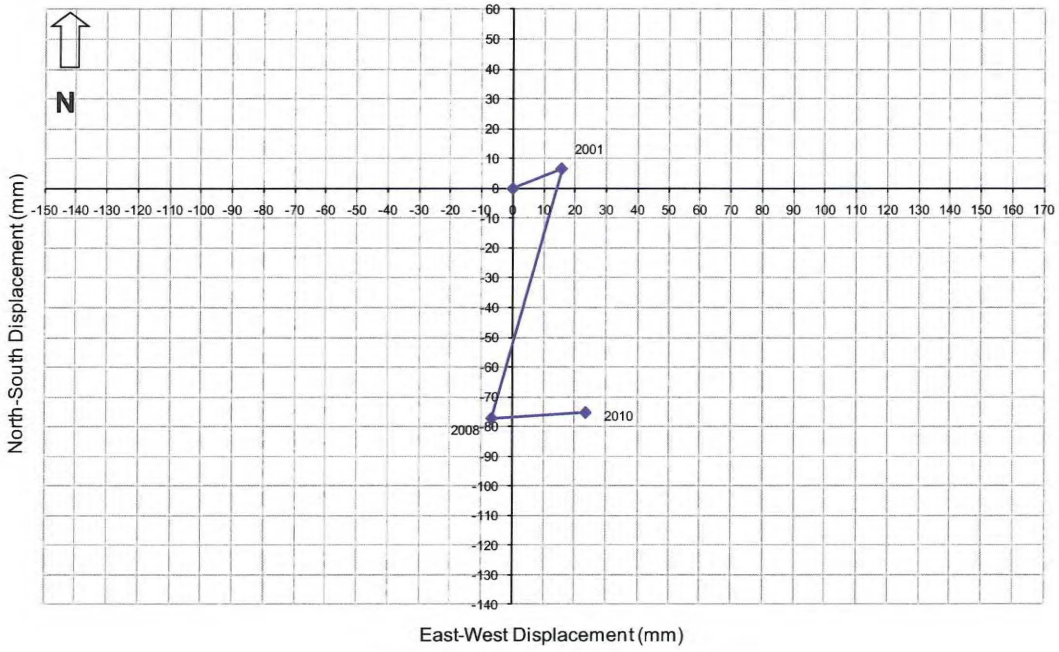

Mount Nansen - Deformation Survey
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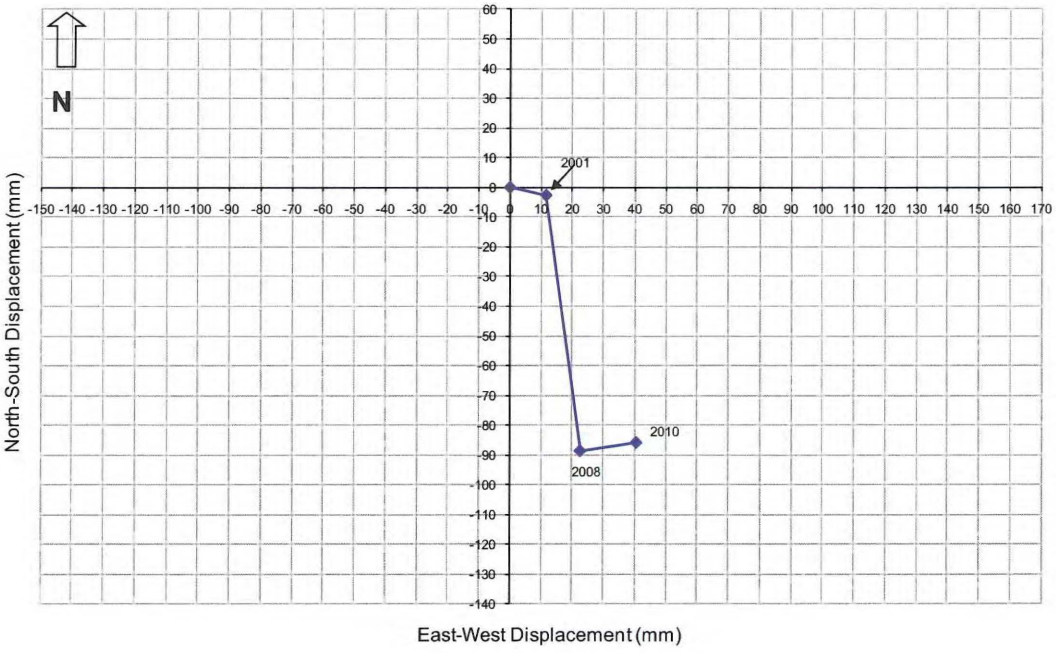

Mount Nansen - Deformation Survey
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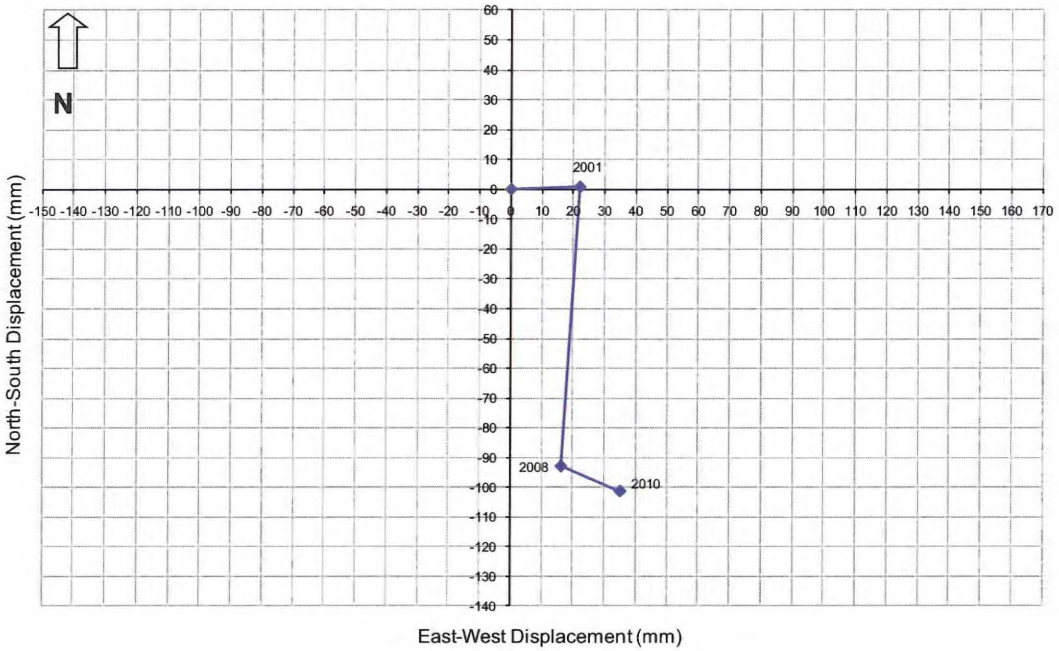

Mount Nansen - Deformation Survey
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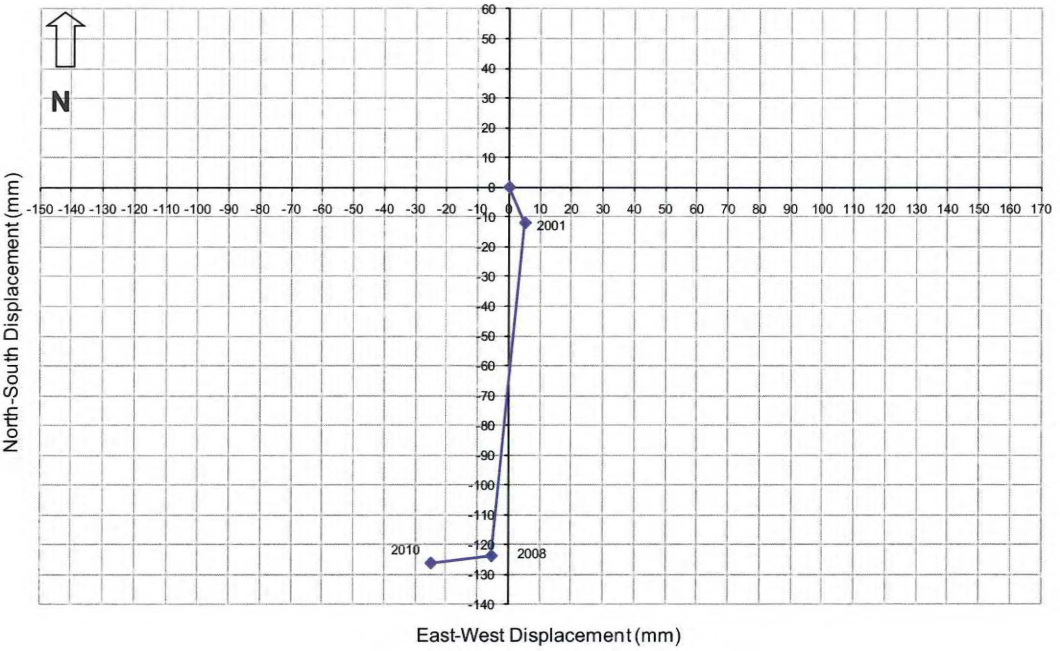
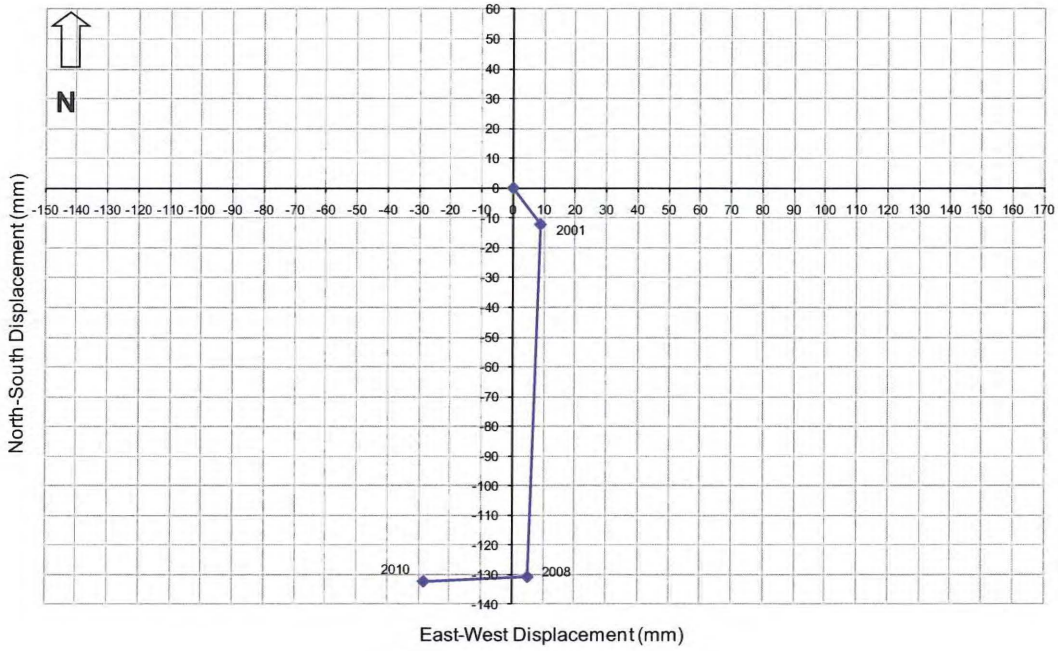


Mount Nansen - Deformation Survey
Pin Number Y4179



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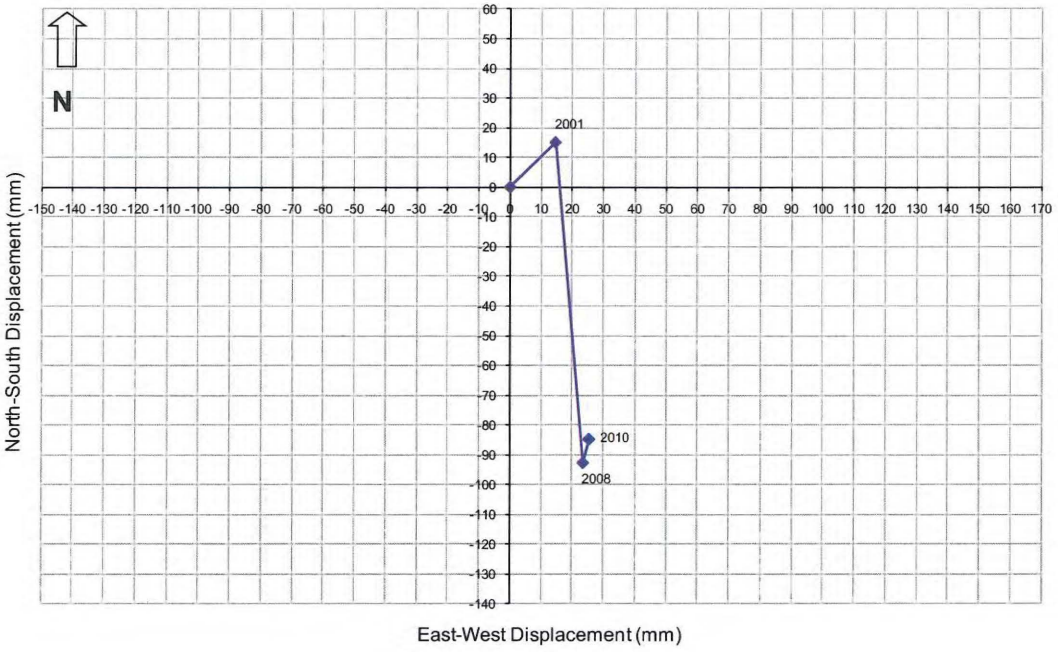

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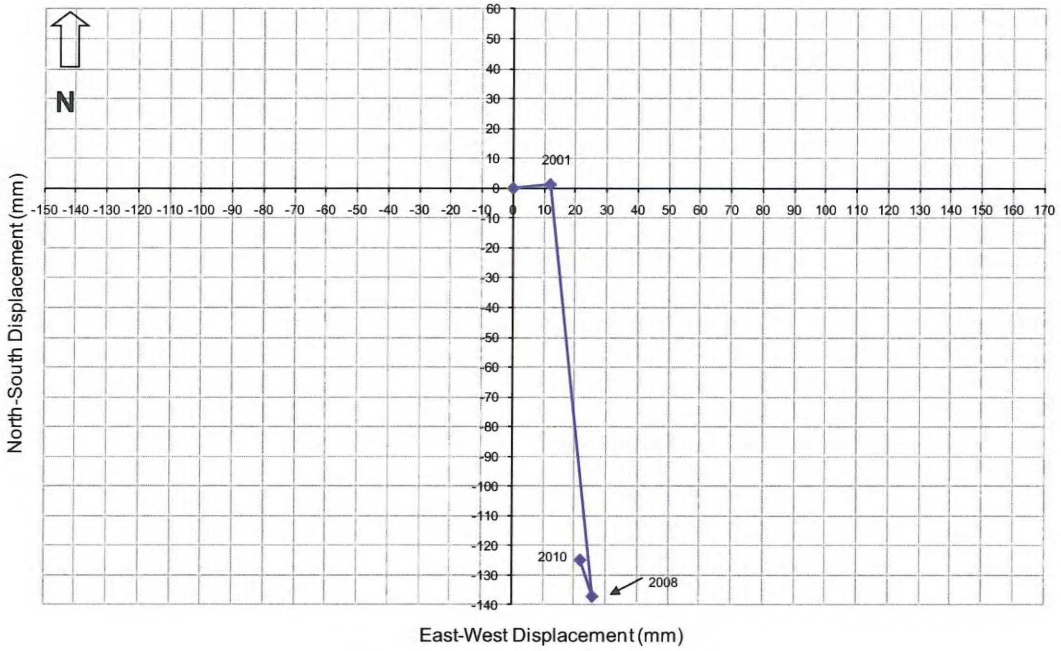

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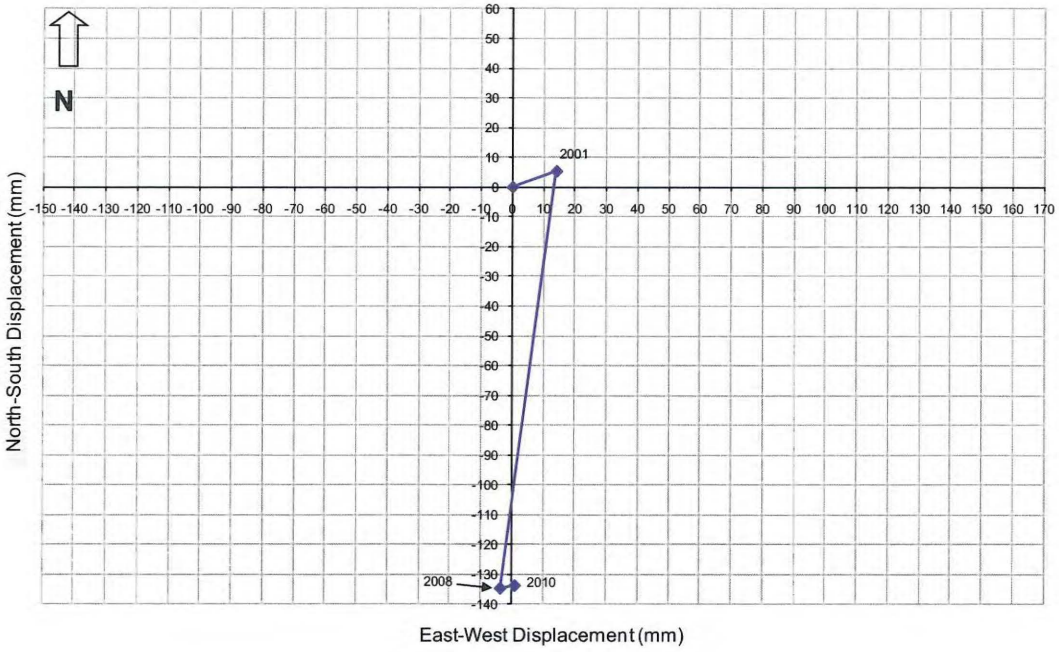

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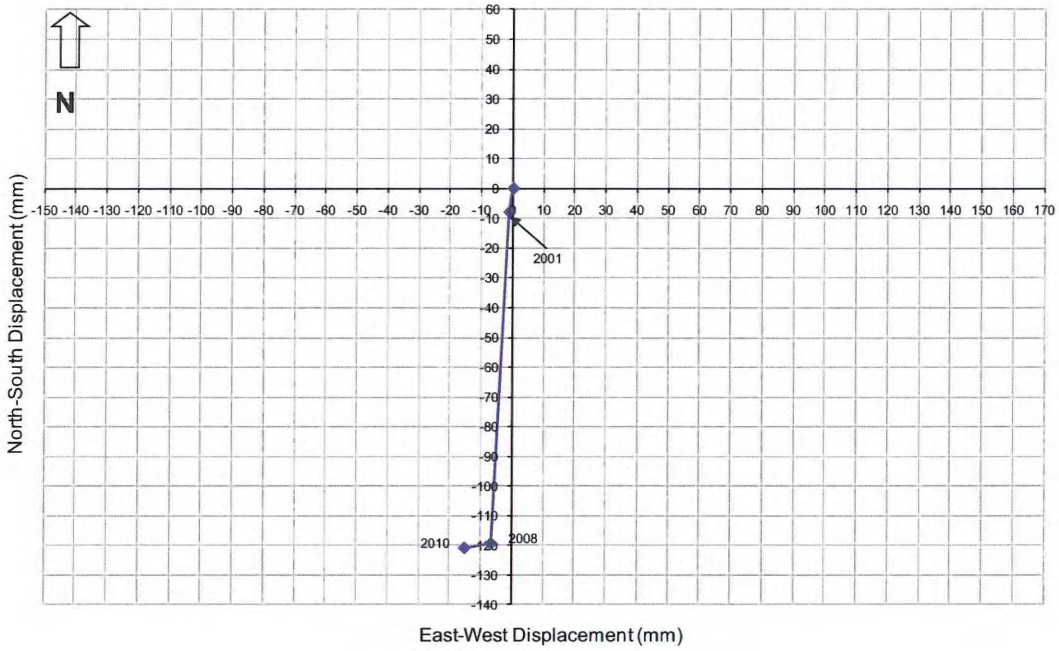

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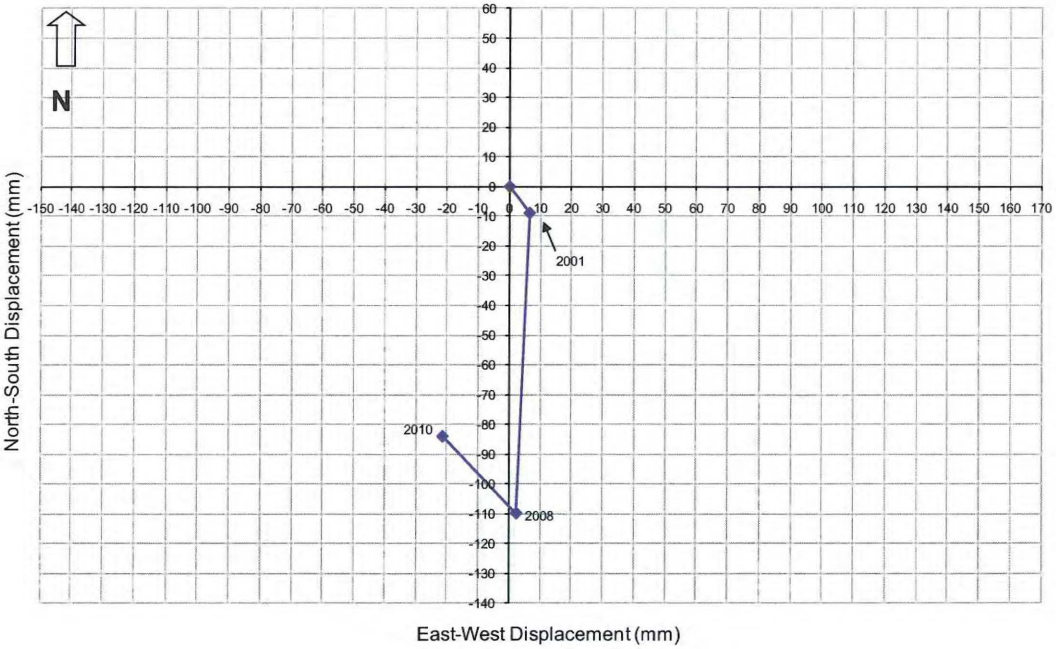

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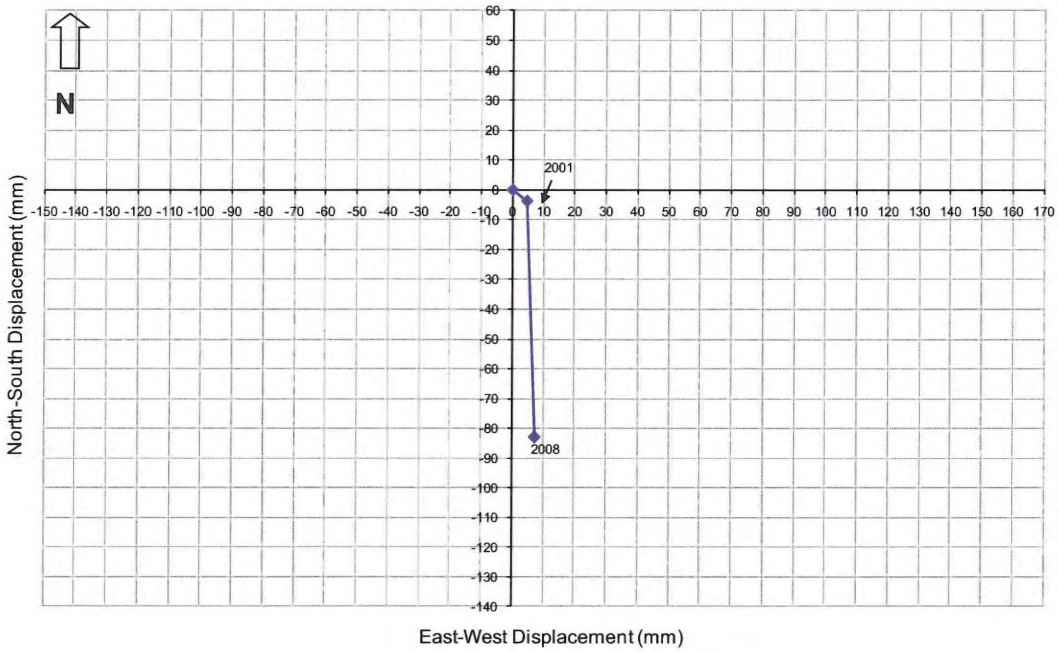

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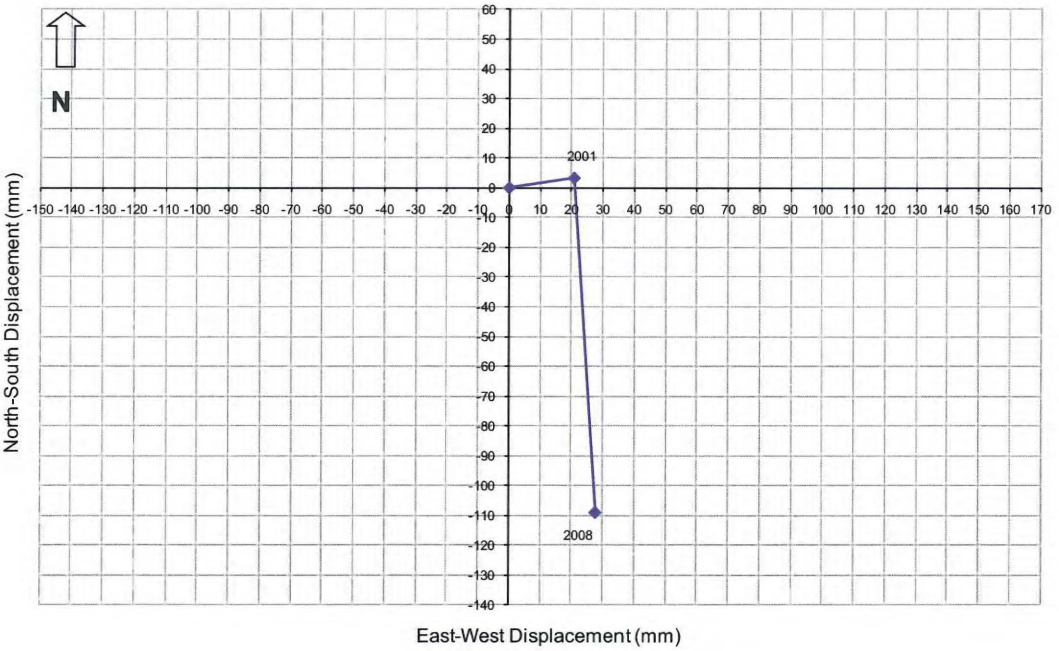

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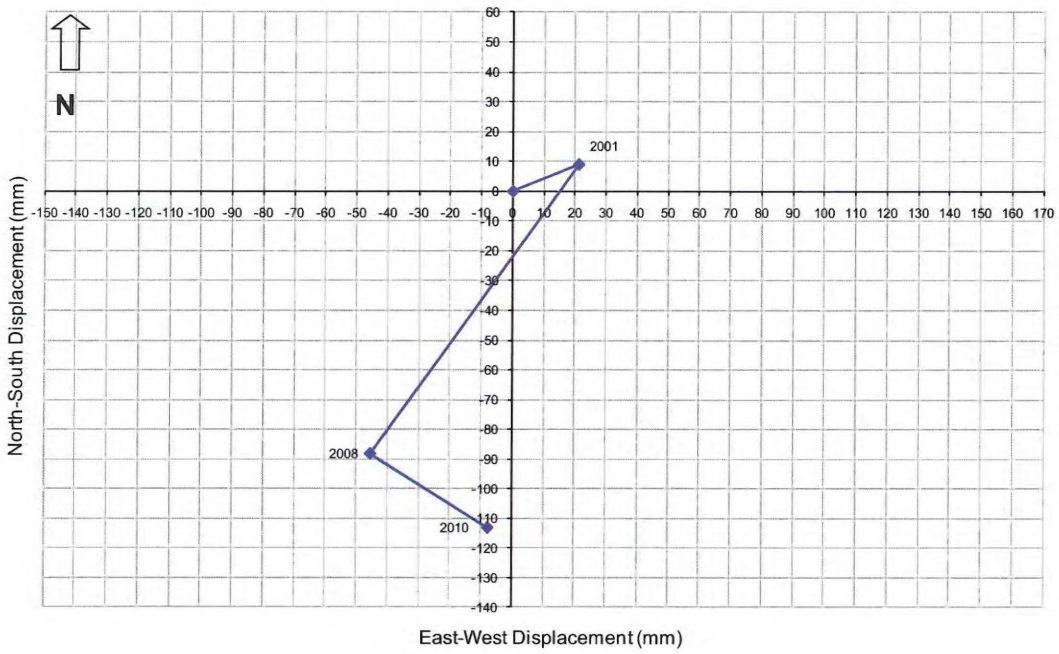

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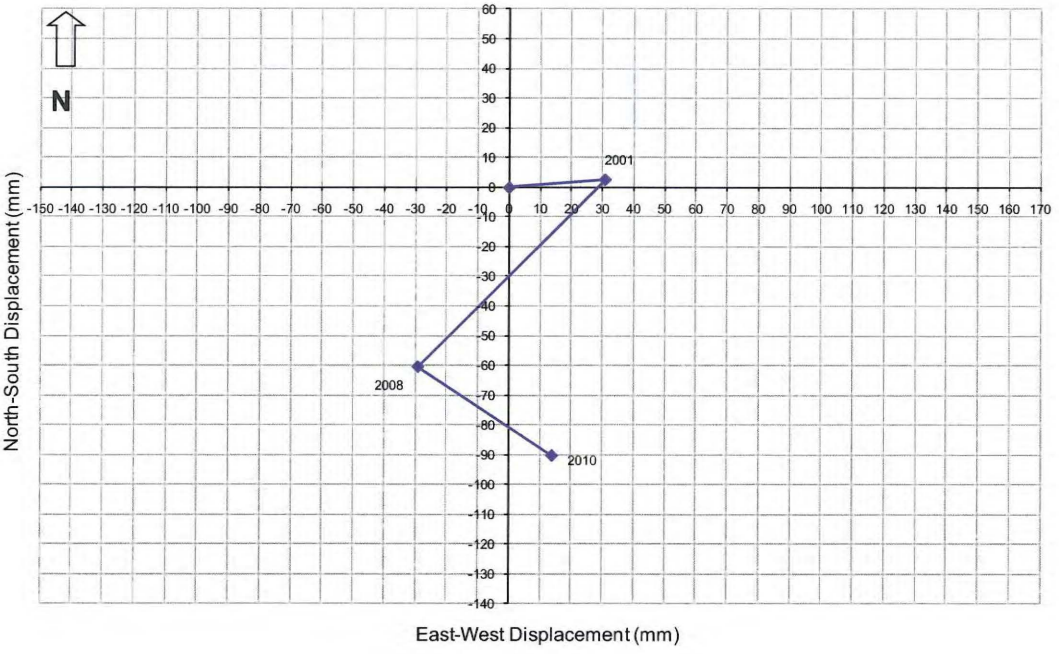

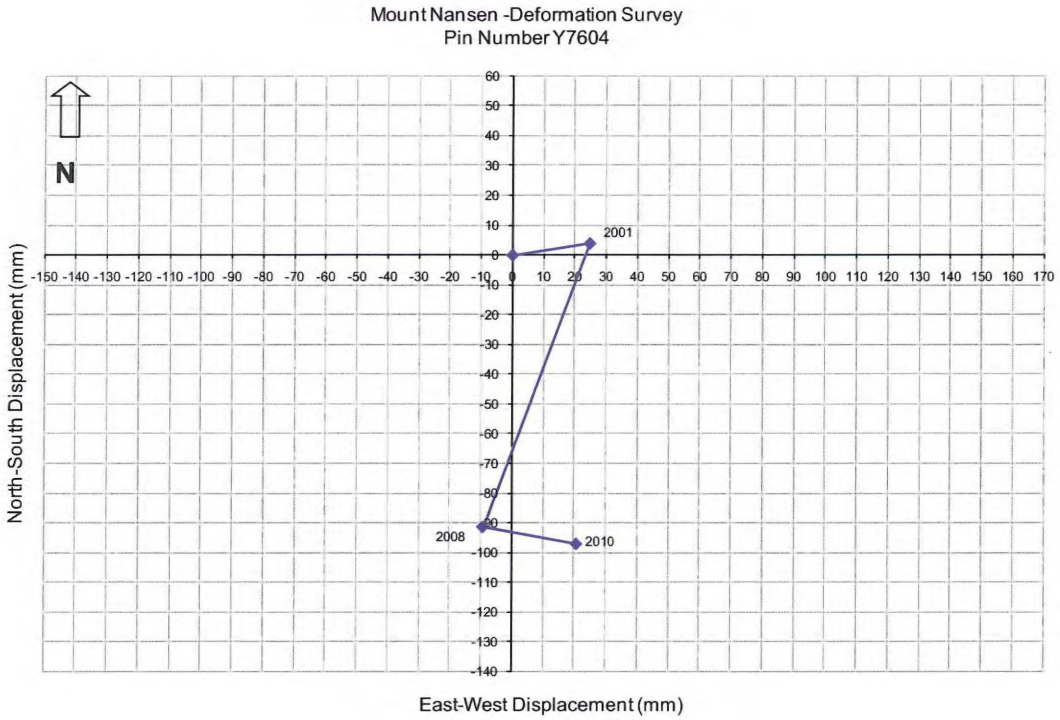
Mount Nansen -Deformation Survey
Pin Number Y7604
N
2001
2008
2010
North-South Displacement (mm)
East-West Displacement (mm)

Appendix B-2

Geotechnical Summary Table

SUMMARY OF GEOTECHNICAL CONSIDERATIONS FOR MINE CLOSURE ALTERNATIVES

ALTERNATIVE	DESCRIPTION	GEOTECHNICAL ASPECTS	GEOTECHNICAL - Key Advantages	GEOTECHNICAL - Key Disadvantages	GEOTECHNICAL - Uncertainty
Option 1 – Tailings Dam Upgrade with Water Cover, Waste Rock in Place	1) Tailings and existing tailings dam will remain in place.	1) Dam upgrading to satisfy the required factors of safety (CDA 2007) for static, pseudo-static and post earthquake conditions.	1) Existing facility is performing satisfactorily from a geotechnical perspective under current conditions (low pond level).	1) Tailings dam subject to ongoing monitoring, maintenance and dam safety reviews, as outlined in the CDA guidelines.	1) Impacts of climate change on performance: Increasing mean annual temperatures will accelerate permafrost degredation, and reduce the effectiveness of thermosyphons and insulation.
	2) Tailings dam will be upgraded with stabilizing toe berm and shear key.	2) A toe berm combined with a shear key embedded in frozen foundation is expected to satisfy all stability cases. Permafrost will be aggraded and maintained with thermosyphons.	2) Some waste rock will be used for the construction of the toe berm, and armoring for channels.	2) Thawed foundation soil beneath tailings dam and proposed toe berm is potentially liquefiable.	2) Dam break analysis has not been conducted for the dam: Extent of downstream flooding and tailings run-out or other environmental impacts caused by failure of the dam have not been quantitatively assessed.
	3) Tailings are covered with a 0.3 m thick sand diffusion layer and a 0.7 m thick water cover on top of soil cover. Edge of water to be set back 50 m from dam crest with beach constructed using clean fill material.	3) Thermal analysis will be required in the final design to incorporate features that will maximize permafrost agradation into the toe berm and mitigate potential for long term degradation of permfrost beneath toe berm and dam.	3) Tailings are not relocated.	3) Stabilization measures require that a shear key/granular caissons be anchored in permafrost or ground remain frozen: Thermal analyses to confirm design objectives required. The condition of the permafrost must be monitored.	3) Potential for ongoing settlement at the south abutment.
	4) Diversion channel and interceptor ditch are backfilled. Drainage swales are provided to channelize seepage and runoff water over backfilled ditch.	4) Long term monitoring, maintenance and regular dam safety reviews required in accordance with the Canadian Dam Association (CDA) guidelines.		4) Seepage through dam and natural groundwater flow likely contributes to thawing of permafrost.	4) The effetiveness of replacing coarse tailings with fine tailings to reduce seepage and maintaining saturation is dependant on material properties
	5) Primary water diversion is through tailings pond to maintain cover providing water quality acceptable for discharge over spillway.	5) Seepage pond to be breached. Seepage water quality unchanged. Drainage must be provided through toe berm.		5) Spillway is susceptable to erosion, and will require armoring and maintenance.	5) The performance of the cover, especially under extreme conditions.
	6) Spillway will be upgraded to accommodate IDF based on 'high consequence" dam classification.	6) Weighted filter will be constructed to reduce potential for piping.		6) Waste rock piles and pit maintain the status quo. (Refer to Option 2B for an alternative)	
	7) Spillway elevation set to provide 0.7 m of water cover over tailings.	7) Replacement of coarse tailings with fine tailings to be further assessed based on properties, location and extents of the various strata.			
	8) A volume of coarse tailings, currently situated against the upstream face of the dam, will be excavated and replaced with fine tailings to reduce seepage, and decrease the volume of unsaturated tailings.	8) The stability of the waste rock piles will be assessed and improved as required. (Option 1 base case)			
	9) Waste rock piles will remain in current locations.				

ALTERNATIVE	DESCRIPTION	GEOTECHNICAL ASPECTS	GEOTECHNICAL - Key Advantages	GEOTECHNICAL - Key Disadvantages	GEOTECHNICAL - Uncertainty
Option 2 – Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place	1) Tailings and existing tailings dam will remain in place.	1) Dam upgrading to satisfy the required factors of safety (CDA 2007) for static, pseudo-static and post earthquake conditions.	1) Existing facility is performing satisfactorily from a geotechnical perspective under current conditions (low pond level).	1) Tailings dam subject to ongoing monitoring, maintenance and dam safety reviews, as outlined in the CDA guidelines.	1) Impacts of climate change on performance: Increasing mean annual temperatures will accelerate permafrost degredation, and reduce the effectiveness of thermosyphons and insulation.
	2) Tailings dam will be upgraded with stabilizing toe berm and shear key.	2) A toe berm combined with a shear key embedded in frozen foundation is expected to satisfy all stability cases. Permafrost will be aggraded and maintained with thermosyphons.	2) Small volume of pond water retained behind dam: Possibility to adopt "Significant" dam classification due to reduced consequences of failure.	2) Thawed foundation soil beneath tailings dam and proposed toe berm is potentially liquefiable.	2) Dam break analysis has not been conducted for the dam: Extent of downstream flooding and tailings run-out or other environmental impacts caused by failure of the dam have not been quantitatively assessed.
	3) Tailings are covered with a 0.1 m thick soil cover on top of tailings and a 0.15 m thick water cover on top of soil cover. Edge of water to be set back 50 m from dam crest with beach constructed using clean fill material.	3) Thermal analysis will be required in the final design to incorporate features that will maximize permafrost agradation into the toe berm and mitigate potential for long term degradation of permfrost beneath toe berm and dam.	3) Wetland habitat with vegetation can be established on the cover.	3) Stabilization measures require that a shear key/granular caissons be anchored in permafrost or ground remain frozen: Thermal analyses to confirm design objectives required. The condition of the permafrost must be monitored.	3) Potential for ongoing settlement at the south abutment.
	4) Diversion channel and interceptor ditch are backfilled. Drainage swales are provided to channelize seepage and runoff water over backfilled ditch.	4) Long term monitoring, maintenance and regular dam safety reviews required in accordance with the Canadian Dam Association (CDA) guidelines.	4) Some waste rock will be used for the construction of the toe berm, and armoring for channels.	4) Seepage through dam and natural groundwater flow likely contributes to thawing of permafrost.	4) The effetiveness of replacing coarse tailings with fine tailings to reduce seepage and maintaining saturation is dependant on material properties
	5) Primary water diversion is through tailings pond to maintain cover providing water quality acceptable for discharge over spillway.	5) Seepage pond to be breached. Seepage water quality unchanged. Drainage must be provided through toe berm.	5) Tailings are not relocated.	4) Seepage through dam and natural groundwater flow likely contributes to thawing of permafrost.	5) The performance of the cover, especially under extreme conditions.
	6) Spillway will be upgraded to accommodate IDF based on 'high consequence" dam classification.	6) Weighted filter will be constructed to reduce potential for piping.		5) Spillway is susceptable to erosion, and will require armoring and maintenance.	
	7) Spillway elevation set to provide 0.15 m of water cover over tailings during wet periods. Some water will be retained in drainage swales and soil cover during dryer periods.	7) Replacement of coarse tailings with fine tailings to be further assessed based on properties, location and extents of the various strata.		6) Waste rock piles and pit maintain the status quo. (Refer to Option 2B for an alternative)	
	8) A volume of coarse tailings, currently situated against the upstream face of the dam, will be excavated and replaced with fine tailings to reduce seepage, and decrease the volume of unsaturated tailings.	8) The stability of the waste rock piles will be assessed and improved as required. (Option 2 base case)			
	9) Waste rock piles will remain in current locations.				

SUMMARY OF GEOTECHNICAL CONSIDERATIONS FOR MINE CLOSURE ALTERNATIVES

ALTERNATIVE	DESCRIPTION	GEOTECHNICAL ASPECTS	GEOTECHNICAL - Key Advantages	GEOTECHNICAL - Key Disadvantages	GEOTECHNICAL - Uncertainty
ALTERNATIVE 1B and 2B (Waste Rock Backfill into Pit)	1) Same as Option 1A and 2A except: Pit is filled as much as possible with remaining waste rock.	1)Tranport and placement of waste rock 3) Plug Pony Creek Adit. 2) Pit walls can be cut back to a safer slope based on future assessments.	1) Pit will be partially filled, somwhat improving public safety with respect to high pit walls and pond. 2) Waste rock piles are removed, and therefore stability of waste rock slopes is not a concern.	1) Will likely have to treat water in open pit in preparation for waste rock.	1) Quality of infiltrated water reporting to bottom of the pit.

ALTERNATIVE	DESCRIPTION	GEOTECHNICAL ASPECTS	GEOTECHNICAL - Key Advantages	GEOTECHNICAL - Key Disadvantages	GEOTECHNICAL - Uncertainty
Option 3 – Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place	1) Tailings will be moved from current location in the Dome Creek valley and placed in the open pit.	1) Excavate tailings and contaminated soil from TMA, transport and place in open pit: Options for transportation include slurry and pump, convey, or load and haul.	1) Existing tailings dam is removed.	1) Tailings dam will be required in new location and new dam will be subject to long term dam safety reviews, monitoring and maintenance in accordance with CDA Guidelines.	1) The relative quantities of coarse and fine tailings is unknown.
	2) Tailings will be covered with 1m of soil and waste rock cover.	2) Tailings must be blended to create a homogeneous material, with a hydraulic conductivity low enough to maintain tension saturation.	2) Dome Creek valley restored.	2) Spillway will be required and subject to long term inspection and maintenance. Water quality could be an issue.	2) The ability to successfully blend and place the tailings in a way that maintains homogeneity of the tailings is unknown.
	3) Dam will be constructed at south end of pit to contain tailings.	3) Spillway and channel will divert excess water back into Pony Creek (assuming it can meet discharge criteria)	3) Proposed dam (in pit) will be built on a competent foundation that is not susceptible to liquifaction or thaw degradation.	3) Potential release of contaminants during transportation of tailings.	3) Proposed tailings dam has not been designed. Seepage control measures at foundation, abutments and perimeter of tailings unknown.
	4) Spillway will be required to maintain water level at approximately top of soil cover and prevent overtopping of dam.	4) Design and construct tailings dam: Structure will be 8 - 10 m high and 40 m wide and will be situated on the ramp at the S end of the pit.	5) Pit will be partially filled, somewhat improving public safety with respect to high pit walls. Pond will create public safety concern.	4) Differential consolidation settlement over extended (20 years plus) time period expected. Cover and/or spillway will likely require periodic maintenance over this period to maintain design water cover depth.	4) Consolidation settlement difficult to acccurately predict: both magnitude and rate.
	5) Waste rock piles will remain in current locations.	5) Evaluate and construct seepage control measures as required.	6) Spillway can likely be constructed in bedrock.	5) Wetted perimeter may require sealing to reduce seepage losses.	5) Regulatory approval may be required to spill water into Pony Creek.
	6) Pony Creek adit will be plugged.	6) Design and conduct Valley restoration: Breach tailings dam. Dispose of dam material, re-contour and re-vegetate. Re-establish creek channel.		6) No opportunity to install pump well into reservoir below tailings should water recovery/treatment be required.	6) Remediation of existing TMA: Extent of contamination of in situ soils is uncertain. Volume of soil requiring in-pit disposal and fill quantities for restoration of area uncertain.
	7) Existing tailings dam to be breached, removed and Dome Creek valley will be restored.	7) Plug Pony Creek adit.			

SUMMARY OF GEOTECHNICAL CONSIDERATIONS FOR MINE CLOSURE ALTERNATIVES

ALTERNATIVE	DESCRIPTION	GEOTECHNICAL ASPECTS	GEOTECHNICAL - Key Advantages	GEOTECHNICAL - Key Disadvantages	GEOTECHNICAL - Uncertainty
Option 4 – Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover	1) Tailings are relocated to pit and stored in a relatively dry condition above a waste rock reservoir. Waste rock will be placed at bottom of pit to an elevation of 1990 m.Tailings are kept above pit water table.	1) Excavate tailings and contaminated soil from TMA, transport and place in open pit: Options for transportation include slurry and pump, convey, or load and haul.	1) Existing tailings dam is removed.	1) Waste rock plug may be considered a "dam" and therefore subject to long term dam safety reviews and maintenance in accordance with CDA Guidelines.	1) Proposed waste rock reservoir and plug have not been designed. Seepage control measures at foundation, abutments and perimeter of waste rock plug unknown.
	2) Waste rock plug at the south end of the pit will provide containment.	2) Design and construct waste rock plug: Structure will be up to 15 m high and 40 m wide and will be situated on the ramp at the S end of the pit.	2) Dome Creek valley restored.	2) Potential release of contaminants during transportation of tailings.	2) Consolidation settlement difficult to acccurately predict: both magnitude and rate.
	3) Tailings and waste rock will be covered with as much waste rock as possible to completely infill open pit.	3) Evaluate and construct seepage control measures as required.	3) Proposed waste rock plug will be built on a competent foundation that is not susceptible to liquifaction or thaw degradation.	3) An effective cover is critical for preventing the infiltration of surface water.	3) Remediation of existing TMA: Extent of contamination of in situ soils is uncertain. Volume of soil requiring in-pit disposal and fill quantities for restoration of area uncertain.
	4) Surface water infiltration will be controlled by a vegetated store-release-divert cover.	4) Design and conduct Valley restoration: Breach tailings dam. Dispose of dam material, re-contour and re-vegetate. Re-establish creek channel.	4) Pit will be completely filled, eliminating public safety concerns with respect to high pit walls and pond.		4) The long term performance of the cover, especially under extreme conditions is unknown.
	5) Surface will be graded to divert runoff away from tailings area.	5) Plug Pony Creek adit.	5) No water diversion required.		
	6) Existing tailings dam to be breached, removed and Dome Creek valley will be restored.		6) Vegetation can be established on soil cover.		
			7) Waste rock piles are removed, and therefore stability of waste rock slopes is not a concern.		
			8) Water at bottom of waste rock reservoir can be pfumped and treated if neceessary.		
			9) Slower release of contaminated porewater to waste rock reservoir may be an advantage if dilution is relied upon.		

Appendix C
Additional Reports

Appendix C-1

Seepage Analysis for Existing Dam

NAVIQ

Naviq Consulting Inc.
Specialist Geotechnical and Permafrost Engineering

GEOTHERMAL STUDY TO ASSESS FEASIBILITY OF THERMOSYPHONS TO MAINTAIN PERMAFROST CONDITIONS – MOUNT NANSEN MINE, YUKON

Prepared for:

AECOM Canada Limited
(AECOM Project Number 60159089)
Winnipeg, MB

Prepared by:

Naviq Consulting Inc.
Calgary AB

Naviq Project No. J012C
October 2010
Revision 0

Important Notice

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EXECUTIVE SUMMARY

This report presents the initial geothermal modeling results that examine the feasibility of using thermosyphons to develop frozen ground and maintaining that ground in a frozen state. Several model geometries and thermosyphon spacings were considered. The model geometry included a closed geometry where an unfrozen soil mass to about 7 m depth was present; the open geometry considered the presence of an open talik to great depth. Thermosyphon spacing from 2 m to 6 m were considered. For all cases climate warming was applied. In most cases the thermosyphons were operated for 25 years and then assumed to be come inoperative. Additional scenarios considered the presence of a surface organic layer as insulation and the long-term effect of climate warming on thermosyphon effectiveness.

The results suggest that thermosyphons at a close spacing may be successful in developing a frozen soil mass and that this soil mass may remain frozen for many years after the thermosyphons become inoperative. Using the thickness of the surface active layer that develops over time as an indication of the success of the thermosyphon system Table E1 shows the depth of the active layer over time for four geothermal scenarios.

Table E1. Comparison of thickness of active layer for open and closed geometries.

Year	Thickness of active layer (m)			
	2 m spacing, closed geometry	4 m spacing, closed geometry	2 m spacing, open geometry	2 m spacing closed geometry with surface organic layer
25	2.0	2.2	2.2	1.5
30	3.8	4.0	4.9	2.3
35	5.5	5.6	7.0	3.2
40	6.8	7.1	9.5	4.5
45	8.0	8.2	>15	5.8

Given that the initial closed geometry considered a surface unfrozen layer to about 7 m, Table E1 shows that the active layer depth reaches about 7 m between Year 35 and Year 40, that is, 10 to 15 years after thermosyphons cease to operate, depending on the thermal model geometry. The application of a surface insulation layer delays the development of a 7 m thick active layer to at least 45 years, that is, 20 years after the thermosyphons cease to operate

Limitations to the study and recommendations for additional studies are discussed.

TABLE OF CONTENTS

EXECUTIVE SUMMARY ii
1.0 INTRODUCTION 4
2.0 BACKGROUND 4
3.0 GEOTHERMAL MODELING GEOMETRIES AND SCENARIOS 4
4.0 GEOTHERMAL MODEL INPUTS 6
5.0 GEOTHERMAL MODELING RESULTS 6
5.1 Closed Geometry 6
5.1.1 2 m Thermosyphon Spacing 6
5.1.2 4 m Thermosyphon Spacing 7
5.2 Open Geometry 7
5.2.1 2 m Thermosyphon Spacing 7
5.2.2 4 m Thermosyphon Spacing 8
5.2.3 6 m Thermosyphon Spacing 8
5.3 Effect of Surface Organic Soil Layer as Insulation - 2 m Thermosyphon Spacing 8
5.4 Effect of Climate Warming on Thermosyphon Operation 9
6.0 DISCUSSION 9
7.0 CLOSURE 10

TABLE OF TABLES

Table 5.1 Summary of geothermal analysis conducted and associated report figures 6
Table 5.2 Comparison of surface thaw layer thickness for cases without and with surface organic (insulation) layer 9
Table 6.1 Comparison of thickness of surface thaw layer for open and closed geometries 10

1.0 INTRODUCTION

This report presents the results of a geothermal assessment of the technical feasibility of using thermosyphons to induce permafrost and maintain frozen conditions in the subgrade at a site in northwest Yukon.

AECOM Canada Ltd (AECOM) retained Naviq Consulting Inc. (Naviq) to provide permafrost engineering input to the Mount Nansen mine closure. This work is conducted under the existing service agreement between AECOM and Naviq, dated June 24, 2010.

2.0 BACKGROUND

As part of the engineering work to develop a long-term closure plan for the Mount Nansen mine in Yukon Territory, AECOM conducted geotechnical drilling and instrumentation at various locations around the tailings containment structure (TCS). In the course of these investigations and data review it was found that an unfrozen zone of soil exists near the toe of the TCS at a shallow depth. The geotechnical assessment of this unfrozen zone was that it was potentially very loose in density and could be liquefiable in the event of ground shaking, such as may arise from an earthquake.

As part of the closure planning one option to mitigate the liquefiable potential of this soil zone was to use thermosyphons to freeze this zone and maintain it in a frozen state for the foreseeable future.

Thermosyphons are a closed passive cooling system that extracts heat from the ground and expels the heat to the atmosphere through a combination of evaporation and condensation. The devices have been used in permafrost applications for over 40 years and have been used to maintain or enhance permafrost in many applications including building foundations, waste containment structures, and support systems for pipelines. Thermosyphons will extract heat from the ground so long as the air temperature is colder than the ground temperature and the ground is warmer than the boiling temperature of the thermosyphon heat exchange fluid (typically carbon dioxide).

This memorandum presents the results of geothermal modeling of thermosyphons placed at 2 m, 4 m and 6 m spacing along a line in one of two geometric scenarios. The intent of this geothermal modeling is to assess the geothermal performance of a single row of thermosyphons to freeze and maintain the soil frozen.

3.0 GEOTHERMAL MODELING GEOMETRIES AND SCENARIOS

The geothermal model used for this study is a proprietary three dimensional heat conduction numerical model developed and operated by Northern Engineering and Scientific Limited of Anchorage Alaska. The program incorporates conductive heat transfer with phase change.

Surface conditions are addressed by either application of "N-factors" or directly by application of a surface energy balance. In the absence of full meteorological input data, such as solar radiation, albedo, wind and cloud cover etc, it is often more technically pragmatic to use the N-factor approach, which was applied in this study. The thermosyphons are modelled to extract heat from the ground only when the air temperature is cooler than the ground temperature and at a rate determined by the air temperature and wind conditions. In the summer the thermosyphons are inoperative.

The geothermal modeling was conducted on two different idealized soil block geometries. Figure 1 presents the so-called "closed" geometry, wherein an unfrozen soil zone is surrounded by frozen soils. Figure 2 presents the so-called "open geometry" where the unfrozen soil zone is an open talik with near vertical boundaries to great depth. While both geometries differs from actual site conditions, from a geothermal perspective and considering that this is feasibility screening-level study, the efficiencies gained in using a simplified geometry are greater than the potential drawbacks. The closed geometry is less conservative from a geothermal perspective than the open geometry because the presence of the underlying permafrost layer in the closed geometry will aid in freezing the unfrozen soil zone.

Based on a review of thermistor data provided in the existing geotechnical reports, the ground temperature within the unfrozen soil block is assumed to be +1.0 °C, while the ground temperature in the surrounding soil is assumed to be -0.5 °C. The depth of the existing unfrozen zone in the closed geometry was assumed to be 5 m, although the thermosyphons were modeled as extending to about 9 m depth.

The soils were assumed to be predominantly fine sand, with some silt and some gravel, with a bulk density of 1650 kg/m^3 and a natural water content of 20%. These soil properties were developed based on examination of EBA boreholes 12861-08 and 12861-10.

Three thermosyphon spacings were considered for this study: 2 m, 4 m and 6 m. Each thermosyphon was assumed to have 15.8 m^2 of radiator area.

For two simulations using the closed geometry with thermosyphon spacings of 2 m and 4 m, a layer of organic soil (as insulation) was applied to the ground surface to assess the value of insulation as a mitigation to climate warming.

The geothermal model was developed and initialized by running for a number of years to reach internal thermal equilibrium. The thermal simulations were begun on June 1 of Year 1. The "thermal year" runs from June 1 to May 31. The thermosyphons were then activated together with the applied annual air temperature warming rate. The thermosyphons were kept active for 25 years and then deactivated for an additional 25 years. Ground temperature data for early spring and late summer periods were recorded and stored for each year of the simulation.

4.0 GEOTHERMAL MODEL INPUTS

Climatic data for the Mount Nansen mine site was provided by AECOM. This included mean monthly air temperature and mean monthly snow cover data. The wind conditions at the mine site were assumed to be a constant wind at 10 km/hour. This value was chosen after review of the long-term climate normal data for the Dawson City airport (to the northwest) and the Whitehorse airport (to the southeast) provided by Environment Canada. The long-term trend in temperature data for the mine site is plotted on Figure 3. From this graph, a climate warming rate of 0.08 °C/year was used for all scenarios. This rate is generally consistent with temperature warming trends from other communities in north-western Canada.

5.0 GEOTHERMAL MODELING RESULTS

This section presents the results of the geothermal modeling conducted to assess the technical feasibility of using thermosyphons to develop and maintain permafrost conditions at the Mount Nansen mine site. Table 5.1 provides a summary of the report sections and the analyses conducted and the associated figures.

Table 5.1 Summary of geothermal analysis conducted and associated report figures

Report Section	Geothermal Scenario	Report Figures
5.1.1	Closed geometry, 2 m thermosyphon spacing	5a – 5l
5.1.2	Closed geometry, 4 m thermosyphon spacing	6a – 6l
5.2.1	Open geometry, 2 m thermosyphon spacing	7a – 7l
5.2.2	Open geometry, 4 m thermosyphon spacing	8a – 8i
5.2.3	Open geometry, 6 m thermosyphon spacing	9a – 9i
5.3	Closed geometry, 2 m thermosyphon spacing, with organic soil insulation surface layer	10a – 10l
5.4	Closed geometry, 2 m thermosyphon spacing with continuous operation	11a – 11e

5.1 Closed Geometry

Figure 4 presents the initial thermal conditions and geometry for the case with a unfrozen zone of limited depth. The temperature regime was based on the thermal conditions described above and in Figure 1.

5.1.1 2 m Thermosyphon Spacing

Selected ground temperature data for the model scenario with thermosyphons at 2 m spacing in the closed geometry are shown in Figure 5a through Figure 5l for the period to Year 45. The ground continues to cool for the first 10 years, while the thermosyphons are operating, and remains relatively thermally static for the next 15 years to Year 25. By March, Year 25, the soil column is colder than -4 °C, compared to the initial temperature of +1 °C.

The effects of climate warming are shown on Figure 5e, for September, Year 25. The ground near the surface is warming to temperatures greater than +5°C.

With the thermosyphons disabled at Year 25, the soils begin to warm. By March, Year 30, the soil column has warmed to between -1 °C and 0 °C with a talik (permanently thawed zone within a permafrost zone) present from about 1.75 m to 4 m depth, as shown in Figure 5g. In September, Year 30 the surface thaw layer is approximately 3.5 m deep.

By March, Year 35 (Figure 5i) the talik has expanded from about 1.5 m to about 5.5 m depth. By September, Year 45 Figure 5l) the surface thaw layer progressing towards 8 m depth.

5.1.2 4 m Thermosyphon Spacing

Selected ground temperature data for the model scenario with thermosyphons at 4 m spacing in the closed geometry are shown in Figure 6a through Figure 6l for the period to Year 45. The soil column continues to cool through the first 25 years. At March, Year 15, the soil zone around the thermosyphons is colder than -2 °C. By March, Year 25, the soil zone has cooled to less than -4 °C.

With the thermosyphons disabled at Year 25, the soils begin to warm rapidly. By March, Year 30, the soil column has warmed to between -1 °C and 0 °C with a talik present from about 1.75 m to 4 m depth, as shown in Figure 6g. In September, Year 30, the surface thaw layer is approximately 4 m deep, and the permafrost is only marginally frozen (see Figure 6f).

By March, Year 35, the talik has expanded from about 1.5 m to about 5.8 m depth, and the surface thaw layer has progressed to 5.75 m depth (see Figure 6h). By September, Year 45, the surface thaw layer is greater than 8 m deep (Figure 6l).

5.2 Open Geometry

The geothermal analysis conducted for the "open geometry" did not consider the presence of a permafrost layer beneath the surface thawed zone. That is, the soil was assumed to be unfrozen to depth, being termed a "through talik". This geometry is more conservative than the "closed geometry" cases.

5.2.1 2 m Thermosyphon Spacing

Selected ground temperature data for the model scenario with thermosyphons at 2 m spacing in the closed geometry are shown in Figure 7a through Figure 7l for the period to Year 45. The ground continues to cool for the first 10 years, while the thermosyphons are operating, and remains relatively thermally static for the next 15 years to Year 25. By September Year 25, the permafrost has advanced to about 15 m depth with a seasonal surface thaw layer of about 2.5 m.

By September Year 30, the permafrost is starting to recede at depth, with the base being at 14 m, while the surface thaw layer is about 5 m deep. At September Year 35, the surface thaw layer is approximately 7 m deep, and the frozen zone extends from 7 m depth to about 13.5 m. By September Year 40, only a small zone of frozen soil remains between 9.5 m and 11.5 m depth. By Year 45 the permafrost has been extinguished.

5.2.2 4 m Thermosyphon Spacing

Selected ground temperature data for the model scenario with thermosyphons are shown in Figure 8a through Figure 8i for the period to Year 35. The ground continues to cool for the first 10 years, while the thermosyphons are operating, and remains relatively thermally static for the next 15 years to Year 25. Thereafter, the ground warms in the ten years after the thermosyphon operations are discontinued. By Year 36, 11 years after the start of the dominant period, the ground temperatures have returned to pre-thermosyphon temperatures, and may be actually warmer than initial conditions because of the applied annual climate warming rate.

5.2.3 6 m Thermosyphon Spacing

Selected ground temperature data for the model scenario with thermosyphons are shown in Figure 9a through Figure 9i for the period to Year 35. The ground continues to cool for the entire 25 years while the thermosyphons are operating. Thereafter, the ground warms quite rapidly in the five to six years after the thermosyphon operations are discontinued. By Year 32, only seven years after the start of the dominant period the ground temperatures have returned to the initial ground temperatures and are likely warmer than initial conditions because of the applied annual climate warming rate.

5.3 Effect of Surface Organic Soil Layer as Insulation - 2 m Thermosyphon Spacing

It was hypothesized that a surface layer of organic soil would be effective in reducing the impact of climate warming, which appears to be a principal driver on degrading the permafrost over time. The organic material had the following properties:

- Thickness = 0.3 m
- Dry Unit Weight = 640 kg/m^3
- Water content = 130%

The remaining soil conditions and boundary conditions were unchanged. The closed geometry was used for these scenarios. Results for the thermosyphon spacing of 2 m are presented herein.

Figures 10a through 10l presents the results for this modeling scenario for Year 1 through Year 45. The thermal results are similar to those presented in Figure 5, except that the permafrost persists for a longer period. The development of the surface thaw layer over time shows the effect of the insulation layer. Table 5.2 compares the surface thaw layer thickness for the case without a surface organic layer (Figure 5) and with a surface organic layer (Figure 10).

The ground temperatures in the soil below the surface thaw layer for the case without a surface organic layer and the case with a surface organic layer were similar.

Table 5.2 Comparison of surface thaw layer thickness for cases without and with surface organic (insulation) layer

Year	Thickness of surface thaw layer (m)	
	No surface organic layer	Surface organic layer
25	2.0	1.5
30	3.8	2.3
35	5.5	3.2
40	6.8	4.5
45	8.0	5.8

5.4 Effect of Climate Warming on Thermosyphon Operation

The final scenario considered in this analysis consisted or maintaining the operation of the thermosyphons for past the normal 25 year period with the applied climate warming rate (0.08 °C/year) until the ground temperatures overwhelmed the effectiveness of the thermosyphons.

Figure 11a through Figure 11e presents the results for this scenario. For this geothermal scenario, the thermosyphons were spaced at 4 m within the closed geometry and modeled to 150 years.

The results show that by Year 50 the influence of the thermosyphons is diminishing transversely to the line of the thermosyphons. In Year 100 the soil is entirely warmed to above freezing, except for a small radial zone of about 2 m radius immediately around the thermosyphon. By Year 150, the entire soil mass is above freezing.

6.0 DISCUSSION

These analyses have shown that it is technically feasible to freeze ground that is slightly warmer than freezing using thermosyphons, and to maintain that ground in a frozen condition for at least one decade after the thermosyphons have ceased operation. The value of surface insulation to mitigate the effects of climate warming is clearly demonstrated, with the results listed in Table 5.2.

The applied climate warming trend of 0.08 °C /year has a significantly negative effect on the long term performance of the thermosyphons. As demonstrated in the Figure 11 series, climate warming will eventually overwhelm the benefit of operating thermosyphons.

Table 6.1 compares the thickness of the surface thaw layer for several of the scenarios considered in this study.

Given that the initial closed geometry considered a surface unfrozen layer to about 7 m (see Figure 1), Table 6.1 shows that the active layer depth reaches about 7 m between Year 35 and Year 40, that is 10 to 15 years after thermosyphons cease to operate, depending on the thermal

model geometry. The application of a surface insulation layer delays the development of a 7 m thick active layer to at least 45 years that is, 20 years after the thermosyphons cease to operate.

Table 6.1 Comparison of thickness of surface thaw layer for open and closed geometries

Year	Thickness of surface thaw layer (m)			
	2 m spacing, closed geometry	4 m spacing, closed geometry	2 m spacing, open geometry	2 m spacing closed geometry with surface organic layer
25	2.0	2.2	2.2	1.5
30	3.8	4.0	4.9	2.3
35	5.5	5.6	7.0	3.2
40	6.8	7.1	9.5	4.5
45	8.0	8.2	>15	5.8

One significant issue that impacts the performance of thermosyphons and the ability of the systems to freeze soils is the presence of ground water. The present geothermal modelling did not consider the impact of conductive heat flow on the geothermal performance. If the results of this study are considered sufficiently favourable to warrant additional investigation then the impact of conductive heat flow arising from groundwater seepage through the thawed zone should be considered.

While multiple rows may provide some additional benefit, it is likely that the geothermal effect will be moderate, rather than significant.

7.0 CLOSURE

This report presents the initial geothermal modeling results that examine the feasibility of using thermosyphons to develop frozen ground and maintaining that ground in a frozen state. The results suggest that thermosyphons at a close spacing may be successful in developing a frost soil mass and that this soil mass may remain frozen for many years after the thermosyphons become inoperative. Recommendations for additional studies are discussed.

We trust the analyses presented herein are of value to AECOM in developing viable long-term mine closure plans. If you have any questions regarding the results presented please feel free to contact the undersigned.

Yours truly,
Naviq Consulting Inc.

James M. Oswell, Ph.D., P.Eng. (AB)
Senior Permafrost Engineer

Reviewed by:
Beez Hazen, P.E.
Northern Engineering and Scientific Limited

FIGURES

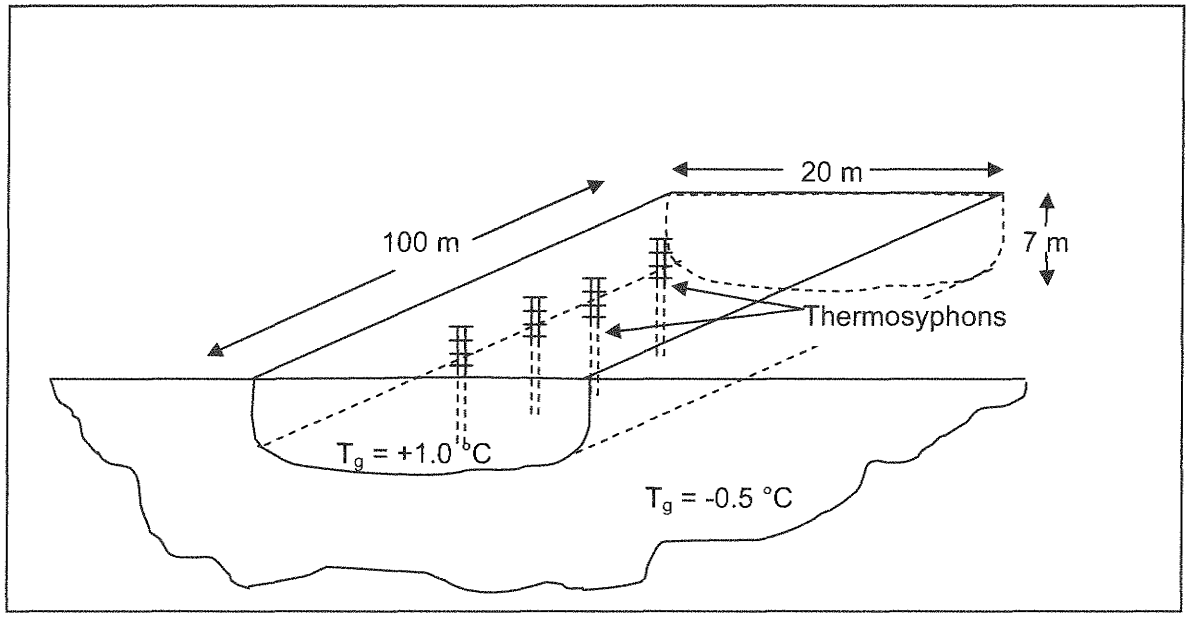


Figure 1. Schematic of the idealized soil geometry for thermosyphon feasibility assessment with closed unfrozen zone, the so-called "closed geometry".

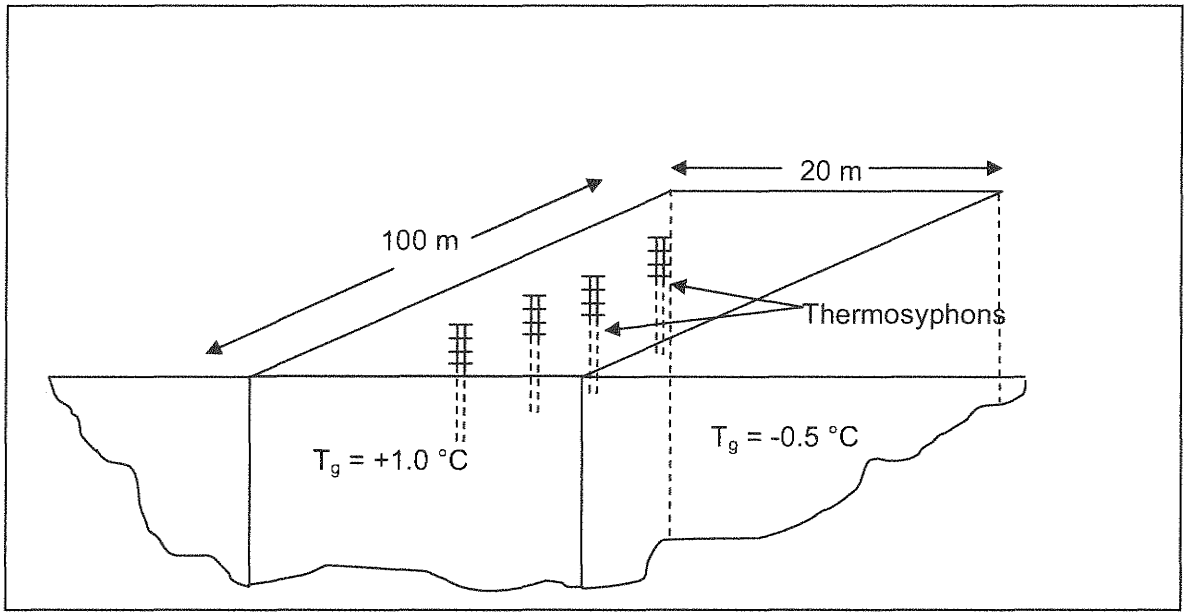


Figure 2. Schematic of the idealized soil geometry for thermosyphon feasibility assessment with open unfrozen zone, the so-called "open geometry".

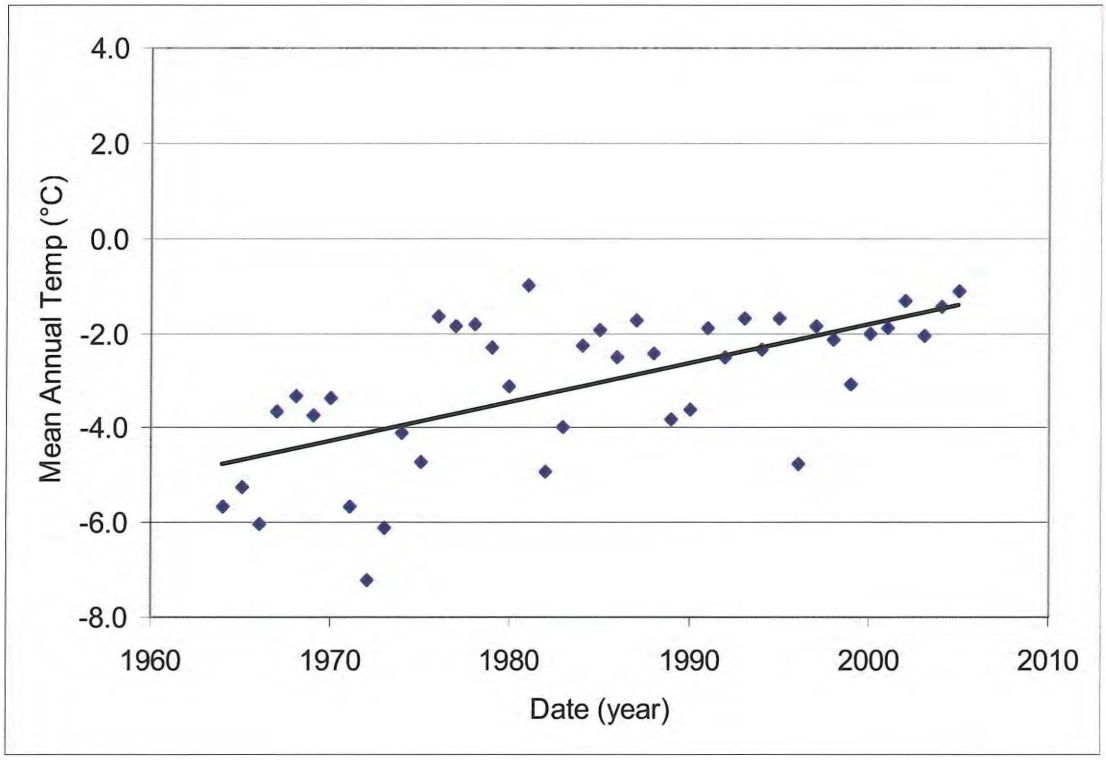


Figure 3. Mean annual air temperature for Mount Nansen mine site. The slope of the solid line represents the historical climate warming rate of the plotted time period. Raw monthly data provided by AECOM.

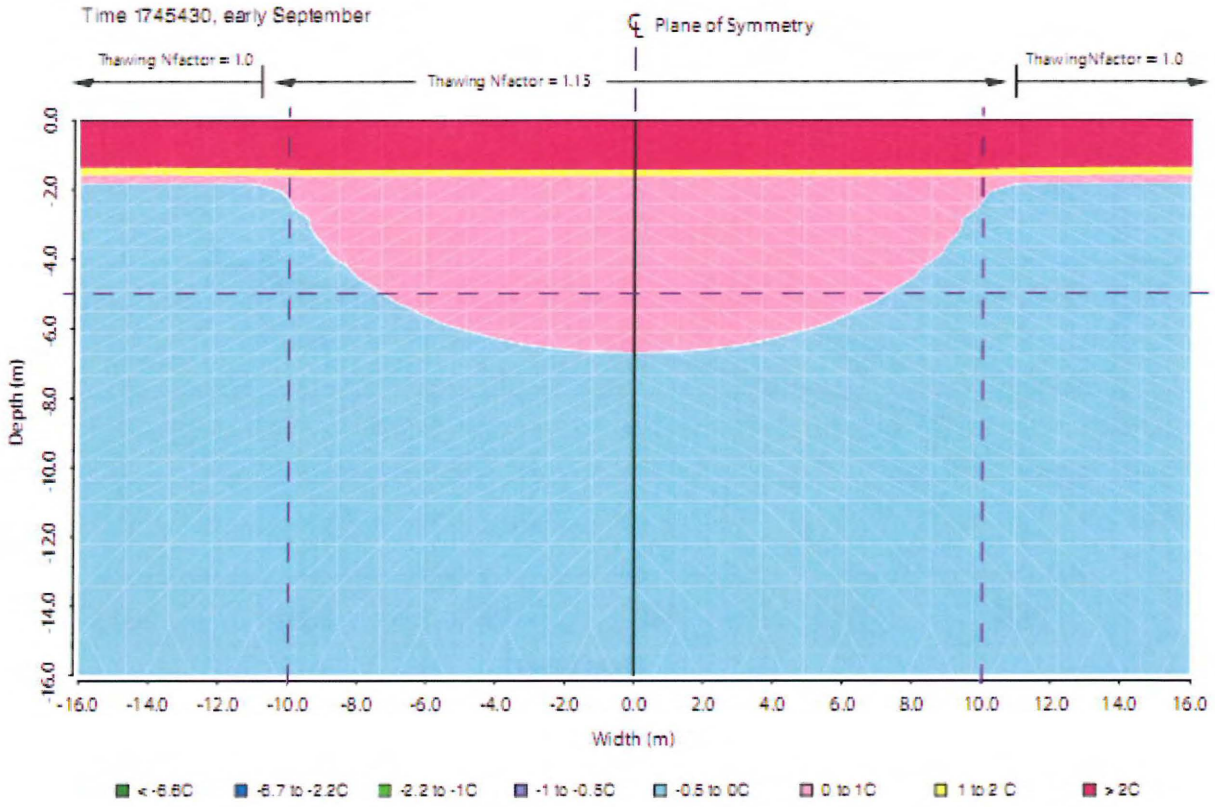
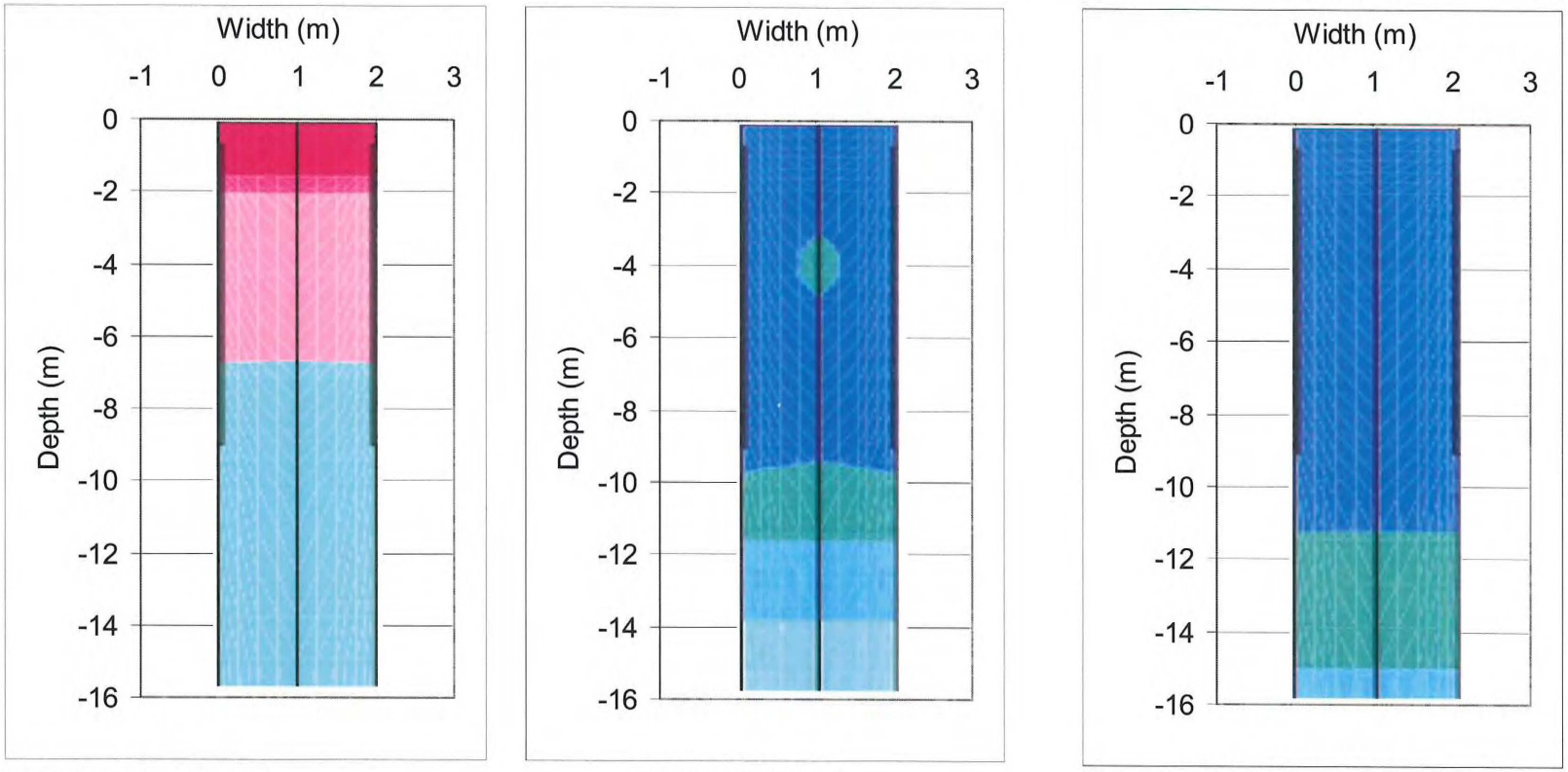


Figure 4. Initial cross section of closed geometry showing temperature regime, in September of Year 1.

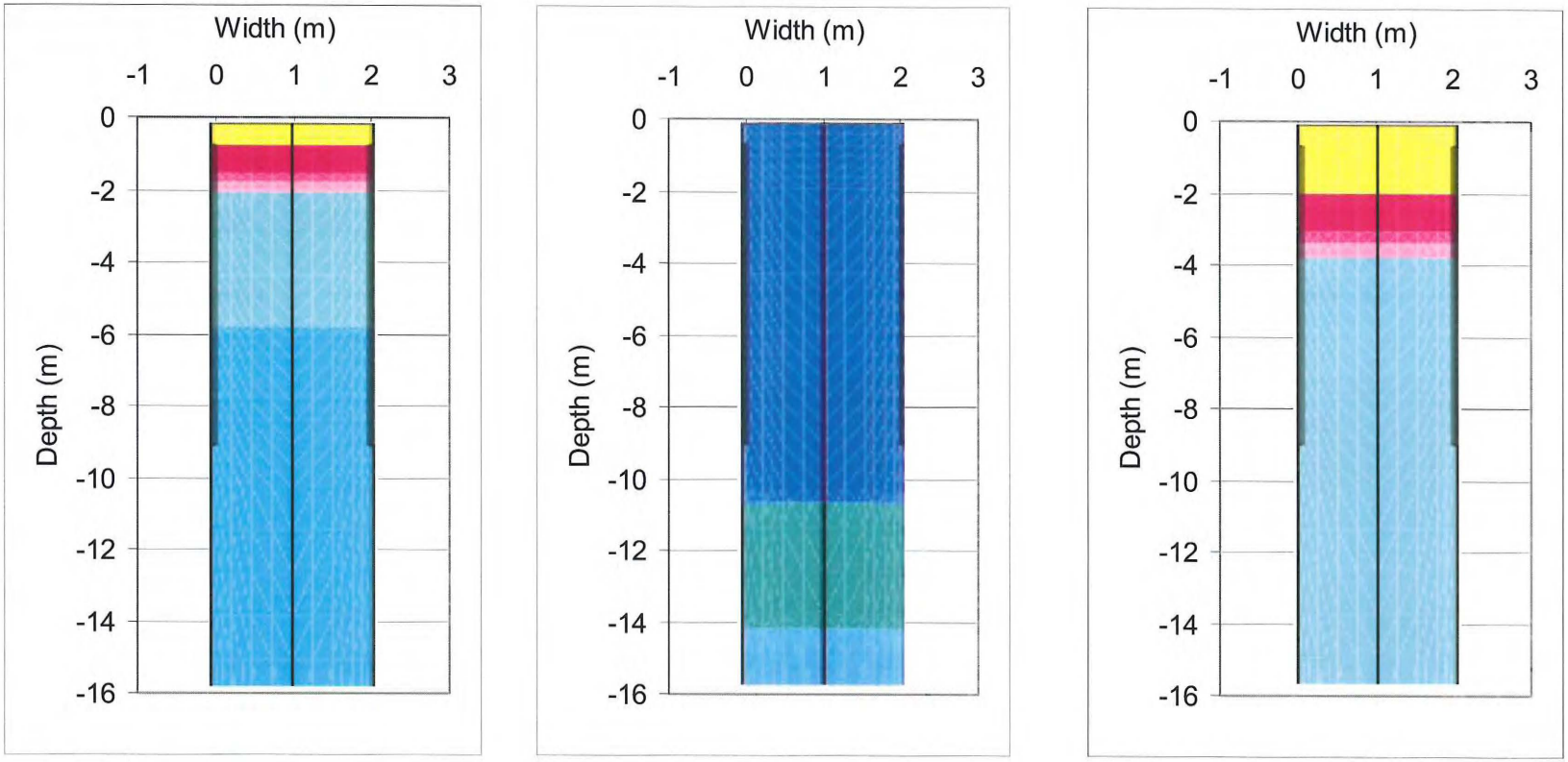


(a) September, Year 1 (b) March, Year 1 (c) March, Year 15

Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C



(d) September, Year 25

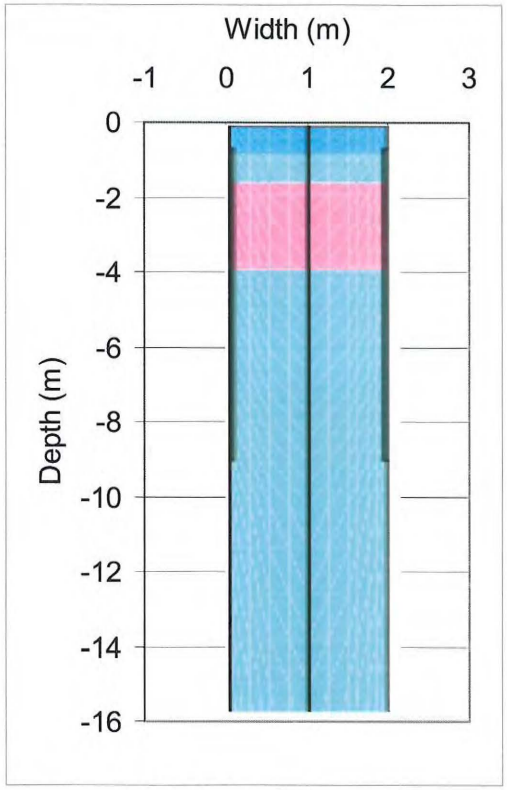
(e) March, Year 25

(f) September, Year 30

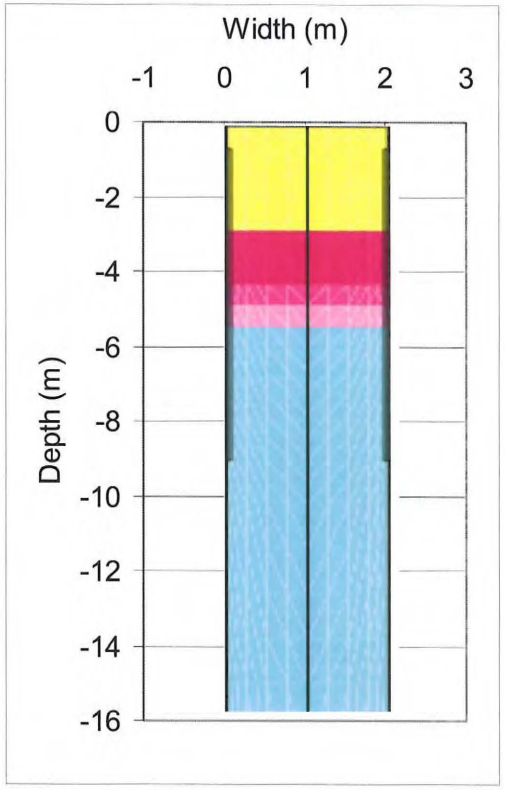
Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

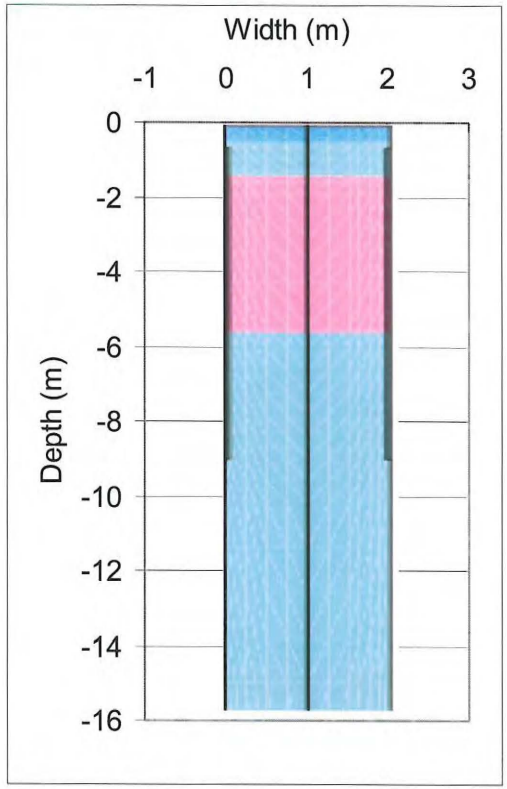
+2 °C to +5 °C > + 5 °C



(g) March, Year 30



(h) September, Year 35

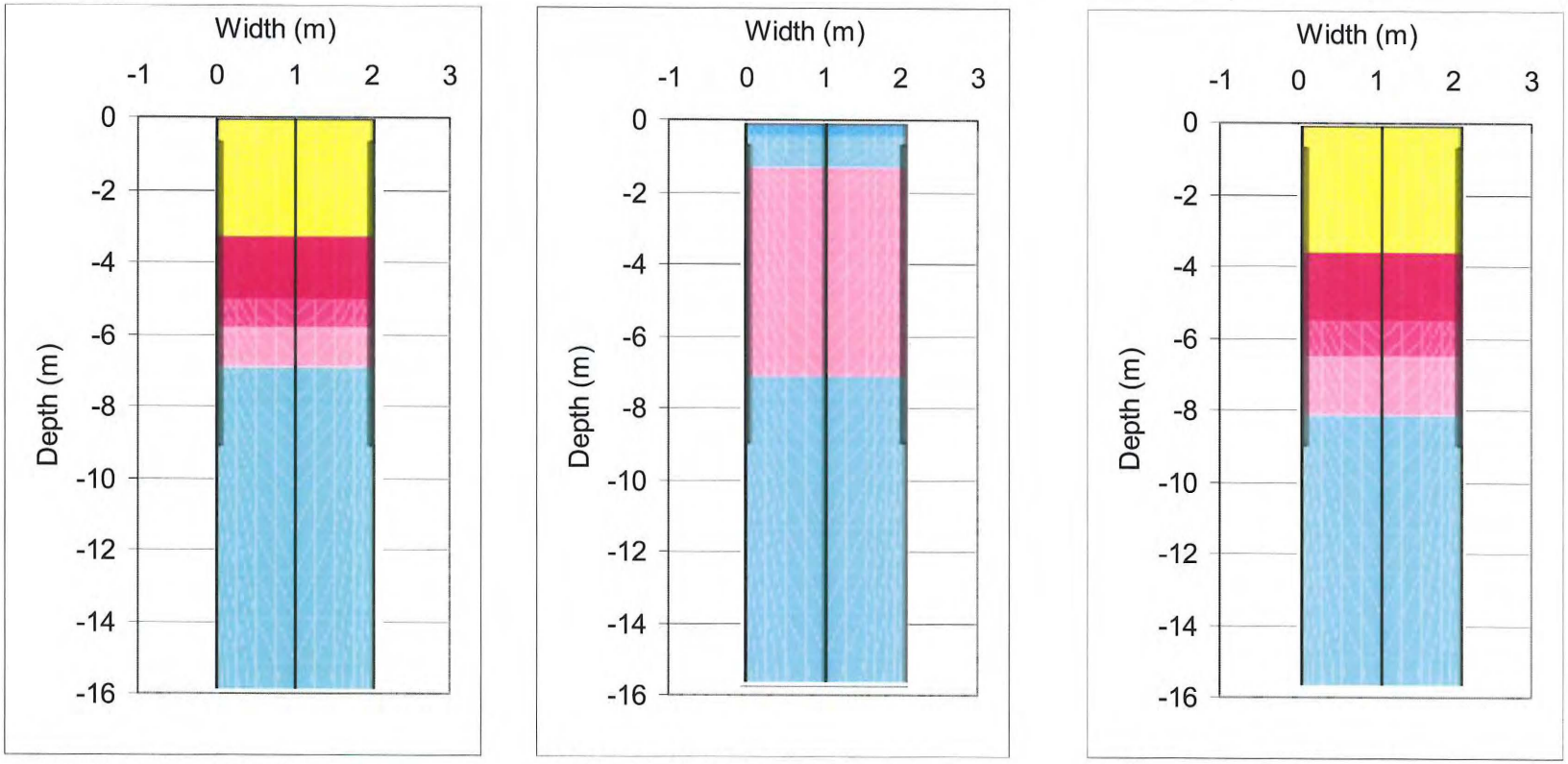


(i) March, Year 35

Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C

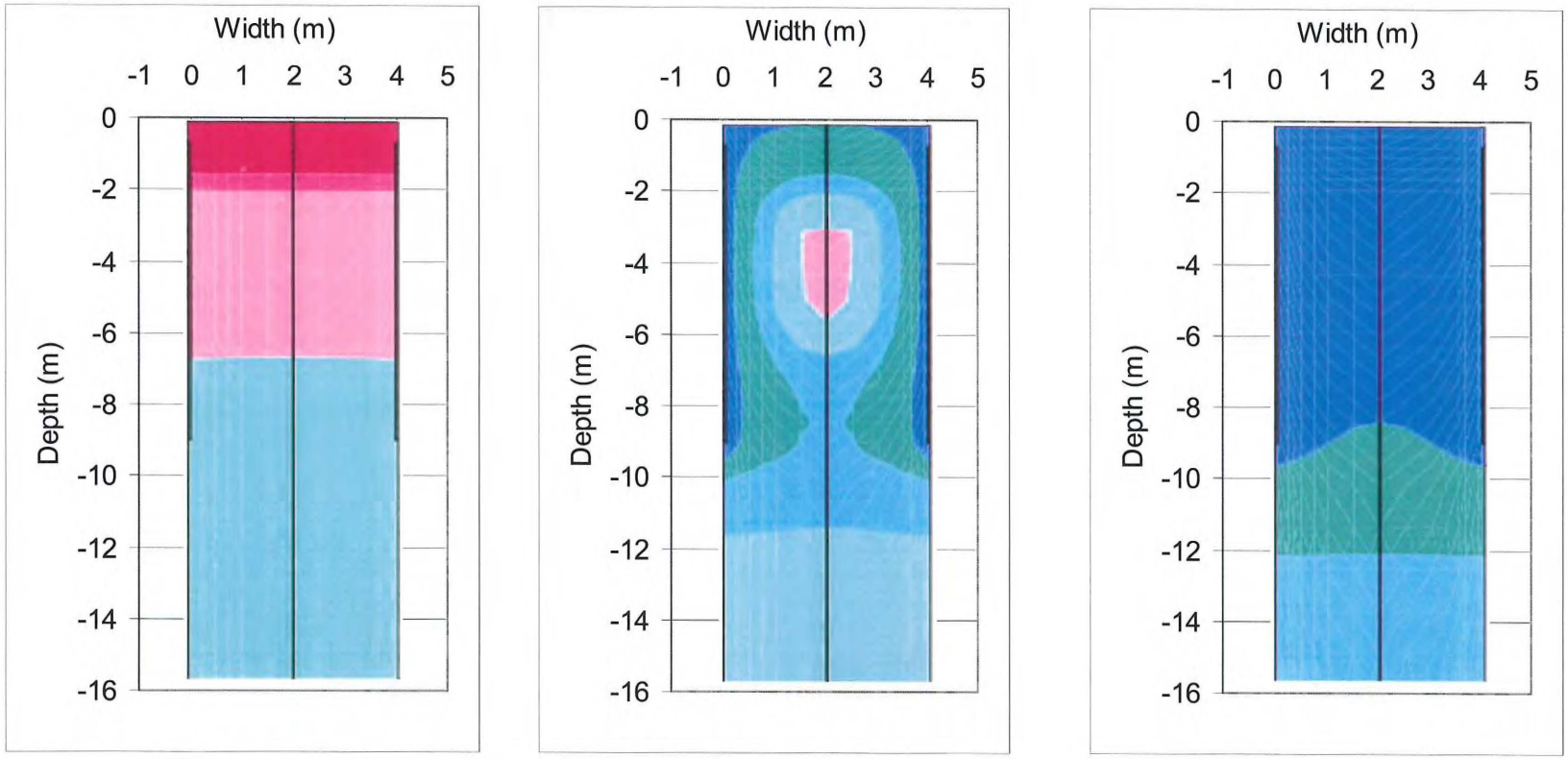


(j) September Year 40 (k) March, Year 40 (l) September, Year 45

Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C

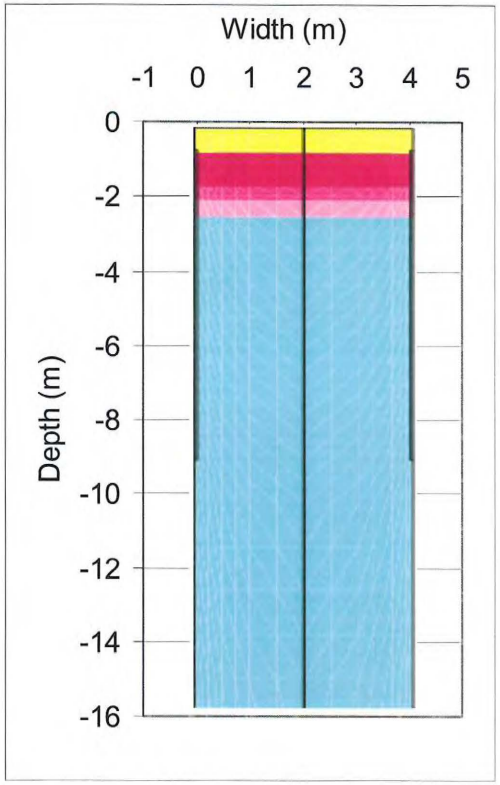


(a) September Year 1 (b) March, Year 1 (c) March, Year 15

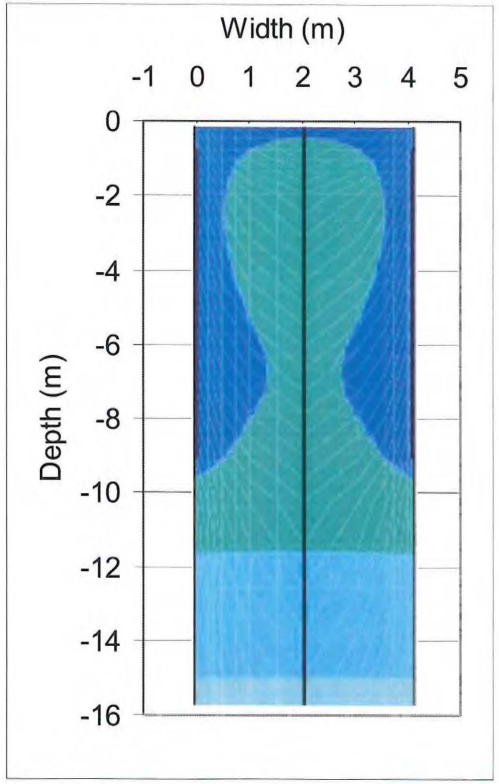
Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

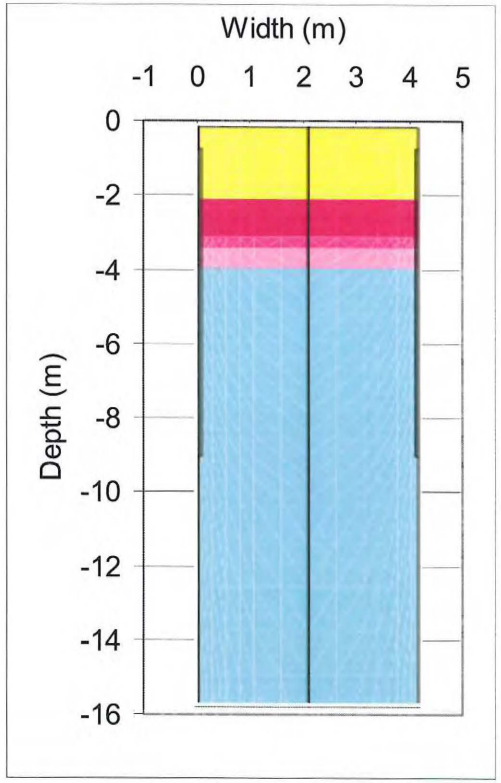
+2 °C to +5 °C > + 5 °C



(d) September, Year 25



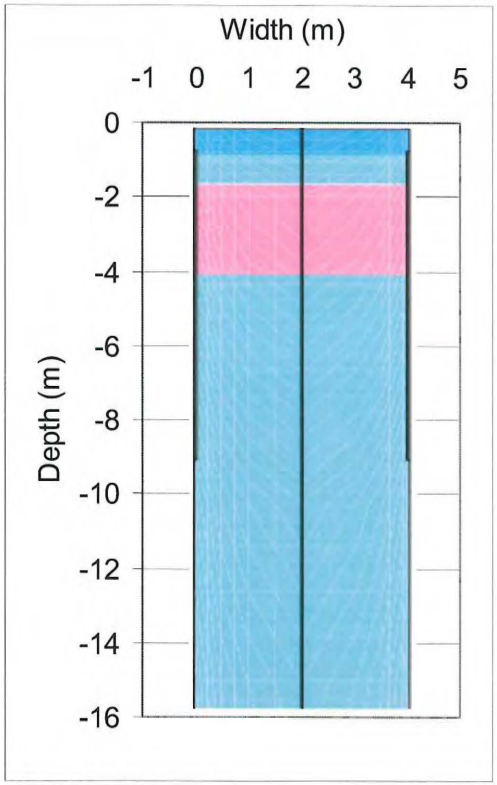
(e) March, Year 25



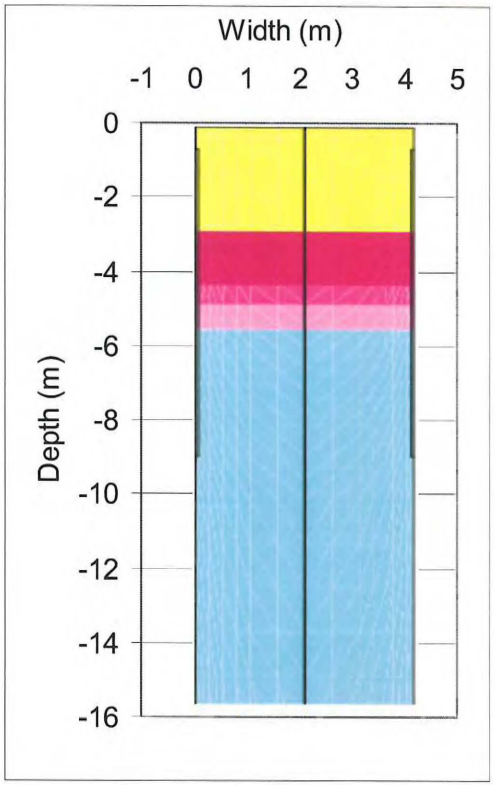
(f) September, Year 30

Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry, continued.

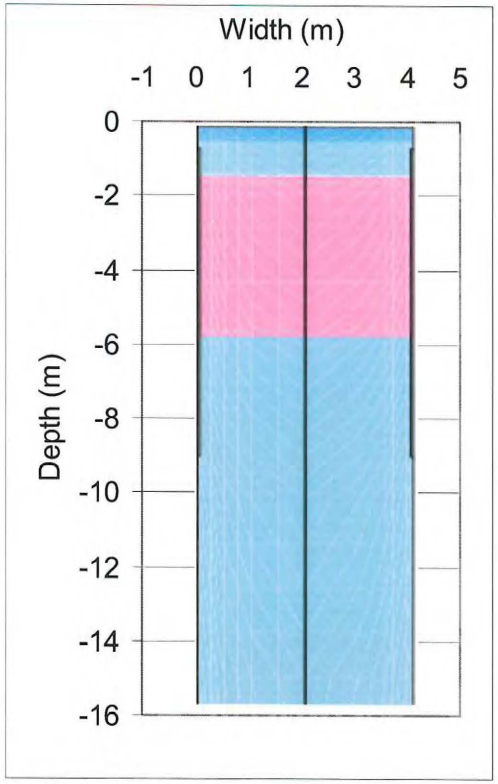
< - 4 °C | - 4 °C to – 2 °C | - 2 °C to -1 °C | - 1 °C to 0 °C | 0 °C to +1 °C | +1 °C to +2 °C | +2 °C to +5 °C | > + 5 °C



(g) March, Year 30



(h) September, Year 35

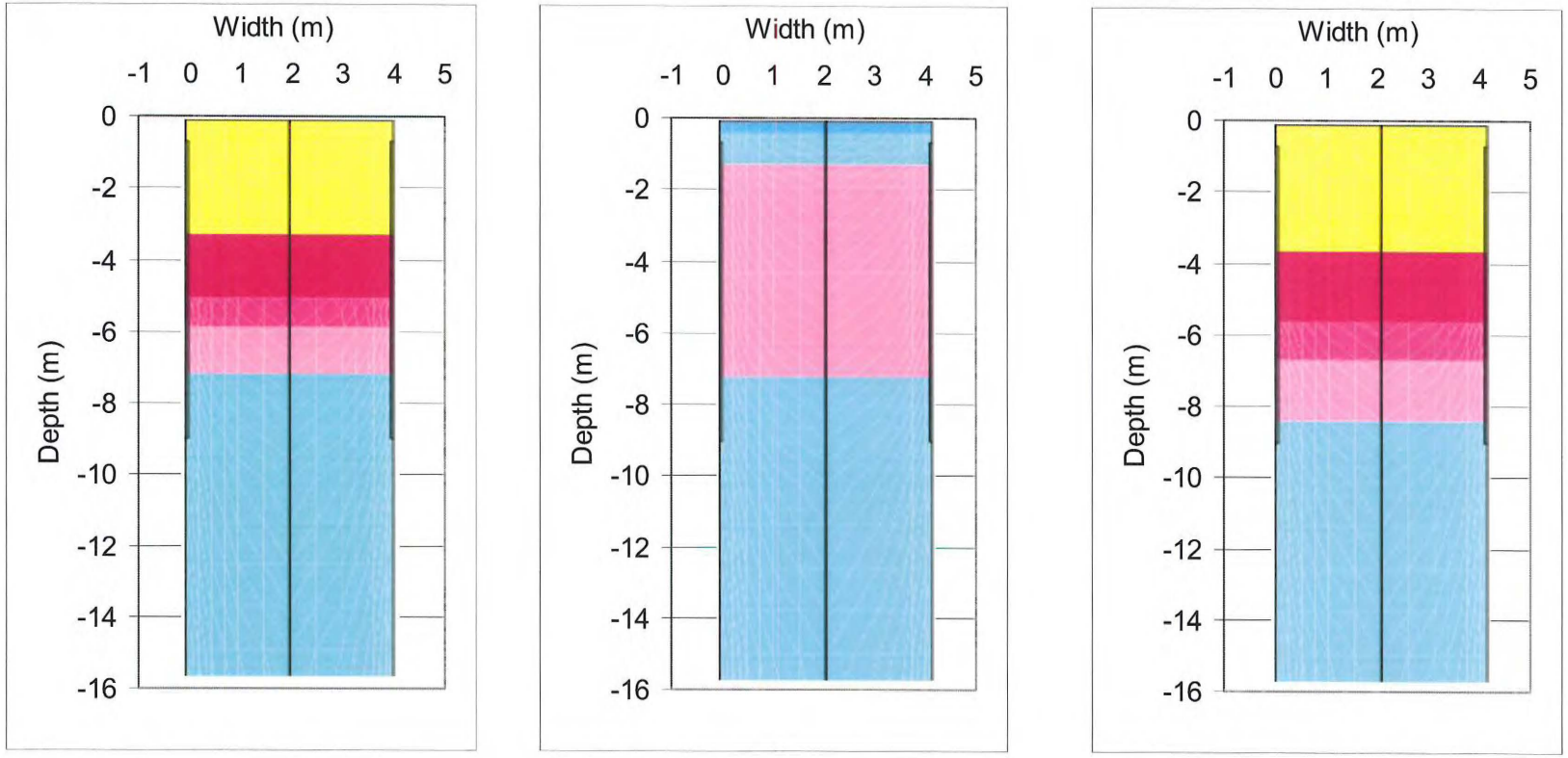


(i) March, Year 35

Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C



(j) September, Year 40

(k) March, Year 40

(l) September, Year 45

Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry, continued.

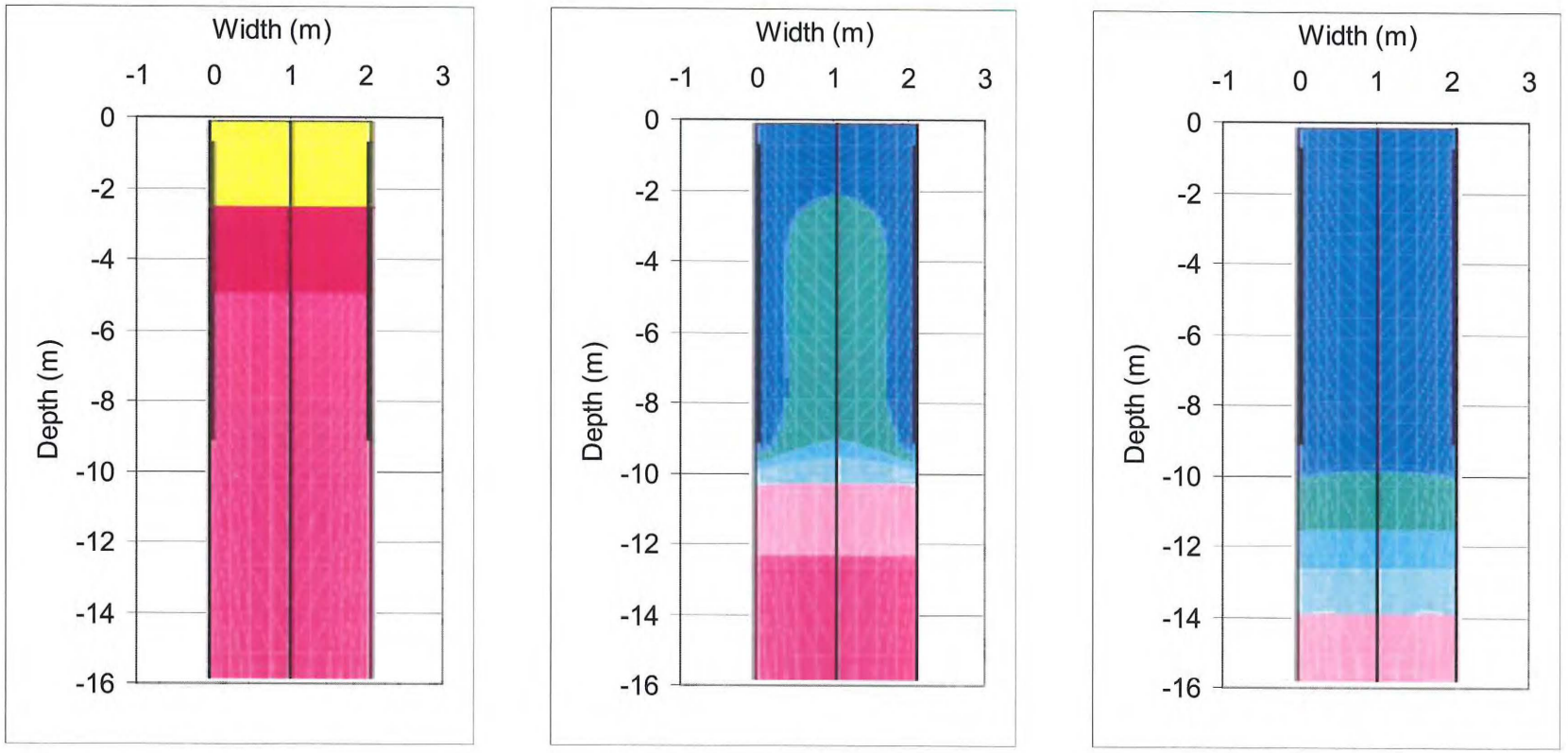
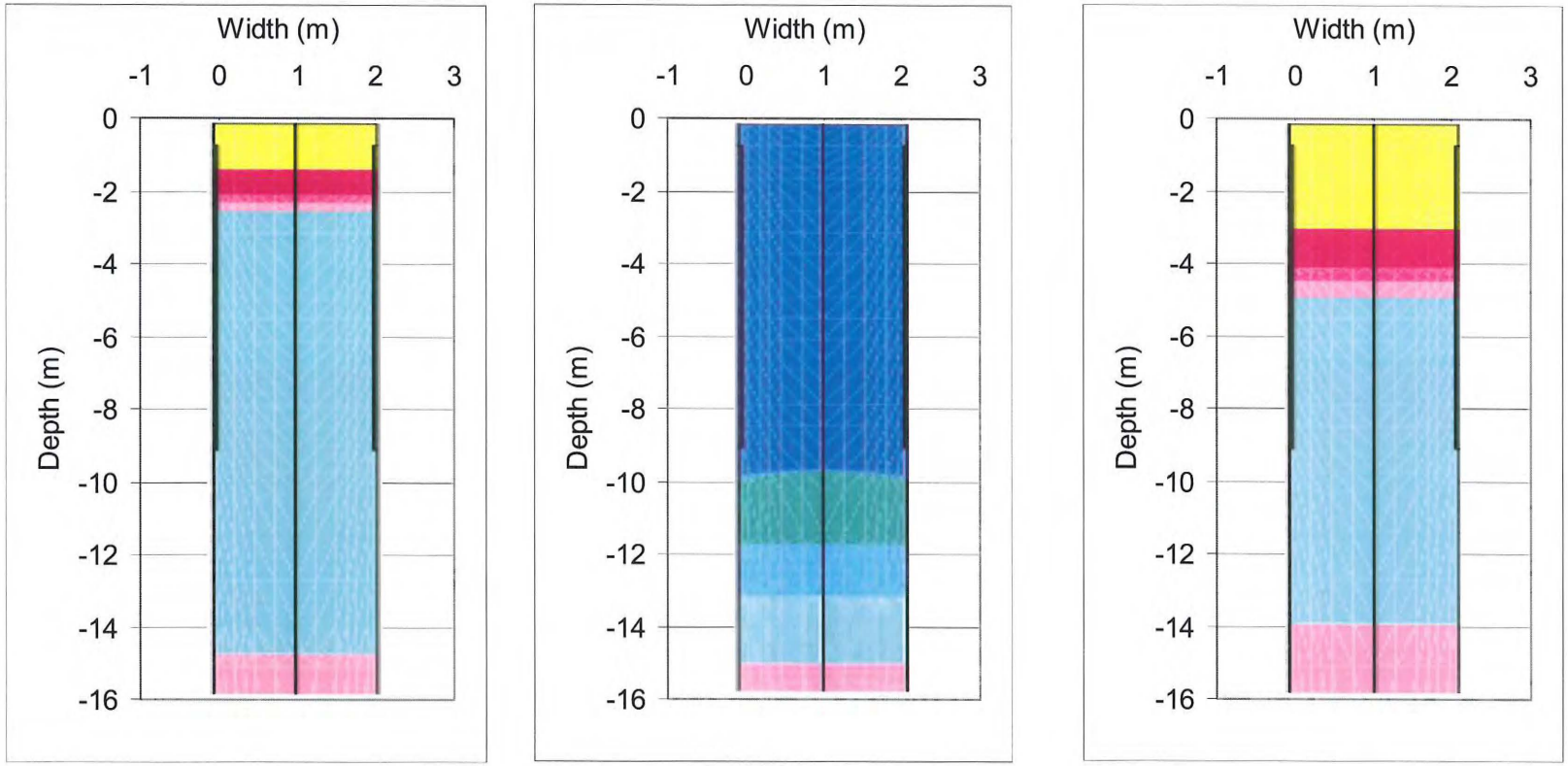


Figure 7. Geothermal results for thermosyphon spacing at 2 m, in open geometry.

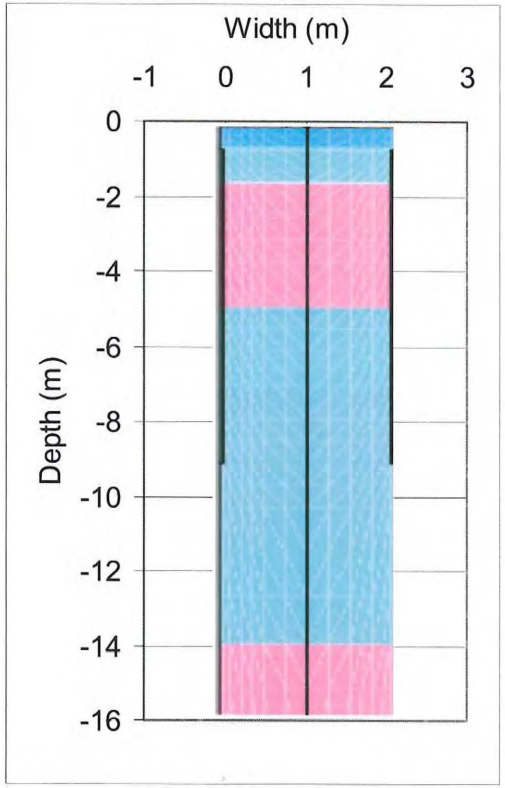


(d) September Year 25 (e) March, Year 25 (f) September, 30

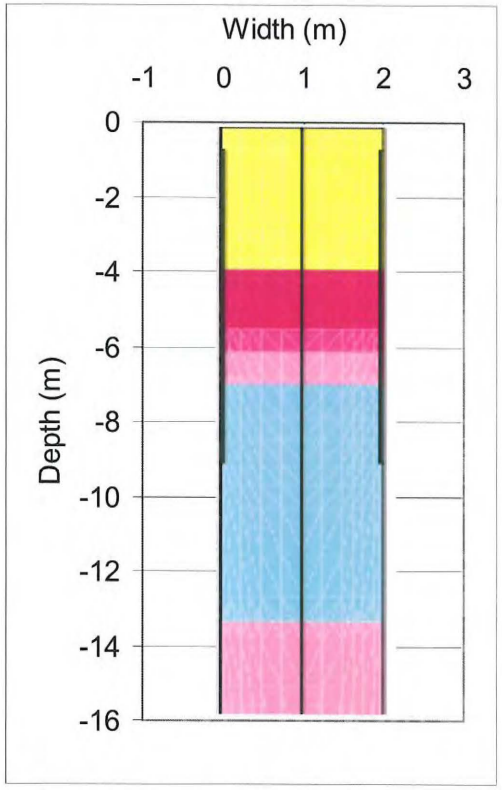
Figure 7. Geothermal results for thermosyphon spacing at 2 m, in open geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

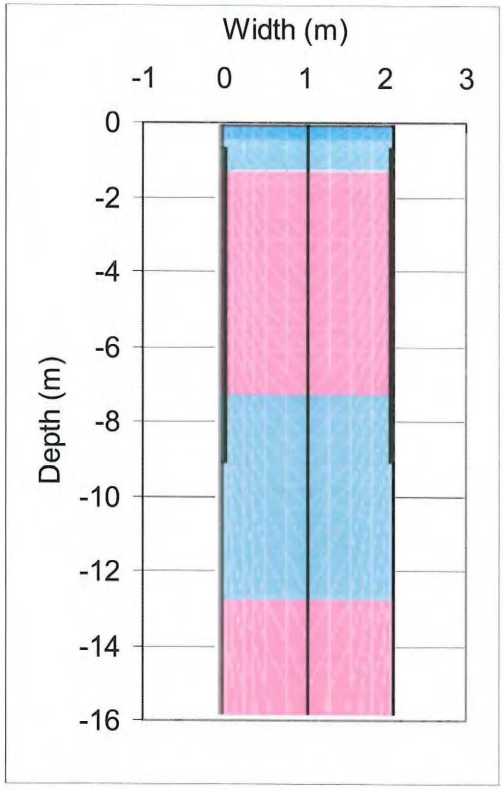
+2 °C to +5 °C > + 5 °C



(g) March, Year 30



(h) September, Year 35

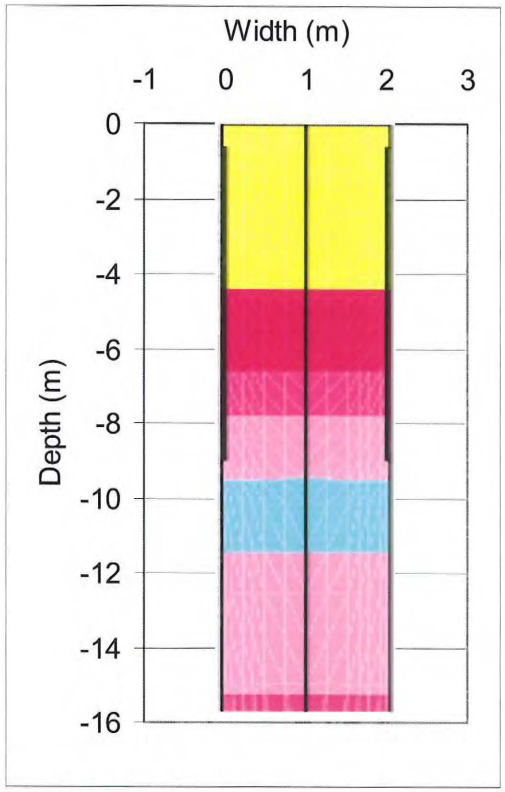


(i) March, Year 35

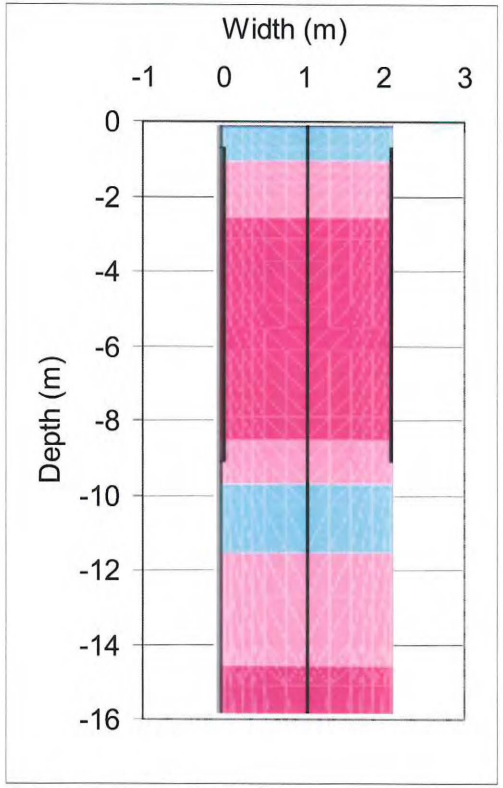
Figure 7. Geothermal results for thermosyphon spacing at 2 m, in open geometry, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

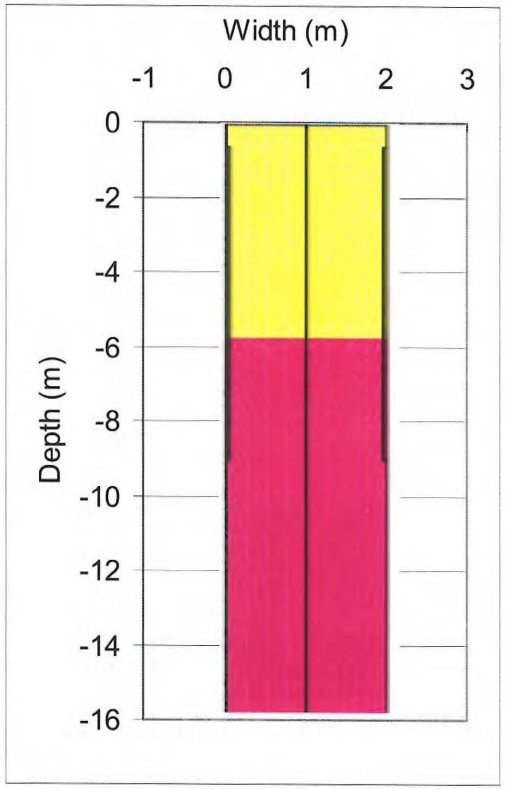
+2 °C to +5 °C > + 5 °C



(j) September Year 40



(k) March, Year 40



(l) September, Year 45

Figure 7. Geothermal results for thermosyphon spacing at 2 m, in open geometry, continued.

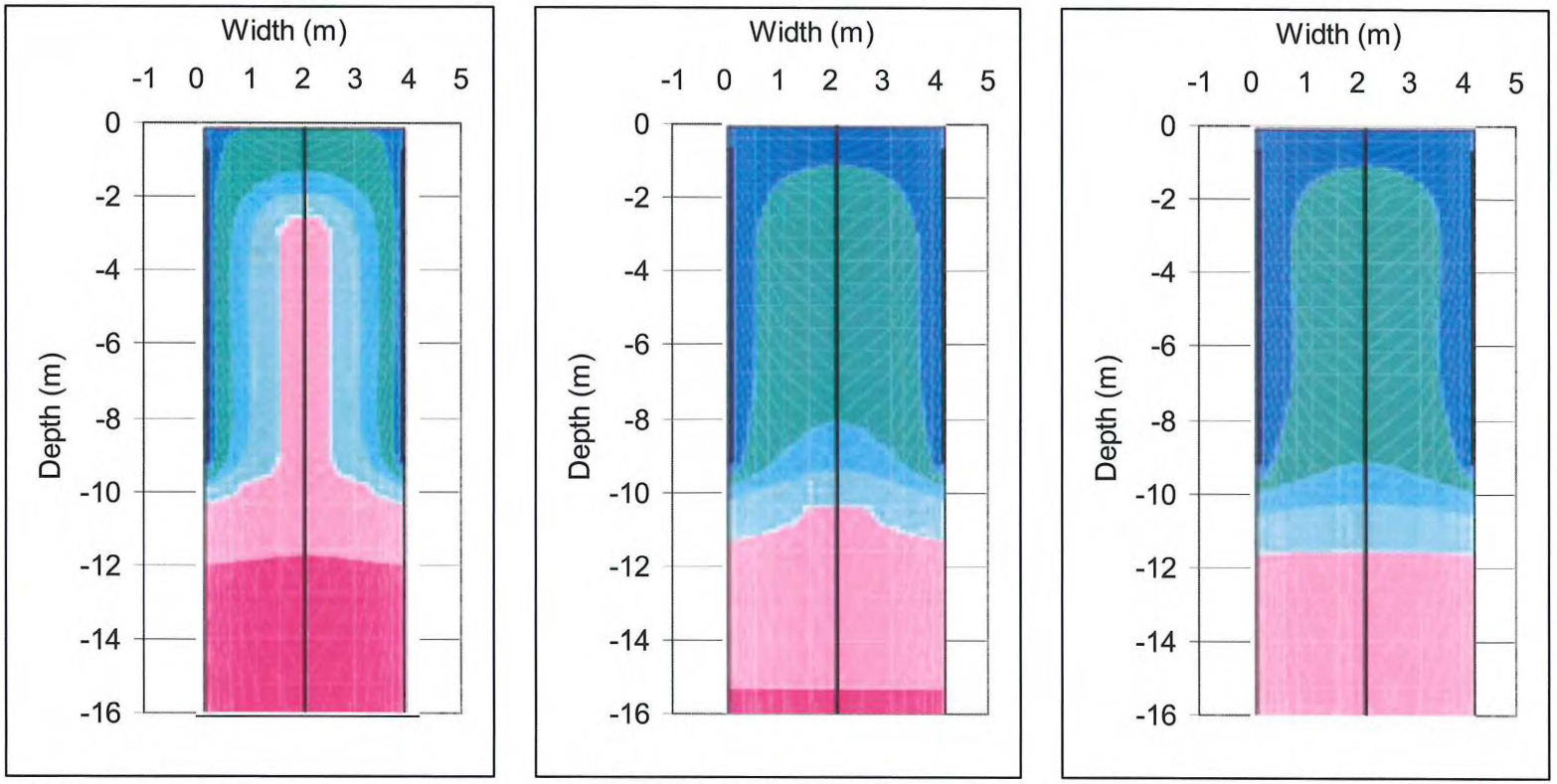


Figure 8. Geothermal results for thermosyphon spacing at 4 m, in open geometry.

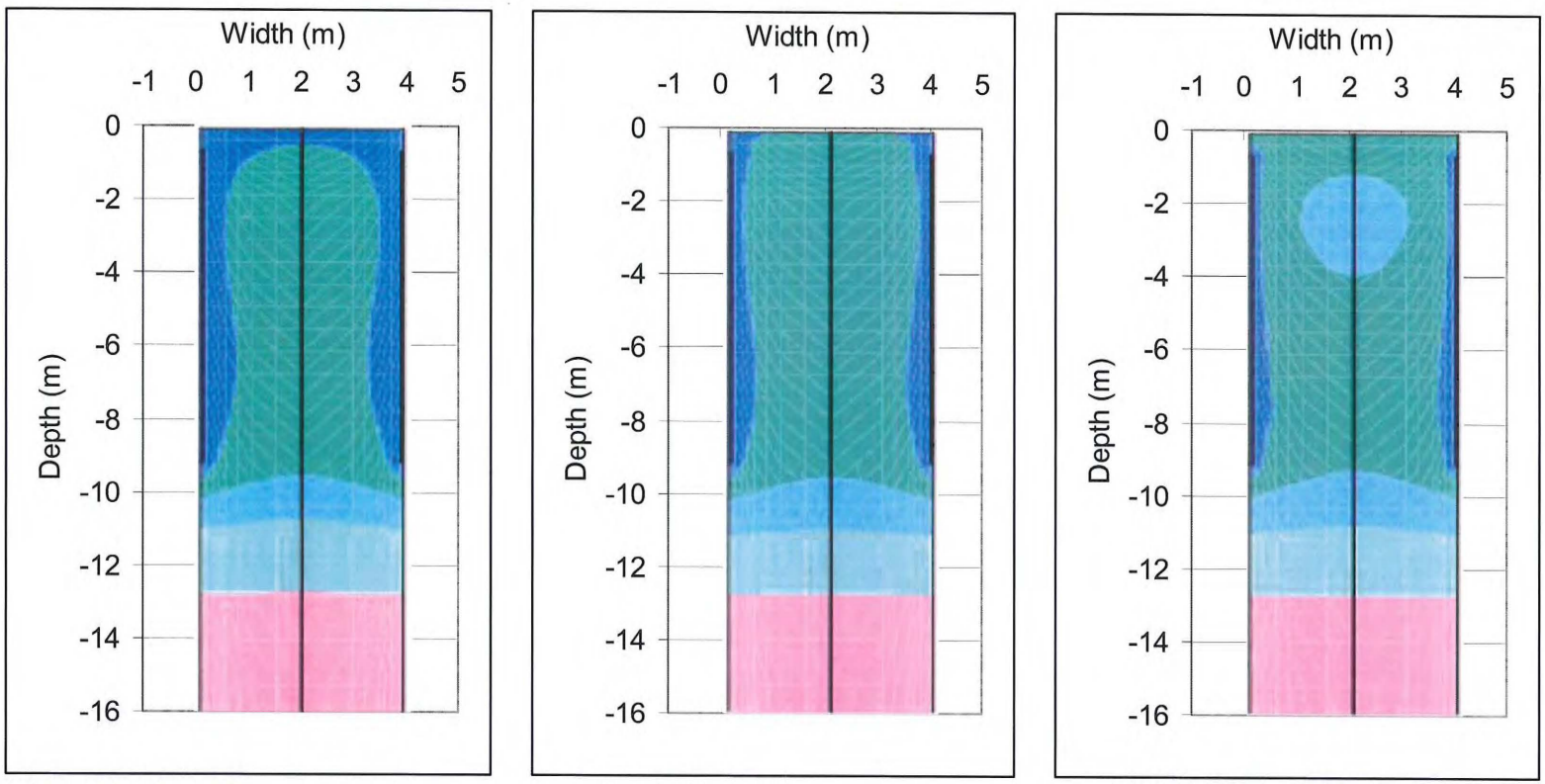
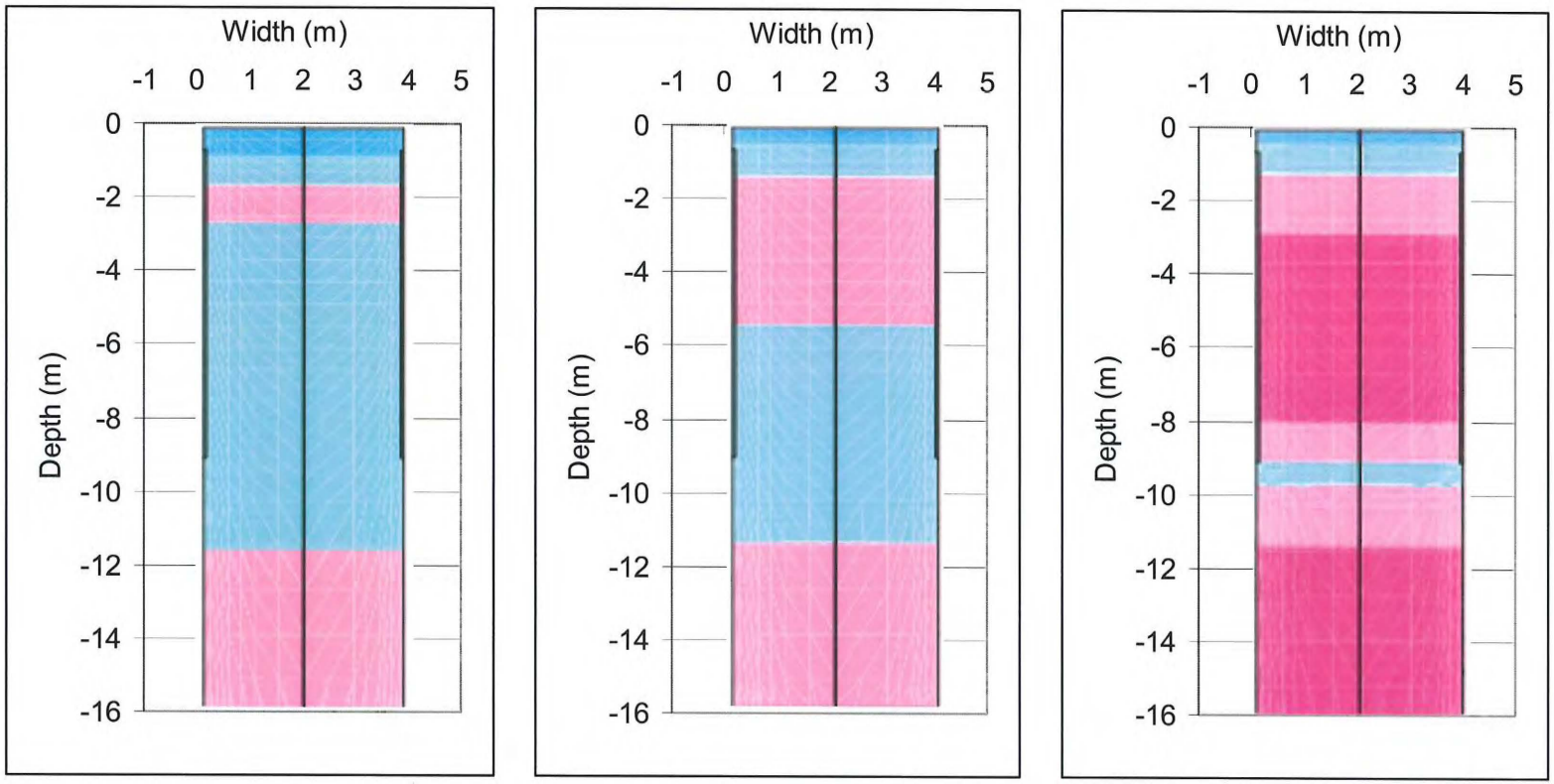


Figure 8. Geothermal results for thermosyphon spacing at 4 m, in open geometry (continued).

< - 4 °C | - 4 °C to – 2 °C | - 2 °C to -1 °C | - 1 °C to 0 °C | 0 °C to +1 °C | +1 °C to +2 °C | +2 °C to +5 °C | > + 5 °C



(g) March, Year 26 (h) March, Year 30 (i) March, Year 35

Figure 8. Geothermal results for thermosyphon spacing at 4 m, in open geometry (continued).

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C +2 °C to +5 °C > + 5 °C

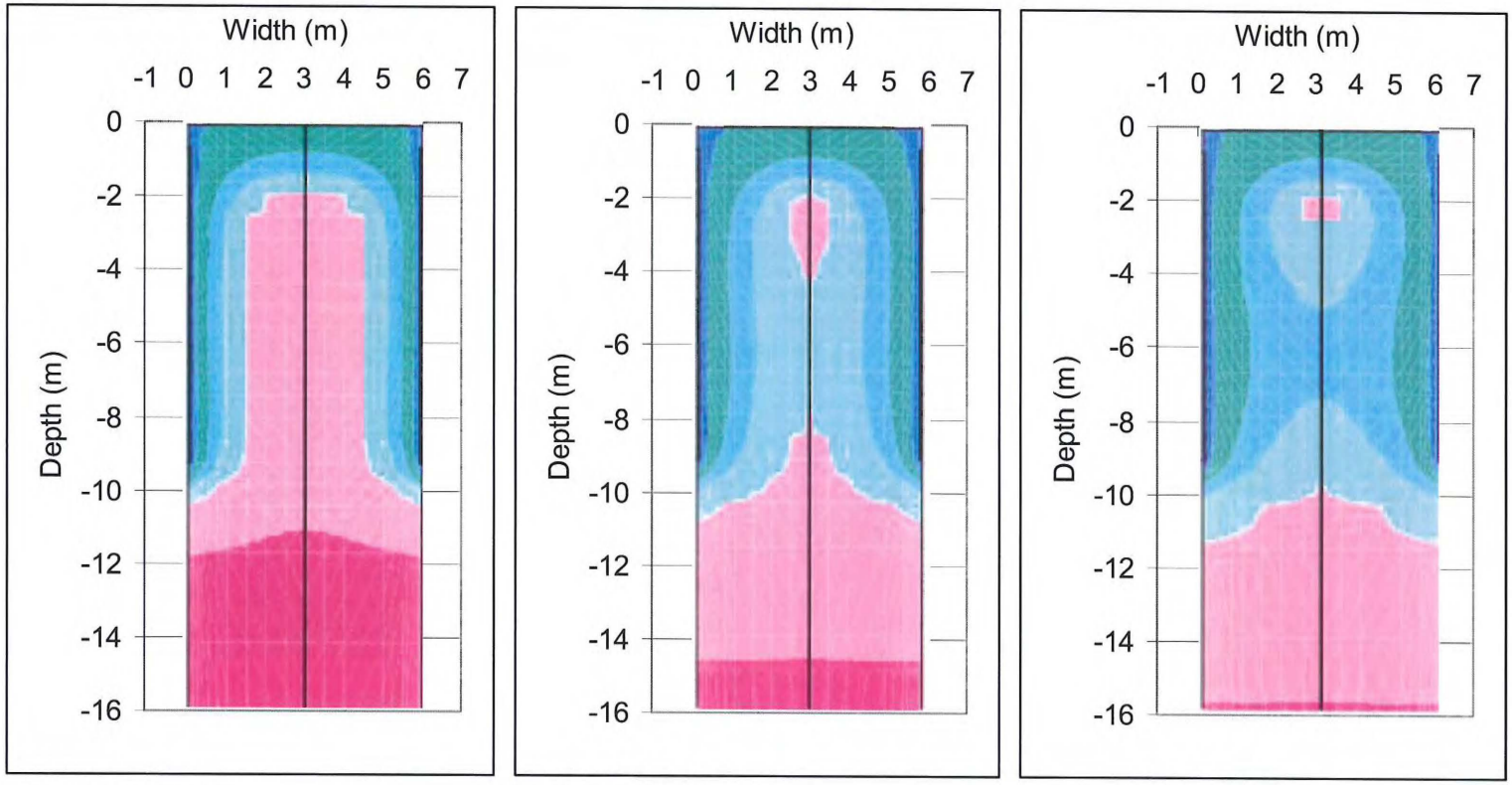
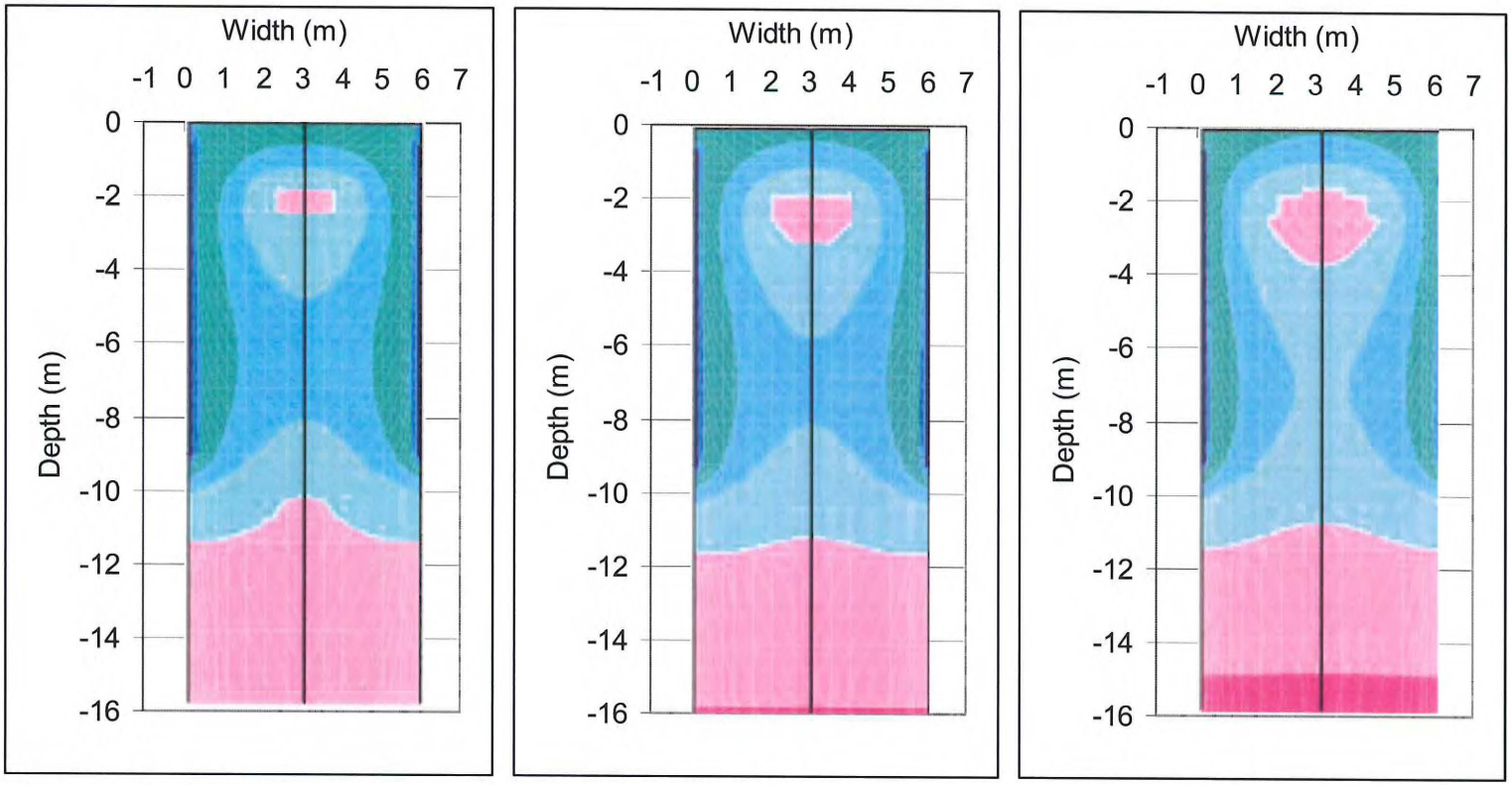


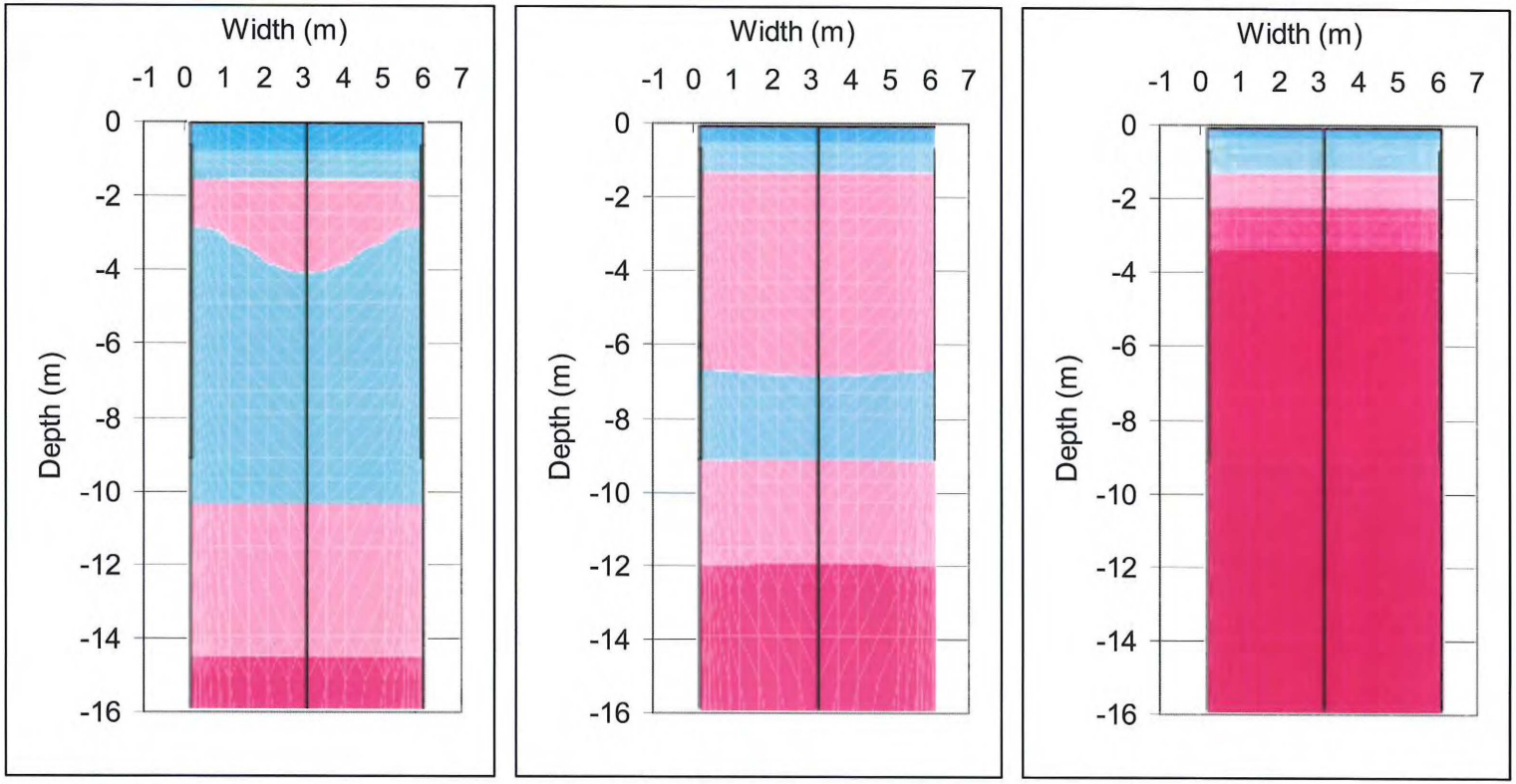
Figure 9. Geothermal results for thermosyphon spacing at 6 m.



(d) March, Year15 (e) March, Year 20 (f) March, Year 25

Figure 9. Geothermal results for thermosyphon spacing at 6 m (continued).

< - 4 °C | - 4 °C to – 2 °C | - 2 °C to -1 °C | - 1 °C to 0 °C | 0 °C to +1 °C | +1 °C to +2 °C | +2 °C to +5 °C | > + 5 °C

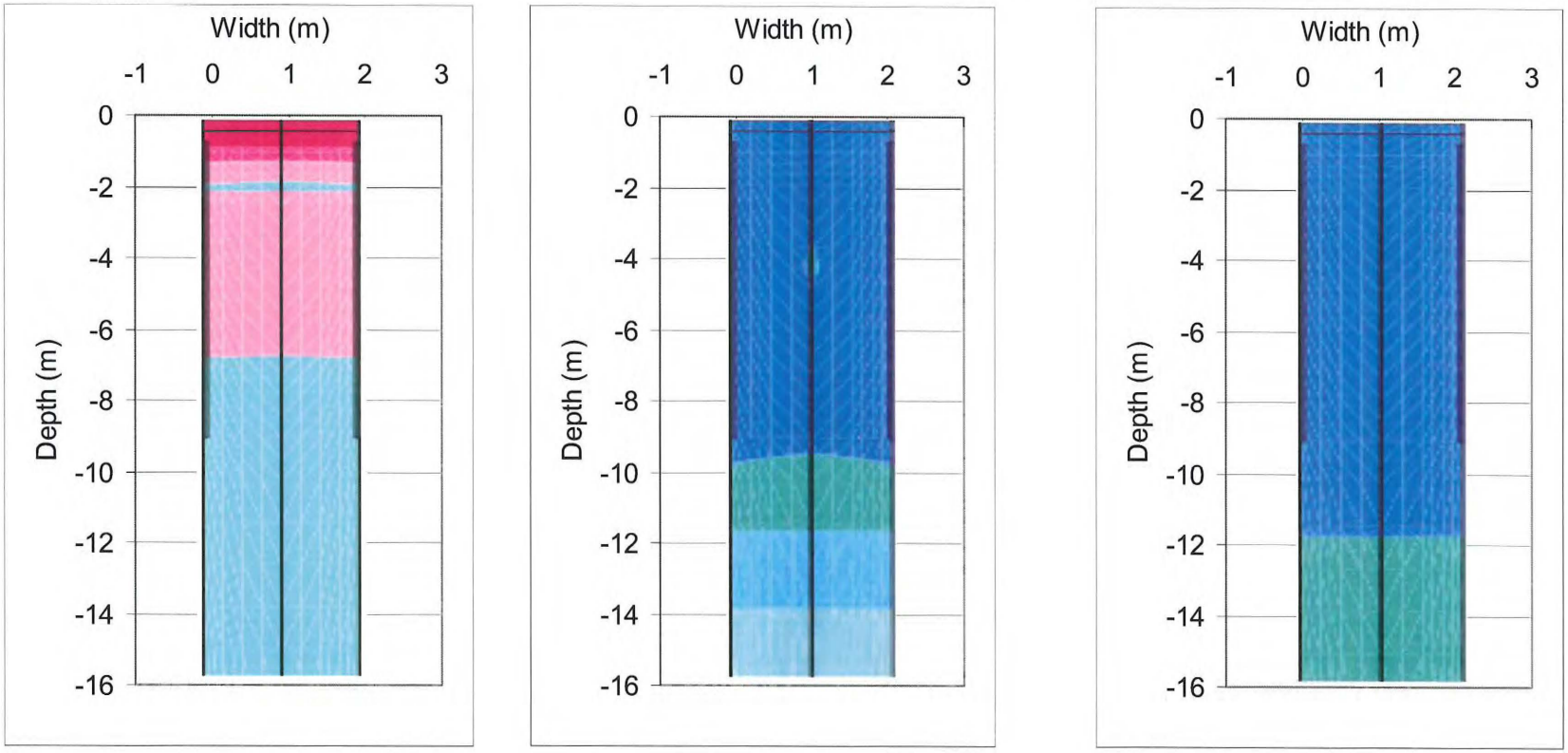


(g) March, Year 26 (h) March, Year 30 (i) March, Year 35

Figure 9. Geothermal results for thermosyphon spacing at 6 m (continued).

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C

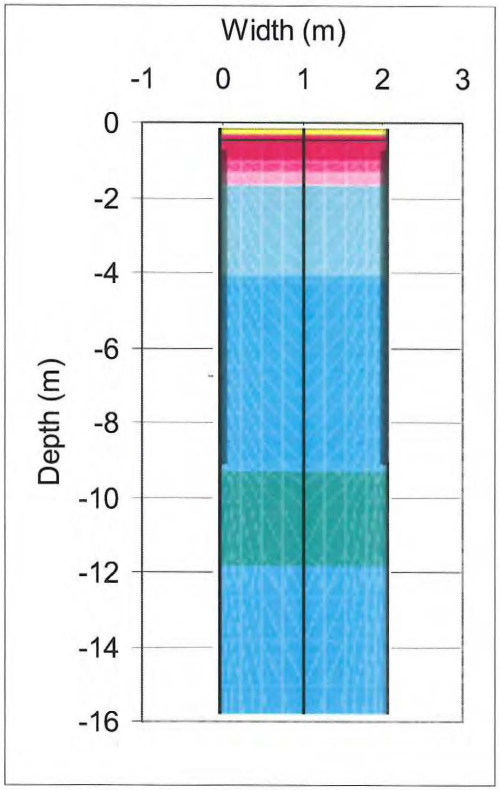


(a) September Year 1 (b) March, Year 1 (c) March, Year 15

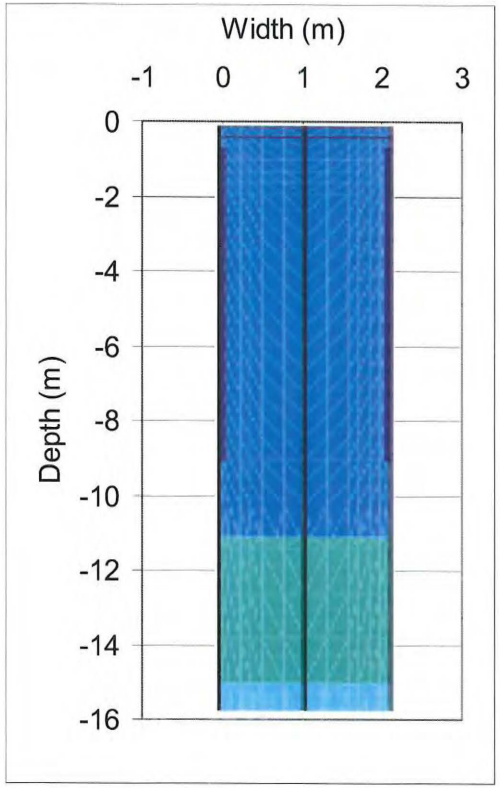
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

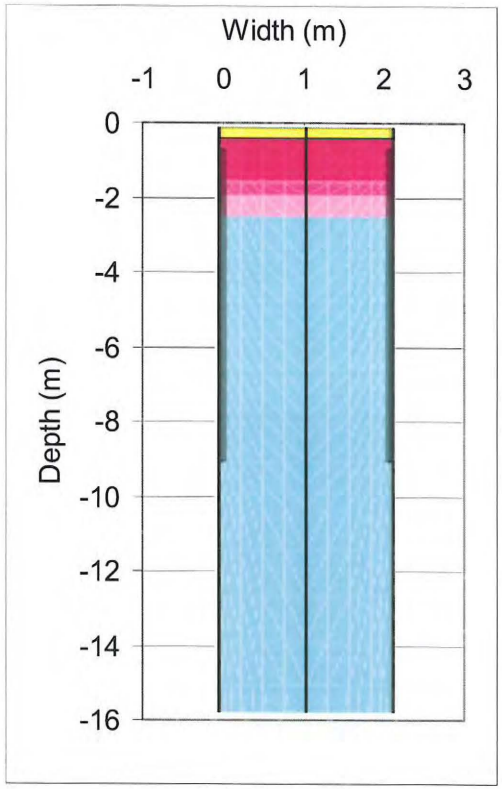
+2 °C to +5 °C > + 5 °C



(d) September Year 25



(e) March, Year 25

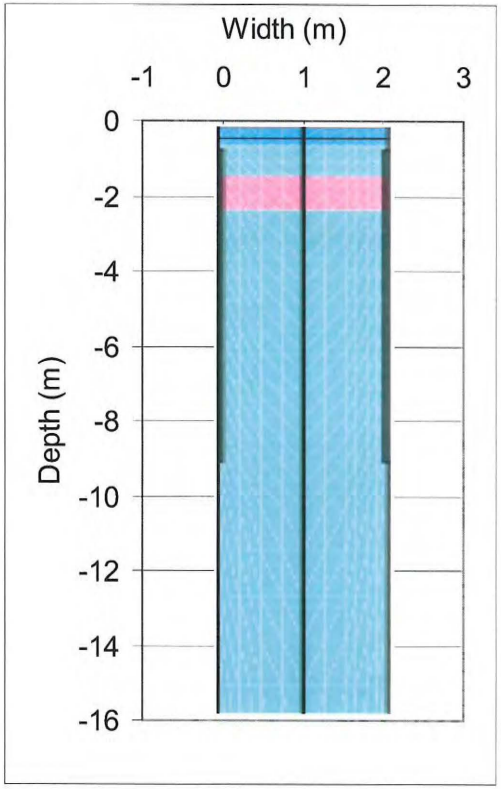


(f) September, Year 30

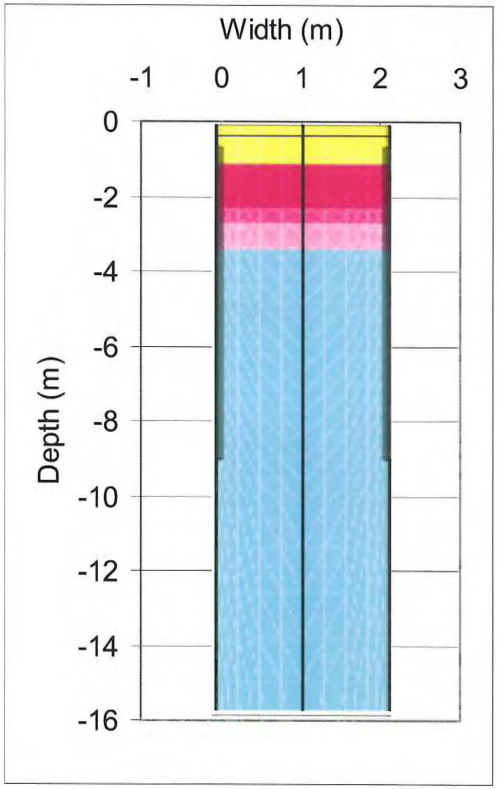
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

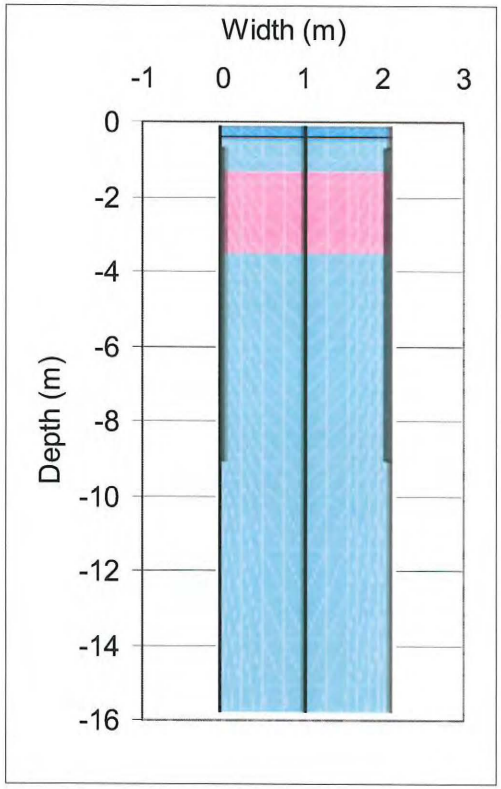
+2 °C to +5 °C > + 5 °C



(g) March, Year 30



(h) September, Year 35

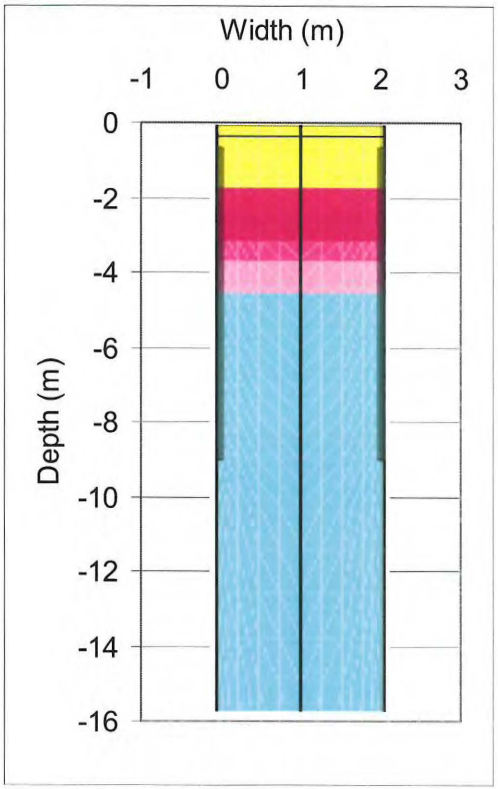


(i) March, Year 35

Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C



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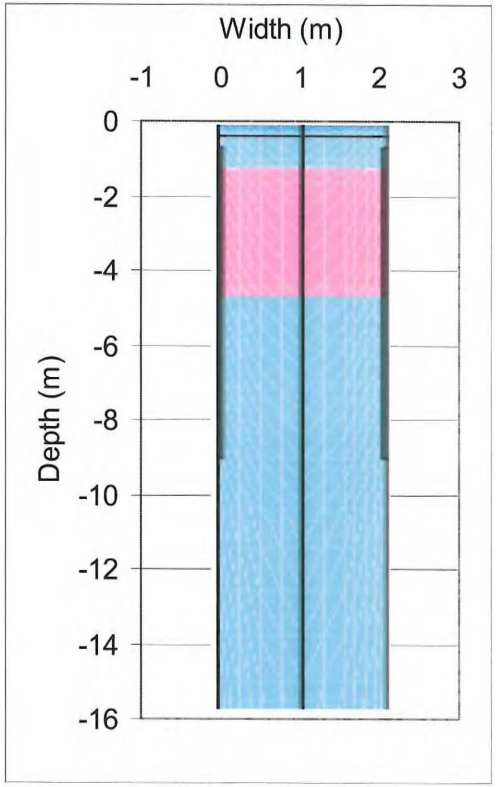

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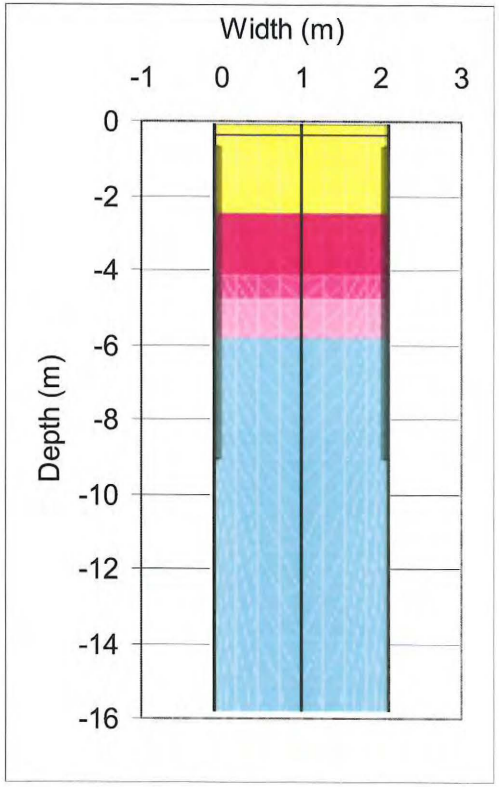
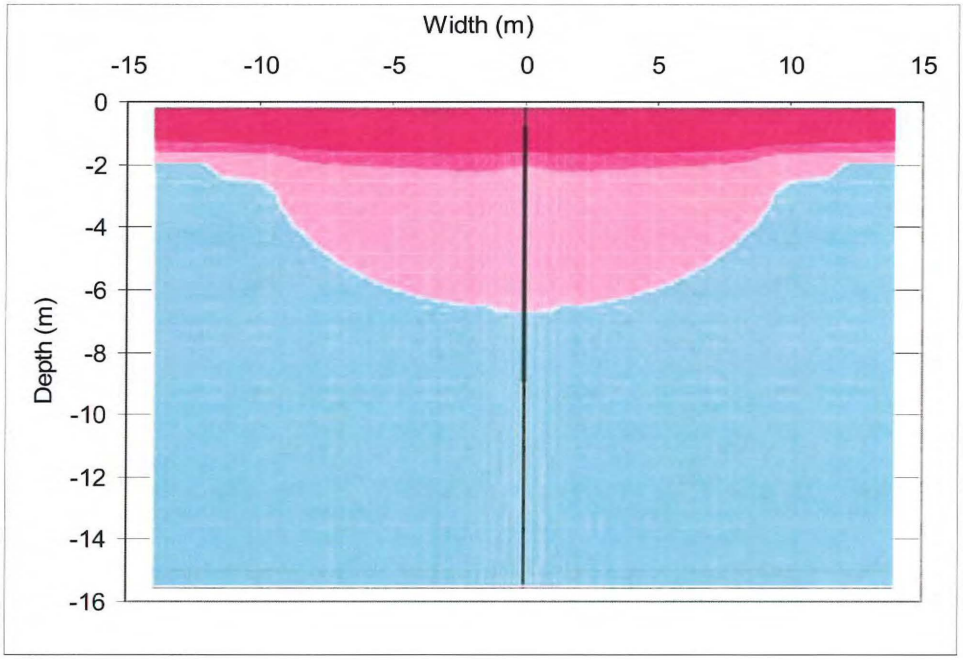


(l) September, Year 45

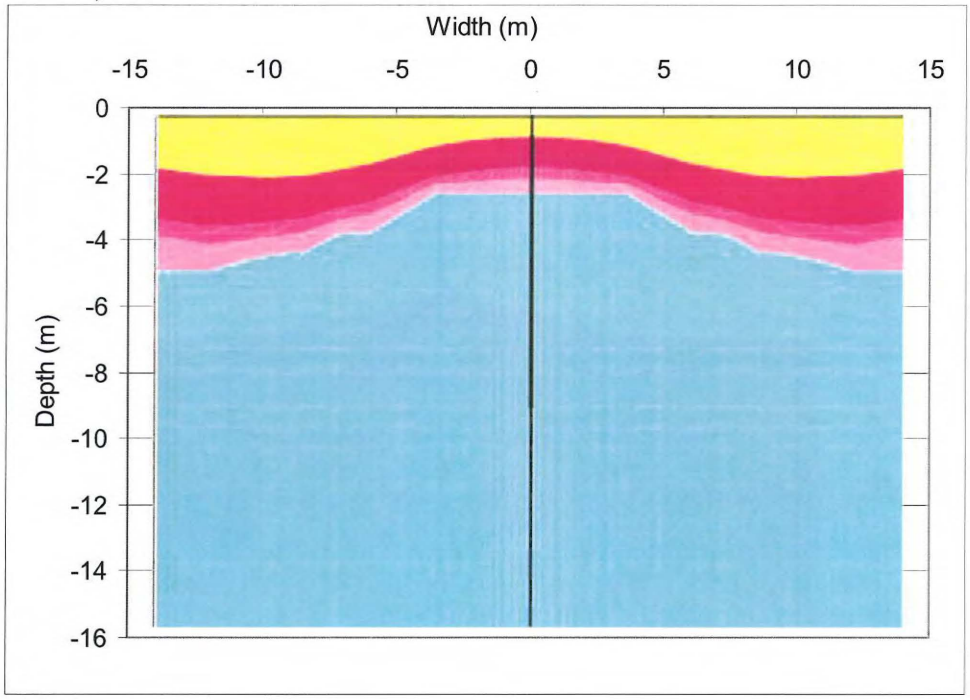
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation, continued.

< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C

+2 °C to +5 °C > + 5 °C

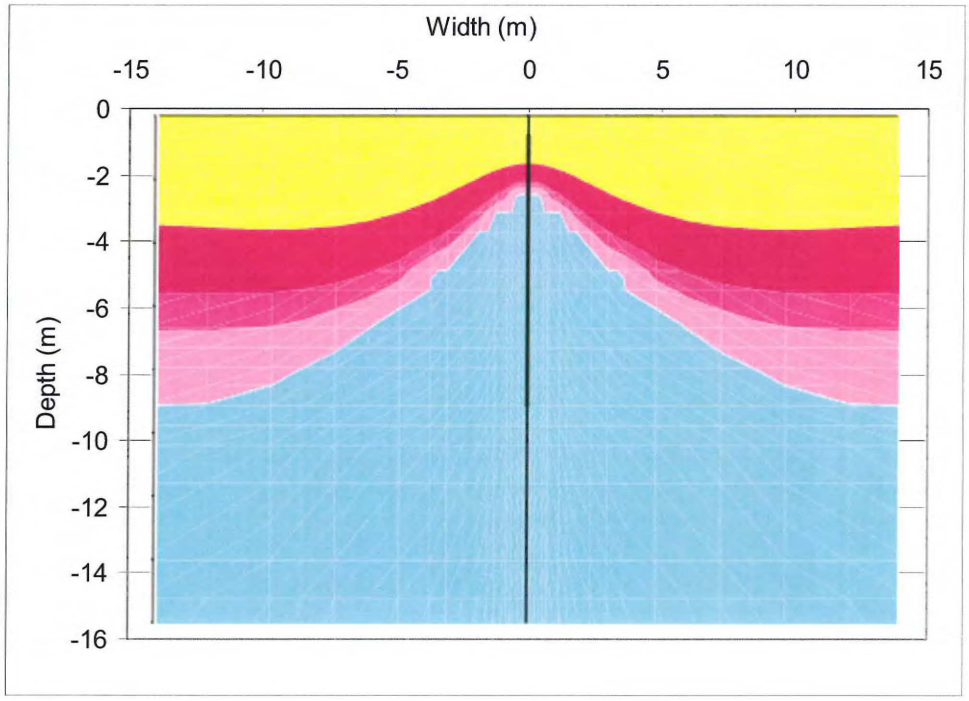


(a) September, Year 1

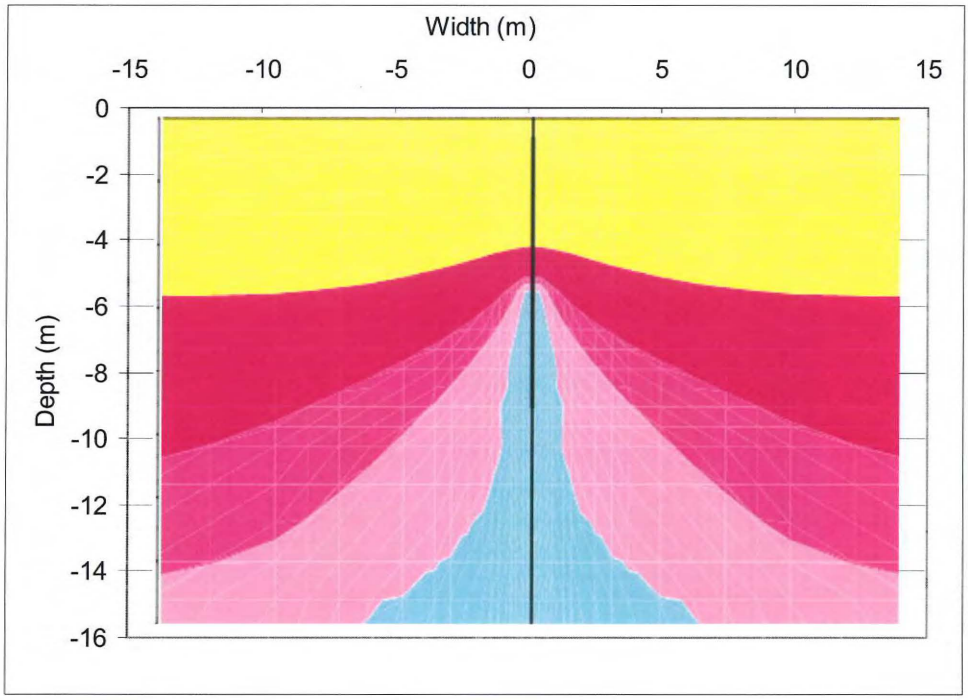


(b) September, Year 25

Figure 11. Geothermal cross section transverse to thermosyphon line (at 4 m spacing) with both thermosyphons and climate warming active past 25 years.

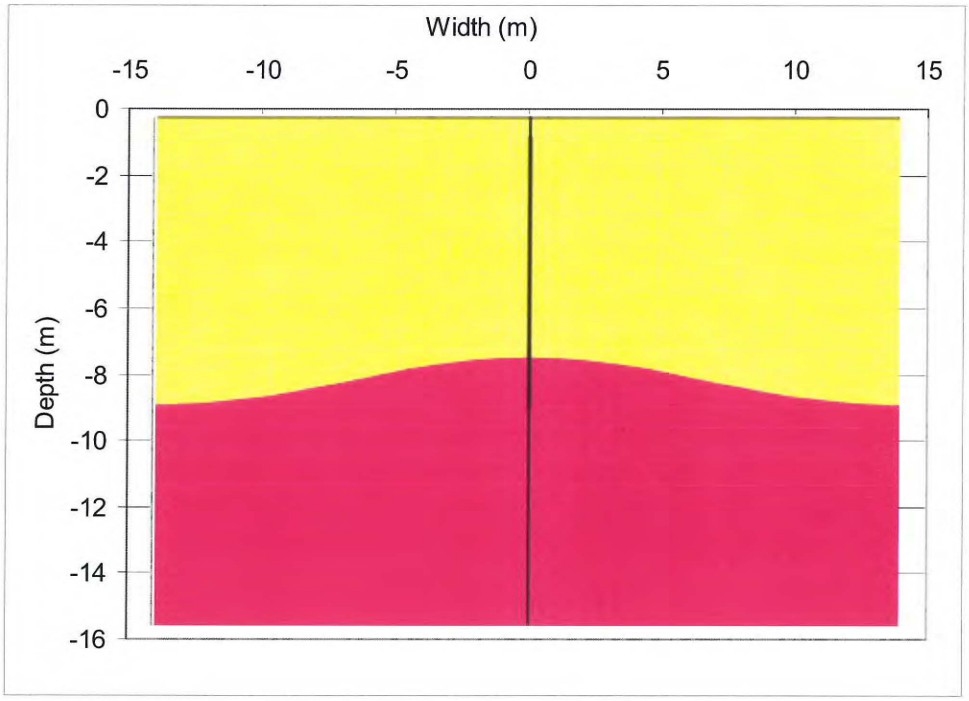


(c) September, Year 50



(d) September, Year 100

Figure 11. Geothermal cross section transverse to thermosyphon line (at 4 m spacing) with both thermosyphons and climate warming active past 25 years, continued.



(e) September, Year 150

Figure 11. Geothermal cross section transverse to thermosyphon line (at 4 m spacing) with both thermosyphons and climate warming active past 25 years, continued

Appendix C-2

Thermal Analysis of Toe-Berm

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Winnipeg, MB, Canada R3P 0Y7
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204 477 5381 tel
204 284 2040 fax

Memorandum

draft for discussion

To	Justin Stockwell	Page	1
CC	Leslie Gomm, Ryan Mills, Eric Blais		
Subject	Mount Nansen Seepage Analysis Through Tailings Dam		
From	Kendall Thiessen		
Date	September 10, 2010	Project Number	60159089 (402.19.1)

Introduction

This memorandum discusses the analysis of seepage through the Mt. Nansen tailings dam under existing and design conditions. The purpose of this analysis is to provide a general understanding of how the two design alternatives (Op
tion 1 and Option 2) will affect the porewater pressure conditions and seepage rates in the tailings, dam and foundation soils.

The options are:

- Option 1 (water cover): Upgrade the dam and current tailings management area. The tailings would be covered with a 300 mm diffusion layer and 700 mm water cover.
- Option 2(saturated cover): Upgrade the dam and current tailings management area. The tailings would be covered with a 1m thick soil cover which is maintained in a saturated state by diverting runoff and flows from Dome Creek over the tailings area..
- Options 3 and 4: Move tailings to a final storage location in the pit. The dam would be breached and the valley restored. Options 3 and 4 are not discussed further in this memo.

The following sections summarize the seepage analysis method and results. The Seep/w module of GeoStudio 2007 was used for this analysis. Only steady state conditions have been considered.

Material Properties

The parameters used in the analysis of the seepage through the Mt. Nansen tailings dam are listed in Table 1. These properties were estimated from slug test results (AECOM 2009), grain size distributions, and empirical relationships. Additional testing and model refinement is recommended for the detailed design stage should either Option 1 (wet cover) or Option 2 (soil cover) be chosen as the preferred closure alternative.

Table 1. Material Parameters Used for Seepage Analysis

Material	K_{sat} m/s	Sat Volumetric Water Content
Dam fill - sand	1.00E-05	0.3
Coarse tailings – sand	1.00E-06	0.49
Fine tailings - silty clay	1.00E-09	0.56
Diffusion layer and soil cover - sand	1.00E-05	0.3
Thawed foundation soil	5.00E-05	na
Toe berm - granular	1.00E-04	0.3
Victoria Creek borrow source	2.5E-07	0.3
Victoria Creek borrow source – amended	2.5E-08	0.3

The soil water characteristic curves (SWCC's) for fine and coarse tailings (measured by MDH Engineered Solutions, 2009) were used in the seepage analysis for the respective soil units. These curves are shown in Figure 2. The hydraulic conductivity functions were estimated from the SWCC's using Fredlund and Xing's formulation which is built into the Seep/W software. The saturated hydraulic conductivities have been assumed based on measured values for similar materials. Actual hydraulic conductivities can only be estimated to within +/- 2.5 orders of magnitude based on the soil classification (Vick 1990). This is especially true for tailings where layering and segregation can result in complex spatial variations in soil conditions.

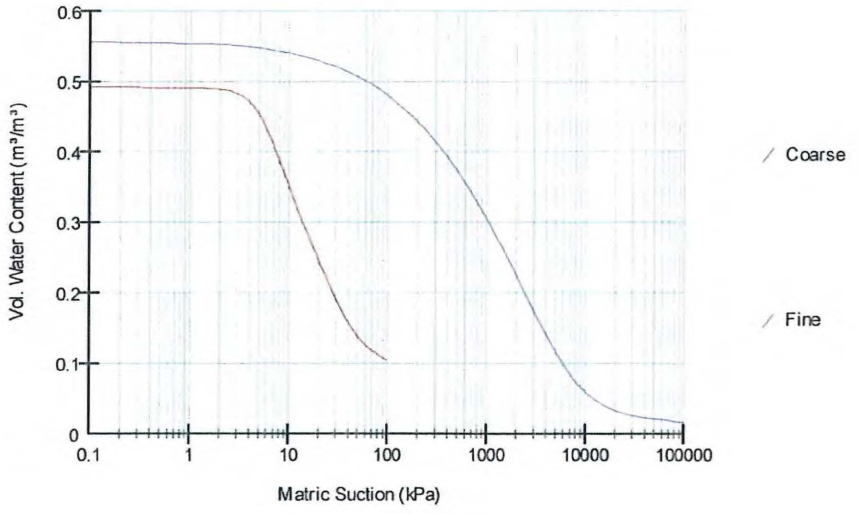

Figure 1. Soil water characteristic curve for coarse and fine tailings

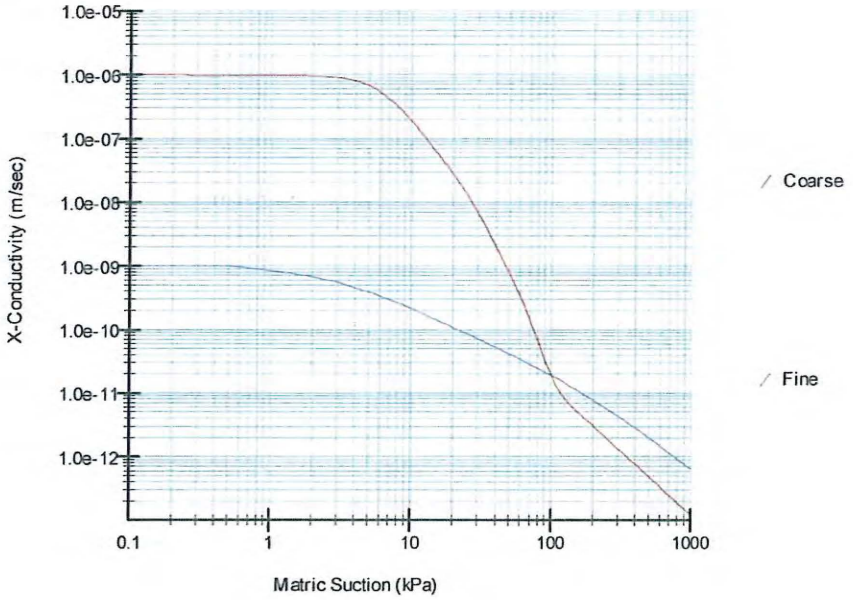

Figure 2. Hydraulic conductivity functions for coarse and fine tailings

Assumptions

A number of assumptions were required in the development of the seepage models in addition to the material properties and boundary conditions:

- It has been assumed for this modeling that there is no GCL or goemembrane in place against the upslope face of the dam. The preliminary design of the tailings dam, by Klohn Leonoff (March 1990) called for a GCL or membrane liner to be placed against the upslope face of the dam to reduce seepage through the dam. It is understood that there were no quality control/assurance inspections of the dam during construction. The specifications, quality of installation, or existence of any seepage control measures cannot be confirmed. A review of the monitoring well data has reinforced the assumption that if a liner was installed, it is largely ineffective.
- The upstream toe-berm (beneath the tailings) has been included in the model geometry. There are no record drawings or other evidence than confirms that this berm was constructed.
- A zone of thawed sand is modeled beneath the entire tailings area.
- It is assumed that under closure conditions the low area, currently the tailings pond, would be backfilled with coarse tailings. Selectively backfilling this area with fine grained tailings would further decrease seepage losses through the tailings.
- Only seepage from the surface through the tailings has been considered (ie. other sources of groundwater have not been considered).
- There is no tail water against the toe of the dam.

Analysis of Existing Conditions

The cross section and piezometric conditions measured in August 2010 were used to calibrate the analysis of the existing conditions. Figure 3 shows the soil regions and Figure 4 shows the calculated total head distribution through the dam. The zones of fine and coarse tailings were estimated from the logs prepared by CANMET (2002). This cross section is typical of the south part of the dam, where the dam height is the greatest, and where coarse tailings were identified near the dam face. Other cross sections have not been considered at this time. All analysis is steady state, and infiltration of precipitation has not been considered. The following sections will discuss the limitations of this analysis in more detail.

The boundary conditions are shown in Figure 3. A pressure head was applied along the surface of the tailings as the source of the seepage through the dam. The seepage rate, and profile of the piezometric surface through the dam are sensitive to the boundary conditions along the top of the tailings near the dam crest. To achieve a porewater pressure distribution similar to that measured by piezometers MW 09-03, 09-04 and 09-23, a total head boundary condition of elevation 1096 m was applied at the ground surface between the tailings pond and the dam crest. To the left (west) of the tailings pond, a pressure = 0 kPa (ie. phreatic surface) was assigned to the surface boundary. Both of the latter two conditions were arbitrarily chosen to approximate the measured porewater pressure distribution. There are other scenarios that can approximate similar porewater pressures at the measured points with various combinations of material parameters and boundary conditions. The calculated seepage through the dam is approximately 1.1×10^{-5} m^2/s (ie. per m length of the dam), based on the presented analysis.

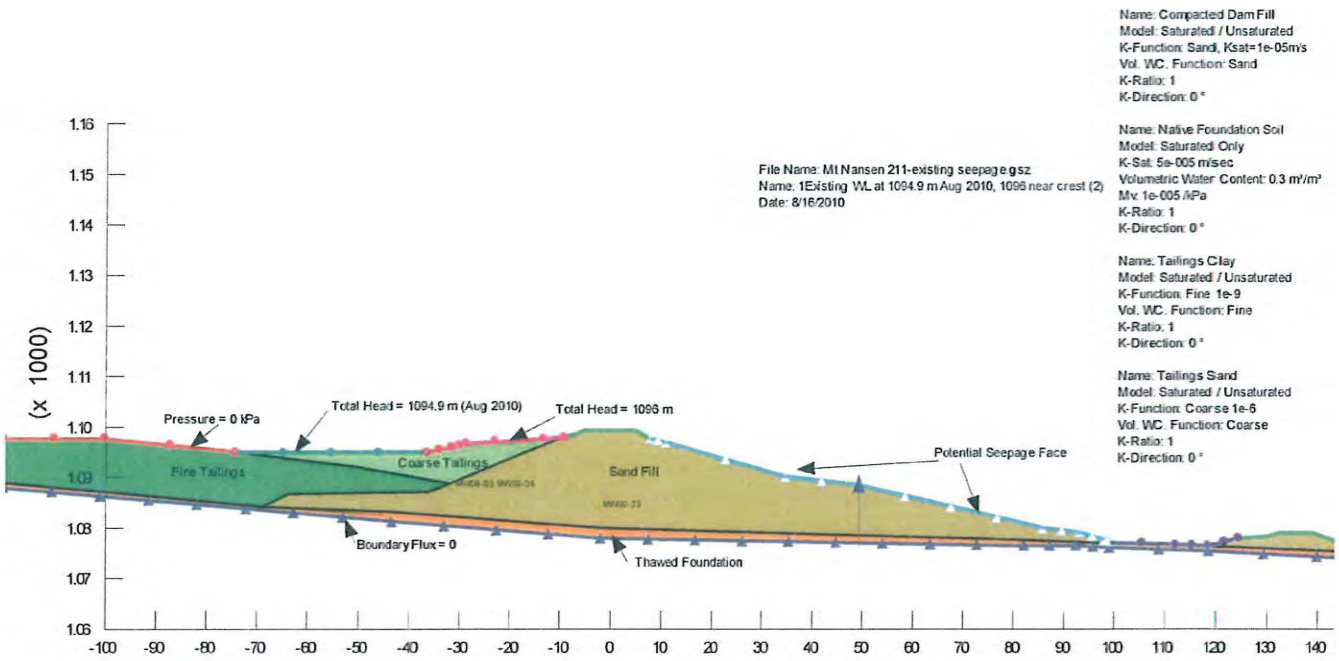

Figure 3. Cross section of tailings dam.

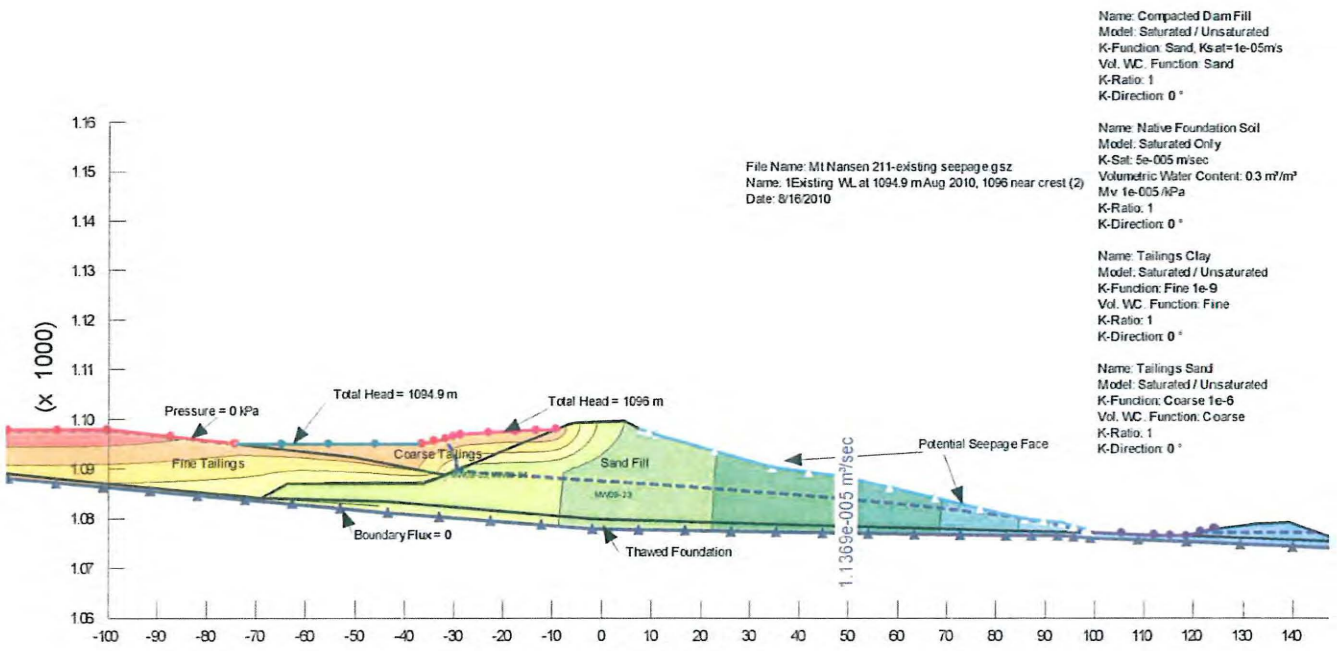

Figure 4. Existing conditions, with contours of total head and piezometric surface plotted.

Analysis of Design Options

The modeled cross section for Option 1 is shown in Figure 5. A flux = 0 boundary condition is applied along the base of the model. A total head boundary condition, equivalent to the design water level, is applied along the tailings surface. Seepage is permitted to exit the system along the downstream face of the dam. The beach area has assigned zero boundary flux condition. This produces a similar seepage rate as applying a total head = 1096 m boundary condition.

As a baseline for comparison, the seepage rates through the modeled cross section of the dam (per metre width) are:

With "wedge" of coarse tailings against dam face

- Option 1 (Water cover) with water level at 1087.75 m: $Q = 6.5 \times 10^{-6}$ m^2/s
- Option 2 (Soil cover) with water level at 1099 m : $Q = 6.7 \times 10^{-6}$ m^2/s

With coarse tailings replaced with fine tailings.

- Option 1 (Water cover) with water level at 1087.75 m: $Q = 4.5 \times 10^{-6}$ m^2/s

A plot of the total head distribution through the dam is shown in Figure 6.

The seepage rates and porewater pressure regimes are quite similar between Option 1 (water cover) and Option 2 (soil cover) because the head conditions are similar and the thin soil cover layer provides minimal resistance to seepage. Figure 7 shows the influence of the head of the tailings pond on the seepage rates. The non-linearity in this relationship is due to the fact that under higher water levels, the water will flood over the beach area. The spillway will be designed in such a way that this would be a temporary condition, and the seepage would likely not reach a steady state.

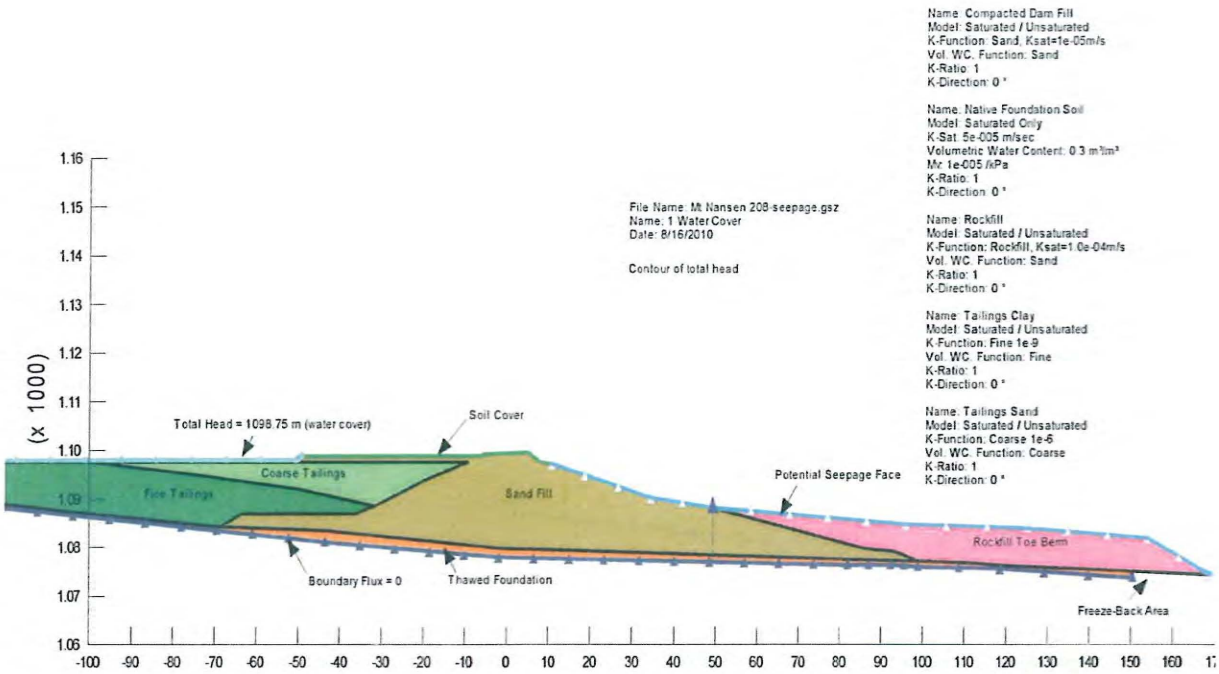

Figure 5. Option 1 (Water cover) modeled section .

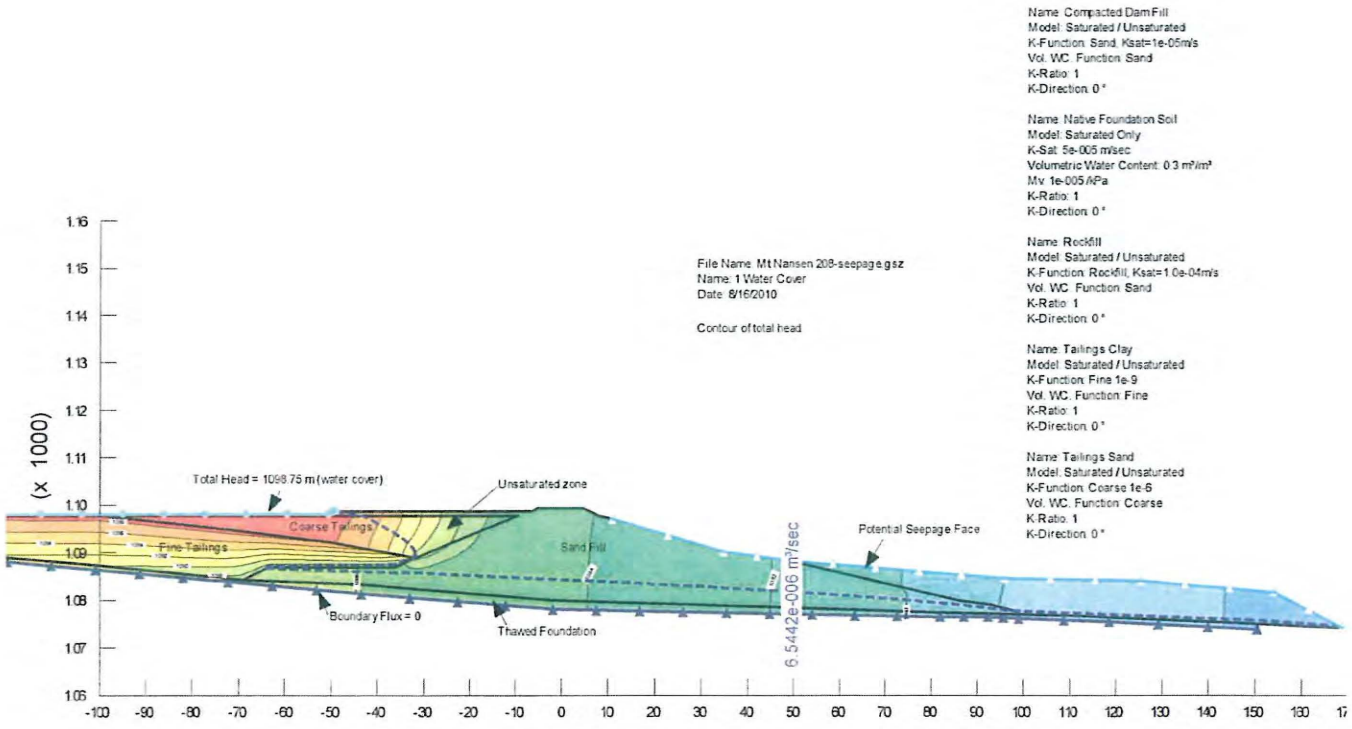

Figure 6. Total head through tailings dam.

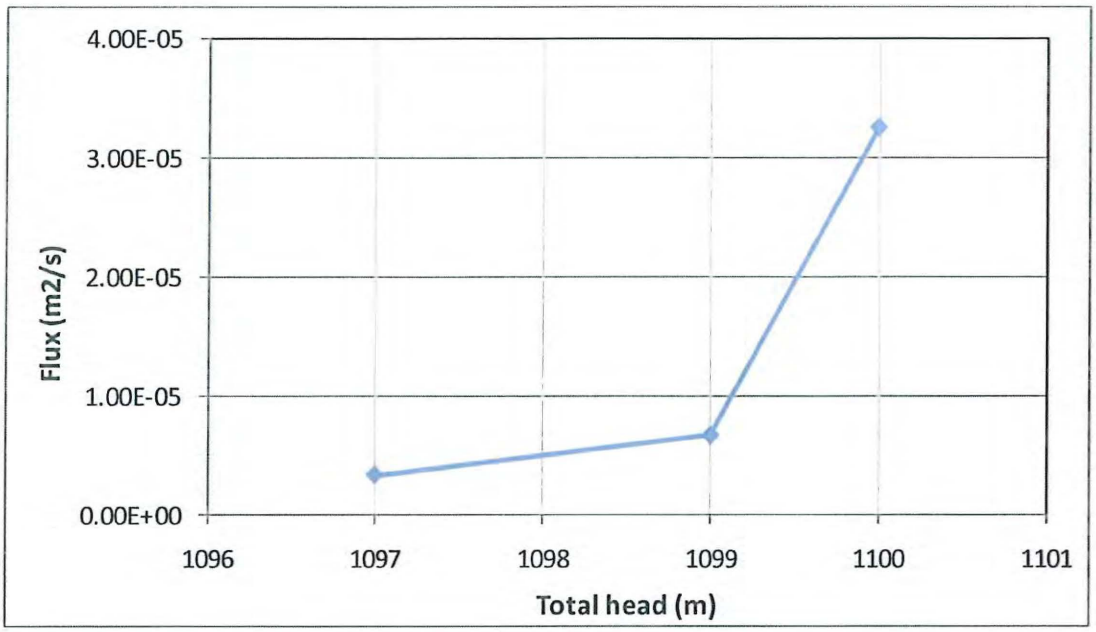

Figure 7. Seepage flux plotted vs. total head

Since most of the seepage volume through the tailings passes through the coarse zone, the total seepage is very sensitive to the extents, geometry, and hydraulic conductivity of the coarse tailings zone. Test holes through the tailings have indicated that the tailings along the northern part of the dam are primarily fine grained. Figure 8 shows the total head distribution calculated through the dam with the assumption that the entire volume of tailings against the dam crest are fine grained. There is approximately a 30% decrease in the seepage through a cross section with fine tailings (Figure 8) versus a cross section with coarse tailings (Figure 6)

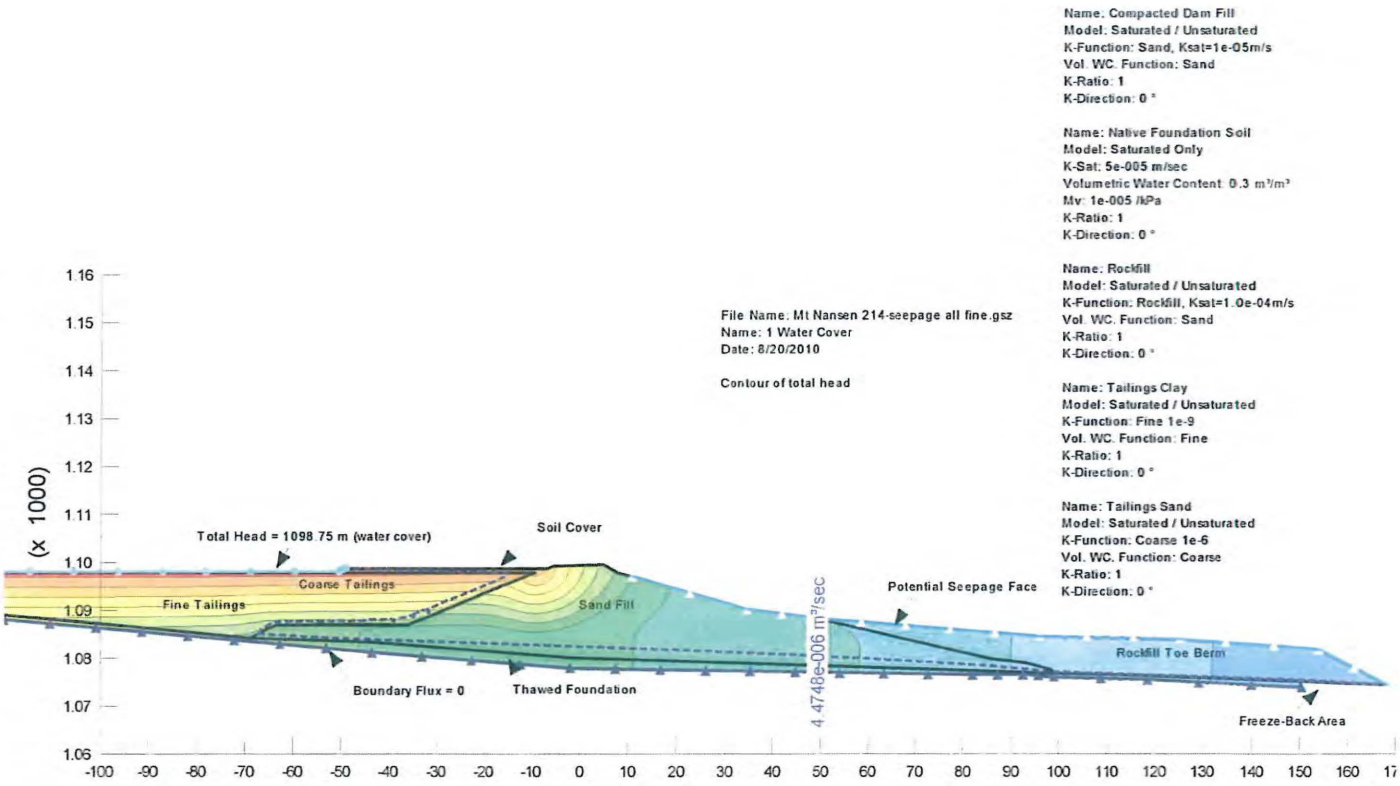

Figure 8. Total head with fine grained tailings against dam.

Upgrade options

Several alternatives have been considered for upgrading the dam to improve its performance with respect to seepage. The objectives of the improvements are to:

- decrease seepage rates
- reduce the volume of unsaturated tailings
- decrease porewater pressures in the dam

Alternative 1: Replace coarse tailings with fine grained soil.

This concept would involve replacing the coarse tailings that are currently situated along the upslope face of the dam with either fine-grained tailings or an uncontaminated soil with a lower hydraulic conductivity. The seepage analysis illustrated in Figure 8, adequately represents this condition. The volume of wedge of coarse tailings against the upslope edge of the dam is estimated to be in the order of 35 000 m^3. The seepage rate is estimated to be 4.5×10^{-6} m^2/s. Replacing the coarse tailings with a material with a higher hydraulic conductivity (ie. clean sand) would result in an increase in seepage and porewater pressures through the dam.

Alternative 2: Place a seepage barrier along upslope face of the tailings dam.

This concept would involve placing a low permeability barrier against the upslope face of the dam, in the zone of coarse tailings. Some of the coarse tailings would be excavated to provide access to the upslope face of the dam. A number of materials or products would be suitable for providing a barrier. A sand or silty sand could be amended with bentonite to decrease the permeability. Figures 9 and 10 illustrate this option. A source of well graded sand with over 20% fine grained material was identified near Victoria Creek, approximately 5km from the site. This material might be suitable for amending for this purpose.

Alternatively, a geo-membrane or geosynthetic-clay liner may be installed as a seepage barrier. It should be noted that the hydraulic conductivity of bentonite is influenced by groundwater chemistry which may influence the design. The seepage rate is estimated to be $5x10^{-6}$ m^2/ for this alternative with a 2 m thick barrier of amended soil against the dam face.

Both of the above options reduce the seepage through the dam, increase the phreatic surface behind the tailings dam, decrease the phreatic surface in the tailings dam. These results are beneficial in several ways:

- The stability of the dam is improved
- The volume of unsaturated tailings is decreased
- The water supply requirements upstream and potential water treatment requirements downstream are reduced.

Both options are similar in their effectiveness. The performance of the alternatives can be optimized through design and specification of materials.

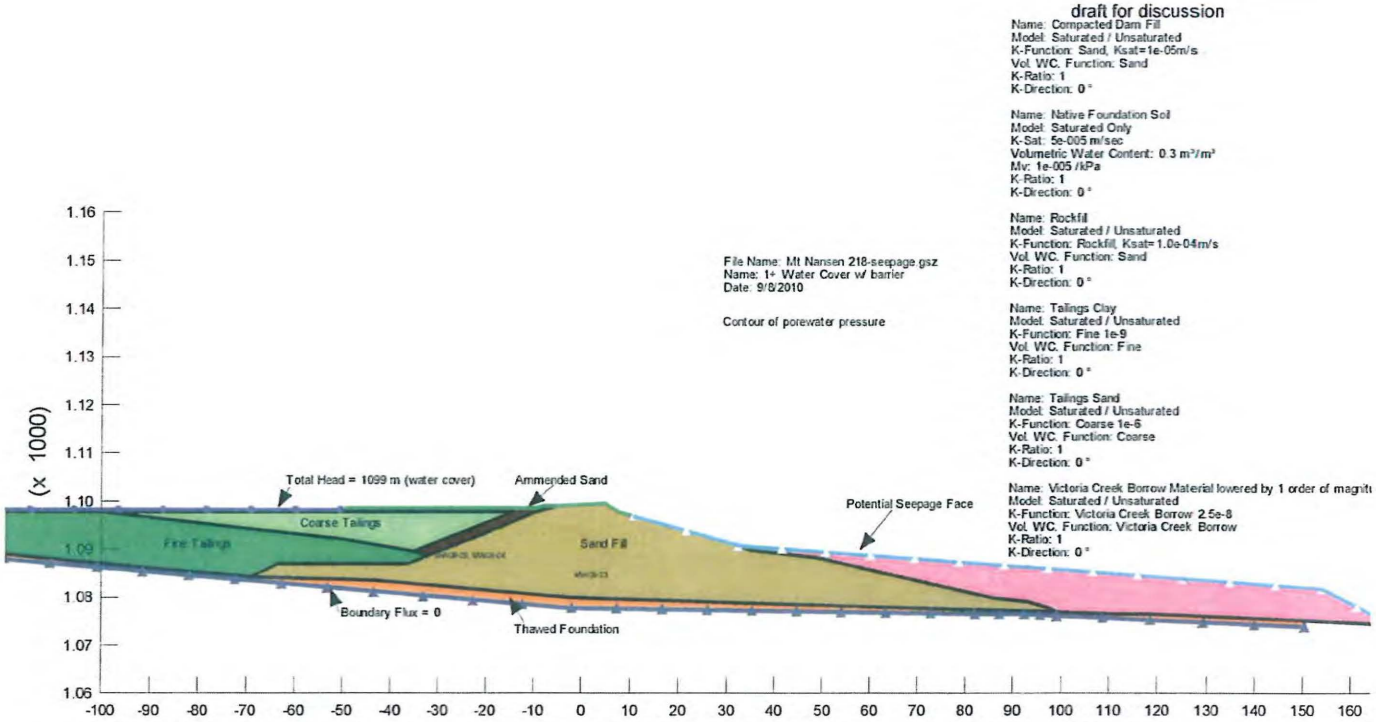

Figure 9: Cross section showing proposed amended sand barrier against upslope face of dam.

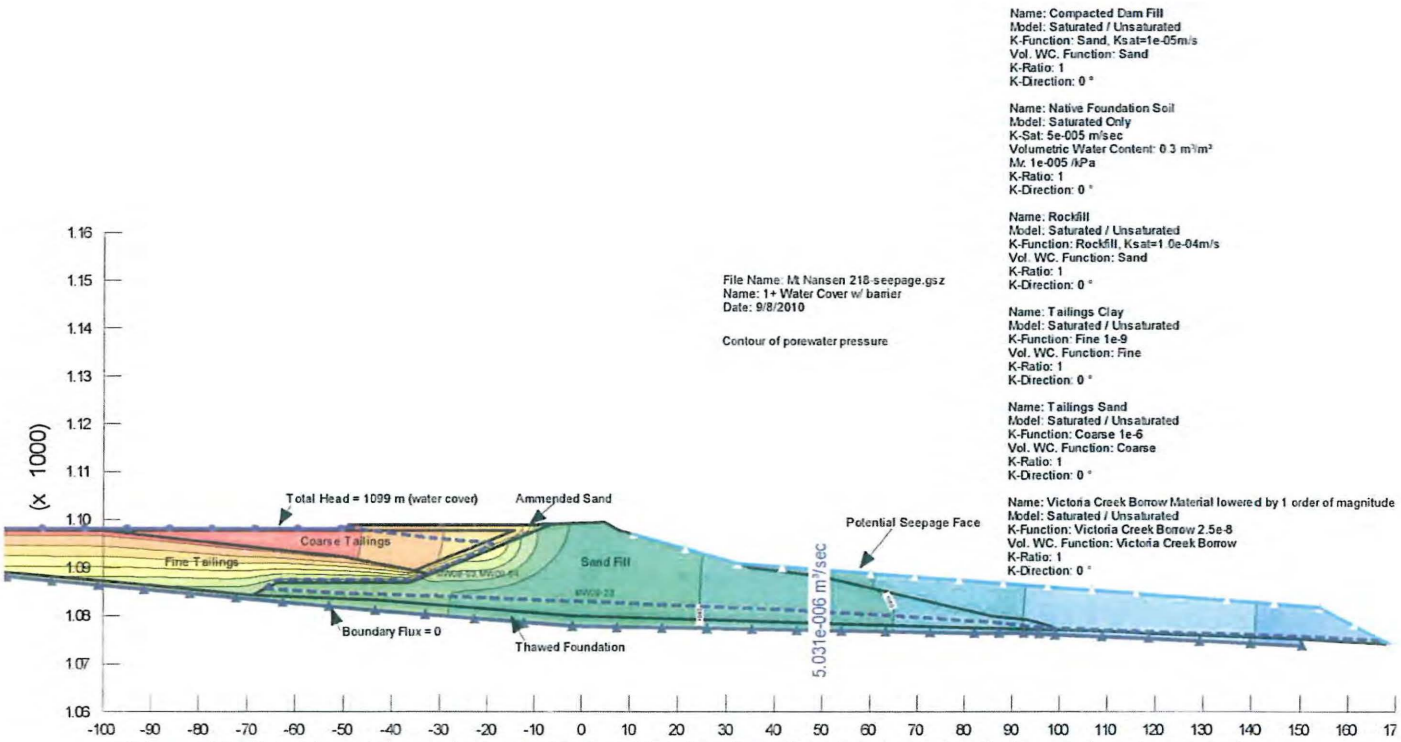

Figure 10: Total head through dam with 2m thick barrier of soil amended with bentonite along upslope face of dam.

Limitations of 2-D analysis

The seepage in the tailings impoundment area is a three dimensional problem, and a two-dimensional, seepage analysis is inadequate in several ways:

- The dam cross section is not constant along its length.
- The thawed zone is not consistent beneath the tailings or the dam
- The zones of tailings (sorted by gradation) are non-uniformly distributed and are not easily delineated.
- Actual flow vectors will not be in the plane of the cross section.

Furthermore, there is no detailed record of the valley topography prior to the construction of the dam (to our present knowledge). The modeled cross section was developed from a limited number of boreholes that extended through the tailings into the foundation material.

The cross section considered is along the centerline of the dam (Section A-A from Drawing 1). The piezometers, to which the model is calibrated (MW 09-03, MW 09-04, MW 09-23, are offset to the south of this cross section.

Discussion

Bearing in mind the limitations of the current knowledge of material properties, and the other limitations, the results of this analysis should be considered as order of magnitude approximations.

The phreatic surface and pressure distributions through the dam are sensitive to the relative hydraulic conductivities and geometries of the tailings, the foundation layer and the dam itself. It is assumed that the toe berm area can be designed in a way that promotes drainage.

The porewater pressures in the dam are very sensitive to the water boundary conditions near the crest of the dam. Based on the currently available information, it has been assumed that the dam fill is more permeable then the coarse and fine tailings, and therefore the greatest head loss will occur in the tailings. This head loss through the tailings directly affects the water levels in the dam, and the seepage volumes through the dam.

Testing is underway (by others) to further characterize the hydraulic conductivity of the fine, coarse and combined tails. It is recommended that if the design of Option 1 or 2 are taken further, the hydraulic conductivities of the, dam fill and foundation material should be measured. Transient seepage analysis will be necessary if the impacts of various temporal events such as precipitation, flooding or drought are to be investigated.

For the current analysis it has been assumed that the soil beach will be offset 50 m from the dam centerline (42m from the upslope edge of the dam crest). The benefit of the soil beach is two-fold: it protects the dam crest from wave action, but more importantly it lowers the phreatic surface through the dam and reduces seepage losses. The lowering of the piezometric pressures in the dam increases the stability of the dam. The effect of the beach width on seepage losses is illustrated in Figure 8.

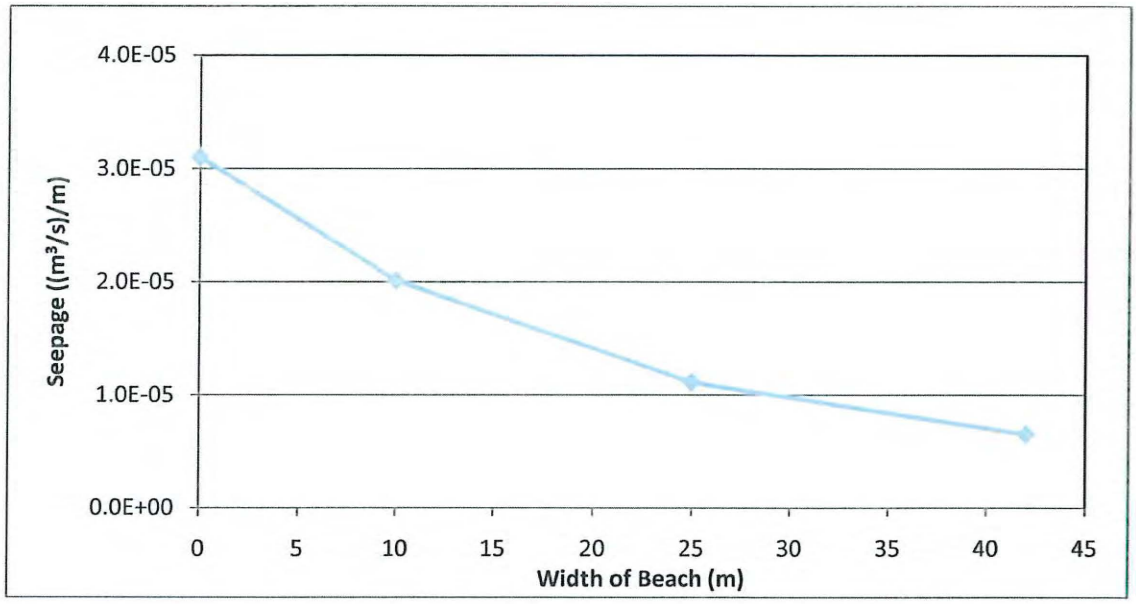

Figure 8. Seepage rate through dam vs. width of beach.

A potentially negative consequence of the lowered piezometric surface is that there is wedge of soil against the upslope face of the dam which becomes unsaturated (Figure 9). It is estimated based on the numerical models that less than 1% of the total flux through the dam would pass through this unsaturated zone.

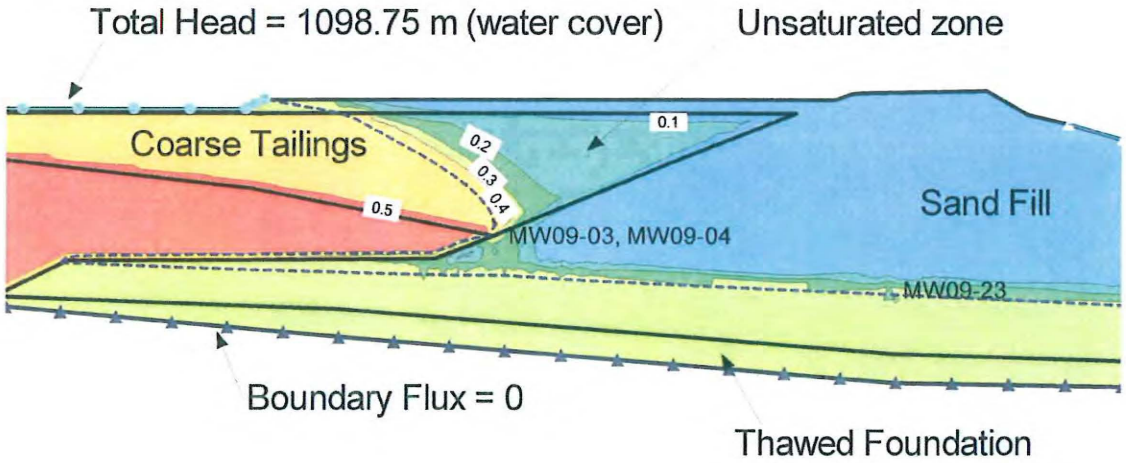

Figure 9. Unsaturated wedge of soil against upslope dam face. Contours showing volumetric water content.

The analysis has shown that installing a upslope seepage barrier or replacing the coarse tailings with fine tailings has several benefits to the overall performance of the tailings management area. More

detailed analysis would be required in the final design stage to optimize the designs. The constructability of the potential upgrades must be considered, as it would require the excavation of a large quantity of material. An alternative that has not been considered in detail would be to construct a grout curtain as a seepage barrier.

References

Vick, S. G.. 1990. Planning, design, and analysis of tailings dams. Bitech Publishers Ltd.. Canada.

Sincerely,

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Appendix D

Cost Estimate

Option 1 - Tailings Dam Upgrade with Water Cover, Waste Rock in Place

Item	Units	Quantity	Unit Price	Total	Notes
Mobilization and demobilization	LS Allowance	1	250,000	250,000	
Toe Berm					
Crush, transport and place rockfill	m^3	40,000	35	1,400,000	
Geosynthetic filter	m^2	5,400	20	108,000	
Ground Improvement					
Thermosyphons	LS Allowance	1	600,000	600,000	1
Drainage, insulation, site prep etc.	LS Allowance	1	900,000	900,000	
Seepage control and treatment		NA	NA	NA	2
Tailings					
Re-grading	m^2	71,000	5	355,000	
Soil cover (0.3m)	m^3	18,000	15	270,000	
Soil Cover Beach	m^3	20,000	15	300,000	
Beach Armouring	m^3	3,300	50	165,000	
Replace coarse tailings with fine tailings	m^3	68,000	12	816,000	3
Spillway					
Excavation	m^3	2,000	10	20,000	
Concrete Overflow	LS Allowance	1	150,000	150,000	
Geotextile	m^2	3,000	10	30,000	
Armouring	m^3	1,000	50	50,000	
South-Side Berm - Fill	m^3	500	10	5,000	
South-Side Berm - Erosion protection	LS Allowance	1	15,000	15,000	
Dome Creek Diversion (into TMA)					4
Excavation	m^3	750	10	7,500	
Geotextile	m^2	675	10	6,750	
Armouring	m^3	340	50	17,000	
Water level controls	LS Allowance	1	50,000	50,000	
Dome Creek Channel and Apron	LS Allowance	1	50,000	50,000	
Dam Raise	LS Allowance	1	25,000	25,000	
Diversion /Interceptor Ditch U/S of spillway					
Fill in interceptor ditch	m^3	3,400	10	34,000	
Fill in diversion channel	m^3	5,400	10	54,000	
Road construction - base	m^3	900	50	45,000	
Diversion channel D/S of spillway	LS Allowance	1	500,000	500,000	
Monitoring Instrumentation	LS Allowance	1	200,000	200,000	
Scale/Flatten Pit Walls	LS Allowance	1	200,000	200,000	
Pit Security - Ditch and Berm	m	1,500	50	75,000	
Subtotal				6,698,250	
Contingency - 30%				2,009,475	
TOTAL ESTIMATED COST				8,707,725	

Option 2 - Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place

Item	Units	Quantity	Unit Price	Total	Notes
Mobilization and demobilization	LS Allowance	1	250,000	250,000	
Toe Berm					
Crush, transport and place rockfill	m^3	40,000	35	1,400,000	
Geosynthetic filter	m^2	5,400	20	108,000	
Ground Improvement					
Thermosyphons	LS Allowance	1	600,000	600,000	1
Drainage, insulation, site prep etc.	LS Allowance	1	900,000	900,000	
Seepage control and treatment		NA	NA	NA	2
Tailings					
Re-grading	m^2	71,000	5	355,000	
Soil cover (1m)	m^3	60,000	15	900,000	
Vegetate Cover	m^2	60,000	3	180,000	
Drainage Swales - geotextile	m^2	5,000	10	50,000	
Drainage Swales - armouring	m^3	1,500	50	75,000	
Soil Cover Beach	m^3	20,000	15	300,000	
Beach Armouring	m^3	3,300	50	165,000	
Replace coarse tailings with fine tailings	m^3	68,000	12	816,000	3
Spillway					
Excavation	m^3	2,000	10	20,000	
Concrete Overflow	LS Allowance	1	150,000	150,000	
Geotextile	m^2	3,000	10	30,000	
Armouring	m^3	1,000	50	50,000	
South-Side Berm - Fill		500	10	5,000	
South-Side Berm - Erosion protection	LS Allowance	1	15,000	15,000	
Dome Creek Diversion (into TMA)					4
Excavation	m^3	750	10	7,500	
Geotextile	m^2	675	5	3,375	
Armouring	m^3	340	50	17,000	
Water level controls	LS Allowance	1	50,000	50,000	
Dome Creek Channel and Apron	LS Allowance	1	50,000	50,000	
Dam Raise	LS Allowance	1	25,000	25,000	
Diversion /Interceptor Ditch U/S of spillway					
Fill in interceptor ditch	m^3	3,400	10	34,000	
Fill in diversion channel	m^3	5,400	10	54,000	
Road construction - base	m^3	900	50	45,000	
Diversion channel D/S of spillway	LS Allowance	1	500,000	500,000	
Scale/Flatten Pit Walls	LS Allowance	1	200,000	200,000	
Monitoring Instrumentation	LS Allowance	1	200,000	200,000	
Pit Security - Ditch and Berm	m	1,500	50	75,000	
Subtotal				7,629,875	
Contingency - 30%				2,288,963	
TOTAL ESTIMATED COST				9,918,838	

Option 1 and 2, Alternative B (partial costs) Backfill pit with waste rock

Item	Units	Quantity	Unit Price	Total	Notes
Fill pit with waste rock	m^3	510,000	5	2,550,000	5
Vegetate waste rock footprint and surface of wasterock in pit	m^2	130,000	3	390,000	
Plug Pony Creek Adit	LS Allowance	1	250,000	250,000	6
Subtotal				3,190,000	
Contingency - 30%				957,000	
TOTAL ESTIMATED COST				4,147,000	

Option 1B and 2B (total costs)

Option 1B	12,854,725
Option 2B	14,065,838

Option 3: Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place

Item	Units	Quantity	Unit Price	Total	
Mobilization and demobilization	LS Allowance	1	500,000	500,000	
Transport and place tailings					
Setup of dredges, pumps and lines	LS Allowance	1	2,000,000	2,000,000	7
Dredge tailings	m^3	300,000	9	2,700,000	
Restore TMA					
Relocate Dam Fill to Borrow Sources	m^3	80,000	5	400,000	
Relocate Dam Fill to Pit	m^3	80,000	12	960,000	
Revegetation - seeding	m^2	75,000	3	225,000	8
Tailings dam - In pit					
Fill Material	m^3	10,000	35	350,000	
Tailings dam liner	m^2	1,000	150	150,000	
Foundation Preparation	LS Allowance	1	500,000	500,000	
Monitoring Instrumentation	LS Allowance	1	200,000	200,000	
Soil cover (1m)	m^3	21,000	15	315,000	
Spillway					
Excavation	m^3	500	20	10,000	
Geotextile	m^2	500	10	5,000	
Armouring	m^3	250	50	12,500	
Re-grade/repair cover	m^2	21,000	5	105,000	9
Plug Pony Creek Adit	LS Allowance	1	250,000	250,000	
Scale/Flatten Pit Walls	LS Allowance	1	200,000	200,000	
Pit Security	m	1,500	50	75,000	
Monitoring Instrumentation	LS Allowance	1	200,000	200,000	
Water Treatment - Capital	LS Allowance	1	1,650,000	1,650,000	10
Water Treatment - Maintenance during construction	per year	5	35,000	175,000	11
Subtotal				10,982,500	
Contingency - 30%				3,294,750	
TOTAL ESTIMATED COST				14,277,250	

Option 4: Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover

Item	Units	Quantity	Unit Price	Total	
Mobilization and demobilization	LS Allowance	1	400,000	400,000	
Transport and place tailings	m^3	300,000	15	4,500,000	12
Restore TMA					
Relocate Dam Fill to Borrow Sources	m^3	80,000	5	400,000	
Relocate Dam Fill to Pit	m^3	80,000	12	960,000	
Revegetation - seeding	m2	75,000	3	225,000	8
Waste rock placement (bottom and top)	m^3	302,000	5	1,510,000	
Soil Cover	m^2	43,000	33	1,397,500	13
Re-grade /repair cover	m^2	43,000	5	215,000	9
Plug Pony Creek Adit	LS Allowance	1	250,000	250,000	
Monitoring Instrumentation	LS Allowance	1	200,000	200,000	
Water Treatment - Capital	LS Allowance	1	1,650,000	1,650,000	10
Water Treatment - Maintenance during construction	per year	5	35,000	175,000	11
Subtotal				11,882,500	
Contingency - 30%				3,564,750	
TOTAL ESTIMATED COST				15,447,250	

General notes:

- A 30% contingency has been included to allow for design changes and items that have not been identified at the current level of design.
- Where possible, costs have been estimated based on discussions with contractors who have experience with similar work in the Yukon or other remote northern mine sites.
- Unit costs for transportation of materials (ie. waste rock, tailings, borrow material) have been estimated based on discussions with several contractors.
- Mob/Demob costs assume that the majority of the required equipment is available locally.
- For Options 1 and 2 (base cases) no additional cost has been included for the re-grading of the remaining waste rock piles. It is assumed that some re-grading is included in the costs of supplying waste rock for the toe berm and other construction activities.
- An options include an allowance for the installation of monitoring equipment.
- The estimates do not include costs associated with engineering, site investigation, monitoring or contract administration.
- Maintenance costs are considered separately.

Specific Notes:

1. Two rows of thermosyphons spaced at 2 m. The estimated cost of supplying and installing the thermosyphons was provided by the supplier who manufactured and installed the thermosyphons that are currently at the Mt. Nansen mine site.
2. It is assumed that seepage water from the TMA would not require treatment or containment (ie. status-quo).
3. A portion of the loose tailings against the dam face will be excavated and replaced with fine tailings with no net volume change in the tailings impoundment.
4. All flow from Dome Creek will be directed into the TMA and the interceptor ditch and diversion channel upstream of the spillway are abandoned.
5. The estimates for transporting waste rock into the pit (Option 1b and 2b) do not allow for extensive sorting of the waste rock.
6. The estimated cost for plugging the Pony Creek Adit was based on the designs and recent construction costs of plugging similar mine adits in the Yukon. Costs are for a massive concrete plug with grouting around the circumference of the adit.
7. Assuming that dredging is the preferred transportation method, and that tailings can be adequately blended in-pipe. Two dredges will be used simultaneously. No allowance is included for accelerating consolidation. It is assumed that an adequate water supply will be available for dredging operations.
8. The cost of valley restoration assumes basic revegetation (ie. seeding). Final closure plans may recommend more extensive restoration activities based on future assessments.
9. Re-grading of surface is assumed to be a one-time maintenance item to address uneven settlement.
10. Costs for water treatment are based on Mount Nansen Mine Water Treatment Study (AECOM 2009) and includes both capital and operating costs for the duration of the construction activities. Water treatment costs may be reduced for Option 4 if the existing pit water can be safely released into the environment without treatment, or if treatment can be done more economically in-situ.

11. There are maintenance costs associated with operating the water treatment plant. It is assumed that the treatment plant will no longer be required once 50% consolidation is achieved. (approximately 5 years). The maintenance costs assume that the treatment plant operator is already employed at the site.
12. The relocation of tailings will have minimal restrictions on sorting, placement or compaction. Tailings may be transported in winter by truck.
13. The cover cost was estimated by Golder (2010).

Environment AECOM

Yukon Government,
Assessment and Abandoned Mines Branch

Hydrogeological Characterization of the Mt. Nansen Mine Site

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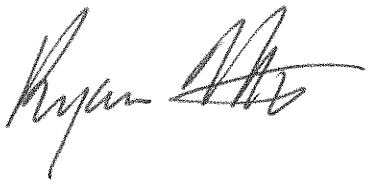

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Table of Contents

Statement of Qualifications and Limitations
Letter of Transmittal
Distribution List

page

1. Introduction 1
1.1 Background 1
1.2 Objectives 1

2. Summary of Hydrogeological Characterization Programs 1
2.1 2009 Field Investigations 2
2.1.1 Borehole Drilling and Groundwater Monitoring Well Installation 2
2.1.2 Surveying 3
2.1.3 Groundwater Sampling 3
2.1.4 Soil Sampling 4
2.1.5 Hydraulic Conductivity Testing 4
2.1.6 Pit Seepage Characterization 5
2.1.7 Physical Characterization of Tailings 5
2.1.8 Pressure Transducer Installation 6
2.2 2010 Field Investigation 6

3. Hydrogeological Conceptual Model 6
3.1 Information Sources 6
3.2 Key Assumptions 7
3.3 Geology 7
3.3.1 Surficial Geology 7
3.3.2 Bedrock Geology 8
3.4 Hydrostratigraphic Units 8
3.4.1 Overburden 9
3.4.2 Shallow Weathered Bedrock 10
3.4.3 Competent Bedrock 10
3.4.4 Tailings 11

4. Groundwater Flow 11
4.1 Shallow Groundwater Flow 11
4.2 Regional Groundwater Flow 12
4.3 Groundwater Flow Surrounding the Brown-McDade Open Pit 13
4.3.1 Regional Context 13
4.3.2 Interaction with Shallow Groundwater Flow System 13
4.3.3 Interaction with Deep Groundwater Flow System 14
4.3.4 Long-Term Pit Lake Elevations 14
4.4 Groundwater Flow Surrounding the Tailings Management Area 15
4.4.1 Regional Context 15
4.4.2 Interaction with Shallow Groundwater Flow System 16
4.4.3 Interaction with Deep Groundwater Flow System 16

5. Soil and Groundwater Quality 17

5.1 Mill Area Evaluation 17
5.1.1 Soil Sampling Results 17
5.1.2 Groundwater Sampling Results 18

6. Discussion of Inputs to Water Balance 19

6.1 Site Wide Water Balance 19
6.1.1 Shallow Groundwater Discharge to the North End of the Pit 19
6.1.2 Deep Groundwater Discharge to the North End of the Pit 20
6.1.3 Deep Groundwater Discharge from the South End of the Pit to Dome Creek 20
6.1.4 Assessment of Seepage Collection Pond Pumping Rates 20
6.1.5 Seepage Collection Pond Source Waters 21
6.2 Pit Lake Water Balance Verification (2009 – 2010) 22
6.2.1 Discharge from Pit Due to Drop of Water Table (2009 – 2010) 22

7. Hydrogeological Implications of Reclamation Options 22

7.1 Options 1A and 2A 22
7.2 Options 1B and 2B 23
7.3 Option 3 24
7.4 Option 4 24

8. Summary of Hydrogeological Uncertainty 25

8.1 Key Assumptions 25
8.2 Hydrogeologic Uncertainties 25

9. References 26

List of Figures

Figure 1 Mt. Nansen Mine Site Overview
Figure 2 Brown-McDade Pit Geology
Figure 3 Conceptual Groundwater Flow
Figure 4 Conceptual Groundwater Flow Beneath the Tailings Management Area (Section A-A')
Figure 5 Conceptual Groundwater Flow North of the Seepage Collection Pond (Section B-B')
Figure 6 Conceptual Groundwater Flow Between the Pit and Dome Creek Valley (Section C-C')
Figure 7 Brown-McDade Pit Lake Elevation (2001 – 2010)
Figure 8 Brown-McDade Pit Lake and Groundwater Elevations (2009 – 2010)
Figure 9 Precipitation and Seepage Collection Pond Pumping Rates (2006 – 2010)
Figure 10 Correlation of Precipitation and Seepage Collection Pond Pumping Rates (2006 – 2010)

List of Tables

Table 1 Summary of Groundwater Monitoring Well and Geotechnical Borehole Installation Details
Table 2 Summary of Mini-Piezometer Installation Details
Table 3 Permeability Testing Results
Table 4 Summary of Physical Soil Property Characterization
Table 5 Summary of Hydrogeological Properties
Table 6 Soil Quality Exceedences - Mill Area
Table 7 Groundwater Quality Exceedences - Mill Area
Table 8 Summary of Outstanding Hydrogeological Uncertainties

Appendices

Appendix A Borehole and Monitoring Well Logs
Appendix B Laboratory Analytical Certificates
Appendix C Groundwater Quality Analytical Results
Appendix D Permeability Testing Results
Appendix E Open Pit Geological Considerations Memo
Appendix F Physical Soil Testing Analytical Results
Appendix G Hydrogeological Calculations
Appendix H Tailings Seepage Collection Pond Water Balance Memo

1. Introduction

This report is a compilation of all hydrogeological data collected prior to June 30, 2010. It summarizes the hydrogeological investigations conducted at the Mt. Nansen mine site during the 2009 and 2010 field seasons and presents the results of the hydrogeological data analysis. This report builds on previous hydrogeological investigations including work conducted by Gartner Lee (2006, 2007 and 2008) and others. The conceptual model presented in this memo is intended to supersede previous hydrogeologic reports as it incorporates the results of the most recent field programs conducted in 2009 and 2010.

1.1 Background

Numerous investigations have been conducted at the abandoned Mt. Nansen mine site in the past. Prior to 2009, three of those investigations have involved assessment of hydrogeological elements of the site. A study conducted by Gartner Lee in 2005 was primarily focused on evaluating the pit water balance and pit lake water quality based on pit lake water level data and a modest sampling program during the summer of 2005 (Gartner Lee, 2005). In early 2007, a follow up study was commissioned to develop a hydrogeological conceptual model for the Brown-McDade open pit based on information collected during the mine permitting process and interviews with on site staff (Gartner Lee, 2007). An attempt to validate this hydrogeological conceptual model was made as part of a limited site characterization program conducted in November 2007 that involved drilling three six inch wells within and surrounding the open pit (Gartner Lee, 2008). As part of the 2007 program, hydraulic conductivity testing was conducted within the pit and catchment based calculations of groundwater travel times to Dome Creek were made. This report is intended to build upon previous work by incorporating hydrogeologic, hydrologic, geochemical and geotechnical information collected and analyzed in 2009 and 2010.

1.2 Objectives

The key objectives of the 2009 and 2010 tasks were to:

- Document drilling observations and survey all wells on site;
- Develop and sample groundwater wells in July and September 2009;
- Conduct hydraulic conductivity testing of tailings, soil and bedrock;
- Characterize groundwater seepage emanating from the north face of the pit;
- Determine the physical properties of the tailings;
- Incorporate recently collected geologic, permafrost and groundwater level information into an updated hydrogeological conceptual model;
- Evaluate groundwater flow at the site in the context of the identified closure alternatives; and
- Provide groundwater related information to facilitate development of a site-wide water balance.

2. Summary of Hydrogeological Characterization Programs

Building on historical hydrogeological evaluations, field investigations were conducted in 2009 and 2010 to address gaps identified in the hydrogeological conceptual model.

2.1 2009 Field Investigations

2.1.1 Borehole Drilling and Groundwater Monitoring Well Installation

An extensive drilling program was planned during the spring of 2009 and conducted between July 7th and July 21st, 2009. Geotech Drilling Ltd. supplied a track mounted Geoprobe 8040DT drill rig with air rotary, mud rotary and direct push drilling capabilities. It was also equipped with a split spoon sampling device and an automatic SPT hammer for geotechnical testing purposes. The same drill rig was utilized for the hydrogeological (AECOM), geotechnical (AECOM) and geochemical (Lorax) investigations. An additional hand held drill was utilized by Lorax to install shallow, narrow diameter wells within the tailings facility.

A total of 21 new monitoring wells were installed as part of the combined hydrogeological, geotechnical and geochemical investigations within and surrounding the tailings management area (TMA), north of the Brown-McDade open pit and downslope of the mill building. Additional boreholes were completed to facilitate thermistor installation on the downstream face of the dam as part of the geotechnical program and are discussed in a separate memo. Within the TMA and downstream of the mill building, all drilling was conducted using direct push drilling technology. Drilling on the downstream face of the main tailings dam and around the open pit was conducted using air rotary drilling combined with split spoon sampling within unconsolidated sediments.

Direct push drilling technology was utilized to drill all boreholes within the TMA and downstream of the mill to facilitate collection of continuous 3" (76 mm) soil cores. Boreholes drilled using direct push technology includes MW09-01, MW09-02, MW09-03, MW09-04, MW09-05, MW09-06, MW09-07, MW09-11, MW09-16, MW09-17, MW09-18 and MW09-19. All cores were brought to surface within acrylic liners, cut open and logged for geologic properties including density, colour, grain size, moisture, plasticity and cohesiveness. All geologic materials were then classified according to the Unified Soil Classification System. After logging each borehole, photographs of each run were taken and representative samples of material were collected and placed in labelled polyethylene bags for later testing. All holes drilled beneath the TMA terminated in permafrost due to drill refusal.

Air rotary drilling technology combined with the ODEX casing system was used for all drilling downstream of the main dam crest and for all boreholes in the vicinity of the open pit including MW09-08, MW09-13, MW09-14, MW09-15, MW09-20, MW09-21, MW09-22, MW09-23 and MW09-24. Geotechnical boreholes GT09-01, GT09-02, GT09-03, GT09-04 and GT09-05 were also drilled in the same way. Drilling in unconsolidated sediments on the downstream face of the tailings dam was conducted using a 4" (102 mm) air rotary/ODEX bit to drill and case from surface down to the bottom of the borehole. Standard penetration tests were conducted at regular intervals and split spoon samples were collected for later analysis.

Surrounding the open pit, drilling through the unconsolidated sediments overlying bedrock was conducted using a 4" (102 mm) air rotary/ODEX bit. After setting the casing into competent bedrock, the ODEX drill bit was retrieved and a 3-7/8" (98 mm) open hole bedrock bit was used to drill the remainder of each borehole. Drilling was completed without injecting water whenever possible. A record of bedrock encountered during drilling was preserved in chip trays by collecting chip samples approximately every 2 feet (0.61 m).

Following completion of each borehole within the TMA (MW09-01, MW09-02, MW09-03, MW09-04, MW09-05, MW09-06 and MW09-07), a flush-threaded 2" (52 mm) schedule 40 PVC groundwater monitoring well was installed through the casing. In all cases, a standard 10 slot screen was wrapped in nylon (Nitex) mesh with an opening of 5 µm to restrict the movement of tailings into each well. Screen lengths and target installation depths were selected in conjunction with Lorax staff to ensure the geochemical and hydraulic information provided by each well was optimal. Whenever possible, the use of a sand filter pack was avoided and wells were allowed to naturally develop. However, this was not always possible and 10/20 quartz filter sand was used when necessary to backfill the borehole annulus surrounding the screen. Following installation of the filter pack, each borehole was grouted to

surface using bentonite chips and a 6" (152 mm) protective PVC casing was installed at surface and backfilled with quartz sand and the well was labelled.

All monitoring wells installed elsewhere on site were completed by lowering conventional 2" (52 mm) flush-threaded PVC screen and riser pipe down the borehole and installing a 10/20 quartz filter pack. Either 10-slot or 20-slot screens were used depending on the nature of the surrounding geologic materials. After installing the filter pack to approximately 0.5 m above the top of the screen, a bentonite chip plug was installed and hydrated. After hydration of the bentonite plug above the screen, a bentonite grout mixture was prepared and pumped down the borehole using a Moyno pump until grout return was observed at surface. A protective lockable steel casing was then installed and set in concrete and the annulus between the PVC riser pipe and the steel casing was backfilled with quartz sand and the well was labelled.

To help identify the nature of interactions between groundwater and surface water, 14 mini-piezometers were installed within the Dome Creek and Pony Creek drainages and within the TMA. Some of the mini-piezometers (MP09-04, MP09-05, MP09-09, MP09-10, MP09-11 and MP09-12) were installed as 1.25" (32 mm) PVC monitoring wells by Rocky Mountain Soil Sampling using a portable gas-powered hammer under the supervision of Lorax staff. The remainder of the mini-piezometers (MP09-01, MP09-02, MP09-03, MP09-06, MP09-07, MP09-08, MP09-13 and MP09-14) were 1" (25 mm) diameter Solinst stainless steel drive points installed by AECOM hydrogeologists using a slide hammer apparatus. All drive point piezometers were fitted with LDPE tubing to facilitate water level measurement and sampling using a peristaltic pump if required at a later date.

A summary of monitoring well and mini-piezometer completion details is provided in Tables 1 and 2 and borehole logs for all monitoring wells that were part of the hydrogeological and geotechnical investigation are included in Appendix A. The location of all groundwater monitoring wells and mini-piezometers installed during the July 2009 field investigation are shown on Figure 1.

2.1.2 Surveying

Following completion of the drilling program, all boreholes, monitoring wells and other points of interest were surveyed using a Thales Promark GPS. At each monitoring well location, the ground surface elevation was surveyed immediately adjacent to the well and the well stickup was measured. Following completion of the survey, the data was post-processed to provide corrected elevations of the ground surface surrounding each groundwater monitoring well. The elevation of the top of each piezometer was then calculated using the surveyed ground elevation and the measured vertical stickup of each monitor. A summary of surveyed borehole and monitoring well co-ordinates is provided in Table 1. Additional survey data was collected in the vicinity of the dam and open pit during 2010.

2.1.3 Groundwater Sampling

Prior to groundwater sample collection, each monitoring well was developed to improve the hydraulic connection between the well and the aquifer and remove drill cuttings from the borehole. Generally, a surge block and inertial footvalve was installed on 5/8" (16 mm) HDPE tubing and lowered to just above the well screen. Pumping was initiated above the well screen and the assembly was slowly lowered deeper into the well. Where permeability of the surrounding formation was sufficient, a Waterra Hydrolift was used to provide continuous pumping. Each well was developed for approximately one hour and then allowed to recover. In some cases, additional development was conducted due to the presence of suspended sediment in purge water.

Following well development, groundwater samples were collected using inertial footvalve pumps for wells surrounding the mill, wells located on the downstream face of the tailings facility and wells located in the vicinity of the open pit. Select wells located within the TMA and on the downstream face of the dam where parameters

sensitive to redox conditions were to be analyzed were purged until field parameters stabilized and sampled using low-flow bladder pumps. The majority of groundwater sampling within the TMA was conducted by Lorax staff. Static groundwater levels were collected prior to sample collection in both July and September 2009 and in June and August 2010 are presented in Tables 1 and 2.

Two sets of groundwater samples were collected, with the first set of groundwater samples collected during the second and third week of July 2009 and the second set of samples collected during the first week of September 2009. Field parameters including pH, conductivity and temperature were recorded prior to collecting each sample. Samples were collected in laboratory provided bottles and placed in coolers complete with ice packs for shipment to the ALS Environmental, a CAEAL accredited laboratory located in Vancouver, British Columbia for analysis. Groundwater samples collected as part of the hydrogeological investigation were analyzed for pH, conductivity, total dissolved solids, hardness, ammonia, nitrate, nitrite, dissolved anions, cyanide species, total organic carbon and dissolved metals. In addition to the above analyses, light extractable petroleum hydrocarbons (LEPH), heavy extractable petroleum hydrocarbons (HEPH) and polycyclic aromatic hydrocarbons (PAHs) were analyzed in samples collected from wells downslope of the mill building as part of a preliminary contaminant investigation targeted at identifying whether any large scale fuel or cyanide spills were impacting groundwater downgradient of the mill site. Dissolved metals samples were field filtered and preserved with nitric acid prior to shipment, while nutrient parameters were preserved with sulphuric acid and some cyanide species were preserved with sodium hydroxide. The remainder of the parameters were shipped to the laboratory unpreserved. The original laboratory results are provided in Appendix B. The results of the analytical testing conducted in 2009 by AECOM and Lorax are tabulated in Appendix C.

2.1.4 Soil Sampling

During installation of groundwater monitors MW09-15, MW09-16, MW09-17 and MW09-18 downslope of the mill building, soil samples were collected from the continuous soil cores brought to surface during direct push drilling for the purposes of hydrocarbon and metals analysis. Two soil sample jars were filled from discrete intervals at or near the water table to help identify the presence of any light non-aqueous phase liquid (LNAPL) or metal contamination as a result of any fuel or ore concentrate spills in the area surrounding the mill building. All samples were collected by hand using latex gloves. Large rocks were removed from the soil prior to placing it in the sample jars. Following sampling, soil samples were placed in coolers complete with ice packs and shipped to ALS Environmental in Vancouver, British Columbia for analysis of LEPH, HEPH and metals. The original soil analytical results are provided in Appendix B.

2.1.5 Hydraulic Conductivity Testing

In order to understand the permeability of the various overburden and bedrock units found on site, rising and falling head slug tests were conducted in MW09-02, MW09-03, MW09-06, MW09-15 and MW09-23. In each case, the static groundwater level was measured using an electronic water level tape and a Solinst pressure transducer attached to a direct read cable was installed to a pre-determined depth and programmed to record groundwater pressure and temperatures at 1 second intervals. After allowing the water level to re-equilibrate, a solid slug of known dimensions was lowered into the well to displace the water column. After the water level recovered to static water level, the solid slug was removed. After the water level had again recovered to static, the pressure transducer was downloaded and removed from the well. This process resulted in a pair of slug tests for each well consisting of one falling head test and one rising head test. All slug test data was analyzed using the Bouwer and Rice solution for an unconfined aquifer. The results of the slug test analyses are presented in Appendix D.

Historical hydraulic conductivity measurements were made in well GLL07-03 shortly after well completion. One rising head slug test and one constant head pumping test were conducted in November 2007, yielding hydraulic

conductivities of 2.7 x 10^{-6} m/s and 1.6 x 10^{-6} m/s, respectively. Long-term pit lake level declines during the winter months have also been used to estimate the hydraulic conductivity of the underlying bedrock. This analysis assumed that there were no other inputs or outputs from the pit lake during the winter months other than seepage from the pit to the underlying groundwater system. This analysis resulted in an estimated hydraulic conductivity of 1 x 10^{-7} m/s.

Additional ex-situ hydraulic conductivity analyses of tailings samples were conducted by Golder Associates in 2010, yielding a range of hydraulic conductivity values for clay (1.1 x 10^{-7} to 1.8 x 10^{-8} m/s), silty sand (8.1 x 10^{-6} to 8.4 x 10^{-6} m/s) and manually mixed tailings (2.6 x 10^{-8} to 4.8 x 10^{-10} m/s).

All available hydraulic conductivity data collected at Mt. Nansen is summarized in Table 3.

2.1.6 Pit Seepage Characterization

During the July and September 2009 field programs, an attempt was made to characterize the volume and quality of seepage entering the north end of the Brown-McDade pit through one of the abandoned cross-cut drifts. During the July visit, the site was accessed by boat and inspected on July 13, 2009 by two AECOM hydrogeologists. At the time of inspection, the drift remained largely full of ice from the previous winter, but evidence of slow melting was observed in the form of small runoff channels in the surface of the ice. Occasional drips of water were also falling from the ceiling at the time of the site visit. During the September site visit, the drift was again inspected and ice was still present in the drift, with only occasional dripping from the drift ceiling which formed a small puddle on the drift floor. Unfortunately no direct measurements of flow into the pit could be made as a result of the ice blockage (July) and general lack of concentrated flow (both July and September).

The presence of numerous north trending faults and the long-term weathering of shallow bedrock has likely resulted in inflows to the pit that take place largely below ground surface and are thus, immeasurable. However, the presence of a large block of ice in the drift, dripping water from the drift ceiling and the presence of a large icing which forms on top of the resistant quartize beds above the drift during fall and early winter indicates a shallow input of groundwater to the pit. During the fall and winter of 2009/10, this icing did not form. Because the summer of 2009 was relatively dry, it is inferred that this shallow active layer discharge to the open pit only occurs in years with moderate precipitation. The geologic structure north of the pit is well described by R. Strohshein in a memo dated August 21, 2009 (Appendix E). The input of groundwater to the pit is most likely the result of flow through the shallow active zone and along northerly trending faults that are exposed in the pit walls and are inferred to extend beneath the Pony Creek channel which provides a source of recharge to the shallow groundwater system.

2.1.7 Physical Characterization of Tailings

To provide an understanding of the physical properties of on site materials including the coarse and fine fractions of tailings and the dam foundation materials, several soil samples were collected from 3" (76 mm) Geoprobe acrylic liners employed during direct push drilling in the vicinity of the TMA. After the soil core was logged, sampling intervals were identified based on soil texture and an understanding of site geology. Each soil sampling interval was separated from the remainder of the core using a utility knife and slid into tared heavy duty polyethylene sample bags for weighing in the field. Each sample bag was labelled with borehole and sampling interval information as well as the sample weight. Because samples were only obtained from full sections of core (i.e., no core loss), the soil volume was known and a field wet density was calculated. The results of field density calculations are provided in Table 4.

Following sample collection and measurement of field wet density, samples were shipped to MDH Engineered Solutions in Saskatoon, Saskatchewan for determination of grain size distributions, water contents, specific gravity,

Atterberg limits and soil moisture characteristic curves, as appropriate. Original laboratory analytical certificates are provided in Appendix F.

2.1.8 Pressure Transducer Installation

Only one pressure transducer was installed in the pit lake prior to the 2009 field investigation. In order to monitor seasonal groundwater level fluctuations and verify the conceptual model of groundwater flow surrounding the pit, three pressure transducers were installed in monitoring wells GLL07-01, GLL07-03 and MW09-15 in July 2009.

2.2 2010 Field Investigation

As part of the 2010 field program, a site visit was conducted on June 30, 2010 to discuss previously identified potential remedial options with other technical staff on site and collect additional hydrogeological information. A second site visit was conducted on August 9, 2010 to collect groundwater level measurements and download pressure transducers.

The pressure transducer monitoring the pit lake has historically required manual surveying of the pit lake water level each time the datalogger was downloaded. To provide an element of redundancy in data collection and preclude the need for manual surveying, an additional pressure transducer was installed in the pit lake in a fixed position. The permanent pit lake elevation monitoring station consisted of Schedule 80 PVC pipe anchored to bedrock to afford some protection against winter ice. The newly installed pressure transducer is equipped with a direct-read cable to facilitate the collection of the recorded data and avoid moving the logger after each data collection event. A second pressure transducer was also installed in monitoring well GLL07-03 to monitor atmospheric pressure variations and facilitate barometric compensation of pressure transducer data. An engineering level survey was completed to obtain the geodetic elevation of the pit lake and facilitate the merger of the new pit lake data with the historical dataset.

Because groundwater levels dropped below the elevation of the pressure transducer in GLL07-03 during the spring of 2010, the pressure transducer in was lowered to a greater depth to ensure the full range of seasonal groundwater fluctuations are captured in the future.

Overall, groundwater levels and other field observations were consistent with previous information. Manual groundwater level measurements in monitoring wells and mini-piezometers were similar to 2009 measurements and together with pressure transducer data, helped to establish the range of seasonal water table fluctuations. Information collected in 2010 is consistent with the site conceptual model developed in 2009 and refined in 2010.

3. Hydrogeological Conceptual Model

3.1 Information Sources

The following information, provided by others and/or in previous studies, was:

- Geological mapping of the area surrounding the Brown-McDade open pit and anecdotal information pertaining to groundwater inflows during mine operations was provided by Altura Environmental Consulting, Robert Stroshein and Yukon Government;
- Groundwater quality data for wells located within the TMA was provided by Lorax Environmental.

- Hydrogeologic information collected during mineral exploration and previous geotechnical and hydrogeological investigations; and
- Pit water levels and tailings seepage collection pond pumping rates (Yukon Government).

3.2 Key Assumptions

The following assumptions were invoked during development of the hydrogeological conceptual model for the site:

- Permafrost is generally continuous on north-facing aspects and in native soils insulated by a layer of organics;
- Permafrost is impermeable;
- Stunted vegetation is indicative of the presence of underlying permafrost;
- Groundwater flow is homogeneous and isotropic;
- the deep groundwater table is a subdued replica of surface topography;
- Dome Creek and Pony Creek function as groundwater flow divides in the lower reaches of their respective catchments; and
- Deep groundwater catchments for Dome Creek and Pony Creek are separated by a no flow boundary running from northwest to southeast between Pony Creek and the northern end of the Brown-McDade pit.

3.3 Geology

3.3.1 Surficial Geology

Surficial geology of the Victoria Creek area has been described in detail by Jackson (1997) and others (EBA, 2009). It is well recognized that the extent of the most recent glaciation did not reach the Mt. Nansen property and the well defined glacial limit of the last glaciations is approximately 30 km east of the mine site. During July 1994, an exploratory drilling program was conducted within the Dome Creek catchment as part of the tailings pond site selection process. Based on the results of all investigations conducted to date, overburden typically ranges in thickness from less than one metre on upland bedrock outcrops to in excess of 20 metres in the centre of the Dome Creek valley.

The predominant soil type within the study area is colluvial blanket sediments, which mantle bedrock throughout much of the study area and range from less than one metre to in excess of 50 metres thick in large landslides (Jackson, 1997). One hole drilled by Archer-Cathro in 1981, revealed colluvium and lacustrine sediments approximately 20 metres thick along the ridge between Dome Creek and Pony Creek. Within the upper Dome Creek valley, complex alluvial sediments are confined to a relatively narrow, linear band along the axis of Dome Creek. At the headwaters, these alluvial complex sediments are overlain by blanket bog sediments less than one metre thick. Near the tailings management area (TMA), the alluvial sediments are overlain by a silty fine to medium aeolian sand that is up to 15 metres thick and was used for borrow material during construction of the tailings dam. Distinctive bedding was observed within the aeolian sand during the July 2009 field program near the confluence of Dome Creek and the diversion channel. Overburden was reported by BYG Resources (1994) to be up to 20 m thick in the centre of the Dome Creek valley. A layer of glacial till overlies bedrock at the confluence of Dome Creek and Victoria Creek, which is in turn overlain by relict alluvial terrace sediments and recent alluvial fan deposits. A small meltwater channel is also present on the south-facing slopes of the Dome Creek valley, just west of the Brown-McDade pit (Jackson, 1997).

Organic soil horizons were observed in several boreholes and test pit locations within the tailings management area. It appears that the tailings were deposited directly on top of the native organic soil layer. A layer of moss

approximately 0.2 to 0.3 metres thick is present throughout much of the Dome Creek valley and mantles the aeolian sand and alluvial sediments in the area surrounding the TMA. During the July 2009 drilling program, the White River ash layer was observed beneath the surficial organic soil horizon in several boreholes, test pits and along road cuts within the Dome Creek valley. The ash layer was observed to be up to three inches (76 mm) thick and rested on top of a buried organic horizon that was in turn underlain by organic rich silty sand.

3.3.2 Bedrock Geology

Bedrock geology of the Mt. Nansen area is described in detail in Strohshein (1999). The Brown-McDade gold-silver deposit in the Mount Nansen mine area is located in the Dawson Range within Yukon-Tanana Terrane (YTT). The YTT Early Mississippian metamorphic rocks are intruded by several plutonic suites (Stroshein, 1999). The bedrock geology of the Mount Nansen property consists of highly deformed Upper Paleozoic or older gneiss and schists that are intruded by Upper Triassic/Juassic granodiorite and syenite batholiths (BYG, 1994). Mid to late Cretaceous mafic to felsic stocks, dykes, volcanic flows and pyroclastic rocks have also intruded into the other rock types. In addition, a series of subparallel anastomosing veins occur in a 2.5 km wide belt that bear precious metals and extend the length of the property. The veins strike northwesterly and exhibit steep northeasterly to moderate southeasterly dips and crosscut all rock types. During August 2009, the geology of the pit and surrounding area was mapped in detail (Stroshein, 2009). The results of the geologic and structural mapping exercise were compiled into a memo (Appendix E) and are represented graphically in Figure 2.

The Brown-McDade open pit occurs in a major northwest trending zone of structural weakness that has undergone multiple episodes of faulting since the emplacement of the ore deposit. According to Stroshein (2009), the host rocks consist of a layered metamorphic sequence in contact with Cretaceous aged hornblende diorite to hornblende granodiorite. This sequence is composed of metamorphosed sedimentary, volcanic and igneous rocks and appears to dip to the north at a shallow angle. The intrusive suite is coeval with the Mount Nansen volcanic rocks in the area. The strongest mineralization was found in a 3 to 40 m wide band located in the hanging wall of the footwall fault and surrounding quartz veins. Altered wall rocks and clay gouge are commonly found associated with the quartz veins and are reported to exist within the identified footwall fault.

Multiple fault and shear zones occur within the vicinity of the open pit. Fault zones are commonly coarse granular host rock or sandy, with some clay content. The fault zones are strongly weathered and reportedly range from less than one metre to five metres in thickness. In some cases, the faults coalesce into zones consisting of multiple faults. The major hanging wall and footwall faults form a graben structure that trends northwest. These major faults are in turn crosscut by a second series of faults that trend north to northeast and are generally steeply dipping to the east or west.

The study area was not glaciated during the last period of continental glaciation and as such, bedrock is deeply fractured and weathered, especially within the faulted and altered sequences. The deep (north) end of the Brown-McDade pit was minded to the depth of weathering.

3.4 Hydrostratigraphic Units

Based on the available information, the following four hydrostratigraphic units have been incorporated into the conceptual flow model:

- Overburden;
- Shallow weathered bedrock;

- Competent bedrock; and
- Tailings.

Each of these units may be frozen or unfrozen based on the presence or absence of permafrost. The area is classified as exhibiting discontinuous permafrost and drill refusal as a result of frozen ground was noted in numerous drill logs, particularly at locations with north facing aspects and within the upper reaches of Dome Creek. Permafrost was also encountered in several boreholes drilled within the TMA as part of both the current and prior (Kwong, 2001) investigations. Permafrost was also encountered while drilling MW09-11, located west of the diversion ditch and south of the Dome Creek channel and completed in native aeolian sand. A number of thermistors have been installed in the vicinity of the TMA, confirming the presence of permafrost within the north and south abutment of the main tailings dam and within the seepage dyke downstream of the seepage collection pond. Boreholes drilled north of the Brown-McDade open pit as part of the 2009 drilling program revealed permafrost in several boreholes including MW09-13, MW09-14, MW09-15 and GLL07-01. The presence of stunted vegetation within both the Pony Creek and Dome Creek catchments indicates that permafrost is relatively widespread in the study area. Permafrost is inferred to function as a no-flow zone (barrier) with respect to groundwater flow. Where permafrost is present, a zone of seasonally unfrozen ground overlying permafrost (active layer) develops during the summer and fall months. A complete discussion of groundwater flow including the seasonality of flow within each hydrostratigraphic unit is provided in Section 6.3.

3.4.1 Overburden

This unit is the uppermost geologic unit and overlies shallow weathered bedrock in most places. It is generally comprised of a combination of glacial, aeolian and alluvial/colluvial deposits depending upon the location within the study area. Overburden is thin to non-existent on topographic (bedrock) highs and within the upper portions of the Dome Creek and Pony Creek catchments, but is greater than 20 metres thick in the lower reaches of the valleys. Where present in upland areas, overburden consists of a thin veneer of colluvium (Jackson, 1997). Surrounding the TMA, fine to medium aeolian sand deposits overlay alluvium and colluvium. Downvalley, this unit is anticipated to be several meters thick and consist primarily of alluvium. Several placer mining claims exist within the Pony Creek and Back Creek catchments.

The physical properties of the overburden have the potential to be quite variable within the study area. Within the Dome Creek valley, slug tests were conducted in MW09-03 (organics/aeolian sand beneath TMA) and MW09-23 (aeolian sand dam fill), producing hydraulic conductivity values of 5.5×10^{-6} m/s and 1.3×10^{-5} m/s, respectively. As such, the hydraulic conductivity of the overburden unit (where unfrozen) is anticipated to range from 10^{-4} m/s to 10^{-6} m/s. Given the texture of the predominant material within the catchment, porosity is anticipated to be approximately 30%. This unit is generally unsaturated within the upland areas of the study area and hosts a water table aquifer within the lower Pony Creek and Dome Creek valleys.

Within upland areas, permafrost is inferred to define the base of this unit over a large portion of the study area. As such, the lateral and vertical extent of the aquifer overlying permafrost changes seasonally. During the frozen months (late fall, winter and early spring), the aquifer within the overburden unit does not transmit significant quantities of water. During the unfrozen months (late spring, summer and early fall), this unit progressively thaws from ground surface downward and forms a seasonal aquifer on top of permafrost. Within the lowland portions of the study area, this hydrostratigraphic unit is inferred to host moving groundwater year round as it receives groundwater discharge from the deeper regional groundwater flow system throughout much of the year.

In the vicinity of the TMA, low permeability tailings and dam fill (primarily aeolian sand) have been deposited on top of native soil and bedrock as shown on Figures 1, 3, 4, 5 and 6.

3.4.2 Shallow Weathered Bedrock

This unit lies beneath overburden and above relatively unweathered competent bedrock throughout much of the study area. Where overburden is not present, this unit forms the uppermost hydrostratigraphic unit. It is derived from the underlying bedrock material that has been affected by a suite of weathering processes including faulting, frost-shattering, solution leaching and oxidation. The base of the weathered bedrock hydrostratigraphic unit is defined by the depth of weathering, which ranges from five metres at the north end of the pit to in excess of 70 metres at the south end of the pit. In the spatial context, this unit is inferred to be thicker in upland areas and thinner in lowland areas. The breccia pipe at the north end of the pit was mined from the pre-mining ground surface down to the full depth of weathering during mine operations (Stroshein, 2009).

The physical properties of the shallow bedrock unit are anticipated to be relatively similar throughout the study area. This hydrostratigraphic unit was largely unsaturated or frozen at all boreholes drilled north of the pit, so hydraulic conductivity testing could not be conducted. Information from one slug test in GLL07-03, (completed in the shallow weathered bedrock unit below the pit) suggests that the bulk hydraulic conductivity of the weathered bedrock mass underlying the open pit is about 2.7×10^{-6} m/s. Similarly, a constant head pumping test also conducted in GLL07-03 indicated a hydraulic conductivity of 1.5×10^{-6} m/s. Based on field observations (structure, jointing, hardness, etc.) and the understanding that bedrock is highly weathered due to a lack of recent glaciations, it is inferred that the porosity of weathered bedrock is on the order of 10%. Most of this unit is unsaturated within the upland portions of the Dome and Pony Creek catchments, but may be saturated at depth or beneath surface water courses such as Pony Creek. This unit primarily functions as a conduit for vertical groundwater recharge from surface to the regional water table, but may host the regional water table where the depth of weathering is extensive (i.e., around topographic highs). Shallow locally perched flow systems may also be present on top of lower hydraulic conductivity horizons or permafrost within the larger, otherwise unsaturated hydrostratigraphic unit.

3.4.3 Competent Bedrock

This unit is the deepest hydrostratigraphic unit within the hydrogeological conceptual model. It underlies the weathered bedrock unit over the majority of the study area and consists of relatively competent bedrock. Within the upland portions of the study area, this hydrostratigraphic unit generally hosts the regional groundwater table. Complex geologic structure within the suite of rock types has resulted in numerous fault sets that cross each other at various angles within the study area (Stroshein, 2009). These faults, together with other joint sets and geologic contacts, form the dominant pathways for groundwater flow within competent bedrock.

The pit lake within the Brown-McDade open pit is underlain by relatively competent bedrock as the majority of the weathered bedrock was removed as ore and waste rock during mining. The rate of water level decline in the pit lake during frozen winter months suggests that the bulk hydraulic conductivity of the relatively competent bedrock mass underlying the open pit is approximately 1×10^{-7} m/s (Gartner Lee, 2005). A slug test conducted in MW09-15, which is completed within a north-south trending fault, determined that the hydraulic conductivity of the faulted zone was on the order of 1.2×10^{-6} m/s. The same borehole produced approximately 7 L/min (0.12 L/s) during air development prior to well installation. As such, the hydraulic conductivity of the competent bedrock unit is inferred to range over approximately one order of magnitude from 1×10^{-6} m/s to 1×10^{-7} m/s. Structural discontinuities within the competent bedrock unit, including those shown on Figure 2, appear to be more permeable than the surrounding competent bedrock. The porosity of massive, competent bedrock is assumed to be on the order of 1% (Freeze and Cherry, 1979), while the porosity of weathered materials within zones of structural weakness are inferred to be 10%, and similar to the overlying hydrostratigraphic unit. The inferred porosity of 1% is consistent with the measured water level rise in MW09-15 during snowmelt in 2010, where 110 mm of snowmelt (Yukon Environment, 2010) brought about nearly 10 metres of water table rise north of the open pit. This unit is not anticipated to be heavily impacted by permafrost and is inferred to be largely unfrozen.

3.4.4 Tailings

This unit is restricted to the area immediately upstream of the tailings dam as shown in Figure 1. It ranges from less than one metre thick at its edges to greater than 12 metres thick in the centre of the TMA. The tailings range in particle size from sand to clay and are underlain by native organic material. Surface water ponds on top of the tailings as a result of onset precipitation and snowmelt and subsequently infiltrates through the tailings, reporting to the underlying groundwater system. In-situ slug tests conducted in silty sand tailings at MW09-02 and silty sand and clay tailings at MW09-06 indicate hydraulic conductivity ranges from 1.04×10^{-6} m/s to 2.04×10^{-6} m/s for silty sand tailings. Additional ex-situ permeameter testing on a variety of tailings samples indicated that hydraulic conductivity can be expected to range from 1.1×10^{-5} m/s to 4.8×10^{-10} m/s. The results of physical testing indicates that tailings exhibit a range in porosity values from 30% for sandy tailings to 50% for clay tailings.

4. Groundwater Flow

Groundwater levels measured during 2009 and 2010 are summarized in Tables 1 and 2, with pressure transducer data collected in the vicinity of the open pit shown on Figures 7 and 8. A map depicting inferred deep groundwater flow pathways is shown on Figure 3. Three cross-sections illustrating groundwater flow beneath the TMA, north of the seepage collection pond and between the open pit and the Dome Creek valley are presented in Figures 4, 5 and 6.

Two groundwater flow systems are present within the study area. During warmer weather, a shallow flow system is present within the active zone on top of permafrost (where present), and a second flow system is present year-round within the deep regional bedrock aquifer. These two systems interact with each other through unfrozen windows in permafrost and where permafrost is generally absent. Groundwater flow is discussed below in the context of the groundwater flow pathway, from recharge through to discharge. At the local scale, the predominantly north-south trending geologic structure will likely influence groundwater flow pathways and hydraulic gradients. However, bedrock is highly fractured, faulted and weathered, and for the purposes of this regional assessment of groundwater flow, it is assumed that groundwater flow is homogeneous and isotropic at the regional scale.

4.1 Shallow Groundwater Flow

The shallow groundwater flow system is hosted entirely within the active zone within the overburden and shallow weathered bedrock hydrostratigraphic units. Shallow groundwater flow occurs seasonally and largely depends on the thickness and extent of the active layer. During frozen months, much of the overburden and shallow weathered bedrock units freeze, and the source of recharge reporting to this aquifer is dramatically reduced or eliminated. Groundwater flow within this unit is assumed to cease when the ground has frozen from surface down to permafrost each winter and begins flowing again in the late spring or early summer following snowmelt.

After the air temperature has dropped below freezing in the fall, but before the aquifer has frozen down to permafrost, groundwater continues to discharge from the shallow groundwater flow system along road cuts and into the pit causing icings to form. Within the Brown-McDade open pit, a large icing forms at the north end of the pit, extending from the uppermost bench down to the surface of the pit lake during early winter months. The icing forms just above the resistant quartzite bedrock identified during geologic mapping at the north end of the pit (Stroshein, 2009) and melts completely over the course of the spring and summer, with discharge reporting to the pit lake as shown on Figure 6.

Throughout the remainder of the upper Dome Creek and Pony Creek catchments, shallow groundwater is anticipated to flow from topographic highs toward topographic lows within the active layer, and eventually discharges to Pony Creek and Dome Creek in the valley bottoms. Where permafrost is not present, groundwater may move vertically into the deeper regional flow system. Where present, permafrost is inferred to restrict recharge to both the shallow and deep groundwater systems and encourage runoff. Beneath the tailings management area, most groundwater flow is inferred to take place above permafrost within the native organic material and underlying sands. The majority of boreholes drilled beneath the tailings management encountered refusal on permafrost, suggesting that the shallow and deep groundwater systems are generally isolated from one another.

Groundwater flow divides within the shallow system are inferred to conform to surface drainage divides. In the vicinity of the open pit, shallow groundwater flow is influenced by the presence of waste rock piles and permafrost. Aggradation of permafrost into the waste rock piles was confirmed during the 2009 field investigation by Altura Environmental Consulting (Altura), who identified permafrost within 20 cm of the surface on the lower west pile and on the south facing slopes of the Dome Creek valley. The 2009 drilling investigation conducted by AECOM also identified the presence of permafrost within waste rock at the northern extent of the east pile and in all other boreholes drilled north of the open pit. The shallow groundwater catchments provided by Altura were discussed in detail in a separate memo (Altura, 2009). The extent of permafrost along the groundwater flow path between the open pit and the TMA is shown conceptually on Figure 6. However, the depth and spatial extent of permafrost have not been confirmed along this groundwater flow pathway.

4.2 Regional Groundwater Flow

The regional groundwater table is inferred to reside within the weathered and competent bedrock units in the upland areas, and within alluvium and organic materials along the lower flanks of the Dome Creek and Pony Creek valley, where groundwater discharges to surface. Permafrost has been observed in the unconsolidated sediments within and downslope of the waste rock piles and TMA; however, the substantial variation in the density, condition and type of vegetation on the south-facing slopes of the Dome Creek valley indicates that permafrost is not continuous within the Dome Creek or Pony Creek valleys. It is assumed that shallow and deep groundwater flow systems will only receive recharge from surface through the unfrozen windows in a landscape that is otherwise mantled by permafrost.

Based on field observations of strong upward groundwater gradients and a lack of permafrost encountered during shallow well installation, the shallow and deep groundwater flow systems connect below the seepage collection pond in the Dome Creek valley and below 1175 m ASL within the Pony Creek valley. Where organics are present, permafrost has been preserved, and the shallow and deep groundwater systems appear to be isolated from one another. Within the Dome Creek valley bottom, particularly near the TMA and in the lower reaches of Dome Creek, the valley bottom aquifer is inferred to discharge to Dome Creek year round. This is supported by recent (2009 – 2010) pumping records from the seepage collection pond that indicate minimum winter pumping rates (calculated on a daily basis) were on the order of 3.5 L/s during the 2009 /2010 winter season and between July 17, 2009 and July 12, 2010 and average pumping rates were 5.11 L/s.

Pony Creek drains a much smaller catchment than Dome Creek. Surficial unconsolidated deposits are limited within the upper portion of the Pony Creek channel (i.e., above 1160 m ASL). Numerous exploration trenches in the Pony Creek catchment confirm that overburden is relatively thin (< 2 m) and the creek often flows directly over shallow fractured bedrock. Mini-piezometers installed in the upper reaches of Pony Creek (MP09-01, MP09-02 and MP09-03) generally indicate flat or slightly downward hydraulic gradients on all measurement dates in 2009 and 2010, suggesting a losing stream located above the regional water table. Within the lower reaches of Pony Creek (MP09-08), a strong upward groundwater gradient was observed on all measurement dates, indicating groundwater

discharge to the stream from the weathered bedrock and alluvial sediments underlying the stream channel. Permafrost was not encountered during installation of any mini-piezometers in the Pony Creek stream channel.

4.3 Groundwater Flow Surrounding the Brown-McDade Open Pit

Groundwater flow in the area surrounding the Brown-McDade open pit is complex and its interaction with the shallow and regional groundwater flow systems merits further discussion. Groundwater levels measured in September 2009 and inferred groundwater flow directions in the area surrounding the open pit are shown in plan and cross-section on Figures 3 and 6, respectively.

4.3.1 Regional Context

Based on field observations and anecdotal information, very little groundwater discharges to the pit above the elevation of the pit lake. However, groundwater discharge to the pit lake has been observed in two locations: 1) above the resistant quartzite bedrock; and, 2) from the easternmost exploration drift at the north end of the pit. This is consistent with the conditions (i.e., deep water table) that would promote the development of an oxidized ore body to significant depth.

The highly fractured and faulted (more permeable) zone surrounding the Brown-McDade pit is inferred to provide a preferential pathway for groundwater flow from Pony Creek toward the north end of the open pit. Several piles of dredge material were placed within the creek channel during historical mineral exploration trenching programs. These dredge spoils appear to inhibit surface water drainage within the Pony Creek channel, and have created several pools of water along an otherwise linear drainage feature. These pools may promote infiltration of surface water to the underlying shallow fractured bedrock aquifer.

Based on long-term pit lake elevations and recent monitoring of the groundwater system surrounding the pit, the pit lake is inferred to be a surficial expression of the regional water table (i.e., pit lake levels are hydraulically connected to the regional water table elevation). During the winter months, the water table is inferred to drop below the elevation of the pit lake, causing downward movement of water from the pit lake to the underlying regional groundwater system. During wet weather periods, groundwater elevations surrounding the pit rise, and groundwater is discharges into the pit lake. The influence of seasonal changes in precipitation on the groundwater system and pit lake elevations is shown in Figure 8. Compared to the groundwater system, the pit lake shows relatively minor fluctuations in response to precipitation events, whereby pit lake elevations have ranged from ~1,181 m ASL to ~1184.5 m ASL (3.5 m) between 2001 and 2010, and groundwater elevations surrounding the pit ranged from ~1,183 m ASL to ~1194 m ASL between 2009 and 2010. This difference is inferred to be primarily the result of differences in porosity. Groundwater elevations frequently exhibit seasonal fluctuations on the order of several metres in low porosity, low permeability bedrock settings similar to those found at Mt. Nansen.

4.3.2 Interaction with Shallow Groundwater Flow System

The majority of flow from Pony Creek to the pit occurs within the shallow fractured bedrock unit. This groundwater flow pathway is evident during late fall and early winter months when a large icing forms on the pit wall at the north end of the pit, discharging to surface slightly above the resistant quartzite beds at approximately 1,195 m ASL. Based on field observations, this groundwater flow pathway is active during two periods of time in the year. During the months of May and June, discharge from the shallow weathered bedrock zone has been observed in some years following the melting of the active layer and in response to snowmelt and freshet in Pony Creek. Groundwater discharge from the shallow weathered bedrock unit to the north end of the pit has also been observed during the months of October, November and December following September and October rainfall, but prior to full freeze back

of the active layer. For the remaining months of the year, this groundwater flow pathway is assumed to be frozen (January to April) or unsaturated (July to September). Based on well yields north of the pit and measured groundwater gradients, the magnitude of groundwater flows through this shallow flow system was estimated to be on the order of 750 m^3 each year as shown in Appendix G. Using an inferred porosity of 10%, the groundwater travel time from Pony Creek to the open pit was estimated to be 157 days or 5.5 months (Appendix G). Groundwater discharge from the active layer to the open pit was not observed over the winter of 2009/2010 as a result of a fairly dry summer and fall in 2009.

4.3.3 Interaction with Deep Groundwater Flow System

At the north end of the pit, the remnants of two exploration drifts remain as short (< 5 metre) tunnels into bedrock approximately four metres above the long-term average pit lake elevation of 1182.4 m ASL. All field observations to date indicate that the westernmost drift remains dry year round. During most of the year, the easternmost drift is full of ice. Groundwater input to the pit from the easternmost drift at the north end of the pit has only been directly observed during the late summer and early fall months after ice in the drift has melted. Groundwater has been observed to drip from the spine of the drift to the floor and seep downward through the floor into bedrock. Groundwater flow in the vicinity of the pit is illustrated in section on Figure 6. Based on geological mapping and measured groundwater elevations, this drift is located within highly faulted bedrock and intercepts the water table. The hydrogeological conceptual model could be tested by conducting a tracer test between Pony Creek and the north end of the pit lake.

Pressure transducer data collected in monitoring wells north of the pit (MW09-15) and within the pit (GLL07-03) are shown on Figure 8 along with pit lake elevations and available precipitation data. For nearly the entire year (July 2009 – June 2010), a north to south gradient is present within the deep regional groundwater flow system. This results in groundwater discharge to the pit lake at the north end of the pit. Based on measured gradients over the 11 month period from July 17, 2009 to June 16, 2010, the groundwater contribution to the open pit from the north was estimated to be 298 m^3/yr. Because the pit is located on top of a sloping water table, a downward gradient prevails at the south end of the pit lake, indicating discharge of water from the pit lake to the deep regional flow system for much of the year. Water eventually flows out of the pit at the southern end, flowing downgradient toward the Dome Creek valley.

Groundwater discharge from the pit lake to the Dome Creek diversion channel and groundwater travel times were estimated using the long-term (2001 – 2010) average gradient as shown in Appendix G. Groundwater discharge is estimated to be on the order of 4,249 m^3/yr, but could be significantly lower (157 m^3/yr) if bedrock permeability is lower. Groundwater travel times are estimated to be on the order of 1 year, but could range quite significantly (i.e., 1 – 26 years) depending on the hydraulic conductivity and porosity of the bedrock unit or the geologic structure in which the groundwater is flowing (Appendix G). For the purposes of this assessment, a porosity of 1% was assumed for the competent bedrock unit.

4.3.4 Long-Term Pit Lake Elevations

Long-term monitoring of pit lake elevations between 2001 and July 1, 2010 indicate that the elevation of the pit lake has fluctuated over a range of approximately 3.54 metres, from 1181.02 m ASL to 1184.56 m ASL, with an average elevation of 1182.3 m ASL. No clear upward or downward trend in pit lake elevations is apparent from the available data. Three pit dewatering events were conducted during July/August 2001, July/August 2002 and September 8-13, 2004 in response to concerns that the pit lake would rise above the elevation of the Pony Creek adit on the east side of the pit, and discharge untreated water from the pit lake to Pony Creek. Since 2004, a partial bulkhead has been installed in the Pony Creek adit, and pit lake levels have been permitted to fluctuate in response to the natural system without any human intervention.

Pit lake levels have shown very little short-term response to precipitation events, but do respond to seasonal changes in groundwater elevations. A pressure transducer installed in MW09-15 exhibited on the order of 10 metres of fluctuation between July 2009 and July 2010. Greater than seven metres of fluctuation were observed in GLL07-03, with trends in seasonal pit lake elevations mimicking those observed in the underlying groundwater system. It appears that the pit lake level may be primarily controlled by underlying groundwater elevations, and to a lesser degree by surface water processes (i.e., direct precipitation, evaporation, runoff, etc.). Porosity is defined as the volume of space that could be occupied by air or water divided by the total volume of geologic material. In the context of a pit lake, the entire volume can be occupied by air or water (i.e., 100% porosity). Because the pit lake has a much larger porosity than the underlying groundwater system (1%), pit lake fluctuations are dampened relative to the groundwater system. Once backfilled with waste rock and/or tailings and the porosity is reduced, the water table will fluctuate more dramatically.

For design purposes, it was assumed that pit lake elevations would not exceed 1190 m ASL. Historical pit lake elevations have not exceeded 1184.5 m ASL during the ten year record. Modelingof regional groundwater flow is required to confirm this assumption. If pit lake levels were to exceed an elevation of approximately 1,185 m ASL, water would drain from the pit toward Pony Creek through the Pony Creek adit. It is understood that the bulkhead installed in the adit was not hydraulically sealed to the roof of the adit and as such, will not retain water should water levels rise that high.

During the winter months, flows in the headwater section of Pony Creek are dramatically reduced and this narrow (<1 m), shallow (<0.5 m) creek eventually freezes to bottom. The ground surface throughout the study area also freezes and eliminates the input of spatially distributed recharge to the groundwater system for the winter months. During the winter, the water table drops several metres, resulting in steeper vertical groundwater gradients beneath the open pit. A long-term record of pit lake elevations suggests a relatively constant net discharge rate from the pit to the underlying groundwater system of 0.2 L/s during the winter months (Gartner Lee, 2005). This estimate assumed that all other inputs and outputs from the pit lake were zero during winter months, which does not appear to be the case based on pressure transducer data collected in MW09-15 over the winter of 2009/10 indicating groundwater discharge to the north end of the pit throughout most of the winter, with the exception of approximately two weeks in late April 2010, just prior to spring freshet (Figure 8). This estimate also assumed that the pit was perched above the regional water table and assumed a strong downward gradient of 1.0, which has since proven not to be the case. Subsequent groundwater discharge calculations based on the long term average pit lake elevation estimate groundwater discharge from the pit lake to the Dome Creek diversion channel to be on the order of 0.005 L/s to 0.135 L/s (157 m^3/yr to 4,249 m^3/yr), depending on the hydraulic conductivity value used in the analysis. The range of uncertainty in hydraulic conductivity could be reduced by conducting a long-term pumping test on GLL07-03 or installing additional monitoring wells south of the open pit. Because the aquifer exhibits a low hydraulic conductivity and the gradient between the open pit and the diversion ditch is fairly insensitive to fluctuations in the pit lake level, discharge from the pit to the underlying groundwater system is inferred to be fairly constant throughout the year. Transverse dispersion will also tend to reduce overall concentrations of analytes along the flow path between the pit and diversion channel.

4.4 Groundwater Flow Surrounding the Tailings Management Area

4.4.1 Regional Context

The tailings management area is underlain by a thin veneer of organics, which is in turn underlain by a combination of silty aeolian sand and alluvial/colluvial sediments associated with the Dome Creek stream channel and mass wasting processes at work on the valley side slopes. Permafrost was encountered in every borehole drilled within

the TMA just below the base of tailings. Above permafrost, the unfrozen native organics and alluvial/aeolian sediments host the shallow groundwater flow system. Beneath permafrost, the deeper groundwater flow system is inferred to report to the alluvial/aeolian package in deeper parts of the Dome Creek valley. The thickness of permafrost beneath the tailings facility has not yet been determined. Inferred groundwater flow patterns in the vicinity of the TMA are shown in plan on Figure 3. Groundwater flow along the axis of the Dome Creek valley is shown on Figure 4, and flow within the terrace north of the tailings dam is shown on Figure 5.

4.4.2 Interaction with Shallow Groundwater Flow System

The shallow aquifer underlying the TMA receives groundwater contributions primarily from the valley bottom aquifer upstream of the TMA and the south-facing slopes of the Dome Creek catchment, as shown on Figures 4 and 6. Surface water and precipitation also infiltrate through the tailings mass and report to the shallow unfrozen aquifer overlying permafrost. A portion of the groundwater reporting to the valley bottom aquifer upwells into the diversion channel and is conveyed downstream around the TMA. Run-off and snowmelt within the TMA catchment raises the level of water in the tailings pond each spring. Two-dimensional groundwater flow through the tailings dam was conducted as part of the geotechnical investigation (AECOM, 2010) to estimate the amount of groundwater seepage through the tailings dam. It is discussed in more detail below.

4.4.3 Interaction with Deep Groundwater Flow System

Low permeability sand to clay size tailings were deposited on top of native materials during mine operations. Groundwater level measurements in nested wells installed in the TMA indicate strong downward vertical groundwater gradients. As shown on Figure 4, the relatively permeable materials beneath the tailings are inferred to function as a drain beneath the TMA and transmit groundwater downvalley along a primarily horizontal flow pathway as the base of the flow system in the upper part of the Dome Creek catchment appears to be limited by fairly extensive permafrost. The overlying tailings are inferred to be tension saturated to saturated with dominant vertical drainage. Near the upstream face of the tailings dam, where the underlying dam fill is relatively permeable, the tailings pond is perched above the underlying groundwater flow system. Tailings porewater and water in the tailings pond is anticipated to slowly infiltrate through the tailings and enter the underlying aquifer. It then flows downgradient through the remnant organics and tailings dam fill and reports to the seepage collection pond. Seepage through the tailings dam has been extensively evaluated using SEEP/W and is discussed as part of the geotechnical evaluation.

Based on investigations conducted during July 2009, the upstream face of the seepage dyke is lined to an elevation above the level of water in the seepage collection pond and permafrost has aggraded into the seepage dyke. It is inferred that permafrost combined with the seepage liner pose a barrier to shallow groundwater flowing along the axis of the Dome Creek valley. However, some seepage may flow around the frozen dam and through the sand terrace north of the seepage dyke. A significant amount of groundwater is inferred to flow through the uppermost unfrozen portions of the aeolian sand deposit located north of the seepage collection pond. The native sand unit on the terrace north of the tailings dam is inferred to be relatively permeable and losses from the diversion channel are inferred to provide recharge to the sand aquifer. Measured groundwater gradients indicate that a portion of the groundwater flowing through the aeolian sand reports to the seepage collection pond, with the remainder reporting to Dome Creek downstream of the seepage dyke. Geochemical data collected from the seepage collection pond and nearby monitoring wells supports this interpretation, because the water in the seepage collection pond generally has lower concentrations than groundwater quality measured immediately upgradient of the seepage collection pond (MW09-21), and higher concentrations than groundwater chemistry measured in a well in the north terrace (MW09-24). Using groundwater chemistry data collected in 2009, mass loading calculations suggest that approximately 66% of the groundwater reporting to the seepage pond originates from the tailings area, with the remaining 34% originating from the terrace north of the seepage collection pond, effectively diluting seepage reporting to the seepage collection pond. Based on long-term data collected from 2006 to 2010, seepage reporting

to the seepage collection pond appears to be relatively constant, with only minor seasonal fluctuations in response to precipitation and snowmelt events.

Groundwater flow into the seepage pond is inferred to be primarily comprised of two components: 1) seepage through the dam, and 2) groundwater flow from the terrace north of the seepage collection pond through the aeolian sand deposit. Based on measured groundwater gradients, a portion of the groundwater flowing within the terrace is likely recharge from the overlying diversion channel (Figure 5). The north facing slopes located south of the seepage collection pond are inferred to be frozen and host a thin active layer. As such, they are not anticipated to contribute a significant amount of groundwater to the seepage collection pond. Water collected in the seepage collection pond is pumped over the frozen seepage dyke and into Dome Creek above its confluence with the diversion channel.

5. Soil and Groundwater Quality

As part of the 2009 hydrogeological investigation, groundwater quality samples were collected in July and September 2009 to validate the hydrogeological conceptual model. The original laboratory analytical results for both soil and groundwater are presented in Appendix B. Interpretation of site wide groundwater quality data was not within the scope of this project. However, preliminary evaluation of groundwater contamination downgradient of the mill building was part of this assessment. Additional work is required to fully characterize contamination of soil and groundwater around the mill building.

5.1 Mill Area Evaluation

Four monitoring wells (MW09-16, MW09-17, MW09-18 and MW09-19) were installed downgradient of the existing mill building to assess potential groundwater and soil contamination as a result of uncontrolled historical petroleum or cyanide releases. During drilling, select soil samples were collected and analyzed for total metals, LEPH, HEPH and PAHs, while groundwater samples collected following well installation were analyzed for physical parameters, anions, dissolved metals, cyanide species, total organic carbon, nutrients, LEPH, HEPH and PAHs. A number of additional groundwater quality samples were collected to support development of the hydrogeological conceptual model and site wide water balance. Soil and groundwater chemistry data for samples collected from the mill area in 2009 were compared to Yukon Contaminated Sites Regulation (YCSR) standards and are presented in Tables 6 and 7, respectively.

5.1.1 Soil Sampling Results

Surficial soil samples were not collected as it was not within the scope of this assessment. Significant quantities of ore and waste rock have been handled and placed around the mill building during mine operations, and shallow soil is likely to exhibit elevated concentrations of metals. A detailed surficial soil sampling program combined with additional test pitting or drilling is required to full assess the extent of contamination around the mill.

Soil analytical results for samples collected during borehole drilling were compared to YCSR numerical and matrix soil standards for parkland and industrial land use. Arsenic concentrations range from 9.4 mg/kg to 13,000 mg/kg and exceeded industrial landuse standards in all samples collected, with the exception of MW09-19 (15' – 16'9"). Antimony and cadmium concentrations exceeded standards for both industrial (IL) and parkland (PL) land use in MW09-16 (6' – 7') and MW09-19 (7'10" – 8'4"). In these two wells, antimony concentrations were 162 mg/kg and 898 mg/kg, respectively. Cadmium concentrations were 41.4 mg/kg and 91.1 mg/kg in MW09-16 (6' – 7') and MW09-19 (7'10" – 8'4"), respectively.

Lead concentrations exceeded parkland landuse standards in MW09-16 (6' – 7') and industrial landuse standards in MW09-19 (7'10" – 8'4") with concentrations of 1,570 mg/kg and 8,260 mg/kg, respectively. MW09-19 (7'10" – 8'4") also exceeded industrial landuse standards for copper and zinc. Zinc also exceeded industrial landuse standards in MW09-16 (6' – 7'). Slightly elevated concentrations of both copper and zinc were reported in all other soil samples submitted for analysis. Silver exceeded parkland landuse standards in MW09-16 (6' - 7'), and industrial landuse standards in MW09-19 (7'10" – 8'4"). One chromium exceedence was also reported in sample MW09-18 (21' – 22').

Soil quality data indicates that MW09-16 (6' – 7') and MW09-19 (7'10" – 8'4") exhibit very high concentrations of a number of metals. The remainder of the soil samples exhibit concentrations that are more indicative of background conditions, with antimony, cadmium, silver and lead concentrations below or near detection limits. High concentrations of arsenic and elevated copper and zinc concentrations seem to be typical of background concentrations based on this limited review.

Elevated metal concentrations are likely related to the presence of abundant scrap metal, low grade ore, waste rock, and potentially old Heustis tailings in the area surrounding the mill. All concentrations of LEPH, HEPH and PAHs in soil were below reported detection limits, indicating that soil near the water table is not contaminated by hydrocarbons in the vicinity of the four boreholes that were sampled. No hydrocarbon odours were observed during the course of borehole drilling, well installation or groundwater sampling in 2009.

5.1.2 Groundwater Sampling Results

Groundwater analytical results for wells within the mill area were also compared to YCSR standards for the protection of aquatic life (AW). Similar to soil, all concentrations of LEPH, HEPH and PAHs were below reported detection limits on July and September 2009 sampling dates, indicating that groundwater in the four monitoring wells downgradient of the mill is not contaminated by hydrocarbons.

The majority of cyanide (total, WAD, cyanate) concentrations were below detection limits on all sampling dates. One exception (MW09-19) exhibited a total cyanide concentration of 0.0146 mg/L, a cyanate concentration of 5.75 mg/L and a WAD cyanide concentration below detection limits on the September 2009 sampling date. Ammonia concentrations ranged from below detection limits to 0.229 mg/L in all wells except MW09-19, where concentrations were 2.24 mg/L. Thiocyanate concentrations were between 1.16 and 1.25 mg/L on all sampling dates in all wells. MW09-19 is located downgradient of the mill and near the former polishing pond. Together, concentrations of cyanide and its degradation products at MW09-19 indicate a potential upgradient source of cyanide. A YCSR-AW standard is only given for weak acid dissociable cyanide, and no standard exists for any other cyanide species. All WAD cyanide concentrations measured remained below standards.

Conductivity values ranged from 1770 to 2670 µS/cm, with neutral to slightly basic pH values ranging from 7.16 to 7.74. Sulphate concentrations exceed YCSR-AW standards in wells MW09-17, MW09-18 and MW09-19 on all sampling dates with concentrations ranging from 1340 to 1490 mg/L. Sulphate concentrations in MW09-16 were slightly below standards, with concentrations of 832 mg/L and 934 mg/L on July and September sampling dates.

Elevated concentrations of arsenic were observed in the area surrounding the mill, with concentrations ranging from 0.0119 to 0.0834 mg/L. Exceedences of AW standards were observed in samples collected during July 2009 at MW09-16 and during September 2009 in wells MW09-18 and MW09-19, with concentrations of 0.0506 mg/L, 0.0526 mg/L and 0.0834 mg/L, respectively.

Concentrations of cadmium were below reported detection limits in all samples except those collected at MW09-16, where two exceedences with concentrations of 0.0558 mg/L and 0.0419 mg/L on July and September 2009 sampling dates, respectively. Dissolved copper, lead and iron concentrations were also generally below detection

limits in all samples with the exception of those collected at MW09-16, where elevated concentrations were observed, but remained below YCSR-AW guidelines. Dissolved zinc concentrations were also below detection limits in all samples except those collected at MW09-16, where two exceedences were reported, with concentrations of 4.44 and 3.66 mg/L on July and September 2009 sampling dates.

MW09-16 is a shallow water table well screened from 0.30 m to 1.83 m. It was installed on a laydown area located east of the former polishing pond that appears to be constructed of waste rock. Elevated sulphate, arsenic, cadmium and zinc concentrations may be the results of runoff and shallow groundwater flow emanating from the area upgradient of MW09-16, where long-term storage of low grade ore and waste rock occurred. A more detailed assessment of potential contaminant sources in the upper reaches of the Dome Creek watershed has since been conducted by Altura Environmental Consulting in 2010.

6. Discussion of Inputs to Water Balance

6.1 Site Wide Water Balance

The updated site wide water balance is based on the revised hydrogeological conceptual model for groundwater flow surrounding the open pit. To support development of the updated site wide water balance, groundwater quantities were estimated based on available information and professional judgment, but only the deep groundwater discharge from the pit to Dome Creek was used in the water quality and contaminant loading model. The following quantities were estimated:

6.1.1 Shallow Groundwater Discharge to the North End of the Pit

The quantity of groundwater discharging to the pit due to flow in the active zone was estimated using a Darcy's Law based on measured gradients between a mini-piezometer installed in Pony Creek and the elevation of the seepage face where it daylights at the north end of the open pit as shown in Appendix G-1. Hydraulic conductivity values obtained from drilling estimates and slug tests at MW09-15 were used as the basis for groundwater flow calculations, with values ranging from 1×10^{-5} m/s to 1.2×10^{-6} m/s. This system is inferred to be active during May and June following freshet and from October through December after fall rains, but before the aquifer freezes down to permafrost. During the remainder of the winter months (January – April), the system is frozen and groundwater is not flowing, while during the summer months (July – September), the system is inferred to be unsaturated based on several years of observations by the on-site caretaker and others during mine development. It is also important to note that the icing does not form every year, suggesting that this flow system is sensitive to changes in infiltration.

Annual groundwater discharge estimates were calculated range from 90 m^3/yr to 750 m^3/yr, with average groundwater travel times between Pony Creek and the open pit ranging from 157 days (5.2 months) to 1311 days (43 months). Groundwater travel times are highly sensitive to porosity, which has not been measured on site and is assumed to be 10% for shallow weathered and oxidized bedrock. If porosity is more similar to that of competent bedrock (1%), estimated travel times would be reduced by an order of magnitude to between 15.7 and 131 days. Because this is a shallow flow system, the magnitude of flows will vary based on the magnitude and timing of recent infiltration from Pony Creek and diffuse recharge. As a result of below average precipitation in 2009, very little seepage reported to the open pit during the fall and winter months of 2009/10 and an icing did not form over the winter, suggesting that in some years, this system does not discharge much groundwater to the pit.

6.1.2 Deep Groundwater Discharge to the North End of the Pit

The deeper regional groundwater system is inferred to discharge groundwater to the north end of the pit. Recently collected pressure transducer data suggests that groundwater discharges to the pit for almost the entire year. The quantity of groundwater discharging from the regional bedrock aquifer to the open pit was estimated using Darcy's Law based on hydraulic conductivity measurements (1.2×10^{-6} m/s) from a monitoring well north of the pit (MW09-15) and measured gradients between MW09-15 and the pit lake. MW09-15 was drilled through highly weathered rock along the inferred extension of a known geologic fault. The height of the seepage face was estimated as 25% of the difference between water levels in MW09-15 and the pit lake. Groundwater fluxes were calculated using the height of the seepage face and the width of the pit, taken as 20 metres. Estimated monthly groundwater inflows are provided in Appendix G-2 and range from 0.9 m^3/month (March 2010) to 48.2 m^3/month (September 2009 and June 2010), for a total of 298 m^3/year.

6.1.3 Deep Groundwater Discharge from the South End of the Pit to Dome Creek

Groundwater discharges from the south end of the pit lake to the deep regional groundwater system and is inferred to flow downgradient to the Dome Creek diversion channel as identified on Figures 3 and 6. The volume of groundwater discharge from the pit to the diversion channel were calculated using Darcy's Law for a range of hydraulic conductivity values. Hydraulic conductivity values ranging from 1×10^{-7} m/s to 2.7×10^{-6} m/s have been measured in GLL07-03 (slug and pumping tests) and estimated from winter pit lake drainage rates. The long-term (2001-2010) pit lake elevation (1182.3 mASL) was used to estimate steady-state gradients between the pit lake and the diversion channel (1100 m ASL), located 825 metres to the south. The aquifer was assumed to be the width of the pit (25 metres) and 20 metres deep for the purposes of the flux calculations. Groundwater discharge estimates range from 0.005 L/s (158 m^3/year) to 0.135 L/s (4247 m^3/year) when the full range of observed hydraulic conductivities are used. Groundwater travel times were also calculated for the range of porosity values attributed to fractured (10%) and competent (1%) bedrock units. Travel times range from 10 to 262 years for a 10% porosity groundwater flow system and from 1 to 26 years based on a 1% porosity system. Groundwater travel time estimates could be improved by conducting a tracer test or a long-term pumping test in the area south of the open pit. Porosity has not been directly measured in the field, but overall estimates appear to be reasonable based on a 10 metre rise in the water table at MW09-15 in response to a 110 mm snowmelt event in 2010.

6.1.4 Assessment of Seepage Collection Pond Pumping Rates

Historical seepage collection pond pumping data was reviewed to confirm the results of two-dimensional seepage modelling through the dam (AECOM, 2010). Estimates of seepage reporting to the seepage collection pond were made based on time-series analysis, correlation analysis and catchment recharge analysis and compared to the results of two-dimensional seepage modelling conducted as part of the geotechnical investigation. The observed permafrost elevation and subsequent observations of a lack of water in MW09-20, which was installed directly on top of permafrost, indicates that minimal seepage is travelling through the seepage dyke. However, some seepage likely travels around the seepage dyke and through the terrace north of the seepage collection pond.

Long term (2006 – 2010) seepage collection pumping data were provided by Yukon Government and were plotted together with available precipitation data on Figure 9. Seepage data indicate that pumping rates fluctuate seasonally in response to changes in tailings pond levels as a result of precipitation and snowmelt. Very little precipitation data is available prior to July 17, 2009. The flow meter used to estimate pumping rates was serviced from July 8-12, 2009. A rapid rise in pumping rates occurs immediately after the flow meter was reinstalled on July 13, 2009. A basic analysis of the historical (2006 – July 8, 2009) and recent (July 13, 2009 to 2010) data was conducted in an attempt to correct the historical data based on recent flow measurements. Given the uncertainty associated with historical seepage collection pond pumping rates, these data should be interpreted with caution.

Recent (2009 – 2010) pumping records from the seepage collection pond that indicate minimum winter pumping rates were on the order of 3.5 L/s between July 17, 2009 and July 12, 2010 and the average pumping rate was 5.11 L/s.The trend analysis of both historical and recent data indicates no systematic change in seepage rates over time. The slight increasing trend in the recent data reflects the relatively short record and the lack of complete seasons of data in the trend analysis. Prior to flow meter servicing, the historical average pumping rate was 2.18 L/s. Recent data collected following servicing/calibration of the flow meter, indicates that the average pumping rate has increased to 5.11 L/s. The average pumping rate for the week prior to servicing was 2.08 L/s, while after servicing, the rate increased by a factor of 2.17 to 4.52 L/s. This increase is inferred to be a product of flow meter servicing and the old data has been corrected based on flow meter measurements collected after servicing. Based on visual estimation, the long term low pumping rates are approximately 1.5 L/s. When corrected by multiplying by a factor of 2.17, historical low flows were approximately 3.30 L/s. Data collected since the flow meter was serviced indicates that the low pumping rate was approximately 3.5 L/s over the winter of 2009/10. As such, long-term low flows (groundwater discharge) reporting to the seepage collection pond are estimated to be on the order of 3.5 L/s.

Two correlation plots were also developed to evaluate the dependency of seepage pond pumping rates on precipitation events on the same day for the July 17, 2009 through July 12, 2010 timeframe as shown in Figure 10. The first correlation plot includes all data and is shown for illustrative purposes only. Because the large number of zero precipitation values did not permit an accurate trend analysis, a second correlation plot was developed for a data set that was filtered to remove all precipitation events below 4 mm. Based on discussions with maintenance staff, it is unlikely that pumping rates would have been adjusted for small precipitation events. The subsequent analysis is based on the filtered data set. It is important to note that any time delay between the precipitation event and adjustment of pumping rates has not been accounted for in the analysis. Using the x-intercept of the second correlation plot, a minimum flow rate (baseflow) of approximately 2.9 L/s is obtained.

Catchment based calculations assuming 10% groundwater recharge and average (283.2 mm) precipitation indicate that the total quantity of groundwater flowing in the catchment above the seepage collection pond is on the order of 2.86 L/s (Appendix G). This estimate is highly sensitive to the recharge coefficient and could be up to 5.71 L/s if a value of 20% is used.

Unit width seepage rates were also estimated using the Seep/w numerical model for the cross-section through the centreline of the tailings dam. Multiplying the unit width seepage estimate for the existing condition by the approximate dam width of 250 metres produces a steady-state seepage rate of 2.8 L/s.

The results of the time series analysis (3.5 L/s), correlation analysis (2.9 L/s), catchment based calculations (2.9 L/s) and numerical seepage modelling (2.8 L/s) indicate groundwater reporting to the seepage collection pond is between 2.8 L/s and 3.5 L/s. The general agreement of these independent estimates with one another improves overall confidence in the estimates.

6.1.5 Seepage Collection Pond Source Waters

Potential sources of water reporting to the seepage collection pond include tailings porewater seepage (e.g., MW09-04, Dome Creek (e.g., surface water station D1), tailings dam seepage (e.g., MW09-21) and lateral groundwater seepage (e.g., MW09-24). An analysis was conducted to identify the relative contribution of specific source waters reporting to the seepage collection pond based on water quality data from samples collected between September 1st and 3rd, 2009 and documented in memo fortmat (Appendix H). The analysis indicates that approximately 66% of the flow reporting to the seepage collection pond originates from the tailings pond and the remaining 34% originates from regional groundwater. A portion of the groundwater reporting to the seepage collection pond may be the result of leakage through the bottom of the unlined diversion ditch north of the tailings facility and seepage collection pond.

6.2 Pit Lake Water Balance Verification (2009 – 2010)

Between July 17, 2009 to June 16, 2010, the pit lake water level declined 0.97 metres, corresponding to a loss of 3,030 m^3 of water from the pit lake. A short-term water balance was developed for the 11 month period of time from July 17, 2009 to June 16, 2010 to determine if the change in water levels within the open pit could be explained using current assumptions about groundwater and surface water flows surrounding the open pit. This period of time was selected based on the time period for which supporting pressure transducer and precipitation data was available.

The short term verification exercise utilized estimates of groundwater flow to and from the pit provided in Section 6.1 for the following quantities of water:

- Shallow Groundwater Discharge to the North End of the Pit (Section 6.1.1);
- Deep Groundwater Discharge to the North End of the Pit (Section 6.1.2); and
- Deep Groundwater Discharge from the South End of the Pit to Dome Creek (Section 6.1.3).

An additional term was developed to account for the loss of water from the pit due to pit lake level decline as described in the following section.

6.2.1 Discharge from Pit Due to Drop of Water Table (2009 – 2010)

The groundwater level surrounding the open pit dropped from 1184.7 m ASL to 1182.2 m ASL between July 17, 2009 and June 16, 2010. Because the pit lake is an expression of the regional water table, the drop in groundwater levels is inferred to cause flow of water from the pit lake to the underlying groundwater system. It is recognized that during periods of water table rise, the pit will gain water from the underlying groundwater system. On a seasonal basis, water will be both gained by, and lost from, the pit as the regional water table rises and falls. The horizontal gradient will simultaneously drive groundwater flow from north to south toward Dome Creek. Using measured groundwater level changes in GLL07-03, an estimated pit lake surface area of 2,500 m^2, and a porosity of 1%, the quantity of water lost from the pit due to seasonal water table decline was estimated to be 62.5 m^3 (Appendix G-4). This estimate is somewhat sensitive to porosity estimates and could be up to ten times greater (625 m^3) if a porosity value similar to that of shallow weathered bedrock (10%) is used.

7. Hydrogeological Implications of Reclamation Options

A detailed description of each reclamation option is not provided within this report. Only the hydrogeological implications of each identified reclamation option are discussed below. A summary of the hydrogeological implications of each option and outstanding uncertainties is provided in Table 8.

7.1 Options 1A and 2A

Option 1A involves upgrading the tailings dam to address stability concerns and maintenance of a water cover on top of the tailings in their current location. Option 2A also involves upgrading the tailings dam, but involves application of a soil cover over the tailings instead of a water cover. Both of these options are viewed as being very similar from a hydrogeological viewpoint. As such, the hydrogeological implications of these two options are discussed together.

Groundwater flow directions are fairly well understood in the area surrounding the existing tailings pond and dam for existing conditions. However, the thickness and continuity of permafrost beneath the tailings facility is not fully understood and has potential implications on groundwater flow pathways. Should the shallow and deep flow systems be connected through unfrozen soil and rock beneath the tailings dam, groundwater may report further downstream than currently expected, but well above the confluence of Dome Creek and Victoria Creek. Both of these options involve maintenance of the tailings in a saturated state and could result in higher groundwater gradients and greater contaminant flux through the tailings mass (and dam) if seepage is not controlled.

With the installation of a toe berm at the base of the dam, the seepage collection pond will be removed and there will not be an opportunity to collect and treat groundwater discharged through the tailings dam, although the seepage pond could be relocated and reconstructed if required. There also remains some uncertainty around the long-term attenuation capacity of the groundwater system both beneath the TMA and between the pit and Dome Creek. A longer groundwater flow path below the toe berm will result. If required, a new seepage pond could be constructed further downslope to facilitate seepage collection.

As with existing conditions, should the pit lake rise above the elevation of the Pony Creek adit, direct discharge of water from the pit lake to Pony Creek could result.

7.2 Options 1B and 2B

Option 1B is the similar to Option 1A, in that it involves upgrading the existing tailings dam and maintaining a water cover over the tailings in their current location, but also involves backfilling the open pit with waste rock. Option 2B is similar to Option 2A, but also involves backfilling of the pit with waste rock.

The deposition of coarse waste rock is not anticipated to affect local or regional groundwater levels in a significant manner if waste rock is placed in the pit after it has been drained. Any displacement of water within the pit is anticipated to be temporary and regional groundwater conditions will soon reestablish an equilibrium level near current levels. The presence of waste rock in the pit will enhance water table fluctuations within the pit as a result of lower porosity. If the water table rises above the elevation of the Pony Creek adit, groundwater discharge to Pony Creek could result. These dramatic fluctuations would most likely occur in response to large precipitation events and snow melt. Three dimensional transient groundwater modeling could be used to evaluate the impacts of precipitation events on groundwater levels within the pit. One-dimensional numerical modeling of seepage through a column of waste rock deposited in the pit was conducted by Golder (2010) and revealed that approximately one percent of mean precipitation would infiltrate to the water table and a capillary fringe on the order of 0.08 m thick would be present.

Given that the pit lake levels are controlled by regional groundwater table fluctuations, a detailed assessment of the long-term implications of any in-pit storage option on groundwater levels and regional groundwater flow would require the development of a three-dimensional numerical groundwater model. This could be developed during the design phase of a project and the findings used to optimize both cover and material selection. Contaminant transport processes could also be simulated as part of this evaluation.

The potential for attenuation of any contaminants that are released from the pit as groundwater seepage has not been investigated or quantified due to the lack of monitoring wells along the groundwater flow pathway between the pit and the Dome Creek diversion channel.

As with existing conditions and Options 1A and 2A, should the pit lake rise above the elevation of the Pony Creek adit, direct discharge of water from the pit lake to Pony Creek could result.

7.3 Option 3

Option 3 involves the relocation of tailings to the open pit and storage in a saturated state. The dam would be breached and the Dome Creek valley would be restored. The integrity and water tightness of the bulkhead within the Pony Creek adit needs to be confirmed prior to implementation of any in-pit storage options.

Preliminary one-dimensional modeling of this scenario indicates that any water contained within the in-pit tailings will remain under tension above the water table and as such, horizontal groundwater flow will be minimal. Should any groundwater travel horizontally from the tailings mass to the unsaturated rock around the pit, it is inferred that it would preferentially flow vertically downward through the unsaturated zone and report to the regional water table. Should short or long term treatment of seepage from the overlying tailings be required, a groundwater extraction well could be installed to collect tailings seepage. The modeling work suggests that this option may require additional water from the surrounding area. Because the surrounding bedrock is quite permeable, it may prove challenging to capture sufficient overland flow for infiltration into the tailings mass to maintain saturation. If water table mounding occurs as a result of the additional infiltration, radial flow outwards from the pit could occur.

The position of the groundwater divide between the Pony Creek and Dome Creek catchments and groundwater flow directions have been assumed based on observations in 4 monitoring wells north of the open pit. Additional monitoring wells should be installed and the extent of permafrost should be evaluated to improve the level of confidence in the hydrogeological conceptual model of the pit prior to implementing any of the in-pit storage options.

It is inferred that shallow groundwater within and surrounding the TMA will exhibit degraded water quality, as will the area surrounding the open pit. This could result in a similar or greater flux into the environment due to uncertainties in the flow pathway and the quality of water emanating from the tailings in the pit. It is assumed that the seepage collection pond below the existing dam would be left in place following removal and revegetation of the Dome Creek valley, and water quality reporting to the seepage collection pond meets relevant criteria.

7.4 Option 4

Option 4 involves the relocation of tailings to the pit, and their storage in a dry condition. A layer of waste rock will be placed in the pit to an elevation above the regional groundwater table, upon which tailings will be placed. A cover will be placed on top of the tailings and designed to minimize infiltration.

The integrity and water tightness of the bulkhead within the Pony Creek adit needs to be confirmed prior to implementation of any in-pit storage options. Some uncertainty surrounds the ability to construct a low permeability cover that will maintain its integrity over time as the tailings consolidate. Increased permeability of the cover could result in increased seepage with poor water quality reporting to the water table underlying the open pit. Should short or long term treatment of seepage from the overlying tailings be required, a groundwater extraction well could be installed through the tailings to collect seepage from the base of the open pit. The exploration spoils that currently restrict flow in Pony Creek could be removed to help reduce the amount of shallow and deep groundwater reporting to the open pit.

For all in-pit storage options, a better understanding of seasonal fluctuations in groundwater levels and the extent of permafrost is required. This information together with additional climate data and pit lake level fluctuations will help improve the pit lake water balance. The pit lake currently acts to buffer water level fluctuations as a result of its high (100%) porosity. Once infilled, it is expected that pit water levels will rise on the order of three times higher for each pit recharge event because the tailings (and/or waste rock) will occupy more than two thirds of the pit volume (i.e., assumed 30% porosity). The long term elevation of the water table underlying the open pit needs to be predicted in relation to the tailings mass for this option in order to predict long term performance. A detailed three-dimensional

transient groundwater model is required to estimate long-term pit lake or groundwater elevations with more certainty and determine groundwater flow changes under various seasonal and operational conditions for any of the in-pit storage options.

8. Summary of Hydrogeological Uncertainty

8.1 Key Assumptions

The following key assumptions were made during the development of the hydrogeological conceptual model and as part of hydrogeological calculations:

- Groundwater flow is in homogeneous and isotropic aquifers;
- The water table is a subdued replica of topography between monitoring wells;
- Hydrogeologic properties (hydraulic conductivity, porosity) are within the range of values stated in the conceptual model;
- Groundwater flow and travel times can be approximated by one-dimensional analytical equations for the purposes of the site wide water balance;
- Tailings will remain tension-saturated for Option 3;
- The water table will not rise above the level of the Pony Creek adit;
- The cover will remain intact for Option 4, despite potential settlement concerns; the
- The Pony Creek adit can be adequately plugged to prevent direct discharge of water from the pit lake to Pony Creek; and
- Overall TMA seepage discharge rates to Dome Creek will not change from present conditions for Options 1 and 2.

Additional assumptions specific to each calculation are clearly stated in Appendix G.

8.2 Hydrogeologic Uncertainties

Upon conclusion of the 2009 and 2010 field investigations and a desktop assessment of the information collected to date, the following hydrogeological uncertainties remain:

- The spatial extent and thickness of permafrost across the study area is unknown. It is unclear what the effects of each identified closure option will be on permafrost based on presently available information. Groundwater flow surrounding the open pit is constrained by the spatial and depth extent of permafrost. Observations of permafrost conditions around the pit have been possible at only 4 borehole locations north of the pit thus far. Additional boreholes located east, south and potentially, west of the pit are required to further assess the extent of permafrost and confirm the hydrogeological conceptual model. The extent and thickness of permafrost has important implications on the inferred position of groundwater flow divides, the degree of connection between the shallow and deep aquifers and on groundwater flow pathways in the Dome Creek valley.

- The position of the shallow and deep groundwater divides between the Dome Creek and Pony Creek catchments has been inferred based on groundwater level measurements in a limited number of wells north of the pit. The complex geologic structure, proximity to Pony Creek and the presence of permafrost in the area could cause the position of these divides to migrate seasonally with the development of an active layer and recharge from Pony Creek. If the divide shifts southward, seepage from the tailings mass could report to Pony

Creek. Continuous data collection from multiple wells is required to improve the understanding of groundwater flow around the open pit. Tracer tests could also provide significant insight into groundwater flow pathways surrounding the open pit.

- The behaviour of the deep groundwater system is not yet fully understood as a result of a limited number of boreholes and sparse water level data. The installation of pressure transducers in a number of wells across the site would dramatically improve the understanding of groundwater flow and validate the hydrogeological conceptual model of the site.

- The integrity and water tightness of the bulkhead within the Pony Creek adit and the rock mass around the adit should be confirmed prior to implementation of any options involving in pit storage of tailings or waste rock.

- Most hydrogeological inputs to the site wide water balance are based on one-dimensional analytical and numerical models. Given the complexity of the geology, permafrost and groundwater flow surrounding the open pit, a three dimensional transient numerical model may be required to fully understand the sensitivities of the groundwater flow system to various inputs and outputs and better understand the implications of in pit storage options on regional groundwater flow. The model would also help address uncertainty in the long-term elevation of the pit lake which is required for detailed design of any in pit storage options.

- Hydraulic conductivity has only been measured in one location along the flow path from the pit to the Dome Creek diversion channel and forms the basis for loading calculations in the site wide water balance. Hydraulic conductivity of fractured bedrock is quite variable in nature and ranges over approximately four orders of magnitude. As such, variation in hydraulic conductivity values has the potential to significantly affect loading calculations. Installation of additional monitoring wells along the flow path would permit collection of additional hydraulic conductivity measurements and help confirm groundwater gradients used to estimate contaminant loading from the pit to the diversion channel. Long-term pumping tests and tracer tests could be used to reduce the level of uncertainty in groundwater flow and travel time estimates.

- Estimates of seepage rates from the open pit are uncertain, and could vary by orders of magnitude, primarily as a result of variations in hydraulic conductivity.

- The degree of attenuation of metals offered by the natural groundwater environment remains uncertain. This could have important implications on estimated contaminant loading rates observed in Dome Creek as a result of groundwater travelling from the Brown-McDade open pit.

A summary of the hydrogeological implications of identified closure options and the associated uncertainty are provided in Table 8.

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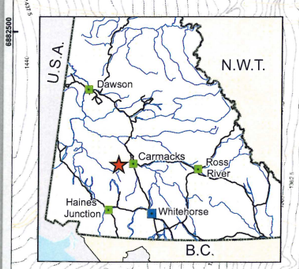
Figures



Pony Creek
Pony U/S
MP07-01
Berm
MP07-02
MP09-01
GL07-01
GL07-02
Pony D/S
Northwest Pile
L1
NW Seep-01
Pit Lake
EL. 1194.7m ASL
(Nov. 2007)
Pony Creek Adit
EL. 1184.3 +3m
East Pile
MW09-11
MW09-14
Pony Creek Adit
EL. +/- 1185m
Pit Site
GL07-03
Ore Stockpile
West Piles
L2
LW-Seep-01
South Pile
South Pit
Southwest Lower Pile
DESS-03
DESS-01
DESS-02
Mine Camp
DX Site
Mill Complex
DI Site
Dry Creek Reference Site
Diversion Channel
Emergency Spillway
Tailings Pond Site
Seepage Pond Return Lines
Tailings Dam Centre
Tailings Pond
Interceptor Ditch (2008 Survey)
Tailings Pile (1105)
Seepage Discharge Site
Seepage Pond
Upper Dome Creek Site
Artesian Well
Back Creek
Victoria Creek
Victoria Creek Reference Site
Back
Upper Victoria Creek Site
Dome Creek
Dome Creek at Road Site
A
A'
B
B'

Legend

- Lysimeter
- Seep
- Water Quality (EDI)
- Waste Rock Outline
- Watercourse
- Monitoring Well (Gartner Lee, 2007)
- Monitoring Well (AECOM, 2009)
- Mini Piezometer (AECOM, 2009)
- Thermistor (AECOM, 2009)
- Section Line
- Pond/Tailings Pond
- Tailings
- Exploration Spoils
- Mine Infrastructure
- Road/Trail

Topography (Except Pit)
- Interm. (0.5m)
- Index 2.5m)

Pit Topography
- Index 2.5m
- Interm. 0.5m

N, W, E, S

1:5,000
UTM Zone 8N, NAD 83
0 50 100
Metres

Topographic data by The Orthoshop, based on 1998 aerial photography at 1:50,000 scale. Brown McDade Pit survey by Underhill Geomatics Ltd, Drawing 281-05B dated March 18, 2003. Inferred fault by B.Y.G. Natural Resources, Inc. Waste rock outlines and sample sites, Altura, 2006. All other data, AECOM, 2009.

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Yukon Government

Project: Mt. Nansen Site Investigation

Mt. Nansen Mine Site

September 2010

AECOM

Figure 1

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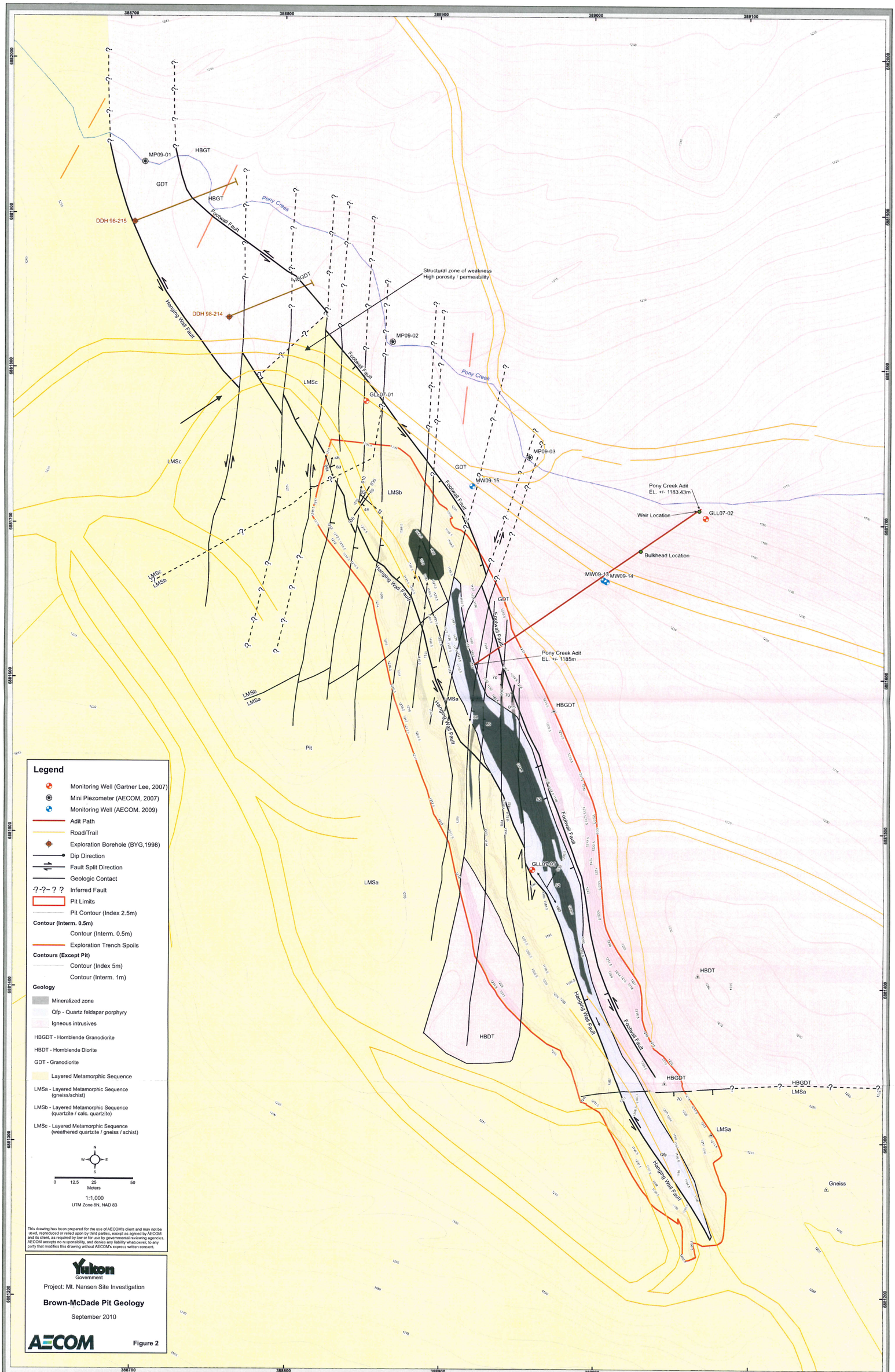

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Yukon Government

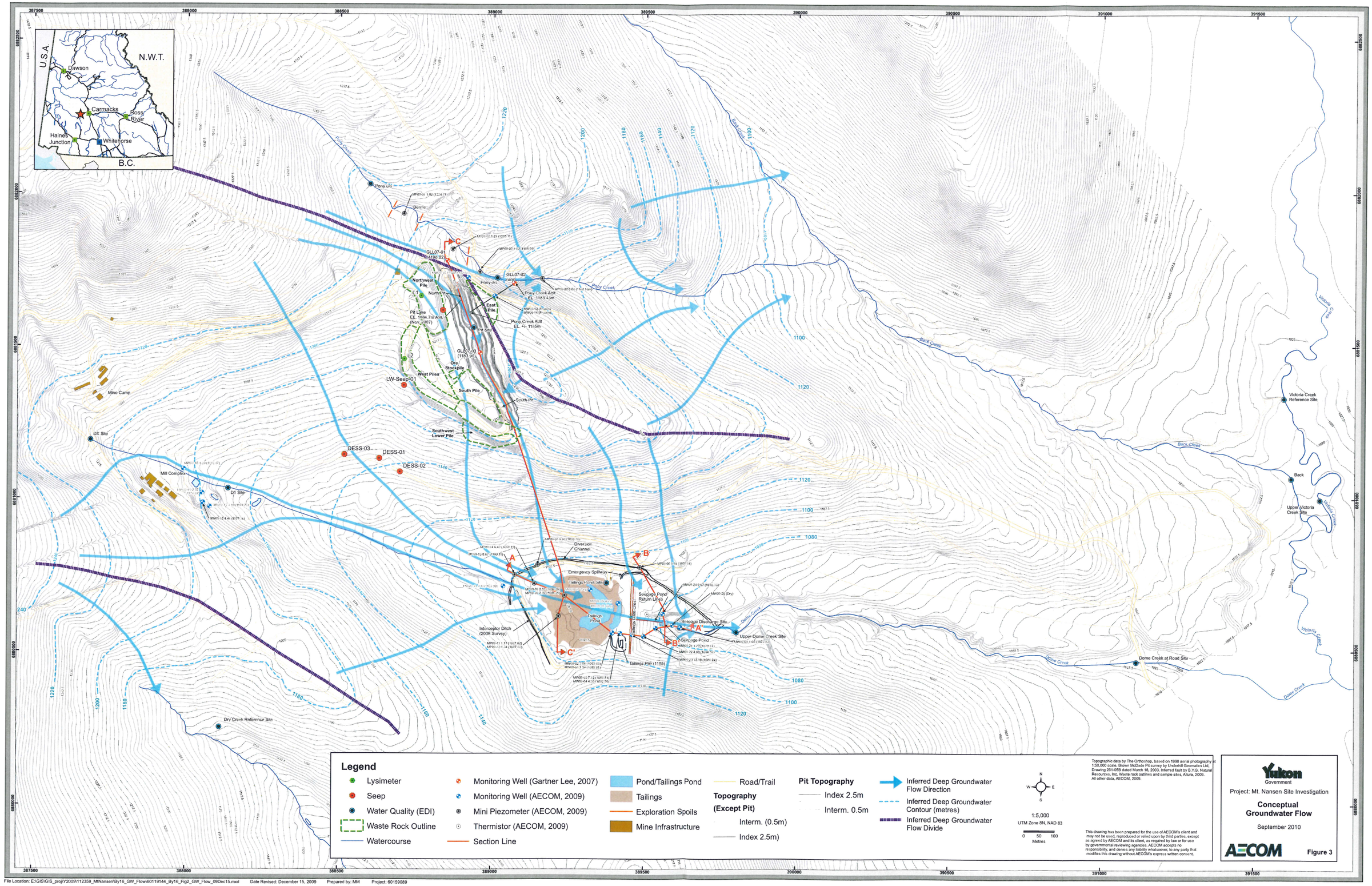
Project: Mt. Nansen Site Investigation

Brown-McDade Pit Geology

September 2010

AECOM

Figure 2



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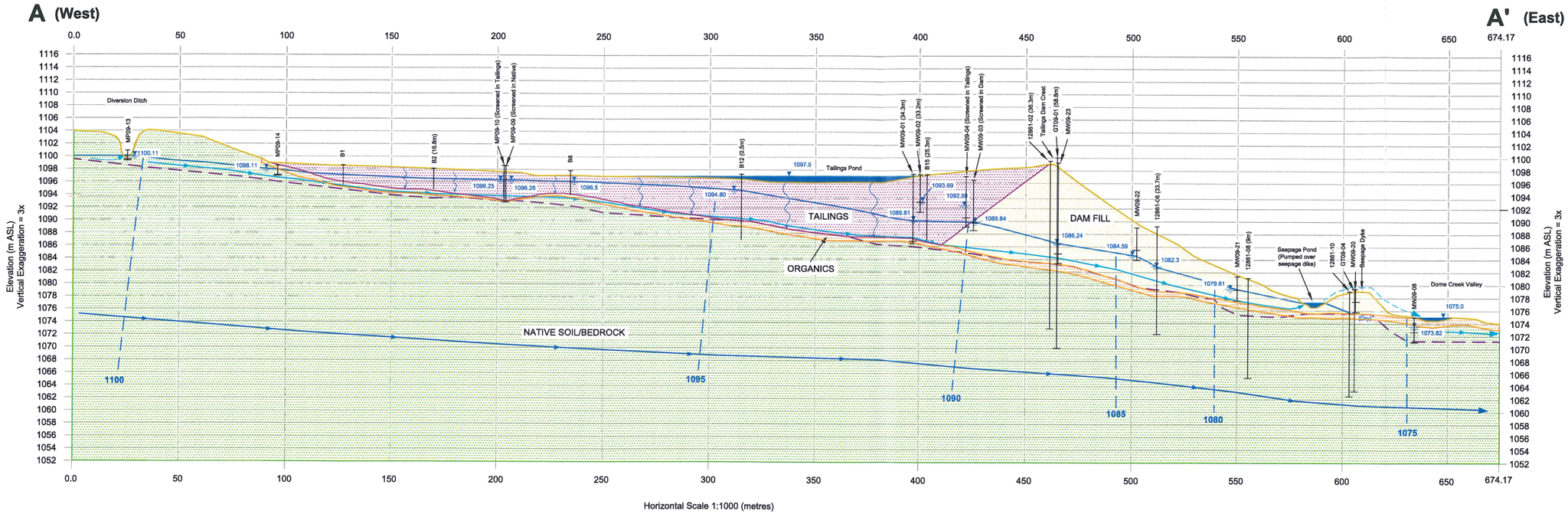

Legend

- Borehole
- Monitoring Well
  - Top of Screen
  - Bottom of Screen
- Inferred Groundwater Elevation in Shallow Aquifer Above Permafrost
- 1079.81 Inferred Groundwater Elevation in Shallow Aquifer
- Inferred Groundwater Equipotential Line
- Inferred Shallow Groundwater Flow Direction
- Inferred Deep Groundwater Flow Direction
- Inferred Top of Permafrost
- Inferred Vertical Flow
- Organics
- Tailings
- Dam Fill
- Native Soil / Bedrock

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Map Sources / Notes:
Top of piezometer, top of screen and bottom of screen elevations, AECOM, Sept. 2009.
Groundwater elevations, AECOM, Sept. 2009.

0 5 10 20 30 40 m
1 : 1000

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Reviewed by: RM Prepared by: MM
Date Issued: September, 2010 Project Number: 60159089

Project: Mt. Nansen Site Investigation

Conceptual Groundwater Flow Beneath the Tailings Management Area (Section A to A')

AECOM

Figure 4

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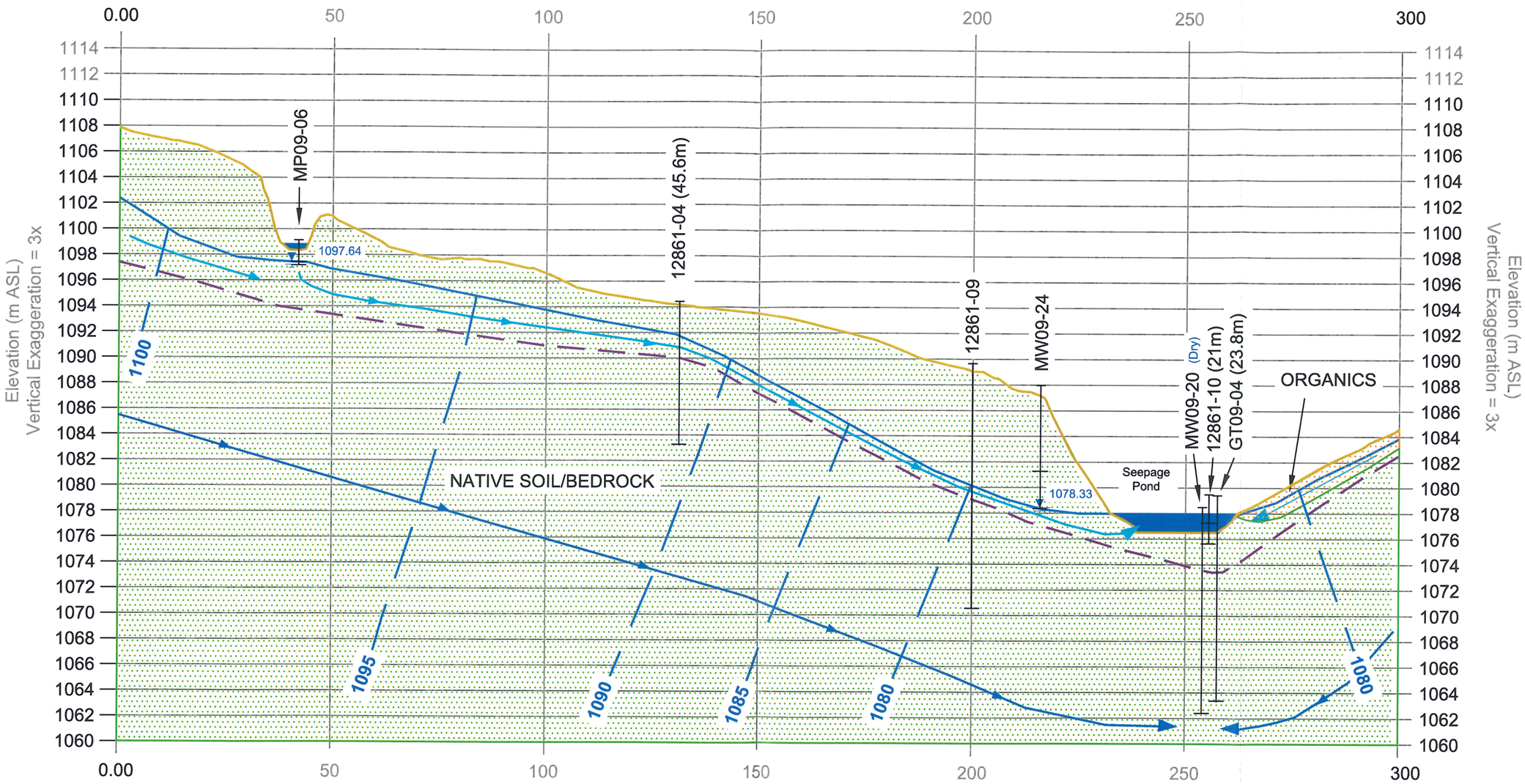
B (North)

B' (South)



0 5 10 20 30 40 m

1 : 1000

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Legend

- Monitoring Well
- Top of Screen
- Bottom of Screen
- Inferred Groundwater Elevation (Deep Aquifer)
- 1079.81 Inferred Groundwater Level
- Ground Surface
- Inferred Top of Permafrost (0° isotherm)
- Organics
- Native Soil / Bedrock
- Inferred Groundwater Equipotential Line
- Inferred Shallow Groundwater Flow Direction
- Inferred Deep Groundwater Flow Direction

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Yukon Government
Mt. Nansen Mine Site Investigation

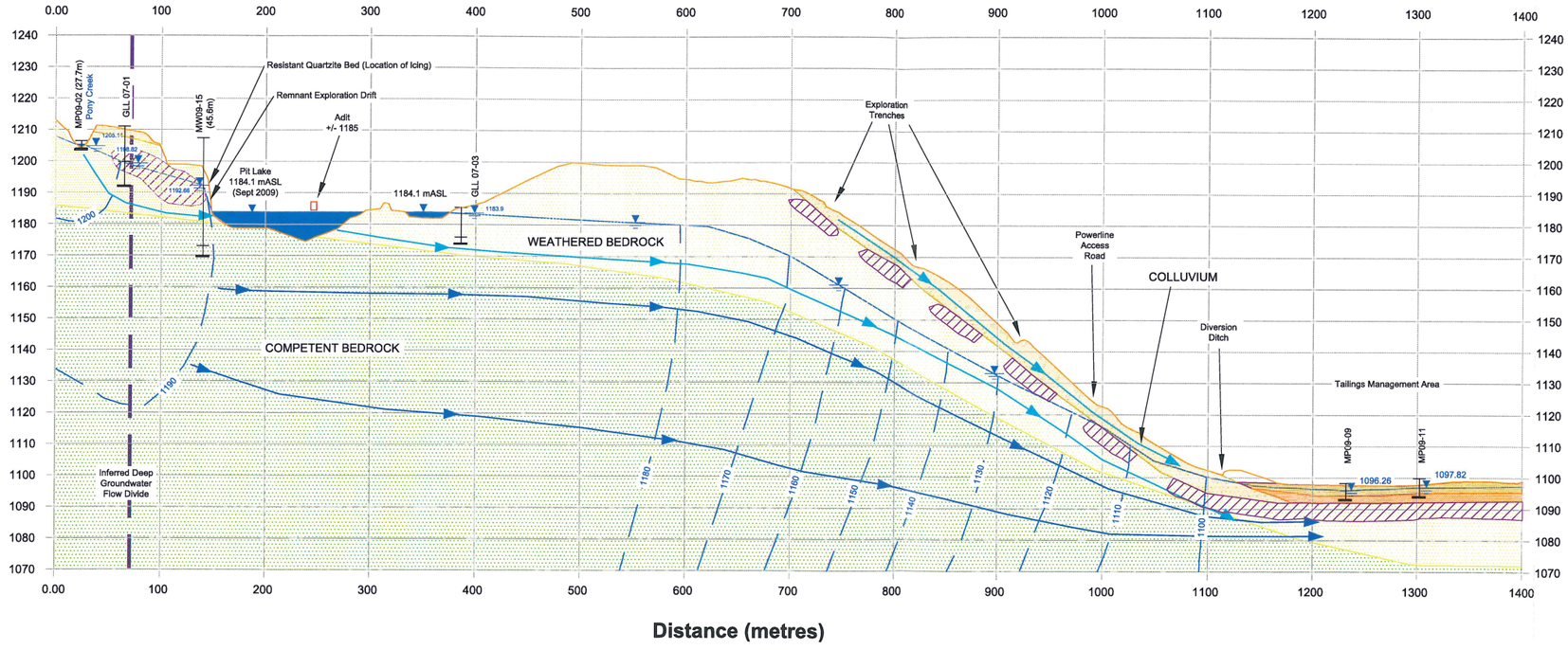
Conceptual Groundwater Flow North of the Seepage Collection Pond (Section B - B')

PROJECT NUMBER	DRAWING NUMBER	ISSUE/REVISION
60159089	Figure 5	1

FILE NAME: 60159089_BY02_FIG5_NANSEN_PROFILES_AA_BB_10SEPT20.DWG BY: MM PLOT: 9/20/2010 2:46:57 PM
B SIZE 11" x 17" (279.4mm x 431.8mm)

(North) **C**

C' (South)



Legend

- Borehole
- Monitoring Well
  - Top of Screen
  - Bottom of Screen
- Inferred Groundwater Elevation (m ASL) (Deep Aquifer)
- 1079.81 Inferred Groundwater Elevation
- Inferred Groundwater Equipotential Line
- Inferred Shallow Groundwater Flow Direction
- Inferred Deep Groundwater Flow Direction
- Inferred Deep Groundwater Flow Divide
- Inferred Vertical Flow
- Organics
- Tailings
- Weathered Bedrock
- Competent Bedrock
- Colluvium
- Permafrost

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Map Sources / Notes:
Top of piezometer, top of screen and bottom of screen elevations, AECOM, Sept. 2009.
Groundwater elevations, AECOM, Sept. 2009.

Horizontal scale
0 10 20 40 60 80 100 m
1 : 2500

File Name: 60159089_Fig02_ProfileCC3_10Sept20.dwg
Reviewed by: RM Prepared by: MH
Date Issued: September, 2010 Project Number: 60159089

Project: Mt. Nansen Site Investigation
Location: West of Carmacks, YT

Conceptual Groundwater Flow Between the Pit and Dome Creek Valley (Section C to C')

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Figure 6

Date Plotted: September 20, 2010 File Location: E:\60\60159089_MtNansen\Rpt_Report_Fig\60159089_Sept2_Fig02.mxd Sept20.dwg

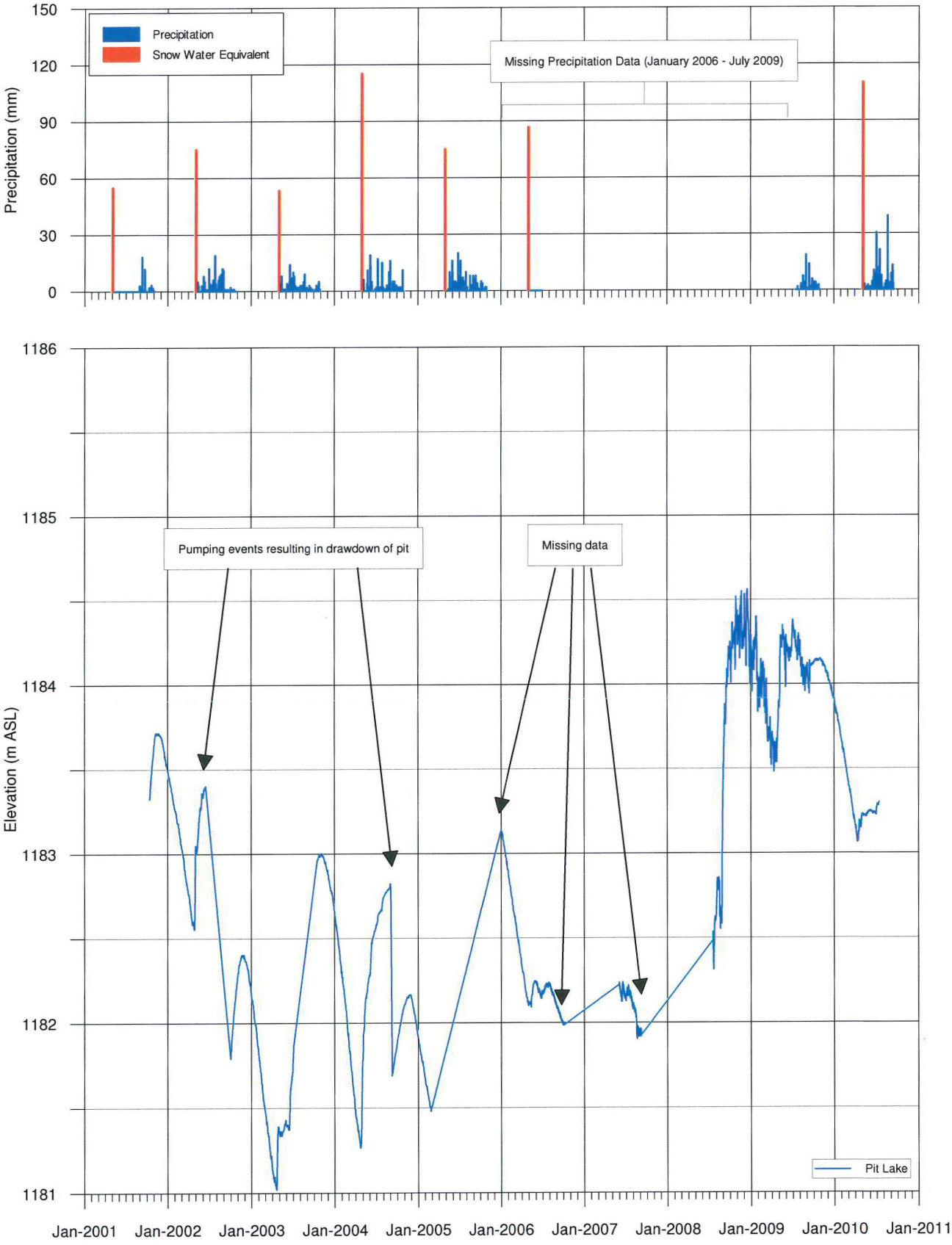

Figure 7. Brown-McDade Pit Lake Elevation (2001 - 2010)

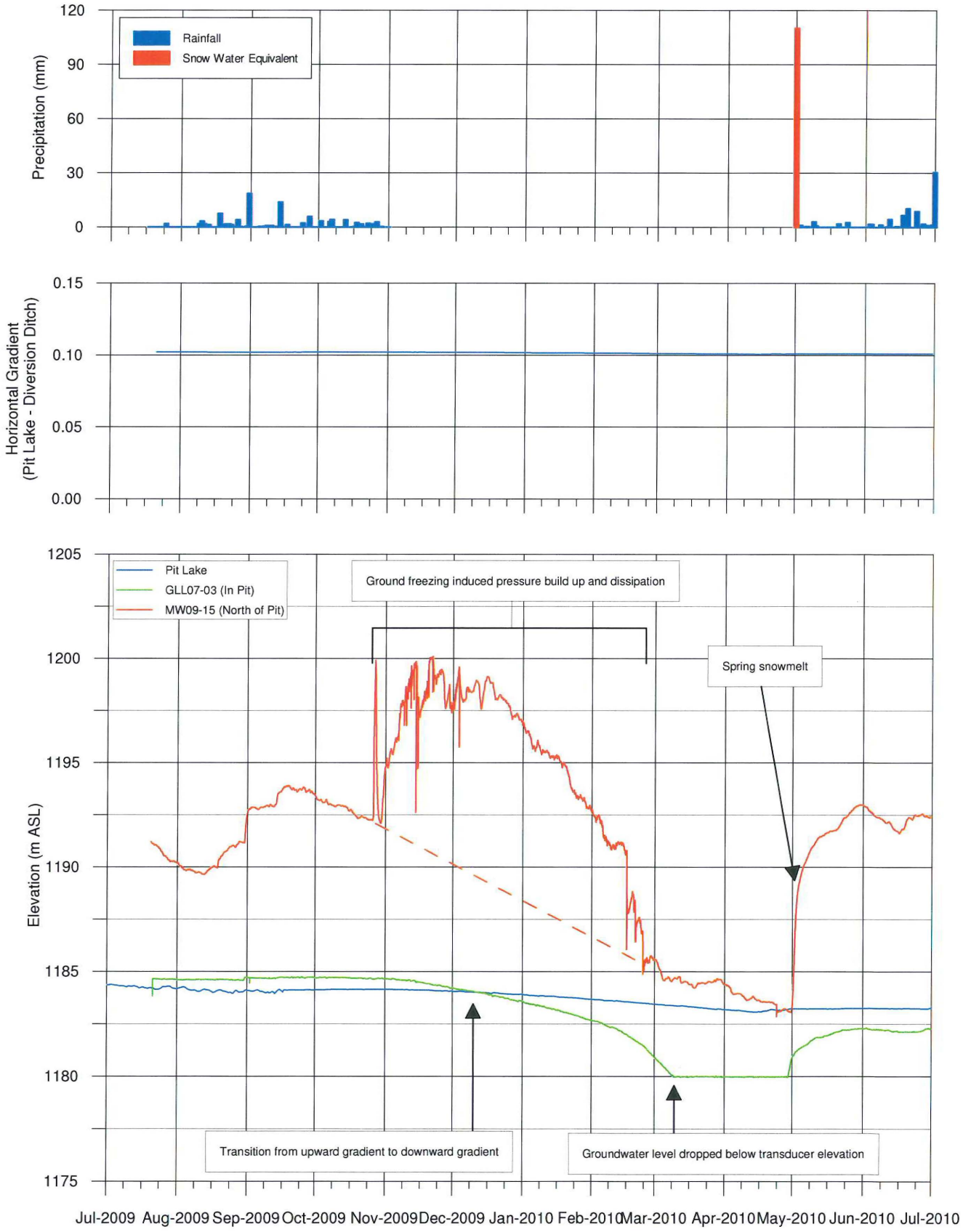

Figure 8. Brown-McDade Pit Lake and Groundwater Elevations (2009 - 2010)

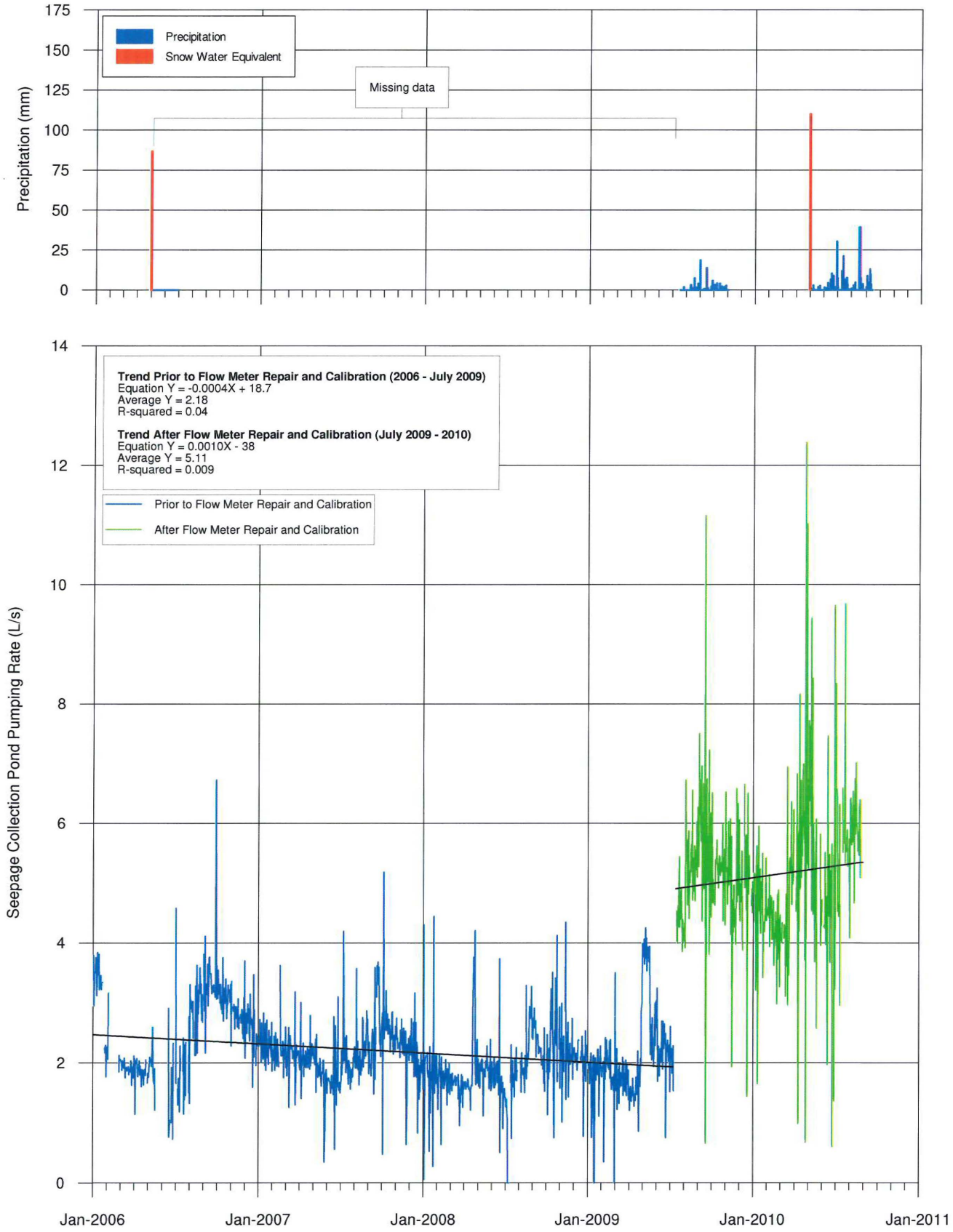

Figure 9. Precipitation and Seepage Collection Pond Pumping Rates (2006 - 2010)

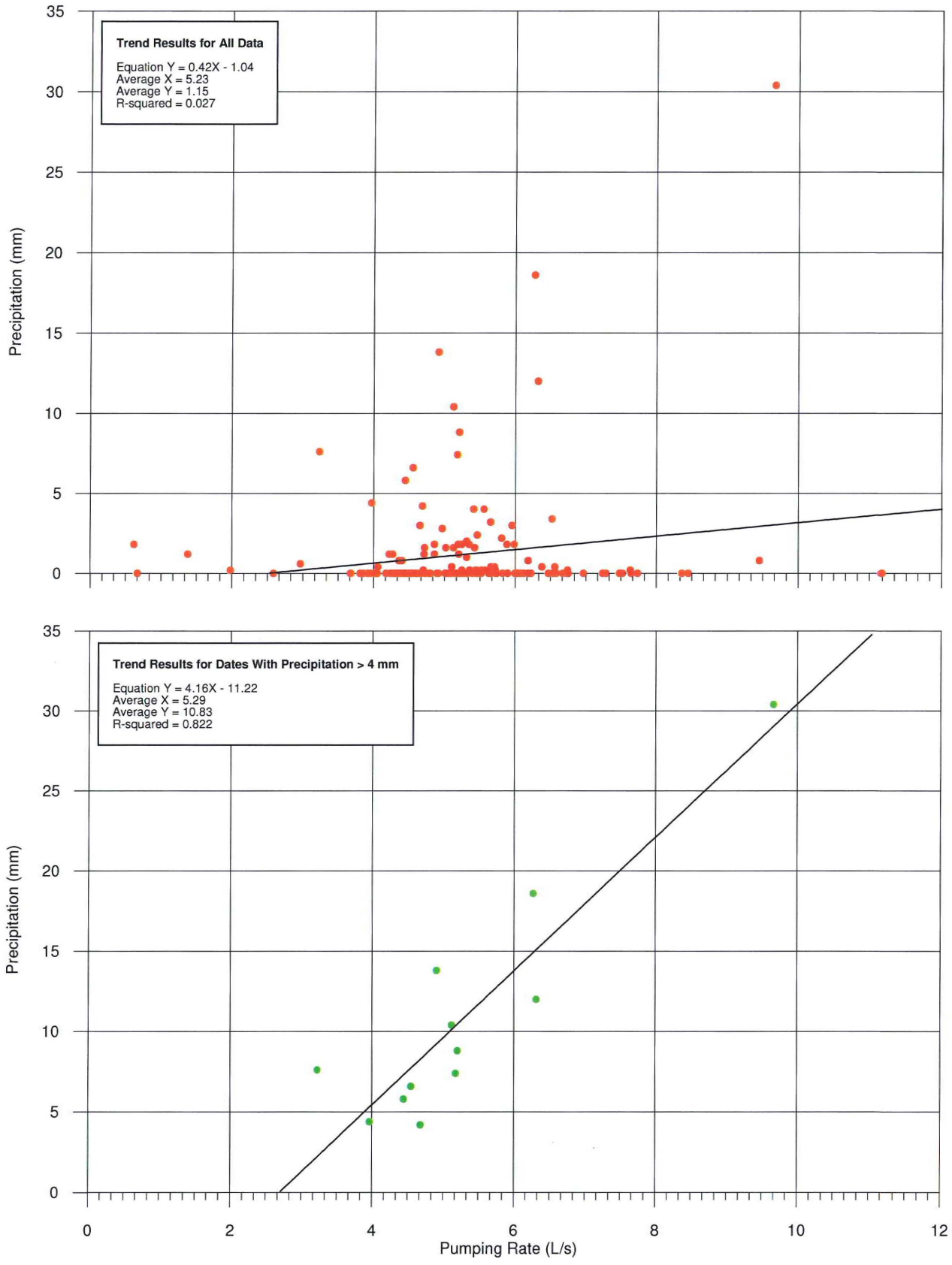

Figure 10. Correlation of Precipitation and Seepage Collection Pond Pumping Rates (2006 - 2010)

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Tables

Table 1. Groundwater Monitoring Well Geotechnical Borehole Installation Details

Station Name	Location		Elevations				Depths					Water Levels				Groundwater Elevations				Comments
	Easting	Northing	Ground Surface Elevation	Top of Piezometer Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Stickup	Borehole Depth Below Ground	Depth to Top of Screen Below Ground	Depth to Bottom of Screen Below Ground	Depth to Bottom of Well Below Top of Pipe	Jul-09	Sep-09	Jun-10	Aug-10	Jul-09	Sep-09	Jun-10	Aug-10	
	m	m	m ASL	m ASL	m ASL	m ASL	m AGS	m BGS	m BGS	m BGS	m BTOP	m BTOP	m BTOP	m BTOP	m BTOP	m ASL	m ASL	m ASL	m ASL	
GT09-01	389459.00	6880612.00	1099.35	1100.37	N/A	N/A	1.03	30.09	N/A	N/A	31.12	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Cross-ref. MW09-23
GT09-02	389498.00	6880549.00	1088.32	1089.13	N/A	N/A	0.80	16.77	N/A	N/A	17.57	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Cross-ref. MW09-22
GT09-03	389510.00	6880620.00	1090.24	1091.11	N/A	N/A	0.88	19.81	N/A	N/A	20.73	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
GT09-04	389593.00	6880583.00	1078.72	1079.55	N/A	N/A	0.83	16.23	N/A	N/A	16.93	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Cross-ref. MW09-20
GT09-05	389591.00	6881551.00	1087.51	1088.08	N/A	N/A	0.57	19.81	N/A	N/A	20.43	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	Cross-ref. MW09-24
GLL07-01	388852.00	6881779.00	1210.46	1211.26	1199.79	1192.17	0.80	18.29	10.67	18.29	19.09	12.95	12.44	14.99	14.92	1198.31	1198.82	1196.27	1196.33	Borehole drilled in 2007, but PVC monitoring well installed in July 2009; Frozen at 16.43 m bTOP on June 30/10
GLL07-02	389071.00	6881706.00	1183.13	1184.51	1180.08	1177.35	1.38	5.78	3.05	5.78	7.16	Dry	Dry	Dry	6.32	<1177.352	<1177.352	<1177.352	1178.19	
GLL07-03	388960.20	6881476.29	1184.84	1185.98	1175.94	1174.25	1.14	10.60	8.91	10.60	11.73	2.13	2.08	4.49	3.22	1183.85	1183.90	1181.49	1182.75	Borehole drilled in 2007, but PVC monitoring well installed in July 2009
MW09-01	389395	6880559	1096.25	1097.35	1086.80	1086.49	1.10	10.67	9.45	9.75	10.97	7.53	7.54	8.55	7.39	1089.82	1089.81	1088.80	1089.96	
MW09-02	389396	6880560	1096.28	1097.25	1093.24	1091.71	0.97	4.57	3.05	4.57	5.28	3.26	3.56	4.18	3.68	1093.99	1093.69	1093.07	1093.58	Well bottom at 4.66 m bTOP on June 30/10. Suspect frozen.
MW09-03	389421	6880558	1096.15	1096.96	1088.07	1087.00	0.81	9.14	8.08	9.14	9.96	6.91	7.12	8.40	7.48	1090.05	1089.84	1088.57	1089.48	Ground elevation increased by 0.21 m during winter of 2009/10 due to backfilling around well
MW09-04	389421	6880559	1096.02	1096.80	1090.53	1089.01	0.79	7.01	5.49	7.01	7.61	3.81	4.30	5.35	4.74	1092.99	1092.50	1091.45	1092.06	Ground elevation increased by 0.29 m during winter of 2009/10 due to backfilling around well
MW09-05	389413	6880656	1095.26	1096.21	1089.48	1088.56	0.96	6.69	5.77	6.69	7.65	Dry	Dry	Dry	Dry	<1088.56	<1177.35	<1088.56	<1088.56	
MW09-06	389414	6880656	1095.32	1096.62	1093.63	1090.58	1.30	4.74	1.70	4.74	6.04	2.95	Dry	2.48	2.60	1093.67	<1090.58	1094.14	1094.02	
MW09-07	389324	6880701	1095.75	1096.78	1093.65	1093.40	1.03	2.36	2.11	2.36	3.39	Dry	Dry	Dry	Dry	<1093.40	<1093.40	<1093.40	<1093.40	
MW09-08	389620	6880577	1073.94	1074.87	1072.63	1071.10	0.93	3.66	1.31	2.83	3.76	1.03	1.05	1.07	1.05	1073.84	1073.82	1073.80	1073.82	
MW09-11	389458	6880632	1107.31	1108.08	1104.62	1103.10	0.77	4.22	2.69	4.22	4.92	4.27	4.18	Frozen at 4.71	4.51	1103.81	1103.90	Frozen at 1103.37	1103.57	
MW09-13	389006	6881664	1208.11	1208.87	1178.24	1172.15	0.76	35.97	29.87	35.97	36.70	33.24	Frozen	Frozen at 9.14	Frozen at 9.14	1175.64	Frozen	Frozen at 1199.73	Frozen at 1199.73	
MW09-14	389008	6881663	1207.85	1208.59	1202.37	1199.32	0.73	10.67	5.49	8.53	11.40	Frozen at 8.13	Frozen	Frozen at 4.22	Frozen at 5.54	<1200.45	<1197.18	Frozen at 1204.37	Frozen at 1204.37	
MW09-15	388921	6881724	1206.82	1207.70	1172.84	1169.79	0.88	37.03	33.99	37.03	37.91	16.74	15.04	13.95	13.94	1190.96	1192.66	1193.75	1193.76	Frozen at 13.96 m bTOP on June 30/10
MW09-16	387992	6881096	1182.81	1183.67	1182.55	1181.03	0.86	1.78	0.26	1.78	2.64	1.21	1.20	1.32	1.07	1182.46	1182.47	1182.35	1182.60	
MW09-17	388078	6880970	1178.03	1178.88	1174.67	1173.15	0.85	4.88	3.35	4.88	5.58	3.88	4.10	3.72	3.55	1175.00	1174.78	1175.16	1175.33	
MW09-18	388056	6880984	1178.93	1179.82	1172.84	1172.04	0.88	6.90	6.10	6.89	7.78	4.40	4.46	4.11	3.79	1175.41	1175.36	1175.71	1176.03	
MW09-19	388053	6881017	1176.84	1177.64	1173.26	1171.73	0.80	5.11	3.59	5.11	5.91	2.61	2.67	2.46	2.20	1175.03	1174.97	1175.18	1175.45	
MW09-20	389593	6880585	1078.64	1079.53	1077.39	1075.86	0.89	3.05	1.26	2.78	3.67	Dry	Dry	3.57	Dry	<1075.86	<1075.86	1075.97	<1075.86	Cross-ref. GT09-04
MW09-21	389537	6880575	1080.68	1081.41	1079.36	1077.83	0.73	3.20	1.32	2.85	3.57	1.67	1.79	1.72	1.80	1079.74	1079.61	1079.68	1079.60	
MW09-22	389498	6880547	1088.34	1089.19	1085.48	1083.96	0.85	4.39	2.86	4.39	5.23	4.85	4.60	Dry	4.51	1084.34	1084.59	<1083.96	1084.68	Cross-ref. GT09-02
MW09-23	389461	6880553	1098.52	1099.43	1085.04	1083.51	0.91	15.00	13.48	15.00	15.92	13.39	13.19	14.30	13.77	1086.04	1086.24	1085.13	1085.66	Cross-ref. GT09-01
MW09-24	389591	6881550	1087.33	1087.99	1081.27	1078.22	0.66	11.28	6.06	9.11	9.77	9.77	9.67	9.91	9.83	1078.22	1078.33	1078.08	1078.16	Cross-ref. GT09-05
TH09-01	389383	6880671	Not measured	No Well	No Well	No Well	No Well	5.18	No Well	No Well	No Well	No Well	No Well	No Well	No Well	No Well	No Well	No well	No well	

Notes:

m BGS	*metres below ground surface*
m AGS	*metres above ground surface;*
m ASL	*metres above mean sea level;*
m BTOP	*metres below top of PVC pipe;*

Table 2. Summary of Mini-Piezometer Installation Details

Station Name	Location		Elevations				Depths					Water Levels							Comments
	Easting (NAD 83)	Northing (NAD 83)	Ground Surface Elevation	Top of Piezometer Elevation	Top of Screen Elevation	Bottom of Screen Elevation	Stickup	Borehole Depth	Depth to Top of Screen	Depth to Bottom of Screen	Depth to Bottom of Well	Depth to GW July 2009	Depth to SW July 2009	Depth to GW Sept. 2009	Depth to SW Sept. 2009	Depth to GW June 2010	Depth to GW Aug. 2010	Depth to SW Aug. 2010	
	m	m	m ASL	m ASL	m ASL	m ASL	m AGS	m BGS	m BGS	m BGS	m BTOP	m BTOP	m BTOP	m BTOP	m BTOP	m BTOP	m BTOP	m BTOP	
MP09-01	388707	6881933	1224.28	1225.73	1224.10	1223.80	1.45	N/A	0.18	0.48	1.63	1.13	1.12	1.02	1.08	N/A	0.98	1.03	Upper Pony Creek
MP09-02	388869	6881815	1204.86	1206.31	1204.66	1204.36	1.46	N/A	0.20	0.50	1.63	1.08	1.08	1.21	1.06	N/A	1.05	1.03	Upper Middle Pony Creek
MP09-03	388958	6881740	1196.22	1197.61	1195.92	1195.62	1.39	N/A	0.30	0.60	1.63	0.70	0.70	1.62	0.67	N/A	0.63	0.62	Lower Middle Pony Creek
MP09-04	389592	6880584	1079.04	1079.90	1078.20	1077.29	0.86	N/A	0.84	1.75	3.05	2.26	Dry	N/A	Dry	2.24	2.23	Dry	Seepage Pond North
MP09-05	389549	6880590	1078.12	1079.17	1077.81	1077.51	1.05	N/A	0.31	0.61	1.83	1.40	Dry	1.43	Dry	1.41	1.41	Dry	Seepage Pond West
MP09-06	389486	6880774	1098.29	1099.28	1097.66	1097.36	0.99	N/A	0.63	0.93	1.63	dry	0.82	1.64	0.80	N/A	2.01	0.80	Div. Channel Bridge
MP09-07	389152	6880783	1099.51	1100.36	1098.66	1098.36	0.85	N/A	0.86	1.16	1.63	0.64	0.65	0.60	0.63	N/A	0.59	0.60	Div. Channel Reclaim
MP09-08	389160	6881722	1167.70	1168.81	1167.11	1166.81	1.11	N/A	0.59	0.89	1.63	0.68	0.89	0.66	0.88	N/A	0.66	0.85	Lower Pony Creek
MP09-09	389240	6880682	1097.20	1098.61	1093.14	1092.94	1.41	N/A	4.06	4.26	5.66	2.47	Dry	2.35	Dry	2.58	2.50	Dry	Tailings Pond North
MP09-10	389240	6880683	1097.23	1098.63	1093.37	1093.37	1.40	N/A	3.86	3.86	5.26	2.51	Dry	2.39	Dry	2.56	2.50	Dry	Tailings Pond North
MP09-11	389221	6880615	1097.78	1098.99	1094.30	1094.00	1.21	N/A	3.48	3.78	4.99	1.45	Dry	1.17	Dry	0.80	1.04	Dry	Tailings Pond South
MP09-12	389221	6880614	1097.78	1098.95	1095.01	1094.71	1.17	N/A	2.77	3.07	4.24	1.45	Dry	1.34	Dry	1.94	1.24	Dry	Tailings Pond South
MP09-13	389077	6880751	1099.94	1100.78	1099.57	1099.26	0.85	N/A	0.36	0.67	1.52	0.52	0.78	0.67	0.72	N/A	0.74	0.74	Div. Channel Dome Inlet
MP09-14	389141	6880722	1097.96	1098.54	1097.33	1097.03	0.58	N/A	0.63	0.93	1.51	0.77	dry	0.43	0.41	N/A	0.51	1.34	Tailings Pond North West

Notes:

m BGS	*Metres below ground surface.*
m AGS	*Metres above ground surface.*
m ASL	*Metres above mean sea level.*
m BTOP	*Metres below top of PVC pipe.*
GW	*Groundwater.*
SW	*Surface Water.*

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Table 3. Permeability Testing Results

Station Name	Hydrostratigraphic Unit Tested	Hydraulic Conductivity m/s	Test Type
Pit Lake	Competent Bedrock	1.00E-07	Pit drainage rates
GLL07-03	Shallow Weathered Bedrock	2.70E-06	Slug test
GLL07-03	Shallow Weathered Bedrock	1.50E-06	Pumping Test
MW09-02	Tailings	1.04E-06	Slug test
MW09-03	Dam Fill	5.53E-06	Slug test
MW09-06	Tailings	2.04E-06	Slug test
MW09-15	Competent Bedrock	1.20E-06	Slug test
MW09-23	Dam Fill	1.29E-05	Slug test
Clay Tailings - Trial 1	Tailings	1.80E-08	Ex-situ Permeameter
Clay Tailings - Trial 2	Tailings	1.10E-07	Ex-situ Permeameter
Silty Sand Tailings - Trial 1	Tailings	8.40E-06	Ex-situ Permeameter
Silty Sand Tailings - Trial 2	Tailings	8.10E-06	Ex-situ Permeameter
Mixed Tailings (Sand and Silt, some Clay) - Tria	Tailings	3.20E-09	Ex-situ Permeameter
Mixed Tailings (Sand and Silt, some Clay) - Tria	Tailings	9.80E-09	Ex-situ Permeameter
Mixed Tailings (Sand and Silt, some Clay) - Tria	Tailings	3.80E-08	Ex-situ Permeameter
Mixed Tailings (Sandy Silt, some Clay) - Trial 1	Tailings	4.80E-10	Ex-situ Permeameter
Mixed Tailings (Sandy Silt, some Clay) - Trial 2	Tailings	5.20E-09	Ex-situ Permeameter
Mixed Tailings (Sandy Silt, some Clay) - Trial 3	Tailings	2.60E-08	Ex-situ Permeameter

Table 4. Physical Soil Property Characterization

Sample Name	Location		Top of Interval	Bottom of Interval	Interval Length		Soil Core Diameter		Sample Volume	Sample Weight	In-situ Density	Material Type	Texture	Physical Testing Conducted
	Easting (m)	Northing (m)	ft BGS	ft BGS	ft	m	in	m	m^3	kg	kg/m^3			
MW09-01	389395	6880559	18	20	2	0.6096	3.25	0.0826	3.26E-03	4.03	1235	Tailings	Clay with minor silt	-
MW09-01	389395	6880559	26	29	3	0.9144	3.25	0.0826	4.89E-03	6.61	1351	Tailings	Clay	Moisture content, Atterberg limits, specific gravity, grain size, soil moisture characteristic curve
MW09-02	389396	6880560	10	15	5	1.5240	3.25	0.0826	8.16E-03	8.1	993	Tailings	Silty sand	Moisture content, Atterberg limits, specific gravity, grain size, soil moisture characteristic curve
MW09-03	389421	6880558	3	4	1	0.3048	3.25	0.0826	1.63E-03	1.88	1152	Tailings	Silty sand	-
MW09-03	389421	6880558	10	11	1	0.3048	3.25	0.0826	1.63E-03	2.26	1385	Tailings	Silty sand	-
MW09-03	389421	6880558	23	24	1	0.3048	3.25	0.0826	1.63E-03	2.31	1416	Tailings	Clay with minor silt	-
MW09-03	389421	6880558	27	28	1	0.3048	3.25	0.0826	1.63E-03	1.07	1312	Half core, Dam	Fine to medium sand, minor silt	Grain size
MW09-04	389421	6880559	16	17	1	0.3048	3.25	0.0826	1.63E-03	2.91	1784	Tailings	Silty sand	-
MW09-07	389324	6880701	11	13	2	0.6096	3.25	0.0826	3.26E-03	4.51	1382	Native	Silty sand	-
MW09-11	389458	6880632	10	13.8	3.8	1.1684	3.25	0.0826	6.25E-03	7.52	2405	Half core, Aeolian	Fine to medium sand	Grain size
TH09-01	389383	6880671	6	7	1	0.3048	3.25	0.0826	1.63E-03	2.39	1465	Tailings	Silty clay	-
TH09-01	389383	6880671	13	14	1	0.3048	3.25	0.0826	1.63E-03	2.4	1471	Native	Aeolian sand	-

Notes:
ft BGS *(Feet below ground surface.*

Table 5. Summary of Hydrogeological Properties

Hydrostratigraphic Unit	Assigned Hydraulic Conductivity (m/s)	Assigned Porosity (%)
Overburden	1×10^{-4} to 1×10^{-6}	30
Shallow Weathered Bedrock	1×10^{-6}	10
Competent Bedrock	1×10^{-6} to 1×10^{-7}	1
Tailings	1×10^{-5} to 5×10^{-10}	30 (Sand) – 50 (Clay)

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Table 6. Soil Quality Exceedences - Mill Area

Sample ID	Soil Quality Guideline		MW09-16 (6'-7')	MW09-17 (11'-12')	MW09-18 (2'-3')	MW09-18 (21'-22')	MW09-19 (7'10" - 8'4")	MW09-19(15'-16'9")
Date Sampled	YCSR - PL [2]	YCSR - IL [1]	15-Jul-09	15-Jul-09	15-Jul-09	15-Jul-09	15-Jul-09	15-Jul-09
Physical Tests								
% Moisture	-	-	11.1	9.68	30.1	7.2	11.7	20
pH	-	-	7.64	7.97	6.39	8.14	6.96	7.13
Metals								
Antimony (Sb)	20	40	***122***	<10	<10	11	***698***	<10
Arsenic (As)	20	20	***1590***	***65.7***	***103***	***205***	***13000***	9.4
Barium (Ba)	500	2000	150	95.1	271	113	99.9	56.6
Beryllium (Be)	4	8	0.5	<0.50	<0.50	0.73	1.25	<0.50
Cadmium (Cd)	2-150	2-150	***41.4***	<0.50	<0.50	<0.50	***91.1***	<0.50
Chromium (Cr)	65	65	16.2	15.6	19.6	***111***	5.1	10.5
Cobalt (Co)	-	-	9.8	8.6	8.3	20	6.7	3.6
Copper (Cu)	150	250	111	44.9	54.5	71.9	***401***	6.4
Lead (Pb)	500	2000	***1570***	<30	<30	<30	***5260***	<30
Mercury (Hg)	15	150	0.151	0.0419	0.0458	0.103	0.426	0.0076
Molybdenum (Mo)	10	40	<4.0	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel (Ni)	100	500	11.8	8.1	12.2	47.8	7.1	5.9
Selenium (Se)	3	10	<2.0	<2.0	<2.0	<2.0	<2.0	<2.0
Silver (Ag)	20	40	***35.2***	<2.0	<2.0	<2.0	***96.9***	<2.0
Thallium (Tl)	-	-	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Tin (Sn)	50	300	<5.0	<5.0	<5.0	<5.0	8.2	<5.0
Vanadium (V)	200	-	56.7	76	60.7	136	22.9	27.4
Zinc (Zn)	150-3000	150-3000	***2760***	60.1	60.3	127	***4300***	24.9
Hydrocarbons								
EPH10-19	-	-	<200	<200	<200	<200	<200	<200
EPH19-32	-	-	<200	<200	<200	<200	<200	<200
LEPH	1000	2000	<200	<200	<200	<200	<200	<200
Polycyclic Aromatic Hydrocarbons								
Acenaphthene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Acridine	-	-	-	-	-	-	-	-
Anthracene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benz(a)anthracene	1	10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(a)pyrene	1	10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(b)fluoranthene	1	10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(g,h,i)perylene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(k)fluoranthene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Dibenz(a,h)anthracene	1	10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Fluoranthene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Fluorene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene	1	10	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene	-	-	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene	5	50	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Phenanthrene	5	50	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Pyrene	10	100	<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Quinoline	-	-	-	-	-	-	-	-

Notes:

All values are in mg/kg unless otherwise stated.

1: Yukon Contaminated Sites Regulation, Generic Numerical or Matrix Soil Standards for Industrial Land, Sep 30, 2002.

2: Yukon Contaminated Sites Regulation, Generic Numerical or Matrix Soil Standards for Park Land, Sep 30, 2002.

BOLD	*Exceedence of YCSR - PL*
BOLD	*Exceedence of YCSR - IL*

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Table 7. Groundwater Quality Exceedences - Mill Area

Sample ID	Water Quality Guideline	MW09-16	MW09-16	MW09-17	MW09-17	MW09-18		MW09-18	MW09-19
Date Sampled	**YCSR AW [1]**	**19-Jul-09**	**01-Sep-09**	**19-Jul-09**	**01-Sep-09**	**19-Jul-09**	**19-Jul-09**	**01-Sep-09**	**01-Sep-09**
Physical Tests									
Conductivity	-	1930	1770	2570	2570	2660	2660	2670	2470
Hardness (as $CaCO_3$)	-	1210	1180	1760	1840	1830	1860	1920	1750
pH	-	7.38	7.23	7.74	7.42	7.71	7.71	7.47	7.16
Total Dissolved Solids	-	1650	1540	2380	2430	2490	2440	2560	2370
Anions and Nutrients									
Acidity (as $CaCO_3$)	-	35.4	31.2	28.5	39.9	30.3	29.7	31.9	45.7
Alkalinity, Total (as $CaCO_3$)	-	298	294	435	434	427	425	426	389
Ammonia as N	1.31 - 18.5 [a]	0.079	<0.020	0.229	<0.020	0.041	0.066	0.021	2.24
Bromide (Br)	-	<2.5	<0.50	<2.5	<1.0	<2.5	<2.5	<1.0	<1.0
Chloride (Cl)	-	<25	<5.0	<25	<10	<25	<25	<10	<10
Fluoride (F)	-	0.152	<0.20	0.144	<0.40	0.143	0.122	<0.40	<0.40
Nitrate (as N)	0.4	<0.25	0.201	<0.25	0.3	<0.25	<0.25	<0.10	<0.10
Nitrite (as N)	0.2 - 2 [b]	<0.050	<0.010	<0.050	<0.020	<0.050	<0.050	<0.020	<0.020
Sulfate (SO4)	1000	934	832	***1360***	***1400***	***1490***	***1470***	***1490***	***1340***
Cyanides									
Cyanide, Weak Acid Diss	0.050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cyanide, Total	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0146
Cyanate (CNO)	-	<1.8	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5.75
Thiocyanate (SCN)	-	-	1.16	-	1.35	-	-	1.23	1.25
Organic / Inorganic Carbon									
Total Organic Carbon	-	-	3.67	-	5.01	-	-	2.89	80.8
Dissolved Metals									
Aluminum (Al)-Dissolved	-	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.050	<0.025
Antimony (Sb)-Dissolved	0.2	0.175	0.102	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025
Arsenic (As)-Dissolved	0.05	***0.0506***	0.0391	0.0119	0.0128	0.0382	0.0423	***0.0526***	***0.0634***
Barium (Ba)-Dissolved	10	0.034	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.077
Beryllium (Be)-Dissolved	0.053	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Bismuth (Bi)-Dissolved	-	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Dissolved	50	0.27	0.19	0.27	0.16	<0.10	<0.10	<0.10	0.4
Cadmium (Cd)-Dissolved	0.0001 - 0.0006 [c]	***0.0558***	***0.0419***	<0.000085	<0.000085	<0.000085	<0.000085	<0.00017	<0.000085
Calcium (Ca)-Dissolved	-	276	273	327	350	352	355	375	373
Chromium (Cr)-Dissolved	0.01, 0.09 [d]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Cobalt (Co)-Dissolved	0.009	0.002	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0030	<0.0015
Copper (Cu)-Dissolved	0.02 - 0.09 [e]	0.01	0.0105	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Iron (Fe)-Dissolved	-	0.389	0.331	<0.030	<0.030	<0.030	<0.030	<0.030	30.4
Lead (Pb)-Dissolved	0.04 - 0.16 [f]	0.0364	0.0284	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025
Lithium (Li)-Dissolved	-	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.050	<0.025
Magnesium (Mg)-Dissolved	-	126	120	230	235	231	236	240	200
Manganese (Mn)-Dissolved	-	0.389	0.208	0.0164	0.0096	0.349	0.409	0.427	1.97
Mercury (Hg)-Dissolved	0.001	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Dissolved	10	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Nickel (Ni)-Dissolved	0.25 - 1.5 [g]	0.0071	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Phosphorus (P)-Dissolved	-	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.41
Potassium (K)-Dissolved	-	6.5	6.4	7.2	7.5	6.9	7.1	7.1	4.9
Selenium (Se)-Dissolved	0.01	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Silicon (Si)-Dissolved	-	5.29	5.28	4.74	4.75	4.8	4.87	4.85	7.6
Silver (Ag)-Dissolved	0.0005 - 0.015 [h]	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00020	<0.00010
Sodium (Na)-Dissolved	-	18.9	9	10.8	11	10	10.2	10.5	14
Strontium (Sr)-Dissolved	-	0.67	0.596	0.972	0.99	0.981	1	1.01	1.01
Thallium (Tl)-Dissolved	0.003	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0020	<0.0010
Tin (Sn)-Dissolved	-	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025
Titanium (Ti)-Dissolved	1	0.013	0.013	0.014	0.014	0.015	0.014	0.014	0.015
Uranium (U)-Dissolved	3	0.0037	0.0029	0.007	0.007	0.0068	0.007	0.0075	<0.0010
Vanadium (V)-Dissolved	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050
Zinc (Zn)-Dissolved	0.75 - 2.4 [i]	***4.44***	***3.66***	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Hydrocarbons									
EPH10-19	-	<0.25	-	<0.25	-	<0.25	<0.25	-	-
EPH19-32	-	<0.25	-	<0.25	-	<0.25	<0.25	-	-
LEPH	0.5	<0.25	-	<0.25	-	<0.25	<0.25	-	-
HEPH	-	<0.25	-	<0.25	-	<0.25	<0.25	-	-
Polycyclic Aromatic Hydrocarbons									
Acenaphthene	0.06	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Acenaphthylene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Acridine	0.0005	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Anthracene	0.001	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Benz(a)anthracene	0.001	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Benzo(a)pyrene	0.0001	<0.000010	-	<0.000010	-	<0.000010	<0.000010	-	-
Benzo(b)fluoranthene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Benzo(g,h,i)perylene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Benzo(k)fluoranthene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Chrysene	0.001	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Dibenz(a,h)anthracene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Fluoranthene	0.002	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Fluorene	0.12	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Indeno(1,2,3-c,d)pyrene	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
2-Methylnaphthalene	-	-	-	-	-	-	-	-	-
Naphthalene	0.01	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Phenanthrene	0.003	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Pyrene	0.2	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-
Quinoline	0.034	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-

Notes:

All values are in mg/L unless otherwise stated.

1: Yukon Contaminated Sites Regulation for the protection of Aquatic Life September 30, 2002.

a: standard varies with pH and temperature. 10°C is assumed. 1.3 mg/L @ pH ≥ 8.5; 3.7 @ pH 8.0 < 8.5; 11.3 @ pH 7.5 <8.0; 18.5 @ pH 7.0 < 7.5; 18.4 @ pH < 7.0.

b: standard varies with chloride concentration. 0.2 @ Cl < 2 mg/L; 0.4 @ CL 2 < 4 mg/L; 0.6 @ Cl 4 < 6 mg/L; 0.8 @ Cl 6 < 8 mg/L; 1 @ Cl 8 < 10 mg/L; 2 @ Cl ≥ 10 mg/L.

c: standard varies with hardness (mg/L $CaCO_3$). 0.0001 @ H < 30; 0.0003 @ H 30 < 90; 0.0005 @ H < 150; 0.0006 @ H 150 < 210.

d: 0.01 mg/L standard is specific to chromium (+6). 0.09 mg/L standard is specific to chromium (+3).

e: standard varies with hardness (mg/L $CaCO_3$). 0.02 @ H < 50; 0.03 @ H 50 < 75; 0.04 @ H 75 < 100; 0.05 @ H 100 < 125; 0.06 @ H 125 < 150; 0.07 @ H 150 < 175; 0.08 @ H 175 < 200; 0.09 @ H ≥ 200.

f: standard varies with hardness (mg/L $CaCO_3$). 0.04 @ H < 50; 0.05 @ H 50 < 100; 0.06 @ H 100 < 200; 0.110 @ H 200 < 300; 0.160 @ H ≥ 300.

g: standard varies with hardness (mg/L $CaCO_3$). 0.25 @ H < 60; 0.65 @ H 60 < 120; 1.1 @ H 120 < 180; 1.5 @ H ≥ 180.

h: standard varies with hardness (mg/L $CaCO_3$). 0.0005 @ H ≤ 100; 0.015 @ H > 100.

i: standard varies with hardness (mg/L $CaCO_3$). 0.075 @ H < 90; 0.15 @ H 90 < 100; 0.9 @ H < 200; 1.65 @ H < 300; 2.4 @ H 300 < 400.

BOLD Exceedence of Yukon Contaminated Sites Regulation for the Protection of Aquatic Life.

Table 8. Summary of Outstanding Hydrogeological Uncertainties

Alternative	Component	Hydrogeology - Key Advantages	Hydrogeology - Key Disadvantages	Hydrogeology - Uncertainty
OPTION 1A - UPGRADE TAILINGS DAM AND MAINTAIN A WATER COVER	Tailings Management Area	Groundwater flow regime reasonably well understood for existing conditions. This option is anticipated to cause minimal changes in the groundwater flow regime	Seepage through the existing dam may contribute to thaw of permafrost. Change will likely be minimal compared to existing conditions.	Effect of changes in permafrost regime on groundwater flow are unknown.
		Quality of seepage through the existing tailings dam is fairly well understood. This option requires only minor modifications to the existing structure.	Increased seepage through the dam relative to existing conditions is expected as a result of increased water levels in the tailings pond.	
		The addition of a toe berm to the dam will lengthen the groundwater flow path and potentially increase the capacity for attenuation.		
	Open Pit	Pit lake storage capacity currently dampens water level fluctuations and minimizes the potential that the water elevations in the pit will rise above the level of the Pony Creek adit.		Integrity of bulkhead in Pony Creek adit is unknown. This will need to be confirmed prior to any in pit placement of tailings or waste rock.
	Overall Site	This option is similar to existing conditions, so the range of possible outcomes are more predictable and more constrained.		The hydrogeological conceptual model is based on limited wells and hydraulic testing data.
				The effects of episodic, seasonal and multi-year variation in precipitation on the hydrogeological conceptual model are uncertain.
OPTION 2A - UPGRADE TAILINGS DAM AND INSTALL A SOIL COVER	Tailings Management Area	Groundwater flow regime reasonably well understood for existing conditions. This option is anticipated to cause minimal changes in the groundwater flow regime.	Seepage through the existing dam may contribute to thaw of permafrost. Change will likely be minimal compared to existing conditions.	Effect of changes in permafrost regime on groundwater flow are unknown.
		Quality of seepage through the existing tailings dam is fairly well understood. This option requires only minor modifications to the existing structure.	Increased seepage through the dam is expected as a result of increased water levels in the tailings pond relative to existing conditions.	
		Seepage through the tailings dam is expected to be reduced relative to Option 1A.		
	Open Pit	Pit lake currently dampens water level fluctuations and minimizes the potential that the water elevations in the pit will rise above the level of the Pony Creek adit.		Integrity of bulkhead in Pony Creek adit is unknown. This will need to be confirmed prior to any in pit placement of tailings or waste rock.
	Overall Site	This option is similar to existing conditions, so the range of possible outcomes is more constrained.		The hydrogeological conceptual model is based on limited wells and hydraulic testing data.
				The effects of episodic, seasonal and multi-year variation in precipitation on the hydrogeological conceptual model are uncertain.
OPTIONS 1B AND 2B - UPGRADE EXISTING TAILINGS DAM AND FILL OPEN PIT WITH WASTE ROCK	Tailings Management Area	See Options 1A/2A above.	See Options 1A/2A above.	See Options 1A/2A above.
	Open Pit		Once the pit is backfilled, groundwater levels within the pit will exhibit greater fluctuation due to a reduction in porosity. This could result in water levels rising above the elevation of the Pony Creek adit, and direct discharge of water from the pit to Pony Creek.	The range of possible water table elevations after the pit is backfilled are unknown. A three-dimensional numerical groundwater model is required to test the sensitivity of groundwater elevations to variations in surface infiltration.
			Treatment of water likely required for removal of water from the open pit prior to backfilling of pit.	Integrity of bulkhead in Pony Creek adit is unknown. This will need to be confirmed prior to any in pit placement of tailings or waste rock.
	Overall Site	This option is similar to existing conditions, so the range of possible outcomes is more constrained, but less predictable than for Options 1A and 2A.		The effects of episodic, seasonal and multi-year variation in precipitation on the hydrogeological conceptual model are uncertain. This effect is amplified for Options 1B and 2B due to lower porosity.
				The effect of changing surface water catchments around the pit on groundwater levels, the position of groundwater divides and groundwater flow is unknown.
				The hydrogeological conceptual model is based on limited wells and hydraulic testing data.

Table 8. Summary of Outstanding Hydrogeological Uncertainties

Alternative	Component	Hydrogeology - Key Advantages	Hydrogeology - Key Disadvantages	Hydrogeology - Uncertainty
OPTION 3 - RELOCATE TAILINGS TO OPEN PIT AND MAINTAIN SATURATED CONDITIONS	Tailings Management Area	Impacts to shallow groundwater within the footprint of the TMA will be reduced in the long term.		
	Open Pit	Potential for groundwater recovery well to be installed in bedrock at bottom of open pit for recovery of contaminated groundwater. Success will be dictated by hydraulic conductivity of bedrock.	Once the pit is backfilled, groundwater levels within the pit will exhibit greater fluctuation due to a reduction in porosity. This could result in water levels rising above the elevation of the Pony Creek adit, and direct discharge of water from the pit to Pony Creek.	The ability to maintain tension saturation of tailings located in the pit has yet to be fully demonstrated in the context of a three-dimesional open pit.
			Groundwater quality beneath the pit will likely be degraded relative to existing conditions.	The effect of placing tailings in the pit on regional groundwater flow is unknown, but it will definitely change the flow system.
			Radial outward flow from the pit could result if the water table rises significantly.	Integrity of bulkhead in Pony Creek adit is unknown. This will need to be confirmed prior to any in pit placement of tailings or waste rock.
			Treatment of water likely required for water in open pit prior to backfilling and for consolidation water for some time following placement.	Effect of tailings consolidation on hydraulic conductivity and seepage through tailings is uncertain.
	Overall Site			The effect of changing surface water catchments around the pit on groundwater levels, the position of groundwater divides and groundwater flow is unknown.
				The effects of episodic, seasonal and multi-year variation in precipitation on the hydrogeological conceptual model are uncertain.
				The hydrogeological conceptual model is based on limited wells and hydraulic testing data.
OPTION 4 - RELOCATE TAILINGS TO OPEN PIT AND MAINTAIN DRY CONDITIONS	Tailings Management Area	Impacts to shallow groundwater within the footprint of the TMA will be reduced in the long term.		
	Open Pit	Less concern about water table mounding and radial outward flow from the pit relative to Option 3.	Groundwater quality beneath the pit will likely be degraded relative to existing conditions.	The ability to maintain tailings in a dry state and minimize the flow of groundwater through the dry tailings is uncertain.
		Potential for groundwater recovery well to be installed in waste rock at bottom of open pit for recovery of contaminated groundwater.	Once the pit is backfilled, groundwater levels within the pit will exhibit greater fluctuation due to a reduction in porosity. This could result in water levels rising above the elevation of the Pony Creek adit, and direct discharge of water from the pit to Pony Creek.	Effect of tailings consolidation on hydraulic conductivity and seepage through tailings is uncertain.
			Cover integrity may be compromised as tailings consolidate. This could result in increased infiltration through the cover and mobilization of contaminated porewater.	Integrity of bulkhead in Pony Creek adit is unknown. This will need to be confirmed prior to any in pit placement of tailings or waste rock.
			Treatment of water likely required for water in open pit prior to backfilling and during consolidation of tailings.	
	Overall Site			The effect of changing surface water catchments around the pit on groundwater levels, the position of groundwater divides and groundwater flow is unknown.
				The effects of episodic, seasonal and multi-year variation in precipitation on the hydrogeological conceptual model are uncertain.
				The hydrogeological conceptual model is based on limited wells and hydraulic testing data.

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Appendix A

Borehole and Monitoring Well Logs

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01 / MW09-23**
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0					SAND (fill), trace gravel, trace silt, trace organics - yellowish orange-brown - moist, compact to dense - medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - matrix supported - presence of roots until 3.05 m below ground surface					1099
1										1098
2										1097
3					- moist with dry lenses		S-1	10-14-15		1096
4										
4	FILL									1095
5										1094
6										1093
7										1092
8										1091
9	FILL				- SAND and GRAVEL		S-2	7-14-15		1090
10					SAND (fill), trace to some gravel, trace silt - yellowish orange-brown - medium grained to fine grained sand (trace coarse sand), sub-rounded - sub-rounded gravel, >0.5 cm to <2 cm - matrix supported - moist, compact to dense					1089
11										
11	FILL									1088
12										1087
13										1086
14					SAND and GRAVEL (fill), trace silt - brown - medium grained to fine grained sand, sub-rounded - sub-angular gravel, >0.5 cm to <2 cm - clast supported		S-3	43-57-48		1085
14	FILL									
15										

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01 / MW09-23**
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS (Becker, Dynamic Cone, SPT (Standard Pen Test) (Blows/300mm), Total Unit Wt (kN/m³), Plastic MC Liquid)	COMMENTS	ELEVATION
15	FILL				- wet, dense to very dense - GRAVEL (fill), sandy						1084
16	SA				SAND (native soil), trace to some silt, trace organics - dark grey - medium grained to fine grained sand, sub-rounded - wet, loose to compact - silt content increases with depth		S-4	7-13-14			1083
17	GRSA				SAND and GRAVEL, trace silt - dark grey - medium grained sand (trace coarse sand), sub-rounded - sub-angular gravel, >0.5 cm to 5 cm - clast supported						1082
18					- wet, very loose		S-5	2-1-2			1081
19	SA				SAND (native soil), trace to some silt, trace organics - dark grey - fine sand, sub-rounded - wet, very loose - sand coarsens with depth - some gravel						1080
20											1079
21	GRSA				SAND and GRAVEL, trace silt - dark grey-brown - medium sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - clast supported - permafrost at 21.5 m below ground surface, Nbn, 2.8C		S-6	4-20-47			1078
22											1077
23					SAND, trace to some silt, trace gravel - dark grey - medium grained to fine grained sand, sub-rounded - sub-angular gravel, <1 cm - compact to dense - SAND and GRAVEL until approx. 27.4 m below ground surface						1076
24											1075
25	SA										1074
26					- fine sand content decreases with depth		S-7	31-61-			1073
27											1072
28					- some gravel SAND and GRAVEL - light grey-brown - fine grained to medium-coarse sand, sub-rounded - sub-angular gravel, <1 cm - coarsening downward sequences						1071
29	GRSA						G-8				1070
30											

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: GT09-01 / MW09-23
LOCATION: Tailings Dam Crest, near TH-03 UTM N 2,097,210.5 E 118,707.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1099.4

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
30					END OF DRILLING at 30.18 m in permafrost (refusal) - 10 cm of heaving at 17.53 m below ground surface MW09-23 install: - Screen interval: 13.41 m - 14.94 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 13.11 m - 14.94 m - Bentonite seal from ground surface to 13.11 m - WL: 13.409 mTPVC (21-Jul-09, 8:30:00 AM) Thermistor install: - 2" PVC pipe SCHED 40 - grout from 30.2 m below ground surface to ground surface - 1" PVC pipe SCHED 40 install inside the 2" PVC pipe SCHED 40 - grout inside the annulus space					1069
31											1068
32											1067
33											1066
34											1065
35											1064
36											1063
37											1062
38											1061
39											1060
40											1059
41											1058
42											1057
43											1056
44											1055
45											

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02 / MW09-22**
LOCATION: Tailings Dam, on Road from South Abutment UTM N 2,097,191.5 E 118,719.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1088.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: Becker | Dynamic Cone | SPT (Standard Pen Test) (Blows/300mm); Total Unit Wt (kN/m³); Plastic | MC | Liquid

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0					SAND (fill), trace silt - medium brown - fine grained to medium grained sand, sub-rounded - moist, loose					1088
1										1087
2	FILL						S-1	5-7-10		1086
3					- some gravel below 2.13 m below ground surface		S-2	5-6-6		1085
4										1084
5	SA				SAND, trace silt, trace organics - wood debris, <2 cm - dark grey - sub-rounded - permafrost at 5.64 m below ground surface, Nbn, 1.6C - gravel content increases with depth to "gravelly"		S-3	1-1-1		1083
6							S-4	28-34-61		1082
7	GRSA				GRAVEL, sandy, trace silt - dark grey - medium to coarse sand, sub-angular - sub-angular gravel, >0.5 cm to 2 cm		S-5	25-42-35		1081
8					SAND, trace silt - dark grey - medium grained sand, sub-rounded					1080
9					- trace gravel (>0.5 cm) below 8.84 m below ground surface - fine grained to medium grained sand below 9.14 m below ground surface		S-6	27-42-34		1079
10										1078
11	SA				- medium grained sand below 10.36 m below ground surface - trace gravel (<2 cm) below 10.67 m below ground surface		S-7	37-38-46		1077
12										1076
13					- fine grained to medium grained sand below 12.19 m below ground surface		S-8	38-47-56		1075
14					- some gravel below 13.41 m below ground surface		S-9	37-45-47		1074
15										

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.77 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02 / MW09-22**
LOCATION: Tailings Dam, on Road from South Abutment UTM N 2,097,191.5 E 118,719.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1088.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
15	SA										1073
16	GRSA				GRAVEL, sandy, trace silt - yellowish orange - fine grained to medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - clast supported		S-10	38-49-60			1072
17					END OF DRILLING at 16.77 m in permafrost (refusal)						1071
18					MW09-22 install: - Screen interval: 1.22 m - 4.27 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 0.92 m - 4.27 m - Bentonite seal from ground surface to 0.92 m - WL: 4.845 mTPVC (22-Jul-09, 8:33:00 AM)						1070
19					Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.77 m below ground surface						1069
20											1068
21											1067
22											1066
23											1065
24											1064
25											1063
26											1062
27											1061
28											1060
29											1059
30											

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.77 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace UTM N 2,097,213.3 E 118,722.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1090.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FI			SAND and GRAVEL(Fill), trace silt - dark brown - moist, loose - medium grained sand, sub-angular - sub-angular gravel, 0.5 cm to <1.5 cm - clast supported - staining on gravel					1090
1									1089
2				SAND (Aeolian), trace silt, trace gravel - orange-brown - moist with dry lenses, loose to compact - fine grained to medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to < 2.5 cm - matrix supported		S-1	4-5-4		1088
3						S-2	4-5-5		1087
4	SA								1086
5				- some gravel below 5.33 m below ground surface		S-3	3-4-5		1085
6				- trace gravel below 6.10 m below ground surface		S-4	6-7-7		1084
7				- some gravel below 7.32 m below ground surface					1083
8	GRSA			SAND and GRAVEL, trace silt - light brown-orange - moist, compact - medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - iron staining on gravel		S-5	4-7-5		1082
9	SA			SAND, trace gravel, trace silt (Aeolian) - orange-brown - moist, compact - medium grained sand, sub-rounded - sub-rounded gravel, 1 cm to 1.5 cm - matrix supported		S-6	3-7-9		1081
10	GRSA								1080
11				SAND and GRAVEL, trace silt SAND, trace gravel, trace silt		S-7	6-8-4		1079
12	SA			- some gravel below 12.19 m below ground surface		S-8	4-5-10		1078
13									1077
14	GRSA			SAND and GRAVEL, trace silt - coarsening downward sequence		S-9	3-7-2		1076
15									

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace UTM N 2,097,213.3 E 118,722.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1090.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
15	GRSA			GRAVEL, sandy, trace silt - coarsening downward sequence		S-10	5-24-16			1075
16	GRSA									1074
17				SAND, some silt, trace gravel - olive grey - very dense - fine grained to medium grained sand, sub-rounded - sub-angular, >0.5 cm to 1 cm - permafrost at 16.52 m below ground surface		S-11	25-52-34		1073
18	SA									1072
19										1071
20				END OF DRILLING at 19.87 m in permafrost (refusal) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 19.86 m below ground surface					1070
21										1069
22										1068
23										1067
24										1066
25										1065
26										1064
27										1063
28										1062
29										1061
30										

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04 / MW09-20**
LOCATION: Seepage Dam Crest UTM N 2,097,202.0 E 118,747.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1078.7

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

BACKFILL TYPE: BENTONITE; GRAVEL; SLOUGH; GROUT; CUTTINGS; SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	SAND and GRAVEL (Fill), trace silt - light brown-orange - moist, very loose - medium grained sand, sub-rounded - gravel sub-angular, from 0.5 cm to >6 cm - matrix supported					1078
1							
2	FILL	SAND (Fill), trace to some silt, trace gravel - light brown-orange - mois, very dense - medium grained sand, sub-rounded - gravel sub-angular, from 2 cm to >4 cm - matrix supported - permafrost at 2.8 m below ground surface, -0.3C, Nbn		S-1	3-2-2		1077
3				S-2	30-40-42		1076
4		SAND (Native soil), trace to some silt, trace to some organic - dark grey-brown - mediumgrained to coarse grained sand, sub-rounded					1075
5				S-3	14-19-20		1074
6	SA						1073
7	SA	- trace gravel below 6.5 m below ground surface - silt content increases with depth - sand becomes finer with depth		S-4	31-39-39		1072
8		SAND and GRAVEL, some silt - dark brown - coarse sand - sub-angular gravel - sub-angular sand		G-5			1071
9				G-6			1070
10	GRSA						1069
11				G-7			1068
12		- gravel content decreases to become SAND, gravelly, trace of silt					1067
13		SAND, trace to some silt, trace gravel - sub-angular gravel, 0.5 cm to < 2 cm - fine grained to medium grained sand, sub-rounded		G-8			1066
14	SA	- SAND, gravelly, trace of silt below 13.41 m below ground surface		S-9	41-71-51		1065
15							1064

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM	LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
	REVIEWED BY: Alex Knop	COMPLETION DATE: 16/7/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04 / MW09-20**
LOCATION: Seepage Dam Crest UTM N 2,097,202.0 E 118,747.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1078.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt (kN/m³) / Plastic MC Liquid	COMMENTS	ELEVATION
15	SA										
	GRSA				SAND and GRAVEL, trace of silt - dark grey-brown - medium sand, sub-rounded - gravel sub-angular, from 0.5 cm to > 4 cm - silt content increases with depth - permafrost temperature: 0.9°C description: Nbn		S-10	67--			1063
16											1062
17					END OF DRILLING at16.23 m in permafrost (refusal)						1061
18					MW09-20 install: - Screen interval: 1.37 m - 2.90 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.10 m - 2.90 m - Bentonite seal from ground surface to1.10 m - WL: Dry (22-Jul-09, 8:25:00 AM)						1060
19											1059
20					Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.10 m below ground surface						1058
21											1057
22											1056
23											1055
24											1054
25											1053
26											1052
27											1051
28											1050
29											1049
30											

AECOM

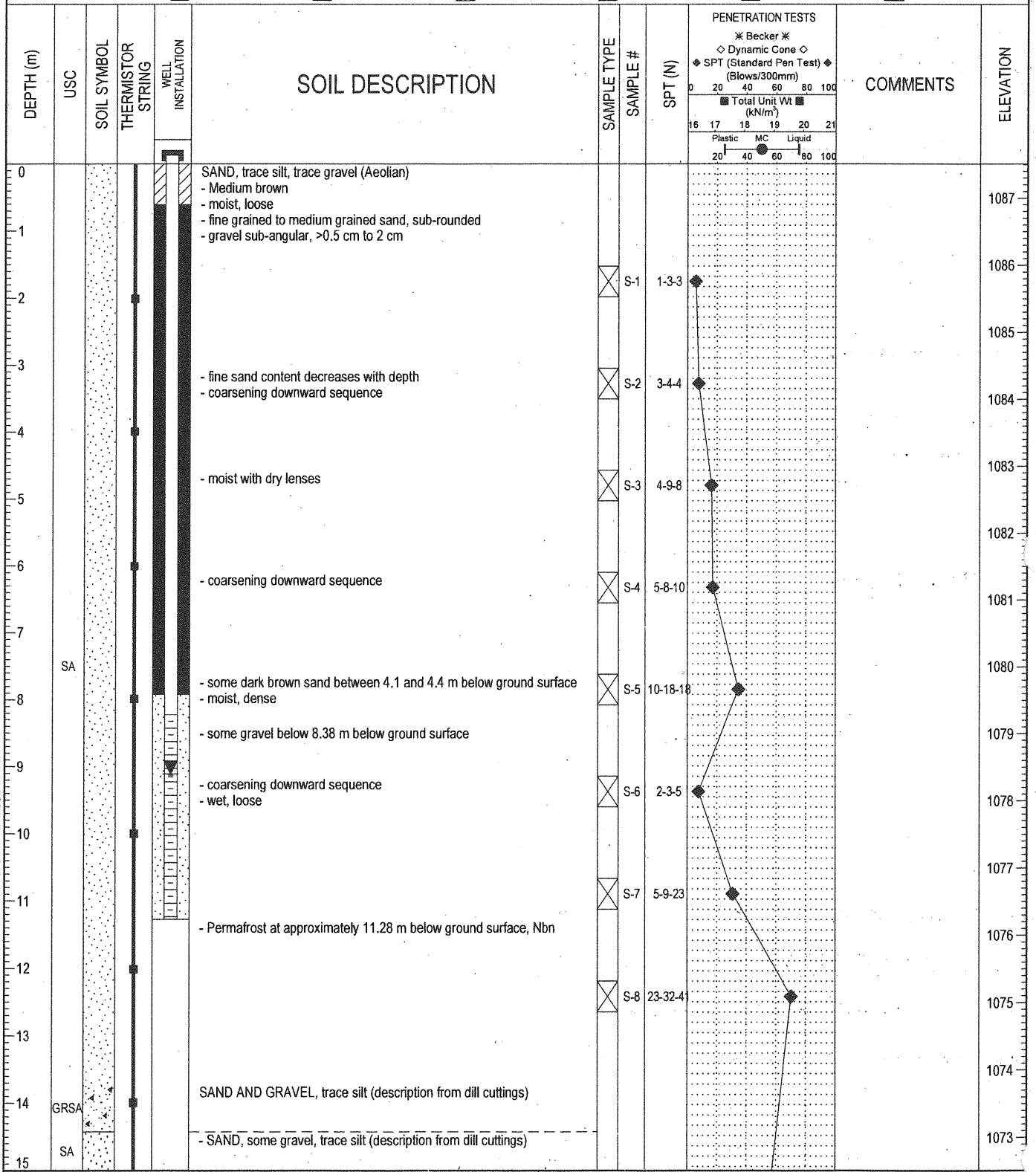
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 16/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-05 / MW09-24**
LOCATION: North terrace, near Seepage Dam UTM N 2,097,214.2 E 118,738.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1087.5

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND



LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 21/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

AECOM

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WNN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: GT09-05 / MW09-24
LOCATION: North terrace, near Seepage Dam UTM N 2,097,214.2 E 118,738.1		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1087.5

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
15	SASI				SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth					1072
16					SAND, trace to some silt, trace gravel - dark grey - dense - fine grained to medium grained sand, sub-rounded - sub-angular gravel, < 1 cm - matrix supported - lenses of organic material, <2 cm					1071
17	SA						S-9	21-26-23		1070
18										1069
19	GRSA				SAND and GRAVEL, trace silt - gravel content increases with depth - sub-angular gravel, < 2 cm - coarse sand, sub-rounded					1068
20					END OF DRILLING at 19.87 m in permafrost (refusal) MW09-24 install: - Screen interval: 8.23 m - 11.28 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 7.82 m - 11.28 m - Bentonite seal from 0.61 m to 7.92 m - Drill cutting from ground surface - WL: 9.774 mTPVC (22-Jul-09, 8:06:00 AM) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 19.86 m below ground surface					1067
21										1066
22										1065
23										1064
24										1063
25										1062
26										1061
27										1060
28										1059
29										1058
30										

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 21/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-01**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded					1096
1							1095
2	SA	SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					1094
3	SM	SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand		S-1			1093
4							1092
5	CI	CLAY TAILINGS - dark yellow brown - wet, medium stiff, cohesive, medium plasticity, slow dilatency - minor silt, fining downward and finely laminated					1091
6				S-2			1090
7		- damp from 7.62 m to 9.14 m					1089
8				S-3			1088
9	SM SA	SILTY SAND - brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, organic odour, twigs and organic matter embedded, sharp contact with overlying clay - encountered heaving sands at approx. 10 m; switched to cable tool drilling					1087
10	SA	SAND - brown - wet, very loose, non-cohesive, non-plastic - coarse subrounded sand with minor angular gravel inferred to be colluvium					1086
11		SAND - brown grading to black below 10.21 m - wet, dense, non-cohesive, non-plastic - coarse sand with increasing silt content downhole, organic odour					1085
12		END OF DRILLING at 10.66 m					1084
13		MW09-01 installation: - Screen interval: 9.45 m - 9.75 m - Screen type: 10-Slot 1.25" PVC SCHED 40 - Filter pack interval: 9.14 m - 9.75 m - Bentonite seal: 8.53 m - 9.14 m - WL: 7.648 m bTOP (8-Jul-09, 8:00 AM)					1083
14							1082
15							

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-02**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	FILL			SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded						1096
1										1095
2	SA			SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded						1094
3										1093
4	SM			SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand		S-1				1092
5				END OF DRILLING at 4.57 m MW09-02 installation: - Screen interval: 3.05 m - 4.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 3.211 m bTOP (9-Jul-09, 11:35 AM)						1091
6										1090
7										1089
8										1088
9										1087
10										1086
11										1085
12										1084
13										1083
14										1082
15										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-03**
LOCATION: South side of tailings empoundment UTM N 2,097,195.3 E 118,691.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.2

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: Becker | Dynamic Cone | SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100 | Total Unit Wt (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1096
1		SILTY SAND TAILINGS - dark yellowish orange - moist becoming wet at 2.31 m, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded		S-1			1095
2	SM						1094
3				S-2			1093
4	SASI SICL	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1092
5		SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency					1091
6	SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					1090
7	CL	CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, high plasticity, slow dilatency		S-3			1089
8	CB SA	COBBLES AND SAND AND SILT - brown - wet, dense, non-cohesive, non-plastic - loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam		S-4			1088
9		SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill					1087
10		END OF DRILLING at 9.14 m					1086
11		MW09-03 installation: - Screen interval: 8.08 m - 9.14 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 7.93 m - 9.14 m - Bentonite seal: 7.32 m - 7.92 m - WL: 6.910 m bTOP (22-Jul-09)					1085
12							1084
13							1083
14							1082
15							

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 9.14 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-04**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1096.0

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					
1		SILTY SAND TAILINGS - dark yellowish orange - moist becoming wet at 2.31 m, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1095
2	SM						1094
3				S-1			1093
4	SASI SICL	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					1092
5		SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency		S-2			1091
6	SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					1090
7		END OF DRILLING at 7.01 m					1089
8		MW09-04 installation: - Screen interval: 5.49 m - 7.01 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 3.810 m bTOP (22-Jul-09)					1088
9							1087
10							1086
11							1085
12							1084
13							1083
14							1082
15							

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 7.01 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WNN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-05**
LOCATION: North side of tailings empoundment UTM N 2,097,224.9 E 2,097,224.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL DESCRIPTION	ELEVATION
0	SICL	SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency	1095
1			1094
2	SM	SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded	1093
3		CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency	1092
4	CL		1091
5	OR SM	ORGANICS - dark brown - wet - primarily moss	1090
6	SA	SILTY SAND - dark brown - moist, dense, non cohesive, non plastic, slow dilatency - fine to medium sand, sub-rounded, occasional angular clast up to 10 mm inferred to be native aeolian sand	1089
7			1088
8		SAND - brown - moist, loose, non-cohesive, non-plastic, slow dilatency - medium sand with minor silt inferred to be native aeolian sand with developed soil horizon	1087
9		END OF DRILLING at 6.71 m	1086
10		MW09-05 installation: - Screen interval: 5.79 m - 6.70 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 5.49 m - 6.70 m - Bentonite seal: 5.18 m - 5.79 m - WL: Dry (22-Jul-09)	1085
11			1084
12			1083
13			1082
14			1081
15			

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100

■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

COMMENTS

SAMPLE TYPE | SAMPLE # | SPT (N)

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 6.71 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-06**
LOCATION: North side of tailings empoundment UTM N 2,097,224.9 E 2,097,224.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	SICL			SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency				✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100		1095
1										1094
2	SM			SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded						1093
3	CL			CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency						1092
4										1091
5				END OF DRILLING at 4.57 m MW09-06 installation: - Screen interval: 1.52 m - 4.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: Naturally developed - Bentonite seal: None - WL: 2.95 m bTOP (22-Jul-09)						1090
6										1089
7										1088
8										1087
9										1086
10										1085
11										1084
12										1083
13										1082
14										1081
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 10/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-07**
LOCATION: North side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1095.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				SILTY SAND FILL - brown - dry, loose, non-cohesive, non-plastic - native fill used for drill pad construction						1095
1	SM									
2	SM OR SA CL			SILTY SAND TAILINGS - dark yellowish brown - moist, medium dense, non-cohesive, non-plastic - fine to medium grained sand, sub-rounded						1094
3				ORGANICS - dark brown to black - moist - fibrous roots and moss becoming more decomposed with depth						1093
4	SM			SAND - dark brown - moist, dense, non-cohesive, non-plastic - fine sand, sub-rounded, inferred to be developing soil horizon within native aeolian sand						1092
5				CLAY - light grey - moist, very dense, cohesive, non-plastic - clay sized volcanic ash sediments						1091
6				SILTY SAND - dark grey to black - moist, dense, cohesive, non-plastic - fine sand, sub-rounded, organic rich, grading coarser with depth						1090
7				END OF DRILLING at 4.57 m						1089
8				MW09-07 installation: - Screen interval: 2.31 m - 2.57 m - Screen type: 10-Slot 2" PVC SCHED 40 wrapped in 5 micron Nitex cloth - Filter pack interval: 2.00 m - 2.57 m - Bentonite seal: None - WL: Dry (22-Jul-09)						1088
9										1087
10										1086
11										1085
12										1084
13										1083
14										1082
15										1081

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 — ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 — Plastic MC Liquid 20 40 60 80 100

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-08**
LOCATION: Downstream of Seepage Dam UTM N 2,097,199.8 E 118,756.2		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1073.9

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: Becker / Dynamic Cone / SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0	GRSA			SAND and GRAVEL, trace silt - orange-brown - moist, loose - medium grained sand, sub-rounded - gravel sub-angular to sub-angular, 0.5 cm to 5 cm - clast supported - presence of organic (roots, grass)						1073
1										
2	SA			SAND, some silt, some organic - dark grey - moist to wet, loose - fine grained to medium grained sand - presence of roots						1072
3	GRSA			SAND and GRAVEL, trace silt - dark yellowish brown - medium grained sand, sub-rounded - sub-angular gravel, 0.5 cm to > 8 cm - clast supported - permafrost at 3.05 m below ground surface, Nbn						1071
4	SA			SAND, trace silt - dark brown and grey - very dense - medium grained sand - presence of wood debris - permafrost, Nbn						1070
5										1069
6				END OF DRILLING at 3.66 m in permafrost (refusal)						1068
7				MW09-08 install: - Screen interval: 1.52 m - 3.05 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.22 m - 3.58 m - Bentonite seal from ground surface to 1.22 m - WL: 1.028 mTPVC (22-Jul-09, 08:28:00 AM)						1067
8										1066
9										1065
10										1064
11										1063
12										1062
13										1061
14										1060
15										

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 3.66 m
REVIEWED BY: Ryan Mills	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-11**
LOCATION: South of Dome Creek and west of Diversion Channel UTM N 2,097,216.6 E 118,706.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1107.3

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				SAND (Aeolian)						1107
				- grey brown						
1				- dry, loose, non-cohesive						1106
				- uniform fine to medium grained sand, sub-rounded, minor silt						
				- becoming moist at 1.37 m						
2	SA			- medium dense (incresing density with depth), becoming wet at 1.92 m						1105
				- increasing silt content with depth with medium sand interbeds, thinly bedded						
				- non-cohesive, non-plastic, slow dilatency						
3				- saturated at 3.25 m, dense, sandy silt interbed <1 cm thick						1104
						S-1				
4				- occasional nugget of frozen sand between 3.66 m and 4.11 m						1103
				- permafrost 4.11 m to 4.22 m, refusal at 4.22 m using direct push drilling method						
				END OF DRILLING at 4.22 m in permafrost (refusal)						
5				MW09-11 install:						1102
				- Screen interval: 2.69 m - 4.22 m						
				- Screen type: 10-Slot 2" PVC SCHED 40						
6				- Filter pack interval: 2.39 m - 4.22 m						1101
				- Bentonite seal from 1.83 m to 2.39 m						
				- Drill cutting from ground surface						
7				- WL: 4.27 m BTOP (22-Jul-09)						1100
8										1099
9										1098
10										1097
11										1096
12										1095
13										1094
14										1093
15										

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.22 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 8/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0				CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet					1208
1	CL					S-1			1207
2				DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet		S-2 S-3			1206
3						S-4			1205
4	BE					S-5 S-6			1204
5				- casing to 4.57 m		S-7 S-8			1203
6				- borehole producing approx. 1-2 L/min during air development		S-9 S-10			1202
7				GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11			1201
8						S-12 S-13			1200
9				- chips coarser from 8.53 m to 10.46 m		S-14			1199
10	BE					S-15 S-16			1198
11						S-17 S-18			1197
12						S-19			1196
13				DIORITE - light grey - dry, slightly weathered feldspars, quartz rich, low mafic content, massive structure - unreactive with HCl, overall less weathered and more competent than overlying rock		S-20 S-21			1195
14	BE					S-22			1194
15						S-23			

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 | Total Unit Wt (kN/m³) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
15						S-24			1193
						S-25			
16						S-26			1192
						S-27			
17						S-28			1191
	BE					S-29			
18						S-30			1190
						S-31			
19						S-32			1189
						S-33			
20				HORNEBLENDE DIORITE - dark grey - dry, potassium feldspar and horneblende mildly weathered, chips fine		S-34			1188
						S-35			
21						S-36			1187
						S-37			
22						S-38			1186
						S-39			
23						S-40			1185
						S-41			
24						S-42			1184
						S-43			
25	BE					S-44			1183
						S-45			
26						S-46			1182
						S-47			
27						S-48			1181
28									1180
29									1179
30									

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WNN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit UTM N 2,097,531.2 E 118,569.0		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1208.1

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
30	BE			QUARTZOLITE - white to light grey - primarily quartz with minor plagioclase feldspar and biotite - very hard (drilling at approx. 1.5 m/hour)		S-49				1178
31						S-50				1177
	BE					S-51				
32						S-52				1176
						S-53				
33				GRANODIORITE - light grey - dry, high quartz content with minor amount of highly weathered potassium feldspar		S-54				1175
34						S-55				1174
	BE					S-56				
35						S-57				1173
						S-58				
36				END OF DRILLING at 35.97 m MW09-13 install: - Screen interval: 29.87 m - 35.97 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 28.34 m - 35.97 m - Bentonite seal from 27.43 m to 28.34 m - Grouted to ground surface - WL: 33.24 m BTOP (22-Jul-09)						1172
37										1171
38										1170
39										1169
40										1168
41										1167
42										1166
43										1165
44										1164
45										

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-14**
LOCATION: Northeast of Brown-McDade pit		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1207.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet						
1	CL					S-1				1207
2				DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet		S-2 S-3				1206
3						S-4				1205
4	BE					S-5 S-6				1204
5				- casing to 4.57 m		S-7 S-8				1203
6				- borehole producing approx. 1-2 L/min during air development		S-9 S-10				1202
7				GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11 S-12				1201
8						S-13				1200
9	BE			- chips coarser from 8.53 m to 10.46 m		S-14 S-15				1199
10						S-16				1198
11				END OF DRILLING at 10.67 m MW09-14 install: - Screen interval: 5.49 m - 8.53 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 5.18 m - 8.53 m - Bentonite seal from 0 m to 5.18 m - WL: Frozen at 8.13 m BTOP (22-Jul-09)						1197
12										1196
13										1195
14										1194
15										1193

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	CL	CLAY (minor SAND and some GRAVEL) - brown - dry, loose, cohesive, non-plastic, rapid dilatency when wet		S-1				1206
1								
2				S-2				1205
3								1204
4				S-3				1203
5	BE	DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - wet 4.88 m to 6.01 m		S-4 S-5 S-6 S-7				1202
6		HORNEBLENDE DIORITE - light grey - dry, slightly weathered, occasional iron staining, chips coarse - casing to 4.57 m; approx. 1 L of water in hole after changing bit		S-8				1201
7	BE			S-9				1200
8				S-10 S-11				1199
9		- highly weathered 8.53 m to 9.14 m - dry, absence of mafic minerals, high degree of iron staining - inferred conductive fracture zone when saturated - slightly weathered from 9.14 m to 14.63 m - dry, light grey		S-12 S-13				1198
10				S-14				1197
11		- quartz vein 10.97 m to 11.58 m		S-15 S-16				1196
12				S-17				1195
13				S-18 S-19				1194
14				S-20				1193
15	BE	GRANODIORITE		S-21				1192

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ♦ SPT (Standard Pen Test) ♦ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
15				- grey-brown - moist from 14.63 m to 16.46 m and dry below, highly weathered and iron stained - rapid drilling rates - highly fractured bedrock 15.94 m to 16.92 m (rapid drilling) - zone of cave during well installation		S-22		✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100		
						S-23				1191
16						S-24				
	BE					S-25				1190
17						S-26				
						S-27				1189
18				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor potassium feldspar, chips fine		S-28				
						S-29				1188
19						S-30				
	BE					S-31				1187
20						S-32				
						S-33				1186
21				GRANODIORITE - grey-brown - moist, highly weathered, heavily fractured and iron stained, rapid drilling rates		S-34				
						S-35				1185
22	BE					S-36				
				DIORITE - light grey - dry, moderately weathered, trace feldspar		S-37				1184
23	BE					S-38				
				GRANODIORITE - orange-brown - moist, highly weathered with high clay mineral content inferred to be fault gouge - potentially conductive fracture zone		S-39				1183
24	BE					S-40				
				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor iron staining, chips fine		S-41				1182
25						S-42				
						S-43				1181
26						S-44				
						S-45				1180
27	BE					S-46				
				- less than 1 m of water in borehole after sitting overnight without rods in hole						1179
28										
										1178
29										
										1177
30										

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit UTM N 2,097,550.1 E 118,541.3		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1206.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: Becker; Dynamic Cone; SPT (Standard Pen Test) (Blows/300mm) 0 20 40 60 80 100; Total Unit Wt (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
30	BE			DIORITE - light grey - dry, soft, moderately weathered, minor iron staining		S-47				
31						S-48				1176
						S-49				
32						S-50				1175
						S-51				
33						S-52				1174
34	BE			- highly weathered from 34.14 m to end of hole at 38.10 m		S-53				1173
						S-54				
35						S-55				1172
				- moist from 35.36 m to 35.38 m						
36						S-56				1171
						S-57				
37				- wet from 35.38 m to end of hole at 38.10 m		S-58				1170
						S-59				
38						S-60				1169
				END OF DRILLING at 38.10 m						
39				MW09-15 install: - Screen interval: 33.98 m - 37.03 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 33.22 m - 37.03 m - Bentonite seal from 32.00 m to 33.22 m - Grouted to ground surface - 0.5 L of WDS-120 polymer used to avoid loss of hole; re-drilled 7 times to remove cave and stabilize borehole - WL: 16.74 m BTOP (22-Jul-09)						1168
40										1167
41										1166
42										1165
43										1164
44										1163
45										1162

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 38.10 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 11/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-16**
LOCATION: Downgradient of Mill		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1182.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0				GRAVEL FILL with some SAND, SILT and CLAY - dark yellowish-brown - dry, dense, non-cohesive, non-plastic - gravel up to 3" diameter						1182
1	GR			- inferred to be waste rock fill for staging area - becomes wet at 1.07 m						
2						S-1				1181
3	SASI			SANDY SILT - black-brown - wet, medium dense, cohesive, rapid dilatency - roots from 2.13 m to 3.66 m - increasing sand content with depth, sand fine to medium grained						1180
4										1179
	SM			SILTY SAND - brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand with very few organics - inferred to be aeolian sand						
5										1178
6				END OF DRILLING at 4.57 m MW09-16 install: - Screen interval: 0.30 m - 1.83 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 0.15 m - 1.83 m - Bentonite seal from 0 m to 0.15 m - WL: 1.21 m BTOP (22-Jul-09)						1177
7										1176
8										1175
9										1174
10										1173
11										1172
12										1171
13										1170
14										1169
15										1168

PENETRATION TESTS: ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.57 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 14/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-17**
LOCATION: Downgradient of Mill UTM N 2,097,319.7 E 118,286.2		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1178.0

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS (✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100)	COMMENTS	ELEVATION
0				SILTY CLAY with some SAND and GRAVEL - orange - dry, dense, cohesive, low plasticity - inferred to be waste rock fill used for road bed construction						
1	SICL			- becomes moist at 1.37 m						1177
2	SASI			SANDY SILT - black - moist, medium dense, cohesive, medium plasticity - odour likely the result of organics in soil; does not smell like hydrocarbon		S-1				1176
3	GR			GRAVEL with some CLAY, SILT and SAND filling interstices - yellow-brown - wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered - gravel to 10 cm along long axis - inferred to be colluvium		S-2				1175
4										1174
5	BE			BEDROCK - dark grey - wet, very dense, fine texture, laminated, friable by hand, very cold - refusal at what is inferred to be frozen bedrock END OF DRILLING at 4.88 m						1173
6				MW09-17 install: - Screen interval: 3.35 m - 4.88 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 2.74 m - 4.88 m - Bentonite seal from 0 m to 2.74 m - WL: 3.88 m BTOP (22-Jul-09)						1172
7										1171
8										1170
9										1169
10										1168
11										1167
12										1166
13										1165
14										1164
15										

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 4.88 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 14/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WNN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-18**
LOCATION: Downgradient of Mill UTM N 2,097,323.9 E 118,279.5		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1178.9

SAMPLE TYPE: GRAB; SHELBY TUBE; SPLIT SPOON; BULK; NO RECOVERY; CORE

BACKFILL TYPE: BENTONITE; GRAVEL; SLOUGH; GROUT; CUTTINGS; SAND

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	COMMENTS	ELEVATION
0	SASI			SANDY SILT - brown with red staining - dry, loose, non-cohesive, non-plastic - organic rich with pervasive roots, mild unknown odour		S-1				
1				SILTY SAND - brown with yellow staining - dry, medium dense, non-cohesive, non-plastic - organics present, sand fine to medium - inferred to be waste rock fill - moist from 1.52 m to 3.81 m, becomes red-brown below 1.52 m, frequent gravel/boulders						1178
2										1177
3	SM									1176
4				- dry from 3.81 m to 4.88 m; loose						1175
5				SILTY SAND TAILINGS - yellow-orange - dry, medium dense, cohesive, low plasticity, rapid dilatency - minor subangular gravel		S-2				1174
6	SM									1173
7	GRSA			SAND and GRAVEL with minor CLAY - brown - wet, loose, non-cohesive, non-plastic - angular gravel sized clasts - inferred to be colluvium, potential bedrock contact at 6.70 m END OF DRILLING at 6.86 m		S-3				1172
8				MW09-18 install: - Screen interval: 6.70 m - 6.86 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 5.94 m - 6.86 m - Bentonite seal from 0 m to 5.94 m - WL: 4.40 m BTOP (22-Jul-09)						1171
9										1170
10										1169
11										1168
12										1167
13										1166
14										1165
15										

PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 6.86 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-19**
LOCATION: Downgradient of Mill		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push-114 mm	ELEVATION (m): 1176.8

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0		No recovery					
	SM	SAND, silty - orange-brown - dry, loose - fine grained to medium grained sand					1176
1	GRSA	SAND and GRAVEL, trace silt - dark brown to orange - moist, dense - medium grained sand, sub-rounded - gravel sub-rounded to sub-angular, 0.5 cm to 7 cm (limited by core barrel)		G-1			1175
2	OR	- clast supported		G-2			
	SA						
3	OR	- presence of wood debris (waste rock?)		G-3			1174
		ORGANIC, some silt, trace sand - black - moist, loose - presence of roots					
4	SA	SAND, gravelly, trace of silt - orange-brown - moist, dense - fine grained sand, sub-rounded - volcanic ash marker		G-4			1173
5							1172
		ORGANIC, some silt, trace sand - dark brown - moist, loose - presence of roots					1171
6		SAND, some silt, trace gravel - dark grey - wet, loose - medium grained sand, sub-rounded - sub-angular gravel, 1 cm to >4 cm - matrix supported					
7							1170
8		END OF DRILLING at 5.11 m in permafrost (refusal)					1169
9		MW09-19 install: - Screen interval: 3.58 m - 5.11 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 3.28 m - 5.11 m - Bentonite seal from ground surface to 3.28 m - WL: 2.614 mTPVC (22-Jul-09, 10:11:00 AM)					1168
10							1167
11							1166
12							1165
13							1164
14							1163
15							1162

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 5.11 m
REVIEWED BY: Ryan Mills	COMPLETION DATE: 15/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-21**
LOCATION: Tailings Dam UTM N 2,097,199.5 E 118,730.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary-114 mm	ELEVATION (m): 1080.7

SAMPLE TYPE: GRAB | SHELBY TUBE | SPLIT SPOON | BULK | NO RECOVERY | CORE

BACKFILL TYPE: BENTONITE | GRAVEL | SLOUGH | GROUT | CUTTINGS | SAND

DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	Ditch Armour on surface - cobbles and boulders up to 1 m - iron staining					
1	FILL	GRAVEL, sandy, trace silt - orange-brown - dry, very dense - fine grained to medium grained sand, sub-rounded - gravel/cobble sub-angular to angular, 0.5 cm to 8 cm (limited by core barrel) - clast supported		G-1			1080
2				S-1	19-32-50		1079
3	FILL SASI SA	SAND, gravelly, trace silt - orange-brown - medium/fine sand, sub-rounded - sub-angular gravel, from 0.5 cm to > 5 cm - clast supported, becomes matrix supported with depth - wet		S-2	41-50-		1078
4		SILT, sandy, trace organic - dark brown					1077
5		SAND, some silt, trace gravel - dark brown - medium sand, sub-rounded - sub-angular gravel, >0.5 cm to <1 cm - matrix supported					1076
6		SAND, some silt, trace to some organic (volcanic ash marker) - light grey END OF DRILLING at 3.20 m in permafrost (refusal)					1075
7		MW09-21 install: - Screen interval: 1.52 m - 3.05 m - Screen type: 10-Slot 2" PVC SCHED 40 - Filter pack interval: 1.22 m - 3.05 m - Bentonite seal from ground surface to 1.22 m - WL: 1.668 mTPVC (22-Jul-09, 8:31:00 AM)					1074
8							1073
9							1072
10							1071
11							1070
12							1069
13							1068
14							1067
15							1066

PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m³)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM	LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 3.20 m
	REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE FIG-2010-06-01-BOREHOLE LOGS-112359.GPJ UMA WINN.GDT 1/6/10

BOREHOLE LOG

PROJECT:. 70803

BOREHOLE: GLL07-01 1 of 1

Mt. Nansen
Mt. Nansen, yukon
FOR: YTG Energy, Mines and Resources, Abandoned Mines Project Office

DATE: 26 October 2007
LOGGED BY JK
GROUND ELEV 1212.55m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
0.9		Light grey coarse GRAVEL, some sand.									UTM 388851.923 W 6881778.708 N
1.5		Silty medium brown ORGANIC HORIZON									
		BEDROCK, weathered									Elevation (TOC) 1213.69 mASL
4.3		BEDROCK - dark yellowish orange at 4.27 m - light grey between 4.88 and 6.1 m									
		- tan coloured between 6.7 and 8.53 m									
		- grey at 9.14 m - yellowish orange at 9.75 m - tan coloured at 10.36 m - becoming yellowish grey and slightly weathered between 10.97 and 11.58 m									
12.8		- moderate competency and yellowish grey at 12.19 m									
		Highly weathered BEDROCK - light yellowish grey between 12.8 and 13.41 m									
		- dark yellowish grey between 14.02 and 14.63 m									
		- light grey between 15.24 and 16.46 m									
18.3		- tan coloured between 17.07 and 18.23 m									
		Borehole terminated at 18.29 m									

Printed: 8 Feb 08
File Location: I:\2007\70803\gINT logs

Gartner Lee Limited

BOREHOLE LOG

PROJECT: 70803

BOREHOLE: GLL07-02 1 of 1

Mt. Nansen
Mt. Nansen, yukon
FOR: YTG Energy, Mines and Resources, Abandoned Mines Project Office

DATE: 26 October 2007
LOGGED BY JK
GROUND ELEV 1185.23m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
0		Light grey coarse GRAVEL, with some sand				GS					UTM 389071.055 W 6881702.619 N
1.5		Sandy silt to silt brown ORGANIC HORIZON				GS					Elevation (TOC) 1186.67 mASL
2.7		Moderately competant, tan coloured BEDROCK				GS					
4.6		Weathered, light tan coloured BEDROCK				GS					
6.1		Borehole terminated at 6.1 m				GS					

Printed: 8 Feb 08
File location: I:\2007\07803\6.NT logs

Gartner Lee Limited

BOREHOLE LOG

PROJECT: 70803

BOREHOLE: GLL07-03 1 of 1

Mt. Nansen
Mt. Nansen, yukon
FOR: YTG Energy, Mines and Resources, Abandoned Mines Project Office

DATE: 25 October 2007
LOGGED BY JK
GROUND ELEV 1186.87m ASL

DEPTH (m)	STRATIGRAPHY	STRATIGRAPHIC DESCRIPTION	MONITOR DETAILS & NUMBER	SAMPLE NUMBER	SAMPLE INTERVAL	SAMPLE TYPE	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % RQD	COMMENTS
0		Weathered BEDROCK									UTM 388960.200 W 6881476.290 N
1		- highly weathered - light brwon grading to light orange				GS					
2						GS					Elevation (TOC) 1187.90 mASL
3		- dark to medium yellowish-orange				GS					
4						GS					
4.6						GS					
5		Compentent BEDROCK - yellowish orange				GS					
6		-dark yellowish orange				GS					
7		- light yellowish orange				GS					
8		- light grey				GS					
9						GS					
10		- becoming highly competent				GS					
10.4						GS					
11		Borehole terminated at 10.36 m									

Printed: 8 Feb 08
File Location: G:\2007\70803\4.3F Logs

Gartner Lee Limited

AECOM

Appendix B

Laboratory Analytical Certificates

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Certificate of Analysis

AECOM CANADA LTD.
ATTN: RYAN MILLS

SPERLING PLAZA
SUITE 490, 6400 ROBERTS STREET
BURNABY BC V5G 4C9

Report Date: 19-AUG-09 09:58 (MT)
Version: FINAL REV. 2

Lab Work Order #: L796959 **Date Received:** 24-JUL-09

Project P.O. #:
Job Reference: YUKON GOV'T 112359- MT NANSEN
Legal Site Desc:
CofC Numbers: A014936, A014937

Other Information:

Comments:

Please note that certain metals detection limits have been increased for some of the samples due to the interferences encountered during the analysis.

ADDITIONAL 10-AUG-09 17:52

Please note that Cyanate detection limits have been increased for some of the samples due to the low sample volumes available for analysis. Furthermore, these samples were analyzed past recommended holding time of 14 days for Cyanate analysis.

This revision, 2, of the report replaces and supersedes all previous revisions. The results of Cyanate anlaysis have been added to the report. All other data remains unchanged.

NATASHA MARKOVIC-MIROVIC
Account Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID	L796959-7	L796959-9	L796959-10	L796959-11	L796959-12
Description					
Sampled Date	15-JUL-09	15-JUL-09	15-JUL-09	15-JUL-09	15-JUL-09
Sampled Time					
Client ID	MW09-16(6FT-7FT)	MW09-17(11FT-12FT)	MW09-18(2FT-3FT)	MW09-18(21FT-22FT)	MW09-19(7FT10
Grouping / **Analyte**					
SOIL					
Physical Tests					
% Moisture (%)	11.1	9.68	30.1	7.20	11.7
pH (pH)	7.64	7.97	6.39	8.14	6.96
Metals					
Antimony (Sb) (mg/kg)	162	<10	<10	11	898
Arsenic (As) (mg/kg)	1980	65.7	103	285	13000
Barium (Ba) (mg/kg)	150	95.1	271	113	99.9
Beryllium (Be) (mg/kg)	0.50	<0.50	<0.50	0.73	1.25
Cadmium (Cd) (mg/kg)	41.4	<0.50	<0.50	<0.50	91.1
Chromium (Cr) (mg/kg)	16.2	15.6	19.6	111	5.1
Cobalt (Co) (mg/kg)	9.8	8.6	8.3	20.0	6.7
Copper (Cu) (mg/kg)	111	44.9	54.5	71.9	401
Lead (Pb) (mg/kg)	1570	<30	<30	<30	8260
Mercury (Hg) (mg/kg)	0.151	0.0419	0.0458	0.103	0.426
Molybdenum (Mo) (mg/kg)	<4.0	<4.0	<4.0	<4.0	<4.0
Nickel (Ni) (mg/kg)	11.8	8.1	12.2	47.8	7.1
Selenium (Se) (mg/kg)	<2.0	<2.0	<2.0	<2.0	<2.0
Silver (Ag) (mg/kg)	35.2	<2.0	<2.0	<2.0	96.9
Thallium (Tl) (mg/kg)	<1.0	<1.0	<1.0	<1.0	<1.0
Tin (Sn) (mg/kg)	<5.0	<5.0	<5.0	<5.0	8.2
Vanadium (V) (mg/kg)	56.7	76.0	60.7	136	22.9
Zinc (Zn) (mg/kg)	2760	60.1	60.3	127	4300
Hydrocarbons					
EPH10-19 (mg/kg)	<200	<200	<200	<200	<200
EPH19-32 (mg/kg)	<200	<200	<200	<200	<200
LEPH (mg/kg)	<200	<200	<200	<200	<200
HEPH (mg/kg)	<200	<200	<200	<200	<200
Polycyclic Aromatic Hydrocarbons					
Acenaphthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Acenaphthylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Benz(a)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(a)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(b)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(g,h,i)perylene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Benzo(k)fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Chrysene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Dibenz(a,h)anthracene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Fluoranthene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Fluorene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
2-Methylnaphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Naphthalene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050
Phenanthrene (mg/kg)	<0.050	<0.050	<0.050	<0.050	<0.050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796959-15				
	Description					
	Sampled Date	15-JUL-09				
	Sampled Time					
	Client ID	MW09-19(15FT-16FT9				
Grouping	Analyte					
SOIL						
Physical Tests	% Moisture (%)	20.0				
	pH (pH)	7.13				
Metals	Antimony (Sb) (mg/kg)	<10				
	Arsenic (As) (mg/kg)	9.4				
	Barium (Ba) (mg/kg)	56.6				
	Beryllium (Be) (mg/kg)	<0.50				
	Cadmium (Cd) (mg/kg)	<0.50				
	Chromium (Cr) (mg/kg)	10.5				
	Cobalt (Co) (mg/kg)	3.6				
	Copper (Cu) (mg/kg)	6.4				
	Lead (Pb) (mg/kg)	<30				
	Mercury (Hg) (mg/kg)	0.0076				
	Molybdenum (Mo) (mg/kg)	<4.0				
	Nickel (Ni) (mg/kg)	5.9				
	Selenium (Se) (mg/kg)	<2.0				
	Silver (Ag) (mg/kg)	<2.0				
	Thallium (Tl) (mg/kg)	<1.0				
	Tin (Sn) (mg/kg)	<5.0				
	Vanadium (V) (mg/kg)	27.4				
	Zinc (Zn) (mg/kg)	24.9				
Hydrocarbons	EPH10-19 (mg/kg)	<200				
	EPH19-32 (mg/kg)	<200				
	LEPH (mg/kg)	<200				
	HEPH (mg/kg)	<200				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/kg)	<0.050				
	Acenaphthylene (mg/kg)	<0.050				
	Anthracene (mg/kg)	<0.050				
	Benz(a)anthracene (mg/kg)	<0.050				
	Benzo(a)pyrene (mg/kg)	<0.050				
	Benzo(b)fluoranthene (mg/kg)	<0.050				
	Benzo(g,h,i)perylene (mg/kg)	<0.050				
	Benzo(k)fluoranthene (mg/kg)	<0.050				
	Chrysene (mg/kg)	<0.050				
	Dibenz(a,h)anthracene (mg/kg)	<0.050				
	Fluoranthene (mg/kg)	<0.050				
	Fluorene (mg/kg)	<0.050				
	Indeno(1,2,3-c,d)pyrene (mg/kg)	<0.050				
	2-Methylnaphthalene (mg/kg)	<0.050				
	Naphthalene (mg/kg)	<0.050				
	Phenanthrene (mg/kg)	<0.050				

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID Description Sampled Date Sampled Time Client ID	L796959-7 15-JUL-09 MW09-16(6FT-7FT)	L796959-9 15-JUL-09 MW09-17(11FT-12FT)	L796959-10 15-JUL-09 MW09-18(2FT-3FT)	L796959-11 15-JUL-09 MW09-18(21FT-22FT)	L796959-12 15-JUL-09 MW09-19(7FT10
SOIL							
Polycyclic Aromatic Hydrocarbons	Pyrene (mg/kg)		<0.050	<0.050	<0.050	<0.050	<0.050
	Surrogate: d10-Acenaphthene (SS) (%)		99	95	103	99	91
	Surrogate: d12-Chrysene (SS) (%)		72	70	84	71	74
	Surrogate: d8-Naphthalene (SS) (%)		94	95	100	97	89
	Surrogate: d10-Phenanthrene (SS) (%)		89	86	94	90	87

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796959-15				
	Description					
	Sampled Date	15-JUL-09				
	Sampled Time					
	Client ID	MW09-19(15FT-16FT9				
Grouping	Analyte					
SOIL						
Polycyclic Aromatic Hydrocarbons	Pyrene (mg/kg)	<0.050				
	Surrogate: d10-Acenaphthene (SS) (%)	94				
	Surrogate: d12-Chrysene (SS) (%)	66				
	Surrogate: d8-Naphthalene (SS) (%)	91				
	Surrogate: d10-Phenanthrene (SS) (%)	84				

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L796959-1 Description: Sampled Date: 14-JUL-09 Sampled Time: Client ID: MW09-15	L796959-2 19-JUL-09 MW09-16	L796959-3 19-JUL-09 MW09-17	L796959-4 19-JUL-09 MW09-18	L796959-5 19-JUL-09 MW09-18R
WATER						
Physical Tests	Conductivity (uS/cm)	1010	1930	2570	2660	2660
	Hardness (as CaCO3) (mg/L)	581	1210	1760	1830	1860
	pH (pH)	7.08	7.38	7.74	7.71	7.71
	Total Dissolved Solids (mg/L)	757	1650	2380	2490	2440
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	23.3	35.4	28.5	30.3	29.7
	Alkalinity, Total (as CaCO3) (mg/L)	288	298	435	427	425
	Ammonia as N (mg/L)	0.331	0.079	0.229	0.041	0.066
	Bromide (Br) (mg/L)	<0.050	<2.5	<2.5	<2.5	<2.5
	Chloride (Cl) (mg/L)	<0.50	<25	<25	<25	<25
	Fluoride (F) (mg/L)	0.070	0.152	0.144	0.143	0.122
	Nitrate (as N) (mg/L)	<0.0050	<0.25	<0.25	<0.25	<0.25
	Nitrite (as N) (mg/L)	0.0027	<0.050	<0.050	<0.050	<0.050
	Sulfate (SO4) (mg/L)	289	934	1360	1490	1470
Cyanides	Cyanide, Weak Acid Diss (mg/L)		<0.0050	<0.0050	<0.0050	<0.0050
	Cyanide, Total (mg/L)		<0.0050	<0.0050	<0.0050	<0.0050
	Cyanate (CNO) (mg/L)		<1.8	<0.50	<0.50	<0.50
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	<0.025	<0.025	<0.025	<0.025	<0.025
	Antimony (Sb)-Dissolved (mg/L)	0.0178	0.175	<0.0025	<0.0025	<0.0025
	Arsenic (As)-Dissolved (mg/L)	0.122	0.0506	0.0119	0.0382	0.0423
	Barium (Ba)-Dissolved (mg/L)	<0.020	0.034	<0.020	<0.020	<0.020
	Beryllium (Be)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	0.27	0.27	<0.10	<0.10
	Cadmium (Cd)-Dissolved (mg/L)	0.00754	0.0558	<0.000085	<0.000085	<0.000085
	Calcium (Ca)-Dissolved (mg/L)	157	276	327	352	355
	Chromium (Cr)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Cobalt (Co)-Dissolved (mg/L)	<0.0015	0.0020	<0.0015	<0.0015	<0.0015
	Copper (Cu)-Dissolved (mg/L)	<0.0050	0.0100	<0.0050	<0.0050	<0.0050
	Iron (Fe)-Dissolved (mg/L)	0.192	0.389	<0.030	<0.030	<0.030
	Lead (Pb)-Dissolved (mg/L)	0.0171	0.0364	<0.0025	<0.0025	<0.0025
	Lithium (Li)-Dissolved (mg/L)	<0.025	<0.025	<0.025	<0.025	<0.025
	Magnesium (Mg)-Dissolved (mg/L)	45.7	126	230	231	236
	Manganese (Mn)-Dissolved (mg/L)	0.905	0.389	0.0164	0.349	0.409
	Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Nickel (Ni)-Dissolved (mg/L)	<0.0050	0.0071	<0.0050	<0.0050	<0.0050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	6.5	7.2	6.9	7.1
	Selenium (Se)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Silicon (Si)-Dissolved (mg/L)	5.85	5.29	4.74	4.80	4.87
	Silver (Ag)-Dissolved (mg/L)	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796959-6
	Description	
	Sampled Date	19-JUL-09
	Sampled Time	
	Client ID	MW09-19
Grouping	**Analyte**	
WATER		
Physical Tests	Conductivity (uS/cm)	2570
	Hardness (as CaCO3) (mg/L)	1740
	pH (pH)	7.29
	Total Dissolved Solids (mg/L)	2260
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	52.7
	Alkalinity, Total (as CaCO3) (mg/L)	389
	Ammonia as N (mg/L)	3.24
	Bromide (Br) (mg/L)	<2.5
	Chloride (Cl) (mg/L)	<25
	Fluoride (F) (mg/L)	0.095
	Nitrate (as N) (mg/L)	<0.25
	Nitrite (as N) (mg/L)	<0.050
	Sulfate (SO4) (mg/L)	1390
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050
	Cyanide, Total (mg/L)	<0.0050
	Cyanate (CNO) (mg/L)	4.26
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	<0.025
	Antimony (Sb)-Dissolved (mg/L)	<0.0025
	Arsenic (As)-Dissolved (mg/L)	0.0769
	Barium (Ba)-Dissolved (mg/L)	0.082
	Beryllium (Be)-Dissolved (mg/L)	<0.0050
	Bismuth (Bi)-Dissolved (mg/L)	<0.20
	Boron (B)-Dissolved (mg/L)	0.32
	Cadmium (Cd)-Dissolved (mg/L)	<0.000085
	Calcium (Ca)-Dissolved (mg/L)	368
	Chromium (Cr)-Dissolved (mg/L)	<0.0050
	Cobalt (Co)-Dissolved (mg/L)	0.0024
	Copper (Cu)-Dissolved (mg/L)	<0.0050
	Iron (Fe)-Dissolved (mg/L)	40.6
	Lead (Pb)-Dissolved (mg/L)	<0.0025
	Lithium (Li)-Dissolved (mg/L)	<0.025
	Magnesium (Mg)-Dissolved (mg/L)	200
	Manganese (Mn)-Dissolved (mg/L)	2.39
	Mercury (Hg)-Dissolved (mg/L)	<0.000020
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0050
	Nickel (Ni)-Dissolved (mg/L)	<0.0050
	Phosphorus (P)-Dissolved (mg/L)	0.46
	Potassium (K)-Dissolved (mg/L)	4.4
	Selenium (Se)-Dissolved (mg/L)	<0.0050
	Silicon (Si)-Dissolved (mg/L)	7.88
	Silver (Ag)-Dissolved (mg/L)	<0.00010

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L796959-1 14-JUL-09 MW09-15	L796959-2 19-JUL-09 MW09-16	L796959-3 19-JUL-09 MW09-17	L796959-4 19-JUL-09 MW09-18	L796959-5 19-JUL-09 MW09-18R
WATER						
Dissolved Metals	Sodium (Na)-Dissolved (mg/L)	7.7	18.9	10.8	10.0	10.2
	Strontium (Sr)-Dissolved (mg/L)	1.48	0.670	0.972	0.981	1.00
	Thallium (Tl)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
	Tin (Sn)-Dissolved (mg/L)	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025
	Titanium (Ti)-Dissolved (mg/L)	0.011	0.013	0.014	0.015	0.014
	Uranium (U)-Dissolved (mg/L)	0.0860	0.0037	0.0070	0.0068	0.0070
	Vanadium (V)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
	Zinc (Zn)-Dissolved (mg/L)	0.437	4.44	<0.0050	<0.0050	<0.0050
Hydrocarbons	EPH10-19 (mg/L)		<0.25	<0.25	<0.25	<0.25
	EPH19-32 (mg/L)		<0.25	<0.25	<0.25	<0.25
	LEPH (mg/L)		<0.25	<0.25	<0.25	<0.25
	HEPH (mg/L)		<0.25	<0.25	<0.25	<0.25
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Acenaphthylene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Acridine (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Anthracene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Benz(a)anthracene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Benzo(a)pyrene (mg/L)		<0.000010	<0.000010	<0.000010	<0.000010
	Benzo(b)fluoranthene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Benzo(g,h,i)perylene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Benzo(k)fluoranthene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Chrysene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Dibenz(a,h)anthracene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Fluoranthene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Fluorene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Indeno(1,2,3-c,d)pyrene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Naphthalene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Phenanthrene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Pyrene (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Quinoline (mg/L)		<0.000050	<0.000050	<0.000050	<0.000050
	Surrogate: d10-Acenaphthene (SS) (%)		93	97	98	96
	Surrogate: d9-Acridine (SS) (%)		90	92	92	89
	Surrogate: d12-Chrysene (SS) (%)		89	91	92	90
	Surrogate: d8-Naphthalene (SS) (%)		87	93	93	83
	Surrogate: d10-Phenanthrene (SS) (%)		94	97	97	97

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796959-6				
	Description					
	Sampled Date	19-JUL-09				
	Sampled Time					
	Client ID	MW09-19				
Grouping	**Analyte**					
WATER						
Dissolved Metals	Sodium (Na)-Dissolved (mg/L)	20.5				
	Strontium (Sr)-Dissolved (mg/L)	0.973				
	Thallium (Tl)-Dissolved (mg/L)	<0.0010				
	Tin (Sn)-Dissolved (mg/L)	<0.0025				
	Titanium (Ti)-Dissolved (mg/L)	0.015				
	Uranium (U)-Dissolved (mg/L)	<0.0010				
	Vanadium (V)-Dissolved (mg/L)	<0.0050				
	Zinc (Zn)-Dissolved (mg/L)	0.0088				
Hydrocarbons	EPH10-19 (mg/L)	<0.25				
	EPH19-32 (mg/L)	<0.25				
	LEPH (mg/L)	<0.25				
	HEPH (mg/L)	<0.25				
Polycyclic Aromatic Hydrocarbons	Acenaphthene (mg/L)	<0.000050				
	Acenaphthylene (mg/L)	<0.000050				
	Acridine (mg/L)	<0.000050				
	Anthracene (mg/L)	<0.000050				
	Benz(a)anthracene (mg/L)	<0.000050				
	Benzo(a)pyrene (mg/L)	<0.000010				
	Benzo(b)fluoranthene (mg/L)	<0.000050				
	Benzo(g,h,i)perylene (mg/L)	<0.000050				
	Benzo(k)fluoranthene (mg/L)	<0.000050				
	Chrysene (mg/L)	<0.000050				
	Dibenz(a,h)anthracene (mg/L)	<0.000050				
	Fluoranthene (mg/L)	<0.000050				
	Fluorene (mg/L)	<0.000050				
	Indeno(1,2,3-c,d)pyrene (mg/L)	<0.000050				
	Naphthalene (mg/L)	<0.000050				
	Phenanthrene (mg/L)	<0.000050				
	Pyrene (mg/L)	<0.000050				
	Quinoline (mg/L)	<0.000050				
	Surrogate: d10-Acenaphthene (SS) (%)	99				
	Surrogate: d9-Acridine (SS) (%)	93				
	Surrogate: d12-Chrysene (SS) (%)	93				
	Surrogate: d8-Naphthalene (SS) (%)	95				
	Surrogate: d10-Phenanthrene (SS) (%)	99				

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	APHA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrite detection is by UV absorbance and not conductivity.

ANIONS-NO3-IC-VA	Water	Nitrate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrate detection is by UV absorance and not conductivity.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN "Cyanide"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN "Cyanide"

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA Water Weak Acid Cyanide by Colorimetric APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CNO-SIE-VA Water Cyanate by SIE APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode.

EC-PCT-VA Water Conductivity (Automated) APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

EPH-SF-FID-VA Water EPH in Water by GCFID BCMOE EPH GCFID

This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Water by GC/FID" (Version 2.1, July 1999). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene and analysed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

EPH-TUMB-FID-VA Soil EPH in Solids by Tumbler and GCFID BCMELP CSR

Extractable Hydrocarbons in Sediment/Soil
This analysis is carried out in accordance with the British Columbia Ministry of Environment, Lands and Parks (BCMELP) Analytical Method for Contaminated Sites "Extractable Petroleum Hydrocarbons in Solids by GC/FID, Version 2.1 July 1999". The procedure, based on EPA 3570, uses a rotary extraction technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene or kept in hexane/acetone and analyzed by capillary column gas chromatography with flame ionization detection (GC/FID). EPH results include Polycyclic Aromatic Hydrocarbons (PAH) and are therefore not equivalent to Light and Heavy Extractable Petroleum Hydrocarbons (LEPH/HEPH).

Accuracy target values for Reference Materials used in this method are derived from averages of long-term method performance, as certified values do not exist for the reported parameters.

F-SIE-VA Water Fluoride by SIE APHA 4500-F "Fluoride"

This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.

F-SIE-VA Water Fluoride by SIE APHA 4500-F Fluoride

This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.

HARDNESS-CALC-VA Water Hardness APHA 2340B

Hardness is calculated from Calcium and Magnesium concentrations, and is expressed as calcium carbonate equivalents.

HG-CCME-CVAFS-VA Soil CVAFS Hg in Soil (CCME) CCME

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by atomic fluorescence spectrophotometry (EPA Method 7000 series).

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

HG-DIS-CCME-CVAFS-VA Water Diss. Mercury in Water by CVAFS (CCME) EPA 3005A/245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

LEPH/HEPH-CALC-VA Water LEPHs and HEPHs BC MOE LABORATORY MANUAL (2005)

Light and Heavy Extractable Petroleum Hydrocarbons in Solids. These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated
by subtracting selected Polycyclic Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Naphthalene and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Indeno(1,2,3-c,d)pyrene, and Pyrene
are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Solids by GC/FID" (Version 2.1, July 20, 1999).

LEPH/HEPH-CALC-VA Soil LEPHs and HEPHs BC MOE LABORATORY MANUAL (2005)

Light and Heavy Extractable Petroleum Hydrocarbons in Solids. These results are determined according to the British Columbia Ministry of Environment, Lands, and Parks Analytical Method for Contaminated Sites "Calculation of Light and Heavy Extractable Petroleum Hydrocarbons in Solids or Water". According to this method, LEPH and HEPH are calculated
by subtracting selected Polycyclic Aromatic Hydrocarbon results from Extractable Petroleum Hydrocarbon results. To calculate LEPH, the individual results for Naphthalene and Phenanthrene are subtracted from EPH(C10-19). To calculate HEPH, the individual results for Benz(a)anthracene, Benzo(b)fluoranthene, Benzo(k)fluoranthene, Benzo(a)pyrene, Dibenz(a,h)anthracene, Indeno(1,2,3-c,d)pyrene, and Pyrene
are subtracted from EPH(C19-32). Analysis of Extractable Petroleum Hydrocarbons adheres to all prescribed elements of the BCMELP method "Extractable Petroleum Hydrocarbons in Solids by GC/FID" (Version 2.1, July 20, 1999).

MET-CSR-FULL-ICP-VA Soil Metals in Soil by ICPOES (CSR SALM) BCMELP CSR SALM METHOD 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

MET-DIS-CCME-ICP-VA Water Diss. Metals in Water by ICPOES (CCME) EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-DIS-CCME-MS-VA Water Diss. Metals in Water by ICPMS (CCME) EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MOISTURE-VA	Soil	Moisture content	ASTM METHOD D2974-00

This analysis is carried out gravimetrically by drying the sample at 105 C for a minimum of six hours.

NH3-SIE-VA	Water	Ammonia by SIE	APHA 4500 D. - NH3 NITROGEN (AMMONIA)

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

PAH-SF-MS-VA	Water	PAH in Water by GCMS	EPA Methods 3510, 3630 & 8270

This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3510, 3630 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure involves extraction of the entire water sample with dichloromethane. The extract is then solvent exchanged to toluene prior to analysis by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PAH-SURR-MS-VA	Soil	PAH Surrogates for Soils	EPA METHODS 3570, 3545A & 8270
PAH-TUMB-H/A-MS-VA	Soil	PAH by Tumbler HEX/ACE with GCMS	EPA METHODS 3570 & 8270.

Polycyclic Aromatic Hydrocarbons in Sediment/Soil
This analysis is carried out using procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846, Methods 3570 & 8270, published by the United States Environmental Protection Agency (EPA). The procedure uses a mechanical shaking technique to extract a subsample of the sediment/soil with a 1:1 mixture of hexane and acetone. The extract is then solvent exchanged to toluene. The final extract is analysed by capillary column gas chromatography with mass spectrometric detection (GC/MS). Surrogate recoveries may not be reported in cases where interferences from the sample matrix prevent accurate quantitation.

PH-1:2-VA	Soil	CSR pH by 1:2 Water Leach	BC WLAP METHOD: PH, ELECTROMETRIC, SOIL

This analysis is carried out in accordance with procedures described in the pH, Electrometric in Soil and Sediment method - Section B Physical/Inorganic and Misc. Constituents, BC Environmental Laboratory Manual 2007. The procedure involves mixing the dried (at <60 C) and sieved (No. 10 / 2mm) sample with deionized/distilled water at a 1:2 ratio of sediment to water. The pH of the solution is then measured using a standard pH probe.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

TL-CSR-MS-VA	Soil	ICPMS Tl in Soil by CSR SALM	BCMELP CSR SALM Method 8

This analysis is carried out using procedures from CSR Analytical Method 8 "Strong Acid Leachable Metals (SALM) in Soil", BC Ministry of Environment, Lands and Parks, 26 June 2001, and procedures adapted from "Test Methods for Evaluating Solid Waste", SW-846 Method 3050B United States Environmental Protection Agency (EPA). The sample is manually homogenized, dried at 60 degrees Celsius, sieved through a 2 mm (10 mesh) sieve, and a representative subsample of the dry material is weighed. The sample is then digested at 90 degrees Celsius for 2 hours by either hotplate or block digester using a 1:1 ratio of concentrated nitric and hydrochloric acids. Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

Method Limitation: This method is not a total digestion technique. It is a very strong acid digestion that is intended to dissolve those metals that may be environmentally available. By design, elements bound in silicate structures are not normally dissolved by this procedure as they are not usually mobile in the environment.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA		

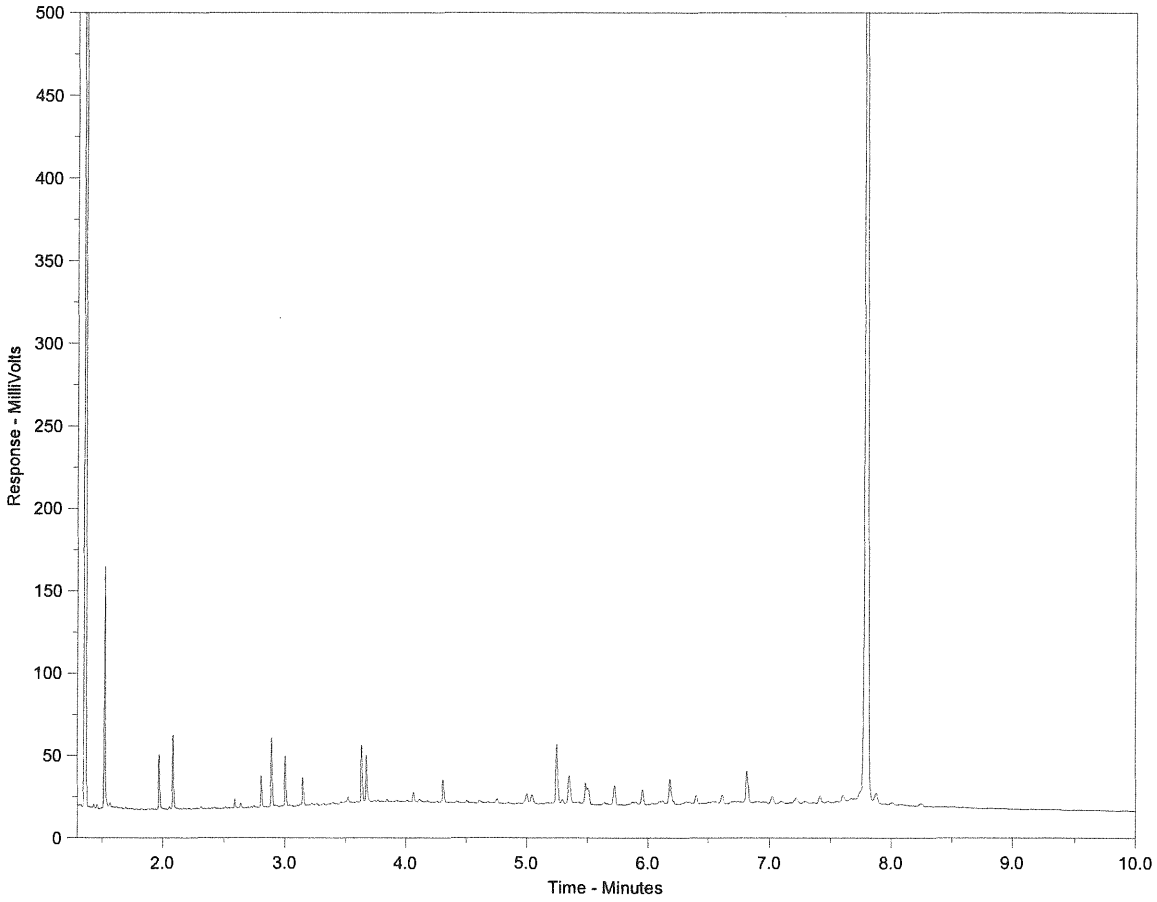
GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-2
Client Sample ID: MW09-16



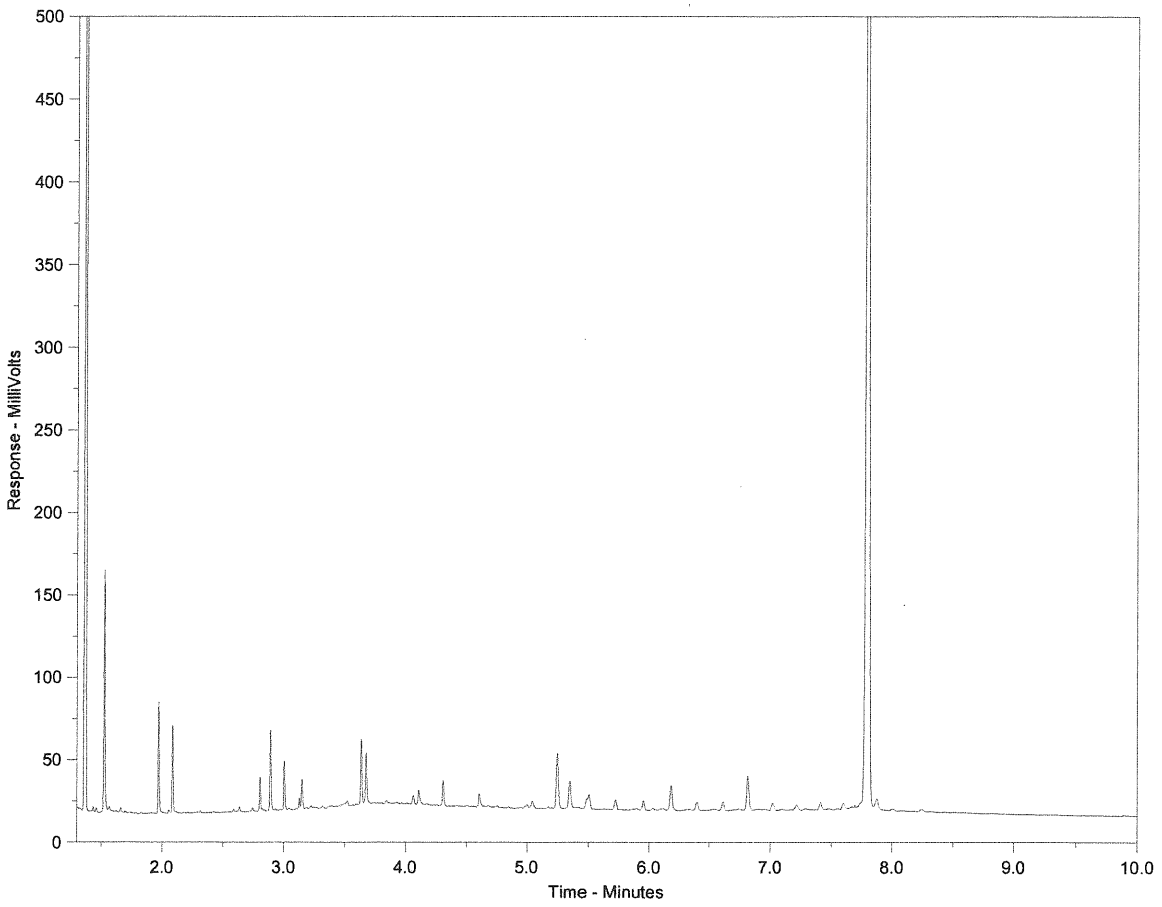
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-3
Client Sample ID: MW09-17



nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F

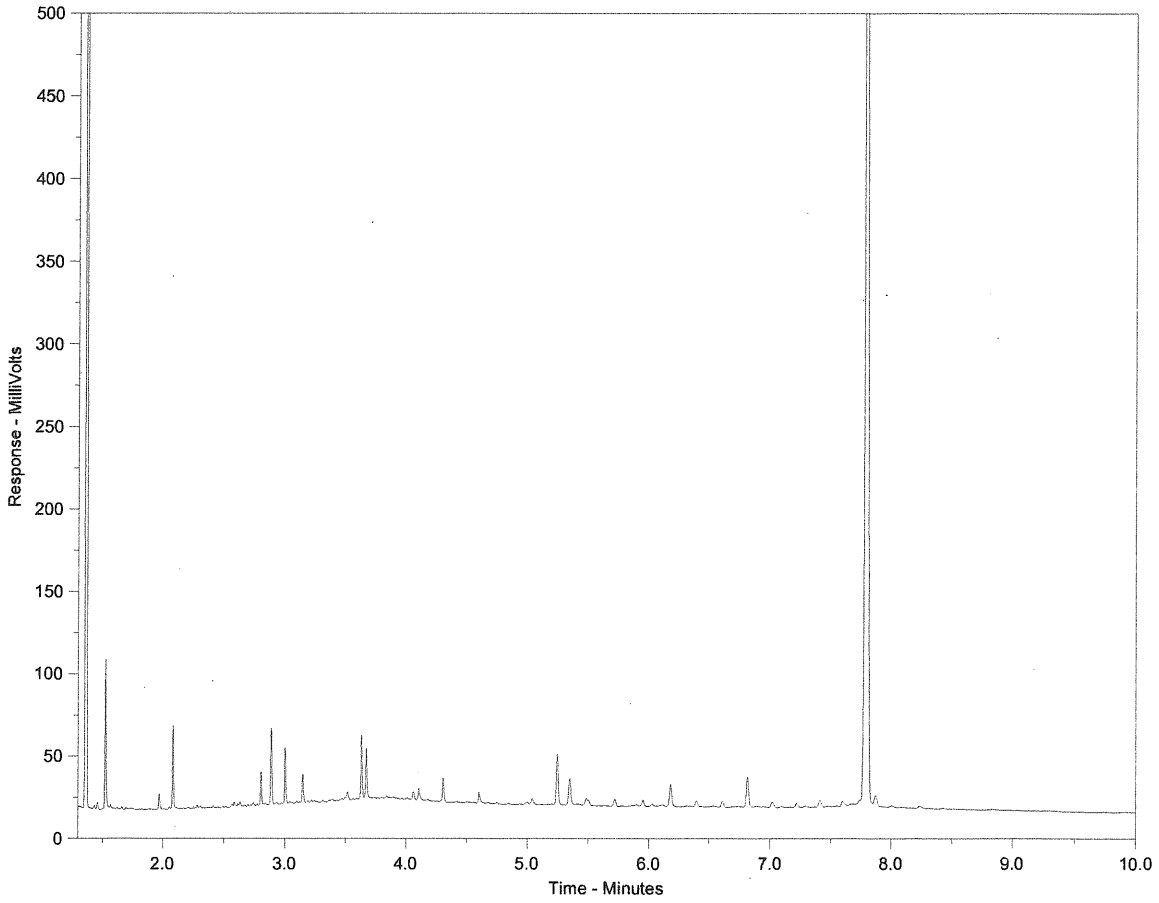
← Gasoline →
← Diesel / Jet Fuels →
← Motor Oils / Lube Oils / Grease →

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-4
Client Sample ID: MW09-18



nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F

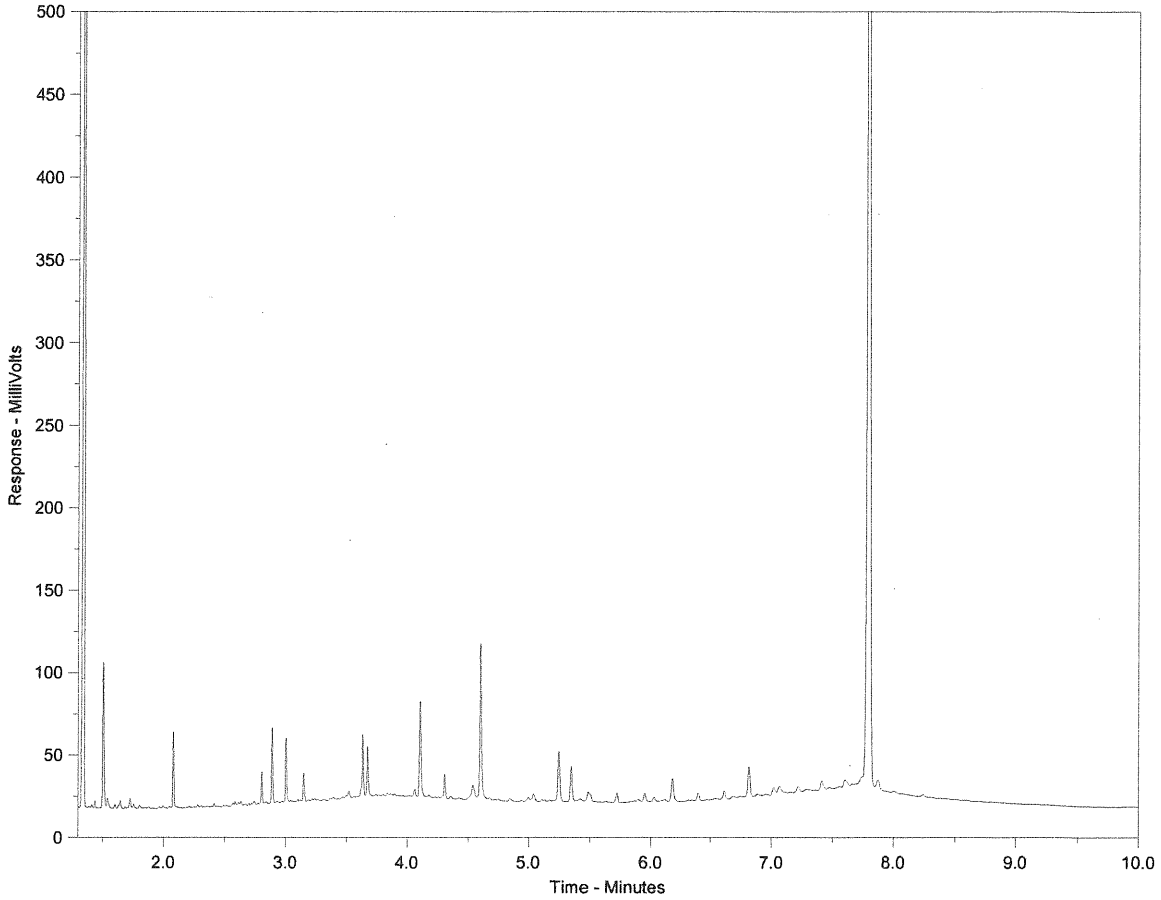
← Gasoline →
← Diesel / Jet Fuels →
← Motor Oils / Lube Oils / Grease →

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-5
Client Sample ID: MW09-18R



nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F

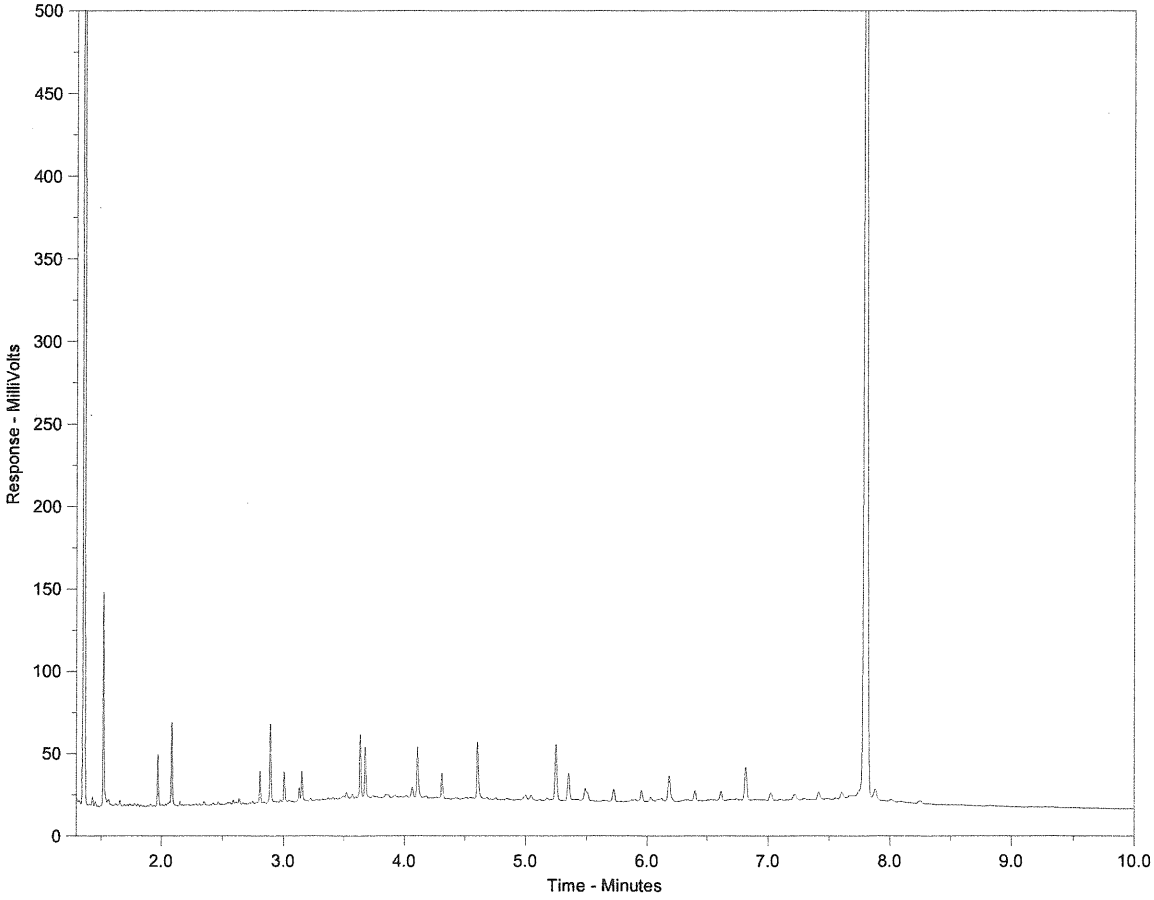
Gasoline
Diesel / Jet Fuels
Motor Oils / Lube Oils / Grease

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-6
Client Sample ID: MW09-19



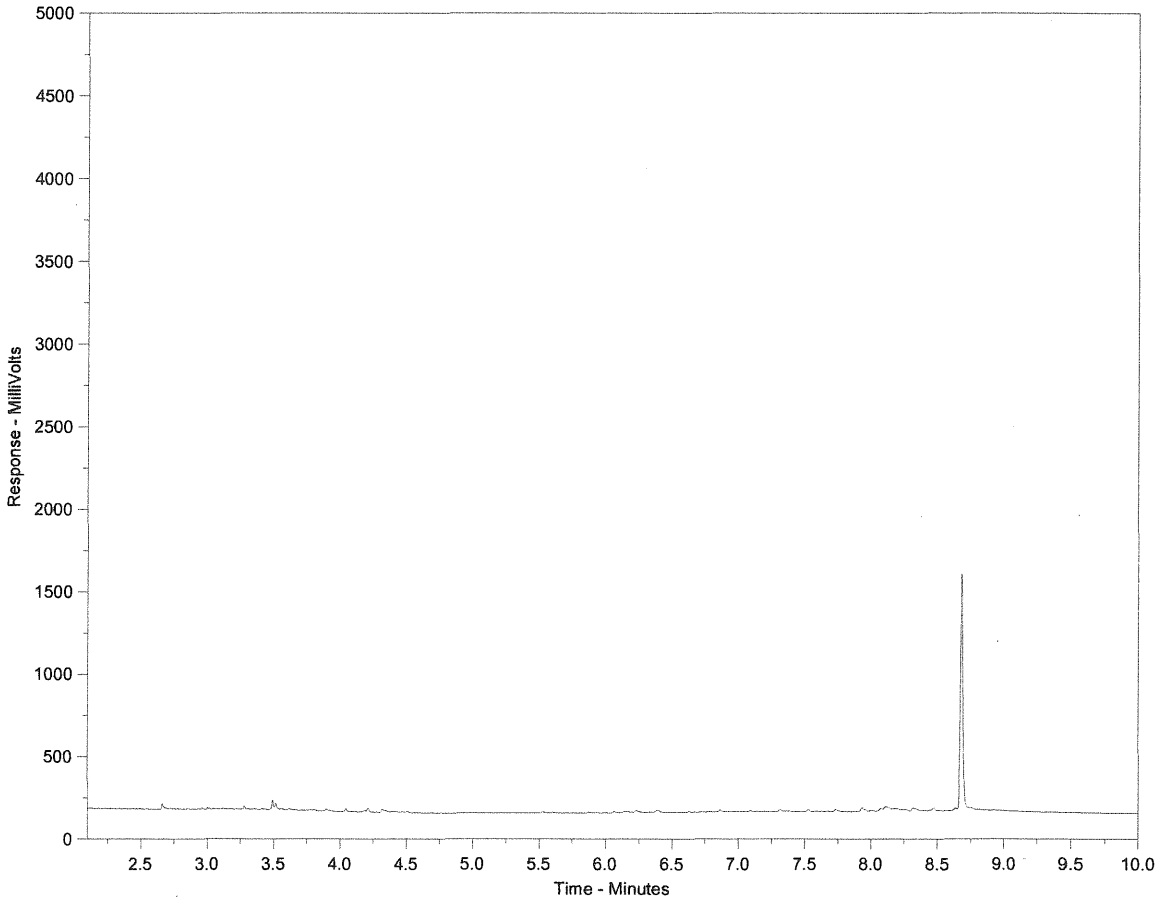
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-7
Client ID: MW09-16(6FT-7FT)



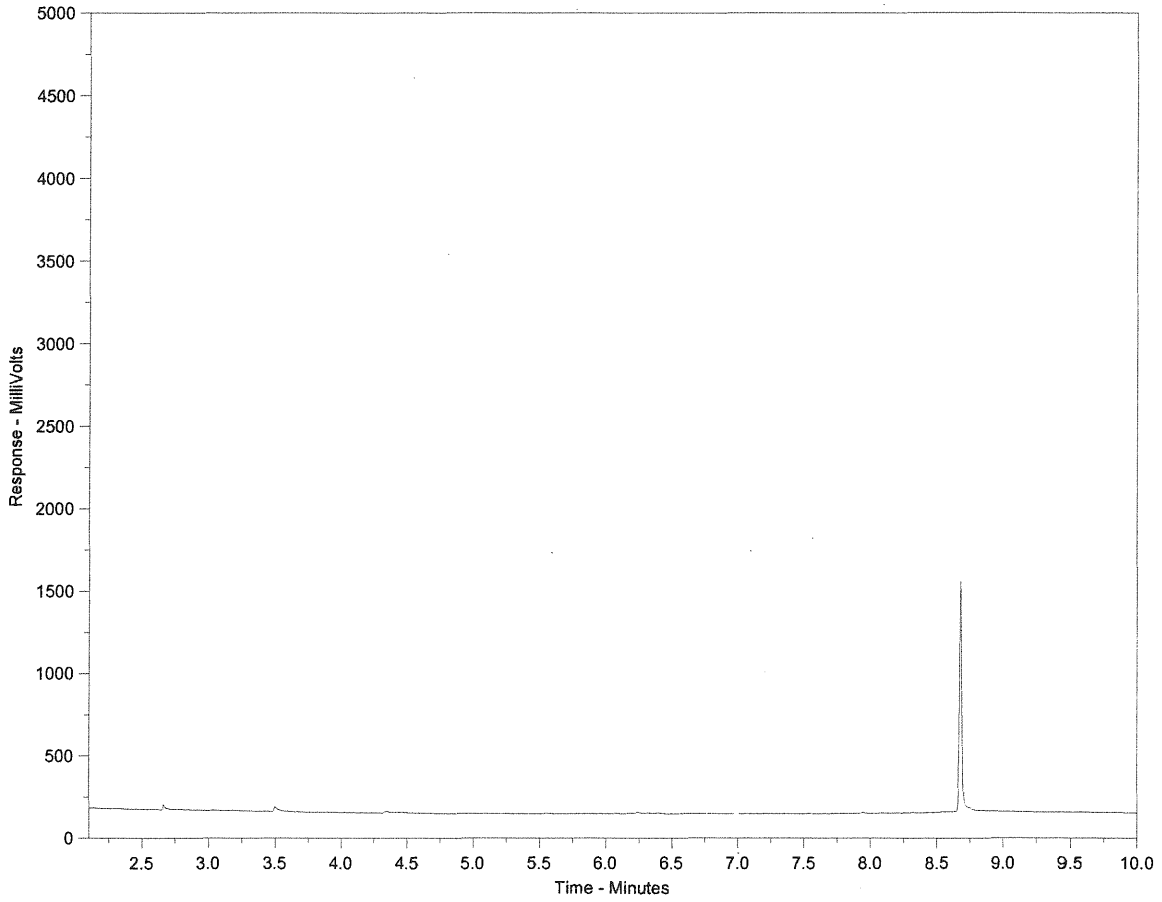
nC10	nC16	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
Gasoline		Motor Oils / Lube Oils / Grease		
Diesel / Jet Fuels				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-9
Client ID: MW09-17(11FT-12FT)



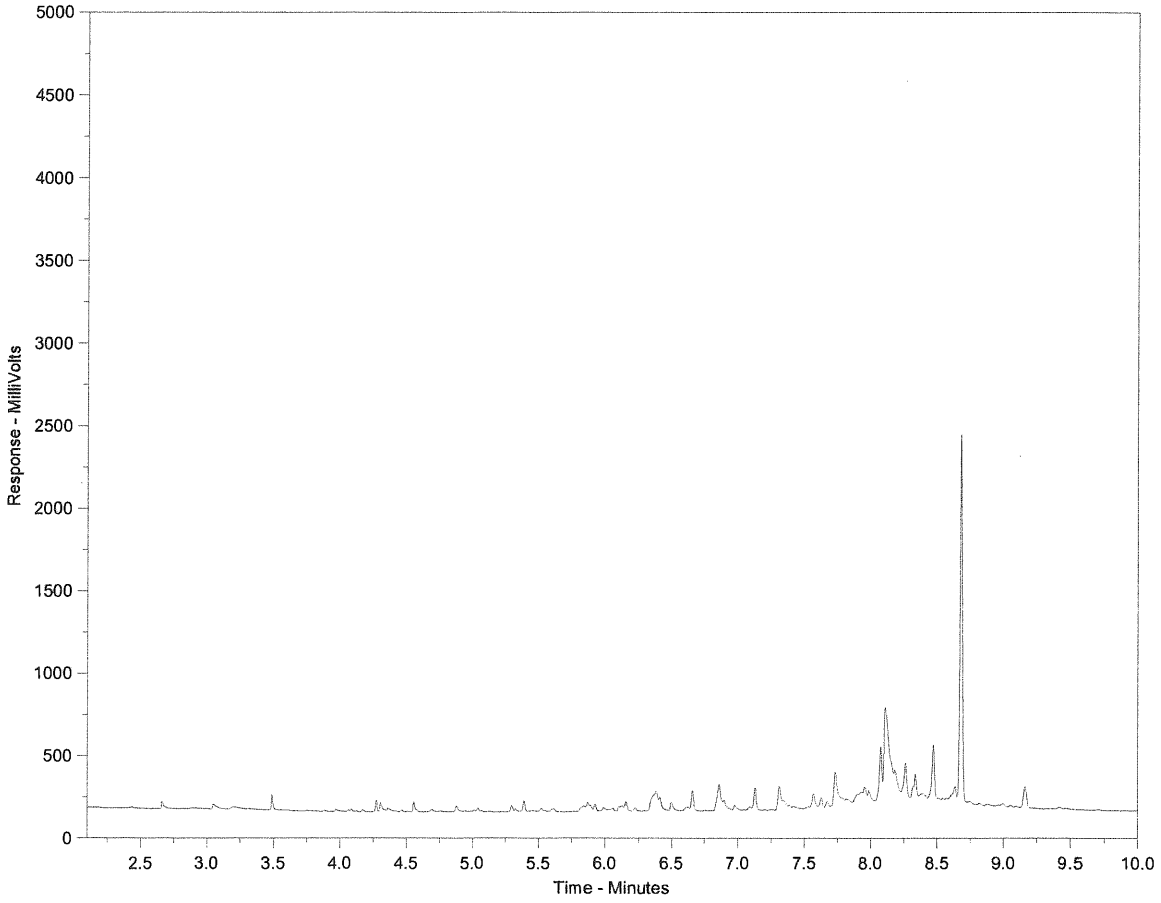
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-10
Client ID: MW09-18(2FT-3FT)



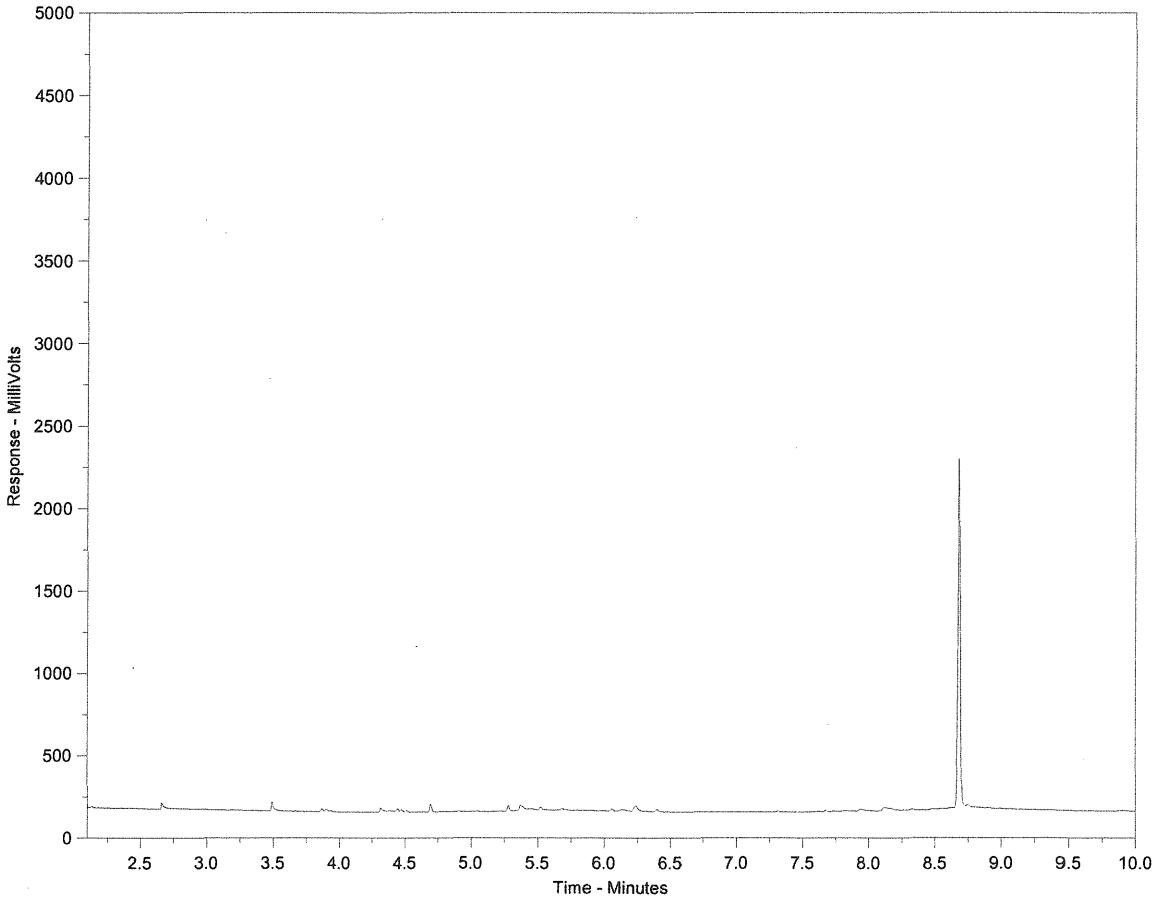
nC10	nC19	nC32	Surrogate	nC40
174°C	330°C	467°C		522°C
346°F	626°F	873°F		972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-11
Client ID: MW09-18(21FT-22FT)



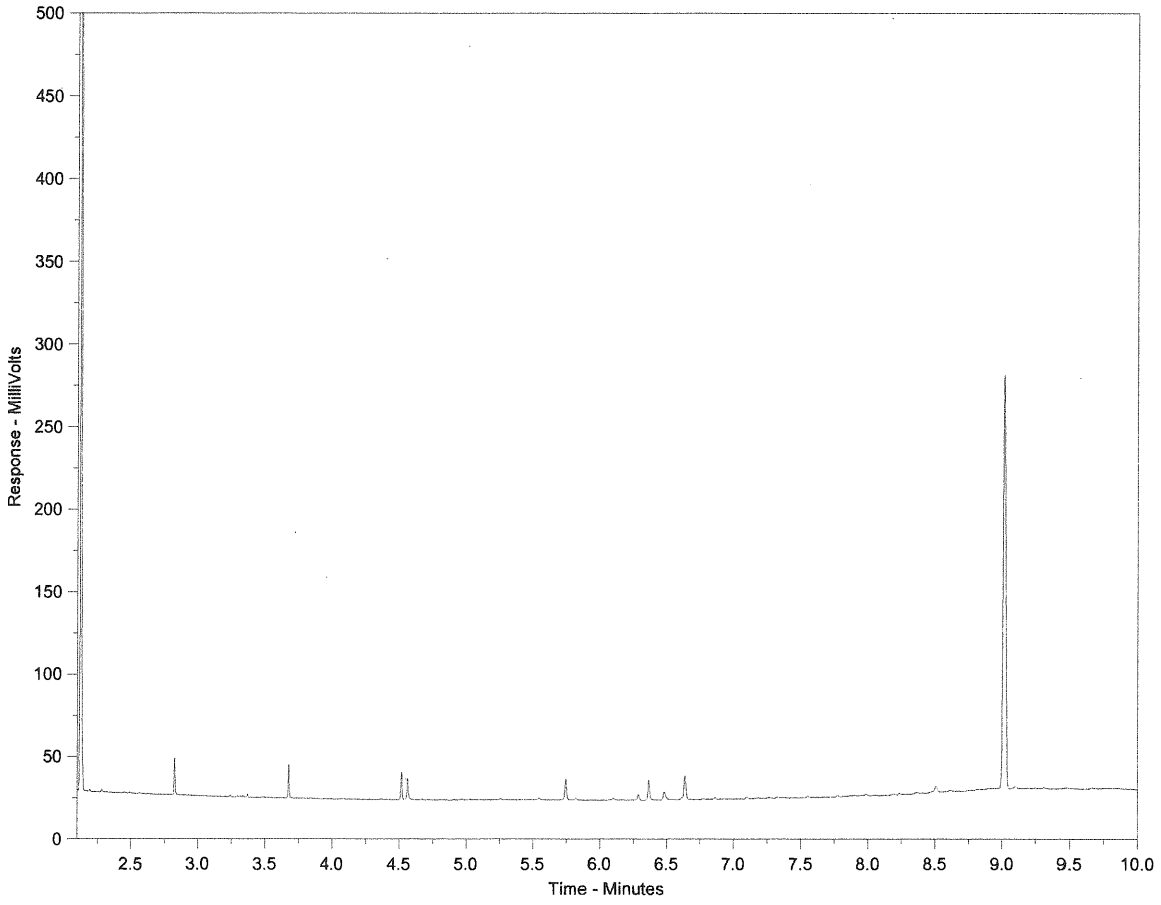
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-12
Client ID: MW09-19(7FT10



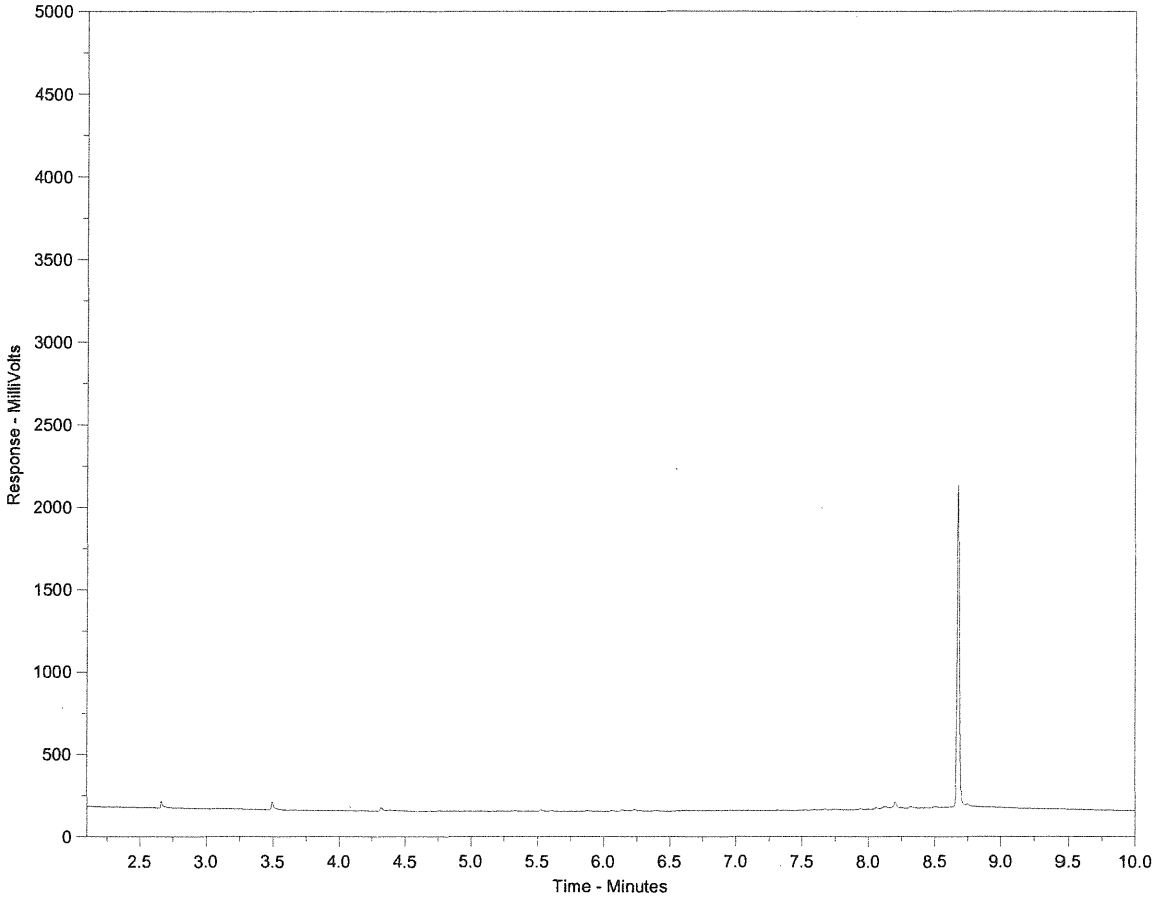
nC10	nC19	nC32	Surrogate	nC40
174°C	330°C	467°C		522°C
346°F	626°F	873°F		972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: WG979617-6#L796959-12
Client ID: MW09-19(7FT10



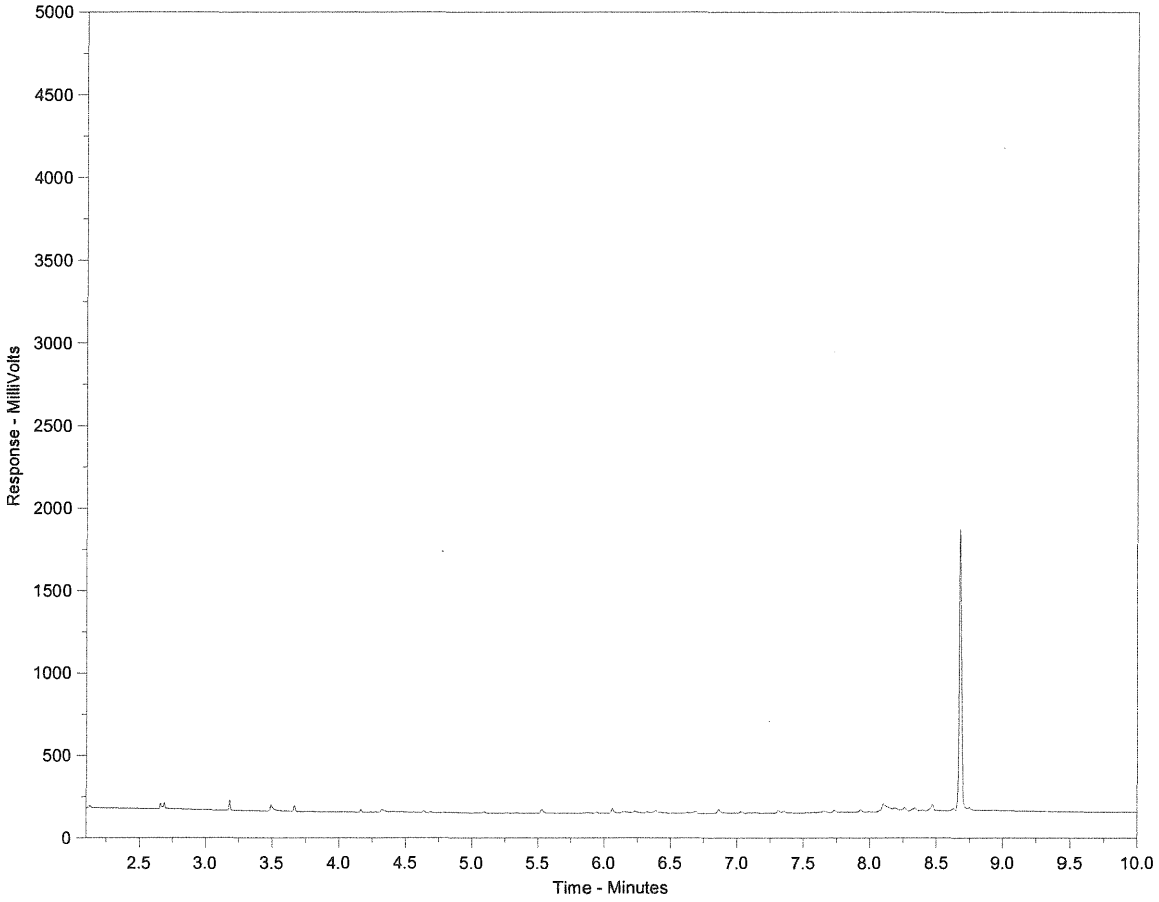
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

Hydrocarbon Distribution Report

ALS Sample ID: L796959-15
Client ID: MW09-19(15FT-16FT9



nC10	nC19	nC32	Surrogate	nC40
174°C	330°C	467°C		522°C
346°F	626°F	873°F		972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

Chromatograms from the ALS HDR Reference Library indicate the patterns of hydrocarbon compounds found in petroleum products, reference standards, and some examples of natural plant and organic materials. The chromatogram from left to right roughly corresponds to increasing boiling point from approximately 174°C to 522°C, a range encompassing most middle distillate and residual petroleum products (diesel, fuel oils, lubricating oils, etc). Comparison of library chromatograms with those of unknown samples may aid in the identification of contaminants. Surrogate compounds, which are added to samples by the laboratory, are not present in HDR library chromatograms.

Please note that retention times may vary between samples by as much as 0.5 minutes.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CANADA TOLL FREE 1-800-668-9878

www.alsenviro.com

COC # A014936

REPORT TO: RYAN MILLS	REPORT FORMAT / DISTRIBUTION
COMPANY: AECOM	STANDARD X OTHER ____
CONTACT:	PDF X EXCEL X CUSTOM ____ FAX ____
ADDRESS: 3001 WAYBURNE DRIVE	EMAIL 1: ryan.mills@aecom.com
SUITE 275, BURNABY B.C. V5G 4W8	EMAIL 2:
PHONE: 604-631-6213 FAX:	
INVOICE TO: SAME AS REPORT ? (YES) / NO	INDICATE BOTTLES: FILTERED / PRESERVED (F/P)
COMPANY:	CLIENT / PROJECT INFORMATION: YUKON GOV'T
CONTACT:	JOB #: 112359 - MT. NANSEN
ADDRESS:	PO /AFE:
	Legal Site Description:
PHONE: FAX:	QUOTE #:
Lab Work Order # (lab use only): L796959	SAMPLER (Initials): RDM

SERVICE REQUESTED

- REGULAR SERVICE (DEFAULT) ✓
- RUSH SERVICE (2-3 DAYS)
- PRIORITY SERVICE (1 DAY or ASAP)
- EMERGENCY SERVICE (<1 DAY / WEEKEND) - CONTACT ALS

ANALYSIS REQUEST

Sample #	SAMPLE IDENTIFICATION (This description will appear on the report)	DATE	TIME	SAMPLE TYPE	LEPH / HEPH / PAH	DISSOLVED METALS + ICP/OES (F)	TOTAL/WAD/SAD CYANIDE (P)	Anion Scan	Ammonia, NO_3, NO_2 (P)	pH conductivity Acidity Alkalinity TDS Hardness (P)	LEPH / HEPH / PAH SOIL	CCME METALS	HAZARDOUS ?	HIGHLY CONTAMINATED ?	NUMBER OF CONTAINERS
	MW09-15	JULY 14/09		WATER		X		X	X	X					
	MW09-16	JULY 19/09			X	X	X	X	X	X					
	MW09-17				X	X	X	X	X	X					
	MW09-18				X	X	X	X	X	X					
	MW09-18-R				X	X	X	X	X	X					
	MW09-19				X	X	X	X	X	X					
	MW09-16 (6 FT - 7 FT)	JULY 15/09		SOIL							X	X			
	MW09-17 (8 FT - 9 FT)										~~X~~	~~X~~			
	MW09-17 (11 FT - 12 FT)										X	X			
	MW09-18 (2 FT - 3 FT)										X	X			

GUIDELINES / REGULATIONS	SPECIAL INSTRUCTIONS / HAZARDOUS DETAILS
CCME GUIDELINES + BEST DET. LIMITS POSSIBLE	

Failure to complete all portions of this form may delay analysis. Please fill in this form *LEGIBLY*.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse page of the white report copy.

RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:
[signature]	JULY 22/09 2PM	MS	July 24
RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:
			10:00

SAMPLE CONDITION (lab use only)

TEMPERATURE	SAMPLES RECEIVED IN GOOD CONDITION ? YES / NO (If no provide details)
16	

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

CHAIN OF CUSTODY / ANALYTICAL REQUEST FORM

CANADA TOLL FREE 1-800-668-9878

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COC # A014937

REPORT TO:	REPORT FORMAT / DISTRIBUTION	SERVICE REQUESTED
COMPANY: AECOM	STANDARD X OTHER ____	REGULAR SERVICE (DEFAULT) ✓
CONTACT: RYAN MILLS	PDF X EXCEL X CUSTOM ____ FAX	RUSH SERVICE (2-3 DAYS)
ADDRESS: 275-3001 MAYBURNE DR.	EMAIL 1: ryan.mills@aecom.com	PRIORITY SERVICE (1 DAY or ASAP)
BURNABY, B.C. V5G 4W3	EMAIL 2:	EMERGENCY SERVICE (<1 DAY / WEEKEND) - CONTACT ALS
PHONE: 604-637-6213 FAX:		ANALYSIS REQUEST

INVOICE TO: SAME AS REPORT ? (YES) / NO	INDICATE BOTTLES: FILTERED / PRESERVED (F/P) → → →
COMPANY:	CLIENT / PROJECT INFORMATION:
CONTACT:	JOB #: 112359
ADDRESS:	PO /AFE:
	Legal Site Description:
PHONE: FAX:	QUOTE #:
Lab Work Order # (lab use only): L796959	SAMPLER (Initials):

Sample #	SAMPLE IDENTIFICATION (This description will appear on the report)	DATE	TIME	SAMPLE TYPE	LEPH / HEPH PAH	CCME METALS	HAZARDOUS ?	HIGHLY CONTAMINATED ?	NUMBER OF CONTAINERS
	MW09-18 (21 FT - 22 FT)	JULY 15/09		SOIL	X	X			
	MW09-19 (7 FT 10" - 8 FT 4")				X	X			
	MW09-19 (8FT 4" - 8 FT 7")								
	MW09-19 (8 FT 9" - 8 FT 10")								
	MW09-19 (15 FT - 16 FT 9")				X	X			

GUIDELINES / REGULATIONS	SPECIAL INSTRUCTIONS / HAZARDOUS DETAILS
CCME + BEST DETECTION POSSIBLE	HOLD OTHER SAMPLES

Failure to complete all portions of this form may delay analysis. Please fill in this form *LEGIBLY*.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse page of the white report copy.

RELINQUISHED BY:	DATE & TIME	RECEIVED BY	DATE & TIME:	SAMPLE CONDITION (lab use only)	
Ryan Mills	JULY 22/09 2pm	MS	July 24	TEMPERATURE	SAMPLES RECEIVED IN GOOD CONDITION ? YES / NO (If no provide details)
RELINQUISHED BY:	DATE & TIME	RECEIVED BY	DATE & TIME: 10:00	12	

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Certificate of Analysis

AECOM CANADA LTD.
ATTN: MARK LAVIGNE
SPERLING PLAZA
SUITE 490, 6400 ROBERTS STREET
BURNABY BC V5G 4C9

Report Date: 18-AUG-09 12:24 (MT)
Version: FINAL REV. 2

Lab Work Order #: L796873 **Date Received:** 24-JUL-09

Project P.O. #: MT. NANSEN HYDROGEO
Job Reference: 112359
Legal Site Desc:
CofC Numbers: C085792

Other Information:

Comments: ADDITIONAL 10-AUG-09 17:55
Please note that Cyanate detection limits have been increased for some of the samples due to the low sample volumes available for analysis. Furthermore, these samples were analyzed past recommended holding time of 14 days for Cyanate analysis.

This revision, 2, of the report replaces and supersedes all previous revisions. The results of Cyanate anlaysis have been added to the report. All other data remains unchanged.

Natasha Markovic-M.

NATASHA MARKOVIC-MIROVIC
Account Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	L796873-1 08-JUL-09 MW09-08	L796873-2 22-JUL-09 MW09-11	L796873-3 21-JUL-09 MW09-21	L796873-4 22-JUL-09 MW09-22	L796873-5 21-JUL-09 MW09-23
WATER						
Physical Tests	Conductivity (uS/cm)	187	433	1630	630	1930
	Hardness (as CaCO3) (mg/L)	72.2	209	711	248	1020
	pH (pH)	7.50	7.96	7.10	7.12	7.50
	Total Dissolved Solids (mg/L)	189	262	1230	389	1630
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	13.9	5.3	38.8	21.1	21.0
	Alkalinity, Total (as CaCO3) (mg/L)	91.1	227	266	176	269
	Ammonia as N (mg/L)	3.27	1.85	6.30	6.65	9.49
	Bromide (Br) (mg/L)	<0.50	<0.050	<2.5	<0.25	<2.5
	Chloride (Cl) (mg/L)	<5.0	3.23	<25	<2.5	<25
	Fluoride (F) (mg/L)	<0.20	0.723	0.057	0.075	0.058
	Nitrate (as N) (mg/L)	<0.050	0.283	1.44	4.79	<0.25
	Nitrite (as N) (mg/L)	<0.010	0.0059	0.058	0.0996	<0.050
	Sulfate (SO4) (mg/L)	16.0	11.0	617	126	879
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	0.0331	<0.0050	0.107
	Cyanide, Total (mg/L)	0.0542	<0.0050	0.0504	0.0165	0.419
	Cyanate (CNO) (mg/L)	<1.6	<1.6	5.0	<1.6	3.5
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	0.118	<0.0050	0.158	0.0332	0.033
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0025	<0.00050	<0.0025
	Arsenic (As)-Dissolved (mg/L)	0.178	0.0182	0.0329	0.0140	0.0100
	Barium (Ba)-Dissolved (mg/L)	0.102	0.169	0.300	0.157	0.089
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0050	<0.0010	<0.0050
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	0.14
	Cadmium (Cd)-Dissolved (mg/L)	<0.000017	0.000082	0.000196	0.000109	0.000184
	Calcium (Ca)-Dissolved (mg/L)	21.8	39.3	247	91.6	327
	Chromium (Cr)-Dissolved (mg/L)	0.0017	<0.0010	<0.0050	<0.0010	<0.0050
	Cobalt (Co)-Dissolved (mg/L)	0.00145	0.00169	0.0268	0.0134	0.0189
	Copper (Cu)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0050	0.0036	<0.0050
	Iron (Fe)-Dissolved (mg/L)	31.9	0.596	19.0	3.46	3.86
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0025	<0.00050	<0.0025
	Lithium (Li)-Dissolved (mg/L)	<0.0050	<0.0050	<0.025	<0.0050	<0.025
	Magnesium (Mg)-Dissolved (mg/L)	4.30	26.9	22.9	4.57	50.1
	Manganese (Mn)-Dissolved (mg/L)	2.09	0.987	7.52	3.88	6.69
	Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0010	0.0100	<0.0050	0.0017	<0.0050
	Nickel (Ni)-Dissolved (mg/L)	<0.0010	0.0033	<0.0050	0.0096	<0.0050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	<2.0	3.2	8.2	5.7	15.5
	Selenium (Se)-Dissolved (mg/L)	<0.0010	0.0010	<0.0050	<0.0010	<0.0050
	Silicon (Si)-Dissolved (mg/L)	8.28	5.50	5.69	4.69	5.35
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.000020	<0.00010	<0.000020	<0.00010

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796873-6	L796873-7			
	Description					
	Sampled Date	22-JUL-09	21-JUL-09			
	Sampled Time					
	Client ID	MW09-24	MW09-25			
Grouping	**Analyte**					
WATER						
Physical Tests	Conductivity (uS/cm)	564	1640			
	Hardness (as CaCO3) (mg/L)	297	710			
	pH (pH)	7.75	7.17			
	Total Dissolved Solids (mg/L)	364	1280			
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	7.5	31.9			
	Alkalinity, Total (as CaCO3) (mg/L)	210	269			
	Ammonia as N (mg/L)	0.032	12.1			
	Bromide (Br) (mg/L)	<0.050	<2.5			
	Chloride (Cl) (mg/L)	0.76	<25			
	Fluoride (F) (mg/L)	<0.020	0.059			
	Nitrate (as N) (mg/L)	2.20	1.37			
	Nitrite (as N) (mg/L)	0.0092	<0.050			
	Sulfate (SO4) (mg/L)	86.6	617			
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	0.0209			
	Cyanide, Total (mg/L)	0.0120	0.0465			
	Cyanate (CNO) (mg/L)	<0.50	6.90			
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	<0.0050	0.150			
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	<0.0025			
	Arsenic (As)-Dissolved (mg/L)	0.00117	0.0341			
	Barium (Ba)-Dissolved (mg/L)	0.077	0.294			
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0050			
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20			
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10			
	Cadmium (Cd)-Dissolved (mg/L)	0.000055	0.000188			
	Calcium (Ca)-Dissolved (mg/L)	88.7	247			
	Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0050			
	Cobalt (Co)-Dissolved (mg/L)	0.00063	0.0272			
	Copper (Cu)-Dissolved (mg/L)	0.0085	<0.0050			
	Iron (Fe)-Dissolved (mg/L)	<0.030	18.7			
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.0025			
	Lithium (Li)-Dissolved (mg/L)	<0.0050	<0.025			
	Magnesium (Mg)-Dissolved (mg/L)	18.4	22.5			
	Manganese (Mn)-Dissolved (mg/L)	0.0115	7.66			
	Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020			
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0010	<0.0050			
	Nickel (Ni)-Dissolved (mg/L)	<0.0010	<0.0050			
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30			
	Potassium (K)-Dissolved (mg/L)	<2.0	8.1			
	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0050			
	Silicon (Si)-Dissolved (mg/L)	5.74	5.61			
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.00010			

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID / Description / Sampled Date / Sampled Time / Client ID				
		L796873-1 08-JUL-09 MW09-08	L796873-2 22-JUL-09 MW09-11	L796873-3 21-JUL-09 MW09-21	L796873-4 22-JUL-09 MW09-22	L796873-5 21-JUL-09 MW09-23
WATER						
Dissolved Metals	Sodium (Na)-Dissolved (mg/L)	4.1	15.3	102	25.6	59.5
	Strontium (Sr)-Dissolved (mg/L)	0.106	0.376	0.927	0.341	0.736
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.00020	<0.0010	<0.00020	<0.0010
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.00050	<0.0025	<0.00050	<0.0025
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	0.019	<0.010	0.015
	Uranium (U)-Dissolved (mg/L)	<0.00020	0.00273	0.0016	0.00067	0.0023
	Vanadium (V)-Dissolved (mg/L)	0.0059	0.0015	0.0052	0.0019	<0.0050
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	0.0099	<0.0050	<0.0050

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L796873-6	L796873-7			
	Description					
	Sampled Date	22-JUL-09	21-JUL-09			
	Sampled Time					
	Client ID	MW09-24	MW09-25			
Grouping	**Analyte**					
WATER						
Dissolved Metals	Sodium (Na)-Dissolved (mg/L)	9.2	99.4			
	Strontium (Sr)-Dissolved (mg/L)	0.467	0.906			
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.0010			
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.0025			
	Titanium (Ti)-Dissolved (mg/L)	<0.010	0.018			
	Uranium (U)-Dissolved (mg/L)	0.00252	0.0016			
	Vanadium (V)-Dissolved (mg/L)	<0.0010	0.0051			
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	0.0104			

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	APHA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrite detection is by UV absorbance and not conductivity.

ANIONS-NO3-IC-VA	Water	Nitrate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrate detection is by UV absorance and not conductivity.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CN-T-L-MAC-HH-COL-VA	Water	Total Cyanide- Low Level by HH Distillat	APHA 4500-CN CYANIDE

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.	
CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN "Cyanide"
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.	
CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.	
CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN "Cyanide"
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.	
CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN Cyanide
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.	
CNO-SIE-VA	Water	Cyanate by SIE	APHA 4500-CN Cyanide
		This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode.	
EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.
		This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.	
F-SIE-VA	Water	Fluoride by SIE	APHA 4500-F "Fluoride"
		This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.	
F-SIE-VA	Water	Fluoride by SIE	APHA 4500-F Fluoride
		This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.	
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B
		Hardness is calculated from Calcium and Magnesium concentrations, and is expressed as calcium carbonate equivalents.	
HG-DIS-CCME-CVAFS-VA	Water	Diss. Mercury in Water by CVAFS (CCME)	EPA 3005A/245.7
		This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).	
MET-DIS-CCME-ICP-VA	Water	Diss. Metals in Water by ICPOES (CCME)	EPA SW-846 3005A/6010B
		This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or	

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-DIS-CCME-MS-VA Water Diss. Metals in Water by ICPMS (CCME) EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA Water Dissolved Metals in Water by ICPOES EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-SIE-VA Water Ammonia by SIE APHA 4500 D. - NH3 NITROGEN (AMMONIA)

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

PH-PCT-VA Water pH by Meter (Automated) APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

TDS-VA Water Total Dissolved Solids by Gravimetric APHA 2540 C - GRAVIMETRIC

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA		

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

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CANADA TOLL FREE 1-800-668-9878

www.alsenviro.com

COC # C085792

Page 1 of

REPORT TO:	REPORT FORMAT / DISTRIBUTION	SERVICE REQUESTED
COMPANY: AECOM	STANDARD ✓ OTHER ___	✓ REGULAR SERVICE (DEFAULT)
CONTACT: Marc Lavigne	PDF ✓ EXCEL ✓ CUSTOM ___ FAX ___	RUSH SERVICE (2-3 DAYS)
ADDRESS: 2251 2nd Avenue	EMAIL 1: marc-andre.lavigne@aecom.com	PRIORITY SERVICE (1 DAY or ASAP)
Whitehorse YT Y1A 5W1	EMAIL 2:	EMERGENCY SERVICE (<1 DAY / WEEKEND) - CONTACT ALS
PHONE: 867.633.6474 FAX: 867.633.		ANALYSIS REQUEST
INVOICE TO: SAME AS REPORT ? (YES) / NO	INDICATE BOTTLES: FILTERED / PRESERVED (F/P) → → →	
COMPANY:	CLIENT / PROJECT INFORMATION:	
CONTACT:	JOB #: 112359	
ADDRESS:	PO /AFE: Mt Nansen Hydrogeo	
	Legal Site Description:	
PHONE: FAX:	QUOTE #:	
Lab Work Order # (lab use only): L796873	SAMPLER (Initials): MAL	

Sample #	SAMPLE IDENTIFICATION (This description will appear on the report)	DATE	TIME	SAMPLE TYPE	General Chemistry (F)	Dissolved Metals (F)	Nutrients (F)	Cyanide (F)	HAZARDOUS ?	HIGHLY CONTAMINATED ?	NUMBER OF CONTAINERS
	MW09-08	July 08/09		GW	✓	✓	✓	✓			4
	MW09-11	July 22/09		GW	✓	✓	✓	✓			4
	MW09-21	July 21/09		GW	✓	✓	✓	✓			4
	MW09-22	July 22/09		GW	✓	✓	✓	✓			4
	MW09-23	July 21/09		GW	✓	✓	✓	✓			4
	MW09-24	July 22/09		GW	✓	✓	✓	✓			4
	MW09-25	July 21/09		GW	✓	✓	✓	✓			4

GUIDELINES / REGULATIONS	SPECIAL INSTRUCTIONS / HAZARDOUS DETAILS

Failure to complete all portions of this form may delay analysis. Please fill in this form *LEGIBLY*.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the reverse page of the white report copy.

RELINQUISHED BY:	DATE & TIME:	RECEIVED BY:	DATE & TIME:	SAMPLE CONDITION (lab use only)	
	13:00 July 24/09		July 24	TEMPERATURE	SAMPLES RECEIVED IN GOOD CONDITION ? YES / NO (If no provide details)
RELINQUISHED BY: ✓	DATE & TIME:	RECEIVED BY:	DATE & TIME: 16:00	5	

REFER TO BACK PAGE FOR REGIONAL LOCATIONS AND SAMPLING INFORMATION

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GENF14.00

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Certificate of Analysis

AECOM CANADA LTD.
ATTN: RYAN MILLS

275 - 3001 WAYBURNE DRIVE
BURNABY BC V5G 4W3

Report Date: 16-SEP-09 15:59 (MT)
Version: FINAL

Lab Work Order #: L814853 **Date Received:** 03-SEP-09

Project P.O. #:
Job Reference: 112359
Legal Site Desc: MT NANSEN MINE,YT
CofC Numbers:

Other Information:

Comments: Certain Metals detection limits have been increased for some of the samples due to the interferences encountered during the analysis.

NATASHA MARKOVIC-MIROVIC
Account Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L814853-1 Description: Sampled Date: 01-SEP-09 Sampled Time: Client ID: GLL07-03	L814853-2 01-SEP-09 MW09-08	L814853-3 02-SEP-09 MW09-11	L814853-4 01-SEP-09 MW09-15	L814853-5 01-SEP-09 MW09-16
WATER						
Physical Tests	Conductivity (uS/cm)	1740	222	659	937	1770
	Hardness (as CaCO3) (mg/L)	1110	99.5	352	579	1180
	pH (pH)	5.66	6.92	7.78	7.28	7.23
	Total Dissolved Solids (mg/L)	1670	233	445	682	1540
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	81.4	26.6	10.9	26.3	31.2
	Alkalinity, Total (as CaCO3) (mg/L)	15.5	88.3	325	276	294
	Ammonia as N (mg/L)	0.103	3.77	2.48	0.100	<0.020
	Bromide (Br) (mg/L)	<0.25	<0.25 *	0.050	<0.50	<0.50
	Chloride (Cl) (mg/L)	<2.5	<2.5 *	4.90	<5.0	<5.0
	Fluoride (F) (mg/L)	0.15	<0.10 *	0.697	<0.20	<0.20
	Nitrate (as N) (mg/L)	0.779	<0.025 *	0.495	<0.050	0.201
	Nitrite (as N) (mg/L)	0.0544	<0.0050 *	0.0277	<0.010	<0.010
	Sulfate (SO4) (mg/L)	529	14.9 *	50.2	271	832
Cyanides	Cyanide, Weak Acid Diss (mg/L)		<0.0050	<0.0050		<0.0050
	Cyanide, Total (mg/L)		0.0104	<0.0050		<0.0050
	Cyanate (CNO) (mg/L)		<0.50	<0.50		<0.50
	Thiocyanate (SCN) (mg/L)	0.82	5.8	1.03	0.93	1.16
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	1.27	23.3	26.2	4.62	3.67
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	1.39	0.0980	<0.0050	<0.010	<0.025
	Antimony (Sb)-Dissolved (mg/L)	<0.0050	<0.00050	<0.00050	0.0023	0.102
	Arsenic (As)-Dissolved (mg/L)	<0.0050	0.284	0.0239	0.187	0.0391
	Barium (Ba)-Dissolved (mg/L)	<0.020	0.126	0.311	<0.020	<0.020
	Beryllium (Be)-Dissolved (mg/L)	<0.010	<0.0010	<0.0010	<0.0020	<0.0050
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
	Boron (B)-Dissolved (mg/L)	<0.10	<0.10	<0.10	<0.10	0.19
	Cadmium (Cd)-Dissolved (mg/L)	0.436	<0.000017	0.000038	0.000758	0.0419
	Calcium (Ca)-Dissolved (mg/L)	336	30.9	65.5	158	273
	Chromium (Cr)-Dissolved (mg/L)	<0.010	<0.0020	<0.0010	<0.0020	<0.0050
	Cobalt (Co)-Dissolved (mg/L)	0.0144	0.00147	0.00096	0.00076	<0.0015
	Copper (Cu)-Dissolved (mg/L)	0.550	<0.0010	<0.0010	<0.0020	0.0105
	Iron (Fe)-Dissolved (mg/L)	11.6	40.7	1.52	1.58	0.331
	Lead (Pb)-Dissolved (mg/L)	0.0114	<0.00050	<0.00050	0.0059	0.0284
	Lithium (Li)-Dissolved (mg/L)	<0.050	<0.0050	<0.0050	<0.010	<0.025
	Magnesium (Mg)-Dissolved (mg/L)	66.4	5.45	45.8	44.5	120
	Manganese (Mn)-Dissolved (mg/L)	10.5	2.32	1.42	0.681	0.208
	Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
	Molybdenum (Mo)-Dissolved (mg/L)	<0.010	<0.0010	0.0079	<0.0020	<0.0050
	Nickel (Ni)-Dissolved (mg/L)	0.014	<0.0010	0.0027	<0.0020	<0.0050
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	2.1	<2.0	4.2	<2.0	6.4

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID	L814853-6	L814853-7	L814853-8	L814853-9	L814853-10
Description					
Sampled Date	01-SEP-09	01-SEP-09	01-SEP-09	01-SEP-09	01-SEP-09
Sampled Time					
Client ID	MW09-17	MW09-18	TRIP BLANK	MW09-19	MW09-21
Grouping / **Analyte**					
WATER					
Physical Tests Conductivity (uS/cm)	2570	2670	<2.0	2470	1790
Hardness (as CaCO3) (mg/L)	1840	1920	<1.1	1750	838
pH (pH)	7.42	7.47	5.66	7.16	6.67
Total Dissolved Solids (mg/L)	2430	2560	<10	2370	1420
Anions and Nutrients Acidity (as CaCO3) (mg/L)	39.9	31.9	<1.0	45.7	143
Alkalinity, Total (as CaCO3) (mg/L)	434	426	<2.0	389	231
Ammonia as N (mg/L)	<0.020	0.021	<0.020	2.24	17.9
Bromide (Br) (mg/L)	<1.0	<1.0	<0.050	<1.0	<1.0
Chloride (Cl) (mg/L)	<10	<10	<0.50	<10	<10
Fluoride (F) (mg/L)	<0.40	<0.40	<0.020	<0.40	<0.40
Nitrate (as N) (mg/L)	0.30	<0.10	<0.0050	<0.10	<0.10
Nitrite (as N) (mg/L)	<0.020	<0.020	<0.0010	<0.020	<0.020
Sulfate (SO4) (mg/L)	1400	1490	<0.50	1340	818
Cyanides Cyanide, Weak Acid Diss (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0169
Cyanide, Total (mg/L)	<0.0050	<0.0050	<0.0050	0.0146	0.0293
Cyanate (CNO) (mg/L)	<0.50	<0.50	<0.50	5.75	20.7
Thiocyanate (SCN) (mg/L)	1.35	1.23	<0.50	1.25	1.98
Organic / Inorganic Carbon Total Organic Carbon (mg/L)	5.01	2.89	<0.50	80.8	42.5
Dissolved Metals Aluminum (Al)-Dissolved (mg/L)	<0.025	<0.050	<0.0050	<0.025	0.152
Antimony (Sb)-Dissolved (mg/L)	<0.0025	<0.0050	<0.00050	<0.0025	<0.0025
Arsenic (As)-Dissolved (mg/L)	0.0128	0.0526	<0.00050	0.0834	0.0443
Barium (Ba)-Dissolved (mg/L)	<0.020	<0.020	<0.020	0.077	0.426
Beryllium (Be)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Dissolved (mg/L)	0.16	<0.10	<0.10	0.40	<0.10
Cadmium (Cd)-Dissolved (mg/L)	<0.000085	<0.00017	<0.000017	<0.000085	0.000162
Calcium (Ca)-Dissolved (mg/L)	350	375	<0.10	373	293
Chromium (Cr)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
Cobalt (Co)-Dissolved (mg/L)	<0.0015	<0.0030	<0.00030	<0.0015	0.0260
Copper (Cu)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
Iron (Fe)-Dissolved (mg/L)	<0.030	<0.030	<0.030	30.4	66.4
Lead (Pb)-Dissolved (mg/L)	<0.0025	<0.0050	<0.00050	<0.0025	<0.0025
Lithium (Li)-Dissolved (mg/L)	<0.025	<0.050	<0.0050	<0.025	<0.025
Magnesium (Mg)-Dissolved (mg/L)	235	240	<0.10	200	26.1
Manganese (Mn)-Dissolved (mg/L)	0.0096	0.427	<0.00030	1.97	6.73
Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
Nickel (Ni)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	0.41	<0.30
Potassium (K)-Dissolved (mg/L)	7.5	7.1	<2.0	4.9	9.4

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L814853-11 Description: Sampled Date: 01-SEP-09 Sampled Time: Client ID: MW09-22	L814853-12 01-SEP-09 MW09-23	L814853-13 01-SEP-09 MW09-24	L814853-14 01-SEP-09 MW09-26	
WATER						
Physical Tests	Conductivity (uS/cm)	543	1890	378	666	
	Hardness (as CaCO3) (mg/L)	244	1030	197	355	
	pH (pH)	6.92	7.30	7.69	7.85	
	Total Dissolved Solids (mg/L)	378	1610	255	434	
Anions and Nutrients	Acidity (as CaCO3) (mg/L)	27.2	24.4	5.9	9.1	
	Alkalinity, Total (as CaCO3) (mg/L)	122	247	107	317	
	Ammonia as N (mg/L)	4.37	8.73	<0.020	2.43	
	Bromide (Br) (mg/L)	<0.50	<0.50	<0.050	0.050	
	Chloride (Cl) (mg/L)	<5.0	<5.0	<0.50	4.96	
	Fluoride (F) (mg/L)	<0.20	<0.20	0.032	0.711	
	Nitrate (as N) (mg/L)	<0.050	<0.050	2.52	0.544	
	Nitrite (as N) (mg/L)	<0.010	<0.010	0.0016	0.0271	
	Sulfate (SO4) (mg/L)	156	916	81.7	51.4	
Cyanides	Cyanide, Weak Acid Diss (mg/L)	<0.0050	0.0190	<0.0050	<0.0050	
	Cyanide, Total (mg/L)	0.0102	0.0324	0.0119	0.0074	
	Cyanate (CNO) (mg/L)	1.14	2.34	<0.50	<0.50	
	Thiocyanate (SCN) (mg/L)	1.20	3.72	<0.50	1.04	
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	13.7	18.8	4.18	26.8	
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	0.0982	0.037	<0.0050	<0.0050	
	Antimony (Sb)-Dissolved (mg/L)	<0.00050	<0.0025	<0.00050	<0.00050	
	Arsenic (As)-Dissolved (mg/L)	0.0368	0.0137	0.00102	0.0235	
	Barium (Ba)-Dissolved (mg/L)	0.115	0.064	0.056	0.315	
	Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0010	<0.0010	
	Bismuth (Bi)-Dissolved (mg/L)	<0.20	<0.20	<0.20	<0.20	
	Boron (B)-Dissolved (mg/L)	<0.10	0.14	<0.10	<0.10	
	Cadmium (Cd)-Dissolved (mg/L)	0.000077	0.000126	0.000034	0.000035	
	Calcium (Ca)-Dissolved (mg/L)	89.9	332	60.4	65.8	
	Chromium (Cr)-Dissolved (mg/L)	<0.0020	<0.0050	<0.0010	<0.0010	
	Cobalt (Co)-Dissolved (mg/L)	0.0123	0.0171	0.00063	0.00097	
	Copper (Cu)-Dissolved (mg/L)	0.0015	<0.0050	0.0057	<0.0010	
	Iron (Fe)-Dissolved (mg/L)	14.6	7.93	<0.030	1.45	
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.0025	<0.00050	<0.00050	
	Lithium (Li)-Dissolved (mg/L)	<0.0050	<0.025	<0.0050	<0.0050	
	Magnesium (Mg)-Dissolved (mg/L)	4.84	47.8	11.3	46.4	
	Manganese (Mn)-Dissolved (mg/L)	3.20	6.06	0.00267	1.38	
	Mercury (Hg)-Dissolved (mg/L)	<0.000020	<0.000020	<0.000020	<0.000020	
	Molybdenum (Mo)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0010	0.0078	
	Nickel (Ni)-Dissolved (mg/L)	0.0092	<0.0050	<0.0010	0.0028	
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	
	Potassium (K)-Dissolved (mg/L)	4.4	14.4	<2.0	4.3	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID / Description / Sampled Date / Sampled Time / Client ID				
		L814853-1 01-SEP-09 GLL07-03	L814853-2 01-SEP-09 MW09-08	L814853-3 02-SEP-09 MW09-11	L814853-4 01-SEP-09 MW09-15	L814853-5 01-SEP-09 MW09-16
WATER						
Dissolved Metals	Selenium (Se)-Dissolved (mg/L)	<0.010	<0.0010	<0.0010	<0.0020	<0.0050
	Silicon (Si)-Dissolved (mg/L)	4.92	8.72	6.03	6.32	5.28
	Silver (Ag)-Dissolved (mg/L)	<0.00020	<0.000020	<0.000020	<0.000040	<0.00010
	Sodium (Na)-Dissolved (mg/L)	8.0	3.8	20.1	6.9	9.0
	Strontium (Sr)-Dissolved (mg/L)	0.354	0.140	0.637	1.32	0.596
	Thallium (Tl)-Dissolved (mg/L)	<0.0020	<0.00020	<0.00020	<0.00040	<0.0010
	Tin (Sn)-Dissolved (mg/L)	<0.0050	<0.00050	<0.00050	<0.0010	<0.0025
	Titanium (Ti)-Dissolved (mg/L)	0.014	<0.010	<0.010	0.011	0.013
	Uranium (U)-Dissolved (mg/L)	<0.0020	<0.00020	0.00346	0.0128	0.0029
	Vanadium (V)-Dissolved (mg/L)	<0.010	0.0048	0.0018	<0.0020	<0.0050
	Zinc (Zn)-Dissolved (mg/L)	23.2	0.0117	<0.0050	0.233	3.66

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L814853-6	L814853-7	L814853-8	L814853-9	L814853-10
	Description					
	Sampled Date	01-SEP-09	01-SEP-09	01-SEP-09	01-SEP-09	01-SEP-09
	Sampled Time					
	Client ID	MW09-17	MW09-18	TRIP BLANK	MW09-19	MW09-21
Grouping	**Analyte**					
WATER						
Dissolved Metals	Selenium (Se)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	<0.0050
	Silicon (Si)-Dissolved (mg/L)	4.75	4.85	<0.050	7.60	5.69
	Silver (Ag)-Dissolved (mg/L)	<0.00010	<0.00020	<0.000020	<0.00010	<0.00010
	Sodium (Na)-Dissolved (mg/L)	11.0	10.5	<2.0	14.0	73.1
	Strontium (Sr)-Dissolved (mg/L)	0.990	1.01	<0.0050	1.01	1.00
	Thallium (Tl)-Dissolved (mg/L)	<0.0010	<0.0020	<0.00020	<0.0010	<0.0010
	Tin (Sn)-Dissolved (mg/L)	<0.0025	<0.0050	<0.00050	<0.0025	<0.0025
	Titanium (Ti)-Dissolved (mg/L)	0.014	0.014	<0.010	0.015	0.019
	Uranium (U)-Dissolved (mg/L)	0.0070	0.0075	<0.00020	<0.0010	0.0010
	Vanadium (V)-Dissolved (mg/L)	<0.0050	<0.010	<0.0010	<0.0050	0.0064
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	0.0076

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L814853-11	L814853-12	L814853-13	L814853-14	
	Description					
	Sampled Date	01-SEP-09	01-SEP-09	01-SEP-09	01-SEP-09	
	Sampled Time					
	Client ID	MW09-22	MW09-23	MW09-24	MW09-26	
Grouping	**Analyte**					
WATER						
Dissolved Metals	Selenium (Se)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0010	<0.0010	
	Silicon (Si)-Dissolved (mg/L)	5.51	5.69	5.62	6.06	
	Silver (Ag)-Dissolved (mg/L)	<0.000020	<0.00010	<0.000020	<0.000020	
	Sodium (Na)-Dissolved (mg/L)	15.4	56.9	8.7	20.3	
	Strontium (Sr)-Dissolved (mg/L)	0.286	0.698	0.295	0.645	
	Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.0010	<0.00020	<0.00020	
	Tin (Sn)-Dissolved (mg/L)	<0.00050	<0.0025	<0.00050	<0.00050	
	Titanium (Ti)-Dissolved (mg/L)	0.011	0.016	<0.010	<0.010	
	Uranium (U)-Dissolved (mg/L)	0.00071	0.0015	0.00058	0.00341	
	Vanadium (V)-Dissolved (mg/L)	0.0044	<0.0050	<0.0010	0.0017	
	Zinc (Zn)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	

* Please refer to the Reference Information section for an explanation of any qualifiers detected.

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Qualifiers for Individual Parameters Listed:

Qualifier	Description
DLM	Detection Limit Adjustment For Sample Matrix Effects

Samples with Qualifiers for Individual Parameters as listed above:

Sample Number	Client Sample ID	Parameters	Qualifier
L814853-2	MW09-08	Nitrate (as N) Sulfate (SO4) Bromide (Br) Chloride (Cl) Nitrite (as N) Fluoride (F)	DLM

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 "Acidity"

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ACY-PCT-VA	Water	Acidity by Automatic Titration	APHA 2310 Acidity

This analysis is carried out using procedures adapted from APHA Method 2310 "Acidity". Acidity is determined by potentiometric titration to a specified endpoint.

ALK-COL-VA	Water	Alkalinity by Colourimetric (Automated)	APHA 310.2

This analysis is carried out using procedures adapted from EPA Method 310.2 "Alkalinity". Total Alkalinity is determined using the methyl orange colourimetric method.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 "Alkalinity"

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ALK-PCT-VA	Water	Alkalinity by Auto. Titration	APHA 2320 Alkalinity

This analysis is carried out using procedures adapted from APHA Method 2320 "Alkalinity". Total alkalinity is determined by potentiometric titration to a pH 4.5 endpoint. Bicarbonate, carbonate and hydroxide alkalinity are calculated from phenolphthalein alkalinity and total alkalinity values.

ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrite detection is by UV absorbance and not conductivity.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
ANIONS-NO3-IC-VA	Water	Nitrate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrate detection is by UV absorance and not conductivity.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 "TOTAL ORGANIC CARBON (TOC)"

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-SCN-VA	Water	Thiocyanate by Colour	APHA 4500-CN "CYANIDE"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

.N-SCN-VA	Water	Thiocyanate by Colour	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN "Cyanide"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN "Cyanide"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CNO-SIE-VA	Water	Cyanate by SIE	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode.

EC-PCT-VA	Water	Conductivity (Automated)	APHA 2510 Auto. Conduc.

This analysis is carried out using procedures adapted from APHA Method 2510 "Conductivity". Conductivity is determined using a conductivity electrode.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness is calculated from Calcium and Magnesium concentrations, and is expressed as calcium carbonate equivalents.

HG-DIS-CCME-CVAFS-VA	Water	Diss. Mercury in Water by CVAFS (CCME)	EPA 3005A/245.7

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by filtration (EPA Method 3005A) and involves a cold-oxidation of the acidified sample using bromine monochloride prior to reduction of the sample with stannous chloride. Instrumental analysis is by cold vapour atomic fluorescence spectrophotometry (EPA Method 245.7).

MET-DIS-CCME-ICP-VA	Water	Diss. Metals in Water by ICPOES (CCME)	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-DIS-CCME-MS-VA	Water	Diss. Metals in Water by ICPMS (CCME)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures may involve preliminary sample treatment by acid digestion, using either hotblock or microwave oven, or filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

NH3-SIE-VA	Water	Ammonia by SIE	APHA 4500 D. - NH3 NITROGEN (AMMONIA)

This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

PH-MAN-VA	Water	pH by Manual Meter	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode.

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H "pH Value"

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

PH-PCT-VA	Water	pH by Meter (Automated)	APHA 4500-H pH Value

This analysis is carried out using procedures adapted from APHA Method 4500-H "pH Value". The pH is determined in the laboratory using a pH electrode

TDS-VA	Water	Total Dissolved Solids by Gravimetric	APHA 2540 C - GRAVIMETRIC

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)

This analysis is carried out using procedures adapted from APHA Method 2540 "Solids". Solids are determined gravimetrically. Total Dissolved Solids (TDS) are determined by filtering a sample through a glass fibre filter, TDS is determined by evaporating the filtrate to dryness at 180 degrees celsius.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # _____

Page 1 of 2

Report to:	**Report Format / Distribution**	**Service Requested:**
Company: AECOM (GAR200)	☑ Standard ☐ Other	☑ Regular Service (Default)
Contact: Ryan Mills	☑ PDF ☑ Excel ☐ Fax	☐ Rush Service (2-3 Days)
Address: 275 - 3001 WAYBURNE DR, Burnaby BC	Email 1: Ryan.Mills@aecom.com	☐ Priority Service (1 Day or ASAP)
	Email 2: Marc-Andre.Lavigne@aecom.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone: Fax:		**Analysis Request**
Invoice To: ☑ Same as Report	Indicate Bottles: Filtered / Preserved (F/P) ----	F/P, , , , , P, P, P, P, , , ,
Company:	**Client / Project Information:**	
Contact:	Job #: 112359	
Address:	PO/AFE:	
Sample	Legal Site Description: Mt Nansen Mine, YT	
Phone: Fax:	Quote #:	
Lab Work Order # (lab use only): L814853	**ALS Contact:** NatashaMM	**Sampler (Initials):** MAL/JF

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	MET-DIS-CCME+ICP-VA	PH, EC, TDS, SCN	Acidity	Alkalinity-T	Anion Scan	Tot-CN	WAD-CN	CNO	TOC	Ammonia	Hazardous?	Highly Contaminated?	Number of Containers
	GLL07-03	01-Sep-09		Water	X	X	X	X	X				X	X			4
	MW09-08	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-11	02-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-15	01-Sep-09		Water	X	X	X	X	X				X	X			4
	MW09-16	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-17	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-18	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5

Guidelines / Regulations

Special Instructions / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:	Date & Time:	Received By:	Date & Time:
	02/09/09		9/9/09 1pm
Relinquished By:	Date & Time:	Received By:	Date & Time:

Sample Condition (lab use only)

Temperature	Samples Received in Good Condition? Y / N (if no provided details)
5	

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES
Environmental Division

Chain of Custody / Analytical Request Form
Canada Toll Free: 1 800 668 9878
www.alsglobal.com

COC # _____

Page 2 of 2

Report to:	Report Format / Distribution	Service Requested:
Company: AECOM (GAR200)	☑ Standard ☐ Other	☑ Regular Service (Default)
Contact: Ryan Mills	☑ PDF ☑ Excel ☐ Fax	☐ Rush Service (2-3 Days)
Address: 275 - 3001 WAYBURNE DR, Burnaby BC	Email 1: Ryan.Mills@aecom.com	☐ Priority Service (1 Day or ASAP)
	Email 2: Marc-Andre.Lavigne@aecom.com	☐ Emergency Service (<1 Day / Wkend) - Contact ALS
Phone: Fax:		Analysis Request
Invoice To: ☑ Same as Report	Indicate Bottles: Filtered / Preserved (F/P)	F/P
Company:	Client / Project Information:	
Contact:	Job #: 112359	
Address:	PO/AFE:	
Sample	Legal Site Description: Mt Nansen Mine, YT	
Phone: Fax:	Quote #:	
Lab Work Order # (lab use only)	ALS Contact: NatashaMM	Sampler (Initials): MAL/JF

Sample #	Sample Identification (This description will appear on the report)	Date dd-mmm-yy	Time hh:mm	Sample Type (Select from drop-down list)	MET-DIS-CCME+ICP-VA	PH, EC, TDS, SCN	Acidity	Alkalinity-T	Anion Scan	Tot-CN	WAD-CN	CNO	TOC	Ammonia	Hazardous?	Highly Contaminated?	Number of Containers
	TRIP BLANK	01-SEP-09		WATER	X	X	X	X	X	X	X	X	X	X			5
	MW09-19	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-21	02-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			6
	MW09-22	02-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-23	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			6
	MW09-24	01-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5
	MW09-26	02-Sep-09		Water	X	X	X	X	X	X	X	X	X	X			5

Guidelines / Regulations

Special Instructions / Hazardous Details

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.
By the use of this form the user acknowledges and agrees with the Terms and Conditions as specified on the adjacent worksheet.

Relinquished By:	Date & Time:	Received By:	Date & Time:
	09/09/09		9/9/09
Relinquished By:	Date & Time:	Received By:	Date & Time:

Sample Condition (lab use only)
Temperature: 5
Samples received in Good Condition? Y / N (if no provided details)

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Certificate of Analysis

LORAX ENVIRONMENTAL SERVICES
ATTN: SKYA FAWCETT
2289 BURRARD STREET
VANCOUVER BC V6J 3H9

Report Date: 16-SEP-09 13:32 (MT)
Version: FINAL

Lab Work Order #: L815006 **Date Received:** 04-SEP-09

Project P.O. #: NOT SUBMITTED
Job Reference: 907-2 MT.NANSEN
Legal Site Desc:
CofC Numbers: 08-038864, 08-038865

Other Information:

Comments:

Andre Langlais
Account Manager

THIS REPORT SHALL NOT BE REPRODUCED EXCEPT IN FULL WITHOUT THE WRITTEN AUTHORITY OF THE LABORATORY.
ALL SAMPLES WILL BE DISPOSED OF AFTER 30 DAYS FOLLOWING ANALYSIS. PLEASE CONTACT THE LAB IF YOU REQUIRE ADDITIONAL SAMPLE STORAGE TIME.

ALS Canada Ltd.
Part of the **ALS Laboratory Group**
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ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID	L815006-1	L815006-2	L815006-3	L815006-4	L815006-5
Description					
Sampled Date	02-SEP-09	02-SEP-09	02-SEP-09	02-SEP-09	03-SEP-09
Sampled Time					
Client ID	MP09-09	MP09-10	MP09-11	MP09-12	MW09-1
Grouping / **Analyte**					
WATER					
Physical Tests Hardness (as CaCO3) (mg/L)	382	196	607	668	943
Anions and Nutrients Ammonia as N (mg/L)	8.50	2.65	1.60	1.98	13.5
Bromide (Br) (mg/L)	<0.50	<0.50	<0.50	<0.50	<5.0
Chloride (Cl) (mg/L)	6.5	<5.0	8.5	6.3	<50
Fluoride (F) (mg/L)	0.64	1.67	0.218	0.20	0.076
Nitrate (as N) (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.50
Nitrite (as N) (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.10
Sulfate (SO4) (mg/L)	179	237	<5.0	59.9	531
Cyanides Cyanide, Weak Acid Diss (mg/L)	0.0335	0.964	0.0099	<0.0050	0.0209
Cyanide, Total (mg/L)	0.125	2.96	0.0747	0.0387	0.0525
Cyanate (CNO) (mg/L)	<0.60	0.54	0.54	<0.50	5.1
Thiocyanate (SCN) (mg/L)	1.96	3.20	4.46	2.89	27.1
Organic / Inorganic Carbon Total Organic Carbon (mg/L)	35.4	48.5	142	55.9	66.8
Dissolved Metals Aluminum (Al)-Dissolved (mg/L)	0.0023	<0.010	0.0244	0.0052	0.0812
Antimony (Sb)-Dissolved (mg/L)	0.109	0.178	0.00098	0.0707	0.00404
Arsenic (As)-Dissolved (mg/L)	5.73	24.2	1.33	9.27	0.215
Barium (Ba)-Dissolved (mg/L)	0.0130	0.00361	0.158	0.0470	0.163
Beryllium (Be)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0010	<0.0025	<0.0025
Bismuth (Bi)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0010	<0.0025	<0.0025
Boron (B)-Dissolved (mg/L)	<0.020	<0.10	0.027	0.114	0.051
Cadmium (Cd)-Dissolved (mg/L)	0.000166	0.00089	0.000229	0.000546	<0.000085
Calcium (Ca)-Dissolved (mg/L)	115	76.0	129	185	293
Chromium (Cr)-Dissolved (mg/L)	<0.0010	<0.0050	<0.0070	<0.0025	<0.0070
Cobalt (Co)-Dissolved (mg/L)	0.00954	0.0896	0.00276	0.00208	0.0110
Copper (Cu)-Dissolved (mg/L)	<0.015	0.725	0.00075	0.00102	<0.00050
Iron (Fe)-Dissolved (mg/L)	0.160	0.496	8.10	1.03	66.4
Lead (Pb)-Dissolved (mg/L)	0.00077	0.00311	0.00023	0.00404	0.00044
Lithium (Li)-Dissolved (mg/L)	<0.010	<0.050	<0.010	<0.025	<0.025
Magnesium (Mg)-Dissolved (mg/L)	23.0	1.49	69.0	50.1	51.7
Manganese (Mn)-Dissolved (mg/L)	0.679	0.260	2.03	3.30	6.05
Molybdenum (Mo)-Dissolved (mg/L)	0.0151	0.0123	0.0246	0.0235	0.00121
Nickel (Ni)-Dissolved (mg/L)	0.0084	0.0367	0.0160	0.0133	0.0033
Phosphorus (P)-Dissolved (mg/L)	0.68	0.54	0.41	<0.30	<0.30
Potassium (K)-Dissolved (mg/L)	32.0	12.6	2.5	6.6	9.0
Selenium (Se)-Dissolved (mg/L)	0.00060	0.00259	0.00111	0.00065	<0.00050
Silicon (Si)-Dissolved (mg/L)	22.7	15.9	12.0	16.7	6.65
Silver (Ag)-Dissolved (mg/L)	0.000079	0.0285	0.000068	<0.000050	<0.000050
Sodium (Na)-Dissolved (mg/L)	36.8	106	39.1	40.1	81.9
Strontium (Sr)-Dissolved (mg/L)	0.731	0.233	0.582	0.633	1.03
Thallium (Tl)-Dissolved (mg/L)	<0.00020	<0.0010	<0.00020	<0.00050	<0.00050

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID: L815006-6 Description: Sampled Date: 03-SEP-09 Sampled Time: Client ID: MW09-2	L815006-7 03-SEP-09 MW09-3	L815006-8 03-SEP-09 MW09-4	L815006-9 03-SEP-09 MW09-6	L815006-10 03-SEP-09 MW09-23
WATER						
Physical Tests	Hardness (as CaCO3) (mg/L)	1440	1510	1480	1550	1070
Anions and Nutrients	Ammonia as N (mg/L)	14.0	10.7	14.7	1.96	9.27
	Bromide (Br) (mg/L)	<2.5	<1.0	<1.0	<1.0	<1.0
	Chloride (Cl) (mg/L)	<25	<10	<10	<10	<10
	Fluoride (F) (mg/L)	0.729	0.56	0.68	<0.40	<0.40
	Nitrate (as N) (mg/L)	<0.25	7.15	<0.10	<0.10	<0.10
	Nitrite (as N) (mg/L)	<0.050	1.14	<0.020	<0.020	<0.020
	Sulfate (SO4) (mg/L)	1690	1570	1610	1450	976
Cyanides	Cyanide, Weak Acid Diss (mg/L)	0.0281	0.0107	0.0239	<0.0050	0.0583
	Cyanide, Total (mg/L)	0.361	0.298	0.0425	<0.0050	0.0729
	Cyanate (CNO) (mg/L)	4.7	1.74	5.9	<0.50	3.0
	Thiocyanate (SCN) (mg/L)	3.11	1.10	1.21	0.71	5.86
Organic / Inorganic Carbon	Total Organic Carbon (mg/L)	6.23	8.80	5.16	6.05	18.1
Dissolved Metals	Aluminum (Al)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	0.0390
	Antimony (Sb)-Dissolved (mg/L)	0.0068	0.439	0.484	0.591	<0.00050
	Arsenic (As)-Dissolved (mg/L)	15.3	3.29	4.06	0.868	0.00912
	Barium (Ba)-Dissolved (mg/L)	0.0138	0.0523	0.00834	0.00564	0.0683
	Beryllium (Be)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0025
	Bismuth (Bi)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0025
	Boron (B)-Dissolved (mg/L)	<0.10	0.28	0.23	0.36	0.152
	Cadmium (Cd)-Dissolved (mg/L)	0.00019	0.00018	<0.00017	0.00827	0.000132
	Calcium (Ca)-Dissolved (mg/L)	488	493	489	548	353
	Chromium (Cr)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	<0.0050	<0.0025
	Cobalt (Co)-Dissolved (mg/L)	0.0122	0.0091	0.0051	0.0038	0.0170
	Copper (Cu)-Dissolved (mg/L)	<0.0010	0.0018	<0.0010	0.0045	<0.00050
	Iron (Fe)-Dissolved (mg/L)	9.46	0.126	<0.030	<0.030	5.55
	Lead (Pb)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	0.00087	<0.00025
	Lithium (Li)-Dissolved (mg/L)	<0.050	<0.050	<0.050	<0.050	<0.025
	Magnesium (Mg)-Dissolved (mg/L)	53.2	69.0	62.7	44.0	47.2
	Manganese (Mn)-Dissolved (mg/L)	23.7	0.761	3.32	14.0	6.88
	Molybdenum (Mo)-Dissolved (mg/L)	0.00974	0.0128	0.0105	0.00899	0.00252
	Nickel (Ni)-Dissolved (mg/L)	<0.0050	<0.0050	<0.0050	0.0059	<0.0025
	Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30	<0.30	<0.30
	Potassium (K)-Dissolved (mg/L)	51.8	31.0	44.0	11.4	15.6
	Selenium (Se)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
	Silicon (Si)-Dissolved (mg/L)	5.36	5.29	9.61	7.43	5.33
	Silver (Ag)-Dissolved (mg/L)	0.00014	0.00012	<0.00010	<0.00010	0.00128
	Sodium (Na)-Dissolved (mg/L)	123	72.7	55.9	28.4	80.9
	Strontium (Sr)-Dissolved (mg/L)	1.08	1.18	1.14	1.02	0.752
	Thallium (Tl)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample ID	L815006-11	L815006-12	L815006-13		
Description					
Sampled Date	03-SEP-09	03-SEP-09	03-SEP-09		
Sampled Time					
Client ID	MP09-5	MW09-200	TS		
Grouping / **Analyte**					
WATER					
Physical Tests Hardness (as CaCO3) (mg/L)	693	1470	1760		
Anions and Nutrients Ammonia as N (mg/L)	8.06	15.4	0.0197		
Bromide (Br) (mg/L)	<0.50	<1.0	<1.0		
Chloride (Cl) (mg/L)	6.6	<10	<10		
Fluoride (F) (mg/L)	<0.20	0.64	0.121		
Nitrate (as N) (mg/L)	5.70	<0.10	0.31		
Nitrite (as N) (mg/L)	0.119	<0.020	<0.020		
Sulfate (SO4) (mg/L)	530	1750	1750		
Cyanides Cyanide, Weak Acid Diss (mg/L)	0.0171	0.128			
Cyanide, Total (mg/L)	0.0219	0.857			
Cyanate (CNO) (mg/L)	3.42	<1.8			
Thiocyanate (SCN) (mg/L)	1.62	2.67	0.54		
Organic / Inorganic Carbon Total Organic Carbon (mg/L)	24.3	6.76			
Dissolved Metals Aluminum (Al)-Dissolved (mg/L)	0.0198	<0.010	<0.010		
Antimony (Sb)-Dissolved (mg/L)	<0.00050	0.0045	0.0500		
Arsenic (As)-Dissolved (mg/L)	0.00355	13.5	0.0026		
Barium (Ba)-Dissolved (mg/L)	0.0440	0.0142	0.0513		
Beryllium (Be)-Dissolved (mg/L)	<0.0025	<0.0050	<0.0050		
Bismuth (Bi)-Dissolved (mg/L)	<0.0025	<0.0050	<0.0050		
Boron (B)-Dissolved (mg/L)	0.071	<0.10	<0.10		
Cadmium (Cd)-Dissolved (mg/L)	0.00239	<0.00017	0.0114		
Calcium (Ca)-Dissolved (mg/L)	232	504	522		
Chromium (Cr)-Dissolved (mg/L)	<0.0025	<0.0050	<0.0050		
Cobalt (Co)-Dissolved (mg/L)	0.0211	0.0117	0.0296		
Copper (Cu)-Dissolved (mg/L)	0.0324	<0.0010	<0.0013		
Iron (Fe)-Dissolved (mg/L)	0.346	8.12	<0.030		
Lead (Pb)-Dissolved (mg/L)	<0.00025	<0.00050	<0.00050		
Lithium (Li)-Dissolved (mg/L)	<0.025	<0.050	<0.050		
Magnesium (Mg)-Dissolved (mg/L)	28.0	50.6	112		
Manganese (Mn)-Dissolved (mg/L)	9.04	20.0	5.62		
Molybdenum (Mo)-Dissolved (mg/L)	0.00034	0.0108	0.00053		
Nickel (Ni)-Dissolved (mg/L)	0.0097	<0.0050	0.0792		
Phosphorus (P)-Dissolved (mg/L)	<0.30	<0.30	<0.30		
Potassium (K)-Dissolved (mg/L)	7.4	49.6	8.5		
Selenium (Se)-Dissolved (mg/L)	<0.00050	<0.00050	<0.00050		
Silicon (Si)-Dissolved (mg/L)	5.07	4.88	6.26		
Silver (Ag)-Dissolved (mg/L)	<0.000050	<0.00010	<0.00010		
Sodium (Na)-Dissolved (mg/L)	79.0	158	6.4		
Strontium (Sr)-Dissolved (mg/L)	0.679	1.03	1.24		
Thallium (Tl)-Dissolved (mg/L)	<0.00050	<0.0010	<0.0010		

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID / Description / Sampled Date / Sampled Time / Client ID				
		L815006-1 02-SEP-09 MP09-09	L815006-2 02-SEP-09 MP09-10	L815006-3 02-SEP-09 MP09-11	L815006-4 02-SEP-09 MP09-12	L815006-5 03-SEP-09 MW09-1
WATER						
Dissolved Metals	Tin (Sn)-Dissolved (mg/L)	<0.00020	<0.0010	<0.00020	<0.00050	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00337	0.00077	0.000211	0.00384	0.00120
	Vanadium (V)-Dissolved (mg/L)	<0.0020	<0.010	0.0507	<0.0050	0.0125
	Zinc (Zn)-Dissolved (mg/L)	0.0044	0.033	0.0048	0.0380	0.0094

ALS LABORATORY GROUP ANALYTICAL REPORT

	Sample ID	L815006-6	L815006-7	L815006-8	L815006-9	L815006-10
	Description					
	Sampled Date	03-SEP-09	03-SEP-09	03-SEP-09	03-SEP-09	03-SEP-09
	Sampled Time					
	Client ID	MW09-2	MW09-3	MW09-4	MW09-6	MW09-23
Grouping	**Analyte**					
WATER						
Dissolved Metals	Tin (Sn)-Dissolved (mg/L)	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050
	Titanium (Ti)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.010
	Uranium (U)-Dissolved (mg/L)	0.00048	0.00513	0.00015	0.00309	0.00157
	Vanadium (V)-Dissolved (mg/L)	<0.010	<0.010	<0.010	<0.010	<0.0050
	Zinc (Zn)-Dissolved (mg/L)	0.462	<0.010	<0.010	0.121	<0.0050

ALS LABORATORY GROUP ANALYTICAL REPORT

Grouping	Analyte	Sample ID Description Sampled Date Sampled Time Client ID	L815006-11 03-SEP-09 MP09-5	L815006-12 03-SEP-09 MW09-200	L815006-13 03-SEP-09 TS		
WATER							
Dissolved Metals	Tin (Sn)-Dissolved (mg/L)		<0.00050	<0.0010	<0.0010		
	Titanium (Ti)-Dissolved (mg/L)		<0.010	<0.010	<0.010		
	Uranium (U)-Dissolved (mg/L)		0.00133	0.00042	0.00019		
	Vanadium (V)-Dissolved (mg/L)		<0.0050	<0.010	<0.010		
	Zinc (Zn)-Dissolved (mg/L)		0.0354	0.244	0.952		

Reference Information

Additional Comments for Sample Listed:

Samplenum	Matrix	Report Remarks	Sample Comments

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
ANIONS-BR-IC-VA	Water	Bromide by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-CL-IC-VA	Water	Chloride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-F-IC-VA	Water	Fluoride by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

ANIONS-NO2-IC-VA	Water	Nitrite by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrite detection is by UV absorbance and not conductivity.

ANIONS-NO3-IC-VA	Water	Nitrate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography". Specifically, the nitrate detection is by UV absorance and not conductivity.

ANIONS-SO4-IC-VA	Water	Sulfate by Ion Chromatography	APHA 4110 B.

This analysis is carried out using procedures adapted from APHA Method 4110 B. "Ion Chromatography with Chemical Suppression of Eluent Conductivity" and EPA Method 300.0 "Determination of Inorganic Anions by Ion Chromatography".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 "TOTAL ORGANIC CARBON (TOC)"

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CARBONS-TOC-VA	Water	Total organic carbon by combustion	APHA 5310 TOTAL ORGANIC CARBON (TOC)

This analysis is carried out using procedures adapted from APHA Method 5310 "Total Organic Carbon (TOC)".

CN-SCN-VA	Water	Thiocyanate by Colour	APHA 4500-CN "CYANIDE"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

CN-SCN-VA	Water	Thiocyanate by Colour	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide and weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method. Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode. Thiocyanate is determined by the ferric nitrate colourimetric method.

CN-T-L-MAC-HH-COL-VA	Water	Total Cyanide- Low Level by HH Distillat	APHA 4500-CN CYANIDE

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN "Cyanide"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-T-MID-HH-COL-VA	Water	Total Cyanide by HH Distillation	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Total or strong acid dissociable (SAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN "Cyanide"

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CN-WAD-MID-COL-VA	Water	Weak Acid Cyanide by Colorimetric	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Weak acid dissociable (WAD) cyanide are determined by sample distillation and analysis using the chloramine-T colourimetric method.

CNO-SIE-VA	Water	Cyanate by SIE	APHA 4500-CN Cyanide

This analysis is carried out using procedures adapted from APHA Method 4500-CN "Cyanide". Cyanate is determined by the cyanate hydrolysis method using an ammonia selective electrode.

F-SIE-VA	Water	Fluoride by SIE	APHA 4500-F "Fluoride"

This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.

F-SIE-VA	Water	Fluoride by SIE	APHA 4500-F Fluoride

This analysis is carried out using procedures adapted from APHA Method 4500-F "Fluoride". Fluoride is determined using a selective ion electrode. This method has a significant negative interference (i.e. results could be biased low) when Al3+ is present in the sample at a concentration greater than 2.5 mg/L.

HARDNESS-CALC-VA	Water	Hardness	APHA 2340B

Hardness is calculated from Calcium and Magnesium concentrations, and is expressed as calcium carbonate equivalents.

MET-DIS-ICP-VA	Water	Dissolved Metals in Water by ICPOES	EPA SW-846 3005A/6010B

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedure involves filtration (EPA Method 3005A) and analysis by inductively coupled plasma - optical emission spectrophotometry (EPA Method 6010B).

MET-DIS-LOW-MS-VA	Water	Dissolved Metals in Water by ICPMS(Low)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures involves preliminary sample treatment by filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

MET-DIS-ULTRA-MS-VA	Water	Diss. Metals in Water by ICPMS (Ultra)	EPA SW-846 3005A/6020A

This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Test Methods for Evaluating Solid Waste" SW-846 published by the United States Environmental Protection Agency (EPA). The procedures involves preliminary sample treatment by filtration (EPA Method 3005A). Instrumental analysis is by inductively coupled plasma - mass spectrometry (EPA Method 6020A).

NH3-COL-VA	Water	Ammonia by Colour	APHA 4500-NH3 "Nitrogen (Ammonia)"

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Analytical Method Reference(Based On)
		This analysis is carried out, on unpreserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using the phenate colourimetric method.	
NH3-COL-VA	Water	Ammonia by Colour	APHA 4500-NH3 Nitrogen (Ammonia)
		This analysis is carried out, on unpreserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using the phenate colourimetric method.	
NH3-SIE-VA	Water	Ammonia by SIE	APHA 4500 D. - NH3 NITROGEN (AMMONIA)
		This analysis is carried out, on sulphuric acid preserved samples, using procedures adapted from APHA Method 4500-NH3 "Nitrogen (Ammonia)". Ammonia is determined using an ammonia selective electrode.	
SE-D-HVAF-VA	Water	Dissolved Selenium in Water by HVAFS	APHA 3030B&E/ISO/CD 17378&9-1 2006:DRAFT
		This analysis is carried out using procedures adapted from "Standard Methods for the Examination of Water and Wastewater" published by the American Public Health Association, and with procedures adapted from "Water Quality - Determination of As/Se/Sb, Part 1 - Hydride Generation Atomic Fluorescence Spectrometry (HG-AFS)", by the International Organization for Standardization (ISO). The procedures may involve preliminary sample treatment by acid digestion, using hotblock, or filtration (APHA 3030B&E). Instrumental analysis is by atomic fluorescence spectrophotometry (ISO/CD 17378&9-1 2006: DRAFT).	

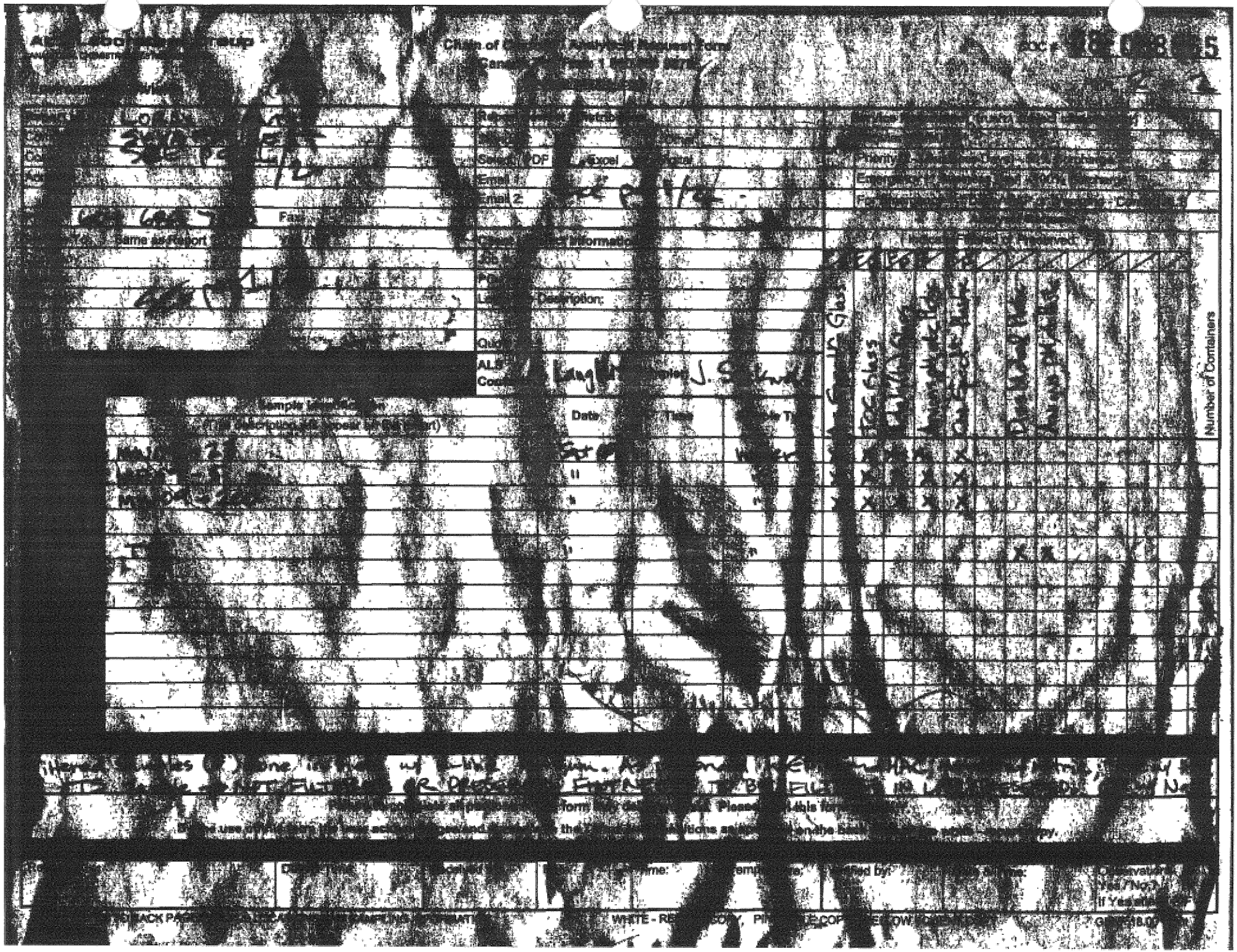
** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency.
mg/kg (units) - unit of concentration based on mass, parts per million
mg/L (units) - unit of concentration based on volume, parts per million
N/A - Result not available. Refer to qualifier code and definition for explanation

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.



AECOM

Appendix C

Groundwater Quality Analytical Results

AECOM

2009 Groundwater Quality Analytical Results

| | Groundwater Monitoring Wells | | |

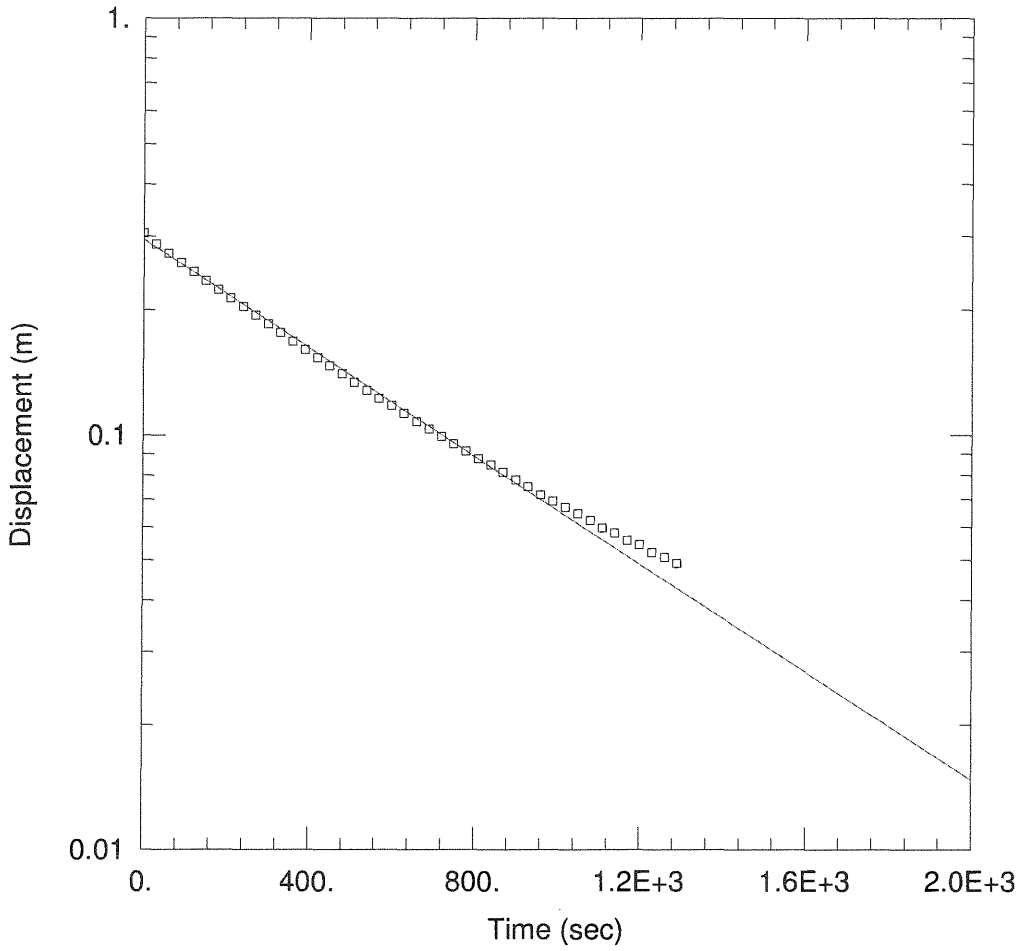
2009 Groundwater Quality Analytical Results

	roundwater Monitoring Wells				Mini-Piezometers										
Sample ID	MW09-23	MW09-24	MW09-24	MW09-26	MP09-04	MP09-05	MP09-5	MP09-09	MP09-09	MP09-10	MP09-10	MP09-11	MP09-11	MP09-12	MP09-12
Date Sampled	3-Sep-09	22-Jul-09	1-Sep-09	1-Sep-09	13-Jul-09	13-Jul-09	3-Sep-09	12-Jul-09	2-Sep-09	12-Jul-09	2-Sep-09	11-Jul-09	2-Sep-09	12-Jul-09	2-Sep-09
Time Sampled	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00	00:00
ALS Sample ID	L815006-10	L796873-6	L814853-13	L814853-14	L791918-1	L791918-2	L815006-11	L791918-11	L815006-1	L791918-9	L815006-2	L791918-7	L815006-3	L791918-8	L815006-4
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests															
Conductivity	-	564	378	666	-	-	-	-	-	-	-	-	-	-	-
Hardness (as $CaCO_3$)	1070	297	197	355	377	684	693	415	382	210	196	722	607	709	668
pH	-	7.75	7.69	7.85	-	-	-	-	-	-	-	-	-	-	-
Total Dissolved Solids	-	364	255	434	-	-	-	-	-	-	-	-	-	-	-
Anions and Nutrients															
Acidity (as $CaCO_3$)	-	7.5	5.9	9.1	-	-	-	-	-	-	-	-	-	-	-
Alkalinity, Total (as $CaCO_3$)	-	210	107	317	-	-	-	-	-	-	-	-	-	-	-
Ammonia as N	9.27	0.032	<0.020	2.43	0.843	8.17	8.06	9.6	8.5	2.94	2.65	1.7	1.6	1.92	1.98
Bromide (Br)	<1.0	<0.050	<0.050	0.05	<0.050	<0.50	<0.50	<0.050	<0.50	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50
Chloride (Cl)	<10	0.76	<0.50	4.96	<0.50	<5.0	6.6	1.96	6.5	1.6	<5.0	11.2	8.5	<5.0	6.3
Fluoride (F)	<0.40	<0.020	0.032	0.711	<0.020	<0.20	<0.20	0.568	0.64	1.5	1.67	0.197	0.218	<0.20	0.2
Nitrate (as N)	<0.10	2.2	2.52	0.544	9.55	15.2	5.7	<0.0050	<0.050	0.026	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrite (as N)	<0.020	0.0092	0.0016	0.0271	0.0264	0.028	0.119	<0.0010	<0.010	0.0019	<0.010	<0.010	<0.010	<0.010	<0.010
Sulfate (SO4)	976	86.6	81.7	51.4	297	634	530	136	179	263	237	<5.0	<5.0	79	59.9
Cyanides															
Cyanide, Weak Acid Diss	0.0583	<0.0050	<0.0050	<0.0050	<0.0050	0.0149	0.0171	<0.0050	0.0335	0.627	0.964	0.0124	0.0099	<0.0050	<0.0050
Cyanide, Total	0.0729	0.012	0.0119	0.0074	<0.0050	0.02	0.0219	<0.0050	0.125	2.69	2.96	0.0591	0.0747	0.0326	0.0387
Cyanate (CNO)	3	<0.50	<0.50	<0.50	<0.50	0.87	3.42	<0.50	<0.60	2.1	0.54	<0.50	0.54	<0.50	<0.50
Thiocyanate (SCN)	5.86	-	<0.50	1.04	0.5	1.11	1.62	1.6	1.96	3.39	3.2	4.3	4.46	2.37	2.89
Organic / Inorganic Carbon															
Total Organic Carbon	18.1	-	4.18	26.8	5.24	15.2	24.3	32	35.4	49.2	48.5	164	142	45.2	55.9
Dissolved Metals															
Aluminum (Al)-Dissolved	0.039	<0.0050	<0.0050	<0.0050	0.0037	0.015	0.0198	0.0045	0.0023	<0.0050	<0.010	0.0353	0.0244	0.0058	0.0052
Antimony (Sb)-Dissolved	<0.00050	<0.00050	<0.00050	<0.00050	0.00055	<0.00050	<0.00050	0.108	0.109	0.163	0.178	0.00148	0.00098	0.0653	0.0707
Arsenic (As)-Dissolved	0.00912	0.00117	0.00102	0.0235	0.00105	0.00132	0.00355	6.58	5.73	24.9	24.2	1.16	1.33	7.56	9.27
Barium (Ba)-Dissolved	0.0683	0.077	0.056	0.315	0.0435	0.0441	0.044	0.0137	0.013	0.00475	0.00361	0.139	0.158	0.053	0.047
Beryllium (Be)-Dissolved	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025	<0.0010	<0.0010	<0.0025	<0.0050	<0.0010	<0.0010	<0.0025	<0.0025
Bismuth (Bi)-Dissolved	<0.0025	<0.20	<0.20	<0.20	<0.0010	<0.0025	<0.0025	<0.0010	<0.0010	<0.0025	<0.0050	<0.0010	<0.0010	<0.0025	<0.0025
Boron (B)-Dissolved	0.152	<0.10	<0.10	<0.10	0.076	0.073	0.071	<0.020	<0.020	<0.050	<0.10	0.027	0.027	0.119	0.114
Cadmium (Cd)-Dissolved	0.000132	0.000055	0.000034	0.000035	0.0028	0.00227	0.00239	0.000134	0.000166	0.000489	0.00089	0.000458	0.000229	0.00091	0.000546
Calcium (Ca)-Dissolved	353	88.7	60.4	65.8	121	237	232	122	115	80.6	76	147	129	195	185
Chromium (Cr)-Dissolved	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.0025	<0.0025	<0.0010	<0.0010	<0.0025	<0.0050	<0.0080	<0.0070	<0.0035	<0.0025
Cobalt (Co)-Dissolved	0.017	0.00063	0.00063	0.00097	0.00153	0.0214	0.0211	0.00828	0.00954	0.0834	0.0896	0.0033	0.00276	0.00215	0.00208
Copper (Cu)-Dissolved	<0.00050	0.0085	0.0057	<0.0010	0.00513	0.0267	0.0324	0.0152	<0.015	0.732	0.725	0.00107	0.00075	0.00199	0.00102
Iron (Fe)-Dissolved	5.55	<0.030	<0.030	1.45	<0.030	<0.030	0.346	0.192	0.16	0.381	0.496	8.55	8.1	0.661	1.03
Lead (Pb)-Dissolved	<0.00025	<0.00050	<0.00050	<0.00050	<0.00010	<0.00025	<0.00025	0.00104	0.00077	0.00212	0.00311	0.00166	0.00023	0.00285	0.00404
Lithium (Li)-Dissolved	<0.025	<0.0050	<0.0050	<0.0050	<0.010	<0.025	<0.025	<0.010	<0.010	<0.025	<0.050	<0.010	<0.010	<0.025	<0.025
Magnesium (Mg)-Dissolved	47.2	18.4	11.3	46.4	18	22.5	28	26.7	23	2.05	1.49	86.3	69	53.7	50.1
Manganese (Mn)-Dissolved	6.88	0.0115	0.00267	1.38	5.25	8.6	9.04	0.81	0.679	0.349	0.26	2.67	2.03	3.83	3.3
Mercury (Hg)-Dissolved	-	<0.000020	<0.000020	<0.000020	-	-	-	-	-	-	-	-	-	-	-
Molybdenum (Mo)-Dissolved	0.00252	<0.0010	<0.0010	0.0078	0.00035	0.00049	0.00034	0.0148	0.0151	0.0139	0.0123	0.0223	0.0246	0.021	0.0235
Nickel (Ni)-Dissolved	<0.0025	<0.0010	<0.0010	0.0028	0.0064	0.0068	0.0097	0.0049	0.0084	0.0413	0.0367	0.0151	0.016	0.0127	0.0133
Phosphorus (P)-Dissolved	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.73	0.68	0.56	0.54	0.43	0.41	<0.30	<0.30
Potassium (K)-Dissolved	15.6	<2.0	<2.0	4.3	4.1	7.2	7.4	34.3	32	12.9	12.6	2.5	2.5	6.3	6.6
Selenium (Se)-Dissolved	<0.00050	<0.0010	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	0.00053	0.0006	0.00191	0.00259	0.00124	0.00111	<0.00050	0.00065
Silicon (Si)-Dissolved	5.33	5.74	5.62	6.06	9.19	3.94	5.07	22.8	22.7	16.2	15.9	13.5	12	16.1	16.7
Silver (Ag)-Dissolved	0.00128	<0.000020	<0.000020	<0.000020	<0.000020	<0.000050	<0.000050	0.000166	0.000079	0.0196	0.0285	0.000061	0.000068	<0.000050	<0.000050
Sodium (Na)-Dissolved	80.9	9.2	8.7	20.3	21.2	92.8	79	34.8	36.8	105	106	44.6	39.1	41.4	40.1
Strontium (Sr)-Dissolved	0.752	0.467	0.295	0.645	0.299	0.706	0.679	0.766	0.731	0.253	0.233	0.694	0.582	0.655	0.633
Thallium (Tl)-Dissolved	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00050	<0.00050	<0.00020	<0.00020	<0.00050	<0.0010	<0.00020	<0.00020	<0.00050	<0.00050
Tin (Sn)-Dissolved	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00050	<0.00050	<0.00020	<0.00020	<0.00050	<0.0010	<0.00020	<0.00020	<0.00050	<0.00050
Titanium (Ti)-Dissolved	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.014	<0.010	<0.010	<0.010
Uranium (U)-Dissolved	0.00157	0.00252	0.00058	0.00341	0.000252	0.00125	0.00133	0.00587	0.00337	0.00111	0.00077	0.000597	0.000211	0.0042	0.00384
Vanadium (V)-Dissolved	<0.0050	<0.0010	<0.0010	0.0017	<0.0020	<0.0050	<0.0050	<0.0020	<0.0020	<0.0050	<0.010	0.0716	0.0507	0.0053	<0.0050
Zinc (Zn)-Dissolved	<0.0050	<0.0050	<0.0050	<0.0050	0.011	0.0286	0.0354	0.0073	0.0044	0.0225	0.033	0.0158	0.0048	0.0451	0.038
Hydrocarbons															
EPH10-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
EPH19-32	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
LEPH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
HEPH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons															
Acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Acridine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(b)fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(g,h,i)perylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Benzo(k)fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Chrysene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Indeno(1,2,3-c,d)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2-Methylnaphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Naphthalene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Quinoline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d10-Acenaphthene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d9-Acridine (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d12-Chrysene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d8-Naphthalene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
d10-Phenanthrene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

All values are in mg/L unless otherwise stat

Appendix D

Permeability Testing Results



WELL TEST ANALYSIS

Data Set: Y:\...\MW09-02.aqt
Date: 12/03/09 Time: 12:45:56

PROJECT INFORMATION

Company: AECOM
Client: Mt. Nansen
Project: 112349

AQUIFER DATA

Saturated Thickness: 2.28 m Anisotropy Ratio (Kz/Kr): 1.

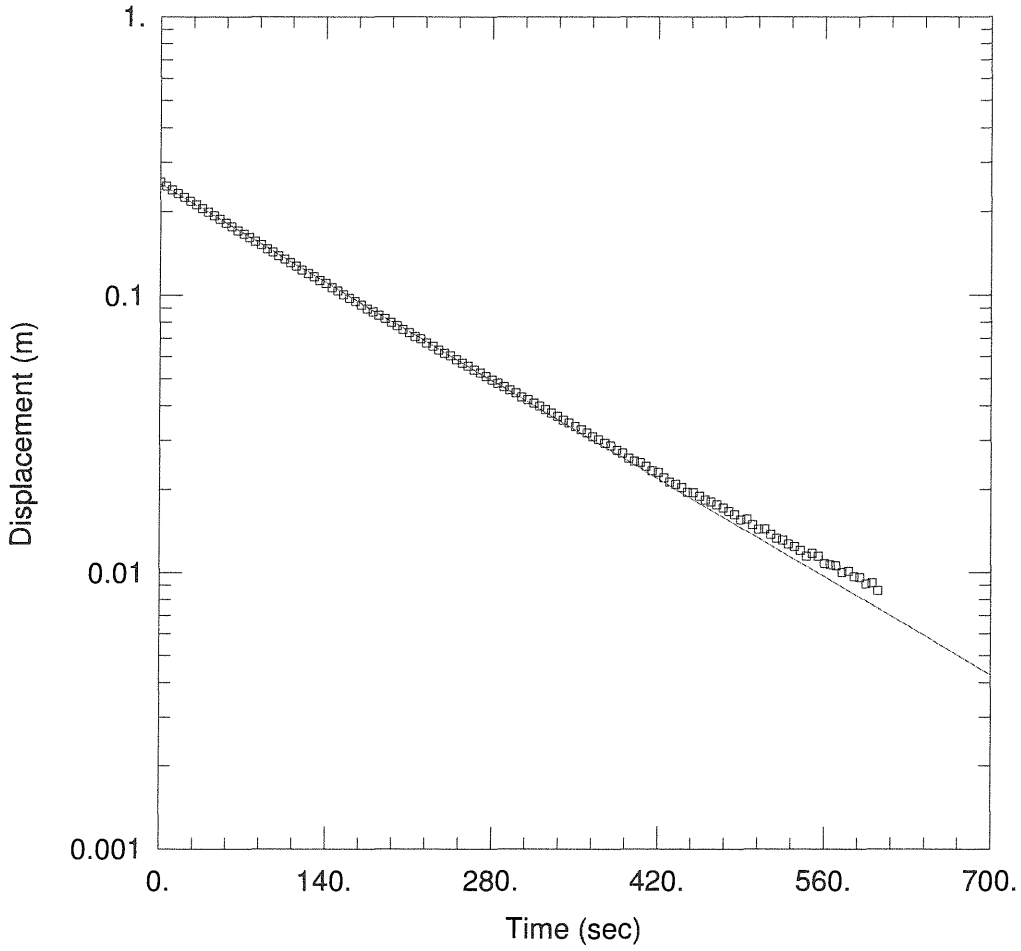
WELL DATA (MW09-02)

Initial Displacement: 0.3053 m
Total Well Penetration Depth: 2.284 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.28 m
Screen Length: 1.524 m
Well Radius: 0.03 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 1.035E-6 m/sec
y0 = 0.295 m



WELL TEST ANALYSIS

Data Set: Y:\...\MW09-03.aqt
Date: 12/03/09 Time: 12:48:21

PROJECT INFORMATION

Company: AECOM
Client: Mt. Nansen
Project: 112349

AQUIFER DATA

Saturated Thickness: 0.91 m Anisotropy Ratio (Kz/Kr): 1.

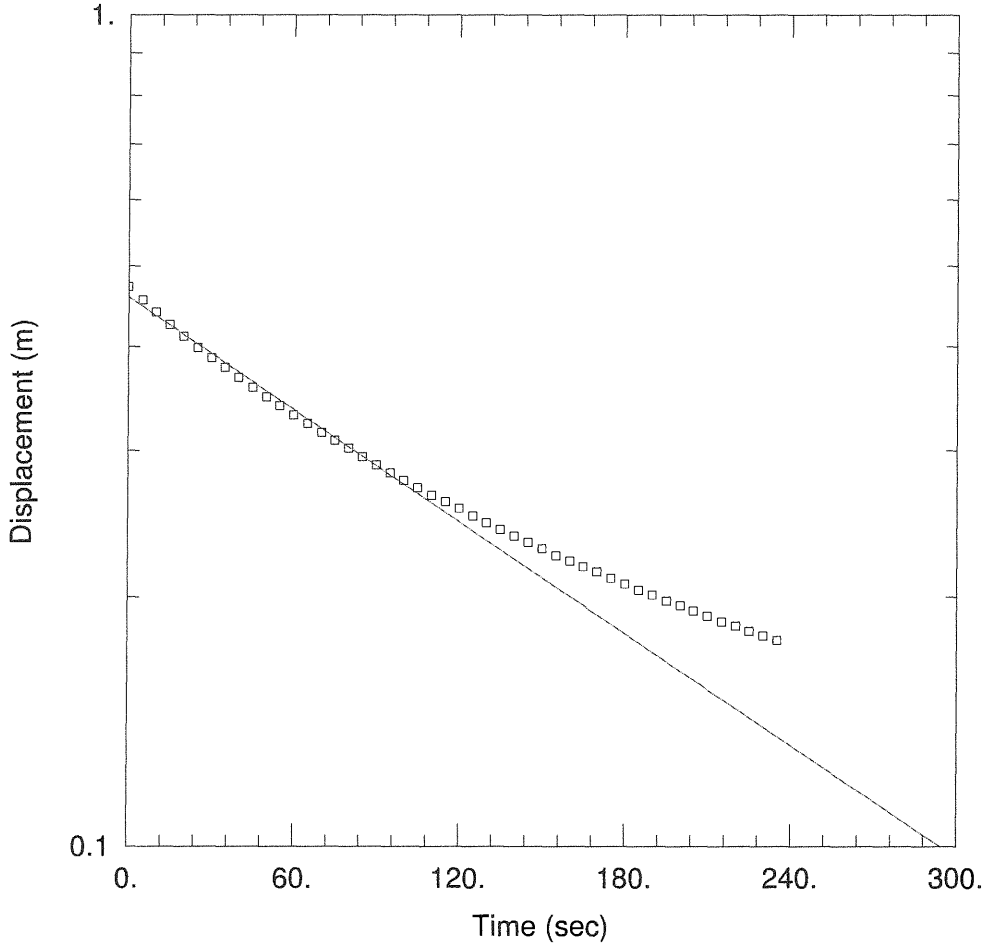
WELL DATA (MW09-03)

Initial Displacement: 0.255 m
Total Well Penetration Depth: 1.067 m
Casing Radius: 0.0254 m
Static Water Column Height: 0.91 m
Screen Length: 1.067 m
Well Radius: 0.03 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 5.525E-6 m/sec
y0 = 0.251 m



WELL TEST ANALYSIS

Data Set: Y:\...\MW09-06.aqt
Date: 12/03/09 Time: 12:48:32

PROJECT INFORMATION

Company: AECOM
Client: Mt. Nansen
Project: 112349

AQUIFER DATA

Saturated Thickness: 2.91 m Anisotropy Ratio (Kz/Kr): 1.

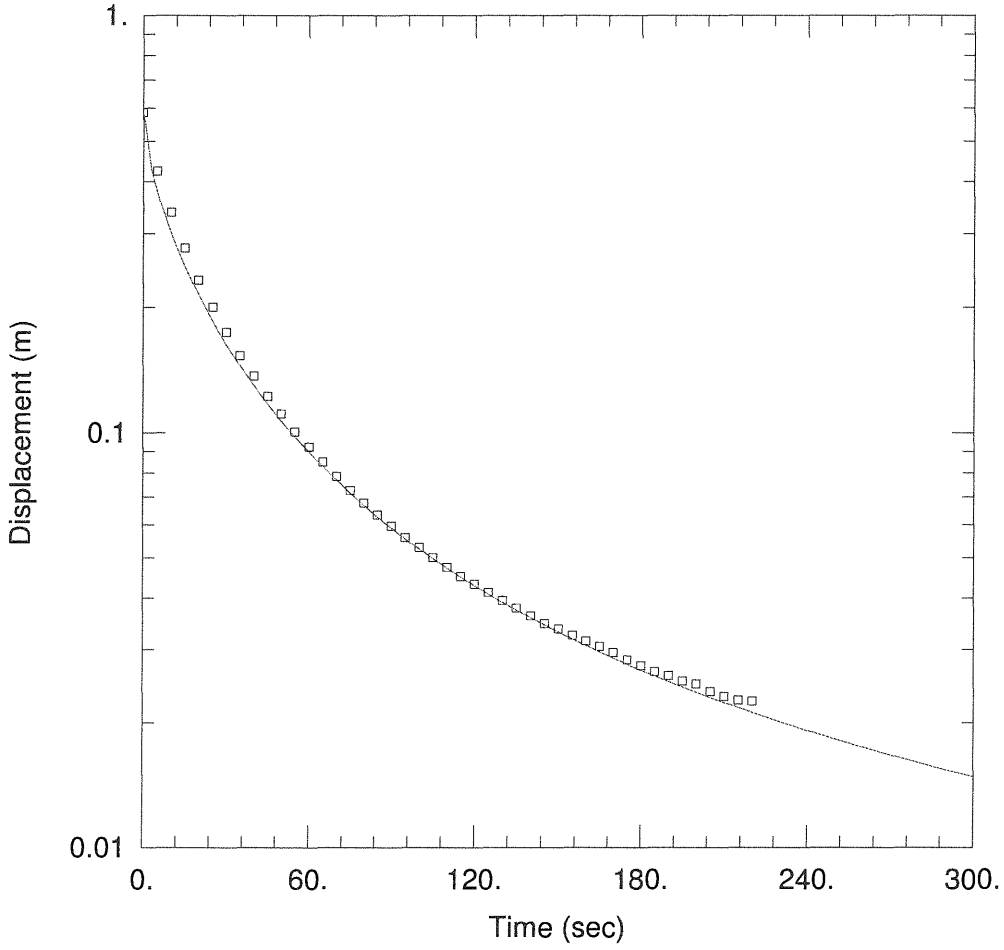
WELL DATA (MW09-06)

Initial Displacement: 0.4723 m
Total Well Penetration Depth: 3.048 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.91 m
Screen Length: 3.048 m
Well Radius: 0.03 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice

K = 2.039E-6 m/sec
y0 = 0.4589 m



WELL TEST ANALYSIS

Data Set: Y:\...\MW09-15_Fracture.aqt
Date: 12/03/09 Time: 12:48:57

PROJECT INFORMATION

Company: AECOM
Client: Mt. Nansen
Project: 112349

AQUIFER DATA

Saturated Thickness: 21.17 m Anisotropy Ratio (Kz/Kr): 1.

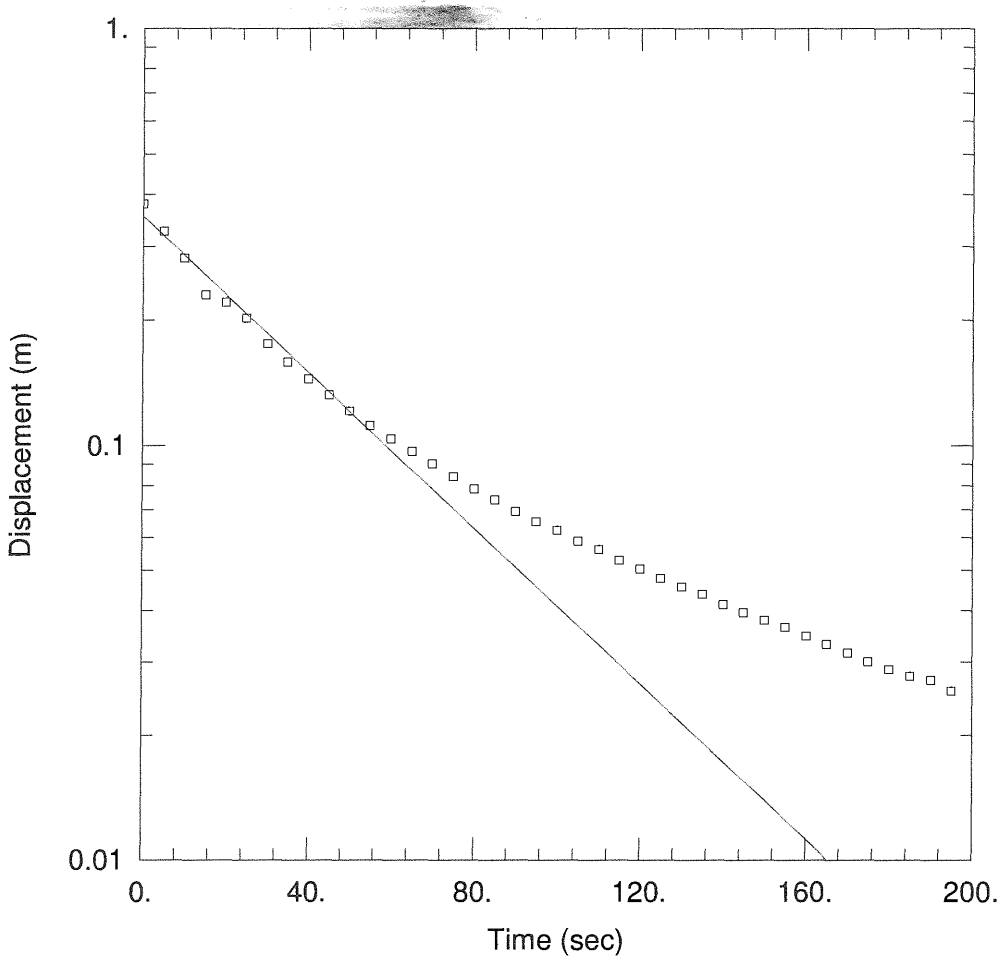
WELL DATA (MW09-15)

Initial Displacement: 0.5858 m
Total Well Penetration Depth: 21.17 m
Casing Radius: 0.0254 m
Static Water Column Height: 21.17 m
Screen Length: 3.048 m
Well Radius: 0.04604 m

SOLUTION

Aquifer Model: Fractured
Solution Method: Barker-Black

T = 2.538E-5 m^2/sec
K' = 1.0E-9 m/sec
S = 0.03
Ss' = 1.0E-6 m^{-1}



WELL TEST ANALYSIS

Data Set: Y:\...\MW09-23.aqt
Date: 12/03/09 Time: 12:49:14

PROJECT INFORMATION

Company: AECOM
Client: Mt. Nansen
Project: 112349

AQUIFER DATA

Saturated Thickness: 2.46 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW09-23)

Initial Displacement: 0.3799 m
Total Well Penetration Depth: 2.46 m
Casing Radius: 0.0254 m
Static Water Column Height: 2.46 m
Screen Length: 1.52 m
Well Radius: 0.05398 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 1.287E-5 m/sec
y0 = 0.3551 m

AECOM

Appendix E

Open Pit Geological Considerations Memo

MEMORANDUM

August 21, 2009

To: Diane Lister

From: Robert Stroshein

Re: Geological Considerations at the Brown-McDade Open Pit

The Brown-McDade open pit mine occurs in a major structurally weak zone that began with the emplacement of the felsic dykes that host the mineralization. There have been multiple episodes of faulting since the emplacement of the deposit. The geology of the pit area is controlled by the structural weakness of the generally northwest trending zone.

The host rocks are a layered metamorphic sequence (LMS) in fault or intrusive contact with Cretaceous (?) aged hornblende diorite to hornblende granodiorite. The LMS is composed of metamorphosed sedimentary, volcanic and igneous rocks. The LMS appears to dip to the northat a shallow dip angle. The intrusive suite is coeval with the Mount Nansen volcanic rocks in the area. The mineralization is a late stage event related to hypabyssal rocks (felsic dykes) of the plutonic suite.

The region was unglaciated during the last period of continental glaciation and therefore the rocks a deeply weathered especially the faulted and altered sequences. The deep end of the pit was mined to the depth of weathering. There was increasing sulphide mineralization at depth in the pit. The sulphide mineralization consisted of primairily pyrite with fine grained sphalerite (Zn) and galena (Pb).

Lithologies

The lithological contacts are generally fault or intrusive related. Along the east wall of the pit diorite to granodiorite intrusive rocks are in fault contact with the metamorphic rocks that dominate the west side of the pit. There are locally thin veneers and slices of fault bounded altered and mineralized rock on the east pit wall.

The central portion of the pit is the mined out ore zone that was intensely altered and weathered. Approximately one fourth to one third of the mined material was milled and with the tailings going to the pond the remainder of the removed material was stacked in the waste piles around the pit. The oxidized and sulphide ore material was hosted by clay altered felsic dykes that have been deformed by multiple stage faulting. At the north end the breccia body has been mined below the weathered and oxidized ore and sulphides (pyrite) are exposed in the pit at and below the water level. There are local patches of interstially weathered pyrite mineralization that exhibit a white oxide coating at surface (possibly hydrozincite). Several selvages and veneers of altered and mineralized rock were left in the pit wall above the water level. There are no visible sulphides in these zones but locally also exhibit the white oxide coating.

The west side of the pit is predominantly metamorphic rocks with fault bounded blocks of ganodiorite and felsic dyke material. The dykes tend to be unaltered but locally thin segments contain mineralization. The southern half the pit wall is composed of primarily sedimentary metamorphic rocks (LMS a) with older intrusive rocks that form gneiss and schist. The northern half of the pit wall is predominantly thick bedded, white to tan weathered metamorphic

sandstones (LMS b) that form resistant quartzite. Near the north end of the pit a unit of calcareous quartzite (metamorphosed sandstone) is exposed in the pit wall.

The north end of the pit is made of light weathering grey quartzite overlain by highly weathered metamorphic rocks (unit LMS c) of gneiss and schist.

There is limited rock exposure north of the pit in the Pony Creek drainage. On the northeast side of the creek there are hornblende granodiorite rocks exposed in old exploration trenches. Within the drainage area a number of exploration diamond drill holes have been located. Examination of some of the drill holes and log records indicate the metamorphic units in fault contact with granodiorite and hornblende granodiorite. Multiple fault/shear zones occur within the drilled sequence. The fault zones are commonly coarse granular host rock to sandy with some clay content. The zones range from less than one meter to intervals of five meters and larger zones with multiple faults. The material is strongly weathered and appears to be porous and permeable. The fault zones cut all the rock units including the granodiorite.

Structural Geology

A number of fault surfaces were observed in the open pit. There are two dominant orientations to the faulting and cross cutting relationships suggest that the faulting occurred as separate episodes after the mineralization was deposited.

The most prominently defined faulting trends northwest and contains the deposit within a graben like structure. The two defining faults are exposed in the pit. The footwall (FW) fault juxtaposes unaltered granodiorite/hornblend diorite with the strongly altered rocks enclosing the mineralized zone. The hanging wall (HW) fault occurs within the altered rocks on the west side pit wall face. The FW fault dips steeply west and the HW fault dips steeply east. Slickensides on the fault surfaces indicate vertical and lateral movement along the faults. The structure defines the predominant northwest trending zone of alteration and structural weakness.

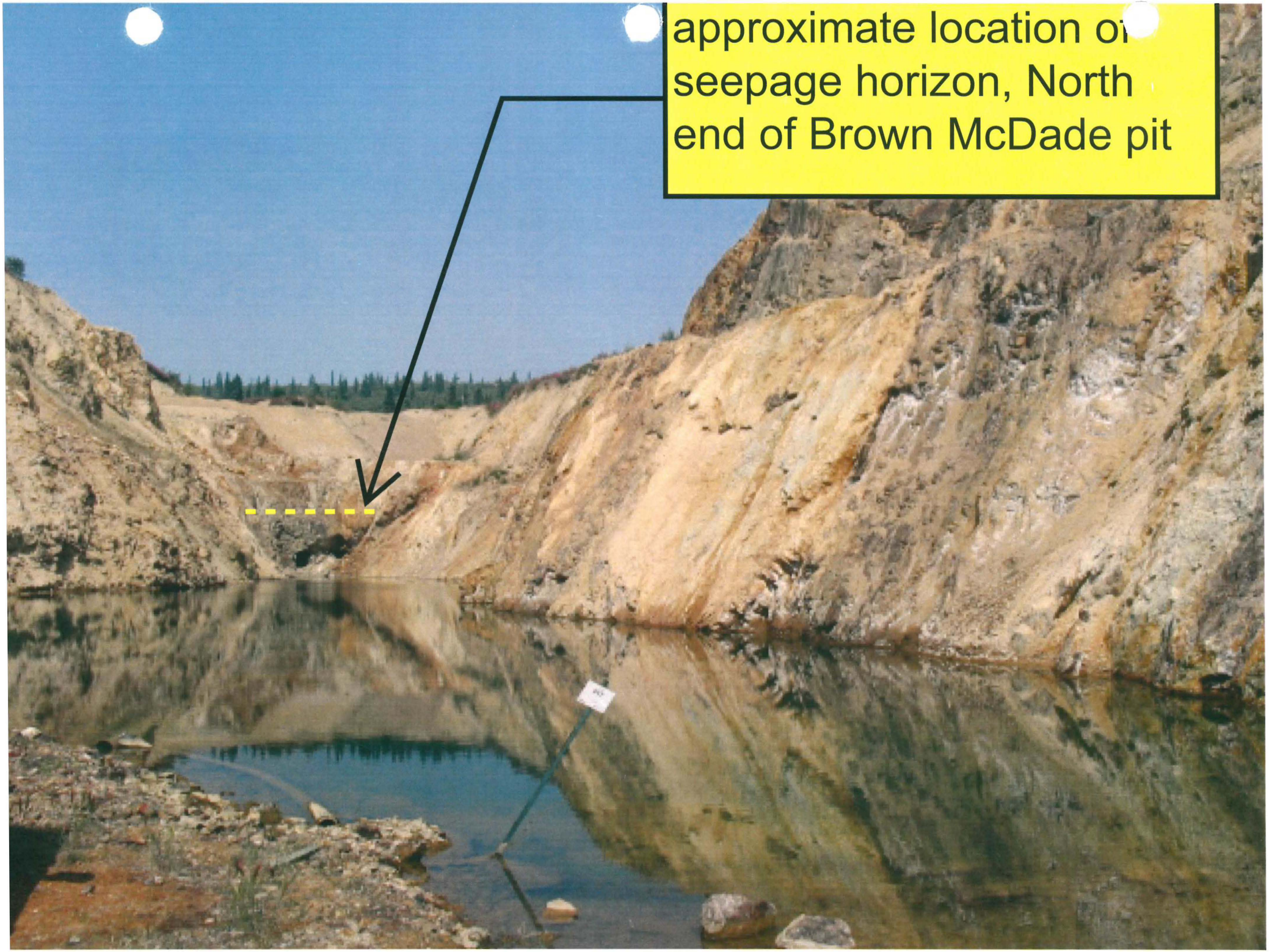
The second set of dominant faulting trends northerly and displace the northwest trending FW and HW faults. Movement along the northerly trending faults is vertical with very little lateral movement as indicated by slickensides on exposed faults. The northerly trending faults dip moderately east forming a series of steps. Drill hole intersections at the northern end of the open pit indicate a swarm of these faults cross cutting all rock types.

Summary

The Brown-McDade open pit is located and bounded by a major structural zone. The pit and the structural zone trend northwesterly. The structural zone intersects the Pony Creek drainage between 100 and 200 meters north of the pit. The structural zone is composed of multiple fault sets that intersect at acute angles. The fault zones have variable widths up to five (5) meters observed in drill hole intersections and are composed of coarse to fine granular material and clay. The intersecting faults create a network of porous and permeable channels.

The south end of the pit is poorly exposed but the structure appears to narrow and is at a higher elevation than the north end of the pit.

The quartzite unit (LMS b) is a resistant bed that does not weather readily and although it is no doubt faulted the lack of weathering the unit has a damming effect on the ground water flow. This has been observed at the north end of the pit where water cascades over the resistant quartzite beds. Photo


approximate location of
seepage horizon, North
end of Brown McDade pit

Appendix F

Physical Soil Testing Analytical Results

PARTICLE-SIZE ANALYSIS REPORT

(Test Reference: ASTM D 422)

Sieve Analysis	Sieve	Diameter (mm)	% Finer
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	100
	# 10	2.00	100
	# 20	0.850	100
	# 40	0.425	100
	# 60	0.250	100
	# 100	0.150	100
	# 200	0.075	100
Hydrometer Analysis		0.0524	93.2
		0.0382	87.0
Dispersing agent:		0.0277	81.6
Sodium Hexametaphosphate		0.0201	75.8
		0.0148	66.6
Dosage of dispersing agent:		0.0109	63.0
40 g/L		0.0078	55.5
		0.0057	51.5
		0.0040	42.8
		0.0030	37.0
		0.0021	29.8
		0.0013	20.7

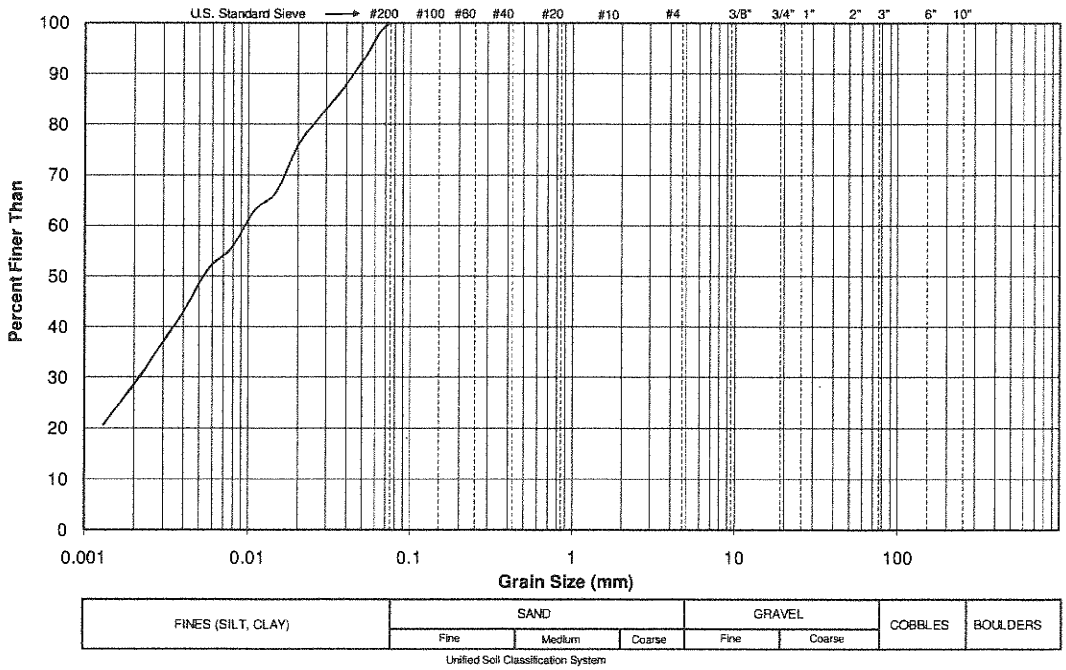
MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No:	L1950
SAMPLE:	MW09-01
DATE:	11-Sep-09

PARTICLE SIZE DISTRIBUTION SUMMARY

% GRAVEL	
% SAND	
% FINES (SILT, CLAY)	100

COMMENTS:



The testing services reported here have been performed in accordance with accepted local industry standards.

The results presented are for the sole use of the designated client only.

This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.

Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

PARTICLE-SIZE ANALYSIS REPORT

(Test Reference: ASTM D 422)

Sieve Analysis	Sieve	Diameter (mm)	% Finer
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	100
	# 10	2.00	100
	# 20	0.850	100
	# 40	0.425	100
	# 60	0.250	100
	# 100	0.150	93
	# 200	0.075	58
Hydrometer Analysis		0.0640	45.9
		0.0478	29.3
Dispersing agent:		0.0347	20.6
Sodium Hexametaphosphate		0.0251	13.2
		0.0179	9.2
Dosage of dispersing agent:		0.0106	7.7
40 g/L		0.0083	6.1
		0.0068	5.5
		0.0048	4.9
		0.0034	4.4
		0.0024	3.4
		0.0013	2.4

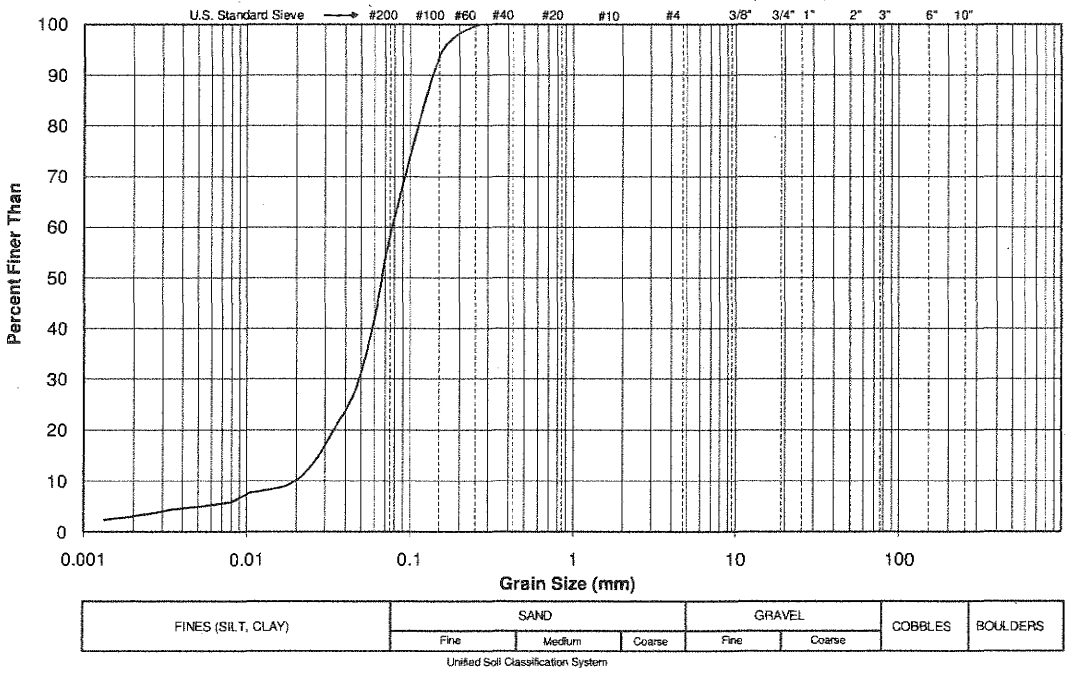
MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No:	L1950
SAMPLE:	MW09-02
DATE:	11-Sep-09

PARTICLE SIZE DISTRIBUTION SUMMARY

% GRAVEL	
% SAND	42
% FINES (SILT, CLAY)	58

COMMENTS:



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PARTICLE-SIZE ANALYSIS REPORT

(Test Reference: ASTM D 422)

Sieve Analysis	Sieve	Diameter (mm)	% Finer
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	98
	# 4	4.75	97
	# 10	2.00	96
	# 20	0.850	93
	# 40	0.425	78
	# 60	0.250	54
	# 100	0.150	30
	# 200	0.075	5

Hydrometer Analysis		
	0.0727	4.3
	0.0515	3.3
Dispersing agent:	0.0365	3.1
Sodium Hexametaphosphate	0.0258	2.6
	0.0183	2.4
Dosage of dispersing agent:	0.0134	1.3
40 g/L	0.0095	1.1
	0.0067	0.1

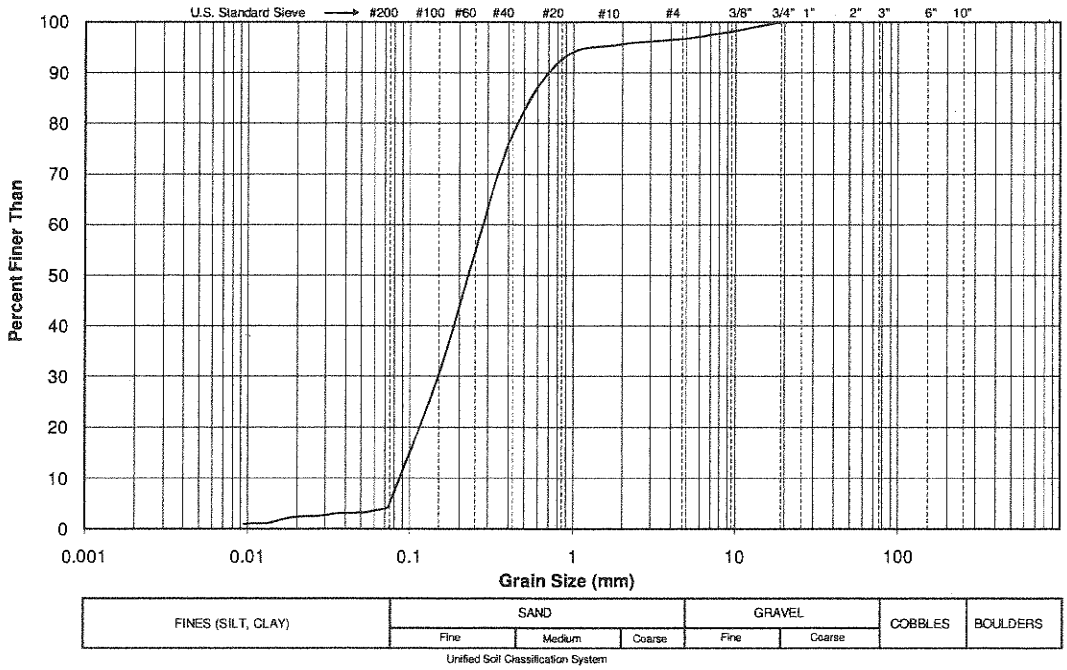
MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No:	L1950
SAMPLE:	MW09-03
DATE:	11-Sep-09

PARTICLE SIZE DISTRIBUTION SUMMARY

% GRAVEL	3
% SAND	92
% FINES (SILT, CLAY)	5

COMMENTS:



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Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

PARTICLE-SIZE ANALYSIS REPORT

(Test Reference: ASTM D 422)

Sieve Analysis	Sieve	Diameter (mm)	% Finer
	3"	76.2	100
	2"	50.8	100
	1"	25.4	100
	3/4"	19.1	100
	3/8"	9.5	100
	# 4	4.75	100
	# 10	2.00	100
	# 20	0.850	100
	# 40	0.425	95
	# 60	0.250	86
	# 100	0.150	69
	# 200	0.075	15

Hydrometer Analysis		
	0.0714	10.7
	0.0515	3.4
Dispersing agent:	0.0365	2.2
Sodium Hexametaphosphate	0.0259	1.6
	0.0183	1.4
Dosage of dispersing agent:	0.0134	1.3
40 g/L	0.0095	1.1
	0.0067	0.7
	0.0067	0.4
	0.0067	0.0

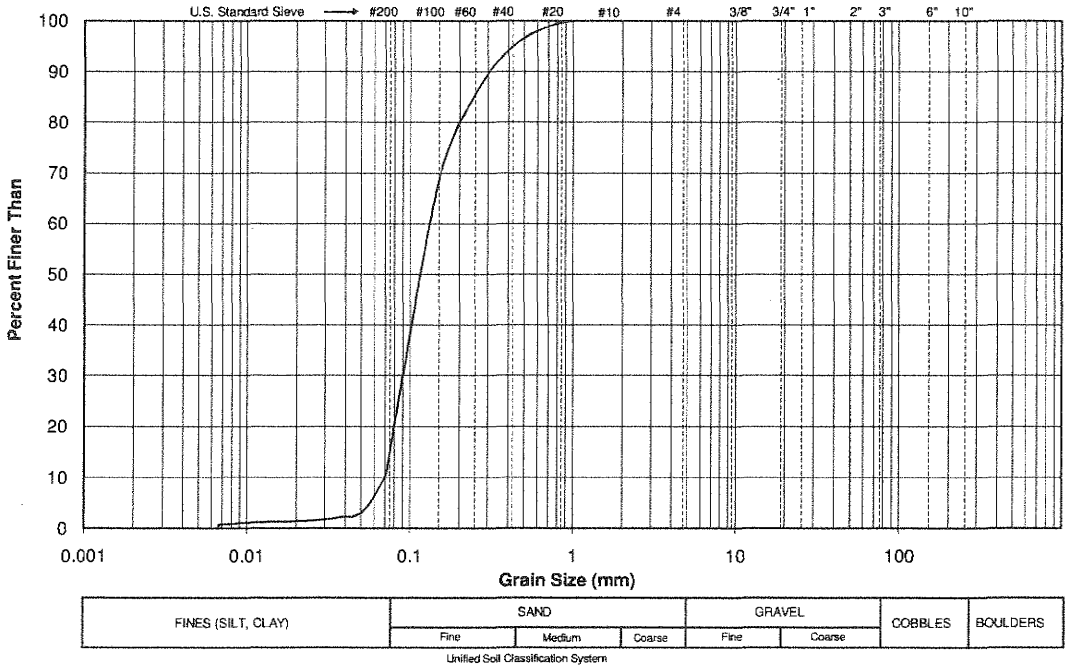
MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No:	L1950
SAMPLE:	MW09-11
DATE:	11-Sep-09

PARTICLE SIZE DISTRIBUTION SUMMARY

% GRAVEL	
% SAND	85
% FINES (SILT, CLAY)	15

COMMENTS:



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Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

MDH ENGINEERED SOLUTIONS

SPECIFIC GRAVITY TEST (FINE MATERIAL)

Project: AECOM, Vancouver
L1950

Technician: CEO Date: Aug 24/09

Sample: MW 09-01

PYCNOMETER DATA:

Pycnometer #: C2A
Mass of pycnometer empty & dry (g): 179.76
Mass of pycnometer with water (g): 678.63
Temperature (°C): 20.8

PRE-TEST SAMPLE INFORMATION:

Water Content (wet sample):
Tare #:
Tare Mass (g):
Wet sample + tare (g):
Dry sample + tare (g):
Water Content (%):

Wet weight (g):
Calc. Dry Weight (g): 49.84

POST-TEST INFORMATION:

Mass of pycnometer, water, & sample (g): 709.52
Temperature (°C): 21.8
Mass of dry sample (g): 49.84

Specific gravity: 2.64

Comments:

MDH ENGINEERED SOLUTIONS

SPECIFIC GRAVITY TEST (FINE MATERIAL)

Project: AECOM, Vancouver
L1950

Technician: CEO Date: Aug 24/09

Sample: MW 09-02

PYCNOMETER DATA:

Pycnometer #: C8A
Mass of pycnometer empty & dry (g): 186.78
Mass of pycnometer with water (g): 685.15
Temperature (°C): 21.1

PRE-TEST SAMPLE INFORMATION:

Water Content (wet sample):
Tare #:
Tare Mass (g):
Wet sample + tare (g):
Dry sample + tare (g):
Water Content (%):

Wet weight (g):
Calc. Dry Weight (g): 49.92

POST-TEST INFORMATION:

Mass of pycnometer, water, & sample (g): 716.71
Temperature (°C): 21.8
Mass of dry sample (g): 49.92

Specific gravity: 2.73

Comments:

WATER CONTENT/ BULK DENSITY/TOTAL ORGANIC CARBON - REPORT

MDH ENGINEERED SOLUTIONS

Client: AECOM, Vancouver
Project: -
MDH Project No: L1950
Date: 19-Aug-09

Water Content						
Sample #	MW 09-01	MW 09-02				
Tare #	DN3	M3				
Tare Mass (g)	106.59	99.29				
Wet sample + tare (g)	541.16	562.56				
Dry sample + tare (g)	393.76	462.97				
Wt. Dry sample (g)	287.17	363.68				
Water Content (%)	51.3	27.4				
Bulk Density						
Sample #						
Mass of sample in air (g):						
Mass of sample + wax in air (g):						
Mass of sample + wax in water (g):						
Wet density (kg/m^3):						
Dry density (kg/m^3):						
Specific gravity of solids						
Total porosity						
Air-filled porosity						
Degree of saturation						
Total Organic Carbon - Inorg & Total C (%)						
Sample #						
Inorganic Carbon						
Total Organic Carbon						
$CaCO_3$ Equivalent						
Total Carbon by Combustion						

Comments:

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Soil-Water Characteristic Curve Test Report

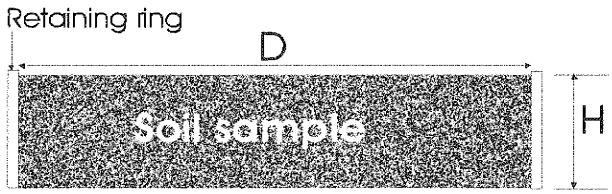
(reference standards: ASTM D6836-02)

MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No.	L1950
DATE:	Sept. 24, 2009

Soil Identification/Sample Description:	MW 09-01
Water used in test:	de-aired water
Method of saturation:	saturation chamber

Test sample data: Initial wet density = 1.675 g/cc
Initial water content = 51.0%



Specimen dimensions

H = 31.00 mm

D = 72.70 mm

Method A - Hanging column test

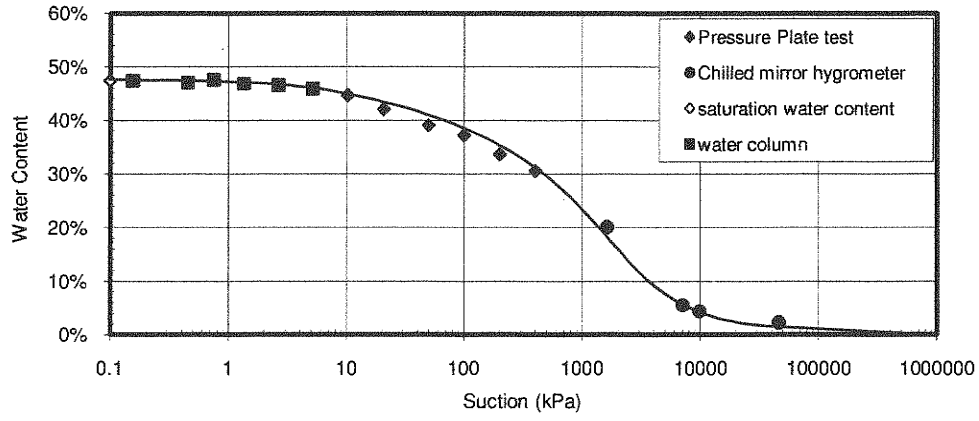
water elevation from (cm) top	water elevation from (cm) base	average suction, kPa	Gravimetric water content, %
3	0.0	0.2	47.4%
6	3.0	0.5	47.1%
9	6.0	0.8	47.7%
15	12.0	1.4	46.9%
28	25.0	2.7	46.6%
53	50.0	5.2	45.9%

Pressure Plate Test

Method	Extraction pressure, kPa	Gravimetric water content, %
C	10	44.6%
C	21	42.0%
C	50	39.0%
C	100	37.2%
C	200	33.6%
C	400	30.6%

Chilled Mirror Hygrometer Test

Method	measured suction, kPa	Gravimetric water content, %
D	1620	20.1%
D	7040	5.5%
D	9810	4.3%
D	45750	2.2%



Soil-Water Characteristic Curve Test Report

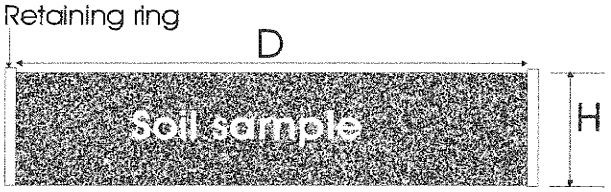
(reference standards: ASTM D6836-02)

MDH ENGINEERED SOLUTIONS

CLIENT:	AECOM, Vancouver
PROJECT:	-
MDH Job No.	L1950
DATE:	Sept. 24, 2009

Soil Identification/Sample Description: MW 09-02
Water used in test: de-aired water
Method of saturation: saturation chamber

Test sample data: Initial wet density = 1.621 g/cc
Initial water content = 27.7%



Specimen dimensions

H = 47.00 mm

D = 72.70 mm

Method A - Hanging column test

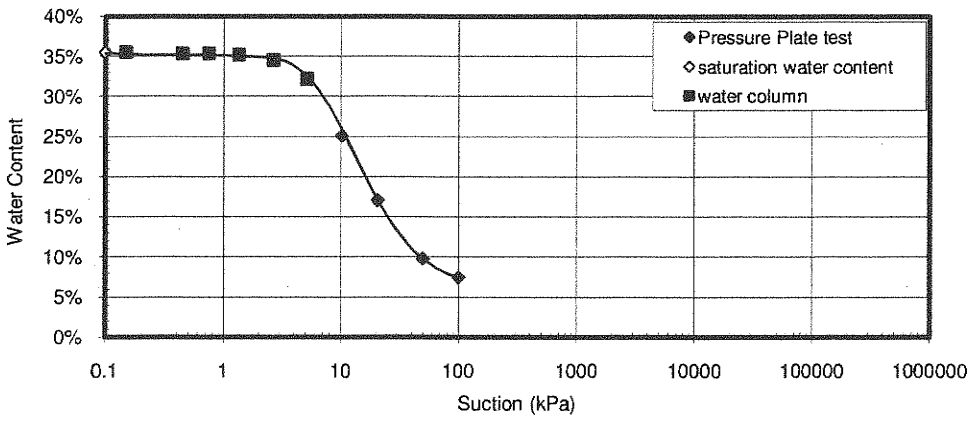
water elevation from (cm) top	water elevation from (cm) base	average suction, kPa	Gravimetric water content, %
3	0.0	0.2	35.5%
6	3.0	0.5	35.4%
9	6.0	0.8	35.3%
15	12.0	1.4	35.2%
28	25.0	2.7	34.5%
53	50.0	5.2	32.2%

Pressure Plate Test (101mm diameter cell)

Method	Extraction pressure, kPa	Gravimetric water content, %
C	10	25.1%
C	21	17.1%
C	50	9.8%
C	100	7.5%

Chilled Mirror Hygrometer Test

Method	measured suction, kPa	Gravimetric water content, %



ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

MDH ENGINEERED SOLUTIONS

Client:	AECOM, Vancouver
Project	-
MDH Job No:	L1950
Technician:	CEO
Date:	21-Sep-2009

Sample: MW 09-01 (air-dried)

Percentage of sample retained on 425-um (No. 40) sieve: NA

Plastic Limit

Tare #	46A	69A	
Tare Wt, g	14.17	14.37	
Wet + Tare, g	18.56	19.35	
Dry + Tare, g	17.53	18.17	average
M%	30.7%	31.1%	30.9%

Liquid Limit (method A)

# of Blows	19	25	49
Tare #	15A	65A	9A
Tare Wt, g	14.57	14.33	14.28
Wet + tare, g	19.16	18.50	18.17
Dry + tare, g	17.55	17.07	16.90
Water content	54.0%	52.2%	48.5%

SUMMARY

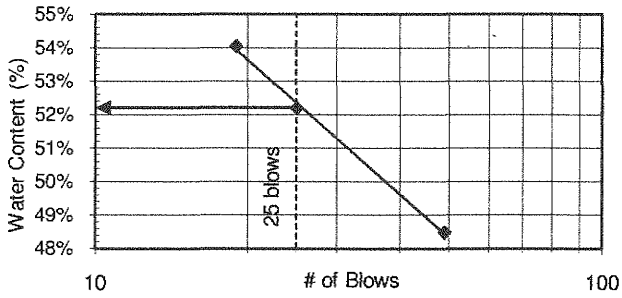
Plastic Limit: 30.9%

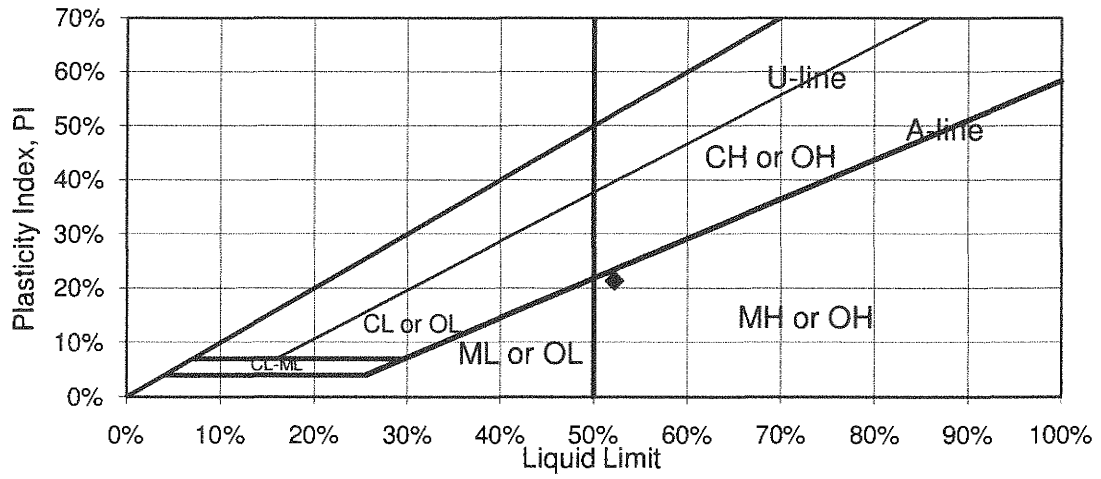
Liquid Limit: 52.2%

Plasticity Index: 21.4%

Classification: MH

Natural Water Content: 51.0%





Comments: -

The testing services reported here have been performed in accordance with accepted local industry standards.

The results presented are for the sole use of the designated client only.

This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.

Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

ATTERBERG LIMITS TEST REPORT

(Test Reference: ASTM D 4318)

MDH ENGINEERED SOLUTIONS

Client:	AECOM, Vancouver
Project	-
MDH Job No:	L1950
Technician:	BC
Date:	11-Sep-2009

Sample: MW 09-02 (air-dried)

Percentage of sample retained on 425-um (No. 40) sieve: NA

Plastic Limit

Tare #	-	-	
Tare Wt, g	-	-	
Wet + Tare, g	-	-	
Dry + Tare, g	-	-	average
M%	-	-	-

Liquid Limit (method A)

# of Blows	-	-	-
Tare #	-	-	-
Tare Wt, g	-	-	-
Wet + tare, g	-	-	-
Dry + tare, g	-	-	-
Water content	-	-	-

SUMMARY

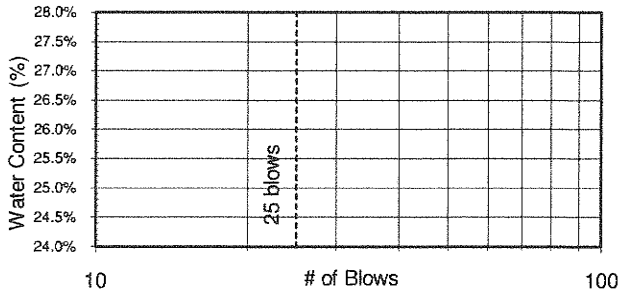
Plastic Limit: -

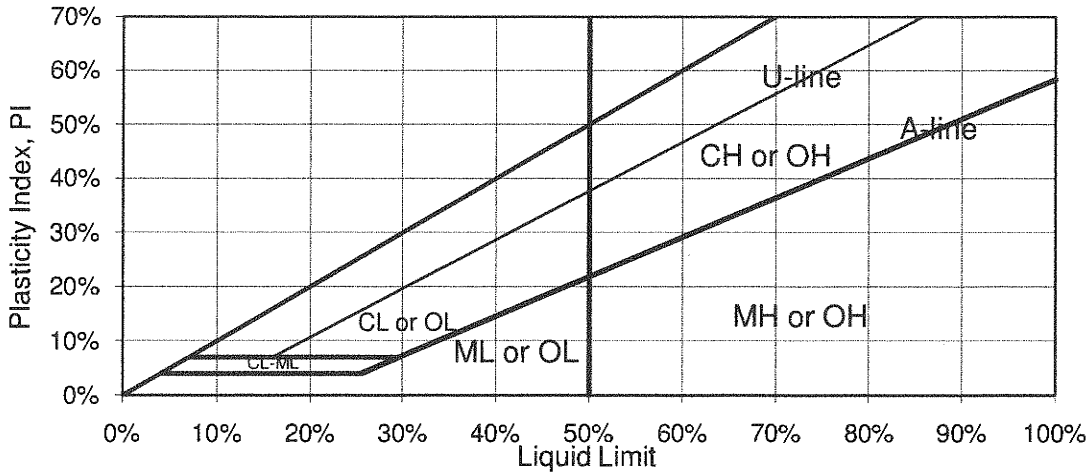
Liquid Limit: -

Plasticity Index: -

Classification: **Non Plastic**

Natural Water Content: n/a





Comments: **Material cannot be rolled. Non-plastic**

The testing services reported here have been performed in accordance with accepted local industry standards.

The results presented are for the sole use of the designated client only.

This report constitutes a testing service only. It does not represent any interpretation or opinion regarding specification compliance or material suitability.

Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

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Appendix G

Hydrogeological Calculations

Appendix G-1. Estimate of Active Zone Flow and Travel Time from Pony Creek to Brown-McDade Open Pit

Purpose

To estimate the contribution of shallow active layer groundwater flow to the pit and associated groundwater travel times

Assumptions

Groundwater flows seasonally within the shallow fractured bedrock within the active zone on top of permafrost from Pony Creek toward the pit.
Timing of flow assumed to be from May 1 to July 1 following spring freshet corresponding to the development of an active layer in spring and from October 1 to December 31 corresponding to slow freezeback of active layer in fall/winter following a fall recharge pulse.
Discharge from the active zone into the pit will freeze on contact with air during the late fall/early winter months and then melt in the spring
Precipitation is sufficient to support flow in active zone. For years where sufficient recharge to the active zone does not occur, discharge to the pit may not occu

Parameters

Wells			
Ground Surface	1206.82	mASL	
Top of fractured bedrock	1203.5	mASL	Wet cuttings start
Bottom of fractured bedrock	1202	mASL	Wet cuttings end
Groundwater elevation at MP09-02	1205.11	mASL	

Pit			
Ground Surface	1208	mASL	
Top of resistant quartzite unit at pit	1193	mASL	Elevation of icing at pit (est. from Stroshein, 2009)
Sulphide/Oxide Interface	1180	mASL	Approximate based on anecdotal information
Elevation of Pit Lake	1185	mASL	Approximate
Elevation of Seepage Face in Pit	1197	mASL	

Gradient in Shallow Aquifer		
Distance between MP09-02 and icing in pit	105	m
Gradient b/w MP09-02 and seepage face in pit	0.077	-

Hydraulic Conductivity			
Upper bound for fractured igneous/mm rock (F+C)	1.00E-04	m/s	
Lower bound for fractured igneous/mm rock (F+C)	1.00E-08	m/s	
Expected value (based on drilling observations)	1.00E-05	m/s	1-2 L/min sustained yield during air development of the active zone
Slug test in MW90-15	1.20E-06	m/s	

Aquifer Properties			
Porosity	0.01		Assumed for fractured bedrock

Calculations

Darcy flux (q) - Ks = 1 x 10^{-5} m/s	7.72E-07	m/s
Saturated thickness of active zone	1.5	m
Width of flow captured by pit	50	m
Cross-sectional area	75	m2
Flow (Q)	5.79E-05	m3/s
Flow (Q)	5.0	m3/day
Flow (Q)	0.0579	L/s

Average Linear Porewater Velocity	7.72E-05	m/s
Travel time	1.36E+06	seconds
	15.7	days
	0.043	years

Darcy flux (q) - Ks = 1.2 x 10^{-6} m/s	9.27E-08	m/s
Saturated thickness of active zone	1.5	m
Width of flow captured by pit	50	m
Cross-sectional area	75	m2
Flow (Q)	6.95E-06	m3/s
Flow (Q)	6.01E-01	m3/day
Flow (Q)	6.95E-03	L/s

Average Linear Porewater Velocity	9.27E-06	m/s
Travel time	1.13E+07	seconds
	131.1	days
	0.4	years

Appendix G-1. Estimate of Active Zone Flow and Travel Time from Pony Creek to Brown-McDade Open Pit

Annual Input to Pit

Months of Flow	5	months
Days per month	30	days
Days of flow (estimated June 1 - December 31)	150	days

Total annual contribution to pit	751	m3/yr	$K_s = 1 \times 10^{-5}$ m/s
	90	m3/yr	$K_s = 1.2 \times 10^{-6}$ m/s

Timing of Flow

January 1 - May 1	No inflow from active zone b/c frozen from ground surface to top of permafrost
May 1 - July 1	Flow into pit following spring thaw and freshet
July 1 - October 1	No inflow from active zone due to lack of recent precipitation
October 1 - December 31	Flow into pit following fall precipitation and recharge prior to ground freeze

Month	Flow	No Flow
January		x
February		x
March		x
April		x
May	x	
June	x	
July		x
August		x
September		x
October	x	
November	x	
December	x	

Appendix G-2. Horizontal Groundwater Discharge from Deep Groundwater Flow System into Pit

Purpose

Groundwater levels north of the pit are generally higher than pit lake levels resulting in groundwater discharge to the pit. Evidence of this discharge is a frozen plug of ice in the easternmost crosscut drift at the north end of the pit. This calculation is intended to quantify the magnitude and timing of groundwater discharge to the open pit based on gradients between groundwater monitoring wells north of the pit and the pit lake.

Assumptions

The pit shell penetrates the regional water table.

The rise and fall in pit lake levels is primarily the result of regional water table fluctuations.

The average pit lake elevation is similar to pre-mining groundwater levels (based on the elevation of the sulphide/oxide contact).

Saturated Darcian groundwater flow is from north to south based on the hydraulic conductivity measured in MW09-15 and gradients measured between MW09-15 and the pit lake.

The continuous record of groundwater levels measured at MW09-15 can be translated using a proportionality to estimated groundwater levels at GLL07-01 (where transducer data is not available).

Measured Hydraulic Conductivity Values	m/s	
Constant rate test in GLL09-03	1.50E-06	
Slug test in GLL09-03	2.70E-06	
Calculated from pit seepage data	1.00E-07	
Slug test in MW09-15	1.20E-06	Used this value due to proximity to seepage face in pit.

Measured Distances between Wells and Pit	m
Distance between GLL07-01 and north wall of pit	30
Distance between MW09-15 and north wall of pit	25

Measured Groundwater and Pit Lake Elevations	July 22/09	Sept. 1/09	Nov. 1/09	April 1/09	June 30/10
Groundwater elevation in GLL07-01 (m ASL)	1198.31	1198.82	-	-	1196.27
Groundwater elevation in MW09-15 (m ASL)	1191.00	1192.77	1192	1184.33	1192.39
Pit lake elevation (m ASL)	1184.21	1184.10	1184.15	1183.17	1183.26

Gradient	July 22/09	Sept. 1/09	Nov. 1/09	April 1/09	June 30/10
Gradient between GLL07-01 and pit lake	0.470	0.491	N/A	N/A	0.434
Gradient between MW09-15 and pit lake	0.272	0.347	0.314	0.046	0.365

Seepage Face	July 22/09	Sept. 1/09	Nov. 1/09	April 1/09	June 30/10
Difference between MW09-15 and pit lake level (m)	6.79	8.67	7.85	1.16	9.13
Height of seepage face est. as 25% of difference between MW09-15 and pit lake elevation (m)	1.70	2.17	1.96	0.29	2.28
Pit lake width est. from plan (m)	20	20	20	20	20
Area of seepage face (m2)	34.0	43.4	39.2	5.8	45.7

Darcy Flux Calculations Based on Spot Groundwater Measurements	July 22/09	Sept. 1/09	Nov. 1/09	April 1/09	June 30/10
Darcy flux based on GLL07-01 and Pit Lake Elevations (m/s)	5.64E-07	5.89E-07	N/A	N/A	5.20E-07
Darcy flux based on MW09-15 and Pit Lake Elevations (m/s)	3.26E-07	4.16E-07	3.77E-07	5.57E-08	4.38E-07

Discharge Calculations Based on Spot Groundwater Measurements	July 22/09	Sept. 1/09	Nov. 1/09	April 1/09	June 30/10	Average
Discharge based on GLL07-01 and Pit Lake Elevations (L/s)	0.019	0.026	N/A	N/A	0.024	0.023
Discharge based on MW09-15 and Pit Lake Elevations (L/s)	0.011	0.018	0.015	0.0003	0.020	0.016
Average Ratio of GLL07-01 to MW09-15 Discharge Values	0.578	0.707	N/A	N/A	0.842	0.709

Approximated Groundwater and Pit Lake Data (Monthly Averages)	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Groundwater elevation in MW09-15 (m ASL)	1191	1191	1193	1192.5	1191	1189	1187.5	1186	1184.5	1184.5	1191	1192
Pit lake elevation (m ASL)	1184.3	1184.2	1184.2	1184.2	1184.2	1184	1183.7	1183.5	1183.3	1183.2	1183.2	1183.2

Gradient	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Gradient between MW09-15 and pit lake	0.268	0.272	0.352	0.332	0.272	0.200	0.152	0.100	0.048	0.052	0.312	0.352

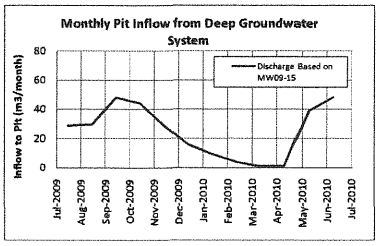
Seepage Face	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Difference between MW09-15 and pit lake level (m)	6.70	6.80	8.80	8.30	6.80	5.00	3.80	2.50	1.20	1.30	7.80	8.80
Height of seepage face est. as 25% of difference between MW09-15 and pit lake elevation (m)	1.68	1.70	2.20	2.07	1.70	1.25	0.95	0.63	0.30	0.32	1.95	2.20
Pit lake width est. from plan (m)	20	20	20	20	20	20	20	20	20	20	20	20
Area of seepage face (m2)	33.5	34.0	44.0	41.5	34.0	25.0	19.0	12.5	6.0	6.5	39.0	44.0

Darcy Flux Calculations	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Darcy flux based on MW09-15 and Pit Lake Elevations (m/s)	3.22E-07	3.26E-07	4.22E-07	3.98E-07	3.26E-07	2.40E-07	1.82E-07	1.20E-07	5.76E-08	6.24E-08	3.74E-07	4.22E-07

Discharge Calculations	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Discharge based on MW09-15 and Pit Lake Elevations (L/s)	0.0108	0.0111	0.0186	0.0165	0.0111	0.0060	0.0035	0.0015	0.0003	0.0004	0.0146	0.0186
Estimated Monthly Discharge based on MW09-15 (L)	28,856	29,724	48,174	44,284	28,765	16,070	9,282	3,629	926	1,051	39,109	48,174
Estimated Monthly Discharge based on MW09-15 (m3)	28.9	29.7	48.2	44.3	28.8	16.1	9.3	3.6	0.9	1.1	39.1	48.2

Timing of Flow (Based on Pressure Transducer Data Collected from MW09-15 and Pit Lake from July 2009 to July 2010

Month	Flow	No Flow	Discharge Based on MW09-15			Comment
			(L/s)	(L/month)	(m^3/month)	
Jul-2009	x		0.0108	28,856	28.9	15 days only
Aug-2009	x		0.0111	29,724	29.7	
Sep-2009	x		0.0186	48,174	48.2	
Oct-2009	x		0.0165	44,284	44.3	
Nov-2009	x		0.0111	28,765	28.8	
Dec-2009	x		0.0060	16,070	16.1	
Jan-2010	x		0.0035	9,282	9.3	
Feb-2010	x		0.0015	3,629	3.6	
Mar-2010	x		0.0003	926	0.9	
Apr-2010	x		0.0004	1,051	1.1	
May-2010	x		0.0146	39,109	39.1	
Jun-2010	x		0.0186	48,174	48.2	16 days only
					298.0	



Appendix G-3. Discharge and Groundwater Travel Times from Pit to Dome Creek through Deep Flow System

Purpose

Estimate the average annual groundwater discharge from the open pit to Dome Creek. The flow rate of deep groundwater and groundwater travel times are also calculated.

Assumptions

Homogeneous and isotropic groundwater flow along flow path.
Groundwater flow along inferred groundwater flow line between pit and diversion ditch as identified on groundwater flow map.
Flow is primarily within the competent bedrock unit system below permafrost.
Porosity of the bedrock system along the groundwater flow path is 1%.

Parameters

Downgradient Discharge Point		
Diversion ditch elevation along gw flowpath	1100	mASL

Pit			
Sulphide/Oxide interface elevation	1180	mASL	Approximate based on anecdotal information
Pit Lake elevation	1182.34	mASL	Average of all data from 2001-2010

Gradient in Regional Aquifer		
Distance between north pit lake and diversion ditch	825	m
Calculated gradient b/w pit lake and diversion ditch	0.100	-

Hydraulic Conductivity			
Based on Constant Rate Pumping Test	1.50E-06	m/s	Based on results of GLL07-03 constant rate test
Based on Slug Test	2.70E-06	m/s	Based on results of GLL07-03 slug test
Based on Winter Pit Level Declines	1.00E-07	m/s	Calculated based on winter pit level data (GLL, 2005)

Aquifer Properties			
Assumed Porosity of Competent Bedrock	0.01		Assumed for fractured bedrock based on MW09-15 response to snowmelt
Assumed Porosity of Shallow Weathered Bedrock	0.1		
Aquifer width	25	m	Approximate based on pit width
Aquifer thickness	20	m	Estimated from cross-section

Calculations

Discharge	High	Intermed.	Low
Darcy flux (m/s)	2.69E-07	1.50E-07	9.98E-09
Discharge (m3/s)	1.35E-04	7.49E-05	4.99E-06
Discharge (L/s)	0.1347	0.0749	0.0050

Travel Time - 1% Porosity	High	Intermed.	Low
Average Linear Porewater Velocity (m/s)	2.69E-05	1.50E-05	9.98E-07
Travel time (seconds)	3.06E+07	5.51E+07	8.27E+08
Travel time (days)	354	638	9567
Travel time (years)	0.97	1.75	26

Travel Time - 10% Porosity	High	Intermed.	Low
Average Linear Porewater Velocity (m/s)	2.69E-06	1.50E-06	9.98E-08
Travel time (seconds)	3.06E+08	5.51E+08	8.27E+09
Travel time (days)	3543	6378	95672
Travel time (years)	9.71	17.47	262

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Appendix G-4. Pit Volume Change Due to Seasonal Groundwater Level Fluctuations During 2009 - 2010

Purpose

Estimate the volume of groundwater gained or lost from the pit in response to seasonal groundwater level changes between July 15, 2009 and June 15, 2010

Assumptions

System exhibits 1% porosity

Pit lake exhibits a surface area of 2500 m2

Parameters

Pit			
Pit Surface area	2500	m2	Approximate based on anecdotal information

Aquifer Properties			
Porosity	0.01		Assumed for fractured bedrock based on MW09-15 response to snowmelt
Aquifer width	25	m	Approximate based on pit width
Aquifer thickness	20	m	Estimated from cross-section

Calculations

Groundwater Level Changes in GLL07-03			Volume Change (m3)
Starting elevation	1184.7	m ASL	
Ending elevation	1182.2	m ASL	-62.5
			-62.5

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Appendix G-5. Annual Groundwater Flow in Dome Creek Sub-Catchments

Purpose

Estimate the volume of groundwater flowing within the Dome Creek sub-catchments as outlined below for comparison with seepage measured at the seepage collection pond and modelling results.

Assumptions

Recharge coefficient is 0.1 due to widespread permafrost within the upper reaches of this relatively steep catchment.
Precipitation conditions based on "average" year.

Parameters

Precipitation		
Average rainfall	283.2	mm
	0.2832	m
Recharge coefficient	0.1	m

Catchment Areas		
Tailings Pond Diversion Ditch	2.716	km2
Tailings Pond	0.464	km2
Total Subcatchment	3.180	km2
Upper Dome Creek Station	3.604	km2

Calculations

Groundwater Flow	m3/yr	L/s
Tailings Pond Diversion Ditch	76,917	2.44
Tailings Pond	13,140	0.42
Total Subcatchment	90,058	2.86
Upper Dome Creek Water Quality Station	102,065	3.24

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Appendix H

Tailings Seepage Collection Pond Water Balance Memo

AECOM

Memorandum

To	Alistair Kent	Page	1
CC	Project team		
Subject	Tailings Seepage Collection Pond Water Balance		
From	Ryan Mills (AECOM) and Justin Stockwell (Lorax)		
Date	November 16, 2009	Project Number	112359

Introduction

This memorandum summarizes the results of mixing calculations conducted to estimate the relative contributions of source waters reporting to the tailings seepage collection pond. The purpose of this task was as follows:

- to refine the hydrogeological conceptual model of groundwater flow for the tailings seepage collection pond;
- to support water balance development for the seepage collection pond; and
- to provide a conceptual model upon which to base the contribution of source waters to the seepage collection pond.

Key Objectives of Task

The key objectives of this task were to:

- To identify the relative contribution of specific source waters reporting to the tailings seepage collection pond.

Task Methodology

Potential sources of water reporting to the seepage collection pond include tailings porewater seepage (e.g., MW09-4), Dome Creek (e.g., Station D1), tailings dam seepage (e.g., well MW09-21) and lateral groundwater seepage (e.g., well MW09-24). Water quality data from samples collected between September 1st and 3rd, 2009 were plotted on a Piper plot (Figure 1) and Schoeller diagram (Figure 2) to visually represent the geochemical signature of potential source waters reporting to the seepage collection pond.

Two distinct geochemical sources are present: seepage from the tailings mass (MW09-04) and relatively dilute groundwater (MW09-24). Well MW09-04 represents porewater seepage emanating from the tailings mass. Well MW09-24 is presumed to represent groundwater flowing laterally into the seepage collection pond from the regional groundwater system. Water from these two-wells appears to represent end-members for mixing in the seepage collection pond.

Tailings seepage travels from the tailings mass and through the tailings dam before discharging to the seepage collection pond. Data from several wells along this flowpath suggest that tailings seepage undergoes dilution and reduction processes as it travels toward the seepage collection pond. Reduction processes are apparent from the behaviour of arsenic, iron, manganese, nitrogen, and sulfur, supporting the notion that

tailings seepage does not behave conservatively as it travels from the tailings mass through the tailings dam and into the seepage collection pond. Reduction processes are less apparent as seepage approaches the seepage collection pond. Nonetheless, seepage from the tailings mass is not behaving "conservatively" as it travels toward the seepage collection pond. As a result, a conservative mixing model can not be applied to source waters from the tailings mass (*e.g.*, MW09-04) to quantify their contribution to the seepage collection pond.

Monitoring well MW09-21 is located at the base of the tailings dam near the seepage collection pond and represents net seepage emanating from the dam, which is a mixture of seepage from the tailings mass and lateral groundwater flow (dilution). While reducing conditions are evident within groundwater sampled from this well, it may be reasonable to apply a conservative mixing model to select parameters.

For the purposes of this evaluation, it was assumed that water reporting to the seepage collection pond is represented by two sources: 1) regional groundwater (i.e., MW09-24); and 2) net seepage emanating from within and under the dam (i.e., MW09-21). The mixing of these two source waters is apparent in that the seepage collection pond exhibits a chemical signature on the Piper plot that is intermediate between these two source waters (Figure 1).

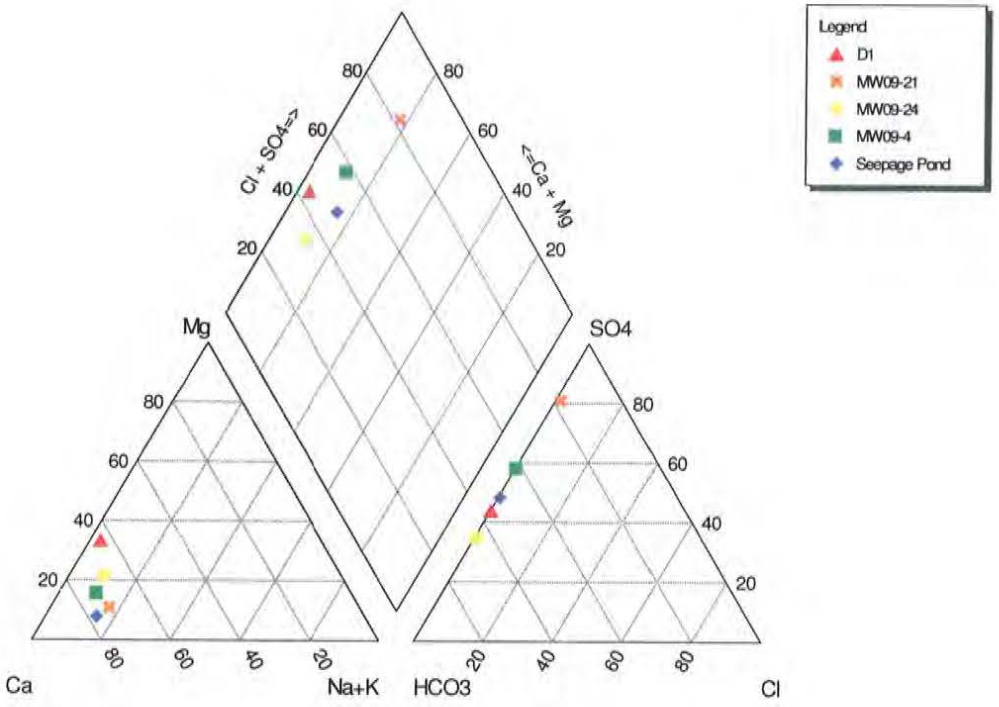

Figure 1. Piper Plot of Potential Sources Reporting to Seepage Collection Pond

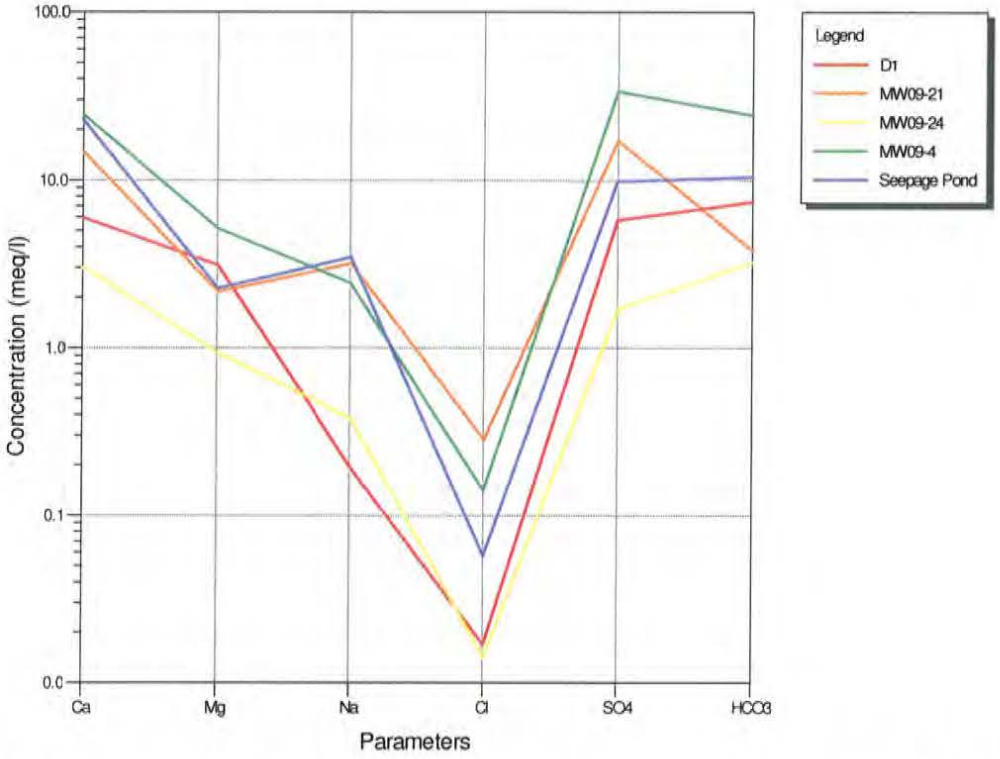

Figure 2. Schoeller Diagram Illustrating Potential Sources Reporting to Seepage Collection Pond

To estimate the relative contribution of each distinct water source to the tailings seepage collection pond, the following formula was solved in an attempt to reduce the residual to zero:

$Q_{Seepage\ Pond} \times C_{Seepage\ Pond} = Q_{MW09-21} \times C_{MW09-21} + Q_{MW09-24} \times C_{MW09-24}$; where

$Q_{Seepage\ Pond}$ is the total volume of seepage pumped out of the pond (assumed to be 1 to solve equation);

$C_{Seepage\ Pond}$ is the concentration of each parameter as measured at the seepage pond water quality sampling location on a given date;

$Q_{MW09-21}$ is the relative contribution of seepage from the tailings facility (MW09-21) to the seepage collection pond;

$C_{MW09-21}$ is the concentration of each parameter as measured at MW09-21 on a given date;

$Q_{MW09-24}$ is the relative contribution of regional groundwater (MW09-24) to the seepage collection pond; and

$C_{MW09-24}$ is the concentration of each parameter as measured at MW09-24 on a given date.

Key Assumptions

The key assumptions used as input to the task were:

- Tailings seepage collection pond is dictated by the mixing of two distinct waters (regional groundwater and net seepage through the tailings dam);
- The chemistry of groundwater in MW09-21 is representative of net seepage emanating through the base of the tailings dam, while MW09-24 is representative of regional groundwater;
- There is no attenuation, dissolution or other chemical reactions occurring along the pathway between these wells and the seepage collection pond;
- The seepage collection pond is well mixed;
- Conductivity, total dissolved solids (TDS), sulphate, calcium, sodium and strontium are suitable indicator parameters for estimating the total loading source waters to the seepage collection pond; and
- The relative contribution from each source water does not change with time.

Information Provided by Others

The following information, provided by others and/or in previous studies, was:

- Surface water quality database (EDI)
- Seepage pond pumping rates (YTG)

Key Results

Table 1 summarizes the results of the seepage pond mixing calculations for the September 2009 groundwater sampling event.

Table 1. Results of Seepage Collection Pond Mixing Calculations

Parameter	Measured Concentrations (mg/L)			Modelled Mixing Ratios	
	MW09-21	MW09-24	Seepage Pond	Fraction MW09-21	Fraction MW09-24
Conductivity	1790	378	1420	0.738	0.262
Total Dissolved Solids	1420	255	983	0.625	0.375
Sulfate	818	81.7	471	0.529	0.471
Dissolved Calcium	293	60.4	210	0.643	0.357
Dissolved Sodium	73.1	8.7	69.2	0.939	0.061
Dissolved Strontium	1.00	0.295	0.65	0.504	0.496
			Average	0.66	0.34
			Median	0.63	0.37
			Minimum	0.50	0.06
			Maximum	0.94	0.50

Using the average mixing ratios for all parameters under consideration, approximately 66% of the flow reporting to the seepage collection pond originates from the tailings pond and the remaining 34% originates from regional groundwater. Based on the measured seepage pond pumping rate in September 2009 of 466 m^3/day (5.4 L/s), approximately 309 m^3/day (3.6 L/s) originates from beneath the tailings facility and the remaining 157 m^3/day (1.8 L/s) originates from the regional groundwater flow system. A portion of the groundwater originating from the regional groundwater flow system may be the result of leakage through the bottom of the unlined diversion ditch north of the tailings facility and seepage collection pond. A strong downward gradient has been observed in the relatively permeable materials forming the base of the diversion ditch on the inferred groundwater flow path upstream of the seepage collection pond.

Recommendations

It is recommended that the results of this evaluation be incorporated into the conceptual model for groundwater and surface water flow in the area downstream of the tailings impoundment.

These mixing ratios should be re-evaluated in the event that additional groundwater and surface water data becomes available to verify the accuracy of these calculations as mixing ratios may change on a seasonal basis in response to changes in infiltration.

RDM:rdm
Encl.

Water AECOM

Yukon Government

Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation

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Table of Contents

page

1. Introduction 1

2. Development of a Mount Nansen Precipitation Data Record 1

2.1 Daily Summer Precipitation 2
2.2 Winter Precipitation 2
2.2.1 Snowmelt Distribution 3
2.3 Monthly Snow Cover Dataset 4

3. Development of a Mount Nansen Temperature Data Record 4

3.1 Mount Nansen Daily Temperature Record Developed 4
3.2 Mount Nansen Monthly Temperature Record Developed 5

4. Development of a Mount Nansen Evaporation Data Record 6

5. Monthly Time Series Flow Calculation 7

5.1 Runoff Coefficient 7

6. Pit and Tailings Pond Inflow Volumes 10

6.1 Background 10
6.2 Methodology 10
6.3 Limitations 11
6.4 Sensitivity Analysis 14
6.5 Conclusions 14

7. Summary of Hydrologic Assumptions, Uncertainty, and Risks 15

List of Figures

Figure 1: Snowmelt Distribution 3
Figure 2: Map Showing Location of Stream Flow Gauge and Precipitation Gauges in Comparison to Mount Nansen Mine 8
Figure 3: Mount Nansen Water Balance Catchment Areas 10

List of Tables

Table 1: Environment Canada Meteorological Gauges 1
Table 2: Regression Formulae Used to Convert Carmacks Daily Temperatures to Mount Nansen 4
Table 3: Mount Nansen Monthly Mean Temperatures (°C) 5
Table 4: Carmacks Monthly Mean Temperatures (°C) 5
Table 5: Mount Nansen Monthly Adjustment Factors (°C) 6
Table 6: Estimated Mean Annual Evaporation Rates 7
Table 7: WSC Gauges 7
Table 8: Runoff/Rainfall Ratio Comparison 9
Table 9: Tailings Pond Catchment - Inflow Volumes 11
Table 10: Tailings Pond Diversion Ditch Catchment - Inflow Volumes 12

Table 11: Combined Tailings Pond Diversion Ditch and Tailings Pond Catchment Area Inflow Volumes 12
Table 12: Pony Creek Diversion Ditch Inflow Volumes 13
Table 13: Pit Watershed Inflow Volumes 13
Table 14: Combined Pony Creek Diversion and Pit Watershed Inflow Volumes 13
Table 15: Sensitivity Analysis on Annual Water Volumes for Tailings Diversion Ditch and Tailings Pond Areas 14
Table 16: Summary of Key Hydrologic Assumptions, Uncertainty and Risks 15

1. Introduction

This report documents the sources of winter precipitation, daily summer precipitation, temperature, and evaporation data and discusses how adjustments were made to account for elevation differences between the Mount Nansen Tailings site and the data sources. The steps taken to estimate the inflow volumes for the mine closure options for the existing tailings pond and the pit area at Mount Nansen are also described in the memo.

2. Development of a Mount Nansen Precipitation Data Record

The seasonal hydrologic processes are significantly different. The winter is a period of limited hydrologic activity. Precipitation accumulates in the form of snow and evaporation is limited to sublimation losses from the snowpack. During the winter period the important parameter is the accumulated snow water equivalent available for the spring freshet.

During the summer parameters such as evaporation play a greater role in the overall water balance and require that a daily record be developed for the Mount Nansen site.

Recorded precipitation data is available for the Mount Nansen Tailings site from a meteorological gauging station installed at the site in 2000. This data is available for the years 2000 – 2009. It was necessary to develop a historical precipitation data record for the years prior to 2000.

A search for precipitation data in close proximity to the Mount Nansen Tailings site was conducted on available Environment Canada Meteorological gauging stations. Three Environment Canada gauging stations were identified that had a good period of record and were closest in proximity to the site. These gauging stations are described in **Table 1**.

Table 1: Environment Canada Meteorological Gauges

Environment Canada Station Name	Climate ID	Data Years	Elevation (m)	Coordinates
Carmacks	2100300	1963-2007	524.9	62°6'0" N 136°18'0" W
Otter Falls NCPC	2100840	1980-2007	829.7	61°1'48" N 137°3'0" W
Pelly Ranch	2100880	1951-2007	454.2	62°49'12" N 137°22'12" W

The precipitation data available for the Mount Nansen Tailings site for the years 2000 – 2009 was used to develop the Mount Nansen Precipitation data set when available. The data set was extended for earlier years based on the available precipitation data recorded at the Carmacks gauging station.

The gauging station at Carmacks was selected to extend the historical precipitation data record for Mount Nansen due to its close proximity to the Mount Nansen Tailings site and it has good period of record.

The Environment Canada gauging station at Carmacks has a period of record from 1964 – 2006. The gauging station has daily records for max, min and mean temperature and daily records for rainfall, snowfall and total

precipitation. Relationships between rainfall and snowfall data were developed to adjust the Carmacks data to the Mount Nansen site.

2.1 Daily Summer Precipitation

The "summer" (May to October) precipitation data recorded at the Mount Nansen Tailings site and Carmacks were compared and it was found that slightly more rainfall was reported at Mount Nansen than was recorded at Carmacks, when compared on a seasonal basis.

The summer precipitation relationship between the Carmacks data and Mount Nansen was developed using the monthly precipitation amounts. An adjustment was made to the summer monthly precipitation equation to compute the daily precipitation. The correlation that expresses the relationship between the two data sets was:

Equation	R^2
$Precip_{MtNan} = 0.9439*Precip_{Carm} + 0.2176$	0.73

This equation was used to convert the Carmacks daily rainfall record into a proxy precipitation record for Mount Nansen.

There was data missing in the Carmacks recorded precipitation. Data from the Environment Canada gauging station at Pelly Ranch was compared to the Carmacks precipitation data sets and were found to be similar to Carmacks precipitation depths. Therefore, Pelly Ranch precipitation was used as is to fill in the missing data for the Carmacks station prior to converting the Carmacks data to the Mount Nansen proxy data using the same regression equations previously developed.

2.2 Winter Precipitation

It has been reported that the spring freshet at Mount Nansen generally occurs mid April to early May and as a result the total over winter precipitation from November 1 to April 30 is required to estimate the runoff during the spring melt event.

The end of March Snow Water Equivalents (SWE) for Mount Nansen from 1976 to 2003 are available in the 2004 Pit Water Balance Input Parameters Report by NHC Ltd. (Appendix C). The SWE record has been extended from 2004 to 2007 based on additional SWE data from R. Janowics of Yukon Environment.

A regression formula was developed for the accumulated snow at Carmacks from November 1 to the end of March SWE data in the NHC report for the years when both sets of data were available. A conversion factor of 0.1 has been adopted to convert snow depth into mm of SWE. The equation implicitly takes into account sublimation losses as this will be reflected in the snow course data.

Equation	R^2
$SnowAccumulated_{MtNan} = 0.5208*SnowAccumulated_{Carm} + 33.583$	0.35

The SWE data is provided to the end of March and does not include any additional snow or rain in April which may contribute to the spring freshet.

A second correlation was performed using April precipitation data for the 2000 to 2005 data recorded at Mount Nansen and Carmacks to estimate April precipitation at Mount Nansen for years when April precipitation data is not available.

Equation	R^2
$SnowAccumulated_{MtNan} = 0.7279*April\ Precip_{Carm} + 1.8708$	0.72

This April precipitation estimate was added to the recorded snow water equivalent data for the years 1976 to 2007 when snow course data was available to compute an estimate of the total overwinter precipitation available for the spring freshet.

In addition, the Mount Nansen snow accumulation for years prior to 1976 were estimated using Carmacks recorded snow for November to March (adjusted by the regression formula) plus April precipitation adjusted by the April regression formula.

Similar to the summer precipitation record data missing for Carmacks precipitation, records during the winter months were filled in using Pelly Ranch data.

2.2.1 Snowmelt Distribution

The snowmelt from the November 1 to April 30 SWE data has been distributed over the months of April and May. Previous analyses of the SWE data have shown that 82% of the SWE melts during the month of April and the remaining 18% melts during the month of May.

A daily snowmelt distribution has been approximated for the November 1 to April 30 SWE data. It has been assumed that the snowmelt begins April 15, peaks at April 23 and finishes May 7. A snowmelt distribution with a shape similar to a dimensionless hydrograph has been developed so that 82% of the total snowmelt occurs from April 15 to April 30 and 18% occurs from May 1 to May 7. The snowmelt distribution is shown in **Figure 1**.

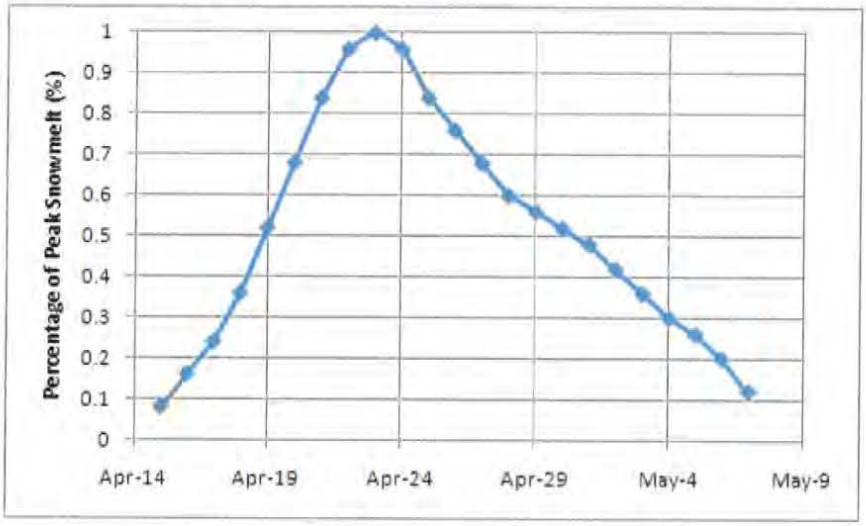

Figure 1: Snowmelt Distribution

The daily precipitation dataset was developed for Mount Nansen consisting of the years 1964 – 2006. The daily records from April 15 to October 31 were computed and assembled for use in flow rate and inflow volume estimation.

2.3 Monthly Snow Cover Dataset

The monthly record of snow cover from 1964 to 2006 was developed using available Mount Nansen SWE data and Carmacks/Pelly Ranch snow accumulation data.

A regression formula was developed for the accumulated snow at Carmacks from November 1 to the end of March SWE data in the NHC report for the years when both sets of data were available. A conversion factor of 0.1 has been adopted to convert snow depth into mm of SWE. The equation implicitly takes into account sublimation losses as this will be reflected in the snow course data.

Equation	R^2
$SnowAccumulated_{MtNan} = 0.5309*SnowAccumulated_{Carm} + 33.438$	0.36

This regression formula differs from the one presented in section 2.2 in that the equation in section 2.2 compares total precipitation recorded at Carmacks to Mount Nansen SWE data. This regression equation compares total snow recorded at Carmacks.

The snow accumulation calculated for each year at the Carmacks gauge was converted for Mount Nansen in the case that Mount Nansen data was not available. The relationship computed for April precipitation between Mount Nansen and Carmacks, as discussed in Section 2.2, was used to convert April Carmacks data to Mount Nansen.

The percentage of cumulative monthly snow cover distribution was computed each year from November to April. The monthly cumulative percentages were multiplied by each year's total overwinter SWE to compute an end of month snow cover depth. It was assumed that the snow cover in April would be reduced by 82% and as such an 82% reduction was made to the end of April snow cover depth.

3. Development of a Mount Nansen Temperature Data Record

3.1 Mount Nansen Daily Temperature Record Developed

The Carmacks temperature data set was used to estimate temperatures at Mount Nansen when recorded data was not available. Coincident data for the two stations was correlated using the mean, maximum and minimum monthly temperatures to develop general relationships that could be used to estimate missing Mount Nansen data. These formulas were used to develop a Mount Nansen temperature record that covers the same time period as the other parameters.

The formulas used to convert the minimum, mean, and maximum Carmacks daily temperatures to Mount Nansen are shown in **Table 2**.

Table 2: Regression Formulae Used to Convert Carmacks Daily Temperatures to Mount Nansen

Temperature	Regression Formula	R^2
Minimum	$Min\ Temp_{Mt\ Nansen} = 1.02*Min\ Temp_{Carmacks} - 2.81$	0.91
Mean	$Mean\ Temp_{Mt\ Nansen} = 0.75*Mean\ Temp_{Carmacks} - 0.6$	0.96
Maximum	$Max\ Temp_{Mt\ Nansen} = 0.54*Max\ Temp_{Carmacks} + 3.52$	0.81

Similar to the precipitation data set gaps in the Carmacks data, temperature data were filled using the temperatures recorded at Pelly Ranch.

3.2 Mount Nansen Monthly Temperature Record Developed

Monthly adjustment factors were developed between the available Mount Nansen monthly mean temperatures and the Carmacks monthly mean temperatures. The average of the monthly mean temperatures was computed for each dataset for the years 2000 to 2005. The Mount Nansen monthly mean temperatures are shown in **Table 3** and the Carmacks monthly mean temperatures are shown in **Table 4**.

The years 2006 to 2008 were excluded from this dataset due to missing data entries. The Mount Nansen meteorological station has an incomplete record for 2006 and 2007, with blank data entries from January 2006 to October 2007. Mount Nansen data is available for 2008 but the Carmacks data stops in February 2007.

Table 3: Mount Nansen Monthly Mean Temperatures (°C)

Month	2000	2001	2002	2003	2004	2005	Average
January	-13.3	-7.1	-12.4	-13.8	-21.5	-17.6	-14.3
February	-9.0	-11.8	-11.5	-9.0	-8.0	-12.3	-10.3
March	-6.8	-9.3	-13.3	-10.6	-11.0	-4.5	-9.3
April	-3.9	-1.8	-6.0	-0.9	-0.7	0.8	-2.1
May	2.8	2.6	4.9	4.1	7.2	8.5	5.0
June	10.6	11.2	10.2	8.8	15.0	11.4	11.2
July	11.2	11.2	12.0	13.4	13.2	11.1	12.0
August	7.8	11.4	8.8	9.8	12.2	10.8	10.1
September	2.2	4.8	5.4	2.8	1.9	5.2	3.7
October	-1.9	-4.0	0.6	0.4	-3.0	-2.4	-1.7
November		-11.4	-3.7		-8.8	-17.2	-10.3
December	-14.0	-18.3	-11.0		-13.5		-14.2

Table 4: Carmacks Monthly Mean Temperatures (°C)

Month	2000	2001	2002	2003	2004	2005	Average
January	-20.9	-13.1	-17.4	-20.4	-31.1	-23.5	-21.1
February	-10.2	-14.9	-14.2	-13.9	-12.1	-15.7	-13.5
March	-6.6	-9.3	-17.6	-10.6	-10.0	-3.3	-9.6
April	-1.4	0.1	-4.9	-1.8	1.7	2.3	-0.7
May	6.0	6.9	6.9	6.6	9.0	11.1	7.8
June	14.0	14.7	12.0	13.1	17.7	14.2	14.3
July	14.8	13.6	16.5	16.4	17.0	14.5	15.5
August	12.1	14.2	13.1	13.1	13.0	13.7	13.2
September	6.7	7.9	8.1	5.9	4.8	7.7	6.9
October	-1.9	-1.2	2.4	1.2	-1.9	0.6	-0.1
November	-9.1	-10.9	-5.1	-15.0	-12.1	-10.6	-9.7
December	-19.4	-28.2	-12.3	-19.6	-17.9	-12.6	-19.5

Typically it was found that Mount Nansen had warmer monthly mean temperatures than Carmacks for December to February. Carmacks had warmer monthly mean temperatures than Mount Nansen for April to October.

An adjustment between the Mount Nansen monthly mean temperatures and the Carmacks monthly mean temperatures was approximated using the computed monthly averages. A monthly adjustment was approximated as

the difference between the Mount Nansen monthly average and the Carmacks monthly average. The approximated monthly adjustments are shown in **Table 5**.

Table 5: Mount Nansen Monthly Adjustment Factors (°C)

Month	Mount Nansen Monthly Average Temperature	Carmacks Monthly Average Temperature	Adjustment
January	-14.3	-21.1	6.8
February	-10.3	-13.5	3.2
March	-9.3	-9.6	0.3
April	-2.1	-0.7	-1.4
May	5.0	7.8	-2.7
June	11.2	14.3	-3.1
July	12.0	15.5	-3.5
August	10.1	13.2	-3.1
September	3.7	6.9	-3.1
October	-1.7	-0.1	-1.6
November	-10.3	-9.7	-0.6
December	-14.2	-19.5	5.3

The Mount Nansen monthly mean temperature dataset was extended using the Carmacks dataset from 1964 to 2008. Monthly mean Mount Nansen temperature data was used as is where data was available. Carmacks data modified using the monthly adjustment factors shown in **Table 5** was used to fill the gaps in the Mount Nansen data. Where both Mount Nansen and Carmacks data did not exist the Mount Nansen monthly average temperatures, shown in **Table 5**, were used to fill in the gaps.

4. Development of a Mount Nansen Evaporation Data Record

Evaporation data is not available at the Mount Nansen Tailings site. The lake evaporation rates estimated for the Pelly Ranch Environment Canada Meteorological gauging station have been used to estimate the evaporation rates at Mount Nansen.

A LogNormal frequency analysis was performed on the Pelly Ranch lake evaporation data by North West Hydraulics. The mean annual lake evaporation was estimated from a 30 year period of record (1965-1995) and was reduced by 19% to account for the elevation difference between the Mount Nansen Tailings site and Pelly Ranch. The mean annual lake evaporation was estimated to be 369 mm.

It was found that lake evaporation occurs during the months of May to September with the majority occurring in June and July. A monthly distribution of the 369 mm mean annual lake evaporation was developed. A daily average lake evaporation was approximated from of each monthly lake evaporation. The monthly distributed and daily averaged lake evaporation rates are provided in **Table 6**.

Table 6: Estimated Mean Annual Evaporation Rates

	Monthly Lake Evaporation Percent Distribution	Monthly Lake Evaporation (mm)	Daily Average Lake Evaporation (mm)
May	23.0%	85	2.7
June	26.5%	98	3.3
July	24.5%	90	2.9
August	17.6%	65	2.1
September	8.4%	31	1.0

5. Monthly Time Series Flow Calculation

A historical monthly flow record from April 1964 to February 2007 was developed for select locations along Pony Creek, Back Creek, Dome Creek and Victoria Creek at Mount Nansen. Available precipitation data has been collected from sources such as Environment Canada and Yukon Environment and aggregated to develop the historical flow estimates at the selected sites.

5.1 Runoff Coefficient

The first step in developing the historical flow data for the selected sites was to obtain a representative runoff coefficient at the mine site. A common approach in estimating the runoff coefficient is to compare a known stream flow event with the corresponding known precipitation event. A search for recorded Water Survey Canada (WSC) stream flow data in closest proximity to the Mount Nansen site yielded three WSC gauges (**Table 7**). The three WSC stream flow gauges and Environment Canada Meteorological gauging stations are shown in **Figure 2**.

Table 7: WSC Gauges

WSC Station Name	Station ID	Data Years	Gross Drainage Area (km^2)	Coordinates
Yukon River at Carmacks	09AH001	1951-1995	81800	62°5'45" N 136°16'18" W
Big Creek Near the Mouth	09AH003	1974-2008	1750	62°34'7" N 137°0'58" W
Nordenskiold River Below Rowlinson Creek	09AH004	1982-2008	6370	62°3'0" N 136°16'45" W

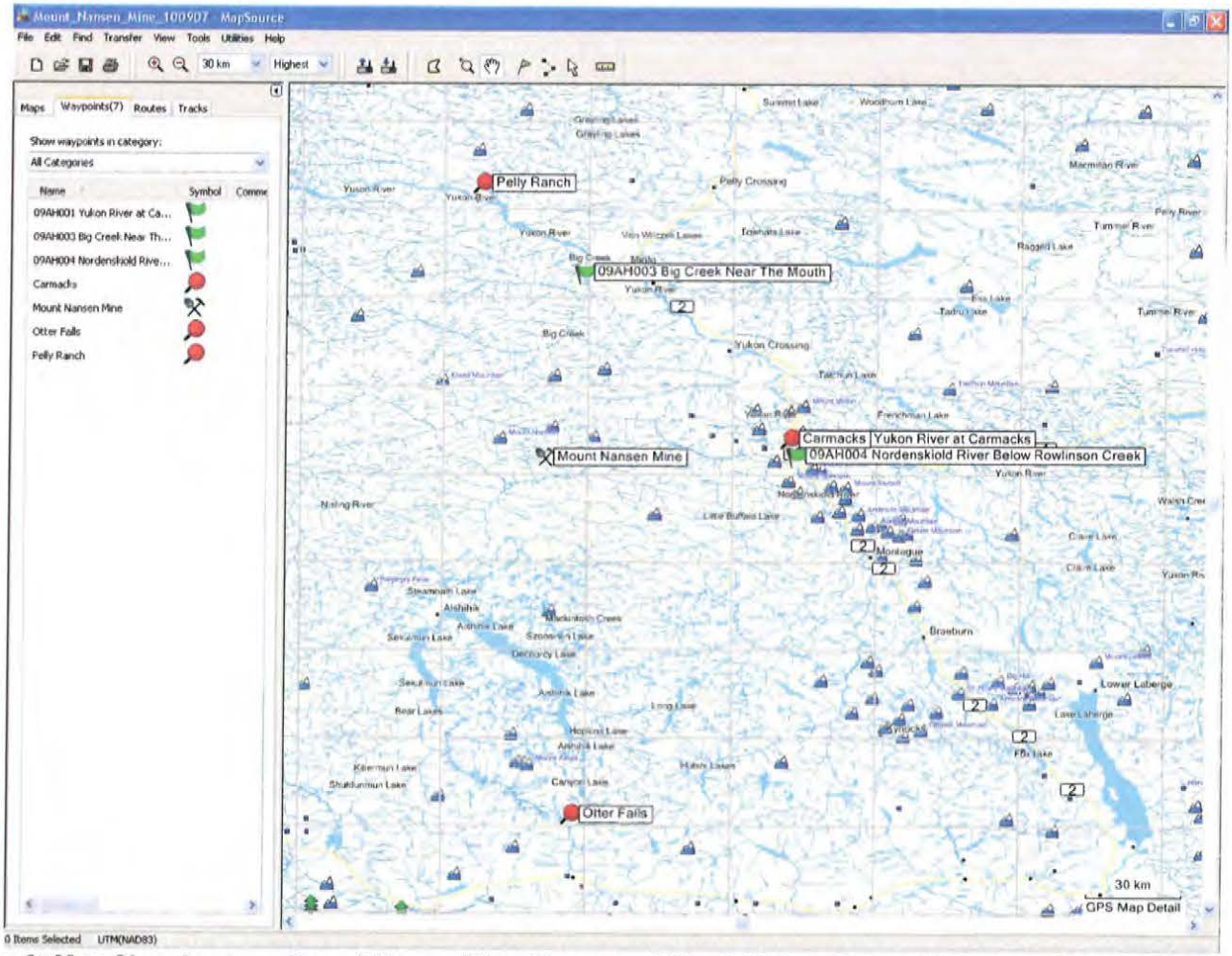

Figure 2: Map Showing Location of Stream Flow Gauge and Precipitation Gauges in Comparison to Mount Nansen Mine

The WSC gauge Big Creek near the Mouth was felt to be most representative of the WSC gauges. Although not ideal it more closely matched the catchment areas at the mine site in terms of size and geography. The estimation of the runoff coefficient was made based on a number of considerations.

One analysis involved comparing the gross precipitation input to the streamflow runoff observed at Big Creek near the Mouth. The Environment Canada gauges Carmacks, Pelly Ranch, and Otter Falls were selected for calculation of the runoff coefficient due to the longer period of record and proximity to the mine site.

The period of record for the WSC gauge Big Creek near the Mouth was analyzed to identify an independent event to calculate the ratio of precipitation to runoff recorded. However, when reviewing the daily data on a yearly time axis it became difficult to identify an event that did not appear to be influenced by a pre-existing event. Most of the large events had additional peaks during the recession of the current event indicating that another event occurred which made the calculation of the runoff volume for the event in review difficult.

At this point it was decided to compare the total annual runoff depth for each year in the period of record to the total annual precipitation recorded at the Carmacks, Otter Falls, and Pelly Ranch gauges. A runoff to rainfall ratio was calculated for each year using the annual runoff depth of the Big Creek WSC gauge and the total precipitation recorded at each of the Environment Canada gauges. An averaged runoff/rainfall ratio was calculated for each gauge as shown in **Table 8**.

Table 8: Runoff/Rainfall Ratio Comparison

Environment Canada Gauge	Runoff/Rainfall ratio
Carmacks	0.46
Otter Falls	0.49
Pelly Ranch	0.41
Average	0.45

Although this is a relatively high annual runoff coefficient it was felt that it does not accurately reflect the conditions at the Mount Nansen Mine Site which includes high slopes, poor soil conditions, and alpine meadow vegetation. The Big Creek watershed has a higher percentage of lowlands, tree coverage and detention storage.

The steepness of the local terrain at the Mount Nansen Site is the predominant factor affecting the time of concentration and runoff coefficient. Reviewing documentation for Rational Method runoff coefficients in mountain environments indicated that runoff coefficients should range between 0.6 to 0.8 for Mountain Terrain (Slopes > 10%) for events with a 2-10 year return period. Watershed slopes for the various sub-basins at the Mount Nansen Mine Site were computed and found to be as high as 40%. This indicated that the runoff coefficient should be at the upper end of the suggested range.

Additional documentation for Rational Method runoff coefficients indicates that a factor of 0.1 be added to the runoff coefficient to account for snowmelt conditions. As such it was decided to use a runoff coefficient of 0.6 to compute the flows in the summer months and a runoff coefficient of 0.8 to compute the runoff in the spring snowmelt during the months of April and May.

Flow records were required for sites along Pony Creek, Back Creek, Dome Creek, and Victoria Creek.

The monthly total depth of precipitation was calculated as the summation of the adjusted Rainfall data and the SWE data. This is used in the calculation of the monthly historical estimates at each required site along the four creeks of interest at the Mount Nansen site.

The monthly flow rate at each required location was calculated as the total volume of water at each month divided by a time step. In this case a time step of seconds was used to develop average monthly flow rates in m^3/s and litres/s. The total volume of water for each month is calculated as the monthly depth of rainfall multiplied by the runoff coefficient and multiplied by the catchment area contributing to the site. The summer runoff coefficient of 0.6 is used in the summer months and the spring runoff coefficient of 0.8 is used in the months of April and May.

6. Pit and Tailings Pond Inflow Volumes

6.1 Background

The success of closure options available for the Mount Nansen mine site are to some degree dependant on the availability of water to keep tailings saturated to a degree that will limit oxidation of the tailings and the development of acidic conditions that would leach residual metals from the tailings.

6.2 Methodology

Two water management options were analyzed for their feasibility. All mine closure options that require a water cover or saturated conditions would utilize natural runoff conveyed by gravity to maintain a water cover over the tailings or saturated conditions to prevent the tailings from oxidizing. The two areas of interest are the existing tailings area or the mine pit which could be used as an alternative to the tailings dam for storage of tailings.

Inflow volumes, based on the historical precipitation record developed for Mount Nansen, were estimated for the existing tailings area with and without the existing diversion ditch and for the pit area with the diversion of the Pony Creek watershed above the pit and into the pit as shown on **Figure** 3.

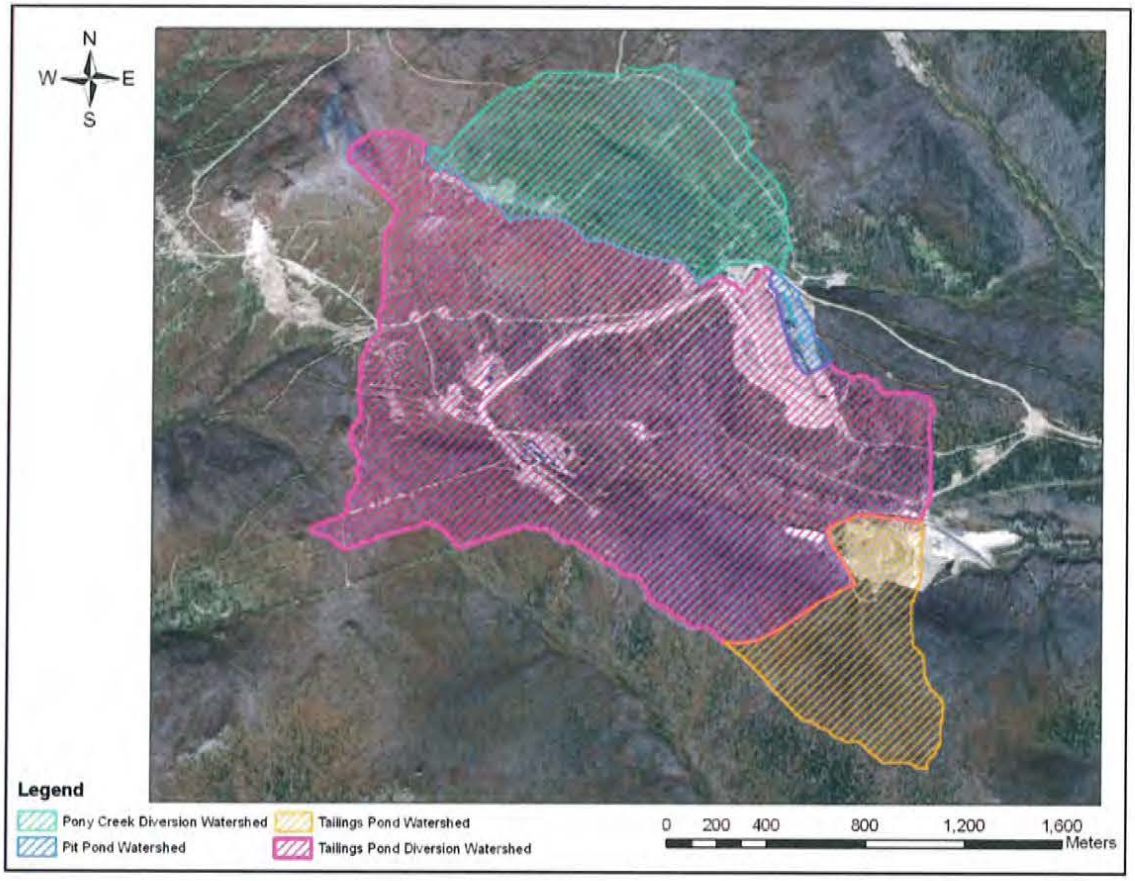

Figure 3: Mount Nansen Water Balance Catchment Areas

6.3 Limitations

The analyses were limited to the availability of surface water from various catchments that could be directed to the two tailings storage options by gravity without the need for pumping facilities.

The two water management options are:

- **Option 1:** Keep tailings in the existing tailings pond and maintain water cover using natural runoff from existing tailings pond catchment
- **Option 2:** Move tailings to the pit area and build a dam at the south side of the pit area. Maintain water cover in the pit area using the natural runoff from Pony Creek.

The monthly inflow volume for each water management option was calculated for each month in the historical record. The total volume of water for each month is calculated as the monthly depth of precipitation multiplied by the runoff coefficient and multiplied by the catchment area contributing to the site.

A runoff coefficient of 0.6 is used in the summer months and a spring runoff coefficient of 0.8 is used for the months of April and May to match the time-series flow analysis conducted.

The monthly inflow volumes were computed for each month in the historical record. 1976 was selected as the dry year condition, 2003 was selected as the typical year condition and 2000 was selected as the wet year condition. The average monthly inflow volumes were computed based on the 43 year period proxy record developed for Mount Nansen.

The dry, typical, wet, and average monthly and annual inflow volumes for the water management option involving the existing tailings pond are summarized in **Table 9**, **Table 10**, and **Table 11**.

Table 9: Tailings Pond Catchment - Inflow Volumes

Tailings Pond Catchment Area = 0.46 km²				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Precip Monthly Volumes (m^3)
April	21,200	17,100	23,500	24,700
May	11,700	12,700	23,000	14,000
June	8,600	18,900	13,100	10,300
July	13,100	17,000	24,500	15,400
August	2,200	10,600	32,600	11,400
September	100	3,600	23,700	8,800
October	1,400	6,400	2,800	5,900
Annual Volume (m^3)	58,300	86,300	143,200	90,500

Table 10: Tailings Pond Diversion Ditch Catchment - Inflow Volumes

Tailings Pond Diversion Ditch Catchment Area = 2.77 km^2				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Precip Monthly Volumes (m^3)
April	126,500	102,300	140,300	147,300
May	69,700	75,700	137,300	83,600
June	51,700	113,100	78,200	61,500
July	78,000	101,500	146,400	92,100
August	13,200	63,200	194,700	68,400
September	800	21,600	141,400	52,600
October	8,600	38,300	16,600	35,300
Annual Volume (m^3)	348,500	515,700	854,900	540,800

Table 11: Combined Tailings Pond Diversion Ditch and Tailings Pond Catchment Area Inflow Volumes

Tailings Pond Diversion Ditch + Tailings Pond Catchment Area = 3.23 km^2				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Monthly Precip Volumes (m^3)
April	147,700	119,400	163,800	172,000
May	81,400	88,400	160,300	97,500
June	60,300	132,100	91,300	71,800
July	91,100	118,500	170,900	107,500
August	15,400	73,800	227,200	79,900
September	1,000	25,200	165,100	61,500
October	10,100	44,700	19,400	41,300
Annual Volume (m^3)	407,000	602,100	998,000	631,500

The dry, typical, wet, and average monthly and annual inflow volumes for the water management option involving the Pony Creek Diversion and Pit Area have been summarized in **Table 12**, **Table 13**, and **Table 14**.

Table 12: Pony Creek Diversion Ditch Inflow Volumes

Pony Creek Diversion Ditch Catchment Area = 0.799 km^2				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Precip Monthly Volumes (m^3)
April	36,500	29,500	40,400	42,500
May	20,100	21,800	39,600	24,100
June	14,900	32,600	22,500	17,700
July	22,500	29,200	42,200	26,500
August	3,800	18,200	56,100	19,700
September	200	6,200	40,700	15,200
October	2,500	11,000	4,800	10,200
Annual Volume (m^3)	100,500	148,500	246,300	155,900

Table 13: Pit Watershed Inflow Volumes

Pit Catchment Area = 0.04 km^2				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Precip Monthly Volumes (m^3)
April	1,900	1,500	2,100	2,200
May	1,000	1,100	2,000	1,200
June	800	1,700	1,200	900
July	1,200	1,500	2,200	1,400
August	200	900	2,900	1,000
September	10	300	2,100	800
October	100	600	200	500
Annual Volume (m^3)	5,210	7,600	12,700	8,000

Table 14: Combined Pony Creek Diversion and Pit Watershed Inflow Volumes

Pony Creek Diversion Ditch + Pit Catchment Area = 0.84 km^2				
	Dry Year (1976) Monthly Volumes (m^3)	Typical Year (2003) Monthly Volumes (m^3)	Wet year (2000) Monthly Volumes (m^3)	Average Precip Monthly Volumes (m^3)
April	38,300	31,000	42,500	44,600
May	21,100	22,900	41,600	25,300
June	15,700	34,300	23,700	18,600
July	23,600	30,700	44,400	27,900
August	4,000	19,200	59,000	20,700
September	300	6,600	42,800	15,900
October	2,600	11,600	5,000	10,700
Annual Volume (m^3)	105,600	156,300	259,000	163,700

6.4 Sensitivity Analysis

A sensitivity analysis was computed on the summer runoff coefficient. Summer runoff coefficients of 0.5 and 0.7 were analyzed. The spring runoff coefficient of 0.8 was not changed in these additional analyses. The sensitivity analysis for the annual water volume for the tailing pond diversion ditch and tailings pond catchment area is summarized in **Table 15**.

Table 15: Sensitivity Analysis on Annual Water Volumes for Tailings Diversion Ditch and Tailings Pond Areas

Tailings Pond Diversion Ditch + Tailings Pond Area = 2.18 km^2				
Summer Runoff Coefficient	Dry Year (1976) Annual Volumes (m^3)	Typical Year (2003) Annual Volumes (m^3)	Wet year (2000) Annual Volumes (m^3)	Average Precip Annual Volumes (m^3)
0.5	377,400	536,300	885,800	571,100
0.6	407,000	602,100	998,000	631,500
0.7	436,600	667,800	1,110,400	691,700

The difference between the selected summer runoff coefficient of 0.6 and summer runoff coefficients of 0.5 and 0.7 is approximately ±10%.

6.5 Conclusions

Opening up the tailings pond diversion ditch watershed to drain into the tailings pond is necessary to ensure there is adequate runoff volume reaching the tailings pond to maintain the required water cover depth above the tailings and limit oxygen entry and oxidation of the tailings. The analysis indicates that this option has the largest monthly and annual inflow volumes for the dry year, typical year, wet year, and average precipitation year conditions.

Even in the extreme dry year condition the annual inflow volume indicates that approximately 400,000 m^3 of runoff could be expected to enter the tailings pond, which should be sufficient to keep the tailings saturated.

7. Summary of Hydrologic Assumptions, Uncertainty, and Risks

The key assumptions, uncertainty and risks associated with the data and hydrologic analyses are summarized in **Table 16**.

Table 16: Summary of Key Hydrologic Assumptions, Uncertainty and Risks

Hydrologic Component	Assumptions	Uncertainty	Risks
Daily Summer Precipitation	That meterological data recorded at other stations can be used to extend the data record for Mount Nansen (Using Carmacks data to fill gaps in Nansen data and Pelly Ranch data to fill gaps in Carmacks data)	The distance and topographic differences between Mount Nansen and Carmacks/Pelly Ranch may have a more complex relationship than can be defined by linear regression	Summer precipitation estimated for Mount Nansen may not be representative resulting in under or over estimating the total summer precipitation
	Linear Regression relationships between data sets is adequate to estimate missing data		
	Linear relationship computed using monthly data can be used to estimate daily precipitation records		
Winter Precipitation	That meterological data recorded at other stations can be used to extend the data record for Mount Nansen (Using Carmacks data to extend Nansen data and Pelly Ranch data to fill gaps in Carmacks data)	The distance and topographic differences between Mount Nansen and Carmacks/Pelly Ranch may have a more complex relationship than a linear regression	Winter precipitation estimated for Mount Nansen may not be representative resulting in under or over estimating the total winter precipitation
	The relationship between Mount Nansen snow course data at the end of March and Carmacks total winter precipitation can be defined by a linear correlation		
	Conversion factor of 0.1 used by Environment Canada to convert cm of snow accumulation to mm of water equivalent is appropriate	Conversion factor of 0.1 is only a "rule of thumb" to convert snow depth reported in cm to mm of Snow Water Equivalent (SWE) data	
	Mount Nansen and Carmacks April snow correlation based on short period of record and monthly values from 2000 - 2005	Based on a short period of record which may not be fully representative of the correlation between Mount Nansen and Carmacks	
Snowmelt Distribution	82% of total overwinter precipitation melts in April with the remaining 18% to melt in May	Monthly percentages of snowmelt distribution are based on the average yearly SWE for the years 1976 - 2008	Estimate of runoff volume may not be represetative in either April or May
	Snowmelt begins April 15, peaks at April 23 and finishes May 7.	Snowmelt is dependent on many factors such as temperature and snow pack density. The snowmelt distribution was approximated to simplify the estimation of runoff volume	
	Snowmelt distribution approximated with a shape similar to a dimensionless hydrograph		

Hydrologic Component	Assumptions	Uncertainty	Risks
Monthly Snow Cover Dataset	Snow accumulation pattern is similar at Carmacks and Mount Nansen	Snow accumulation patterns are different resulting in errors in computing frost penetration	Errors in estimating performance of Mount Nansen Thermo siphons
Daily Temperature Record	Relationship between Mount Nansen and Carmacks minimum, mean, and maximum monthly temperatures can be reasonably estimated using a linear regression	The distance and topographic differences between Mount Nansen and Carmacks/Pelly Ranch may have a more complex relationship than a linear regression	Error in predicting the minimum, mean, and maximum temperature at Mount Nansen
	Pelly Ranch data can be used to fill gaps in Carmacks data		
Monthly Temperature Record	Monthly adjustment factors computed from period of record (2000 - 2005) between Mount Nansen mean temperatures and Carmacks mean temperature are representative	The distance and topographic differences between Mount Nansen and Carmacks/Pelly Ranch may have a more complex relationship than a linear regression	Under predicting or over predicting the monthly temperatures at Mount Nansen
Evaporation Data Record	Mount Nansen evaporation can be estimated using Pelly Ranch lake evaporation rates	Mount Nansen evaporation data is not available to compare with Pelly Ranch data	Error in predicting the total lake evaporation at Mount Nansen
	Mean annual lake evaporation was estimated based on a Lognormal frequency analysis of 30 years of record (1965 - 1995) and reduced by 19% to account for elevation difference between Mount Nansen and Pelly Ranch	The Lognormal distribution may not be the most representative distribution for the evaporation data	
		Mount Nansen evaporation data is not available to compare with Pelly Ranch data	
	Percentage of total mean annual evaporation was estimated and distributed over the months of May to September	The monthly evaporation percentages were based on the average monthly evaporation rates at Pelly Ranch	
Runoff Coefficient	Summer runoff coefficient of 0.6 used to compute runoff volume for the months of June to October	The summer runoff coefficient can range from 0.5 to 0.7	Error in predicting the historical flow time series or the Tailings Pond and Pit area inflow volume estimates
	Spring runoff coefficient of 0.8 used to compute runoff volume for the months of April and May	The spring runoff coefficient was estimated as the largest summer runoff coefficient (0.7) and modified to account for a spring runoff condition in mountainous terrain	