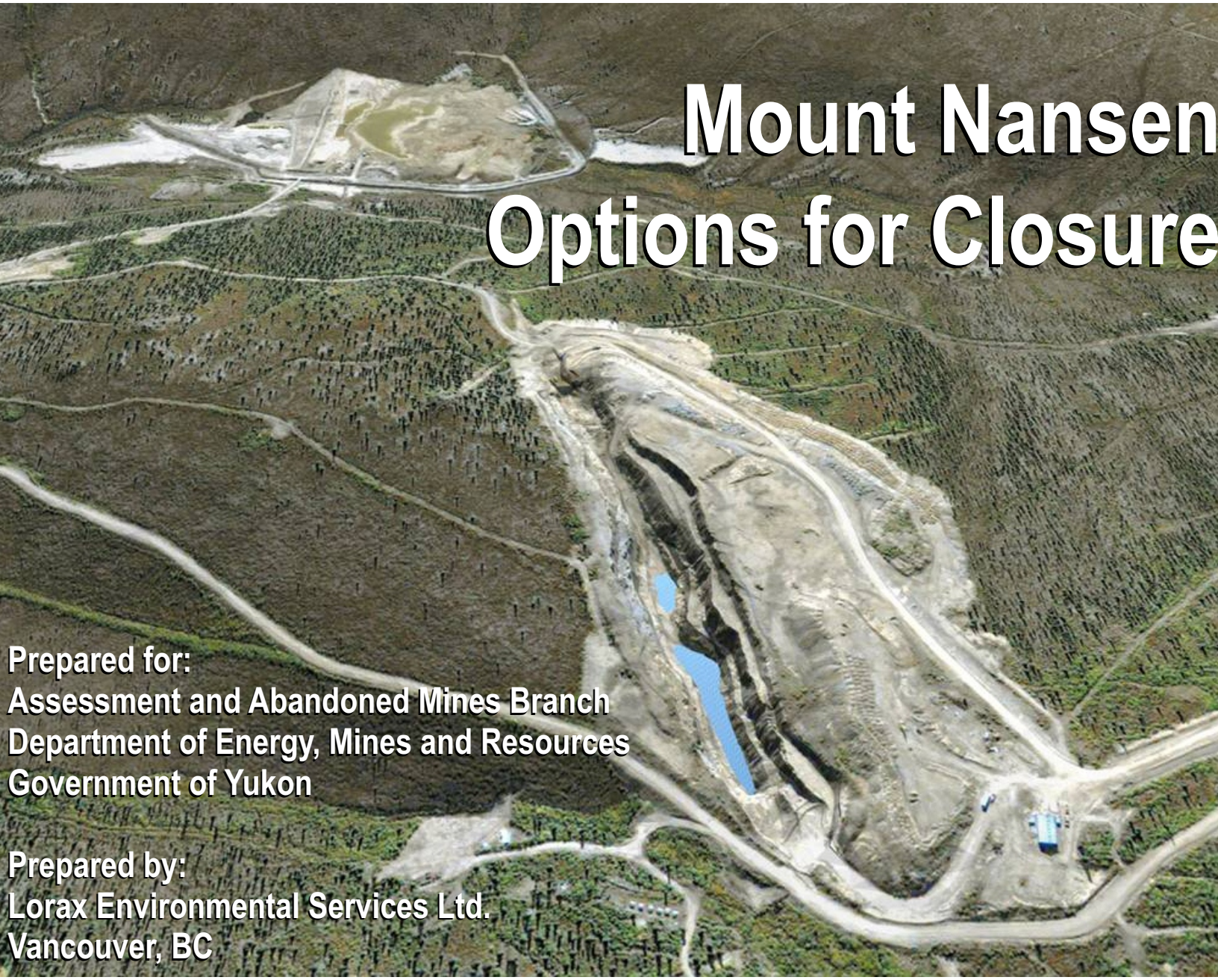
Yukon



Mount Nansen Options for Closure

Prepared for:
Assessment and Abandoned Mines Branch
Department of Energy, Mines and Resources
Government of Yukon

Prepared by:
Lorax Environmental Services Ltd.
Vancouver, BC

July 2011

LORAX ENVIRONMENTAL

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1. Introduction

1.1 Overview and Objectives

This document presents information in support of the evaluation of closure options for the Mount Nansen Mine, an abandoned gold and silver mine located 180 km north of Whitehorse (Yukon, Canada) and currently under the oversight of the Yukon Government (Figure 1.1-1). The report represents the synthesis of a large body of information generated since the site was abandoned in 1999. This report focuses on the technical evaluation of closure options, but also provides background information on the closure process, community engagement, and independent peer review.

The primary objective of this document is to provide the technical information necessary from which to evaluate the merits of the previously defined closure alternatives and ultimately select a preferred closure option for Mt. Nansen. This evaluation will be reviewed by federal, Yukon and First Nation governments (the parties). The design and performance of the closure options are specifically assessed with respect to geotechnical stability, water management, geochemistry, water quality, and costing. This document does not make recommendations with regards to a preferred closure option, nor does the report rank the options against specific closure criteria. Rather, the objective of this report is to provide the technical information required to form the basis for a closure decision framework.

The analysis presented in this report, and the level of detail provided with respect to design, performance and costing, has been conducted to the pre-feasibility level. In this context, geotechnical engineering and closure cost estimates are conceptual. Closure costs are defined as Class D estimates (or ASTM E2516-06 Class 5) and range from approximately -25% to +40% / +75%. Feasibility-scale information, which would include more detailed information with respect to final design specifications, implementation protocols, major equipment requirements, scheduling, and costing, will be generated for the final closure plan following selection of a preferred option or variation of options.

Discussion of risk is restricted to key geotechnical elements (*e.g.,* dam failure). For other components (geochemistry, water balance, hydrogeology), a formal risk assessment is not included. Rather, general discussions of uncertainty as they apply to performance are provided. The Yukon Government has proposed that a formalized risk assessment for all components be the topic of a forthcoming workshop involving the parties following review of this document.

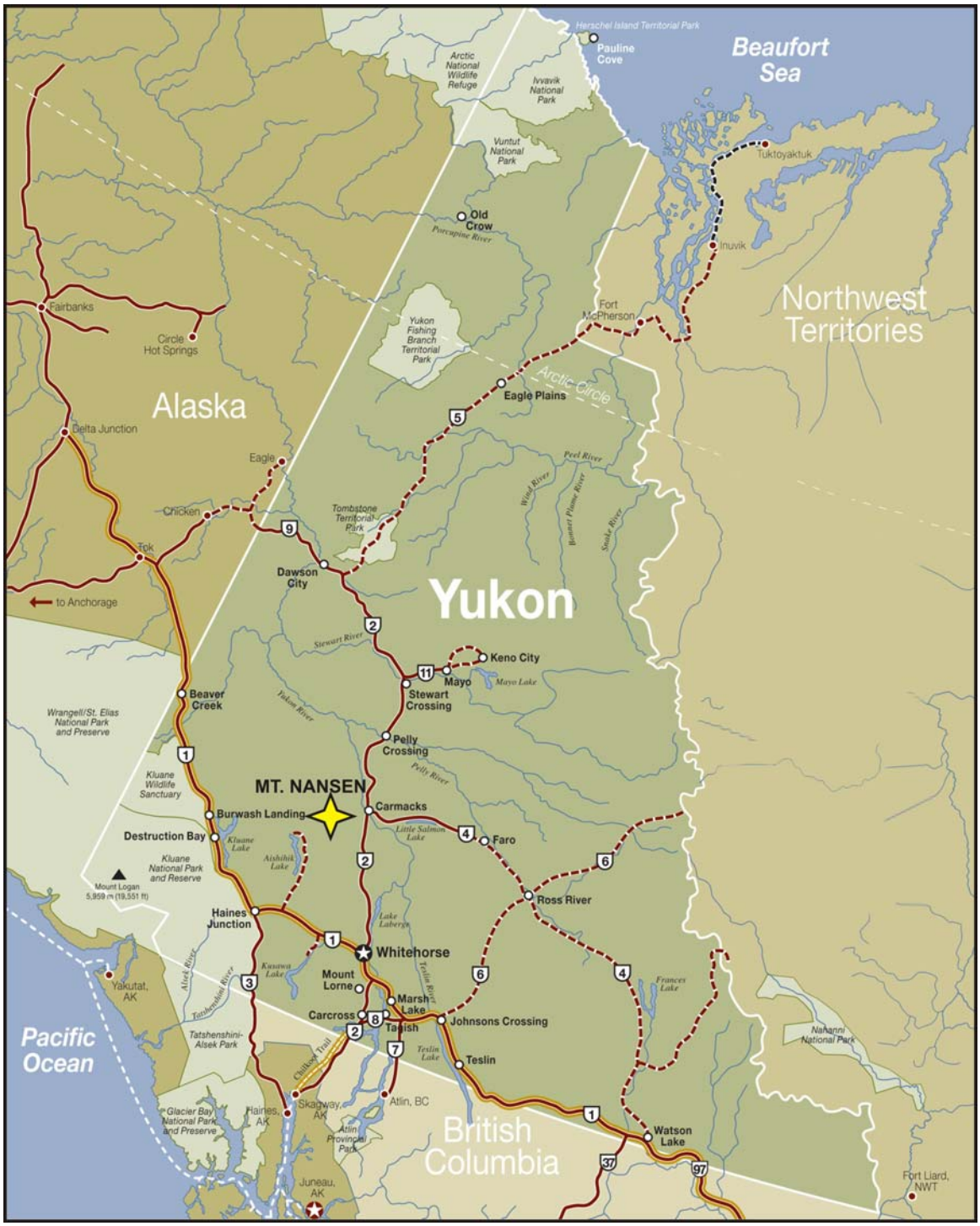

Figure 1.1-1: Mt. Nansen Site Location Map

1.2 Report Structure

Following this introduction, relevant background information to the project is provided with respect to site history, closure issues, progressive remediation measures and site investigations (Chapter 2). The framework for mine closure is described in Chapter 3, which provides a chronology of the closure planning process, closure objectives and scheduling. Within Chapter 3, details of the community engagement process and independent peer review are presented. The history surrounding the development of the various closure alternatives is presented in Chapter 4, and provides a chronology detailing the options initially proposed in 2008 (Yukon Government, 2008), those further evaluated in 2009 (AECOM, 2010), and those alternatives carried forward for the prefeasibility evaluation presented herein.

Chapter 5 presents the results of the prefeasibility assessment with regards to the various short-listed closure options. For each closure alternative, the objectives, key assumptions, performance and uncertainty are discussed with respect to the various technical disciplines, including geotechnical, water management, geochemistry, water quality, and closure costing. Closure elements common to all closure options (mill site restoration, road decommissioning, *etc*.) are also described.

1.3 Acknowledgements and Supporting Documentation

The work summarized in this report has been carried out in collaboration with Gomm Environmental Engineering Consulting and AECOM. Altura Environmental Consulting (Altura) and Golder Associates have also provided key contributions to this report. Environmental Dynamics Incorporated (EDI) has also provided essential support with sample collection and water quality monitoring.

Several attachments are included with this report. These attachments are largely technical in nature and provide supporting information as follows:

Appendix A: Comments from the Parties on Previous Closure Reporting (Little Salmon/Carmacks First Nation, Canada, IPRP, and Yukon)

Appendix B: Geochemical Characterization (Lorax Environmental Services Limited)

Appendix C: Geotechnical Engineering (AECOM), Water Management (AECOM and Golder Associates), and Costing (AECOM and Altura Environmental Consulting)

Appendix D: Climate and Hydrology Characterization (AECOM)

Appendix E: Hydrogeology Characterization (AECOM)

Appendix F: Water Balance and Water Quality Modeling (Gomm Environmental Engineering Consulting)

Appendix G: Supplemental Technical Memorandum (AECOM)

2. Background

2.1 Site Location and History

The Mt. Nansen Mine is an abandoned gold and silver mine located 60 km west of Carmacks, and 180 km north of Whitehorse (Yukon, Canada) (Figure 1.1-1). The current property covers approximately 1,200 ha and is within the Little Salmon/Carmacks First Nation traditional territory. The mine is accessible year round by a 60 km long, all-weather road from Carmacks, Yukon.

Exploration in the Mt. Nansen project area commenced in the 1940s, with mining operations occurring over three discrete periods beginning in the late 1960's. Between 1968 and 1969, approximately 10,000 tonnes of flotation tailings were generated from ore mined from the Huestis and Webber underground developments. The operation closed down due to poor gold and silver recoveries. At this time, the Brown-McDade deposit was explored underground from an adit collared adjacent to Pony Creek. During the second period of mining between 1975 and 1976, approximately 5,000 tonnes of ore from the Huestis deposit were processed through the existing mill. Again, poor recoveries forced the premature closing of this operation. The last stage of active mining occurred between 1996 and 1999, during which time BYG Natural Resources Inc. (BYG) accessed ore from the Brown-McDade zone. This open pit operation processed approximately 269,000 tonnes of ore through the existing mill at a production rate of approximately 500 tonnes per day, producing approximately 35,700 ounces of gold. BYG ceased operations in February, 1999 due to difficulties meeting their water license requirements, lower than expected gold and silver recoveries, and an inability to meet required financial security payments. The BYG operation was further compounded by environmental concerns during the later stages of operations relating to the geotechnical and operational aspects of managing the tailings facility (*i.e.*, tailings dam), as well as a failure to meet effluent toxicity requirements.

Operations ceased in early February 1999 following the declaration of voluntary receivership by BYG, with D. Manning and Associates Inc. appointed as receiver for physical assets. Following resignation by D. Manning and Associates, responsibility was subsequently transferred to the federal Department of Indian Affairs and Northern Development (DIAND/INAC) as an abandoned site in August 1999. In April 2003, the Devolution Transfer Agreement between Canada and the Yukon came into effect and project management was transferred to the Government of Yukon (GY) who continues to oversee the care and maintenance for the site.

GY has enacted an Order-In-Council (OIC) placing a prohibition from staking (quartz and placer) over approximately 1,200 hectares of land covering the mine site footprint. Such measures will not permit re-staking this ground and thereby minimize interference with remedial efforts (Figure 2.1-1).

2.2 Closure Issues

The Mt. Nansen property is defined by the Mt. Nansen Order In Council (OIC) Boundary identified in the 2006 Yukon OIC (Figure 2.1-1). As detailed in the report "Options for Closure of Mt. Nansen" (Yukon, Energy, Mines and Resources, 2008), the primary closure issues include the stability of the tailings impoundment, water quality and site infrastructure. Related mine features are summarized in Table 2.1-1 and illustrated in Figure 2.1-1. As well, a rendered 3-D image illustrates the current site in Figure 2.1-2. Detailed discussions of the existing liabilities with respect to geochemical and geotechnical aspects are provided in Appendices B and C, respectively.

Table 2.1-1:
Summary of existing closure issues at Mt. Nansen Mine

Tailings Impoundment	• Tailings dam: potential for dam instability associated with inadequate construction (foundation stripping, compaction of fill, and beach development) and permafrost degradation. • Diversion structures and spillway: upgrades required to ensure adequate sizing and stability. • Seepage rate: higher than expected seepage rates due to inadequate tailings beach development and suspect or missing dam liner (per design). • Seepage water quality: metal leaching of arsenic associated with reductive dissolution in saturated zones. Potential for development of acid rock drainage in unsaturated zones. • Current form not compatible with traditional land use.
Open Pit	• Potential hazard for people and wildlife. • Water quality: elevated levels of As, Cd, and Zn. • Current form not compatible with traditional land use.
Waste Rock / Ore	• Neutral mine drainage with elevated levels of Cd and Zn. • Potential for localized acid rock drainage (ore) • Angle of repose slopes are not compatible with traditional land use.
Mill Site	• Infrastructure: only partial decommissioning has occurred. • Potential for contaminated soils to be addressed. • Drainages from historic workings and/or mine waste contribute significantly to loadings of mine-related parameters to Dome Creek.

386500 387000 387500 388000 388500 389000 389500 390000 390500 391000 391500 392000 392500

6883100 6882600 6882100 6881600 6881100 6880600 6880100 6879600 6879100 6878600

N

Pony u/s
Pony d/s
Pit Lake
Pony Creek
Back Creek
Mine Camp Area
Pit
Pit Outline
D1 Site
DX Site
Mill Area
Tailings Pond
Diversion Ditch
Tailings Pond Site
Spillway
Seepage Pond
Interceptor Ditch
Dam Crest
Seepage Discharge Site
Upper Dome Creek Site
Dome Creek
Dome Creek @ Road Site
Victoria Creek Reference Site
Upper Victoria Creek Site
Back
Victoria Creek
Victoria Creek @ Road Site
Dry Creek Reference Site

CLIENT::

Yukon Government

Legend

- Surface Water Quality Stations
- Mine Road
- Public Road
- Mt. Nansen OIC Boundary
- Mill Area
- Mine Camp Area
- Tailings Dam
- Ponds
- Tailings
- Mine Infrastructure
- Pit Outline
- Waste Rock Area

Topography (Excepit Pit)

- Index (5m)
- Interm. (1m)

Meters
0 335 670 1,340

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:20,000

DATE: NOV 2nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Water Balance and Water Quality Predictions

TITLE: **Mount Nansen Mine Site Current Conditions and Surface Water Quality Monitoring Stations**

PROJECT No: **J907-4**

FIGURE No: **2.1-1**

LORAX ENVIRONMENTAL
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Website: www.lorax.ca

Figure 2.1-2: Rendered Image of Current Conditions at Mount Nansen, Looking South

2.3 Remediation Measured Completed to Date

A chronological summary of remediation measures completed to date at the Mt. Nansen property is presented in Table 2.2-2.

Table 2.2-2:
Summary of remediation measures completed to date at Mt. Nansen Mine

Mine Area	Remediation Measure	Year
Tailings Impoundment	• Water treatment to achieve water license discharge standards • Replacement of seepage control dyke. • Upgrading of emergency spillway. • Installation of seepage capture dam. • Installation of monitoring wells.	• 1999-2004 • 2000 • 2000/2001 • 2001 • 2009
Open Pit	• Installation of hydraulic plug in Pony Creek Adit to improve portal stability and reduce potential for hydraulic connection between pit and Pony Creek. • Installation of groundwater monitoring wells	• 2006 • 2007 & 2009
Waste Rock	• Relocation of ~5,000 m^3 of wasterock in Pony Creek area to open pit • Relocation of ~8,000 m^3 of low-grade ore stockpile to open pit	• 2008 • 2009
Mill Site	• Removal of hazardous chemicals • Demolition of mill crusher building • Huestis portal rehabilitation • Test filling of old exploration trench	• 2006 • 2009 • 2007 • 2008

2.4 Site Investigations

Since the shutdown of operations in 1999, numerous site investigations in support of closure planning for the site have been conducted during the care and maintenance period. The studies have examined various aspects relevant to site closure, including those relating to health and safety, economic potential, fish and wildlife management, terrestrial and aquatic effects, geotechnical stability, tailings and waste rock geochemistry, hydrology, hydrogeology and reclamation. Brief descriptions of the investigations and reports produced to date are provided by GY (2008). Copies of these documents are available for review from the Government of Yukon, Department of Energy, Mines, and Resources, Assessment and Abandoned Mines Branch.

Since 2008, numerous technical investigations have been completed and are incorporated into this closure synopsis. These evaluations include the technical appendices and their

supporting documentation (Section 1.3), as well as additional technical evaluations referenced within this document.

3. Closure Planning Framework

3.1 Governance

In April 2003, management of the Mount Nansen Mine Site was devolved to the Government of Yukon (GY) with funding provided through the Government of Canada. Mount Nansen is defined as a "Type II Site" as identified in the "Yukon Northern Affairs Program Devolution Transfer Agreement". Under the devolution transfer agreement, Canada, GY, and the Little Salmon/Carmacks First Nation (LSCFN) have agreed to cooperate in matters relating to the remediation of the site. Government of Yukon (GY), Department of Energy,Mines and Resources, Assessment and Abandoned Mines Branch (AAM) manages care and maintenance of the Mt. Nansen site, as well as development and implementation of remediation plans with funding provided by the Government of Canada (GC).

In 2006, a contribution agreement was signed between GY and LSCFN to formally acknowledge cooperation between the two governments, and supporting their common involvement in the project. GY, LSCFN, and Canada continue to develop a final closure and remediation plan that will address the historical environmental liabilities associated with the Mt. Nansen property. Yukon, together with the LSCFN and Canada, are working towards a final closure and remediation plan to be submitted through the *Yukon Environmental and Socio-economic Assessment Act* (YESAA) process.

A technical working group involving Canada, LSCFN Technical Advisory Committee (TAC), and Yukon has been established to discuss technical and scientific studies and their implementation into the final closure and remediation plan. In this regard, a diverse team of technical consultants has conducted numerous investigations for the Mt. Nansen technical working group on a wide range of closure planning aspects and disciplines.

GY, LSCFN, INAC, and the INAC Independent Peer Review Panel (IPRP) have provided feedback on previous closure reporting (AECOM, 2010). These comments have been incorporated into the following report and are included in Appendix A for reference. A summary and checklist of the most salient comments are also provided in Appendix A.

3.2 Closure Objectives

Closure objectives for the Mt. Nansen Project were established through consultation with LSCFN and GC and were developed to aid in the closure planning process. Closure objectives capture the interests and values of the parties and include objectives that may

not be recognized by all technical disciplines or assessments. A detailed discussion on closure objectives is provided in GY, 2008 (Section 4 and Appendix C).

Closure objectives for the Mt. Nansen Project include the following:

- Protect human health and safety;
- Protect and restore the environment including land, air, water, as well as fish and wildlife and their habitats;
- Return mine site to an acceptable state that reflects original, traditional and pre-mining land use;
- Maximize local, Yukon and First Nation benefits; and
- Manage risk in a cost effective manner.

Detailed descriptions of closure objectives are available in GY, 2008 (Section 4 and Appendix C).

4. Development of Closure Options

4.1 Initial Proposed Closure Options

Initial closure options for the Mt. Nansen Site were outlined in a Government of Yukon publication titled "*Options for Closure of Mt. Nansen Mine – Technical Review Version*" (GY, 2008). The purpose of this document was to identify viable closure options for consideration by the parties. The report included numerous closure options for the main components of the mine site, including the tailings storage facility (TSF), waste rock piles, and open pit. The options presented for the tailings included:

- Upgrade the dam and leave tailings in place with contouring and potential cover;
- Relocate tailings out of Dome Creek to a new facility adjacent to Dome Creek below the current TSF;
- Relocate tailings to the Brown-McDade open pit; or
- Freeze tailings in-situ.

The options presented for the open pit included:

- Leave the pit as is, with no infill;
- Partially backfill the pit with waste rock and/or tailings; or
- Completely backfill the pit with waste rock and/or tailings.

Each of the options for the tailings and the pit was assessed for technical feasibility and economic viability. As well, a preliminary risk assessment was presented.

4.2 Options Screening Evaluation

In March 2009, GY, AECOM, and Lorax hosted a workshop and data gap analysis with the parties. The objectives of the workshop were to identify and prioritize data gaps, as well as to discuss, identify, and screen viable closure options for further evaluation. The following five closure alternatives formed the basis of discussion during the workshop:

- 1 – Care and maintenance for entire site (Status Quo);
- 2 – Care and maintenance for the Tailings Storage Facility (TSF) with partial or complete pit backfill with waste rock;
- 3 – Upgrade TSF with partial or complete pit backfill with waste rock;
- 4 – Relocate all tailings to pit and decommission TSF with options to partially or completely backfill the open pit with waste rock; and

- 5 – Decommission TSF, restore Dome Creek, and create new TSF, with options to partially or completely backfill the open pit with waste rock.

4.2.1 Alternatives Excluded from Future Consideration

Status quo closure options (Alternative 1 and 2) were included on the alternatives list as a point of comparison or base case. During the March 2009 Workshop, consensus was achieved that care and maintenance of the TSF (*i.e.*, status quo) did not represent a viable closure for the Mount Nansen site. This conclusion was based on the following considerations:

- Residual geotechnical risks associated with the tailings dam:
    - Foundation built upon unstable permafrost; and
    - Diversion ditches and spillway construction are not suitable for closure and require seasonal maintenance.
- Residual geochemical risks associated with the tailings:
    - Due to water management considerations associated with dam stability, large portions of the tailings remain unsaturated and therefore pose a risk for development of acid mine drainage in the long-term.

Additional residual risks associated with the "status quo" include the following:

- Open pit (physical hazard);
- Pit lake (water quality);
- Pony Creek Adit (potential pathway for pit lake discharge to Pony Creek);
- Waste rock reclamation (regrade and revegetation);
- Mill contamination, demolition, and reclamation; and
- Site restoration and revegetation (exploration trenches, roads, mine camp, pipelines, power lines, and other infrastructure and clearings).

Closure Alternative 5 (relocation of the TSF to another impoundment in the Dome Creek catchment) was identified as a last resort alternative that should only be explored in the event Alternatives 3 and 4 were found to be unfeasible. Given the feasibility of Alternatives 3 and 4, Alternative 5 was excluded from further consideration. Further, consensus was achieved that Option 5 would not adequately address the geochemical and geotechnical residual risks associated with the tailings due to the following:

- Increase in overall tailings disturbance area;

- Feasibility of relocating fine-grained tailings to a hill-slope TSF;
- Long-term geotechnical stability for a hill-slope TSF underlain by permafrost; and
- Long-term geochemical stability of unsaturated tailings within a hill-slope TSF.

4.2.2 Alternatives Selected for Further Evaluation and Refinement

Following the data gap workshop, a planning workshop was hosted by AECOM, Whitehorse in April, 2009. Various consultants and the parties and/or their technical representatives participated in the workshop. The purpose of the planning workshop was to develop work plans to address data gaps identified previously, and to organize a staged approach for evaluating alternatives for closure. Based on feedback from the parties during the March and April, 2009 workshops, four viable alternatives were selected for Mt. Nansen. These options were prioritized for further refinement, characterization, and evaluation as follows:

- 3A - Upgrade TSF (reinforce tailings dam and cover tailings) with no backfill of waste rock or open pit reclamation;
- 3B - Upgrade TSF (reinforce tailings dam and cover tailings), backfill open pit with waste rock;
- 4A – Excavate and relocated tailings (wet or dry) to the open pit, restore Dome Creek valley; and
- 4B - Excavate and relocated tailings (wet or dry) with waste rock to the open pit, restore Dome Creek valley.

Work plans were developed during the closure planning workshop (April, 2009) and implemented during the summer of 2009. The alternatives were evaluated in terms of geotechnical stability, geochemistry, climate and hydrology, hydrogeology, and potential impacts to surface water quality. The culmination of this work was summarized in a closure options evaluation by AECOM (2010) titled "*Overview of Mt. Nansen Closure Alternatives Characterization*". Although the work presented in AECOM (2010) helped to advance the overall process of selecting a preferred option, the residual risks and uncertainties presented within the report were deemed too significant to select a closure option for further advancement in the closure process.

4.3 Options Recommended for Prefeasibility Assessment

In order to advance the closure planning process, GY hosted a workshop in April 2010 to develop a path forward. Representatives from AECOM, GEEC, and Lorax participated in the workshop in addition to the project parties (YG, LSCFN, and INAC). During the

workshop, the parties expressed concern that the degree of uncertainty associated with several alternatives was too large and prevented meaningful comparison of closure alternatives to allow selection of a preferred option for closure. Detailed comments from the parties are provided in Appendix A.

GY hosted a 2010 kickoff workshop in June, 2010. Representatives from AECOM, GEEC, and Lorax participated in the workshop in addition to the project parties. Two notable outcomes from the workshop included: 1) further refinement of closure options; and 2) specific work plans for addressing areas of uncertainty. Refinement of the closure options resulted in specific details to the closure design (*e.g.,* tailings cover design) and resulted in a more focused plan to base future technical investigations (*e.g.,* tailings water balance). Specific work plans were devised to address specific areas of uncertainty. Further, an integrated approach between the various technical consultants was developed in an effort to provide a consistent, balanced evaluation of each options performance, risks, and benefits. A new naming convention for closure options was also developed as follows:

- Options 1A and 1B: Tailings Dam Upgrade with Water Cover (Option A denotes waste rock in place; Option B denotes pit backfill with waste rock);
- Options 2A and 2B: Tailings Dam Upgrade with Saturated Soil Cover (Option A denotes waste rock it in place; Option B denotes pit backfill with waste rock);
- Option 3: Tailings (Wet) Backfill into Pit with High Infiltration Cover, Waste Rock in Place; and
- Option 4: Tailings (Dry) and Waste Rock Backfill into Pit with Low Infiltration Cover.

The closure options listed above form the basis for the technical evaluation presented in this report. Closure options are presented in Chapter 5, and discussed with respect to purpose, performance, and uncertainty with respect to the following technical components: geotechnical engineering, water management, geochemistry, water balance (climate, hydrology, hydrogeology), and surface water quality. Conceptual estimates of capital closure costs are also provided.

5. Prefeasibility Assessment of Short-Listed Closure Options

This chapter provides a discussion of the prefeasibility level assessment of the short-listed closure options. The evaluation of each short-listed, closure option includes a discussion of the option objective or purpose, key assumptions, performance and uncertainty with respect to technical disciplines discussed below.

5.1 Assessment Methods

As outlined in Chapter 1, the objective of this document is not to make recommendations with respect to a preferred closure option, nor rank the closure options against various closure criteria. Rather, the primary objective is to provide the prerequisite information necessary for the parties to evaluate the relative merits and residual risks of the various closure alternatives. In this regard, the design and performance of the closure options were assessed with respect to five components, including:

- Mine waste geochemistry;
- Geotechnical engineering;
- Water management;
- Water balance and surface water quality; and
- Cost.

These criteria closely link to the closure objectives outlined in Section 3.2. Safety, as it relates to mine hazards (*e.g.,* open pit), is also considered. As part of the assessment for each option, the key assumptions, anticipated performance, and areas of uncertainty are described. These components have been summarized from technical reports in support of geochemistry (Appendix B), geotechnical aspects (Appendix C), hydrology (Appendix D), hydrogeology (Appendix E), water balance and quality modeling (Appendix F) and costing (Appendix C). For a thorough analysis of each of these components, the reader is directed to the appropriate appendix.

The following chapter presents the results of the prefeasibility assessment of Common Closure Elements (Section 5.2), Current Condition (Status Quo) (Section 5.3), and short-listed closure options as introduced in Section 4.2 and summarized below:

- Section 5.4: Options 1A and 1B – Tailings Dam Upgrade with Water Cover (Option B denotes pit backfill with waste rock);

- Section 5.5: Options 2A and 2B: Tailings Dam Upgrade with Saturated Soil Cover (Option B denotes pit backfill with waste rock);
- Section 5.6: Option 3: Tailings (Wet) Backfill into Pit with High Infiltration Cover, Waste Rock in Place; and
- Section 5.7: Option 4: Tailings (Dry) and Waste Rock Backfill into Pit with Low Infiltration Cover.

5.1.1 Scope

Only those facilities, installations, and significant ground disturbances within the 'Mt. Nansen OIC Boundary' are considered. This limit, shown in Figure 2.1-1, is defined as the area bounded by existing quartz claims held by others, coupled with the perimeter identified in the 2006 Yukon Order in Council (O.I.C.). This Order in Council prohibits entry for prospecting or for the purposes of placer and quartz claim staking in order "to facilitate reclamation of the lands as a result of mining activity."

5.1.2 Approach

The analysis presented in this report, and the level of detail provided with respect to design, performance and costing, has been conducted to a pre-feasibility level. In this context, geotechnical engineering designs, remedial activities, and closure cost estimates are conceptual. Closure costs are defined as Class D estimates (or ASTM E2516-06 Class 5) and range from approximately -25% to +40% / +75%. Feasibility-scale information, which would include more detailed information with respect to final design specifications, implementation protocols, major equipment requirements, scheduling, and costing, will be generated for the final closure plan following selection of a preferred option or variation of options.

A surface water model has been devised using Goldsim to evaluate each closure option (Appendix F). The primary objective of the surface water model is to provide a basis for comparing the environmental merits and performance of each closure option with regards to surface water quality. The following approach was taken to best achieve this objective:

- Mill area contaminant loadings were excluded from the assessment in order to illustrate the differences between the closure options;
- Water quality predictions have been made for Victoria Creek downstream of the project where fish presence has been confirmed and where net loads from the mine coalesce; and

- A reasonable degree of conservatism has been built into the model in an effort to compare the options equally. Assumptions regarding model inputs and their conservatism are described for each option in the sections below.

Predicted water quality conditions are also compared to CCME guidelines for the protection of aquatic life (*e.g.,* CCME); however an environmental effects assessment has not been conducted as part of this evaluation. Specifically, residual project and cumulative effects as they relate to aquatic resources are not discussed from the perspective of biological impact. Such an assessment would require consideration to a full suite of variables including site-specific factors that govern metal bioavailability, studies in support of site-specific water quality objectives, and site-specific species assemblages.

5.2 Closure Costing of Common Elements

5.2.1 Overview

The following section provides a description of common closure elements to the Mt. Nansen Mine Site. These elements are described separately as they are common to all closure options and variations for Mt. Nansen. A detailed inventory, evaluation, and capital cost estimate for closure is provided in Appendix C-2. Common closure elements have been defined by Government of Yukon (F. Patch, personnel communications, October 2010), are limited to features within the Mt. Nansen OIC Boundary (Section 5.1) as illustrated in Figure 5.2-1, and include the following:

- Mill Area;
- Camp and Site Ancillary Buildings (camp, mine shop, water storage tank building above camp);
- Roads;
- Exploration Trenches;
- Miscellaneous infrastructure (*e.g.*, power supply infrastructure, pipelines, Victoria Creek pump house, core storage areas); and
- Other Areas requiring revegetation and site restoration (*e.g.*, exploration clearings and adit disturbance areas, borrow areas, *etc.*)

Further the following assumptions have been made regarding the evaluation of Common Closure Elements:

386000 387000 388000 389000 390000 391000 392000

6883000
6882000
6881000
6880000
6879000

N

1
2
A
B
C
D
E

CLIENT::

Yukon Government

Legend

- 1 Open Pit and Waste Rock
- 2 Tailings
- Mine Road
- Public Road
- Mt. Nansen OIC Boundary

Common Elements

- A Mill
- B Camp and Ancillary Buildings
- C Exploration Trenches
- D Pump House
- E Clearings
- Powerlines (Active)
- Powerlines (Inactive)

Meters
0 350 700 1,400

SCALE:	1:20,000
DATE:	OCT 6th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Common Closure Elements

PROJECT No:	FIGURE No:
J907-4	**5.2-1**

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- All facilities and workings will be fully decommissioned and will no longer see any use; hence buildings will be removed or demolished. Powerlines, pipelines, tanks and other ancillary equipment will be removed from service. Non-public exploration and mine roads will be decommissioned. It is recognized that it may be deemed appropriate to maintain or re-purpose certain buildings or infrastructure in support of on-going care and maintenance, or to provide services to other interested parties (*e.g.*, Little Salmon/Carmacks First Nation).
- Assessments considered integral to carrying out the closure activity have been included in some areas as 'Pre-Closure' activities. It is important to note that these investigations are limited in scope and their assigned costs are not intended to include any required engineering, design, or detailed planning.
- Road and trail differentiation is based on information provided by Government of Yukon. Trails have been defined to require no specific closure measures.

An overview, general inventory, and 'Class D' cost estimate (see Section 1.3.3) for the Common Closure Elements are provided in the following sections. Common Element closure costs are conceptual and are defined as -25% to +75%.

5.2.1.1 Summary of Common Element Closure Costs

A summary of the estimated closure costs for the six Common Elements is provided in Table 5.2-1. Discussion of overview, approach, and uncertainty for each Common Closure Element is given in the following sections.

Table 5.2-1:
Summary of Estimated Closure Costs for Common Elements

		Pre-Closure Phase	Active Closure Phase
#	**Component**	**Estimated Cost**	**Estimated Cost**
1	**Mill Area**	$ 78,000	$ 2,440,000
2	**Camp and Ancillary Buildings**	$ 40,000	$ 390,000
3	**Roads**	$ 25,000	$ 210,000
4	**Exploration Trenches**	$ 15,000	$ 210,000
5	**Miscellaneous Infrastructure**	$ 15,000	$ 210,000
6	**Revegetation and Site Restoration of Other Areas**	$ 5,000	$ 210,000
	Subtotal	$ 178,000	$ 3,670,000
	TOTAL ESTIMATED COST		**$ 3,850,000**

5.2.2 Mill Area

5.2.2.1 Overview

The Mill Area is illustrated in Figure 5.2-2 and includes mill buildings, ponds, roads, platforms, equipment laydown areas, miscellaneous products, pipelines, and powerlines.

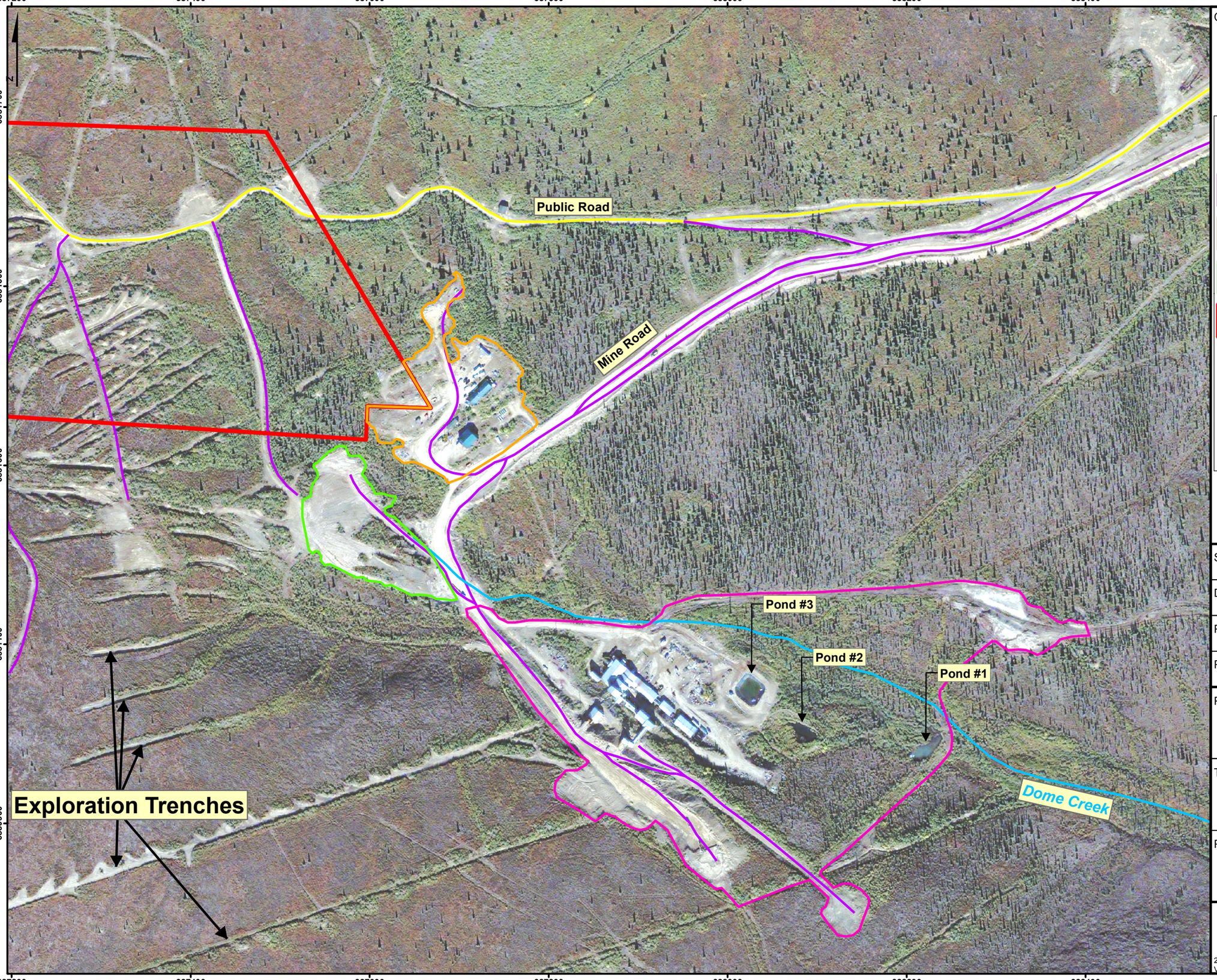
Site History

According to reports the Mill Area first saw significant use during two brief mining campaigns in the 1960's and 1970's (Conor Pacific, 2000). During that time approximately 22,000 tonnes of ore mined from the nearby Huestis workings was transported to the mill area and processed via froth flotation to produce a sulphide concentrate. Airphotos and company personnel report that at least some ore was brought to the mill via a lower adit which at one time daylighted just northwest of the mill buildings. Approximately 20,000 tonnes of tailings were reportedly discharged below the mill; the two remnant decant structures remain mainly intact in the naturally revegetated area downhill from the main mill platform (Pond #1 and #2). A third decant structure is visible in old air photographs and is now the site of a geomembrane-lined pond on the lower mill platform (Pond #3). This newer pond was used during the 1990's mining phase for water supply and after for cyanide treatment.

During preparation for mining in the 1990's the mill underwent retrofitting to accommodate a cyanidation circuit, thickener, and other updated process equipment. A set of diesel-powered generators was installed in part of the old warehouse building and remain in operation today.

Previous Investigations

Closure-related studies specific to the Mill Area include a site-wide Historical Review, Site Assessment, and Field Sampling Program (Conor Pacific, 2000), a Limited Phase 2 Environmental Site Assessment (Kearah & WERI, 2008), preliminary geochemical investigations (Altura 2009b, Lorax 2010a), and installation and monitoring of four shallow piezometers (AECOM, 2009). Water quality monitoring has been routinely conducted at stations DX, upstream of the mill area, and D1, just below the mill complex (EDI Environmental Dynamics, 2008).



CLIENT::

Yukon Government

Legend

- Mill Area
- Mine Camp
- Contoured Heustis Workings
- Mt. Nansen OIC Boundary
- Dome Creek
- Mine Road
- Public Road

Meters
0 70 140 280

SCALE:	1:4,000
DATE:	OCT 6th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Mill and Mine Camp Area

PROJECT No:	FIGURE No:
J907-4	**5.2-2**

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With respect to potential environmental liabilities, salient conclusions from the aforementioned studies include the following:

- Hazardous Products: most hazardous products inside mill and in main laydown areas have been removed, including asbestos and PCBs; however residual amounts hazardous materials remain in tanks and vessels within the mill. Groundwater monitoring of four Mill Area wells installed during 2009 has not identified detectable hydrocarbon concentrations.
- Tailings: Approximately 2,000 tonnes of the 20,000 tonnes of tailings has been identified in the easternmost pond (Pond #1) in the Mill Area. The tailings were reportedly reprocessed and discharged to the current TMA in the late 1990's (Brodie, 1998). A borehole log from 2009 suggests that tailings may also exist near Pond #2, but the nature and thickness of this material cannot be confirmed.
- Water Flow Paths: Reconnaissance, excavations, and previous studies indicate that zones below the main mill platform and the vegetated zones below Pond #3 are within a shallow groundwater zone and effectively discharge to the Dome Creek watershed. Above this zone, a seep possibly associated with the lower Huestis adit area appears to contribute to water quality degradation of Dome Creek. Remediation costs have been assumed for the adit; however additional investigations are required to determine if this is necessary.
- Water Quality: Dome Creek water quality shows increased Cd, Zn, As, and sulphate concentrations along the reach transecting the Mill Area. Mineralized material (ore) is likely contributing to the flux of metals to Dome Creek. Preliminary assessments suggest that mineralized fill and a seep just west of the mill (possibly associated with an historic adit opening in this area as described above) are likely the primary contributors to Dome Creek metal loading in the vicinity of the mill. Water quality observations from Upper Dome Creek suggest mill contributions are not increasing over time and are stable. The mill area appears to be the primary source of Cd and Zn (and to a lesser degree sulphate) to Dome Creek (the TMA is the primary source of As to Dome Creek). Investigations suggest As and metal concentrations are partially attenuated downstream, possibly through co-precipitation with Fe-Mn oxide compounds (Lorax, 2010a).

5.2.2.2 Approach

Objectives

Specific objectives for Mill Area closure include the following:

- reduce zinc and cadmium loading to Dome Creek;
- minimize surface and near surface water flow through mill platform area;
- ensure that a complete inventory of mill tailings deposits is completed and where feasible, tailings are stored in a location offering long term physical and chemical stability (*e.g.*, open pit or current TMA);
- restore upper Dome Creek watercourse for long term physical stability;
- remove hazardous products;
- ensure treatment of hydrocarbon contaminated soil; and
- decommission and recycle/dispose of buildings.

Components, Assumptions, and Uncertainty

Based on site evaluations conducted to date, closure costing for the Mill Area considers the following main components and key assumptions given in Table 5.2-2.

Main assumptions and uncertainties affecting the Mill Area closure cost estimate include the following:

- Remediation of underground workings and uncertainty associated with suspected adit(s);
- Water treatment costs. Costs for temporary sediment control measures have been assumed where potentially applicable, but since sampling of ponds indicates compliance with existing water license levels for metals, there is no allowance for additional water treatment;
- Removal of up to 1000m^3 of tailings;
- Additional landfill or cover material is not required;
- Removal of up to 6500 m^3 of mineralized material (this is considered a conservative approximation); and
- Minor amounts of remaining hazardous products require removal.

5.2.2.3 Closure Cost Estimate

The estimated closure cost (Pre-Closure Phase + Active Closure) for the Mill Area is approximately $2,518,000 (Table 5.2-1). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

Table 5.2-2:
Main Components and Key Assumptions for Closure Costing of the Mill Area

Component	**Key Assumptions**
Mill buildings	Minor amounts of residual hazardous products No asbestos, no PCB's Minor amounts of lead-containing paint
Old refuse disposal area principally containing non-hazardous waste with some hazardous waste	Minor amounts of hazardous products Remaining waste can be landfilled in-situ
Laydown areas containing metal, pipes, abandoned equipment, miscellaneous waste and consumables	Minor amounts of hazardous products
Three Ponds #1, #2, #3 (two earthen, one geomembrane lined). Pond #1 (earthen) confirmed to contain sulphide and metal-rich tailings	Apart from tailings identified in Pond #1, no other deposits of recoverable tailings Water in all ponds meets Water License effluent discharge requirements
Records indicate 20,000 to 25,000 tonnes of tailings were deposited in the mill area during the early phases of mine development (1960's and 1970's)	Preliminary investigations confirmed approximately 2000 tonnes of tailings are contained within Pond #1. Tailings were reportedly reprocessed and relocated to the current TMA. Cost estimates assume only 2000 tonnes of tailings will require relocation.
Fuel and miscellaneous petroleum product storage in concrete containment and fuel dispensing area	2 X 10,000 gallon (45,500L) diesel tanks Likelihood of hydrocarbon-contaminated soil and concrete
Mill Disturbance Area: rock fill platforms	4 ha, in a series of 5 platforms. Lower platform contains approximately 6500 m^3 of potentially ARD/ML material within or near the saturated zone and will require relocation
Dome Creek watercourse, some sectors with platforms and scrap metal pushed to the edge of the stream	Culvert, scrap metal to be removed from watercourse
Rail tanker reportedly with residual pressure and containing a minor amount of sulphur dioxide	0.08 L sulphur dioxide (Kearah and WERI, 2008)

5.2.3 Camp and Site Ancillary Buildings

5.2.3.1 Overview

The Camp and Site Ancillary Buildings include the main camp area along with the mine shop, adjacent bone-yard, and laydown areas, as well as the water storage tank above the camp. The main camp area is shown in Figure 5.2-2. Note that this area lies in close proximity to the OIC boundary, with some of the camp clearing lying outside of these limits.

It is understood that the main camp area was constructed in the 1960-70's mining era and then upgraded during the mid-1990's when several Atco®-style camp trailers were used to house mine employees. These trailers have since been removed from site.

The remaining camp kitchen, office/bunkhouse, and workshop are currently in use to support ongoing care and maintenance activities, and their upkeep is managed by the Government of Yukon. Water for camp use is supplied by a stand-alone water tank that is filled by water truck. A power line runs from the mill site for electricity. Most of the buried and on-surface water lines in the camp area are inactive. Domestic sewage is reportedly disposed of in a tank and drain field system, with the tank contents periodically pumped and transported off-site. The specific location of the system has not been confirmed for this estimate. Other materials in the vicinity of the camp include core storage areas, at least one shed in disrepair, and miscellaneous consumables. Propane and gasoline tanks are located in the lower platform of the camp area and are still in use.

The mine shop is unheated, and sees occasional use in supporting ongoing care and maintenance activities. Miscellaneous consumables, tools and components, the majority no longer in use, are stored within and around the building.

Previous Investigations

Conor Pacific (2000) included review of the Camp and Site Ancillary Building areas as part of their Historical Review, Site Assessment, and Field Sampling Program, however from review of other available documents it is not clear what aspects have since been remediated during the current care and maintenance phase. Conor Pacific notes above-ground fuel storage at both the camp area and the mine shop complex. Altura (2009c) noted a strong hydrocarbon odour in a geochemical investigation test pit in the road bed immediately below the camp, however to date no follow-up work has been completed to determine the source.

The Camp and Ancillary Building sites are assumed to have relatively low levels of potential environmental liability, nonetheless the following aspects are considered to

apply to these areas: i) presence of localized hydrocarbon-contaminated soil, ii) presence of minor amounts of lead-containing paint, and iii) presence of minor amounts of hazardous products. It is understood from communication with Yukon Government Assessment and Abandoned Mines that no PCB-containing fixtures remain on site (F. Patch, personal communications, Oct, 2010). It is also assumed that no asbestos products are present (consistent with site assessment findings for the mill complex).

5.2.3.2 Approach

Objectives

Specific objectives to the Camp and Site Ancillary Buildings include:

- remove hazardous products;
- ensure treatment of hydrocarbon contaminated soil; and
- decommission and recycle/dispose of buildings.

Components, Assumptions, and Uncertainty

Based on site evaluations conducted to date, closure costing for the Mine Camp Area has been conducted for the main components and key assumptions listed in Table 5.2-3. The portion of the Camp Area clearing outside of the OIC boundary is not included in the closure cost estimate (Figure 5.2-2).

Since it is desirable to continue using the camp facilities while the major site work is being undertaken, the camp area would likely be decommissioned as late in the active closure phase as is feasible. Further, as mentioned previously it has been acknowledged that the camp facilities ultimately may not be decommissioned should a local or private party show interest in using, buying, and/or assuming liability for it (***e.g.***, Little Salmon / Carmacks First Nation).

Main assumptions and uncertainties affecting the Mine Camp Area closure cost estimate include the following:

- Mine camp buildings may not require demolition in the event of a requirement for continuous site presence following active closure or a decision to cede the facility to a third party; and
- Limited assessments suggest that most hazardous products have been removed from site; however there appears to have been no systematic assessment for hydrocarbon-contaminated soil.

Table 5.2-3:
Main Components and Key Assumptions for Closure Costing of the Camp and Site Ancillary Buildings

Component	Key Assumptions
Camp Buildings: Kitchen, office/bunkhouse, workshop/garage	Minor amounts of residual hazardous products No asbestos, no PCB's Minor amounts of lead-containing paint (some buildings pre-date late 1970's ban)
Clearings, Camp area	2 ha, in a series of 4 platforms connected by roads Minor amounts of residual hazardous products, minor refuse to be removed Minor laydowns of supplies and small equipment Core storage in various areas
Fuel and Propane storage, lower camp platform	Gasoline in one 2000 gallon (4,550L) 'enviro tank', fuel dispensing equipment in current use - potential for hydrocarbon soil contamination from fuel dispensing 4 – 1000 lb. propane tanks, in current use
Water Tank Building, above camp adjacent to main Nansen road	35,500 gallon (161,500L) wood stave water tank housed in stand-alone building (T.W. Higgs, 1994), not in use; clearing 500 m^2
Mine Shop and laydown ('Ketza Construction Yard')	Metal clad building approximately 250m^2, Minor laydowns of supplies and small equipment, 1500m^2 metal and miscellaneous scrap yard to southeast, equipment parking platform to north, potential for hydrocarbon soil contamination due to maintenance activities and fuel tanks during mining; total 0.8ha area.

5.2.3.3 Inventory and Cost

The estimated closure cost for the Camp and Site Ancillary Buildings is approximately $430,000 (Table 5.2-1).). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

5.2.4 Roads

5.2.4.1 Overview

Site History

As shown in Figure 5.2-1, there is an extensive network of roads in over the Mt. Nansen site, developed over the last 70 years to support mineral exploration as well as quartz and placer mining needs. The roads range from narrow temporary accesses for trenching campaigns to an approximately 15m-wide thoroughfare at one time used by mine haul trucks. The roads are in various states of repair and currently see different levels of use.

Certain thoroughfares through the Mt. Nansen OIC are used by other operations in the area and are designated as 'Public', and shown in Figure 5.2-1. These sections will remain active and will not be decommissioned and reclaimed as part of the Mt. Nansen site closure.

Previous Investigations

Conceptual closure and cost estimates for road decommissioning are based on Altura's general site familiarity as well as preliminary mapping information provided by Assessment and Abandoned Mines. No detailed mapping or ground-truthing of the more remote roads has been conducted to date, and their state of repair and environmental liability issues are largely unknown.

Roads are surfaced with locally-sourced material, have a highly compacted running surface, were typically constructed with cut and fill method, and in some sections are ditched with culverts installed. It is understood that there are no bridge crossings to be removed.

The 1.2 km mine haul road merits specific consideration in that the original road, a cut and fill structure, was substantially widened, straightened, and bermed in the late 1990's by dumping waste rock hauled from the Brown McDade pit (Altura, 2009c, 2009d). As a result, several sections of the haul road have long angle of repose slopes that cannot readily be resloped and integrated with the surrounding terrain. Haul road test pit characterization by Altura (2009c) indicated that:

- berm material, particularly along the eastern sector towards the mine, exhibits mixing with potentially reactive highly altered and sulphidic material;
- excess road bed could be suitable for use elsewhere as low-reactivity construction material (providing that there is field quality control and avoidance of berm material and zones near the mill); and
- soil and rock with a strong hydrocarbon odour were encountered in a test pit in the haul road bed below the camp, and it is considered likely that a minor amount of roadbed material will require soil remediation.

Many trails exist throughout the Mt. Nansen site. Trails are considered thoroughfares that are not passable by regular vehicle, have little or no constructed roadbed, and are largely vegetated.

5.2.4.2 Approach

Objectives

Specific objectives to closure of site Roads are:

- prevent future ingress by light vehicles or equipment
- minimize erosion
- encourage natural revegetation

Components, Assumptions, and Uncertainty

Components and key assumptions for the closure evaluation of site Roads are given in Table 5.2-4. Items not included in the closure cost estimate include:

- Trails (as noted in Section 3.1.2); and
- Public roads (Figure 5.2-1) which are thoroughfares within the Mt. Nansen OIC boundary that are utilized by other parties such as placer miners and hunters for accessing areas within and beyond the immediate Mt. Nansen site. Public roads will not be decommissioned as part of Mt. Nansen closure activities.

Main assumptions and uncertainties affecting reclamation of Roads within the Mt. Nansen OIC include the following:

- Road surfaces will be de-compacted to 0.8m depth and re-contoured to integrate with the surrounding terrain;
- Culverts will be removed, and water bars or other control structures will be created as required to minimize erosion and direct surface water and seepage through the disturbance;
- Surfaces will be left undulating and non-compacted, and as available, materials such as organics, natural coarse woody debris will be distributed over the final surface;
- Revegetation is assumed over approximately 10 percent of narrower road areas;
- Revegetation on the haul road is assumed to take place over 25 percent of the disturbance area owing to its slope and size; and
- An on-ground inventory of roads to be reclaimed has not yet been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge.

Table 5.2-4:
Main Components and Key Assumptions for Closure Costing of Roads

Component	Key Assumptions
Public Roads	6.5 km within OIC Boundary No closure activities on these roads
Mine Roads	Total 11.6 km within OIC Boundary, not including haul road described below All Mine Roads to be ultimately decommissioned Minor amount of roadbed material will require hydrocarbon remediation All material geochemically stable
Haul Road	1.2 km of 15m-width haul road from mine shop to mill A portion of the berms (up to 1000m^3) potentially leachable material; all other haul road material insitu is considered to have minimal potential effect to water quality. Minor amount of roadbed material will require hydrocarbon remediation
Trails	No closure activities on trails

5.2.4.3 Inventory and Cost

The estimated closure cost for Mine Roads is approximately $235,000 (Table 5.2-1). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

5.2.5 Exploration Trenches

5.2.5.1 Overview

Numerous exploration trenches within the Mt. Nansen OIC have not been reclaimed by previous operators. Trenches are visible as long linear features, typically clustered around a mineralized zone of interest (Figures 5.2-1 and 5.2-2). Many trenches at the Mt. Nansen site are several hundred metres in length.

Site History

Most of the trenching was carried out from the mid-1980's through to the late 1990's. In general, trenching programs during this period entailed initial pre-stripping of the top 0.5m of vegetation and sub-soil with a bulldozer, and trenching to approximately 1 to 2m depth by 1m width with a large excavator. Sidecast material was typically piled on one or both sides of the exposed trenches. The Huestis zone trenches above the mill present a special reclamation challenge. They are very long and generally over 3m deep. These trenches were initially excavated with a dozer in the 1970's and deepened in the 1980's

with an excavator. Some sections of these trenches were recently filled in as part of the care and maintenance activities and thus provide a valuable, field-truthed cost estimate.

Previous Investigations

No detailed mapping or ground-truthing of the Mt. Nansen exploration trenches has been conducted to date, and their current condition and environmental liability issues are largely unknown. Open trenches present a public safety hazard in those areas frequented for animal, plant and berry harvesting, and may cause alterations to wildlife movement patterns. Some trenches alter the drainage characteristics of the area, and thereby present ongoing erosion concerns. In rare cases, local water quality may be influenced by acid rock drainage and/or metal leaching from naturally occurring mineralization.

Due to mine development and other later workings, some trenched areas at Mt. Nansen are no longer easily accessible for heavy equipment to carry out reclamation activities. Thus, the decision to carry out relatively inaccessible trench-filling work should be weighed against the potential impacts from accessing them.

5.2.5.2 Approach

Objectives

Specific objectives to the closure of site Exploration Trenches are:

- protect public safety
- minimize erosion
- restore natural drainage characteristics as feasible
- encourage natural revegetation

Components, Assumptions, and Uncertainty

Components and key assumptions for the closure evaluation of site Exploration Trenches are given in Table 5.2-5.

Main assumptions and uncertainties affecting reclamation of Exploration Trenches within the Mt. Nansen OIC include the following:

- A rate of 75 equipment hours per kilometre has been applied to deeper trenches in the Heustis area above the mill;
- Due to potential impacts created by re-accessing some trenches, it is assumed that only 80 percent of the remaining 11km of trenches will be filled. A rate of 60 equipment hours per kilometre is applied to these areas;

- Trenches will be accessed via a temporary trail, utilizing existing trails and roads where possible.
- The trenches will be backfilled using available sidecast material, and recontoured to integrate as possible with the surrounding terrain;
- Water bars or other control features will be created as required to minimize erosion and direct surface water and seepage across the trenching disturbance into natural depressions or drainages;
- Backfilled surfaces will be left undulating and non-compacted, and as available, materials such as organics, natural coarse woody debris will distributed over the final surface;
- Due to the narrow linear nature of the disturbance, no re-vegetation activities are assumed, except in those areas requiring additional erosion control. For the purposes of costing, revegetation is assumed to take place over 2 percent of the trenches backfilled; and
- Field-truthing of exploration trenches for reclaimation has not been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge.

Table 5.2-5:
Main Components and Key Assumptions for Closure Costing of Trenches

Component	Key Assumptions
Trenches	Approximately 15 linear km of total trenches within OIC Boundary 2 linear km of deep trenches already backfilled during care and maintenance; 2 linear km of deep trenches remaining 80% of outstanding 11 km can be feasibly backfilled Field verification required

5.2.5.3 Inventory and Cost

The estimated closure cost for Exploration Trenches is approximately $225,000 (Table 5.2-1). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

5.2.6 Miscellaneous Infrastructure

5.2.6.1 Overview

Other Common Element infrastructure and facilities include power supply infrastructure, pipelines and other specific facilities described in the following paragraphs.

Power Supply Infrastructure: these are existing line routes, both active and inactive, across the property, along with associated transformers and switchgear (Figure 5.2-1). The lines known to be active transmit power generated from the site generator facility located at the millsite and it is understood that they include: i) mill site to camp, ii) mill site to tailings pond and seepage pond, and iii) tailings pond to Victoria Creek pumphouse. Other lines are assumed to be inactive (condition unknown) include: i) mill site to mine shop, ii) camp to water tank, and iii) Pony Creek to Victoria Creek pumphouse. There is no systematic inventory of remaining powerline infrastructure nor switchgear, and it is understood that all remaining transformers on site are in service and located at the mill site, camp or Victoria Creek pumphouse areas.

Pipelines: main pipeline routes include those from Victoria Creek pumphouse to the tailings area, tailings area to the mill, and from the mill to camp and water tank areas. There are several intermediate pump shacks in the tailings area in various states of repair. There has been no systematic inventory of pipelines completed, and at least one, and in many cases two or three partial lines of pipes may be located along these routes. There are several other minor pipeline sections noted remaining within the mine, tailings, and camp areas; as well, there is potentially an older pipeline originally installed along the old powerline route from Victoria Creek to Pony Creek.

Victoria Creek Pumphouse: Victoria Creek pumphouse is located adjacent to Victoria Creek and approximately 2km east of the tailings impoundment. The facility was originally commissioned and used during the 1960's to 1970's mining periods for supply of fresh water for processing and for the camp. The facility is still used for filling the site water truck for supply of camp water. It is understood that water is supplied from a single artesian well with multi-staged submersible pump, and housed in a wood frame pumphouse (F. Patch, pers. comm., 2010; T.W. Higgs, 1994). The pumphouse is located in a clearing covering an approximately 1000 m^2 area.

Core Storage Areas: diamond drill core is stored in several locations at the old Pony Creek exploration camp, and at the mine camp area. The majority of the core storage areas have core boxes are well-labelled and intact. The boxes are either stacked or on racks that have fallen into disrepair.

5.2.6.2 Approach

Objectives

Objectives for closure of the Miscellaneous Infrastructure components are consistent with the over-arching site-wide criteria, and no specific objectives have been identified.

Components, Assumptions, and Uncertainties

Closure costing for Miscellaneous Infrastructure considers the main components and key assumptions given in Table 5.2-6.

Assumptions and uncertainties affecting the Miscellaneous Infrastructure closure cost estimate include the following:

- Power supply infrastructure will be deactivated by qualified industrial electricians, remnant power cable and switchgear will be removed, and disposed of along with general site waste, with recycling and salvage as feasible;
- Older power poles may be cut down at the base and bucked up to remain in the field, newer power poles may be salvageable, and are assumed to be cut off at the base and transported out of the field;
- Transformers will be salvaged or disposed of in accordance with applicable regulations ;
- Most powerline right-of-ways are narrow and infrequently used, and thus, minimal re-vegetation requirements are assumed;
- There is insufficient information to allow for further development of a closure strategy, in particular with respect to vehicular access to power line right-of-ways, and details on infrastructure remaining in the field. Thus for preliminary costing purposes a blanket allowance has been assumed;
- Above-surface pipelines along with remnant insulation and debris will be removed from the field to be disposed of or salvaged;
- Usable equipment in pump shacks will be salvaged, and the buildings removed from site and dismantled or salvaged;
- Minimal re-vegetation requirements are assumed. Due to insufficient information on remaining infrastructure and access, a blanket allowance has been assumed for preliminary costing purposes;
- Down-hole pump and piping will be removed from the artesian well at Victoria Creek and the well will be sealed;
- The pumphouse equipment will be removed from the site and salvaged or disposed of, along with the pumphouse building;
- The pumphouse clearing will be re-graded and left in a state conducive to promoting natural revegetation with a minor allowance for active re-vegetation;

- Where possible, intact drill core will be amalgamated to a common storage area: i) construction of a open, roofed storage shelter for long term preservation of the core on site, and/or ii) transfer of representative intervals to the H. S. Bostock Core Library for long term archiving. Core that is to be no longer stored may be emptied from the boxes and placed in the Brown McDade waste rock pile. The boxes may then be disposed of along with other site wood refuse;
- An on-ground inventory of power lines and pipelines has not yet been completed. All costing assumptions are based on satellite photo interpretation, general site knowledge, and other limited information. Degree of access to these sites and the actual amount of cable and other infrastructure remaining in the field will greatly influence decommissioning cost. Additional site information is required; and
- It is understood that the water supply well at Victoria Creek is artesian, however no further details are available. The specific well decommissioning strategy and associated cost will greatly depend on the nature of the aquifer, well configuration, and closure requirements.

Table 5.2-6:
Main Components and Key Assumptions for Miscellaneous Infrastructure

Component	Key Assumptions
Power Supply Infrastructure	Active lines: approximately 5km Historical lines, condition unknown: approximately 4km No hazardous products Limited vehicular access Field verification required
Pipelines	5km of main pipeline routes plus 4 km of miscellaneous pipeline sections in other areas Multiple and/or partial segments of pipeline, majority above ground Pump shacks in various states of repair No hazardous products Limited vehicular access Field verification required
Victoria Creek Pumphouse	One artesian well (characteristics unknown), submersible multi-stage pump, pumphouse 1000 m^2 clearing
Core Storage Areas	Vehicular and heavy equipment access

5.2.6.3 Inventory and Cost

The estimated closure cost for Miscellaneous Infrastructure is approximately $225,000 (Table 5.2-1). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

5.2.7 Miscellaneous Clearings

5.2.7.1 Overview

Given the long mining and exploration history in the area, there are numerous clearings and minor disturbances within the Mt. Nansen OIC boundary that have revegetated naturally and for which site restoration is expected to be relatively simple. Restoration and revegetation of these areas is addressed in the section below.

5.2.7.2 Approach

Objectives

The objectives for remediation of Miscellaneous Clearings include site stabilization for erosion control and enhancement of on-going, natural revegetation. Most sites will require surface preparation including re-contouring, surface roughening, and partial revegetation.

Components, Assumptions, and Uncertainty

Based on available information, there are several sizeable clearings ($\geq$1,000m^2) at the Mt. Nansen site including the following:

- Over 8ha of clearing disturbance has been identified across the exploration and mining areas; and
- Tailings diversion system and upstream and downstream borrow disturbances.

Main uncertainties affecting the Revegetation and Site Restoration of Other Areas closure cost estimate include:

- For costing purposes, 16ha of small clearing disturbance is assumed;
- Surface preparation (removal of minor debris, erosion and runoff control measures, de-compaction, re-contouring, surface roughening) is assumed at an average of 20 heavy equipment hours per hectare;
- Revegetation measures assume that owing to their small size that certain clearings will require minimal revegetation effort, at an assumed average of 15% of the disturbance area;

- An on-ground inventory of clearings to be reclaimed has not yet been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge, and assume that remediation of these sites will be straightforward.
- It has been assumed that clearing areas do not contain refuse, hazardous waste, or hydrocarbon contamination requiring special management; and
- The projected disturbance for new or expanded borrow areas to be used for closure work has not been determined. While some conservatism is built into the current estimates, any significant additional borrow disturbance will require an added allowance for remediation.

5.2.7.3 Inventory and Cost

The estimated closure cost for Revegetation and Site Restoration of Other Areas is approximately $215,000 (Table 5.2-1). Detailed closure cost estimates are provided in Table 2-2 of Appendix C-9.

5.3 Current Condition (Status Quo)

Characterization of geotechnical and geochemical features of the Mount Nansen TSF demonstrate that the status quo at Mount Nansen is not acceptable for final closure. In terms of geotechnical considerations, site investigations conducted by AECOM (AECOM, 2008; 2010) have demonstrated that the tailings dam does not meet the requirements of the 2007 Canadian Dam Association (CDA) Guidelines. Based on the CDA Guidelines, the current facility was found to be inadequate with respect to: 1) stability under earthquake loading scenarios; and 2) the capacity and condition of the spillway. Thawing of permafrost beneath the dam and internal erosion of the dam has also contributed to settlement of the dam crest. These geotechnical aspects require remediation to ensure long-term stability. Secondary issues with regards to the performance of the diversion channel, interceptor ditch, and seepage through the dam were also identified as items requiring maintenance or remediation.

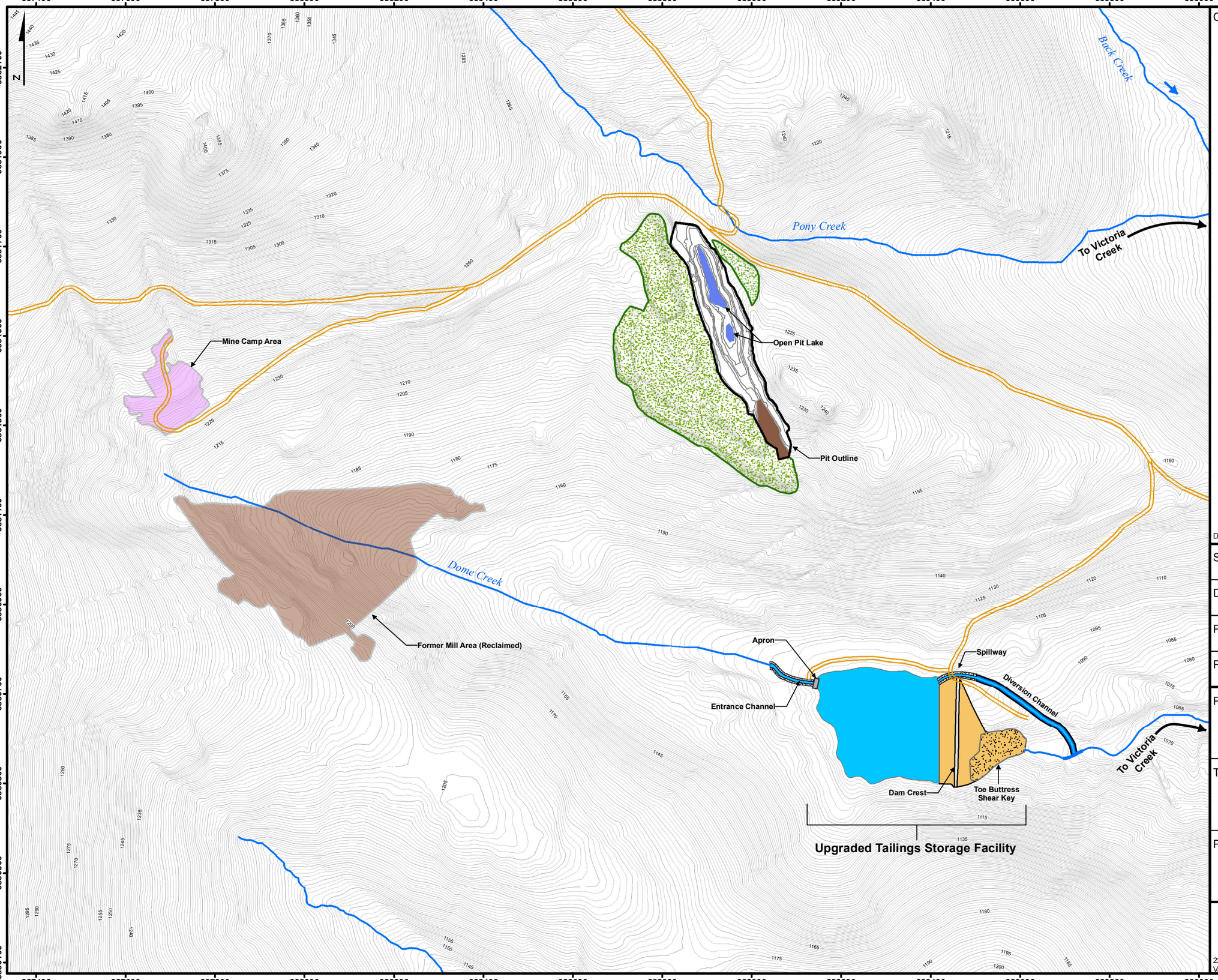
From a geochemical perspective, data in support of the metal leaching (ML) and acid rock drainage (ARD) assessment (Appendix B) indicate that the tailings materials have the potential to generate acidic drainages upon desaturation and exposure to oxygen. The development of acidic drainages is an unacceptable scenario given the predicted high levels of sulfate, trace elements (*e.g.*, As, Cd, Zn) and acidity in seepage waters under low pH conditions. In order to minimize the potential for ML/ARD, long-term management must ensure permanently saturated conditions and the current configuration of the TSF does not meet such requirements.

Given the considerations above, the status quo option was excluded from the options analysis and is not considered further in this report. Additional discussion regarding the development of closure options is provided in Chapter 4.

5.4 Options 1A and 1B: Tailings Dam Upgrade with Water Cover

5.4.1 Overview

Option 1 involves remediation of the existing tailings facility through upgrading of the dam structure and development of a permanent water cover over the tailings (Figure 5.4-1). Within this option, Option 1A maintains the waste rock piles in place (with possible re-grading) while Option 1B entails backfilling of waste rock into the open pit (Figure 5.4-2).



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Water Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:8,000

DATE: OCT 22nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure option 1A: Tailings Dam Upgrade with Water Cover, Waste Rock in Place

PROJECT No:	FIGURE No:
J907-4	**5.4-1**

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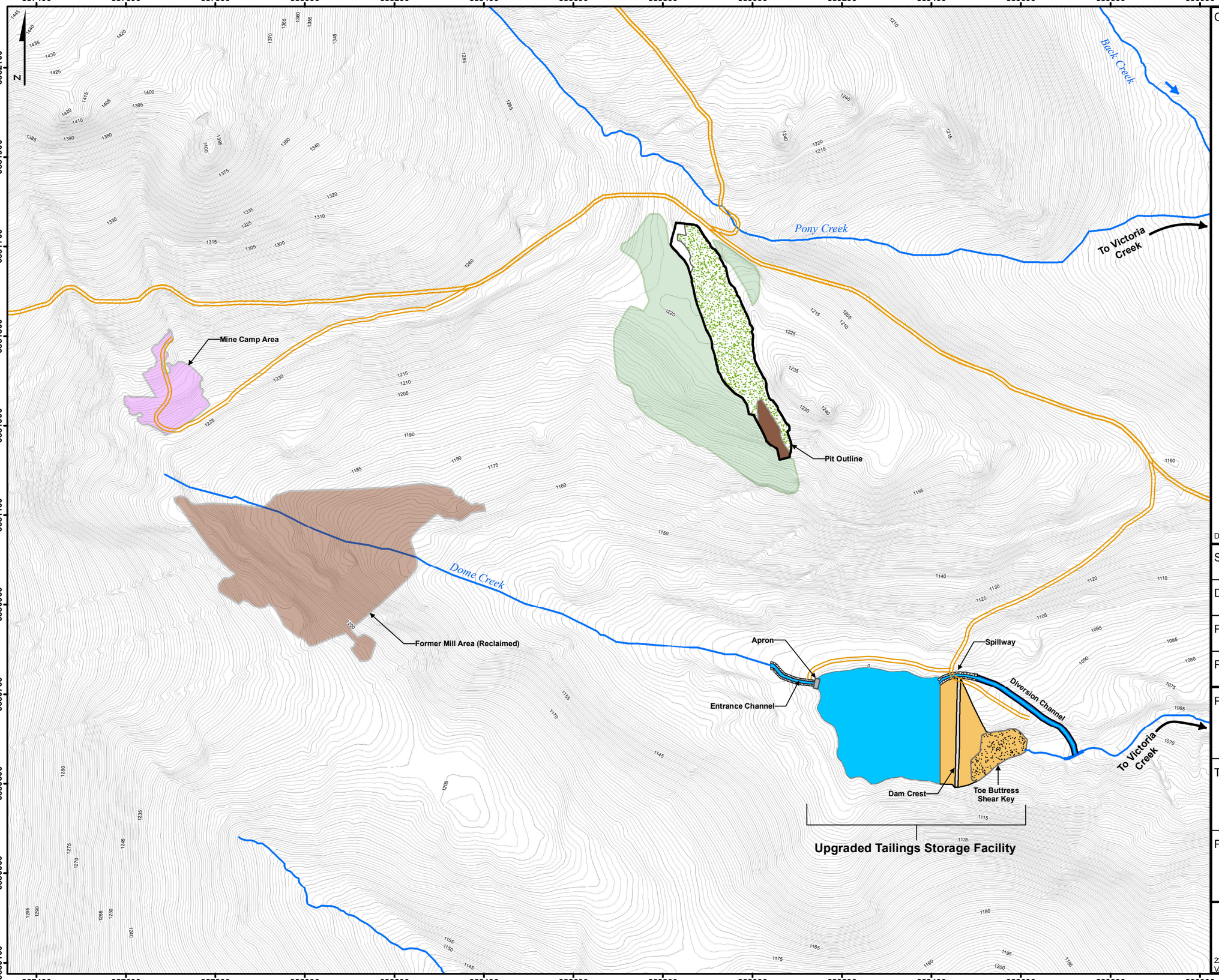

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit_Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Water Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

TITLE:

Closure Option 1B: Tailings Dam Upgrade with Water Cover, Waste Rock Backfill into Pit

PROJECT No:	FIGURE No:
J907-4	**5.4-2**

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The primary objectives of Option 1 are to:

1) Ensure the long-term geotechnical stability of the existing tailings dam;
2) Minimize the potential for tailings oxidation and ML/ARD through the maintenance of a permanent water cover and saturation of tailings solids; and
3) Restore the open pit area to a condition more compatible with the original land use via waste rock backfill (Option 1B only).

As part of Option 1, tailings will first be graded to allow placement of a 0.3 m diffusion-barrier layer. The purpose of the sand layer is to minimize contamination of the water cover from the underlying tailings, as well as to physically stabilize the tailings and prevent their erosion by water and/or wind. A permanent water cover will be maintained on the tailings through the diversion of flow from Dome Creek. Permanently saturated conditions will minimize the potential for sulfide mineral oxidation, thereby precluding the development of acidic drainages and associated metal leaching. A ponded area of 6 hectares (ha) will be created. The maximum water depth (~0.7 m) will be controlled by the elevation of the TSF spillway. Minimum water levels will be dominantly controlled by variations in inflows from Dome Creek; during dry periods, some exposure of the sand diffusion layer may occur.

As part of Option 1B, approximately 500,000 m^3 of waste rock will be backfilled to the open pit (Figure 5.4-2). This will result in the removal and re-location of all existing waste piles into the pit area. The top surface of the backfilled waste rock will be graded to topography compatible with pre-mining land use and revegetated.

A summary of key elements associated with Options 1A and 1B is provided in Table 5.4-1. In the sections to follow, more detailed discussions are provided with respect to the design, performance and uncertainty relating to geotechnical measures, water management, geochemistry, water quality and cost.

Table 5.4-1:
Key closure elements associated with Option 1

Option	Closure Element	Description
1A and 1B	Placement of sand diffusion layer and water cover over the tailings.	A 0.3 m thick sand diffusion layer and 0.7 m water cover will be placed over the tailings. A water cover (6 ha in area) will be maintained over the sand layer to foster a permanently saturated environment for tailings storage, thereby minimizing the potential for tailings oxidation and associated ML/ARD. The combined sand and water cover will also serve to physically stabilize the tailings and minimize water/wind erosion and tailings resuspension.
1A and 1B	Remediation of existing tailings dam.	Upgrades to the existing tailings dam are required to ensure acceptable factors of safety for various loading conditions. Proposed measures are designed to ensure protection against dam failure resulting from overtopping, internal erosion (piping), slope instability, and liquefaction under seismic loading conditions.
1A and 1B	Diversion of Dome Creek into TSF.	In order to maintain saturated conditions within the tailings deposits, diversion of Dome Creek into the tailings pond will be required. This will require armouring of the Dome Creek outlet channel into the TSF.
1A and 1B	Upgrading of TSF spillway.	In order to meet flood-flow requirements, upgrading of the spillway from the tailings pond will be required. The spillway will be used to discharge water from the TSF and control the pond water elevation
1A and 1B	Upgrading of water diversion channel at TSF.	Additional armouring and upgrading of the diversion channel downstream of the emergency spillway may be required
1A and 1B	Tailings Dam Crest	The beach against the upstream face of the dam will be constructed with locally available, inert, Aeolian sand. A layer of non acid generating waster rock will be placed over top to prevent wind and water erosion at the dam crest.
1A and 1B	TSF Seepage control	Two measures are proposed to decrease seepage through the tailings dam: 1) coarse tailings located against the face of the dam will be excavated and replaced with fine tailings; or 2) a liner will be installed between the tailings and dam face. Such measures are required to reduce seepage while maintaining tailings saturation.
1A	Waste rock	Waste rock will be left in place. Physical stability of existing waste rock piles will be assessed, re-graded, and re-vegetated as necessary.
1B	Waste rock and Open Pit	Waste rock will be backfilled into open pit to eliminate void and create landscape more compatible with original land use.

5.4.2 Geotechnical

5.4.2.1 Overview

A number of geotechnical considerations are associated with the evaluation of Option 1, the most important being related to dam stability and water management. A summary of the key considerations for Option 1 are:

- Stability and upgrading of the existing tailings dam and associated works to address the effects of liquefiable soils on the stability of the dam; minimizing seepage through the dam; and upgrading the dam spillway to safely pass potential flood flows;
- Upgrading and sizing of water diversion structures associated with the existing tailings management area;
- Assessing stability and contouring remaining waste rock piles; and
- Placing and contouring waste rock into open pit.

Details of the geotechnical assessment of Option 1 are provided in Appendix C-1 and the most salient components are summarized below.

Upgrades to Dam and Stability Analysis

As stated previously, Option 1 (*e.g.*, 1A and 1B) requires that the existing dam undergo a number of upgrades to increase the factors of safety (FS) for dam stability under a wide range of potential loading conditions. Determining the appropriate design factors of safety (FS), in order to ensure dam stability in perpetuity requires that the dam structure be appropriately classified in accordance with the Canadian Dam Association's, (CDA) *Dam Safety Guidelines* (CDA, 2007). For Option 1, a preliminary classification of *High* consequence facility has been assigned to the Mount Nansen tailings structure. The dam classification of *High* consequence dictates the seismic loading factors for slope stability analysis, design flows (spillway design), and the frequency for dam safety reviews and maintenance and operations.

Existing Dam Stability Characterization

In order to determine the requirements for upgrading the current dam configuration, a stability analysis and assessment of the *existing* (*i.e.*, non-upgraded) tailings dam was performed considering both static (*e.g.,* existing seepage) loads and potential seismic loadings. With respect to the latter, peak ground accelerations (PGA) for the mine site area were estimated using the current seismic hazard model and information developed

by the Geological Survey of Canada for the 2005 Edition of the National Building Code of Canada. A peak (horizontal) ground acceleration of 0.11g, representing a predicted return period of 1 in 2,500, was considered for the pseudo-static loading and this value is consistent with a *High* consequence classification. The CDA (2007) guidelines allow a minimum factor of safety of 1.0 for the pseudo-static loading case for dams with a classification of *High*. For the purposes of assessing existing dam stability at Mt. Nansen, a slightly more conservative factor of safety of 1.1 was assumed for subsequent analysis. A summary of the required factors of safety for dam slope stability for static and pseudo-static loads are summarized in Table 5.4-2 below.

Table 5.4-2:
Loading Cases for Slope Stability Analysis

Case	Loading Condition	Peak Ground Acceleration (return period)	Dam Classification	Minimum FS Against Slope Instability
Static	Steady-state seepage	not applicable (NA)	NA	1.5
Pseudo-static	Earthquake	0.11g (1 in 2,500 yrs)	High	1.1[a]
Static	Post-earthquake	NA	NA	1.2

a: CDA (2007) Guidelines allow a minimum FS of 1.0 for this loading case

In performing stability analysis of the existing tailings dam configuration, a typical stratigraphic profile, perpendicular to the dam center-line was developed. Groundwater elevations through the dam were conservatively assumed to be at levels coincident with the highest levels recorded historically.

The engineering properties of the profile soil units used in the stability analysis are summarized in Table 5.4-3. Soil properties were developed based on engineering judgment 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.

Table 5.4-3:
Soil Properties Used in Slope Stability Analysis

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
Foundation Soil (thawed)	19	28	0
Foundation Soil (Post Earthquake)	19	0	14.4
Rock Fill	21	45	0

Based on the assumed piezometric conditions, seismic loadings and soil properties outlined above, the factor of safety for each of the loading cases was calculated and compared to the required minimum factor of safety to assess the current dam stability in the absence of any upgrades. Results of this analysis are summarized in Table 5.4-4.

Table 5.4-4:
Calculated Factors of Safety for Existing Dam Configuration

Case	Loading Condition	Minimum Acceptable Factor of Safety	Calculated Factor of Safety
Static	Steady state seepage	1.5	1.74
Pseudo Static (PGA 0.11g)	Earthquake	1.1	1.12
Static	Post Earthquake	1.2	0.56

As shown, the existing tailings dam has an adequate factor of safety (>1.7) for the steady state seepage condition assuming high groundwater levels through the dam. Under seismic (pseudo-static) loading conditions, the factor of safety for a 1 in 2,500-yr return period earthquake is 1.12 and exceeds the minimum factor of safety of 1.1. However, the calculated factor of safety for the post-earthquake loading condition is only 0.56 and well below the minimum FS of 1.2. For this latter reason, dam upgrading alternatives were evaluated to determine the requirements for ensuring dam stability at closure under expected and potential loading conditions.

Dam Upgrades

A combination of dam buttressing and ground improvement techniques will be required in order to improve the factors of safety for the dam, primarily for the post-earthquake conditions. While the inclusion of a toe buttress in the upgrade design increases the

calculated factors of safety for the static and pseudo-static loading condition, it is 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. As such, the additional overburden pressure provided by the toe buttress does not effectively increase soil strength.

To address the latter, the inclusion of a shear key in the upgrade design will be necessary in order to achieve an acceptable factor of safety for the dam. A detailed discussion of ground improvement methods including shear key design are provided in Appendix C-6. The primary design calls for a shear key that would essentially replace a portion of the thawed and potentially liquefiable soil with higher strength material beneath the toe buttress of the dam. The shear key could consist of either high strength granular material in a thawed state or frozen foundation material. 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. Collectively, any theoretical failure (slip) surface must then pass through the shear key; it is for this reason that the presence of a shear key increases the factor of safety.

Because the shear key must be keyed into frozen ground, protection against thawing of the permafrost is a critical component of the shear key design and some form of long-term maintenance of the permafrost is required. Alternative mitigation measures that do not require permafrost, such as rock cassions, have also been proposed, however their specific application and cost are not well defined (Appendix C-6). For the prefeasibility assessment, the use of thermosyphons to maintain frozen foundation has been assumed. In support of this assumption, a thermal analysis was conducted by Naviq Consulting to assess the feasibility of developing and maintaining permafrost freeze-back in the thawed foundation and into the toe berm (Appendix I of Appendix C-1). 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. Results indicated that while thermosyphons would be able to provide the necessary freeze-back, their long-term performance is uncertain, and they would require regular maintenance, monitoring, and replacement. A more detailed discussion of the warming sensitivity analysis is provided in Appendix C-1. Uncertainty remains in the detailed design and performance of ground improvement methods for the dam; however a range of alternative designs addresses these uncertainties.

Drainage is another key consideration for the shear key. Measured ground settlements (from observations of monitoring pins) are greater than would be expected from permafrost degradation alone and it is possible that the settlement is related to internal erosion, an observation that warrants close monitoring during subsequent condition assessments. Upgrading the dam therefore includes the placement of a drainage filter 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. Managing seepage while maintaining permafrost conditions within the shear key has been given special consideration, as described in Appendix C-6.

Stability Analysis of Upgraded Dam

A stability analysis was conducted on the upgraded dam that included the following design modifications:

- Toe berm construction against the downstream face of the existing dam;
- Drainage filter on downslope face of the dam along the interface of the dam and toe buttress;
- Construction of a shear key with thermosyphons to ensure maintenance of frozen ground and/or permafrost. Shear key can include granular fill or frozen foundation.

The results of the stability analysis for the upgraded dam is provided in Table 5.4-5 and compares the calculated factors of safety for the upgraded dam with the existing dam. As illustrated, the upgraded dam satisfies the minimum factors of safety for all loading cases evaluated and raises the factors of safety for the static and pseudo static case well above the minimum values. The configuration of Option 1 with respect to the dam and the proposed dam upgrades is presented in Figure 5.4-3.

Table 5.4-5:
Comparison of Calculated Factors of Safety for Existing and Upgraded Dam

		Factor of Safety		
Case	**Loading Condition**	**Minimum Acceptable**	**Existing Dam Condition**	**Upgraded Dam with Toe Butress and Granular Shear Key**
Static	Steady state seepage	1.5	1.74	2.62
Pseudo Static (PGA 0.11g)	Earthquake	1.1	1.12	1.6
Static	Post Earthquake	1.2	0.56	1.26

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 11/05/25 3:03:52 PM
ISSUED: 0A
AECOM FILE NAME: 60159089-08-B-F01-R0X.dwg Saved By: cloustonc
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CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT GRADED TO FIT NATURAL TOPOGRAPHY
REMOVE BRIDGE
SPILLWAY CONTROL
ACCESS ROAD
FORD CROSSING
ACCESS ROAD
DOME CREEK
PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET
ACCESS ROAD
RECONSTRUCT EMERGENCY SPILLWAY
DIVERSION CHANNEL
ENTRANCE CHANNEL
DROP STRUCTURE (TYP)
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
APRON
BORROW AREA TO BE RE-VEGETATED
ACCESS ROAD
ARMOURED DRAINAGE SWALES
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
1097.5
NORTH TERRACE
PLACE ADDITIONAL ARMOURING AS REQUIRED
CREEK CHANNEL
CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT REMOVED TO FIT NATURAL TOPOGRAPHY
DRY CHANNEL
ROCK FILL TOE BERM 7% SLOPE
END OF DIVERSION CHANNEL
ARMOURED DRAINAGE SWALES
ROCK FILL TOE BERM 10% SLOPE
ZONE OF GROUND FREEZING WITH THERMOSYPHONS
DOME CREEK
SEEPAGE
SEEPAGE
DRAINAGE DITCH
SEEPAGE
CREEK

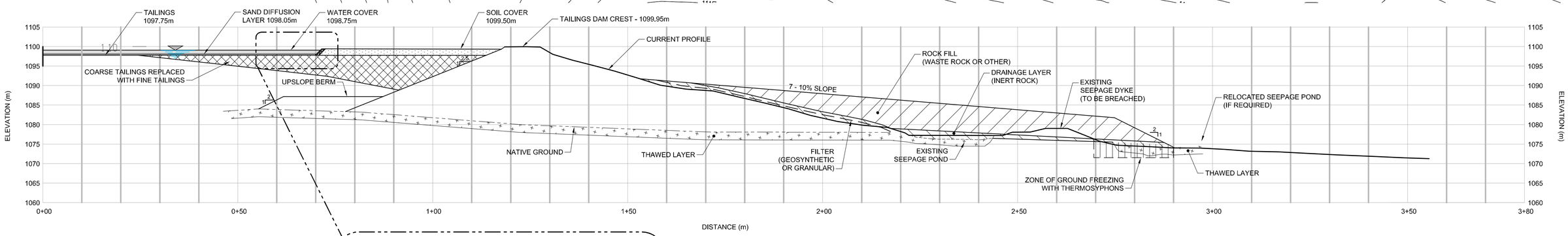
MOUNT NANSEN

0 12.5 25 37.5 m

LEGEND

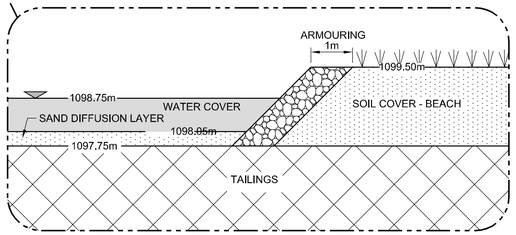
SURVEY BENCH MARK

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



PROFILE A -

0 5 10 15 m



SCALE: NTS

Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 1
Site Plan & Profile
Drawing - 01

Sand Diffusion and Water Cover

As described previously, a 0.3 m thick layer of coarse sand material will be directly laid on top of the tailings material. In addition, a 0.7 m deep water cover will be maintained over top of the sand diffusion barrier in order to maintain the tailings underwater and prevent the onset of tailings oxidation. The purpose of the sand layer is to provide a coarse cover material within the water cover to prevent the resuspension of tailings from wind or wave action.

A beach area will be formed between the crest of the upgraded dam and the water elevation within the impoundment. 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.

Waste Rock Stability

The bulk of the existing waste rock piles will remain in place for closure Option 1A, although some waste rock will be used for other construction activities (*e.g.,* constructing the toe-berm, and spillway armouring). Some additional grading will be required to improve the stability of the piles. Currently the slopes of the waste rock piles are at the angle of repose, which yields a calculated factor of safety of unity (1), under static conditions above the water table. Long-term stability, considering various loading conditions, would require an increased factor of safety that would be determined during detailed design. For the purposes of the present assessment, waste rock regrading for Option 1A has been assumed and included in the cost assessment.

For Option 1B, 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 (Appendix B). The surface of the waste rock in the pit will 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. To the extent possible, vegetation would be established on the surface of the waste rock. The re-exposed natural ground surface beneath the current waste rock piles would also be vegetated.

Pit Wall Stability

The pit walls consist of weathered rock. The talus accumulated on the benches and at the base of the pit confirms that there has been ongoing spawling and erosion of the pit walls. No large-scale instability of the pit walls was noted but evidence such as a 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 and have been factored in the cost analysis for Option 1A.

5.4.2.2 Key Assumptions

The key assumptions employed in the geotechnical evaluation of Option 1A and 1B are as follows:

- The existing dam has an appropriate classification of *High* consequence;
- The dam factors of safety for various loading scenarios can be improved through construction of a toe buttress and shear key;
- Future thawing or degradation of the permafrost can be halted through the use of thermosyphons to maintain frozen ground conditions;
- If thawing cannot be arrested and/or freezing impracticable with thermosyphons, other ground improvement measures, such as rock cassions, have been proposed to a depth of 12m (Appendix C-6); and
- Coarse tailings currently against the dam face can be removed and replaced with finer tailings (or comparably low permeability material) to limit seepage through the dam and maintain all tailings in a saturated state.

5.4.2.3 Performance and Uncertainty

There are a number of regular operations and maintenance items that must be considered with respect to ensuring adequate performance of Option 1 and include the following:

- Dam safety reviews will need to be conducted at the minimum intervals as specified by the Canadian Dam Association Guidelines.
- Dam maintenance and toe-berm maintenance will be required on a regular basis
- Some maintenance is anticipated for the water cover 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.
- Deformations should be monitored at regular intervals after the construction of remedial measures 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.
- The physical stability of the waste rock piles should be considered as part of site inspections.
- 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.
- Because of the maintenance requirements described above, access to the site should be maintained to accommodate the maintenance, and monitoring programs.

The principal uncertainties with respect to successful implementation of Option 1A and 1B from a geotechnical perspective relate to the ability to upgrade the dam sufficiently to ensure stability in perpetuity and the safe storage of saturated tailings. The most important aspect to increasing dam stability is the success of the toe buttress and underlying shear key to offset the presence of liquefiable soils within the foundation of the dam. In order for the shear key to perform as designed, the shear key must be keyed into frozen ground that remains frozen. The extent of, and impacts related to, continued global warming are poorly understood and difficult to predict with existing modeling tools. The ability of thermosyphons to maintain frozen conditions under a warmer climate regime are unknown and long-term monitoring of performance will be integral to the success of Option 1A and 1B. Rock cassions have been proposed as an alternative design that does not rely upon permafrost; however their specific application and cost are not well defined. Rock cassions application is limited to a depth of ~12m, and the applicable depth to competent ground (e.g., bedrock) is uncertain (Appendix C-6).

Also important is the ability to control and limit seepage through the dam, particularly under the saturated conditions specified in Option 1A and 1B. Uncertainty exists in the ability to improve the dam face seepage characteristics by replacing coarse tailings with

fine tailings; however additional cost provisions have been made for the installation of a liner if needed.

The long term integrity of the sand diffusion cover is also uncertain under the climate conditions at Mt. Nansen. Winter freeze-up typically produces ice thickness well in excess of 1 m, suggesting that frozen conditions will likely extend through the water cover and into a portion of the sand diffusion layer. During spring thaw and ice break-up, portions of the sand diffusion cover may be displaced and redeposited at another location within the impoundment, leaving sections of the tailings without a sand cover. This could potentially result in tailings resuspension during the ice-free periods. Additional design considerations to manage resuspension are described in Appendix C-8.

5.4.3 Water Management

5.4.3.1 Overview

Water management assumptions, uncertainties and risks for Option 1A and B are discussed in the next two sections. The overview and description found here also applies directly to Options 2A and B.

As shown in Figure 5.4-3 a permanent saturated cover will be maintained on the tailings by diverting flows from Dome Creek into the impoundment. A ponded area of 6 hectares (ha) will be created, where the maximum water depth (~0.7 m) will be controlled by the elevation of the outflow spillway. Based on an area of 6 ha (60,000 m^2) and a maximum water depth of 0.7 m, a volume on the order of 70,000 m^3 will be available to maintain saturation conditions throughout the year. The water requirements for the saturated soil cover (Option 2) are less than for a water cover (Option 1) due to reduction in evaporation.

Though the impacts on Dome Creek are anticipated to be small (*i.e.*, ponded area compared to Upper Dome Creek catchment area), evaporation rates from the water cover can be expected to exceed rates from the land surface. The introduction of water cover, a higher dam crest (change in storage capacity), and the Dome Creek diversion would continue to "dampen" the Dome Creek hydrograph downstream of the site compared to a pre-mine situation. The effects of such changes on the flow regime of the creek are likely minimal and may in fact increase stream-bank stability. Furthermore, results from hydrogeological studies suggest that changes to groundwater flows would be minimal at the TSF post-implementation of this option.

For Option 1B, the addition of waste rock to the pit lake will have an influence on its water balance. Rates of evaporation from the open water surface would diminish, and the

presence of rock (decrease in storage) may influence local water levels. At this time, the effects of changing surface water catchments around the pit on groundwater levels, groundwater divide, and groundwater flow is not known with certainty. Of particular concern is the susceptibility of the pit to overflow into Pony Creek via the Pony Creek Adit. As a precaution, costs estimates have been made to further seal the adit prior to pit backfill.

5.4.3.2 Key Assumptions

From a water management perspective, the success of this option is contingent on tailings pond water balance (*i.e.*, hydrology and water balance, Section 5.4.5) and includes the management of seepage water through the tailings mass and through the tailings dam, and on the design, monitoring and maintenance of water management structures/controls at the site (dam and crest, spillway, diversion structure, channels). The following assumptions relate most strongly to site hydrology, water management, and the required water infrastructure for the site:

Seepage Control

Seepage through the dam occurs under existing conditions and could potentially increase with increased pond water levels expected under Option 1. Moreover, increased seepage through the dam face could also result in the potential drying out of tailings near the upstream face of the dam. This material is more permeable than the majority of tailings in the impoundment. As such, Option 1A and 1B needs to include measures to reduce seepage rates through the tailings dam at closure.

A 2-dimensional seepage analysis was performed for the tailings dam (Appendix C-1 and Appendix H within that document) for the existing condition to characterize seepage through the dam and evaluate the effects of seepage control strategies. The analysis indicated that a significant reduction in seepage through the dam could occur 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 of a volume of tailings and or the use of lower permeability material or liner.

Spillway Upgrading

Option 1 requires upgrading of the dam closure spillway in order to safely pass flood flows through and over the impoundment. Peak flow rate and volume estimates were computed for the tailings pond to evaluate the necessary spillway upgrading for closure Options 1A and 1B.

Based on the classification of *High* consequence, the CDA (2007) requires that the Inflow Design Flood (IDF) should be estimated as 1/3 between the 1,000-year event and the Probable Maximum Flood (PMF). 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 (Appendix D). 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 (Appendix D).

The 1000-year and 10,000-year rainfall intensities have been extrapolated from the Intensity-Duration-Frequency curves 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. It should be noted that CDA discourages the extrapolation of flood statistics beyond the 1,000-year event and the 10,000 year event 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. Details of the approach are described in Appendix C-1.

A 6-hour storm duration has been assumed for the analysis and in the determination of appropriate spillway dimensions. The assumed 6 hour storm duration peak flow rate for the 1000 year, 10,000 year, 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. Further details are provided in Appendix C-1.

To pass these flows and volumes, various potential spillway widths of 5 m, 7 m 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 allowable water level rise in the tailings pond has been assumed as 1 m. The results of the modeling for various spillway widths and design flow events are summarized in Table 5.4-6.

Based on the above analysis, an upgraded spillway of 5 m width has been selected in the conceptual design to safely 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 final spillway elevation will be dependent upon the final cover design.

Table 5.4-6:
Summary Results of Tailings Pond Spillway Modeling

Design 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	89,000	2.8	0.5
	7			3.1	0.4
	10			3.4	0.3
10,000 - year	5	4.8	107,000	3.5	0.6
	7			3.8	0.5
	10			4.1	0.4
Inflow Design Flood	5	6.8	153,000	5.2	0.7
	7			5.6	0.6
	10			6	0.5
Probable Maximum Flood	5	12.5	281,000	10.3	1.1
	7			11	0.9
	10			11.5	0.8

Dome Creek Diversion and Downstream Diversion Channel Upgrading

Based on water balance modeling for the site (GEEC 2010), it has been determined that in order to maintain a water cover over the tailings for Option 1, it will be necessary to divert the flows in Dome Creek to the tailings impoundment. To accommodate this, the diversion channel upstream of the spillway will be backfilled and graded to fit the natural slope contours. Armouring of the Dome Creek inlet to the tailings facility will be necessary (Figure 5.4-3) to avoid erosion of the tailings material.

The diversion channel, downstream of the tailings impoundment spillway for Option 1, will likely require upgrading with additional armouring. In addition, drop structures in the steeper sections of the diversion channel will also likely require upgrades to maintain acceptable flow velocities and these upgrades have been included in the cost assessment.

Open Pit Lake and Pony Creek Adit (Option 1B)

As part of Option 1B, approximately 510,000 m^3 of waste rock will be backfilled to the open pit (Figure 5-4). Of interest from a water management and cost perspective, is the relationship between water levels in the pit and the overflow elevation of Pony Creek adit. The addition of waste rock to the pit lake would reduce available storage and alter the influence the water balance of the pit site (*e.g.*, evaporation from waste rock is anticipated to be lower than from an open water surface). The pit lake is presently situated at a topographic high (*i.e.,* drainage area that influences the pit is small), and historical data show a disconnection between the pit lake surface and adit. However, it is not clear whether addition of waste rock will affect pit water levels appreciably. The pit lake is not expected to overflow into the Pony Creek Adit; however, as a contingency, costs associated with sealing the adit have been included.

5.4.3.3 Performance and Uncertainty

The primary performance issues, uncertainties and risks for Option 1 and 2 include dam failure, spillway failure and cover efficacy.

Tailings Dam and Spillway Considerations

- Performance and uncertainty is directly linked to the success of the approach taken to decrease seepage rates, reduce the volume of unsaturated tailings, and decrease porewater pressures in the tailings dam (*i.e.*, use of liner or tailings blend).
- Water management assumptions that pertain to current/past conditions (*e.g.*, air temperature, precipitation, permafrost thickness and extent) cannot be extrapolated to the future with certainty.

Cover System

- The performance of the cover system is inextricably linked to the water management plan for the site (*i.e.,* the plan that governs the design, construction, maintenance and monitoring of infrastructure). Much like the performance of the tailings dam, unforeseen maintenance costs may be incurred to repair or enhance performance of the cover system.
- Performance of the cover is dependent on efficacy under a wide range of environmental conditions (*e.g.,* warmer climate where the likelihood of winter discharge events increases).

Water Diversion Structures and Channels

- New water diversion structures will require regulatory approval, as well as routine maintenance.

5.4.4 Geochemistry

5.4.4.1 Overview

Source terms describing drainage chemistry predictions were developed for the tailings in the impoundment, pit lake, and waste rock stored subaerially (1A and 1B) and saturated in the pit (1B). The development of these source terms and a description of existing geochemical conditions are discussed in detail in Appendix B. Acid base accounting and laboratory-based kinetic experiments indicate that the tailings are potentially acid generating. In other words, acidic drainages and associated metal leaching are likely to develop in the long-term if the tailings are exposed to oxygen over extensive periods of time. In this regard, the primary objective of Options 1A and 1B is to maintain the tailings in a saturated state to preclude the development of acidic drainages. In contrast

to the tailings, the waste rock piles are already extensively oxidized and are categorized primarily as non-acid generating.

From a geochemical standpoint, Option 1A closely resembles the *status quo* (*i.e.*, tailings and wasterock left in place)). In Option 1B, the waste rock is moved to the pit where a portion will reside below the water table. The transfer of waste rock from subaerial conditions (oxidizing environment) to saturated conditions (reducing environment) will affect mineral solubility equilibria, potentially resulting in the release of metals. A significant portion of waste rock will also remain above the water table and subaerially exposed. Therefore, the chemistry of the drainage from the pit will be dictated by a combination of geochemical processes occurring in both unsaturated and saturated waste rock environments. To incorporate conservatism into the waste rock source terms under Option 1B, the saturated and unsaturated values for each parameter were compared and the highest value was selected as the backfilled waste rock source term.

5.4.4.2 Key Assumptions

Numerous assumptions were made in deriving source terms for Options 1A and 1B as described below.

Option 1A:

- The geochemical mechanisms that currently dominate remobilization and attenuation within the tailings impoundment, waste rock piles, and pit lake, will continue to be the dominant mechanisms controlling metal mobility in the future;
- All components (pit lake, tailings, and waste rock) have reached pseudo-equilibrium and shifts in this equilibrium state will be minimal with time;
- The groundwater flow paths through the tailings will remain constant (*i.e.,* neither dam upgrades nor degradation of permafrost will significantly alter the groundwater flowpath through and under the impoundment);
- Tailings will remain saturated and will not produce acidic drainage;
- A small diffusive flux of As, Mn, and sulfate (only) from the tailings to the overlying water cover is expected;
- The unsaturated ore field bin, upon which ore source terms were based, is representative of long-term drainage from unsaturated ore; and
- Waste rock is non-acid generating.

Option 1B:

The relocation of waste rock to the pit as part of Option 1B introduces a further set of assumptions with respect to waste rock behaviour:

- As the waste rock is excavated and relocated to the pit, the organic soils underlying the piles will be relocated into the pit along with the waste rock. A portion of the waste rock placed in the pit will be below the water table and saturated. Under these conditions (saturated and presence of organics) suboxic conditions will develop in waste rock pore spaces;
- Metals associated with extensively oxidized waste rock materials are primarily associated with soluble and oxide phases which will be subject to dissolution following submergence and exposure to suboxic conditions;
- Source terms for the saturated waste rock were developed using data generated from the saturated waste rock field bin. This assumes that the field bin has reached an equilibrium state that will be representative of the suboxic conditions that are likely to develop within the pit environment;
- The waste rock stored in the pit above the water table (unsaturated conditions) is assumed to exhibit drainage similar to the current subaerially exposed waste rock piles; and
- The chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both unsaturated and saturated waste rock.

5.4.4.3 Performance and Uncertainty

The source terms developed for each mine component under Options 1A and 1B are provided in Table 5.4-7. The degree of uncertainty associated with the source terms derived for the tailings, waste rock, and the pit lake under Option 1A is low relative to

Table 5.4-7:
Options 1A and 1B Geochemical Source Terms (mg/L)

Parameter	Best Estimate						Upper Estimate					
	Tailings Impoundment		*Pit*		Waste Rock Pile (1A)	Ore	*Tailings Impoundment*		*Pit*		Waste Rock Pile (1A)	Ore
	Seepage	Diffusive Flux ($mg/m^2/day$)	Lake (1A)	Waste Rock (1B)			Seepage	Diffusive Flux ($mg/m^2/day$)	Lake (1A)	Waste Rock (1B)		
Ca	241	-	385	368	368	431	24	-	470	346	346	431
Mg	33	-	124	93	93	297	5	-	163	91	91	297
As	0.04	0.1	0.02	0.1	0.007	0.03	0.3	0.1	0.08	1	0.02	0.04
Cd	0.0009	-	0.02	0.03	0.03	0.09	0.002	-	0.03	0.2	0.2	0.2
Cu	0.009	-	0.03	0.04	0.04	0.02	0.02	-	0.09	0.2	0.2	0.04
Fe	13	-	0.5	2	0.01	0.03	40	-	3.0	5	0.06	0.05
Mn	8	0.1	3	143	5	49	10	0.1	7	181	29	97
Zn	0.02	-	2	5	5	10	0.1	-	3	34	34	31
Sulfate	663	49	1230	2040	1530	2265	1380	49	1690	2940	2940	2680
Ammonia	6	-	0.2	1	0.03	0.03	12	-	0.4	2	0.1	0.09
CN (Tot)	0.7	-	-	-	-	-	0.5	-	-	-	-	-
WAD CN	0.03	-	-	-	-	-	0.2	-	-	-	-	-
Cyanate	2	-	-	-	-	-	18	-	-	-	-	-
Nitrate	3	-	2	0.3	2	0.3	10	-	4	1	10	0.9
Nitrite	0.3	-	0.06	0.1	0.02	0.08	0.6	-	0.3	0.4	0.4	0.1

Notes:
Under the Waste Rock 1B column shaded cells represent terms dominated by unsaturated chemistry, non-shaded cells represent terms dominated by saturated chemistry

Options 3 and 4 due to the fact that there is a large historic dataset from which the source terms were derived. Specifically, the existing data set provide considerable insight into the geochemical mechanisms controlling the remobilization and attenuation of contaminants of concern.

The principal uncertainties associated with Option 1A relate to whether the geochemical processes observed over the past 3-10 years accurately represent a robust proxy for future conditions in the long-term (decadal to century time scales). In particular, the attenuation of As and other trace elements within zones of sulfate reduction has a pronounced effect in minimizing loadings from the tailings facility. Uncertainty also relates to potential changes in seepage flow paths. For example, if dam upgrades or the degradation of permafrost alter groundwater flowpaths through the impoundment, there is the possibility that the attenuation of As and other metals may decrease. Similarly, if the pit lake undergoes significant fluctuations in the water table elevation it may be possible to see higher metal loadings due to increased sulfide oxidation rates during extremely low lake levels, and flushing of soluble metal-bearing phases during periods of high lake levels.

Source terms for the subaerially exposed waste rock (Options 1A and 1B) were derived from data for natural seeps emanating from waste piles on site. These seeps have not been disturbed by construction or human activity, have potentially been active for up to 10 years, and serve as a representative measure of natural weathering processes. Given these considerations, there is a reasonable degree of confidence with regards to the long-term drainage characteristics of subaerially exposed waste rock.

With regards to the waste rock stored in a saturated state below the water table (Option 1B), suboxic conditions are predicted to develop within waste rock pore spaces. To some degree, organic soils underlying the waste rock will inadvertently be transported with the waste rock to the pit. This material will further contribute to the development of suboxic conditions through oxidation of the organic components. Source terms for the saturated waste rock were derived from data collected from waste rock + organics field bin that has evolved from oxic to suboxic conditions. It is not clear if this field bin has reached steady-state redox conditions, and therefore there is some uncertainty with regards to the potential for metal release from these materials under strongly suboxic conditions. Under conditions of more pronounced suboxia, for example, arsenic concentrations in waste rock drainages could be expected to be higher than those values currently observed in the field bin.

Low-grade ore exists as backfill above the southern end of the open pit; however, no drainage chemistry is available from this material as no visible seeps have been identified. To compensate for the absence of field data, a field bin was constructed which

maintains low-grade ore materials in an unsaturated condition. Data collected for this bin were used to derive source terms for the unsaturated ore material. There is significant uncertainty around the usage of drainage chemistry from the field bins in general due to the fact that only 1 year of drainage chemistry has been collected since their installation in July 2009. Based on the drainage chemistry observed to date, it does not appear that the unsaturated ore bin has reached equilibrium and therefore may not be representative of longer-term drainage conditions; further data collection is required to constrain the existing uncertainty.

5.4.5 Surface Water Quality

5.4.5.1 Overview

A water balance and water quality model was developed in Goldsim to support the assessment of closure Option 1A and 1B (Appendix F). Key inputs to the model included precipitation and water quality chemistry from the various source terms (*e.g.*, tailings seepage, waste rock, ore, background Victoria Creek, *etc.*) For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Appendix B). For each scenario, the model was run on a monthly time step for a calendar year (12 months).

The overarching objective of the water balance and water quality modeling was to provide a tool to directly compare the environmental merits and performance of each closure option. To this end, and in order to best illustrate the differences between the closure options with regards to water quality, mill area contaminant loadings were excluded from the assessment. Currently, mill area loadings are a dominant control on downstream water quality and inclusion would obscure the differences in final water quality under the proposed closure scenarios. For these reasons - in concert with the fact that the mill area is a common closure element to all options and will be remediated (Section 5.2) - mill area loadings were ignored in order to differentiate resultant water quality effects from each of the closure options.

In order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Water quality predictions for the above parameters are considered long-term or steady-state estimates. Details of the water balance and water quality model, including model configuration, assumptions and results, are provided in

Appendix F. For the summary presented herein, only the Best Estimate results from the model are presented; all data are described and presented in Appendix F.

For Option 1A and 1B, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for Option 1A and 1B are summarized below.

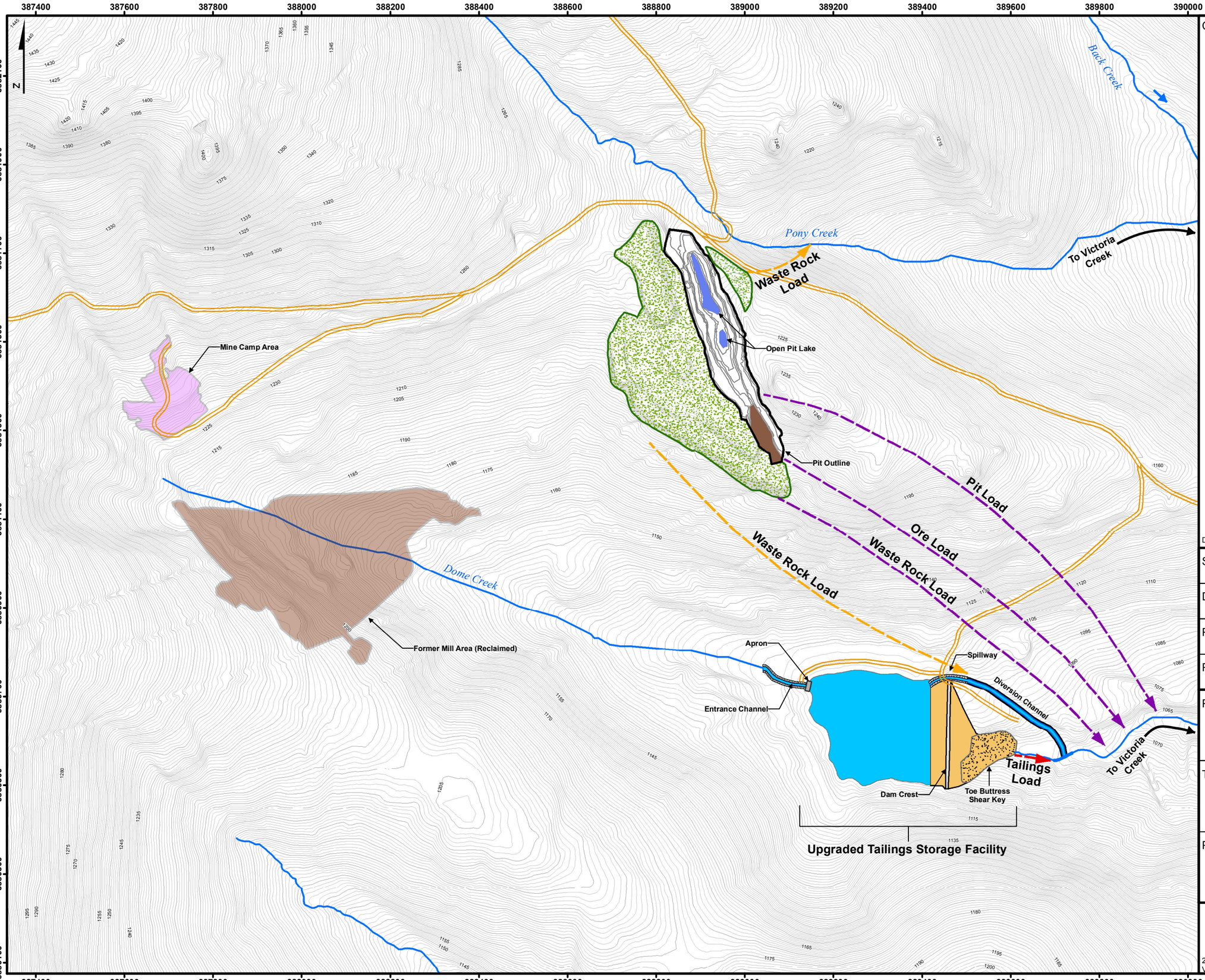
Option 1A:

- Year-round seepage from tailings storage area;
- Seasonal, shallow seepage from portions of waste rock on surface;
- Year-round, deep groundwater seepage from the low-grade ore within the pit;
- Year-round, deep groundwater seepage from portions of waste rock on surface; and
- Year-round, deep groundwater seepage from the pit lake.

Option 1B:

- Year-round seepage from tailings storage area;
- Year-round, deep groundwater seepage from the low-grade ore within the pit; and
- Year-round, deep groundwater seepage from the waste rock backfilled pit.

For Option 1 (1A and 1B), schematics depicting the key components of the water quality model are presented in Figure 5.4-4 and Figure 5.4-5, respectively.



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Water Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure Option 1A:Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.4-4**

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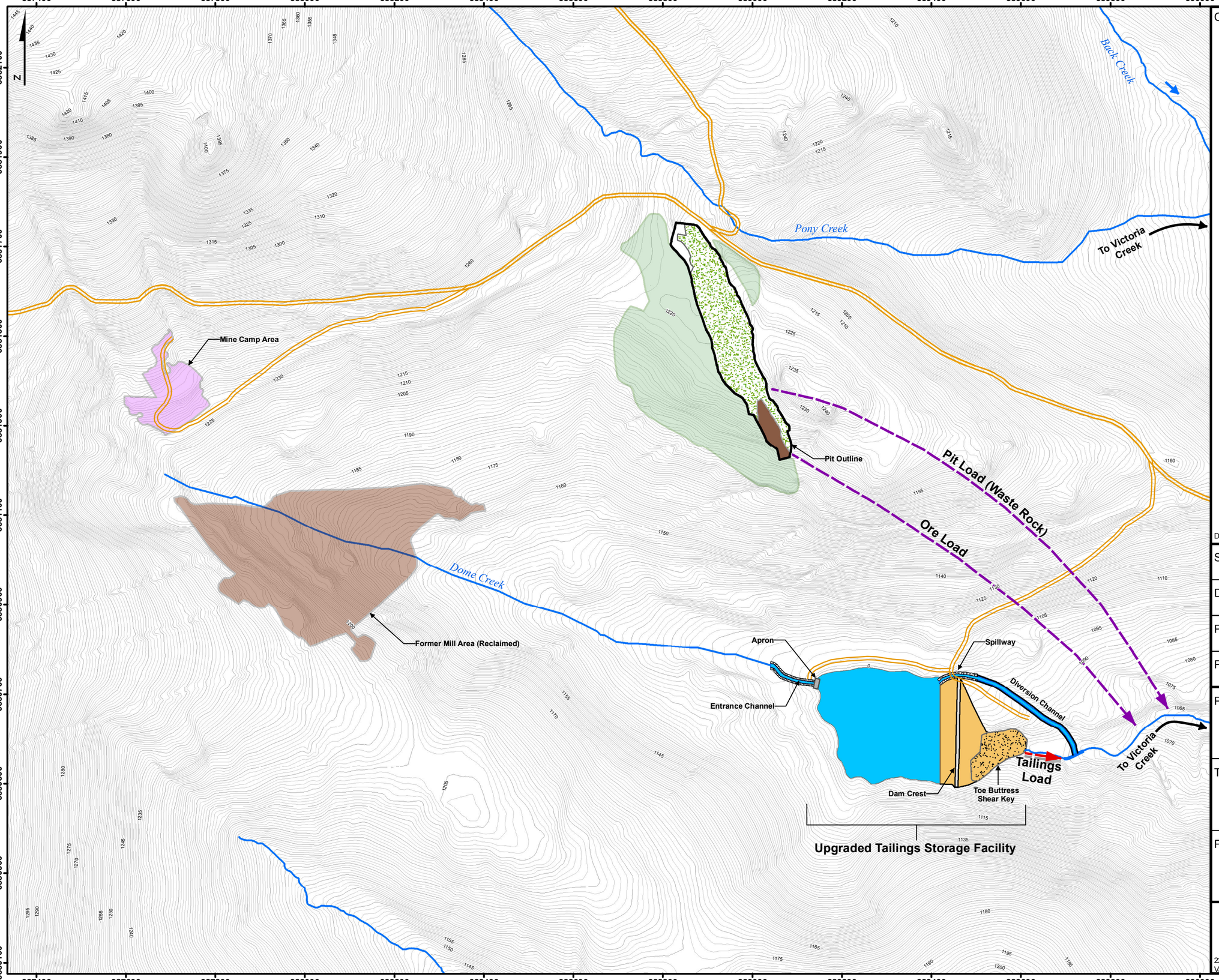

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit_Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Water Cover)
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

TITLE:

Closure Option 1B: Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.4-5**

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5.4.5.2 Key Assumptions

The following are the key assumptions that have been incorporated into the water balance and water quality model for Option 1A and 1B:

- The mill area has been fully reclaimed and as such the water quality upstream of the mill area was assigned to represent the upstream or background water quality in Dome Creek (*i.e.*, the model predictions exclude mine-related loadings emanating from the mill area);
- For un-impacted catchment areas, a runoff coefficient of 0.8 was assumed for spring freshet (April and May) and a runoff coefficient of 0.6 for the remaining open water season months (Appendix D);
- No attenuation (*i.e.*, removal of dissolved metals from solution) is assumed to take place along either the shallow or deep groundwater flow paths from the pit and waste rock areas.
- To support the modeling, a synthetic historical precipitation record was generated for Mount Nansen based on climate data from Carmacks and Mount Nansen between 2000 to 2006 (Appendix D and Appendix F);
- Based on the synthetic precipitation record, dry, wet and average annual precipitation conditions were selected for modeling;
- Annual lake evaporation was estimated based on data from the Pelly Ranch Environment Canada Meteorological gauging station: 369 mm/year (Appendix D and Appendix F);
- For Dome Creek, zero flow was assumed during the winter months (November through March) as attempts to measure winter flow indicates frozen conditions through to the substrate; and
- For Victoria Creek, site monitoring indicates the presence of winter flow. For the model, monthly flow in Victoria Creek was estimated based on the monthly flow distribution in the Nordenskiold River.
- The water cover is modeled as a reservoir with inflows from onset precipitation and runoff from the surrounding catchment area. Outflows include discharge of excess water via the spillway, evaporation from the pond surface area, and vertical infiltration through the tailings and tailings dam;

- Vertical infiltration through the tailings and tailings dams was based on two-dimensional modeling work carried out by AECOM (Appendix C-1) and set to ~1.2 L/s;
- The overall long term seepage rate discharging from the toe of the upgraded dam to the receiving environment was assumed to be similar to the historical low-flow seepage pumping rate for the existing seepage collection pond and was assumed to be constant throughout the year at 3.5 L/s;
- The pit is left as is for Option 1A and the discharge rate from the pit to the receiving environment (*i.e.,* Dome Creek) used in the model was conservatively set to the maximum discharge rate estimated using Darcy's Law for a range of hydraulic conductivities: ~0.13 L/s (Appendix E);
- For seepage from waste rock, a key assumption is that there is no net surface runoff. Snowmelt and onset precipitation either evaporates or infiltrates into the waste rock;
- Waste rock removal or recontouring will not lead to additional chemical loading to Dome Creek;
- Monthly net-infiltration rates for the waste rock dumps were based on the results of a one-dimensional unsaturated flow model developed by Golder (Appendix C-3) and monthly net-infiltration rates were applied uniformly to the entire waste rock surface area;
- Depending on the specific configuration of the dumps, water that infiltrates into the dumps either reports to the receiving environment as variable shallow groundwater seepage or continuous deep groundwater seepage;
- Diffusion rates of arsenic, manganese and sulfate from the tailings porewater to the water cover were estimated to be 8.6, 7.4 and 2,967 grams per day (g/day), respectively; and
- Diffusion of dissolved constituents from the tailings porewater to the water cover is assumed to occur year-round, except between December through March when frozen conditions are present.
- For Option 1B, all the waste rock is relocated into the pit resulting in a reduction in the waste rock footprint from 114,550 m^2 to 36,000 m^2;
- Net-infiltration through the backfilled waste rock in Option 1B was based on the results of a one-dimensional unsaturated flow model (Appendix C-3). The modeling provided computed fluxes including evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the waste;

- Two independent approaches were used to estimate the annual flux through the pit that is partially backfilled. Both estimates yielded fluxes that were very low and well below 0.5 L/s (~0.14 L/s). Accordingly, the assumed groundwater discharge rate from the pit to Dome Creek was assumed to be 0.14 L/s for Option 1B.

5.4.5.3 Performance and Uncertainty

Performance

Water quality predictions for each of the model runs were used to assess the performance of Option 1A and 1B through comparison to existing water quality in the downstream receiving environment in Victoria Creek; CCME Guidelines for the Protection of Aquatic Life are also included as a point of reference.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 1A and 1B are presented in Table 5.4-8 and Table 5.4-9.

Table 5.4-8:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 1A - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0020	0.0055
Cadmium	0.00034[a]	0.00003	0.0003	0.00012	0.00051
Zinc	0.03	0.009	0.02	0.018	0.062
Sulfate		30	61	36	106

Notes:
a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Table 5.4-9:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 1B - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0020	0.0059
Cadmium	0.00034[a]	0.00003	0.0003	0.00006	0.00028
Zinc	0.03	0.009	0.02	0.010	0.035
Sulfate		30	61	35	98

Notes: as per Table 5.4-7

Analysis of the water quality database has shown that existing metal levels in Victoria Creek are governed predominantly by particulate fractions, and show elevated levels in conjunction with TSS (Appendix F). However, there are no consistent seasonal trends in the data, which implies TSS events are governed by variables other than freshet flows, including storm events and upstream placer mining activities. Accordingly, maximum winter concentrations were used for the comparison as they most accurately reflect the range of current water quality conditions during the more sensitive winter low flow period when higher concentrations are predicted to occur. Note however that winter water quality data are limited to only a few samples from 2007 to 2010.

The most salient points (for Best Estimate/Average Flow Scenario) of the water quality predictions for Option 1A are as follows:

For all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. These results are a direct function of the conservative assumptions that the seepage rate from the tailings and discharge rate from the deep groundwater system will remain constant throughout the year despite varying flows in Victoria Creek.

- *Sulfate*
    - In general, the predicted concentrations for sulfate (median = 36 mg/L) are similar to existing sulfate concentrations (median = 30 mg/L) in Victoria Creek, except for winter low flow periods (Table 5.4-8). During this period, the predicted maximum concentration of 106 mg/L is notably higher than the maximum observed winter sulfate concentration (61 mg/L).
    - The primary source of the higher predicted sulfate concentrations in the winter low flow period is the invariant discharge of tailings seepage to the receiving environment at a rate of 3.5 L/s. In reality, it would be anticipated that the seepage discharge would decrease over the winter period, and as such, the winter predictions are considered to be conservative.
- *Arsenic*
    - Predicted concentrations of arsenic (median = 0.002 mg/L) are comparable to existing arsenic concentrations in Victoria Creek (median = 0.0016 mg/L) and are well below the CCME guideline of 0.005 mg/L (Table 5.4-8).
    - Maximum concentrations of arsenic are predicted to occur during winter low flow (peaking at 0.0055 mg/L). This value marginally exceeds the CCME

guideline, although is within the range of the existing maximum winter concentrations (maximum = 0.0075 mg/L).

- The predicted loading associated with tailings seepage is the dominant source of arsenic to the receiving environment.

- *Cadmium*
  - Predicted cadmium concentrations are higher than the existing values currently observed in Victoria Creek.
  - The predicted median cadmium concentration (0.00012 mg/L) is approximately 4 times higher than the existing median concentration in Victoria Creek data (0.00003 mg/L) but well below the CCME guideline (Table 5.4-8).
  - Maximum concentrations of cadmium are predicted to occur in winter (January to March) at concentrations above the draft CCME guideline.
  - The predicted maximum cadmium concentration of 0.00055 mg/L is approximately twice the existing maximum winter concentration 0.0003 mg/L.
  - The predicted loading from seepage from the waste rock dumps is the dominant source of cadmium to the receiving environment.

- *Zinc*
  - The predicted median zinc concentration (0.018 mg/L) is approximately twice the existing median concentration (0.009 mg/L) but below the CCME guideline of 0.03 mg/L.
  - Maximum concentrations of zinc are predicted to occur in winter at concentrations above the CCME guideline.
  - The predicted maximum zinc concentration (0.062 mg/L) is 3 times the existing winter maximum concentration (0.02 mg/L).
  - The predicted loading from seepage from the waste rock dumps is the dominant source of zinc to the receiving environment.

For both cadmium and zinc, the over estimation of concentrations in Victoria Creek is primarily due to the conservative assumptions for seepage from the waste rock dumps to the receiving environment. Observations on site and elsewhere (***e.g.,*** Faro) suggest that south facing slopes do not produce significant seepage due to evaporation. Despite numerous attempts to collect seepage, seeps have not been found from south facing

dumps southwest of the Mt. Nansen pit. As a result, seepage rates from these areas are likely overestimated. Further, seepage from portions of the dumps is assumed to infiltrate into the bedrock aquifer and discharge to Victoria Creek via Dome Creek at a constant rate through the year. This assumption may lead to the overestimation of flows in the winter and underestimation of flows during the active flow period. A further aspect contributing to model conservatism is that the model does not take into account any attenuation of dissolved constituents along the flow path to the receiving environment. Some degree of cadmium and zinc attenuation in the subsurface environment can be expected through adsporption/precipitation processes. Attenuation of cadmium and zinc appears to be currently occurring in the vicinity of the mill area in upper Dome Creek and below the tailings impoundment in lower Dome Creek. The persistence and long-term performance of these mechanisms are however uncertain and therefore not included in the model.

Key highlights of the model results for Option 1B are:

- Similar to Option 1A, for all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to continuous loadings from the site during periods of minimal flow and available dilution.
- *Sulfate*
    - In general, the predicted concentrations of sulfate for Option 1B (median = 35 mg/L; maximum = 98 mg/L) are comparable to those for Option 1A (median = 36 mg/L, maximum = 106 mg/L) (Table 5.4-9).
    - Similar to Option 1A, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.
- *Arsenic*
    - Predicted concentrations of arsenic for Option 1B (median = 0.002 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L (Table 5.4-9).
    - The predicted loading from tailings seepage is the dominant source of arsenic to the receiving environment hence little change would be expected between 1A and 1B.
- *Cadmium*
    - The predicted cadmium concentrations for Option 1B (median = 0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option

1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.

- Comparison of the predicted cadmium concentrations for Option 1B in Victoria Creek to those for Option 1 indicates an improvement in performance (Table 5.4-9).
- The improvement in water quality relates to a decrease in loading from waste rock. Although still the dominant source of cadmium to the receiving environment, the waste rock contributes significantly less loading primarily due to the overall reduction of the waste rock footprint.

- *Zinc*
  - The predicted zinc concentrations for Option 1B (median = 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions (Table 5.4-9).
  - Comparison of the predicted zinc concentrations for Option 1B in Victoria Creek to those for Option 1 indicates an improvement in performance.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint.

Overall, the Best Estimate Average Precipitation model results for Option 1B are comparable to Option 1A and indicate that Victoria Creek water quality would not be degraded for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B indicates an overall improvement compared to those predicted for Option 1A. The predicted decrease in cadmium and zinc concentrations in the receiving environment under Option 1B relative to Option 1A are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling to the open pit.

Uncertainty

As with all predictive models, there are uncertainties related to the various inputs and assumptions that form the basis of the model. Some of these uncertainties are general in nature and apply to all of the options such as monthly flow rates, annual precipitation, evaporation and background or upstream water quality. Others are unique to the specific closure options such as source term chemistry and source discharge or flow rates. Where there is more understanding and/or historical data to support the model assumptions, there is less uncertainty associated with the predicted results. The following provides a

summary of the key uncertainties associated with the modeling results for Option 1A and 1B.

- For the tailings area, Options 1A and 1B have less overall uncertainty associated with the water quality predictions in comparison to the other options primarily due to the long-term flow and water quality records for the seepage collection pond. Specifically, the performance of the existing tailings facility with regards to seepage rates and water quality is predicted to provide a defensible proxy for the performance of Option 1 over the long term. This provides a reasonable amount of confidence in the predictions.
- Conservatism has been incorporated into the model to account for various uncertainties. One key component of conservatism is the assumption of constant seepage rate to Victoria Creek from both the tailings area and from deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism results in high predicted winter concentrations which generally exceed historical winter maximum concentrations. These results suggest the winter flux of contaminants assumed in the model is high and overpredict winter concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months.
- With respect to the tailings area water balance for Option 1A and 1B, one of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain a water cover of 0.7 m, particularly during the open water, non-frozen period. A two-part assessment of the available water supply was carried out for Option 1 as part of the water balance modeling work (Appendix F). The first assessment was carried out assuming a runoff coefficient of 0.8 for spring runoff (April and May) and a runoff coefficient of 0.6 for the remaining open water season months as per AECOM (2010) (Appendix D). Although consistent, it is unclear if these proposed coefficients adequately represent runoff conditions at the site for all locations and conditions.
- A sensitivity analysis was performed for Option 1 assuming a lower runoff coefficient of 0.4 for all the open water season months. Results of this assessment indicate that inflows to the tailings area are generally sufficient to maintain a water cover during the open water season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the water cover to maintain the tailings in a saturated state.
- One of the key assumptions for the Tailings in Place Options (Options 1A and 1B) is that the attenuation processes that act to reduce arsenic concentrations along

subsurface flow paths will continue in the long-term. This assumption is supported by the high concentrations of DOC which persist in Dome Creek and near surface groundwater at locations above and below the tailings impoundment.

5.4.6 Costs

The estimated capital costs for implementing Options 1A and 1B are presented in Table 5.4-10 and Table 5.4-11. The estimated costs include a 30 percent contingency as well as a 15% contingency to cover costs for design engineering, routine inspections and site supervision. These estimates are considered to be Class D estimates (or ASTM E2516-06 Class 5), with an accuracy of -25 +40 percent.

The capital cost estimates do not include the *Pre-Closure Phase Common Closure Element* costs which are described in Section 5.2 and Appendix C-2 and C-9. The estimated capital cost for Option 1A is approximately $15.6 M. Option 1B has an estimated capital cost of roughly $19.3 M. More details related to cost assumptions and breakdown of individual components are found in Appendix C-1, C-2 and C-9.

Table 5.4-10:
Summary of Estimate Capital Costs for Option 1A

Work Item Description	Units	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization	L.S.	1	$ 250,000	**$ 250,000**
Construction of Toe Berm				
Crush, transport and place rockfill	m^3	40,000	$ 35	$ 1,400,000
Geosynthetic filter placement	m^2	5,400	$ 20	$ 108,000
Sub Total				**$ 1,508,000**
Ground Improvement				
Thermosyphons	L.S.	1	$ 600,000	$ 600,000
Drainage, insulation, site prep. etc.	L.S.	1	$ 900,000	$ 900,000
Sub Total				**$ 1,500,000**
Tailings Management Area (TMA)				
Regrading	m^2	71,000	$ 5	$ 355,000
Sand diffusion barrier cover (0.3 m)	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 tails with fine tails	m^3	68,000	$ 12	$ 816,000
Final site preparation, revegetation				$ 34,000
Sub Total				**$ 1,940,000**
Spillway				
Excavation	m^3	2,000	$ 10	$ 20,000
Concrete Overflow	L.S.	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	L.S.	1	$ 15,000	$ 15,000
Sub Total				**$ 270,000**
Dome Creek Diversion into TMA				
Excavation	m^3	750	$ 10	$ 7,500
Geotextile	m^2	675	$ 10	$ 6,750
Armouring	m^3	340	$ 50	$ 17,000
Water Level Controls	L.S.	1	$ 50,000	$ 50,000
Dome Creek Channel and Apron	L.S.	1	$ 50,000	$ 50,000
Sub Total				**$ 131,250**
Dam Raise	L.S.	1	$ 25,000	**$ 25,000**
Diversion/Interceptor Ditch Upstream of Spillway				
Fill in interceptor ditch	m^3	3,400	$ 10	$ 34,000
Fill in Interceptor diversion channel	m^3	5,400	$ 10	$ 54,000
Sub Total				**$ 88,000**
Reslope, regrade and revegetate Waste Rock Storage area				**$ 142,000**
Plug Pony Creek Adit	L.S.			**$ 250,000**
Road construction - base	m^3	900	$ 50	**$ 45,000**
Diversion channel d/s of spillway	L.S.	1	$ 500,000	**$ 500,000**
Monitoring Insrumentation	L.S.	1	$ 200,000	**$ 200,000**
Scale/flatten pit walls	L.S.	1	$ 200,000	**$ 200,000**
Pit safety (signage and berm)	L.S.	1	$ 24,000	**$ 24,000**
Common Elements - Active Closure				**$ 3,670,000**
Sub Total				**$ 10,743,250**
15% Contingency for Engineering Design and Supervision				**$ 1,611,488**
30% Contingency				**$ 3,222,975**
TOTAL ESTIMATED CAPITAL COST - OPTION 1A				**$ 15,577,713**

Table 5.4-11:
Summary of Estimate Capital Costs for Option 1B

Work Item Description		Units	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization		L.S.	1	$ 250,000	**$ 250,000**
Construction of Toe Berm					
Crush, transport and place rockfill		m^3	40,000	$ 35	$ 1,400,000
Geosynthetic filter placement		m^2	5,400	$ 20	$ 108,000
Sub Total					**$ 1,508,000**
Ground Improvement					
Thermosyphons		L.S.	1	$ 600,000	$ 600,000
Drainage, insulation, site prep. etc.		L.S.	1	$ 900,000	$ 900,000
Sub Total					**$ 1,500,000**
Tailings Management Area (TMA)					
Regrading		m^2	71,000	$ 5	$ 355,000
Sand diffusion barrier cover (0.3 m)		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 tails with fine tails		m^3	68,000	$ 12	$ 816,000
Final site preparation, revegetation					$ 34,000
Sub Total					**$ 1,940,000**
Spillway					
Excavation		m^3	2,000	$ 10	$ 20,000
Concrete Overflow		L.S.	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		L.S.	1	$ 15,000	$ 15,000
Sub Total					**$ 270,000**
Dome Creek Diversion into TMA					
Excavation		m^3	750	$ 10	$ 7,500
Geotextile		m^2	675	$ 10	$ 6,750
Armouring		m^3	340	$ 50	$ 17,000
Water Level Controls		L.S.	1	$ 50,000	$ 50,000
Dome Creek Channel and Apron		L.S.	1	$ 50,000	$ 50,000
Sub Total					**$ 131,250**
Dam Raise		L.S.	1	$ 25,000	**$ 25,000**
Diversion/Interceptor Ditch Upstream of Spillway					
Fill in interceptor ditch		m^3	3,400	$ 10	$ 34,000
Fill in Interceptor diversion channel		m^3	5,400	$ 10	$ 54,000
Sub Total					**$ 88,000**
Backfill Pit with Waste Rock					
Load, haul, backfill pit with waste rock		m^3	510,000	$ 5	$ 2,550,000
Regrade and revegetate pit fill, safety measures					$ 53,000
Plug Pony Creek Adit		L.S.	1	$ 250,000	$ 250,000
Sub Total					**$ 2,853,000**
Regrade and revegetate Waste Rock Storage area					**$ 123,000**
Road construction - base		m^3	900	$ 50	**$ 45,000**
Diversion channel d/s of spillway		L.S.	1	$ 500,000	**$ 500,000**
Monitoring Insrumentation		L.S.	1	$ 200,000	**$ 200,000**
Scale/flatten pit walls		L.S.	1	$ 200,000	**$ 200,000**
Common Elements - Active Closure					**$ 3,670,000**
Sub Total					**$ 13,303,250**
15% Contingency - Engineering Design and Supervison					**$ 1,995,488**
30% Contingency					**$ 3,990,975**
TOTAL ESTIMATED CAPITAL COST - OPTION 1B					**$ 19,289,713**

5.5 Options 2A and 2B: Tailings Dam Upgrade with Saturated Soil Cover

5.5.1 Overview

Option 2 (A and B) includes many of the key elements of Option 1, both of which entail remediation of the existing tailings facility through upgrading of the dam structure and maintaining the tailings in a saturated condition. The major difference between these options is that Option 2 includes the placement of a soil cover as opposed to a water cover (Figure 5.5-1). As with Option 1, Option 2A maintains the waste rock piles in place (Figure 5.5-2) while Option 2B includes waste rock relocation to the open pit (Figure 5.5-3).

The objectives of Option 2 are the same as Option 1, with the additional objective of restoring the tailings area to a more natural condition that will allow the establishment of vegetation. In this regard, the objectives include:

1) Ensure the long-term geotechnical stability of the existing tailings dam;
2) Minimize the potential for tailings oxidation and ML/ARD through the maintenance of saturation at the soil cover / tailings interface and within the tailings deposits;
3) Restore the tailings area to a condition more compatible with the original land use through the provision of a medium conducive to the establishment of wetland vegetation; and
4) Restore area of open pit to a condition more compatible with the original land use via waste rock backfill (Option 2B only).

As part of Option 2, the tailings will first be graded to allow placement of a minimum 1 m thick soil cover over the tailings. The soil cover will not be installed as a flat surface; rather the cover will be constructed with topographic irregularities (swales) to be representative of a more natural surface that will allow for efficient flow and infiltration of water. With the removal of the water cover, the soil cover results in improved physical stability of the tailings and the tailings dam due to the absence of wave or ice-induced erosion. The cover will be partially flooded during freshet and will remain dry through the rest of the year, resulting in varied vegetation. The maintenance of saturated conditions within the soil cover will be maintained through the diversion of Dome Creek into the TSF. Maximum water level will be controlled by the elevation of the spillway from the TSF, while minimum water levels will be dominantly controlled by variations in inflows from Dome Creek. During periods of high inflow, near complete inundation of the soil cover can be expected. During dry periods, decreased water levels will expose

large areas of the soil cover. As part of Option 2B, waste rock will be managed as that described for Option 1B (*e.g.*, waste rock to open pit and reclaimed)

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 11/05/25 3:08:49 PM
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AECOM FILE NAME: 60159088-06-B-FIG2-R0X.dwg
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CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT GRADED TO FIT NATURAL TOPOGRAPHY

ACCESS ROAD

SPILLWAY CONTROL

REMOVE BRIDGE

DOME CREEK

PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET

ACCESS ROAD

ACCESS ROAD

RECONSTRUCT EMERGENCY SPILLWAY

ENTRANCE CHANNEL

APRON

DROP STRUCTURE (TYP)

PRIMARY DRAINAGE SWALE

ARMOURED DRAINAGE SWALES

CREEK CHANNEL

DRY CHANNEL

REGRADED TAILINGS AREA:
TAILINGS ELEV. 1097.75m
SOIL COVER ELEV. ±1098.75m
WATER COVER ELEV. ±1098.90m
SPILLWAY ELEV. 1098.90m
SOIL COVER AREA 6.0ha

SOIL COVER BEACH
AREA 1.26ha
ELEV. 1099.65m

TAILINGS DAM CREST

NORTH TERRACE

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

DRY CHANNEL

SWALE

ROCK FILL TOE BERM 7% SLOPE

END OF DIVERSION CHANNEL

ARMOURED DRAINAGE SWALES

ROCK FILL TOE BERM 10% SLOPE

ZONE OF GROUND FREEZING WITH THERMOSYPHONS

DRAINAGE DITCH

SEEPAGE

SEEPAGE

SEEPAGE

CREEK

DOME CREEK

MOUNT NANSEN

0 12.5 25 37.5 m

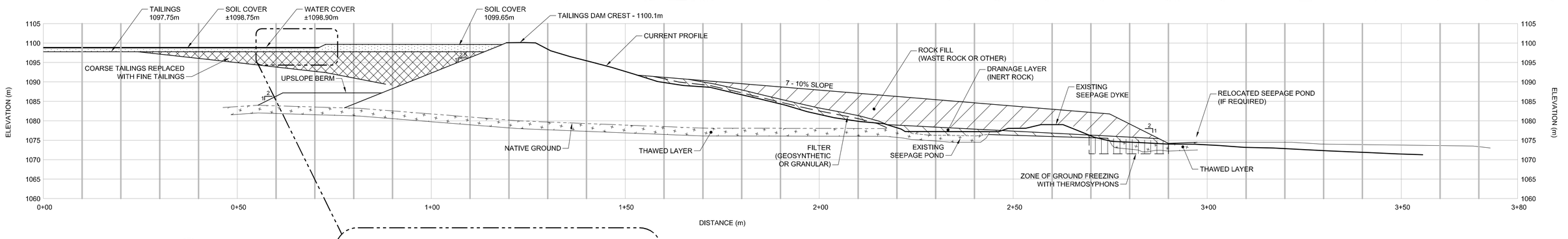
LEGEND

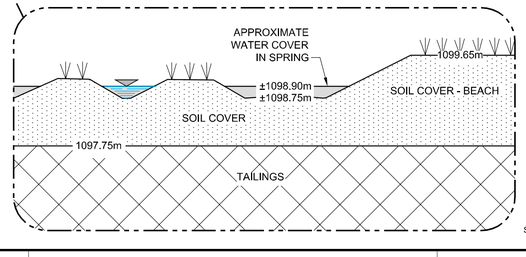
SURVEY BENCH MARK

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

PROFILE A

0 5 10 15 m





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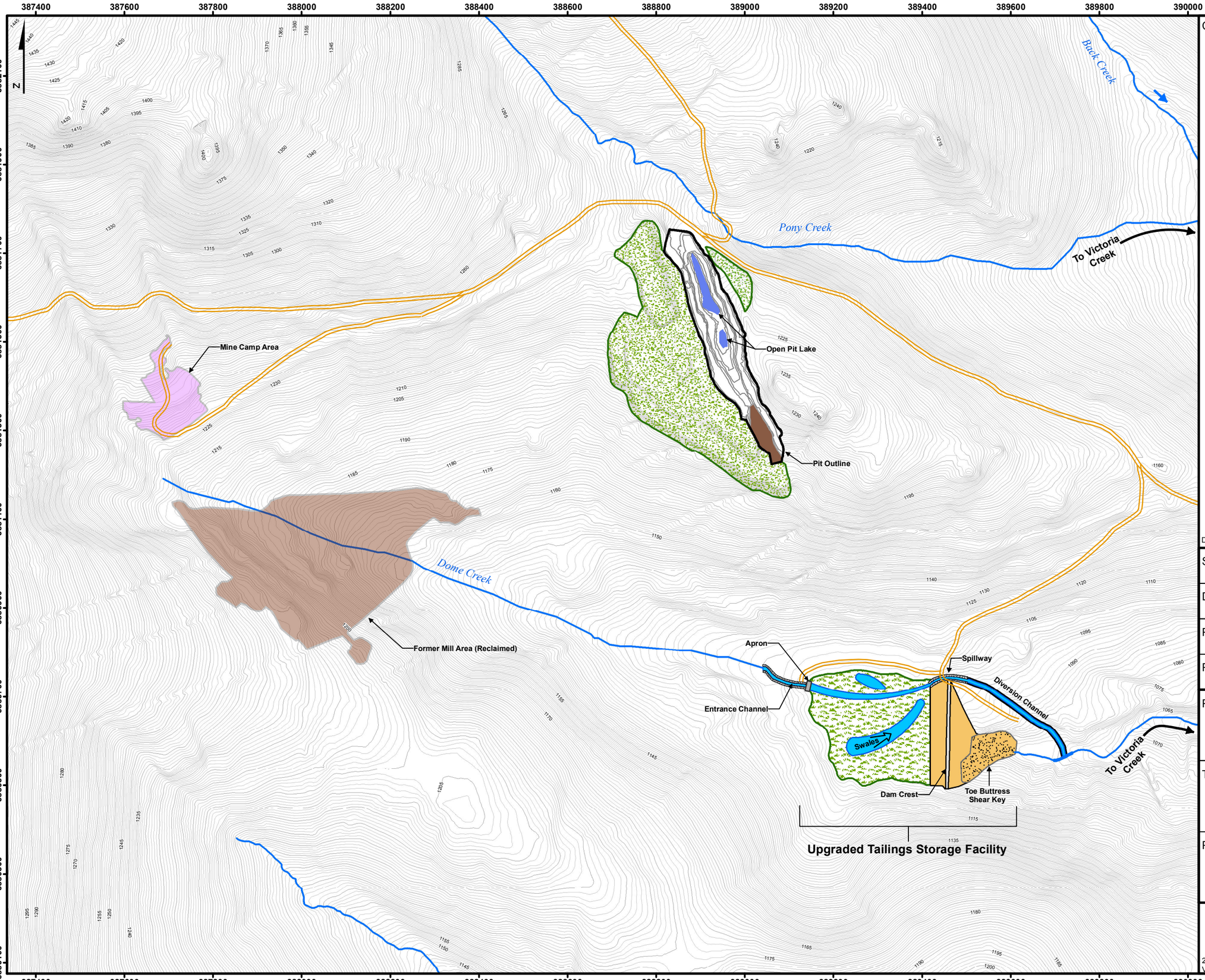
Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 2
Site Plan & Profile
Drawing 02

AECOM



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Saturated Soil Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data Courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

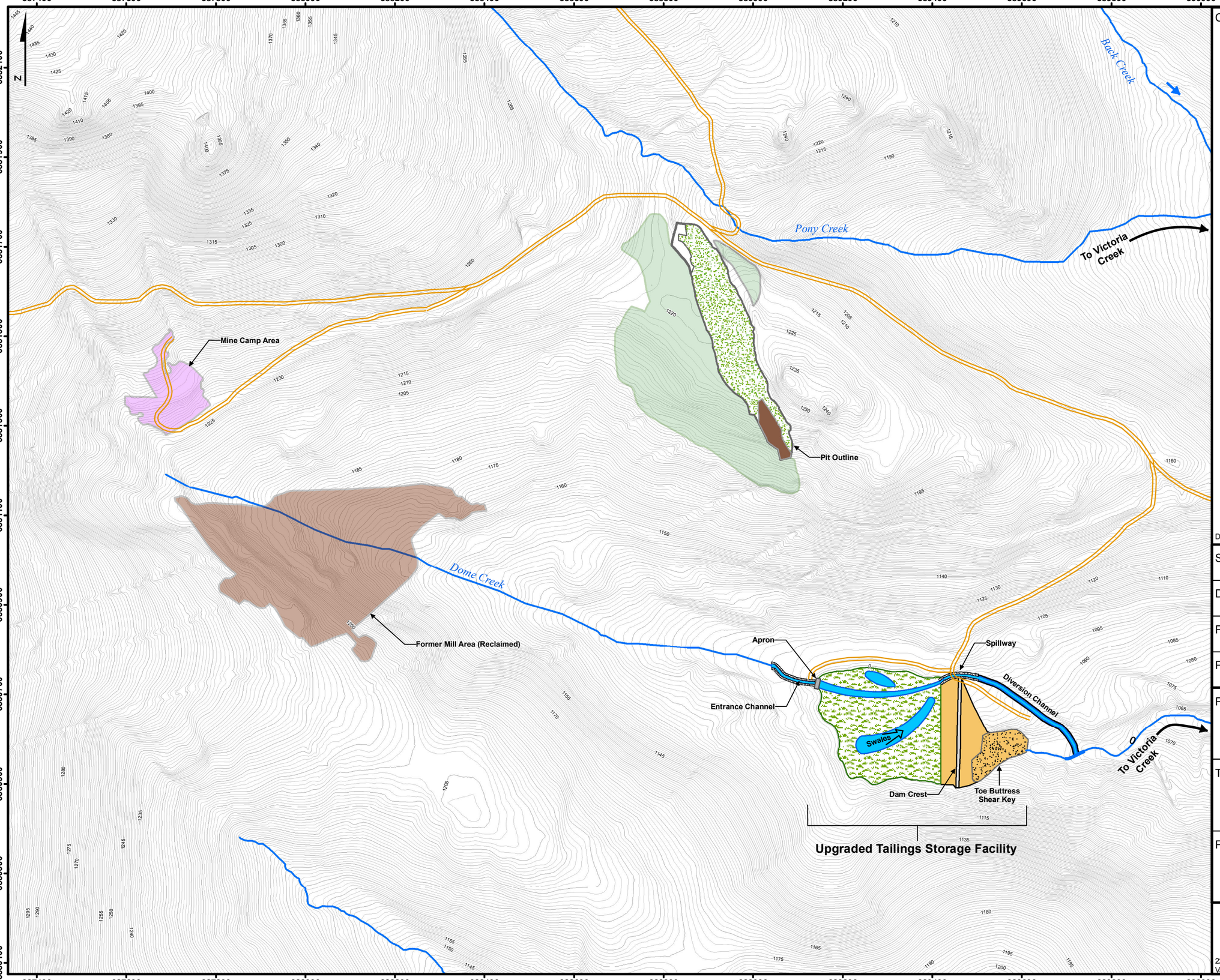
PROJECT:

Mount Nansen Options for Closure

TITLE: **Closure Option 2A: Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place**

PROJECT No:	FIGURE No:
J907-4	**5.5-2**

LORAX ENVIRONMENTAL
2289 Burrard St.
Vancouver, BC, V6J 3H9
Phone: (604) 688-7173
Website: www.lorax.ca



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Dam Area
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Saturated Soil Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:8,000

DATE: OCT 22th, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE: **Closure Option 2B: Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock Backfill into Pit**

PROJECT No:	FIGURE No:
J907-4	**5.5-3**

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A summary of key elements associated with Options 2A and 2B is provided in Table 5.5-1. In the sections that follow, more detailed discussions are provided with respect to the design, performance and uncertainty relating to geotechnical measures, water management, geochemistry, water quality and cost.

Table 5.5-1:
Key closure elements associated with Option 2

Option	Closure Element	Description
2A and 2B	Placement of a saturated soil cover over the tailings.	A 1.0 m thick saturated soil cover will be placed on top of the tailings. The soil cover will also serve to physically stabilize the tailings and minimize water/wind erosion.
2A and 2B	Remediation of existing tailings dam.	Upgrades to the existing tailings dam are required to ensure acceptable factors of safety for various loading conditions. Proposed measures are designed to ensure protection against dam failure resulting from overtopping, internal erosion (piping), slope instability, and liquefaction under seismic loading conditions.
2A and 2B	Diversion of Dome Creek into TSF.	In order to maintain saturated conditions within the tailings deposits, diversion of Dome Creek into the tailings pond will be required. This will require armouring of the Dome Creek outlet channel into the TSF.
2A and 2B	Upgrading of TSF spillway.	In order to meet flood-flow requirements, upgrading of the spillway from the tailings pond will be required. The spillway will be used to discharge water from the TSF and control the pond water elevation
2A and 2B	Upgrading of water diversion channel at TSF.	Additional armouring and upgrading of the diversion channel downstream of the emergency spillway may be required
2A and 2B	Tailings Dam Crest	The beach against the upstream face of the dam will be constructed with locally available sand. A layer of non acid generating waster rock will be placed over top to prevent wind and water erosion at the dam crest.
2A and 2B	TSF Seepage control	Two measures are proposed to decrease seepage through the tailings dam: 1) coarse tailings located against the face of the dam will be excavated and replaced with fine tailings; or 2) a liner will be installed between the tailings and dam face. Such measures are required to reduce seepage while maintaining tailings saturation.
2A	Waste rock	Waste rock will be left in place. Physical stability of existing waste rock piles will be assessed, re-graded, and re-vegetated as necessary.
2B	Waste rock and Open Pit	Waste rock will be backfilled into open pit to remove void and create landscape more compatible with original land use.

5.5.2 Geotechnical

5.5.2.1 Overview

The overview of geotechnical considerations provided in Section 5.4.2.1 for Option 1 is applicable for Option 2A and 2B with the exception of the detail related to saturated soil cover design; all other components related to dam upgrades, waste rock stability and pit wall stability are identical and are not repeated herein. Geotechnical considerations for the soil cover for Option 2 are summarized below and are provided in more detail in Appendix C-1.

Soil Cover

As previously described, a saturated soil cover will be placed directly on top of tailings. 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 total "soil" volume required for the cover has been estimated to be approximately 60,000 m^3. This quantity of suitable material is not available at the mine site. 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 material is a well-graded gravelly sand containing 16% silt and 6% clay. 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 Aeolian and 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.

5.5.2.2 Key Assumptions

The key assumptions employed in the geotechnical evaluation of Option 2A and 2B are similar to those described for Option 1 and are as follows:

- The existing dam has an appropriate classification of *High* consequence;
- Future thawing or degradation of the permafrost can be halted through the use of thermosyphons to maintain frozen ground conditions;
- If thawing cannot be arrested and/or freezing impracticable with thermosyphons, other ground improvement measures will be available;
- Coarse tailings currently against the dam face can be removed and then replaced with finer tailings to limit seepage through the dam; and
- A suitable quantity of suitable soil cover material is readily available.

5.5.2.3 Performance and Uncertainty

The same performance and uncertainties described in Section 5.4.2.3 for Option 1 are applicable for Option 2A and 2B. In addition, the presence of an irregular cover, designed to promote vegetation growth as well as maintain saturated conditions will likely require significant maintenance in the early years following cover placement. Regrading of the tailings material will be necessary and differential settlement following regarding and cover placement may result in a drainage surface that does not perform satisfactorily. The time and amount of maintenance required to stabilize the cover and ensure hydrological characteristics of the covered impoundment perform acceptably is a significant uncertainty of Option 2.

5.5.3 Water Management

5.5.3.1 Overview

The maintenance of saturated conditions within the soil cover will be maintained through the diversion of Dome Creek into the TSF. Maximum water level will be controlled by the elevation of the spillway from the TSF, while minimum water levels will be predominantly controlled by variations in inflows from Dome Creek. During periods of high inflow, near complete inundation of the soil cover can be expected. During dry periods, it is hypothesized that decreased water levels will expose large areas of the soil cover.

Though the impacts on Dome Creek are anticipated to be small (*i.e.*, newly covered area compared to Upper Dome Creek catchment area is small), evaporation rates from the soil

cover are expected to exceed rates from the land surface pre-cover. The introduction of the high infiltration soil cover, a higher dam crest (change in storage capacity) and the Dome Creek diversion would continue to "dampen" the Dome Creek hydrograph downstream of the site. The effects of such changes on the flow regime of Dome Creek are anticipated to remain small. The addition of waste rock to the pit lake will have an influence on its water balance. Once filled, rates of evaporation from the cover would be lower than for an open water surface, and the presence of rock (decrease in storage) may influence local water levels. At this time, the effects of changing surface water catchments around the pit on groundwater levels, groundwater divide and flow is not known.

5.5.3.2 Key Assumptions

Assumptions and considerations presented here closely parallel those presented in Section 5.4.3 and are briefly summarized below.

Spillway design

A hydraulic analysis has been carried out to size and cost spillway – many of the key details are summarized for Option 1A and B in section 5.4.3. Peak flows rates for the 1000-yr, 10,000 yr, probable maximum flood and inflow design flood were determined to be 4.0, 4.8, 12.5 and 6.8 m^3/s respectively. These rates translate to event volumes of 89,000, 107,000, 281,500 and 153,000 m^3 and were used to optimize spillway design.

Diversion Channel Upgrading

Implementation of Options 2 will require the direction of flows from the tailings pond diversion catchment (Upper Dome Creek) into the proposed tailings pond. To accommodate this, the diversion ditch upstream of the spillway will be backfilled and graded to fit the natural slope contour and the Dome Creek channel will be diverted over the tailings.

Open Pit Lake and Pony Creek Adit (Option 2B)

As part of Option 2B, approximately 500,000 m^3 of waste rock will be backfilled to the open pit (Figure 5-4). As per Option 1, there is concern that water levels at the waste rock storage site may rise and connect to the Pony Creek adit (and Pony Creek). As a contingency, closure costs to seal the bulkhead in the adit have been included.

5.5.3.3 Performance and Uncertainty

There are many similarities in performance and uncertainty when Options 1 and 2 are directly compared. The primary performance issues, risks and uncertainties for Option 2

include dam failure, spillway failure and cover efficacy. In general, the risks associated with Option 2 are assumed to be less than Option 1 owing to the smaller water volumes (*e.g.,*<10,000 versus 70,000 m^3) required to maintain the respective cover systems and the assumed shorter run-out should a dam breach occur under Option 2. The considerations presented below parallel those presented in Section 5.4 for Option 1.

Cover System for Option 2

- The performance of the cover system is inextricably linked to the water management plan for the site (*i.e.,* the plan that governs the design, construction, maintenance and monitoring of infrastructure). Much like the performance of the tailings dam, routine and unforeseen maintenance costs will be incurred
- Performance of the cover is linked to the ability of coarse grained tailings to maintain saturation and on performance under a wide range of environmental conditions. Cover effectiveness has yet to be tested rigorously under a range of conditions.

Water Diversion Structures and Channels

- New water diversion structures will require regulatory approval, and frequency and cost for routine or unexpected maintenance going forward is uncertain.

5.5.4 Geochemistry

5.5.4.1 Overview

As part of the Option 2 analysis, source terms for the water quality prediction model were developed for the tailings in the impoundment, pit lake, and waste rock stored subaerially (2A and 2B) and saturated in the pit (2B). The development of these source terms, as well as a description of existing geochemical conditions, is discussed in detail in Appendix B. From a geochemical standpoint, Options 2A and 2B will exhibit the same geochemical performance as Options 1A and 1B. Specifically, under both Options 1 and 2, the tailings will be maintained in a saturated state to preclude sulfide oxidation and associated metal leaching under acidic conditions. Accordingly, the mass loading model assumes that the geochemical processes currently controlling metal mobility will persist under Option 2A.

As per Option 1B, Option 2B involves relocating waste rock to the pit where a portion will be stored below the water table, potential resulting in the release of metals associated with phases that are unstable in suboxic settings (*e.g.*, Fe oxides). A significant portion of waste rock will also remain above the water table in an unsaturated state. Accordingly, the leaching properties of waste rock stored in the pit, and resulting

drainage chemistry, will reflect a combination of geochemical processes occurring within both unsaturated and saturated settings.

5.5.4.2 Key Assumptions

The assumptions in support of the derivation of source terms for Options 2A and 2B are essentially the same as those presented under Options 1A and 1B in Section 5.4.4.2.

Option 2A:

- The geochemical mechanisms that currently dominate remobilization and attenuation within the tailings impoundment, waste rock piles, and pit lake, will continue to be the dominant mechanisms controlling metal mobility in the future.
- All components (pit lake, tailings, and waste rock) have reached pseudo-equilibrium and shifts in this equilibrium state will be minimal in the long term;
- The groundwater flow paths through the tailings will remain constant (*i.e.,* neither dam upgrades nor degradation of permafrost will significantly alter the groundwater flowpath through and under the impoundment);
- Tailings will remain saturated and will not produce acidic drainage;
- The unsaturated ore field bin, upon which ore source terms were based, is representative of long-term drainage from unsaturated ore; and
- Waste rock is non-acid generating.

All the assumptions made under Option 2A will apply to Option 2B with the exception of those relating to waste rock:

- Suboxic conditions will develop in the porewaters of saturated waste rock;
- Metals in the extensively oxidized waste rock are primarily associated with soluble and oxide phases which will be subject to dissolution under saturated/suboxic conditions;
- Source terms derived for saturated waste rock from data generated from the saturated waste rock field bin are representative of the suboxic conditions that are likely to develop within the pit;
- Waste rock stored in the pit and above the water table is assumed to exhibit drainage characteristics similar to that currently observed for subaerially exposed waste rock piles; and

- The chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both unsaturated and saturated portions of waste rock.

5.5.4.3 Performance and Uncertainty

The source terms developed for each mine component under Options 2A and 2B are provided in Table 5.5-2. As discussed for Option 1A, the degree of uncertainty associated with the source terms derived for Option 2A is less compared to other options given the availability of extensive historic data for the tailings impoundment that provide insight into both remobilization and attenuation mechanisms.

The areas of uncertainty for Option 2A are the same as those for Option 1A. The major uncertainty associated with Option 2A relates to whether the geochemical processes observed over the past 3 to10 years accurately represent a proxy for long-term conditions (see section 5.4.4.3 for more detail). There is also uncertainty relating to whether the drainage chemistry data for waste rock are representative of the all waste rock types. As described in Section 5.4.4.3, there is also significant uncertainty associated with the representativeness of the field bin data collected to date in support of long-term drainage predictions for the saturated waste rock and unsaturated ore.

Table 5.5-2:
Options 2A and 2B Geochemical Source Terms (mg/L)

	Best Estimate					**Upper Estimate**				
	Tailings	*Pit*				*Tailings*	*Pit*			
Parameter	Seepage	Lake	Waste Rock (2B)	Waste Rock Pile (2A)	Ore	Seepage	Lake	Waste Rock (2B)	Waste Rock Pile (2A)	Ore
Ca	241	385	368	368	431	24	470	346	346	431
Mg	33	124	93	92.7	297	4.6	163	91	91	297
As	0.04	0.02	0.12	0.0068	0.026	0.3	0.08	1.2	0.023	0.041
Cd	0.0009	0.02	0.027	0.033	0.09	0.0015	0.03	0.18	0.18	0.201
Cu	0.009	0.03	0.04	0.039	0.015	0.015	0.09	0.23	0.23	0.036
Fe	13	0.5	2.15	0.01	0.03	40	2.97	5.3	0.06	0.05
Mn	8	2.91	143	4.8	49	10	6.9	181	29	97.4
Zn	0.02	1.76	5.14	5.14	10.4	0.1	2.92	34	34	31.2
Sulfate	663	1230	2040	1530	2265	1380	1690	2940	2940	2680
Ammonia	6	0.18	1.25	0.03	0.03	12	0.4	1.5	0.12	0.093
CN (Tot)	0.7	-	-	-	-	*0.5*	-	-	-	-
WAD CN	0.03	-	-	-	-	*0.15*	-	-	-	-
Cyanate	2	-	-	-	-	*18*	-	-	-	-
Nitrate	3	1.71	0.32	2	0.33	10	3.85	1.37	9.96	0.85
Nitrite	0.3	0.06	0.1	0.023	0.08	0.6	0.3	0.40	0.36	0.1

Notes:
Under the Waste Rock 2B column shaded cells represent terms dominated by unsaturated chemistry, non-shaded cells represent terms dominated by saturated chemistry

5.5.5 Surface Water Quality

5.5.5.1 Overview

A water balance and water quality model was developed in Goldsim to support the assessment of closure Option 2A and 2B. Key inputs to the model included precipitation and water quality chemistry from the various source terms (*e.g.*, tailings seepage, waste rock, ore, background Victoria Creek, *etc*.). For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Appendix B). For each scenario, the model was run on a monthly time step for a calendar year (12 months).

The overarching objective of the water balance and water quality modeling was to provide a tool to directly compare the environmental merits and performance of each closure option. To this end, and in order to best illustrate the differences between the closure options with regards to water quality, mill area contaminant loadings were excluded from the assessment. Currently, mill area loadings are a dominant control on downstream water quality and inclusion would obscure the differences in final water quality under the proposed closure scenarios. For these reasons - in concert with the fact that the mill area is a common closure element to all options and will be remediated (Section 5.2) - mill area loadings were ignored in order to differentiate resultant water quality effects from each of the closure options.

In order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Water quality predictions for the above parameters are considered long-term or steady-state estimates. Details of the water balance and water quality model, including model configuration, assumptions and results, are provided in Appendix F. For the summary presented herein, only the Best Estimate results from the model are presented; all data are described and presented in Appendix F.

For Option 2A and 2B, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for Option 2A and 2B are summarized below.

Option 2A:

- Year-round seepage from tailings storage area;
- Seasonal, shallow seepage from portions of waste rock on surface;

- Year-round, deep groundwater seepage from the low-grade ore within the pit;
- Year-round, deep groundwater seepage from portions of waste rock on surface; and
- Year-round, deep groundwater seepage from the pit lake.

Option 2B:

- Year-round seepage from tailings storage area;
- Year-round, deep groundwater seepage from the low-grade ore within the pit; and
- Year-round, deep groundwater seepage from the waste rock backfilled pit.

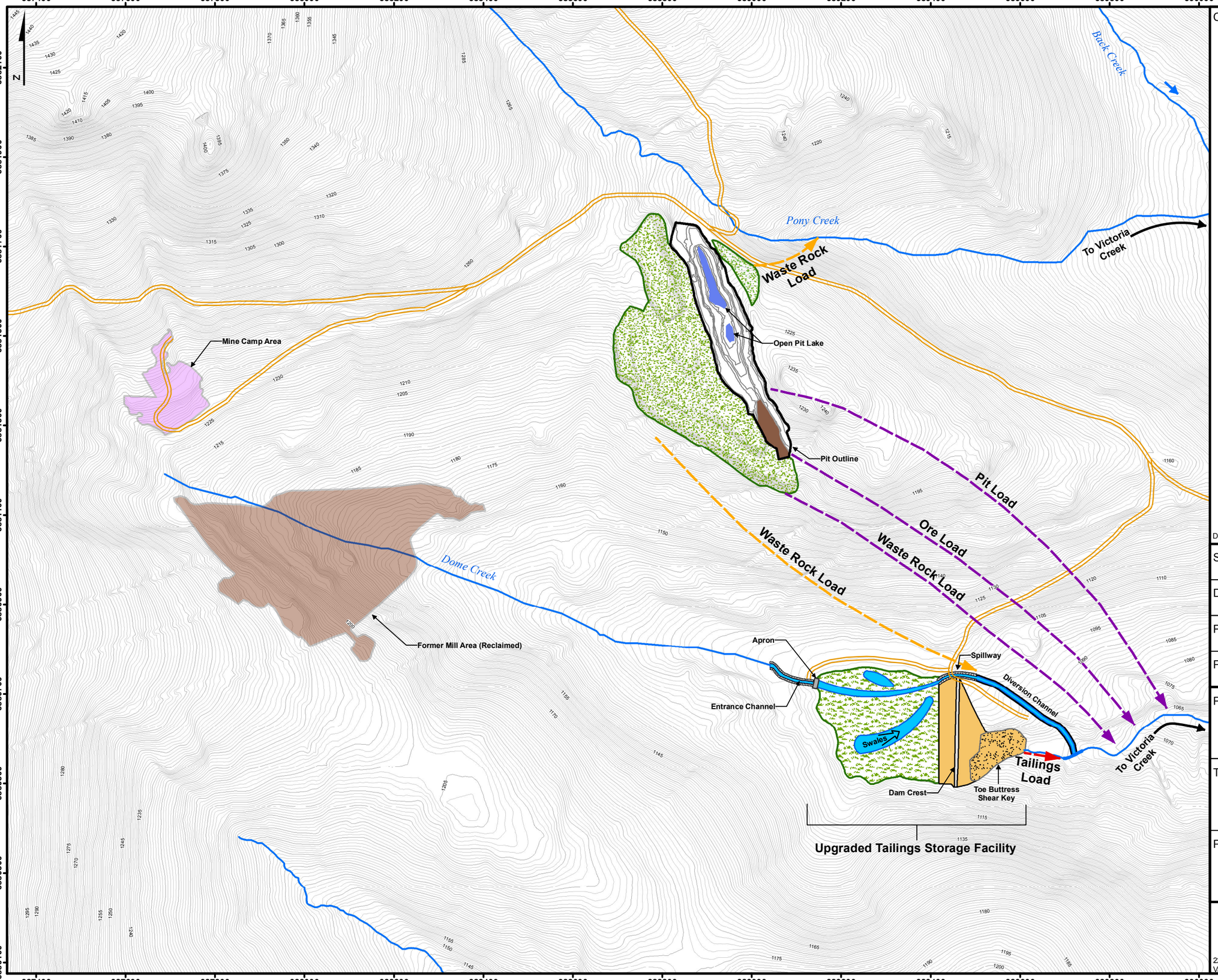
For Option 2 (2A and 2B), schematics depicting the key components of the water quality assessment are presented in Figure 5.5-4 and Figure 5.5-5, respectively.

5.5.5.2 Key Assumptions

The key assumptions incorporated into the water balance and water quality model for Option 2A are the same as those outlined in Section 5.4.5.2 for Option 1A with the exception of those related to the tailings area, and specifically the tailings cover.

The following are the key assumptions that have been incorporated into the water balance and water quality model for Option 1A and 1B:

- The mill area has been fully reclaimed and as such the water quality upstream of the mill area was assigned to represent the upstream or background water quality in Dome Creek (*i.e.*, the model predictions exclude mine-related loadings emanating from the mill area);
- For un-impacted catchment areas, a runoff coefficient of 0.8 was assumed for spring freshet (April and May) and a runoff coefficient of 0.6 for the remaining open water season months;
- No attenuation (*i.e.*, removal of dissolved metals from solution) is assumed to take place along either the shallow or deep groundwater flow paths from the pit and waste rock areas.
- To support the modeling, a synthetic historical precipitation record was generated for Mount Nansen based on climate data from Carmacks and Mount Nansen between 2000 to 2006 (Appendix D and Appendix F);
- Based on the synthetic precipitation record, dry, wet and average annual precipitation conditions were selected for modeling;



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data Courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure Option 2A: Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.5-4**

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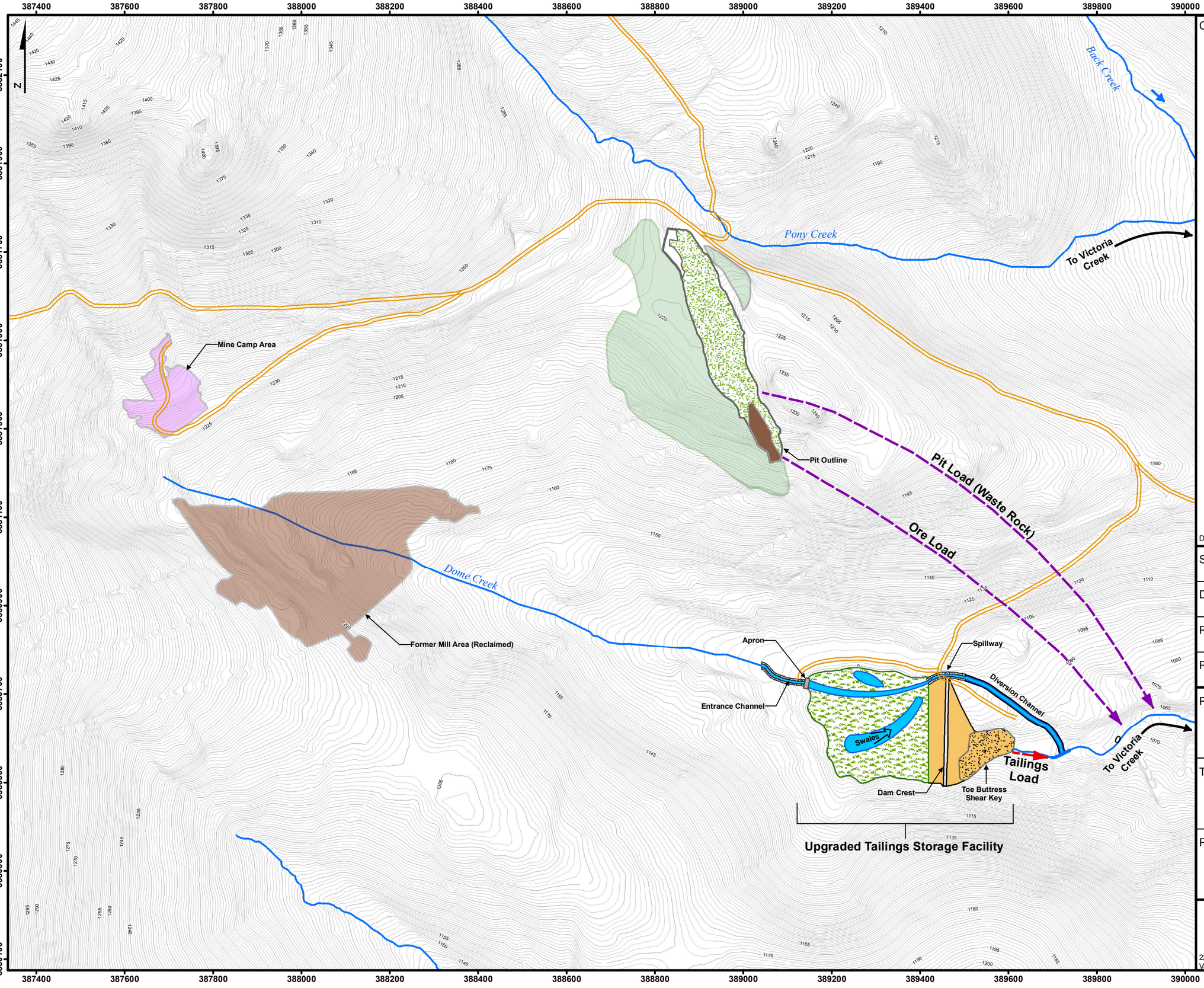

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Dam Area
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Deep Groundwater Seepage
- Tailings Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure Option 2B: Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.5-5**

LORAX ENVIRONMENTAL
2289 Burrard St.
Vancouver, BC, V6J 3H9
Phone: (604) 688-7173
Website: www.lorax.ca

- Annual lake evaporation was estimated based on data from the Pelly Ranch Environment Canada Meteorological gauging station: 369 mm/year (Appendix D and Appendix F);
- For Dome Creek, zero flow was assumed during the winter months (November through March) as attempts to measure winter flow indicates frozen conditions through to the substrate; and
- For Victoria Creek, site monitoring indicates the presence of winter flow. For the model, monthly flow in Victoria Creek was estimated based on the monthly flow distribution in the Nordenskiold River.
- The tailings cover area is modeled as a shallow reservoir with a maximum water depth of 0.25 m.
- Inflows to the tailings cover area include onset precipitation and runoff from the surrounding catchment area. Outflows include discharge of excess water via the spillway, evaporation from the pond surface area, and infiltration through the tailings and tailings dam.
- Infiltration rate through the tailings and tailings dams was based on two-dimensional modeling work carried out by AECOM (Appendix C-1) and set to 1.7 L/s.
- The overall long term seepage rate discharging from the toe of the upgraded dam to the receiving environment was assumed to be similar to the historical low-flow seepage pumping rate for the existing seepage collection pond and was assumed to be constant throughout the year at 3.5 L/s;
- The pit is left as is for Option 2A and the discharge rate from the pit to the receiving environment (*i.e.,* Dome Creek) used in the model was conservatively set to the maximum discharge rate estimated using Darcy's Law for a range of hydraulic conductivities: ~0.13 L/s (Appendix E);
- For Option 2B, all the waste rock is relocated into the pit resulting in a reduction in the waste rock footprint from 114,550 m^2 to 36,000 m^2;
- Net-infiltration through the backfilled waste rock in Option 2B was based on the results of a one-dimensional unsaturated flow model (Appendix C-3). The modeling provided computed fluxes including evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the waste;
- Two independent approaches were used to estimate the annual flux through the pit that is partially backfilled. Both estimates yielded fluxes that were very low and well

below 0.5 L/s (~0.14 L/s). Accordingly, the assumed groundwater discharge rate from the pit to Dome Creek was assumed to be 0.14 L/s for Option 2B.

5.5.5.3 Performance and Uncertainty

Performance

Water quality predictions for each of the model runs were used to assess the performance of Option 2A and 2B through comparison to existing water quality in the downstream receiving environment in Victoria Creek; CCME Guidelines for the Protection of Aquatic Life are also included as a point of reference.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 2A and 2B are presented in Table 5.5-3 and Table 5.5-4.

Table 5.5-3:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 2A - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0019	0.0055
Cadmium	0.00034[a]	0.00003	0.0003	0.00012	0.00051
Zinc	0.03	0.009	0.02	0.018	0.062
Sulfate		30	61	36	106

Notes:
a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Table 5.5-4:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 2B - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0019	0.0059
Cadmium	0.00034[a]	0.00003	0.0003	0.00006	0.00028
Zinc	0.03	0.009	0.02	0.010	0.035
Sulfate		30	61	35	98

Notes: as per Table 5.5-3

The most salient points (for Best Estimate/Average Flow Scenario) of the water quality predictions for Option 2A are as follows:

- For all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. These results are a direct function of the conservative assumptions that the seepage rate from the tailings and discharge rate from the deep groundwater system will remain constant throughout the year despite varying flows in Victoria Creek.
- *Sulfate*
    - In general, the predicted concentrations for sulfate (median = 36 mg/L) are similar to existing sulfate concentrations (median = 30 mg/L) in Victoria Creek, except for winter low flow periods (Table 5.5-3). During this period, the predicted maximum concentration of 106 mg/L is notably higher than the maximum observed winter sulfate concentration (61 mg/L).
    - The primary source of the higher predicted sulfate concentrations in the winter low flow period is the invariant discharge of tailings seepage to the receiving environment at a rate of 3.5 L/s. In reality, it would be anticipated that the seepage discharge would decrease over the winter period, and as such, the winter predictions are considered to be conservative estimates.
- *Arsenic*
    - Predicted concentrations of arsenic (median = 0.0019 mg/L) are comparable to existing arsenic concentrations in Victoria Creek (median = 0.0016 mg/L) and are well below the CCME guideline of 0.005 mg/L (Table 5.5-3).
    - Maximum concentrations of arsenic are predicted to occur during winter low flow (peaking at 0.0055 mg/L). This value marginally exceeds the CCME guideline, although is within the range of the existing maximum winter concentrations (maximum = 0.0075 mg/L).
    - The predicted loading associated with tailings seepage is the dominant source of arsenic to the receiving environment.
- *Cadmium*
    - Predicted cadmium concentrations are higher than the existing values currently observed in Victoria Creek.
    - The predicted median cadmium concentration (0.00012 mg/L) is approximately 4 times higher than the existing median concentration in

Victoria Creek data (0.00003 mg/L) but well below the CCME guideline (Table 5.5-3).

- Maximum concentrations of cadmium are predicted to occur in winter (January to March) at concentrations above the draft CCME guideline.
- The predicted maximum cadmium concentration of 0.00051 mg/L is approximately twice the existing maximum winter concentration 0.0003 mg/L.
- The predicted loading from seepage from the waste rock dumps is the dominant source of cadmium to the receiving environment.

- *Zinc*
  - The predicted median zinc concentration (0.018 mg/L) is approximately twice the existing median concentration (0.009 mg/L) but below the CCME guideline of 0.03 mg/L.
  - Maximum concentrations of zinc are predicted to occur in winter at concentrations above the CCME guideline.
  - The predicted maximum zinc concentration (0.062 mg/L) is 3 times the existing winter maximum concentration (0.02 mg/L).
  - The predicted loading from seepage from the waste rock dumps is the dominant source of zinc to the receiving environment.

As discussed previously in Section 5.4.5.3, the over estimation of cadmium and zinc concentrations in Victoria Creek is primarily due to the conservative assumptions for seepage from the waste rock dumps to the receiving environment and the fact that no attenuation along the flowpath is included in the model assumptions.

Key highlights of the model results for Option 2B are:

- Similar to Option 2A, for all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to continuous loadings from the site during periods of minimal flow and available dilution.
- *Sulfate*
  - In general, the predicted concentrations of sulfate for Option 1B (median = 35 mg/L; maximum = 98 mg/L) are similar to those for Option 2A (median = 36 mg/L, maximum = 106 mg/L) (Table 5.5-4).

- Similar to Option 2A, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- *Arsenic*
  - Predicted concentrations of arsenic for Option 2B (median = 0.0019 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 2A (median = 0.0019 mg/L, maximum = 0.0055 mg/L (Table 5.5-4).
  - The predicted loading from tailings seepage is the dominant source of arsenic to the receiving environment hence little change would be expected between 2A and 2B.

- *Cadmium*
  - The predicted median cadmium concentrations for Option 2B (0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option 2A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.
  - Comparison of the predicted cadmium concentrations for Option 2B in Victoria Creek to those for Option 1 indicates an improvement in performance (Table 5.5-4).
  - The improvement in water quality relates to a decrease in loading from waste rock. Although still the dominant source of cadmium to the receiving environment, the waste rock contributes significantly less loading primarily due to the overall reduction of the waste rock footprint.

- *Zinc*
  - The predicted zinc concentrations for Option 2B (median = 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 2A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions (Table 5.5-4).
  - Comparison of the predicted zinc concentrations for Option 2B in Victoria Creek to those for Option 1 indicates an improvement in performance.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint.

Overall, the Best Estimate Average Precipitation model results for Option 2B are comparable to Option 2A and indicate that Victoria Creek water quality would not be degraded for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B indicates an overall improvement compared to those predicted for Option 2A. The predicted decrease in cadmium and zinc concentrations in the receiving environment under Option 2B relative to Option 2A are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling to the open pit.

Uncertainty

The key uncertainties associated with modeling results for Option 2 are similar to those outlined for Option 1. One of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain the tailings in a saturated state, and specifically, if the proposed runoff coefficients are representative of runoff conditions at the site for all locations and conditions. Results of a sensitivity analysis (Appendix F) indicate that inflows to the tailings area are generally sufficient to maintain the assumed 0.25 m water cover during the open water season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the saturated soil cover to maintain the tailings in a saturated state.

5.5.6 Costs

The estimated capital costs for implementing Options 2A and 2B are presented in Table 5.5-5 and Table 5.5-6. The estimated costs include a 30 percent contingency as well as a 15% contingency to cover costs for design engineering, routine inspections and site supervision. These estimates are considered to be Class D estimates (or ASTM E2516-06 Class 5), with an accuracy of -25 +40 percent.

The capital cost estimates do not include *Pre-Closure Phase Common Closure Element* costs which are described in Section 5.2 and Appendix C-2 and C-9. For Option 2A, the estimated capital cost is approximately $17.1 M. Option 2B has an estimated capital cost of approximately $20.8 M. More details related to cost assumptions and breakdown of individual components are found in Appendix C-1 and C-2 and C-9.

Table 5.5-5:
Summary of Estimate Capital Costs for Option 2A

Mobilization and Demobilization		L.S.	1	$ 250,000	**$ 250,000**
Construction of Toe Berm					
Crush, transport and place rockfill		m^3	40,000	$ 35	$ 1,400,000
Geosynthetic filter placement		m^2	5,400	$ 20	$ 108,000
Sub Total					**$ 1,508,000**
Ground Improvement					
Thermosyphons		L.S.	1	$ 600,000	$ 600,000
Drainage, insulation, site prep. etc.		L.S.	1	$ 900,000	$ 900,000
Sub Total					**$ 1,500,000**
Tailings Management Area (TMA)					
Regrading		m^2	71,000	$ 5	$ 355,000
Soil Cover (1.0 m)		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 tails with fine tails		m^3	68,000	$ 12	$ 816,000
Final site preparation, revegetation					$ 124,000
Sub Total					**$ 2,965,000**
Spillway					
Excavation		m^3	2,000	$ 10	$ 20,000
Concrete Overflow		L.S.	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		L.S.	1	$ 15,000	$ 15,000
Sub Total					**$ 270,000**
Dome Creek Diversion into TMA					
Excavation		m^3	750	$ 10	$ 7,500
Geotextile		m^2	675	$ 10	$ 6,750
Armouring		m^3	340	$ 50	$ 17,000
Water Level Controls		L.S.	1	$ 50,000	$ 50,000
Dome Creek Channel and Apron		L.S.	1	$ 50,000	$ 50,000
Sub Total					**$ 131,250**
Dam Raise		L.S.	1	$ 25,000	**$ 25,000**
Diversion/Interceptor Ditch Upstream of Spillway					
Fill in interceptor ditch		m^3	3,400	$ 10	$ 34,000
Fill in Interceptor diversion channel		m^3	5,400	$ 10	$ 54,000
Sub Total					**$ 88,000**
Reslope, regrade and revegetate Waste Rock Storage area					**$ 142,000**
Road construction - base		m^3	900	$ 50	**$ 45,000**
Plug Pony Creek Adit		L.S.	1	$ 250,000	**$ 250,000**
Diversion channel d/s of spillway		L.S.	1	$ 500,000	**$ 500,000**
Monitoring Insrumentation		L.S.	1	$ 200,000	**$ 200,000**
Scale/flatten pit walls		L.S.	1	$ 200,000	**$ 200,000**
Pit safety (signage and berm)		L.S.	1	$ 24,000	**$ 24,000**
Common Elements - Active Closure		L.S.	1	$ 24,000	**$ 3,670,000**
Sub Total					**$ 11,768,250**
15% Contingency - Engineering Design and Supervision					**$ 1,765,238**
30% Contingency					**$ 3,530,475**
TOTAL ESTIMATED CAPITAL COST - OPTION 2A					**$ 17,063,963**

Table 5.5-6:
Summary of Estimate Capital Costs for Option 2B

Work Item Description		Units	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization		L.S.	1	$ 250,000	**$ 250,000**
Construction of Toe Berm					
Crush, transport and place rockfill		m^3	40,000	$ 35	$ 1,400,000
Geosynthetic filter placement		m^2	5,400	$ 20	$ 108,000
Sub Total					**$ 1,508,000**
Ground Improvement					
Thermosyphons		L.S.	1	$ 600,000	$ 600,000
Drainage, insulation, site prep. etc.		L.S.	1	$ 900,000	$ 900,000
Sub Total					**$ 1,500,000**
Tailings Management Area (TMA)					
Regrading		m^2	71,000	$ 5	$ 355,000
Soil Cover (1.0 m)		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 tails with fine tails		m^3	68,000	$ 12	$ 816,000
Final site preparation, revegetation					$ 124,000
Sub Total					**$ 2,965,000**
Spillway					
Excavation		m^3	2,000	$ 10	$ 20,000
Concrete Overflow		L.S.	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		L.S.	1	$ 15,000	$ 15,000
Sub Total					**$ 270,000**
Dome Creek Diversion into TMA					
Excavation		m^3	750	$ 10	$ 7,500
Geotextile		m^2	675	$ 10	$ 6,750
Armouring		m^3	340	$ 50	$ 17,000
Water Level Controls		L.S.	1	$ 50,000	$ 50,000
Dome Creek Channel and Apron		L.S.	1	$ 50,000	$ 50,000
Sub Total					**$ 131,250**
Dam Raise		L.S.	1	$ 25,000	**$ 25,000**
Diversion/Interceptor Ditch Upstream of Spillway					
Fill in interceptor ditch		m^3	3,400	$ 10	$ 34,000
Fill in Interceptor diversion channel		m^3	5,400	$ 10	$ 54,000
Sub Total					**$ 88,000**
Backfill Pit with Waste Rock					
Load, haul, backfill pit with waste rock		m^3	510,000	$ 5	$ 2,550,000
Regrade and revegetate pit fill, safety measures					$ 53,000
Plug Pony Creek Adit		L.S.	1	$ 250,000	$ 250,000
Sub Total					**$ 2,853,000**
Regrade and revegetate Waste Rock Storage area					**$ 123,000**
Road construction - base		m^3	900	$ 50	**$ 45,000**
Diversion channel d/s of spillway		L.S.	1	$ 500,000	**$ 500,000**
Monitoring Insrumentation		L.S.	1	$ 200,000	**$ 200,000**
Scale/flatten pit walls		L.S.	1	$ 200,000	**$ 200,000**
Common Elements - Active Closure					**$ 3,670,000**
Sub Total					**$ 14,328,250**
15% Contingency - Engineering Design and Supervision					**$ 2,149,238**
30% Contingency					**$ 4,298,475**
TOTAL ESTIMATED CAPITAL COST - OPTION 2B					**$ 20,775,963**

5.6 Option 3 – Pit Backfill with Wet Cover on Tailings, Dam Removal and Valley Restoration

5.6.1 Overview

Option 3 involves the re-location of ~300,000 m^3 of tailings and underlying contaminated soil from their existing location in the TSF to the open pit. These materials will be maintained in a saturated state to the extent possible via placement of a high infiltration cover over the tailings (Figure 5.6-1). By removing the tailings deposits and any underlying contaminated soils, this option also allows for the restoration of the Dome Creek valley in the area of the TSF (Figure 5.6-2). The primary objectives of Option 3 are to:

1) Remove the geotechnical liability associated with maintaining a tailings dam in the Dome Creek valley;
2) Restore the Dome Creek valley in the area of the TSF to a more natural condition compatible with original land use;
3) Minimize the potential for tailings oxidation and ML/ARD through the maintenance of saturated conditions within the tailings deposits (maximize cover infiltration) in the backfilled pit; and
4) Restore the area of open pit to a condition more compatible with the original land use via tailings backfill and associated cover reclamation.

As part of Option 3, tailings in the backfilled pit will be covered with at least 1 m of non-acid-generating waste rock. The physical characteristics of waste rock (coarse material) and associated grading will enhance infiltration into the tailings. The purpose of the cover is to allow infiltration into the tailings from precipitation and snow melt, while providing a barrier to evaporation (*e.g.* capillary break) from the tailings solids. In this manner, the system is designed to maximize the degree of saturation within the tailings. Maximizing tailings saturation is desirable from the perspective of minimizing the potential for acid rock drainage and associated metal leaching. The cover will also serve to physically stabilize the tailings and prevent wind/water erosion.

In order to minimize the potential for ARD, maintaining the tailings at 85% saturation is desirable. The tailings are heterogeneous and the coarse fraction are highly sensitive to desaturation. In this regard, the design for Option 3 requires that the coarse and fine tailings be well-mixed to achieve desired water holding properties. Option 3 does not include diversion of water from Pony Creek as a potential source of make-up water, but is viewed as a viable contingency measure if warranted. Based on a preliminary assessment

of tailings removal methods, blending and transporting the tailings may occur through dredging and transport via pipeline slurry. The effectiveness at which the tailings can be removed, blended, transported, and deposited into the open pit remains uncertain.

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AECOM FILE NAME: 60156089-06-B-F03-R0X.dwg Saved By: cdoststonc
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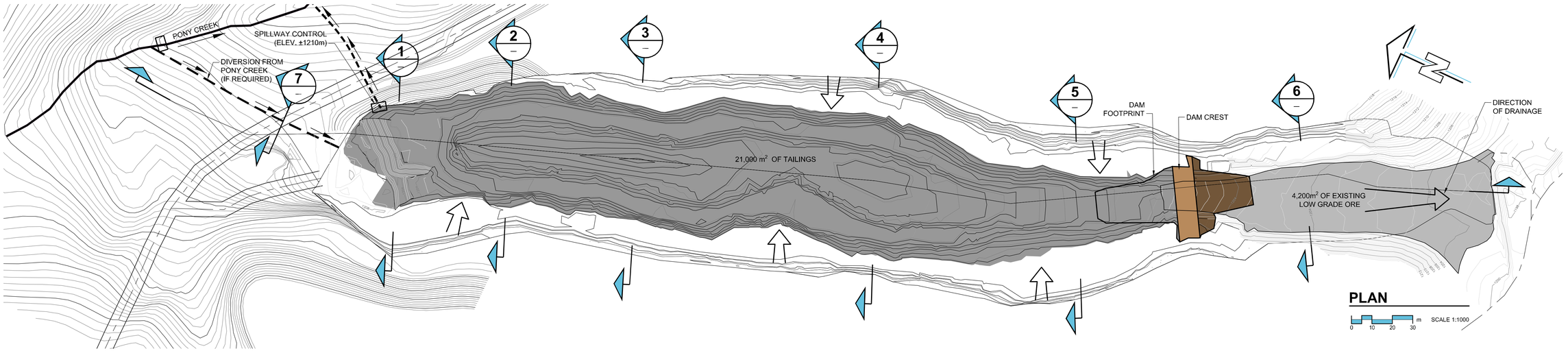
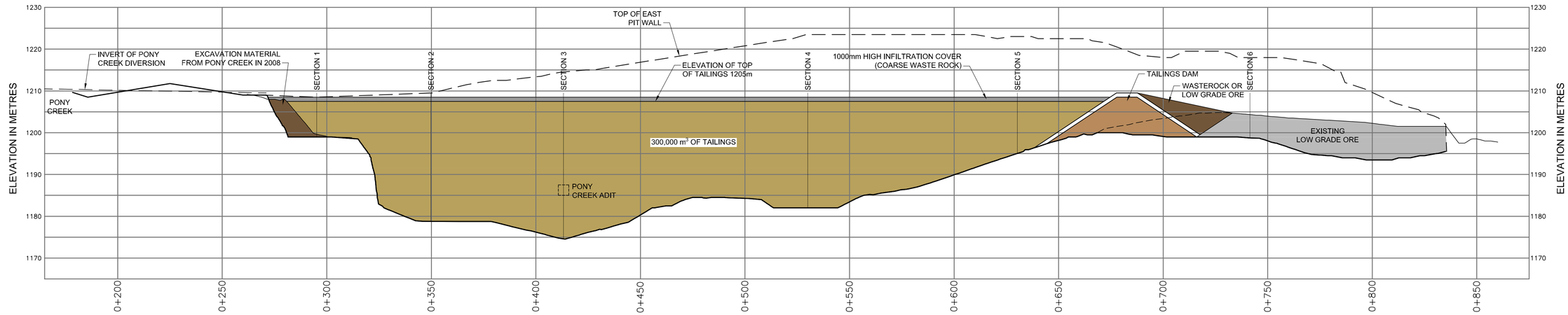
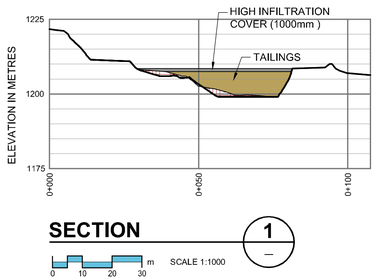
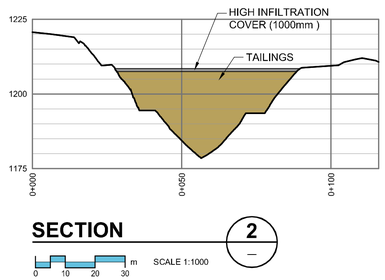
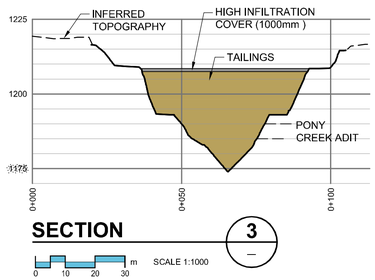
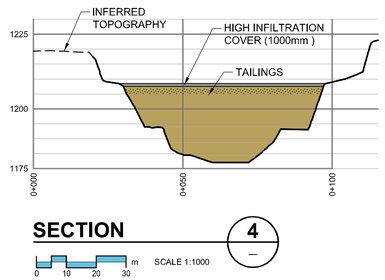


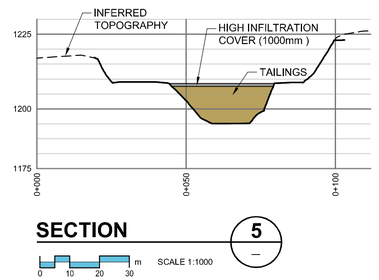


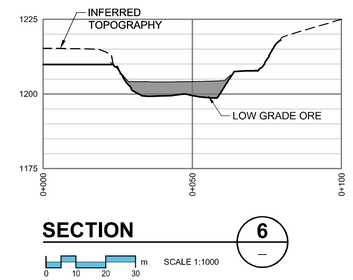








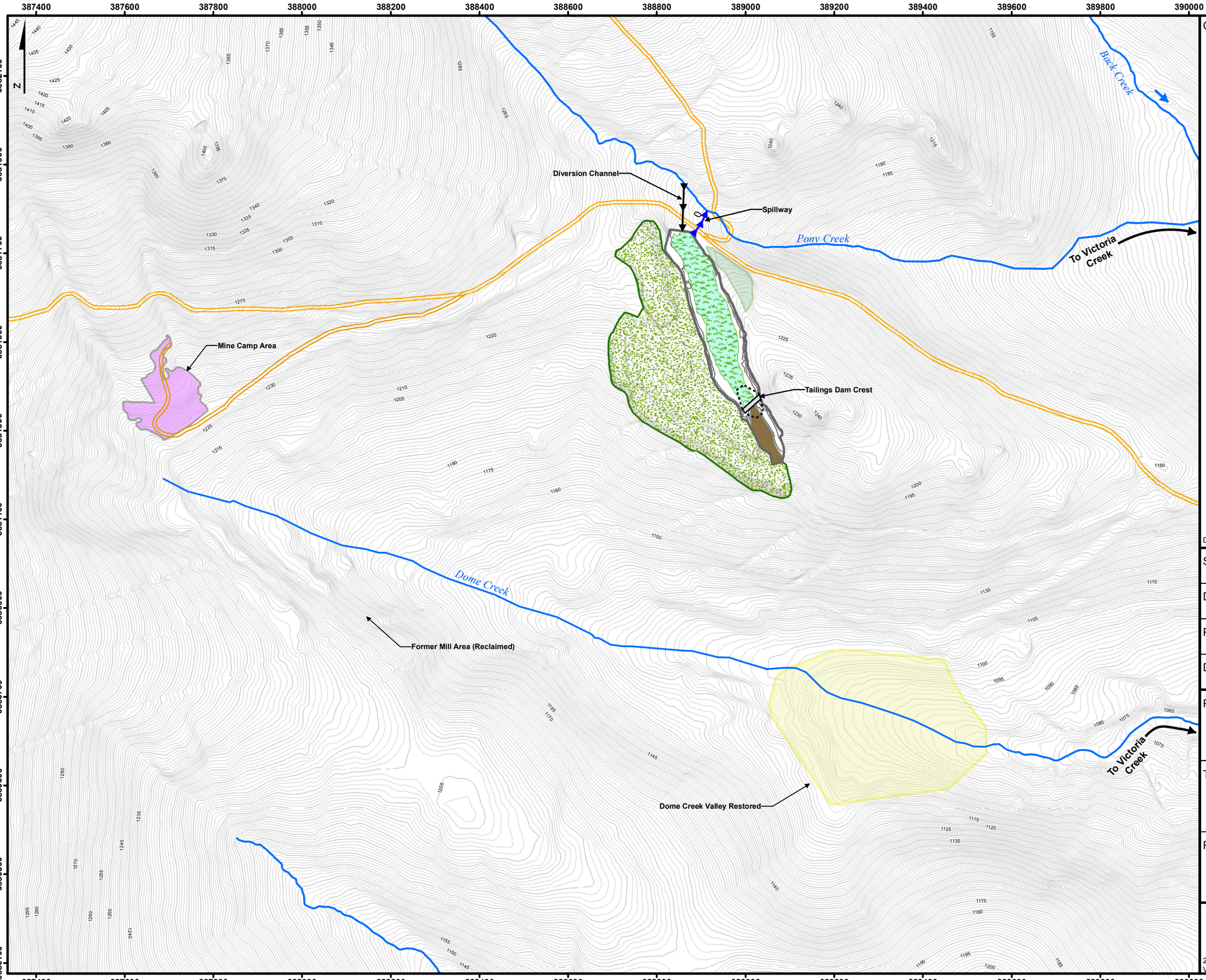




Government of Yukon
Mt. Nansen Closure Alternatives Characterization

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

AECOM



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Tailings Dam Footprint
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings with High Infiltration Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:8,000

DATE: OCT 22nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

DATA SOURCE: J.S.

PROJECT:
Mount Nansen Options for Closure

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

PROJECT No:	FIGURE No:
J907-4	**5.6-2**

LORAX ENVIRONMENTAL
2289 Burrard St.
Vancouver, BC, V6J 3H9
Phone: (604) 688-7173
Website: www.lorax.ca

A dam at the south end of the open pit, on the order of 8 to 10 m in height, will be required to contain the backfilled tailings (Figure 5.6-1). A liner will likely be required to minimize seepage losses through the dam. The liner would extend into the bedrock foundation to minimize the potential for foundation seepage. The dam would be constructed using locally available materials, such as inert waste rock and/or granular borrow. As such, the geotechnical liability associated with dam structures will remain on site. Specifically, the same requirements for routine inspections, dam safety reviews and maintenance would apply to a dam constructed to contain tailings in the open pit.

Under most flow conditions, there will be no surface water discharges from the pit owing to infiltration into the tailings and some evaporation from the waste rock surface. However, some provision will be required to allow surface water to exit the facility for extreme wet periods. This will involve construction of a bedrock spillway at the north end of the pit.

Restoration of the Dome Creek Valley to a setting compatible with the original land use will involve a series of sequenced engineering, environmental, and revegetation measures. Further assessment will be required to develop final remedial plans for the TSF. At a minimum, restoration of the TSF area will entail:

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

A summary of key elements associated with Option 3 is provided in Table 5-2. In the sections to follow, more detailed discussions are provided with respect the design, performance and uncertainty relating to geotechnical measures, water management, geochemistry, water quality and cost.

Table 5.6-1:
Key closure elements associated with Option 3

Option	Closure Element	Description
3	Tailings and Pit	Relocation of approximately 300,000 m^3 of tailings and contaminated soil from the TMA to the open pit. Tailings will be stored saturated to the extent possible through application of a high infiltration waste rock cover. Grain size characteristics of waste rock cover and associated grading will allow for maximum infiltration while minimizing losses due to evaporation. The cover will also serve to physically stabilize the tailings to prevent water/wind erosion.
3	In-Pit Dam	Construction of a dam at south margin of the pit will be required to impound the tailings. The dam will be subject to Canadian Dam Association guidelines with respect to construction, inspection and maintenance requirements.
3	Waste rock	Waste rock will be left in place, with the exception of approximately 21,000 m^3 for use in the tailings cover.
3	Tailings Storage Facility	Re-location of tailings will allow restoration of the Dome Creek valley in the area of the TSF to a condition compatible with the original land use.
3	Pony Creek Adit	Additional measures may be required to provide a more effective seal of the Pony Creek adit to minimize the hydraulic connection between the pit and Pony Creek.

5.6.2 Geotechnical

5.6.2.1 Overview

As previously described, approximately 300,000 m^3 of tailings would be relocated to the open pit and maintained in a saturated state in Option 3. The principle of the design 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 sulfide oxidation and acid generation. 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; and
- control fugitive dust and limit erosion of the tailings and cover.

The analysis considered a high infiltration 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 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 their cover (Figure 5.6-1). It is assumed the height of the dam is expected to be in the order of 8 to 10 m. A liner may be required to minimize seepage losses through the dam; these losses may 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.

The design of the dam will need to follow the 2007 Canadian Dam Association guidelines, including the spillway which would be designed for the IDF associated with a *High* consequence classification. As discussed, 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.

Tailings Properties

The design for Option 3 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 (Appendix C-3) 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 demonstrated that the hydraulic conductivity of mixed tailings (blended in the laboratory) ranged from approximately $3x10^{-7}$ to $1.5x10^{-9}$ m/s. Laboratory blended tailings samples had a higher density (1850 kg/m^3) than the tailings in the current tailings management area (990 – 1785 kg/m^3) (Appendix C-3). Samples of higher density (under saturated conditions) will generally have a lower hydraulic conductivity than less dense material. Overall, it is not considered likely that the entire relocated tailings mass would have densities similar to those produced in the laboratory and the prescribed hydraulic conductivity may be difficult to achieve. This would also be true if the relocated tailings are not homogeneously blended.

Costing of Option 3 has assumed that blending and transporting the tailings would be acheived by dredging the tailings and transporting them in a slurry form (*i.e.,* 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. Under this scenario, segregation of the tailings upon placement into the pit would be a concern.

Differential settlement due to tailings consolidation will be expected under Option 3 and has important implications on spillway location and design.

Treatment of the porewater (expelled during consolidation of the tailings) may be required during dredging and tailings relocation. Water recycling will be maximized to reduce the volume of water that may require treatment. Treatment considerations are described in Appendix C-7 and cost estimates have been included in the design (Appendix C-9).

Waste Rock Stability

The bulk of the existing waste rock piles will remain in place for closure Option 1A, although some waste rock will be used for cover material and in-pit dam construction. Some additional grading may be required to improve the stability of the piles following removal of the waste rock for the cover and dam construction. Currently the slopes of the waste rock piles are at the angle of repose, which yields a calculated factor of safety of unity (1), under static conditions above the water table. Long-term stability, considering various loading conditions, would require an increased factor of safety that would be determined during detailed design. For the purposes of the present assessment, waste rock regrading for Option 3 has been assumed and included in the cost assessment.

5.6.2.2 Key Assumptions

The key assumptions employed in the geotechnical evaluation of Option 3 are as follows:

- Tailings can be blended and transported to the pit for deposition as a homogeneous blend;
- Tailings can be deposited in the pit such that the bulk hydraulic conductivity of the tailings mass is consistent and less than approximately $5x10^{-9}$ m/s;
- A new in-pit dam can be successfully constructed with suitable inert material at the south-end of the pit to contain the tailings with minimal seepage occurring around the structure; and
- The Pony Creek Adit can be successfully sealed.

5.6.2.3 Performance and Uncertainty

The most notable performance and uncertainty related to Option 3 is the ability to create a blend of tailings that achieves the required hydraulic properties (*i.e.*, a homogeneous mixture with a hydraulic conductivity of less than of $5x10^{-9}$ m/s) and density characteristics. These would be difficult to ensure at the field scale of a dredging operation.

The other uncertainty relates to the effects of differential settlement on the cover integrity and performance through tailings consolidation. As such, additional maintenance and repairs of the final cover will likely be required and have been included in the cost assessment.

5.6.3 Water Management

5.6.3.1 Overview

A dam at the south end of the open pit will be required to contain the tailings and water cover (Figure 5.6-1) for Option 3. 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.

The design of the dam is envisioned to respect the 2007 Canadian Dam Association guidelines, including the spillway which would be designed for the IDF associated with the location. The soil cover for Option 3 is similar to that of Option 2, except that it is likely that there will be extended periods where there is no surface water under this option. A layer of coarse waste rock could be placed over top of the soil cover to prevent wind erosion, and reduce evaporation.

With the reclamation of the valley, changes in the hydrology can be expected as conditions return to pre-mining condition.

5.6.3.2 Key Assumptions

<u>Spillway and Pony Creek Diversion</u>

Under normal operating conditions, a spillway would not be active because inflows are expected to be lower than the sum of losses to infiltration, seepage and evaporation. However, since the tailings are contained by a dam, it is necessary to provide some provision for the routing of excess surface water to prevent overtopping of the dam. Routing water north into Pony Creek is proposed for Option 3 and may require some excavation through bedrock.

A contingency provision for a diversion channel from Pony Creek to the pit area is included in the event that tailings desaturation becomes a concern. Should the diversion be necessary, a side hill diversion channel would be required as shown on Figure 5.6-1. 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. Preliminary climate modeling and water balance estimated (Appendix C-4) suggest the Pony Creek diversion will not be required to maintain 85% saturation within the tailings mass.

Pony Creek Adit and Pony Creek

Under this scenario, it is assumed that it will be necessary to provide a more effective seal at the Pony Creek adit to reduce this potential pathway for groundwater loss. A cost estimate has been provided.

5.6.3.3 Performance and Uncertainty

The key performance and uncertainties related to water management issues for Option 3 are as follows:

- Foundation and abutment conditions at the dam location may pose challenges during construction. Furthermore, maintenance and repair of seals in sidewalls, foundation, and adit may affect performance over long-term.
- Seepage from tailings backfill into surrounding bedrock remains an uncertainty. A significant uncertainty at this time is the volume of seepage losses that can be expected around the perimeter of the tailings mass into fractured bedrock and the possible requirement for seepage control measures in this regard.

Cover system

- Reliability of water supply (Pony Creek diversion) to maintain saturated conditions of the tailings;
- Consequences of differential settlement with respect to cover integrity, surface drainage and spillway design; and
- Frequency and cost for routine or unexpected maintenance.

Water Diversion Structures and Diversion Channels

- New water diversion structures will require regulatory approval, and frequency and cost for routine or unexpected maintenance going forward is uncertain;

- There are challenges associated with maintaining side-hill channels (Pony Creek to open pit), as well as requirements to cross entrance and spillway channels under this option; and
- Potential consolidation will be an important consideration in establishing spillway control. 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.

Existing Tailings Management Area

- Once the tailings are removed from the existing TMA, it is expected that a reclamation process will be initiated. Some of these efforts will affect the hydrology and water balance of the area, as conditions return to a pre-mining "state" (*e.g.*, re-vegetation, contouring and drainage improvement).

5.6.4 Geochemistry

5.6.4.1 Overview

As part of Option 3, source terms for the water quality prediction model were developed for tailings stored in the pit, as well as for waste rock and ore stored subaerially. The development of these source terms are discussed in detail in Appendix B. Similar to Options 1 and 2, the primary objective of Option 3, from a geochemical perspective, is to maintain the tailings in a saturated state and minimize the potential for tailings oxidation and the development of acidic drainage. This will necessitate excavation, blending, transportation and, and placement of tailings in the pit which may lead to notable short-term water quality degradation. The removal of tailings from the tailings impoundment will also result in the removal and entrainment of organic deposits underlying the tailings. Under tension-saturated conditions and in the presence of organic matter, the tailings are likely to develop mildly to strongly suboxic conditions within the pit in the longer-term. As per the status quo and Options 1 and 2, suboxic conditions throughout the tailings will promote the mobilization of the redox sensitive tailings phases (Fe and Mn oxides) and associated metals (primarily As but may also include Zn, Cu, and Cd).

As outlined for Options 1 and 2, the attenuation mechanisms (*e.g.,* sulfide precipitation) currently operating within the tailings impoundment are assumed to apply to the long-term water quality predictions. The same assumptions do not apply to Option 3. Specifically, the pit environment may not be suitable for the development of sulfide precipitation processes which currently account for significant metal attenuation within the impoundment. Although this form of attenuation has not been accounted for in the model, given the long groundwater flow path between the pit and surface receptors, and

the long travel time in groundwater, significant attenuation (*e.g.*, sorption to clay minerals) is likely along the groundwater flow path. The absence of attenuation assumed for Option 3 imparts conservatism into the water quality predictions.

For Option 3, waste rock will be stored subaerially and is expected to behave in a manner similar to the status quo condition.

5.6.4.2 Key Assumptions

Derivation of source terms for Option 3 includes the following assumptions:

- The tailings remain at or above 85% saturation and will not produce acidic drainage;
- Under tension-saturated conditions and in the presence of organic matter the tailings will be mildly to strongly suboxic; redox mechanisms will be the dominant control on the release and attenuation of the metals of concern;
- Drainage chemistry data for the unsaturated ore field bin, upon which ore source terms were based, is representative of long-term drainage from unsaturated ore;
- Drainage currently observed within subaerially stored waste rock is representative of longer-term drainage; and
- Waste rock is non-acid generating.

5.6.4.3 Performance and Uncertainty

The geochemical source terms derived for Option 3 are shown in Table 5.6-2. The performance and uncertainties regarding waste rock and ore source terms are the same as those for Options 1A and 2A and are described in greater detail in section 5.4.4.3 and Appendix B. In summary, there is uncertainty relating to whether the data used in deriving subaerial waste rock source terms are representative of all waste rock. Also, there is uncertainty as to whether drainages from the unsaturated ore field bin are representative of long-term drainage conditions.

With the exception of Zn, total cyanide and WAD cyanide, the "Best Estimate" and "Upper Estimate" source terms for tailings are within an order of magnitude (Table 5.6-2). This narrow range in values generally reflects the conservative approach taken in the derivation of the Best Estimate source terms.

Table 5.6-2:
Option 3 Geochemical Source Terms, all values in mg/L

Parameter	Best Estimate			Upper Estimate		
	Tailings in Pit	Waste Rock Pile	Ore	Tailings in Pit	Waste Rock Pile	Ore
Ca	136	368	431	470	346	431
Mg	50	93	297	45	91	297
As	9	0.007	0.03	15	0.02	0.04
Cd	0.001	0.03	0.09	0.001	0.2	0.2
Cu	0.002	0.04	0.02	0.002	0.2	0.04
Fe	3	0.01	0.03	15	0.06	0.05
Mn	5	5	49	24	29	97
Zn	0.05	5	10	0.5	34	31
Sulfate	1700	1530	2265	2000	2940	2680
Ammonia	15	0.03	0.03	15	0.1	0.09
CN (Tot)	0.04	-	-	0.9	-	-
WAD CN	0.03	-	-	0.2	-	-
Cyanate	6	-	-	6	-	-
Nitrate	0.1	2	0.3	0.1	10	0.9
Nitrite	0.09	0.02	0.08	0.09	0.4	0.1

Relative to Options 1 and 2, there is significantly more uncertainty associated with the tailings source terms derived for Option 3. Although it is very likely that the tailings porewater will become suboxic, it is unclear as to whether Mn-reduction or Fe-reduction will dominate. In mine waste, significantly more metals are released when Fe-reduction dominates due to the predominance of metal-bearing Fe-oxides. Another unknown is the rate of Mn or Fe-reduction that may occur within the in-pit tailings. If the rate is fairly slow, then the flux of metals released to the environment will be lower in comparison to a higher dissolution rate scenario.

As outlined above, the potential for attenuation within the pit and along the groundwater flow paths is not clear. Potential attenuation mechanisms include: 1) adsorption/co-precipitation with to Fe oxides (Bowel, 1994); 2) sorption to clay minerals (Violante and Pigna, 2002; Manning and Goldberg, 1997); and 3) precipitation as secondary sulphide minerals in suboxic settings (Martin and Pedersen, 2002). The assumption that no attenuation of metals will occur under Option 3 is considered conservative, as some degree of metal removal can be expected along the groundwater flow path.

Lastly, *in-situ* groundwater and porewater sampling may be biased. Groundwater sampling from the tailings mass is biased toward the more porous tailings intervals (*e.g.*, silt and sand). It is possible that porewater in the clay, which encompasses a large proportion of the tailings, has a different chemical signature compared to its sand and silt counterparts and is not adequately represented.

Monitoring well MP09-10, the only well screened over a clay-rich tailings interval, exhibits distinctly elevated As, Cu, total and WAD cyanide concentrations that are characteristic of process waters. While process water has been flushed from the coarser tailings layers (Appendix B), process water exhibits longer retention within the lower permeability clay materials. In the long-term, process water will be flushed from the tailings entirely. However, in the short-term, (*i.e.*, during disturbance associated with relocation), drainage chemistry with a strong process water signature may be encountered and treatment may be required. Table 5.6-3 compares the source terms (long-term drainage predictions) to groundwater thought to be representative of process water trapped within the extensive clay lenses which may be released during transport. Most notably, copper is predicted to be two orders of magnitude greater in the short-term compared to long-term.

Table 5.6-3:
Option 3 Geochemical Source Terms compared to predicted short-term drainage, all values in mg/L

Parameter	Long-term		Short-term
	Best Estimate	*Upper Estimate*	
As	9.3	15	25
Cu	0.002	0.002	0.8
CN (Tot)	0.04	0.9	3
WAD CN	0.03	0.2	1

5.6.5 Surface Water Quality

5.6.5.1 Overview

A water balance and water quality model was developed in Goldsim to support the assessment of closure Option 3. Key inputs to the model included precipitation and water quality chemistry from the various source terms (*e.g.*, tailings seepage, waste rock, ore, background Victoria Creek, *etc*.) For this option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet

year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Appendix B). For each scenario, the model was run on a monthly time step for a calendar year (12 months).

The overarching objective of the water balance and water quality modeling was to provide a tool to directly compare the environmental merits and performance of each closure option. To this end, and in order to best illustrate the differences between the closure options with regards to water quality, mill area contaminant loadings were excluded from the assessment. Currently, mill area loadings are a dominant control on downstream water quality and inclusion would obscure the differences in final water quality under the proposed closure scenarios. For these reasons - in concert with the fact that the mill area is a common closure element to all options and will be remediated (Section 5.2) - mill area loadings were ignored in order to differentiate resultant water quality effects from each of the closure options.

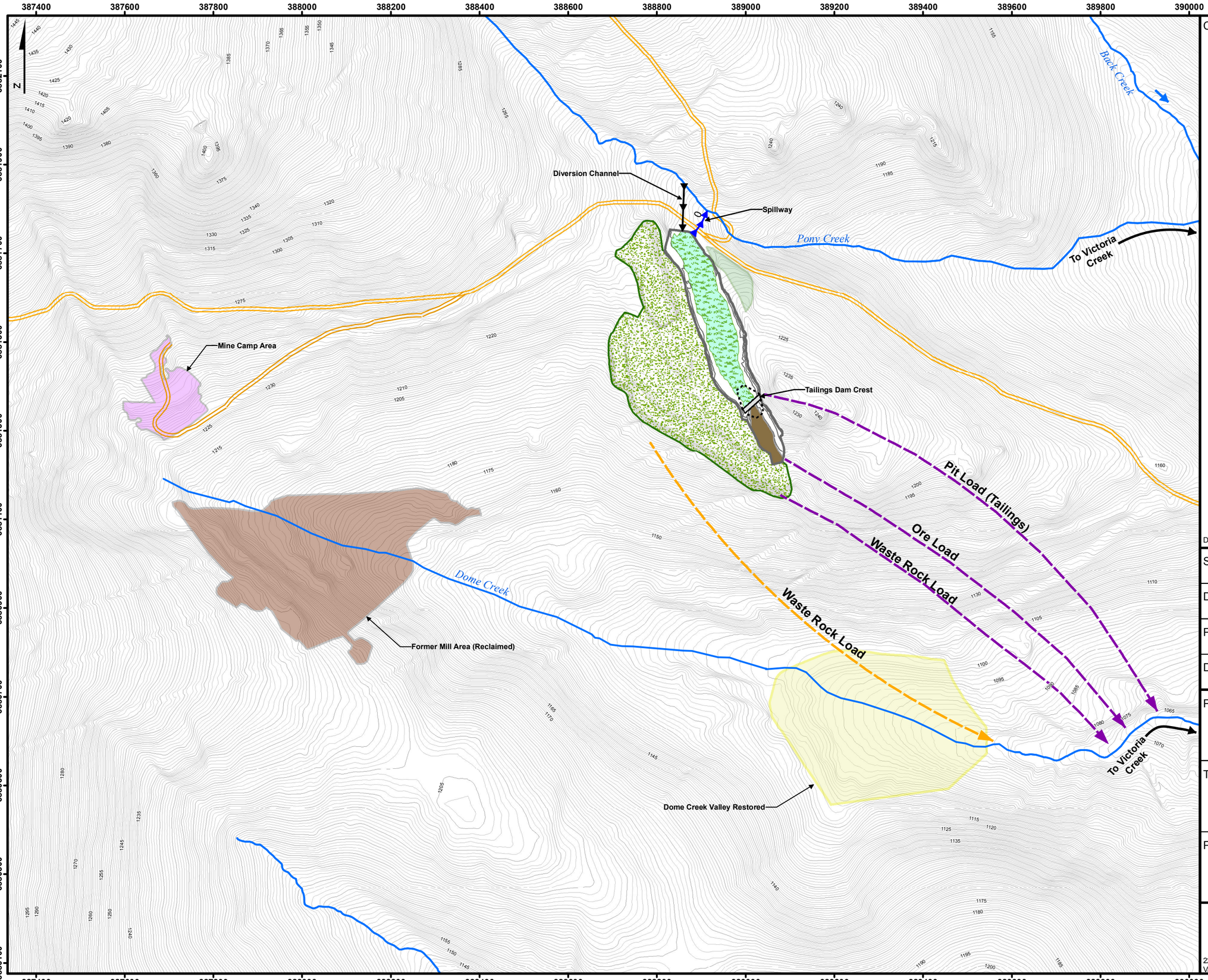
Following tailings relocation to the pit, restoration of the TSF was assumed to result in the restoration of ambient water quality to Dome Creek. This assumption was applied to Option 3 to illustrate the differences in long-term water quality between the other closure options.

In order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Water quality predictions for the above parameters are considered long-term or steady-state estimates. Details of the water balance and water quality model, including model configuration, assumptions and results, are provided in Appendix F. For the summary presented herein, only the Best Estimate results from the model are presented; all data are described and presented in Appendix F.

For Option 3, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for Option 3 are summarized below.

- Year-round, deep groundwater seepage from the low-grade ore within the pit;
- Year-round, deep groundwater seepage from portions of waste rock on surface; and
- Year-round, deep groundwater seepage from tailings within the backfilled pit.

For Option 3, a schematic depicting the key components of the water quality model are presented in Figure 5.6-3.



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
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- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Tailings Dam Footprint
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings with High Infiltration Cover)
- Shallow Groundwater Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
DATA SOURCE:	J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure Option 3: Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.6-3**

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5.6.5.2 Key Assumptions

The following are the key assumptions relevant to the water balance and water quality model for Option 3:

- The mill area has been fully reclaimed and as such the water quality upstream of the mill area was assigned to represent the upstream or background water quality in Dome Creek (*i.e.*, the model predictions exclude mine-related loadings emanating from the mill area);
- The former TSF area is assumed to return to ambient water quality conditions in the long-term following Dome Creek restoration;
- For un-impacted catchment areas, a runoff coefficient of 0.8 was assumed for spring freshet (April and May) and a runoff coefficient of 0.6 for the remaining open water season months;
- Attenuation of arsenic (*i.e.*, removal of dissolved arsenic from solution) is assumed to take place along groundwater flow paths between the pit and receiving water courses. A 50% loading reduction is assumed as outlined in Appendix B and Appendix F;
- To support the modeling, a synthetic historical precipitation record was generated for Mount Nansen based on climate data from Carmacks and Mount Nansen between 2000 to 2006 (Appendix D and Appendix F);
- Based on the synthetic precipitation record, dry, wet and average annual precipitation conditions were selected for modeling;
- Annual lake evaporation was estimated based on data from the Pelly Ranch Environment Canada Meteorological gauging station: 369 mm/year (Appendix D and Appendix F);
- For Dome Creek, zero flow was assumed during the winter months (November through March) as attempts to measure winter flow indicates frozen conditions through to the substrate; and
- For Victoria Creek, site monitoring indicates the presence of winter flow. For the model, monthly flow in Victoria Creek was estimated based on the monthly flow distribution in the Nordenskiold River.
- Tailings are relocated to the pit and the tailings area has been reclaimed and does not provide any contaminant loading to the receiving environment;
- Tailings are relocated to the pit and covered with waste rock to enhance infiltration;

- The relocated tailings are assumed to be homogeneous with a uniform hydraulic conductivity of 1 x 10^{-8} m/s, which is a conservative input for calculating fluxes;
- The annual fluxes of water through the top and bottom of the tailings were based on the results of a one-dimensional water balance model developed by Golder (Appendix C-3). This one-dimensional model does not consider surface inflows from other areas of the pit catchment and the only source of water considered was direct precipitation to the tailings footprint;
- A target saturation level of 85% is assumed to prevent tailings oxidation and the development of acidic conditions. The model assumes this target saturation level is achieved during all precipitation conditions. This also assumes that flow from the surrounding catchment provides any additional inflow required to maintain the tailings at 85% saturation (estimated at 420 m^3 annually for dry and average conditions);
- Based on one-dimensional modeling results, a flux of approximately 0.1 L/s through the bottom of the tailings was adopted for all precipitation conditions;
- The long term discharge rate from the pit to Dome Creek was set to 0.14 L/s;
- All waste rock remains on surface except for the relocation of the East Pile to the pit for use as cover material for the tailings;
- For seepage from waste rock, a key assumption is that there is no net surface runoff. Snowmelt and onset precipitation either evaporates or infiltrates into the waste rock dumps;
- Monthly net-infiltration rates for the waste rock dumps were based on the results of a one-dimensional, unsaturated, flow model developed by Golder (Appendix F). The monthly, net-infiltration rates were applied uniformly to the entire waste rock surface area;
- Depending on the specific configuration of the dumps, water that infiltrates into the dumps either reports to the receiving environment as variable, shallow groundwater seepage or continuous, deep groundwater seepage;

5.6.5.3 Performance and Uncertainty

Performance

Water quality predictions for each of the model runs were used to assess the performance of Option 3 through comparison to existing water quality in the downstream receiving

environment in Victoria Creek; CCME Guidelines for the Protection of Aquatic Life are also included as a point of reference.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 3 are presented in Table 5.6-4.

Table 5.6-4:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 3 - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0034	0.022
Cadmium	0.00034[a]	0.00003	0.0003	0.00009	0.00038
Zinc	0.03	0.009	0.02	0.017	0.059
Sulfate		30	61	30	44

Notes:
a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 3 are:

- Similar to all options, peak concentrations for all parameters occur during the winter, low-flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock) which are assumed to remain constant throughout the year.
- *Sulfate*
    - In general, predicted concentrations of sulfate (median = 30 mg/L, maximum = 44 mg/L) are lower than those for Option 1 and 2 (maximum = 106 mg/L). The lower sulfate concentrations predicted for Option 3 reflect the removal of seepage from the tailings area which represents the primary source of sulfate to Victoria Creek.
- *Arsenic*
    - Predicted concentrations of arsenic for Option 3 (median = 0.0034 mg/L, maximum = 0.022 mg/L) are higher than those for Options 1 and 2 (median = 0.002 mg/L, maximum = 0.0055 mg/L).

  - The predicted loading from saturated tailings stored in the pit is the dominant source of arsenic to the receiving environment.

- *Cadmium*
  - The predicted cadmium concentrations for Option 3 (median = 0.00009 mg/L, maximum = 0.00038 mg/L) are slightly lower than those predicted for Option 1A and 2A and are well below the CCME guideline.
  - The predicted loading from waste rock is the dominant source of cadmium to the receiving environment.
- *Zinc*
  - The predicted zinc concentrations for Option 3 (median = 0.017 mg/L, maximum = 0.059 mg/L) are similar than those predicted for Option 1A and 2A and are generally below the CCME guideline, except during winter low flow conditions.
  - Similar to cadmium, the predicted loading from waste rock is the dominant source of zinc to the receiving environment.

Overall, the Best Estimate Average Precipitation model results for Option 3 show comparable values for cadmium and zinc in comparison to Option 1A and 2A. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentration in Victoria Creek compared to current conditions and those predicted for Option 1 and 2. This largely relates to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 3 are significantly higher than those predicted for Option 1 and 2. The increase in arsenic largely reflects the assumption that no attenuation will occur along the groundwater flow path from the pit to the receiving environment.

Uncertainty

The uncertainties associated with the modeling results for Option 3 are as follows:

- A significant amount of conservatism has been incorporated into the model to account for various uncertainties. One key component of this conservatism is the assumption of constant seepage rate from both the tailings area and the deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism is reflected in the higher predicted winter concentrations which generally exceed historical winter maximum concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months.

- The sensitivity of the system to variations in precipitation conditions was evaluated for three precipitation conditions: average year, dry year and wet year. As expected, during dryer years, there is less dilution capacity in the receiving environment and therefore higher predicted concentrations. Conversely, during wet precipitation years, the additional flow in the receiving environment results in lower predicted concentrations.
- A critical uncertainty associated with Option 3 is related to the feasibility of attaining a desired level of tailings saturation (85%) in the pit. As discussed in the 2010 geotechnical analysis (Appendix C-1), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity. The water balance and water quality model for Option 3 assumed that the tailings are well mixed with a uniform hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings.
- The results of one-dimensional modeling indicate that a minimum annual addition of 420 m^3 of water is required to ensure tailings saturation levels are maintained at 85% or higher (*i.e.*, water that must come from outside the tailings footprint). The water quality modeling for this option assumed that the surrounding catchment of the pit area can provide the water to offset this deficit. To ensure sufficient water is available, a water balance assessment was carried for dry and average conditions. Assuming the surface area of the tailings placed in the pit is 21,000 m^2 and the entire pit catchment for Option 3 is 33,930 m^2, the residual pit catchment area is 12,930 m^2. Based on this assessment, this residual catchment area can provide an additional 2,328 m^3/year of potential inflow during a dry year and 3,663 m^3/year during an average year. Assuming a runoff coefficient of 0.4, these water volumes translate to 931 m^3 and 1,465 m^3 during dry and average conditions, respectively. Such volumes are sufficient to offset the assumed, modeled deficit, and therefore maintain tailings saturation.
- A relevant uncertainty is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The Option 3 loading model for tailings placement in the open pit does not account for any attenuation of arsenic along the groundwater flow path between the pit and Dome Creek. In this context, attenuation refers to adsorption and precipitation processes that result in the removal of dissolved arsenic from solution. The presence of silt-clay facies in the underlying deposits in the area certainly suggests that the adsorption of arsenic to clay minerals may play a dominant role in arsenic removal. The magnitude of removal cannot be quantified.

However, given the long groundwater flow path (825 m) between the pit and surface receptors, and the likely travel time in groundwater (1 to 26 years), significant attenuation is likely. This will affect both the timing and magnitude of arsenic loadings to Dome Creek. The considerations presented here suggest that the predicted water quality for Option 3 (and 4), particularly for arsenic, are overly conservative and represent maximum possible concentrations. In reality, a similar level of arsenic attenuation may occur for an in-pit tailings scenario to that observed currently in the existing tailings storage area. The removal mechanisms described for arsenic also apply to other relevant trace elements, including zinc and cadmium.

- Groundwater discharge was conservatively estimated to be approximately 0.14 L and is calculated from first principles and site observations, including several years of pit lake elevation data (Appendix E). The estimated flux rate, while conservative, is sufficiently low such that water quality in Victoria Creek is relatively insensitive to seepage quality degradation from the pit (*e.g.,* from un-attenuated tailings seepage; Appendix F). Groundwater flux rates, while considered conservative, remain uncertain.

5.6.6 Costs

The estimated capital cost for implementing Option 3 is summarized in Table 5.6-5. The estimated costs include a 30 percent contingency as well as a 15% contingency to cover costs for design engineering, routine inspections and site supervision. The estimate is considered to be Class D estimate (or ASTM E2516-06 Class 5), with an accuracy of -25 to +40 percent.

The capital cost estimates do not include *Pre-Closure Phase Common Closure Element* costs which are described in Section 5.2 and Appendix C-2 and C-9. For Option 3, the estimated capital cost is approximately $23.9 M. More details related to cost assumptions and breakdown of individual components are found in Appendix C-1, C-2 and C-9.

Table 5.6-5:
Summary of Estimate Capital Costs for Option 3

Work Item Description	Units	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization	L.S.	1	$ 500,000	**$ 500,000**
Transport and Place Tailings				
Set up dredges, pumps and lines	L.S.	1	$ 2,000,000	$ 2,000,000
Dredge tailings	m^3	300,000	$ 9	$ 2,700,000
Sub Total				**$ 4,700,000**
Restore Tailings Management Area (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
Excavate metal contaminated soils	m^3	11,000	$ 12	$ 132,000
Restoration of Dome Creek valley				$ 1,670,000
Sub Total				**$ 3,162,000**
Construct in-pit Tailings Dam				
Fill material	m^3	10,000	$ 35	$ 350,000
Tailings dam liner	m^2	1,000	$ 150	$ 150,000
Foundation preparation	L.S.	1	$ 500,000	$ 500,000
Monitoring instrumentation	L.S.	1	$ 200,000	$ 200,000
Sub Total				**$ 1,200,000**
High infiltration cover over tailings (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
Sub Total				**$ 27,500**
Regrade and repair cover	m^3	21,000	$ 5	**$ 105,000**
Reslope, regrade and revegetate Waste Rock Storage area				**$ 142,000**
Plug Pony Creek Adit	L.S.	1	$ 250,000	**$ 250,000**
Scale/flatten pit walls	L.S.	1	$ 200,000	**$ 200,000**
Revegetate pit fill, pit safety (signage and berm)	L.S.	1	$ 49,000	**$ 49,000**
Monitoring Insrumentation	L.S.	1	$ 200,000	**$ 200,000**
Water Treatment - Capital	L.S.	1	$ 2,000,000	**$ 2,000,000**
Common Elements - Active Closure				**$ 3,670,000**
Sub Total				**$ 16,520,500**
15% Contingency - Engineering Design and Supervision				**$ 2,478,075**
30% Contingency				**$ 4,956,150**
TOTAL ESTIMATED CAPITAL COST - OPTION 3				**$ 23,954,725**

5.7 Option 4 – Pit Backfill with Dry Cover on Tailings, Dam Removal and Valley Restoration

5.7.1 Overview

Similar to Option 3, Option 4 involves the re-location of ~300,000 m^3 of tailings and underlying contaminated soil from their existing location to the open pit. In contrast to Option 3, Option 4 is designed to maintain the tailings in a dry condition to the extent possible via storage of the tailings above the water table and placement of a low infiltration (water shedding) cover (Figure 5.7-1). This option also entails the backfilling of ~344,000 m^3 of waste rock into the pit. Restoration of the Dome Creek valley in the area of the TSF is also a common element to both Options 3 and 4 (Figure 5.7-2). The primary objectives of Option 4 are to:

1) Remove the geotechnical liability associated with maintaining a tailings dam in the Dome Creek valley;
2) Restore the Dome Creek valley in the area of the TSF to a more natural condition compatible with the original land use;
3) Minimize the potential for tailings oxidation and ML/ARD through the maintenance of dry conditions within the tailings deposits (minimize infiltration); and
4) Restore area of open pit to a condition more compatible with the original land use via tailings and waste rock backfill.

As part of Option 4, several design measures will be implemented to minimize water contact with the tailings. Firstly, the tailings will be stored above the local water table through the placement of ~44,000 m^3 of coarse waste rock into the pit bottom prior to tailings placement (Figure 5.7-1). The tailings would then be placed in one continuous layer (up to 25 m thick) over the waste rock. A further 300,000 m^3 of waste rock would then be placed on top of the tailings and graded to direct surface runoff away from the backfilled pit. A low infiltration cover designed to minimize infiltration would then be placed on top of the waste rock. The most viable option for this site is a sythethic barrier cover system that does not rely upon vegetation and evaporation for performance (Appendix C-4). The encapsulation of the tailings will provide an effective means to physically stabilize the tailings and prevent water/wind erosion.

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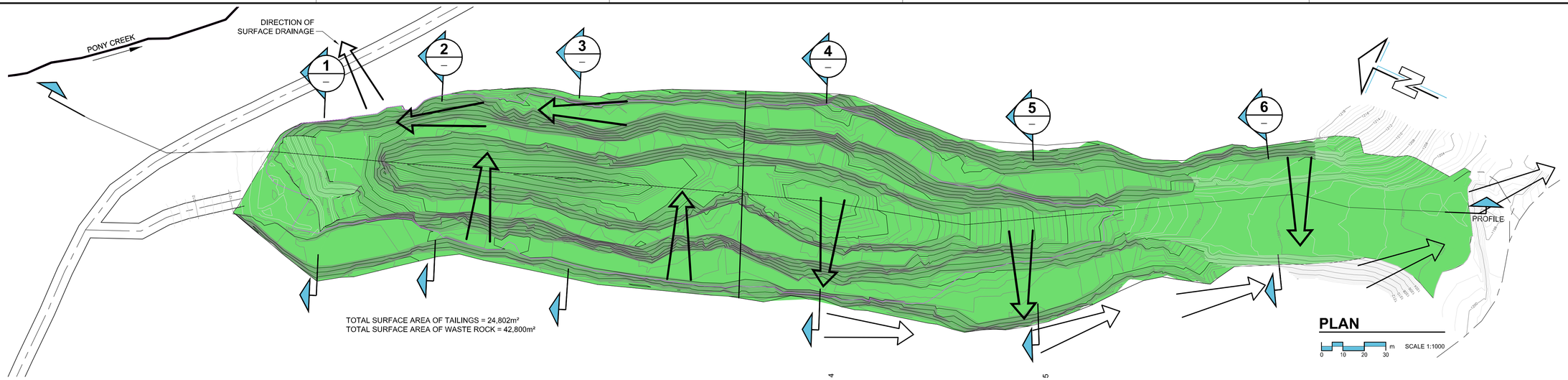

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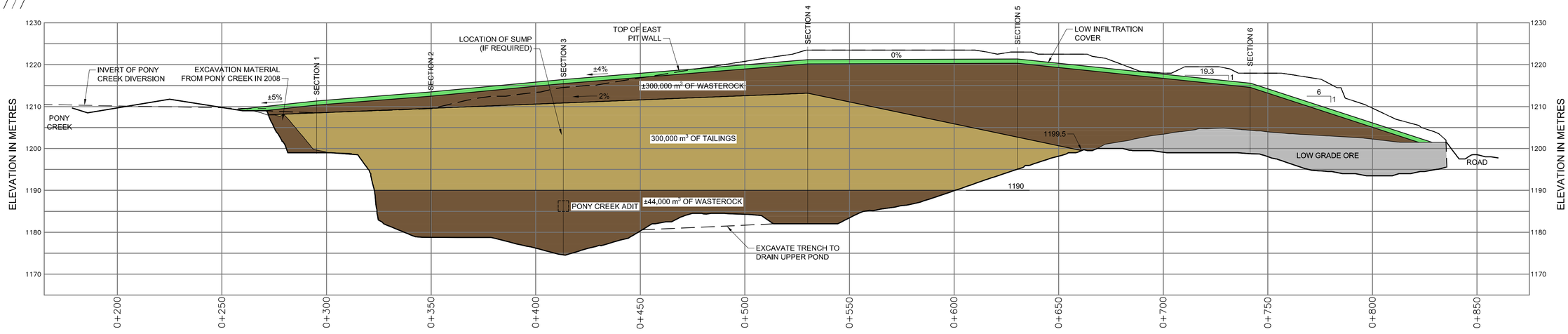

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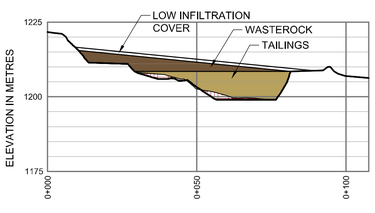

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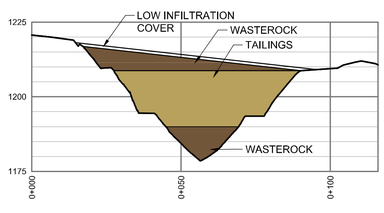

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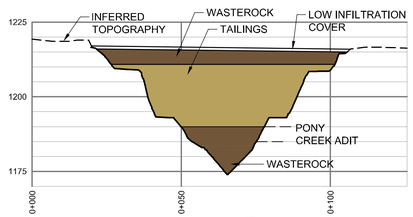

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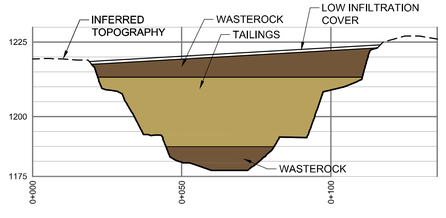

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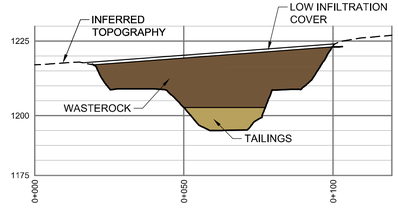

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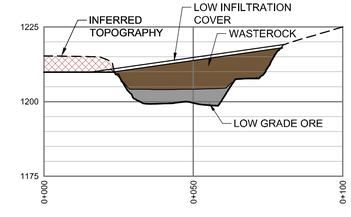

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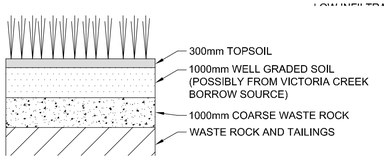

COVER

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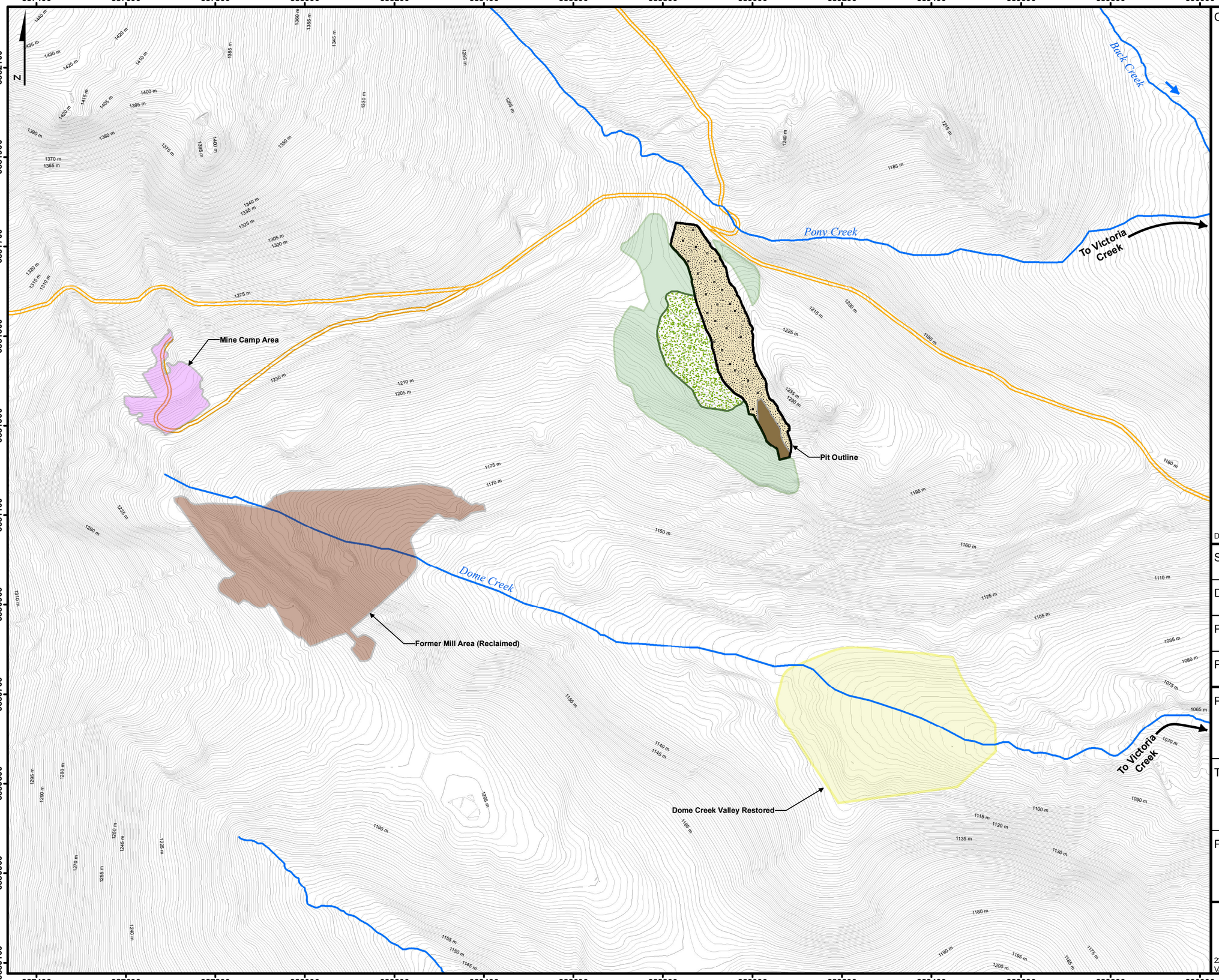
Government of Yukon
Mt. Nansen Closure Alternatives Characterization

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



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings + Waste Rock with Low Infiltration Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOMM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Options for Closure

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

PROJECT No:	FIGURE No:
J907-4	**5.7-2**

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The relocation of tailings for Option 4 would be similar to that for Option 3 except that the coarse and fine tailings would not require blending. This contrast to Option 3 will influence tailings transport methods. Preliminary evaluation of tailings transport indicates that tailings relocation by mechanical removal presents a more viable option for Option 4 (as opposed to dredging and transport via pipeline slurry in Option 3).

Preliminary geotechnical assessments indicate that if the tailings are placed with a gradual slope towards the south end of the pit, a waste rock dam at the southern margin of the pit will not be required to maintain stability of the tailings. This would remove the geotechnical liability associated with the inspection and maintenance of dam structures as outlined by the Canadian Dam Association. This differs from Option 3 which will require an in-pit tailings dam to impound the tailings.

Runoff from the pit area will typically be limited to snowmelt and heavy storm events owing to the water storage afforded by the cover system. In this regard, grading will route runoff flows to Pony Creek for the northern half of the pit area, and to Dome Creek for runoff generated in the southern half of the backfilled pit (Figure 5.7-1).

A summary of key elements associated with Option 4 is provided in Table 5.7-1. In the sections to follow, more detailed discussions are provided with respect the design, performance and uncertainty relating to geotechnical measures, water management, geochemistry, water quality and cost.

Table 5.7-1:
Key closure elements associated with Option 4

Option	Closure Element	Description
4	Tailings and Pit	Relocation of approximately 300,000 m^3 of tailings and contaminated soil to the open pit. Tailings will be stored in a dry condition to the extent possible through storage of tailings above the water table and placement of a synthetic cover designed to minimize infiltration. The cover will also serve to physically stabilize the tailings to prevent water/wind erosion.
4	In-Pit Dam	Preliminary assessment indicates that an in-pit dam structure will not be required.
4	Waste rock	Re-location of ~344,000 m^3 of waste rock to open pit. Approximately 156,000 m^3 of waste rock will be left in place and regarded and revegetated as necessary.
4	Tailings Storage Facility	Re-location of tailings will allow restoration of the Dome Creek valley in the area of the TSF to a condition compatible with the original land use.
4	Pony Creek Adit	Additional measures may be required to provide a more effective seal of the adit to minimize the hydraulic connection between the pit and Pony Creek.

5.7.2 Geotechnical

5.7.2.1 Overview

Option 4 requires that the tailings be relocated to the pit above the water table. A mass of waste rock (~44,000 m^3) will serve to separate the tailings from the water table. The relocation of the tailings in Option 4 will not require specific blending requirements. The gradation of the waste rock used for the base as well as 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.

A waste rock plug at the south end of the pit may or may not be required for containment of the tailings. Preliminary assessments have shown that if the tailings are placed with a gradual slope, the plug would 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.

Upon completion of tailings relocation, consolidation and resulting settlement is expected to occur. 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 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; it may also take considerably longer for thaw induced settlement to occur.

A low infiltration cover is proposed for Option 4 with the objective of the cover design to reduce infiltration of precipitation and snow melt water into the tailings material. For this prefeasibility assessment, five cover options were considered and are described in detail in Appendix C-4. The assessment concluded that a synthetic barrier cover system would be the most viable option as it does not rely on evaporation or a vegetative cover for performance. The synthetic cover design has the following preliminary design specifications:

- 0.5 m of well graded Victoria Creek soil for cover dressing and aesthetic growth medium;
- 0.3 m drainage sand (local Aeolian sand);
- Geosynthetic liner (to act as a barrier to infiltration);
- 0.5 m protective transition sand (local Aeolian sand); and
- 1 m coarse waste rock.

Because of the anticipated differential consolidation settlement, the soil cover design will need to consider the uneven settlement of the tailings with time and final regrading of the cover may have to be delayed by several years. In this same vein, there are a number of operational and maintenance items to be considered for closure Option 4:

- Some maintenance is anticipated for the cover for 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 or shed surface water effectively.

- Treatment of the porewater (expelled during consolidation of the tailings) may be required for some period of time. The period of time that treatment would be required for would be dependent on tailings seepage water quality, attenuation by saturated waste rock, and dilution. Treatment considerations are described in Appendix C-7 and cost estimates have been included in the design (Appendix C-9).
- 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. Over the long-term, occasional inspections may be conducted by helicopter 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.

5.7.2.2 Key Assumptions

The key assumptions employed in the geotechnical evaluation of Option 4 are as follows:

- Waste rock of suitable quality can be placed at the bottom of the pit and can successfully isolate the tailings from the water table (Note that locally available inert, Aeolian sand may be used as an alternative to backfill the pit bottom);
- Suitable waste rock material is available to be used as filter layers within the tailings deposit in the pit;
- A low infiltration cover will perform as designed and successfully limit infiltration recharge to the tailings backfill.

5.7.2.3 Performance and Uncertainty

The most notable uncertainties related to geotechnical considerations for Option 4 are as follows:

- No requirement for a waste rock plug or dam to contain the tailings and waste rock. 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 time taken and magnitude of consolidation settlement of relocated tailings is uncertain and is in part dependent on transportation and placement methods;
- The long-term integrity of the low infiltration cover and the ability to limit recharge to the tailings. Differential consolidation of the tailings will likely result in low depression areas that could result in ponding and excess infiltration. Maintenance of

the cover during the consolidation period will likely be required in the form of regrading.

5.7.3 Water Management

5.7.3.1 Overview

As part of Option 4, several design measures will be implemented to minimize water contact with the tailings. Under most flow conditions, there will be no surface water discharges from the pit area owing to the water storage afforded by the cover system and evaporative losses from the vegetated surface. Runoff can be expected during wet periods associated with freshet and storm events. Under such circumstances, grading will route runoff flows to Pony Creek for the northern half of the pit area, and to Dome Creek for runoff generated in the southern half of the pit (Figure 5.7-1).

In this scenario, it will be necessary to seal the Pony Creek Adit as it may become submerged once water levels in the pit stabilize. Any water 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 could 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. Costs for a long-term pump and treat are not built into the base costs of this option; however a design and cost estimate has been provided as a provisional cost in an effort to quantify residual risk associated with this option. Provisional treatment costs are summarized in Section 6.1.1 and described in detail in Appendix C-7.

5.7.3.2 Key Assumptions

<u>Tailings Consolidation Draindown</u>

As the tailings consolidate, 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. This volume would increase substantially if the tailings were transported to the pit by dredging or slurry. The collection and treatment of this porewater has been accounted for in the base costs of this option, as described in Appendix C-7.

5.7.3.3 Performance and Uncertainty

The most notable uncertainties related to water management considerations for Option 4 are as follows:

Open pit

- There is less concern with radial outward flow of groundwater from the pit under Option 4 as compared to Option 3. However, the ability to maintain tailings in a dry state and to minimize groundwater flow through the tailings mass is uncertain;
- As previously described, the ability of the cover to limit seepage in consideration of differential settlement, freeze-thaw cycling and long-term degradation remains uncertain;
- Consequences of differential settlement with respect to surface drainage and spillway design; and
- The frequency and cost for routine or unexpected pit maintenance.

5.7.4 Geochemistry

5.7.4.1 Overview

As part of Option 4, source terms for the water quality prediction model were developed for tailings and waste rock backfilled in the pit, and waste rock and ore stored subaerially. The development of these source terms are discussed in detail in Appendix B. Similar to all other options, the objective of Option 4 is to minimize the development of acidic drainage. In contrast to all other options, the tailings in Option 4 will be stored as dry as possible above the water table. Hence it is assumed that some degree of sulfide oxidation will occur. However, emplacement of a low infiltration cover will minimize flow through the tailings and hence minimize the overall transport (*i.e.,* load) of metals from the backfilled pit to aquatic receptors.

Following tailings relocation to the pit, restoration of the TSF was assumed to result in the restoration of ambient water quality to Dome Creek. This assumption was applied to Option 4 to illustrate the differences in long-term water quality between the other closure options.

As with Options 1B and 2B, Option 4 involves the relocation of some waste rock to the pit where a portion will be stored below the water table, potentially resulting in the remobilization of metals that are unstable in suboxic environments (*e.g.*, Fe oxides). A portion of waste rock will also remain above the water table and subaerially exposed. Therefore, the chemistry of the drainage from the pit will be dictated by a combination of

geochemical processes occurring within both unsaturated and saturated waste rock settings. A small portion of the waste rock may also be left in its current location and subaerially exposed.

5.7.4.2 Key Assumptions

The assumptions made in the derivation of source terms for Option 4 include the following:

- Sulfide oxidation will occur within the tailings and acidic conditions in tailing porewaters will develop over the long term;
- Given their similar geological origins and solid-phase chemistry, the acid rock drainage originating from Mt. Nansen tailings will be similar to that observed at the Arctic Gold and Silver site;
- There will be no attenuation of metals along the flowpath from the backfilled pit to Victoria Creek;
- Waste rock is non-acid generating;
- The drainage currently observed within the subaerially stored waste rock is representative of longer-term drainage quality;
- Suboxic conditions will develop in the saturated waste rock porewater (*e.g.,* pit bottom backfill);
- Metals associated with extensively oxidized waste rock are primarily associated with soluble and oxide phases which will be subject to dissolution under saturated/suboxic conditions;
- Source terms for the saturated waste rock were developed using data generated from the saturated waste rock field bin. This assumes that the field bin has reached an equilibrium state that will be representative of the suboxic conditions that are likely to develop within the pit environment;
- The waste rock stored in the pit and above the water table is assumed to exhibit drainage characteristics similar to the current subaerially exposed waste rock piles;
- The chemistry of drainage from waste rock in the pit is dictated by a combination of geochemical processes occurring within both unsaturated and saturated waste rock; and
- Drainage chemistry data for the unsaturated ore field bin, upon which ore source terms were based, is representative of long-term drainage from unsaturated ore.

5.7.4.3 Performance and Uncertainty

The geochemical source terms derived for Option 4 are shown in Table 5.7-2. Given the assumed acidic nature of tailings porewaters, drainage originating from the tailings in Option 4 exhibits concentrations of Cd, Cu, and Zn that are orders of magnitude greater than those provided for other options. Arsenic and sulfate concentrations are also elevated for Option 4. Therefore, the performance of this option is highly dependent on the success of the cover to reduce infiltration through the tailings mass.

Option 4 presents the greatest amount of uncertainty with regards to the tailings source terms due to difficulties in extrapolating static and short-term kinetic tests far into the future. The Arctic Gold and Silver Tailings analogue site provides some degree of confidence, particularly due to the similarities between the two sites, both geochemically and geographically. However, this certainty is limited by the lack of long-term data from the Arctic Site (drainage chemistry is represented by a single seepage quality sample). Evaluating temporal tends, such as seasonality of drainage chemistry or verification of chemical equilibrium in site drainages, is therefore not possible.

Table 5.7-2:
Option 4 Geochemical Source Terms (mg/L)

Parameter	Best Estimate				Upper Estimate			
	Pit		Waste Rock Pile	Ore	Pit		Waste Rock Pile	Ore
	Tailings	*Waste Rock*			*Tailings*	*Waste Rock*		
Ca	250	368	368	431	250	346	346	431
Mg	60	93	93	297	60	91	91	297
As	28	0.1	0.007	0.03	28	1	0.02	0.04
Cd	0.2	0.03	0.03	0.09	0.2	0.2	0.2	0.2
Cu	1	0.04	0.04	0.02	1	0.2	0.2	0.04
Fe	574	2	0.01	0.03	574	5	0.06	0.05
Mn	29	143	5	49	29	181	29	97
Zn	26	5	5	10	26	34	34	31
Sulfate	2500	2040	1530	2265	2500	2940	2940	2680
Ammonia	7	1	0.03	0.03	7	2	0.1	0.09
CN (Tot)	0.07	-	-	-	0.07	-	-	-
WAD CN	0.03	-	-	-	0.03	-	-	-
Cyanate	2	-	-	-	2	-	-	-
Nitrate	3	0.3	2	0.3	3	1	10	0.9
Nitrite	0.3	0.1	0.02	0.08	0.3	0.4	0.4	0.1

Humidity cell tests were also used to constrain source terms for this acidic scenario. While these tests provide valuable information on the leaching behavior of metals from tailings under acidic conditions, they only represent primary release rates with no consideration given to the influence of field conditions that govern the actual metal concentrations in drainage. For this reason, laboratory-based kinetic tests are typically conducted in concert with field-based tests that better represent site-specific conditions. The unsaturated tailings field bin installed in 2009 for this purpose has not yet evolved to acidic conditions, and therefore cannot be used to constrain the drainage chemistry predictions.

The performance and uncertainties regarding the unsaturated waste rock and ore source terms are the same as those described for Options 1A, 2A, and 3 and are described in greater detail in section 5.4.4.3. In summary, there is uncertainty as to whether the data used in deriving unsaturated waste rock source terms are truly representative of the waste rock component as a whole. Further, there is uncertainty with regards to the assumption that drainages from the unsaturated ore and the waste rock + organics field bins are representative of long-term drainage conditions.

5.7.5 Surface Water Quality

5.7.5.1 Overview

A water balance and water quality model was developed in Goldsim to support the assessment of closure Option 4. Key inputs to the model include precipitation and water quality chemistry from the various source terms (*e.g.*, tailings seepage, waste rock, ore, background Victoria Creek, *etc*.) For this option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Appendix B). For each scenario, the model was run on a monthly time step for a calendar year (12 months).

The overarching objective of the water balance and water quality modeling was to provide a tool to directly compare the environmental merits and performance of each closure option. To this end, and in order to best illustrate the differences between the closure options with regards to water quality, mill area contaminant loadings were excluded from the assessment. Currently, mill area loadings are a dominant control on downstream water quality and inclusion would obscure the differences in final water quality under the proposed closure scenarios. For these reasons - in concert with the fact that the mill area is a common closure element to all options and will be remediated

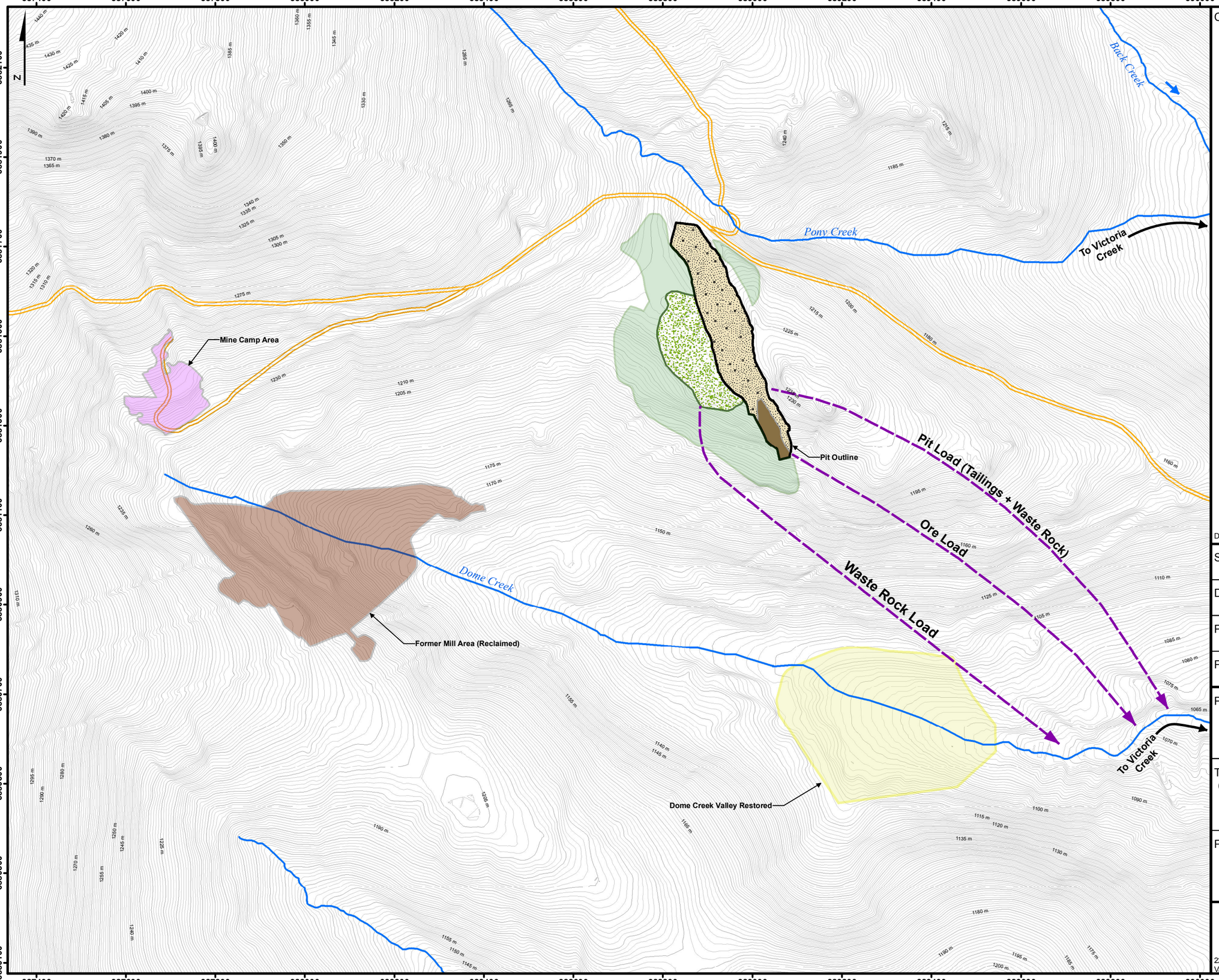
(Section 5.2) - mill area loadings were ignored in order to differentiate resultant water quality effects from each of the closure options.

In order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Water quality predictions for the above parameters are considered long-term or steady-state estimates. Details of the water balance and water quality model, including model configuration, assumptions and results, are provided in Appendix F. For the summary presented herein, only the Best Estimate results from the model are presented; all data are described and presented in Appendix F.

For Option 4, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for Option 4 are summarized below.

- Year-round deep groundwater seepage from the low-grade ore within the pit; and
- Year-round deep groundwater seepage from the backfilled pit.

For Option 4, a schematic depicting the key components of the water quality model are presented in Figure 5.7-3.



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings + Waste Rock with Low Infiltration Cover)
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0 150 300 600

Data courtesy of AECOMM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

TITLE:

Closure Option 4: Schematic of Source Loadings for Water Quality Model

PROJECT No:	FIGURE No:
J907-4	**5.7-3**

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5.7.5.2 Key Assumptions

The following are the key assumptions relevant to the water balance and water quality model for Option 4:

- The mill area has been fully reclaimed and as such the water quality upstream of the mill area was assigned to represent the upstream or background water quality in Dome Creek (*i.e.*, the model predictions exclude mine-related loadings emanating from the mill area);
- The former TSF area is assumed to return to ambient water quality conditions in the long-term following Dome Creek restoration;
- For un-impacted catchment areas, a runoff coefficient of 0.8 was assumed for spring freshet (April and May) and a runoff coefficient of 0.6 for the remaining open water season months;
- Attenuation of arsenic (*i.e.*, removal of dissolved arsenic from solution) is assumed to take place along groundwater flow paths between the pit and receiving water courses. A 50% loading reduction is assumed as outlined in Appendix B and Appendix F;
- To support the modeling, a synthetic historical precipitation record was generated for Mount Nansen based on climate data from Carmacks and Mount Nansen between 2000 to 2006 (Appendix D and Appendix F);
- Based on the synthetic precipitation record, dry, wet and average annual precipitation conditions were selected for modeling;
- Annual lake evaporation was estimated based on data from the Pelly Ranch Environment Canada Meteorological gauging station: 369 mm/year (Appendix D and Appendix F);
- For Dome Creek, zero flow was assumed during the winter months (November through March) as attempts to measure winter flow indicates frozen conditions through to the substrate; and
- For Victoria Creek, site monitoring indicates the presence of winter flow. For the model, monthly flow in Victoria Creek was estimated based on the monthly flow distribution in the Nordenskiold River.
- Tailings are relocated to the pit and the tailings area is reclaimed. The restored tailings area of Dome Creek valley does not provide any contaminant loadings to the receiving environment.

- Sulfide oxidation will occur within the tailings and acidic conditions in tailings porewaters will develop over the long term. Given their similar geological origins and solid-phase chemistry, it is assumed that the acid rock drainage originating from Mt. Nansen tailings will be similar to that observed at the Arctic Gold and Silver site.
- Tailings are underlain by a waste rock drainage layer (44,000 m^3) and covered with 300,000 m^3 of waste rock and a synthetic, low-infiltration cover system
- Golder (2010; Appendix C-4) carried out infiltration modeling of the proposed divert-store-release soil cover which indicated that fluxes through the bottom of the capillary break would be less than 1% of annual precipitation (Appendix F). This modeled infiltration rate is low compared to the typical infiltration rates for the type of cover applied, which reportedly ranges from 2% to 5% MAP. To account for these observations, a long-term infiltration rate of 5% of average annual precipitation was selected for modeling purposes.
- In addition to the actual footprint of the relocated tailings (24,800 m^2), the pit catchment also includes an additional covered area of 9,600 m^2. For modeling purposes, it was assumed that the water from this additional area eventually infiltrates through the tailings.
- A long-term infiltration rate through the tailings of ~0.05 L/s was estimated.
- In addition to the vertical flow, there is a component of horizontal flow through the waste rock underlying the tailings and is assumed to be the difference between the total pit discharge rate and the vertical infiltration rate through the tailings or 0.09 L/s.
- Groundwater discharge from the pit was conservatively estimated to be approximately 0.14 L and is calculated from first principles and site observations, including several years of pit lake elevation data (Appendix E). The estimated flux rate, while conservative, is sufficiently low such that water quality in Victoria Creek is relatively insensitive to seepage quality degradation from the pit (*e.g.,* from un-attenuated tailings seepage; Appendix F). Groundwater flux rates, while considered conservative, remain uncertain.
- The low-grade ore remains in place but is incorporated under the pit cover.
- For seepage from waste rock, a key assumption is that there is no net surface runoff. Snowmelt and onset precipitation either evaporates or infiltrates into the waste rock dumps.
- Monthly net-infiltration rates for the waste rock dumps were based on the results of a one-dimensional unsaturated flow model developed by Golder (Appendix F). The

monthly net-infiltration rates were applied uniformly to the entire waste rock surface area; and

- Depending on the specific configuration of the dumps, water that infiltrates into the dumps either reports to the receiving environment as variable shallow groundwater seepage or continuous deep groundwater seepage.

5.7.5.3 Performance and Uncertainty

Performance

Water quality predictions for each of the model runs were used to assess the performance of Option 4 through comparison to existing water quality in the downstream receiving environment in Victoria Creek; CCME Guidelines for the Protection of Aquatic Life are also included as a point of reference.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 4 are presented in Table 5.7-3.

Table 5.7-3:
Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 4 - Best Estimate Source Terms and Average Precipitation Conditions

		Existing Water Quality[b]		**Predicted Water Quality**	
Parameter	*CCME Guideline*	*Median*	*Winter Maximum[c]*	*Median*	*Maximum*
Arsenic	0.005	0.0016	0.0075	0.0023	0.009
Cadmium	0.00034[a]	0.00003	0.0003	0.00006	0.00035
Zinc	0.03	0.009	0.02	0.012	0.058
Sulfate		30	61	30	40

Notes:
a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 3 are:

- Similar to all options, peak concentrations for all parameters occur during the winter, low-flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock) which are assumed to remain constant throughout the year.

- *Sulfate*
    - In general, the predicted concentrations of sulfate (median = 30 mg/L, maximum = 40 mg/L) are lower than those for Options 1 and 2 but comparable to Option 3 (median = 31 mg/L, maximum = 43 mg/L). The lower sulfate concentrations predicted for Option 4 reflect the removal of seepage from the tailings area.
- *Arsenic*
    - Predicted concentrations of arsenic for Option 4 (median = 0.0023 mg/L, maximum = 0.009 mg/L) are slightly higher than those for Option 1 and 2 (median = ~0.002 mg/L, maximum = 0.0055 mg/L) but similar to Option 3.
    - The predicted loading from tailings stored in the pit is the dominant source of arsenic to the receiving environment, and assumes no attenuation along the groundwater flow path.
- *Cadmium*
    - The predicted cadmium concentrations for Option 4 (median = 0.00006 mg/L, maximum = 0.00035 mg/L) are similar to those predicted for the other options and well below the draft CCME guideline.
    - The predicted loading from the tailings stored in the pit is the dominant source of cadmium to the receiving environment.
- *Zinc*
    - The predicted zinc concentrations for Option 4 (median = 0.012 mg/L, maximum = 0.058 mg/L) are similar than those predicted for the other options and generally below the CCME guideline, except during winter, low-flow conditions.
    - Similar to cadmium, the predicted loading from the tailings in the pit is the dominant source of zinc to the receiving environment.

Overall, the Best Estimate Average Precipitation model results for Option 4 are comparable to Option 1A with respect to cadmium and zinc. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentrations compared to current conditions owing to removal of the seepage loading from the current impoundment. For arsenic, the predicted concentrations for Option 4 are similar to Option 3, and are significantly higher than those predicted for Option 1, Option 2, and current conditions. The higher arsenic predictions for Options 3 and 4 can be linked to a higher tailings source term and the assumption of zero attenuation along groundwater

flow paths. The results for Option 4 also demonstrate that despite the assumption that acidic conditions develop within in-pit tailings, such conditions do not have a marked effect on increasing the loading to Victoria Creek when compared to Option 3. This can be related to the low water flux through the tailings (*e.g.,* tailings / waste rock cover) which offsets the higher source term concentrations in the loading calculations.

Uncertainty

The uncertainties associated with the modeling results for Option 4 are as follows:

- Low-infiltration cover modeling indicates that fluxes through the bottom of the capillary break would be less than 1% of the total annual precipitation. This modeled infiltration rate is low compared to the typical infiltration rates for these types of covers which typically range from 2% to 15% (Appendix F). For the loading model, an infiltration rate of 15% of average annual precipitation was conservatively assumed to account for cover degradation and the anticipated decrease in performance in the long-term. This uncertainty relates to a range in possible infiltration rates. Implications of a lower infiltration would be a reduction in the loading of constituents from the tailings mass to Victoria Creek.
- The uncertainty with regards to potential for the attenuation of arsenic and other parameters along the groundwater flow path has relevance to Option 4.

5.7.6 Costs

The estimated capital cost for implementing Option 4 is summarized in Table 5.7-4. The estimated costs include a 30 percent contingency as well as a 15% contingency to cover costs for design engineering, routine inspections and site supervision. The estimate is considered to be Class D estimate (or ASTM E2516-06 Class 5), with an accuracy of -25 to +40 percent.

The capital cost estimates do not include *Pre-Closure Phase Common Closure Element* costs which are described in Section 5.2 and Appendix C-2 and C-9. For Option 4, the estimated capital cost is approximately $27 M. More details related to cost assumptions and breakdown of individual components are found in Appendix C-1, C-2 and C-9.

Table 5.7-4:
Summary of Estimate Capital Costs for Option 4

Work Item Description		Units	Quantity	Unit Cost	Total Cost
Mobilization and Demobilization		L.S.	1	$ 400,000	**$ 400,000**
Transport and Place Tailings		m^3	300,000	$ 15	**$ 4,500,000**
Restore Tailings Management Area (TMA)					
Relocate dam fill to borrow sources		m^3	80,000	$ 5	$ 400,000
Excavate Metal Contaminanted Soil		m^3	11,000	$ 12	$ 132,000
Relocate dam fill to pit		m^3	80,000	$ 12	$ 960,000
Restoration of Dome Creek valley					$ 1,670,000
Sub Total					**$ 3,162,000**
Waste Rock Placement (bottom and top)		m^3	344,000	$ 5	**$ 1,720,000**
Low Infiltration Synthetic Cover		m^3	43,000	$ 55	**$ 2,365,000**
Regrade and repair cover		m^3	43,000	$ 5	**$ 215,000**
Regrade and revegetate Waste Rock Storage area					**$ 123,000**
Plug Pony Creek Adit		L.S.	1	$ 250,000	**$ 250,000**
Revegetate pit fill, pit safety (signage and berm)		L.S.	1	$ 46,000	**$ 46,000**
Monitoring Insrumentation		L.S.	1	$ 200,000	**$ 200,000**
Water Treatment - Capital		L.S.	1	$ 2,000,000	**$ 2,000,000**
Common Elements - Active Closure					**$ 3,670,000**
Sub Total					**$ 18,651,000**
15% Contingency - Engineering Design and Supervision					**$ 2,797,650**
30% Contingency					**$ 5,595,300**
TOTAL ESTIMATED CAPITAL COST - OPTION 4					**$ 27,043,950**

6. Summary of Closure Options Evaluation

This chapter provides a summary comparison of the key aspects of the closure options presented for Mt. Nansen. An overview of the geotechnical and cost considerations is presented in Section 6.1. Geochemical and water quality aspects of the closure options are summarized and compared in Section 6.2. A summary of the most salient components of each closure option described is presented in Table 6.1-1.

6.1 Geotechnical and Water Management Considerations

Geotechnical and water management considerations for each closure option are summarized in Table 6.1-1. Options 1 and 2 require a combination of dam buttressing and ground improvement techniques in order to improve the factors of safety for the dam, primarily for the post-earthquake conditions owing to the presence of liquefiable soils in thawed ground beneath the dam. The ground improvement techniques will involve some form of a shear key. 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. Because the shear key must be keyed into frozen ground, protection against thawing of the permafrost is a critical component of the shear key design and some form of long-term maintenance of the permafrost is required. The ability for thermosyphons to maintain the frozen ground in perpetuity, under potentially changing (*e.g.* warming) climatic conditions, is the primary uncertainty and residual risk related to Options 1 and 2. Rock cassions have also been designed as a ground improvement alternative that does not rely on permafrost; however the cost and application of rock cassions at depths greater than 12m is uncertain.

The water balance modeling for Options 1 and 2 indicate little residual risk with respect to potential acid generation occurring in the tailings resulting from the formation of unsaturated conditions in the tailings mass.

Under Options 3 and 4, the complete removal of the tailings dam and relocation of the tailings to the pit obviates the geotechnical concerns related to long-term stability of the existing tailings dam. A much smaller in-pit "dam" would be required in Option 3 to safely contain the relocated tailings. While this dam would fall under CDA guidelines and require regular inspection, foundation instabilities are not a concern under this option, as dam foundations are easily keyed into bedrock. Option 4 likely does not require an in-pit dam to contain the relocated tailings and waste rock and hence concerns related to dam stability are not applicable.

Table 6.1-1:
Summary Comparison of Key Components of Mt. Nansen Closure Options

Description	Option 1A	Option 2A	Option B (for Options 1 and 2)	Option 3	Option 4
	Dam upgrade with water cover; waste rock and pit in place	Dam upgrade with saturated soil cover; waste rock and pit in place	Same for 1B and 2B; pit backfill with waste rock	Tailings backfill in pit with high infiltration cover. Waste rock in place	Waste rock and tailings backfill in pit with low infiltration cover.
Closure Components					
Surface Water Diversions	Upgrade diversion into and out of TMF	Upgrade diversion into and out of TMF	*Not Applicable*	Construct diversion from Pony Creek to pit TMF and spillway back to Pony Creek (as contingency)	*Not Applicable*
Dams	Upgrade spillway and stabilize dam	Upgrade spillway and stabilize dam	*Not Applicable*	Construct TMF dam at south end of pit	*Not Applicable*
Tailings	Water cover with diffusion barrier	Saturated soil cover	*Not Applicable*	Relocate to pit bottom High infiltration cover	Relocate to pit above water table Low infiltration cover
Waste Rock	Regraded and revegetated	Regraded and revegetated	Relocate waste rock to pit	Regraded and revegetated	Relocated to pit bottom and above tailings Low infiltration cover
Open Pit	Protective berm*	Protective berm*	Backfilled with waste rock	Backfilled with tailings	Backfilled with tailings and waste rock
Monthly Water Quality Predictions at Victoria Creek**					
Sulfate (mg/L) - median (max)	36 (106)	36 (106)	35 (98)	30 (44)	29 (40)
Arsenic (mg/L) - median (max)	0.0020 (0.0055)	0.0019 (0.0055)	0.0020 (0.0059)	0.0034 (0.022)	0.0023 (0.009)
Cadmium (mg/L) - median (max)	0.00012 (0.00051)	0.00012 (0.00051)	0.00006 (0.00028)	0.00009 (0.00038)	0.00006 (0.00035)
Zinc (mg/L) - median (max)	0.018 (0.062)	0.018 (0.062)	0.010 (0.035)	0.017 (0.059)	0.014 (0.058)
Estimate Closure Costs (Class D -25 to +40%)					
Capital Cost Estimate	$ 15,580,000	$ 17,064,000	$19,290,000 to $20,776,000	$ 23,955,000	$ 27,045,000
Common Element Pre-Closure Phase	$ 178,000	$ 178,000	$ 178,000	$ 178,000	$ 178,000
Operation Care and Maintenance (Life-Cycle Costs)	$ 7,825,000	$ 7,825,000	$7,500,000 to $7,825,000	$ 4,525,000	$ 3,750,000
Total Estimated Cost	***$ 23,583,000***	***$ 25,067,000***	***$26,968,000 to $28,454,000***	***$ 28,658,000***	***$ 30,973,000***

Table 6.1-1 (continued):
Summary Comparison of Key Components of Mt. Nansen Closure Options

Description	Option 1A	Option 2A	Option B (for Options 1 and 2)	Option 3	Option 4
	Dam upgrade with water cover; waste rock and pit in place	Dam upgrade with saturated soil cover; waste rock and pit in place	Same for 1B and 2B; pit backfill with waste rock	Tailings backfill in pit with high infiltration cover. Waste rock in place	Waste rock and tailings backfill in pit with low infiltration cover.
Uncertainty and Residual Risk					
Dam Stability	Low to moderate with respect to maintaining frozen ground within shear key	Low to moderate with respect to maintaining frozen ground within shear key	Low to moderate with respect to maintaining frozen ground within shear key	Waste rock "Dam" will be subject to CDA requirements. Low uncertainty and risk related to long-term stability of dam and containment	Not Applicable
Tailings Water Balance and Cover Performance	Low uncertainty with regards to maintaining tailings saturation over long term.			High uncertainty with respect to achieving desired level of tailings saturation. Associated risk of localized acid generation in coarser blended materials	Moderate uncertainty with regards to water flux through low-infiltration cover. Consolidation, rooting, heaving revegetation could diminish integrity of impermeable cover over time.
Tailings Seepage Quantity	Low uncertainty given extensive historic data record for tailings seepage flows.			Moderate uncertainty related to long-term discharge rate from tailings-filled pit.	Moderate uncertainty related to long-term discharge rate from tailings-filled pit.
Waste Rock Seepage Quantity	Moderate uncertainty related to estimated volume of seepage from waste rock.		Moderate uncertainty related to long-term discharge rate from backfilled pit.	Moderate uncertainty related to estimated volume of seepage from waste rock.	Moderate uncertainty related to estimated volume of seepage from waste rock.
Pit Seepage Quantity	Rrelatively low uncertainty as this option is a continuation of status quo conditions. Water flux from pit based on conservatively high estimate of hydraulic conductivity.			Moderate uncertainty related to long-term discharge rate from tailings-filled pit.	Moderate uncertainty related to long-term discharge rate from tailings-filled pit.
Tailings Seepage Quality	Low uncertainty given extensive historic data record for tailings seepage water quality.		Low uncertainty given large historic data set.	Moderate uncertainty related to potential for localized acid generation, leaching rates, and attenuation mechanisms along groundwater flow paths.	High uncertainty for source terms related to a lack of acidic drainage data. Moderate uncertainty related to potential for attenuation along groundwater flow paths.
Waste Rock Seepage Quality			Moderate uncertainty (backfilled waste rock) due to a lack of data pertaining to saturated waste rock seepage	Relatively low uncertainty given the large historic dataset from which the source terms were derived.	Moderate uncertainty (backfilled waste rock) due to a lack of data pertaining to saturated waste rock seepage
Pit Lake Seepage Quality			*Not Applicable*	*Not Applicable*	*Not Applicable*
Potential for Long-term Water Treatment	Low - Good containment; opportunities for passive technologies	Low - Good containment; opportunities for passive technologies	Low - Good containment; opportunities for passive technologies	Moderate - Poor containment; may require active treatment and control	Moderate - Poor containment; may require active treatment and control

Notes:
*Protective berm or similar is required for physical safety (pit walls are considered stable).
**Long-term predictions. Modeled scenario includes "Best Estimate" source terms and average flow conditions.

Option 3 carries a significant degree of uncertainty with respect to water management and specifically, the maintenance of tension saturated tailings in perpetuity within the pit, which is required to prevent tailings oxidation and potential acid mine drainage. Modeling of the hydraulic characteristics of the relocated tailings highlighted the importance of achieving a well-blended tailings mixture within the pit in order to ensure that tailings remain saturated; the ability to achieve a homogenous blend during the remediation process is a high uncertainty. Accordingly there remains a residual risk for Option 3 that portions of the tailings may become acid generating in the pit.

Water management of Option 4 relies on a synthetic, low infiltration cover to limit water flux into the relocated tailings and the potential for transport of contaminants out of the backfilled pit. The low infiltration (5% MAP) cover proposed for Option 4 is an engineered synthetic membrane that is not dependant upon evaporation or vegetation for performance but does relay on the ability to effectively shed water following precipitation and snowmelt periods. As such, success of the cover is linked to grade control and cover integrity. The relocation of tailings to the pit will invariably result in post-deposition, differential settlement of the tailings that could affect cover performance. The formation of depressions and the potential for ponded water on the cover could increase infiltration rates beyond those assumed in water quality modeling. Collectively, there is a moderate uncertainty with respect to cover performance for Option 4 and the ability to limit water fluxes through the cover and into the tailings in perpetuity.

6.1.1 Provisional Water Treatment Considerations

Estimates of provisional costs for water quality mitigation have been considered for short-term and long-term treatment. Cost estimates are summarized in Table 6.1-2 for short-term considerations and in Table 6.1-3 for long-term water quality considerations. Approaches to water treatment are discussed in detail in Appendix C-7. Provisional treatment costs are intended solely for the purpose of facilitating a comparative estimate of residual risk for each of the Mount Nansen closure options.

If active treatment is required for multiple aspects of a single option, then the only one capital investment for a treatment plant is assumed to be required, as reflected in the cost estimates. Some short-term and long-term treatments have been included in the base costs summarized in Table 6.1-1. Provisional costs outlined in the tables below are in addition to base cost estimates.

Table 6.1-2:
Summary of Estimated Short-Term Provisional Treatment Costs by Option

Option	Capital	Annual O&M
Option 1A/2A	$2,250,000	$38,000
Option 1B/2B	$2,415,000	$38,000
Option 3/4	(Included in Base Costs)	(Included in Base Costs)

Table 6.1-3:
Summary of Estimated Long-Term Provisional Treatment Costs by Option

Option	Capital	Annual O&M
Option 1A/2A	$627,000	$7,000
Option 1B/2B	$292,531	$7,000
Option 3/4	$2,250,000	$38,000

6.2 Geochemistry and Water Quality

Water quality predictions for the various closure options are summarized in Table 6.1-1 with respect to the major parameters of concern (sulfate, arsenic, cadmium and zinc). In order to provide a basis for comparison, median and maximum predicted values for Victoria Creek are compared for average flow conditions and best-estimate source term concentrations. Detailed discussion of the water quality predictions is provided in Appendix F.

Inspection of the water quality predictions illustrates that the options can be pooled into three major groupings based on similarities in the model output:

- Options 1A and 2A: These options show nearly identical water quality predictions, which reflect the common model inputs with respect to water balance, source term concentrations and attenuation mechanisms. Model results for Option 1A and 2A are comparable to existing water quality conditions in Victoria Creek and thus the can be used as a defensible analogue to existing conditions;
- Options 1B and 2B: Options 1B and 2B water quality predictions are identical and reflect the common model inputs associated with the tailings area water balance and source terms, as well as the shared water balance and source term inputs associated with back-filled waste rock;

- Options 3 and 4: Option 3 (high infiltration cover) and Option 4 (low infiltration cover) show very similar water quality predictions despite contrasting water balances and chemical environments of deposition. Specifically, despite the assumption that acidic conditions develop within the tailings as part of Option 4, such conditions do not have a marked effect on increasing contaminant loadings when compared to Option 3. This can be related to the effect of the low infiltration cover in reducing the water flux through the tailings, which offsets the higher source term concentrations in the loading calculations.

Among these option groupings, performance is dependent on the parameter of interest. For sulfate, median concentrations are similar between all options. Options 1A/B and 2A/B show comparable maximum sulfate predictions for Victoria Creek (maximum concentrations of 106 to 98 mg/L). In contrast, maximum sulfate predictions for Options 3 and 4 (maximum concentrations of 43 to 40 mg/L) are slightly more favourable. The lower predicted sulfate concentrations in Victoria Creek as part of Options 3 and 4 largely relate to a decrease in the water flux (and hence loading) associated with in-pit tailings placement in comparison to the higher seepage flux from the tailings facility.

Arsenic shows contrasting trends to sulfate, which relates to its mode of remobilization from the tailings (suboxic environments) and attenuation. For Options 1A/B and 2A/B, arsenic concentrations are low and consistent between options (median concentrations of ~0.002 mg/L; maximum concentrations of ~0.006 mg/L). By comparison, Options 3 and 4 exhibit similar median estimates to Options 1 and 2 (median concentrations ~0.002 to 0.003 mg/L), but have marked increases in predicted maximum concentrations Victoria Creek (maximum concentrations of ~0.022 to ~0.009 mg/L). The increase in arsenic loadings associated with in-pit tailings placement primarily reflects the higher arsenic source term concentration despite assumed attenuation removal rates of 50%. Maximum concentrations are exacerbated by the assumption that pit fluxes remain constrant throughout the year, resulting in elevated winter concentrations when dilution is low. This is considered a conservative assumption, since some degree flow reduction can be expected in the winter. In this manner, the maximum (winter) water quality predictions for arsenic for Options 3 and 4 are considered to be conservative (high estimates).

For cadmium and zinc, the predicted water quality for Options 1B and 2B indicate a moderate improvement compared to Option 1A/2A (current conditions). The predicted reductions in cadmium and zinc concentrations associated with Option 1B/2B are primarily a result of waste rock footprint reduction after backfilling the open pit. Cadmium and zinc predictions associated with Options 3 and 4 show values similar in

magnitude to those for Options 1A/2A, illustrating no significant change in performance with respect to existing conditions.

In order to best assess the merits of each option, the water quality predictions must be viewed with an understanding of model uncertainties and assumptions. In overview, options that maintain the tailings in their current configuration (Options 1 and 2) are associated with a greater degree of confidence in the water quality predictions in comparison to those options involving tailings relocation to the pit (Options 3 and 4). Such conclusions relate to our understanding of the existing tailings facility. Specifically, the extensive flow and water quality records for seepage waters emanating from the current tailings facility provide a defensible proxy for future conditions. In particular, the attenuation mechanisms responsible for the removal of trace elements along sub-surface flow paths can be expected to persist in the long-term (multiple decades). In essence, the model results for Option 1A/2A are comparable to existing water quality conditions in Victoria Creek and thus can be used as a defensible analogue to the current conditions. The model does predict somewhat higher winter values in comparison to the status quo. This is related in part to the assumption of a constant tailings seepage rate (throughout the year) in the model.

In contrast to Options 1 and 2, more uncertainty is associated with both the flow and chemical signatures for in-pit tailings placement options (Options 3 and 4). In particular, there is considerable uncertainty with regards to potential for attenuation along groundwater flow paths for seepage originating from in-pit tailings. In this regard, the assumption of 50% attenuation combined with the constant annual discharge flux imparts some degree of conservatism into the model output for Options 3 and 4.

Key assumptions and uncertainties apply to the water balances for all options, which have direct implications to water quality predictions. For Options 1 and 2, a key assumption is that the tailings can be maintained in a saturated state to prevent the development of acidic conditions, thereby minimizing the potential for metal leaching. Based on sensitivity modeling of the water balance, there is a considerable degree of confidence that saturated conditions can be maintained. In contrast, a lower degree of confidence is associated with the water balances for Options 3 and 4. A critical uncertainty associated with Option 3 is the feasibility of attaining a desired level (85%) of tailings saturation. In particular, there is a high level of uncertainty with regards to the feasibility of blending the coarse and fine tailings sufficiently to achieve a desired bulk hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings. In this instance, the uncertainty regarding the final *in situ* hydraulic conductivity of the mixed tailings translates to potentially

unfavourable consequences. Specifically, poor blending increases the potential for localized zones of acid generation in the tailings and increased loadings from the pit.

For the Option 4 water balance, there is uncertainty regarding the water flux through the low-infiltration cover and into the tailings. To account for this uncertainty, a conservative infiltration rate of 5% of average annual precipitation was assumed. Implications of a lower infiltration rate would result in a reduction in loadings from the tailings-filled pit. Accordingly, the overall loading from the backfilled tailings as part of Option 4 is not considered conservative (high).

6.3 Summary

Closure options have been developed for the Mount Nansen Mine to a pre-feasibility or conceptual level of design. Rendered images of the Mount Nansen Mine in its current condition (Figure 6-1) and following implementation of proposed closure options (Figure 6-2) are provided for illustrative purposes.

Closure plan designs have taken into consideration geotechnical engineering, geochemistry, local climate, hydrology, and hydrogeology. A refinement of closure options has been provided based on these site-specific factors. An evaluation of each short-listed closure options has been conducted including geotechnical stability and long-term performance of water balance and surface water quality. Comparisons have been made between the closure option designs, but the options have not been formally ranked. An effort has been made to provide reviewers with an unbiased, integrated, comparative assessment upon which to select a preferred closure and reclamation design for the Mount Nansen Mine.

Figure 6-1: Rendered Image of Current Conditions at Mount Nansen, Looking South

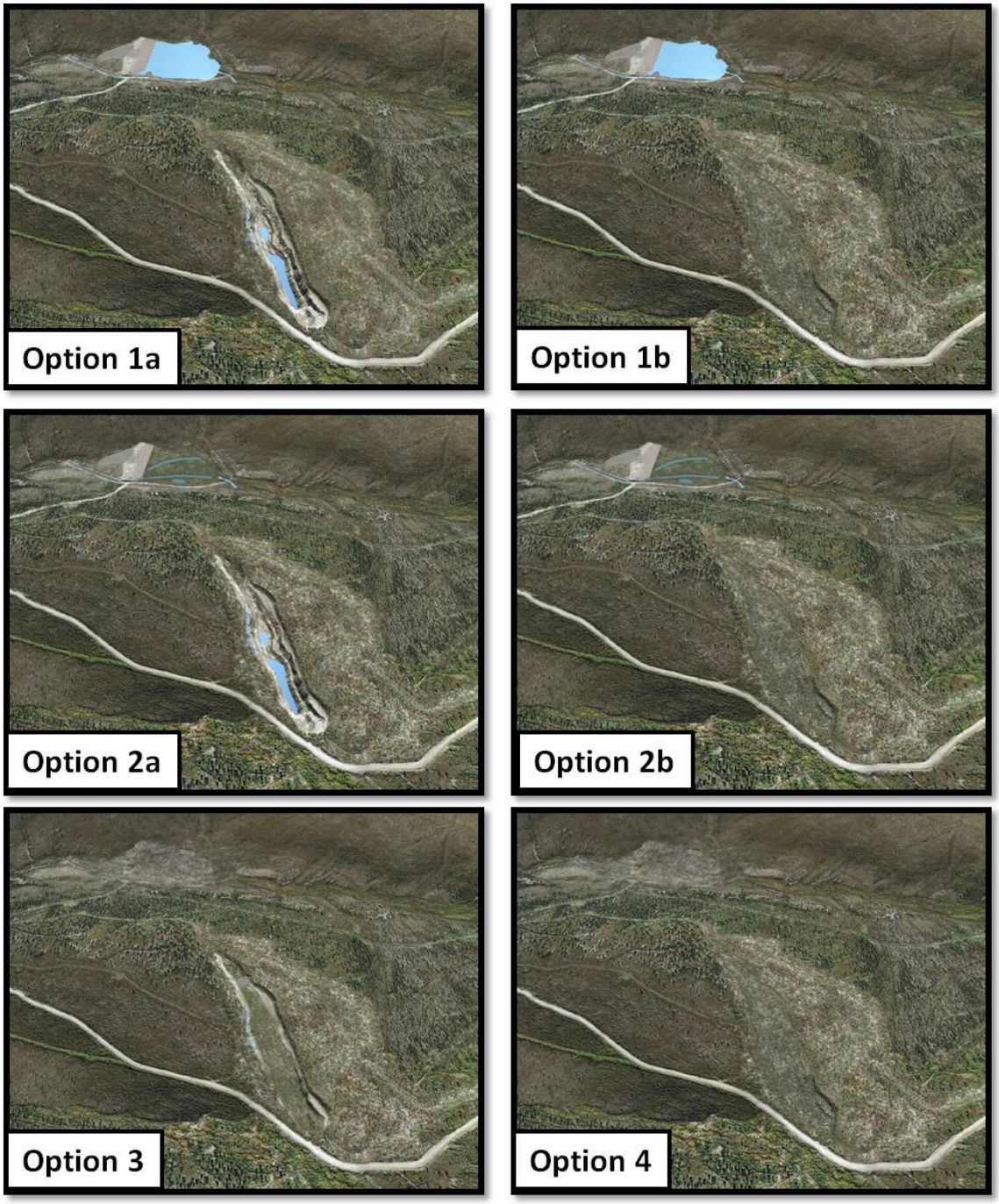

Figure 6-2: Rendered Image of Options for Closure at Mount Nansen, Looking South

Appendix A: Reporting Comments

Appendix A-1: Comments on Draft Report "Overview of Mt. Nansen Closure Alternatives" (AECOM, 2010)

Appendix A-2: Comments on draft Report "Mt. Nansen Options for Closure" (Lorax, 2010)

Yukon

APPENDIX A: REPORTING COMMENTS

APPENDIX A-1: COMMENTS ON DRAFT REPORT "OVERVIEW OF MT. NANSEN CLOSURE ALTERNATIVES" (AECOM, 2010)

IPRP MT. NANSEN SUBGROUP – TECHNICAL REVIEW, MARCH 2010
LSCFN (SLATER) – REVIEW REPORT, APRIL 2010
INAC – SUMMARY OF IPRP REVIEW, JUNE 2010
LSCFN (CSP2) – REVIEW OF MT. NANSEN GEOCHEMICAL ASSESSMENT, JULY 2010
LORAX – SUMMARY TRACKING TABLE, NOVEMBER 2010

Yukon

TECHNICAL MEMORANDUM

DATE: 29 March 2010

TO: **Angeline Lovatt (INAC)**

FROM: ***IPRP Mt. Nansen Subgroup***

SUBJECT: **Technical Review: "Overview of Mt. Nansen Alternatives Characterization" (Draft report from AECOM to YG Abandoned Mine Lands Staff, dated 26 February 2010)**

cc: **Frank Patch (YG), Andrew Liddiard (INAC); J. Brodie, T. Eldridge, T. Mudder, K. Raven (IPRP, Mt Nansen Subgroup)**

BACKGROUND

Indian and Northern Affairs Canada (INAC) and the Yukon Government (YG) are responsible for management and ultimate closure of abandoned mining operations at Mt. Nansen Yukon. Contractors to YG, lead by AECOM (Vancouver, BC), have been scoping the mine closure. In conjunction with YG, INAC, and technical consultants to the Little Salmon and Carmacks First Nation, the AECOM team has developed and prioritized alternative closure scenarios for the Mt. Nansen site.

At this stage, AECOM has been directed to consider four basic alternatives. Two alternatives (called group 3) involve remediating the existing tailings system. Alternative 3A considers three variants for covers (and minor differences over stabilizing the embankment), but does not propose any remediation for waste rock or the pit. Alternative 3B carries the tailings-closure options of 3A, but proposes to backfill waste rock into the open pit. There also are two alternatives (Class 4) that suppose relocation of the tailings to the open pit, ranging from saturated tailings with no movement of waste rock (4A) to "dry" disposal of tailings over backfilled waste rock (4B). The AECOM report and its supporting documents detail the options, provide estimates of the water-quality impacts associated with each, and present order-of-magnitude[1] costs estimates.

INAC, on behalf of themselves and the designated review team for YG, asked a subgroup of the Independent Peer Review Panel (IPRP) to review and comment on "Overview of Mt. Nansen Alternatives Characterization" (Draft report from AECOM to YG Abandoned Mine Lands Staff, dated 26 February 2010). The Mt. Nansen subgroup Review Team is:

[1] The report does not call these "order of magnitude" costs, and as presented, the cost estimates have a large number of significant figures. However, given the very preliminary stage of the alternatives analysis, one could not reasonably call these even pre-feasibility studies. Therefore, we term them, as would most in the mining industry "order-of-magnitude" estimates.

- John Brodie, P.Eng. (Geotechnical Engineering)
- Terry Eldridge, P.Eng. (Geotechnical Engineering)
- Mark Logsdon (Geochemistry; Mt. Nansen Review Team Chair)
- Ken Raven, P.Eng., P.Geo. (Hydrogeology)

In addition Dr. Terry Mudder, the IPRP Chairman, reviewed aspects of the water balance, water quality, and policy setting. The review memorandum is a consensus document of the Mt. Nansen Review Team.

Purpose and Objectives

The purpose of the review memorandum is to evaluate the AECOM report's presentation of closure alternatives for the major mine workings, within our terms of reference (see below).

Specific objectives include commenting on:

- The framework for evaluating impacts
- The critical elements of closure alternatives with respect to geotechnical engineering and civil works
- The critical elements of closure alternatives with respect to hydrogeology
- The manner and reliability with which geochemical source terms have been developed and how those source terms are combined with the hydrogeology to establish likely ranges of water quality outcomes for the alternatives under consideration.

Note that the scope of the AECOM report is limited to the principal mining units at Mt. Nansen, i.e., (a) the tailings dam and its impounded tailing, (b) the waste rock, and (b) the partially flooded open pit of the Brown McDade mine. The report and the closure alternatives it describes and evaluates do not consider the processing facilities or any other infrastructure at Mt. Nansen. Although we were asked to review the specific report, the Review Team would point out that demolition of the processing plant and other infrastructure will generate solid wastes that must be managed, and if YG and INAC wished to look at placing clean construction debris in the open pit, then this would have subsequent implications for at least space, if not final water quality.

Terms of Reference

In an e-mail to the Mt. Nansen Review Team on February 1, 2010, Mr. Andrew Liddiard (INAC) defined the terms of reference for this review:

1. Have the options been adequately addressed?
2. Are there any other reasonable closure options that were not addressed that should be?
3. Is there enough information on the proposed alternatives to be able to make a choice of a preferred option?

3a. If not, what additional data gaps need addressing to be able to chose a preferred option?

YG also asked, through INAC, that we consider the current ability of site evaluations to adequately describe and assess the effect of pit waters on Dome Creek.

To execute these terms of reference, we were provided with the AECOM report (including its appendices) and a relatively large body of supporting technical documents used to develop the AECOM position. The principal technical reports assessed by the Mt. Nansen Review Team to address our terms of reference include:

- Overview of Mt. Nansen Alternatives Characterization, Draft Report prepared by AECOM, February 10, 2010.
- AECOM Borehole Logs – GT09-01 to GT09-05
- Mount Nansen –Tailings Dam Stability – Alternative 3, Draft Memorandum prepared by AECOM, December 10, 2009
- Mount Nansen: Spillway for Alternative 3, Draft Memorandum prepared by AECOM, December 7, 2009
- Mount Nansen – Alternative 4 – Restoration of Valley after Relocation of Tailings, Draft Memorandum prepared by AECOM, December 3, 2009
- Mount Nansen: Pony Creek Diversion Channel – Alternative 4A(i), Draft Memorandum prepared by AECOM, December 3, 2009
- Mount Nansen – Alternatives for Pit Disposal (as part of Alternative 4), Draft Memorandum prepared by AECOM, December 3, 2009
- Mount Nansen: Dam Classification – Alternatives 3 and 4, Draft Memorandum prepared by AECOM, December 7, 2009
- Mount Nansen – Dam Stabilization (Alternative 3) and Pit Disposal (Alternative 4) – Cover Alternatives Draft Memorandum prepared by AECOM, January 14, 2010
- Mount Nansen – Pit Disposal Scenarios – Consolidation of Tailings (Alternative 4) Draft Memorandum prepared by AECOM, December 7, 2009
- Mount Nansen – Pit Disposal – Tailings Transport Methods for Alternative 4, Draft Memorandum prepared by AECOM, December 3, 2009
- Mount Nansen: Dome Creek Diversion Channel - Alternative 3, Draft Memorandum prepared by AECOM, December 3, 2009
- Hydrogeological Field Investigation Summary, Memorandum prepared by AECOM, December 3, 2009.
- Hydrogeological Conceptual Model, Memorandum prepared by AECOM, December 15, 2009.
- Mt. Nansen Water Quality Model for the Alternatives Assessment, Memorandum prepared by AECOM, February 11, 2010.
- Receiving Water Quality Assessment of Closure Options for Mt. Nansen, Memorandum prepared by Leslie Gomm (GEEC), February 26, 2010.
- Pit Backfill – Waste Rock Management and Cover Sensitivity, Draft memorandum from Lorax Environmental to AECOM, November 20, 2009
- Derivation of Tailings and Pit Lake Source Terms, Draft memorandum from Lorax Environmental to AECOM, November 15, 2009

- Derivation of Brown McDade Waste Rock and Ore Source Terms, Draft memorandum from Lorax Environmental to AECOM, November 15, 2009
- Derivation of Waste Rock Water Balance, Draft memorandum from Lorax Environmental to AECOM, November 14, 2009
- "Best Case" and "Lower Bound" Source Term Estimates, Draft memorandum from Lorax Environmental to Dr. Leslie Gomm, February 01,2010.

In addition to these written materials produced by the AECOM team, the Mt. Nansen Review Team reviewed its field notes and findings from the August 2009 field visit to Mt. Nansen. The team members also relied on their professional experience, collectively at hundreds of mines all over the world, developed over decades of experience for each team member. Mr. Logsdon communicated with Ms. Lovatt (INAC) via e-mail concerning certain matters of regulatory background.

MAJOR COMMENTS

1. The reports are generally clear and well written, and the supporting materials (tables and figures) are of good quality. There is no great difficulty in understanding what AECOM and its team hasdone or what they mean in their presentations.

2. The report does not have a clear and concise summary of what must be achieved, in terms of requirements of YG, INAC and LSCFN. In the opinion of the Review Team, it is essential for any analysis of engineering alternatives to begin with a clear statement of outcomes that (a) must be accomplished and (b) must be avoided. These then become key design objectives that relate engineering options to specific performance, against which all alternatives can be judged and ranked.

   In particular, the report needs to set out, at the very beginning of the document, closure requirements for (a) water quality and (b) physical safety at the site. The water-quality criteria should be presented in terms of specific regulatory limits (or other promulgated goals) including not only numeric criteria (if applicable) but also points of compliance. The Review Team understands from our site visit that the water-quality criteria for successful closure are the CCME guidelines, applied in Victoria Creek. That seems to be implicit in the document, but it really to be stated clearly and succinctly. Similarly, reviewers and other users need to understand what role physical safety associated with the open pit plays with respect to design objectives. Understanding this goal, if it is one, is important to evaluating the necessity for and effectiveness of pit-backfill schemes, and the potential trade-offs with water quality outcomes that might be associated with such actions.

3. The Review Team considers that the four generalized options for closure that AECOM was asked to consider represent an adequate range of practicable options for a site with the nature and extent of issues presented by Mt. Nansen. Distinctions at the level of alternative covers or use of drains as an element of pit backfilling can only be made during feasibility-level engineering. The AECOM report and its

supporting documents provide adequate information, clearly stated, that describes the essential elements of the four generalized options.

4. The Review Team does not believe that other technical closure options (that are not minor variations of these) need be considered.

5. Although (Major Comment 2 above) considering that the AECOM analysis needs a clear statement of the overall closure objectives to which the alternatives can be directly tied, the Review Team considers that there is sufficient information available that YG and INAC, in consultation with LSCFN, can choose a preferred alternative. The Review Team's opinion is that the technical data and analysis for water quality outcomes support remediating the tailings dam (Alternative 3). However, current information is inadequate to make a clear decision as between the three schematic cover options for remediated tailings in place. Whether 3A or 3B should be preferred depends on whether there is a requirement or preference for backfilling the pit in order to protect public safety. If there is, then 3B is clearly preferred; 3A would not achieve the safety design-objective. If there is no design objective for safety related to the pit, then presumably the Governments could evaluate the costs and benefits and make a decision as between 3A and 3B, when more detailed engineering and costs are available. The Review Team notes that other, simpler and less costly alternatives for controlling safety, such as berms (as will be used at Faro), also could be considered in conjunction with Alternative 3A.

   The water-quality outcomes for the Class 4 alternatives are not superior to those for Class 3, and in fact have very high levels of uncertainty, with much greater potential for high-risk outcomes. Even if additional studies were to significantly narrow the current range of Class 4 water-quality outcomes – and this is far from clear, certainly for near- to mid-term studies at plausible costs -, it seems a very remote possibility that the reduction would be entirely at the high-impact end and that the outcomes would, with high precision be close to the lowest possible end of the range. And even if they were, it is not clear that such differences as might exist would be meaningful. Furthermore, the Review Team is not entirely convinced that the Alternative 4 options have entirely covered the various risks associated with relocation of the tailings. We therefore conclude that the likelihood of improved decision-making, in terms of alternative selection, is not great, while the delays in action and costs of further effort could be very significant.

   In summary, based on the current analysis, it appears highly certain that either Alternative 3A or 3B would provide entirely satisfactory outcomes, especially when water quality is considered in Victoria Creek. Even if additional studies were conducted, the best probable outcome for Alternative 4 would be equivalent in terms of water quality to those of Alternative 3. A saturated-tailings alternative that leaves high-As surface waters is not an acceptable outcome.

Additional studies might improve understanding of the groundwater flow system and its transport behavior between the pit and Dome Creek. To do this would require a significant amount of additional hydrogeological investigation, at very substantial cost. Additional modeling without more field data would be unlikely to be useful or even scientifically

defensible. However, it does not appear at all likely that even if there were better understanding of the hydrogeology and transport system between the pit and Dome Creek, one would reach a different decision on closure alternatives – provided we are correct in understanding that the point of compliance is Victoria Creek. The current evaluations show that the Alternative 3 options would be effective at protecting Victoria Creek.

DETAILED COMMENTS

This section provides specific comments developed by Mt. Nansen Review Team members, organized by major technical area. They are presented in the format developed by the specific reviewers. Where similar comments have been made by different reviewers, this section limits repetition.

Geotechnical Comments:

1. Tailings dam stability related to warm permafrost foundation and a layer of very loose to loose sand in the foundation. Buttressing of the downstream face of the dam is presented in the documentation and drawings and in the opinion of the Review Team is the appropriate method to improve stability of this dam. Thermosyphons are shown Figures 01, 02 and 03, but neither is a discussion provided nor is any mention made in the cost estimate. While effective at maintaining frozen ground conditions, thermosyphons require maintenance. The extent of dam stabilization works that are proposed require a detailed review, particularly the parameters used for the stability analyses. The assumptions that have been made on performance following an earthquake are likely excessively conservative and are resulting in an oversized stabilizing buttress. This issue will not affect the decision on which option to select for closure.
2. Diversion ditch performance and the need for ongoing maintenance of this channel through the natural silty sand deposits in the area. A larger channel with flatter side slopes and erosion protection is proposed and is an appropriate design for this type of channel. Post-closure care and maintenance will be required.
3. Spillway channel requires upgrading for a larger flow. A channel incorporating drop structures is proposed. Again, post-closure care and maintenance will be required, most likely on an annual basis because the diversion channel and spillway are located on the abutment above the dam, and failure of the spillway could direct flows across the dam.
4. Pit wall stability is a minor issue. The significant open pit issue is ease of access and therefore safety, related to accidental or even purposeful entry into the pit.
5. Waste rock dump stability is a minor issue.
6. From a construction perspective, upgrading the tailings dam and ancillary water management structures will be less complicated than relocating the tailings to the open pit. Much less material will be relocated, less equipment will be required to operate on and around the tailings, and less water and sediment will be managed

during the construction period. The current work has not compared sediment and metal loads released downstream during a construction program to move the tailings into the pit, against the loads that could be released over a period of decades if the tailings are covered and left in place.

7. If the tailings are left in place, upgrading the existing diversion channel on the north side of the valley and routing the spillway done the left abutment using drop structures will mean post-closure care and maintenance will be needed, likely on an annual basis. A very flat toe berm (surface slope of 7 to 10%) is proposed to stabilize the dam. If this is constructed from rockfill, routing the spillway down the dam face should be considered. This would eliminate the diversion channel and spillway and the largest care and maintenance issue on the site. Precedent for this type of closure is the El Indio Mine in Chile.

Hydrogeology Comments:

The four closure options (3A, 3B, 4A-wet and 4A-dry) considered for the site under three source water chemistry scenarios (best estimate, best case, lower bound) address in varying degrees, what appear to be the central closure issues of tailings dam foundation stability, tailings seepage/treatment and open pit physical hazards. The waste rock extracted from the Brown McDade pit does not appear to be acid generating or to leach metals significantly, whereas the tailings may have moderate metals COC concentrations as represented by arsenic, cadmium and zinc, depending upon final saturation and redox conditions of these materials upon closure. The four selected closure options adequately address the main closure issues given the estimated waste source chemistries. Other closure options are not necessary to provide a reasonable set of alternatives for closure of the Mt. Nansen mine.

From a hydrogeological perspective, there is sufficient information on the likely performance of the proposed alternatives to allow for selection of a preferred closure option. The pit water balance, groundwater levels near the pit and directions and rates of groundwater flow from waste sources to receiving surface waters have been defined at an appropriate conceptual level to support evaluation and selection of closure options. While there remains hydrogeological uncertainty in the distribution of depth and thickness permafrost at the mine site, in the exact position of some groundwater divides near the pit, in the exact deep groundwater system flow paths and in the attenuation of metals in the groundwater systems, these uncertainties will not be resolved easily and are not critical to closure option assessment and selection.

One area where there is significant hydrogeological uncertainty is the degree to which future saturation of emplaced tailings within the pit will be achieved and maintained under Option 4A-wet, when the bulk the tailings will be placed above the local groundwater table. Under this option the tailings are added to the pit to an elevation of 25 m higher than the current pit lake water level and a water cover is added such that the tailings stay at least in tension saturation. To achieve these saturated conditions requires that the water table in the tailings is maintained at least within 10 m of the surface of the tailings or at least 15 m higher than the currently assumed local pit groundwater elevations. The degree to which the tailings can be maintained in a saturated state would be dependent upon the relative bulk hydraulic

conductivity of the tailings and bedrock. If the bedrock is more permeable than the tailings, which appears to be case, it would be difficult to maintain saturation of the complete tailings thickness because surface water will preferentially drain to the adjacent more permeable bedrock than seep into the deeper less permeable tailings. For this situation the performance of the tailings wet backfill option may be more likely intermediate between that of wet and dry than of simply wet.

A hydrogeological factor that should be considered in the evaluation of closure options is the ease with which remedial activities could be implemented if the source term chemistries for the main source of dissolved metals (i.e., the tailings) are greater than assumed or if collection and treatment is deemed necessary at some future time to meet water quality objectives at a compliance point. Clearly, capture and treatment of contaminated groundwater from the complex fractured bedrock surrounding and underlying the pit will be much more difficult than undertaking such work at the downstream end of the current tailings management facility. Consequently, consideration of the ability to capture contaminated groundwater and to minimize treatment if any were needed would favour leaving the tailings in place.

The source water chemistry of Scenario 3 - the lower bound, is the case where the tailings are relocated to the pit and a series of unspecified engineering and design activities are undertaken that result in very low source water concentrations for the tailing placed in the pit. Given the lack of specifics and the expectation that tailings relocation would result in significant increases in source water concentrations due to mechanical and geochemical disturbances, one should give little consideration to this scenario in evaluation of closure options.

In selecting a preferred closure option, it is important that the following four sets of data that are provided in the documentation are given due consideration:

1. The general observation that moving tailings to the pit results in "best estimate" source water and in receiving water COC concentrations that are orders of magnitude greater for arsenic, but within factors of 2 to 3 for cadmium, compared to leaving the tailings in place.

2. The water quality comparison figures for receiving waters given in Appendix D to the February 26, 2010 Gomm Memorandum that show the uncertainty and range in water quality predictions based on mean monthly maximum concentrations are significantly greater for moving tailings than for leaving tailings in place. For arsenic and cadmium the potential maximum concentrations in Victoria Creek for moving the tailings are about 100 and 10 and times greater, respectively, than for leaving tailings in place. The only scenario where moving tailings results in lower range and maximum concentration is for zinc with the tailings being maintained wet. Given comments above on the potential difficulties in maintaining saturation, this prediction may be overly optimistic.

3. Moving materials (waste rock and/or tailings) into the pit is the only long-term options that address the very real physical hazards posed by the pit.

Baseline Water-Quality Comments:

At present the Review Team understands that the Yukon Government has designated Victoria Creek as the receiving system for the mine site as it is in this creek that fish are first noted. This designation appears to be in line with YG protocol. There are potentially differing opinions of whether or not other streams and other points along them could be included for compliance based on the interpretation and implementation of federal definitions and regulations associated primarily with DFO. However, further assessment of the physical habitat associated with Back, Dome, Pony, and Victoria Creeks indicated poor habitat in Pony Creek likely prohibited reproduction while natural cascades located at the confluence of Dome and Victoria Creeks and in Back Creek were of sufficient height to likely preclude upstream migration of fish including arctic grayling. AECOM concurred with the current YG approach for compliance with some minor reservations.

The background water quality at the reference stations in several instances exceeded CCME guidelines for multiple constituents due to natural mineralization along the creeks. Therefore, regardless of the remediation alternative implemented ongoing impacts to water quality downstream in Victoria Creek would be likely at least on a periodic basis.

Geochemistry Comments:

The methodologies used by Lorax to establish ranges of potential source-term chemistries are generally appropriate and well supported. The data available for the exercise are appropriate to the level of the project and to support decision-making. However, the Review Team is concerned that, however sound the methodology may be for estimating the "Lower Bound" source terms, the assumptions about hydrological and engineering controls needed to achieve the modeled system are too hypothetical to be weighted equally with "Best Estimate". The "Lower Bound" values may be of heuristic use (e.g., as inputs to the GoldSim models), but the Review Team does not find them compelling as strong point-estimates of lower-range impacts.

The critical feature of the analysis is the recognition of the direction and general scope of impacts if the tailings are moved and disposed in a saturated state. Whereas addition studies would doubtless allow Lorax/AECOM to develop more precise estimates for the less-well constrained parts of the system, it is extremely unlikely that further studies would qualitatively change outcomes or move "best estimates" to a significantly different range. Very large data sets, notably different from that currently available, would be needed to move the statistics in a more precise and convincing manner.

The use of the combined geochemical and hydrogeologic data in a dynamic-systems simulator like GoldSim, is an appropriate way to consider the range of probable system outcomes. Although the Review Team did not try to re-create calculations, the GoldSim software is well-tested, and the outcomes make sense in terms of the conceptual models available for the natural system.

Cost Comments:

At the level of detail of current engineering for the alternatives, the estimated costs for all closure options are comparable, ranging from $5.8 to $8.1M (3A) to $12.4 to 14.7 M (3B), to $9.0 M (4A-wet) to $9.6 to 14.3 M (4B-dry). These cost estimates indicate there is a minor cost premium ($1-3 M) for moving tailings into the pit, and a larger one ($6.6M) for moving waste rock into the pit. The Review Team considers that the costs for moving the tailings, particularly too avoid spillage and to remediate the residual impacts at the old tailings site, may be under-appreciated. In addition, there may be substantially less expensive ways to backfill the pit with waste rock (given its proximity to the pit) than to manage it entirely by truck haulage and placement.

CONCLUSIONS AND RECOMMENDATIONS

The AECOM team has made substantial progress at site characterization and engineering alternatives analysis since the Review Team's site visit in August 2009.

The report needs to include, essentially at the beginning of its presentation, a clearer summary of closure goals, e.g., (a) to protect water quality at Victoria Creek; (b) to eliminate risk of inadvertent entry (falling) into the open pit. These high-level requirements, which we presume derive from policy direction provided by YG and INAC, are needed to clearly frame design objectives. Although they can be inferred from the overall text, these sorts of large-scale requirements need to be expressed explicitly.

The four closure options (3A, 3B, 4A-wet and 4A-dry) considered for the site under three source water-chemistry scenarios (best estimate, best case, lower bound) address in varying degrees, what appear to be the central closure issues of tailings dam foundation stability, tailings seepage/treatment and open pit physical hazards. The waste rock extracted from the Brown McDade pit does not appear to be acid generating or to leach metals to any significant amount, whereas the tailings may have moderate metals COC concentrations as represented by arsenic, cadmium and zinc, depending upon final saturation and redox conditions of these materials upon closure. The four selected closure options adequately address the main closure issues given the estimated waste source chemistries. Other closure options are not necessary to provide a reasonable set of alternatives for closure of the Mt. Nansen mine. It seems unlikely that additional investigations would change the basic characterization or likely performance-rankings of the alternatives.

Although the Review Team has, as directed, limited its review to the document submitted, the reviewers do recommend that YG and INAC request AECOM to prepare a site-wide closure plan that accounts for the management of demolition debris from the existing infrastructure. In order to allow consideration of the Brown - McDade pit for placement of clean fill, we recommend that this closure component be brought to the same level of detail for characterization as has the tailings/waste rock/pit work. If the demolition debris can be backfilled into the pit, then the amount of waste rock that needs to me moved to remedy the physical safety risk may be small enough that there is little cost impact.

Based on the water-quality evaluations and the level of certainty for decision-making, the Alternative 3 options are superior to the Alternative 4 options. If physical safety for the pit is important for agency decision-making [and we think it likely that this is so], then Alternative 3B appears to us to be the best-performing option. However, the Review Team notes that there are closure alternatives (e.g., berms) that could be implemented to control safety risks at much lower cost than backfilling. For any closure-in-place action, there will be need for modest post-closure inspection and maintenance, specifically for diversion ditches and channels.

There is insufficient information available currently to distinguish the outcomes for the three cover options at a remediated tailings site in terms of water quality. Additional design detail, and then, at least pre-feasibility – level cost estimates would be needed to support final decision making by YG and INAC. A "sponge cover" that melds as landform and vegetation with the existing wetland upstream and adjacent to the tailings impoundment, thereby creating likely the most aesthetic physical result, would appear likely to be well received by LSCFN, and in addition it likely would reduce long-term maintenance concerns.

In summary, the Mt. Nansen Review Team considers that the current state of investigations and alternatives evaluation, as documented by AECOM in this report, is sufficient for decision making, once these alternatives are considered in conjunction with management of construction debris from closure of the existing infrastructure.

REVIEW REPORT

Re:

Mt. Nansen Mine Closure Options Characterization
AECOM, February 2010

Prepared by

Bill Slater Environmental Consulting
For
Little Salmon Carmacks First Nation

April 22, 2010

1.0 Introduction and Overview

This report provides the results of a review of the characterization of mine closure options for the Mt. Nansen Mine prepared by AECOM with assistance from Altura Environmental Consulting and Lorax Environmental. The review was completed by Bill Slater of Bill Slater Environmental Consulting at the request of the Little Salmon Carmacks First Nation's (LSCFN) Mt Nansen Mine Closure Technical Advisory Committee. The Technical Advisory Committee has also commissioned some specific technical reviews related to specific aspects and components of the options characterization. As a result, the level of technical detail in this review is limited in some areas.

As part of this review a variety of documents provided by AECOM through a SharePoint site have been considered. This includes all of the documents contained in the final report folder as well as a number of other documents available on the SharePoint. In addition, a number of previous reports have been referenced and considered to provide background information to support the review. There was substantial field work completed in the summer of 2009 to support characterization of options. Some of the results from the field work are contained in the series of memos that comprise the final "report" while other results have not been provided at all. Where possible, these results were also reviewed. I note that many of the memos supporting the analysis were prepared in late 2009 but were not provided for review at that time. As can be seen from the level of comments provided below, it is apparent that earlier sharing of approaches may have led to more effective outcomes. This should be considered for any subsequent work phases.

The options description and characterization completed by AECOM was initiated in part following LSCFN's review of a 2008 options report. That report lacked sufficient information to understand the details of the proposed options or their expected performance in areas of key importance for LSCFN including environmental performance. LSCFN prepared a detailed response to that report and identified many specific information gaps that were needed to support options characterization and selection of a preferred closure approach. At the time, LSCFN's technical advisory committee expressed the need for a detailed description of practical and feasible alternatives with sufficient design detail to allow for balanced interpretation of performance against key objectives. Discussions with Yukon Government following LSCFN's review of the 2008 report led to the development of initial lists of information gaps, and the scoping for work to be completed by AECOM.

Overall, the work completed by AECOM fails to meet the goals set out in late 2008. There is no coherent, comprehensive description of the proposed alternatives or their performance. The alternative descriptions are very conceptual with inadequate detail to allow scientists to predict performance of the closure options with any level of certainty. As a result, there is also no coherent, comprehensive description of expected performance of the options. The characterization information that is provided for some options identifies a large level of uncertainty arising because the design detail provided does not

allow more effective predictions. It is important to note however that the tools developed for evaluating performance could be used effectively if only there were design details available to guide appropriate assumptions for making predictions.

With respect to the characterization of options, there is no comprehensive, consistent and cogent identification of risks associated with specific options. All of the options have risks, some of which could have been addressed by design changes and some which probably cannot. Those that could have been addressed by design changes should have been identified and the designs revised accordingly. For outstanding risks, the importance of these should have been discussed.

For this project, the difference in risks is of critical importance for evaluating the options, and they need to be addressed consistently. From reviewing the information provided by AECOM, it is apparent that this has not been done. The most important risks for some options are geochemical while for others they are geotechnical. Some risks are discussed independently in memos prepared by different members of the team, but no attempt has been made to determine how these risks related to each other. Other risks have probably been missed entirely because there wasn't any effort taken to comprehensively identify risks for the options. This needs to be done before any evaluation of options can be completed. Completing this task would require a broad discussion involving an overall design and assessment team, with participation from other relevant parties – most likely those who will eventually need to select a preferred closure option.

Ultimately, the lack of detail in the descriptions of proposed alternatives has, in my view, led to an unbalanced characterization of options for this site. The information is not sufficient for moving forward to evaluate and select preferred options. Significant redirection of the work will be needed in order to achieve the goals that LSCFN laid out in its review of the earlier options report. This is unfortunate because it will lead to an further delay in the selection and implementation of a closure plan for this site.

The above overview describes the major issues identified in the review of AECOM's options characterization. Some more detailed comments about specific components of the work are provided below. These comments will need to be considered when further work is initiated on the options descriptions and characterization.

2.0 Geotechnical Memoranda

For most of the options, the geotechnical components are the primary "works" for the closure plan. Overall there is very little detail provided about what works need to be done for each of the options and how they will be done. Concepts are identified but in general there is not sufficient detail to be able to determine how the facilities will perform. Many of the "designs" are simply generic concepts (e.g. channel designs) or concepts that have worked at other locations (e.g. covers). There are important site specific conditions and objectives that need to be addressed before the costs or the performance can be predicted.

2.1 Placement Scenarios

AECOM has identified a number of placement scenarios for waste rock or tailings in the pit. The memo lacks any rationale for identification of the proposed approaches and fails to provide any analysis of what each of the options is intended to achieve, making it impossible to evaluate comparative performance.

- The memo makes a basic assumption about a 1m thick cover on tailings in the pit, but there is no description of a cover design, what the cover intended to achieve or expected performance. This information is fundamental to understanding performance of any of the alternatives that include covers.
- Option 4Ai – Water Cover on Tailings in the Pit
    - The memo proposes a design with a complete water cover. However, other investigations and analyses confirm the capability of Mt. Nansen tailings to remain tension saturated at up to 10 above the water table. No rationale is provided for the need to maintain this full water cover, a design decision that appears to create significant unnecessary challenges for this option including (1) increased contaminant loading predictions due to increased seepage estimates from the pit and (2) water balance challenges resulting from increased seepage estimates and increased evaporation.
    - No rationale is provided for the proposal to locate the dam at the invert of the pit rather than further south. An alternate location may provide additional storage capacity at a lower elevation, helping to address water balance and seepage concerns.
- Option 4Aii – Tailings in Pit with Waste Rock Drains
    - The purpose, objectives and expected performance for the proposed drains should be identified as a rationale for the increased effort and expense that will be needed to implement this option. Accelerated consolidation is identified as an outcome, but what benefits does this bring? If the tailings are more chemically stable when saturated, then the rationale for providing accelerated drainage needs to be confirmed. Some suggestions are contained in the discussion section of the memo, but without some analysis about expected cover performance, these statements lack support.
    - The memo proposes future design to address migration of tailings into drain material. Given the total areas of drains, costs could be substantial for filter materials. Without some design information it is not possible to adequately characterize the option.
    - A liner is identified between tailings and the waste rock plug at the south end of the pit. Its purpose, design and expected long-term (permanent) performance are not discussed.
- Option 4Aiii – Tailings in Pit with Single Waste Rock Drainage Zone
    - The option proposes tailings placement at a slope of 9.5:1. Analysis needs to be provided to confirm that the tailings will be stable at this gradient in both static and seismic conditions. Without this, it is not clear whether this is a feasible option.

    - If analysis shows that these gradients are stable, mechanisms need to be identified for tailings placement – how will this slope be achieved as relocation proceeds? The discussion section of the memo references the need to understand this – but we cannot assess feasibility of the option without some further information.
- Option 4Bi – Tailings in Pit with Waste Rock Drains and Additional Rock to Fill Pit
    - See comments on Option 4Aii.
    - Rationale should be provided for the proposed soil cover over the entire area, as compared to a cover over the area draining to the pit.
- Option 4Bii – Tailings in Pit with Single Waste Rock Drainage Zone and Additional Waste Rock to Fill Pit
    - See comments on Options 4Aiii and 4Bi.

2.2 Cover Options

The objectives and methodology identified for completing the task related to cover alternatives is not adequate for defining practical and feasible cover options for selection of closure alternatives at Mt. Nansen. As a result, the memo adds little, if anything, to the previous information about covers for this site.

In order to evaluate alternatives, we need to understand (1) what we want covers to do for us, (2) what cover concepts will be used, and (3) how we expect the covers to perform at this site. None of these three questions are addressed by the AECOM memo. Ultimately we also need to understand what cover materials are available for construction and at what cost.

The question of what covers should do at the site appears to be misinterpreted by AECOM in the "key assumptions" suggesting that they are intended to minimize oxidation of tailings and contamination of surface water. While this may be the purpose of some of the covers, it is not a complete reflection of what covers should or could do. For example, many of the soil covers will not prevent oxidation. Instead, they minimize infiltration, thereby reducing contamination of groundwater – that may be their main purpose at this site. Many covers are also intended to reduce dust, minimize uptake by plants and/or provide a growth medium. The purposes of various covers at Mt. Nansen are fundamental to selecting/designing specific covers and understanding the options.

The question of what cover concepts will be used at the site needs to consider the above cover purposes, available materials, site-specific climatic conditions and materials that will be covered (grain sizes, moisture properties, etc.). Instead, AECOM has made cover recommendations based on generic covering approaches at other sites in Canada. Conceptual site-specific designs and performance need to be provided.

The question of cover performance can only be estimated from the above site-specific design information. Instead AECOM has referenced generic performance of other covers at other sites. More detailed, site-specific predictions about cover performance in

meeting desired objectives are needed. Without this comparative information for various options, we cannot complete a defensible options analysis.

Some further specific comments include:

- AECOM suggests that the most significant disadvantage of dry covers is the continued oxidation of tailings due to residual concentration of oxygen. It is unlikely that "residual" oxygen is the problem – more likely it is continued movement of oxygen through the cover materials.
- The AECOM memo identifies specific shortfalls for soil covers that can be addressed by variations in cover design. For example, upward movement of water by root suction and capillary action may be addressed by incorporation of a capillary break layer. This illustrates the need for site-specific designs with consideration of the cover objectives.
- For water covers, AECOM states "there is some risk that the water quality will exceed acceptable levels" in the event of a discharge. There will almost certainly be discharges in some circumstances though this is difficult to determine because of the lack of overall coherent, consolidated descriptions of the specific options – in this case, including a water balance for a water cover. The risks for discharge of contaminated water are fundamental to the feasibility of the proposed option and the risk needs to be quantified and addressed.
- AECOM states that the dam raise will not alter the stability analysis results. However, the analysis results (Stability Analysis memo) do not appear to take the proposed raise into consideration. Dam stability appears to only be considered for a single option and no statements are made about its application to other designs.
- A large soil cover beach is illustrated in the figures for some covers. The rationale and expected performance for this component is not described in any text.
- AECOM states a potential for increased seepage through the dam due to the increased pond operating level. However, modeling for water balance/contaminant loading assumes constant seepage that is consistent with current conditions – even though seepage has been on an increasing trend over the past several years. This is not conservative and results in biased outcomes for this option when compared with very conservative assumptions for other options.
- AECOM proposes that potential high contaminant levels in the water cover could be addressed by increasing flow through the pond by dilution from Dome Creek. Dilution in this way should not be seen as an acceptable mitigation approach. In a late 1990s water board decision, the mine operators at Mt. Nansen were rebuked for utilizing such dilution approaches.
- For a sponge cover, AECOM suggests that less stringent dam classification for seepage and stability should be considered. They provide no rationale to support this assertion even though the phreatic surface in the dam is at virtually the same elevation as for a water cover.

2.3 Consolidation of Tailings

The memo about tailings consolidation provides some useful input about expected performance of tailings after disposal in the pit. In order to benefit the options evaluation

however, the results of this memo need to be carried forward into the design of options. The memo makes suggestions about what mitigation may be required for specific options, but these mitigations do not appear to be incorporated in design or costing.

For options with tailings in a single layer, for example, settlement is expected to continue for more than 20 years and cover maintenance will be required. AECOM suggests a possibility of overbuilding covers by 2m, but this does not appear to be a practical solution because it will not address differential settlement – an issue which AECOM cites. The degree of expected maintenance needs to be identified as this is the proposed solution. It needs to be part of a coherent and consolidated description of this option including incorporation in cost estimates.

In terms of the actual analysis completed, the memo would benefit from some additional details about the rationale for assumptions and selected tailings properties. It is not clear why the selected parameters are appropriate for the tailings and conditions at Mt. Nansen because no details are provided.

2.4 Tailings Transport Methods

AECOM's memo on tailings relocation methods appears to reach an appropriate conclusion, that relocation of tailings by mechanical means during the winter is probably reasonable for Mt. Nansen. However, this conclusion is based on very limited information and analysis. It is surprising that there is no reference to previous work done at Mt. Nansen to investigate trafficability of tailings in winter and the conditions of tailings after winter handling. It is also surprising that the analysis did not take advantage of information from the evaluation of tailings relocation methodologies for the Faro Mine – work that is readily available through the Abandoned Mines Branch of Yukon Government.

As with several other components of the options characterization, the tailings relocation methodologies are not developed to the level of a conceptual option design that allows us to understand what a tailings relocation program would entail, including the excavation of tailings in the valley, transport to the pit, placement in the pit, water management, dust management, etc. A conceptual understanding of all of these components is needed in order to compare the costs, risks and performance of the various mine closure options.

2.5 Dam Classifications

The conclusions about dam classifications reached by AECOM appear to be consistent with the classification categories described in the Dam Safety Guidelines of the Canadian Dam Association. It is worth noting that the classification criteria in the Dam Safety Guidelines do not include any reference to potential social or cultural consequences associated with a dam failure. As a result the consequence categories may not be reflective of LSCFN's perspectives about the dam. AECOM has proposed that environmental, cultural and hydraulics experts would need to be involved in subsequent

discussions about the appropriate classification during the final design stage. It would be useful for LSCFN to be involved in that discussion if the dam remains in place.

AECOM notes that any modifications to the dam would trigger a new dam safety review. Note that the last dam safety review completed for this structure was in 2002 by EBA Engineering. At that time, EBA recommended a subsequent review in 5 years. The Dam Safety Guidelines suggest reviews every 7 years for dams classified in the "high" consequence category. As stated previously by LSCFN's team, a comprehensive dam safety review is past due for this structure especially given its past performance record.

In describing the consequences of dam failures for various options, tailings liquefaction and mobilization is only identified for the soil cover. Tailings would also be liquefiable for the water cover and sponge cover options and tailings mobilization may be greater for these options. Overall, this is unlikely to affect the classifications but it certainly affects the characterization of risks for these options because the consequences of mobilizing tailings into Dome and Victoria Creeks could be severe.

The final point in the recommendations suggests that there is little difference between the failure consequence for failure of the valley tailings dam or a new pit tailings dam – with water covers. This does not seem consistent with the results presented in the Table contained in the memo, which suggests that consequences are less because volumes of water and tailings retained by a pit dam are smaller and the facility is not directly in a stream channel. This illustrates the need for a consistent and comprehensive consideration of risks for all of the closure options.

2.6 Stability Analysis

The memo describing the results of the stability analysis lacks sufficient detail to confirm the assumptions, input and results of the work completed and interpret whether it presents a conservative estimate of current dam conditions, likely performance and necessary upgrades. The memo describes a methodology that proposes to carry out the necessary tasks, but it fails to provide any details about the work completed.

Sources for design event sizes and rationale for these inputs are not provided in the memo. The methodology in the memo proposes to compile borehole data from the 2009 drilling program and other historic information, but no data or analyses are provided. Results and interpretation of the drilling program should be provided in this memo or summarized in a separate report. The memo proposes to develop startigraphic profiles for the dam. This has apparently been completed, but no sections showing borehole information or inferred stratigraphy are provided. In fact, the memo doesn't even reference a plan of borehole locations. Permafrost conditions under the dam are important for the stability analysis, but no details are provided about any thermal analysis conducted or even any interpretation of thermister data. Table 1 lists material properties used in the stability analysis, with references to sources for these properties. However, there is no discussion about the relevance of these parameters or the extent of data used to develop them. All of this information needs to be identified and defended to support the

analysis completed. Without such information, it is not possible to confirm the conclusions reached and whether it is feasible to leave the dam in place in the long-term.

The AECOM memo identifies significant dam safety issues for the tailings dam. This is consistent with previous analyses. AECOM's analysis concludes that the dam does not meet the required factors of safety for post earthquake conditions. The Dam Safety Guidelines require a factor of safety of 1.2 while the stability analysis estimates a value of 0.56. This is an extremely low factor of safety and suggests that the dam would almost certainly fail under a design earthquake event. The problem lies in the thawed foundation soils beneath the dam and AECOM proposes that this can be addressed by freezeback of the foundation soil into a toe berm or by construction of a shear key into frozen soils. Note that this relies on existence of frozen soils.

AECOM's analysis did not consider all permafrost degradation scenarios. The stability of the dam relies on direct contact of the toe berm or a shear key with frozen foundation soils. Without this frozen contact, it appears that stability cannot be assured. AECOM has suggested that the proposed configuration could address thawing to a depth of 4m as long as contact with permafrost is maintained at the shear key. Thawing to depths greater than this has not been evaluated. In fact, the liquefaction potential of currently frozen soils and the depth to bedrock are currently unknown. Finally, AECOM states that "it would not be practical to stabilize the dam in a way that would ensure the required factors of safety under all potential future ground conditions."

In my view, without further analysis, this is a fatal flaw for any option that proposes to leave the tailings dam in place. Any proposal to retain the dam needs to be supported by either: (1) thermal analysis, taking into consideration long-term climate change, that demonstrates that foundations will remain frozen, or (2) a dam upgrade design that will address thawed foundations at depth.

2.7 Spillway

AECOM has proposed spillway and diversion designs that provide capacity for a 1:1000 year flood event. This does not appear consistent with the requirements of the Dam Safety Guidelines which propose design floods of "1/3 Between 1/1000 and PMF (Probably Maximum Flood)" for a "High Consequence" dam. AECOM's memo about dam classification concludes that the dam is a High Consequence structure for a water cover condition, and "Significant to High" for a sponge cover. In my view, the consequences of failure by flooding are the same for all cover types because the water would convey tailings into the downstream environment. As a result, it seems reasonable to consider the same design flood event for all cover types and the design floods need to be revised to those specified in the Dam Safety Guidelines for High Consequence structures.

The methodology for arriving at design flows is not provided. There are numerous assumptions, recommendations and conclusions stated about the size of design events, but no rationale is provided for any of them. For the design of spillway upgrades for the

tailings dam, AECOM's initial design assumptions state a design flow rate of "10m^3/s or less" but it is not clear what "or less" is intended to mean. Subsequently, the memo proposes that a capacity of 5m^3/s will be adequate to convey flows that may result from a failure of the diversion, after taking into account the attenuation. In the final recommendations, AECOM proposes a spillway with capacity for 10m^3/s for water and sponge cover options. No rationale or analysis for these capacities is provided. A subsequent statement in the final recommendations suggests that the spillway needs to be upgraded to convey 18m^3/s. Overall it is completely impossible to discern what spillway capacities are proposed and what the rationale is for any recommendations.

The Dome Creek 1:1000 year flows are estimated to be approximately 18m^3/s. There are references to previous reports, but it is not clear what report is the source for this information and whether AECOM has done any evaluation of more recent data and information to confirm the validity of the design event sizing. In fact, the memo indicates that analysis to determine or confirm design flows has not been done, suggesting that it needs to be done later. These capacities need to be determined now because they are fundamental to the feasibility and costs of closure options.

Smaller spillway capacities (5-10m^3/s) are proposed based on attenuation of flows in the impoundment, with the greatest reduction for the soil cover option. However, the recommendations for the soil cover option state that the spillway invert will be below the cover elevation. This indicates that attenuation capacity would likely be negligible. AECOM further states that the proposed capacity will be adequate because the tributary area is small. This seems to indicate that sizing did not consider failure of the diversion. In my view the spillway design for the dam must consider a potential diversion failure. Without this, the diversion is a much higher risk structure. I note further that no information is provided about flood routing calculations that led to the attenuation conclusions. There is a good chance that flood routing and flood attenuation results would be different for soil covers, sponge covers and water covers, but no detail is provided for this either.

AECOM's memo contains both a "conclusions and recommendations" section and a "recommendations" section. As a result, it is again unclear what is being proposed. In one point, AECOM proposes that the spillway needs to be armoured to prevent erosion. While this is true, it is not helpful in evaluating the feasibility of the proposed closure option, or its cost. All spillways need to be armoured but more detail is needed for an options characterization.

On a similar note, AECOM has provided a drawing and spillway sizing for a generic spillway that could convey the proposed design flow. Again, this is not sufficient to understand feasibility at this site. Erosion control has been a challenge at this site and the current spillway has never been seen as adequate. The lower portion of the diversion has failed on more than one occasion and required repair. Generic designs are not sufficient for evaluating the expected performance, risks and costs of closure options. More detail is needed.

AECOM recommends that the adequacy of the armouring and drop structure should be assessed more closely and upgraded if needed. That should have been completed as part of the characterization because we need to know what works will be part of each options and what they will cost. AECOM was asked to identify and characterize what upgrades would be necessary. It has been known for many years that assessment and upgrading would be needed. More detail is needed now to understand and evaluate options for closure.

AECOM's memo proposes that a spillway with a 5m base width can convey flows of $5m^3/s$ with a depth of 0.7m, but the memo proposes that the spillway shown in illustration "A" can convey $18m^3/s$ with its base width of 4m. Depth is not clear. A real spillway design is needed that takes into account soil conditions, appropriate flow rates, velocities, effectiveness of erosion control, etc. Without this, it is not possible to characterize the proposed closure options.

For the soil cover option, AECOM appears to suggest that the current spillway capacity is adequate – "considering the limited tributary area." This is completely contrary to findings of the 2002 dam safety review and AECOM's 2008 inspection report on the dam. Since a failure of the diversion needs to be considered in the spillway design, it is not clear how the capacity of the existing spillway could now be considered adequate.

Overall, the spillway memo does not provide adequate information to understand what upgrades are needed to establish flood routing capacity appropriate for mine closure. Without this information the feasibility, expected performance and costs of the proposed option cannot be determined. Further design information is needed to support any useful evaluation of closure options.

2.8 Diversion Channel

Similar to the memo about spillway design, the Diversion Channel memo does not provide adequate information about what needs to be done to provide long-term conveyance of Dome Creek flows and ensure physical stability of the tailings impoundment. The methodology described in the memo proposes a generic approach to design which cannot address the site-specific needs at this site including highly erodible materials, inadequate past performance, conveyance of minimum winter flows and permafrost degradation. Substantially more detail will be required to define closure options with sufficient information to allow options evaluation.

AECOM makes assumptions about inflow from precipitation, runoff and groundwater being sufficient to maintain water cover with the diversion and interceptor ditches in operation. Later the memo notes that water quality in a water cover could be problematic and require treatment before discharge. This leads to an approach that proposes maintaining a water cover while minimizing spilling of excess cover water. Without a more detailed water balance, it is not possible to determine whether the water cover will be feasible with the proposed approach or the extent of water treatment that might be required.

The assumptions with respect to the water balance for storing tailings in the valley contrast sharply with those for options that consider storing tailings in the pit. For valley storage, little effort has been taken to evaluate the ability to maintain a water cover or what water treatment costs would arise. In my view, this has resulted in optimistic assumptions about the performance of these options, their complexity and their costs. For the pit options on the other hand, significant uncertainty has been raised about the ability to maintain a cover and the implications on the overall closure approach. In my view, these different assumptions about complexity and performance have led to an unbalanced options characterization.

AECOM proposes that the diversion channel will need to be widened to accommodate the design flows. They also identify the need for channel armouring. But, no design details are provided for how either of these would be accomplished. Neither a channel alignment nor long-section is provided. Gradients need to be identified along with appropriate mechanisms for armouring, seepage control, etc. Given past challenges with the diversion, additional details are needed.

The memo identifies the need for "regular cleaning" of the diversion to remove sedimentation. Since its initial construction, sediment removal has been a significant cost and challenge for this diversion. If this is expected to be a long-term component of site activities, appropriate administrative structures and costs need to be described as part of the options characterization. Also, it is worth noting that some types of armouring are likely to be incompatible with sedimentation removal requirements.

The recommendations propose armouring of the interceptor ditch and flattening of slopes to "slow slope degradation and reduce sediment load." This facility is excavated in fine-grained frozen soils that are thawing. Construction of functional diversions in these circumstances is very challenging and warrants a more detailed description of how this could be accomplished. Without this information, the cost of the options cannot be evaluated.

The diversion memo fails to provide any information about how the channel will be designed to convey low winter flows. Icing and glaciation have been issues at this site in the past and such events are likely in the future. These winter events can lead to diversion failures during freshet due to channel blockage by ice. The design needs to incorporate considerations for conveyance of small flows in freezing conditions.

Given the lack of information as described above, it is not possible to develop a realistic understanding of the costs associated with the diversion facilities for any of the options.

Note that comments pertaining to evaluation of design flood events, as discussed above in relation to the spillway, also apply to the diversion work.

2.9 Pony Creek Diversion

The AECOM memo about the Pony Creek Diversion includes an assumption that Pony Creek flows will be adequate to maintain a water cover. However it also states an assumption that further assessment will be necessary to determine whether a cover can be maintained. These "assumptions" appear contradictory and it is not clear which one was used in completing the work to evaluate the Pony Creek diversion concept. Also, I note that the authors of this memo relied on Gartner Lee's 2007 hydrogeological study which has now been superseded by 2009 work. Relevance of the new work to the proposed plan should be confirmed.

Two overflow concepts are identified for the pit, one flowing to Pony Creek and the other to Dome Creek. Which one of these concepts is used in water quality modeling? In either case, design events and channel designs have not been provided. These are needed in order to characterize the options adequately for evaluation purposes.

The memo identifies the potential for contamination of a water cover over tailings in the pit. Has this contamination been considered in water quality and loading models and/or have treatment costs been included in cost estimates for this option?

Diverting Pony Creek would require some form of headworks dam. No information or consideration is provided for this.

Overall, the memo provides little design information about diversions, spillways and channels for a Pony Creek diversion. Further information will be needed to characterize the options adequately for an options evaluation.

In this case, AECOM has chosen to highlight the concerns about the proposed water cover option in the pit:

- Diverting Pony Creek to maintain a water cover is not a desirable option because:
  - Diverting Pony Creek would be an additional environmental impact (vs. leaving the tailings in their current location, or placing them in the pit with a dry cover). If possible, it would be desirable to leave Pony Creek relatively untouched.
  - Diversion structures, spillways and tailings dams require ongoing maintenance and are not walk-away solutions.
  - The cover water will potentially introduce additional contaminants into Pony Creek or Dome Creek, depending on the choice of spillway options.

Presenting pros and cons of options may have been a reasonable part of AECOM's scope, but it has not been done for other options. In this case, it is worth noting that the long-term requirement for diversion structures, dams, and spillways is identified as a con for in-pit options, though these would be much more significant for options that leave tailings in the valley. Unfortunately, AECOM has not chosen to identify these issues for those options. Similarly, the issue of contamination arising through a water cover is identified for this option. I note that the area of water covered tailings would be larger if the tailings remain in the valley, leading to a greater possibility for contaminant loading but this issue was not identified for that option.

2.10 Restoration of Valley

AECOM's memo about valley restoration provides a description of concepts that have been considered. As with other components, the memo provides only limited detail. For this component however, it would probably be difficult to complete a detailed plan at this time. Regardless, there are some questions about the assumptions and findings of AECOM's memo that warrant some further consideration because they will be relevant to option cost estimates.

- The memo appears to propose complete removal of the dam, with the material spread over the surface of the former tailings impoundment. It also proposes covering of the entire area with local soil as well as filling of all ditches with local soil. The level of activity proposed seems to go beyond that necessary for mine site reclamation and may increase the cost for this option. Adequate activity needs to be undertaken to ensure long-term physical stability of the area, but this does not necessarily entail complete re-establishment of original terrain.
- The "local soil" for covering the area is not described. Many of the local materials are quite erodible. Efforts will be needed to stabilize the area. Some additional information would be useful about why covers will be needed, what type of soil materials will be used and how they will be effective for establishing vegetation.
- While much of the valley restoration will need to be "designed" in the field, there will be a new channel required. Some design details about for the proposed channel are needed in order to understand the cost of the option. A reasonable assumption would be that a completely new, erosion resistant channel would be needed through the former tailings area. Channel sizing could be commensurate with the reduced risk because tailings would not be present in the valley.
- AECOM has assumed that a significant amount of contaminated soil will be present in the valley and require relocation to the pit. The geochemical characterization completed by Lorax seems to reach a different conclusion – that the attenuation of metals occurs in the organic layer. It would be useful to reconcile the findings of the two investigations.

3.0 Hydrogeological Investigations and Model

AECOM has provided a memo titled "Hydrogeological Conceptual Model" dated December 15. The memo refers to five figures and two appendices which are not included with the memo on the Sharepoint site. Some of the material appears to be available within other documents, but other components do not seem to be available at all. The missing information includes two key figures as well as the calculations contained in Appendix B. Since many of the assumptions that support the calculations, and therefore the results, are not contained in the text, it is not possible to fully review the hydrogeological modeling results without the missing information. The comments provided below are provided without the benefit of this information and therefore may reflect an incomplete understanding of the work that has been done.

- Section 6.2.3 provides results of bulk hydraulic conductivity calculations for the pit, based on recorded water levels in the pit over a number of years. The calculations rely on various assumptions about other inflows, groundwater gradients, etc. but these assumptions cannot be confirmed because no information is provided. Given AECOM's assertion that the pit water is part of the regional groundwater table, the assumptions about gradients could have substantial effects on the seepage rate predictions.
- The estimates of flow through the competent bedrock unit appear to rely on bulk hydraulic conductivity, though fault zones are noted. If faults provide highly conductive zones, then the bulk hydraulic conductivity could be of little relevance to seepage rates.
- In Section 6.3.3, AECOM concludes that seepage flows at the north end of the pit are essentially seasonal. The memo states that this is "based on field observations" but no details are provided about what observations have been taken to confirm that flow stops in summer and winter but is active through May/June and October through December. Have observations been made in winter to conclude that flow is not occurring at this time – it appears that this would be difficult to determine given the extent of icing that occurs?
- The memo assumes that flow at the north end of the pit results from a fault-based pathway between Pony Creek and the pit. During the gap analysis phase of AECOM's work, the concept of confirming this through water quality comparisons was discussed. If this approach was completed, no results have been provided. It would be useful to confirm this assumption.
- The volume of water entering the pit from the north seep and the travel time from Pony Creek have been estimated using well yields and groundwater gradients. This approach assumes that the flows are not occurring in fault zones. It seems probable that flows could be larger if they occur via faults.
- AECOM considered the pit water level data provided by Yukon Government, concluding that the pit water level fluctuates over time but has not risen above 1184.5 over the eight year period of record. From this, AECOM infers that the pit water level is a surficial expression of the groundwater table. While Yukon Government's data are not provided as part of the memo, they are available on the portal site. It is interesting to note that the highest pit levels were recorded in 2008 and 2009, with the 2009 peak being slightly lower than 2008. Note that the pit was pumped out in 2002 and 2004. Pit levels appear to have recovered beyond the 2004 initial levels by late 2005. Data for 2006 and 2007 are limited and do not provide much assistance in interpretation. Based on this information, it would be possible to conclude that the pit level is rising over time. While this could be a reflection of the regional groundwater table, there is no reference to corresponding groundwater levels that confirm rising trends at the same time as the rising pit water level. In my view, AECOM needs to provide additional information and analysis to support the proposed hydrogeological model for the pit, especially since it differs substantially from previous models.
- AECOM suggests that the regional water table is expected to drop several metres during the winter. There do not appear to be data to support this assertion.

- Section 6.3.4 states that "permafrost was encountered in every borehole drilled in the tailings management area just below the base of the tailings." The logs for these holes do reference permafrost – is it assumed that the boreholes terminated at refusal in permafrost?
- Plan and section figures showing groundwater, permafrost, soil conditions, etc. are not included for the tailings area and are critical in understanding the interpretation of hydrogeology.
- Section 6.3.4 describes AECOM's inference that the tailings essentially behave as a tension saturated unit with downward vertical gradients. If this is the case, the seepage through the tailings unit becomes critical to understanding the loading of contaminants. This seepage will likely vary depending on cover type – water versus soil. Therefore, to understand the performance of the proposed options, the cover and tailings units need to be modeled to predict flow rates. It is not sufficient to utilize water quality results from downstream areas because it appears that these have already been diluted by the underflow of cleaner groundwater in the Dome Creek aquifer because the downward gradient conditions in the tailings area suggests that seepage that passes through the tailings appears to comprise only a small component of the water that accumulates below the tailings facility.
- AECOM appears to conclude that the seepage collection dyke provides a barrier to tailings seepage and that all contaminated seepage is collected at this location. The thermistor data indicates that the seepage collection dyke is frozen. Note that this was an important component of the design and is likely a result of the thermosyphons. The drilling results confirm presence of permafrost in the north and south abutments, but no sections are provided to illustrate the permafrost elevations in relation to the seepage collection dyke. When I observed the site in 2008, there was significant seepage present near the toe of the seepage collection dyke, but it is not clear what the source might be (seepage dyke, north abutment, south abutment) or its quality. Some illustrations and analysis would be useful to support the conclusions that no seepage is bypassing the system currently (either around or below the seepage collection pond) and what the implications are for performance of proposed closure options.
- The memo recommends further instrumentation, data collection and analysis to help refine the understanding of potential permafrost degradation within the tailings impoundment. However, the geotechnical evaluation has assumed limited permafrost degradation, resulting in optimistic assumptions about geotechnical performance. The outcomes are critical to performance of some proposed closure options and have potential to identify fatal flaws with these options. As such, additional information is needed if tailings dam stabilization options are to receive continued consideration.
- AECOM has made several recommendations related to the needs and approaches for data collection. These warrant further discussion before they are implemented.
- AECOM's memo on the hydrogeological modeling references a separate memo related to the water balance for the seepage collection pond. This memo is available on the Sharepoint site, though not specifically an appendix to AECOM's final report. Some comments on this memo are provided below as they affect the hydrogeological modeling.

- AECOM notes that the contaminant concentrations for some parameters (e.g. arsenic) indicate that reduction processes occur between the tailings and the seepage pond. For other parameters, these processes are not likely occurring and the comparison of water quality at the pond and in the tailings may provide some information about the extent to which dilution may also account for reduced contaminant levels downstream.
- The analysis completed by AECOM concludes that seepage from the tailings pond accounts for approximately 3.6L/s of the total flow from the seepage pond (approximately 66%). In my view, this predicted flow rate provides evidence that the tailings seepage probably receives significant dilution from the Dome Creek aquifer before it reaches the seepage collection pond. 3.6L/s is approximately 114,000m^3/year. The 2009 Lorax report identifies the tailings area as approximately 46,000m^2. Mean annual precipitation is given as 284mm by AECOM. Even if all the water falling on the tailings infiltrated through the materials, this would only account for approximately 13,000m^3/yr. It is more likely that the infiltration through the tailings is 25% or less of the incident precipitation given the fine-grained, low-permeability nature of the tailings described by AECOM. If this would suggest that dilution alone could account for approximately 40 times reduction in contaminant levels, without consideration of attenuation mechanisms.

4.0 Geochemical Characterization

Note that several of the geochemical memos reference a November 2009 Lorax Report entitled "Mt Nansen Geochemical Site Assessment and Source Term Development." This report does not appear to be available and was not provided upon request. From the references, I assume that this report summarizes the 2009 field programs and analyses completed by Lorax. Many of the comments below may be clarified by the information contained in that report.

The overall approach to source term development for predicting future water quality conditions generally relies on prediction of future conditions on the basis of currently available data from the site. The worst-case source term estimates have been developed based on the most adverse results currently available. This approach inherently assumes that geochemical conditions have reached their worst at some locations on the site and that monitoring has captured results from these locations. In my view, this broad assumption warrants some further discussion and consideration, especially given Lorax's assertion that the materials at this site are potentially acid generating. If this is the case, then conditions could easily deteriorate in future, leading to outcomes more adverse than those predicted by the worst-case.

4.1 Tailings and Pit Lake Source Terms

The various approaches taken by Lorax for predicting water quality emanating from the tailings source, either in the pit or in the valley, warrant some further discussion and

evaluation. With the information provided, the approaches appear to bias the results for different options.

In the case of tailings remaining in the valley, Lorax appears to make optimistic assumptions about geochemical performance, essentially assuming that the tailings are currently stable and will remain that way in the long-term. The basis for this conclusion is that current conditions appear to be stable and will hopefully stay that way. A worst-case condition is presented, but even that relies heavily on current data downgradient of the tailings, assuming no further deterioration of tailings geochemistry, and permanent continuation of existing attenuation mechanisms. The best-estimates of tailings source terms are assumed to be very close to the best-case conditions.

For options where tailings are moved to the pit, Lorax makes very conservative assumptions about how the tailings will perform and also about the engineering conditions for both tailings relocation activities and physical stability/covering. The analysis assumes that no attenuation will occur, that the tailings will generate acid or be stored in reducing conditions, that relocation techniques will not be effective for compaction, and that covers will not reduce infiltration. The best-estimate values are assumed to be very close to these worst-case conditions.

While it is beneficial to consider very conservative conditions, all options need to be considered equally. This does not appear to be the case in this instance.

Various specific comments about the memo are provided below.

- The methodology described by Lorax for parameters to use as source terms includes identification of parameters that "exceeded the CCME guideline in multiple wells." It is not clear how this comparison is defined statistically: for example, does the comparison use mean values, or a particular portion of samples?
- "Worst-case" source terms for pit water are developed on the basis of "consistent spikes." Some definition of what constitutes a consistent spike would be useful.
- For arsenic, cadmium, zinc and nitrate concentrations, Lorax has utilized more recent arsenic data to predict "worst case" because concentrations have increased over time. If the concentrations are increasing over time, it does not appear conservative to assume that present values represent the worst-case.
- Figure 1 provides plots of sulphate concentrations in Dome Creek, seepage and tailings pond waters. Lorax states that the concentrations downstream are typically more dilute than both the incoming water (D1) and seepage. The graph does not appear to support this conclusion for sulphate. There are occasional such conditions, but generally, the water quality downstream of the tailings impoundment has higher sulphate concentrations than the water above – likely evidence of loading from the seepage collection pond.
- The conclusion that the seepage and upstream sources are the dominant contributors of loading to Dome Creek is likely accurate at the present time, but there is no evidence that supports extrapolation of this conclusion into the future. Loading from the tailings and the pit to the deeper groundwater could eventually

contribute load to Dome Creek. Monitoring wells are not currently in place that provide any information about the water quality in deeper groundwater.

- For conditions that leave the tailings in place, Lorax has assumed that water quality and flow rates will continue as they are today – with seepage similar to current levels 5L/s and water quality equivalent to that observed in the seepage collection pond currently. The basis for this conclusion appears to be primarily related to the existing data set that has seen improved water quality as the porewater from mine operations has been displaced from the system and high contaminant levels associated with operations have dissipated. Lorax has suggested that attenuation mechanisms are removing metal contaminants now, and they will continue to be effective forever, resulting in a constant long-term tailings source. The memo states "this mechanism is presumed to be infinite" as a "key assumption" but no reference or rationale is provided for this statement. In my view, this is not a conservative assumption and contrasts sharply with the very conservative approach taken by Lorax for evaluating source terms for tailings once placed in the pit.
- Even the "worst-case" source term for the tailings remaining in the valley relies on existing conditions and makes no assumptions that things could deteriorate further than current conditions. In addition, the worst-case estimates rely on water quality from MW09-08, located near surface on the north abutment downstream of the seepage collection pond. It is not clear why a worst case would not assume water quality similar to that used for the in-pit storage (MP09-12 and MW09-04).
- The hydrogeological team has concluded that seepage from the tailings does not bypass the seepage collection pond because permafrost remains as a barrier. If this is the case, the water quality present in MW09-08 may be indicative of seepage that occurred prior to construction of the seepage collection dyke. It is possible that this water has not yet been displaced because the seepage collection pond has removed the upstream source of water. Taking a different approach, Lorax has suggested that the conditions at MW09-08 may indicate seepage bypass. It would be useful if gradient information were available to conclude the direction and rate of travel at MW09-08.
- Lorax has assumed that the tailings source term will be consistent regardless of the cover type applied to the tailings in the valley. However, if tailings are placed in the pit, the analysis proposes that reducing conditions under a water cover will lead to arsenic release. It is not clear why this mechanism would not also occur for tailings in the valley.
- For tailings stored in the pit, Lorax states that there is little evidence to suggest that attenuation processes will occur in the pit. However, no details are provided to support this conclusion. Some information provided discusses the concept of providing organic materials that would provide attenuation capacity. However, in this case, organics are considered detrimental because they could lead to reducing conditions and release of arsenic iron and manganese. The assumptions underlying the conclusions of various options do not appear to be consistent and need to be reconciled.
- Lorax proposes that data from the tailings bins are needed to assist in predicting water quality for tailings in the pit. Would this same data not be useful for predicting source terms for tailings in the valley?

- The best-estimate scenario for tailings placed in the pit under water cover assumed that currently observed suboxic conditions persist after tailings are moved to the pit and that water quality is consistent with that currently observed in MP09-12 and MW09-04 where there is evidence of similar conditions. Why was this similar approach not taken for tailings that remain in the valley. This approach would require an estimate of seepage through the tailings assuming a vertical gradient – and an assumption that this load would be added to Dome Creek in the long-term.
- Worst-case estimates for the in-pit water cover option assume strongly suboxic conditions resulting in the release of some contaminants. This worst-case should also be applied to other options.
- For tailings placed dry in the pit, Lorax assumes that the tailings will produce acidic drainage. Note that the tailings would also do this if they dry out in the current impoundment. The hydrogeological model does not incorporate the low-permeability tailings in the modeling and there and as a result does not provide any predictions about whether the water table will remain stable within the tailings in the long-term.
- Lorax states a key assumption that "at present, water bypassing the seepage collection pond does not enter Dome Creek or Victoria Creek." What is the basis for this statement?
- Lorax notes that changes in the valley may alter the flow paths and attenuation mechanisms. However, for these options, this is considered a worst-case scenario while for in-pit options, these potential engineering outcomes are considered to be the best-estimate. The approaches are not consistent.
- The different approaches taken for the stabilization versus relocation options is reflected in the "interpretation of results and conclusions section" with a statement that the narrow range between best-estimate and worst-case for relocation options "reflects a more conservative approach to obtaining best estimate source terms." Conservative approaches need to be taken for all options, not just relocation options.

4.2 Lower-Bound Source Term Estimates

Lorax has provided a memo that describes lower-bound estimates for contaminant concentrations for options that include storage of tailings in the pit. This lower-bound is defined as "the lowest concentration that might be reasonably achieved for tailings placed in the pit" and is intended to describe lowest contaminant concentrations that could reasonably be achieved for these options.

To support development of these estimates, Lorax assumes inclusion of engineering and design changes that have not been explicitly identified in the existing closure plans, possibly including chemical amendments that may be added to the tailings, reactive organic layers placed beneath the tailings, an engineered cover over the tailings or any combination of these that might optimize the performance of the tailings and minimize the release of constituents from the pit. In the summary memo of source terms, Lorax concludes that the feasibility of lower-bound estimates has not been proven because it includes "engineering and design changes that have not been explicitly identified in the

existing closure plans." In my view, this highlights the inadequacy of the closure option design and characterization. An iterative design process is needed – one where the issues and risks identified by various disciplines are discussed and addressed by appropriate design changes.

Lorax asserts that arsenic from the tailings impoundment is attenuated by sulphide precipitation in reducing conditions on the flow path between the tailings and Dome Creek. Lorax's 2009 report on the tailings was inconclusive about the attenuation mechanism. I assume that the programs completed in 2009 have provided more conclusive information, but no results or analysis have been presented to support the conclusions stated. The memo does state that the attenuation process is not described by the water quality differences between the seepage pond and the tailings. This appears to be conflicting evidence about the attenuation and also draws into question the decision to use the seepage collection pond data for developing source terms for the tailings remaining in the valley. Additional explanation is needed to support the conclusions reached.

The water quality for the lower-bound estimates was based on water quality from the seepage collection pond, but the concentrations were increased by a factor of 1.5 to account for dilution that is occurring in the seepage collection pond. This does not seem like a reasonable approach. Overall, the flow through the tailings will be less once they are placed in the pit than in the tailings area because the covered area for the tailings is much smaller (approximately 1/3 according to areas described in costs estimates). Therefore, the dilution of water from the pit will be greater before it reaches the seepage collection pond area because it too will be diluted by the same flows in the Dome Creek aquifer.

4.3 Waste Rock Characterization – Altura Memos

Altura's series of memos generally provide a good summary of the field work and analyses completed during 2009. The memos and their appendices provide sufficient detail to understand the findings and conclusions.

The data collected in 2009 shows significant variability in the waste rock but also provides evidence that management of waste rock for closure warrants more consideration than has been devoted previously. It appears that much of the rock will not be suitable for construction purposes and that waste rock types are not segregated. Altura has evaluated some potential segregation criteria to identify rock that could be acceptable for construction purposes. The work suggests that a very detailed characterization and segregation plan would be needed if waste rock is to be used for construction purposes.

Seepage water contains elevated concentrations of some metals, highlighting the need to implement effective closure measures for waste rock.

Altura's summary report provides some information from a separate memo about the characterization of the mine-to-mill haul road. Note that the actual memo does not

appear to be available on the SharePoint site – only an out-of-date link to download the report. The summary material indicates that the haul road contains some metal leaching materials that may require well-defined closure measures. These measures need to be identified prior to options characterization because they may differ depending on actions taken for other site components.

4.4 Waste Rock Water Balance

Lorax has provided a memo describing the waste rock water balance. The memo appears to provide a conservative assessment of flows through the waste rock in its current state. The inputs are to be used for the contaminant load modeling and appear suitable for this purpose for current conditions.

No water balance information is provided for any covered waste rock and it is not clear whether the same water balance assumptions would apply to waste rock that is relocated and covered (e.g. in the pit). Would the same infiltration assumptions apply in these cases?

To complete the options characterization, the water balance model needs to take into account conditions that will change at closure for each of the options. This will require a more thorough definition of what closure measures will be taken for waste rock. For example, will it be covered and, if so, what will be the effectiveness of the proposed covers?

4.5 Waste Rock Source Terms

Waste rock source term estimates are described in a Lorax memo. The described methodology relies heavily on construction of waste rock field bins and evaluation of chemistry on the basis of samples collected from these bins. Results of field bin experiments are referenced to a November 2009 Lorax report which has not been provided.

The memo states an assumption that the current seepage chemistry (from 2 seeps) provides a realistic bound on future chemistry. This assumption warrants some justification especially since some of the waste rock has been identified as potentially acid generating. If this is the case, seepage water quality could deteriorate over time. At this site, it appears likely that the deterioration could be very slow because the materials are weakly acid generating. As a result, the current chemistry may not be reflective of long-term conditions. In order to evaluate this, it would be useful to understand whether any trends have been observed in seepage water quality (maybe not currently possible due to inadequate data set).

On p. 2, the memo refers to best-estimate concentrations that describe the expected median effluent concentrations. It is not clear if these were developed using median values from existing sources. If so, then additional explanation is required regarding the

conclusion that the results are conservative and represent "slightly higher than median concentrations."

On p. 4, the memo states:

> "Given the current level of uncertainty in drainage from ore materials at Mt. Nansen, the best estimate values for ore source terms were chosen to represent the greatest amount of spread between the best-estimate and worst case values. Depending on which is farthest from the maximum value, best estimate ore source terms were obtained from either the median or mean concentrations calculated from the ore field weathering bin experiment."

The methodology is not clear here but seems to indicate that the best-estimate was selected to provide a higher range between that estimate and the worst-case estimate. This appears non-conservative for the purposes of developing a best-estimate.

The memo does not describe any methodology for determining contaminants of concern from waste rock. I assume that the same list of contaminants was considered as that for tailings. If this is the case, it would be useful to confirm that no additional contaminants warrant concern on the basis of results from waste rock or pit sampling in addition to those identified from tailings porewater and groundwater conditions.

4.6 Pit Backfill

A Lorax memo provides recommendations related to selection of waste rock for any pit backfill and also on sensitivity of cover performance for covered tailings.

For the dry storage of tailings in the pit, the memo recommends grading of the pit to allow runoff perpendicular to the long axis of the pit – apparently to reduce infiltration. It is not clear how this approach will achieve the desired outcome. However, taking this approach appears to require substantial additional effort both for the pit backfill and for relocation of additional waste rock to ensure that pit runoff does not flow onto waste rock. Rationale for the proposal needs to be provided.

In my view, effective runoff management is critical for this option, but could likely be achieved with less effort than that proposed by Lorax. Details should be part of an overall options description which should form the basis of the characterization work. This needs to be completed before options evaluation is undertaken.

Lorax has assumed that flow through a tailings cover will represent long-term flux through the tailings. This is only a reasonable assumption if the tailings are more permeable than the cover or the surrounding material. More detail is needed about the proposed cover design and expected performance before it is possible to determine how the pit backfill options will perform with respect to flux through the tailings. Note that the upper bound assumption of cover performance for the sensitivity analysis is 50% infiltration. It is very unlikely that 50% of precipitation will flow through the cover materials if any effort is made at cover construction.

5.0 Surface Water

5.1 Hydrology Field Summary

The Hydrology Program Progress Summary provides a good summary of the work done to characterize flows at the site. As with many mining projects, the characterization of flows has not been a focus in the past and will present challenges for closure planning. The current work will help to support the closure planning process. No further comments are provided on this memo.

5.2 Baseline Water Quality Report

The Water Quality Baseline Characterization provides a good summary of conditions at the site and is useful to support understanding of various closure options. Some points for consideration are provided below.

AECOM completed analysis only for parameters that exceeded CCME guidelines. It is not clear how this exceedence was determined – whether based on a medians or maximums or some other statistic. Although it does not appear to have been done, it would have been useful to coordinate the data analysis for surface water quality with the contaminants of concern identified through the source term development work. Also, there may be parameters for which there is no CCME guideline or for which the concentrations do not exceed the guideline, but which are still important indicator parameters. Were these types of parameters also carried through the analysis phase?

The definition of reference conditions and the identification of appropriate reference sites for water quality appears to warrant some further investigation and analysis. Clearly site DX should not be used as a reference site. It appears that there is no suitable reference location in Dome Creek. DX should be considered a mine impacted site. Analysis may be required to identify sites in adjacent catchments that can be used for reference purposes in the long-term.

The program has used two reference sites for Victoria Creek, but one is suspected of being contaminated by backwater effects from Back Creek. Data from this potentially affected site should either be removed from the reference data set or an analysis should be completed on concurrent data to confirm that it is an effective reference location.

Section 4.2 proposes modifications to the monitoring program that would allow delineation of effects in Pony Creek between those from the pit and those from the waste rock. What types of monitoring would be suitable for defining this distinction?

Section 4.3 concludes that any impacts from Pony Creek on Back Creek are overpowered by effects from placer mining. The conclusion appears to be based on a graphical comparison of arsenic and cadmium concentrations for the two creeks over two summer sampling periods, with no low-flow data. Further data and analysis would be needed to support the conclusion that is stated. First, the parameters of concern from placer mining and hard-rock mining are often different. For chemical parameters, hard-rock mining tends to produce contaminants in a more bioavailable form, while placer mining

"chemical" contaminants are usually associated with solids. Second, placer mining is a seasonal activity and during low-flow periods when the water quality effects from Mt. Nansen may have the greatest influence on downstream water quality, placer mining is generally not having any effects.

Section 4.4 provides a rationale for considering Victoria Creek upstream of Dome Creek as "background" water quality for the purposes of Mt. Nansen. In my view, this site is not representative of background water quality because it is affected by inflows from Back Creek which contains contaminants from both Mt. Nansen and upstream placer mining activities. Instead, Victoria Creek upstream of Back Creek should be considered as representative of background conditions. Then, if necessary, the evaluation of effects on water quality should consider the inputs from Back Creek, including those from Mt. Nansen. The water quality monitoring program should be revised, if needed, to allow completion of load balances to determine the sources of effects.

5.3 Water Quality Model

The water quality model integrates much of the information that is described in other memos. As a result, many of the comments contained elsewhere in this report will affect the water quality modeling and will need to be considered in any future iterations of the modeling work.

The water quality model assumes that all contaminants from the current tailings pond are captured by the seepage collection pond and that none escape the site by any other pathways. This assumption is applied for all closure options that leave tailings in the valley. In my view, this is an optimistic assumption and there is significant potential for contaminants to bypass the seepage collection system. This could occur through contaminant migration into deeper groundwater, lateral seepage around the collection pond or seepage through the pond.

With current assumptions about water quality from the tailings, these potential bypasses are not considered important. In my view, there is a remaining risk of deteriorated water quality from the tailings and if this occurs, the bypass components will become important because treatment can only be applied for the water that can be collected. Consideration needs to be given to how collection would/could be done and the contaminant load model needs to be adjusted to evaluate effects on receiving waters.

AECOM's memo states that a small component of the tailings load arises from the perched tailings pond on the surface of the tailings. Figure 2 does not show this as part of the model. Some additional explanation of how that load is incorporated would be useful.

AECOM describes a pit water balance calibration and implies substantial certainty with the results of this calibration. Essentially, the calibration takes the approach that seepage inflows and outflows from the pit as well as water levels are known over the past several years. By applying these "known" values, AECOM uses the pit water balance model to

determine appropriate runoff coefficients for the pit catchment, in order to make the balance work. In my view, there are some significant uncertainties that remain for this calibration and the results have significant implications for some of the proposed closure options, especially the water cover option for the pit.

The values that AECOM assumed for "known" inputs are, in my view, some of the most uncertain values in the overall balance. For example, the seepage inflows to the pit have been inherently difficult to quantify. Flow rates have never been accurately measured. As a result, the inflows could be substantially larger or smaller than those assumed. Seepage outflows are based on limited understandings about rock permeabilities and groundwater gradients. Until this year, the gradient information was based primarily on two locations – the pit and one well. The hydrogeological modeling has indicated the degree of uncertainty about the pit outflows that occur from seepage.

Ultimately, AECOM makes the statement "that actually relatively little groundwater makes up the water balance inflows to the pit" as though this were a result of the calibration. In fact, it appears that this was an assumption for the purposes of the calibration and therefore could not fail to be a "result."

On p. 6 the memo describes assumptions about seepage flows from the pit catchment including an assumption that no seepage from waste flows to the pit. For waste rock located with in the pit surface catchment, AECOM has essentially assumed that there is no surface flow (probably reasonable) and that the seepage does not go to the pit. Is this seepage accounted for somewhere else in the model because there will be substantial water that will flow into this waste rock and report somewhere?

In Section 4.1.2, the memo references an underlying assumption that the pit will not fill up and spill, but will reach equilibrium with time. To balance this underlying assumption, AECOM has calibrated seepage rates in the modeling to ensure that the modeling will be consistent with this assumption. However, the conclusions section of the memo states "the pit is not expected to reach a level higher than the Pony Creek Adit in the long-term." This is not truly a conclusion from the work completed as this maintenance of equilibrium is an underlying assumption.

AECOM states that this assumption is applied to all alternatives and should not overly bias the results. From a water modeling perspective, this may be true, but the same assumption has been applied to option design resulting in design challenges for maintaining a water cover in the pit – potentially overstating some of the challenges for this option.

AECOM notes that it was unable to obtain precipitation data for 2008 and 2009, which would have addressed a relatively wet period. Both Western Copper Corporation and Capstone Resources likely have precipitation data from nearby sites for those periods. They also likely have data for overlapping periods with the Mt. Nansen and Carmacks stations perhaps allowing effective use of these data for Mt. Nansen analysis.

On p. 7, AECOM references a unit runoff for the Mt. Nansen site of approximately 300mm. This compares with a stated mean annual precipitation of 284mm (p.4). These two values do not seem to reconcile and should be checked.

On p. 8, AECOM states: "It turns out that all of the source terms enter the receiving environment by the Upper Dome Creek monitoring station." Though stated as a conclusion, it should be noted that this is really an assumption. There remains the possibility that some deeper groundwater could enter the system below this location, but that has not been considered to-date.

Table 6 in the memo describes some key assumptions for the modeling. Some comments and questions arise from these assumptions:

- Option 3A
    - The tailings source term is assumed to be the same regardless of cover type (i.e. water, soil, sponge). It is likely that seepage rates will change for the water cover options and this could change the source terms. Also, there are risks that have not been considered related to potential deterioration of water quality conditions. These may differ for different covers.
    - As noted in comments above, I consider it optimistic to assume that the current seepage pond water quality is reflective of long-term future conditions.
    - The model assumes that the Pony Creek adit will be sealed and will not leak. This is not likely to be the case. If water rises above the adit level, there should be an assumption that some water from the pit will exit through the adit – either with or without treatment as appropriate.
    - The assumption that pit water quality will remain as it currently is may also be optimistic.
- Option 3B
    - AECOM reasonably assumes there will be no evaporation from the pit if it is filled with waste rock. Is the pit model adjusted in this case to determine what water levels would be expected?
- Option 4A Wet
    - It appears that AECOM has assumed that the tailings would be completely covered with water. However, other documents have suggested that up to 10m of tension saturation is possible. If this is the case, lower water levels would be possible and seepage would also be substantially lower than the assumed rate as tension saturation does not contribute to the phreatic surface or potential seepage.

On p. 10, the memo discusses tailings seepage rates and effects on source terms. Comments about source terms are provided elsewhere in this review report. Seepage rates are clearly increasing with time, not a surprising outcome when considering the thawing foundations in the dam. The decreasing trend in sulphate is identified as a rationale for concluding that contaminant loads will not increase with time. In my view, this is not sufficient rationale. The tailings are likely not producing sulphate as oxidation

does not appear to be occurring at this time. However, sulphate was present in the original process water and the reduced concentrations at the seepage pond may reflect a reduction in the amount of original process water reaching this location. If this is the case, the reduced sulphate levels may not be predictive of future conditions for other contaminants.

In Section 4.3.3, AECOM provides a range of seepage rates "through" the tailings for the water cover/pit storage option – 2-4L/s. The 5L/s seepage pond rate is suggested as a reasonable comparison to support this seepage rate. While the seepage out of the pit may reach these levels, it is not reasonable, in my view, to assume that seepage through the tailings will reach these levels. As per the comments elsewhere in this memo, it is unlikely that all of the water reaching the seepage pond has flowed "through" the tailings. In fact, only a small portion of it has likely done so. This will also be the case in the pit. In my view, this may account for a significant portion of the difference in contaminant concentrations between the wells under the tailings and the seepage collection pond. The amount of water that will actually be contaminated by flowing through the tailings in the pit appears to be less than the total expected seepage flow. While the assumptions may be conservative for evaluating this particular option, similar conservativeness has not been applied to other options.

Section 4.3.3 references tailings relocation by slurrying. Is this the proposed approach for this option?

Section 4.3.4 identifies the need to evaluate cover effectiveness in order to characterize some options. This is true and should have been done as part of this work, though AECOM states that it is outside the scope. In my view the development of cover options including an understanding of performance for infiltration is fundamental to characterizing the closure options.

Section 4.3.5 provides rationale for the decision to model all of the cover options for the tailings remaining in the valley as one for the purpose of predicting contaminant loading. It seems likely that the options involving establishment of a greater hydraulic gradient (water and sponge covers) could cause larger flux through the tailings and result in greater contaminant loading.

Comments about source terms as described in Section 4.3.6 of the memo are provided elsewhere in this report.

In Section 4.3.8, AECOM discusses the results of a partial calibration of the load model. AECOM suggests that because the current conditions to not equate to the predictions, the model may be overpredicting some sources. It should be recognized that the model is meant to predict future conditions. It does not consider attenuation or travel times. As a result, it would be expected to overpredict loading at the current time. This type of calibration should not be seen as an indication that the source term predictions are overly conservative.

In the conclusions section, AECOM notes that the sources from upstream of the tailings have been removed from the model. This means that the model may underpredict the actual loading that will occur in downstream locations in the future. Cleanup of that area may reduce these sources to some extent, but it is not likely to eliminate them.

5.4 GEEC Memo

Gomm Environmental Engineering Consultants prepared a memo describing the approaches taken for source terms and sensitivity of the contaminant estimates to changes in some input parameters. In conducting the sensitivity analysis, GEEC concludes that the results of modeling are relatively insensitive to changes in pit seepage rates when compared to the source term inputs. This illustrates the importance of source term assumptions in the results of the analysis. It appears that with minor changes in assumptions about source terms, the outcomes could be substantially different with respect to preferred options.

It is clear from the analysis presented by GEEC (Table 6) that dry storage in the pit could provide the best performance for water quality for all three major contaminants of concern if the approach can be designed to operate effectively. Unfortunately AECOM has not provided adequate design information to provide any certainty about the performance of this proposed option.

Indian and Northern Affairs Canada | Affaires indiennes et du Nord Canada

Memorandum

Date: **15 June, 2010**

To: **Mt. Nansen Project Team (INAC, YG, LSCFN)**

From: **Andrew Liddiard (INAC)**

Subject: **Summary of Main Points in the Independent Peer Review Panel's assessment of: "Overview of Mt. Nansen Alternatives Characterisation" by AECOM**

This memorandum serves as a supplement to the Technical Memorandum by the Independent Peer Review Panel (IPRP) dated March 29, 2010. Several members of the Mt. Nansen Project Team expressed disappointment with the IPRP's memo, so the focus of this note is to identify the IPRP's main points and some additional information gained through discussions with the chair of the Mt. Nansen IPRP, Mark Logsdon. The information is presented as simply and succinctly as possible in an effort to avoid ambiguity.

- The IPRP believes that both Options 3 and 4 could be executed to adequately protect the environment measured at Victoria Creek.
- The IPRP believes that any additional study on source terms (with the goal of shrinking the error bars on the range of values) would result in comparable increase in confidence in the data that go into both Options 3 and 4. Therefore there would be no significant net gain in the ability to differentiate between Option 3 and Option 4. This additional study would come at significant cost and delay to the project. *It is for this reason that the IPRP concluded that there was sufficient information currently available for the Mt. Nansen Project Team to make a decision on a Preferred Option.*
- The IPRP's statement on the accuracy of the geochemical elements of the AECOM report is very succinct and the full meaning is easily missed. The IPRP stated: "The methodologies used by Lorax to establish ranges of potential source-term chemistries are generally appropriate and well supported." There is significant implied meaning to this statement. Mr. Logsdon clarified that this statement applies equally to the data used in both Options 3 and 4 and that, without conducting a thorough and costly re-analysis of Lorax's work (which was <u>not</u> the IPRP's mandate), the work presented leaves no reason to doubt it is the best data available at the present time.
- The IPRP focused its comments on risk to a) the risks to groundwater, b) the risks due to uncertainties and c) the risks to human health.
- The IPRP identified risks due to uncertainties in the AECOM description of Option 4, such as "unspecified engineering and design activities…that result in very low source water concentrations". The IPRP also noted that the uncertainties in chemical source terms, particularly the upper-end of possible source terms, are much greater for Option 4 than for Option 3. This implies that there is a greater probability of adverse environmental outcomes for Option 4 than for Option 3.
- The IPRP identified that Option 4A relies on tension saturation of the tailings, but AECOM did not identify or elaborate on the potential risks or uncertainties surrounding

the ability to maintain that tension saturation. Mr Logsdon pointed out that a very high degree of characterization is needed to assure the success of a tension saturation condition, which obviously comes at a cost to the project.

- The IPRP favoured Option 3 because the range of possible source-term chemistries is smaller than for Option 4 (in particular, there is less risk of elevated arsenic and cadmium concentrations anywhere in the system) and because the AECOM report failed to provide a compelling technical case for Option 4 that would change the opinions formed during the IPRP site visit in August 2009. Such a case would have addressed the above two points, among others; would have presented justification for the additional capital cost to move tailings; and would have included methods of mitigating the known risks associated with relocating tailings.
- Mr Logsdon agreed that Option 4 could be a "walk away" solution if the probability of success is high enough (editorial note: defining "high enough" would presumably be done through the options evaluation and selection process). Based on the Lorax work, elevated arsenic (and perhaps also cadmium) would be a high probability at least locally in the vicinity of the pit. This condition would necessitate some hydraulic containment and/or institutional controls, and perhaps short-term water treatment to keep contaminated water from getting into the fractured bedrock. The AECOM report did not include any substantial discussion of these points.
- Mr. Logsdon also thinks that Option 3 could evolve (perhaps 5 to 10 years) into a "walk away" solution, as revegetation and drainage stabilize, depending on details of both planning and field execution. If the drainage is engineered to distribute water well and allow the existing wetland to expand across the tailings area that could establish a stable drainage system that does not rely on engineered ditches that have to be maintained. The AECOM report did not include any substantial discussion of these points.
- Editorial note: the "walk away" solutions identified in the above two points may both still require some degree of monitoring, for the pit seepages in Option 4 and for the dam and channels in Option 3.
- Lastly, Mr Logsdon pointed out that not every risk needs to be, or can be, addressed in a closure plan.

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Date: July 8, 2010
Ref: Review of Mt. Nansen Tailings Closure Geochemistry

An initial review of documents related to the closure of the Mt. Nansen waste materials was performed by CSP2 in April 2010. Following this, discussions were held with Lorax (Skya Fawcett and Justin Stockwell) and new documents were provided. In particular, the Lorax report "Mount Nansen Geochemical Assessment in Support of Evaluating Closure Options" dated November 2009, with supporting data on monitoring well chemistry and drilling logs. The assistance of Lorax through fruitful discussions and with locating documents and soil boring logs (from AECOM) is gratefully acknowledged.

Three closure options are currently on the table:

1. Leave the tailings in place but reinforce the dam to allow for greater saturation of tails.
2. Move the tailings to the pit and keep them under water.
3. Move the tailings to the pit and keep them dry.

The last option in the list was not considered by this author in detail. There is ample evidence that the tails will generate acid over time if not kept from oxygen, mobilizing both metals[1] and acid in the long term. Potentially dry storage could be considered if there is room in the pit to contain the volume of lime that would be necessary to neutralize acid production.

The other two options each have advantages and disadvantages, and either would be preferable to the current status quo.

The Yukon Government contracted Lorax Environmental to assess the data and analyze the options. They have developed an operational hypothesis regarding arsenic concentration decreases that occur between the tailings impoundment and the seepage collection pond. The hypothesis is that arsenic is being removed through precipitation as arsenic sulfides, with sulfide generated by anoxic sulfate-reducing bacteria (SRB), which are encouraged in growth by both the influx of dissolved organic carbon (DOC) from Dome Creek and by the organic layer that lies beneath the tailings impoundment and tailings dam. The new documents were reviewed to determine whether they supported the operational hypothesis.

Essentially there are two issues: 1) What is the mechanism by which arsenic is removed along the vertical flow path between the tailings and the underlying soil? 2) What is the mechanism by which arsenic is removed along the horizontal flow path through the tailings dam?

[1] In this memo, the term metals is used to refer to both metals and metalloids (such as arsenic) for simplicity.

While there is evidence of sulfide production and metal sulfide precipitation in the tailings impoundment, there is no evidence that Dome Creek DOC contributes to microbial growth and sulfide production, nor is there evidence to support such activity along the water flow path that moves through the tailings dam. In order to further substantiate the working hypothesis, it is recommended that:

- DOC measurements need to be taken at the surface water of Dome Creek upgradient of the mill facilities, immediately upgradient of the tailings impoundment, and in pore-water at current monitoring wells. This will not add any substantial cost to the current sampling.

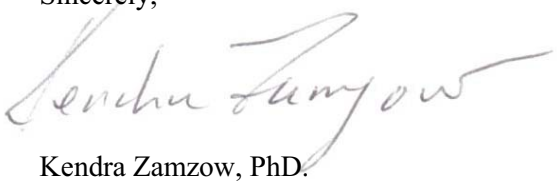
- Vertical profiles of soil pore-water chemistry be produced, including measurements of dissolved oxygen (dO), redox potential (E_h), DOC, sulfate, pH, arsenic (total, As^{+3}, As^{+5}), iron (total, Fe^{+2}, Fe^{+3}), and sulfide-sensitive metals (cadmium, copper, lead, antimony, zinc). This would clearly identify the sulfate-reduction zone, if there is one.[2] This should be conducted at the rear, center and front of the tailings impoundment as well as along the tailings dam flow path where there is limited evidence supporting arsenic removal by sulfide precipitation.

It is important to ascertain the importance of incoming DOC in the process of removing arsenic and metals. If it is a key element, this strengthens the argument for a closure option with the tailings remaining in place; if it is not a key element, there may be advantages to moving the tailings to the pit as a final closure option. In addition to a long term secure storage, it would offer an environment without permafrost and one in which the pH and iron could be adjusted during and after the move to optimize arsenic adsorption and co-precipitation.

If microbial activity is the primary promoter of metal removal this removal mechanism could be enhanced by adding carbon sources that SRB can use directly (ethanol, methanol, used antifreeze, etc).

Both options could be improved by allowing the discharge to flow through a wetland prior to entering natural waterways. This promotes arsenic removal both through precipitation (wetlands promote SRB activity) and through sorption to iron oxide plaque on root systems.[3]

Sincerely,



Kendra Zamzow, PhD.
Center for Science in Public Participation

[2] Precedence for profiles in tailings can be found at McCreadie et al, 2000
[3] Sookyun and Park, 2003.

I. Working hypothesis

A. Components of the hypothesis

The hypothesis is dependent on the following hydrology and microbial actions

- DOC being present in Dome Creek
- Dome Creek water entering the tailings impoundment
- Water with DOC flushing vertically through the tails into the underlying organic layer and soil
- Water carrying metals from tailings pore-water into underlying soil
- Water moving laterally downgradient along the underlying organic layer, above the permafrost layer, the length of the tailings impoundment and tailings dam to the seep collection pond
- Microbes in the soil producing sulfide
- Metal ions and arsenic ions in pore-water binding to sulfide as a solid precipitate (e.g. CdS, CuS, FeAsS, As_2S_3, etc)

This author did not review documents that would verify if water moved vertically from the tailings pond, or from the beach vertically through tails and into underlying soil. Nor were documents reviewed that would determine whether water moved laterally downgradient just above the permafrost, although it is reasonable to assume so.[4]

B. Microbial processes

Microbial energetics

Microbial populations have a specific pattern that they follow as they grow and consume carbon, based on the energy they can obtain by engaging in certain metabolic processes. All metabolic reactions are based on moving electrons from one place to another. Microbes use carbon as a fuel, and like any fuel, they oxidize (burn) it. The process of oxidation frees up electrons that have to be put somewhere – what they are put into is then "reduced".

The most energy is obtained by putting the electrons into oxygen, making water (aerobic respiration). Once oxygen is consumed, then the following will be used, in this order (Figure 1):

- Nitrate will be reduced to nitrite, nitrogen, and ammonia ($NO_3 \rightarrow NH_4$)
- Manganese will be reduced,
  - e.g. solid manganese oxides become free mobile manganese ion ($Mn^{4+} \rightarrow Mn^{2+}$)
- Iron will be reduced
  - e.g. solid iron oxides become free mobile iron ions ($Fe^{3+} \rightarrow Fe^{2+}$)
- Sulfate will be reduced to sulfide ($SO_4^{2-} \rightarrow S^{2-}$)
- Carbon dioxide will be reduced to methane ($CO_2 \rightarrow CH_4$)

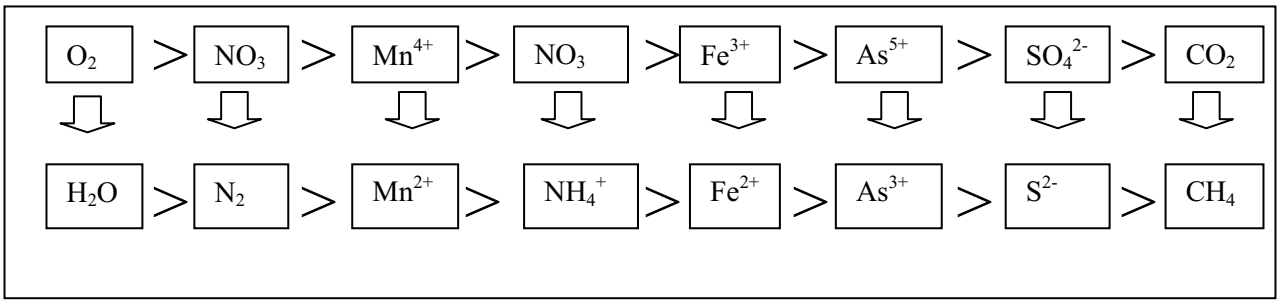


Figure 1. Microbial Energetic Sequence. Oxidized species are on the top row and reduced species are on the bottom row. Species that provide the most energy are on the left, with decreasing energy availability as to the right; this follows the transition from an oxidizing environment to an increasingly reduced environment. Aerobic bacteria (using oxygen) gain the most energy. Manganese and iron reducers gain more energy than arsenic reducers or sulfate reducing bacteria.

Microbial effects on metal species

Microbes can either assist in the release of metals or in the precipitation, or even in sorption.

- Under mildly reducing conditions, iron and manganese reducers will dissolve solid metal oxides, increasing dissolved metal concentrations in water. If arsenic is sorbed to these solid metal oxides, it will desorb and concentrations will increase in water.
- Arsenic reduction (As^{5+} to As^{3+}) may cause sorbed arsenic (usually As^{5+}) to become the more mobile As^{3+}, increasing arsenic concentrations in water (Figure 2).
- Bacteria can methylate both As^{3+} and As^{5+}, and the methylated forms sorb to ferrihydrite and other aluminum, manganese, and iron (hydroxy) oxides at similar pH/pE environments as the free ions.
- In a very reduced environment (generally E_h of -200 mV or lower), sulfate will also be reduced to sulfide, promoting precipitation of aqueous metals as solid metal sulfides, decreasing metal concentrations in water (e.g. Fe^{2+} precipitates as FeS, Zn^{2+} as ZnS, etc). As^{3+} precipitates as metal sulfide (FeAsS or As_2S_3) (Figure 3). If the environment does not support sulfate reducers, no arsenic precipitation as sulfides will occur.

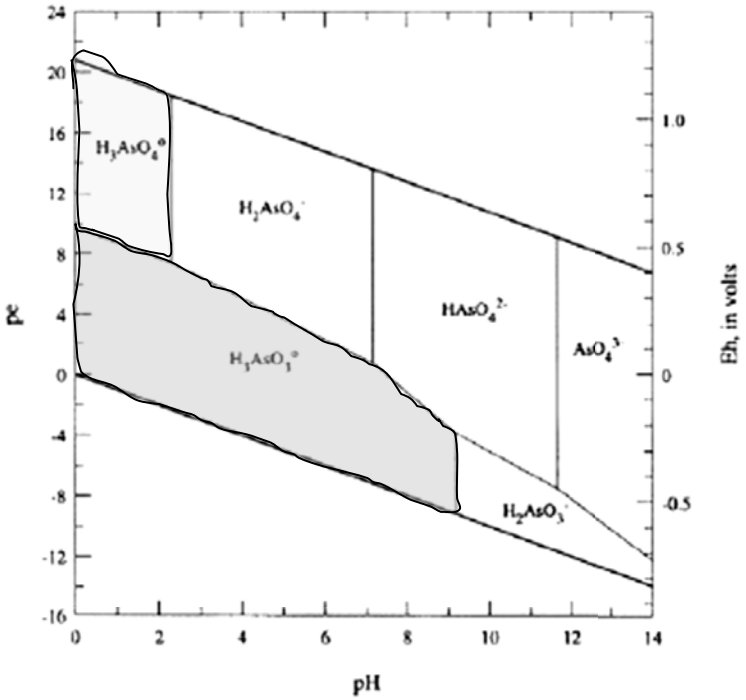


Figure 2. Aqueous arsenic species pE/pH diagram. Both As^{5+} (H_3AsO_4) and As^{3+} (H_3AsO_3) lose hydrogen ions with increasing pH, and become more able to sorb to mineral species. The stable, mobile species are shaded. Conditions are held at 298.15K and 1 atmosphere pressure (Nordstrom and Archer, 2003).

A mildly reducing environment may support microbes that reduce iron and arsenic,[5] increasing their concentrations in water, while a strongly reducing environment is needed to support sulfate-reducing bacteria (SRB) that will precipitate iron and arsenic as sulfides. However, the same SRB that reduce sulfate to generate sulfide may methylate arsenic promoting sorption rather than precipitation,[6] or reduce arsenate As^{5+} to the As^{3+} ion which may become mobile or may precipitate as As_2S_3.[7] Therefore, even in an environment that favors SRB, the reactions can be complex.

[5] Lim et al, 2008; Reyes et al, 2009
[6] Lafferty and Loeppert, 2005
[7] Newman et al, 1997

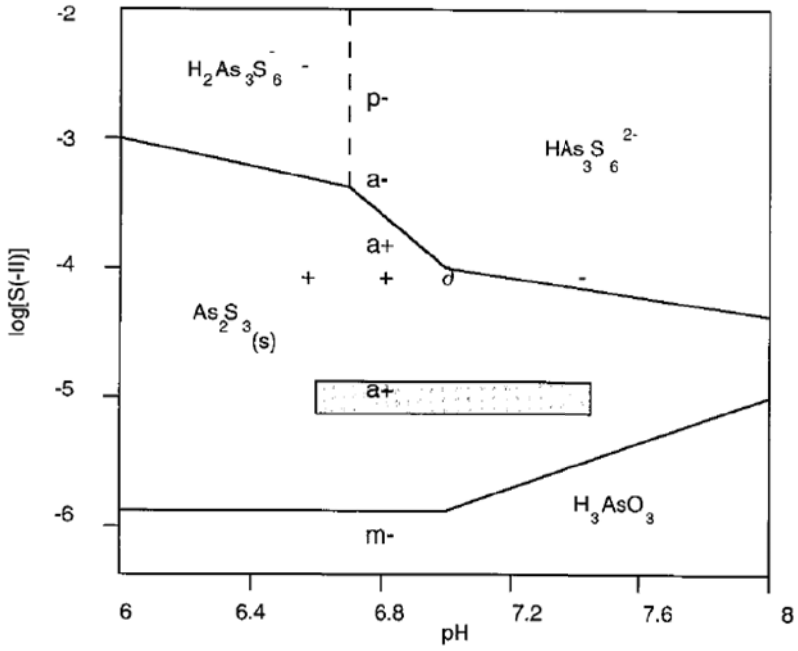


Figure 3. Arsenic sulfide precipitation by sulfate-reducing bacteria. In a lab experiment, precipitation by the sulfate reducer *Desulfotomaculum auripigmentum* was dependent on pH and sulfide concentration, when arsenic concentration was held to 1 mM. The area defined as stable As_2S_3 was observed both abiotically and as bacterial-induced precipitation. The rectangular box with "a+" inside it is a region in which As_2S_3 precipitation was expected, but was only observed abiotically, not bacterially. (Newman et al 1997)

SRB have limitations.

- They will not compete well when the environment allows for the presence of iron and manganese reducers, which obtain more energy from the carbon.
- They are unable to use cellulose (plant material) as a carbon source, and are dependent on other microbes to "cut up" the cellulose into smaller bits (small alcohols, lactic acid, etc) that they are able to use – if they have no usable carbon to consume, they will not transfer electrons into sulfate, and there will be no sulfide produced and no metal sulfide precipitation.
- Oxygen is toxic to them.
- Hydrogen sulfide, which they produce as part of sulfate reduction, is toxic to them (in mg/L concentrations).[8]

C. Non-microbial processes

Non-microbial processes involve sorption/desorption activities or co-precipitation rather than precipitation. Arsenic can sorb to metal (oxy) hydroxides, ferric (oxy) hydroxysulfates, micas, clays, and organic material.[9]

In general, we expect As^{3+} to be mobile and As^{5+} to sorb (Figure 2), but this is dependent on pH, redox, and available surfaces.

- The log constant of As^{5+} sorbing to hydrous ferric oxide is 29; the log constant for As^{3+} is 5.4.[10]
- In alkaline environments (pH 8-10), As^{3+} will sorb or co-precipitate to ferrihydrite;[11] it is possible that some of this activity occurs in the Mt. Nansen tailings impoundment, particularly where process chemicals remain. Optimal sorption to clays and metal oxides may be around pH 8.5.[12]

[8] Zamzow et al, 2006
[9] Jia and Demopoulos, 2005; Magalhaes, 2002; Goldberg, 2002; Goldberg and Johnson, 2001
[10] Morel and Hering, 1993. Table 8-2.
[11] Lafferty and Loeppert, 2005; Jia and Demopoulos, 2005
[12] Goldberg, 2002; Goldberg and Johnson, 2001

- At neutral pH, As^{5+} is the ion expected to sorb, and may sorb or co-precipitate best to ferrihydrite at pH 3.5-5.5,[13] although other researchers found the best sorption at pH 5 (clays) and pH 7 (metal oxides).[14]
- Conversion of As^{5+} to As^{3+} does not always result in increased mobility; it may result in precipitation as As_2S_3.[15]

A change in pH occurs along the tailings dam flow path, where significant arsenic removal is observed. The decrease from pH 8 to pH 6.5 may promote the release of sorbed As^{3+} (and either increased concentration in water or removal as arsenic sulfide species), but may also promote the increased sorption of As^{5+}. It may also change the dominant available species from manganese (oxy) hydroxides to iron (oxy) hydroxides (Figure 4), which could affect the strength of sorption.

Desorption has been described microbially (due to reduction of metal oxides bearing sorbed arsenic), but can also happen abiotically through abiotic reduction or through the influence of phosphates or sulfates that promote desorption.[16] Potentially, the presence of high sulfate may influence the concentrations of mobile arsenic in the impoundment and along the tailings dam path. However, three wells of four in the tailings dam have very high sulfate while only one has high arsenic and two have low arsenic concentrations, indicating that if sulfate influences desorption, it is not the dominant mechanism controlling arsenic.

The following non-microbial processes may also occur:

- dilution
- reduction by UV light (surface)
- abiotic oxidation and reduction
- transformation to volatile methylarsines

If sorption and co-precipitation are dominant mechanisms for removal, rather than sulfide precipitation, we would not expect to see sulfide-sensitive metals decrease.

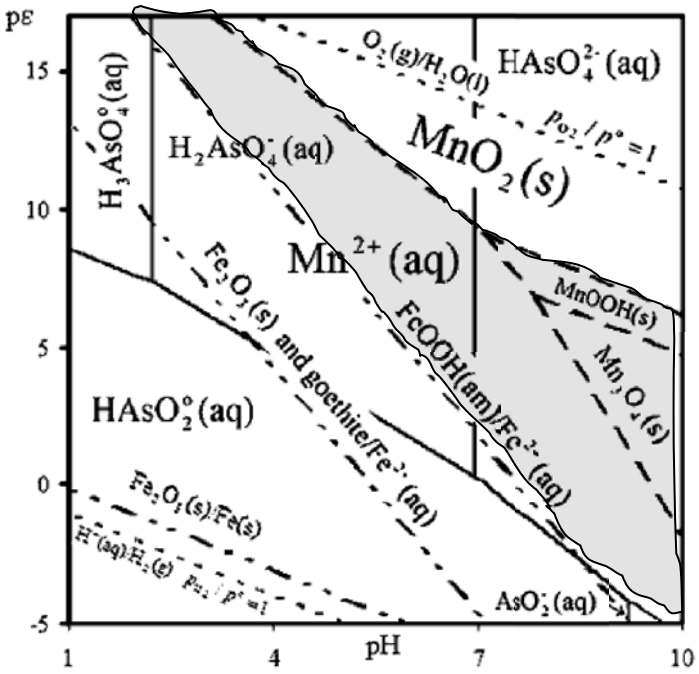


Figure 4. Iron, manganese, and arsenic redox equilibrium diagram. This pE/pH diagram describes areas of stability for solids, amorphous species, and aqueous species. The area of influence for FeOOH(am) and MnOOH are shaded. Oxic or mildly reducing environments at pH greater than 7 favor iron and manganese hydroxide stability and may promote sorption of arsenic. For oxic environments of pE near 5, decreasing the pH may shift the dominant species from solid manganese hydroxide to amorphous iron hydroxide, depending on concentrations. The diagram was developed with Mn and Fe at 10^{-5}M (2002 Magalhaes).

[13] Lafferty and Loeppert, 2005; Goldberg and Johnson, 2001
[14] Goldberg, 2002
[15] Newman et al, 1997
[16] Lafferty and Loeppert, 2005

D. Verifying the hypothesis

In order to verify the mechanism, it would be very helpful to have vertical profiles that could define which zones contain nitrate reducers, iron reducers, manganese reducers, and sulfate reducers; whether any of these zones coincide with arsenic reduction; and whether a decrease in arsenic concentrations is accompanied by a decrease in sulfide-sensitive metals. Physical parameters that affect microbial growth (DOC, pH, dO, E_h) need to be taken along the vertical profile as well; particularly E_h, which helps define the limits of SRB activity (Figure 5).

This will indicate whether microbial activity is present, but will not ascertain with certainty whether an influx of DOC from the River Valley is a necessary part of this process. For that, we need actual measurements of DOC upgradient of the mill, upgradient of the tailings pond, and at all monitoring wells.

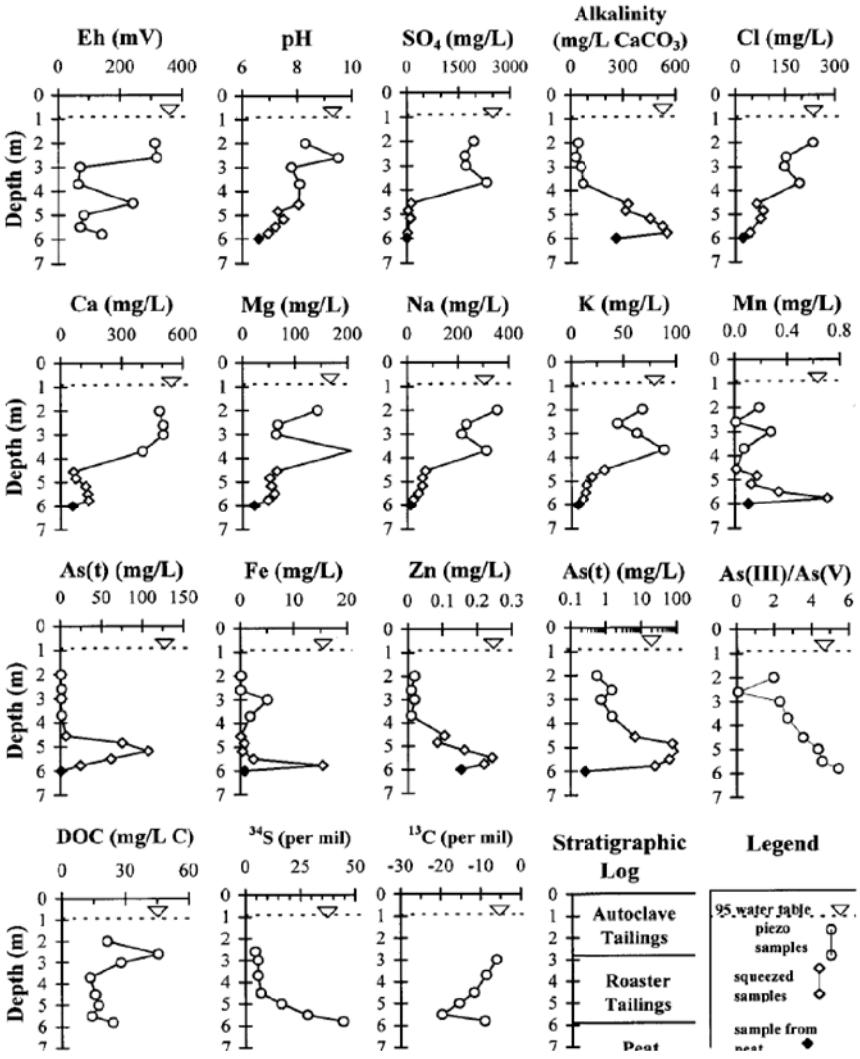


Figure 5. Vertical profiles. Data are from piezometers 2-3.7m deep and from squeezing soils 4.5-6 m deep; the filled sample at the bottom of the profile indicates a pore-water sample from underlying peat (McCreadie et al 2000).

It is possible that the organic layer beneath the tails pond provides all of the carbon being used by microbes, in which case the argument for leaving the tails in place becomes weaker. It also becomes necessary to determine the importance of the organic material under the tailings dam itself, and the effect of dam stabilization on permafrost under the dam.

If indeed the primary or only carbon source is the organic layer, there could be an argument for moving the tails to the pit. This move would allow the organic material (OM) to be better mixed throughout the tails. In addition, it appears that some of the OM below the tailings impoundment now is beneath the permafrost and inaccessible. SRB are sensitive to temperature, and perform better in warmer environments. In the pit, there would be no permafrost layer and more carbon might be available.

II. Monitoring wells

Pore-water chemistry from monitoring wells was reviewed to determine consistency with the microbial-based attenuation hypothesis.

A. Locations

Wells are located in the following places (Figures 6 to 8):

- In the back of the tailings impoundment are two sets of wells that screen the tailings area above and also the native soil below (MP 09-09/MP 09-10 and MP 09-11/MP 09-12). Water chemistry in these sets can tell us if analytes are changing as water moves vertically from the tailings to the soil below.
- In the front of the tailings impoundment are three wells, not necessarily hydrologically connected either vertically or horizontally. These are MW 09-02, MW 09-04, and MW 09-06. Wells MW 09-02 and MW 09-04 are close to each other near the tailings dam, and may be along the same horizontal flow path.
- Screened within the dam are four wells (MW 09-03, MW 09-23, MW 09-22, and MW 09-21). Water chemistry in these should tell us how analytes change as water moves along the horizontal flow path from the front of the tailings impoundment towards the seepage collection pond.

All of the wells were place in July 2009. Data is only available for July 2009 and September 2009. A close up of wells along the tailings dam path and in the impoundment just before the dam is in Figure 8.

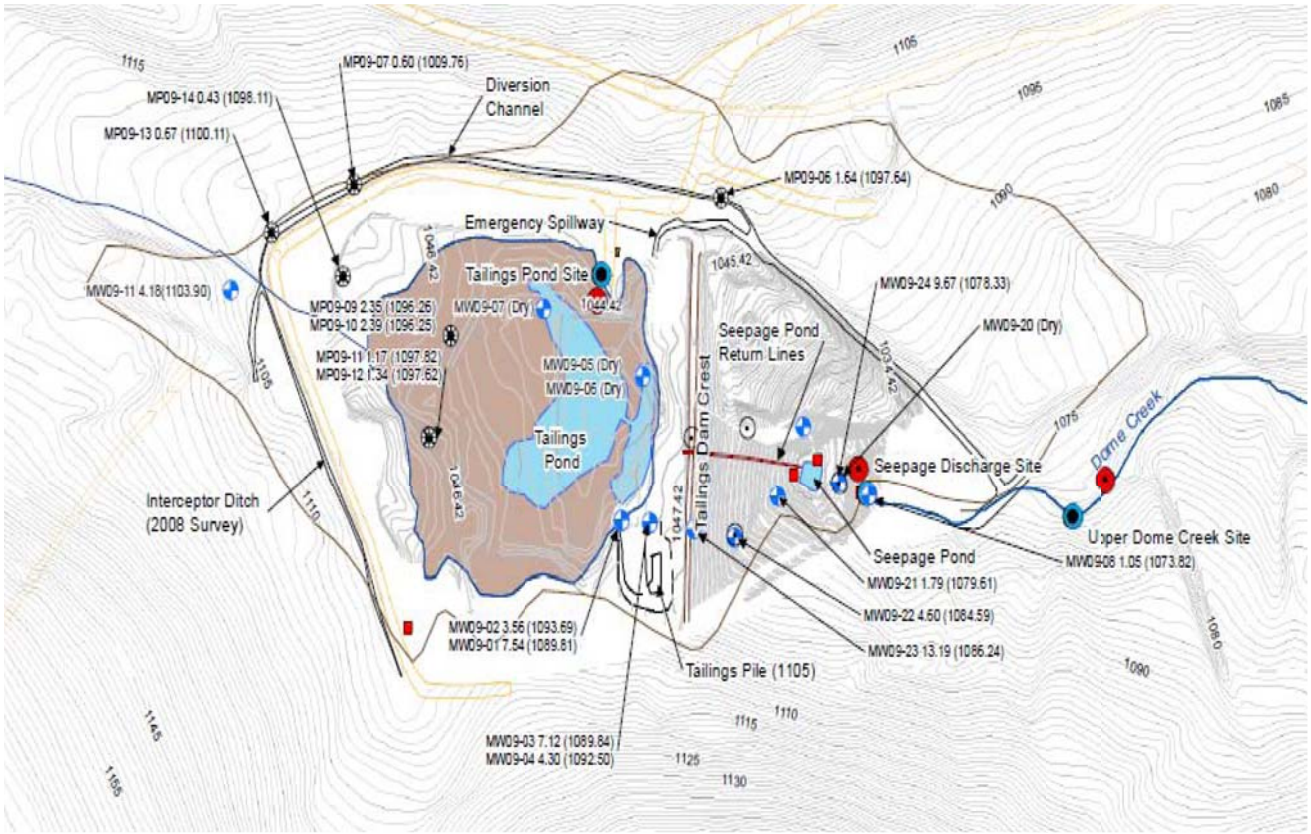


Figure 6. Layout of monitoring wells at the tailings impoundment, tailings dam, and seepage collection pond. Lorax, November 2009.

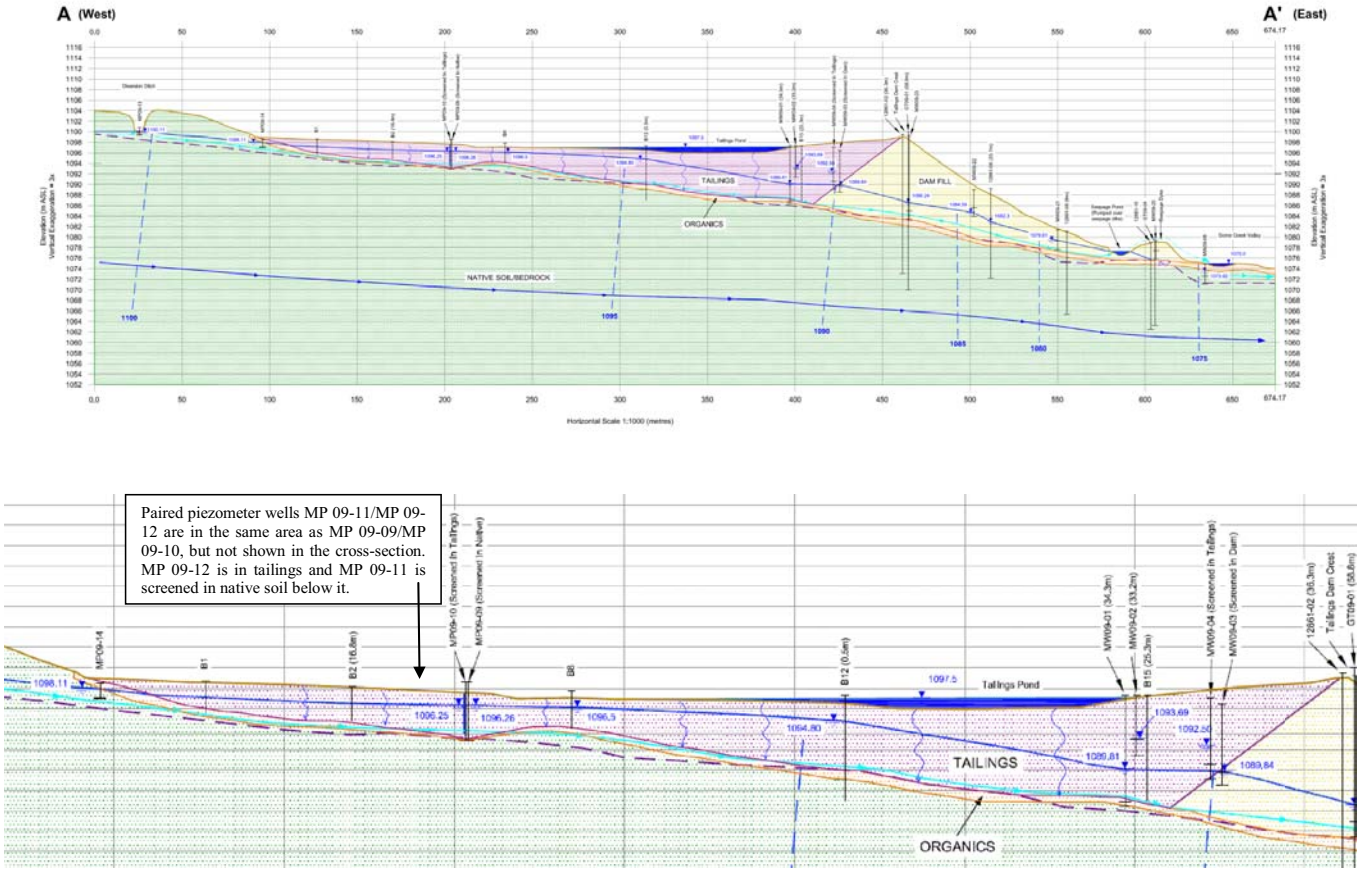


Figure 7. Cross-section of the tailings pond area. The diagram above is the full cross-section. The diagram below is a focus on the tailings impoundment. The black dotted line is roughly the level of permafrost; the blue line is the estimated level of groundwater, and the orange layer is the estimated layer of organic material. Adapted from AECOM 2010.

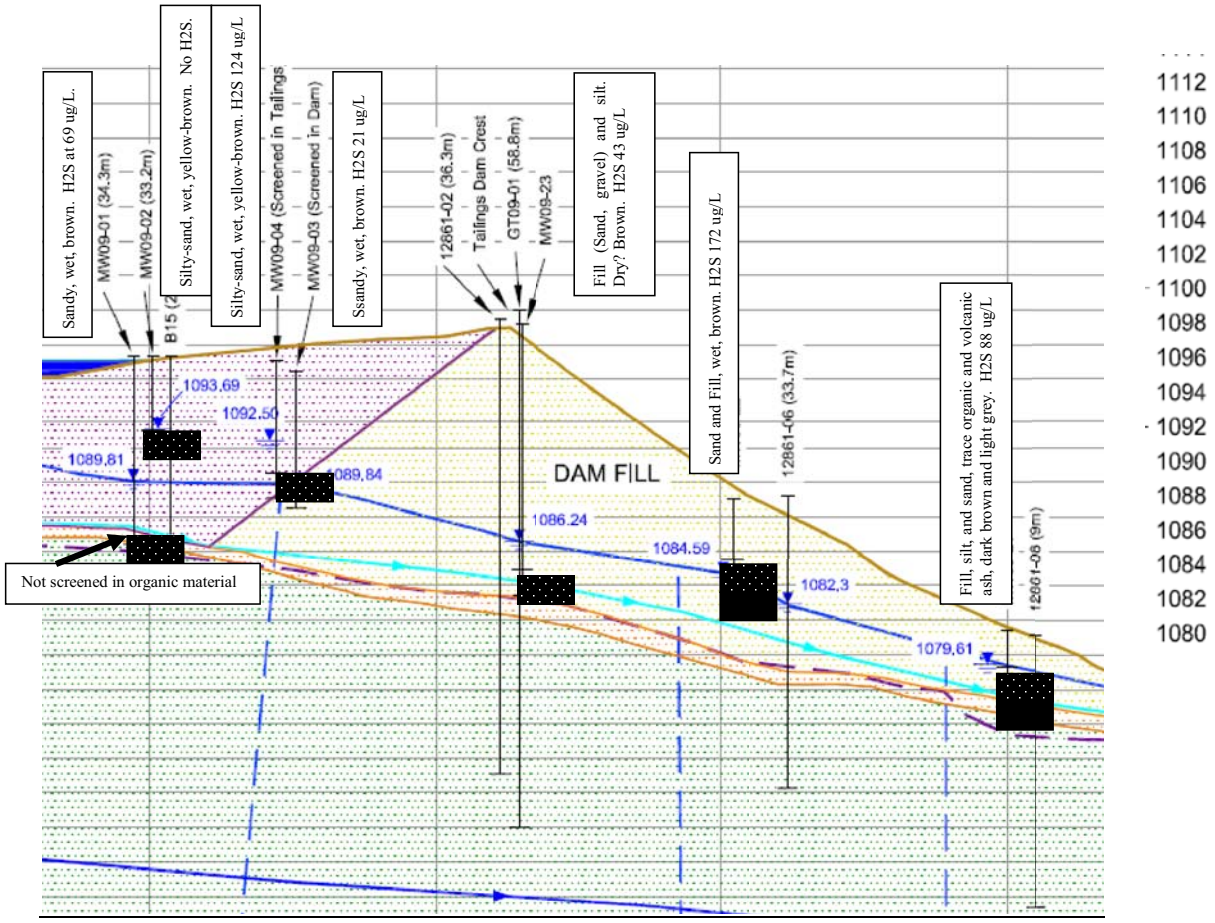


Figure 8. Close up cross-section of tailings dam wells. The material the well is screened in, soil color, and concentration of hydrogen sulfide are noted where known. Black soil, organic matter, and hydrogen sulfide may indicate the presence of sulfate-reducing bacteria (SRB) and metal precipitation as sulfides. Black soil and organic matter are not encountered. Hydrogen sulfide does not reach the mg/L concentrations that would be indicative of a strong SRB presence. Adapted from AEOM 2010 and AECOM soil boring logs provided by Lorax.

B. Dilution effect

By tracking very soluble elements, such as chloride and fluoride, it can be determined if water is being diluted. Sulfate and sodium can also be good indicators, but both are found in processing chemicals and because sulfate concentrations can change with SRB activity; they should not be used as the only indicators. If freshwater is entering along the tailings water flow path, there should be a decrease in anions and sodium at that point.

Vertical flow path

The drop in sulfate between tails at MP 09-12 and soil at MP 09-11 strongly indicates SRB activity; the well set MP 09-11/MP 09-10 indicates some possible influence from dilution, although the pattern is not as consistent as at the horizontal flow path (Figure 9).

Front of the tailings impoundment

The wells at the front of the impoundment may not be hydrologically connected. Although MW 09-02 and MW 09-04 are close together, well MW 09-02 is may be above the groundwater saturation zone, according to the map provided by AECOM (Figures 6 and 7), but according to soil bore logs, both were in wet silty-sand material of a yellow-brown color. There is little difference in anion and sodium concentrations, except higher concentrations in well MW 09-02 where some process water appears to be trapped (high cyanide present there as well).

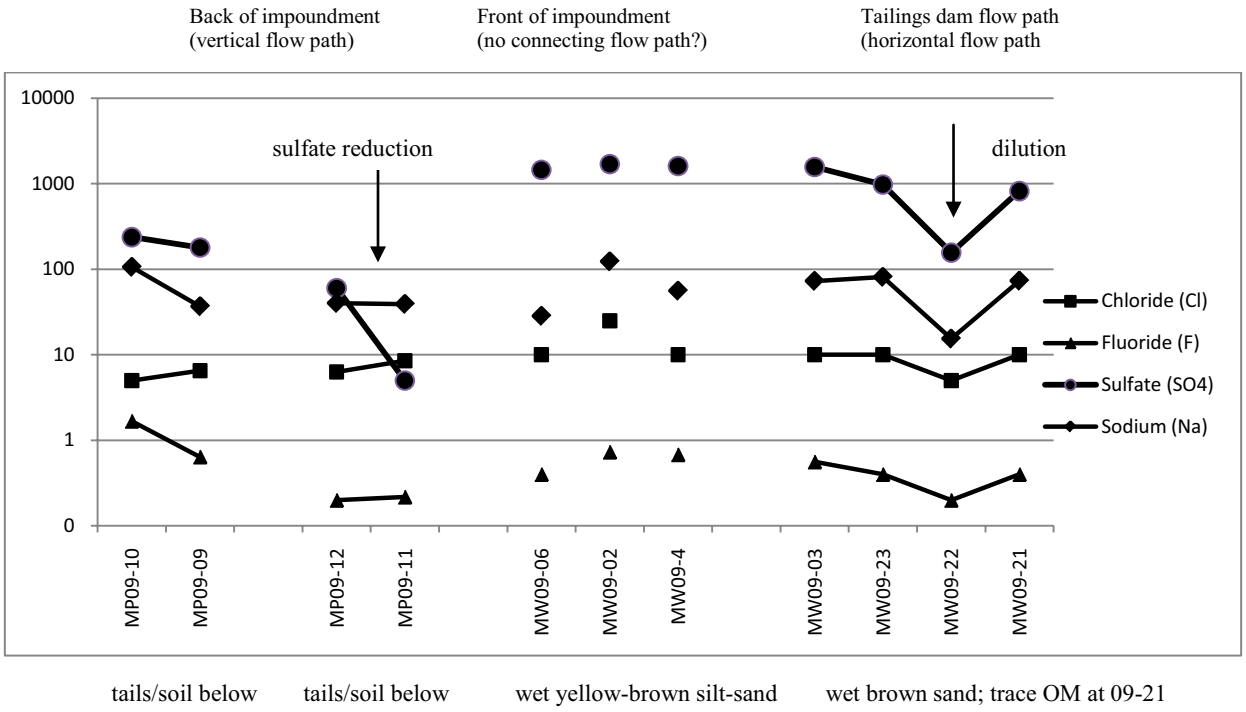


Figure 9. Anion chemistry. A dilution effect will decrease the concentrations of all anions and sodium. Note the well set 09-12 and 09-11, in which only sulfate decreases, indicating that the decrease is due to sulfate reduction occurring in the native soil, not due to dilution. Note that in the tailings dam path, all anions and sodium decrease in concentration at MW 09-22, indicating a possible source of freshwater. This appears to be a localized effect, as ions have regained their previous concentration at the next downgradient well. The wells at the front of the impoundment are probably not hydrologically linked, so no pattern is expected. MW 09-02 may have trapped process water, explaining the higher ion concentrations. All analytes are in mg/L.. Data from Lorax 2009.

Flow through tailings dam
All of the wells in the dam flow path are screened in the estimated groundwater saturation zone and should be along the same flow path. The "dip" at MW 09-22 may indicate a source of fresh water intruding into the dam, causing the decrease in all the anions and in sodium. This appears to be a temporary effect, with concentrations returning to "normal" at the downgradient well, therefore dilution likely does not explain analyte concentrations, except at MW 09-22. The source of fresh water should be determined, and whether MW 09-22 and MW 09-23 are on the same flow path.

It is interesting to note that a strong sulfate reduction signal only occurs at the well set MP 09-12/MP 09-11.

C. Sulfide species
Competition
It should be emphasized that metals compete with arsenic to bind to sulfide. Several divalent metals easily bind to sulfide: mercury, cadmium, copper, zinc, iron etc. If sulfide precipitation is occurring, concentrations of all sulfide-sensitive metals should decrease, with the amount dependent on the metal concentration and the affinity for sulfide. The stability constants (as logs) for metal sulfide species are:[17]

Table 1. Stability constants for metal sulfide species

Species	Log K
HgS	53
Ag_2S	50
CuS	36
PbS	28
CdS, NiS	27
ZnS	25
FeS	18
MnS	14

The formation of As_2S_3 from $As(OH)_x$ has a formation constant of 14-18,[18] indicating several species will outcompete arsenic, depending on concentrations.

It has been suggested that thioarsenites such as As_2S_3 will only persist in iron-limited environments.[19] Where iron exists, precipitation of FeS is more likely to dominate. However, FeS may not be entirely a competitor. Luo et al 2008 observed that, despite high sulfide concentrations ($10^{-2.6}$ M total sulfide, $10^{-2.9}$ M H_2S as maximums), arsenic was not removed below 100 ug/L until $FeCl_2$ was added to the solution, at which point 95-98% of 1000 ug/L of arsenic was removed consistently. This suggests that while iron may compete with arsenic to form sulfides, iron sulfide species likely assist in removal of arsenic through sorption.[20]

Concentration
Precipitation of arsenic as a sulfide will also depend on pH, the concentration of arsenic, and the concentration of sulfide. Wilkin et al 2003 suggest that, when arsenic is in concentrations of $10^{-5.6}$ M to $10^{-4.8}$ M, at neutral pH, sulfide concentrations need to be greater than $10^{-4.3}$ M in order to form

[17] Morel and Hering, 1993. Table 6-3.
[18] Wilkin et al, 2003. (speciation of arsenic in sulfide waters)
[19] ibid
[20] Also see Welch et al 2003 for iron effects on arsenic removal.

thioarsenites as the dominant species. This experiment was conducted without significant concentrations of divalent metals that could compete with arsenic for sulfide.

However, very high sulfide concentrations (H_2S near 10^{-3} M) are toxic to SRB;[21] if SRB die from sulfide toxicity, total sulfide levels will decrease. This suggests that there is a pH-total sulfide range that is optimal. Sulfide species change with pH according to:

$$H_2S \underset{pK1=7}{\rightleftharpoons} HS^- \underset{pK2=13.9}{\rightleftharpoons} S^{2-} \qquad \text{(Equation 1)}$$

At neutral pH, nearly half of total sulfide is in the H_2S form toxic to SRB and nearly half is in the HS^- form, with very little in the S^{2-} form needed to precipitate divalent metals. More alkaline pH favors more S^{2-} and less H_2S.

Sulfide concentrations as measured and calculated at Mt. Nansen are low enough that toxic H_2S is not an issue, but are lower than the concentration potentially needed to precipitate As_2S_3. Measurements of sulfide in water at Mt. Nansen have been provided as H_2S. Concentrations of total sulfide and S^{2-} can be calculated (Equations 1 and 2, Table 2):

$$[\text{Total Sulfide}] = [H_2S] * (1 + 10^{pH-pK1}) \qquad \text{(Equation 2)}$$

$$[S^{2-}] = ((10^{pK2} * 10^{pK1}) * [\text{Total sulfide}]) / (10^{-pH})^2 \qquad \text{(Equation 3)}$$

Given specific well pH and H_2S concentrations measured in pore-water at Mt. Nansen, the total sulfide ranges from $10^{-4.7}$ to $10^{-6.3}$ M (red lines in Figure 10); arsenic ranges from 8 ug/L to 24,000 ug/L total, or $10^{-3.8}$ to 10^{-7} M (blue lines in Figure 10). Based on information from Wilkin, this would provide only a very small area that would favor As_2S_3 formation, even at neutral pH (yellow triangle).

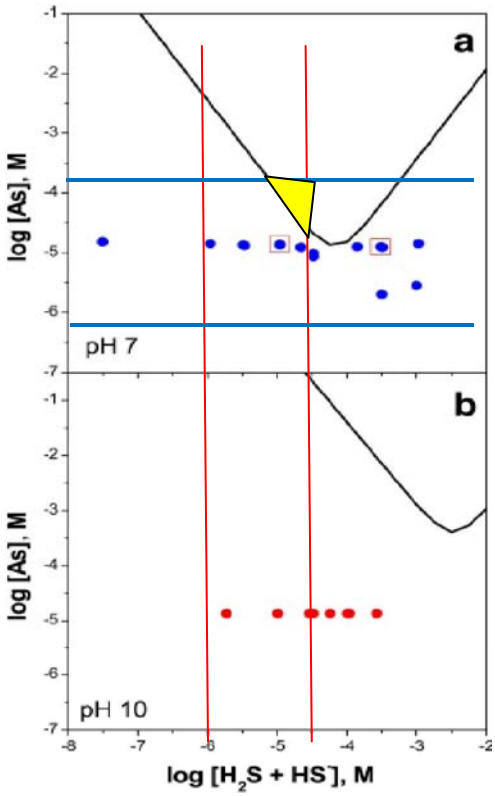


Figure 10. Saturation of As_2S_3 at different pH, As, and S concentrations. The V-shaped curve represents the predicted solubility of As_2S_3 in experiments. The water at Mt. Nansen has arsenic generally ranging from 500-22,000 ug/L (6.7 uM to 293 uM, blue lines) and H_2S from 10 – 100 ug/L (3.1 uM to 312 uM), with total sulfide calculated as 1-34 uM (indicated by red lines) (Wilkin et al, 2003).

[21] see Luo et al 2008 for discussion of sulfide toxicity and the ranges of toxic levels in literature

Table 2. Arsenic and Sulfide concentrations in Mt. Nansen pore-water. Data is from Lorax November 2009.

			$[As]_T$		$[S]_T$		$[H_2S]$	
	Well	pH	ug/L	M	ug/L	M	ug/L	M
Tailings	MW 09-02	7.37	13009	$10^{-3.8}$	nd	nd	nd	nd
	MW 09-04	8.38	3717	$10^{-4.3}$	600	$10^{-4.7}$	24	$10^{-6.2}$
	MW 09-06	7.73	649	$10^{-5.1}$	nd	nd	nd	nd
	MW 09-10	7.39	24337	$10^{-3.5}$	698	$10^{-4.7}$	20	$10^{-6.2}$
	MW 09-12	7.39	10970	$10^{-3.8}$	162	$10^{-6.3}$	47	$10^{-5.9}$
Native substrate	MW 09-01	nd	172	$10^{-5.6}$	nd	nd	nd	nd
	MP 09-09	8.16	4813	$10^{-4.2}$	726	$10^{-4.7}$	47	$10^{-5.9}$
	MP 09-11	6.79	1066	$10^{-4.9}$	234	$10^{-5.1}$	145	$10^{-5.4}$
Tailings Dam	MW 09-03	7.96	2940	$10^{-4.4}$	213	$10^{-5.2}$	21	$10^{-6.2}$
	MW 09-23	7.01	8	10^{-7}	87	$10^{-5.6}$	43	$10^{-5.9}$
	MW 09-22	6.92	nd	nd	315	$10^{-5.0}$	172	$10^{-5.3}$
	MW 09-21	6.67	28	$10^{-6.4}$	129	$10^{-5.4}$	88	$10^{-5.6}$
Range (log)				-3.8 to -7		-4.7 to -6.3		-5.3 to -6.2

Sulfide-sensitive metals in Mt. Nansen pore-water

The following graph illustrates that there is likely sulfide precipitation occurring in the tailings impoundment at the organic layer, but there is little evidence that it is occurring along the flow path through the dam (Figure 11).

In paired wells screened in tailings and native soil, there is a distinct and consistent drop in metals that precipitate with sulfide; recall the strong SRB signal at MP 09-12/MP 09-11. The corresponding increase in H_2S does not necessarily mean more sulfide is available; the pH drops[22] (not shown), and this alone shifts total sulfide away from S^{2-} and towards H_2S (equation 1).

This pattern is not observed along the horizontal flow path; except for arsenic and antimony, analytes change little along the horizontal flow path.

- Cadmium shows little change
- Copper shows little change (MW 09-21 has a high limit of detection and should not be used)
- Zinc shows little change (MW 09-23 and 09-22 at the limit of detection)

This indicates that analytes such as cadmium, copper, and zinc are decreased in pore-water concentration ***prior to*** reaching the tailings dam – possibly through sulfide precipitation with vertically flowing water moving from the surface of the tailings impoundment down to underlying soil.

[22] If SRB are active, the pH should actually increase, not decrease; however, it is likely that other processes, such as bacterial reduction of organic material to organic acids and possibly pH of underlying soil are also influencing the environment.

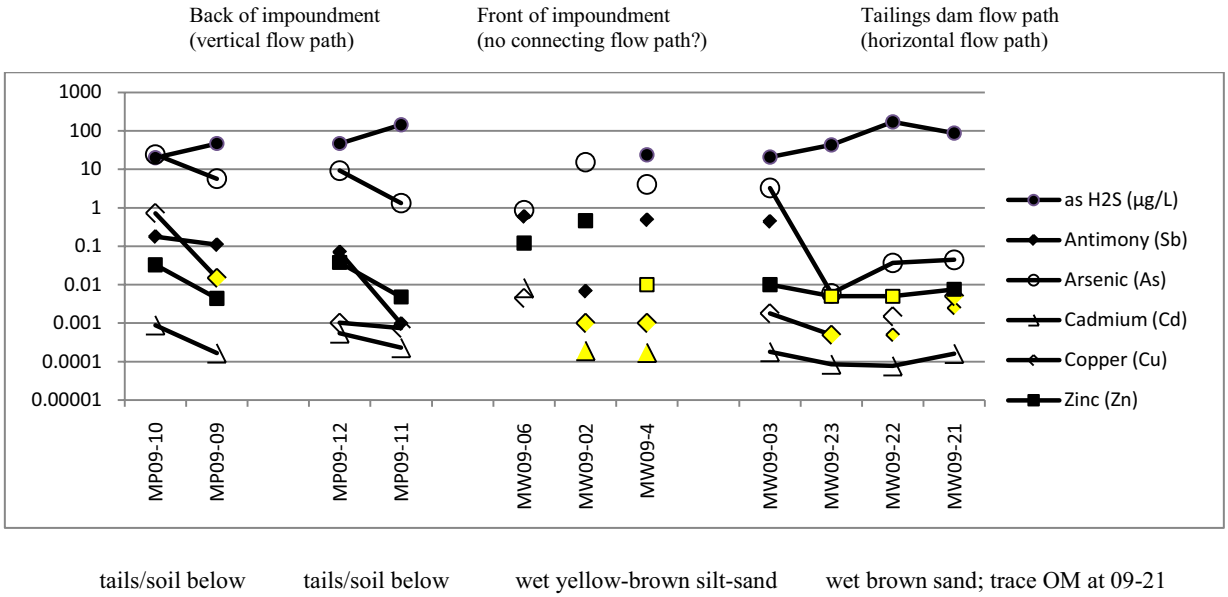


Figure 11. Sulfide-sensitive metals. There is a distinct and consistent drop in metals with a corresponding increase in H2S in wells with a vertical flow path. This pattern is not observed in wells along the horizontal flow path through the tailings dam. Yellow indicates analytes detected at the limit of detection. Analytes with the same symbols (e.g. antimony and copper) have icons of different sizes to distinguish them when both have yellow fill. All analytes are in mg/L except H2S, in ug/L. The well MW 09-22 may be the site of freshwater intrusion, which could affect analyte concentrations.

Metalloids in Mt. Nansen pore-water

Arsenic and antimony behave differently than divalent metals such as those discussed above. Arsenic and antimony concentrations decrease as water moves through the dam towards the seepage collection pond. It is not clear whether the mechanism is sulfide precipitation, because sulfide-sensitive metals are already in very low concentrations when they enter the dam and cannot be used to verify the mechanism at the arsenic removal region. It may be that the low concentrations remove competition for sulfide (except for iron), allowing arsenic to precipitate; however, the lack of corroborating evidence based on soil color and organic matter content, as well as other factors noted in this review, indicates there is not enough data to conclusively determine sulfide precipitation as the mechanism.

It is interesting to note that arsenic declines ***prior*** to the well affected by freshwater intrusion, therefore dilution is not the reason for the decrease. However, it is possible that dilution keeps analyte concentrations at that one well lower than they would be otherwise, and the "pattern" in the dam wells might be less consistent than would be determined at first glance.

D. Microbial effects on metal and arsenic removal

If sulfide precipitation is the mechanism for decreasing metal concentrations in pore-water, then there should be evidence that SRB are active. Sulfate would decrease, sulfide would increase, metals would decrease, and dissolved oxygen would be very low.

Vertical flow path

In Figure 12, we see indicators of microbial activity in the soil beneath the tailings pond. Dissolved oxygen is low (indicating an environment where SRB can survive), sulfate decreases as sulfide increases (indicating SRB are consuming sulfate), total organic carbon is high (indicating a food source), and

manganese and iron both increase (indicating a reducing environment in which iron and manganese reducing bacteria are active).[23]

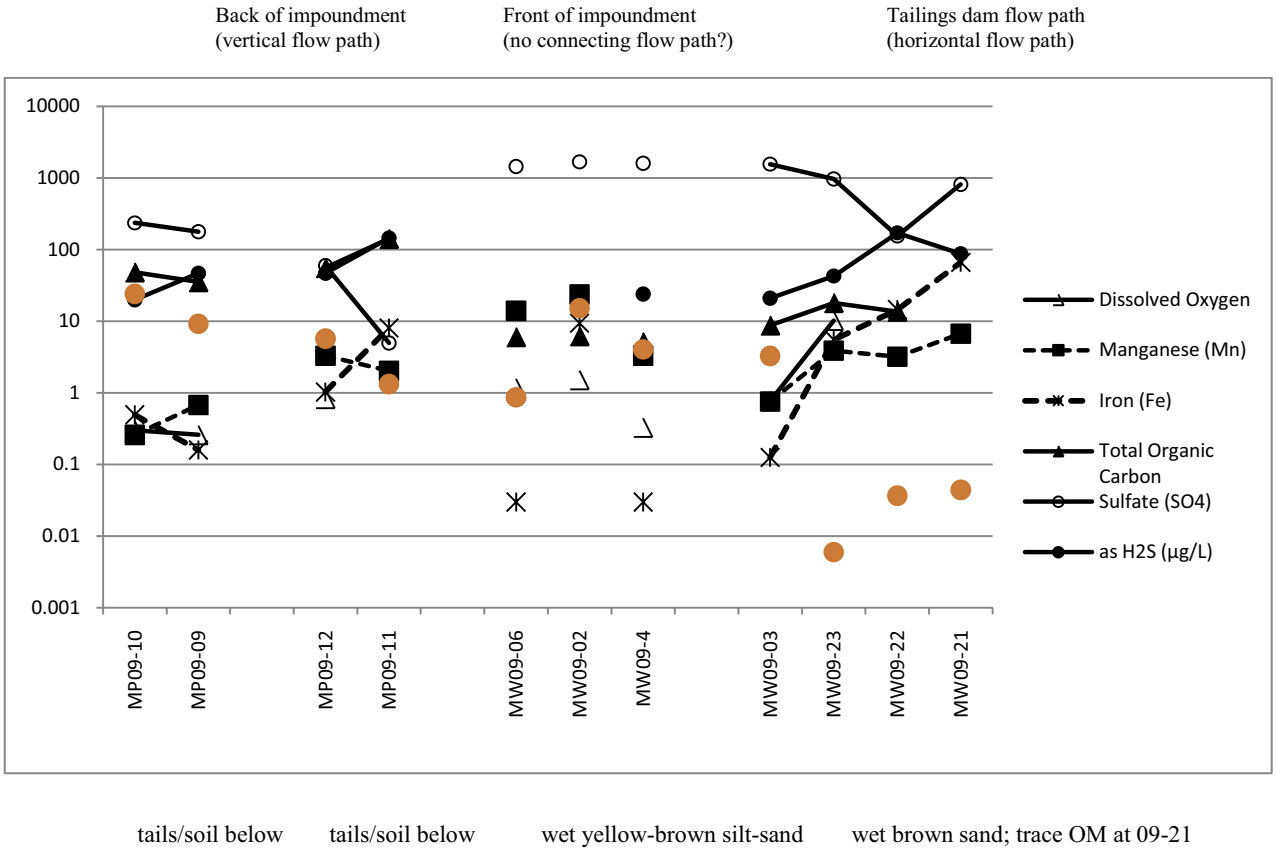


Figure 12. Indicators of microbial activity. All analytes are in mg/L except H_2S, in ug/L. Arsenic is overlaid, as colored circles. Freshwater intrusion may affect analyte concentrations at MW 09-22.

Front of the impoundment

At the front of the impoundment, wells have lower total organic carbon and higher oxygen (except at MW 09-04), providing less optimal conditions for SRB. Sulfate concentrations do not decrease and sulfide is low in the one well with an H_2S measurement (MW 09-04). All of these indicate that SRB are not active in the tailings impoundment, which is to be expected. The varying iron concentrations may be related to heterogeneity in tails or local oxidation.

Flow through tailings dam

Within the tailings dam, there are indicators of microbial activity, but it is not fully clear that microbially-induced sulfide precipitation is the mechanism for arsenic removal.

[23] It is not clear why iron decreases at MP 09-10/09 and increases at MP 09-12/11; this may be due to heterogeneity within the tails, different reducing environments, different microbial complexes, etc.

Supporting a microbial theory:

- The relatively high total organic carbon and the pattern of sulfate concentration decrease with H_2S increase in the first three wells points to SRB activity.
- Manganese and iron increase, particularly iron, and this could indicate a reducing environment with reducing bacteria.

However,

- Dissolved oxygen is low at MW 09-03, the interface of the tailings impoundment and the dam, but high at the next downgradient well; dissolved oxygen measurements were not taken at the remaining dam wells. The high oxygen in MW 09-23 makes it unlikely SRB are active there.
- pH declines at every step along the path, and particularly between MW 09-03 and MW 09-23. The decline in pH may be partly responsible for the increase in H_2S. A change in pH may increase abiotic arsenic sorption (see next section).
- Iron is high, indicating that iron-reducing bacteria may out-compete SRB.
- There is lack of a clear pattern with divalent metals (due to initially low concentrations and varying LOD concentrations).

Full data on oxygen concentrations and E_h would be helpful in interpreting the information and measurement of total sulfide with total sulfate would be a better indicator of SRB activity.

E. pH effect on arsenic removal

A potential mechanism not explored is the effect of pH and iron on arsenic removal. The pH affects two components: the amount of sulfide available to bind metals, and the ability of mobile arsenic species to sorb to iron. In particular, As^{5+} may sorb best at pH 3.5-5.5.[24]

Sulfide species and pH

While very low pH is not found at the Mt. Nansen system, along the flow path at the tailings dam, pH steadily declines (pH 7.96, 7.01, 6.9, 6.7) (Figure 13, Table 2). At pH 7, 50% of sulfide is in the H_2S form and 50% is HS^-, with very little of the S^{2-} that can bind metals; as pH decreases, more sulfide shifts to H_2S and even less is available for metal sulfide precipitation. This may explain the observed increase in H_2S concentration, despite the high oxygen, along the flow path.

Arsenic sorption and pH

With the drop in pH from 8 to 6.7 along the dam flow path, arsenic (as As^{5+}) may more easily sorb or co-precipitate. This may be dependent on concentration and speciation; two references indicates that As^{3+} binds optimally at pH 8-10, and although they differ on the optimal pH for As^{5+} binding, they agree that it improves at pH less than 7.[25]

Arsenic precipitation and pH

Sorption bonds are weaker than the covalent bonds found in As_2S_3, FeS, and other precipitates. Weaker bonds are subject to greater instability, particularly in dynamic environments such as a tailings pond subject to changes in precipitation and groundwater flux. In order for arsenic to precipitate as a stable As_2S_3, sulfide and arsenic must be available in high enough concentration, the pH must be in the right range, there must be limited competition from iron and other metals, there must be a reducing atmosphere that favors SRB, and there may need to be the right species of SRB present.[26]

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[24] Lafferty and Loeppert, 2005

[25] Lafferty and Loeppert, 2005; Goldberg, 2002

[26] Newman et al, 1997.

Figures 13-14 graph the pertinent components for arsenic precipitation or sorption. While the tailing/soil pairs, as has been mentioned, indicate metal and arsenic sulfide precipitation in the soil,[27] the pattern through the tailings dam is different; the drop in arsenic coincides with the decline in pH. This leaves open the argument that the decline in pH from near 8 to below 6.5 may be part of the reason for arsenic removal, as sorption with iron oxides.

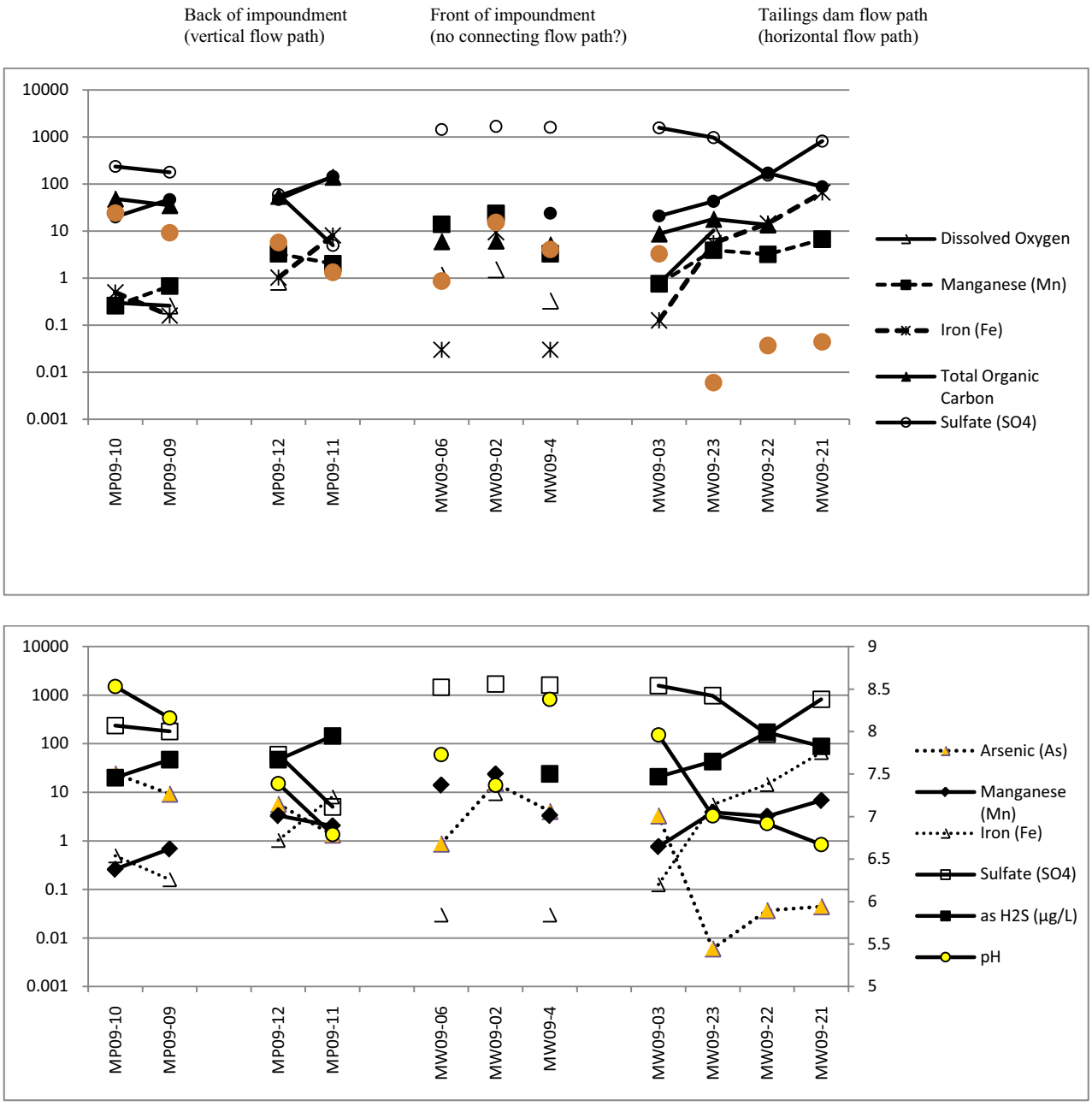

Figure 13. Pattern of arsenic precipitation in impoundment and tailings dam. Arsenic and pH are highlighted. Data is adapted from Lorax November 2009

[27] Note that it is not necessarily clear whether arsenic precipitates as As_2S_3 in soil or is removed through sorption by FeS or FeS_2 as it precipitates.

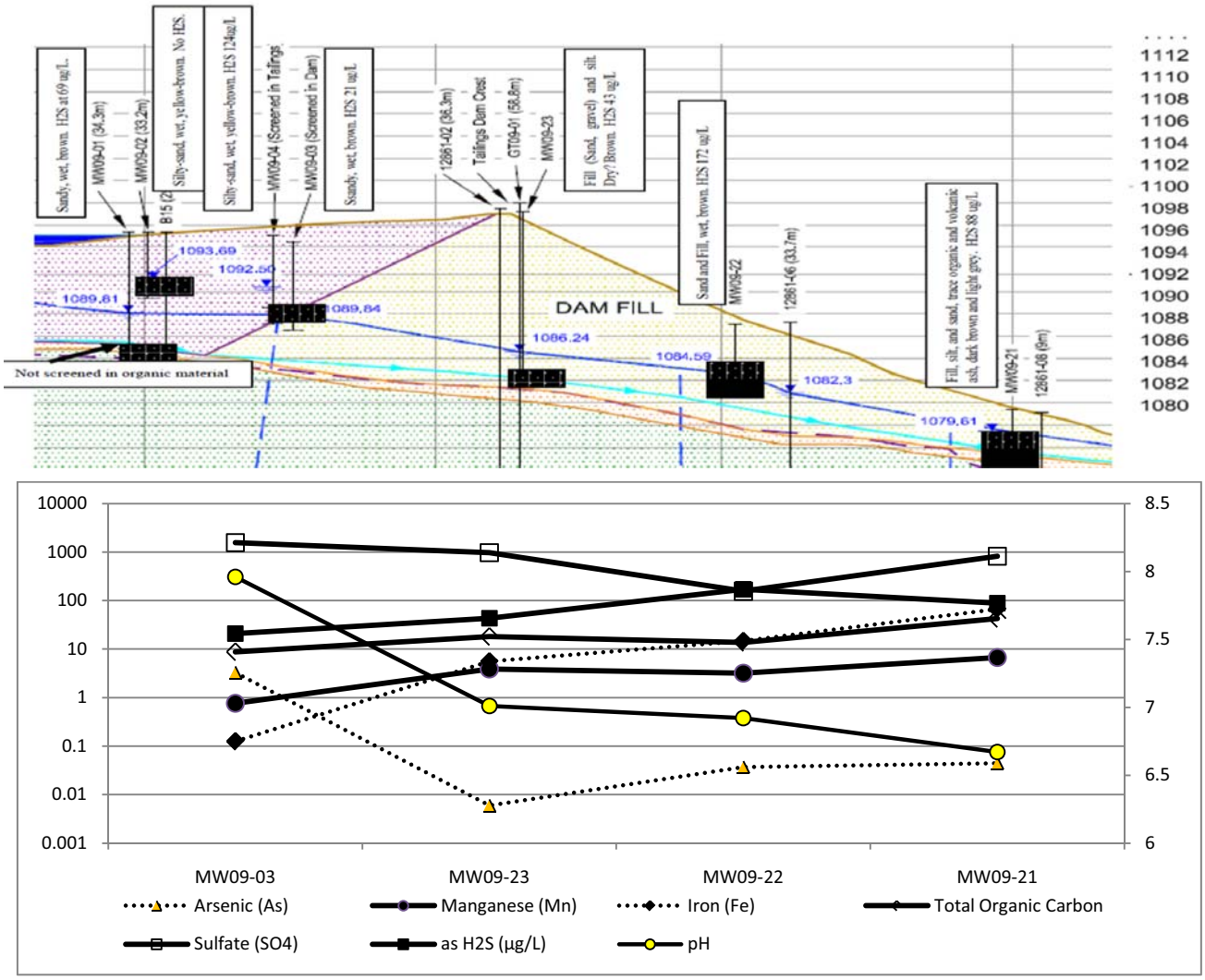

Figure 14. Tailings dam pore-water analytes. Although H2S is present, it is in low concentrations. None of the wells are screened in organic material (some slight OM at MW 09-21) and none have the black soil typical of sulfide. There is little to no clay; if sorption is a mechanism it is likely on metal (oxy) hydroxides.

III. Summary and Closing Thoughts

Biotic and abiotic activities occur together, and it can be very difficult to discern the influences of one over the other (Figure 15). Sorption and co-precipitation of arsenic are affected by pH and the concentrations of many species, including arsenic, iron, manganese, and sulfates. In addition, redox plays a critical role. A mildly reducing environment promotes iron and manganese reducing bacteria and the likely increase of both elements, along with the release of any sorbed arsenic, which will likely be in the (generally more) mobile As^{3+} form, although in an alkaline environment As^{3+} may find amorphous iron (oxy) hydroxides to sorb to. A strongly reducing environment promotes sulfide production and the precipitation of metal sulfides and arsenic sulfide, but there is competition between metals and arsenic for binding sites, the range of potential pH/pE regions where As_2S_3 precipitation may occur is limited, the range of arsenic-sulfide concentrations at Mt. Nansen may not favor As_2S_3 precipitation, and the same

SRB may methylate arsenic (promoting sorption rather than precipitation). Additionally, even with high sulfide and high arsenic concentrations, iron may play a critical role in arsenic removal.

Although there is evidence for metal sulfide precipitation in native soil underlying the tailings impoundment, the evidence that this is also occurring under the tailings dam is less strong. In part, SRB activity may depend on melting permafrost. As permafrost melts, carbon in the organic material becomes more available to microbes, and temperature-sensitive microbes such as SRB will be more active in warmer soils. At the tailings dam, the melting that may improve SRB activity may also destabilize the tailings dam. The only monitoring wells that are noted to end in permafrost are in the tailings dam (MW 09-22 and MW 09-21); all wells screened within the tailings impoundment and the first dam well have no permafrost noted.[28] Where the permafrost lies above the organic material, there is not likely to be much microbial activity.

To determine whether metal sulfide precipitation is the primary mechanism for arsenic removal, it would be useful to have vertical profiles of analytes to determine if and where the microbial zone is. There is precedence for this, and an example of the data that could be collected is shown in Figure 5.[29]

Because the working hypothesis hinges on a continual input of DOC as an active part of the attenuation process, DOC needs to be measured both in surface water and in the vertical profile. Vertical profiles should include E_h, dO, sulfate, total sulfide, pH, arsenic (as As^{+3} and As^{+5}) and iron (Fe^{2+}, Fe^{3+}) to inform whether sulfate reducing bacteria are active.

If DOC coming in from the Dome river valley is a critical component, consideration should be made to leaving the tails in place. However, if DOC is determined to not be a critical component, there may be benefit to moving the tailings to the pit. In addition to a long term secure storage, it would offer an environment without permafrost and one in which the pH and iron could be adjusted during and after the move to optimize arsenic adsorption and co-precipitation.

If microbial activity is the primary promoter of metal removal, then this removal mechanism could be enhanced by adding carbon sources that SRB can use directly (ethanol, methanol, used antifreeze, etc)

Whether the pit option or the improved dam option are chosen, either could improve arsenic removal by allowing the discharge to flow through a wetland prior to entering natural waterways. This promotes arsenic removal both through precipitation (wetlands promote SRB activity) and through sorption to iron oxide plaque on root systems.[30]

[28] The second dam well, MW 09-23, ends in permafrost at 30 m, but the well is screened near 15 m.
[29] McCreadie et al, 2000
[30] Sookyun and Park, 2003

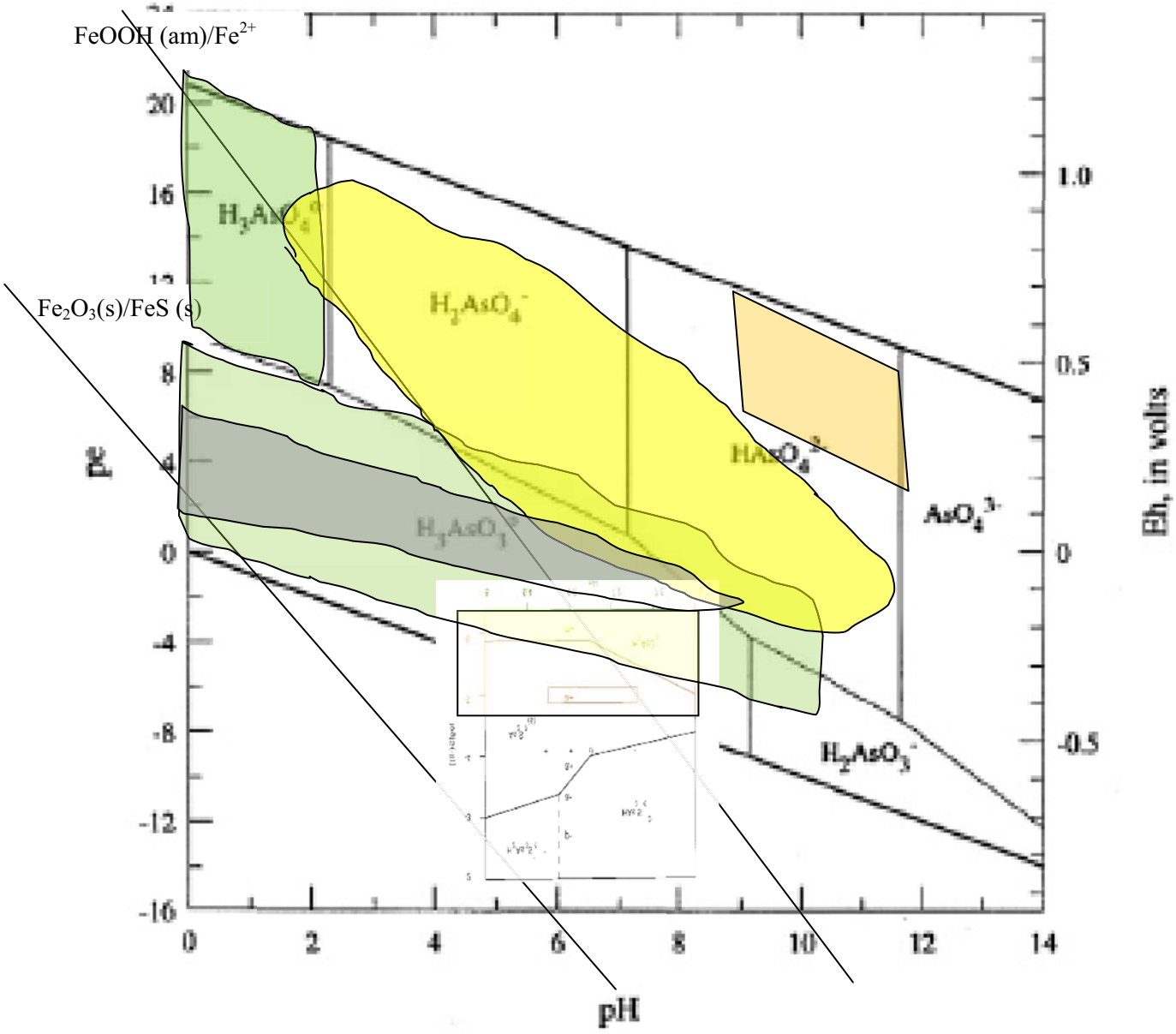

Figure 15. Components that influence arsenic precipitation. The base pE/pH diagram is from Nordstrom and Archer 2003. The re-design is not meant to be accurate, but to combine many of the properties discussed in the review to indicate the complexity of the possible arsenic removal mechanisms. The green coloration indicates sections where As^{5+} and As^{3+} are mobile. The gray shape is the area of stable orpiment (As_2S_3) from the same author. Above that would be stable As_2O_3, then As_2O_5. Overlaid are potential regions of influence of FeOOH/Fe2+ and Fe2O3(s)/FeS (s) (equilibria lines), region of potential influence of MnOOH (orange box), region of potential influence of amorphous FeOOH (yellow shape), and area of expected SRB activity (pink box, based on pH of 4.5-8 and pE of -100 to -400). The pH/log S chart from Newman et al that indicates the region of As2S3 precipitation is inset with the log S scale inverted, as sulfide would be expected to be in higher concentration at lower pE.

References

AECOM. 2010. Mt. Nansen Alternatives Characterization, draft. Figure 4, groundwater flow. Project 112359-60119144. Assessment and Abandoned Mines Branch, Yukon Government.

Goldberg, S. 2002. Competitive adsorption of arsenate and arsenite on oxides and clay minerals. *Soil Sci. Soc. Am. J.* 66: 413-421.

Goldberg, S and CT Johnson. 2001. Mechanisms of arsenic adsorption on amorphous oxides evaluated using macroscopic measurements, vibrational spectroscopy, and surface complexation modeling. *J. Colloidal and Interface Science* 234: 204-216.

He, TY, AG Fitzmaurice, A Bilgin, S Choi, P O'Day, J Horst, J Harrington, HJ Reisinger, DR Burris, and JG Hering. 2010. Geochemical processes controlling arsenic mobility in groundwater: a case study of arsenic mobilization and natural attenuation. *Applied Geochemistry* 25: 69-80.

Jia, Y and GP Demopoulos. 2005. Adsorption of arsenate onto ferrihydrite from aqueous solution: influence of media (sulfate vs nitrate), added gypsum, and pH alteration. *Environ. Sci. Technol.* 39: 9523-9527.

Lafferty, BJ and RH Loeppert. 2005. Methyl arsenic adsorption and desorption behavior on iron oxides. *Environ. Sci. Technol.* 39: 2120-2127.

Lee, K-Y, K-W Kim, and S-O Kim. 2010. Geochemical and microbial effects on the mobilization of arsenic in mine tailings soil. *Environ. Geochem. Health* 32: 31-44.

Lim, M-S, IW Yeo, Y Roh, K-K Lee, and MC Jung. 2008. Arsenic reduction and precipitation by *Shewanella* sp. – batch and column tests. *Geosciences J.* 12 (2): 151-157.

Lorax Environmental Services, Ltd. 2009. Mount Nansen geochemical assessment in support of evaluating closure plan options. Department of Energy, Mines, and Resources. Yukon Government.

Luo, Q, TK Tsukamoto, KL Zamzow, and GC Miller. 2008. Arsenic, selenium, and sulfate removal using an ethanol-enhanced sulfate-reducing bioreactor. *Mine Water and the Environment* 27: 100-108.

Magalhaes, MCF. 2002. Arsenic – an environmental problem limited by solubility. *Pure Appl. Chem.* 74 (10): 1843-1850.

McCreadie, H, DW Blowes, CJ Ptacek, and JL Jambor. 2000. Influence of reduction reactions and solid-phase composition on pore-water concentrations of arsenic. *Environ. Sci. Technol*. 34 (15): 3159-3166.

Morel, FMM and JG Hering. 1993. Principles and Applications of Aquatic Chemistry. Wiley and Sons, NY NY.

Newman, DK, TJ Beveridge, and FMM Morel. 1997. Precipitation of arsenic trisulfide by *Desulfotomaculum auripigmentum*. *Appl. Environ. Microbiol.* 63 (5): 2022-2028.

Nordstrom, DK and DG Archer. 2002, Arsenic Thermodynamic Data and Environmental Geochemistry. *in* Welch, AH and KG Stollenwerk, eds., Arsenic in Ground Water: Geochemistry and Occurrence: Boston, Kluwer Academic Publishers, p. 1-26.

Reyes, C, CW Saltikov, KJ Tufano, and S Fendorf. 2009. How iron and arsenic reduction pathways in metal-reducing bacteria influence arsenic fate and transport. *Geochimica et Cosmochimica Acta* 73 (13) Supplement 1.

Sookyun, W and SS Park. 2003. Modeling the fate and transport of arsenic in wetland sediments. *Korean J. Limnol.* 36 (4): 434-446.

Welch, AH, KG Stollenwerk, DK Maurer, and LS Feinson. 2003. In-situ arsenic remediation in a fractured, alkaline aquifer. *in* Welch, AH and KG Stollenwerk, eds., Arsenic in Ground Water: Geochemistry and Occurrence: Boston, Kluwer Academic Publishers, p. 403-419.

Wilkin, RT, D Wallschlager, and RG Ford. 2003. Speciation of arsenic in sulfide waters. *Geochem. Trans.* 4 (1): 1-7.

Zamzow, KL, TK Tsukamoto, and GC Miller. 2006. Waste from biodiesel manufacturing as an inexpensive carbon source for bioreactors treating acid mine drainage. *Mine Water and the Environment* 25: 163-170.

Collated Summary of Comments (AECOM, 2010)	Comment Response: Mt. Nansen - Options for Closure (Lorax, 2010)
General	
Need a balanced assessment of all the risks associated with each option	Integrated process with regularly scheduled workshops between technical consultants
Options need to be evaluated with an integrated approach (input from all disciplines)	
Need an integrated water balance that incorporates the various components of each option	Workshops focused on refinement of water balance and water quality model inputs, which integrates all disciplines
Need to assess the environmental implications of each cover option (seepage rates, water quality, water balance, effectiveness)	Water balance and water quality model has been devised for each option, which has a specific cover design.
Potentially elevated metal levels in Option 4 may necessitate hydraulic containment and/or treatment	An environmental effects assessment has not been conducted in support of defining treatment requirements.
Treatment of demolition debris not addressed (IPRP)	Common Closure Elements addressed in Section 5.2 (Lorax, 2010).
Geochemistry	
Need to demonstrate the long-term nature of attenuation mechanisms in scenario 3	Groundwaters upstream of TSF were sampled and analyzed for DOC.
The source of metal loading from the millsite needs to be characterized	Preliminary characterization of mill area was conducted (Appendix B and Appendix C-2)
Evaluate whether current Waste Rock seepage quality is reflective of long-term quality	Waste-rock field bins, waste rock seeps and lysimeters were sampled through 2010 and are scheduled for future sampling (Appendix B)
Approach to source term derivation is inconsistent between options	Source term derivation has been refined with an improved data set (Appendix B)
Evaluate long-term fate of waste rock in the pit	Waste rock field bins which mimic pit conditions are being sampled on a monthly basis (Apendix B)
Potential for water quality issues associated with a water cover (pit) should be evaluated	A water cover for is not part of the design for Option 3 and is not expected (Appendix F)
Water Quality Modeling	
Input parameters are highly uncertain (water balance, seepage rates, precipitation)	Input parameters have been refined but remain unceratin. A consistent approach has been taken to compare the options (Appendix F)
Geotechnical	
Uncertainty related to tailings dam stability related to warm permafrost foundation	Detailed designs have addressed the management of dam foundation concerns related to permafrost (Appendix C-1)
Permafrost degradation scenarios need to be considered	Thermal modeling has been conducted (Appendix C-1)
Risks associated with potential seepage from the Pony Creek adit need to be addressed	Preliminary design and contingency costs have been provided (Appendix C-1)
Tailings relocation methodologies not developed enough to allow for comparison with other options	Refinement of tailings relocation methods for Options 3 and 4 are reflected in the new cost estimates (Appendix C-1)
Adequacy of spillway armouring and drop structure should be addressed	Conceptual design and drawings haven been provided (Appendix D and Appendix C-1)
Spillways and Diversion channel need to be designed to meet site-specific needs	Conceptual design and drawings haven been provided (Appendix D and Appendix C-1)
Diversion channel design needs to incorporate considerations for low flows in freezing conditions	These concepts will be addressed with detailed design following selection of a preferred closure option
Design details for proposed channel (valley restoration) are required	Conceptual design and remediation costs have been provided (Appendix C-2)
Hydrogeology/Hydrology	
Uncertainty regarding long-term saturation of tailings emplaced in the pit	Detailed modeling was conducted in support of the design and evaluation of Option 3 (Appendix C-3)
Water balance for the pit when backfilled with tailings/waste rock uncertain	Pit water balance refinement and infiltration modeling has been conducted (Appendix C-3, Appendix E, and Appendix F)
Water balance for the tailings impoundment during dry years- will tailings be exposed?	A sensitivity analysis for Option 1 addressed this concern (Appendix F)
How will the water balance change under each cover scenario?	Detailed water balances were developed for each option; focus of regularly scheduled workshops (Appendix F)
If permafrost degrades below the tailings impoundment, how will the flow path be altered?	Concepts regarding changes in flowpath associated with Option 1 and 2 and their uncerainty are discussed in Appendix C-1 and Appendix E.
Influence of highly conductive zones (faults) on overall hydraulic conductivity should be evaluated (pit disposal option)	This has been addressed and has been identified as an area of uncerainty (Appendix C-3)
Further analysis required to confirm that no seepage is bypassing the seepage collection system	Downstream water quality supports this hypothesis (Appendix F)
Costing	
Costs for moving tailings likely underestimates	Costs have been refined and are specific to each option (Appendix C-1)
Less expensive ways to backfill the pit with waste rock should be considered	Alternate backfill methods and costs are provided in Appendix C-2.
Costing for different covers (including maintenance costs)	Cover costs and maintenance have been included (Appendix C-1 and C-4).
Costing required for maintenance of the diversion channel	Maintenance costs have been included (Appendix C-1)

APPENDIX A: REPORTING COMMENTS

APPENDIX A-2: COMMENTS ON DRAFT REPORT "MT. NANSEN OPTIONS FOR CLOSURE" (LORAX, 2010)

YUKON – REVIEW OF DRAFT MT. NANSEN OPTIONS FOR CLOSURE, DEC. 2010
IPRP –REVIEW OF MT. NANSEN OPTIONS FOR CLOSURE REPORT, DEC. 2010
INAC – COMMENTS OF DRAFT "MT. NANSEN OPTIONS FOR CLOSURE" REPORT, JAN. 2010
LSCFN (SLATER) – MT. NANSEN OPTIONS FOR CLOSURE REVIEW, JAN. 2011
LSCFN (CSP^2) – REVIEW OF MT. NANSEN GEOCHEMICAL ASSESSMENT, JAN. 2011
LSCFN (HFM) – MT. NANSEN MINE CLOSURE, GEOTECH REVIEW, JAN. 2011
LSCFN (STEPANEK) – MT NANSEN, GROUND IMPROVEMENT CONCEPTS, FEB. 2011
LORAX – RESPONSE AND PROPOSED APPROACH TO COMMENTS, MARCH 2011
LSCFN (SLATER) – RESPONSE TO PROPOSED LORAX APPROACH, APRIL 2011
LSCFN (HFM) – MT. NANSEN CLOSURE, GEOTECH, MAY 2011
LSCFN (HFM) – MT. NANSEN CLOSURE, COST ESTIMATE, JUNE 2011
LSCFN (SLATER) – OUTSTANDING INFORMATION NEEDS, JUNE 2011
LORAX – SUMMARY TRACKING TABLE, JULY 2011

Energy, Mines and Resources
Assessment and Abandoned Mines
Box 2703, K-419
Whitehorse, Yukon Y1A 2C6

December 28, 2010

Attention: ***Justin Stockwell; Environmental Hydrogeochemist; Lorax Environmental Services Ltd.***

Re: ***Review of the Draft Mount Nansen Options for Closure Report***

Assessment and Abandoned Mines has completed its review of the draft *Mount Nansen Options for Closure Report*. In general the report is well organized, thorough and generally easy to understand. The options are well laid out with the uncertainties clearly articulated. Each option is presented in a similar context to allow for a level comparison.

Please find attached comments, questions, and edits which have been applied to the "Word" version of the draft report using MS Review. In addition to the specific comments contained within the report, the following general comments should be considered.

- For each discipline the underlying assumptions have been clearly provided to support the conclusions reached. It would be helpful if the rationale for making those assumptions were, where possible, provided in the text or given a specific reference.
- Throughout the text references are provided and in some cases simply identify an Appendix, such as the second to last paragraph on p. 5-32, which states,"…is provided in Appendix C-1." That Appendix is large and specific section numbers and/or page numbers would be helpful. Where plausible and appropriate please provide specific references.
- There seem to be inconsistencies in the costing between the geotechnical estimates and those reported in the Lorax report. For example, pit safety for options 1A and 2A in the Lorax report are $24,000 while in the AECOM report (Appendix D) they are $75,000. Please incorporate an explanation as to the reason for these differences.

With the consideration of comments identified, as well as those provided by the parties, Assessment and Abandoned Mines believes the Options as identified and described will enable the parties to move forward with an evaluation followed by the selection of a preferred option.

Should you have any questions or concerns please do not hesitate to contact my office.

Sincerely,

Patricia Randell

Project Manager

TECHNICAL MEMORANDUM

DATE: December 10, 2010

TO: Andrew Liddiard (INAC)

FROM: IPRP Mt. Nansen Subgroup, Terry Eldridge, John Brodie and Ken Raven

SUBJECT: **Independent Peer Review: "Mt. Nansen Options for Closure" (Draft report from Lorax Environmental Services to GY Assessment and Abandoned Mines Branch, dated November, 2010)**

Background

The Government of Yukon (GY) and Indian and Northern Affairs Canada (INAC) are responsible for management and ultimate closure of abandoned mining operations at Mt. Nansen Yukon. As part of the ongoing process to develop the closure plan for the various areas of the Mt. Nansen site, Lorax Environmental Services Ltd. prepared the draft report titled "Mt. Nansen Options for Closure", dated November 2010. This report builds on the information collected and closure concepts that have been developed since the site was abandoned in 1999, and in particular furthers the work presented in the AECOM report "Overview of Mt. Nansen Alternatives Characterization", dated June 2010.

INAC, on behalf of themselves and the designated review team for GY, asked a subgroup of the Independent Peer Review Panel (IPRP) to review and comment on the Lorax draft report. The Mt. Nansen subgroup review team is:

- John Brodie, P.Eng. (Geotechnical Engineering)
- Terry Eldridge, P.Eng. (Geotechnical Engineering, Mt. Nansen Review Team Chair)
- Ken Raven, P.Eng. P.Geo. (Hydrogeology and Geochemistry)

Mr. Mark Logsdon, who was the previous chair of the Mt. Nansen Review Team was not able to participate in this review.

This review memorandum is a consensus document of the Mt. Nansen Review Team.

Scope and Objectives of the Peer Review

As defined by INAC Statement of Work, the review has focused on high-level scientific and engineering design concepts that are suitable industry solutions for the issues present at the Mount Nansen site. It is assumed that detailed solutions will be resolved at the engineering stage once Governments (INAC, YG, LSCFN) agree on a preferred closure option.

The specific objectives of this Peer Review are:

1. Assess whether or not the proposed closure options provide a reasonable span of possible closure options for consideration.

2. Identify whether or not the individual options are described in a way that will facilitate the use of the report's technical information as part of a Multiple Accounts Analysis (MAA), which is the next step in the closure option evaluation and selection process.

3. Identify any information gaps that should be addressed or work that should be undertaken prior to embarking on selection of the preferred closure option.

As outlined in the INAC Statement of Work, the IPRP is not to identify a preferred closure option in their review. The selection of the preferred closure option will be made by senior representatives from each of the three Governments (INAC, YG, LSCFN) by evaluating the performance of the options against project objectives, based on (a) the Closure Options Report, (b) the IPRP review of the Closure Options Report, and (c) the MAA summary report.

Document Reviewed

The draft Lorax report includes the text of the report and six main appendices. The appendices include much of the background on the project and technical information prepared by a number of consultants other than Lorax, as follows:

Appendix A: Stakeholder Comments on Previous Closure Reporting (Little Salmon Carmacks First Nation, INAC, and IPRP)

- Appendix A-1: Stakeholder Comment Summary Tracking Table
- Appendix A-2: Little Salmon / Carmacks First Nation – Review Report, April 2010
- Appendix A-2: IPRP Mt. Nansen Subgroup – Technical Review, March 2010
- Appendix A-3: INAC – Summary of IPRP Review, June 2010

Appendix B: Geochemical Characterization (Lorax Environmental Services Limited)

Appendix C: Geotechnical Engineering (AECOM), Water Management (AECOM and Golder Associates), and Costing (AECOM and Altura Environmental Consulting)

- Appendix C-1: Geotechnical Assessment and Costing of Closure Alternatives (AECOM)
- Appendix C-2:Common Element and Supplemental Cost Estimates for Conceptual Closure Planning (Altura)
- Appendix C-3: Cover Infiltration Modeling for Options 1, 2, 3 and B (Golder Associates)
- Appendix C-4: Cover Infiltration Modeling for Option 4 (Golder Associates)

Appendix D: Climate and Hydrology Characterization (AECOM)

Appendix E: Hydrogeology Characterization (AECOM)

Appendix F: Water Balance and Water Quality Modeling (Gomm Environmental Engineering Consulting)

General Comments

The draft report improves the closure documentation that was available for review in March, 2010. The Lorax draft report organizes, refines, expands, updates and pulls together the closure option assessment work in a coherent manner under a single cover. This greatly facilitates the presentation and review of closure options for the Mount Nansen site. As summarized in Appendix A-1, the draft report addresses many of the comments provided on the earlier AECOM report, although some design and performance uncertainties remain in several aspects of the closure options.

The closure options considered have been sensibly renumbered and slightly modified from those described in the earlier AECOM report. The closure options outlined in the draft Lorax report include common closure elements, and four groups of short-listed options (1A, 1B, 2A, 2B, 3 and 4). Option 1 is a tailings dam upgrade with water cover and Option 2 is a tailings dam upgrade with a saturated soil cover. Options A have the waste rock remaining in place, whereas Options B have waste rock backfilled to the pit. Option 3 has the tailings placed wet in the Brown-McDade open pit with a high infiltration cover and waste rock left in place. Option 4 has tailings placed dry in the pit with a low infiltration cover and waste rock also placed in the bottom of the pit. Designs for covers for in-place tailings management have also been updated.

As we have previously stated, the four groups of closure options considered for the site address in varying degrees, what appear to be the central closure issues of tailings dam foundation stability, tailings seepage/treatment and open pit physical hazards. The four groups of closure options adequately address the main closure issues given the estimated waste source chemistries and waste area water balances. The waste rock extracted from the Brown-McDade pit does not appear to be acid generating or to leach metals to any significant amount, whereas the tailings may have moderate metals COC concentrations as represented by arsenic, cadmium and zinc, depending upon final saturation and redox conditions of these materials upon closure. Other options are not necessary to provide a reasonable set of alternatives for closure of the Mount Nansen mine.

Downstream surface water quality for these four groups of closure options are assessed using GoldSim under two source water chemistry scenarios (conservative best case and worst case) and three precipitation conditions (dry, average and wet years). While the presentation of two source water chemistry scenarios is an improvement over the somewhat confusing three scenarios presented by AECOM (best estimate, best case and lower bound), we caution on the use of the term “worst case”. One can always find ways to make the “worst case” worse. Calling the worst case, a pessimistic case or upper concentration case would be more appropriate.

The report addresses the closure of common mine elements including the mill area, camp and ancillary buildings, roads, exploration trenches, miscellaneous infrastructure and other areas that was raised as concern with the AECOM report. The draft Lorax report notes that the mill area drainage is the major contributor to downstream water quality loading, such that quantitative comparative evaluation of closure options on downstream water quality necessitated the removal of mill drainage. This is implicitly equivalent to assuming that the mill area drainage will be remediated to background conditions. While this assumption may be appropriate for the purposes of the evaluation of the different closure options for non-common elements, it places a high performance requirement on the mill area closure in the overall assessment of mine closure. Consequently, some discussion confirming the likely ability to fully remediate the mill area drainage is warranted.

The draft report provides a generally coherent framework for evaluating the design and performance of closure options, considering geotechnical, water management, geochemistry and surface water quality elements and costs. For each element of each closure option, the draft report provides an overview and summary of the key assumptions, performance issues and uncertainties. The descriptions of the key assumptions, performance issues and uncertainties of each closure option are reasonably complete as well as providing a fair and objective evaluation. A comparative assessment of key aspects of the closure options considering geotechnical, cost, geochemical and water quality considerations is also provided in Section 6 of the draft report. This comparative assessment provides important insight to what design features of each closure option ultimately control both on-site water quality and downstream water quality within Victoria Creek.

Although one may argue with the treatment and assessment of some specific components of each closure option, the Mount Nansen Review Team is of the opinion that the proposed options provide a reasonable span of possible closure options for consideration for the Mount Nansen mine site. Furthermore, the common description of the elements of each closure option, as outlined above, should allow for completion of a Multiple Accounts Analysis to assist in closure option evaluation and selection.

The draft Lorax report provides additional information and description of technical studies and conceptual models that support the design and performance assessment of closure options, beyond those given in the AECOM report and supporting documentation. Given this improved documentation, the Mount Nansen Review Team considers that the current state of investigations, site information and options evaluation as outlined in the draft Lorax report is sufficient to allow for selection of a preferred closure option. While there obviously remains some design issues that need to be resolved at the engineering feasibility and detailed design stages, we do not identify any critical information gaps or required works that need to be completed in order to move to closure option selection. The Mount Nansen Review Team expects that detailed design of the selected option will not strictly adhere to the conceptual plans as presented by Lorax, but instead will develop technical and practical improvements to reduce risk, reduce cost and improve overall performance.

Specific Comments

1. There remains considerable uncertainty on the long-term performance of Option 3 that considers tailings placement within the pit under saturated or at least tension-saturated conditions that will prevent tailings oxidation, ARD and metals release. In addition to the concerns on the ability to maintain tailings saturation based on assessment of the higher hydraulic conductivity of the pit wall bedrock versus the emplaced tailings expressed in our March, 2010 review, recent tailings testing and modelling work completed by Golder (Appendix C-3) show that the emplaced tailings may not be of low enough bulk hydraulic conductivity to maintain tension saturation over the long term. This concern is stated in several locations in the draft Lorax report and is summarized as a major uncertainty in the performance of Option 3. As stated on page 6-3,

   > "*Modeling of the hydraulic characteristics of the relocated tailings highlighted the importance of achieving a well blended tailings mixture within the pit in order to ensure that tailings remain saturated; the ability to achieve a homogeneous blend during the remediation process is a high uncertainty. Accordingly, there remains a residual risk for Option 3 that portions of the tailings becoming acid generating in the pit."*

2. Option 3 assumes blending of coarse and fine tailings from two dredging operations. This may be difficult to achieve, particularly toward the end of the dredging operation and is likely to result in poorly blended material in the upper portion of the in pit tailings deposit. It is the upper portion of the new tailings deposit where this objective is most important.

3. A very low hydraulic conductivity of 5×10^{-9} m/s is the basis for the water quality prediction for Option 3. This is at or below typical hydraulic conductivity for even very fine tailings. It is not clear how this can be achieved considering the operational issues associated with blending and discharge of tailings, along with water management in the confines of the long and narrow open pit.

4. The assumptions of infiltration through the low infiltration cover for tailings placed in the pit at 15% of mean annual precipitation may be pessimistically high. For Faro, low infiltration covers were assumed to allow 3 to 8% of mean annual precipitation,

and rudimentary covers were assumed to allow 15 to 25% of mean annual precipitation. Given the infiltration values for the catchment above the current tailings collection pond are estimated at 10% of mean annual precipitation (page 21 of Appendix E), the 15% value does seem high.

5. Options 1 and 2 focus on stabilization in-place with saturated conditions for the control of ARD. It is noted only the silty sand fraction is PAG (likely the ore from the late stage of mining when oxide ore transitioned to sulphide ore). There does not seem to be a stabilize-in-place tailings strategy using unsaturated conditions (i.e. not relying upon a water cover). An "unsaturated" approach would lessen the stability requirements. Some options which may allow an unsaturated closure for the tailings are:
    - removal of the silty (PAG) fraction (for in pit disposal),
    - ameliorating the silty fraction with lime/limestone
    - placing a low permeability cover over the tailings (note that this strategy is considered possible for relocated tailings)

6. The conceptual hydrogeologic model for the mine site has been updated and expanded. The model now includes the tailings as a hydrostratigraphic unit and measurements of hydraulic conductivity of the tailings based on lab permeameter testing reported by Golder. This testing allows for more detailed assessment of the saturation potential and of leakage rates from the tailings to underlying groundwater transport pathways both within the pit and the existing tailings facility.

7. New water level and flow information collected in 2010 has improved the conceptualization of groundwater flow in the vicinity of the Brown-McDade open pit and the water balance for the pit. Quantitative estimates of shallow and deep groundwater discharge to and from the pit are now provided as are traceable calculations of groundwater travel times from Pony Creek to the pit and from the pit to Dome Creek.

8. New water balance and groundwater flow assessment have been provided for the existing tailings management facility based on time-series analyses of historical (2006-2010) low flow seepage data, correlation analyses with precipitation events,

2-D groundwater flow modeling, and catchment-based calculations. These multiple methods of analysis provide confidence in the long-term seepage rate from the tailings area as 3.5 L/s.

9. Appendix E on Hydrogeology Characterization contains new sections on Hydrogeological Implications of Reclamation Options (Section 7) and Summary of Hydrogeological Uncertainty (Section 8). These new sections provide additional insight and assessment of the role of hydrogeological characterization in the assessment of closure options.

10. As we have previously stated, a hydrogeological factor that should be considered in the evaluation of closure options is the ease with which remedial activities could be implemented if the source term chemistries for the main source of dissolved metals (i.e., the tailings) are greater than assumed or if collection and treatment is deemed necessary at some future time to meet water quality objectives at a compliance point. Clearly, capture and treatment of contaminated groundwater from the complex fractured bedrock surrounding and underlying the pit will be much more difficult than undertaking such work at the downstream end of the current tailings management facility.

11. Geochemical source terms have been revised based on the new data and reassessment of existing data as described in detail in Appendix B: Geochemical Characterization. The new source terms are given in summary tables in the main body of the draft Lorax report. There are some errors in Table 5.5-2 that summarize geochemical source terms for Options 2A and 2B. Table 5.52 lists diffusive flux rates for the tailings impoundment that will have a saturated soil cover. As stated in Section 5.7.2 of Appendix B, no diffusive flux is considered for this Option as the soil cover is assumed to prevent upward migration of contaminants. Furthermore the source terms for saturated soil and waste rock in the pit and waste rock piles outside pit given in Table 5.5-2 for Option 2 are different than those given on Table 5.4-7 for Option 1. There should be no difference between these source terms as both Options treat the material in and beside the pit the same. It is assumed that these apparent errors are simply transcription errors between Appendix B and the main

Lorax report and do not represent a more fundamental problem.

12. The geochemical report refers to the MEMPR guidelines from 1997 for classifying PAG and non-PAG materials. MEND 2009 Prediction Manual for drainage chemistry from sulphidic geologic materials has an updated guideline for classifying materials:

    "For cases where AP and NP are equally exposed and AP generates acid identical to pyrite and NP neutralizes acid like calcite, samples with an NPR less than 1.0 are PAG and samples with an NPR greater than 2.0 are non-PAG. A sample with an NPR between 1.0 and 2.0 is capable of generating acid rock drainage (ARD)."

13. The geochemical report indicates that "Sulfur species and NPR values are also within the range presented in Kwong *et al.* (2002). Therefore, the tailings sample selected for laboratory-based kinetic test work is considered to be representative of the tailings mass, with respect to ABA results." Comparison of the 2002 data with the 2009/2010 data, and particularly the differences in the NP, AP and NPR between the 2002 report and the 2010 report would give an idea of the changes in tailings geochemistry over about a 10 year period. This comparison could be important as it appears that the tailings are very slowly acid generating (current pond water is discharged without treatment), and the comparison could serve to characterize the geochemical risk.

14. Overall, there is much greater certainty in the water quality source terms and hence the performance of Options 1 and 2 (leaving the tailings in place) than for Options 3 and 4 (moving the tailings to the pit). This is due to the historical water quality record for the existing tailings management facility and the uncertainty in effects of mechanical and geochemical disturbance associated with tailings relocation on contaminant release rates and the uncertainty in the ability to maintain stable wet or dry geochemical conditions within the tailings mass within the pit

15. From a geochemical and hydrogeological perspective, there is sufficient information on the likely performance of the proposed alternatives to allow for selection of a preferred closure option. The waste source terms, waste source and pit water balances, and directions and rates of groundwater flow from waste sources to

receiving surface waters have been defined at an appropriate conceptual level to support evaluation and selection of closure options.

16. There remains unavoidable geochemical uncertainty in how waste source terms will develop in the long term given uncertainty over redox and saturation conditions for tailings. There is also hydrogeological uncertainty in the distribution of depth and thickness permafrost at the mine site, in the exact position of some groundwater divides near the pit, in the exact deep groundwater system flow paths and in the attenuation of metals in the groundwater systems. These geochemical uncertainties will not be resolved easily and are not considered critical to closure option assessment and selection at this time.

17. Options 1 and 2 include stabilization of the existing tailings dam to ensure post-earthquake stability by placing a rockfill buttress on the downstream face, constructing a shear key through thawed and potentially liquefiable soils near the toe of the buttress and installing thermosyphons to promote and maintain frozen conditions within the area of the shear key. As we previously stated in our review of the March 2010 AECOM report, the extent of dam stabilization works that are proposed require a detailed review, particularly the parameters used for the stability analyses. The assumptions that have been made on performance post-earthquake are likely conservative and are resulting in significant works to reinforce the dam. The extent of the buttress and location of thermosyphons (if any are installed) will require resolution during the feasibility and detail engineering stage. Ground freezing will have an impact on seepage pathways within the dam, buttress and foundation and this should also be considered. The details of how the tailings dam will be reinforced is not likely to affect the decision on which option to select for closure.

18. In Options 1 and 2 upgrading the existing diversion channel on the north side of the valley and routing the spillway down the left abutment will mean post-closure care and maintenance will be needed. A very flat toe berm (surface slope of 7 to 10%) is proposed to stabilize the dam. Routing the spillway down the rockfill buttress could be considered to eliminate the spillway on the abutment and to allow the height of

the central section of the dam to be reduced.

19. Quantity takeoffs and cost estimation has been carried out in sufficient detail to provide a Class D estimate to allow selection of the preferred closure option.

Minor Items to be Resolved

1. It is not clear why the objectives of the options vary slightly (i.e. Option 2 has same objectives as Option 1, plus establishing a wetland as a land use consideration).

2. The spillway design concept appears to be based upon a very conservative approach. (Mt. Nansen is in a very similar meteorological setting as Faro however the design flows are proportionally 50% greater than at Faro). This is unlikely to materially affect the evaluation of closure options. However, the hydraulic assessment might be revisited in detailed design should in-place stabilization be the preferred closure strategy.

3. Option 2, page 5-67, it is noted that the soil cover will involve 36,000 m^3 of material for the 1 m thick layer. On page 5-38, the area of the water cover is 60,000 m^2.

4. Option 4 involves placement of 300,000 m^3 of tailings and 344,000 m^3 of rock in the pit, and configured with a slope to preclude the need for a dam in the pit. (Earlier work (Brodie 2002), found that the pit had a capacity of ~ 300,000 m^3 if a 10 m high dam was constructed at the south end – which is consistent with Option 3). Clarification of the configuration and capacity for Option 4 is required.

Conclusions

The Mount Nansen Review Team considers that the four groups of closure options considered for the site adequately address the central closure issues of tailings dam foundation stability, tailings seepage/treatment, waste rock seepage/treatment and open pit physical hazards. Other options are not necessary to provide a reasonable set of alternatives for closure of the Mount Nansen mine.

The Mount Nansen Review Team is of the opinion that the proposed options provide a reasonable span of possible closure options for consideration for the Mount Nansen mine site. Furthermore, the common description of the elements of each closure option, as outlined above, should allow for completion of a Multiple Accounts Analysis to assist in closure option evaluation and selection. The Mount Nansen Review Team also considers that the current state of investigations, site information and options evaluation as outlined in the draft Lorax report is sufficient to allow for selection of a preferred closure option.

The report addresses the closure of common mine elements including the mill area, camp and ancillary buildings, roads, exploration trenches, miscellaneous infrastructure and other areas. The mill area drainage is identified as a major contributor to downstream water quality loading necessitating the remediation of mill area drainage. As such, some discussion confirming the likely ability to fully remediate the mill area drainage is warranted.

TECHNICAL MEMORANDUM

To: Patricia Randell, Project Manager, YG

From: Karen Ballantyne, Project Officer, INAC Yukon Region

Date: January 10, 2011

Re: INAC Comments on Draft "Mount Nansen Options for Closure" Report

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INAC has completed a cursory review of the draft copy of the "Mount Nansen Options for Closure" report. The following is a compilation of comments based on information provided in the report. Some examples are provided with a comment as a means of highlighting a concern but are not necessarily the only case in point.

Remediation versus Restoration

- Reclamation activities need to be reflective of the fact that this is an abandoned mine site and not an active mine/exploration site.

- The report seems to be geared towards restoration and not remediation/reclamation. A "Status Quo" approach on certain components is an option. Example: Decompacting and recontouring and revegetating the roads and reclaiming all exploration trenches. Why are roads de-compacted to a depth of 0.8m vs. scarification of the top 0.15m? Why are trenches that have already started to naturally re-vegetate being re-disturbed and then re-vegetated? What is the action and cost to re-vegetate versus allowing natural re-vegetation? What are the concerns at these locations, I.e. Human health and/or environmental issues that warrant this level of restoration?

- Comparing predicted water quality conditions to CCME guidelines provides a conservative approach for project closure. If an environmental effects assessment was evaluated and site specific water quality objectives were formulated, closure options would change and cost would possibly be reduced. (See pg 5-3)

- Will YG assume responsibility for public roads that are not part of the C&M on site after reclamation is complete? The only roads on site should be for C&M and inspection of closure options; all other roads should be closed once reclamation activities have been completed. (See section 5.2.4.2)

Clarification

- The report indicates that Class D estimates range from -25% to +75% for Common Closure elements but -25% to +40% for the closure options; are these considered Class D estimates with these ranges; which range is used?

- It is unclear where the debris from the demolition of the mill or laydown areas will be landfilled. (Table 5.2-2)

- It is unclear where the debris from the demolition of the camp and ancillary buildings will be landfilled. (Table 5.2-3)

- 5.4.5.3 It would be good to delineate the concentrations from each source as opposed to total concentrations to allow the reader to understand the effects of each point source. Revegetation is indicated as part of the option but does not affect geochemistry analysis therefore, other than aesthetics, what is the purpose of the revegetation? (Please see previous comments under "Remediation vs. Restoration)

- 5.6.3.1 Indicates that hydrology can be expected to return to pre-mining conditions with the reclamation of the valley; however, it does not indicate the time required to achieve this or the water quality objectives during this interim period. Example: TSS to Dome Creek. Will water require to be treated to achieve objectives during this time? There could be significant design and cost implications during this period depending on duration. (Discussed again on pg 5-99)

- 5.6.3.2 Discusses a contingency provision for a diversion channel from Pony Creek to the pit area in the event that tailings desaturation becomes a concern however previous sections indicate tailings saturation is not achievable. This indicates that tailings desaturation will be a concern and that the channel will be required.

- Option 4 indicates treatment of pore water from the tailings; how will it be collected and where will it be treated? Different possibilities for these items could affect timelines and costs.

Sensitivity

- A sensitivity analysis was done for only one assumption in the report. What is the comfort level regarding certain closure elements without a sensitivity analysis? Why were sensitivity analyses not done on other closure elements? Example: 5.6.3.3 Seepage from tailings backfill into surrounding bedrock remains uncertain which affects all geochemistry results. What is the sensitivity of this assumption?

- If the sensitivity analyses of closure option elements are not of significant concern as related to human health and environmental requirements/liabilities then the focus should be on aspects of the options that do have measurable impacts to human health and environmental liabilities.

- Diminishing returns have to be considered in the sensitivity analysis. I.e. The cover infiltration of either the 15% infiltration vs. 3% infiltration has little impact on the overall environmental impact of the flux from the pit but they do have significant cost differences.

- Assumptions have to be based on the known information that has been confirmed and/or on the best relevant technical knowledge or experience.

More Information Required

- Risk assessment of various components (geochemistry, water balance, hydrogeology) not included. (See pg 1-1)

- Gradation and availability of granular construction materials are not indicated; therefore it is uncertain as to whether the costs are reflective of the required materials. Example: Sand diffusion layer indicated in Option 1: is the sand an available material at the site or will it need to be a produced material and imported?

- It is assumed that no asbestos products are present in the camp and ancillary buildings. Why was this not confirmed as it will affect cost and demolition timelines?

- No systematic assessment of hydrocarbon contaminated soil has been completed to date. Why has this not been confirmed as it will affect cost and demolition timelines?

- Options 1A and 2A the waste rock will be left in place and that physical stability will be assessed, the piles regraded and revegetated. Why has a preliminary stability analysis not been completed to date? An analysis would better define the scope of reclaiming the waste rock dumps and associated costs for these options.

- Option 1B and 2B place the waste rock back in the pit however the volume of the pit is not indicated in the pit. Will this become a mounded area? What is the volume of the pit?

- Options 3 and 4 indicate tailings and contaminated soil will be moved to the pit. What thickness of contaminated soil is expected and what is the remaining soil stratigraphy, as this will affect costs? There are no closure measures for the tailings storage facility outlined in these options which could significantly change the cost of these options. (pg5-89)

Cost

- Options 1B and 2B cost for backfilling pit with waste rock is only $5, this value seems low compared to other material unit costs. The cost should be around $9-$10 which would make the estimate approximately $2M short; what assumptions were made for the $5/m3?

- O&M is estimated for Option 4 but has not been calculated for the other three options. O&M estimates should include specific horizons.

- C&M cost estimates are not included in the costing for the options.

- Timeframe of costs.

- Class D estimate but with a 30% contingency. The contingency should be a part of the estimate and not added onto the estimate as this decreases the accuracy of the Class D estimate.

- Cost estimates cannot be indicative of total cost of project; additional information and costing will be required for closure plan. Example: 5.2.2.3 Where will the mill material be landfilled?

- Report indicates engineering, design or detailed planning is not included in closure cost; however given the complexity of the specific option, these costs could vary greatly. A fixed percentage of total costs or some method should be added to the closure cost option to provide a more meaningful value.

- 5.4.2.3 Indicates that numerous ongoing O&M costs are required; however, these are not covered in the estimate.

- 5.4.6 Indicates that design engineering, routine inspections and operations and maintenance are expected to be similar for all options this is believed to not be the case. Example: Waste rock in place would likely require more inspections than if the waste rock was moved to the pit.

- 5.5.2.3 Indicates time and amount of maintenance required to stabilize the cover and ensure hydrological characteristics is a significant uncertainty which affects ongoing costs.

- Life cycle costs of materials and closure components need to be included in the cost estimates for the options as these have long-term financial implications to both INAC and YG.

- All associated costs with each option need to be included in the cost estimates, such as: life cycle, C&M, capital costs, interim treatment/reclamation.

- Detailed engineering/allowance and construction services need to be included. I.e. Based on fixed percentages of reclamation cost of each option.

Please be advised that the above comments are cursory in nature and do not represent an in-depth review of the draft report. Once YG provides initial feedback to the concerns listed, INAC will verify if a further detailed review is required. Should Yukon Government or Lorax have any questions or concerns with the above comments, please contact Karen Ballantyne at (867) 667-3866 or Karen.Ballantyne@inac-ainc.gc.ca.

Sincerely,

Karen Ballantyne

Memorandum

To: Robert Moar, Leta Blackjack, James Baker, Mike Vance
Little Salmon Carmacks First Nation

From: Bill Slater: Bill Slater Environmental Consulting

Cc: Patricia Randell, Frank Patch – Yukon Government
Kriss Sarson, Jason Berkers – INAC

Date: January 6, 2011

Re: "Mt. Nansen Options For Closure." Lorax Environmental. November 2010.

This memo is an update to the version that I sent on December 21, 2010, containing a few minor editorial changes.

I have reviewed the draft report "Mt. Nansen Options for Closure" (Lorax Report) prepared for Yukon Government by Lorax Environmental. My review included the main Lorax Report, documents contained in Appendices A through F and an AECOM memo dated December 9, 2010 and titled "Additional Concepts for Long-term Stabilization of Mt. Nansen Tailings Dam." This memo compiles the results of my review, beginning with a short description of the review context and followed by my overall review findings and finally some specific concerns that should be addressed or clarified before we proceed with the next steps of the options evaluation. I anticipate that additional comments will be provided by Ms. Kendra Zamzow (geochemical) as well as Mr. Bud McAlpine and Mr. Milos Stepanek (geotechnical). These additional comments will help support LSCFN's technical participation in the options evaluation.

1.0 Review Context

My review has been completed on the basis of my understanding that the Lorax Report is intended to provide adequate description and characterization of mine closure options to allow Canada, Yukon and LSCFN to proceed with evaluation and selection of options. In the past few months, we have discussed the processes that we will utilize to evaluate and select options. I have reviewed the report on the assumption that the options evaluation process will proceed in accordance with those discussions, including presentation/ discussion of options in LSCFN community, completion of options risk analysis, technical options evaluation (multiple accounts analysis) and community options evaluation. I have assumed that LSCFN will have a substantive, direct role in the evaluation and decision-making processes. If this role were to change, the information requirements for the Lorax Report would also change.

2.0 Overall Review Findings

As you know, this is the third iteration of a closure options report for Mt. Nansen, with the first version prepared by Yukon Government in 2008, and the second version prepared by AECOM in 2009/10. The Lorax Report provides a much more thorough description, analysis and characterization of options than either of the previous versions. However, I have some remaining concerns about whether the report provides a balanced characterization of the options. The main areas of concern about balance and consistency are addressed in Section 3 of this memo.

I provided my interpretation of the information needs to support options evaluation in a table dated May 19, 2010 and titled "Mt. Nansen Options Characterization Information Needs for Options Evaluation." The Lorax Report addresses most of the information needs identified in the first two categories of that table: "1. Component Descriptions/Designs" and "2. Expected Performance of Options." Within these categories, there are some areas that require some additional clarification and refinement. These are described in Section 3 of this memo.

With respect to the third category "3. Risks and Uncertainties of Options," the Lorax Report does not, in my view, provide sufficient characterization to proceed directly with an options evaluation process. The report identifies some uncertainties for each of the closure options and provides some characterization of risks. In general, this appears to have been undertaken within specific disciplines of the options characterization (i.e. geochemical uncertainties, geotechnical uncertainties, water balance uncertainties). As a result, there is not an overall multi-disciplinary risk evaluation.

For example, the most critical uncertainties for Tailings-in-Valley options are primarily geotechnical and entail down-side risks. In contrast, the Tailings-in-Pit options are primarily geochemical and the characterization presented provides primarily for up-side risks. A systematic approach is needed to interpret and characterize the risks consistently for all options. The issues of balance and consistency between options will need to be addressed before a risk analysis can be completed.

Subject to the issues identified in Section 3 of this memo, with the information provided in the Lorax Report and its supporting documents however, it will now be practical for the multi-party evaluation team to conduct a risk analysis for the closure options. In my view, this approach is preferable as risk analysis is inherently subjective and the perspectives of the participants are important in the outcomes. Therefore it is appropriate that Canada, Yukon and LSCFN conduct a risk analysis for the options as part of the evaluation process.

SRK's proposal for facilitating the evaluation process included a risk analysis component. The proposal envisioned that one day of the evaluation workshop would be used for risk assessment. Given the current status of risk analysis, it appears that additional effort will be required. A separate risk analysis workshop may be needed, so that there will be time to revise the options after the assessment if needed – for example

to incorporate additional mitigation measures within the design, and to re-characterize the options after consideration of mitigation.

Overall, I recommend, subject to clarifications and refinements to address the issues described in Section 3 of this memo, that LSCFN agree to proceed with the proposed options evaluation and selection process on the basis of the information contained in the Lorax Report and its supporting documents.

3.0 Issues to be Addressed Prior to Risk Assessment and Options Evaluation

Land Reclamation

The overall approach for re-vegetation of disturbed areas, described in the "Common Element and Supplemental Cost Estimates" is as follows: "The overall conceptual revegetation approach for the Mt. Nansen site is to achieve closure objectives by encouraging natural revegetation through use of appropriate surface preparation methods and locally-sourced materials." The cost estimates assume active re-vegetation for 25% of the disturbed areas and rely on natural recovery for the remaining area.

While this approach meets the minimum requirements specified in the Yukon's guidelines for reclamation after exploration projects, it is not consistent with reclamation methods generally applied at closed mines. In my view, a more active approach should be taken for reclamation. Because the reclamation requirements differ for each of the options, changes in general requirements will affect the cost comparison between options. As a result, clarification is needed before proceeding with options evaluation.

From the perspective of consistency among options, it is noteworthy that options that include tailings relocation to the pit include more extensive efforts at re-vegetation. This includes placement of soil materials to support plant growth and active re-vegetation of 100% in some areas and 50% in other areas. No clear rationale is provided for this increased effort for these options and it creates a cost premium. For example, the cost for tailings area land reclamation with the soil cover option is estimated as $120,000 while the cost for valley restoration is estimated as over $1,600,000. Both options will include re-vegetation of a soil surface and establishment of a channel for Dome Creek through the tailings area. These costs appear incongruous and need to be re-evaluated and rationale provided before proceeding with the options evaluation.

Tailings Dam Stability

The "Geotechnical Assessment and Costing of Mt. Nansen Mine Closure Alternatives" (Appendix C) prepared by AECOM, in my view, does not provide adequate information to demonstrate the long-term feasibility of the proposed dam stabilization measures. The stabilization method proposed relies on maintaining permafrost at the location of the shear key. AECOM has identified several other stabilization concepts, but there is no site-specific information to demonstrate that these methods could be used at Mt. Nansen.

The analysis completed by Naviq Consulting (Appendix C-2) confirms that thawed foundations will likely occur in the long-term, especially when considering global

warming. I note that the thermal analysis does not consider the effects of water flowing through the area of the proposed shear key, but water flows will be at least equivalent to those currently happening at the site. Unlike the current seepage collection pond for which thermosyphons appear to have been effective for the past decade, the proposed shear key will not (in fact cannot) have a seepage barrier that will eliminate water flow. Water flows through frozen materials will likely result in dramatically higher rates of thaw as they are often a substantial source of heat transfer. As a result, the thermal analysis probably significantly over-predicts the effectiveness of the proposed thermosyphons. Thawing is likely to occur and alternate methods for stabilization should be proposed as the primary mechanism.

Information should be provided to demonstrate performance at Mt. Nansen and effects need to be considered in the options characterization before proceeding with the evaluation process because the changes may affect cost and risks. It may also affect the flow paths for contaminants and related effects on attenuation mechanisms that have been assumed for geochemical analyses. In my view, the approach taken here does not demonstrate the same level of conservativeness in geotechnical design as that for the tailings relocation options.

Tailings Beach

The information provided in the Lorax Report and its attachments leave some uncertainty about the material that will be used for construction of the tailings beach in the tailings-in-valley options. Various options are discussed including fine tailings, locally available sand, amended coarse tailings. The water quality model assumes the use of fine tailings while the geotechnical assessment proposes use of sand. The proposed option should be clarified and applied consistently for water quality predictions and costing.

The loading model assumes that no water contacts the tailings beach materials, utilizing a runoff coefficient of 1.0. As a result, this material is not considered in load models, though it is potentially acid generating material that may be exposed to oxidizing conditions. Rationale should be provided for not considering this material in load modeling.

Tailings – Sand Diffusion Layer

For Option 1, Lorax proposes a 0.3m sand diffusion-barrier layer and suggests that it will prevent erosion of the tailings by water and/or wind. Some clarification is needed about the effectiveness of this layer in preventing water erosion during high flow events because the entire flow of Dome Creek will be routed through the tailings pond and a thin layer of sand is unlikely to prevent erosion. The geotechnical report suggests that ice in the pond may also damage the sand layer. It is not clear whether additional armouring has been incorporated into costs estimates. Effects of ice also need to be addressed.

Source Terms for Options 1A and 1B

The source terms listed in Table 5.4-7 of the Lorax Report appear to contain some errors. Clarification/corrections should be provided. My review has assumed that source terms stated elsewhere have been applied throughout the Lorax analysis and supporting work.

In-Valley Tailings Source Terms

Based on water balance analysis for the tailings area, Lorax has estimated the infiltration through the tailings as 1.7L/s while the flow from the seepage collection pond is estimated as 3.5L/s. This appears to confirm dilution of tailings source water. However, water quality from the seepage collection pond is used directly as tailings source water quality for modeling. Clarification is needed about how these flow rates and source terms were applied within the modeling, and the results of the assumptions.

Waste Rock Reclamation

The AECOM geotechnical assessment (Appendix C) proposes that no reclamation is required for existing waste rock areas if left in place. In contrast, for waste rock re-location options, AECOM proposes active re-vegetation of both the relocated waste rock and the exposed area after moving waste rock. No rationale is provided for the different approaches which create a cost premium for waste rock relocation options. More consistent approaches need to be presented and characterized, or a thorough rationale should be provided for the different approaches.

Long-term Thermosyphon Operation and Maintenance

AECOM's geotechnical assessment (Section 2.2.11) does not identify the need for long-term maintenance and operation of thermosyphons or other methods for maintaining frozen conditions at the shear key. It is not clear whether the cost estimates for Options 1 and 2 include such costs. This should be confirmed before the evaluation process begins.

AECOM Geotechnical Evaluation of Option 3

In Appendix C, AECOM's geotechnical evaluation of Option 3 (saturated tailings in pit) requires clarification in several areas.

- AECOM states objectives for Option 3 and these are repeated in the Lorax Report. For Option 3, a key objective appears to be missing – minimizing the long-term geotechnical risks. This is the primary rationale for developing this option and needs to be identified as a key objective.
- The analysis appears to assume that seepage would occur from tension saturated tailings in the pit – laterally into the bedrock and eventually to surrounding groundwater. This is not consistent with my understanding of soil moisture behaviour. If the soil water is held in tension saturation, there is little likelihood that flow would occur into the surrounding bedrock at elevations above the water table. The statements contained in AECOM's geotechnical analysis should be confirmed and adjusted as needed.
- AECOM appears to assume that a dam constructed in the pit to retain tension saturated tailings would have the same risks, consequence category and maintenance requirements as a dam in the valley. In my view, this is not necessarily the case because the outflow of tailings during any failure would likely be substantially lower if the tailings are not saturated. Also, the facility would not be located in a creek valley and a substantial outflow would be required before any impact on the aquatic environment would occur. Permafrost and foundation conditions are much more favourable at the pit location. Finally, the in-pit dam is

not as susceptible to flood events because it is not located in a valley and the current spillway proposal is not located on the dam structure.

Tailings Homogeneity for Option 3

The Lorax Report and supporting documents highlight the importance of completely homogeneous tailings when placed in the pit, to ensure soil moisture characteristics that will support tension saturation. This is identified as a major uncertainty for this option. In my view, the uncertainty and importance are both overstated, giving the impression that this option is impractical.

With respect to the uncertainty, given the characteristics of the fine tailings, it appears unlikely that the in-pit tailings deposit would provide conditions for draining of significant portions of tailings as though they were coarse soils. This would require contiguous columns or layers of coarse materials that could act as drains, and these would have to terminate in direct contact with high permeability zones in the bedrock. With some planning and QA/QC during tailings relocation, this type of scenario could be easily avoided. If there are no contiguous columns or layers which terminate adjacent to very permeable materials, significant draining of the tailings mass is unlikely to occur.

With respect to the importance of the permeability, the analysis completed by Golder concludes that tension saturation may deteriorate, especially in dry conditions. However, Golder's analysis considers only incident precipitation directly on the surface of the pit: not even direct catchment runoff is incorporated. Golder's analysis also predicts that very modest additions of water would support tension saturation, even if the tailings achieve the less conservative permeabilitities (higher permeabilities) shown in test work. Table 1 of Appendix C-3 indicates that addition of approximately 1100m^3/year of water would be sufficient to maintain 85% saturation even in dry years with higher permeability assumptions. The contaminant loading report (Appendix F) indicates that this water would be available from the additional pit catchment area.

Note that the contaminant load modeling report estimates that that 12000m^3 of water would be required to maintain a full water cover at the tailings in the valley. However, this is not identified as a significant uncertainty for in-valley options.

It is not consistent for the Lorax Report to specifically identify complex alternate mitigation options for tailings dam stability for Options 1 and 2, while failing to even mention relatively simple mitigative options for maintaining tension saturation for Option 3. The report should be revised to address this inconsistency.

Option 3 Hydrogeology

In the hydrogeology characterization (Appendix E) AECOM states: "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." This statement is not supported by the analysis completed by Golder (Appendix C-3) which indicates that the volume of water required would be quite small. The AECOM statement should be confirmed and adjusted as needed.

Geochemical Predictions

I have not reviewed geochemical predictions in detail as I understand that Ms. Zamzow will be reviewing this component. However, I am concerned about the consistency of predictions used for the tailings-in-pit versus tailing-in-valley options. While I appreciate that there are different levels of certainty about the information available, I do not agree with the balance of assumptions taken for developing source terms. One example is presented below.

For in-pit options, the source terms for both best-estimate and worst-case assume that no attenuation will occur, while for in-valley options, the source terms for both best-estimate and worst-case assume that attenuation will continue as it currently is. Lorax acknowledges uncertainty about both predictions, suggesting that for in-pit options attenuation "can be expected" and that the predictions are "overly conservative and represent maximum possible concentrations." Thus the estimate for in-pit options does not appear to represent a best-estimate. Lorax also identifies uncertainties about continuation of attenuation mechanisms in the valley, noting that there are changes which could result in reduced attenuation for these options. Given these uncertainties, changes seem warranted: the best-estimate for in-pit options should consider some level of attenuation and possibly, the worst-case for in-valley options should consider at least a partial loss of attenuation. In my view, this would result in predictions that are based on more consistent assumptions.

Cover Performance Predictions

Based on modeling for Option 4, Golder has estimated that a store-release-divert soil cover could reduce infiltration to less than 1% of total annual precipitation, though typical infiltration rates for this type of cover are 2% to 15%. The water quality model assumes that infiltration is 15%.

In the geotechnical report, AECOM states: "The objective of the concept design is to limit this infiltration so that long term groundwater treatment is not required." Given the stated objective, it appears reasonable to assume that significant effort and design would be undertaken to establish an effective cover. Cover infiltration is difficult to predict and I would not support modeling using the 1% value estimated by Golder. On the other hand, given the modeling results and the objective of the proposed option, utilizing the lower end of "typical" performance values appears overly conservative for the "best-estimate" modeling. It may be more realistic to complete best-estimate predictions that assume better performance, and worst-case predictions that assume complete cover failure with infiltration that exceeds 15%.

Also, the type of cover that will be utilized for tailings in Option 3 needs clarification. It is my understanding that a high permeability cover is required. However, the Lorax Report (S. 5.6.3.1) proposes a cover that is "similar to Option 2" which is a low permeability cover. Also, Appendix C-3 is unclear about what type of cover has been assumed in the analysis, initially identifying a low permeability cover: "Option 3: Relocate the tailings into an on-site abandoned open pit and install a 1-meter thick soil

cover over the tailings (the same option described above for the previous phase of the work)." The same report later states: "A 1-meter layer of coarse waste rock was assumed to be placed on top of the tailings for all scenarios." What type of cover is proposed and modeled?

Pit Seepage Rates

The load modeling (Appendix F) assumes conservative seepage rates from the pit – 0.1347L/s based on a high estimate of pit permeability. This high seepage rate appears to have a significant influence on downstream predictions of water quality. However there is a substantial range in estimates of bedrock permeability. Also, it is not clear that the tailings in the pit would allow seepage to occur at such rates, as the permeability of tailings is less than that assigned to the pit walls to determine seepage rates. Also, it is not clear that the catchment contains sufficient water to support seepage at these rates. Clarification and additional rationale would be useful.

Oxide Ore

The contaminant loading model assumes that the oxide ore material recently relocated to the pit will be incorporated into the cover material for Option 4. This material will likely lead to some additional contaminant loading from runoff (though perhaps not in the model). The closure method does not appear to be addressed in the Lorax Report. Clarification is needed.

Water Quality Issues - Mill Area

The Lorax Report and attachments provides some characterization of conditions in the mill area. Currently, sources in this area are the dominant contaminant loading to Dome Creek. The "Common Element and Supplemental Cost Estimate" prepared by Altura assumes that these sources will be addressed and no treatment will be required. However, the same report provides the description of closure activities for the mill area and does not include measures that are likely to address the water quality issues. Given the current information available, there appears to be significant likelihood that greater efforts will be required to address closure issues in this area. Costs for this are probably common to all options but are likely to be higher than current estimates.

Note that contaminant loading from the mill area is not included in the current contaminant loading model. As a result, the predictions may underestimate the long-term water quality downstream of the site for some parameters.

Analysis of Cadmium Concentrations

Section 3.3.1.9 of Appendix B (Geochemical Characterizaton) describes the analysis of cadmium concentrations in the pit. The conclusions are based on cadmium concentrations being below the guideline concentrations. However, the data do not support this. Clarification/correction should be provided and the analysis reconsidered as a result.

Best-Estimate Saturated Waste Rock Source Terms

Clarification should be provided about consistency of the approaches taken for the development of an arsenic source term for saturated waste rock in comparison to the approach taken for in-situ waste rock.

For saturated waste rock, the best-estimate source term is the highest recorded arsenic concentration in the pit to date. This approach appears to assume that dilution and/or attenuation mechanisms that are currently functioning in the pit will stop if waste is placed in the pit. No evidence is provided to support this conclusion. In contrast, the best-estimate arsenic source term for in-situ waste rock is the median of data from seeps. However, the seep data could be affected by dilution from groundwater or other sources, and could be experiencing some attenuation that may not be effective in the long-term especially once permafrost thaws.

Cost Consistency for Options

A consistency check should be completed for costing for the various options. Some examples that warrant consideration include:

- Option 3 includes costs for tailings cover maintenance and repair, while Options 1 and 2 do not. The tailings covers are also susceptible to damage with the in-valley options. Potential for damage may be greater in the valley due to continuous water flows. Also, the total cover area is larger for valley options, thus increasing potential maintenance costs.
- Only in-pit options include costs for water treatment. The bulk of the cost is capital cost for establishing treatment facilities. All options require some re-grading and relocation of tailings. Also, all options require cleanup in the mill area where current seepage concentrations are high and in some cases exceed effluent limits. As a result, there appears to be a high likelihood that water treatment facilities (capital costs) will be required for all options, though operating costs may be slightly different.
- Option 3 includes a cost for relocation of dam fill materials to borrow areas. What is the purpose of this activity which appears to create a cost premium?

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"Technical Support for Grassroots Public Interest Groups"

Robert E. Moar, B.Sc. (Engineering), MBA
Little Salmon Carmacks First Nation
Carmacks, Yukon
Y0B 1C0

cc: Bill Slater
Date: January 23, 2011
Ref: Review of Mt. Nansen Geochemical Assessment in Support of Closure Options

This report is the latest in a series of reports produced by Lorax to examine the geochemical mechanisms controlling water chemistry at the Mt. Nansen mine area, in preparation for developing a closure plan. Biogeochemical mechanisms for preventing arsenic and heavy metals from entering creeks downstream, and the potential for tails to go acidic under different scenarios were analyzed. Assumptions were then made to discuss long term closure options. An argument is developed in the geochemical assessment that biological mechanisms are the primary method for arsenic and heavy metal removal between the tailings impoundment and the seepage collection pond below the tailings dam. The key points in the hypothesis are that organic carbon (DOC) is carried into the impoundment where water flows vertically into the soil under the impoundment, which contains sulfate-reducing bacteria (SRB), and the bacteria use the carbon to produce sulfide and consequently remove arsenic and metals as sulfide species. Essentially, the soil under the impoundment acts as a natural bioreactor and the tailings dam as a "permeable reactive barrier".

For this mechanism to be an effective treatment in the long term, both a *biological* balance and a *hydrologic* balance need to be maintained. Key arguments in the geochemical assessment are based on data from three sampling dates (July 2009, September 2009, July 2010). This is a very small data set to work with, and critically does not consider changes in water flow, physical parameters, and the biological community in winter and during snowmelt.

Hydrologic Balance. There is an assumption that the critical flow patterns (vertically into the underlying soil and horizontally across the underlying soil downgradient from upper tails to the dam and out) will not change. The hypothesis is that water flows vertically into the underlying soil, is trapped in the organic layer by underlying permafrost, and therefore moves through the organic underlying soil from the upper to lower impoundment and out the dam. There is no modeling to support whether this pattern can be maintained

a) After consistent saturation. Once consistent saturation occurs, the water may flow *over the top* of the tails rather than flowing vertically down into the soil. This is referred to as "short – circuiting"; if the water carrying DOC does not move vertically into the soil beneath the impoundment, SRB will not receive the carbon they require. Potentially excess stream water could provide dilution, but dilution would not decrease the load of metals entering the receiving waters over the long term.

b) If the Arctic continues to warm, potentially thawing the permafrost layer in sections and allowing water to flow vertically beneath the soil organic layer.

Biological balance. There is an assumption that the current attenuation process will continue indefinitely. This appears to be based entirely on the assumption that Dome Creek will continue to supply organic carbon indefinitely. However, there are many other parameters that need to come together for arsenic/metal sulfide precipitation to be effective.

- The microbial community as a whole can easily have shifts in dominant organisms. In particular there may be competition between methanogens and SRB in a highly reduced environment, or between iron-reducing bacteria and SRB in a less reduced environment. Microbial ecologic systems are dynamic, and changes in pH, temperature, redox, dissolved oxygen, and types of organic material can all affect the ratio of different types of organisms. Part of the ecosystem requires a population of bacteria that will use the type of complex carbons that are brought in by the stream and metabolize them into the smaller carbons that SRB can utilize (small alcohols and organic acids), a necessary commensal relationship that needs to be maintained. As an example of how conditions can change populations, the Lorax Geochemical Assessment document outlined well how a "suboxic" environment (dominated by iron-reducing bacteria) will release contaminants as iron hydroxides are eaten away, while a "reducing" environment (dominated by SRB) will precipitate dissolved metals as metal sulfides. Monitoring wells and discharge water chemistry will need to be monitored to determine if shifts away from an SRB-dominant environment are occurring, and contingency plans should be in place to either re-establish the SRB community (potentially by adding ethanol or other carbon sources that can be immediately utilized by SRB) or treat discharge water.

- Flow and temperature affect SRB activity.
    - Low temperatures in winter reduce SRB activity.
    - Flow increase with precipitation events may reduce the amount of carbon available to SRB if water does not continue to move vertically into the underlying soil. This may cause SRB activity to slow.

Reduced SRB activity due to flow and temperature affects may not result in increased metal concentrations at discharge, but it will reduce the precipitation of metals in the preferred location, beneath the impoundment.

Critically, all biological treatment systems eventually clog up and need to be dredged. The precipitation of metals by the SRB mechanism depends on an exchange of small, usable carbons from upper layers down to SRB and an exchange of waste sulfide from the lower layers where the SRB exist to the upper layers where it contacts metals. Eventually, precipitating metals form a layer that decreases or stops this exchange. The SRB then decline in activity due to a combination of reduced carbon and buildup of sulfide, which is toxic to them; additionally sulfide does not reach the dissolved metals in the upper pore layers and therefore does not precipitate. Experience with man-made wetlands, natural wetlands, and semi-passive bioreactors have shown that systems must be dredged or flushed to maintain the SRB mechanism. This eventuality must be planned for.

It would be prudent to have a water treatment plant during the re-structuring of the dam and tails.

- Disturbing the tails is expected to release metals and arsenic into the water column, based on studies by Kwong et al 2002. Potentially acid-generating tails will be exposed to oxygen and water during the disturbance, and secondary minerals formed over the past decade will easily leach as the water cover is established.
- Contaminants sorbed to oxyhydroxides will encounter more reducing conditions when the tails are flooded, and this will likely cause a temporary increase in pore-water contaminants such as zinc as they desorb.
- A beach constructed of fine tailings is proposed. If the tails are carbonate and/or of highly weathered material, this should pose no problem. However, a significant amount of tails contain pyrite, either as free minerals or embedded in quartz. Exposed over time as a beach, they will develop acid. Because this will be at the dam face, there will be little opportunity for an SRB-related mechanism to precipitate these metals.
- Should the soil layer beneath the impoundment become clogged with metal-arsenic sulfide precipitates a water treatment plant may be required to meet discharge limits.

Instead of, or in addition to, a water treatment plant, a wetland could be established below the seep collection pond to encourage the growth of SRB. This wetland would be amenable to dredging, should the attenuation mechanism in the impoundment fail.

Regarding the option of storing tails in the pit under a saturated cover, the most salient issue is the technical feasibility of keeping the tails saturated, and the rate of discharge of water. If the tails can remain in a saturated state, the pit provides a secure storage location for the long term.

1. There is an assumption, based on field bin tests, that material placed in the pit will enter a "mildly suboxic" or "strongly suboxic" state that will release contaminants. A pit environment is vertically constrained, and carbon can only penetrate to a certain depth, probably in the range of centimeters. Potential mitigation methods, such as mixing in enough organic material to induce a reducing atmosphere, or plugging the adit to Pony Creek with clay and organic material to create adsorptive surfaces and a "permeable reactive barrier" environment that supports SRB, are not considered as part of a "Best Estimate".

2. Regardless of the microbial community that develops, the primary issue is the rate at which contaminated water will leave the pit. If the rate of release is low enough, it is irrelevant whether contaminants become permanently sequestered as sulfides.

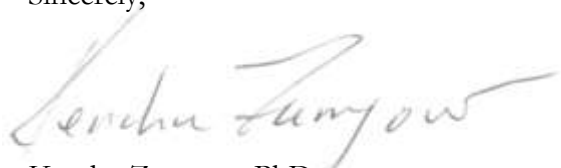
3. The discharge from the pit could easily be routed into a wetland system, either placed where the tailings impoundment is now, or in a location downgradient of the seepage collection pond, as discussed earlier. This option would provide both a stable environment for the tails and water treatment in a wetland that could be dredged. Given the route water would travel to such an installed wetland, it is reasonable to assume that dissolved organic carbon would enter in concentrations similar to currently observed emanating from Dome Creek and the drainage ditches.

The geochemical assessment appears to provide a "Best Case" scenario for the option of upgrading the dam, while not considering the highly likely short-term release of contaminants during the

construction period and not considering the potential failure of the SRB attenuation mechanism due to changes in microbial population or clogging of pores and the soil layer in a "Worst Case" scenario. Similarly, regarding the option of relocating the tails, the "Best Case" does not include potential mitigation options that could easily be incorporated.

The government needs to proceed realistically, with a more balanced review of the two options. Both should include contingency plans and infrastructure to implement water treatment at least in the short term, and a long term contingency plan through traditional water treatment or through installation of a wetland should be part of the assessment.

Sincerely,



Kendra Zamzow, PhD.
Center for Science in Public Participation

References

Kwong, YTJ, A Kapoor, and J-F Fiset. 2002. Assessment of the Chemical Stability of Impounded Tailings at Mount Nansen, Yukon Territory. CANMET Report MMSL 02-011 (CR).

Lorax Environmental Services, Ltd. 2010. Mt. Nansen Mine Geochemical Assessment in Support of Evaluating Closure Plan Options (Draft). *for* Assessment and Abandoned Mines Branch, Department of Energy, Mines, and Resources; Government of Yukon. October.

HFM Consulting Ltd
mcalpineb@northwestel.

Little Salmon Carmacks First Nation
Post Office Box 135
Carmacks, YK

Date: January 26, 2011

Attn: Ms. Leta Blackjack

Re: Mount Nansen Mine Closure

Dear Madam

Attached please find our review of the Mount Nansen Mine Closure report prepared by Lorax in November 2010. Our review was restricted to the options for the use of the existing tailings area as the permanent location for all tailings.

Our opinion is that the proposals in the report for the use of the existing tailings area, do not, as detailed in the report demonstrate that the project components are feasible, achievable and will meet definite performance expectations.

Thank you for the opportunity to participate in this review with the Little Salmon Carmacks First Nation. If you have any questions we would be pleased discuss the results of the review with you.

We would be pleased to participate in any further review if that would be of assistance to LSCFN.

Best Regards

H F McAlpine
HFM Consulting Ltd

HFM CONSULTING and 517611 ALBERTA CORP.

January 26, 2011

Little Salmon Carmacks First Nation
P. O. Box 135
Carmacks, YK
Y0B 1C0

Attn.: Ms. Leta Blackjack

Re: Mount Nansen Mine Closure.

Dear Madam:

Further to your request we have reviewed relevant portions of the draft document for the above project, dated November 2010 prepared by Lorax Environmental and December 9, 2010 memo prepared by AECOM. The terms of reference have been set in an e-mail dated December 22, 2010 as follows:

Review the Lorax and AECOM analysis and reporting related to the tailings dam at Mt. Nansen, including for both existing conditions and the proposed upgrades.

- Identify whether assumptions for the analysis are conservative
- Comment on the feasibility and practicality of the proposed upgrades
- Comment on the application of the CDA Guidelines

The review was restricted to the tailings pond, as a permanent storage facility only. The undersigned considered the geotechnical aspects of the project, as presented in the report and detailed in Appendix C. Consideration was given to observations made during the mine visits, undertaken from 1996 to 2005.

Tailings dam – existing conditions.

The most recent and comprehensive review of the existing tailing facility was undertaken by EBA Engineering Consultants Ltd. (EBA) in 2002 and summarized below:

1. Inadequate seismic stability
2. Lower than acceptable static stability
3. Excessive seepage rates
4. Higher than predicted permafrost degradation
5. Inadequate spillway capacity

The facility was considered unsuitable for abandonment and a significant flood event was identified as the greatest short term risk.

Insofar as the dam construction is concerned, the foundation preparation (stripping of organics- Photo1) was not completed to the design specifications and the compaction of sand fill was not well controlled (Photo2), likely resulting in poorly compacted zones within the dam body.

Permafrost degradation and localized piping were identified as possible safety concerns.

Photo 1: Dam foundation. Available equipment could not excavate frozen organics.

Photo 2: Moisture conditioning of construction material (sand). Note rough surface of the north abutment.

Feasibility and practicality of proposed upgrades

The prediction of satisfactory performance for the proposed dam upgrade relies on several key assumptions about the construction and performance of project components. However, the information provided does not demonstrate that the assumed performance of project components is feasible and achievable. The project assumes:

- *Dam stability can be achieved with addition of toe buttress and shear key.*

  The existing seepage dyke is proposed to be breached, not removed. The dyke was extended in 2000 by a trench excavated 2 m into the then frozen valley deposits (silt and sand with organics and ground ice).The bottom of the trench was covered with bentonite/sand mixture and the remainder and the dyke were constructed using local sand. The construction took place in November 2000 during sub-zero temperatures. The compaction quality of the dyke material was not determined. No thermistors have been installed in the key trench and the performance of this installation was never verified.

  The dyke, and possibly its key trench (if not frozen) could be a weak segment proposed in the rock fill toe. This has not been considered in the analysis.

  The proposed filter (geo-synthetic or granular) and the rock fill berm cover the valley bottom and the down slope portion of the dam does not extend to dam abutments.

  Heavy seepage was observed along the dam interface with both valley slopes. Piping could develop in these zones.

Photo 3: Seepage discharged from the south abutment.

- *Future thawing could be controlled with thermosyphons . Both proposals in the 2010 report for upgrading the dam require that the foundation remains frozen.*

  The report acknowledges potential problems associated with ongoing global warming and the long-term performance of thermosyphons. The shear key performance is conditioned by the preservation of frozen ground. Thermosyphons are probably unsuitable for maintaining frozen conditions past the next 50 to 100 years given the current climate warming. This system will require maintenance during that period, and as such, cannot be considered a "walk away" type of technology. Their use is not recommended in areas where flows could contact frozen zones. Seepage at the Nt. Nansen tailings dam was measured to be 2 to 3 l/s several years ago. Recent estimates indicate as much as 100 % bigger seepage (per.com. F. Patch from B. Wheeler, on- site system operator/ maintainer.)
  Long term performance of thermosyphons is questionable.

- *Seepage through the dam could be controlled by replacing coarse tailings with finer tailings.*

  This assumption was not verified by testing of tailings (grain size, hydraulic conductivity) and therefore it effectiveness is unsupported.

  Construction procedures and source of finer tailings are not discussed in the Report. No consideration is given to tailings characteristics (moisture content, density). Tailings excavation and transfer, including temporary stockpile of either finer or coarser tailings are not discussed.
  Compaction of saturated or semi-saturated tailings is not achievable and, consequently, significant reduction of seepage rates, by implementing this measure, is uncertain.

Assumptions applied in stability analyses.

Soil properties selected for the dam stability analyses are based on previous tests and engineering judgment. Soil parameters used in the analyses are, in my opinion, reasonable, not necessarily conservative. Shear strength of compacted sand fill (34 dg) represents a reasonable value; however, it does not account for zones of poorly compacted material. Similarly, value of 28 dg for thawed, amorphous organics inclusions in dam foundation is likely an un-conservative estimate.

Main uncertainties are associated with performance of proposed seepage, erosion and permafrost thaw control measures, as acknowledged in the report. Phreatic line assumed in the 2002 dam safety review is more conservative than the line estimated by AECOM. As a result, dam safety review concluded that the static factor of safety is lower than required while the AECOM report concludes the safety guideline is met. In this regard, the 2010 report is un-conservative. Data to support the analysis was not found in the report.

Dome Creek Diversion.

It is recommended (in the Report) to divert the Dome creek flows into the tailings impoundment and discharge the flow over a spillway located on the north valley slope, using an upgraded channel with drop structures. The system is proposed to be designed for $6.8 m^3/s$. The 2002 dam safety report evaluated stable flow capacity of the existing spillway channel to be about $1.2 m^3/s$. In order to accommodate the design flow, the entire spillway must be reconstructed.

The spillway and the channel traverse terrain comprised of sand with silt and inclusions of organics. These deposits have been frozen and because of spillway channel construction and flow diversion, the permafrost surface receded to unknown depths. Thawed permafrost triggered significant ground deformations and displacement of channel rip rap in the past. Ground thawing and sand piping completely destroyed the temporary spillway channel in 1997 (Photos 4 and 5) and required significant repairs in the fall of 2000 and summer of 2001 (Photo 6).

Photo 4: Thawed and eroded sand in the temporary spillway.

Photo 5: Discharge of a pipe, eroded under the spillway in May 1997.

Foundation conditions for the proposed large capacity spillway channel are, in our opinion, very poor and wider channel would likely involve degradation of previously disturbed as well as undisturbed ground.

Piping is considered to be a significant hazard not only to the spillway but also to the dam.

The alignment of the outlet of the spillway channel is at about 90° angle to the creek channel and without a stilling basin.

Design flow (significantly exceeding previous events) would likely erode the existing creek channel and damage the spillway outlet.

Photo 6: Eroded spillway rip rap during the 1999 freshet.

Routing Dome Creek through tailings pond.

Either alternative, tailings flooding or soil cover with flow channels, requires extensive grading of tailings surface. The grading would cause surface disturbances and produce a layer or heaps of loose and readily erodible and transportable tailings.

Flows ranging from small volumes to 6.8 m^3/s torrent will cause icing during the winter and erosion and transport of tailings during warm seasons. It would be difficult to maintain the design soil cover and ice build-up could block local channels and the spillway.

Ponds and channels are attractive to some animals, such as beavers. These could impact hydraulic conditions of creek inlet, waterways and the spillway.

Aufeis or glaciations could adversely affect the tailings pond inlet, pond capacity, outlet and the spillway. These conditions were experienced in the diversion channel, the spillway and on a number of drainage

Application of CDA Guidelines.

It is our opinion that authors of the Report and the dam operator considered the principles outlined in the 2007 Dam Safety Guidelines and pertinent Technical Bulletins, except the following :

- Dam safety management, Principle 1c *Due diligence shall be exercised at all stages of dam' s life cycle.*

Prior to decommissioning and closure, the dam owner should prepare a detailed plan for withdrawing the dam from service, indicating measures necessary for dam safety. The possibility that any remaining dam might be exposed to loads not foreseen in the original design or exposed to unacceptable conditions should be carefully addressed.

Closure requirements for tailings dams should be considered at the initial design stage and at all subsequent design and construction phases.

- Record Keeping and Management (section 2.4.3).

There are no references in the Report to data compiled during yearly inspections and instrument readings.

- Engineering analyses to demonstrate that the dam, foundation and abutments will remain stable under all hazards and loading conditions.

Conclusions.

It is our opinion that the Mount Nansen tailings pond, located in the Dome creek valley was designed without considering its abandonment. The valley plain is an inherent part of the stream drainage, through which flood waters are conveyed.

The valley morphology and ground conditions render safe diversion of major flows through or past the dam very difficult. The flow through concept, as proposed in the Report, presents a hazard to the long term stability of this structure.

Irregularities in foundation preparation and compaction of dam materials were recorded during construction

Dam foundation is sensitive to thermal conditions, either due to seepage or climate. Sand used for dam construction and forming dam abutments is erodible and could be subject to piping. The principal uncertainties to ensure stability of the dam in perpetuity are acknowledged, in the Report (section 5.4.2.3) as:

1. The toe buttress and shear key to offset the presence of liquefiable foundation soils
2. The ability of thermosyphons to maintain frozen conditions in the shear key zone.
3. The ability to improve dam seepage characteristics by replacing coarse tailings with fine tailings.
4. The long term integrity of the sand diffusion layer.
5. The piping hazard.

Regular maintenance of the inflow structure and the spillway should be considered.

Regular maintenance of the inflow structure and the spillway should be considered.

The proposal to use the tailings pond as a permanent storage facility, upgraded as proposed in the Report, is in our view severely flawed and does not provide a long term storage plan that meets definite performance expectations.

Yours truly

M. Stepanek M.Sc., P.Eng.

H.F. Mc Alpine

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250 769 4171

Milos Stepanek

Memo

To: Robert Moar

From: Milos Stepanek

Cc: McAlpine, Bill Slater

Date: Feb 2011

Re: **Mt. Nansen, additional ground improvement concepts.**

Further to your e-mail of January 28, 2011 I have reviewed (again) the AECOM 12-09-10 letter and my views regarding the alternative methods are summarized below.

Ground improvement alternatives to enhance the stability of Mt. Nansen tailings dam, listed on p. 3 of the Dec. 9, 2010 AECOM letter, represent a "shopping list" and, as acknowledged on p. 4 of the same letter, the ground conditions would have to be further determined and evaluated. Existing geotechnical information is insufficient to determine which, and if any, of the listed method would be suitable for the improvement of ground conditions.

As noted on p. 4 of the AECOM letter, evaluation of alternative ground improvement methods will require determination of

- Thickness, extent and characteristics of the permafrost zone.
- Depth to bedrock or other competent, non-liquefiable stratum.
- Characteristics and properties of frozen materials.

The ground for these treatments would have to be deliberately thawed to ensure relatively homogeneous conditions for the treatment.

I also agree that the costs of alternative ground improvement methods, listed in the AECOM letter, would be higher than thermosyphones and the currently proposed shear key.

It is my opinion, that explosive compaction, jet grouting and soil mixing are unsuitable to marginally suitable methods for ground improvement at the Mt. Nansen dam site. Vibro and dynamic compaction methods are commonly used to improve foundations for buildings and similar projects, rather than a dam.

This notwithstanding, issues such as seepage, piping hazard, stability of inlet and spillway channels, erosion and transport of sand cover would remain unresolved.

If you have any questions regarding the above, please call at your convenience.

Best regards Milos Stepanek

TECHNICAL MEMORANDUM

To: **Patricia Randell** **Date:** **2 March 2011**
Cc: **Leslie Gomm**

From: **Justin Stockwell** **Project #: J907-4**

Subject: **Response and Proposed Approach to Address Comments on Draft Mt. Nansen Options for Closure Report**

The following memorandum outlines our response to comments on the draft report title "Mt. Nansen Options for Closure", which was submitted to Assessment and Abandoned Mines in November 2010.

The following comments were included in this response:

- IPRP (from Andrew Liddiard) – 10 December 2010;
- Assessment and Abandoned Mine (from Patricia Randell) – 28 December 2010;
- LSCFN (from Bill Slater) – 6 January 2011;
- INAC (from Karen Ballantyne) – 10 January 2011;
- CSP^2 for LSCFN (from Kendra Zamzow) – 23 January 2011.

Comments have been collated into a tracking spreadsheet (Mt Nansen Closure Report_Collated Comments_Lorax Response_2Mar2011.XLS) and are included as an attachment. Comments have been provided by Lorax, Gomm Environmental Engineering, and AECOM. Comments are collated per source, as listed above, and include the following information: tracking number, comment, response, to be addressed in revisions (yes or no), and where addressed (e.g., memoranda or revised report). Responses are provided and include a brief explanation of how applicable comments will be addressed.

Comments will be addressed with supporting memoranda and subsequent updates to the final Mt. Nansen Options for Closure Report and final Mt. Nansen Water Balance and Water Qualit Model Report (Appendix F). Supporting memoranda include the following:

- Water Quality Sensitivity Analysis; and
- Closure Design and Supplemental Closure Cost Update.

A sensitivity analysis will be conducted to address several comments. The following attached spreadsheet provides a summary of current model inputs, range of measurements per input parameter, and associated assumptions for each closure option as applied to the current water quality model (Appendix F):

- Mt Nansen_Water Quality Model Inputs and Assumptions_21Feb2011.XLS.

The approach for conducting a sensitivity analysis is provided in Table 1 below. The sensitivity analysis will move forward following input from the parties.

The closure design and supplemental cost update memorandum will be provided by AECOM and Lorax. The memo will address comments around closure design and will provide supplemental closure costs, as requested from the parties and as outlined in the comment tracking table (attached).

Table 1. Proposed Approach for Conducting a Water Quality Model Sensitivity Analysis of the Mt. Nansen Closure Options.

Option	Sensitivity/Parameter	Modeled Value	Proposed Sensitivity Value(s)	Rational for Selection of Sensitivity Inputs
Option 1 and 2	Tailings Arsenic Source Term	Best (Judgement) Estimate and Less Favourable	(1) Upper Estimate (Previously termed "Worst-Case") Source Term (2) Option 3 Source Term (Best Estimate) reduced by factor 0.75.	(1) Upper Estimate based on fluctuations/anomalies in seepage WQ data; (2) Apply Option 3 (best judgement estimate) source term, which assumes no attenuation from the saturated tailings - factor 0.75 accounts for GW dilution observed in seepage collection pond.
Option 1 and 2	Seepage Rate to Dome Creek	3.5 L/s	No sensitivity proposed	Tailings seepage rates are based on baseflow measures from long-term monitoring data (pumping rates from the seepage collection pond). The seepage value applied to teh loading model (3.5 L/s) is the maximum long-term baseflow estimate. Baseflow estimates were used as this period best represents seepage from the tailings mass due to the following: no active pumping from the tailings area to the seepage pond, no significant precipitation inputs to the seepage pond, and less lateral GW input to the seepage collection pond. Seepage estimates are considered consevative and represent existing seepage rates from the tailings mass. For closure Options 1 and 2, seepage rates are expected to decrease following dam upgrades to the beach area (addition of liner or replacement of high-K tails with low-K tails).
Option 3	Attenuaton of Arsenic	0%	20% and 50%	Based on removal by sorption (20%) and/or reduction (50%) along the groundwater flowpath to Dome or Victoria Creek.
Option 4	Attenuaton of Arsenic	0%	20% and 50%	Based on removal by sorption (20%) and/or reduction (50%) along the groundwater flowpath to Dome or Victoria Creek.
Option 4	Cover Infiltration	15% of Mean Annual Precipitation	5% of Mean Annual Precipitation	The original modeled infiltration rate was set at 15%, the upper bound of the typical range of infiltration for the proposed vegetated store-and-release cover. This upper value was selected based on professional judgement and actual experience with the **long-term** performance of these covers. A lower estimate of 5% has been selected for the sensitivity analysis for Option 4 which corresponds a to the upper range of anticipated performance for a synthetic barrier cover system (Golders 2010. Conceptual Assessment of Low-Infiltration Covers for the Mt. nansen Project).
Option 4	Source Term Water Quality	Best (Judgement) Estimate is uncertain, therefore Less Favorable estimate was used in model	Use Best (Judgement) Estimate for Option 3	Assume that the talings do not go acid and therefore seepage water quality would be the same as that used for Option 3.

Memorandum

To: Leta Blackjack, Sheila Garvis, Robert Moar
Little Salmon Carmacks First Nation

From: Bill Slater, Bill Slater Environmental Consulting

Date: April 1, 2011

Re: Lorax Proposed Responses to Comments about Mt. Nansen Options Report

As requested, I have reviewed Lorax's proposed approaches for addressing concerns identified with the November 2010 options characterization for Mt. Nansen. These responses were provided by Patricia Randell as attachments to an email dated March 3, 2011 and included: (1) a cover memo with a table describing potential sensitivity analyses, (2) a spreadsheet describing specific approaches for addressing (or not) each comment provided and (3) a spreadsheet describing assumptions used in water balance and contaminant load modeling. The proposed sensitivity analysis was discussed at a meeting on March 30. My comments on the remaining documents are provided in this memo.

Comments and Responses Spreadsheet

My notes about the "comments and responses" spreadsheet are provided in the following table.

Lorax Table Reference	Notes
IPRP No.2	Lorax proposes not to further address contaminant loading from the mill area at this time. This approach is only acceptable if the potential loading in this area will not be sufficient when combined with loadings from any of the pit/tailings options to cause unacceptable environmental effects in the downstream aquatic environment. If expected combined loading could lead to unacceptable effects, then closure options for pit/tailings will need to consider the overall loading – including more characterization of effects from the mill area prior to options selection.
LSCFN No.1	Lorax proposes that LSCFN's comments related to risk assessment as well as balance and consistency among characterization of options will not be addressed in the revised options characterization because they will be addressed in the risk assessment. While it is reasonable to suggest that the risk assessment needs will be addressed during a subsequent process (as proposed in my January memo) that does not negate the need to provide a balanced characterization of the options. In fact, conducting a functional risk assessment will require that we have a balanced characterization. The discussions at the meeting on March 30 suggest that the final characterization should be revised to address the issues of balance and consistency.
LSCFN No. 2	Lorax does not propose any changes to address questions about the adequacy of the proposed re-vegetation approaches. At the very least, some rationale should be provided for the decision to prepare cost estimates on the basis of minimal re-vegetation activities. Also, any instances where the costing for any option varies from these minimal requirements should be clearly identified so that the differences between options are readily notable.

LSCFN No.3	Lorax states that the re-vegetation activities for the valley after tailings removal will be much more intensive than for those involved in covering tailings and therefore proposes that LSCFN's comment about inconsistency among options need not be addressed. In my view, this appears to overlook a number of issues associated with covering tailings. Tailings are contaminated material and therefor require greater care in establishing covers. The need for vegetation on such covers is likely more immediate than for valley sands. Infiltration control may be needed for tailings, while it is not for sands. The characterization report should be revised with a clear rationale for why additional re-vegetation effort is needed for the valley, and/or why it is not needed for tailings. This comment is linked to No.2 and illustrates the need for a coordinated approach to evaluating re-vegetation needs – why are specific prescriptions appropriate in certain circumstances.
LSCFN No.4	Lorax proposes that issues related to demonstrating effectiveness of dam stabilization measures do not need to be addressed because they are already addressed in the December 2010 memo from AECOM. As stated in my January letter and also in comments provided by Mr. Stepanek and Mr. McAlpine, the AECOM memo from December was considered in our previous review. It does not address the comments and therefore should not be considered as an adequate response. These comments require further action.
LSCFN No.5	Lorax proposes that issues related to the potential impact of seepage flows on the proposed dam stabilization measures are beyond the scope and budget of the current work. If this is the case, then the scope should be revised. AECOM identified this issue in the earlier characterization and it was discussed at a meeting on January 6, 2011. At that time, AECOM proposed some possible solutions for the seepage related issues, proposing some "combination of rock drains and insulation." However, AECOM acknowledged that they were not aware of any instances where such approaches had been implemented. If seepage cannot be managed without overcoming the freezing capabilities of the proposed thermosyphons, then the option proposed will not work. This must be resolved before the option is carried forward for further consideration as a feasible option.
LSCFN No.7	Lorax confirms that sand will be used for the tailings beach. The implications of using sand need to be addressed in the estimates of flow rates and water quality if there are implications.
LSCFN No.9	Lorax proposes that concerns about potential erosion of the sand diffusion layer are addressed by a July 2010 AECOM memo related to wave action. The memo has not been provided to-date so it is not clear whether this memo addresses issues related to both extreme flows and wind. If so, then the content can be reviewed when it is provided. If not, then additional rationale will be needed.
LSCFN No.12	Lorax proposes that no additional information is needed about reclamation of waste rock. As noted in the comments provided in January, it is not clear what is proposed for each option and what the associated costs will be. At the very least, consistency and clarity must be addressed in the updated characterization document.
LSCFN No.15	Lorax proposes that concerns about AECOM's analysis of pit options do not need to be revised to address the incorrect characterization of seepage flows out of the pit – noting that seepage from tension saturated areas will flow vertically to the water table and then exit the pit horizontally. While Lorax's characterization of the flow path is correct, the comment provided by LSCFN refers to an assumption by AECOM that flow will occur from the entire area of the pit that is subject to tension saturation – directly through the pit

	walls. This is simply not the case and the analysis and interpretation must be revised to address this issue.
LSCFN No.17	Lorax states that LSCFN's issue about characterization of the uncertainty related to mixing of tailings is "noted." However, they do not propose any restatement of the characterization of the risk in the report. No rationale is provided for noting the comment but not addressing it.
LSCFN No.18	Lorax notes that tailings in the lab were susceptible to desaturation. The LSCFN comment does not argue that the tailings would not desaturate when the water table is dropped lower and the tension increases. The degree of desaturation relates to the tailings properties as a whole. The comment from LSCFN argues that perfect mixing on the scale of an entire pit will not be the driver in the behavior of the tailings – that they will still behave like they are mixed unless there are contiguous layers or columns of coarse material that provide access to a high flow drainage network. Thus, the comment has not been addressed by the reference to lab testing and needs to be further addressed in balancing the characterization of risks for the various options. The November 2010 presentation presents this as a near-fatal risk for this option while the seepage flow risk is ignored for the dam upgrades. This is not a balanced presentation of potential risks and it must be addressed in the updated characterization.
LSCFN No.20	Lorax proposes no changes to address questions about the difference between water requirements to maintain a water cover in the valley versus those needed to maintain tension saturation in the pit. The response references the difference in catchment areas between the two areas. However, what is needed is a fair comparison of the catchment areas/inflows versus the anticipated water needs, potentially considering seasonal needs. This should be addressed in the final characterization.
LSCFN No.27	In response to concerns about incorporating low-grade ore material as part of the cover in a backfilled pit, Lorax suggests that the loading be incorporated into the modeling. A rationale should also be provided for why this material would be used as part of a cover, and not placed under the cover where effects from loading would be minimized.
LSCFN No.33	Lorax indicates that water treatment costs will not be part of any options that do not include tailings relocation to the pit. As a result, the options characterization assumes that all other options can be undertaken without any adverse effects on water quality for any water that may require discharge. I believe that this would be challenging and would anticipate that water treatment would be required for other options too.
LSCFN No.34	Lorax clarifies that tailings relocation options include costs for relocation of all dam material with some of the material relocated to nearby borrow areas instead of the pit. Regardless, this remains a costly undertaking and it is unclear why all dam fill would require relocation. Rationale should be provided.
LSCFN (CSP^2) No.2	In response to concerns about altered flow paths that may change the effectiveness of attenuation mechanisms, Lorax argues that no further characterization or explanation is needed in the final report because water will always pass through organic layers. Note that passing through may not be the same as travelling horizontally along. Also, some areas under the dam may be void of organics, making horizontal travel even more important. This could be changed by melting permafrost.
LSCFN (CSP^2) No.3	Lorax references previous incidents of seasonal flooding as rationale for not addressing concerns raised about potential effects of seasonally high water levels on seepage water quality. Note that sustained water levels as high as those proposed for ongoing operation for options 1 and 2 have not been experienced since water quality reached acceptable

	contaminant concentrations. As a result, the data available do not necessarily reflect conditions that could arise with the proposed closure options. Risks are still possible and should be identified in the final characterization.
LSCFN (CSP^2) No.7	In response to CSP^2 concerns about clogging of systems that rely on sulphate reduction bacteria for contaminant removal, Lorax implies that the materials beneath the Mt. Nansen tailings are not susceptible because it is not a biological treatment system. However, in this case, it is my understanding that the materials are being asked to perform as a treatment system so the issue needs to be addressed.
LSCFN (CSP^2) No.11	Lorax appears to accept CSP^2's concern about the need for contingency treatment mechanisms, but does not propose to revise the characterization report. The acknowledgement should be reflected in the report and addressed in costing.
LSCFN (CSP^2) No.13	Lorax's response to CSP^2's comments about the need for balance among characterization of options indicates that this can be addressed by sensitivity analysis. As discussed at the meeting on March 30, sensitivity analysis is only one component of addressing the balance issues. In some cases, changes to the described options characterization may be needed to address outcomes arising from sensitivity analysis or other re-characterizations.

Water Quality Model Inputs and Assumptions Spreadsheet

The concept of preparing a table that summarizes assumptions used for water quality modeling was developed at the January 6 meeting. The idea arose to provide a mechanism for more easily comparing the approaches used for modeling of each option. The table achieves this objective for some model parameters including receiving water conditions (flows and quality) and flow rates. However, the tables do not provide any summary information for source loads, instead noting reference to other documents. While the references are useful, the table needs to provide a short summary of the basis for assumptions and inputs.

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mcalpineb@northwestel.

Little Salmon Carmacks First Nation
Post Office Box 135
Carmacks, YK

Date: May 18, 2011

Attn: Mr. William Fairclough

Re: Mount Nansen Mine Closure

Dear Sir:

Further to your request we have reviewed the May 5th, 2011 AECOM memo "Additional Concepts for the Long-term Stabilization of Mt. Nansen Tailings Dam". The memo may be a partial response to our review of January 26th 2011 which outlined issues with concepts presented in AECOM memo dated December 9, 2010 and November 2010 Lorax report "Mt. Nansen Options for Closure"".

The November 2010 Lorax report had listed several issues requiring redress in order to provide for the satisfactory containment at the existing tailings location. These were:

1. The toe buttress and shear key to offset the presence of liquefiable foundation soils
2. The ability of thermosyphons to maintain frozen conditions in the shear key zone.
3. The ability to improve dam seepage characteristics by replacing coarse tailings with fine tailings.
4. The long term integrity of the sand diffusion layer.
5. The piping hazard

AECOM's May 5th memo is intended to address concerns about the long-term ability to maintain frozen conditions for the shear key using thermosyphons. Although AECOM considers other alternatives, it continues to maintain the option of attempting to stabilize the tailings system by the use of thermosyphons to freeze the ground to prevent liquefaction during seismic events as the primary dam stabilization measure. As discussed in the following memo by Mr. Milos Stepanek P.Eng., there are several issues, in our opinion, which are not

adequately resolved in the AECOM conceptual design report. These are:
1/ the use of thermosyphons to maintain frozen ground conditions appears incompatible with current (and likely unstoppable) trends in climatic warming trends,
2/ no rational or assessable design for the effective management of seepages is provided (it is our understanding that detailed mapping/locations of seepages are also not known). The use of thermosyphons to freeze seepage flows has little or no technical precedence and the ability of seepages to adversely effect thermosyphon performance is known.
3/ thermosyphon design life, even if it is as long as 50 years, is still short in comparison to the design life of the tailings system (perpetuity).

The AECOM memo provides comment on other methods of ground improvement strategies, but rates only two with medium to high level of confidence in their feasibility. These are: excavate and replace, and rock fill caissons. The memo notes however that there is currently inadequate geotechnical information to design these. The base estimate for the rock fill caissons is $12.5 M assuming a depth of 12 m., but details on how this was estimated were not provided.

The attached memo by Mr. Milos Stepanek P.Eng., outlines some of the difficulties associated with the site of the Mt. Nansen tailings system and concepts for its upgrading. The shortcoming of the original design of the system and current lack of adequate information regarding its geotechnical conditions presents a substantial challenge to establishing satisfactory conditions for remedial work design or assessment.

It is our view, that in part at least, the failure to resolve technical issues stems from unclear objectives. The November Lorax report contained comments from the Peer Review Panel which provided some assistance in this regard when it suggested:

"In the opinion of the Review Team, it is essential for any analysis of engineering alternatives to begin with a clear statement of outcomes that (a) must be accomplished and (b) must be avoided. These then become key design objectives that relate engineering options to specific performance, against which all alternatives can be judged and ranked."

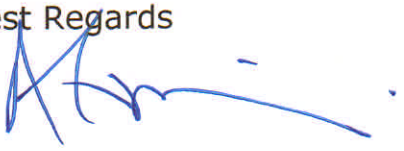
However the undertaking of this task appears to have not been completed prior to the drafting of the Lorax 2010 closure alternatives report , the December 2010 AECOM memo or the May 5 2011 AECOM memo. The incompleteness of this task to counsel or direct the degree, longevity and robustness that proposed remedial measures for the Mt. Nansen tailings system need to achieve, may have, contributed to the presentation of concepts that do not provide the technical resolution of liabilities to a clear and definitive end.

Closure

Our opinion is that the primary proposal (maintaining frozen conditions using thermosyphons) in the report for the use of the existing tailings area, does not demonstrate that the project will meet definite performance expectations. The design of alternate concepts, would rely on information yet to be obtained, would have to meet constraints that have not yet been fully discussed (see comment above) and be undertaken in geotechnical conditions that are very undesirable for a dam (memo by Mr. Milos Stepanek P. Eng.).

Thank you for the opportunity to participate in this review with the Little Salmon Carmacks First Nation. If you have any questions we would be pleased discuss the results of the review with you.

Best Regards



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Milos Stepanek

Memo

To: McAlpine

From: Milos Stepanek

Cc:

Date: May 18, 2011

Re: **Mt. Nansen tailings dam, additional concepts for long – term stabilization, AECOM letter dated May 5, 2011.**

Introduction

I have reviewed the AECOM 05-05-11 memorandum and my opinion regarding the proposed stabilization methods is presented below. There are several key geotechnical conditions, adversely affecting the performance of the existing dam, which render the design of stabilization measures very difficult and the long term stability of this dam uncertain. I recall statement by C.P. Berkey (AIME Tech. Pub. 215, p.4):

Dam must stand. Not all of them do, and there all degrees of uncertainty about them. Reservoirs must hold water. Not all of them do, and there are may ways by which water may be lost. The work must be done safely as a construction job. Not all of them are, and there are many sources of danger. The whole structure must be permanent and the work has a right to be done within original estimates. Not all of them are, and there are many reasons for their failure or excess cost, most of them geologic or of geologic dependence.

As discussed in the following paragraphs, the existing Mt. Nansen dam represents a safety hazard, very difficult to mitigate, in my opinion.

General

The design of this dam and it construction disregarded conventional practice of *zoned earth dams,* in my view. Dams comprised exclusively of one material type are only rarely constructed. It is very difficult to control seepage and ensure stability of homogeneous dams.
No *cutoff key* and an *insufficient upstream seepage control blanket* was designed and constructed. Instead, the designer assumed preservation of ground permafrost and development of a frozen dam core.

.

The original design was based on insufficient geotechnical data and inadequate understanding of potential effects of local site conditions on the design, specifically:

1. Insufficient data on dam foundation conditions (depth to bedrock or other competent stratum).
2. Insufficient data on permafrost conditions and its distribution in the dam foundation and abutments.
3. Absence of adequate soil material, lead to design and construction essentially of a homogeneous dam comprised of permeable, poorly compacted sand.

The following conditions were not fully appreciated by the design and further complicate the current design of proposed stabilization measures:

4. The tailings pond, with water cover or with saturated soil cover, functions as a heat source and adversely impacts permafrost. (This would also adversely affect efficiency of cooling devices, i.e. thermosyphones, if installed as the main part of the proposed stabilization measures.)
5. Subsurface erosion (piping) occurs along the spillway which has caused its failure and reconstruction on two previous occasions. Piping has also occurred at the dam toe which led to construction of a toe berm.
6. The dam material and foundation soils are liquefiable during smaller than the design seismic event. This condition would worsen as more foundation material thaws.

Proposed stabilization measures and performance problems.

AECOM propose *pemafrost enhancements* with thermosyphones and/or *ground improvement alternatives* as viable stabilization measures.

Permafrost enhancement using thermosyphones is considered feasible by AECOM (p. 3) if some thawing at the dam toe is acceptable. Seepage along the dam and through it foundation represents a significant source of heat, accelerating thawing of frozen ground and decreasing the thermosyphones performance. AECOM proposes flows through the toe berm to be channelized using conduits, however, no design is forwarded. Separation of seeps from the underlying permafrost and their conveyance through the toe berm would be very difficult, unreliable and unprecedented measure. In my opinion, this condition will render the pimary stabilization measure ineffective.

In addition, thermosyphones would have to be maintained and more comprehensive assessment of climate changes and ground conditions is required to assess their long term performance, as acknowledged in the memo on p. 4.

In the case of the continuing warming trend (or insufficient function of thermosyphones – writer's view) AECOM acknowledges that would be necessary to adopt additional but unspecified ground improvement measures in order to regain the dam stability.

Ground improvement alternatives are divided, in the AECOM memo, into two groups (p.5):

1. Densification and cementation techniques requiring thawing of existing ground, and
2. Replacement methods which, depending on actual ground conditions, could impact the dam stability during construction. Rock fill caisons would mitigate these concerns provided the foundation sand remains frozen during construction.

On page 6 of its memorandum AECOM] states: "There is inadequate subsurface information to develop these concepts further at this time ..." yet AECOM has "confidence that there is an engineering solution to maintaining the stability of the Mt. Nansen tailings dam with or without the permafrost."

It should be appreciated; that the tailings dam, and associated structures; do not meet the 2007 Dam Safety Guidelines and **the issue is not to maintain the existing condition but to upgrade the stability and function of the dam to an acceptable level.**

AECOM's memorandum, on pages 6 and 7, summarizes (without setting any cost or time estimate) investigation programs required to assess the ground improvement alternatives. Available estimates of the depth to bedrock or a competent bearing layer (estimated as little as 5 m or possibly greater than 30 m) offer very little confidence insofar as the performance, sizing and costing of the ground improvement measures is concerned, in my opinion.

Consequently, Table 01 on page 9 of the memorandum, summarizing potential ground improvements, their depth ranges and level of confidence (assumed by AECOM) is believed to be a very crude and unreliable summary, in my view.
Excavation and ground replacement is classified at the highest level of confidence. However, the estimated depth of the replacement material is in the range of 0–6 m (zero being likely a typo). This depth estimate is unsupported by any evaluation and it is the smallest of estimated depth ranges for other measures.

This all notwithstanding, the memorandum on page 9 states, apparently as the safe alternative: "*Enhance the permafrost and utilize it as an element of the stabilization measures. If and when climate changes begin to overwhelm the permafrost and thermosyphones, ground improvement measures should be implemented.*" With respect to this, it is the writer's opinion that the thermosyphones will not even control permafrost under existing conditions.

This above referenced AECOM recommendation is modified on page 10, first paragraph as follows:

"*If it is desirable to eliminate the uncertainty regarding the long term effectiveness of maintaining permafrost with thermosyphons, then other methods of ground improvement should be considered...*"

This statement demonstrates, in my view, uncertainties associated with this conclusion. In order to alleviate the confidence level, AECOM recommends (on p.

10) unspecified geotechnical/geophysical investigations, including testing of frozen soil samples, further evaluation of thawing systems and climate prediction modeling.

Closure

The Mt. Nansen tailings dam is located in a geologically sensitive area and the dam design does not consider fully the ground and environment conditions, in my opinion. These conditions make rehabilitation of the dam to meet current safety regulations very difficult.

The proposed stabilization methods are commonly used to improve ground conditions for industrial structures. Their application, especially with significant seepage flows, is unprecedented and unproven in dam engineering.

It is my summary opinion:

1. The proposed stabilization measures would not ensure maintenance free abandonment of the tailings facility
2. These measures would not ensure the long term safety of the dam and associated structures, as required by current regulations.

Consequently, it would be prudent to consider more assured methods of long term storage of tailings than rehabilitation of potentially unstable dam located on the sensitive ground.

Should you have any questions or require further clarification, call at your convenience.

Milos Stepanek, P. Eng.

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Little Salmon Carmacks First Nation
Post Office Box 135
Carmacks, YK

Date: June 1, 2011

Attn: Mr. William Fairclough

Re: Mount Nansen Mine Closure

Dear Sir:

Further to your request we have reviewed the report "Summary of Estimated Closure Costs, Mt. Nansen Mine Site" prepared by AECOM May 2011.

Our comments are related to two aspects, the "Consulting, Engineering, Design and Site Supervision" estimates and components missing from the cost analysis.

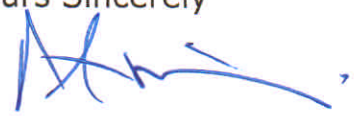
The AECOM summary of costs uses a fixed percentage of the estimated capital cost of the works, as its estimate of cost for "consulting, engineering, design and site supervision" estimate. It is our opinion (see attached memo by Mr. M. Stepanek P.Eng.) that the complexity of the task for these measures, for the option of leaving the tailings in the present location, is underrated due to the adverse geotechnical environment of the existing tailings location and the likely extra costs to modify/upgrade/reconstruct the thermosyphon option when it fails to perform to requirements and expectations. An estimate, which considers the more complex nature of the existing location and tasks necessary to investigate, design and verify performance, would be more likely to provide a reasonable estimate of this option's cost. (Please note our previous memo regarding the expected performance of the option.)

Our second comment relates to the current conditions of the tailings system. The spillway from the dam down to Dome creek has had problematic history with at least two known significant failures. There was work undertaken in the fall of 2000 to improve the spillway, but due to inclement weather the task was not completed as intended and subsequent inspections by EBA and BK Hydrology opined that the

spillway was not adequate. However the task of reconstructing the spillway from the dam down to Dome Creek is not apparent in the costing presented in the AECOM report. This reconstruction task would be required for both options which leave the tailing in-situ.

Thank you for the opportunity to participate in this review with the Little Salmon Carmacks First Nation. If you have any questions we would be pleased discuss the results of the review with you.

Yours Sincerely



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Milos Stepanek

Memo

To: Bud McAlpine

From: Milos Stepanek

CC:

Date: June 1, 2011

Re: Mt. Nansen Mine, Estimated Closure Costs, AECOM letter May, 13, 2011

Introduction

Further to the request of Mr. Moar, I have reviewed the estimated costs of the dam stabilization and tailings relocation into the open pit alternatives. This review did not consider the selection of unit rates, assumed volumes or material costs. My review was limited to the evaluation of efforts that are likely required and the technical complexity of proposed engineering measures.

Engineering Costs of Alternatives

Consideration was given to two basic tailings deposition alternatives:

1. Tailings dam upgrade with saturated soil cover or water cover.
2. Relocation of tailings into the open pit, incl. toe berm.

Costs of engineering, design and site supervision of dam upgrade (apparently including site investigations) was estimated as **$ 1,609,665**

Costs of the same activities for transfer of tailings into the pit was estimated at **$ 2,476,252.50**

These estimates are unrealistic, in my opinion. The design of dam rehabilitation, including thermosyphones, design of a toe berm, design of spillway etc. will require considerable more field investigations, laboratory work and analyses than relatively routine transfer of tailings and design of a plug dam on bedrock foundation.

If we assume, cost of transfer of tailings of about $ 2.5 M being correct, then cost of the dam upgrade and associated actions must be grossly underestimated or vice versa.

Operation costs of the upgraded tailings dam are expected to be bigger (**$ 7.8 M)** than for tailings located in the pit (**$ 4.5 M).** The cost difference is, in this case, logical, though its actual value may be more significant.

Construction Costs Estimates

The construction cost estimate for the dam rehabilitation does not include allowance for ground improvement measures if thermosyphones are insufficient to maintain frozen ground. This possibility is included as a part of proposed Alternative 1 in the AECOM memorandum of May 6, 2011.

Cost of the spillway reconstruction appears to be provided for in the 30 % construction allowance. However, the existing spillway (downstream from the crest of the dam) is not structurally sound and designed for the long term function. Consequently, the construction cost allowed for in the budget likely does not allow for it proper reconstruction.

Closure

It is my opinion that estimated costs of additional site investigations, laboratory studies, analysis and designs should not be based on the same percentage of the construction cost. Consideration should be given to necessary effort and complexity of issues.

There also appears to be lack of consideration for some construction costs and related contingencies. For example, contingency for the dam upgrade is set at $ 3.2 M and for tailings relocation $ 4.9 M, again, not reflecting complexities of the work.

I trust that my notes would be of assistance to you. If you any questions, please call at your convenience.

Milos Stepanek, p.Eng.

Memorandum

To: Mt. Nansen TAC – William Fairclough, Robert Moar, Leta Blackjack, Mike Vance, Sheila Garvis, Johnny Sam

From: Bill Slater

Date: June 20, 2011

Re: Outstanding Information Needs for Options Evaluation Process

As discussed at our TAC meeting on June 16, I have compiled this memo to provide a short-list of outstanding information needs and clarifications that the TAC concluded are needed to support the upcoming risk assessment and options evaluation processes, currently scheduled for July 14-15 and July 20-21. As we discussed, Mr. McAlpine and Mr. Stepanek have identified several areas of concern about the proposed dam upgrade options, associated risks and cost estimates. Our TAC review has identified some additional areas of concern related to characterization of some of the options. Once these information needs are addressed, the TAC hopes that there will be sufficient information to proceed with the risk assessment and options evaluation processes, recognizing that other remaining concerns identified by the TAC and our reviewers will need to be considered in evaluating the performance of the proposed options and assessing their risks.

At our meeting on June 16, the TAC concluded that the concerns and issues described below need to be addressed before we proceed with the options assessment and evaluation processes.

Conveyance of seepage water for dam upgrade options

The review responses from Mr. McAlpine and Mr. Stepanek express significant concern about the implications of seepage flows on the ability of thermosyphons to maintain frozen conditions for the proposed shear key, a critical component for long-term dam stability. The issue was also raised in my memo dated January 6, 2011 and a memo from Mr. Stepanek and Mr. McAlpine dated January 26, 2011. Mr. Stepanek in his May 18, 2011 memo summarizes the issue succinctly:

> ***"Separation of seeps from the underlying permafrost and their conveyance through the toe berm would be a very difficult, unreliable and unprecedented measure. In my opinion, this condition will render the primary stabilization measure ineffective."***

AECOM's May 5 memo on ground improvements acknowledges that groundwater flows through the area of the shear key "requires future consideration" and proposes a concept of channelizing and insulating the flows to separate them from the underlying permafrost. However, there are currently no details about thermal effects of seepage flows or the geometry of the proposed channelization/ insulation concept. To-date, AECOM has been unable to identify other projects where this concept has

been applied to demonstrate the feasibility of the concept. At the meetings on May 30-31, AECOM opined that seepage flows may affect permafrost in only part of the shear key and that the remaining portions would provide stability. If this is under consideration, further stability analysis is needed to support the concept.

Based on the reports and reviews, the TAC concluded that the information provided to-date is not sufficient to demonstrate that the proposed stabilization approach for the dam is feasible without the inclusion of other methods (e.g. rock caissons). The inadequacy of dam upgrade options needs to be addressed before we proceed to options evaluation because we should only evaluate options for which we have can demonstrate an expectation of performance. Either additional information is needed to support the proposed concept, or other methods should be incorporated as part of the option design.

Costing and Methodology for Tailings Relocation

Some further clarification about tailings relocation methodology and justification for the expected costs is needed before we proceed to the options evaluation stage. All of the information provided to-date on tailings relocation methods and costing is provided in AECOM's November 2010 Geotechnical Assessment and Costing Report. That report does not provide any details about how the relocation methods would be conducted, or about the rationale for the costs provided.

AECOM proposes that tailings relocation for Option 3 would rely on dredging, using two dredges to mix coarse and fine tailings. However, the practicalities of operating two dredges in the small Mt. Nansen tailings pond have not been characterized. Likewise, there is no explanation of the potential water management and dam stability risk issues associated with dredge operation – e.g. what water levels will be required in the dam, will the dredges operate in ponds, how will tailings beaches be addressed? Overall, additional rationale is needed for the selection of dredging as a relocation option. This needs to include additional details about the proposed dredging operation.

There appear to be remaining inconsistencies about water management and water treatment needs. AECOM proposes that 300,000 to 500,000 m^3 of water will be needed to relocate the tailings for Option 3. This is likely only the water to create tailings slurry. What additional water will be needed for dredge ponds? What are the implications on treatment costs? How will water recycle be done from the pit? It should be possible to make estimates of water treatment requirements from these volumes. AECOM also assumes that adequate water will be available for dredging operations and that there will be no cost for this. Additional analysis should be done to confirm that adequate water is available and what the source would be.

For Option 4, AECOM proposes tailings relocation using mechanical methods. This will have substantially less implications for water management and substantially lower volumes requiring treatment. However, the treatment costs are assumed to be the same for both. This needs to be reconciled prior to the options evaluation process.

For both relocation methods, there are no details or rationale for the closure costs. Both methods are identified as having similar total costs, but these provide little confidence without additional details about how the relocations would be conducted and a more thorough cost analysis.

Costing for Ongoing Operation, Maintenance and Monitoring

Section 4 of AECOM's summary of estimated closure costs addresses post-closure operation, maintenance and monitoring costs for each of the options. The cost tables provide annual and periodic costs, and also net present values. The net present values are utilized for the overall costs estimates. The TAC discussed the use of net present values and recognizes that this approach is common in engineering cost estimates. However, the TAC also recognized that for a government project, no investment account will likely be created to establish certainty for long-term operation, monitoring and maintenance costs. As a result, the utilization of net present value in cost estimates for the options fails to acknowledge that the real long-term costs will be directly deferred to future generations – with the associated risk that local people will suffer environmental, health and land use effects if those generations are unwilling or unable to incur the costs for the necessary activities. Uncertainties associated with that deferral will need to be addressed as part of the risk assessment and options evaluation.

AECOM has utilized an interest rate of 4% for calculating net present values for the ongoing costs, and notes that this rate has been discounted to account for inflation. Additional rationale should be provided for selecting 4% as a long-term real rate of return for cost estimates. Lower real rates of return are commonly used – mostly in the range of 2.5-3%.

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IPRP	Source Terms	1	**General Comment:** One can always find ways to make the "worst case" worse. Calling the worst case, a pessimistic case or upper concentration case would be more appropriate.	**Noted. We will revise "worst case" terminology to "upper estimate".**	Yes	Closure Report				
IPRP	Mill Area	2	**General Comment:** The draft Lorax report notes that the mill area drainage is the major contributor to downstream water quality loading, such that quantitative comparative evaluation of closure options on downstream water quality necessitated the removal of mill drainage. This is implicitly equivalent to assuming that the mill area drainage will be remediated to background conditions. While this assumption may be appropriate for the purposes of the evaluation of the different closure options for non-common elements, it places a high performance requirement on the mill area closure in the overall assessment of mine closure. Consequently, some discussion confirming the likely ability to fully remediate the mill area drainage is warranted.	**Noted. It was not our intention to suggest that mill reclamation would result in drainage quality returning to background. We will add specific statements to the water quality modeling and prediction assumptions to clarify this point. Further investigations are needed to adequately estimate mill contamination and to estimate success of mill reclamation.**	No		Lorax proposes not to further address contaminant loading from the mill area at this time. This approach is only acceptable if the potential loading in this area will not be sufficient when combined with loadings from any of the pit/tailings options to cause unacceptable environmental effects in the downstream aquatic environment. If expected combined loading could lead to unacceptable effects, then closure options for pit/tailings will need to consider the overall loading – including more characterization of effects from the mill area prior to options selection.	**Overall loadings from the mill area will be included as part of the evaluation of the detailed (feasiblity) design and in support of the final closure plan. Further characterization of the mill area has been identified as a key uncertainty that requires investigation. Water quality monitoring on Victoria Creek currently meets guidelines. Overall closure activities, including reclamation of the mill area, are expected to result in an improvement in surface water quality. Therefore, unacceptable effects on water quality are not expected.**		
IPRP	Option 3 - Tailings Relocation	3	**Specific Comment #2:** Option 3 assumes blending of coarse and fine tailings from two dredging operations. This may be difficult to achieve, particularly toward the end of the dredging operation and is likely to result in poorly blended material in the upper portion of the in pit tailings deposit. It is the upper portion of the new tailings deposit where this objective is most important.	**This is a concern that will be addressed during detailed design. The finest tailings are likely to be located in the deepest zone (bottom) of the current tailings impoundment. It is assumed that these tails will be removed last and will form the upper cap on top of the pit impoundment.**	No		If it is determined that the assumptions for the tailings are not achievable and the implications (performance and cost) of continuing are of significance then these issues will be reviewed and discussed with parties before advancing.	**All of the options have components with varying degrees of uncertainty, as the options are at a conceptual level of design. Depending on the option selected, these uncertainties should be prioritized for refinement during detailed design stage.**		
IPRP	Taillings Hydraulic Conductivity	4	**Specific Comment #3:** A very low hydraulic conductivity of 5×10^{-9} m/s is the basis for the water quality prediction for Option 3. This is at or below typical hydraulic conductivity for even very fine tailings. It is not clear how this can be achieved considering the operational issues associated with blending and discharge of tailings, along with water management in the confines of the long and narrow open pit.	**Noted. This value was estimated from particle size distribution data using the Hazen's method. Lab testing confirmed that this value is theoretically possible, as lab tests of mixed tailings had hydraulic conductivities that ranged from 4.8×10^{-10} m/s to 3.8×10^{-8} m/s (Appendix C-3 and C-4).**	No		Acknowledging that under the ideal conditions of a lab it may possible to generate the report hydraulic conductivity, but under actual site conditions it may not be possible to achieve this. Unless it is possible to detail a field process that will recreate lab results, what is the confidence level associated with this premise.	**There is a moderate degree of confidence that the tailings can be mixed to create an average hydraulic conductivity assumed in the model. There is a moderate to high degree of confidence that the tailings can be preferentially disposed of in the pit (e.g., coarse tailings on bottom, fine tailings above) to meet the design constraints assumed by the model.**		
IPRP	Option 4	5	**Specific Comment #4:** The assumptions of infiltration through the low infiltration cover for tailings placed in the pit at 15% of mean annual precipitation may be pessimistically high. For Faro, low infiltration covers were assumed to allow 3 to 8% of mean annual precipitation, and rudimentary covers were assumed to allow 15 to 25% of mean annual precipitation. Given the infiltration values for the catchment above the current tailings collection pond are estimated at 10% of mean annual precipitation (page 21 of Appendix E), the 15% value does seem high.	**For the purposes of this assessment, a simple cover using locally available materials was designed. The long-term, perpetual performance of this cover (infiltration) was required for closure; however, perpetual performance of any cover design has not previously been demonstrated elsewhere. As a result, a conservative assumption with respect to infiltration was assumed. The infiltration rates proposed for the Faro project are design and performance objectives. Further clarification of the assumed conservative infiltration rate will be provided. In addition, sensitivity analysis will be carried out using a range of practicable and achievable long term infiltration rates.**	Yes	Assumptions Memo Sensitivity Run Memo				
IPRP	Options 1 and 2	6	**Specific Comment #5:** Options 1 and 2 focus on stabilization in-place with saturated conditions for the control of ARD. It is noted only the silty sand fraction is PAG (likely the ore from the late stage of mining when oxide ore transitioned to sulphide ore). There does not seem to be a stabilize-in-place tailings strategy using unsaturated conditions (i.e. not relying upon a water cover). An "unsaturated" approach would lessen the stability requirements. Some options which may allow an unsaturated closure for the tailings are: § removal of the silty (PAG) fraction (for in pit disposal), § ameliorating the silty fraction with lime/limestone, § placing a low permeability cover over the tailings (note that this strategy is considered possible for relocated tailings).	**In a bulk sense, the tailings have been classified as PAG or capable of generating ARD, based on their ABA characteristics (Appendix B, Table 5-3). Maintaining a water cover over PAG material is a best management practice. The tailings have remained largely saturated in the long-term and have remained geochemically stable. Dam upgrades and/or tailings relocation (beach area) would allow for complete saturation of the tailings. Ameliorating the tailings with an amendment would require mixing and disturbance. Reagents may affect geochemical stability (e.g., lime would like cause arsenic to become unstable). Performance of a low-permeable cover in the long-term remains uncertain; however this approach has been considered for Option 3. The application of a low-permeable cover to the beach area (e.g., where tails are currently unsaturated) would not alter the final predicted water quality estimate presented within our evaluation (a cover may not prevent seasonal, lateral flow of water into the unsaturated tailings); this approach could be considered in the final design of the Option 1 or 2, if selected.**	No					
IPRP	Geochemistry	7	**Specific Comment #11:** Geochemical source terms have been revised based on the new data and reassessment of existing data as described in detail in Appendix B: Geochemical Characterization. The new source terms are given in summary tables in the main body of the draft Lorax report. There are some errors in Table 5.5-2 that summarize geochemical source terms for Options 2A and 2B. Table 5.52 lists diffusive flux rates for the taillings impoundment that will have a saturated soil cover. As stated in Section 5.7.2 of Appendix B, no diffusive flux is considered for this Option as the soil cover is assumed to prevent upward migration of contaminants. Furthermore the source terms for saturated soil and waste rock in the pit and waste rock piles outside pit given in Table 5.5-2 for Option 2 are different than those given on Table 5.4-7 for Option 1. There should be no difference between these source terms as both Options treat the material in and beside the pit the same.	**This is a transcription error. The diffusive flux terms are not applicable to Option 2. Further, the open pit (lake and waste rock) source terms should mimic those presented for Option 1 (Table 5.4-7). These tables will be corrected in the final draft of the report. Correct values are provided in Appendix B.**	Yes	Closure Report	What was the response to the IPRP's specific comments 6-10 as they do not appear here.	**IPRP Specific Comments 6-10 were cited as observations made during the review and did not require a response.**		
IPRP	Tailings Geochemistry	8	**Specific Comment #12:** The geochemical report refers to the MEMPR guidelines from 1997 for classifying PAG and non-PAG materials. MEND 2009 Prediction Manual for drainage chemistry from sulphidic geologic materials has an updated guideline for classifying materials: "For cases where AP and NP are equally exposed and AP generates acid identical to pyrite and NP neutralizes acid like calcite, samples with an NPR less than 1.0 are PAG and samples with an NPR greater than 2.0 are non-PAG. A sample with an NPR between 1.0 and 2.0 is capable of generating acid rock drainage (ARD)."	**Noted. In a bulk sense, the NPR of tailings is less than 1.0, which identifies them as PAG. This classification does not alter our approach or assumptions regarding the management of tailings.**	No					

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IPRP	Tailings Geochemistry	9	**Specific Comment #13:** The geochemical report indicates that "Sulfur species and NPR values are also within the range presented in Kwong et al. (2002). Therefore, the tailings sample selected for laboratory-based kinetic test work is considered to be representative of the tailings mass, with respect to ABA results." Comparison of the 2002 data with the 2009/2010 data, and particularly the differences in the NP, AP and NPR between the 2002 report and the 2010 report would give an idea of the changes in tailings geochemistry over about a 10 year period. This comparison could be important as it appears that the tailings are very slowly acid generating (current pond water is discharged without treatment), and the comparison could serve to characterize the geochemical risk.	**Noted. A screening comparison was made internally and differences were within the variability of material tested. In general, we expect the bulk of tailings, which are under water cover, to not be reacting or oxidizing. The proposed investigation would be most relevant to the sandy tailings within the beach area, which are currently not under water cover.**	No					
IPRP	Closure Objectives	10	**Specific Comment #18:** In Options 1 and 2 upgrading the existing diversion channel on the north side of the valley and routing the spillway down the left abutment will mean post-closure care and maintenance will be needed. A very flat toe berm (surface slope of 7 to 10%) is proposed to stabilize the dam. Routing the spillway down the rockfill buttress could be considered to eliminate the spillway on the abutment and to allow the height of the central section of the dam to be reduced.	**The suggested alternative will be considered at the feasibility and detailed design stage, should one of these options be selected.**	No		What was the response to the IPRP's specific comments 14-17 as they do not appear here.	**IPRP Specific Comments 14-17 were cited as observations made during the review and did not require a response.**		
IPRP	Closure Objectives	11	**Minor Items to be Resolved #1:** It is not clear why the objectives of the options vary slightly (i.e. Option 2 has same objectives as Option 1, plus establishing a wetland as a land use consideration).	**Clarification will be provided on the closure objectives as they are applied to each of the closure options.**	Yes	Closure Report				
IPRP	Dam upgrade/Spillway	12	**Minor Items to be Resolved #2:** The spillway design concept appears to be based upon a very conservative approach. (Mt. Nansen is in a very similar meteorological setting as Faro however the design flows are proportionally 50% greater than at Faro). This is unlikely to materially affect the evaluation of closure options. However, the hydraulic assessment might be revisited in detailed design should in-place stabilization be the preferred closure strategy.	**Faro is a much bigger watershed and probably used a snowmelt event as the design event. A rainfall event is the critical event at Nansen due to a contributing area of only 3.3 km2 . Rainfall on a small watershed has the potential to produce a higher peak flow rate than a snowmelt event for the same watershed. In addition larger watersheds have a smaller difference between flow rates reported as mean daily and instantaneous peaks.** **If required, this is a relativley minor cost addition with spillway excavation and armouring adding up to $70,000 total.**	Yes	Cost Memo and Closure Reporting, as required.				
IPRP	Option 2	13	**Minor Items to be Resolved #3:** Option 2, page 5-67, it is noted that the soil cover will involve 36,000 m^3 of material for the 1 m thick layer. On page 5-38, the area of the water cover is 60,000 m^2.	**The volume of 36,000 m^3 is a misprint. The correct volume is 60,000 m^3 and is reflected in the cost estimate. This will be corrected in the final draft of the report.**	Yes	Closure Report				
IPRP	Option 4	14	**Minor Items to be Resolved #4:** Option 4 involves placement of 300,000 m^3 of tailings and 344,000 m^3 of rock in the pit, and configured with a slope to preclude the need for a dam in the pit. (Earlier work (Brodie 2002), found that the pit had a capacity of ~ 300,000 m^3 if a 10 m high dam was constructed at the south end – which is consistent with Option 3). Clarification of the configuration and capacity for Option 4 is required.	**In Option 4, the tailings and upper layer of waste rock are designed to remain unsaturated. Waste rock placed on top of the tailings will be mounded to conform to the higher pit wall to the north. The objective of mounding waste rock is to completely fill in the pit depression, prevent snow accumulation, and enhance runoff. The volume of waste rock required to achieve this final land form is consistent with the design.**	No					
INAC	Restoration Vs. Remediation	1	The report seems to be geared towards restoration and not remediation/reclamation. A "Status Quo" approach on certain components is an option.	**Noted.**	No					
INAC	Restoration Vs. Remediation	2	Comparing predicted water quality conditions to CCME guidelines provides a conservative approach for project closure. If an environmental effects assessment was evaluated and site specific water quality objectives were formulated, closure options would change and cost would possibly be reduced. (See pg 5-3)	**The evaluation is not an environmental assessment. For this assessment of closure options, environmental performance (ie: water quality predictions) are compared for the options and against CCME guidelines. The closure options themselves are not necessarily designed to meet CCME, nor is CCME considered an absolute closure objective. What is most critical at this stage of the process is how the options compare to each other in performance. Once an option is selected and subsequent detailed design developed, a more detailed assessment of the potential environmental effect will be carried out as part of the YESAA Project Proposal, during which time an environmental effects assessment will be conducted and, if necessary, site-specific water quality objectives may be proposed.**	No		For clarity purposes, if site specific water quality objectives are required as a result of the regulatory review which may impact (negatively) on the original assumptions used to evaluate & select the preferred option there may be a need to review the selected course of action. No action required at this time, more of a process consideration.	**Noted.**		
INAC	Restoration Vs. Remediation	3	Will YG assume responsibility for public roads that are not part of the C&M on site after reclamation is complete? The only roads on site should be for C&M and inspection of closure options; all other roads should be closed once reclamation activities have been completed. (See section 5.2.4.2)	**Noted. This will be addressed during the execution of the closure plan. Roads left on site will be purely for maintenance and access purposes.**	No					
INAC	Restoration Vs. Remediation	4	Reclamation activities need to be reflective of the fact that this is an abandoned mine site and not an active mine/exploration site.	**It is unclear what is meant by this comment. No further response is required other than perhaps by GY.**	No					
INAC	Restoration Vs. Remediation	5	The report seems to be geared towards restoration and not remediation/reclamation. A "Status Quo" approach on certain components is an option. Example: Decompacting and recontouring and revegetating the roads and reclaiming all exploration trenches. Why are roads de-compacted to a depth of 0.8m vs. scarification of the top 0.15m? Why are trenches that have already started to naturally re-vegetate being re-disturbed and then re-vegetated? What is the action and cost to re-vegetate versus allowing natural re-vegetation? What are the concerns at these locations, I.e. Human health and/or environmental issues that warrant this level of restoration?	**Noted. Statements regarding revegetation approach and rationale will be provided.**	Yes	Closure Report		**Conceptual reclamation and revegetation measures assume both generally accepted best management practices and techniques as well as industry standards to achieve closure objectives.** **In response to specific comments on mitigation measures: i) while shallow scarification to 0.15m would be a suitable measure for relatively un-compacted trails, we do not consider this technique sufficient to provide for appropriate loosening and erosion prevention of compacted running surfaces; and ii) the comment inaccurately states that the costing estimate assumes that all exploration trenches will be backfilled.** **It is acknowledged that this may not be desirable nor feasible, and costing thus assumes ~20 percent trenches (11km) will not be backfilled subject to field verification.**		
INAC	Restoration Vs. Remediation	6	Will YG assume responsibility for public roads that are not part of the C&M on site after reclamation is complete? The only roads on site should be for C&M and inspection of closure options; all other roads should be closed once reclamation activities have been completed. (See section 5.2.4.2)	**Noted.**	No					
INAC	Clarification	7	The report indicates that Class D estimates range from -25% to +75% for Common Closure elements but -25% to +40% for the closure options; are these considered Class D estimates with these ranges; which range is used?	**Yes. Both are considered Class D estimates, as they are considered conceptual in design.**	No					
INAC	Clarification	8	It is unclear where the debris from the demolition of the mill or laydown areas will be landfilled. (Table 5.2-2)	**It has been assumed that debris will be landfilled.**	No					

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INAC	Clarification	9	It is unclear where the debris from the demolition of the camp and ancillary buildings will be landfilled. (Table 5.2-3)	**It has been assumed that debris will be landfilled.**	No					
INAC	Clarification	10	5.4.5.3 It would be good to delineate the concentrations from each source as opposed to total concentrations to allow the reader to understand the effects of each point source. Revegetation is indicated as part of the option but does not affect geochemistry analysis therefore, other than aesthetics, what is the purpose of the revegetation? (Please see previous comments under "Remediation vs. Restoration)	**Source concentrations have been provided for each mine feature (e.g., waste rock or tailings). Revegetation and reclamation measures are proposed to limit erosion and to provide the parties with a relative measure of actions required to reclaim the site.**	No					
INAC	Clarification	11	5.6.3.1 Indicates that hydrology can be expected to return to pre-mining conditions with the reclamation of the valley; however, it does not indicate the time required to achieve this or the water quality objectives during this interim period. Example: TSS to Dome Creek. Will water require to be treated to achieve objectives during this time? There could be significant design and cost implications during this period depending on duration. (Discussed again on pg 5-99)	**These considerations were included in the supplemental cost estimate provided in Appendix C-2 (Altura). Further, detailed costs and phased approach are provided in Appendix A of this report.**	No					
INAC	Clarification	12	5.6.3.2 Discusses a contingency provision for a diversion channel from Pony Creek to the pit area in the event that tailings desaturation becomes a concern however previous sections indicate tailings saturation is not achievable. This indicates that tailings desaturation will be a concern and that the channel will be required.	**Tailings desaturation under Option 3 has been identified as an area of uncertainty. The diversion channel and associated costs are included for contingency.**	No					
INAC	Clarification	13	Option 4 indicates treatment of pore water from the tailings; how will it be collected and where will it be treated? Different possibilities for these items could affect timelines and costs.	**Porewater may be collected in the current tailings impoundment during relocation and/or from the pit as the tailings consolidate. Porewater treatment requirements remain uncertain and associated costs have been provided for contingency.**	No					
INAC	Sensitivity	14	A sensitivity analysis was done for only one assumption in the report. What is the comfort level regarding certain closure elements without a sensitivity analysis? Why were sensitivity analyses not done on other closure elements? Example: 5.6.3.3 Seepage from tailings backfill into surrounding bedrock remains uncertain which affects all geochemistry results. What is the sensitivity of this assumption?	**A technical memo will be issued to outline model inputs and water quality sensitivity. Sensitivity runs will focus on components of the project that most influence environmental performance of the options.**	Yes	Water Quality Prediction Report				
INAC	Sensitivity	15	If the sensitivity analyses of closure option elements are not of significant concern as related to human health and environmental requirements/liabilities then the focus should be on aspects of the options that do have measurable impacts to human health and environmental liabilities.	**See above**	Yes	Water Quality Prediction Report				
INAC	Sensitivity	16	Diminishing returns have to be considered in the sensitivity analysis. I.e. The cover infiltration of either the 15% infiltration vs. 3% infiltration has little impact on the overall environmental impact of the flux from the pit but they do have significant cost differences.	**Noted.**	Yes	Water Quality Prediction Report				
INAC	Sensitivity	17	Assumptions have to be based on the known information that has been confirmed and/or on the best relevant technical knowledge or experience.	**Noted.**	No					
INAC	Risk Assessment	18	Risk assessment of various components (geochemistry, water balance, hydrogeology) not included. (See pg 1-1)	**Noted. A risk assessment will be completed as part of the evaluation process.**	No	Risk Assessment to be conducted by others following finalization of this report.	Just a point of clarity, is there a window of time between the risk assessment and the evaluation process to allow for everyone to digest the results of the risk assessment before proceeding with the evaluation process.	**Yes, at the January 7, 2011 meeting it was agreed that the risk assessment will take place a week prior to the evaluation (MAA).**		
INAC	Materials/sources	19	Gradation and availability of granular construction materials are not indicated; therefore it is uncertain as to whether the costs are reflective of the required materials. Example: Sand diffusion layer indicated in Option 1: is the sand an available material at the site or will it need to be a produced material and imported?	**Noted. Borrow materials used in the current design have been sourced locally and are reflected in the cost estimates. Sand diffusion layer material is readily and abundantly available adjacent to the tailings facility (e.g., same material used to construct the dam)**	No					
INAC	Mill Area	20	It is assumed that no asbestos products are present in the camp and ancillary buildings. Why was this not confirmed as it will affect cost and demolition timelines?	**Can INAC confirm if assessment of asbestos products was included in site assessment work carried out in 1998 under INAC's Waste and Contaminants Project? If it is present, the cost will be common to all options being assessed and does not impact the specifics of this project.**	No					
INAC	Mill Area	21	No systematic assessment of hydrocarbon contaminated soil has been completed to date. Why has this not been confirmed as it will affect cost and demolition timelines?	**Similar to response above. Confirm if hydrocarbon assessment was included in 1998 assessments. AECOM's screening level hydrocarbon assessment of the mill area was negative (2009). If hydrocarbons are present, cost would be common to all options and not impact the specifics of this project.**	No					
INAC	Waste Rock	22	Options 1A and 2A the waste rock will be left in place and that physical stability will be assessed, the piles regraded and revegetated. Why has a preliminary stability analysis not been completed to date? An analysis would better define the scope of reclaiming the waste rock dumps and associated costs for these options.	**Waste rock stability has been assumed to not be an issue. Waste rock piles are relatively small, dry, and have been in place for over ten years without major failure concerns. Regrading is proposed to prevent erosion and allow for revegetation.**	No					
INAC	Option 1/2B	23	Option 1B and 2B place the waste rock back in the pit however the volume of the pit is not indicated in the pit. Will this become a mounded area? What is the volume of the pit?	**Clarification of the pit volume, volume of rock to be placed in the pit and final configuration of the pit in Option 1B and 2B will be provided.**	Yes	Closure Report, as required.				
INAC	Tailings Area Reclamation	24	Options 3 and 4 indicate tailings and contaminated soil will be moved to the pit. What thickness of contaminated soil is expected and what is the remaining soil stratigraphy, as this will affect costs? There are no closure measures for the tailings storage facility outlined in these options which could significantly change the cost of these options. (pg5-89)	**Soil under the tailings was characterized in 5 locations up to 1m depth below the tails-native soil interface. It was assumed that a soil thickness of 15 cm was relocated to the pit (Appendix B - Section 5.3). Quantity of soil excavation has not been included, but will be in the updated costing memo.**	Yes	Costing Memo and Closure Report, as required.				
INAC	Cost	25	Options 1B and 2B cost for backfilling pit with waste rock is only $5, this value seems low compared to other material unit costs. The cost should be around $9-$10 which would make the estimate approximately $2M short; what assumptions were made for the $5/m3?	**Discussed with local contractor. Pelly construction suggested a rate of $2-3/cm. This is a short haul, and would require no special handling. Previous estimate (2009) at $10 was criticized for being too high. We believe that $5/cm is appropriate**	Yes	Costing Memo				
INAC	Cost	26	O&M is estimated for Option 4 but has not been calculated for the other three options. O&M estimates should include specific horizons.	**Was included in AECOM's Geotechnical Report (Section 4.1.1)**	Yes	Costing Memo (as required)				
INAC	Cost	27	C&M cost estimates are not included in the costing for the options.	**See above.**	Yes	Costing Memo (as required)				
INAC	Cost	28	Timeframe of costs.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Yes	Costing Memo				

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INAC	Cost	29	Class D estimate but with a 30% contingency. The contingency should be a part of the estimate and not added onto the estimate as this decreases the accuracy of the Class D estimate.	**Contingency has been added to all options openly and evenly for the parties' consideration.**	No					
INAC	Cost	30	Cost estimates cannot be indicative of total cost of project; additional information and costing will be required for closure plan. Example: 5.2.2.3 Where will the mill material be landfilled?	**Noted. This element will be considered once a Closure Option has been selected and detailed design can be pursued. Material will be land-filled in place. INAC should provide specific feedback on specific costs that have not been included.**	To be determined	NA				
INAC	Cost	31	Report indicates engineering, design or detailed planning is not included in closure cost; however given the complexity of the specific option, these costs could vary greatly. A fixed percentage of total costs or some method should be added to the closure cost option to provide a more meaningful value.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Yes	Costing Memo				
INAC	Cost	32	5.4.2.3 Indicates that numerous ongoing O&M costs are required; however, these are not covered in the estimate.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Yes	Costing Memo	Provided response is unclear and does appear to address the issue.	**O&M costs have been provided per option in the supplemental closure costing memo**		
INAC	Cost	33	5.4.6 Indicates that design engineering, routine inspections and operations and maintenance are expected to be similar for all options this is believed to not be the case. Example: Waste rock in place would likely require more inspections than if the waste rock was moved to the pit.	**Athough not assessed in detail, these varied costs were included in Table 12 (Section 4.1.1) in AECOM's geotechnical report. We agree that actual O & M costs will vary by option.**	Yes	Costing Memo				
INAC	Cost	34	5.5.2.3 Indicates time and amount of maintenance required to stabilize the cover and ensure hydrological characteristics is a significant uncertainty which affects ongoing costs.	**No response required.**	No		Why is no response required?	**The comment provided by LSCFN is noted. Uncertainties associated with the more complex cover on the tailings impoundment are incorporated into the cost estimate, which is substantially higher than Option 1.**		
INAC	Cost	35	Life cycle costs of materials and closure components need to be included in the cost estimates for the options as these have long-term financial implications to both INAC and YG.	**Providing life cycle costs was not included in the original scope. Lifecycle costing would require consensus on assumption for duration of activity and lifespan of individual components.**	No		Explanation is unclear as life cycle costs would be based on the individual project components and be based on best technical knowledge. The life cycle costs would be provided by the consultants and not require consensus. There may be some discussion around the assumptions or reasons for individual life cycle costs similar to current discussions for the individual closure options.	**AECOM has included Net Present Value (NPV) calculations for capital, operations and maintenance costs for all options. Items considered to have a finite life (ie. thermosyphons and provisional water treatment facilities) were included in this calculation. The main elements (ie. dams, fill etc) are considered to have an indefinite lifespan. The operations and maintenance budget allows for repairs to covers, spillways, diversion channels etc.**		
INAC	Cost	36	All associated costs with each option need to be included in the cost estimates, such as: life cycle, C&M, capital costs, interim treatment/reclamation.	**See above for notes on O & M costs and engineering allowances.**	Yes	Costing Memo				
INAC	Cost	37	Detailed engineering/allowance and construction services need to be included. I.e. Based on fixed percentages of reclamation cost of each option.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Yes	Costing Memo	It is assumed that the allowance for engineering services will be backed out of the continency allowance, i.e. the contingency will be reduced proportionally.	**The allowance for engineering has been added as a separate estimate. This estimate may be revised or removed, as deemed appropriate by the parties.**		
LSCFN	Risk Assessment	1	With respect to the third category "3. Risks and Uncertainties of Options," the Lorax Report does not, in my view, provide sufficient characterization to proceed directly with an options evaluation process. The report identifies some uncertainties for each of the closure options and provides some characterization of risks. In general, this appears to have been undertaken within specific disciplines of the options characterization (i.e. geochemical uncertainties, geotechnical uncertainties, water balance uncertainties). As a result, there is not an overall multi-disciplinary risk evaluation. For example, the most critical uncertainties for Tailings-in-Valley options are primarily geotechnical and entail down-side risks. In contrast, the Tailings-in-Pit options are primarily geochemical and the characterization presented provides primarily for up-side risks. A systematic approach is needed to interpret and characterize the risks consistently for all options. The issues of balance and consistency between options will need to be addressed before a	**Noted. Risk Assessment will be part of follow-up work as part of MAA**	No		Lorax proposes that LSCFN's comments related to risk assessment as well as balance and consistency among characterization of options will not be addressed in the revised options characterization because they will be addressed in the risk assessment. While it is reasonable to suggest that the risk assessment needs will be addressed during a subsequent process (as proposed in my January memo) that does not negate the need to provide a balanced characterization of the options. In fact, conducting a functional risk assessment will require that we have a balanced characterization. The discussions during the (conference call) meeting on March 30 (2011) suggest that the final characterization should be revised to address the issues of balance and consistency.	**The revised closure report will endeavor to provide a more balanced comparison of the options, as discussed during the March 30 conference call / meeting. For example, the approach to estimating water quality predictions has been revised to consider uncertainty in a more balanced manor. Uncertainties will remain between the options that can not be resolved at this stage of the evaluation, as the design of the options is conceptual. In an effort to be transparent, key uncertainties have been clearly outlined and presented for the parties to consider in the comparison of the options and for future evaluation (e.g., multi-disciplinary risk evaluation).**		
LSCFN	Land Reclamation	2	The overall approach for re-vegetation of disturbed areas, described in the "Common Element and Supplemental Cost Estimates" is as follows: "The overall conceptual revegetation approach for the Mt. Nansen site is to achieve closure objectives by encouraging natural revegetation through use of appropriate surface preparation methods and locally-sourced materials." The cost estimates assume active re-vegetation for 25% of the disturbed areas and rely on natural recovery for the remaining area. While this approach meets the minimum requirements specified in the Yukon's guidelines for reclamation after exploration projects, it is not consistent with reclamation methods generally applied at closed mines. In my view, a more active approach should be taken for reclamation. Because the reclamation requirements differ for each of the options, changes in general requirements will affect the cost comparison between options. As a result, clarification is needed before proceeding with options evaluation.	**Noted. Costing has been provided with clear application. Reclamation activities and associated costs may be revised as required by the parties.**	No		Lorax does not propose any changes to address questions about the adequacy of the proposed re-vegetation approaches. At the very least, some rationale should be provided for the decision to prepare cost estimates on the basis of minimal re-vegetation activities. Also, any instances where the costing for any option varies from these minimal requirements should be clearly identified so that the differences between options are readily notable.	**The measures suggested are intended to encourage natural succession and self-propagation processes while providing sufficient physical stabilization of surfaces. The technique considers methods such as 'pocket' or 'island' planting, which are frequently used at mine sites. This approach assumes an acceptance that in this environment, natural succession and self-propagation is a many-year process. The costing is nonetheless formatted such that costs for a more a more aggressive approach could be approximated by assuming a higher active revegetation percentage.**		
LSCFN	Land Reclamation	3	From the perspective of consistency among options, it is noteworthy that options that include tailings relocation to the pit include more extensive efforts at re-vegetation. This includes placement of soil materials to support plant growth and active re-vegetation of 100% in some areas and 50% in other areas. No clear rationale is provided for this increased effort for these options and it creates a cost premium. For example, the cost for tailings area land reclamation with the soil cover option is estimated as $120,000 while the cost for valley restoration is estimated as over $1,600,000. Both options will include re-vegetation of a soil surface and establishment of a channel for Dome Creek through the tailings area. These costs appear incongruous and need to be re-evaluated and rationale provided before proceeding with the options evaluation.	**Valley restoration will require substantially more effort and cost than the covering of the tailings surface following upgrade of the dam. A detailed, phased approach to valley restoration is provided in Appendix A of Appendix B-2 (Altura).**	No		Lorax states that the re-vegetation activities for the valley after tailings removal will be much more intensive than for those involved in covering tailings and therefore proposes that LSCFN's comment about inconsistency among options need not be addressed. In my view, this appears to overlook a number of issues associated with covering tailings. Tailings are contaminated material and therefor require greater care in establishing covers. The need for vegetation on such covers is likely more immediate than for valley sands. Infiltration control may be needed for tailings, while it is not for sands. The characterization report should be revised with a clear rationale for why additional re-vegetation effort is needed for the valley, and/or why it is not needed for tailings. This comment is linked to No.2 and illustrates the need for a coordinated approach to evaluating re-vegetation needs – why are specific prescriptions appropriate in certain circumstances.	**For Option 2 and 3, the tailings need to remain saturated. Infiltration control is not a design criteria for these options. Option 4 does require infiltration control and an engineered, synthetic cover has been proposed (this is a revision to the store-release-divert cover originally proposed). Revegetation in the valley has been deemed a higher priority due to the higher value of the riparian area and a more agressive revegetation effort has been applied to protect against erosion. Revegetation costs have been provided per unit area and may be revised as required by the parties.**		

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LSCFN	Dam Stability	4	The "Geotechnical Assessment and Costing of Mt. Nansen Mine Closure Alternatives" (Appendix C) prepared by AECOM, in my view, does not provide adequate information to demonstrate the long-term feasibility of the proposed dam stabilization measures. The stabilization method proposed relies on maintaining permafrost at the location of the shear key. AECOM has identified several other stabilization concepts, but there is no site-specific information to demonstrate that these methods could be used at Mt. Nansen.	**See technical memo provided by AECOM on dam stability (9Dec2010).**	Yes	AECOM Memo (9Dec2010)	Lorax proposes that issues related to demonstrating effectiveness of dam stabilization measures do not need to be addressed because they are already addressed in the December 2010 memo from AECOM. As stated in my January letter and also in comments provided by Mr. Stepanek and Mr. McAlpine, the AECOM memo from December was considered in our previous review. It does not address the comments and therefore should not be considered as an adequate response. These comments require further action.	**A revised memo has been provided by AECOM (May, 2011) to address these comments.**		
LSCFN	Dam Stability	5	The analysis completed by Naviq Consulting (Appendix C-2) confirms that thawed foundations will likely occur in the long-term, especially when considering global warming. I note that the thermal analysis does not consider the effects of water flowing through the area of the proposed shear key, but water flows will be at least equivalent to those currently happening at the site. Unlike the current seepage collection pond for which thermosyphons appear to have been effective for the past decade, the proposed shear key will not (in fact cannot) have a seepage barrier that will eliminate water flow. Water flows through frozen materials will likely result in dramatically higher rates of thaw as they are often a substantial source of heat transfer. As a result, the thermal analysis probably significantly over-predicts the effectiveness of the proposed thermosyphons. Thawing is likely to occur and alternate methods for stabilization should be proposed as the primary mechanism.	**Impacts of seepage were identified as a factor, but current analysis did not consider seepage. This would require additional levels of complexity, beyond the scope and budget of the current work. Future analysis may consider seepage, and consider measures for mitigating the effects of seepage.** **Although beyond the scope of the current analysis, mitigating measures could include channelization of seepage flows and insulation of permafrost.** **Future iterations will consider alternative stabilization methods, and these alternative methods may become the "primary" stabilization mechanism, based on those assessments. It is important to note that we have reasonable confidence that a solution can be found, once more site information is gathered.**	No		Lorax proposes that issues related to the potential impact of seepage flows on the proposed dam stabilization measures are beyond the scope and budget of the current work. If this is the case, then the scope should be revised. AECOM identified this issue in the earlier characterization and it was discussed at a meeting on January 6, 2011. At that time, AECOM proposed some possible solutions for the seepage related issues, proposing some "combination of rock drains and insulation." However, AECOM acknowledged that they were not aware of any instances where such approaches had been implemented. If seepage cannot be managed without overcoming the freezing capabilities of the proposed thermosyphons, then the option proposed will not work. This must be resolved before the option is carried forward for further consideration as a feasible option.	**Seepage through the toe berm has been considered, but design details have not been developed. The concept would include channelization of seepage flows, and insulation of the permafrost from these flows. An allowance has been included in the cost estimates for implementing these measures.**		
LSCFN	Dam Stability	6	Information should be provided to demonstrate performance at Mt. Nansen and effects need to be considered in the options characterization before proceeding with the evaluation process because the changes may affect cost and risks. It may also affect the flow paths for contaminants and related effects on attenuation mechanisms that have been assumed for geochemical analyses. In my view, the approach taken here does not demonstrate the same level of conservativeness in geotechnical design as that for the tailings relocation options.	**The geotechnical considerations are different between in-pit and in-place options. The geotechnical considerations are more significant for the in-place option, but have been approached with industry standard safety factors for performance. Ongoing monitoring and inspection is required for compliance with CDA Guidelines (Options 1, 2 and 3).**	No					
LSCFN	Tailings Beach	7	The information provided in the Lorax Report and its attachments leave some uncertainty about the material that will be used for construction of the tailings beach in the tailings-in-valley options. Various options are discussed including fine tailings, locally available sand, amended coarse tailings. The water quality model assumes the use of fine tailings while the geotechnical assessment proposes use of sand. The proposed option should be clarified and applied consistently for water quality predictions and costing.	**Locally sourced aeolian sand will be used for the tailings beach.**	Yes	Closure Report; Water Quality Model Report	Lorax confirms that sand will be used for the tailings beach. The implications of using sand need to be addressed in the estimates of flow rates and water quality if there are implications.	**These considerations have been evaluated within the Geotechnical Evaluation conducted by AECOM (2-D seepage analysis) and concluded that a substantial change in flow rates is not expected.**		
LSCFN	Tailings Beach	8	The loading model assumes that no water contacts the tailings beach materials, utilizing a runoff coefficient of 1.0. As a result, this material is not considered in load models, though it is potentially acid generating material that may be exposed to oxidizing conditions. Rationale should be provided for not considering this material in load modeling.	**Locally sourced aeolian sand will be used for the tailings beach and will not affect seepage water quality.**	Yes	Closure Report; Water Quality Model Report				
LSCFN	Tailings - Sand Diffusion Layer	9	For Option 1, Lorax proposes a 0.3m sand diffusion-barrier layer and suggests that it will prevent erosion of the tailings by water and/or wind. Some clarification is needed about the effectiveness of this layer in preventing water erosion during high flow events because the entire flow of Dome Creek will be routed through the tailings pond and a thin layer of sand is unlikely to prevent erosion. The geotechnical report suggests that ice in the pond may also damage the sand layer. It is not clear whether additional armouring has been incorporated into costs estimates. Effects of ice also need to be addressed.	**See attached AECOM memo on wave action and re-suspension of material (AECOM, July 2010).** **Inlet and outlet areas of the TMA will require erosion protection (as shown on drawings). Inlet and outlet of TMA will be protected with armouring to reduce potential for erosion. Potential for adhesion and transport of sand from diffusion layer, by ice, will need to be monitored, and may require periodic maintenance.**	Yes	Memo attached (AECOM, Sediment Transport, July 2010)	Lorax proposes that concerns about potential erosion of the sand diffusion layer are addressed by a July 2010 AECOM memo related to wave action. The memo has not been provided to-date so it is not clear whether this memo addresses issues related to both extreme flows and wind. If so, then the content can be reviewed when it is provided. If not, then additional rationale will be needed.	**This memo will be provided. Note that Option 2 may be considered as an alternative.**		
LSCFN	Source Terms for Options 1A and 1B	10	The source terms listed in Table 5.4-7 of the Lorax Report appear to contain some errors. Clarification/corrections should be provided. My review has assumed that source terms stated elsewhere have been applied throughout the Lorax analysis and supporting work.	**This is a transcription error. The diffusive flux terms are not applicable to this option. Further, the open pit (lake and waste rock) should mimic those presented for Option 1 (Table 5.4-7). Corrected Tables will be provided in response memo to replace these incorrect tables.**	Yes					
LSCFN	Options 1 and 2 Source Terms	11	Based on water balance analysis for the tailings area, Lorax has estimated the infiltration through the tailings as 1.7L/s while the flow from the seepage collection pond is estimated as 3.5L/s. This appears to confirm dilution of tailings source water. However, water quality from the seepage collection pond is used directly as tailings source water quality for modeling. Clarification is needed about how these flow rates and source terms were applied within the modeling, and the results of the assumptions.	**Loading to Dome Creek is based on seepage flow rates and water quality measured from the seepage collection pond. These loading rates have been used in the model.**	No					
LSCFN	Waste Rock Reclamation	12	The AECOM geotechnical assessment (Appendix C) proposes that no reclamation is required for existing waste rock areas if left in place. In contrast, for waste rock re-location options, AECOM proposes active re-vegetation of both the relocated waste rock and the exposed area after moving waste rock. No rationale is provided for the different approaches which create a cost premium for waste rock relocation options. More consistent approaches need to be presented and characterized, or a thorough rationale should be provided for the different approaches.	**Resloping and revegetation of existing waste rock surfaces has been included in the closure options, as described in Appendix C-2 (Altura).**	No		Lorax proposes that no additional information is needed about reclamation of waste rock. As noted in the comments provided in January, it is not clear what is proposed for each option and what the associated costs will be. At the very least, consistency and clarity must be addressed in the updated characterization document.	**Proposed waste rock reclamation activities and associated costs will be clearly presented in the updated report.**		

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LSCFN	Long-term Thermosyphon Operation and Maintenance	13	AECOM's geotechnical assessment (Section 2.2.11) does not identify the need for long-term maintenance and operation of thermosyphons or other methods for maintaining frozen conditions at the shear key. It is not clear whether the cost estimates for Options 1 and 2 include such costs. This should be confirmed before the evaluation process begins.	**Annual operating costs for thermosyphons are considered nominal. The life-expectancy of thermosyphons is unknown, and we have not allowed for future replacement costs. If temerature increases do not exceed the performance capabilities of the thermosyphons, then future replacement should be expected.**	Yes	Costing Memo				
LSCFN	AECOM Geotech Evaluation of Option 3	14	First Bullet - AECOM states objectives for Option 3 and these are repeated in the Lorax Report. For Option 3, a key objective appears to be missing – minimizing the long-term geotechnical risks. This is the primary rationale for developing this option and needs to be identified as a key objective.	**Noted.**	Yes	Closure Report				
LSCFN	AECOM Geotech Evaluation of Option 3	15	Second Bullet - The analysis appears to assume that seepage would occur from tension saturated tailings in the pit – laterally into the bedrock and eventually to surrounding groundwater. This is not consistent with my understanding of soil moisture behaviour. If the soil water is held in tension saturation, there is little likelihood that flow would occur into the surrounding bedrock at elevations above the water table. The statements contained in AECOM's geotechnical analysis should be confirmed and adjusted as needed.	**Seepage from tension saturated tailings will flow vertically to the water table, and then laterally out of the pit.**	No		Lorax proposes that concerns about AECOM's analysis of pit options do not need to be revised to address the incorrect characterization of seepage flows out of the pit – noting that seepage from tension saturated areas will flow vertically to the water table and then exit the pit horizontally. While Lorax's characterization of the flow path is correct, the comment provided by LSCFN refers to an assumption by AECOM that flow will occur from the entire area of the pit that is subject to tension saturation – directly through the pit walls. This is simply not the case and the analysis and interpretation must be revised to address this issue.	**This comment is noted. The correct analysis and interpretation has been carried forward in the water balance and water quality model, as described by GEEC. As a result, the analysis and interpretation conducted in support of the options characterization does not require revision.**		
LSCFN	AECOM Geotech Evaluation of Option 3	16	Third Bullet - AECOM appears to assume that a dam constructed in the pit to retain tension saturated tailings would have the same risks, consequence category and maintenance requirements as a dam in the valley. In my view, this is not necessarily the case because the outflow of tailings during any failure would likely be substantially lower if the tailings are not saturated. Also, the facility would not be located in a creek valley and a substantial outflow would be required before any impact on the aquatic environment would occur. Permafrost and foundation conditions are much more favourable at the pit location. Finally, the in-pit dam is not as susceptible to flood events because it is not located in a valley and the current spillway proposal is not located on the dam structure.	**Agreed, there is significantly less risk associated with a dam situated in the pit (Option 3), but it would still be classified as a dam, and would still require regular dam safety reviews. A brief memo (update of Nov 2009 memo) may be warranted to address dam classifications for each option.**	Yes	Update of Nov 2009 Memo (dam classification)				
LSCFN	Tailings Homogeneity for Option 3	17	The Lorax Report and supporting documents highlight the importance of completely homogeneous tailings when placed in the pit, to ensure soil moisture characteristics that will support tension saturation. This is identified as a major uncertainty for this option. In my view, the uncertainty and importance are both overstated, giving the impression that this option is impractical.	**Noted.**	No.		Lorax states that LSCFN's issue about characterization of the uncertainty related to mixing of tailings is "noted." However, they do not propose any restatement of the characterization of the risk in the report. No rationale is provided for noting the comment but not addressing it.	**Modeling has suggested that tailings are susceptible to desaturation due to heterogeneity. As a result, placement of the tailings in the pit will require special management, either through selective placement (e.g., coarse tailings in the pit base and fine tailings at the surface) or enhanced mixing. While the current conceptual design has not clearly defined how the tailings backfill will be managed, there is a moderate degree of confidence that it can be managed effectively.**		
LSCFN	Tailings Homogeneity for Option 3	18	With respect to the uncertainty, given the characteristics of the fine tailings, it appears unlikely that the in-pit tailings deposit would provide conditions for draining of significant portions of tailings as though they were coarse soils. This would require contiguous columns or layers of coarse materials that could act as drains, and these would have to terminate in direct contact with high permeability zones in the bedrock. With some planning and QA/QC during tailings relocation, this type of scenario could be easily avoided. If there are no contiguous columns or layers which terminate adjacent to very permeable materials, significant draining of the tailings mass is unlikely to occur.	**Tailings were thoroughly mixed in the lab and tested for hydraulic conductivity. The results of these tests were used in the flux modeling (Appendix C-3). With this control in the lab, the mixed tailings were susceptible to desaturation. Desaturation may lead to oxidation and development of acidic conditions and enhanced metal leaching.**	No		Lorax notes that tailings in the lab were susceptible to desaturation. The LSCFN comment does not argue that the tailings would not desaturate when the water table is dropped lower and the tension increases. The degree of desaturation relates to the tailings properties as a whole. The comment from LSCFN argues that perfect mixing on the scale of an entire pit will not be the driver in the behavior of the tailings – that they will still behave like they are mixed unless there are contiguous layers or columns of coarse material that provide access to a high flow drainage network. Thus, the comment has not been addressed by the reference to lab testing and needs to be further addressed in balancing the characterization of risks for the various options. The November 2010 presentation presents this as a near-fatal risk for this option while the seepage flow risk is ignored for the dam upgrades. This is not a balanced presentation of potential risks and it must be addressed in the updated characterization.	**The updated closure report will provide a more balanced presentation of the potential risks, as noted.**		
LSCFN	Tailings Homogeneity for Option 3	19	With respect to the importance of the permeability, the analysis completed by Golder concludes that tension saturation may deteriorate, especially in dry conditions. However, Golder's analysis considers only incident precipitation directly on the surface of the pit: not even direct catchment runoff is incorporated. Golder's analysis also predicts that very modest additions of water would support tension saturation, even if the tailings achieve the less conservative permeabilitities (higher permeabilities) shown in test work. Table 1 of Appendix C-3 indicates that addition of approximately 1100m^3/year of water would be sufficient to maintain 85% saturation even in dry years with higher permeability assumptions. The contaminant loading report (Appendix F) indicates that this water would be available from the additional pit catchment area.	**Agreed. Pony Creek diversion structures are included as part of the design for Option 3 as these structures may be required to supplement water needed to maintain tailings saturation.**	No					
LSCFN	Tailings Homogeneity for Option 3	20	Note that the contaminant load modeling report estimates that that 12000m^3 of water would be required to maintain a full water cover at the tailings in the valley. However, this is not identified as a significant uncertainty for in-valley options.	**Noted. The Dome Creek catchment above the current tailings impoundment is substantially larger and different than the pit catchment, which straddles a ridge divide.**	No		Lorax proposes no changes to address questions about the difference between water requirements to maintain a water cover in the valley versus those needed to maintain tension saturation in the pit. The response references the difference in catchment areas between the two areas. However, what is needed is a fair comparison of the catchment areas/inflows versus the anticipated water needs, potentially considering seasonal needs. This should be addressed in the final characterization.	**These comparisons have been made in water balance and water quality model report by GEEC. The comparison will be presented more clearly in the updated options characterization report and the revised water balance and water quality report.**		
LSCFN	Tailings Homogeneity for Option 3	21	It is not consistent for the Lorax Report to specifically identify complex alternate mitigation options for tailings dam stability for Options 1 and 2, while failing to even mention relatively simple mitigative options for maintaining tension saturation for Option 3. The report should be revised to address this inconsistency.	**Explicit language will be added to the closure report that describe alternate mitigation options to maintain tailings saturation for Option 3 (e.g., diversion of Pony Creek, pumping of water)**	Yes	Closure Report				
LSCFN	Option 3 Hydrogeology	22	In the hydrogeology characterization (Appendix E) AECOM states: "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." This statement is not supported by the analysis completed by Golder (Appendix C-3) which indicates that the volume of water required would be quite small. The AECOM statement should be confirmed and adjusted as needed.	**Noted. The evalution conducted by Golder (Appendix C-3) assumed only direct precipitation as an input, as did the overall analysis. Direction of overland flow, or diversion of Pony Creek is merely provided for contingency. More detailed tailings characterization and modeling (e.g., 2-D) may be required at the detailed design and evaluation phase, as required should Option 3 be selected.**	No					

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LSCFN	Geochemical Predictions	23	I have not reviewed geochemical predictions in detail as I understand that Ms. Zamzow will be reviewing this component. However, I am concerned about the consistency of predictions used for the tailings-in-pit versus tailing-in-valley options. While I appreciate that there are different levels of certainty about the information available, I do not agree with the balance of assumptions taken for developing source terms. One example is presented below. For in-pit options, the source terms for both best-estimate and worst-case assume that no attenuation will occur, while for in-valley options, the source terms for both best-estimate and worst-case assume that attenuation will continue as it currently is. Lorax acknowledges uncertainty about both predictions, suggesting that for in-pit options attenuation "can be expected" and that the predictions are "overly conservative and represent maximum possible concentrations." Thus the estimate for in-pit options does not appear to represent a best-estimate. Lorax also identifies uncertainties ab	**Attenuation is occurring in the current tailings impoundment. The mechanisms for these attenuation processes appear to be defined. The mechanism for attenuation within the pit do not appear to be applicable within the pit-bedrock system. Attenuation may occur outside of the bedrock system where GW discharges to surface (e.g., valley floor sediments). A sensitivity analysis will be conducted to evaluate attenuation for all options.**	Yes	Water Quality Prediction Report				
LSCFN	Cover Performance Modeling (Option 4)	24	Based on modeling for Option 4, Golder has estimated that a store-release-divert soil cover could reduce infiltration to less than 1% of total annual precipitation, though typical infiltration rates for this type of cover are 2% to 15%. The water quality model assumes that infiltration is 15%. In the geotechnical report, AECOM states: "The objective of the concept design is to limit this infiltration so that long term groundwater treatment is not required." Given the stated objective, it appears reasonable to assume that significant effort and design would be undertaken to establish an effective cover. Cover infiltration is difficult to predict and I would not support modeling using the 1% value estimated by Golder. On the other hand, given the modeling results and the objective of the proposed option, utilizing the lower end of "typical" performance values appears overly conservative for the "best-estimate" modeling. It may be more realistic to complete best-estimate predictions that assume better performance, and worst-case predictions	**For the purposes of this assessment, a simple cover using locally available materials was designed. The long-term, perpetual performance of this cover (infiltration) was required for closure; however, perpetual performance of any cover design has not previously been demonstrated elsewhere. As a result, a conservative assumption with respect to infiltration was assumed. The infiltration rates proposed for the Faro project are design and performance objectives. Further clarification of the assumed conservative infiltration rate will be provided. In addition, sensitivity analysis will be carried out using a range of practicable and achievable long term infiltration rates.**	Yes	Water Quality Prediction Report				
LSCFN	Cover Performance Modeling (Option 3)	25	Also, the type of cover that will be utilized for tailings in Option 3 needs clarification. It is my understanding that a high permeability cover is required. However, the Lorax Report (S. 5.6.3.1) proposes a cover that is "similar to Option 2" which is a low permeability cover. Also, Appendix C-3 is unclear about what type of cover has been assumed in the analysis, initially identifying a low permeability cover: "Option 3: Relocate the tailings into an on-site abandoned open pit and install a 1-meter thick soil cover over the tailings (the same option described above for the previous phase of the work)." The same report later states: "A 1-meter layer of coarse waste rock was assumed to be placed on top of the tailings for all scenarios." What type of cover is proposed and modeled?	**The proposed and modeled cover for Option 3 has been designed as coarse and durable waste rock. Note, Option 2 does not include a low-permeability cover.**	Yes	Closure Report				
LSCFN	Pit Seepage Rates	26	The load modeling (Appendix F) assumes conservative seepage rates from the pit – 0.1347L/s based on a high estimate of pit permeability. This high seepage rate appears to have a significant influence on downstream predictions of water quality. However there is a substantial range in estimates of bedrock permeability. Also, it is not clear that the tailings in the pit would allow seepage to occur at such rates, as the permeability of tailings is less than that assigned to the pit walls to determine seepage rates. Also, it is not clear that the catchment contains sufficient water to support seepage at these rates. Clarification and additional rationale would be useful.	**Provide more details on the modeling of seepage from the pit for each of the options including assessment of the available water supply to the pit for each option. Where appropriate sensitivity analysis will be carried out using a range of practicable and achievable long term seepage rates from the pit for each option. Note - the flux of water through the tailings in Options 3 and 4 is defined by tailings and the tailings-flux modeling conducted by Golder (Appendix C-3 and C-4).**	yes	Sensitivity Analysis Memo				
LSCFN	Oxide Ore	27	The contaminant loading model assumes that the oxide ore material recently relocated to the pit will be incorporated into the cover material for Option 4. This material will likely lead to some additional contaminant loading from runoff (though perhaps not in the model). The closure method does not appear to be addressed in the Lorax Report. Clarification is needed.	**The Low-Grade Stockpile is incorporated into the wate quality model for each option. For Option 4, it is included in the covered area, with contaminant loading from infiltration through the cover into the pile included in the loading to the downstream receiving environment. Further clarification will be provided in the closure report.**	Yes	Closure Report	In response to concerns about incorporating low-grade ore material as part of the cover in a backfilled pit, Lorax suggests that the loading be incorporated into the modeling. A rationale should also be provided for why this material would be used as part of a cover, and not placed under the cover where effects from loading would be minimized.	**The design cover for Option 4 does cover the backfilled ore to minimize loading from this component, as descibed in the technical report by GEEC. Ore has not been proposed to be used as part of the cover. The revised reports will make this clear.**		
LSCFN	Water Quality Issues - Mill Area	28	The Lorax Report and attachments provides some characterization of conditions in the mill area. Currently, sources in this area are the dominant contaminant loading to Dome Creek. The "Common Element and Supplemental Cost Estimate" prepared by Altura assumes that these sources will be addressed and no treatment will be required. However, the same report provides the description of closure activities for the mill area and does not include measures that are likely to address the water quality issues. Given the current information available, there appears to be significant likelihood that greater efforts will be required to address closure issues in this area. Costs for this are probably common to all options but are likely to be higher than current estimates.	**Noted and agreed that additional work is required to address the closure issues in the mill area. Costs for clean-up of the mill area may be more than the current estimates. This cost will be common to all options being assessed and does not impact the specifics of this project. Additional provisions will be added to account for future characterization of the mill area.**	Yes	Costing Memo				
LSCFN	Water Quality Issues - Mill Area	29	Note that contaminant loading from the mill area is not included in the current contaminant loading model. As a result, the predictions may underestimate the long-term water quality downstream of the site for some parameters.	**Agreed. Note, however, that reclamation of the mill area is assumed to result in long-term improvements to surface water quality. Further, it has been assumed that treatment of water discharging from the mill is not required.**	No					
LSCFN	Analysis of Cadmium Concentrations	30	Section 3.3.1.9 of Appendix B (Geochemical Characterizaton) describes the analysis of cadmium concentrations in the pit. The conclusions are based on cadmium concentrations being below the guideline concentrations. However, the data do not support this. Clarification/correction should be provided and the analysis reconsidered as a result.	**Noted. The data will be reviewed and revised accordingly. Any revisions will not change the analysis or results of the Closure Report.**	Yes	Geochem Report (Appendix B)				

Agency	Area	Tracking #	Comment	Response	To Be Addressed in Revisions	Where Addressed	Second Round of Comments	Second Round Response	Third Round of Comments	Third Round Response
LSCFN	Best-Estimate Saturated Waste Rock Source Terms	31	Clarification should be provided about consistency of the approaches taken for the development of an arsenic source term for saturated waste rock in comparison to the approach taken for in-situ waste rock. For saturated waste rock, the best-estimate source term is the highest recorded arsenic concentration in the pit to date. This approach appears to assume that dilution and/or attenuation mechanisms that are currently functioning in the pit will stop if waste is placed in the pit. No evidence is provided to support this conclusion. In contrast, the best-estimate arsenic source term for in-situ waste rock is the median of data from seeps. However, the seep data could be affected by dilution from groundwater or other sources, and could be experiencing some attenuation that may not be effective in the long-term especially once permafrost thaws.	**Seepage from waste rock that is backfilled into the pit and saturated will likely be different than currently observed seepage quality. This is particularly true for parameters that are sensitive to changes in redox, namely arsenic. As a result, a different approach has been taken to evaluate the As source term in this environment. This approach places more emphasis on pit lake water quality, which may be more representative of pit-bottom redox conditions that will influence As solubility. Note, the amount of As that is readily available to leach from the waste rock is very large. Redox will be the controlling factor that dictates the ultimate concentration of As in flooded waste rock.**	No					
LSCFN	Cost Consistency for Options	32	A consistency check should be completed for costing for the various options. Some examples that warrant consideration include: • Option 3 includes costs for tailings cover maintenance and repair, while Options 1 and 2 do not. The tailings covers are also susceptible to damage with the in-valley options. Potential for damage may be greater in the valley due to continuous water flows. Also, the total cover area is larger for valley options, thus increasing potential maintenance costs.	**For Option 3, maintenance of cover is required because of short-medium term settlement/consolidation of tailings. Tailings in valley are already consolidated.**	Yes	Costing Memo and Closure Report				
LSCFN	Cost Consistency for Options	33	• Only in-pit options include costs for water treatment. The bulk of the cost is capital cost for establishing treatment facilities. All options require some re-grading and relocation of tailings. Also, all options require cleanup in the mill area where current seepage concentrations are high and in some cases exceed effluent limits. As a result, there appears to be a high likelihood that water treatment facilities (capital costs) will be required for all options, though operating costs may be slightly different.	**Considering the re-location of tailings, there is potentially a need for water treatment, and short term treatment should be considered.** **It has been assumed that the mill area does not currently require treatment. Reclamation activities are expected to improve water quality emanating from the mill.**	Yes	Costing Memo and Closure Report	Lorax indicates that water treatment costs will not be part of any options that do not include tailings relocation to the pit. As a result, the options characterization assumes that all other options can be undertaken without any adverse effects on water quality for any water that may require discharge. I believe that this would be challenging and would anticipate that water treatment would be required for other options too.	**See provisional treatment and associated costs memo by Altura.**		
LSCFN	Cost Consistency for Options	34	• Option 3 includes a cost for relocation of dam fill materials to borrow areas. What is the purpose of this activity which appears to create a cost premium?	**For Options 3 and 4, 1/2 of the dam fill is relocated to borrow (adjacent to the impoundment) at a reduced cost relative to relocation to the pit (Appendix D of Appendix C-1 (Geotech and Costing)). Original designs did not remove, regrade, or restore the dam fill.**	No		Lorax clarifies that tailings relocation options include costs for relocation of all dam material with some of the material relocated to nearby borrow areas instead of the pit. Regardless, this remains a costly undertaking and it is unclear why all dam fill would require relocation. Rationale should be provided.	**Dam fill has been relocated an removed from the watercourse to reduce ongoing site maintenace (erosion control) and in an effort to reclaim the landscape to its natural landform. Half of the dam fill is proposed to be relocated to a borrow area adjacent to the dam and half to the pit (due to potential contamination). These costs may be removed from the estimate, as deemed necessary by the parties.**		
GY	Cover Memo	1	Assumption rationale and references from technical reports	**Noted. Closure Report will be updated as requested**	Yes	Updated Closure Report				
GY	Cover Memo	2	More specific reference notation needed (sub-section)	**Noted. Closure Report will be updated as requested**	Yes	Updated Closure Report				
GY	Cover Memo	3	Inconsistency in cost estimates reported in Closure Report from those reported in technical reports	**Costing has been provided by AECOM (Appendix C-1) and Altura (Appendix C-2). Where overlap exists, specific reference will be provided. In the specific case of pit safety, costs estimated by Altura were carried forward in the Closure Report.**	Yes	Updated Closure Report				
GY	Into Sections 1 to 4	4	General comments on process, language, objectives, etc.	**Report will be revised as suggested from comments and track changes**	Yes	Updated Closure Report				
GY	Approach	5	F(8): To what degree would such an assessment affect the evaluation of options?	**An effects assessment would not likely change the outcome of the Closure Report. It might put into context the residual risk to water quality from the various options. This evaluation will likely be conducted during the risk assessment stage.**	Yes	Risk Assessment; incorporation into Closure Report				
GY	Mill Area	6	F(9): What is the load contributed by this seep? This causes some concern when its significance is not stated. Will it require remediation or mere long term monitoring?	**This seep is not well defined, nor is the load. More detailed characterization is required.**	No					
GY	Mill Area	7	F(10):Are these loads greater than the waste rock and pit water contributions? Are they likely to increase or decrease over time?	**The mill area is not well defined, so it is difficult to state how loads will change in the future. In general, mine waste and disturbances do not appear to be potentially acid generating. As a result, loads are more likely to remain constant or diminish over time.**	No					
GY	Mill Area	8	F(11): Is this an assumption or an uncertainty?	**Language will be revised. These are assumptions.**	Yes	Closure Report				
GY	Option 1	9	Is the 0.3 m sand diffusion-barrier layer fine or coarse	**The diffusion sand is the locally available Aeolian sand (med to fine) which was used to construct the dam**	Yes	Updated Closure Report				
GY	Dam Stability	10	We need to consider what mitigations would be required if the climate warms to the extent that the shear key thaws and what those mitigations might cost. This will be considered a residual risk.	**See previously provided technical memo from AECOM on dam stability (9Dec2010).**	Yes	AECOM Memo (9Dec2010)				
GY	Dam Stability	11	AECOM's memo, issued in December will need to be incorporated or included in some manner, possibly within the appendices.	**Include the information provided in AECOM's memo dated December 9, 2010 (Additional concepts for long-term stabilization of Mt. Nansen Tailings Dam) in the updated closure report. This will include costing aspects as well.**	Yes	Closure Report				
GY	Dam Stability	12	This calculation (mean temperature rise) may be inadequate since it does not consider any acceleration of warming but assumes a linear increase consistent with that of the previous 40 years.	**Provide rational on the appropriateness of the assumptions used for estimating the annual temperature rise rate for future climate warming for the site. If necessary provide examples of other rates used for similar assessments in the Yukon to support the assumptions adopted for this assessment.**	Yes	Closure Report				
GY	Dam Stability	13	We need to have a cost for alternative approaches that will be used for ground freezing for this as it is a residual risk.	**No alternative feasible methods of ground freezing have been identified.**	Yes	Costing Memo				
GY	Option 1	14	Is there a mitigation for the uncertainty related to the long-term integrity of the sand diffusion layer and, if so, does it have a cost?	**See attached AECOM memo on wave action and re-suspension of material (AECOM, July 2010).** **Inlet and outlet areas of the TMA will require erosion protection (as shown on drawings)** **Inlet and outlet of TMA will be protected with armouring to reduce potential for erosion.** **Potential for adhesion and transport of sand from diffusion layer, by ice, will need to be monitored, and may require periodic maintenance.** **An alternative design is provided by Option 2.**	Yes	Updated Report Costing Memo				
GY	Option 1	15	Replacement of coarse zone with fine tailngs in Option 1. Is this possible without dewatering most of the tailings. Dewatering the tailings is likely to produce water which would require treatment prior to discharge unless some storage facility could be found. There are no costs for water treatment listed for this option.	**It has been assumed that mitigation of the beach (coarse tailings) will be possible without dewatering and subsequent treatment. Previous relocation of tailings from the beach area has suggested this is reasonable.**	No					

Agency	Area	Tracking #	Comment	Response	To Be Addressed in Revisions	Where Addressed	Second Round of Comments	Second Round Response	Third Round of Comments	Third Round Response
GY	Geochemistry	16	Section 5.4.4.1 Acid base accounting and laboratory-based kinetic experiments indicate that the tailings are potentially acid generating. In other words, acidic drainages and associated metal leaching are likely to develop if the tailings are exposed to oxygen over extensive periods of time. Please be more specific.	**Clarification will be provided.**	Yes	Closure Report				
GY	Geochemistry	17	It would be helpful to explain what these terms mean and why they were chosen (Conservative Best Estimate and Worst Case). These terms show up again in 5.4.5.1 without definition.	**Noted. We will consider revising "worst case" terminology to "upper estimate".**	Yes	Closure Report				
GY	Water Treatment	18	Is it likely that there will be additional chemical loading to Dome Creek during or immediately after waste rock removal or recontouring which may require water treatment?	**The waste rock is unsaturated and is not expected to release substantially different volumes/loads of contaminants during relocation or regrading.**	No					
GY	Model Assumptions	19	Where possible, rationale should be provided for the model assumptions.	**Rational behind model assumptions are provided in detail in the supporting model document. Review model assumptions and ensure adequate rational is provided to support assumption.**	Yes	Water Quality Prediction Report				
GY	Water Quality	20	Why are predicted maximum arsenic concentrations for Options 1 less than winter maximum? See bullet two on p. 5-58	**Provide a more detailed discussion of how the predicted results compare to existing water quality data.**	Yes	Closure Report and Water Quality Model Report				
GY	Water Treatment	21	Does the replacement of coarse tails with fine tails require dewatering of the tails, in which case water treatment may be required? This also applies to option 1B.	**It has been assumed that mitigation of the beach (coarse tailings) will be possible without dewatering and subsequent treatment. Previous relocation of tailings from the beach area has suggested this is reasonable.**	No					
GY	Option 2	22	Has uptake of contaminants into plants and their possible ingestion by animals been considered when developing the conceptual plan for the tailings cover in Option 2? Will the cover be adequate to withstand traffic by large ungulates?	**Plant uptake has not been evaluated. This will presumably be evaluated as part of the detailed design, effects assessment and YESAA Project Proposal. Detailed cover design (e.g., ungulate traffic consideration) will be implemented at the design stage. Minor changes will not affect the option evaluation of associated costs.**	No					
GY	Geochemistry	23	Section 5.5.4.3 there is also significant uncertainty associated with the representativeness of the field bin data collected to date in support of long-term drainage predictions for the saturated waste rock and unsaturated ore. Please be more specific.	**Clarification will be provided.**	Yes	Closure Report				
GY	Option 2	24	As in options 1, 1A, replacement of coarse tails with fine may require dewatering. 'if storage is not available then treatment prior to discharge may be required. No cost is included here. This would also apply to 2B	**It has been assumed that mitigation of the beach (coarse tailings) will be possible without dewatering and subsequent treatment. Previous relocation of tailings from the beach area has suggested this is reasonable.**	No					
GY	Option 3	25	There is no costing of the spillway or the Pony Creek inflow diversion for Option 3	**Costing for these features has been included in Table 5.6-5 and in the costing evaluation by AECOM (Appendix D of Appendix C-1).**	No					
GY	Option 4	26	It is unclear where topsoil required for Option 4 will be found nearby the site. It may form an additional cost.	**Sources of growth and borrow material will be reviewed and provided; ensure cost of excavation, transport and placement in included in the costing.**	Yes	Costing Memo (as required)				
GY	Water Treatment	27	There is no cost estimate for this contingency pumping from the covered pit discussed for Option 4 although it may significantly increase long term maintenance cost.	**Clarification on interim water treatment activities during and after closure implementation for each of the options will be provided. It was assumed water treatment would be required in the short term during primary consolidation. Updated costs will be provided, as required.**	Yes	Costing Memo (as required)				
GY	Geotechnical	28					There is an element which may affect the stability of the frozen ground under the new proposed toe berm for the Mt. Nansen dam. The seepage pond currently collects most of the seepage flowing under the dam and redirects this seepage to the surface waters of Dome Creek. Once the seepage pond is covered there seems to be no consideration of where the seepage flows will go or what impact they may have on the permafrost or the frozen key. (Comment provided separately by e-mail on 9May2011 in response to Ground Improvement Memo by AECOM)	**Seepage through the toe berm has been considered, but design details have not been developed. The concept would include channelization of seepage flows, and insulation of the permafrost from these flows. An allowance has been included in the cost estimates for implementing these measures.**		
LSCFN (CSP^2)	Tailings Geochem	1	Pg1, Paragraph2	**Weekly to bi-monthly data have been collected since 2005 and demonstrated that As attenuation has been steadily occurring through a range of flows and temperatures for a substantial period of time.**	No					
LSCFN (CSP^2)	Tailings Geochem	2	Pg1, Paragraph3 (Hydrologic Balance)	**Movement of seepage from the tailings mass (porewater) must pass through the underlying soils and/or the dam. Dam reclamation will not alter these pathways.**	No		In response to concerns about altered flow paths that may change the effectiveness of attenuation mechanisms, Lorax argues that no further characterization or explanation is needed in the final report because water will always pass through organic layers. Note that passing through may not be the same as travelling horizontally along. Also, some areas under the dam may be void of organics, making horizontal travel even more important. This could be changed by melting permafrost.	**For contingency purposes, a constructed, passive, porous, attenuation barrier has been proposed. The concept and cost estimate for this design is described in a provisional treatment memo provided by Altura.**		
LSCFN (CSP^2)	Tailings Geochem	3	Pg1, Paragraph3, bullet a)	**The tailings impoundment has been flooded in the past and is frequently flooded seasonally during spring freshet. Short-circuiting effects on seepage water quality have not been observed.**	No		Lorax references previous incidents of seasonal flooding as rationale for not addressing concerns raised about potential effects of seasonally high water levels on seepage water quality. Note that sustained water levels as high as those proposed for ongoing operation for options 1 and 2 have not been experienced since water quality reached acceptable contaminant concentrations. As a result, the data available do not necessarily reflect conditions that could arise with the proposed closure options. Risks are still possible and should be identified in the final characterization.	**Risks associated with an increased water elevation (Option 1/2) will be identified and discussed in the revised characterization report.**		
LSCFN (CSP^2)	Tailings Geochem	4	Pg1, Paragraph3, bullet b)	**This is a valid concern, however tailings porewater would have to pass through the organic layer in order to travel beneath it.**	No					
LSCFN (CSP^2)	Tailings Geochem	5	Pg2, first bullet	**Agreed. There are many unknowns, and our investigations have not characterized all aspects of As attenuation processes. Long-term, monthly monitoring data (5 yrs) suggest that As attenuation is stable and performs well under a wide range of conditions (temp, flow, pond height, etc).**	Yes	Water Quality Prediction Report				
LSCFN (CSP^2)	Tailings Geochem	6	Pg2, second bullet	**Noted. Winter WQ results have indicated that As attenuation is occurring throughout cold winter months; gradients through the impoundment are not expected to change substantially. Further, elevated pond height in past and seasonally does not appear to affect As stability.**	Yes	Water Quality Prediction Report				
LSCFN (CSP^2)	Tailings Geochem	7	Pg2, last paragraph	**Noted. However this is not a biological treatment system.**	No		In response to CSP^2 concerns about clogging of systems that rely on sulphate reduction bacteria for contaminant removal, Lorax implies that the materials beneath the Mt. Nansen tailings are not susceptible because it is not a biological treatment system. However, in this case, it is my understanding that the materials are being asked to perform as a treatment system so the issue needs to be addressed.	**For contingency purposes, a constructed, passive, porous, attenuation barrier has been proposed. The concept and cost estimate for this design is described in a provisional treatment memo provided by Altura.**		
LSCFN (CSP^2)	Tailings Geochem	8	Pg3, first bullet	**Agreed, however previous disturbances (mounding, excavation, and trenching of tailings, including unsaturated beach tails) have not shown noticeable effects to tailings pond or seepage collection pond water quality.**	No					
LSCFN (CSP^2)	Tailings Geochem	9	Pg3, second bullet	**Agreed, however these processes have not been observed when the tailings impoundment was flooded in the past or seasonally following freshet.**	Yes	Water Quality Prediction Report				
LSCFN (CSP^2)	Tailings Geochem	10	Pg3, third bullet	**The beach will be constructed of med/fine aeolian sand (same material used to construct the dam)**	No					

Agency	Area	Tracking #	Comment	Response	To Be Addressed in Revisions	Where Addressed	Second Round of Comments	Second Round Response	Third Round of Comments	Third Round Response
LSCFN (CSP^2)	Tailings Geochem	11	Pg3, fourth bullet	**Noted, however a passive wetland would likely preclude the need for a water treatment plant (as stated in the following paragraph).**	No		Lorax appears to accept CSP^2's concern about the need for contingency treatment mechanisms, but does not propose to revise the characterization report. The acknowledgement should be reflected in the report and addressed in costing.	**For contingency purposes, a constructed, passive, porous, attenuation barrier has been proposed. The concept and cost estimate for this design is described in a provisional treatment memo provided by Altura.**		
LSCFN (CSP^2)	Tailings Geochem	12	Pg3, pit disposal, bullet 1)	**It has been assumed that Pony Creek will not be a conduit for flow or contaminants; thoroughly mixing tailings with a finite source of organic material can not be achieved with a high degree of certainty.**	No					
LSCFN (CSP^2)	Tailings Geochem	13	Pg3, pit disposal, bullet 2)	**Agreed. The anticipated flux of contaminants out of the pit is very low.**	Yes	Water Quality Prediction Report	Lorax's response to CSP^2's comments about the need for balance among characterization of options indicates that this can be addressed by sensitivity analysis. As discussed at the meeting on March 30, sensitivity analysis is only one component of addressing the balance issues. In some cases, changes to the described options characterization may be needed to address outcomes arising from sensitivity analysis or other re-characterizations.	**The updated closure report will provide a more balanced presentation of the potential risks, as noted.**		
LSCFN (CSP^2)	Tailings Geochem	14	Pg3, pit disposal, bullet 3)	**Noted, however the passive collection and management of fracture-controlled groundwater can not be achieved with a high degree of certainty.**	No					
LSCFN (CSP^2)	Tailings Geochem	15	Pg3, last paragraph	**Long-term water quality estimates have been made for the various options to assist in the development of a closure plan. A sensitivity analysis will be conducted for the various options with input from stakeholders.**	Yes	Water Quality Prediction Report				
LSCFN (R Moar)	Tailings Relocation	1	Email (16May2011) I haven't read this version yet. One thing I noticed before was that the budget for relocating the tailings was by dredging slurry and I thought that we already decided and confirmed with a contractor that moving the tailings in the winter by truck and excavator was a whole lot cheaper.	**In the early stages of this project development, it was assumed that the tailings could be relocated in winter for all options. Option 3 now requires that coarse and fine tailings need to be blended to achieve necessary hydraulic conductivity to maintain saturation. Based on discussions with an experienced contractor, it was concluded that blending and transporting the tailings could be done most economically and practically through dredging and mixing in-pipe, en route to the pit. This method has been used in the cost estimate for Option 3. Transporting the tailings in winter by truck remains the preferred method for Option 4. If either Option 3 or 4 are selected, it may be advantageous to allow the successful bidder to determine the most appropriate relocation method for the tailings, based on some performance criteria.**	No					
LSCFN (HFM - Geotch May2011)	Dam Stability	1							**Comments provided by HFM emphasis uncertainty in dam stabilization measures and opined that proposed freezing methods will not meet long-term dam performance expectations.**	**See revised Ground Improvement Memo (AECOM, July2011)**
LSCFN (HFM - Cost Estimate Jun2011)	Cost Estimate	1							**Comments provided by HFM raise concerns with costing estimates for engineering and design do not adequately consider complexity of the work.**	**Detailed cost estimates have been provided for the purposes of evaluating and comparing the options and are consistent with the conceptual level of design. Once an options is selected, then a refined cost estimate will be developed based on detailed design.**
LSCFN (B Slater memo 20Jun2011)	Geotech	1							**Conveyance of seepage water for dam upgrade options - request additional design and consideration for seepage management while maintaining permafrost**	**See revised Ground Improvement Memo (AECOM, July2011)**
LSCFN (B Slater memo 20Jun2011)	Costing and Tailings Relocation	2							**Costing and Methodology for Tailngs Relocation - rational for talings relocation methods and associated cost estimates**	**See Tailings Relocation Memo (AECOM, July2011)**
LSCFN (B Slater memo 20Jun2011)	Costing Methodology	3							**Costing of Ongoing Operation, Maintenance, and Monitoring (Use 4% NPV)**	**The choice of the discount rate in net present value calculations is a function of several factors, including the forecasted return on investment and inflation. AECOM has chosen to use an annual discount rate of 4%. This value has been used by AECOM and others for similar assessments in the past. The value of 4% is similar to the 3.5% discount rate that is used in British Columbia as directed by the Supreme Court of British Columbia (pursuant to section 56 of the Law and Equity Act). For a project such as this, with replacement and maintenance costs that may extend to perpetuity, it is not reasonable to calculate a discount rate based on short term economic conditions, and historical rates should be considered. The long term costs for all options have been calculated using the same discount rate, and are therefore comparable.**

Appendix B: Geochemical Characterization (Lorax)

Yukon

Mt. Nansen Mine

Geochemical Assessment in Support of Evaluating Closure Plan Options

Prepared for:
Assessment and Abandoned Mines Branch,
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Government of Yukon

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July 2011

LORAX ENVIRONMENTAL

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1. Introduction

The Mount Nansen Mine (Mt. Nansen) is a former gold and silver mine located in Central Yukon, approximately 60 km west of Carmacks (Figure 1-1). Oxide and sulfide ores were mined from the Brown-McDade Pit between 1996 and 1999, producing arsenic and cyanide-bearing tailings, which are currently stored in an impoundment within the Dome Creek watershed, down-gradient of the mill. Additional mine materials remaining on site include waste rock, which is currently stored in a stockpile located immediately west of the Brown-McDade pit and ore, with which the Brown-McDade pit ramp was backfilled in early 2009. The site was abandoned by the owner in 1999 with inadequate funding to implement an environmentally-responsible mine closure plan or the requisite post-closure monitoring program. Mt Nansen is now classified as an Abandoned Type II site under the care of the Government of Yukon (GY). An image of the current state of the Mt Nansen Mine site is shown in Figure 1-2.

Numerous environmental studies have been undertaken at the site under the guidance of Indian and Northern Affairs Canada (INAC) Water Resources (1999-2003) and GY (2003 to present) in an effort to manage environmental risks and develop a rehabilitation plan for the site. The results of these studies have advanced understanding of site environmental conditions, key physical and geochemical processes and challenges related to mine site reclamation and closure, which have in turn assisted in identifying the major environmental liabilities that exist at Mt. Nansen.

Numerous parties and local communities are involved in the remediation and closure of Mt. Nansen, which is within the traditional territory of the Little Salmon Carmacks First Nation. Currently, the Assessment and Abandoned Mines Branch of the Department of Energy, Mines and Resources (EMR AAMB) of GY is implementing a process to evaluate and develop a closure plan for the Mt. Nansen site. EMR AAMB published a report entitled: *"Options for Closure of Mt. Nansen Mine"* (GY, 2008), which provides an overview of viable early closure options being considered for Mt. Nansen.

Figure 1-1: Mt. Nansen Site Location Map

Figure 1-2: Rendered Image Showing the Current Mt. Nansen Mine Site

EMR AAMB commissioned Lorax Environmental Services Limited (Lorax) to conduct an investigation of mine materials at Mt. Nansen with the ultimate objective of developing scientifically-defendable chemistry source term estimates for drainages from geologic materials that will require storage at closure. In order to achieve the objectives of this investigation, representative samples of tailings, waste rock and ore were collected during two site visits (April and July 2009). These samples underwent bulk characterization analyses and results were subsequently compared to historical data to determine how well they represent materials present at site. Laboratory (humidity cells) and field kinetic test programs (field weathering bins and saturated columns) were developed for each mine waste type to mimic different closure storage option conditions. Groundwater wells were installed in July 2009 and were subsequently sampled on three occasions over a one-year period: July, 2009; September, 2009; and, July, 2010. These data provide an insight into current, in-situ geochemical processes dictating the fate and transport of potential contaminants. The data collected from these experiments and

monitoring programs was used to derive realistic chemistry source term estimates for the various mine features at Mt. Nansen under different closure storage options.

This report provides a description of the methodology and the detailed geochemical dataset from which source terms for the various mine features under investigation were estimated. These source terms constitute a key input to the water quality model used to evaluate various closure options under investigation (GEEC, 2010).

The design of the geochemical characterization study and approach taken for determining source terms associated with mine features at Mt. Nansen were developed in view of the following short-list of closure options, as defined in the Mount Nansen Closure Plan Options Evaluation (Lorax, 2010):

- Option 1A – Tailings dam upgrade with water cover, waste rock in place, open pit lake (Drawing 1);
- Option 1B – same as option 1A with waste rock relocation into the open pit, covering the pit lake (Drawing 1);
- Option 2A – Tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake (Drawing 2);
- Option 2B – same as option 2A with waste rock relocation into the open pit, covering the pit lake (Drawing 2);
- Option 3 – tailings backfill into open pit (covering the pit lake) with high infiltration cover, waste rock in place, Dome Creek reclaimed (Drawing 3);
- Option 4 – tailings and waste rock backfill into pit (covering pit lake) with low infiltration cover, Dome Creek reclaimed (Drawing 4).

Figure 1-3 shows images depicting how the mine site will appear under each of these options.

Following this introduction, Chapter 2 includes a discussion of field methods, including sample selection, test procedures and analytical methods utilized in the present study. A description of the salient characteristics of the Brown-McDade open pit is provided in Chapter 3. Chapter 4 provides a description of the solid phase geochemistry, drainage quality and source term estimations for the Mt. Nansen waste rock and ore. Geochemical characterization of the Mt. Nansen tailings solids, associated water quality and derivation of source terms for the tailings is described in Chapter 5. Chapter 6 provides a description of the mill site as it pertains to the present study. The most salient findings of the present geochemical characterization study and recommendations for closure of Mt. Nansen are provided in Chapter 7.

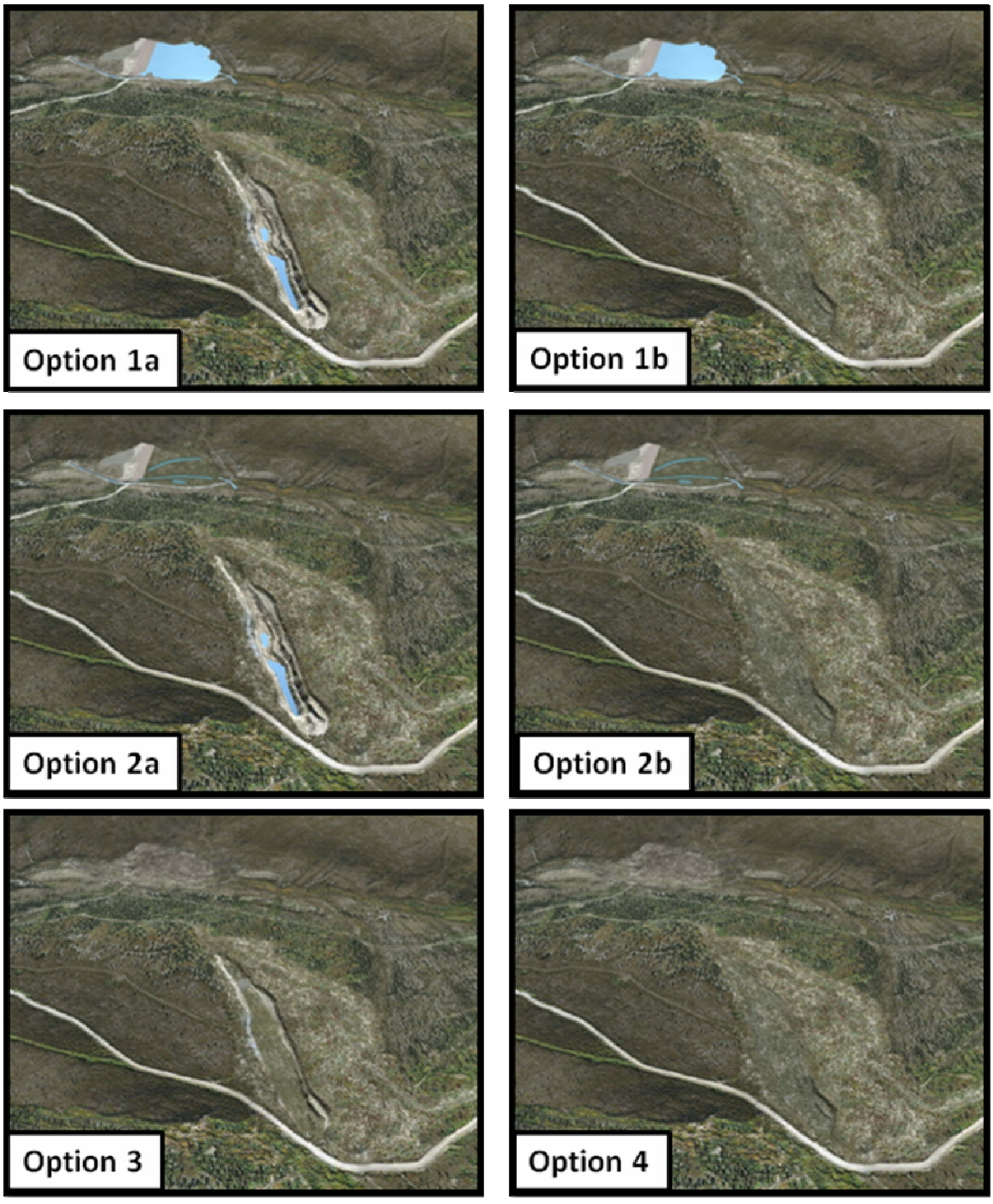

Figure 1-3: Rendered Images Depicting the Mt. Nansen Closure Options

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CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT GRADED TO FIT NATURAL TOPOGRAPHY
REMOVE BRIDGE
SPILLWAY CONTROL
ACCESS ROAD
FORD CROSSING
ACCESS ROAD
DOME CREEK
PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET
ACCESS ROAD
RECONSTRUCT EMERGENCY SPILLWAY
ENTRANCE CHANNEL
DIVERSION CHANNEL
DROP STRUCTURE (TYP)
APRON
BORROW AREA TO BE RE-VEGETATED
ARMOURED DRAINAGE SWALES
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
ACCESS ROAD
NORTH TERRACE
PLACE ADDITIONAL ARMOURING AS REQUIRED
CREEK CHANNEL
CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT REMOVED TO FIT NATURAL TOPOGRAPHY
ROCK FILL TOE BERM 7% SLOPE
END OF DIVERSION CHANNEL
DRY CHANNEL
ARMOURED DRAINAGE SWALES
ROCK FILL TOE BERM 10% SLOPE
ZONE OF GROUND FREEZING WITH THERMOSYPHONS
DOME CREEK
DRAINAGE DITCH
SEEPAGE
SEEPAGE
SEEPAGE
CREEK

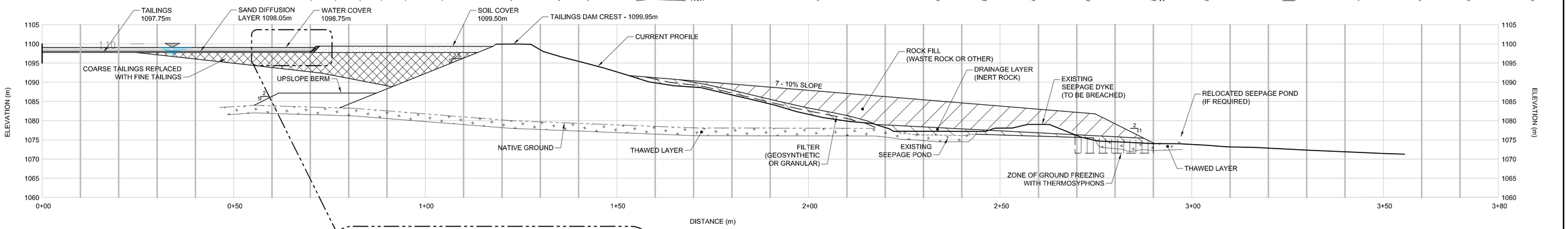
MOUNT NANSEN

0 12.5 25 37.5 m

LEGEND

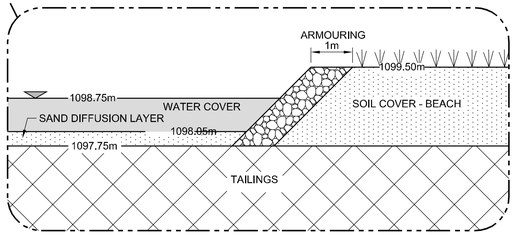
SURVEY BENCH MARK

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



PROFILE A -

0 5 10 15 m



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Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 1
Site Plan & Profile
Drawing - 01

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

ACCESS ROAD

SPILLWAY CONTROL

REMOVE BRIDGE

DOME CREEK

PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET

ACCESS ROAD

ACCESS ROAD

RECONSTRUCT EMERGENCY SPILLWAY

ENTRANCE CHANNEL

APRON

DROP STRUCTURE (TYP)

#1 #2 #3 #4 #5 #6 #7 #8 #9 #10 #11 #12 #13

PRIMARY DRAINAGE SWALE

ARMOURED DRAINAGE SWALES

CREEK CHANNEL

DRY CHANNEL

REGRADED TAILINGS AREA:
TAILINGS ELEV. 1097.75m
SOIL COVER ELEV. ±1098.75m
WATER COVER ELEV. ±1098.90m
SPILLWAY ELEV. 1098.90m
SOIL COVER AREA 6.0ha

SOIL COVER BEACH
AREA 1.26ha
ELEV. 1099.65m

TAILINGS DAM CREST

NORTH TERRACE

ROCK FILL TOE BERM 7% SLOPE

ROCK FILL TOE BERM 10% SLOPE

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

DRY CHANNEL

SWALE

ARMOURED DRAINAGE SWALES

SEEPAGE

SEEPAGE

SEEPAGE

CREEK

END OF DIVERSION CHANNEL

DOME CREEK

ZONE OF GROUND FREEZING WITH THERMOSYPHONS

DRAINAGE DITCH

1095 1092.5 1090 1087.5 1085 1082.5 1080 1077.5 1075 1105 1102.5 1100 1097.5 1115 1112.5 1110 1107.5 1120 1117.5

0 000

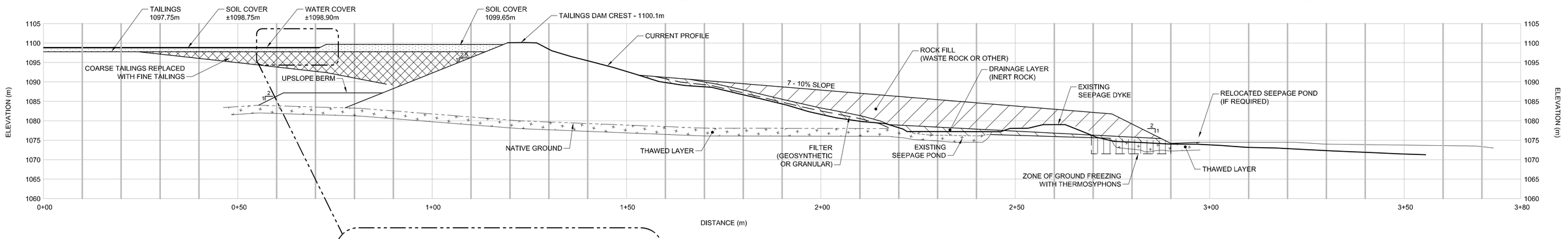
MOUNT NANSEN

0 12.5 25 37.5 m

LEGEND

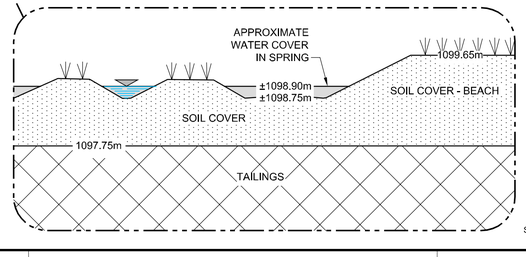
SURVEY BENCH MARK

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



PROFILE A

0 5 10 15 m



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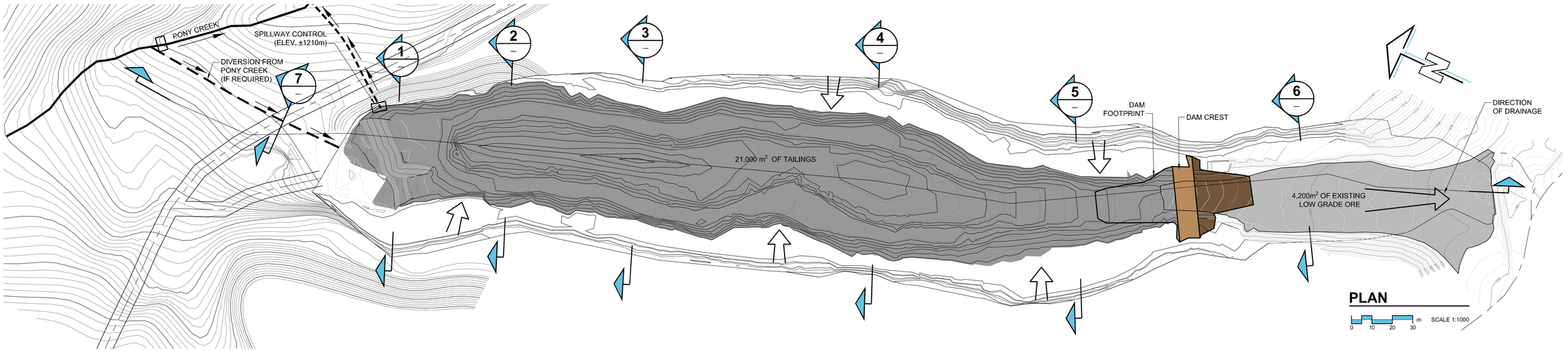
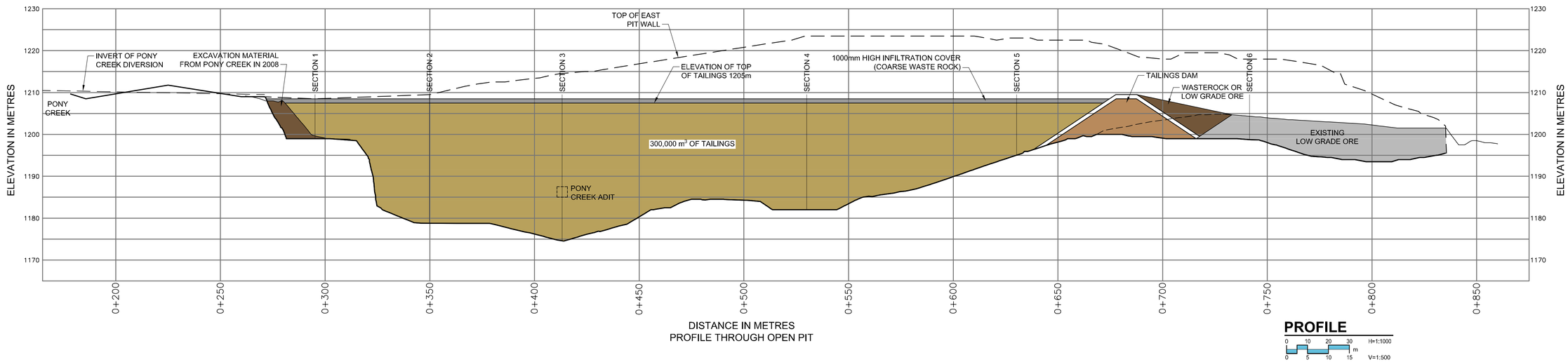
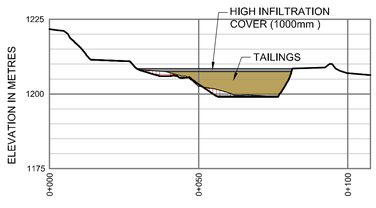
Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 2
Site Plan & Profile
Drawing 02







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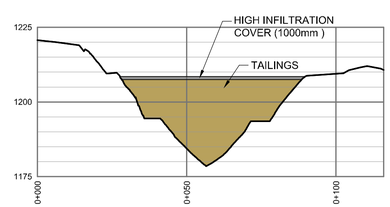

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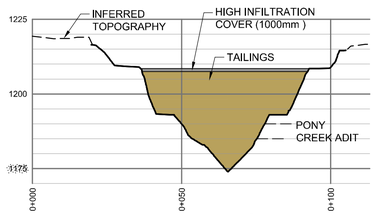

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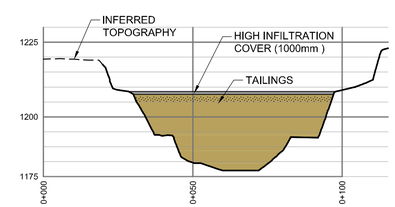

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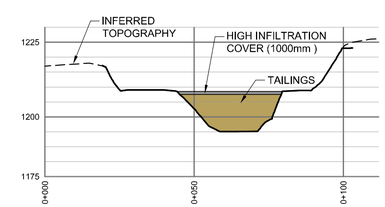

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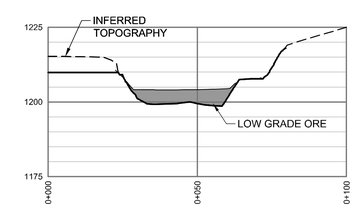

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Government of Yukon
Mt. Nansen Closure Alternatives Characterization

AECOM

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

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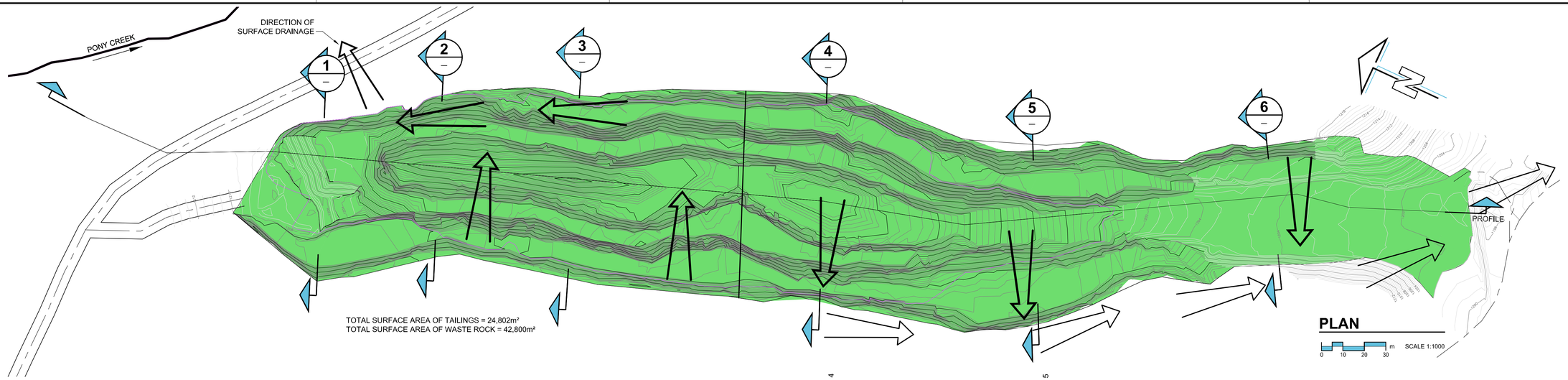

PLAN

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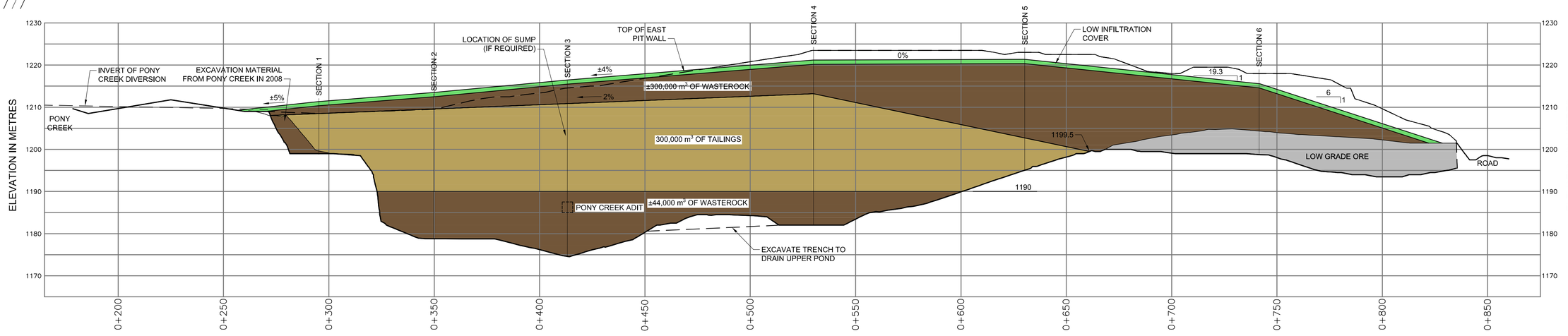

DISTANCE IN METRES
PROFILE THROUGH OPEN PIT

PROFILE

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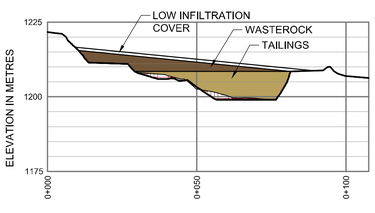

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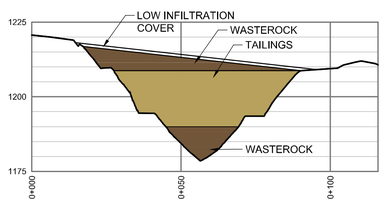

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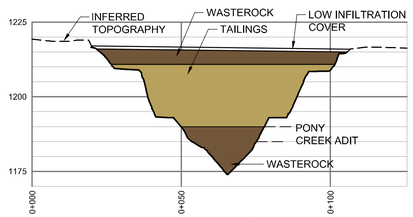

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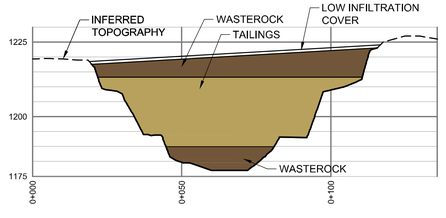

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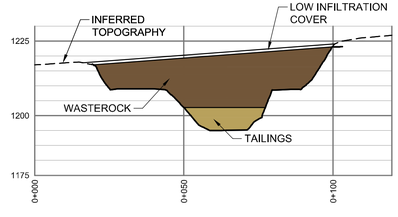

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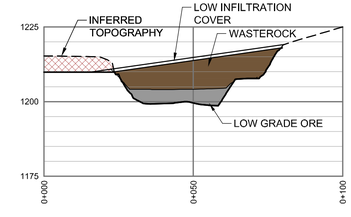

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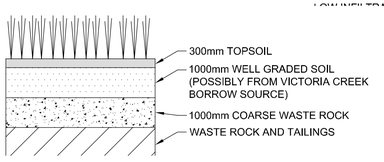

COVER

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Government of Yukon
Mt. Nansen Closure Alternatives Characterization

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

2. Geochemical Characterization Tests and Study Methodology

The data acquisition component of the geochemical characterization program involved the collection of tailings, waste rock and ore material for bulk geochemical characterization as well as the establishment of field- and laboratory-based test work to obtain estimates of drainage chemistry from mine materials under various storage conditions being investigated. In addition, groundwater wells were installed in the tailings impoundment, within the dam and around the seepage collection pond. Groundwater samples were collected from these wells on three separate occasions over a one-year period (mid-2009 to mid-2010). The rationale used in sample selection, the methods used in the design of the geochemical characterization tests and the analytical methods used are described in the following sections. Section 2.5 presents a summary of the historic and recent external data sources that are referenced and discussed in this report and which have contributed to the overall geochemical characterization of the site and development of source term estimates.

2.1 Sample Selection

2.1.1 Pit Wall Rock

Sampling along several benches of the pit wall was conducted in late July of 2009 and 14 samples were selected for static testing. In most cases, samples were composites over intervals of several tens of meters in order to obtain average-condition values. The geochemical samples taken from the pit were collected using a rock hammer to loosen and extract the sample and then hand-loaded into the sample bag. Samples were then double-bagged in heavy duty clear plastic sample bags.

During the 2009 pit sampling program, secondary mineral products were sampled for mineralogical investigations. The samples were collected from a small talus fan of highly weathered and sulfidic material at the lower east wall of the pit. It should be noted that the area sampled represented an anomalously thick and concentrated accumulation of secondary mineral products.

Also incorporated in the geochemical characterization of the Brown-McDade pit wall rock are historic samples, including: 1) 13 rock samples collected from the oxide zone of the pit during operations in November of 1996; and, 2) six rock samples collected from the lower wall and pit floor in 1999 (post-operations).

2.1.2 Waste Rock

The main objective of the waste rock characterization program conducted as part of this investigation was to derive conservative drainage chemistry estimates from waste rock located within the Brown-McDade stockpile. To achieve this objective, waste rock material was sampled from immediately adjacent to Lysimeter 1 (Figure 2-1). This location was selected for waste rock selection due to the fact that it has been identified as the location for the "worst case" lysimeter (higher than median metal and sulfide-S concentrations) and the fact that field-based drainage data are already available from these materials for comparison.

Waste rock material was selected by scraping the surface of the waste rock pile with a backhoe. The scraped material was placed in a small stockpile from which material was selected for the waste rock kinetic tests. A total of 360 kg of waste rock was collected in 18 rice sacs and transported to the Mt. Nansen maintenance shed for further sample processing (Section 2.2.3).

For closure options involving placement of waste rock in the pit, it was assumed that a portion of the underlying soils will be transported into the pit with the waste rock during backfilling. Depending on the amount and nature (labile verses refractory) of the organic material, co-deposed organic matter may have a significant influence on the redox geochemistry of the pit lake water column. This is of particular concern for redox sensitive species such as arsenic, which is present in relatively high concentrations in Mt. Nansen waste rock (Altura, 2009a; 2009b). Given the size of the Brown-McDade waste rock stockpile, it was difficult to excavate test pits to the underlying organic material in order to obtain a sufficient amount of organic material for field testing purposes. Therefore, organic material from immediately adjacent to the Brown-McDade waste rock stockpile was collected for incorporation into the waste rock saturated field column test (Figure 2-2). Inspection of organic material from both these areas indicated that although the organic material beneath the waste stockpile is significantly compressed (Figure 2-3), they are of a similar composition and therefore the organics used in the field column test are representative of the material under the waste dump that will be partially backfilled to the Brown-McDade pit under certain closure options.

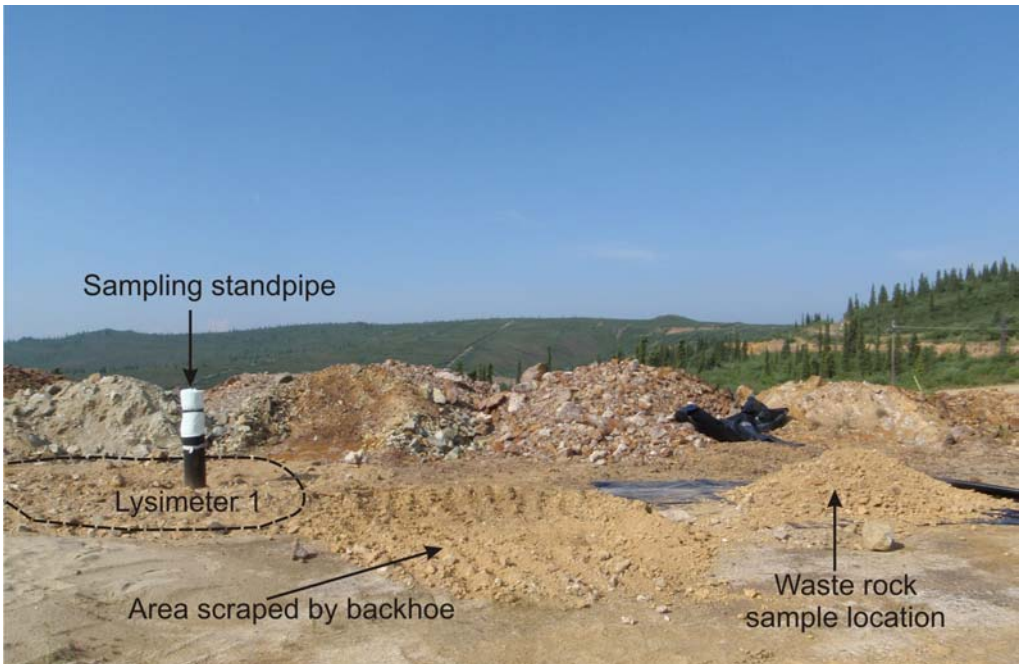


Figure 2-1: Mt. Nansen Waste Rock Sample Collection Site

Figure 2-2: Organic Material Incorporated into the Saturated Waste Rock Field Column

Figure 2-3: Organic Layer beneath the Waste Rock/Ore Stockpile (between the Northwest and South Waste Rock Piles)

2.1.3 Ore

Ore that had been backfilled into the ramp of the Brown-McDade pit in early 2009, was sampled and subjected to geochemical characterization test work, the results from which would facilitate estimation of the source term associated with ore remaining at site. Prior to the collection of samples, a backhoe was used to dig four test pits in the backfilled material to confirm the presence of ore material (Figure 2-4). Approximately 40 kg was collected from each test pit (160 kg total) by scraping up the entire section of exposed test pit wall surface and creating a small talus cone (Figure 2-4). The material from the talus cone was shoveled into large rice sacs and transported back to the Mt. Nansen maintenance shed for further sample processing.

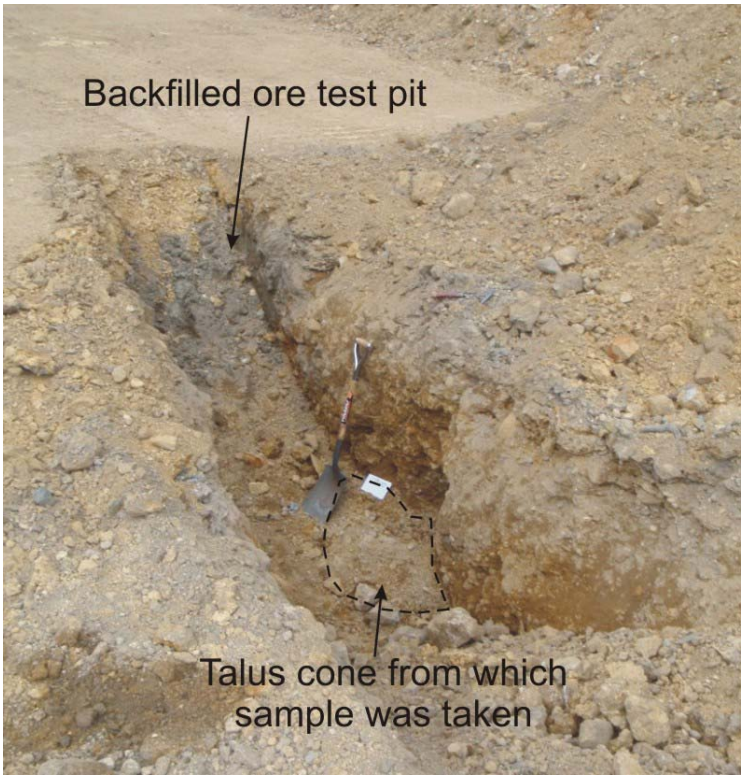


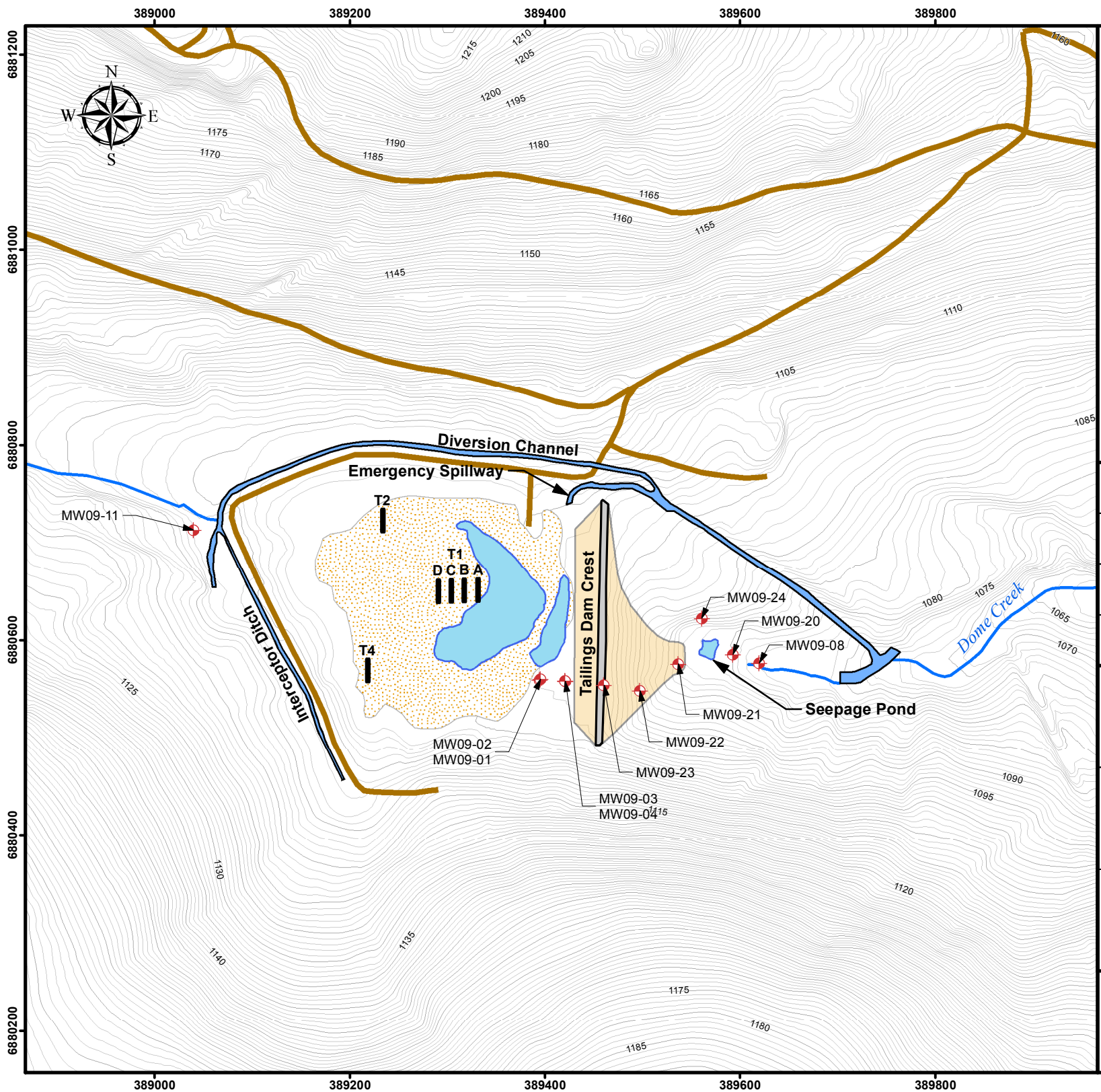
Figure 2-4: Sampling at the Backfilled Ore Test Pit

2.1.4 Tailings

Tailings samples were collected during two separate site visits in April and July, 2009. Tailings sampling site locations are shown in Figure 2-5. In April, six trenches were excavated: three in the centre of the tailings impoundment (T1a, T1c and T1d) and three on the west side of the tailings impoundment (T2 and T4; Table 2-1). The position of each of the trenches was based on accessibility and on locations where specific grain sizes (clay, silt and sand) were found at the near-surface by Kwong *et al.* (2002). The tailings mass is not homogeneous in terms of grain size and tailings chemistry can vary significantly therein (Kwong *et al.,* 2002). The primary objective of the April tailings sampling program was to collect samples of different grain sizes to compare drainage pH and metal leaching between each grain size grouping. Each of the trenches was approximately 1.5-2 m deep and 3-4 m in length. Samples were collected from the trench wall at 1-1.5 m intervals. The samples collected included clay-sized (T1a and T1d), silty-clay (T4, T2-2 and T2-3) and sandy-silt (T1c and T2-1) tailings. Geochemical analyses of these samples revealed similar chemistry for samples with similar grain sizes. Samples with similar grain sizes and chemistry were then composited to form three distinct sample sets: clay, silty-clay and sandy-silt which were used as part of the laboratory-based humidity cell program (Section 2.2.3).

In total, 27 tailings samples, representing clay, silty-clay and sand were collected from drill core of holes MW09-01, MW09-04 and MW09-05 (Table 2-2). These samples were also collected to obtain a sample set representative of the different grain sizes present in the tailings mass. A sample (Pile 09-01) was also collected from the relatively dry sandy tailings pile located along the dam abutment that has been draining for two years. Both exposed dry surface tailings and underlying saturated tailings from the west end of the tailings impoundment were analyzed in order to facilitate a comparison of acid-base accounting (ABA) and shake flask extractions results for tailings samples exposed to subaerial conditions and saturated tailings. These samples are included in the 2009 tailings statistical analyses (Table 5-2).

Drill core samples and a bulk sample of sand and silty-clay, which was collected from 0-1 m below the tailings surface at the east end of the tailings impoundment, underwent field kinetic testing. As part of the drainage characterization program at Mt. Nansen, it was assumed that a portion of the underlying soil organic matter would be transported into the pit with the tailings material during backfilling activities. A small amount of organic matter can potentially have a significant influence on redox geochemistry; therefore, a sample of the organic material underlying the tailings impoundment was also collected for field kinetic testing. The underlying organic layer was exposed for detailed observation by excavating down to 1 m below the tailings at the east end of the pond. The organic layer was black, contained large pieces of organic debris and emitted a distinct sulfidic scent. Co-mixed tailings and organic matter samples were kept saturated (not exposed to air) and subjected to field kinetic tests to derive estimates of source terms associated with tailings for closure options that involve post-closure storage of tailings under saturated conditions in perpetuity (*viz.,* 1A, 1B, 2A, 2B, and 3).



CLIENT: Yukon Government

Legend

- Trenches
- Monitoring Wells
- Mine Road
- Ponds
- Tailings Dam
- Tailings

Meters
0 20 40 80 120 160

Data courtesy of AECOM

Figure for illustrative purposes only

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DATE: June 23, 2011

PROJECTION: NAD 1983 UTM Zone 8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Water Balance and Water Quality Predictions

TITLE:
Tailings Impoundment - Location of Tailing Collection Sites, Trenches,and Monitoring Well Boreholes

PROJECT No:	FIGURE No:
J907-4	2-5

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Table 2-1:
Summary of Tailings Samples Collected from 1-1.5 m Deep Test Pits during April 2009 Site Visit

Trench	Sample ID	Location of test pit	Particle Size Description
T1a	T1a-1	Center of tailings impoundment	Clay
	T1a-2	Center of tailings impoundment	Clay
	T1a-3	Center of tailings impoundment	Clay
T1c	T1c-1	Center of tailings impoundment	silty-clay
	T1c-2	Center of tailings impoundment	silty-clay
T1d	T1d-1	Center of tailings impoundment	Clay
	T1d-1	Center of tailings impoundment	Clay
T2	T2-1	East end of tailings impoundment	silty-clay
	T2-2	East end of tailings impoundment	sandy-slit
	T2-3	East end of tailings impoundment	sandy-slit
T3	T3-1	East end of tailings impoundment	silty-clay
	T3-2	East end of tailings impoundment	silty-clay
	T3-3	East end of tailings impoundment	silty-clay
T4	T4-1	East end of tailings impoundment	sandy-slit
	T4-2	East end of tailings impoundment	sandy-slit

Table 2-2:
Summary of Tailings Samples Collected from Drill Core during July 2009 Site Visit

Drill Hole	Sample ID	Particle Size Description
MW09-01	MW09-01 (10'-13' comp)	Clay
MW09-04	MW09-04 (13'8" – 14'2")	Clay
	MW09-04 (14'5" – 15'5")	sandy silt
MW09-05	MW09-05 (5' – 6')	sandy silt
	MW09-05 (9' – 10')	silty clay
	MW09-05 (14' – 15')	Clay

2.1.5 Native Substrate Beneath Tailings Impoundment

Besides the collection of tailings and underlying organic material, native substrate materials, including native sands and organics, were also collected from the Mt. Nansen tailings impoundment area. The objectives of the native substrate sampling program were:

- To determine the chemistry of the underlying native substrate and the depth and extent of contamination by the tailings;

- To estimate the amount of native materials that need to be considered in the remediation plan; and,
- To identify the elements that may be naturally elevated in the native materials.

To achieve these objectives, nine samples of native substrate below the tailings impoundment were collected from five drill holes in the tailings impoundment area. Table 2-3 provides a summary of the drill hole, interval, and sample ID for tailings impoundment native substrate samples collected for this investigation.

Table 2-3:
Summary of Drill Holes, Intervals and Sample Identifications for Native Substrate Samples Collected from below the Tailings Impoundment

Drill Hole	From (m)	To (m)	Sample ID
MP09-09	3.98	4.32	MP09-09 (13'1"-14'2")
MP09-11	3.35	3.66	MP09-11 (11-12')
MW09-01	9.14	9.45	MW09-01 (30-31')
	9.45	9.75	MW09-01 (31-32')
MW09-05	5.26	5.41	MW09-05 (17'3"-17'9")
	5.41	5.56	MW09-05 (17'9"-18'3")
	5.72	6.40	MW09-05 (18'9"-21')
MW09-07	2.29	2.41	MW09-07 (7'6"-7'11")
	2.41	2.57	MW09-07 (7'11"-8'5")

2.1.6 Mill Site

A total of 14 solid phase samples were collected in 2010 as part of the mill area characterization program. Twelve rock fill samples were taken from a total of 8 trenches around the immediate mill site and one sediment core sample each from Pond #1 and Pond #2 were also taken.

An excavator was utilized for trenching; excavations were typically 1.5 to 2 m depth and 6 to 8 m in length. Sampling locations were selected to characterize the various platform areas of the mill, as well as targeting specific sites such as the historic ore transfer point and areas around the mill thought to be possibly underlain by old tailings. Samples were typically only taken from those excavations containing zones of moderate to highly altered material, or where sulfides were visible in the rock samples examined. Rock types encountered were described with respect to alteration, staining, estimated abundance of fines and presence of sulfides (Appendix E). Where discernible, the original protolith was noted. The occurrence of any seeps or ponded water was also noted.

Sediments from ponds #1 and #2 were obtained from a location at the water's edge of each pond using an Edelman hand auger which allows for sediment cores to be taken in 15 cm increments. Cores obtained were laid out in sequence, photographed and described. The top few centimetres of core (at the solids/water interface) were set aside and the remainder taken for ABA testing and elemental analyses.

2.2 Kinetic Test Design

Both laboratory-based (humidity cells – tailings only) and field-based kinetic tests (field weathering bins and saturated columns) were conducted as part of this investigation. Kinetic testing was conducted to evaluate reaction rates and depletion times for minerals contained in mine waste as well as determine estimates of metal leaching rates. The results of these tests are used to assess the availability of Neutralization Potential (NP) measured in the static tests and the pH buffering trends associated with the material. Ultimately, kinetic testing can help establish the mobility of metals that may be of environmental concern in drainages from the various waste materials.

The following sections discuss the experimental design for both the laboratory- and field-based programs. Further description of kinetic test methodology and analytical results are provided in Appendix B.

2.2.1 Humidity Cell Testing

All the tailings material from the April sampling (Section 2.1.1) was composited into three sample sets for humidity cells: 1) clay tailings; 2) silty clay tailings; and, 3) sandy silt tailings. A description of the humidity cells used for the Mt. Nansen tailings laboratory kinetic program is provided in Table 2-4. Note that humidity cells T4, T5 and T6 are split samples of T1, T2 and T3, respectively, which have been depleted of available carbonate phases. Standard humidity cell test durations in excess of ten years are generally required to deplete the carbonate NP and evaluate buffering capacity of non-carbonate minerals that predominate in the latter stages of acid rock drainage (ARD) development.

Pre-treating the tailings samples with a weak acid will effectively remove carbonate phases to evaluate advanced leaching characteristics of the sample and the ability of residual non-carbonate NP to buffer acidic drainage. Upon the depletion of carbonate in a system, dissolution of non-carbonate minerals become the primary control on pH buffering. However, this methodology may also deplete sulphide phases and affect non-carbonate phases. Therefore, interpretation of the results from the pre-leached samples takes this laboratory artifact into account.

Table 2-4:
Description of Humidity Cells used for Mt. Nansen Tailings Kinetic Program

HC	Material Description	Samples included in Composite
T1	tailings clay composite sample	T1a-1, T1a-2, T1a-3, T1d-1, T1d-2
T2	tailings sand silt composite sample	T2-2, T2-3, T4-1, T4-2
T3	tailings silt clay composite sample	T1c-1, T1c-2, T2-1, T3-1, T3-2, T3-3
T4	carbonate depleted sub-sample of T1	T1a-1, T1a-2, T1a-3, T1d-1, T1d-2
T5	carbonate depleted sub-sample of T2	T2-2, T2-3, T4-1, T4-2
T6	carbonate depleted sub-sample of T3	T1c-1, T1c-2, T2-1, T3-1, T3-2, T3-3

Sub-samples of tailings composites used in the humidity cell tests underwent particle size determination (PSD) and static test work, including ABA, solid phase elemental determination (aqua regia digestion) and shake flask extractions (SFE). Results of these analyses were compared to the tailings mass in order to assess whether the samples selected for kinetic testing are representative of the tailings mass as a whole. A description of the analytical procedures used in this investigation is provided in Section 2.3.

Laboratory-based humidity cells are typically composed of Plexiglas cylinders (10.2 cm inside diameter, 25.5 cm length) filled with 1 kg of sample and crushed to a particle size of less than 6 mm. The sample material was placed on a perforated Plexiglas disk covered in a nylon mesh. The contents of the cell were subjected to moist air for three days followed by dry air (< 10% relative humidity) for three days. At the end of each wet/dry cycle (*i.e.,* the seventh day), the contents of the cell were leached with a volume (typically 500 mL) of distilled de-ionized water (Lapakko, 2003; Price, 1997). The purpose of the leaching step is to recover any readily soluble reaction products that have formed due to mineral dissolution or sulfide oxidation in order to determine the dissolved load contributed from the previous week. The leachate was then analyzed for pH and various parameters of interest (principally metals). The leaching behaviour of geologic materials evolves over time as mineral phases that contribute to the leaching signature are consumed or become unavailable to water rinsing soluble loads from the weathering surface.

2.2.2 Field Based Tests

Two types of field kinetic tests were constructed at Mt. Nansen: 1) unsaturated weathering bins, which were designed to mimic storage conditions in a subaerial unsaturated environment (tailings, waste rock and ore) and 2) saturated field column tests, which were designed to investigate the effect of saturated conditions on drainage chemistry from backfilled and saturated materials (waste rock and tailings; Table 2-5).

Field-based tests are advantageous over laboratory tests because they more closely resemble the conditions present within natural waste piles, including site-specific climatic conditions, scale and grain-size. The following sections discuss the protocols for both types of field tests employed in this investigation.

Table 2-5:
Summary of Mt. Nansen Field Kinetic Program Contents and Conditions

Bin	Material Description	Saturated/ Unsaturated	Mass (kg)
1	Waste rock from near Lysimeter 1 (Altura, 2009a)	unsaturated	166
2	Ore that was backfilled into Brown-McDade pit ramp	unsaturated	156
3	Waste rock + organics (same waste rock as Bin 1)	saturated	161
4	Tailings + organics Bin	saturated	132
5	Sand Tailings	unsaturated	146

2.2.2.1 Unsaturated Field Weathering Bins

Unsaturated field weathering bins were constructed for tailings, waste rock and ore material. This particular type of test work is designed to mimic conditions within subaerially-stored, unsaturated geologic materials. The following section presents a description of the design and methods used to construct the Mt. Nansen unsaturated field bins.

Tailings

The unsaturated tailings field bins were constructed by placing tailings sand material collected from the tailings impoundment area in a HDPE tote (100 cm wide, 120 cm long, 116 cm tall; Figure 2-6). Prior to filling the barrel, the top was cut off using a reciprocating saw, rinsed once with a 1% hydrochloric acid (HCl) solution and twice with distilled de-ionized water. A hole was then drilled in the spigot of the bin, through which acid-washed fittings and tubing were installed in order to allow leachate to drain (Figure 2-6). Two plies of acid-washed nylon mesh were placed over the drain opening at the bottom of the bin in order to prevent small grains from clogging the tubing draining the bin. To promote drainage from the tailings sand material in this bin, approximately 5 cm (~80 kg) of 10/20 washed, silica filter sand was placed in the bottom of the bin (Figure 2-7). Approximately 5 cm of tailings sand (~80 kg) was placed on top of this drainage layer. A 20 L sample collection jug, to which the drainage tubing was attached, was placed in a plastic tote in front of the unsaturated field bin (Figure 2-8). Water, as natural precipitation or manual irrigation, percolates through the field weathering bin

material and drains into the collection jugs beneath the bin. Once a month, the collection jug was sampled and the leachate volume noted.

Prior to filling each HDPE barrel, the kinetic test material was homogenized on a piece of plywood and a sub-sample was collected using the "cone and quarter" technique. Briefly, this technique involved pouring the material into a cone and dividing the cone into quarters (Figure 2-9). Two opposite quarters were removed from the pile and placed in the field bin. The remaining two quarters are re-coned and the process is repeated until approximately 10 kg of material remains. The remaining material was collected and submitted for static testing and grain size analysis. A sample of the tailings sand used to promote drainage was also collected for characterization.

Figure 2-6: Unsaturated Tailings Field Test Set-up

Figure 2-7: Filter Sand Drainage Layer in the Unsaturated Field Weathering Bin

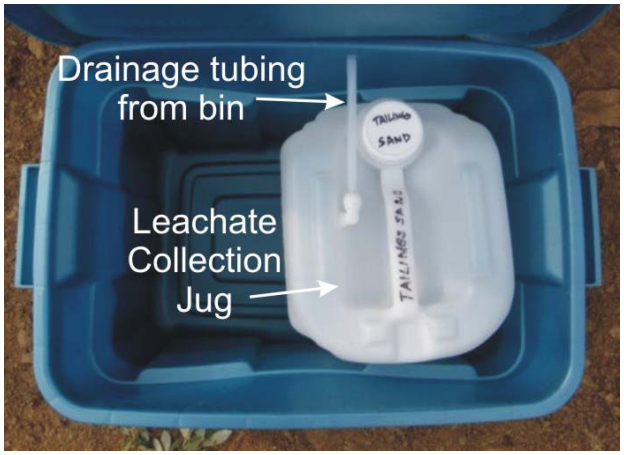


Figure 2-8: Leachate Collection System for the Tailings Field Weathering Bin

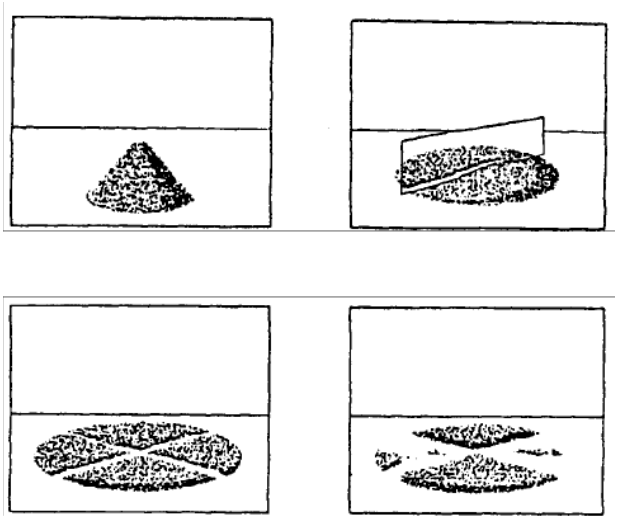


Figure 2-9: Schematic Diagram showing the "Cone-and-Quarter" Technique

Waste Rock and Ore

The waste rock and ore unsaturated field bins were constructed using HDPE barrels (76 cm high, 56 cm diameter; Figure 2-10). One bin was filled ¾ full with waste rock collected near Lysimeter 1 (Altura, 2009a; Section 2.1.2) and the other bin was filled ¾ full with ore collected from the backfilled Brown-McDade pit ramp (Section 2.1.3). Prior to filling each barrel, the top was cut off using a reciprocating saw, rinsed once with a 1% HCl solution and twice with distilled de-ionized water. A hole was then drilled in the bottom of the bin, through which acid-washed fittings and tubing were installed in order to allow leachate to drain (Figure 2-10). Two plies of acid-washed nylon mesh were placed over the drain openings at the bottom of each bin in order to prevent small grains from clogging the tubing draining each test. A 20 L sample collection jug, to which the drainage tubing was attached, was placed in a plastic tote in front of the unsaturated field bin (Figure 2-11). Water, as natural precipitation or manual irrigation,

percolates through the field weathering bins and drains into the collection jugs located beneath each bin. Once a month, the collection jug was sampled and the leachate volume noted.

Prior to filling each HDPE barrel, the kinetic test material was homogenized on a piece of plywood and a sub-sample was collected using the "cone and quarter" technique described previously and illustrated in Figure 2-9.

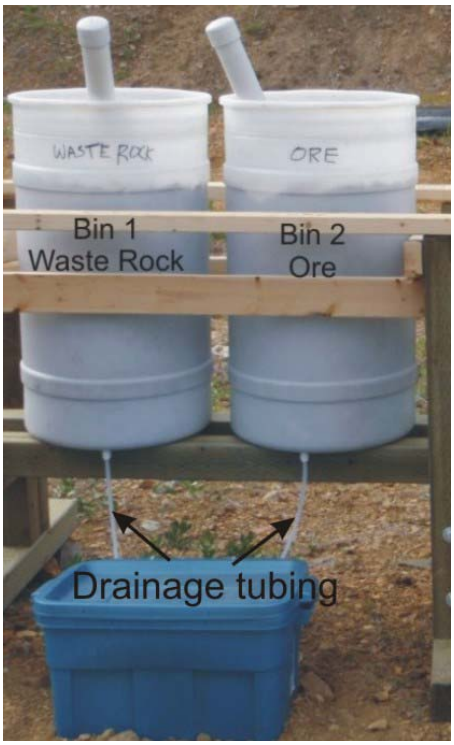


Figure 2-10: Waste Rock and Ore Field Weathering Test Set-up

Figure 2-11: Sample Collection System for Waste Rock and Ore Field Weathering Tests (Bin 1 and 2, Figure 2-10)

2.2.2.2 Saturated Field Column Tests

Two saturated field column tests were initiated at Mt. Nansen; one filled with tailings and one filled with waste rock. Both of these tests, designed to mimic saturated backfilled conditions in the Brown-McDade pit, are described below.

Tailings

The tailings saturated field column test, shown in Figure 2-12, was constructed by mixing 120 kg of sand-sized tailings with 30 kg of silty clay tailings, both of which were collected from the east end of the Mt. Nansen tailings impoundment (Section 2.1.1). This mixture was created in order to ensure that the full range of tailings grain sizes were represented in the saturated column test while still allowing easy drainage. As previously discussed, organic matter (approximately 8.5% by weight) was mixed with tailings mixture (sand + clayey silt) prior to placement in the bin. The tailings mix and organic matter were homogenized on a piece of plywood and a sub-sample was collected using the "cone and quarter" technique described in Section 2.2.2.1 and Figure 2-9. Note that a sample of the tailings sand used to promote drainage at the base of the tailings field tests was collected for characterization. Water quality from this field test provides information on the influence of organics on tailings and metal mobilization (*e.g.,* arsenic) in the backfilled pit.

The saturated tailings test setup was constructed using a 76 cm high HDPE barrel with a 48 cm diameter (Figure 2-12). Prior to filling the barrel, the top was cut off and subsequently rinsed with a 1% HCl solution and twice with distilled de-ionized water. A hole was drilled into the bottom of the barrel through which acid-washed fittings and tubing was installed in order to allow leachate collection (Figure 2-12). Two plies of acid-washed nylon mesh were placed over the drain opening at the bottom of the barrel in order to prevent small grains from clogging the tubing draining the bins. Prior to filling with tailings material, approximately 10 cm of 10/20 filter sand was added to the bottom of the barrel in order to provide a layer with high hydraulic conductivity to promote drainage from the saturated column test.

These column tests were designed to maintain water cover above the test material and thereby keep them permanently saturated (Figure 2-13). Unlike the unsaturated field bin, where leachate is allowed to percolate through the tailings sand and collect in a jug beneath the bin, leachate from this test was collected directly from the test barrel using attached drainage tubing. Samples were filtered using an in-line 0.45 μm filter with a peristaltic pump. Distilled de-ionized water was periodically added to the bin in order to maintain a permanent water cover over the tailings.

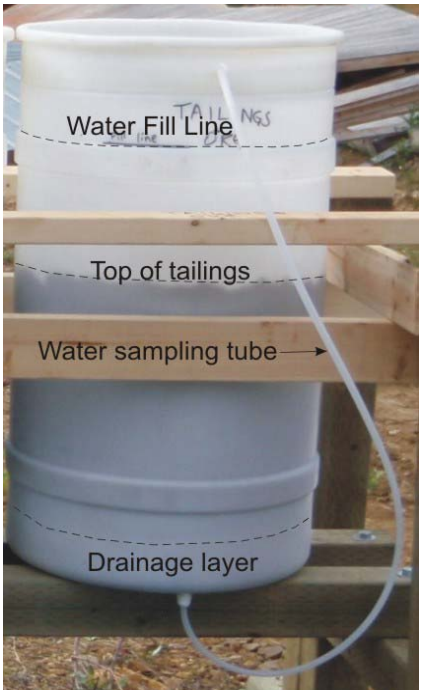


Figure 2-12: Tailings Saturated Field Column Test Set-up

Figure 2-13: Water Cover in the Tailings Saturated Field Column Test

Waste Rock

The saturated waste rock field column test (Bin 3; Table 2-5; Figure 2-14) was constructed by incorporating approximately 2% organic matter into Bin 3 (waste rock + organics) to assess the potential influence of organic material on the chemistry that would develop in a saturated backfilled scenario. The organic material incorporated into this bin was collected from moss deposits located immediately adjacent to the waste rock stockpile (Section 2.2.2). The tailings mix and organic matter were homogenized on a piece of plywood and a sub-sample was collected using the "cone and quarter" technique described in Section 2.2.2.1 and Figure 2-9. A sample of the tailings sand used to promote drainage at the base of the tailings field tests was also collected and submitted to the analytical laboratory.

Similar to the saturated tailings field column, the saturated waste rock column was constructed using a 76 cm high HDPE barrel with a 48 cm diameter (Figure 2-14). Prior to filling the barrel, the top was cut off using a reciprocating saw and subsequently rinsed with a 1% HCl solution and twice with distilled de-ionized water. A hole was drilled into the bottom of the barrel through which acid-washed fittings and tubing was installed in order to allow leachate collection (Figure 2-14). Two plies of acid-washed nylon mesh were placed over the drain opening at the bottom of the barrel in order to prevent small grains from clogging the tubing draining the bins. Prior to filling with waste rock material, approximately 10 cm of 10/20 filter sand was added to the bottom of the barrel in order to provide a layer with high hydraulic conductivity to promote drainage from the saturated column.

Unlike the unsaturated field weathering test, where leachate was allowed to percolate through the test material and collect in a jug below, leachate from this test was removed directly by using an attached drainage tube during each sampling event. Samples were filtered using in-line 0.45 μm filters with a peristaltic pump. Distilled de-ionized water was periodically added to the field column in order to maintain the water level above the surface of the test (waste rock) materials, thereby keeping the waste rock permanently saturated (Figure 2-14).

Figure 2-14: Saturated Waste Rock Field Column Set-up

2.3 Groundwater Sampling

A drilling program was conducted between July 7th and July 21st, 2009 using a Geotech drill rig with air rotary, mud rotary, and direct push drilling capabilities. Piezometers were also installed by Rocky Mountain Soil Sampling using the low disturbance, pionjar drilling methods. A total of fourteen 2" groundwater wells were installed in and around the tailings impoundment (*e.g.,* MW designation, Appendix F). Four wells were installed in the mill area for the purposes of the geochemical investigation. Six 1 ¼" mini-piezometers (*e.g.,* MP designation) were installed in the tailings area as well as around the seepage collection pond. Wherever possible, drilling was completed without injecting water. Sand filter packs were avoided and wells were allowed to develop naturally. Three sets of groundwater samples were collected in July 2009, September 2009 and July 2010. Field parameters (*e.g.,* pH, conductivity and dissolved oxygen) were recorded prior to sample collection.

The 2" monitoring wells were sampled using either a Geotech peristaltic pump or a QED 1 ¾" portable bladder pump operated with an MP10 controller and MP3020 electric compressor (Figure 2-15). The bladder pump was used in wells in which the water levels exceeded 25 ft below top of casing (~7.6 m, the operating limit of the peristaltic pump), but was also used in coordination with the peristaltic pump on wells with shallower water levels to save time and thereby improve sampling efficiency. The one exception was MW09-01, which had a deep water level and was sampled with the peristaltic pump and 5/8" Waterra tubing. The ¼" peristaltic tubing was threaded into the Waterra tubing which was actuated by hand to keep the water level inside the tubing near ground surface. The peristaltic pump was also used for sampling the 1¼" mini-piezometers.

The discharge lines from the pumps were connected to separate flow cells coupled with YSI 600 XLM multi-parameter probes (Figure 2-15). In wells which could sustain continuous flow, the wells were purged until water quality parameters stabilized and at least three casing volumes had been purged. Furthermore, in most cases, more than three bore volumes were purged (a bore volume is the volume of water in the casing plus the volume in the filter pack, if one was used, assuming 30% porosity). Several wells completed in the tailings area (MW09-02, MP09-09,-11,-12) had very slow recharge rates. In the case of the wells with a "MP" designation, two bore volumes were removed with an aliquot from this purge used for determining field parameters. The wells were then allowed to recover (typically overnight) and groundwater samples were collected from the third purge for chemical analyses.

Figure 2-15: Groundwater Sampling using a Bladder Pump at MW09-03 (left) and a Peristaltic Pump at MW09-04 (right))

The wells were sampled for the parameters listed in Table 2-6 with all samples field-filtered using a 45 micron high capacity in-line filter. Due to the redox sensitivity of some of the parameters (in particular, iron, arsenic, and sulfide), every effort was made to minimize the exposure of water samples to air. This was partly accomplished by employing the low-flow sampling methods discussed above and adjusting flow rates to minimize drawdown in the well (where possible). An outlet tube was attached to the filter and sample bottles (where applicable, pre-charged with preservatives) were filled with the tip of the outlet tube kept at the bottom of the bottle to enable immediate mixing with the preservative and minimize exposure to air. Special care was given to the arsenic speciation bottle which was sealed with parafilm first and then punctured with the outlet tube for filling. Other bottles (not containing preservative) were also filled from the

bottom and allowed to overflow, with acid preservative added at the end (where required). A field duplicate and field blank were collected for quality assurance/quality control (QA/QC) purposes. Samples were stored in coolers with icepacks and refrigerated until transported to the analytical laboratories (Table 2-6).

In addition to the collection of groundwater samples, the interception ditch and three groundwater seeps (B, C and D) were sampled upstream of the tailings impoundment for dissolved organic carbon (DOC). The ditch and seeps were sampled on July 3rd, 2010, when little/no rain was observed throughout the day and temperatures were relatively high. Site A corresponds to the interception ditch, upstream (south) of the confluence with Dome Creek (Figure 2-16). Sites B, C and D are located on the upstream bank of the diversion channel, downstream of the confluence with Dome Creek (Figure 2-17).

The ditch and seeps were sampled using syringes as close as possible to where they discharged at surface. The sample was filtered through a 45-micron syringe filter prior to adding the preservative (if necessary).

Table 2-6:
Parameters Analyzed and Analytical Laboratories Utilized

Parameter	Sample Size	Bottle	Preservative	Pre-charged (Y/N)	Filtered (Y/N)	Laboratory
Metals	125 mL	plastic	HNO_3	N	Y	ALS Environmental (Vancouver)
DOC	125 mL	amber glass	HCl	N	Y	
Ammonia	250 mL	amber glass	H_2SO_4	N	Y	
Cyanide	500 ml	plastic	NaOH	Y	Y	
Anions	1 L	plastic	-	N	Y	
Arsenic Species (III and V)	125 mL	amber glass	EDTA + acetic acid	Y	Y	ALS Environmental (Edmonton)
Sulfide	8 mL	plastic	Zn-Acetate	Y	Y	UBC DEOS*

N*UBC DEOS = University of British Columbia Department of Earth and Ocean Sciences

Figure 2-16: Interception Ditch Upstream of Confluence with Dome Creek (Site A)

Figure 2-17: Groundwater Seeps Entering the Dome Creek Diversion Channel

2.4 Analytical Methods

The following sections provide a brief description of the methods that were used in the analysis of both the solid phase and water samples for the Mt. Nansen geochemical study described in this report.

2.4.1 Solid Samples

A summary of the analyses conducted as part of the Mt. Nansen geochemical assessment in support the closure option evaluation study is provided in Table 2-7. The following sections provide a brief description of the analytical techniques utilized. To get better representatives of the higher surface area particles, and to partially normalize for the particle size effect on sample composition the smaller than ¼" size fraction for most of the waste rock and ore samples were submitted for geochemical analysis. A comparison of the geochemical characteristics of the greater than ¼" size fraction was carried out waste rock collected for construction of lysimeters in 2008. The results of this comparative study are provided in a technical report by Altura (2009b).

2.4.1.1 Acid-Base Accounting and Sulfur Speciation

The ABA procedure involves a suite of static tests that are utilized as predictors of the potential for the acid generating potential of solid phase samples. Measurements included in ABA are acid potential (AP) and neutralizing potential (NP) of a sample. An accounting technique is used to compare the AP and NP with standard criteria thereby giving an indication of a sample's theoretical acid generation potential.

Typically, the full analytical suite included in ABA consist of: paste pH; total sulfur; sulfate-sulfur; sulfide-sulfur; total carbon; total inorganic carbon; and, siderite-corrected NP. However, as indicated in Table 2-7, the organic material samples were only analyzed using a partial ABA parameter list, which included total sulfur, sulfide-sulfur, sulfate-sulfur, total carbon and total inorganic carbon.

2.4.1.2 Shake Flask Extraction

Shake flask extractions were conducted as described by Price A. W. in *"Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia",* using a 24-hour NanoPure water leach extraction test at 3:1 liquid to solid ratio. The leachate was filtered and submitted for analyses for then parameters: pH; conductivity; acidity; alkalinity; sulfate; chloride; fluoride; nitrate; nitrite; ammonia; total organic carbon; and, dissolved metals. Dissolved metal analysis of the filtered and preserved leachate was conducted by Inductive Coupled Plasma Mass Spectroscopy (ICP-MS). The procedures utilized are outlined in *"Standard Methods for the Examination of Water and Wastewater",* 20th Edition APHA AWWA, and WEF, 1998.

Table 2-7: Summary of Samples Collected and Geochemical Analyses in Support of Mt. Nansen Closure Options Evaluation

Sample	ABA[1]	Partial ABA[2]	Sulfur[3]	SFE[4]	AR metals[5]	PSD[6]	Sample Details
Tailings							
T1a-1	X				X		component of humidity cells T1 and T4
T1a-2	X				X		component of humidity cells T1 and T4
T1a-3	X				X		component of humidity cells T1 and T4
T1c-1	X				X		component of humidity cells T3 and T6
T1c-2	X				X		component of humidity cells T3 and T6
T1d-1	X				X		component of humidity cells T1 and T4
T1d-2	X				X		component of humidity cells T1 and T4
T2-1	X				X		component of humidity cells T3 and T6
T2-2	X				X		component of humidity cells T2 and T5
T2-3	X				X		component of humidity cells T2 T5
T3-1	X				X		component of humidity cells T3 and T6
T3-2	X				X		component of humidity cells T3 and T6
T3-3	X				X		component of humidity cells T3 and T6
T4-1	X				X		component of humidity cells T2 and T5
T4-2	X				X		component of humidity cells T2 and T5
MW09-01 (10'-13' comp)			X	X	X		drill hole sample
MW09-04 (13'8" – 14'2")			X	X	X		drill hole sample
MW09-04 (14'5" – 15'5")			X	X	X		drill hole sample
MW09-05 (5' – 6')			X	X	X		drill hole sample
MW09-05 (9' – 10')			X	X	X		drill hole sample
MW09-05 (14' – 15')			X	X	X		drill hole sample
MW09-05 (17'3" - 17'9")			X	X	X		drill hole sample
Pile 09-02			X	X	X		collected from the 1105 pile
SL09-01			X	X	X		surface grab sample
UL09-01			X	X	X		subsurface grab sample
Tailings facility Native Substrate							
MP09-09 (13'1"-14'2")			X		X		drill hole sample
MP09-11 (11-12')			X		X		drill hole sample
MW09-01 (30-31')			X		X		drill hole sample
MW09-01 (31-32')			X		X		drill hole sample
MW09-05 (17'3"-17'9")			X		X		drill hole sample
MW09-05 (17'9"-18'3")			X		X		drill hole sample
MW09-05 (18'9"-21')			X		X		drill hole sample
MW09-07 (7'6"-7'11")			X		X		drill hole sample
MW09-07 (7'11"-8'5")			X		X		drill hole sample
Humidity Cell Composites							
Humidity Cell T1	X				X	X	clay sized composite of Apr-09 samples
Humidity Cell T2	X				X	X	sandy silt composite of Apr-09 samples
Humidity Cell T3	X				X	X	silty clay composite of Apr-0 samples
Humidity Cell T4	X				X	X	clay sized composite of Apr-09 samples
Humidity Cell T5	X				X	X	sandy silt composite of Apr-09 samples
Humidity Cell T6	X				X	X	silty clay composite of Apr-09 samples
Field Kinetic Tests							
Waste Rock Bin	X			X	X	X	**Bin 1** sub-sample
Ore Bin	X			X	X	X	**Bin 2** sub-sample
WR Org		X		X	X		organic material included in Bin 3
WR + Org	X			X	X	X	**Bin 3** sub-sample
Tailings Sand	X			X	X	X	component of Bin 4
Tailings clayey silt	X			X	X	X	component of Bin 4
OR 09-01		X		X	X		organic material included in Bin 4
Tails + Org Bin	X			X	X	X	**Bin 4** sub-sample
Tailings Impoundment Sand	X			X	X	X	**Bin 5** sub-sample

Notes: 1. ABA = acid base accounting = paste pH, total S, sulfate-S, sulfide-S, total C, total inorganic C, NP; 2. Partial ABA = total S, sulfide-S, sulfate-S, total C, total inorganic C; 3. sulfur = sulfur speciation = total sulfur, sulfate-sulfur, sulfide-sulfur, insoluble sulfur; 4. SFE = shake flask extraction analysis; 5. AR metals = solid phase analysis following aqua regia digestion of sample; and 6. PSD = particle size distribution analysis.

2.4.1.3 Solid Phase Elemental Analysis

Solid-phase elemental data are used to identify elements that are enriched in geologic materials and could potentially leach from stockpiles. This information is useful in combination with ABA results to establish the geochemical properties of geologic materials. As well, establishing the solid phase elemental content of waste rock is an important first step in evaluating the elements that may become problematic in waste rock deposits.

Although not conclusive, the degree of enrichment of an element over crustal abundance can be used as a general indicator of the metals of potential concern, which should be scrutinized in leaching tests. However, it is important to keep in mind that solid-phase elemental concentrations well above crustal abundances do not necessarily indicate that a metal will be elevated in drainage waters due to the fact that the rate of leaching is dependent on the mineralogical association of the element, the geochemical stability of those minerals, kinetics of the chemical reactions and the aqueous geochemistry of the infiltrating waters.

2.4.1.4 Particle Size Distribution

Tailings, waste rock and ore samples were analyzed for their particle size distribution. Tailings samples were analyzed using screen sizes of >0.250 mm; 0.18 mm; 0.15 mm; 0.125 mm; 0.075 mm; 0.053 mm; 0.045 mm; 0.038 mm; and, <0.038 mm. Waste rock and ore samples were analyzed using screen sizes of 12.5 mm; 9.5 mm; 6.3 mm; 1.7 mm; 0.425 mm; 0.150 mm; and, 0.053 mm. Following particle size analysis of waste rock and ore field bin samples, all material less than 6.3 mm in diameter was composited and subjected to geochemical static testing.

2.4.1.5 Mineralogical Assessment (X-Ray Diffraction)

Two samples of precipitates collected from rock surfaces within the Brown-McDade pit and eight waste rock samples from the 2008 geochemical characterization program were submitted to the Queen's University Department of Geological Sciences and Geological Engineering for qualitative x-ray diffraction analysis. The surface precipitates were assessed to gain a better understanding of soluble products and of potential solubility constraints of the rock exposed in the pit. The purpose of assessing the waste rock samples was to gain a better understanding of the various sulfur-bearing phases and potential neutralizing minerals available in various geochemical categories of waste rock.

2.4.2 Groundwater and Leachate Samples

In addition to characterization of solid phase materials, the present study involved the collection and analysis of groundwater samples from monitoring wells installed within and adjacent to the tailings impoundment and leachate samples from field and laboratory kinetic tests. Table 2-8 provides a summary of the parameters analyzed and the analytical method for each parameter.

Table 2-8:
Summary of Water Quality Parameters and Analytical Methods for the Mt. Nansen Geochemical Characterization Program

Parameter	Symbol	Units	Method Reference
Physical Tests			
Conductivity	Cond.	mS/cm	APHA 2510
Hardness (as $CaCO_3$)	Hard.	mg $CaCO_3$/L	APHA 2340B
pH	pH	pH units	APHA 4500-pH
Total Dissolved Solids	TDS	mg/L	APHA 2540 C-Gravimetric
Anions and Nutrients			
Acidity (as $CaCO_3$)	Acidity	mg $CaCO_3$/L	APHA 2310
Alkalinity, Total (as	Alk	mg $CaCO_3$/L	APHA 310.2
Ammonia as N	NH_3-N	mg/L	APHA 4500-NH3
Bromide (Br)	Br	mg/L	APHA 4110 B
Chloride (Cl)	Cl	mg/L	APHA 4110 B
Fluoride (F)	F	mg/L	APHA 4110 B
Nitrate (as N)	NO_3-N	mg/L	APHA 4110 B
Nitrite (as N)	NO_2-N	mg/L	APHA 4110 B
Sulfate (SO_4)	SO_4	mg/L	APHA 4110 B
Cyanides			
Cyanide, Weak Acid Diss	CN-WAD	mg/L	APHA 4500-CN
Cyanide, Total	CN_{Total}	mg/L	APHA 4500-CN
Cyanate (CNO)	CNO	mg/L	APHA 4500-CN
Thiocyanate (SCN)	SCN	mg/L	APHA 4500-CN
Carbon and Sulfide			
Total Organic Carbon	TOC	mg/L	APHA 5310 TOC
as H_2S (µg/L)	H_2S	mg/L	Cline, 1969
Dissolved Metals			
Aluminum	Al	mg/L	EPA SW-846 3005A/6020A
Antimony	Sb	mg/L	EPA SW-846 3005A/6020A
Arsenic	As	mg/L	EPA SW-846 3005A/6020A
Barium	Ba	mg/L	EPA SW-846 3005A/6020A
Beryllium	Be	mg/L	EPA SW-846 3005A/6020A
Bismuth	Bi	mg/L	EPA SW-846 3005A/6020A
Boron	B	mg/L	EPA SW-846 3005A/6020A
Cadmium	Cd	mg/L	EPA SW-846 3005A/6020A
Calcium	Ca	mg/L	EPA SW-846 3005A/6010B
Chromium	Cr	mg/L	EPA SW-846 3005A/6020A
Cobalt	Co	mg/L	EPA SW-846 3005A/6020A
Copper	Cu	mg/L	EPA SW-846 3005A/6020A
Iron	Fe	mg/L	EPA SW-846 3005A/6010B
Lead	Pb	mg/L	EPA SW-846 3005A/6020A
Lithium	Li	mg/L	EPA SW-846 3005A/6020A
Magnesium	Mg	mg/L	EPA SW-846 3005A/6010B
Manganese	Mn	mg/L	EPA SW-846 3005A/6020A
Molybdenum	Mo	mg/L	EPA SW-846 3005A/6020A
Nickel	Ni	mg/L	EPA SW-846 3005A/6020A
Phosphorus	P	mg/L	EPA SW-846 3005A/6010B
Potassium	K	mg/L	EPA SW-846 3005A/6010B
Selenium	Se	mg/L	APHA 3030 B&E
Silicon	Si	mg/L	EPA SW-846 3005A/6010B
Silver	Ag	mg/L	EPA SW-846 3005A/6020A
Sodium	Na	mg/L	EPA SW-846 3005A/6010B
Strontium	Sr	mg/L	EPA SW-846 3005A/6020A
Thallium	Tl	mg/L	EPA SW-846 3005A/6020A
Tin	Sn	mg/L	EPA SW-846 3005A/6020A
Titanium	Ti	mg/L	EPA SW-846 3005A/6010B
Uranium	U	mg/L	EPA SW-846 3005A/6020A
Vanadium	V	mg/L	EPA SW-846 3005A/6020A
Zinc	Zn	mg/L	EPA SW-846 3005A/6020A
Speciated Metals			
Arsenic, Trivalent	As^{3+}	mg/L	Kohlmeyer *et al.*, 2002
Arsenic, Pentavalent	As^{5+}	mg/L	Kohlmeyer *et al.*, 2002

2.5 External Sources of Data

Below is a summary of the external data sources which were either incorporated into the geochemical interpretations of Mt. Nansen waste and/or considered during source term development.

- Historical geochemical characterization of waste rock and ore materials at Mt. Nansen (Altura, 2009a);
- Mineralogical analysis of Mt. Nansen tailings (Jambor, 2005);
- Mt Nansen tailings characteristics (CANMET study by Kwong *et al.* (2002));
- Assessment reports of Arctic and Venus Tailings (Altura, 2009c);
- Drainage quality from constructed lysimeter tests in waste rock piles and of natural seeps from waste dumps (data provided by EDI/Altura, Aug 23, 2010);
- Surface water quality from the open pit, tailings impoundment, and tailings seepage collection pond (EDI, Aug 23, 2010); and,
- Groundwater well logs and water quality results (AECOM, 2010).

3. Brown-McDade Open Pit

3.1 Introduction

The results of the geochemical characterization test work for the solid phase (pit wall rock) and water quality of the pit lake water column are presented and discussed in this chapter. The results of the geochemical test work were interpreted and used to derive chemistry source terms for Mt. Nansen closure options 1A and 2A (Chapter 1). For these closure option scenarios, an open pit lake will exist, as represented by current conditions (*e.g.,* no tailings or waste rock placed in the open pit).

Results of the pit wall solid phase characterization test work and pit lake water quality analyses are presented and discussed in sections 3.2 and 3.3, respectively. Estimation of source terms and long-term predictions of pit lake water quality for Mt. Nansen (Options 1A and 2A) are presented in Section 3.4.

3.2 Pit Wall Solid Phase Characterization

Solid samples collected from the upper oxide zone and lower sulfide zone of the Brown-McDade pit in 1996, 1999 and 2009 underwent ABA testing, solid phase elemental determination (following aqua regia digestion) and determination of the water soluble fraction (using shake flask tests). Statistical summaries of the results from these solid phase tests are presented in the following sections, including maximum, minimum, median and 90th and 10th percentile values. The 90th and 10th percentile values are used for the interpretation of the test results to eliminate bias introduced by spurious data points and unrepresentative outliers, which are a common feature of any large analytical dataset such as the one being assessed in the present study.

3.2.1 Acid-Base Accounting (ABA)

ABA results for upper and lower pit wall samples are presented in Table 3-1. Note that values reported to be below the detection are presented at the analytical detection limit to facilitate statistical assessments conducted for the interpretation of analytical data. ABA test results consisting of paste pH, acid potential, neutralization potential and net potential ratio are presented and discussed in subsequent sections below.

Table 3-1:
Statistical Summary of ABA Characteristics for Upper (Oxide) and Lower (Sulfide) Pit Wall Samples

ABA Parameter	Unit	*Upper Pit Wall - Oxide Zone*						*Lower Pit Wall - Sulfide Zone*					
		Max	90th percentile	Median	10th percentile	Min	*n*	Max	90th percentile	Median	10th percentile	Min	*n*
Paste pH		8.1	7.7	7.1	6.1	5.9	19	7.9	7.6	6.7	3.0	2.4	14
TIC	%	0.6	0.57	0.3	0.06	0.01	6	3.8	2.2	0.4	0.01	0.01	14
CaNP	kg $CaCO_3$/t	50.0	47.5	26.7	4.98	0.80	6	85.1	57.0	27.0	0.8	0.5	14
Total S	%	2.4	1.04	0.3	0.09	0.06	19	36.2	15.3	1.6	0.15	0.02	14
Sulfate-S	%	0.8	0.24	0.0	0.01	0.01	19	2.2	1.6	0.4	0.03	0.01	14
Sulfide-S	%	2.2	0.84	0.2	0.08	0.01	19	34.0	14.3	1.2	0.07	0.02	14
AP	kg $CaCO_3$/t	67.8	26.4	6.4	2.63	0.30	19	1064	448	36.3	2.1	0.6	14
NP	kg $CaCO_3$/t	76.5	47.6	13.7	-2.14	-4.36	19	54.3	44.4	23.9	-8.5	-30.5	14
NPR (CaNP/AP)		117	59.5	2.0	0.25	0.23	6	10.2	4.7	0.9	0.02	0.001	14
NPR (NP/AP)		120	3.5	1.5	-0.7	-1.3	19	13.4	5.4	0.9	-0.1	-0.4	14

Notes:
TIC = Total Inorganic Carbon
CaNP = carbonate neutralization potential in kg $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
Sulfate S determined by 25% HCl leach with Gravimetric Finish
Sulfide S determined by Total S – Sulfate S
AP calculated from sulfide sulfur * 31.25
NP = bulk NP for 1996 and 1999 samples via modified Sobek method and for 2009 samples via siderite corrected method
NPR = net potential ratio

3.2.1.1 Paste pH

Paste pH values provide information on the amount and availability of neutralizing potential in solid phase samples. If carbonate is the main neutralizing mineral and there is no active sulfide oxidation, paste pH values are typically buffered between 8 and 9. Paste pH values for the upper pit wall (oxide zone) samples range from 6.1 to 7.7 with a median value of 7.1, indicating that samples from the oxide zone are characterized by circum-neutral pH values. Paste pH values for the lower pit wall (sulfide zone) samples range between 3.0 and 7.6, indicating that some of these samples are acid generating and that the lower wall samples have a greater potential to be acid generating than the upper wall samples. As expected, lower paste pH values for the lower wall samples correlate with higher total sulfur concentrations (Figure 3-1). Samples indicated to have the lowest paste pH values were taken from the east wall of the pit.

Collectively, paste pH values were consistent with expectations, with lower values reflecting potential acid generation by oxidation of sulfide minerals in the lower walls of the pit (sulfide zone) and higher pH, slightly alkaline values measured in samples from the upper pit wall (oxide zone), which is significantly depleted in sulfide minerals and therefore not prone to acid generation.

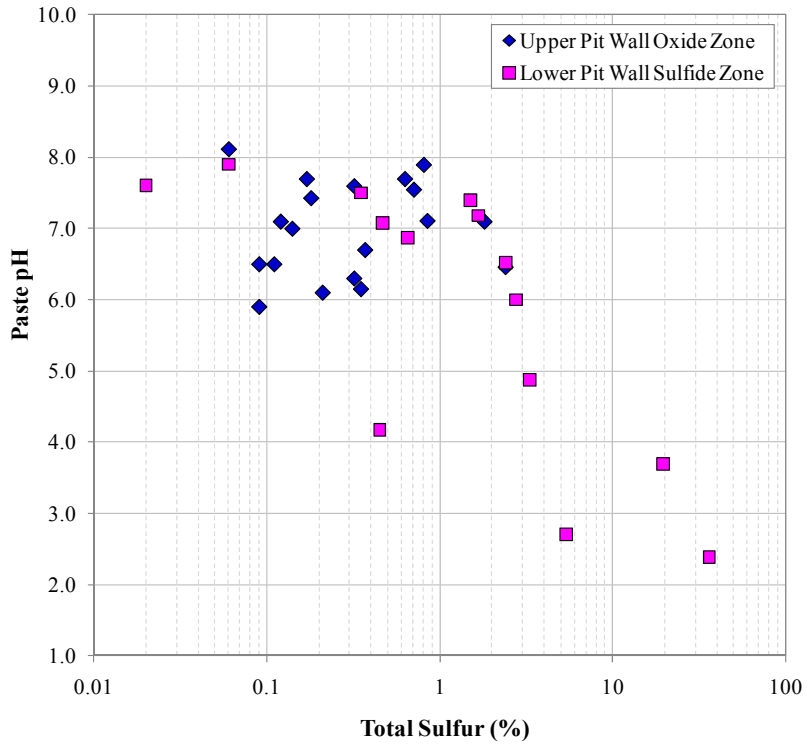


Figure 3-1: Paste pH versus Total Sulfur for Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

3.2.1.2 Acid Potential

Given that the generation of acid is predominantly associated with the oxidation of sulfide mineral, it is important that the quantity and form of sulfur-bearing mineralization be determined. The Mt. Nansen pit wall samples were analyzed for their total, sulfate and sulfide-sulfur concentrations (Table 3-1). Total sulfur values for the upper pit wall samples range from a 10th percentile of 0.09 wt. %S to a 90th percentile of 1.04 wt. %S. The lower pit wall samples are considerably higher, ranging from a 10th percentile of 0.15 wt. %S to a 90th percentile of 15.3 wt. %S (Table 3-1). Samples PWE-06 and PF-TP03 from the lower pit wall, in particular, contain very high concentrations of total sulfur (36.2 wt. %S and 19.5 wt. %S).

Sulfide-sulfur makes up the majority of the sulfur budget for the upper and lower pit wall samples (Table 3-1, Figure 3-2). Sulfide-sulfur was determined by calculation (*i.e.,* Total S – Sulfate-S) and therefore assumes that all non-sulfate sulfur (*i.e.,* including acid insoluble sulfur) is derived from sulfide minerals. However, several samples from both the upper and lower walls of the pit contain a notable proportion of sulfur associated with sulfate mineralization (Table 3-1, Figure 3-2). To appropriately assess the AP of a sample, the content of acid producing sulfates need to be determined in addition to the reactive sulfide phases.

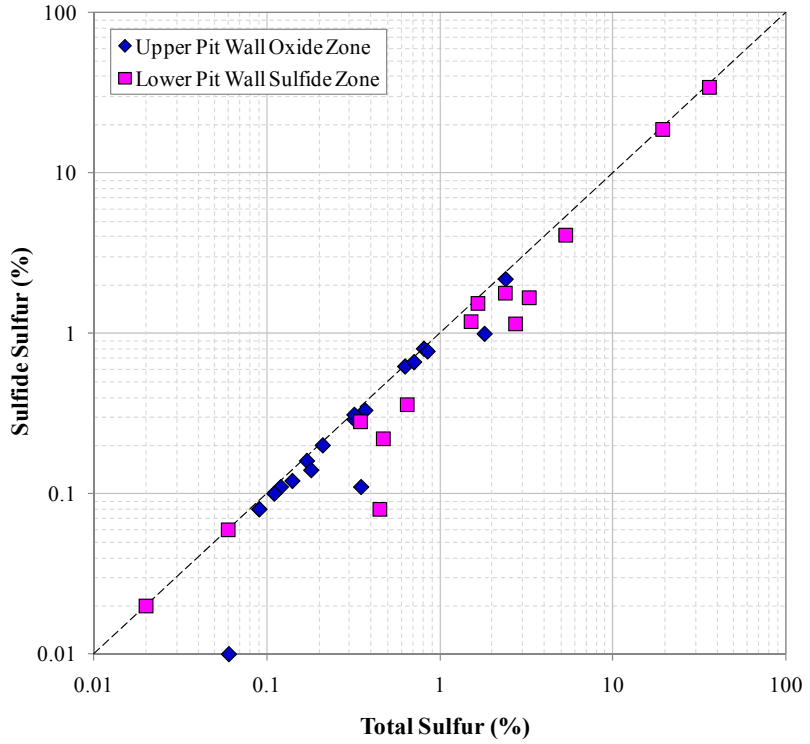


Figure 3-2: Total Sulfur versus Sulfide_Sulfur for Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

Samples of secondary mineral products were collected on July 30, 2009 from a small talus fan of highly weathered sulfidic material at the bottom of the east wall of the Brown-McDade pit. The purpose of this sampling was to identify secondary mineral products and thereby gain a better understanding of the potential solubility constraints of the rock exposed in the pit. Detailed results are provided in appendices A8 and A9 in Altura (2009b). The mineralogy of the secondary minerals indicates a dominance of magnesium and iron sulfate minerals forming in the various precipitates. Specifically, the precipitates are composed of siderotil ($FeSO_4 \cdot 5(H_2O)$); melanterite ($FeSO_4(H_2O)_7$); epsomite ($MgSO_4(H_2O)_7$); pentahydrite ($MgSO_4 \cdot 5(H_2O)$); and, hexahydrite ($MgSO_4 \cdot 6(H_2O)$. The results of the mineralogical investigation indicate that there is a potential for secondary sulfate phases to contain stored acidity; however, while smaller formations of similar-looking products are seen in some other areas of the pit, it should be noted that the area sampled represented an anomalously thick and concentrated accumulation of these products.

Given the uncertainty of the contribution of acidity from secondary sulfate phases, and to avoid overestimating the acid generating potential of the pit walls, sulfide-sulfur (non-sulfate-sulfur) values were used to calculate AP and to further assess the ARD potential of the pit wall samples.

3.2.1.3 Neutralization Potential

In sulfide-bearing rock undergoing weathering, such as that of the Brown-McDade pit wall rock, ARD will result if there is insufficient production of neutralizing alkalinity to buffer the generated acidity. The neutralizing potential (NP) of weathering materials is dependent on the content of minerals that dissolve when exposed to acidic conditions and act to buffer acidity.

While many mineral dissolution reactions may result in acid buffering, the minerals most typically responsible for acid neutralization are fast dissolving carbonates. Aluminosilicate minerals may also contribute to the total neutralizing capacity of a sample; however, rates of silicate dissolution are much slower and thus the ability of these minerals to buffer acidic waters are still not well defined. When mineralogical data are not available, NP of a waste material is generally (conservatively) based on CaNP, which provides information on the specific contribution of carbonate minerals to the neutralization potential of a sample. However, the efficacy of carbonate minerals to neutralize acidity varies depending on the specific carbonate phases present. For example, iron-bearing carbonate minerals, such as ankerite which contains ferrous iron (Fe^{2+}), are much less effective at neutralizing acid than calcite. This is due to the fact that the Fe^{2+} liberated is oxidized to ferric iron (Fe^{3+}), which then precipitates as $Fe(OH)_3$

producing acidity in the process. Therefore, although Fe-bearing carbonate minerals contribute to the neutralizing potential of a sample, the net capacity of a sample to neutralize acid decreases as the amount of Fe-bearing carbonate minerals increase (Jambor *et al.*, 2003).

Carbonate NP values provide information on the specific contribution of carbonate minerals to the NP of a sample whereas bulk NP values are not mineral specific. In general, CaNP and bulk NP values for the Mt. Nansen pit wall samples are low, with 90th percentile values < 57 mg $CaCO_3$/L. CaNP versus bulk NP values for pit wall samples are shown in Figure 3-3. The dashed line represents the points along which samples would plot if all measured bulk NP were a result of calcite ($CaCO_3$) dissolution. Data points above this line indicate that these samples contain iron-bearing carbonate minerals. Points below this line indicate that the measured NP has a non-carbonate component, since the measured bulk NP of a sample is higher than the CaNP value. The negative bulk NP values represent lower pit wall samples which are acid generating.

In general, the upper pit wall samples plot on the dashed line, indicating that calcite is the dominant available neutralizing mineral in this zone. The lower pit wall samples plot either on the line or above the line, indicating that iron-carbonates may form part of the carbonate mineral assemblage in this zone. To avoid overestimating the available CaNP of the pit walls, bulk NP values were used to assess the ARD potential of the pit wall samples.

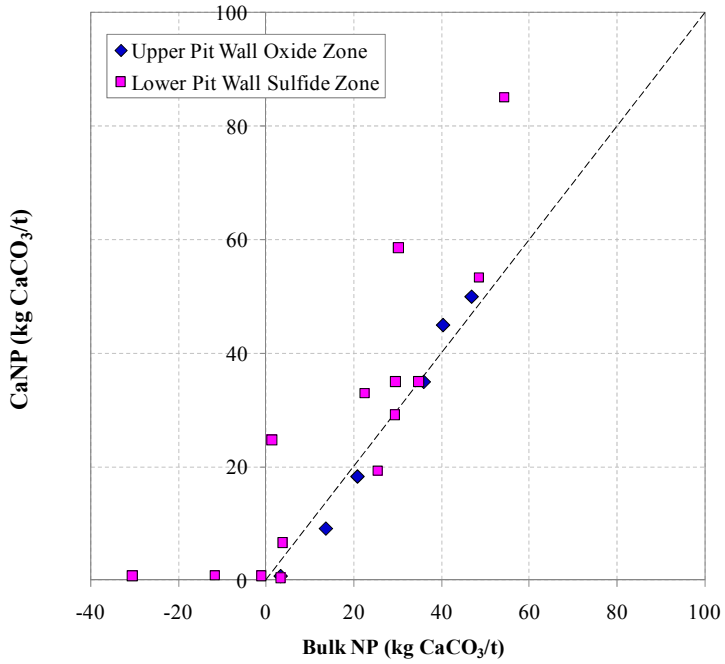


Figure 3-3: Bulk NP versus CaNP for the Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

3.2.1.4 Net Potential Ratio

The net potential ratio (NPR), which is calculated by dividing the NP of a sample by its AP, is often used to indicate the likelihood of a sample to generate acidic drainage and are therefore used as a screening step in mine waste geochemical assessments to determine whether more detailed ARD test work is needed to determine the risk of acid generation. Guidelines adopted by the British Columbia Ministry of Energy Mines and Petroleum Resources (Price and Errington, 1998) suggest that samples with NPR values less than 1 are likely to generate ARD and samples with NPR values greater than 4 are unlikely to generate acidity and therefore do not require any further ARD testing. Samples with NPR values between 1 and 3 have an uncertain potential to generate ARD and is dependent on the specific sulfur-bearing and neutralizing mineral assemblage of the sample.

The data in Table 3-1 and Figure 3-4 indicate that the majority of the Brown-McDade pit upper and lower wall samples are either likely (NPR < 1) or possibly (1 < NPR < 2) acid generating (median NPR values of 1.5 and 0.9). The nature of acid generation in the upper pit wall (oxide zone) samples appears to be related more to their relatively low NP rather than their AP as can be seen in the poor relation between NPR and total sulfur in Figure 3-4. The significance of this observation has to do with the amount of acidity generated by the exposed pit walls. While the residual sulfides in the exposed oxide regions of the pit wall may be acid-generating now or in the future, the amount of acidity will be relatively low owing to the low sulfide contents. The nature of the acid generation in the pit bottom samples, on the other hand, appears to be directly related to the higher concentration of total and sulfide-sulfur content of the samples (Figure 3-4).

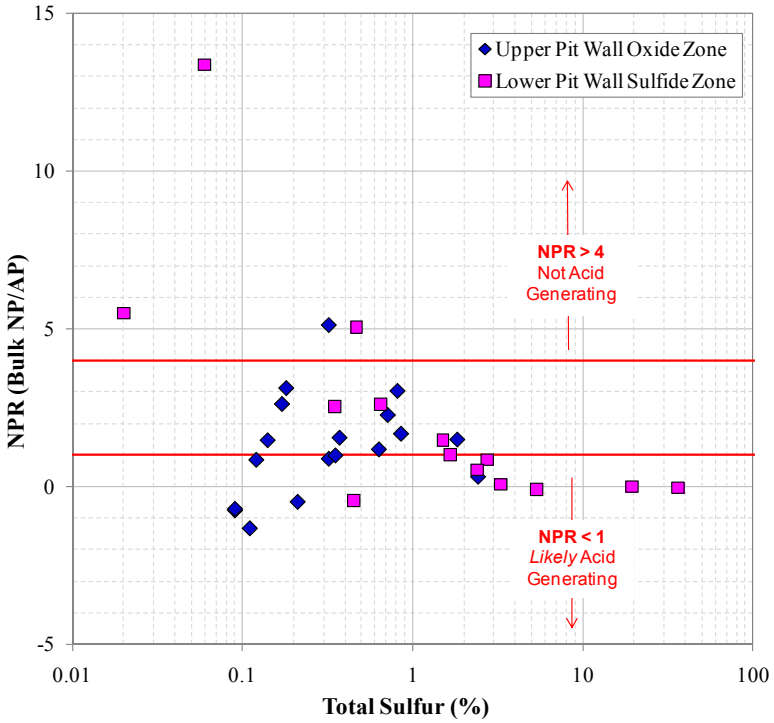


Figure 3-4: NPR versus Total Sulfur for Brown-McDade Pit Wall Samples

3.2.2 Solid Phase Element Determination

Solid phase metals concentrations were used to identify the degree of metals enrichment in the various waste materials. This information can be used in combination with ABA results to establish the geochemical properties of pit wall samples. The degree of enrichment of an element over crustal abundance can be used as a general indicator of the metals that are elevated in solid phase and may be of potential concern for pit lake water quality. In this way, total elemental abundances are used as a screening step to identify parameters that may be of environmental concern. However, solid phase metal concentrations well above crustal abundance do not necessarily indicate that the metal will be leached at a high rate from the material. Rather, the rate of metal leaching is related to the metal's mineralogical association and the aqueous geochemistry of infiltrating waters. An indicator of significant solid phase enrichment is assigned herein to be values greater than or equal to three times the crustal abundance. These values are indicated as light grey shaded cells in Table 3-2. Values greater than, or equal to, ten times their crustal abundance are shown as medium grey and those greater than, or equal to, 100 times their crustal abundance as dark grey in Table 3-2. Values for elements that were indicated to be present in concentrations below detection were set at the analytical limit to facilitate statistical analysis of the geochemical dataset.

Table 3-2:
Statistical Summary of Solid Phase Metal Concentrations for Upper (Oxide) and Lower (Sulfide) Pit Wall Samples[1]

Metal	Unit	Upper Pit Wall - Oxide Zone						Lower Pit Wall - Sulfide Zone						Average Crust Values
		Max	90th percentile	Median	10th percentile	Min	n	Max	90th percentile	Median	10th percentile	Min	n	
Ag	ppm	10.6	4.88	1.8	0.64	0.1	19	381	87.1	5.2	0.66	0.5	14	0.075
As	ppm	3331	1055	129	30.6	5	19	2655	2042	388	88.8	39	14	1.8
Bi	ppm	16.1	10.4	3.2	1.25	0.1	6	233.8	67.4	6.1	2.02	2.5	8	*0.17*
Ca	%	2.57	2.05	0.564	0.137	0.064	19	2.02	1.942	1.24	0.24	0.22	14	
Cd	ppm	55.9	31.5	9.7	1.5	0.2	19	175.3	24.2	12.8	6.16	4	14	0.15
Cu	ppm	1315	517	110	15.4	3.8	19	22846	633	190	31.2	28	14	60
Fe	%	5.14	4.74	3.09	1.47	0.23	6	10	7.43	4.87	2.83	3.48	8	5.6
Hg	ppm	105	54	10	0.060	0.039	19	0.132	0.116	0.091	0.066	0.073	8	*80*
Mg	%	0.78	0.645	0.43	0.215	0.07	6	0.56	0.488	0.28	0.07	0.07	8	
Mn	ppm	1874	1859	1656	763	94	6	3286	2502	1455	263	305	8	950
Ni	ppm	13.9	12	8.3	5	2.6	6	13.9	9.02	7	3.32	3.5	8	84
Pb	ppm	782	417	103	49.4	8.8	19	12524	3881	443	29.2	18	14	*12.5*
Sb	ppm	141	52.2	21	8.8	0.7	19	1336	229	48	10.12	5	14	*0.2*
Se	ppm	0.5	0.5	0.5	0.5	0.5	6	4.3	1.26	0.5	0.5	0.5	8	*0.05*
Zn	ppm	10200	3655	968	309	19	19	10380	1891	1170	216	112	14	70

Notes: 1. Values greater than or equal to 3 times the average continental crust concentration are shaded in light grey, values greater than or equal to 10 times the average crust concentration are shaded in medium grey, and values greater than or equal to 100 times the average crust concentration are shaded in dark grey
2. Average continental crustal abundances are according to Price (1997); values in italics are from CCR (1985)

Table 3-2 demonstrates that Ag, As, Bi, Cd, Cu, Pb, Sb, Se and Zn are present in elevated concentrations with respect to average crustal concentrations in median values for the upper and lower wall samples from the Brown-McDade pit. In particular, samples PWE-06 and PF-TP03) from the lower wall which contains considerably higher total and sulfide-sulfur values also contain metal concentrations in excess of a 100 times their respective average crustal concentration.

3.2.3 Water Soluble Constituents (Shake Flask Extraction Tests)

Shake flask extractions (SFE) are utilized in testing materials which may contain readily leachable elemental constituents associated with non-sulfide mineral phases and/or partially weathered primary sulfide minerals that may host secondary oxidation products. Given the weathered nature of the exposed Brown-McDade pit wall rock, the dissolution of secondary minerals in the SFE provides insight into the water soluble drainage chemistry that would be released from the pit walls. Table 3-3 presents the statistical summary of SFE results for the upper and lower pit wall samples collected in 2009. Included in the table are the 90th and 10th percentile values and maximum, minimum and median values of SFE results as well as the maximum Canadian Council of the Ministers of Environment (CCME) guidelines for the protection of aquatic life for comparison.

Median values for sulfate and dissolved concentrations of Ag, Al, Cd, Cu, Mn and Zn are elevated in the lower pit wall samples with respect to maximum CCME guidelines. Additionally, 90th percentile values of dissolved As, Cr, Fe, Pb, Sb and Se are also above the guideline. With the exception of Al and Cr, the parameters indicated to be elevated in SFE are consistent with parameters indicated to be elevated by elemental analyses of samples subsequent to aqua regia digestion (Section 3.1.2). For the upper pit wall samples, only median values of dissolved Cd and Zn and 90th percentile values of sulfate and dissolved Cu are indicated to be elevated with respect to maximum CCME guidelines. In general, SFE results for the lower pit wall samples are higher by up to three orders of magnitude than SFE results for the upper pit wall samples, suggesting that considerably higher concentrations of metals are stored in water soluble secondary sulfate and oxide phases in the lower pit wall samples. The low pH values for some of the lower pit wall samples indicate that, consistent with mineralogical investigations of the sampled precipitates (Section 3.1.1.2), secondary phases contain stored acidity.

Table 3-3:
Water Soluble Parameters from Pit Wall Samples[1]

Parameter	Unit	Upper Pit Wall - Oxide Zone (*n* = 5)					Lower Pit Wall - Sulfide Zone (*n* = 8)					CCME Max[2]
		Max	90th percentile	Median	10th percentile	Min	Max	90th percentile	Median	10th percentile	Min	
pH		7.8	7.8	7.8	6.9	6.3	7.7	7.7	6.4	2.4	2.4	
Redox	mV	323	316	298	258	258	519	466	291	249	236	
Conductivity	uS/cm	338	338	80.3	54.6	43.2	5410	4066	2014	1007	880	
Total Acidity	mg $CaCO_3$/L	6.44	6.44	4.99	4.14	3.85	9750	5008	39.57	7.21	6.72	
Alkalinity	mg $CaCO_3$/L	52.1	52.1	42.6	18.1	2.47	49.6	44.4	30.6	11.5	1.45	
Sulfate	mg/L	104	104	13.0	1.8	1.0	10211	5849	1179	518	439	*100*
Hardness	mg $CaCO_3$/L	175	175	39.6	22.6	13.8	2330	2232	1357	584	440	
Dissolved Metals												
Ag	mg/L	0.000018	0.000016	0.000007	0.000005	0.000005	0.0012	0.0006	0.0001	0.00001	0.00001	0.0001
Al	mg/L	0.037	0.032	0.025	0.003	0.003	127	85.6	0.84	0.0028	0.0020	0.1
As	mg/L	0.014	0.014	0.013	0.006	0.005	60.0	30.0	0.0035	0.0009	0.0008	0.005
B	mg/L	0.050	0.050	0.050	0.050	0.050	3.00	3.00	0.30	0.05	0.05	
Ba	mg/L	0.045	0.045	0.031	0.019	0.012	0.030	0.0231	0.0099	0.0009	0.0005	
Be	mg/L	0.00001	0.00001	0.00001	0.00001	0.00001	0.020	0.0123	0.0005	0.00001	0.00001	
Bi	mg/L	0.000006	0.000006	0.000005	0.000005	0.000005	0.016	0.0049	0.00003	0.00001	0.00001	
Ca	mg/L	52.7	52.7	13.2	7.51	3.92	487	457	328	156	141	
Cd	mg/L	0.0018	0.0016	0.0012	0.00003	0.00003	4.79	2.34	0.19	0.0016	0.0014	0.000055a
Co	mg/L	0.00013	0.00010	0.00006	0.00002	0.00001	0.59	0.40	0.0050	0.00002	0.00002	
Cr	mg/L	0.00020	0.00016	0.00010	0.00010	0.00010	0.043	0.037	0.0005	0.0001	0.0001	0.001c
Cu	mg/L	0.0056	0.0050	0.0032	0.0019	0.0010	120	49.7	0.23	0.0016	0.0009	0.004b
Fe	mg/L	0.026	0.026	0.015	0.002	0.002	3880	1719	0.030	0.002	0.002	0.3d

Table 3-3:
Water Soluble Parameters from Pit Wall Samples[1] (continued)[1]:

Parameter	Unit	Upper Pit Wall - Oxide Zone (*n* = 5)					Lower Pit Wall - Sulfide Zone (*n* = 8)					CCME Max[2]
		Max	90th percentile	Median	10th percentile	Min	Max	90th percentile	Median	10th percentile	Min	
Dissolved Metals												
Hg	ug/L	0.020	0.020	0.020	0.014	0.010	0.50	0.50	0.21	0.0170	0.010	
K	mg/L	2.35	2.35	1.43	1.30	1.28	6.59	5.59	4.55	0.50	0.50	
Li	mg/L	0.0016	0.0015	0.0013	0.0005	0.0005	0.080	0.0611	0.0185	0.0024	0.0023	
Mg	mg/L	10.6	10.6	1.64	0.91	0.88	271	268	129	47.5	21.2	
Mn	mg/L	0.073	0.073	0.037	0.002	0.001	96.1	94.6	14.4	0.01	0.01	*3.8e*
Mo	mg/L	0.0016	0.0014	0.0011	0.0002	0.0001	0.003	0.0030	0.0004	0.0003	0.0002	0.073
Na	mg/L	2.24	1.58	0.37	0.36	0.35	8.74	6.94	1.85	0.50	0.50	
Ni	mg/L	0.00069	0.00057	0.00040	0.00024	0.00016	0.13	0.10	0.0091	0.0004	0.0002	0.15b
P	mg/L	0.11	0.07	0.01	0.01	0.01	11.7	6.91	0.0100	0.0037	0.0030	
Pb	mg/L	0.00037	0.00037	0.00034	0.00018	0.00018	0.058	0.026	0.0011	0.0001	0.0001	0.007b
S	mg/L	44.0	44.0	5.00	3.00	3.00	3490	2034	457	201	166	
Sb	mg/L	0.0063	0.0063	0.0037	0.0013	0.00091	0.35	0.12	0.0032	0.0007	0.0002	*0.02f*
Se	mg/L	0.00024	0.00024	0.00013	0.00005	0.00005	0.009	0.0041	0.0004	0.0002	0.0002	0.001
Si	mg/L	3.64	3.34	1.94	1.67	1.67	6.11	5.33	3.10	1.25	1.02	
Sn	mg/L	0.00001	0.00001	0.00001	0.00001	0.00001	0.018	0.007	0.00005	0.00001	0.00001	
Sr	mg/L	0.18	0.18	0.04	0.03	0.03	1.04	0.79	0.45	0.18	0.10	
Ti	mg/L	0.00050	0.00050	0.00050	0.00050	0.00050	0.030	0.030	0.0030	0.0005	0.0005	
Tl	mg/L	0.000036	0.000036	0.000011	0.000006	0.000006	0.0003	0.0003	0.0001	0.00005	0.00005	
U	mg/L	0.00026	0.00026	0.00013	0.000039	0.000003	0.041	0.017	0.0005	0.0002	0.0002	
V	mg/L	0.00050	0.00038	0.00020	0.00020	0.00020	0.37	0.13	0.0010	0.0002	0.0002	
Zn	mg/L	0.114	0.088	0.049	0.0013	0.0012	371	177	11.6	0.02	0.02	0.03

Notes: 1. Shaded values exceed CCME guidelines for total metals

2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are B.C. MOE maximum guidelines for protection of freshwater aquatic life for total metals; a) Cd guideline = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$, based on a hardness of 180 mg $CaCO_3$/L; b) criteria based on hardness of > 180 mg $CaCO_3$/L; c) guideline for Cr(VI); d) criteria is for dissolved iron; e) irrigation guideline, protection of aquatic life not proposed; f) working guideline based on proposed Ontario guideline for protection of freshwater aquatic life

3.3 Pit Lake Water Quality

Pit lake water chemistry at Mount Nansen has been monitored regularly since December 2005. However, the data prior to December 2007 is not representative of stable conditions in the pit lake due to active management (*e.g.,* dewatering and artificial fertilization), which would have significantly impacted water quality in the pit lake water column. Furthermore, analytical methods improved in December 2007, resulting in more accurate data for trace metals in waters. An approximate $2^{1/2}$-year time-series of a suite of geochemical parameters has been evaluated and includes the following: total metals (As, Cd, Cu, Fe, Mn, Sb and Zn) and major anions (SO_4^{2-}, NH_3, NO_3^- and NO_2^-). These data are presented and discussed in the following sections. Additional water quality parameters of interest in the pit lake including total suspended solids (TSS), hardness, pH, total alkalinity and aluminum were also evaluated.

Geochemical data are provided for each of the three major zones of the pit lake: top, middle and bottom. Statistical data (mean, median, maximum and minimum) for key water quality parameters in the entire pit lake water column; the top zone; middle zone; and bottom zone of the pit lake are presented in Tables 3-4, 3-5, 3-6 and 3-7, respectively. Based on the evaluation of these data, long-term source term estimates were derived for the pit lake water column. The following sections describe the methodology adopted and the results of the geochemical evaluation of the pit lake and predictions of source terms for the Mt. Nansen closure options that do not involve storage of mine waste in the Brown-McDade pit lake.

3.3.1 Results and Discussion

3.3.1.1 Total Suspended Solids

Concentrations for total suspended solids (TSS) rarely exceeded 10 mg/L in each of the three limnological zones (Figure 3-5). Median TSS concentrations for the top, middle and bottom zones of the pit lake were 4, 4, and 5 mg/L, respectively (Tables 3-5, 3-6, and 3-7, respectively). TSS concentrations in the pit lake are therefore relatively low with slightly higher concentrations measured in the bottom layer. Slightly higher TSS concentrations measured periodically in the bottom layer may be due to minor natural resuspension of bottom sediments or possibly an artifact introduced by the sampling procedure (contact between the water sampler and bottom sediments resulting in localized resuspension of sediments).

Table 3-4:
Pit Lake Water Quality Statistics
Complete Water Column (December 2007 to present)

Parameter	Unit	*n* < DL[1]	Mean	StDev	Median	Max	Min	CCME Max[2]
Sulfate	mg/L	81 0	934	308	862	1740	357	100
Ammonia	mg/L	81 37	0.12	0.1	0.085	0.44	0.005	0.019
Nitrate	mg/L	81 2	1.29	0.9	1.22	4.01	0.06	13
Nitrite	mg/L	81 67	0.18	0.15	0.14	0.54	0.04	0.06
As	mg/L	81 0	0.014	0.02	0.009	0.12	0.0036	0.005
Cd	mg/L	81 0	0.014	0.008	0.011	0.035	0.0031	0.27a
Cu	mg/L	81 0	0.026	0.03	0.018	0.1	0.002	0.004b
Fe	mg/L	81 8	0.24	0.61	0.08	3.5	0.014	0.3c
Mn	mg/L	76 0	1.44	1.89	0.72	7.73	0.078	0.2d
Sb	mg/L	81 0	0.0057	0.002	0.0062	0.0099	0.0007	0.02e
Zn	mg/L	81 0	1.52	0.66	1.36	3.09	0.49	0.03
Ca	mg/L	81 0	315	79	322	501	155	--
Mg	mg/L	81 0	98	33	95	168	41	--
Hardness	mg/L	63 0	1140	320	1150	1860	490	--

Notes: 1. N = number of samples in study; < DL = number of samples below the analytical detection limit;
2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) Cd guideline = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$, based on a median hardness of the entire water column; b) guideline is based on a hardness of > 180 mg $CaCO_3$/L; c) guideline is for dissolved Fe; d) irrigation guideline, none proposed for protection of aquatic life; and e) working guideline based on proposed Ontario guideline for protection of aquatic life.

Table 3-5:
Pit Lake Water Quality Statistics
Top Zone of Water Column (December 2007 to present)

Parameter	Unit	*n* < DL[1]	Mean	StDev	Median	Max	Min	CCME Max[2]
Sulfate	mg/L	27 0	720	143	733	915	357	100
Ammonia	mg/L	27 15	0.079	0.05	0.065	0.17	0.011	0.019
Nitrate	mg/L	27 0	1.71	1.1	1.42	4.01	0.3	13
Nitrite	mg/L	27 23	0.12	0.08	0.11	0.22	0.04	0.06
As	mg/L	27 0	0.0098	0.004	0.0093	0.02	0.004	0.005
Cd	mg/L	27 0	0.01	0.005	0.0091	0.018	0.003	0.23a
Cu	mg/L	27 0	0.019	0.015	0.01	0.05	0.002	0.004b
Fe	mg/L	27 3	0.071	0.045	0.06	0.2	0.02	0.3c
Mn	mg/L	25 0	0.38	0.3	0.23	1	0.078	0.2d
Sb	mg/L	27 0	0.0076	0.002	0.0083	0.01	0.005	0.02e
Zn	mg/L	27 0	1.17	0.4	1.21	1.9	0.49	0.03
Ca	mg/L	27 0	258	53	265	329	155	--
Mg	mg/L	27 0	74	20	72	117	41	--
Hardness	mg/L	21 0	941	224	934	1240	489	--

Notes: 1. N = number of samples in study; < DL = number of samples below the analytical detection limit;
2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) Cd guideline = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$; b) guideline is based on median hardness of the top zone of the water column; c) guideline is for dissolved Fe; d) irrigation guideline, none proposed for protection of aquatic life; and e) working guideline based on proposed Ontario guideline for protection of aquatic life.

Table 3-6:
Pit Lake Water Quality Statistics
Middle Zone of Water Column (December 2007 to present)

Parameter	Unit	*n* < DL[1]	Mean	StDev	Median	Max	Min	CCME Max[2]
Sulfate	mg/L	27 0	853	210	848	1420	550	100
Ammonia	mg/L	27 13	0.063	0.055	0.04	0.18	0.005	0.019
Nitrate	mg/L	27 0	1.39	0.73	1.38	2.72	0.31	13
Nitrite	mg/L	27 22	0.19	0.2	0.14	0.54	0.04	0.06
As	mg/L	27 0	0.0097	0.005	0.009	0.023	0.005	0.005
Cd	mg/L	27 0	0.015	0.009	0.0099	0.035	0.006	0.26a
Cu	mg/L	27 0	0.029	0.03	0.016	0.085	0.002	0.004b
Fe	mg/L	27 3	0.1	0.08	0.085	0.37	0.016	0.3c
Mn	mg/L	25 0	0.96	1.17	0.62	5.08	0.1	0.2d
Sb	mg/L	27 0	0.006	0.002	0.0062	0.009	0.002	0.02e
Zn	mg/L	27 0	1.64	0.74	1.34	3.09	0.63	0.03
Ca	mg/L	27 0	293	66	285	469	177	--
Mg	mg/L	27 0	91	27	94	164	49	--
Hardness	mg/L	21 0	1048	245	1087	1740	644	--

Notes: 1. N = number of samples in study; < DL = number of samples below the analytical detection limit;
2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) Cd guideline = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$; b) guideline is based on median hardness of middle zone of the water column; c) guideline is for dissolved Fe; d) irrigation guideline, none proposed for protection of aquatic life; and e) working guideline based on proposed Ontario guideline for protection of aquatic life.

Table 3-7:
Pit Lake Water Quality Statistics
Bottom Zone of Water Column (December 2007 to present)

Parameter	Unit	*n* < DL[1]	Mean	StDev	Median	Max	Min	CCME Max[2]
Sulfate	mg/L	270	1230	287	1250	1740	804	*100*
Ammonia	mg/L	279	0.18	0.12	0.18	0.44	0.006	0.019
Nitrate	mg/L	272	0.74	0.46	0.65	1.68	0.06	13
Nitrite	mg/L	2718	0.22	0.15	0.14	0.46	0.09	0.06
As	mg/L	270	0.022	0.03	0.009	0.12	0.005	0.005
Cd	mg/L	270	0.016	0.008	0.012	0.034	0.005	0.32a
Cu	mg/L	270	0.032	0.03	0.021	0.1	0.004	0.004b
Fe	mg/L	272	0.54	0.99	0.15	3.5	0.014	0.3c
Mn	mg/L	260	2.91	2.38	2.6	7.73	0.087	0.2d
Sb	mg/L	270	0.0036	0.002	0.0035	0.008	7E-04	*0.02e*
Zn	mg/L	270	1.76	0.66	1.51	2.96	0.51	0.03
Ca	mg/L	270	380	70	378	533	269	--
Mg	mg/L	270	127	28	133	176	73	--
Hardness	mg/L	210	1429	260	1420	1857	972	--

Notes: 1. N = number of samples in study; < DL = number of samples below the analytical detection limit;
2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) Cd guideline = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$; b) guideline is based on mean hardness of bottom zone of the water column; c) guideline is for dissolved Fe; d) irrigation guideline, none proposed for protection of aquatic life; and e) working guideline based on proposed Ontario guideline for protection of aquatic life.

Such generally low TSS concentrations in the Brown-McDade pit lake water column indicates low input of detrital material reflecting low rates of erosion in the local watershed. The observed TSS levels may reflect the presence of inorganic and organic authogenic materials (formed in situ in the pit lake) through primary production of organic matter (phytoplankton) and/or precipitation of inorganic mineral phases (Ministry of Environment, 1998).

3.3.1.2 Water Hardness

The hardness of water (reported as mg calcium carbonate/L) is dependent on its calcium and magnesium content, with higher concentrations of these elements resulting in higher hardness values. The observed range in hardness (between December 2007 and July 2010) for the entire pit lake water column was between ~500 and 2,000 mg/L (Figure 3-6). The Brown-McDade pit lake is therefore characterized by hard water (water with $CaCO_3$ concentrations greater than 120 mg/L is categorized as "hard"). The hardness of the pit lake water is likely due to weathering and dissolution of carbonate-rich rocks, which occur in abundance at the Mt. Nansen.

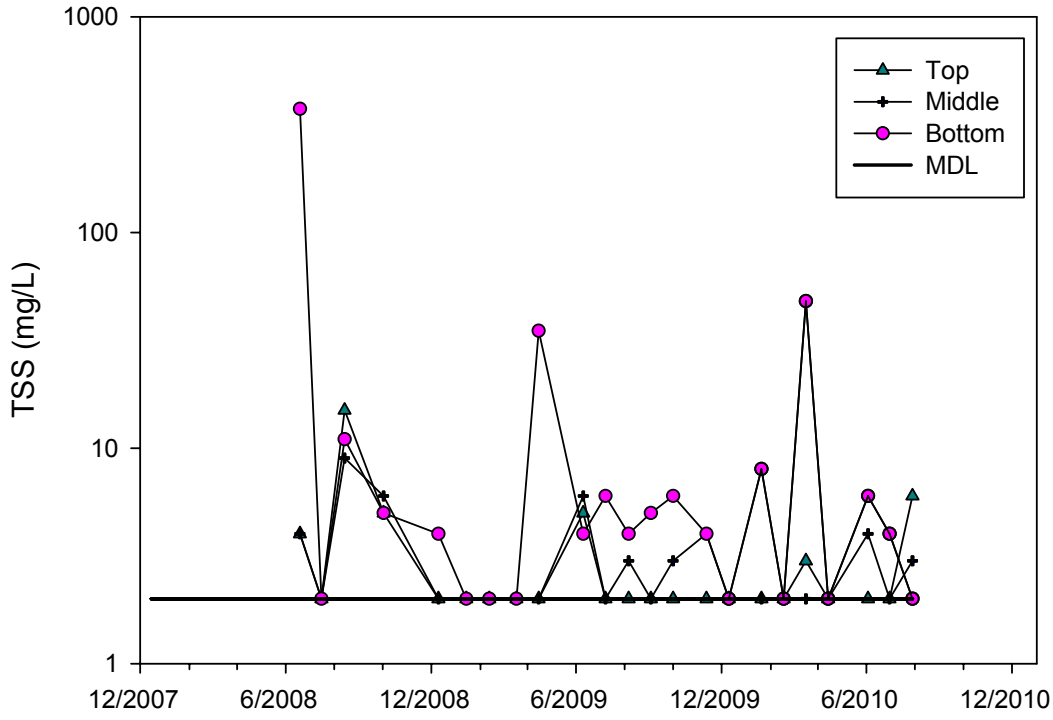


Figure 3-5: Semi-log Plot of TSS in Pit Lake Water Column

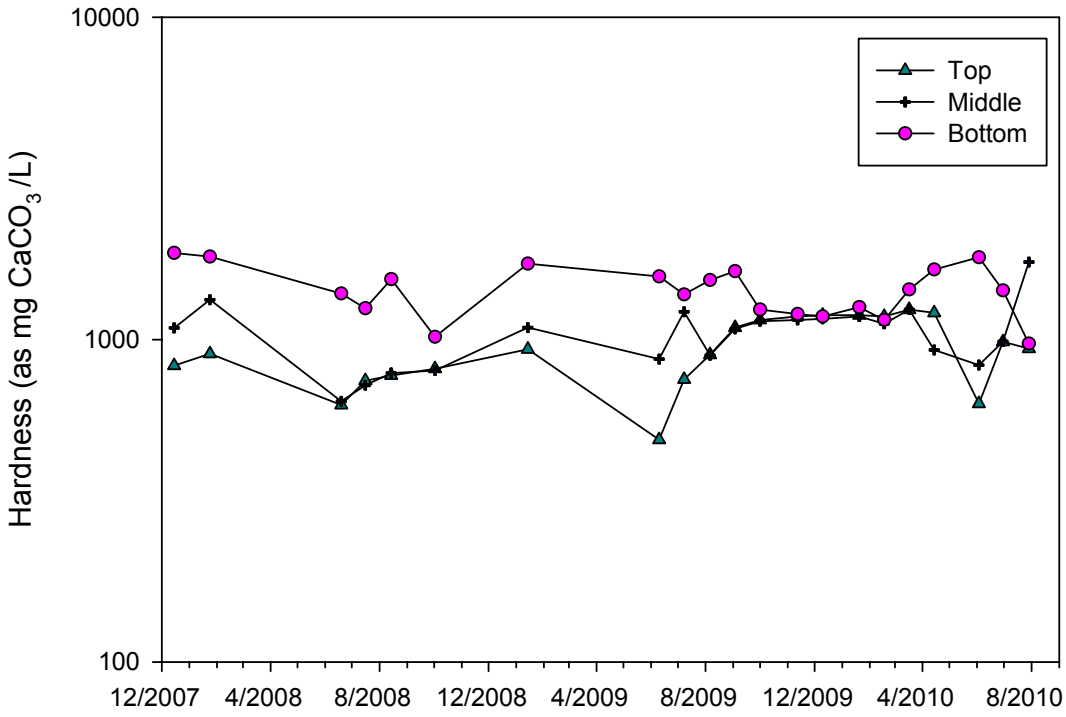
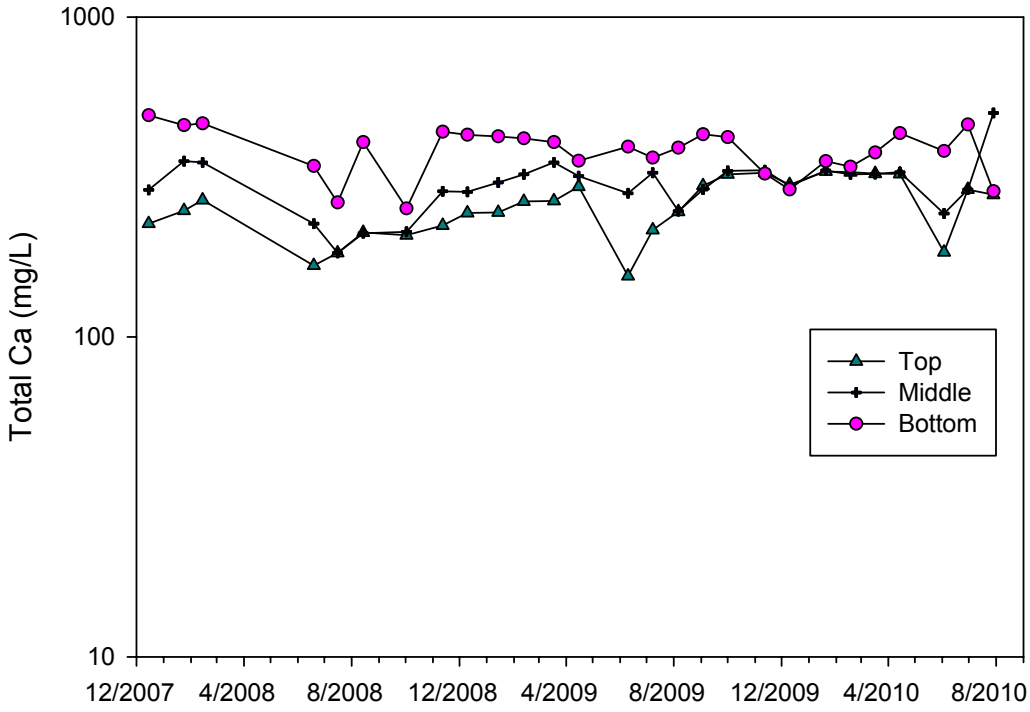


Figure 3-6: Semi-log Plot of Hardness (as mg $CaCO_3$/L) in Pit Lake Water Column

Total Ca and Mg concentrations in the three zones of the pit lake are shown in Figure 3-7(a) and 3-7(b), respectively. Mean calcium concentrations are approximately 3-fold higher than magnesium, indicating that the bulk of the total hardness in pit lake waters is from calcium (Figure 3-7 and Table 3-4). Time-series data for Ca and Mg show a similar trend with increases and decreases in Ca concentrations being mirrored by Mg, albeit at lower concentrations. This relationship indicates that solid-liquid phase partitioning for these elements is controlled by the same carbonate mineral. Based on the observed Ca:Mg weight ratio of 3:1 and atomic weights for Ca (40) and Mg (24), the molar ratio of Ca:Mg in the carbonate mineral controlling solid-liquid phase equilibrium is expected to be 2:1.

Both Ca and Mg concentrations show a trend of increasing concentrations with depth in the pit lake water column resulting in a chemically stratified pit lake, likely resulting from physical stratification of the pit lake driven with increases in water salinity (and thereby density) with depth in the pit lake water column. The observed chemical stratification with increasing concentrations with depth also suggests that the source of these parameters is the bottom of the flooded pit.

a)



b)

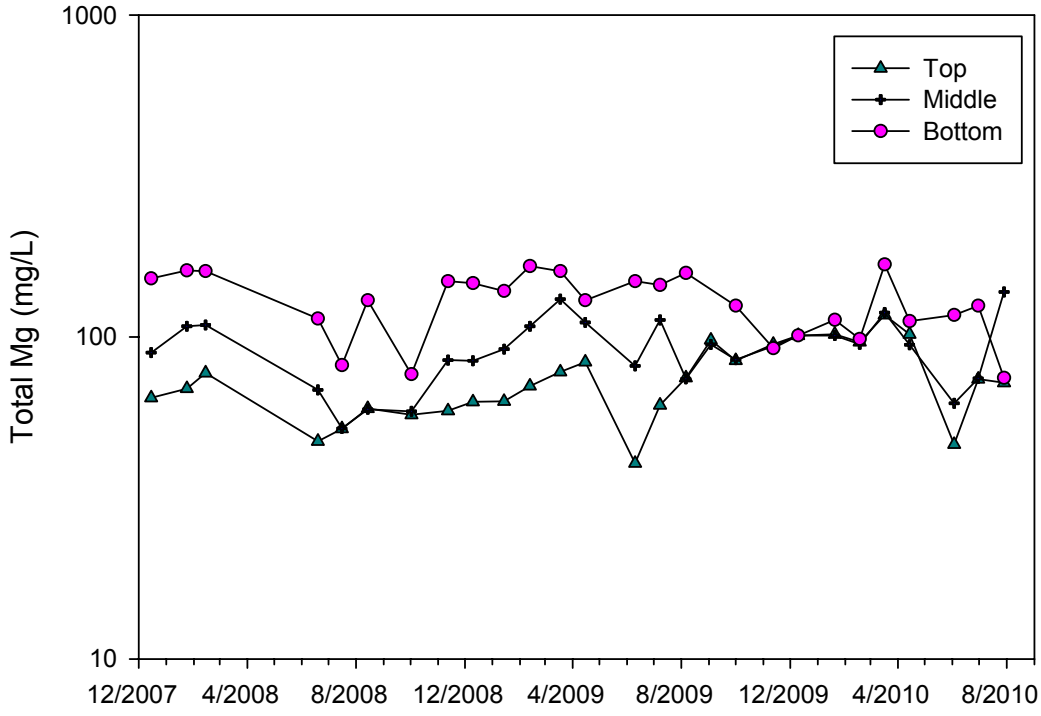


Figure 3-7: Semi-log Plot of (a) Total Calcium and (b) Total Magnesium in Pit Lake Water Column

A strong positive correlation between total calcium and total magnesium concentrations further supports the tenet that the solid-liquid partitioning of these two elements is controlled by dissolution/precipitation of the same carbonate phase (Figure 3-8).

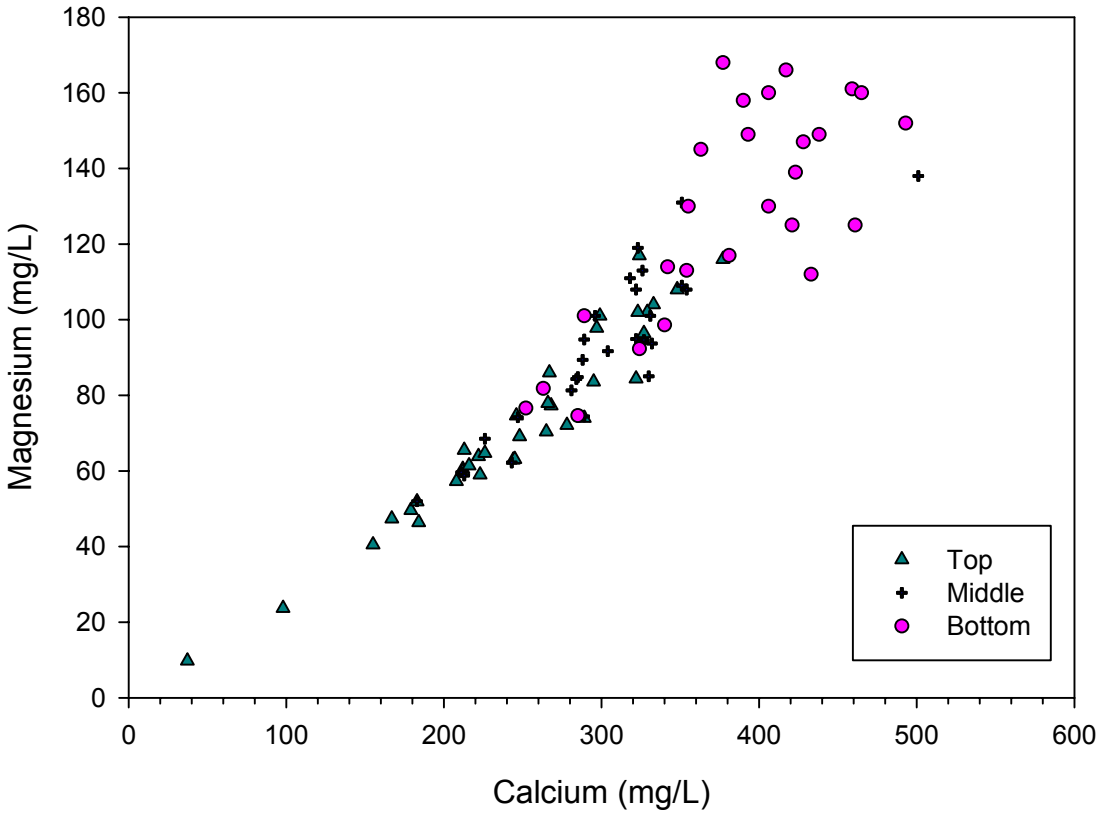


Figure 3-8: Relationship between Calcium and Magnesium Concentrations in Pit Lake Waters

3.3.1.3 pH and Alkalinity

The pH of pit lake waters ranged between ~7 and 8 over the monitoring period (December 2007 to present), exhibiting little special variability throughout the entire water column (Figure 3-9). The circum-neutral to slightly alkaline pH of pit waters throughout the 2.5 years of monitoring demonstrates that dissolution of carbonate minerals provides significant buffering capacity against acidity generated by sulfide oxidation.

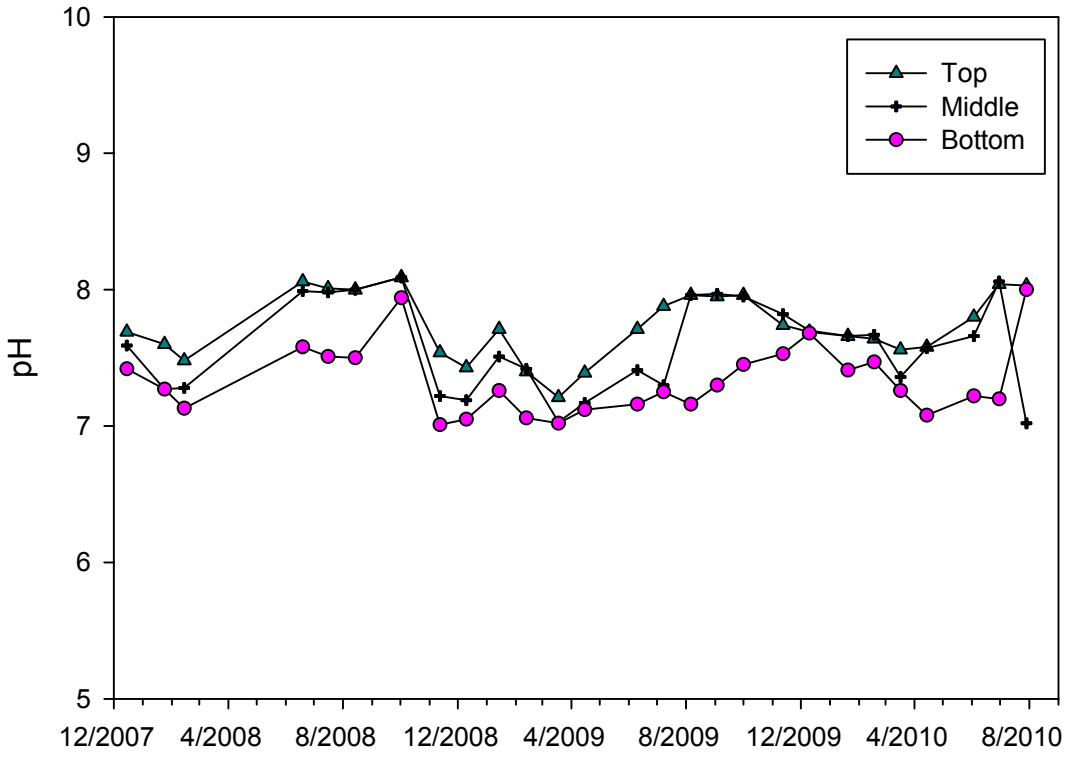


Figure 3-9: Time-series of pH in the Pit Lake Water Column

Total alkalinity (as mg/L total $CaCO_3$) was high in each of the three pit lake zones (top, middle and bottom; Figure 3-10). The B.C. Guidelines designates total alkalinity levels above 20 mg/L as having low sensitivity to acid inputs. The minimum observed total alkalinity for the entire water column was 24.3 mg/L, and relatively higher mean values were observed in the bottom (226 ± 30 mg/L; Table 3-7) in comparison to the top (156 ± 50 mg/L; Table 3-5) and middle zones (180 ± 40 mg/L; Table 3-6).

Seasonal trends were also identified with higher alkalinity values exhibited in the spring compared to the summer lows, possibly due to increased alkalinity contributions from snowmelt runoff. The overall alkalinity has effectively buffered the waters from acidity and accounts for the circum-neutral to slightly alkaline pH range observed in the p[it lake water column. Waters with relatively high total alkalinity normally occur in watersheds hosted by carbonate-rich rock. Hence, the presence of metamorphosed carbonates in the Brown-McDade pit would account for the high total alkalinity that was observed. Furthermore, in the hypolimnion (deep layer) of deep lakes such as pit lakes, reducing conditions may persist to promote the reduction of sulfate, which is also known to generate alkalinity (Davison and Woof, 1990).

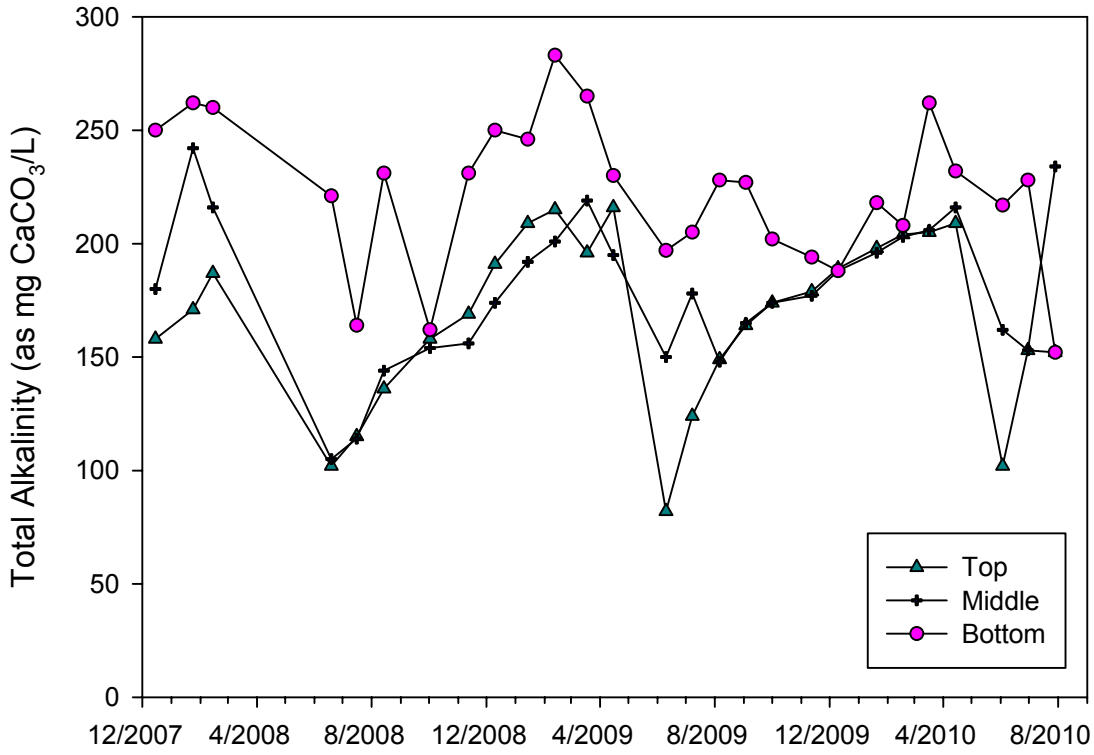


Figure 3-10: Total Alkalinity (as mg $CaCO_3$/L) in Pit Lake Water Column

3.3.1.4 Sulfate

While no CCME guideline exists for sulfate, the observed concentrations in each zone of the pit lake were above the maximum acceptable level (100 mg/L sulfate) provided in the B.C. water quality guidelines (Figure 3-11). Elevated sulfate concentrations in water result in poor aesthetics (discoloration and bad smell) rather than toxicity to aquatic organisms and therefore only a few jurisdictions include a criterion for sulfate in their water quality regulations. As presented in tables 3-5, 3-6 and 3-7, the mean sulfate concentrations generally increased with water depth in the pit lake. The high sulfate concentrations in the pit lake are attributed to oxidation of the sulfide minerals present in the host rock of the pit.

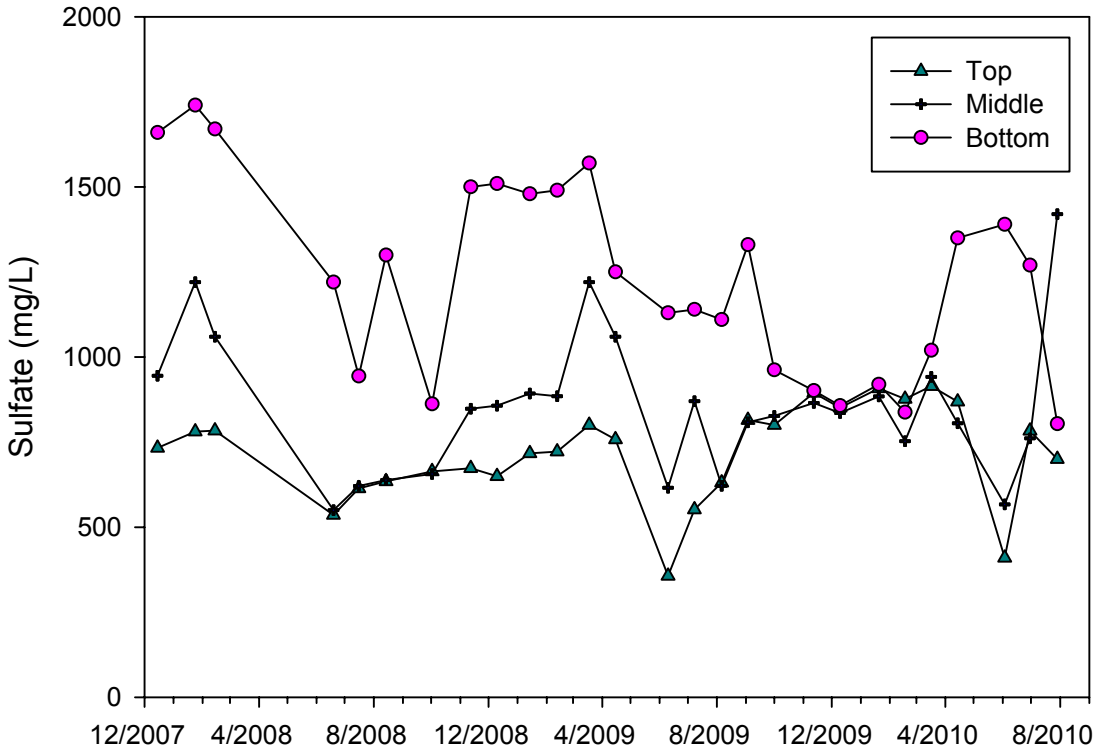


Figure 3-11: Plot of Sulfate in Pit Lake Water Column

The increasing sulfate concentration with pit lake water depth is consistent with increasing concentrations of Ca and Mg with depth as described previously. The strong positive correlation between sulfate and both calcium and magnesium concentration in pit lake waters further supports a linkage in the processes responsible for the cycling of these components in the Brown-McDade pit lake system (Figure 3-12 and Figure 3-13, respectively). The predominant geochemical processes responsible for the chemistry of the Brown-McDade pit lake are the oxidation of sulfide minerals resulting in generation of sulfate and acidity (decrease in pH) and the resulting dissolution of carbonate minerals which result in increasing pH and ultimately circum-neutral pH of the pit lake water column, consistent with empirical data presented and discussed in Section 3.3.1.3.

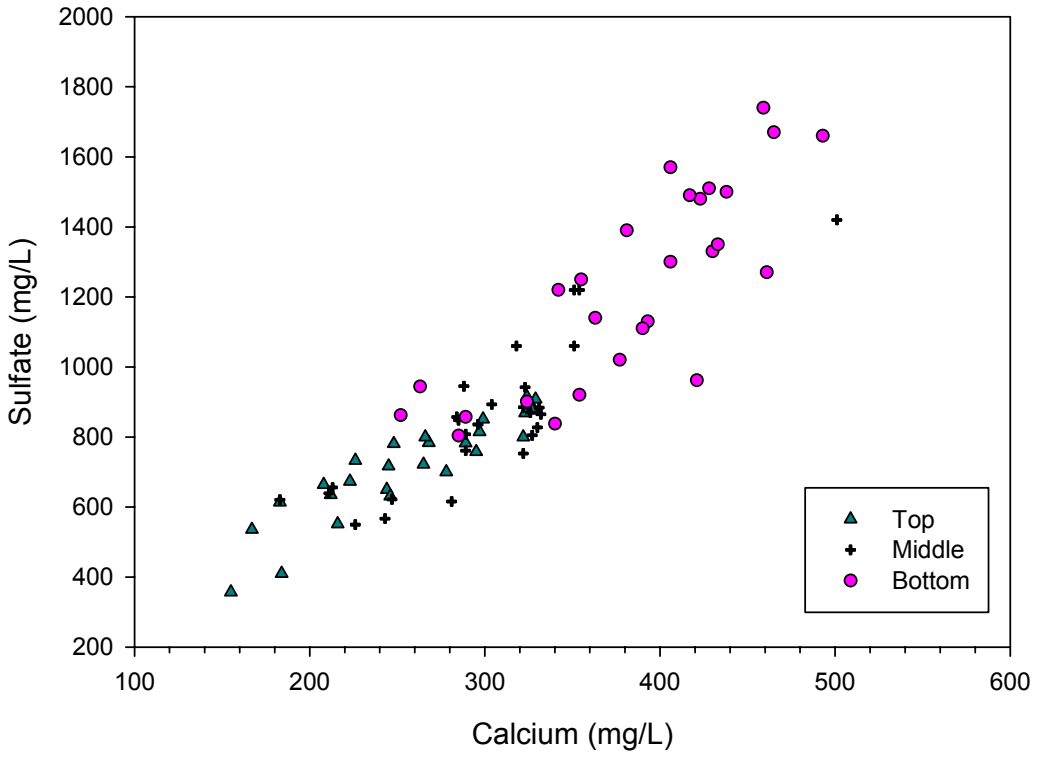


Figure 3-12: Calcium versus Sulfate in Pit Lake Water Column

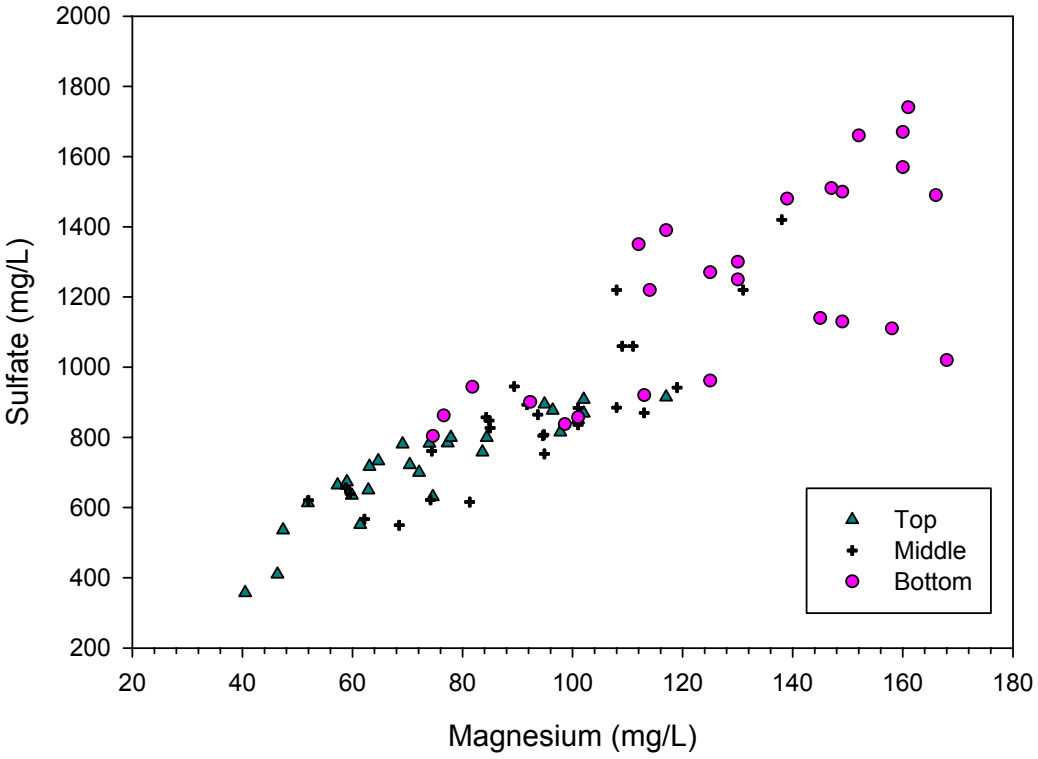


Figure 3-13: Magnesium versus Sulfate in Pit Lake Water Column

3.3.1.5 Total Iron

Time-series of total and dissolved iron concentrations are presented in Figure 3-14. Based on mean concentrations the total Fe concentrations increased with zonal depth (Table 3-5 to Table 3-7). The most dramatic differences between total Fe concentrations in the bottom and the other zones were observed between December 2007 and the summer of 2009, thereafter the differences were negligible. In the bottom zone of the pit lake, a decline in total Fe is observed with time. No clear correlation between TSS and total Fe is evident, while a relationship between total Fe and total Al may exist. Dissolved Fe was rarely detected, which was expected since the pH of the pit lake is neutral to alkaline.

There is reason to view the dissolved Fe data with caution since the water samples were not filtered and preserved immediately in the field. The time lag between sample collection and filtration/preservation in the analytical laboratory may have resulted in the oxidation of ferrous iron to ferric iron and its subsequent precipitated out of solution. Interpretation of the iron data therefore focused on the total fraction rather than the dissolved fraction, which may have been unrepresentative of the actual dissolved iron concentrations due to artifacts introduced due to delay in filtration and preservation of the sample as described above. This cautionary approach was adopted for interpretation of all metals, since their solid-liquid phase partitioning may have been influenced by redox sensitive phases. For example, precipitation of iron oxides is known to result in scavenging of other metals (*e.g.,* Cd and Zn) from solution. The interpretation of metal data in the present study was therefore focused on the total metal fraction.

3.3.1.6 Total Aluminum

In each of the three pit lake vertical zones, total Al concentrations rarely exceeded 0.1 mg/L (Figure 3-15). An overall decline in total Al was observed from the summer of 2008 to present in each zone. Relatively higher concentrations were observed in the bottom (Max = 0.5 mg/L) compared to the top and middle zones (Max = 0.1 mg/L for both top and middle). Dissolved Al is also presented; however, concentrations were rarely above the method detection limit, which is expected at pH values between 6 and 8 at which Al is most insoluble. At neutral pH, it is uncommon to find Al concentrations above 1 mg/L since Al rapidly sorbs to sediments and precipitates from solution. Aluminum concentrations are expected to remain relatively stable in the long-term due to the circum-neutral pH of pit lake waters due to the significant buffering capacity of the system by the presence of abundant carbonate phases.

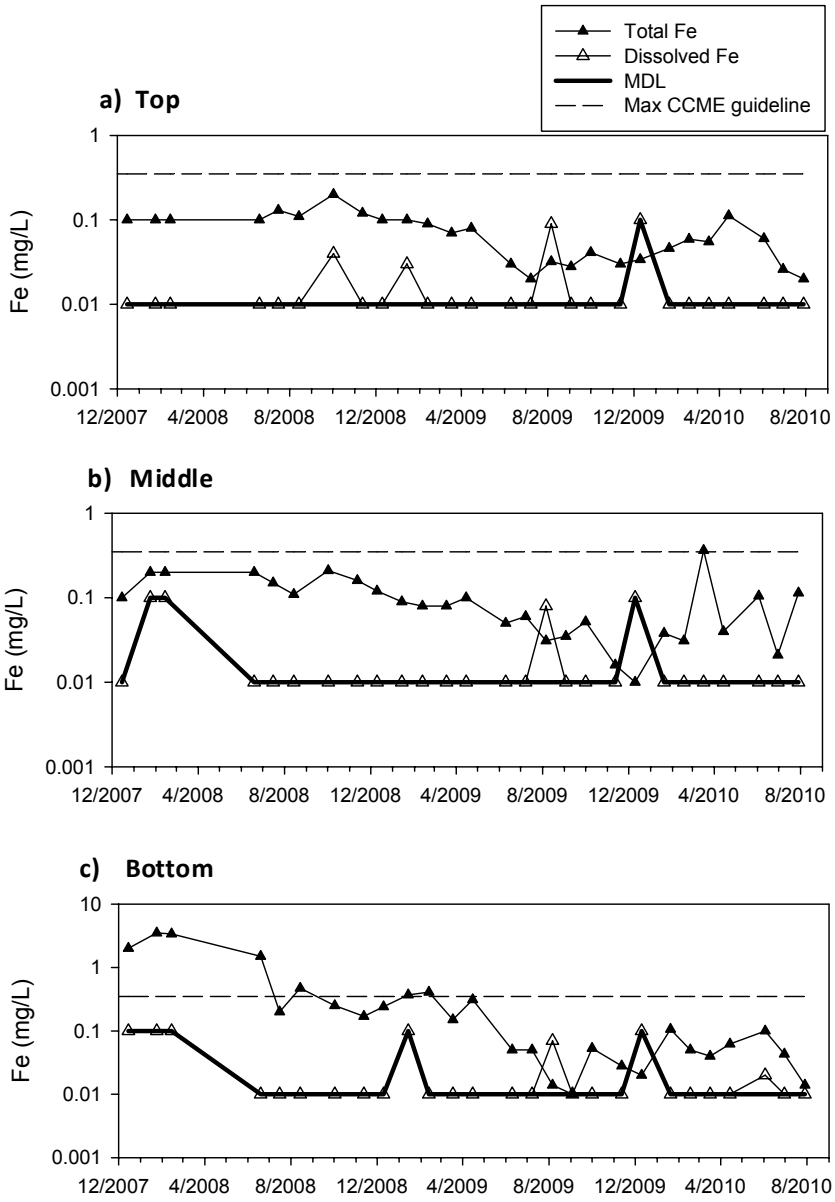


Figure 3-14: Semi-log Plot of Total and Dissolved Iron in (a) Top Zone, (b) Middle Zone and (c) Bottom Zone of the Brown-McDade Pit Lake (MDL shown is for the Dissolved Fraction)

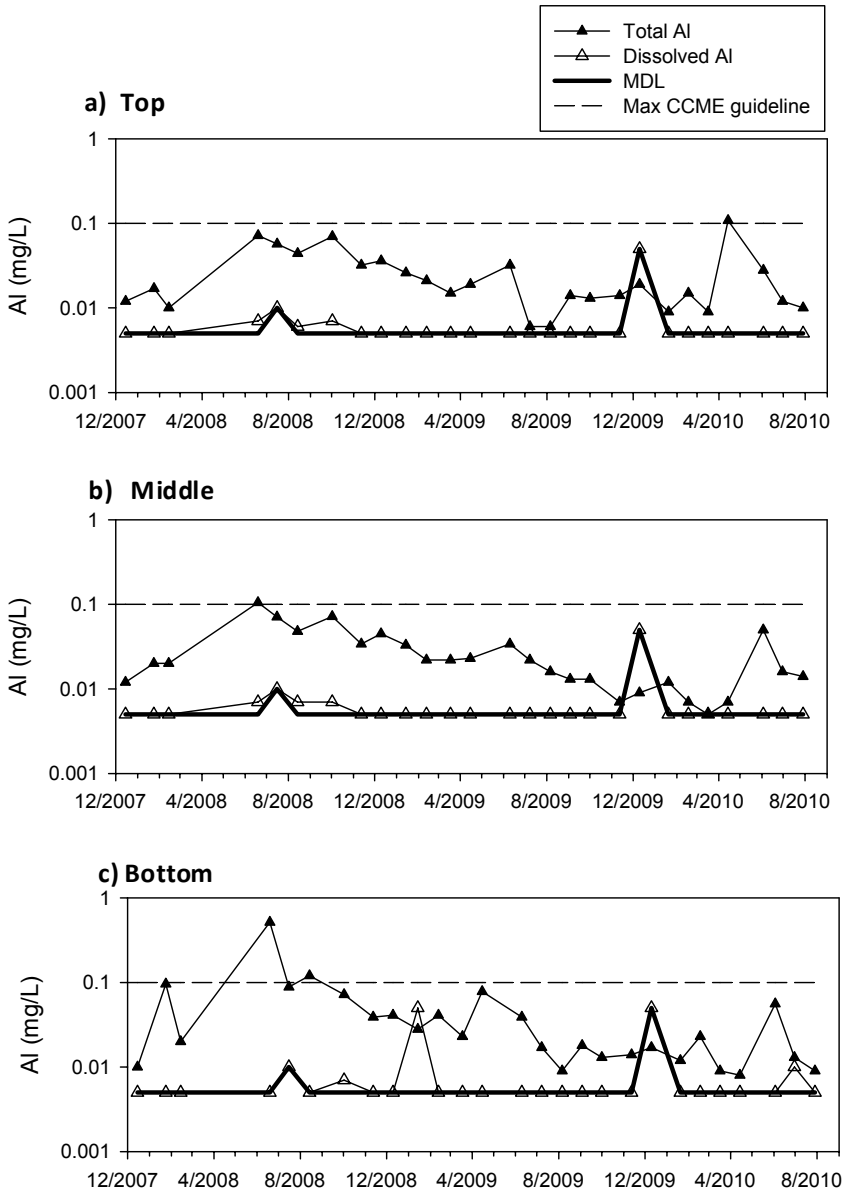


Figure 3-15: Semi-log Plot of Total and Dissolved Aluminum in (a) Top Zone, (b) Middle Zone and (c) Bottom Zone of the Pit Lake (MDL shown is for the Dissolved Fraction)

3.3.1.7 Total Arsenic

The total As concentrations remained below 0.02 mg/L from December 2007 until the last sampling date (July 2010) in the top and middle zones of the pit lake, while slightly lagging behind in the bottom zone but eventually stabilizing at the same concentration (Figure 3-16). With few exceptions, total As concentrations in each of the three limnological zones were above the maximum acceptable level (5.0 µg/L) for the protection of aquatic life (CCME guidelines, 2007). Only in the summer of 2009 was the total As concentration below the maximum contaminant level (MCL), and this was limited to samples from the top zone of the water column. The mean total arsenic concentration observed for the entire water column from June 2009 to present was 14 ± 20 µg/L (Table 3-4). Mean total As was highest in the bottom zone of pit lake (22 ± 30 µg/L, Table 3-7) compared to the top (9.8 ± 4 µg/L, Table 3-5) and middle zones (9.7 ± 5 µg/L, Table 3-6). Ultimately, the removal of arsenic from the water column was likely caused either by sorption to oxide minerals precipitating or by co-precipitation with iron oxides.

3.3.1.8 Total Antimony

Total antimony (Sb) concentrations for each of the three limnological zones were below the maximum contaminant level (0.02 mg/L, B.C. Guidelines) from December 2007 to the last sampling event in July 2010 (Figure 3-17). Trends in total and dissolved antimony concentration (data not shown) appear to be the same, indicating that no antimony is bound to suspended particulate matter. Within the entire water column, the mean Sb concentration was 5.7 ± 2 µg/L (Table 3-4). In each pit lake zone, the concentrations were relatively stable throughout the course of the monitoring period, only oscillating between 1 and 10 µg/L Sb.

The commonly accepted view is that Sb is highly mobile in near neutral oxidizing environments (Filella *et al.*, 2009). The decrease in Sb concentration in the pit lake at depth could result from a shift in redox conditions from oxidizing to more reducing conditions. Chemical stratification of the pit lake is demonstrated by changes in concentration of several parameters with depth. The stratification of deep lakes tends to promote anoxic or reducing conditions in the hypolimnion, particularly if organic decomposition is prominent. However as expected, reducing conditions were not observed in the epilimnion (top layer) due to the exchange of oxygen across the air-water interface resulting in oxygenated waters in the upper zone of the pit lake. Other physicochemical processes that could influence the behavior of Sb in the pit lake include aqueous-solid phase partitioning and mode of association with major/minor element phases (*Trainor et al.*, 2006).

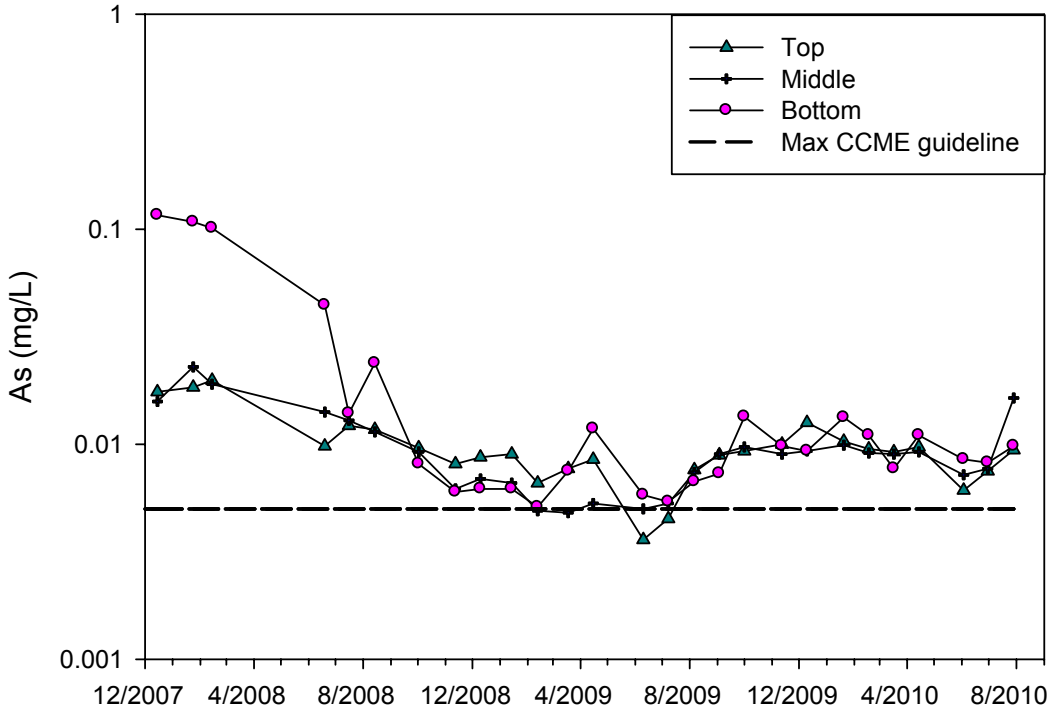


Figure 3-16: Semi-log Plot of Total Arsenic in Pit Lake Water Column

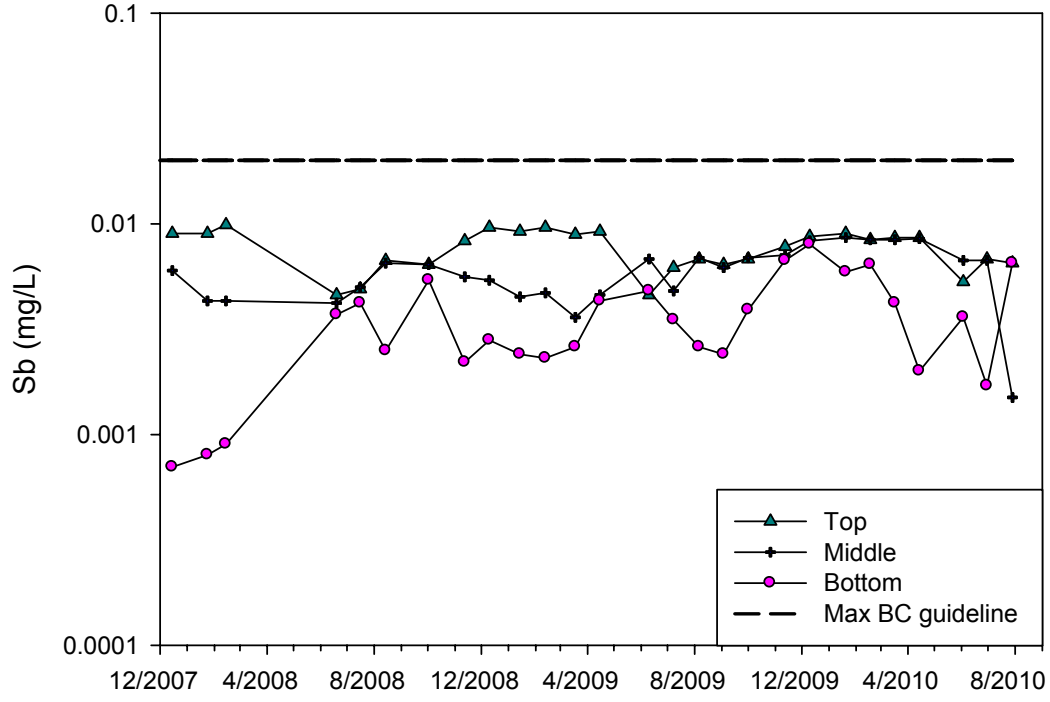


Figure 3-17: Semi-log Plot of Total Antimony in Pit Lake Water Column

3.3.1.9 Total Cadmium

Total Cd concentrations in each of the three pit lake zones are below the revised, hardness-dependant, CCME Guidelines, as illustrated in Figure 3-18. The mean concentration for the entire water column was 0.014 ± 0.008 mg/L, from December 2007 to present (Table 3-4). As presented in Tables 3-5, 3-6, and 3-7, the maximum concentrations were observed in the spring of 2009 for each zone, and may correspond to enhanced erosion or leaching in response to higher runoff from the melting of an abnormally large snowpack that was observed that year. Generally, the trends in Cd appear to be relatively steady.

Cadmium and Zn are chemical analogs and are commonly associated with one another. A relationship between the two cations was observed in the pit lake (Figure 3-19) and supports the notion that these metals leach proportionally from the surrounding rock.

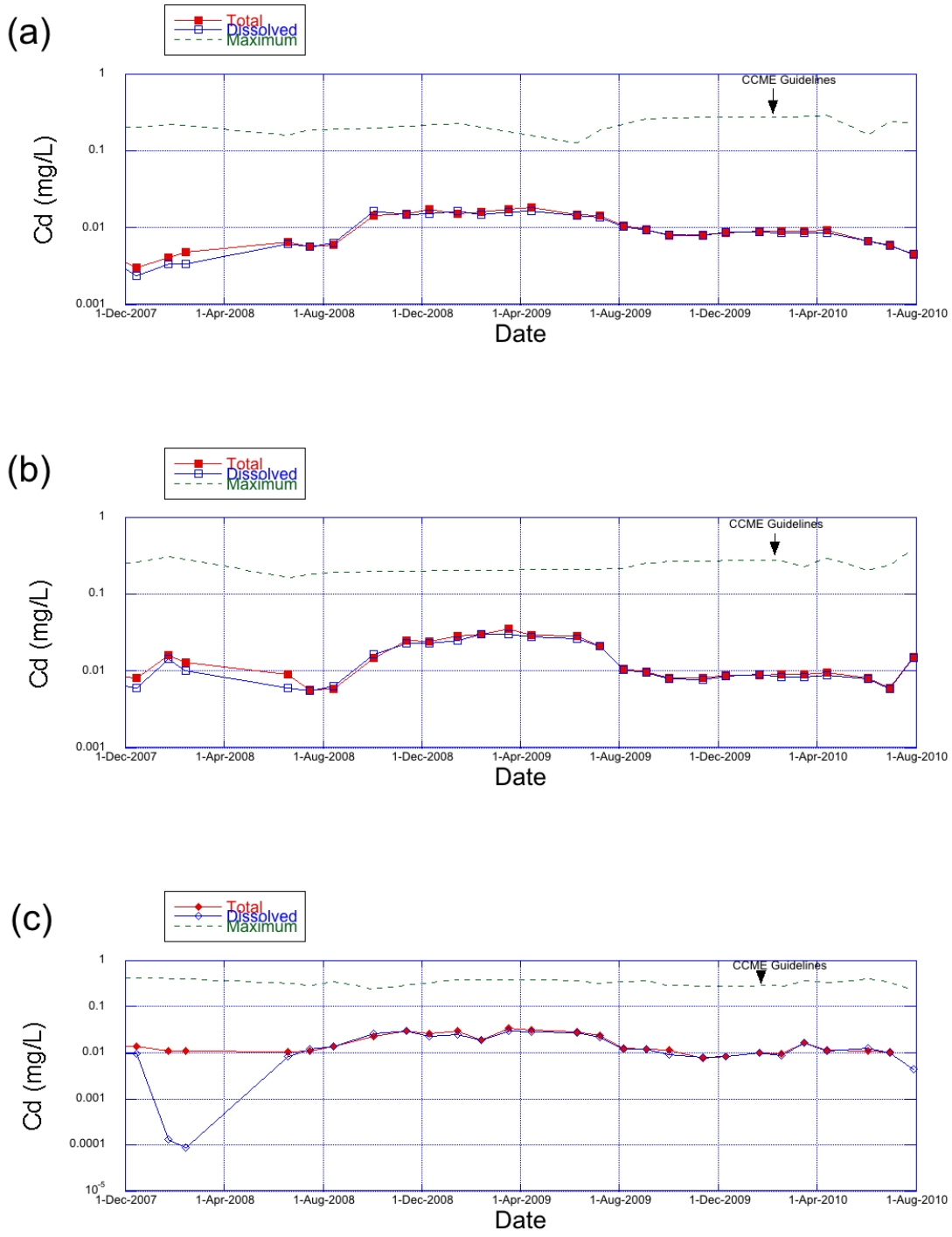


Figure 3-18: Semi-log Plot of Total and Dissolved Cadmium in (a) the Top Zone, (b) the Middle Zone and (c) the Bottom Zone of the Pit Lake

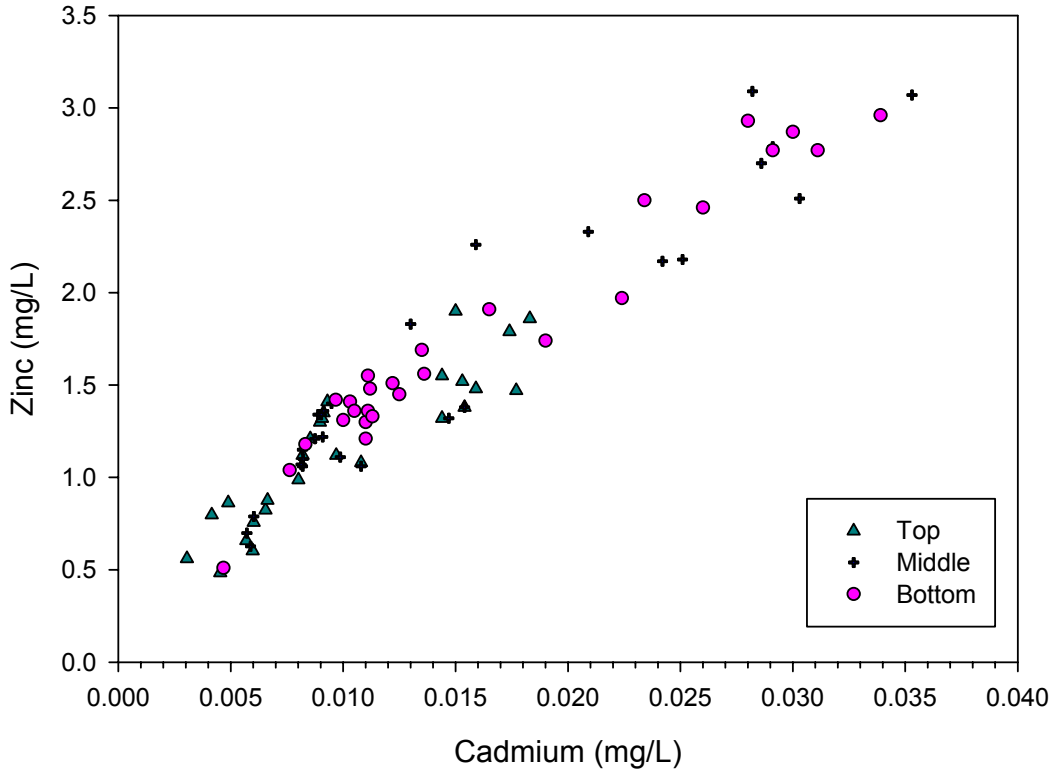


Figure 3-19: Plot of Cadmium versus Zinc in Pit Lake Water Column

3.3.1.10 Total Zinc

Total Zn concentrations have exceeded the maximum acceptable levels (30 µg/L, CCME Guidelines) in each of the three zones of the pit lake from December 2007 to the final sampling interval in July 2010 (Figure 3-20). Seasonal trends in increasing Zn are evident. As presented in Tables 3-5 to 3-7, the maximum total Zn concentrations were observed in the summer of 2009 (middle ~ bottom ~ 3 mg/L > top = 1.9 mg/L). Elevated total Zn concentrations likely resulted from the leaching of pit walls and waste rock seepage. The concentrations in each zone were more consistent after August 2009, which is attributed to a relative decline in leaching from the pit bottom. In addition, waste rock seepage that infiltrates to the water table may have been significantly diluted.

Zn is acutely and chronically toxic to fish and other aquatic organisms, however, toxicity decreases with increasing hardness. Despite the high total hardness of the pit lake water, the elevated Zn concentrations remain a concern with respect to the ecology of the local watershed.

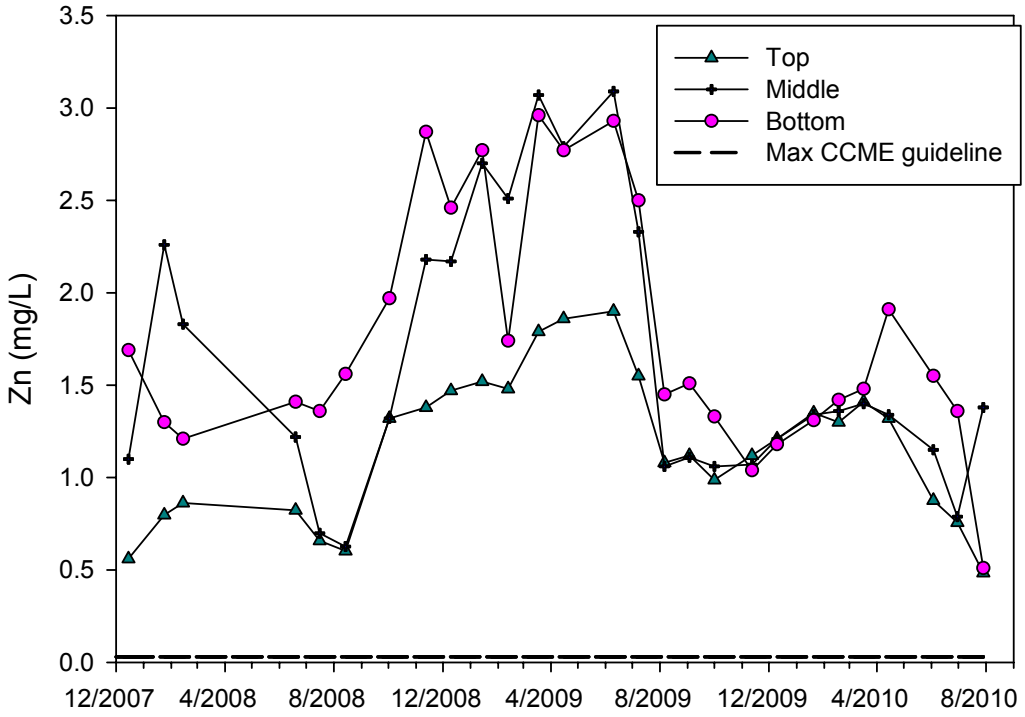


Figure 3-20: Plot of Total Zinc in Pit Lake Water Column

3.3.1.11 Total Copper

Total Cu concentrations have also exceeded the maximum acceptable levels (4 µg/L at a water hardness > 180 mg/L $CaCO_3$, CCME Guidelines) in each of the three zones of the pit lake throughout the water quality monitoring period (December 2007 – July 2010) with few exceptions (Figure 3-21). As presented in Tables 3-5 to 3-7, maximum total Cu concentrations were observed in the winter of 2009 (middle = 0.09 mg/L > bottom = 0.07 mg/L > top = 0.04 mg/L) and have since declined. Enhanced Cu leaching may have been caused by the abnormally high precipitation that was observed. Despite the observed decline, total Cu concentrations within the pit lake remain a concern.

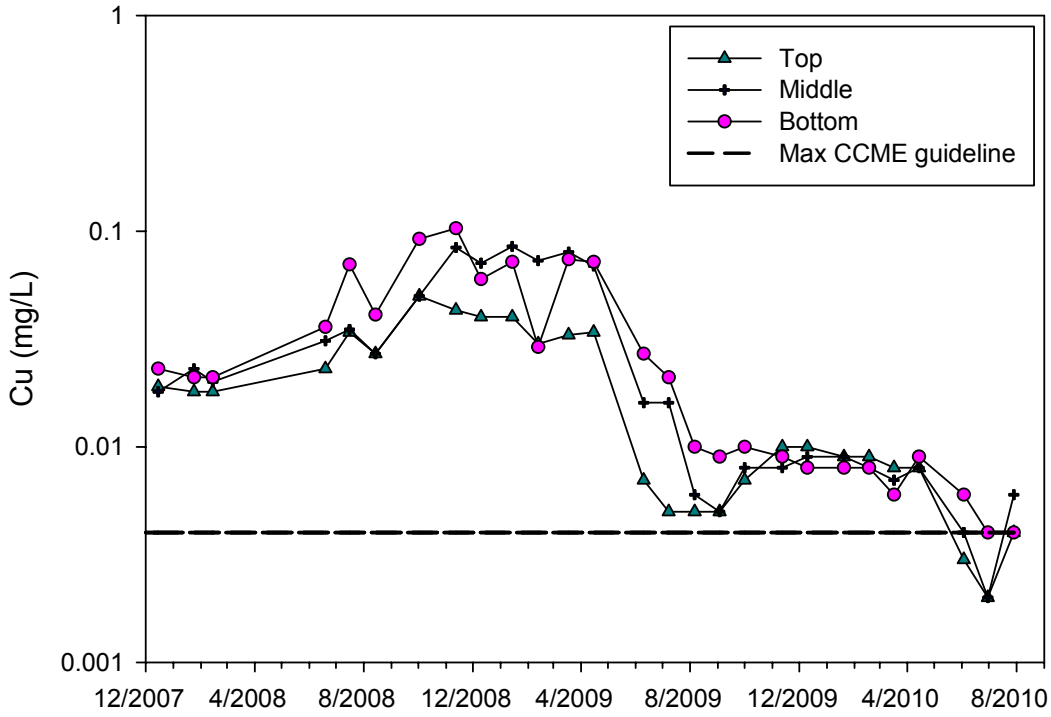


Figure 3-21: Semi-log Plot of Total Copper in Pit Lake Water Column

3.3.1.12 Total Manganese

While no CCME guidelines exist for Mn, the observed total Mn concentrations were safely below the B.C. Guidelines maximum acceptable level (Figure 3-22). Higher maximum concentrations were observed in the bottom zone of the pit lake (7.73 mg/L; Table 3-7) compared to the top (1.0 mg/L; Table 3-5) and middle (5.08 mg/L; Table 3-6) zones, which may be indicative or more reducing conditions at depth. Seasonal oscillations in total Mn were observed with relative increases occurring during the winter and spring compared to summer.

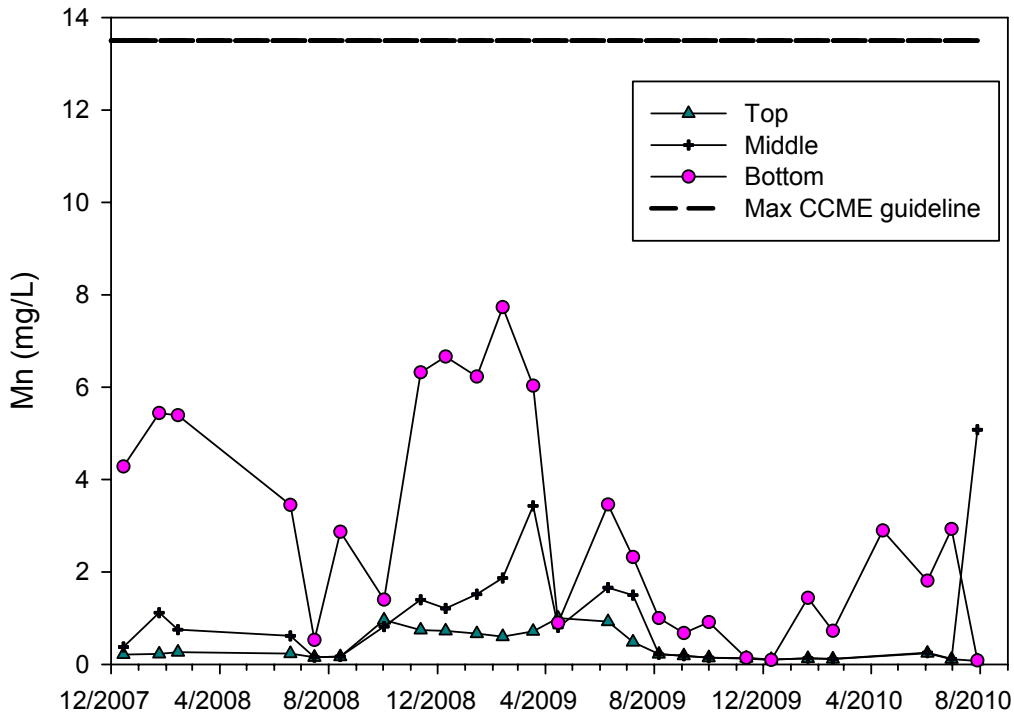


Figure 3-22: Plot of Total Manganese in Pit Lake Water Column

3.3.1.13 Ammonia

With few exceptions, the observed ammonia concentrations from each pit lake zone were above the CCME Guideline (19 µg ammonia-nitrogen/L; Figure 3-23). The highest values were observed in the bottom zone (Max = 0.44 mg/L; Table 3-7) during the winter of 2008. Particularly in the bottom zone of the pit lake, seasonal trends indicate relatively higher ammonia concentrations in the winter and spring compared to summers. As the most reduced form of nitrogen, higher ammonia concentrations may reflect enhanced reducing conditions in the lake, particularly in the hypolimnion. The suspected source of ammonia in the mine waters is limited to residue from blasting materials during pit development. Ultimately, ammonia in the pit lake water column is not expected to be a long-term concern due to the finite source, rather a steady decline in ammonia is expected with time.

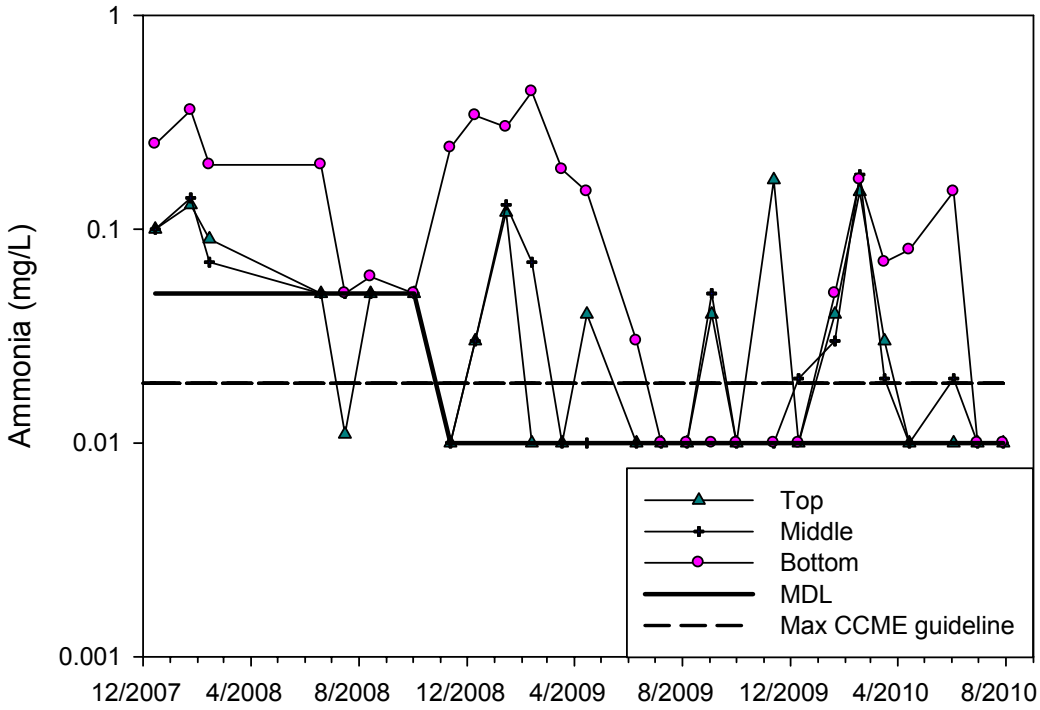


Figure 3-23: Semi-log Plot of Ammonia in Pit Lake Water Column

3.3.1.14 Nitrate

Observed nitrate concentrations from December 2007 to present were consistently below the CCME Guideline (13 mg/L, Figure 3-24). The mean nitrate concentration in the bottom zone (0.63 ± 0.5 mg/L, Table 3-7) was typically lower than in the top (1.54 ± 1.1 mg/L, Table 3-5) and middle zones (1.25 ± 0.7 mg/L, Table 3-6). As the most oxidized compound of nitrogen, nitrate is expected to be more abundant in oxidizing environments, such as the top zone of the pit lake. An inverse relationship between nitrate and ammonia is observed in the bottom zone, the zone most typically impacted by seasonal reducing conditions. In all likelihood, the cycling of nitrogen in the pit lake water column involves reduction of nitrate to ammonia in the reducing waters of the hypolimnion and conversion of ammonia to nitrate by the reverse chemical reaction in the oxygenated waters of the epilimnion. The suspected source of nitrate to the pit lake is blasting residues in seepage from waste rock.

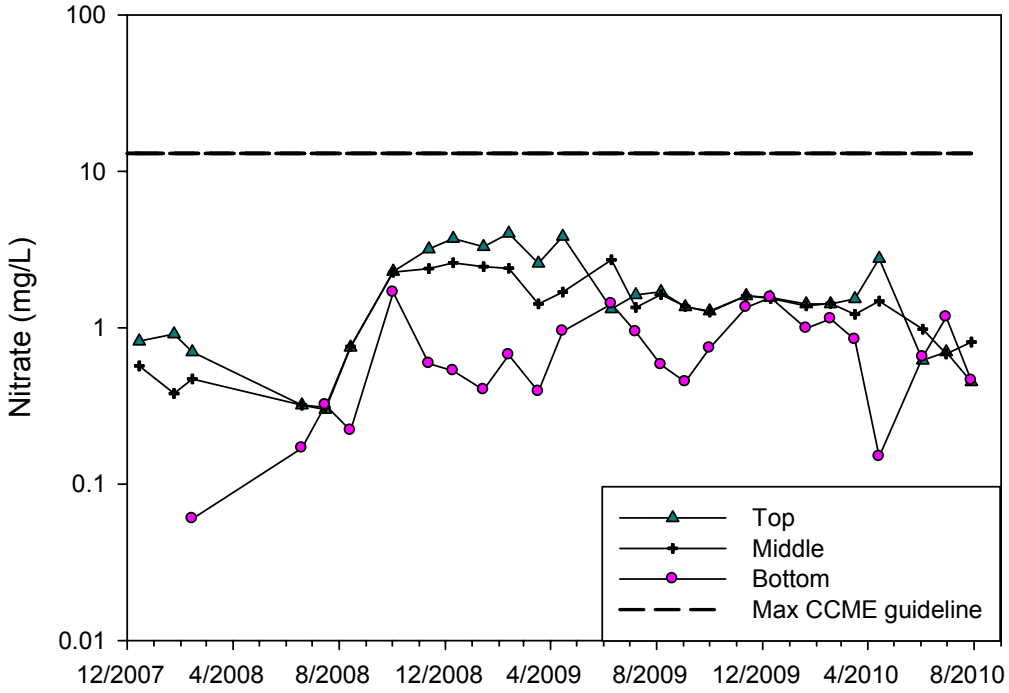


Figure 3-24: Semi-log Plot of Nitrate in Pit Lake Water Column

3.3.1.15 Nitrite

The majority of the water quality analyses yielded nitrite values below the method detection limit (MDL). However, there was some detectable nitrite in several water samples collected between the summer of 2008 and December 2009 (Figure 3-25). Detectable nitrite was either at or above CCME's maximum acceptable level (60 µg/L) in each of the three pit lake zones (top, middle and bottom). As an intermediate in the nitrogen cycle, nitrite is unstable as it either rapidly oxidizes to nitrate (nitrification) or is reduced to ammonia and then to nitrogen gas (denitrification). The presence of nitrite in surface waters is typically minute. The major contributing nitrogen source to the pit lake is likely residue of explosives (ANFO) used in mining. Given this finite source of no forms of nitrogen are expected to be of environmental concern over the long-term.

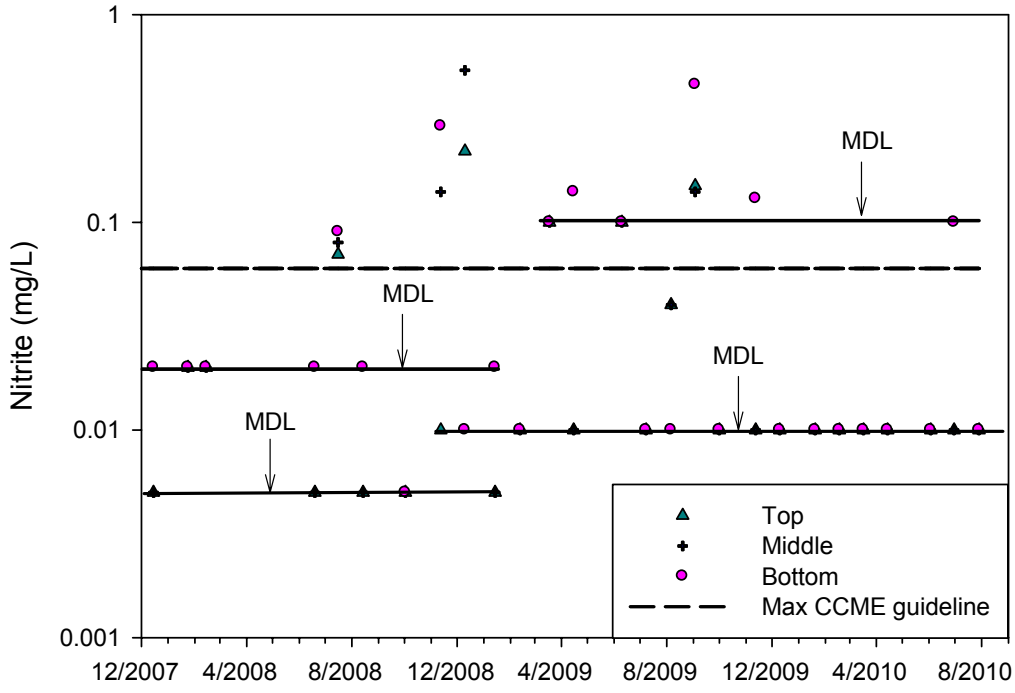


Figure 3-25: Semi-log Plot of Nitrite in Pit Lake Water Column

3.4 Source Term Development

Water quality parameters of concern, for which source terms would be required, were selected by screening measured concentrations of parameters from various mine site components (*e.g.*, groundwater, surface and pit lake water quality, waste rock seepage chemistry, and tailings water chemistry) against CCME freshwater aquatic life guidelines. Parameters which exceeded guidelines on multiple occasions were selected for source term estimation. Constituents related to screened parameters were also included. For example, WAD cyanide exceeded guidelines; thus all cyanide and nitrogen species were included in the source term evaluation.

A set of "Conservative Best Estimate" and reasonably conservative "Worst Case" source terms were developed. The "Conservative Best Estimate" is a best estimate of long-term seepage chemistry based on professional judgment and statistical evaluation of existing data. "Conservative Best Estimate" source terms were obtained first, by determining the layer that consistently contained the highest concentration of each parameter of interest. The source term was then calculated by averaging the concentration of the parameter within the most concentrated layer since December 2007, which provides a conservative estimate. The reasonably conservative "Worst Case" source terms were determined by

averaging all data that is greater than or equal to the value for the 90th percentile. This approach simplified the method of deriving a reasonably conservative "Worst Case" set of source terms, while removing bias.

The "Worst Case" source term is a reasonably conservative upper bound, also based on professional judgment and a statistical evaluation of existing data. The source terms are intended to represent seepage chemistry in the long term. The derived source terms are considered to be constant concentrations that do not vary over time**.** This assumption is made in an effort to maintain consistency between the various source terms and between the various options**.** Further, insufficient data exist to develop variable or seasonal terms for the various closure options under consideration.

Several underlying assumptions were made in deriving long-term pit lake source terms, as follows:

- Acidic conditions (low-pH) will not occur in the pit lake in the short-term or long-term;
- Measured water quality data are representative of seasonal variability in the pit lake water column; and
- Observed pit lake water quality from 2007 to present is representative of present and future conditions in the pit lake.

Source terms for long-term pit lake water quality were derived for options 1A and 2A and were based on pit lake water chemistry data measured at different depths in the pit lake water column (top, middle and bottom) from December 2007 to the present (Table 3-8).

Table 3-8:
Mt. Nansen Long-Term Pit Lake Chemistry Estimates

Parameter	Unit	Conservative Best Estimates	Worst Case
Sulfate	mg/L	1230	1690
Ammonia	mg/L	0.18	0.4
Nitrate	mg/L	1.71	3.85
Nitrite	mg/L	0.06	0.3
As	mg/L	0.02	0.08
Cd	mg/L	0.02	0.03
Cu	mg/L	0.03	0.09
Fe	mg/L	0.5	2.97
Mn	mg/L	2.91	6.9
Zn	mg/L	1.76	2.92
Ca	mg/L	385	470
Mg	mg/L	124	163

4. Waste Rock and Ore Characterization

4.1 Introduction

The following sections discuss the solid-phase and drainage quality characterization results for Mt. Nansen waste rock and ore. The characterization of ore and waste rock included a field bin and lysimeter program and seep water quality assessment. Results from these investigations are interpreted and applied toward the development of source terms. These source terms are key inputs to water quality modeling for two principal of the closure options being evaluated: unsaturated and subaerial storage of waste rock and ore (Options 1A, 2A, 3, and 4) and saturated backfilled waste rock stored in the pit (Options 1B, 2B, and 4).

The solid phase characterization of waste rock and ore is presented in Section 4.2. Section 4.3 follows and includes the drainage water quality from waste rock field bins, lysimeters, and seeps. Drainage quality from low-grade ore is described in Section 4.4. Lastly, Section 4.5 is a discussion and presentation of waste rock and ore source terms.

4.2 Solid Phase Characterization

Waste rock and ore samples underwent testing for particle size distribution (PSD), acid-base accounting (ABA), solid phase elemental concentration determination (aqua regia digestion) and shake flask extractions (SFE). Results from these solid phase characterization tests are presented below.

4.2.1 Particle Size Distribution

Particle size distribution (PSD) in waste rock varies substantially. PSD is a proxy for particle surface area, which is a controlling factor in mine waste reactivity (Jambor, 2003). The PSD determined from sub-samples collected from the Mt. Nansen waste rock and ore field bins are presented in Table 4-1. These data indicate that ore and waste rock sub-samples are predominantly composed of particles greater than 0.425 mm, with the largest proportion of material in the 1.7 to 6.3 mm fraction. To ensure a conservative geochemical assessment for Mt. Nansen waste, the less than 6.3 mm (-1/4") fraction of the field bin sub-samples were used for static test work (*e.g.*, ABA and extraction analysis).

Table 4-1:
Particle Size Distribution for Mt. Nansen Field Kinetic Test Sub-samples

Sieve Size (mm)	Waste Rock (Bin 1) (%)	Waste Rock + Organics (Bin 3) (%)	Ore (Bin 2) (%)
>12.50	9.9	10.9	9.4
9.500	13.7	12.1	13.1
6.300	18.7	13.6	16.5
1.700	25.7	22.5	28.6
0.425	18.9	22.1	19.1
0.150	6.8	9.5	6.7
0.053	3	4.3	3.2
<0.053	3.3	5	3.5

Notes: Gravel: 4.75 - 75 mm, Sand: 0.075 - 4.75 mm, Silt: 0.01 - 0.075 mm
Shaded values indicate size fractions submitted for static test work

4.2.2 Acid-Base Accounting

Tables 4-2 and 4-3 present the ABA results for waste rock and ore field bin sub-samples, respectively. Also presented in the tables are the 90th and 10th percentile values and maximum, minimum and median values of ABA results for historic waste rock and ore samples collected from the Mt. Nansen site between 1989 and 2009 (Altura, 2009a). The 90th and 10th percentile values are used in the proceeding discussion, rather than maximum and minimum values, in order to more appropriately represent the variation in the large datasets and avoid highlighting outliers. Note that values reported to be below detection were set at the analytical limit for statistical calculations and data presentation purposes.

Table 4-2:
ABA Results for Waste Rock Field Test Sub-samples Compared to ABA Statistics for Historic Composite Waste Rock Samples (1989 – 2009)

Parameter	Unit	*Statistical Summary for Historic Composite Waste Rock Samples (Altura, 2009a)*						*Lorax Field Tests*		*Components*	
		Max	90th percentile	Median	10th percentile	Min	*n*	Waste Rock (Bin 1)	WR + Organics (Bin 3)	Organics	Bin 3 (full PSD)
Paste	pH	9	8.2	7.8	6.5	3.9	*123*	5.37	5.44	3.36	-
TIC	%	1.4	0.7	0.4	0.08	<0.01	*51*	0.12	0.12	0.03	0.14
Total C	%							0.17	1.02	40.6	0.87
Organic C	%							0.05	0.01	40.6	0.73
Total S	%	10.5	1.5	0.3	0.09	0.01	*123*	1.08	1.1	0.27	-
Sulfate-S	%	1.1	0.7	0.1	0.01	<0.01	*123*	0.75	0.73	0.07	-
Sulfide-S	%	9.9	1	0.2	0.01	<0.01	*123*	0.3	0.36	0.08	-
Insoluble S	%							0.03	0.01	0.12	-
Non-Sulfate S	%	9.9	1	0.2	0.01	<0.01	*123*	0.33	0.37	0.2	-
CaNP	$kgCaCO_3/t$	113	54.2	31.7	6.7	<0.8	*51*	10	10	2.5	-
Bulk NP	$kgCaCO_3/t$	100	56	29.2	4.5	-8.1	*123*	18.7	18.6	-42.8	-
SAP	$kgCaCO_3/t$	308	31.3	7.5	<0.31	0.2	*123*	9.4	11.3	2.5	-
AP	$kgCaCO_3/t$	308	31.2	7.5	<0.31	0.1	*123*	10.3	11.6	6.3	-
NPR (CaNP/SAP)		169	18.7	2.7	0.7	0.003	*50*	1.1	0.9	1	-
NPR (CaNP/AP)		163	18.7	2.7	0.7	0.003	*123*	1	0.9	0.4	-

Analytical Notes:

TIC = Total Inorganic Carbon
Sulfate S determined by 25% HCL with Gravimetric Finish
Sulfide S determined by Sobek 1:7 Nitric Acid with Gravimetric Finish
AP calculated from Non-Sulfate S * 31.25; SAP calculated from Sulfide-S
CaNP = neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
BulkNP = NP via siderite corrected neutralization potential for field bin sub-samples, NP via Sobek method for historic waste rock samples (1989 – 2009)

The ABA results for the waste rock field bins sub-samples generally fall within the upper range of ABA values from the historic data set (Table 4-2). Therefore, the waste rock selected for field based kinetic test work is considered to be somewhat conservative in regards to acid generating potential (*i.e.,* higher sulfide and lower NP). Two exceptions include: 1) paste pH values for both waste rock sub-samples, which are indicated to have values slightly lower than the 10th percentile value for the composite samples; and, 2) sulfate-sulfur values for both waste rock sub-samples, which are indicated to be slightly higher than the 90th percentile value for the composite samples. In general, the waste rock sub-samples have sulfur species and acid potential (AP) values slightly above median concentrations from the historic dataset and neutralization potential (NP) values lower than median concentrations for the historic dataset.

Table 4-3:
ABA Results for the Ore Field Test Sub-sample Compared to ABA Statistics for Historic Composite Ore Samples (1989 – 2009)

Parameter	Unit	*Statistical Summary for Historic Composite Ore Samples (Altura, 2009a)*						Ore (Bin 2)
		Max	90th percentile	Median	10th percentile	Min	*n*	
Paste pH	pH	7.4	7.1	6.4	5.0	3.0	*11*	5.18
TIC	%	0.2	0.2	0.1	0.1	0.1	*8*	0.16
Total-S	%	14.6	10.2	1.7	0.2	0.03	*11*	2.23
Sulfate-S	%	1.2	1.0	0.8	0.1	0.1	*11*	0.99
Sulfide-S	%	13.8	9.6	0.8	0.1	0.01	*11*	1.05
Non-Sulfate S	%	13.8	9.60	0.77	0.06	0.01	*11*	1.24
SAP	$kgCaCO_3/t$	431	300	24.1	1.9	0.3	*11*	32.8
AP	$kgCaCO_3/t$	431	300	24.1	1.9	0.3		38.8
CaNP	$kgCaCO_3/t$	20.0	20.0	11.3	5.3	4.2	*8*	13.3
Bulk NP	$kgCaCO_3/t$	17.3	15.3	7.1	4.5	4.4	*11*	21.3
NPR (CaNP/SAP)		8.0	3.2	0.4	0.2	0.1	*8*	0.4
NPR (CaNP/AP)		8.0	3.2	0.4	0.2	0.1	*11*	0.3

Analytical Notes:
TIC = Total Inorganic Carbon
Sulfate-S determined by 25% HCl leach with Gravimetric Finish
Sulfide-S determined by Sobek Method (1:7 Nitric Acid with Gravimetric Finish)
AP calculated from Non-Sulfate S * 31.25; SAP calculated from Sulfide-S
CaNP = carbonate neutralization potential in kg $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
BulkNP = NP via siderite corrected neutralization potential for field bin sub-samples, NP via Sobek method for historic waste rock samples (1989 – 2009)

Similar to waste rock, the ABA results for the ore sub-sample (Bin 2) generally fall within the range of ABA values of the historic samples (Table 4-3). Therefore, the ore material selected for field based kinetic test work is considered to be representative of Mt. Nansen ore, with respect to ABA results. Two exceptions include: 1) sulfide sulfur, which is indicated to be slightly higher in the field test sub-sample than the 90th percentile value for the composite historic samples; and, 2) bulk NP, which is indicated to be higher in the sub-sample than the 90th percentile (and maximum) value for the composite samples. In general, the ABA results for the ore field test sub-sample are slightly above median values of the composite results.

4.2.2.1 Paste pH

Paste pH values are useful in that they provide information on the amount and availability of NP. If carbonate is the main neutralizing mineral and there is no active sulfide

oxidation, paste pH values are typically buffered between 8 and 9. The waste rock and ore field test sub-samples have paste pH values of less than 5.5 (tables 4-2 and 4-3), suggesting that these samples do not have a significant amount of excess NP.

4.2.2.2 Sulfur Species and Acid Potential

The generation of acid is predominantly associated with the oxidation of sulfide minerals; therefore, it is important that the amount and form of sulfur-bearing mineralization be determined. The Mt. Nansen field test sub-samples were analyzed for their total, sulfate, and sulfide-sulfur concentrations. Total sulfur values for all three sub-samples are high, with 1.1 wt. %S in the waste rock (Bin 1) and 2.2 wt. %S in the ore (Bin 2) sub-samples (tables 4-2 and 4-3). Sulfide-sulfur makes up less than 50% of the total sulfur budget in each waste rock and ore field test sub-samples, with a large proportion of the remaining sulfur budget for the sub-samples being associated with sulfate mineralization (tables 4-2 and 4-3).

To properly assess the AP of a sample, the content of acid producing sulfates should also be determined in addition to reactive sulfides. Mineralogical assessment via x-ray diffraction (XRD) were conducted on seven waste rock samples and one sample from the ore stockpile to gain a better understanding of the sulfur phases and potential neutralizing minerals available in various geochemical categories of waste rock. Gypsum occurs in three of the eight samples, in particular those containing lower carbonate NP (CaNP). Of note is that these three samples are also the three samples from the suite most elevated in sulfide sulfur (0.21 to 1.17%), indicating that the gypsum may be an acid-neutralization by-product (Appendix A.9 *in* Altura, 2009b). Three of the four samples comprising lower NP also contain jarosite ($KFe^{3+}{}_3[(OH)_3{\cdot}SO_4]_2$, a precipitate formed under low pH conditions. The mineral appears to be most abundant in two samples, one containing very low CaNP and bulk NP, which returned paste pH values of 4.5 and 5.5. The results of this mineralogical assessment indicate that acid generating sulfate minerals are present in the Mt. Nansen waste rock.

Notable concentrations of insoluble sulfur are also indicated for the field bin sub-samples, particularly the ore. The possibility of organic sulfur in the Mt. Nansen samples cannot be dismissed due to the intentional addition of organic matter to the waste rock + organics (Bin 4) and the fact that sulfur occurs as both organic and inorganic forms in soils. Analyses conducted on the organic matter component (waste rock + organics in Table 4-2) indicate higher insoluble sulfur proportions for the organic matter sample relative to the mixed bin sub-sample. This may support the presence of non-acid generating organic sulfur; however, analytical methods used to determine sulfide-sulfur for the Mt. Nansen investigation involved leaching of samples with a 1:7 nitric acid

solution, a method that is very effective at oxidizing Fe-sulfide minerals, such as pyrite; but not as effective at completely leaching other non-iron sulfide minerals, particularly from organic matter. The ore mineralization of the Brown-McDade deposit at Mt. Nansen consists of arsenopyrite, galena, sphalerite and sulfosalts (Altura, 2009a). Therefore, it is possible that the resulting sulfide-sulfur values reported in tables 4-2 and 4-3 underestimate the amount of acid generating sulfur in the samples. Furthermore, Bin 1 (waste rock) and Bin 2 (ore) are not expected to contain organic matter, yet still comprise notable concentrations of insoluble sulfur.

Given the uncertainty and short-lived contribution of acidity from secondary sulfate phases, and to avoid overestimating the long term acid generating potential of the pit walls, sulfide sulfur and non-sulfate sulfur (total sulfur – sulfate sulfur) values are used to calculate AP and to further assess the ARD potential of the pit wall samples. These values incorporate insoluble sulfur as undigested sulfide phases that will contribute to the overall acidity of the samples.

4.2.2.3 Neutralization Potential

Both siderite corrected NP (ScNP) and carbonate NP (CaNP) values were determined for the Mt. Nansen samples. Siderite corrected NP values provide information on the bulk NP of a sample and are not mineral specific, while CaNP values provide information on the specific contribution of carbonate minerals to the neutralization potential of a sample. The Mt. Nansen waste rock and ore field bins sub-samples contain low to moderate concentrations of ScNP with values of ~18.5 kg $CaCO_3$/t in the Bin 1 (waste rock) and Bin 3 (waste rock + organics) sub-samples and 21.3 kg $CaCO_3$/t in the Bin 2 (ore) sub-sample. Slightly lower concentrations of CaNP are indicated for the waste rock and ore bins sub-samples with values of 10 kg $CaCO_3$/t indicated for Bin 1 (waste rock) and Bin 3 (waste rock + organics) sub-samples and 13.3 kg $CaCO_3$/t reported for the Bin 2 (ore) sub-sample. These results suggest that non-carbonate minerals are a significant contributor to the NP of waste rock and ore at Mt. Nansen; however, in the absence of mineralogical data, total inorganic carbon is conservatively used to estimate NP (=CaNP) in subsequent NPR calculations.

4.2.2.4 Net Potential Ratio

The net potential ratio (NPR), which is calculated by dividing the NP of a sample by its AP, is used to assess the likelihood of the Mt. Nansen waste rock and ore samples to generate acidic drainage, whereby, samples with NPR values less than 1 are likely to generate ARD and samples with NPR values greater than 4 do not require any further ARD testing (Price, 1997). Samples with NPR values between 1 and 3 have an uncertain

potential to generate ARD. Tables 4-2 and 4-3 indicate that sub-samples collected from the waste rock and ore field bins have NPR values of less than 1 (AP calculated with sulfide-S and non-sulfate S) and therefore have an elevated potential to generate acidic leachate.

4.2.3 Solid Phase Metals

Tables 4-4 and 4-5 present summary statistics for solid phase metal abundances from waste rock (Bins 1 and 3) and ore (Bin 2) sub-samples, respectively. As well, these tables include summary statistics (minimum, maximum, median, 90th percentile, and 10th percentile values) describing metal abundances in the historic sample dataset (Altura, 2009a). The solid phase metals results for the waste rock bin sub-samples fall within the upper range of metal values of the respective composite samples (Table 4-4). Therefore, it can be concluded that the waste rock selected for field based kinetic test work will yield conservative values with respect to solid phase metals results. A comparison of data from the Bin 1 (waste rock) and Bin 3 (waste rock + organics) sub-samples suggests that the influence of organics on the solid phase chemistry is negligible given that ABA and solid phase metal values for both sub-samples are very similar.

The solid phase metals results for the Bin 2 (ore) sub-sample generally fall within the upper range of metal values from the historic data set (Table 4-5). Also, sulfur is indicated to be higher than the maximum value of the composite results.

Solid-phase metals data are used to identify which metals are enriched in the various waste materials. The degree of enrichment of an element over crustal abundance can be used as a general indicator of the metals that could be of potential concern, and which should be scrutinized in kinetic leaching tests. However, solid-phase metal concentrations well above crustal abundance do not conclusively indicate that the metal will be leached at a high rate from the material. Rather, the rate of metal leaching is related to the metal's mineralogical association and the aqueous geochemistry of the infiltrating waters.

An indicator of significant solid-phase enrichment is assigned values greater than or equal to three times the average crustal abundance (light grey). Also highlighted are values indicated to be 10 times the crustal abundance (medium grey) and 100 times the crustal abundance (dark grey).

The results of the aqua regia digestion indicate that silver (Ag), arsenic (As), bismuth (Bi), cadmium (Cd), copper (Cu), lead (Pb), antimony (Sb), selenium (Se) and zinc (Zn) are present in elevated concentrations with respect to average crustal concentrations in all field bins sub-samples, most notably in the Bin 2 (ore) sub-sample. In particular, Ag, As, Cd, Pb and Sb are elevated by more than 100 times the crustal concentrations.

Additionally, mercury (Hg) is elevated in all bin sub-samples with respect to crustal abundances. Solid phase concentrations of manganese (Mn), although not highlighted in the tables, are presented due to the high values indicated for the waste rock bins sub-samples.

Table 4-4:
Solid Phase Metals Results for Waste Rock Field Tests Sub-samples Compared to Metal Statistics for Historic Composite Waste Rock Samples (1989 – 2009)

Metal	Unit	*Statistical Summary for Historic Composite Waste Rock Samples (Altura, 2009a)*[1]						Waste Rock (Bin 1)	WR + Organics (Bin 3)	Average Crust Values[2]
		Max	90th percentile	Median	10th percentile	Min	*n*			
Ag	ppm	71.4	12.2	2.1	0.4	0.1	119	10.1	10.2	0.075
As	ppm	6399	1206	239	35.2	5.0	119	916	862	1.8
Bi	ppm	65.9	20.0	6.0	0.6	0.2	55	14.6	14.1	*0.17*
Cd	ppm	93.1	35.9	13.4	1.4	0.1	119	23.7	21.6	0.15
Cu	ppm	1315	354	99.2	15.8	3.0	119	354	350	60
Hg	ppm	0.60	0.26	0.10	0.023	0.005	77	0.27	0.35	*80*
Mn	ppm	10300	3807	2244	1291	536	55	2617	2560	950
Pb	ppm	3354	954	283	38	12	119	678	573	*12.5*
S	%	9.0	2.0	0.7	0.1	0.1	50	1.02	0.98	0.035
Sb	ppm	646.5	125.7	20.0	1.0	1.0	119	25.3	40.0	*0.2*
Se	ppm	2.0	0.5	0.5	0.5	0.5	55	0.4	0.5	*0.05*
Zn	ppm	10200	3336	1264	245	50	119	2052	1857	70

Notes: 1. Values equal to or greater than 3 times the average continental crustal concentration are shaded in light grey; values equal to or greater than 10 times the average continental crustal concentration are shaded in medium grey; and values equal to or greater than 100 times the average continental crustal concentration are shaded in dark grey
2. Average continental crust abundances according to Price (1997). Italic values are from CRC (1985)

Table 4-5:
Solid Phase Metals Results for the Ore Field Test Sub-sample Compared to Statistics for Historic Composite Ore Samples (1989 – 2009)

Metal	Unit	*Statistical Summary for Historic Composite Ore Samples (Altura, 2009a)*[1]						Ore (Bin 2)	Average Crust Value[2]
		Max	90th percentile	Median	10th percentile	Min	*n*		
Ag	ppm	43.5	43	0.075	7.3	5.2	10	33.9	0.075
As	ppm	9280	4028	1.8	1170	522	10	3266	1.8
Bi	ppm	42.1	40.2	0.17	5.9	0.4	10	33.6	*0.17*
Cd	ppm	41.7	27	0.15	13.9	5.4	10	27.4	0.15
Cu	ppm	2630	526	60	115	52.9	10	374	60
Hg	ppm	1	0.6	80	0.2	0.1	9	0.33	*80*
Mn	ppm	6839	3010	950	1172	102	10	1605	950
Pb	ppm	2804	2553	12.5	1280	602	10	2286	*12.5*
S	%	1.7	1.7	0.035	0.2	0.2	9	2.14	0.035
Sb	ppm	441	324.3	0.2	55.3	18.1	10	147	*0.2*
Se	ppm	2	0.6	0.05	0.5	0.5	10	0.6	*0.05*
Zn	ppm	3330	2148	70	1143	578	10	1957	70

Notes: 1. Values equal to or greater than 3 times the average continental crustal concentration are shaded in light grey; values equal to or greater than 10 times the average continental crustal concentration are shaded in medium grey; and values equal to or greater than 100 times the average continental crustal concentration are shaded in dark grey
2. Average continental crust abundances according to Price (1997). Italic values are from CRC (1985)

4.2.4 Water Soluble Constituents (Shake Flask Extractions)

The water soluble constituents of the waste rock and ore field bins sub-samples were determined by SFE tests. Shake flask extractions are particularly useful for materials which may contain readily leachable elemental constituents associated with non-sulfide mineral phases and/or partially weathered primary sulfide minerals that may host secondary oxidation products. Given the weathered nature of the Mt. Nansen deposit together with the weathering and oxidation that has occurred since placement of waste rock and ore materials, the dissolution of secondary minerals in SFE data will provide insight into the water soluble drainage chemistry that would be released from the Mt. Nansen waste rock and ore. Table 4-6 and Table 4-7 present the results for SFE tests conducted on Mt. Nansen waste rock and ore field test sub-samples, respectively. Summary statistics (including 90th percentile, 10th percentile, maximum, minimum, and median values) of SFE data from the historic data set are also presented, for comparative purposes. Parameters indicated to be consistently below the analytical detection limit were not included in these tables.

The SFE results for the waste rock field tests sub-samples (Bin 1 and Bin 3) fall within the statistical distribution of the historic waste rock SFE dataset and are therefore considered to be consistent with the larger dataset (Table 4-6). The SFE results from the ore field test sub-sample (Bin 2) indicates notably higher concentrations of sulfate, Ag, As, Co, Cu, Li, Mn, Ni, S, Sb and Se relative to the maximum value measured in the historic ore samples (Table 4-8). Therefore, the material selected for Bin 2 is considered to provide a conservatively high representation of existing ore material at Mt. Nansen.

Water soluble metals concentrations exhibit similar trends to the aqua regia extraction (bold values in tables 4-6 and 4-7). Concentrations of dissolved Cd, Cu, Mn and Zn in SFE from waste rock and ore field tests sub-samples exceed the Canadian Council of Ministers of the Environment's (CCME) maximum water quality guidelines for the protection of aquatic life (shaded values in tables 4-6 and 4-7). Additionally, concentrations of dissolved arsenic and antimony in SFE from the ore sub-sample also exceed CCME guidelines. Elevated concentrations of metals in SFE do not provide a direct measure of drainage chemistry from waste rock and ore at the site and are only compared to CCME guidelines here in order to highlight the water soluble parameters leaching from the Mt. Nansen waste and could contribute to drainage degradation. This is particularly true given that the water soluble metals measured in SFE are dissolved concentrations while CCME criteria govern total metals. The high concentrations observed in SFE from the Mt. Nansen field bin sub-samples are likely due to the abundant oxidation products that formed in these materials pre- and post-mining.

Table 4-6:
Results of Shake Flask Extractions for Mt. Nansen Waste Rock Field Tests Sub-samples Compared to Statistics for Historic Waste Rock Samples (1989 – 2009)

Parameter[1]	Unit	*Statistical Summary for Historic Composite Waste Rock Samples (n = 22) (Altura, 2009a)*					Waste Rock (Bin 1)	WR + Organics (Bin 3)	CCME Max[2]
		Max	90th percentile	Median	10th percentile	Min			
pH		8.1	8.1	7.7	6.5	3	7.6	7.2	
Redox	mV	543	431	391	300	272	331	338	
Conductivity	uS/cm	2566	2111	735	138	78.9	2369	2347	
Hardness	mg/L	1680	1452	421	79.6	41.9	1580	1540	
Acidity (pH 8.3)	mg /L	450	11.7	4.3	1.8	1.7	7.3	12.3	
Alkalinity	mg/L	73.9	72.6	39.8	12	2.8	14.8	9.6	
Sulfate	mg/L	1803	1416	346	4.7	3	1690	1770	*100*
Major Anions	meq/L	37.8	30.2	8.1	1.6	0.8	35.5	37.07	
Major Cations	meq/L	38.4	29.3	8.5	1.6	0.9	2.36	2.53	
Dissolved Metals									
Ag	mg/L	0.011	0.0001	0.000005	0.000005	0.000005	**<0.00003**	**0.00004**	0.0001
Al	mg/L	12.9	0.013	0.0072	0.0051	0.0045	0.003	0.004	0.1
As	mg/L	0.030	0.024	0.0053	0.0022	0.00013	**0.0016**	**0.0039**	0.005
Ca	mg/L	585	480	136	23.9	13.2	527	507	
Cd	mg/L	0.53	0.034	0.0020	0.000032	0.00002	**0.042**	**0.081**	0.000017a
Co	mg/L	0.175	0.0012	0.000018	0.0000082	0.000006	0.00071	0.0022	*0.11*
Cu	mg/L	1.53	0.12	0.0014	0.00059	0.00035	**0.0042**	**0.017**	0.004b
Fe	mg/L	28.1	0.011	0.006	0.003	0.001	0.006	0.009	0.3
Hg	mg/L	0.1	0.048	0.01	0.01	0.01	**<0.00005**	**<0.00005**	2.6E-05
K	mg/L	7.04	5.06	2.99	1.54	0.19	6.56	8.33	
Mg	mg/L	116	54.4	14.6	4.95	2.14	64.8	67.2	
Mn	mg/L	91.5	7.31	0.0032	0.00054	0.00045	**6.14**	**15.0**	0.2c
Mo	mg/L	0.0072	0.0026	0.00053	0.0001	0.00005	<0.0003	<0.0003	0.073
Na	mg/L	3.35	1.94	0.495	0.22	0.18	0.96	1.27	
Ni	mg/L	0.050	0.0046	0.00045	0.00028	0.00023	0.0029	0.0072	0.15b
P	mg/L	0.064	0.00087	0.000072	0.000025	0.000016	<0.01	0.019	
Pb	mg/L	0.065	0.019	0.0075	0.0031	0.002	**0.00021**	**0.00071**	0.007b
S	mg/L	669	519	130.5	3.2	3	**514**	**524**	
Sb	mg/L	0.039	0.013	0.0017	0.00086	0.0003	**0.0027**	**0.0023**	*0.02d*
Se	mg/L	0.00044	0.0004	0.000075	0.00005	0.00004	**0.0003**	**0.0003**	0.001
Si	mg/L	5.58	2.81	1.96	0.77	0.633	1.86	3.13	
Sr	mg/L	0.75	0.60	0.24	0.078	0.0295	0.673	0.773	
Tl	mg/L	0.0005	0.00016	0.00008	0.000013	0.000005	0.00017	0.00022	0.0008
U	mg/L	0.020	0.0012	0.00030	0.000026	0.000004	0.00004	0.00001	*0.3*
Zn	mg/L	47	3.14	0.043	0.0015	0.0012	**0.645**	**2.6**	0.03

Notes: 1. Acidity, alkalinity and hardness are expressed in units of $CaCO_3$; bold indicates metals which were elevated in aqua regia digestion (Table 4-5); Shaded values exceed CCME guidelines for total metals

2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are B.C. MOE maximum guidelines for protection of freshwater aquatic life for total metals (updated August 2006); a) interim guideline; b) criteria based on hardness of > 180 mg $CaCO_3$/L; c) irrigation guideline, protection of aquatic life not proposed; d) working guideline based on proposed Ontario guideline for protection of freshwater aquatic life

Table 4-7:
Results of Shake Flask Extractions for Mt. Nansen Ore Field Test Sub-sample Compared to Statistics for Historic Ore Samples (1989 – 2009)

Parameter[1]	Unit	*Statistical Summary for Historic Composite Ore Samples (n = 6) (Altura, 2009a)*					Ore (Bin 2)	CCME Max[2]
		Max	90th percentile	Median	10th percentile	Min		
pH		7.5	7.4	7.0	6.7	6.7	6.8	
Redox	mV	347	347	335	315	315	363	
Conductivity	uS/cm	1861	1861	1742	1309	1008	2530	
Acidity (to pH 8.3)	mg/L	9.8	9.8	7.7	6.0	5.2	9.0	
Alkalinity	mg/L	26.3	18.2	9.3	7.1	5.7	11.5	
Sulfate		1240	1240	1113	844	586	1889	*100*
Major Anions	meq/L	26.0	26.0	23.3	17.9	12.7	39.58	
Major Cations	meq/L	26.8	26.8	24.3	17.0	12.3	3.48	
Dissolved Metals								
Hardness	mg/L	1300	1300	1190	833	606	1760	
Ag	mg/L	0.00005	0.00005	0.00004	0.00002	<0.000005	**0.0005**	0.0001
Al	mg/L	0.006	0.006	0.005	0.003	0.002	0.006	0.1
As	mg/L	0.039	0.030	0.021	0.015	0.011	**0.0429**	0.005
Ca	mg/L	394	394	365	271	205	551	
Cd	mg/L	0.045	0.045	0.038	0.011	0.002	**0.0445**	0.000017a
Co	mg/L	0.0035	0.0035	0.0015	0.00012	0.00002	0.00444	*0.11*
Cu	mg/L	0.0055	0.0055	0.0031	0.0024	0.0020	**0.0063**	0.004b
Fe	mg/L	0.022	0.022	0.012	0.007	0.006	0.024	0.3
Hg	mg/L	<0.00005	<0.00005	<0.00005	<0.00003	<0.00001	**0.0003**	0.000026
K	mg/L	5.49	5.26	4.12	3.94	3.94	7.81	
Mg	mg/L	77.2	77.2	67.4	38.5	22.6	94.4	*NP*
Mn	mg/L	15.6	15.6	9.2	1.6	0.01	**20.4**	0.2c
Mo	mg/L	0.00042	<0.00036	<0.0003	<0.0003	<0.0003	<0.0005	0.073
Na	mg/L	2.78	1.99	1.00	0.69	0.69	1.66	
Ni	mg/L	0.007	0.007	0.004	0.001	0.000	0.0081	0.15b
P	mg/L	0.011	0.011	<0.01	<0.01	<0.01	**<0.02**	
Pb	mg/L	0.0017	0.0017	0.0007	0.00034	0.00013	**0.00077**	0.007b
S	mg/L	464.0	464.0	411.0	293.5	214.0	**589**	
Sb	mg/L	0.036	0.036	0.023	0.015	0.013	**0.06**	*0.02d*
Se	mg/L	0.0004	0.0004	0.0003	0.00014	0.00008	0.0007	0.001
Si	mg/L	2.98	2.96	1.81	1.73	1.73	2.67	
Sr	mg/L	0.42	0.42	0.34	0.31	0.28	0.629	
Tl	mg/L	0.0002	0.0002	0.00014	0.000085	0.000059	0.00024	0.0008
U	mg/L	0.000085	0.000048	<1E-05	<0.00001	<0.00001	0.00003	*0.3*
Zn	mg/L	2.45	2.45	1.83	0.31	0.02	**1.11**	0.03

Notes: 1. Acidity, alkalinity and hardness are expressed in units of $CaCO_3$; bold indicates metals which were elevated in aqua regia digestion (Table 4-5); Shaded values exceed CCME guidelines for total metals

2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are B.C. MOE maximum guidelines for protection of freshwater aquatic life for total metals (updated August 2006); a) interim guideline; b) criteria based on hardness of > 180 mg $CaCO_3$/L; c) irrigation guideline, protection of aquatic life not proposed; d) working guideline based on proposed Ontario guideline for protection of freshwater aquatic life

4.3 Waste Rock Drainage

Waste rock drainage water quality is represented by leachate from field weathering bins, field lysimeters, and natural seeps. Results from the waste rock field bin program are presented in Table 4-8. Constructed lysimeters were installed in late 2008 and are described in Altura (2009a). Sampling of lysimeters and seeps commenced in 2009 (Altura, 2009a). Tables 4-9 and 4-10 present the water quality from waste rock lysimeter leachate and natural waste rock seeps, respectively. Also presented in each table, for reference, are CCME maximum water quality guidelines. Note that parameters which were consistently below the analytical detection limit are not presented in these tables.

To date, six (6) leachate samples have been collected from each of the waste rock field bins. The pH values for the field bin leachate samples are lower than pH values measured in SFE. However, pH values are seen to increase with time toward neutral levels (~ 7) in the waste rock field bins, lysimeter experiments and seeps samples, which is congruent with the flushing of existing oxidation products. The exception is LW Seep, where a consistent pH of 6.5 – 7.0 is maintained.

In general, concentrations from waste rock field bin leachate decrease with time, with the initial flushing consisting of considerably higher values for some parameters (Table 4-8). For example, Cd, Cu, Mn and Zn concentrations are an order of magnitude higher in the initial leachate sample relative to subsequent leachate samples.

The leachate results for the saturated column experiment in Bin 3 (waste rock + organics) do not follow the same trend as the unsaturated waste rock field bin (Bin 1 – waste rock), but are generally indicated to be leaching constituents in higher concentrations than Bin 1 (waste rock). In particular, sulfate, As, Mn, Ni and Sb are indicated to be up to an order of magnitude higher in leachate from Bin 3 (waste rock + organics) relative to that of Bin 1 (waste rock).

Sulfate, Cd, Cu, Mn and Zn are indicated to be leaching from the waste rock field bins (bins 1 and 3) in concentrations higher than the maximum CCME guidelines. Additionally, Se is indicated to exceed the CCME guideline in one sample from the waste rock (Bin 1) and As, Ni and Sb also exceeded the guidelines in the waste rock + organics Bin. These elevated parameters are consistent with elevated concentrations identified in solid phase metal determination (aqua regia) and in SFE data discussed in sections 4.1.3 and 4.1.4, respectively.

Table 4-8:
Mt. Nansen Waste Rock Field Kinetic Test Leachate Results

Parameter[1]	Unit	Detection Limit	Unsaturated Waste Rock (Bin 1)						Saturated Waste Rock + Organic (Bin 3)						CCME[2]
			23-Jul-09	6-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	23-Jul-09	5-Aug-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Max
Physical															
pH				6.8	7.2	7.2	7.1	7.5		6.3	6.7	6.5	6.6	6.4	
Conductivity	µS/cm	1		2600		2220	2460	5030		3150		3470	3470	5140	
TSS	mg/L	1				<2	<2	<2				10	8	<2	
TDS	mg/L	5		2650	1970	2320	2460	3280		3320	3310	3950	3460	3540	
Anions and Nutrients															
T-Alkalinity	mg/L	5		39.6	34	16	24	47		280	390	237	249	167	
Bicarbonate	mg/L	5				20	30	60				290	300	200	
Carbonate	mg/L	6				<6	<6	<6				<6	<6	<6	
Hydroxide	mg/L	5				<5	<5	<5				<5	<5	<5	
Chloride	mg/L	0.02	<50	<50	<25	0.45	2.3	0.58	<50	<50	<50	4.48	5.3	2.08	
Fluoride	mg/L	0.02	0.152	0.167	0.165				0.064	0.054	0.065				
Sulfate	mg/L	0.05	1890	1710	1360	1280	1410	1870	1890	2040	2140	2180	2040	1920	*100*
Ammonia-N	mg/L		<0.0050	0.044	0.0079	<0.01	<0.01	<0.01	0.354	0.978	1.29	1.4	1.2	1.54	0.019a
Nitrate-N	mg/L	0.01	<0.50	0.75	6.24	0.15	<0.1	<0.01	<0.50	0.58	<0.5	0.13	<0.1	<0.01	13
Nitrite-N	mg/L	0.01	<0.10	0.32	<0.05	<0.01	<0.1	<0.01	<0.10	0.34	<0.1	<0.01	<0.1	<0.01	0.06
Orthophosphate-P	mg/L	0.002				<0.002	0.002	<0.002				0.014	0.005	0.01	
Cyanides															
Total Cyanide	mg/L	0.001	-	-	-				0.0067	<0.005	-				0.005b
Cyanide (WAD)	mg/L	0.002	-	-	-				<0.005	<0.005	-				
Cyanate (CNO)	mg/L	0.2	-	-					<0.50	0.59					
Thiocyanate	mg/L	0.1	-						0.97						
Total organic C	mg/L	0.5	1.29	1.79	1.1	1.6	1.8	1.8	17.3	38.1	37.5	24.2	36.3	15.4	

Table 4-8:
Mt. Nansen Waste Rock Field Kinetic Test Leachate Results (continued)

Parameter[1]	Unit	Detection Limit	Unsaturated Waste Rock (Bin 1)						Saturated Waste Rock + Organic (Bin 3)						CCME[2]
			23-Jul-09	6-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	23-Jul-09	5-Aug-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Max
Dissolved Metal															
Hardness	mg/L	5	1920	1890	1410	1340	1690	2340	1860	2290	2320	2250	2170	2400	
Ag	mg/L	0.00001	<0.00005	<0.00005	<0.00005	<0.00001	<0.00001	<0.00005	<0.0001	<0.0002	<0.0005	0.00002	<0.00001	<0.00005	0.0001
Al	mg/L	0.005	<0.005	<0.005	0.0116	<0.005	0.008	<0.025	0.034	<0.020	<0.05	0.009	0.012	<0.02	0.1
As	mg/L	0.0002	0.00138	0.00152	0.00095	0.0011	0.0013	0.004	0.0017	0.0397	0.007	0.0197	0.0098	0.002	0.005
Ba	mg/L	0.001	0.00631	0.00922	0.00459	0.01	0.013	0.04	0.0808	0.0654	0.0728	0.032	0.036	<0.005	
Ca	mg/L	0.1	456	442	337	355	416	566	496	499	558	487	500	524	
Cd	mg/L	0.00001	0.13	0.0468	0.0174	0.0094	0.0112	0.0243	0.0521	0.015	<0.00085	0.00917	0.0357	0.0118	0.000017c
Co	mg/L	0.00002	0.00108	<0.00050	<0.0005	0.00021	0.00042	0.107	0.0933	0.0778	0.174	0.156	0.154	0.0003	*0.11*
Cr	mg/L	0.0004	<0.0025	<0.0025	<0.0025	0.0054	<0.0004	<0.002	<0.005	<0.010	<0.025	0.0029	0.0035	<0.002	0.001d
Cu	mg/L	0.001	0.0167	0.0085	0.00614	<0.001	0.002	<0.005	0.0028	0.0165	<0.005	0.003	0.007	<0.005	0.004e
Fe	mg/L	0.01	<0.030	<0.030	<0.03	<0.01	<0.01	0.06	<0.030	0.08	5.28	5.17	0.17	<0.05	0.3
K	mg/L	0.1	6.4	5.9	3.5	3	4	16	8.2	50.6	11	13	15	3	
Li	mg/L	0.001	<0.025	<0.025	<0.025	0.004	0.003	0.01	<0.050	<0.10	<0.25	0.009	0.01	0.006	
Mg	mg/L	0.1	191	191	139	110	159	226	151	253	226	251	224	265	
Mn	mg/L	0.0002	17.1	1.79	0.242	0.0669	0.167	161	29.4	91.3	134	152	181	0.0578	0.2f
Mo	mg/L	0.0001	<0.00025	<0.00025	<0.00025	<0.0001	<0.0001	0.0005	<0.0005	0.0015	<0.0025	0.0005	0.0005	<0.0005	0.073
Na	mg/L	0.1	2.3	<2	<2	0.8	<1	3	7.2	24	5.8	5	4	<1	
Ni	mg/L	0.001	0.0144	0.0037	<0.0025	0.004	0.006	0.097	0.301	0.085	0.194	0.119	0.108	<0.005	0.15e
Pb	mg/L	0.0001	<0.00025	<0.00025	<0.00025	0.0001	0.0004	<0.0005	<0.00050	<0.0010	<0.0025	0.0007	0.0001	<0.0005	0.007e
Sb	mg/L	0.0002	0.00077	0.00072	<0.0005	0.0005	0.0008	0.002	0.0014	0.0154	<0.005	0.0007	0.0009	0.001	*0.02g*
Se	mg/L	0.0006	0.00093	0.00117	0.00075	0.0009	0.001	<0.003	0.00069	<0.0005	<0.0005	0.001	0.0011	<0.003	0.001
Si	mg/L	0.05	2.92	2.32	1.3	0.71	1.2	7.5	7.73	6.7	8.65	6.7	7	1.5	
Sr	mg/L	0.001	1.02	0.799	0.546	0.615	0.705	1.24	1.24	1.89	1.21	1.27	1.34	0.858	
Tl	mg/L	0.00001	<0.0005	<0.00050	<0.0005	0.00006	0.00008	0.00042	<0.0010	<0.0020	<0.005	0.00028	0.00046	0.00012	0.0008
U	mg/L	0.0004	<0.00005	0.000096	0.000176	<0.0004	<0.0004	<0.002	0.00024	0.00124	0.00783	0.0039	0.0037	<0.002	*0.3*
V	mg/L	0.0001	<0.005	<0.005	<0.005	<0.0001	<0.0001	0.002	<0.010	<0.020	<0.05	0.0025	0.0029	<0.0005	
Zn	mg/L	0.001	9.88	1.88	1	0.361	0.367	4.64	7.89	1.96	0.576	2.04	4.92	0.44	0.03

Notes: 1. Hardness and alkalinity are presented in units of $CaCO_3$; TSS: total suspended solids; TDS: total dissolved solids; shaded values exceed CCME guidelines for total metals
2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are British Columbia Ministry of the Environment (BC MOE) maximum water quality guidelines for protection of freshwater aquatic life for total metals (updated August 2006); a) criteria is conservatively based on the un-ionized NH_3; b) criteria is for free cyanide; c) interim guideline; d) criteria is for the more toxic Cr(VI); e) criteria are based on water hardness of >180 mg/L as $CaCO_3$; f) irrigation guideline, protection of aquatic life not proposed; g) BC MOE guideline, based on proposed Ontario guideline

Table 4-9:
Summary Statistics for Mt. Nansen Waste Rock Lysimeter Results (2009/2010)

Parameter[1]	Units	Detection Limit	L1 *(n = 6)*			L2 *(n = 5)*			CCME[2]
			Min	Median	Max	Min	Median	Max	Max
Conductivity	uS/cm		1820	3130	4660	414	1370	2910	
Hardness	mg/L	1	1240	2380	2750	176	751.5	1450	
pH	pH	0.1	6.99	7.28	7.49	7.52	7.71	7.74	
TDS	mg/L	10	1910	2770	3600	227	838	1780	
Total Alkalinity	mg/L	2	30	46.5	75	25	62	79	
Ammonia (as N)	mg/L	0.005	<0.01	0.04	0.09	0.01	0.03	0.12	0.019a
Chloride	mg/L	0.5	0.79	1.14	1.57	0.39	0.475	0.66	
Nitrate (as N)	mg/L	0.005	0.27	0.55	1.17	0.14	0.18	0.41	13
Nitrite (as N)	mg/L	0.001	<0.01	0.01	0.33	<0.01	<0.01	0.1	0.06
Sulfate	mg/L	0.5	1340	2075	2940	146	642	1220	*100*
Dissolved Metals									
Ag	mg/L	0.00001	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.0001	0.0001
Al	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.1
As	mg/L	0.0001	0.0027	0.0035	0.0056	0.0057	0.0077	0.0088	0.005
B	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	
Ba	mg/L	0.00005	0.002	0.004	0.004	0.005	0.011	0.022	
Be	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	
Bi	mg/L	0.0001	<0.0001	<0.001	<0.001	<0.0001	<0.001	<0.001	
Ca	mg/L	0.05	271	425.5	514	46.9	171	363	
Cd	mg/L	0.00001	0.0067	0.0075	0.0323	0.00073	0.00137	0.00237	0.000017b
Co	mg/L	0.0001	0.00011	0.00019	0.00101	0.00007	0.00012	0.00016	*0.11*
Cr	mg/L	0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.001c
Cu	mg/L	0.001	<0.001	0.0035	0.01	<0.001	<0.001	<0.002	0.004d
Fe	mg/L	0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	0.3
Hg	mg/L	0.00001	<0.00001	<0.00001	<0.01	<0.00001	<0.00001	<0.01	0.000026
K	mg/L	2	1.8	4.85	7	1.4	3.8	7	
Li	mg/L	0.005	0.003	0.007	0.013	0.001	0.004	0.009	
Mg	mg/L	0.1	95.5	295.5	488	14.4	75.2	131	
Mn	mg/L	0.00005	0.014	0.088	4.64	0.0007	0.0074	0.051	0.2e
Mo	mg/L	0.00002	0.00003	<0.0001	0.00006	<0.00002	<0.0001	<0.0001	0.073
Na	mg/L	2	0.4	0.85	1.4	0.2	1	1.4	
Ni	mg/L	0.0005	0.002	0.003	0.008	0.001	0.002	0.003	0.15d
P	mg/L	0.01	<0.01	<0.015	<0.02	<0.01	<0.01	0.08	
Pb	mg/L	0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0001	0.007d
S	mg/L		445	676	831	48.8	206	408	
Sb	mg/L	0.0001	0.001	0.0013	0.0022	0.0009	0.0013	0.0015	*0.02f*
Se	mg/L	0.0005	0.0006	0.00145	0.0044	0.0006	<0.0006	0.0006	0.001
Si	mg/L	0.05	0.45	1.19	1.92	0.52	1.33	2.2	
Sn	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Sr	mg/L	0.0001	0.443	0.837	1.04	0.15	0.689	1.09	
Ti	mg/L	0.01	<0.0004	<0.0004	0.031	<0.0003	<0.0004	0.0068	
Tl	mg/L	0.0001	0.00009	0.00011	0.00015	<0.00001	<0.00002	0.0001	
U	mg/L	0.00001	0.0004	0.0008	0.0013	0.0004	0.0011	0.0019	*0.3*
V	mg/L	0.0001	<0.0001	<0.0001	0.00014	0.00007	<0.0001	0.00008	
Zn	mg/L	0.001	0.154	0.363	2.39	0.032	0.038	0.08	0.03

Notes: 1. Hardness and alkalinity are presented as units of $CaCO_3$; TDS: total dissolved solids; shaded values exceed CCME guidelines for total metals; 2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are British Columbia Ministry of the Environment (BC MOE) maximum water quality guidelines for protection of freshwater aquatic life for total metals (updated August 2006); a) criteria is conservatively based on the un-ionized NH_3; b) interim guideline; c) criteria is for the more toxic Cr(VI); d) criteria are based on water hardness of >180 mg/L as $CaCO_3$; e) irrigation guideline, protection of aquatic life not proposed; f) BC MOE guideline, based on proposed Ontario guideline.

Table 4-10:
Summary Statistics for Mt. Nansen Waste Rock Natural Seeps (2009/2010)

Parameter[1]	Units	Detection Limit	NW Seep-1 *(n = 11)*			LW Seep-1 *(n = 8)*			CCME[2]
			Min	Median	Max	Min	Median	Max	Max
Conductivity	uS/cm		1120	1900	2400	2240	2550	3410	
Hardness	mg/L	1	708	1215	1650	1300	1760	1950	
pH	pH	0.1	7.3	7.75	8.13	6.49	6.66	6.96	
TDS	mg/L	10	784	1530	1940	1690	2185	2410	
Total Alkalinity	mg/L	2	44	54	64	28	39.5	58	
Ammonia (as N)	mg/L	0.005	<0.01	<0.01	0.08	<0.01	0.035	0.08	0.019a
Chloride	mg/L	0.5	0.07	0.32	3.7	0.53	1.035	1.38	
Nitrate (as N)	mg/L	0.005	0.01	0.31	0.55	6.35	8.66	9.96	13
Nitrite (as N)	mg/L	0.001	<0.01	<0.01	0.1	<0.01	<0.01	0.36	0.06
Sulfate	mg/L	0.5	515	1040	1300	1120	1530	1740	*100*
Dissolved Metals									
Ag	mg/L	0.00001	<0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.0001	0.0001
Al	mg/L	0.005	<0.005	<0.005	0.016	<0.005	<0.005	0.016	0.1
As	mg/L	0.0001	0.0047	0.0105	0.0227	0.0004	0.00075	0.0012	0.005
B	mg/L	0.004	<0.004	<0.004	<0.005	<0.004	<0.004	<0.004	
Ba	mg/L	0.00005	0.005	0.009	0.016	0.007	0.008	0.012	
Be	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	
Bi	mg/L	0.0001	<0.0001	<0.001	<0.001	<0.0001	<0.001	<0.001	
Ca	mg/L	0.05	185	353	463	346	374	420	
Cd	mg/L	0.00001	0.00185	0.0024	0.0032	0.11	0.1375	0.184	0.000017b
Co	mg/L	0.0001	0.00009	0.00021	0.00041	0.00199	0.00825	0.0194	*0.11*
Cr	mg/L	0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.001c
Cu	mg/L	0.001	0.002	0.003	0.024	0.11	0.1795	0.225	0.004d
Fe	mg/L	0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.05	0.3
Hg	mg/L	0.00001	<0.00001	<0.00001	<0.01	<0.00001	<0.00001	<0.01	0.000026
K	mg/L	2	2	3.6	5.2	1	1.6	2	
Li	mg/L	0.005	0.002	0.006	0.006	0.004	0.005	0.006	
Mg	mg/L	0.1	41.6	86.1	121	90.5	188	219	
Mn	mg/L	0.00005	0.0021	0.0096	0.208	16.6	23.7	28.6	0.2e
Mo	mg/L	0.00002	<0.00007	<0.0001	0.00016	<0.00002	<0.0001	<0.0001	0.073
Na	mg/L	2	2	4.3	5.7	7.3	10	12.9	
Ni	mg/L	0.0005	0.001	0.003	0.009	0.024	0.0305	0.04	0.15d
P	mg/L	0.01	<0.01	<0.01	0.1	<0.01	<0.02	0.1	
Pb	mg/L	0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	0.0002	0.007d
S	mg/L		3.7	296	433	1.4	482.5	560	
Sb	mg/L	0.0001	0.0016	0.0021	0.0036	0.0006	0.00095	0.0014	*0.02f*
Se	mg/L	0.0005	<0.0006	<0.0006	0.0008	<0.0006	<0.0006	<0.0006	0.001
Si	mg/L	0.05	2.52	3.35	3.73	4.1	4.765	6.31	
Sn	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0009	
Sr	mg/L	0.0001	0.423	0.854	1.21	0.884	0.9545	1.11	
Ti	mg/L	0.01	0.0004	0.0004	0.0066	0.0004	0.00065	0.0175	
Tl	mg/L	0.0001	0.00002	0.00005	0.00006	0.00005	0.00006	0.0001	
U	mg/L	0.00001	0.0004	0.0008	0.001	<0.0004	<0.0004	0.001	*0.3*
V	mg/L	0.0001	<0.00005	<0.0001	0.00021	<0.00006	<0.0001	0.00011	
Zn	mg/L	0.001	0.055	0.115	0.182	17.7	24.45	34.2	0.03

Notes: 1. Hardness and alkalinity are presented as units of $CaCO_3$; TDS: total dissolved solids; shaded values exceed CCME guidelines for total metals; 2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are British Columbia Ministry of the Environment (BC MOE) maximum water quality guidelines for protection of freshwater aquatic life for total metals (updated August 2006) ; a) criteria is conservatively based on the un-ionized NH_3; b) interim guideline; c) criteria is for the more toxic Cr(VI); d) criteria are based on water hardness of >180 mg/L as $CaCO_3$; e) irrigation guideline, protection of aquatic life not proposed; f) BC MOE guideline, based on proposed Ontario guideline.

The results of the lysimeters and natural seeps are similar in terms of parameters of concern. Sulfate, As, Cd, Cu, Mn and Zn exceed the CCME guidelines. As expected, values measured for L1 (*i.e.,* "worst case waste rock") are higher than L2 (*i.e.,* "average case waste rock"), with the exception of arsenic. Parameters measured in LW Seep samples are generally two orders of magnitude higher than values reported for NW Seep samples, except arsenic, which is consistent with the lower pH values reported in the LW Seep. Additionally, dissolved constituents in LW Seep samples are relatively constant, remaining within the same order of magnitude.

Parameters of concern identified above are discussed in greater detail in Section 4.5 – Source Term Development.

4.4 Ore Drainage

Low-grade ore exists as backfill above the southern end of the open pit. No drainage chemistry is available from this material, as no visible seeps have been observed. A field bin was designed as a proxy for ore drainage chemistry.

Leachate results for the ore field bin (Bin 2) are presented and compared with CCME maximum water quality guidelines in Table 4-11. Note that parameters which are consistently below the analytical detection limit are not presented in the tables in this section of the report. Complete data can be found in Appendix B2.

To date, six (6) leachate samples have been collected from Bin 2. Similar to waste rock, discussed previously, the initial pH value reported for Bin 2 leachate is slightly lower than the pH value reported from SFE; however, the pH values in the leachate samples are seen to increase with time, which is congruent with the flushing of soluble oxidation products from existing ore materials at Mt. Nansen. In general, the leachate results from Bin 2 follow a similar trend to that of the Bin 1 (waste rock); in that concentrations of dissolved constituents tend to decrease with time (Table 4-11). However, the leached constituents from Bin 2 are considerably higher than from Bin 1 (waste rock), particularly for sulfate, As, Mn, Sb, Se and Zn, a result that is congruent with the higher sulfide and solid-phase elemental content of ore material (Tables 4-3 and 4-5) compared to waste rock (Tables 4-2 and 4-4).

Sulfate, As, Cd, Cu, Mn, Sb, Se and Zn are leaching from the ore Bin in concentrations excess of CCME guidelines. These elevated parameters are consistent with elevated concentrations identified in SFE data (Table 4-7).

Parameters of concern identified above are discussed in greater detail in Section 4.5 – Source Term Development.

Table 4-11:
Leachate Results for Mt. Nansen Ore Field Kinetic Test

Parameter[1]	Unit	Detection Limit	Bin 2. Ore Bin (unsaturated)						CCME Max[2]
			23-Jul-09	06-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	
pH				6.5	6.8	6.7	6.6	7	
Conductivity	µS/cm	1		3460		2890	3020	6020	
TSS	mg/L	1				3	6	<2	
TDS	mg/L	5		3790	2890	3080	3410	4120	
T-Alkalinity	mg/L	5		22.8	22.8	5	8	32	
Bicarbonate	mg/L	5				<5	<5	40	
Carbonate	mg/L	6				6	10	<6	
Chloride	mg/L	0.02	<50	<50	<25	2.2	2.4	0.86	
Fluoride	mg/L	0.02	0.125	0.113	0.09				
Sulfate (SO_4)	mg/L	0.05	2680	2620	1930	1840	1780	2600	*100*
Ammonia (as N)	mg/L		0.0147	0.093	0.0242	<0.01	<0.01	<0.01	0.019a
Nitrate (as N)	mg/L	0.01	<0.50	0.85	<0.25	0.14	<0.1	0.12	13
Nitrite (as N)	mg/L	0.01	<0.10	<0.10	<0.05	<0.01	<0.1	<0.01	0.06
Orthophosphate-P	mg/L	0.002				0.007	0.007	0.01	
Total Organic-C	mg/L	0.5	2.64	3.16	1.69	1.3	2	2.4	
Dissolved Metal									
Hardness	mg/L	5	2530	2520	1830	1970	2170	2920	
Ag	mg/L	0.00001	0.00095	<0.0002	<0.0001	<0.00001	0.00001	<0.00005	0.0001
Al	mg/L	0.005	<0.020	<0.020	<0.01	<0.005	<0.005	<0.02	0.1
As	mg/L	0.0002	0.0173	0.0321	0.0227	0.0173	0.0279	0.038	0.005
B	mg/L	0.004	<0.20	<0.20	<0.1	<0.004	<0.004	<0.02	
Ba	mg/L	0.001	0.0157	0.0146	0.00803	0.008	0.01	0.01	
Be	mg/L	0.00004	<0.010	<0.010	<0.005	<0.00004	<0.00004	<0.0002	
Bi	mg/L	0.001	<0.010	<0.010	<0.005	<0.001	<0.001	<0.005	
Ca	mg/L	0.1	462	432	358	384	442	507	
Cd	mg/L	0.00001	0.201	0.108	0.0702	0.0452	0.0457	0.0716	0.000017b
Co	mg/L	0.00002	0.0272	0.0116	0.0072	0.00289	0.00248	0.003	*0.11*
Cr	mg/L	0.0004	<0.010	<0.010	<0.005	<0.0004	0.0005	<0.002	0.001c
Cu	mg/L	0.001	0.0364	0.0216	0.0159	0.003	0.005	0.006	0.004d
Fe	mg/L	0.01	<0.030	<0.030	<0.03	<0.01	0.02	<0.05	0.3
K	mg/L	0.1	8	7.7	5	4.6	7	7	
Li	mg/L	0.001	<0.10	<0.10	<0.05	0.009	0.008	0.02	
Mg	mg/L	0.1	334	350	229	246	259	402	
Mn	mg/L	0.0002	97.4	64.9	45	28.7	21.6	36.4	0.2e
Mo	mg/L	0.0001	<0.0010	<0.0010	<0.0005	<0.0001	<0.0001	0.001	0.073
Na	mg/L	0.1	4	3.1	2.4	1.3	1	<1	
Ni	mg/L	0.001	0.058	0.028	0.0183	0.013	0.013	0.02	0.15d
Pb	mg/L	0.0001	0.0043	0.0054	0.00261	0.0011	0.0035	0.0009	0.007d
Sb	mg/L	0.0002	0.0332	0.0335	0.0219	0.0226	0.0229	0.031	*0.02f*
Se	mg/L	0.0006	0.00211	0.00188	0.00092	0.001	0.0006	<0.003	0.001
Si	mg/L	0.05	4.23	2.93	2.28	1.32	2.6	4.2	
Sn	mg/L	0.0001	<0.0020	<0.0020	<0.001	<0.0001	<0.0001	<0.0005	
Sr	mg/L	0.001	1.13	0.855	0.656	0.758	0.82	1	
Ti	mg/L	0.01	<0.010	<0.010	<0.01	<0.01	<0.1	<0.1	
Tl	mg/L	0.00001	<0.0020	<0.0020	<0.001	0.00012	0.00014	0.00027	
U	mg/L	0.0004	<0.0002	<0.00020	<0.0001	<0.0004	<0.0004	<0.002	*0.3*
V	mg/L	0.0001	<0.020	<0.020	<0.01	<0.0001	<0.0001	<0.0005	
Zn	mg/L	0.001	31.2	8.39	8.28	4.02	4.03	6.34	0.03

Notes: 1. Hardness and alkalinity are presented as units of $CaCO_3$; TDS: total dissolved solids; shaded values exceed CCME guidelines for total metals; 2. Canadian Council of Ministers of the Environment maximum water quality guidelines for the protection of aquatic life (updated December 2007) for total metals; italic values are BC MOE maximum water quality guidelines for protection of freshwater aquatic life for total metals (updated August 2006); a) criteria is conservatively based on the un-ionized NH_3; b) interim guideline; c) criteria is for the more toxic Cr(VI); d) criteria are based on water hardness of >180 mg/L as $CaCO_3$; e) irrigation guideline, protection of aquatic life not proposed; f) BC MOE guideline, based on proposed Ontario guideline.

4.5 Source Term Development

Solid phase and drainage quality characterization results for Mt. Nansen waste rock and ore were used to derive "Conservative Best Estimate" and "Worst Case" source term concentrations. These source terms will be used to evaluate and compare closure options through application in the Mt. Nansen water quality model (GEEC, 2010). The following sections describe the general approach and rationale employed during development of the waste rock and ore source terms. Source terms were developed for each of the closure options being considered for waste rock and ore, including:

1) options 1A, 2A, 3 and 4 - subaerial unsaturated waste rock and ore storage; and

2) options 1B, 2B, and 4- a combination of unsaturated and saturated backfilled waste rock and ore storage in the Brown-McDade pit.

4.5.1 Waste Rock

4.5.1.1 Options 1A, 2A, 3, and 4: Subaerial Unsaturated Storage of Waste Rock

Five main sources of data were evaluated during the development of "Conservative Best Estimate" and "Worst Case" source terms for subaerial, unsaturated waste rock (*e.g.*, waste rock piles in their current location). The five sources of data included in this evaluation are:

1) Lysimeter 1 (L1): "Worst Case" waste rock (constructed in late 2008 by Altura) (Altura, 2009a);
2) Lysimeter 2 (L2): "Average Case" waste rock (constructed in late 2008 by Altura) (Altura, 2009a);
3) NW Seep-01: natural seep located on the pit side of the northwest waste rock pile;
4) LW Seep-01: natural seep located at the toe of the lower west waste rock pile; and,
5) Waste rock field bin: constructed using material collected near L1 in mid July 2009.

While all the above mentioned sources of data are considered in this evaluation, it should be noted that the natural seeps, which have not been disturbed by construction or human activity and have potentially been active for up to 10 years, are used as general benchmarks against which all the source term estimations have been qualitatively evaluated.

The key assumptions that were made in the evaluation of source terms for water quality modeling include:

- All source of data (lysimeters, seeps, and field) have reached equilibrium and shifts in this equilibrium state will be minimal;
- Waste rock is non-acid generating.

"Conservative Best Estimate" Source Term Development

The first step in source term development was to determine the median concentrations of each element in three separate scenarios, including:

1) Each individual sample site (*i.e.,* median values for each of L1, L2, NW Seep-01, LW Seep-01 and waste rock Field Bin (Bin 4)). In this scenario, the (1) median and (2) average values of the five sample sites were calculated to derive a number which best estimates the central tendency (both weighted and un-weighted) of the median values of each of these sample sites;

2) All sample sites together (*i.e.,* median values for the entire data set from all five sample sites together); and,

3) Natural seeps only *(i.e.,* NW Seep-01 and LW Seep-01).

The data from these calculations are presented in Table 4-12. It should be noted that, to remain conservative, all concentrations that were reported to be below detection were set at the limit of detection for all statistical calculations.

Table 4-12:
Median and Average Concentrations Calculated for Scenarios A to C for Subaerial/Unsaturated Waste Rock

Parameter	Unit	Unsaturated Waste Rock "Conservative Best Estimate" Scenario[1]				CCME[2] Maximum Water Quality Guidelines
		A(1) **Median** (of all median values) *n = 5*	A(2) **Mean** (of all median values) *n = 5*	B **Median** (all samples) *n = 39*	C **Median** (seeps only, bench-mark) *n = 19*	
Sulfate (SO_4)	mg/L	1530	1369	1315	1150	*100*
Ammonia (as N)	mg/L	0.03	0.025	0.02	0.02	*12*[a]
Nitrate (as N)	mg/L	0.325	2	0.475	0.49	13
Nitrite (as N)	mg/L	0.01	0.023	0.01	0.01	0.06
Dissolved Metals						
As	mg/L	0.0035	0.0048	0.00425	0.0068	0.005
Cd	mg/L	0.0075	0.033	0.0071	0.00316	0.00006[b]
Cu	mg/L	0.0035	0.039	0.005	0.013	0.004[c]
Fe	mg/L	0.01	0.014	0.01	0.01	0.3[d]
Mn	mg/L	0.088	4.8	0.091	0.143	*3.8*[e]
Zn	mg/L	0.363	5.14	0.2935	0.142	0.03
Ca	mg/L	374	350.5	367.5	368	
Mg	mg/L	175	164	123	92.7	

Notes: 1. Shaded values exceed the maximum water quality criteria; blue parameters are additional to previous source term development
2. Canadian Council of Ministers of the Environment (CCME) maximum water quality guidelines for the protection of aquatic life. Guidelines in italics are British Columbia Ministry of Environment (BC MOE) maximum water quality guidelines for the protection of aquatic life for total metals (updated August 2006); a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C, b) working guideline based on a hardness >210 mg $CaCO_3$/L (10 exp (0.86[log{hardness}]-3.2)); c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L; d) guideline is for dissolved Fe; e) guideline based on a water hardness of > 300 mg $CaCO_3$/L.

The median concentrations for each scenario reported in Table 4-12 were compared to each other as well as trends in the waste rock leachate dataset (Figures 4-1 to 4-10) in order to select the most appropriate "best estimate" value for subaerial unsaturated "As Is" waste rock. The following sections discuss source term development for each of the parameters being considered in this evaluation.

Sulfate

Figure 4-1 provides a plot showing the concentrations of sulfate reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12 for comparative purposes. As noted previously, because they are naturally occurring and are considered representations of undisturbed drainage from the waste rock pile, NW Seep and LW Seep are considered benchmarks against which the sulfate source term will be evaluated. Concentrations of sulfate in drainage from Mt. Nansen are on the same order of magnitude and relatively consistent, with each scenario plotting in the centre of the data. Only concentrations from L2 are notably lower.

Based on the data provided in Table 4-12 and in Figure 4-1, 1,530 mg/L (median of median values – A(1), Table 4-12) is considered a conservative best estimate of sulfate concentrations from the waste rock drainage dataset.

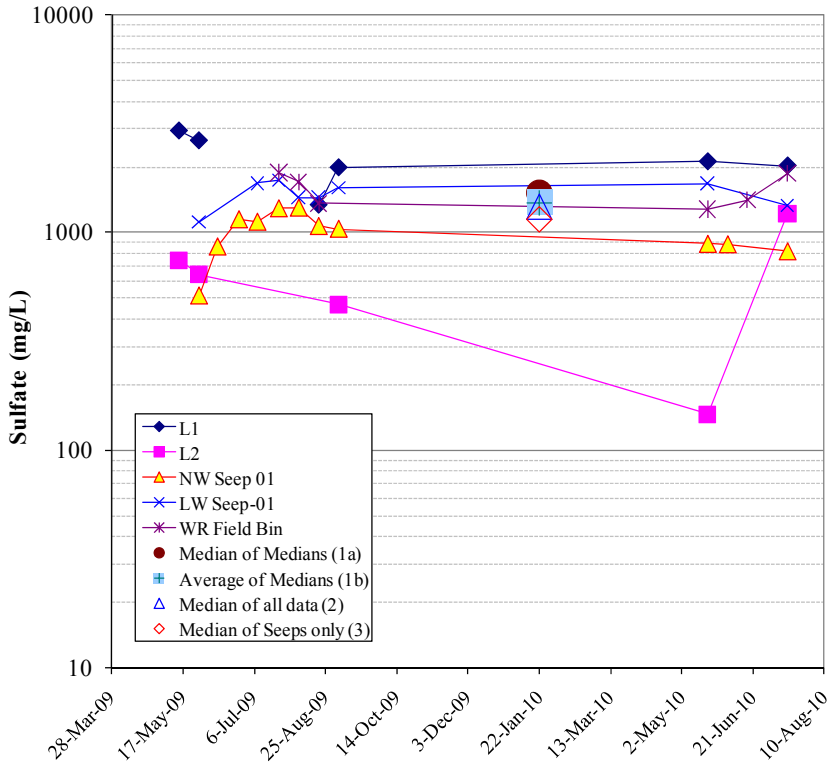


Figure 4-1: Sulfate concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

Arsenic (As)

Figure 4-2 provides a plot showing the concentrations of dissolved arsenic reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12 for comparative purposes. The highest concentrations of dissolved As are reported from the NW Seep, which is located on the pit side of the northwest waste rock pile. Arsenic in drainage from L2 is also high despite the relatively low sulfate values. Drainage from the LW Seep-01 has the lowest concentrations of arsenic. Note that drainage from LW Seep-01 contains some of the highest sulfate values (Figure 4-1) and dissolved metal concentrations (specifically, Cd, Cu, Mn, Zn and nitrate) (figures 4-3, 4-4, 4-6, 4-7 and 4-8), consistent with lower pH values (6.5 – 7). The data suggest that LW Seep represents drainage from a region of the waste rock pile where sulfide oxidation (sphalerite and chalcopyrite) is occurring.

Comparison of the median As values (Table 4-12) plotted in Figure 4-2 with the waste rock seepage data indicates that 0.0068 mg/L (median of seeps only – B, Table 4-12) provides the most conservative best estimate of arsenic concentrations from Mt. Nansen waste rock.

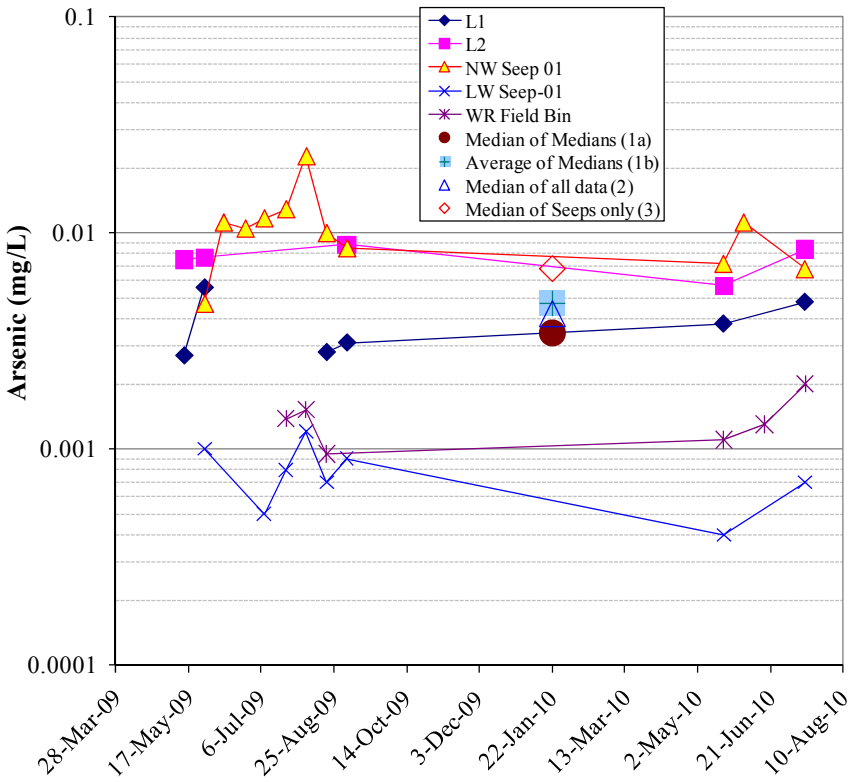


Figure 4-2: Dissolved Arsenic Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters, and Field Bin Leachate for 2009 and 2010 Field Seasons

Cadmium (Cd)

Figure 4-3 provides a plot showing the concentrations of Cd reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12 for comparative purposes. Concentrations of Cd in the natural seep located at the toe of the lower west waste rock pile (LW Seep-01) are an order of magnitude higher compared to other drainages assessed for this study. Considering the elevated concentrations of Cd in drainage from LW Seep-01, and that it is being used as a benchmark for the source term estimates, 0.033 mg/L (average of medians – A(2), Table 4-12) provides the most conservative best estimate of Cd concentrations from waste rock.

Copper (Cu)

Figure 4-4 provides a plot showing the concentrations of dissolved Cu reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes. Comparison of the median Cu values (Table 4-12) plotted in Figure 4-4 with the waste rock seepage data indicate that 0.039 mg/L (average of medians – A(2), Table 4-12) provides the most conservative best estimate of Cu concentrations from waste rock.

Iron (Fe)

Figure 4-5 provides a plot showing the concentrations of dissolved Fe reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes. It is important to note that, with the exception of LW Seep-01, a majority of reported Fe concentrations are below the limit of detection (0.01 mg/L). Given the fact that dissolved Fe concentrations are less than detection for all but a few sampling events, the spikes in Fe concentrations observed in early August 2009 from LW Seep and NW Seep are most likely the result of total Fe associated with colloidal particles that are less than 0.45 μm in diameter. Therefore, even though concentrations of up to 0.06 mg/L are reported from waste rock seepage data, the best estimate for dissolved Fe concentrations from Mt. Nansen waste rock is 0.01 mg/L.

Manganese (Mn)

Figure 4-6 provides a plot showing the concentrations of dissolved Mn reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes. Comparison of the median dissolved Mn values (from Table 4-12) plotted in Figure 4-6 with the waste rock seepage data indicate that 4.8 mg/L (average of medians – A(2), Table 4-12) provides the most reasonably conservative best estimate of dissolved Mn concentrations from waste rock at Mt. Nansen.

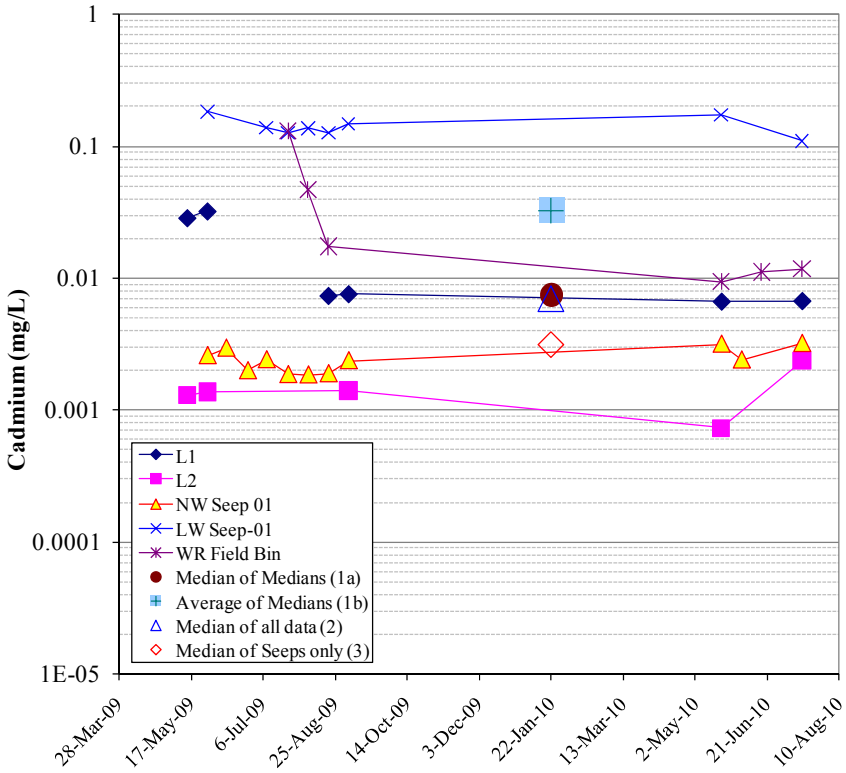


Figure 4-3: Dissolved Cadmium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

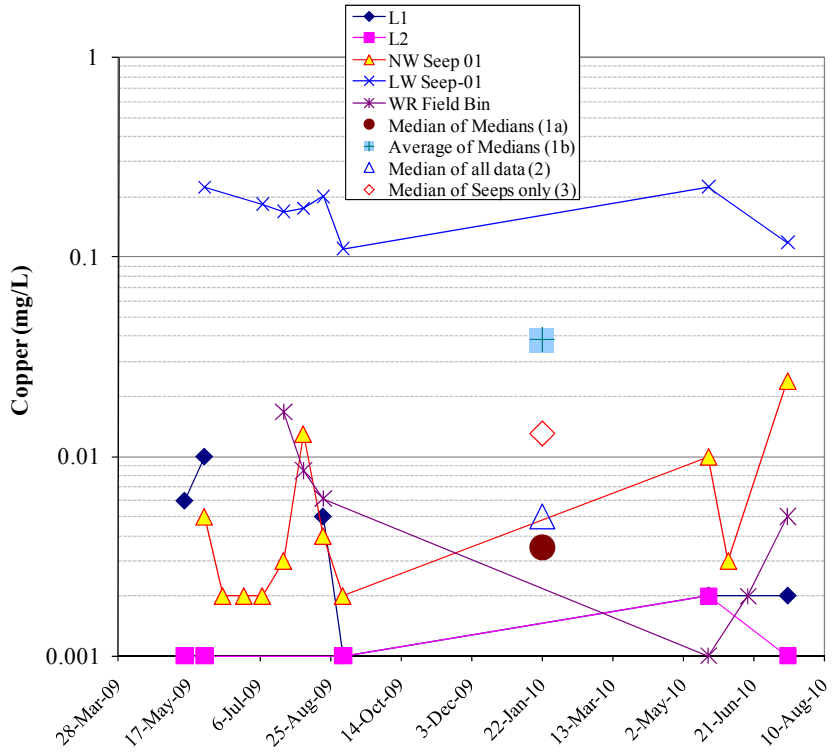


Figure 4-4: Dissolved Copper Concentrations from Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin

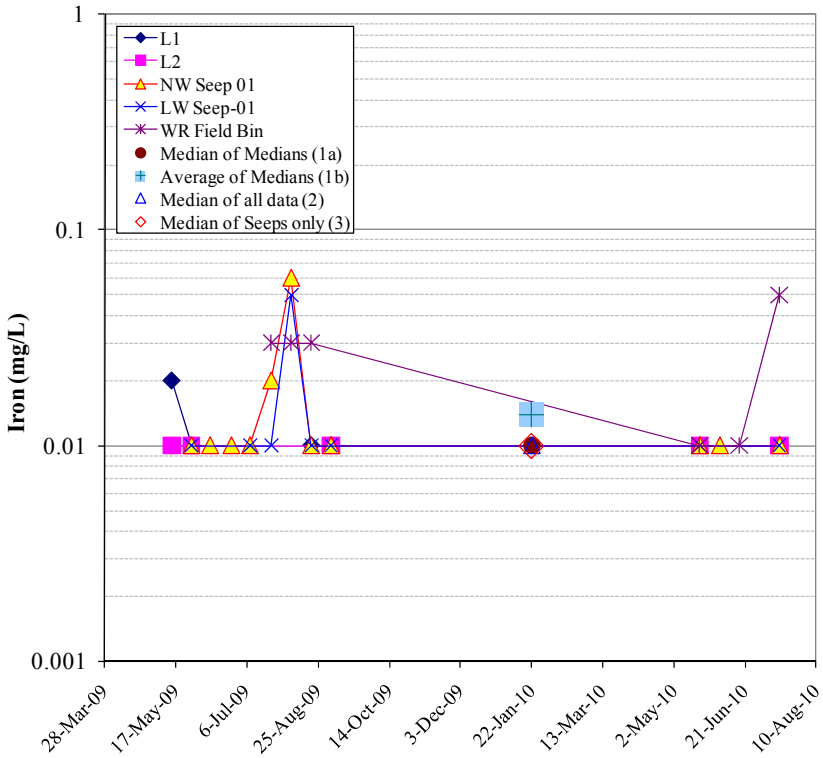


Figure 4-5: Dissolved Iron Concentrations in Mt. Nansen Waste Rock Seeps, lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

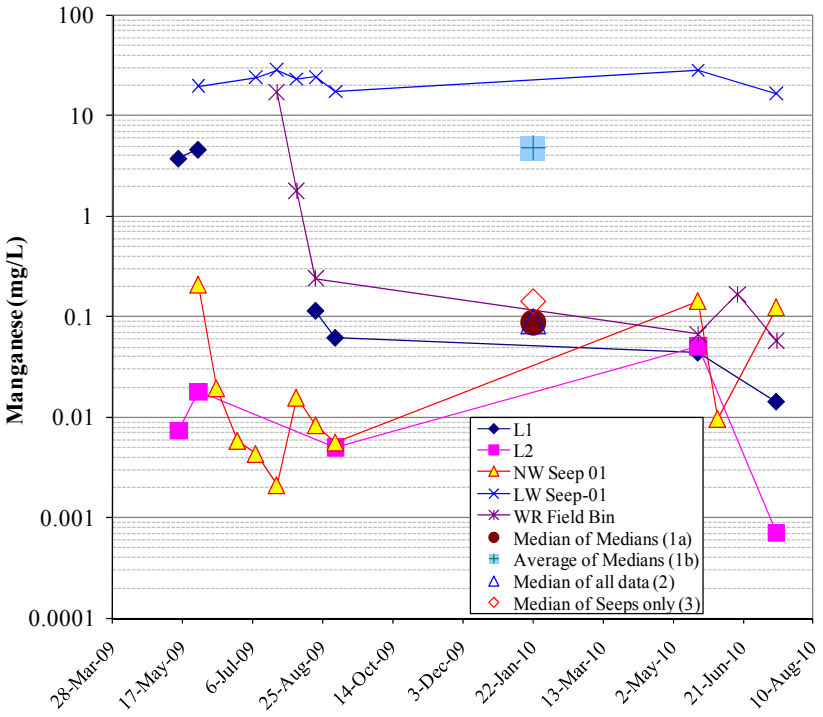


Figure 4-6: Dissolved Manganese Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

Zinc (Zn)

Figure 4-7 provides a plot showing the concentrations of dissolved Zn reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes.

Comparison of the median Zn values (Table 4-12) plotted in Figure 4-7 with the waste rock seepage data indicate that 5.14 mg/L (average of medians – A(2), Table 4-12) provides the most reasonably conservative best estimate of dissolved Zn concentrations from waste rock at Mt. Nansen.

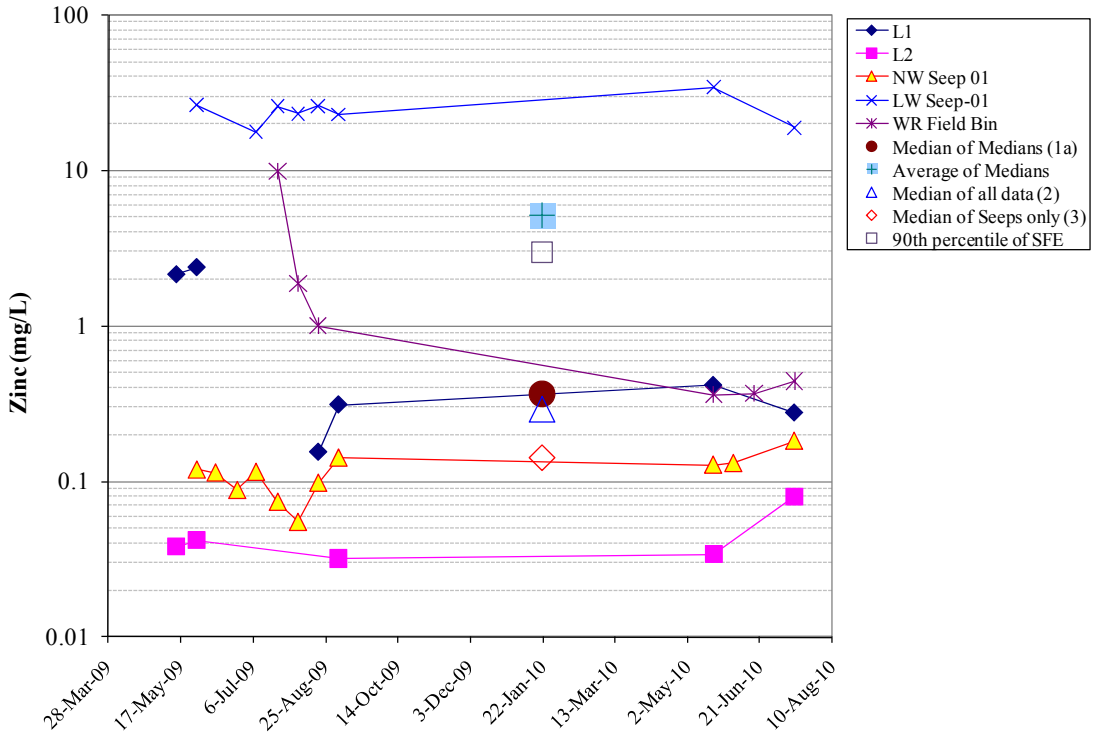


Figure 4-7: Dissolved Zinc Concentrations from Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin

Nitrate-N, Nitrite-N and Ammonia-N

Figure 4-8 provides a plot showing the concentrations of nitrate-N reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes. Comparison of the median nitrate-N values (Table 4-12) plotted in Figure 4-8 with the waste rock seepage data indicates that 2.0 mg/L (average of medians – A(2), Table 4-12) provides the most reasonably conservative best estimate of nitrate-N concentrations from waste rock at Mt. Nansen.

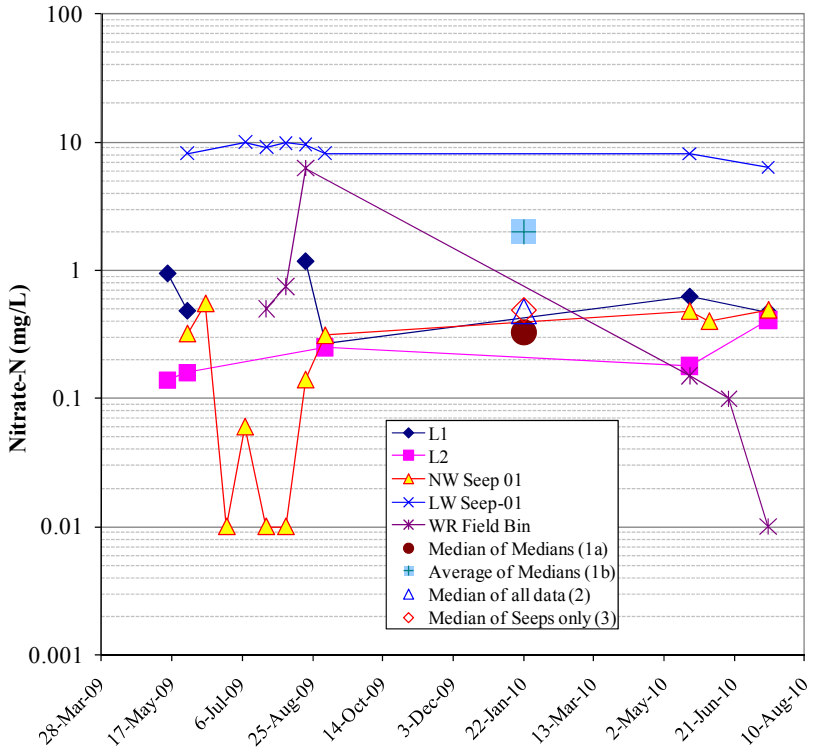


Figure 4-8: Nitrate-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

Figure 4-9 provides a plot showing concentrations of nitrite-N reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as median values calculated in Table 4-12, for comparative purposes. Nitrite values are often at or below the limit of detection (0.01 and 0.1 mg/L) in drainage from Mt. Nansen waste rock. However, a comparison of median nitrite-N values (Table 4-12) plotted in Figure 4-9 with the waste rock seepage data indicates that 0.023 mg/L (average of medians – A(2), Table 4-12) provides the most reasonably conservative best estimate of nitrite-N from Mt. Nansen waste rock.

Figure 4-10 provides a plot showing the concentrations of ammonia-N reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes. Comparison of the median ammonia-N values (Table 4-12) plotted in Figure 4-10 with the waste rock seepage data indicates that 0.030 mg/L (median of medians – A(1), Table 4-12) provides the most reasonably conservative best estimate of ammonia-N concentrations from waste rock at Mt. Nansen.

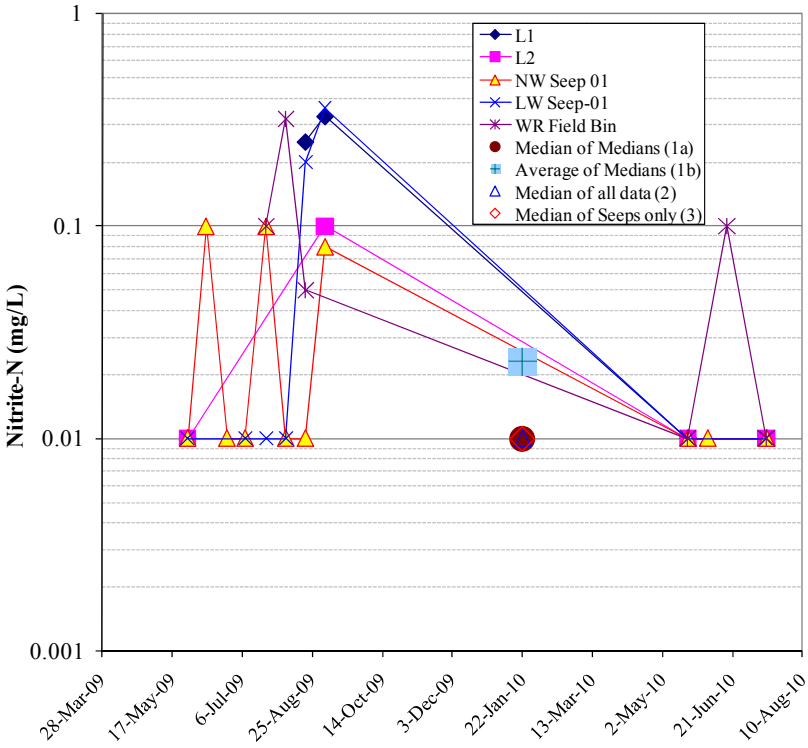


Figure 4-9: Nitrite-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

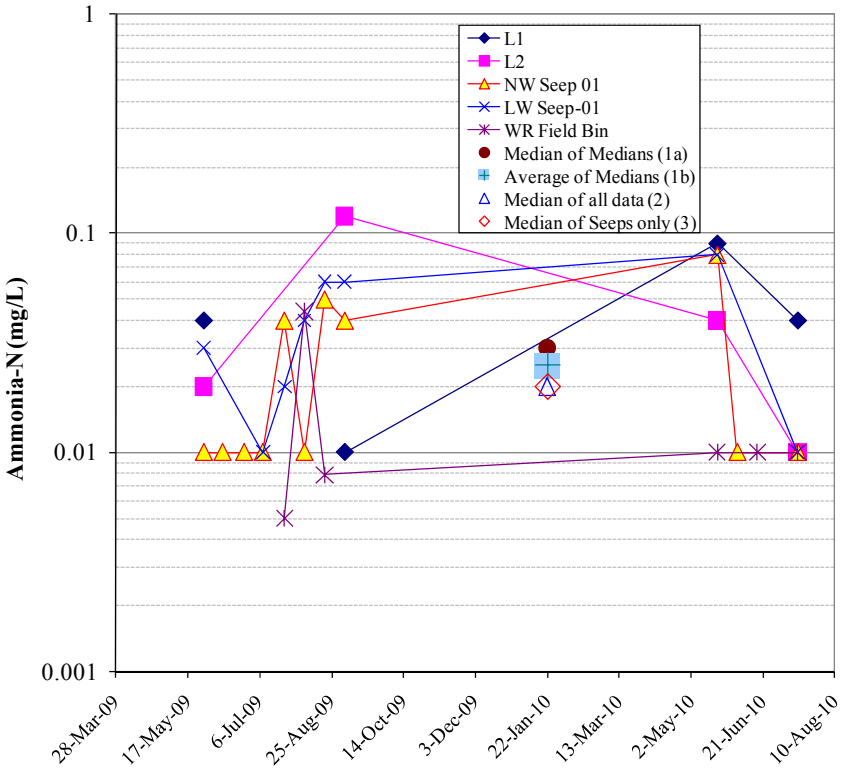


Figure 4-10: Ammonia-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

Calcium (Ca) and Magnesium (Mg)

Figure 4-11 provides a plot showing the concentrations of dissolved Ca reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes.

Comparison of the median Ca values (from Table 4-12) plotted in Figure 4-11 with the waste rock seepage data indicate that 368 mg/L (median of seeps only and median of all data – 3 and 2, Table 4-12) provides the most reasonably conservative best estimate of dissolved Ca concentrations from waste rock at Mt. Nansen.

Figure 4-12 provides a plot showing the concentrations of dissolved Mg reported for L1, L2, NW Seep, LW Seep, and the waste rock Field Bin as well as the median values calculated in Table 4-12, for comparative purposes.

Comparison of the median Mg values (from Table 4-12) plotted in Figure 4-12 with the waste rock seepage data indicate that 92.7 mg/L (median of seeps only – C, Table 4-12) provides the most reasonably conservative best estimate of dissolved Mg concentrations from waste rock at Mt. Nansen.

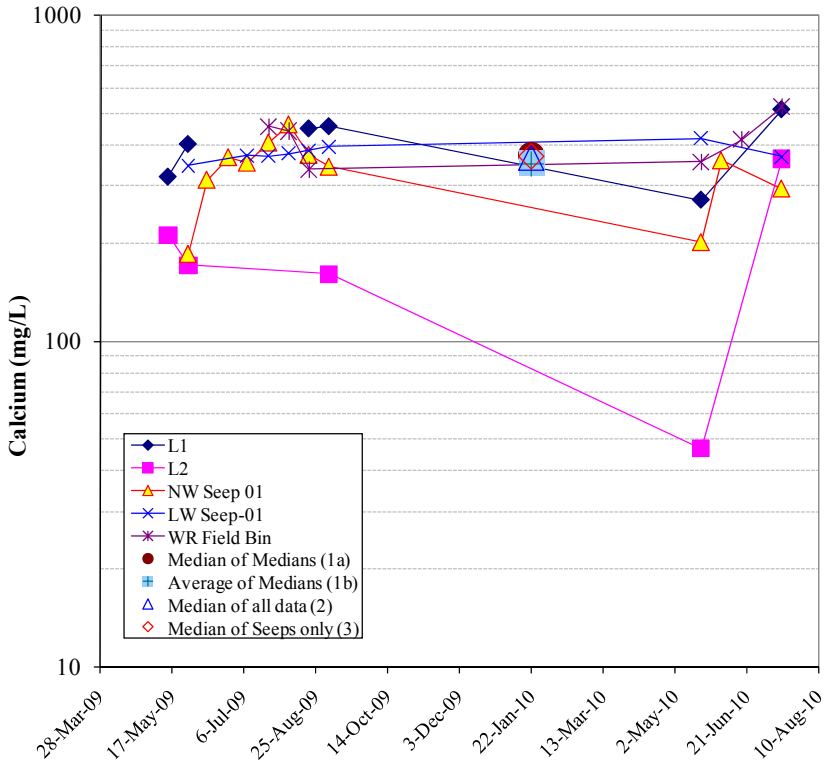


Figure 4-11: Dissolved Calcium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

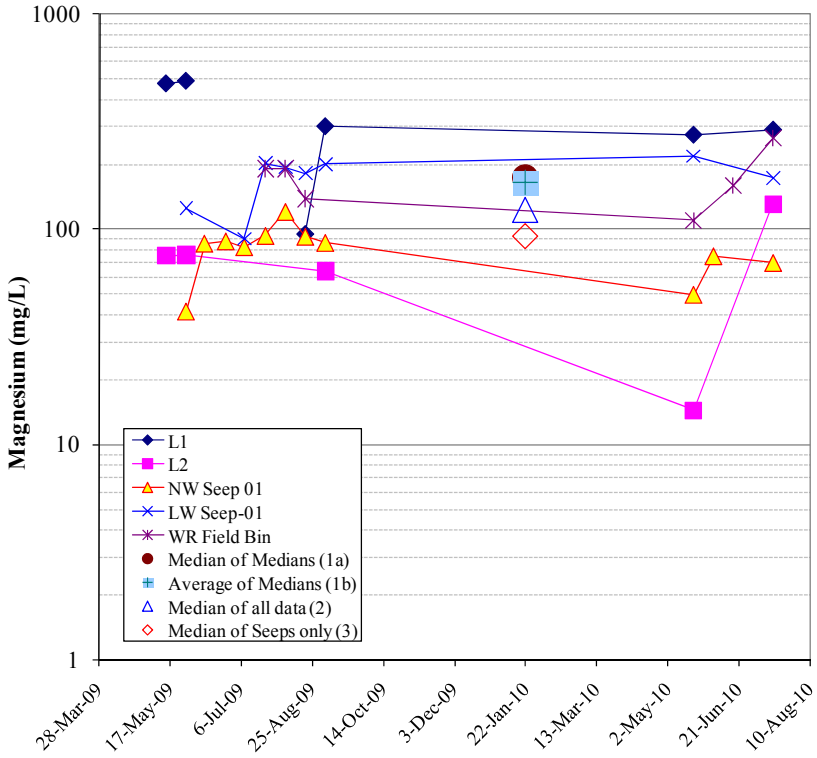


Figure 4-12: Dissolved Magnesium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

"Worst Case" Source Term Development

In order to develop a robust set of source terms, not only is it important to consider the most reasonable best estimate of drainage expected from the Mt. Nansen waste rock pile, but also it is important to conduct sensitivity testing on the receiving environment water quality model by considering potential "Worst Case" concentrations that may be expected from waste rock at Mt. Nansen. In the current evaluation, the "Worst Case" source terms from subaerial unsaturated waste rock have been developed by considering the maximum concentrations obtained from any of the five sources of drainage data obtained from Mt. Nansen waste rock over the 2009 and 2010 seasons as well as 90th percentile values for SFE test results conducted on waste rock during static testing (Table 4-13). Note that the 90th percentile values are applied to avoid incorporating outliers in the source term predictions. "Worst Case" values for all parameters except Zn were derived from the maximum drainage quality values (Table 4-13) and, for the most part, were based on drainage quality from LW Seep-01.

Table 4-13:
Values Considered for "Worst Case" Subaerial Unsaturated Waste Rock Source Term Estimates

Parameter	Unit	Max of all Waste Rock Drainage	90th percentile of SFE (*n* = 23)
Sulfate (SO_4)	mg/L	2940	1526
Ammonia (as N)	mg/L	0.12	
Nitrate (as N)	mg/L	9.96	
Nitrite (as N)	mg/L	0.36	
Dissolved Metals			
As	mg/L	0.0227	0.023
Cd	mg/L	0.184	0.041
Cu	mg/L	0.225	0.109
Fe	mg/L	0.06	0.011
Mn	mg/L	28.6	7.48
Zn	mg/L	34.2	2.99

Notes: Shaded values reflect values which were carried over to Table 4-14 and applied in the water quality prediction model.

Source Terms for Subaerial Unsaturated Waste Rock

A summary of the "Conservative Best Estimate" and "Worst Case" source terms for subaerial unsaturated waste rock storage at Mt. Nansen is provided in Table 4-14.

Table 4-14:
Mt. Nansen Subaerial Unsaturated Waste Rock Source Term Estimates

Parameter	Unit	"Conservative Best Estimate"	"Worst Case"
Sulfate (SO_4)	mg/L	1530	2940
Ammonia (as N)	mg/L	0.03	0.12
Nitrate (as N)	mg/L	2	9.96
Nitrite (as N)	mg/L	0.023	0.36
Dissolved Metals			
As	mg/L	0.0068	0.0227
Cd	mg/L	0.033	0.184
Cu	mg/L	0.039	0.225
Fe	mg/L	0.01	0.06
Mn	mg/L	4.8	28.6
Zn	mg/L	5.14	34.2
Ca*	mg/L	368	346
Mg*	mg/L	92.7	91

Notes: * Worst case values for Ca and Mg are the lowest values obtained from LWSeep-01

Other Metals (Sb, Pb, Ni, Se and Ag)

Other metals, including Ag, Ni, Sb and Se have been indicated to exceed CCME guidelines in leachate samples from Mt. Nansen waste rock and/or ore field kinetic tests. However these metals were not elevated in samples collected from natural seeps, which have been used as a benchmark against which all the source term estimations have been qualitatively evaluated. As previously discussed, the natural seeps at Mt. Nansen have not been disturbed by construction or human activity and have potentially been active for up to 10 years.

Despite the low concentrations of Ag, Ni, Sb and Se in the Mt. Nansen seeps, source terms were developed for these metals (Table 4-15). However, the "Conservative Best Estimate" source terms developed using the approach described for the other metals never exceeded the CCME guideline. Only the "Worst Case" source term for Se exceeded the CCME guideline (0.001mg/L), and only by a factor of four (0.0044 mg/L). These metals were excluded from further consideration in the water quality modelling of Mt. Nansen closure options.

Table 4-15:
Mt. Nansen Subaerial Unsaturated Waste Rock Source Term Estimates for Ag, Ni, Sb and Se

Parameter	CCME[1]	Unsaturated Waste Rock Source Terms	
		"Conservative Best Estimate"	"Worst Case"
Ag	0.0001	0.00001	0.0001
Ni	0.15	0.0086	0.04
Sb	0.02	0.0017	0.012
Se	0.001	0.0006	**0.0044**

[1]Canadian Council of Ministers of the Environment (CCME) maximum water quality guidelines for the protection of aquatic life
Bold = Exceeds CCME guideline

4.5.1.2 Options 1B, 2B, and 4: Backfilled Saturated and Unsaturated Waste Rock

Options 1B, 2B, and 4 involve the relocation and deposition of waste rock into the open pit. The option designs dictate that a portion of the waste rock will be saturated (below the water table) and a portion of the waste rock will be unsaturated (above the water table). Therefore, the chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both the unsaturated and saturated waste rock.

Numerous assumptions were made in evaluating source terms for the backfilled scenario:

- As the waste rock is excavated and relocated the organics underlying the piles will be relocated into the pit along with the waste rock. A portion of the waste rock placed in the pit will be below the water table and be saturated. Under these

conditions (saturated and presence of organics) suboxic conditions will develop in porewater;

- Metals in the extensively oxidized waste rock are primarily associated with soluble and oxide phases which will be subject to dissolution under saturated/suboxic conditions;
- Source terms for the saturated waste rock were developed using data generated from the saturated waste rock field bin, thereby assuming the bin has reached an equilibrium state equivalent to the suboxic conditions that are likely to develop within the pit;
- The waste rock stored in the pit and above the water table is assumed to exhibit drainage similar to the current subaerially exposed waste rock piles;
- Waste rock is non-acid generating.

The chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within the unsaturated and saturated waste rock. Source terms for these backfill options were derived by selecting the most conservative values from the unsaturated/subaerially exposed waste rock source terms (section 4.5.1.1) and the saturated waste rock source terms. The approach to determining the saturated waste rock source terms is described below.

A saturated field column was constructed to investigate the behaviour of saturated backfilled waste rock in the Brown-McDade Pit in order to develop estimates of source chemistry from this material (Figure 2-14, Chapter 2). This test involved mixing waste rock from the area of Lysimeter 1 and organic matter (Figure 2-2, Chapter 2) and ensuring the mixture is permanently saturated during the course of the test. The purpose of incorporating organic material into the saturated waste rock field column was to evaluate the source terms associated with the suboxic conditions that would be realized in saturated waste rock that was co-disposed with remnant underlying organic material. Additional information regarding the saturated field column kinetic test set up and test materials is provided in Chapter 2.

The following discussion presents the general approach and considerations employed in developing waste rock source terms for waste rock backfilled into the Brown-McDade pit, and thereby kept permanently saturated post-closure.

"Conservative Best Estimate" Saturated Source Term Development

Six water samples were collected from the Mt. Nansen saturated field column experiment during the 2009 and 2010 field seasons. Table 4-16 and Figure 4-13 provide the results

of these sample events for the parameters of concern that are being considered for source term development at Mt. Nansen (*e.g.*, parameters that exceed CCME guidelines). The purpose of this test is to evaluate the behavior of constituents of concern under the suboxic conditions that are expected when waste rock is permanently maintained under a water cover.

Based on the six leachate samples collected from the saturated/backfilled waste rock-organics field kinetic test, it is difficult to conclusively determine whether suboxic conditions have been established. A consistent increase in ammonia and Mn in the 2009 and 2010 leachate samples suggest that the Eh of porewater within the saturated waste rock is decreasing, causing a resultant increase in these redox sensitive species (Figure 4-13). However, concentrations of other redox sensitive species, such as arsenic, antimony and, in particular, iron, fluctuate in leachate samples collected from the bin in 2009 and 2010. As well, there is a decrease in Cd and Zn in 2009 leachate samples, which may additionally have been a reflection of evolving suboxia and subsequent removal of these elements from solution. However, concentrations of these metals in the 2010 leachate samples increase. In general, concentrations of metals and sulfate fluctuate in leachate from the saturated waste rock-organics field column test. Additional leachate sample analyses are needed to definitively say that suboxic conditions have in fact been established in the field column.

Care should be taken when interpreting these data, due to the fact that only six samples have been collected and results, at this point, are considered preliminary. Further monitoring would be needed to determine the evolution of this system and to better evaluate and constrain the redox influenced drainage values. The "Conservative Best Estimate" source terms presented in Table 4-18, therefore, represent the behavior of constituents under the current conditions in the saturated field column containing waste rock and organic material. There is significant uncertainty as to whether these data represent the long-term behavior of constituents under established suboxic conditions.

"Conservative Best Estimate" values have been determined using the higher of the median or mean concentrations listed in Table 4-16. The iron value for July 15, 2010 was not applied in the statistical summary of Table 4-16. The value is questionable based on quality assurance and quality control results from the water quality analyses.

Table 4-16:
Saturated Waste Rock + Organic Field Column Data and Summary Statistics

Parameter	Unit	Saturated Bin 3 - Waste Rock + Organic Bin						Summary Statistics (*n* = 6)			CCME[2]
		23-Jul-09	5-Aug-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Median	Mean	Max	
Sulfate (SO_4)	mg/L	1890	2040	2140	2180	2040	1920	2040	2035	2180	*100*
Ammonia (as N)	mg/L	0.354	0.978	1.29	1.4	1.2	1.54	1.25	1.13	1.54	*12*[a]
Nitrate (as N)	mg/L	<0.50	0.58	<0.5	0.13	<0.1	<0.01	0.315	0.3	0.58	13
Nitrite (as N)	mg/L	<0.10	0.34	<0.1	<0.01	<0.1	<0.01	0.1	0.11	0.34	0.06
Dissolved Metals											
As	mg/L	0.0017	0.0397	0.007	0.0197	0.0098	0.004	0.0084	0.013	0.0397	0.005
Cd	mg/L	0.0521	0.015	<0.00085	0.00917	0.0357	0.0243	0.015	0.025	0.0521	0.00006[b]
Cu	mg/L	0.0028	0.0165	<0.005	0.003	0.007	<0.005	0.005	0.0066	0.0165	0.004[c]
Fe	mg/L	<0.030	0.08	5.28	5.17	0.17	<0.06	0.17	2.15	5.28	0.3[d]
Mn	mg/L	29.4	91.3	134	152	181	161	113	98	181	*3.8*[e]
Zn	mg/L	7.89	1.96	0.576	2.04	4.92	4.64	2	2.971	7.89	0.03
Ca	mg/L	496	499	558	487	500	524	499.5	510.7	558	
Mg	mg/L	151	253	226	251	224	265	238.5	228.3	265	

Notes:

1. Shaded values exceed the maximum water quality criteria; blue parameters are additional to previous source term development

2. Canadian Council of Ministers of the Environment (CCME) maximum water quality guidelines for the protection of aquatic life. Guidelines in italics are British Columbia maximum water quality guidelines for the protection of aquatic life, presented for reference where CCME criteria are absent; a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C, b) working guideline based on a hardness >210 mg $CaCO_3$/L (10 exp (0.86[log{hardness}]-3.2)); c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L; d) guideline is for dissolved Fe; e) guideline based on a water hardness of > 300 mg $CaCO_3$/L

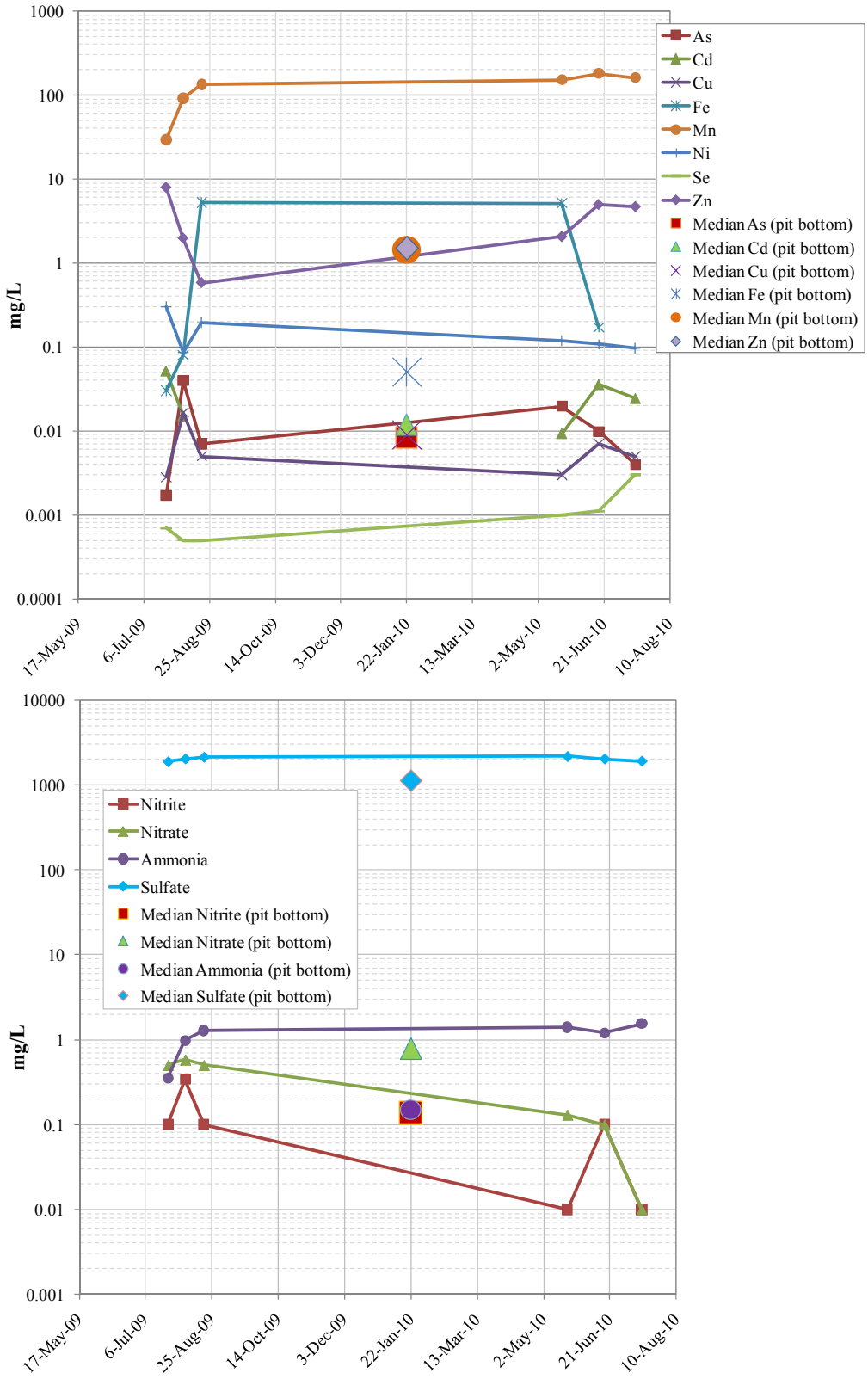


Figure 4-13: Composition of Leachate from the Saturated Waste Rock Field Column (2009 and 2010) and Median Water Quality Values from Brown-McDade Pit Bottom Waters

"Worst Case" Saturated Source Term Development

"Worst Case" source term concentrations for the saturated/backfilled waste rock scenario were developed by comparing the maximum concentrations obtained from the waste rock and organics field test leachate samples from 2009 and 2010 (Table 4-16) with the 90th percentile values for pit bottom water chemistry for 2009 and 2010 (Table 4-17). Whichever value was higher was conservatively selected as the "Worst Case" source term concentration for backfilled/saturated waste rock + organics. Note that the 90th percentile values were applied to avoid incorporating outliers in the source term predictions which may be caused by sampling artifacts (*e.g.*, disturbance of pit bottom sediments).

Median values for the water quality samples collected from the Brown-McDade pit bottom are within the range of concentrations measured in leachate samples from the saturated waste rock field column (Figure 4-13).

"Worst Case" values for all parameters except nitrate, nitrite and Cu were derived from the maximum drainage quality data obtained from the saturated waste rock field column (Bin 3). Concentrations of nitrate, nitrite and Cu measured in pit bottom water were applied in order to provide more conservative "Worst Case" estimates.

Table 4-17:
Values Considered for "Worst Case" Saturated Waste Rock Source Term Estimates

Parameter	Unit	Maximum from Bin 3 Leachate (*n* = 6)	90th Percentile Pit Bottom (*n* = 18)
Sulfate (SO_4)	mg/L	2180	1483
Ammonia (as N)	mg/L	1.54	0.314
Nitrate (as N)	mg/L	0.58	1.37
Nitrite (as N)	mg/L	0.34	0.396
Dissolved Metals			
As	mg/L	0.0397	0.0086
Cd	mg/L	0.0521	0.0277
Cu	mg/L	0.0165	0.0524
Fe	mg/L	5.28	0.065
Mn	mg/L	181	6.94
Zn	mg/L	7.89	2.58

Notes: Shaded values reflect values which were carried over to Table 4-18 and applied in the water quality prediction model

Source Terms for Saturated Waste Rock

A summary of the "Conservative Best Estimate" and "Worst Case" source terms for saturated waste rock scenario is presented in Table 4-18. Due to difficulty in determining whether the saturated field test has evolved enough to develop and reflect suboxic

conditions, "Conservative Best Estimate" and "Worst Case" values for arsenic under a saturated backfilled waste rock scenario were derived differently from the other parameters. The "Conservative Best Estimate" value for arsenic release under saturated conditions was derived from the highest value from the pit bottom water quality samples (0.12 mg/L). The sample from which the value was derived contained depressed nitrate, elevated ammonia and Mn, and slightly elevated Fe compared to other samples, suggesting the presence of suboxic conditions in Brown-McDade pit bottom waters. The "Worst Case" value for dissolved arsenic under saturated conditions was derived from taking the "Worst Case" drainage value from the saturated tailings field column and scaling it based on the median solid phase concentration of arsenic in Mt. Nansen tailings (3,027 mg/L) and the median solid phase concentration of arsenic in Mt. Nansen waste rock (239 mg/L) to derive a value for arsenic of 1.2 mg/L. This is based on the assumption that arsenic in both waste rock and tailing is primarily associated with Fe-oxides and will be released under suboxic conditions.

Table 4-18:
Mt. Nansen Saturated Waste Rock Source Term Estimates

Parameter	Unit	"Conservative Best Estimate"	"Worst Case"
Sulfate (SO_4)	mg/L	2040	2180
Ammonia as N	mg/L	1.25	1.54
Nitrate (as N)	mg/L	0.32	**1.37**
Nitrite (as N)	mg/L	0.1	**0.4**
Dissolved Metals			
As	mg/L	0.12	1.2
Cd	mg/L	0.027	0.052
Cu	mg/L	0.0066	**0.052**
Fe	mg/L	2.15	5.28
Mn	mg/L	143	181
Zn	mg/L	3.67	7.89
Ca	mg/L	497.5	487
Mg	mg/L	220	151

Notes: Bold values are 90th percentile values of pit bottom water analyses (Table 4-17), which are higher than maximum values in leachate from the saturated waste rock + organics field column

* Worst case values for Ca and Mg are the lowest values measured in leachate from the saturated waste rock + organics field column (Bin 3)

Due to the fact that equilibrium conditions have not yet been established in the saturated waste rock field column experiment at Mt. Nansen, it is important to note that for some elements, such as sulfate, ammonia, Fe, Mn, As and Sb, the concentrations reported potentially underestimate the long term concentrations, which may increase as suboxic

conditions are more fully established. On the other hand, elements such as Ag, Cd, Cu and Zn, may be overestimated in Table 4-18. Therefore, monitoring of the Mt. Nansen saturated waste rock field column should continue through closure in order to provide better constraints on the saturated/backfilled waste rock source terms.

Backfilled Waste Rock Source Terms

To incorporate conservatism into the waste rock source terms under options 1B, 2B, and 4 the saturated and unsaturated values for each parameter were compared and the highest value was selected as the backfill waste rock source term. For example, the dominant contribution of As in the pit drainage will originate from saturated waste rock, hence the saturated As term will dominate the pit drainage chemistry and the saturated As term is applied to the entire mass of waste rock in the pit. The only exception to this approach is the nitrogen species which are more likely to be dominated by geochemical processes occurring in the porewater rather than infiltration through the unsaturated material. Table 4-19 shows a comparison of the unsaturated and saturated source terms and the final backfilled waste rock source terms.

Table 4-19:
Mt. Nansen Backfilled Waste Rock Source Term Estimates

	Conservative Best Estimate			Worst Case		
Parameter	**Unsaturated Waste Rock**	**Saturated Waste Rock**	**Backfilled Waste Rock**	**Unsaturated Waste Rock**	**Saturated Waste Rock**	**Backfilled Waste Rock**
Ca	368	498	368	346	487	346
Mg	93	220	93	91	151	91
As	0.007	0.1	0.1	0.02	1	1
Cd	0.03	0.03	0.03	0.2	0.05	0.2
Cu	0.04	0.007	0.04	0.2	0.05	0.2
Fe	0.01	2	2	0.06	5	5
Mn	5	143	143	29	181	181
Zn	5	4	5	34	8	34
Sulfate	1530	2040	2040	2940	2180	2940
Ammonia	0.03	1	1	0.1	2	2
CN (Tot)	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
WAD CN	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Cyanate	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*	*n/a*
Nitrate	2	0.3	0.3	10	1	1
Nitrite	0.02	0.1	0.1	0.4	0.4	0.4

Note: The shaded cells are the values carried forward for the Backfill Source Terms

4.5.2 Subaerial, Unsaturated Ore

An unsaturated field weathering bin was constructed to investigate the behaviour of unsaturated/backfilled ore in the Brown-McDade pit and to develop an estimate of source chemistry from this material. It was therefore assumed that the unsaturated ore field bin has reached equilibrium and significant changes in drainage chemistry are unlikely.

The following discussion presents the general approach and considerations employed in developing this source term.

"Conservative Best Estimate" Source Term Development

Six water samples were collected from the Mt. Nansen unsaturated ore field kinetic test during the 2009 and 2010 field seasons. Table 4-20 provides a summary of the leachate data for the parameters of concern for which source terms were developed along with a statistical summary of the data. The "Conservative Best Estimate" source term values for the Mt. Nansen ore were determined using the higher of the median or mean concentrations listed in Table 4-20.

"Worst Case" Source Term Development

"Worst case" estimates were developed by comparing the maximum concentrations obtained from the ore field bin leachate samples for the 2009 and 2010 seasons as well as the 90th percentile values for SFE test results conducted on ore samples during static testing (Table 4-21). Whichever value was highest was conservatively selected as the "Worst Case" concentration for unsaturated/backfilled ore. The SFE test results and a statistical summary are provided in Table 4-21. The 90th percentile values were applied in data interpretation and statistical assessment to avoid incorporating unrepresentative data points in the source term predictions. "Worst Case" values for all parameters, except arsenic, were derived from the maximum drainage quality data obtained from the unsaturated ore field kinetic test. Concentrations of arsenic measured in SFE leachate were applied in order to provide a more conservative "Worst Case" estimate.

Source Terms for Unsaturated Backfilled Ore Closure Option

A summary of the source terms for the Mt. Nansen unsaturated/backfilled ore are presented in Table 4-22.

Table 4-20:
Leachate Data and Summary Statistics for Unsaturated Ore Field Kinetic Test

Parameter[1]	Unit	Bin 2. Ore Bin Unsaturated						Summary Statistics			CCME[2]
		23-Jul-09	6-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Median	Mean	Maximum	
Sulfate (SO_4)	mg/L	2680	2620	1930	1840	1780	2600	2265	2242	2680	*100*
Ammonia (as N)	mg/L	0.0147	0.093	0.0242	<0.01	<0.01	<0.01	0.012	0.027	0.093	*12*[a]
Nitrate (as N)	mg/L	<0.50	0.85	<0.25	0.14	<0.1	0.12	0.195	0.33	0.85	13
Nitrite (as N)	mg/L	<0.10	<0.10	<0.05	<0.01	<0.1	<0.01	0.075	0.062	0.100	0.06
Dissolved Metal											
As	mg/L	0.0173	0.0321	0.0227	0.0173	0.0279	0.038	0.025	0.026	0.038	0.005
Cd	mg/L	0.201	0.108	0.0702	0.0452	0.0457	0.0716	0.071	0.090	0.201	0.00006[b]
Cu	mg/L	0.0364	0.0216	0.0159	0.003	0.005	0.006	0.011	0.015	0.036	0.004[c]
Fe	mg/L	<0.030	<0.030	<0.03	<0.01	0.02	<0.05	0.030	0.028	0.05	0.3[d]
Mn	mg/L	97.4	64.9	45	28.7	21.6	36.4	40.7	49	97.4	*3.8*[e]
Zn	mg/L	31.2	8.39	8.28	4.02	4.03	6.34	7.31	10.4	31.2	0.03
Ca	mg/L	462	432	358	384	442	507	437	431	507	
Mg	mg/L	334	350	229	246	259	402	297	303	402	

Notes:

1. Shaded values exceed the maximum water quality criteria; blue parameters are additional to previous source term development
2. Canadian Council of Ministers of the Environment (CCME) maximum water quality guidelines for the protection of aquatic life. Guidelines in italics are British Columbia maximum water quality guidelines for the protection of aquatic life, presented for reference where CCME criteria are absent; a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C, b) working guideline based on a hardness >210 mg $CaCO_3$/L (10 exp (0.86[log{hardness}]-3.2)); c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L; d) guideline is for dissolved Fe; e) guideline based on a water hardness of > 300 mg $CaCO_3$/L

Table 4-21:
Values Considered for "Worst Case" Unsaturated Ore Source Term Estimates

Parameter	Unit	Maximum from Bin 2 Leachate (*n* = 6)	90th percentile SFE (*n* = 5)
Sulfate (SO_4)	mg/L	2680	1629
Ammonia (as N)	mg/L	0.093	
Nitrate (as N)	mg/L	0.85	
Nitrite (as N)	mg/L	0.1	
Dissolved Metal			
As	mg/L	0.038	0.0412
Cd	mg/L	0.201	0.0447
Cu	mg/L	0.036	0.006
Fe	mg/L	0.05	0.023
Mn	mg/L	97.4	18.5
Zn	mg/L	31.2	2.2

Shaded values reflect values which were carried over to Table 4-22 and applied in the water quality prediction model.

Table 4-22:
Mt. Nansen Unsaturated Backfilled Ore Source Term Estimates

Parameter	Unit	"Conservative Best Estimate"	"Worst Case"
Sulfate (SO_4)	mg/L	2265	2680
Ammonia (as N)	mg/L	0.03	0.093
Nitrate (as N)	mg/L	0.33	0.85
Nitrite (as N)	mg/L	0.08	0.10
Dissolved Metals			
As	mg/L	0.026	**0.041**
Cd	mg/L	0.090	0.201
Cu	mg/L	0.015	0.036
Fe	mg/L	0.03	0.05
Mn	mg/L	49	97.4
Zn	mg/L	10.4	31.2
Ca*	mg/L	431	368
Mg*	mg/L	297	92.7

Notes: Bold values are 90th percentile values obtained from shake flask extraction tests conducted on ore samples (Table 4-21), which are higher than the maximum values in leachate from the unsaturated ore field test

* Worst case values for Ca and Mg are the best case estimates obtained from unsaturated waste rock

5. Tailings Characterization

5.1 Introduction

Mt. Nansen tailings characterization test work, including static tests (particle size distribution, ABA, metals, and shake flask extraction results) on tailings (Section 5.2) and native substrate beneath the tailings (Section 5.3), tailings kinetic program (Section 5.4), tailings drainage chemistry (Section 5.5), and acidic tailings analog (Section 5.6) are presented and discussed in this chapter. The test work results were in turn used to elucidate the geochemical mechanisms controlling the release and attenuation of arsenic and other metals in groundwater flowing from the tailings impoundment to the seepage collection pond. Finally, the information was used to derive chemistry source terms for each Mt. Nansen closure option being evaluated (Section 5.7).

5.2 Tailings Static Characterization

Tailings were analyzed for particle size distribution (PSD), acid-base accounting (ABA), solid phase elemental determination (aqua regia digestion) and shake flask extractions (SFE). Results from these static characterization tests are presented and discussed in the sections below.

5.2.1 Particle Size Distribution

Table 5-1 presents the particle size distributions for the Mt. Nansen tailings humidity cell sub-samples, field bins sub-samples and individual field bin component samples, as described in Section 2.2.

The sand-silt and silt-clay humidity cells contain a range of particle sizes, with the 0.053 – 0.075 mm fraction comprising the majority of the sand-silt sub-sample and the <0.038 mm fraction comprising the majority of the silt-clay sub-sample. The clay humidity cell sub-sample is composed of <0.038 mm particles, which makes up 93% of the total sample.

Results of the individual tailings components samples demonstrate the variation in particle sizes possible in the tailings impoundment. The tailings sand sample is composed predominantly of silt-sized particles while the tailings clayey-silt sample contains a large clay fraction (~35%). The tailings material used in the unsaturated tailings impoundment sand field bin (Bin 5) is predominantly composed of sand sized particles (0.045 mm to 0.250 mm), with the 0.180 to 0.250 mm grain size comprising the largest fraction (24.3%). The tailings placed in the saturated tailings + organics field bin (Bin 4) has a more evenly distributed particle size range, however, the 0.075 mm to 0.125 mm grain size comprises the largest fraction (21.7%).

Table 5-1:
Particle Size Distribution for Tailings Field Test Sub-samples, Component Samples and Humidity Cell Sub-samples

Sieve Size	*Tailings Humidity Cells*			*Field Test (Bin 4) Component Samples*		*Tailings Field Tests*	
	T1 & T4 Clay	T2 & T5 Sand Silt	T3 & T6 Silt Clay	Tailings Clayey Silt	Tailings Sand	Tailings + Organics (Bin 4)	Tailings Sand (Bin 5)
(mm)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
>0.250	-	-	-	5.7	5.3	14.3	9.1
0.18	-	-	-	-	5.1	12.2	24.3
0.15	0.3	26.3	19.8	7	4	6.2	12.8
0.125	-	-	-	-	6.9	8.6	21.5
0.075	1	9.8	25.5	21.9	25.1	21.7	22.6
0.053	1.7	33.3	2.2	-	-	-	-
0.045	1.5	5.6	15.5	15.9	21.3	15.7	7.1
0.038	2.8	3.3	2	14.4	12.5	6.4	0.7
<0.038	92.7	21.7	35	35.5	19.9	14.9	2

Notes: Gravel: 4.75 - 75 mm, Sand: 0.075 - 4.75 mm, Silt: 0.01 - 0.075 mm
Description of Tailings Components Samples: Pile 09-01: Dry sand collected but not used in either tailings bins; Tailings Sand and Tailings Clayey Silt are components that were used in the Tailings + Organics Bin mix

5.2.2 Acid-Base Accounting

ABA results of sub-sampled tailings used in the tailings humidity cell experiments are provided in Table 5-2. These data are compared to the statistical distribution for clay, silty-clay and sandy-silt tailings samples collected during the 2009 field season (Section 2), and the clay and silt samples described in Kwong et al. (2002). The data in Table 5-2 demonstrate that the tailings humidity cell sub-samples fall within the respective ranges of the statistical summaries (Table 5-2). Sulfur species and NPR values are also within the range presented in Kwong *et al.* (2002) and in table 5-16. Therefore, the tailings sample selected for laboratory-based kinetic test work is considered to be representative of the tailings mass, with respect to ABA results. Note that values reported to be below detection were set at the value of the detection limit for statistical calculations and data presentation purposes.

ABA results of sub-sampled tailings used in the tailings field bin experiments are provided in Table 5-3.

Table 5-2:
ABA Results for Tailings Humidity Cell Sub-samples Compared to ABA Statistics for Tailings Composite Samples (2009) and Kwong et al. (2002) Samples According to Particle Sizes

		Clay (Kwong et al. and 2009 Statistics)				*Silt (Kwong et al. 2002)*				*Silty Clay (2009 Statistics)*				*Sandy Silt (2009 Statistics)*				*Lorax Humidity Cells*		
Parameter	**Unit**	**Max**	**Median**	**Min**	***n***	**Max**	**Median**	**Min**	***n***	**Max**	**Median**	**Min**	***n***	**Max**	**Median**	**Min**	***n***	**T1 &T4 Clay**	**T2 & T5 Sand Silt**	**T3 & T6 Silt Clay**
Paste pH		9.1	8.0	7.5	12	8.5	7.8	6.8	21	7.9	7.4	7	6	7.4	7.2	6.8	4	8.0	7.5	8.1
TIC	%	0.63	0.25	0.10	12	0.71	0.30	0.06	21	0.7	0.19	0.1	6	0.80	0.50	0.25	4	0.44	0.36	0.34
Total S	%	3.0	1.5	0.30	15	4.3	2.4	0.8	22	3.3	2.0	0.04	6	7.3	4.6	0.57	5	2.3	4.9	2.2
Sulfate S	%	1.6	0.88	0.09	15	0.85	0.44	0.09	22	1.5	0.23	0.01	6	0.82	0.54	0.44	5	1.2	0.72	0.74
Sulfide S	%	1.7	0.83	0.03	15	3.6	2.0	0.4	22	2.2	0.40	0.02	6	6.7	3.4	0.11	5	0.98	3.8	1.1
Insoluble S	%	0.50	0.16	0.05	9	-	-	-	-	-	-	-	-	-	-	-	-	0.08	0.29	0.42
Non-Sulfate S	%	1.9	0.53	0.12	9	-	-	-	-	2.6	0.44	0.03	6	6.9	3.9	0.12	5	1.1	4.1	1.5
CaNP	$kgCaCO_3/t$	53	21	8.6	12	60	25	5.2	21	58	16	4.2	6	67	41	21	4	37	30	28
Bulk NP	$kgCaCO_3/t$	54	26	14	12	43	21	7.4	22	58	24	13	6	58	39	21	4	42	32	34
SAP	$kgCaCO_3/t$	52	26	0.94	15	114	63	13	22	68	13	0.6	6	209	106	3.4	5	31	120	33
AP	$kgCaCO_3/t$	58	17	3.8	9	-	-	-	-	80	14	0.9	6	216	122	3.8	5	33	129	46
NPR (CaNP/AP)		2.8	0.82	0.22	12	1.1	0.44	0.14	21	4.4	1.7	0.40	6	0.50	0.30	0.10	4	1.1	0.20	0.60
NPR (Bulk NP/AP)		3.2	0.87	0.37	12	1.3	0.37	0.15	22	13.5	4.2	0.50	6	0.50	0.30	0.10	4	1.3	0.20	0.70

Notes: TIC: Total Inorganic Carbon
Sulfate S determined by 25% HCL with Gravimetric Finish
Sulfide S determined by Sobek 1:7 Nitric Acid with Gravimetric Finish
AP calculated from Non-Sulfate S * 31.25; SAP calculated from sulfide S * 31.25
CaNP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
BulkNP = NP via siderite corrected neutralization potential for field bin sub-samples, NP via Sobek method for waste rock composite samples (1989 – 2009)
n = number of samples used in statistical summary

Table 5-3:
ABA Results for Tailings Field Test Sub-samples Compared to ABA Statistics for Tailings Samples (2009), Kwong et al. (2002) Samples, and Tailings Component Samples

		Kwong et al. and 2009 Tailings Samples Statistics						*Lorax Field Tests*		*Field Test Component Samples*			
Parameter	**Unit**	**Max**	**90th percentile**	**Median**	**10th percentile**	**Min**	***n***	**Tailings + Organics (Bin 4)**	**Tailings Sand (Bin 5)**	**Pile 09-01**	**Tailings Sand**	**Tailings Clayey Silt**	**OR 09-01**
Paste pH		9.1	8.5	7.7	7.1	6.8	45	6.0	7.3	7.0	6.6	6.2	4.4
Total C	%	-	-	-	-	-	-	1.2	0.81	0.37	0.46	0.37	23
Organic C	%	-	-	-	-	-	-	0.23	0.01	0.09	0.08	0.08	23
TIC	%	0.80	0.65	0.30	0.09	0.05	45	0.40	0.22	0.28	0.38	0.29	0.25
Total S	%	7.3	4.2	2.2	0.79	0.04	54	3.3	1.6	1.4	2.7	3.1	2.0
Sulfate S	%	1.6	1.1	0.53	0.12	0.01	54	0.78	0.20	0.27	0.67	0.7	0.18
Sulfide S	%	6.7	3.3	1.3	0.13	0.02	54	2.3	1.2	0.94	1.9	1.6	0.77
Insoluble S	%	0.63	0.51	0.17	0.02	0.01	26	0.21	0.19	0.16	0.17	0.88	1.01
Non-Sulfate S	%	6.9	4.3	0.87	0.09	0.03	26	2.5	1.4	1.1	2.02	2.44	1.78
CaNP	$kgCaCO_3/t$	67	55	25	7.4	4.2	45	33	18	23	32	24	21
Bulk NP	$kgCaCO_3/t$	58	43	24	12	7.4	46	35	18	21	35	28	4.8
SAP	$kgCaCO_3/t$	209	104	41	4.0	0.63	54	72	37	29	58	49	24
AP	$kgCaCO_3/t$	216	134	27	2.8	0.94	26	79	43	34	63	76	56
NPR	(CaNP/SAP)	4.4	1.5	0.51	0.19	0.10	45	0.50	0.50	0.80	0.50	0.50	0.90
NPR	(CaNP/AP)	14	2.0	0.46	0.18	0.10	46	0.40	0.40	0.70	0.50	0.30	0.40

Notes:
TIC: Total Inorganic Carbon
Sulfate S determined by 25% HCL with Gravimetric Finish
Sulfide S determined by Sobek 1:7 Nitric Acid with Gravimetric Finish
AP calculated from Non-Sulfate S * 31.25; SAP calculated from sulfide S * 31.25
CaNP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
BulkNP = NP via siderite corrected neutralization potential for field bin sub-samples, NP via Sobek method for waste rock composite samples (1989 – 2009)
n = number of samples used in statistical summary
Description of Component Samples: Pile 09-01: Dry sand collected but not used in either tailings bins; Tailings Sand, Tailings Clayey Silt and OR 09-01 are components that were used in the Tailings + Organics Bin mix.

These data are compared to the individual composite samples from which tailings were selected, as well as to the full range of tailings sampled during the 2009 field program (Section 2) and the samples collected by Kwong et al. (2002). Summary statistics include 90th and 10th percentile values, maximum, minimum, and median values. The 90th and 10th percentile values are used in discussions rather than maximum and minimum values in order to more appropriately represent the variation in the larger data set and to avoid errors introduced by the inclusion of unrepresentative outliers. The ABA results for tailings used in the field bin generally fall within the range of ABA values of their respective composite samples (Table 5-3). Therefore, the tailings material selected for field-based kinetic test work is considered to be representative of the tailings mass with respect to ABA results.

Overall, the tailings + organics Bin sub-sample has lower paste pH and higher NP and AP (total and sulfide-sulfur) compared to the tailings impoundment sand bin (Bin 5) (Table 5-3). The lower paste pH for the tailings + organics sub-sample appears to be due to the presence of organic matter which has a paste pH of 4.4

Also presented in Table 5-3 are the results of the individual samples used to create the field bin materials, organized in order of decreasing grain size. The results suggest that paste pH decreases with particle size. The highest NP and AP values correspond to the tailings sand and tailings clayey-silt samples. The influence of organic matter on the tailings + organics (Bin 4) is not clear; however, sample OR09-01 (organic material from below the tailings impoundment) is indicated to contain notable concentrations of total and sulfide sulfur and a significantly depressed paste pH value relative to the tailings samples.

5.2.2.1 Paste pH

Paste pH values provide information on the availability of neutralizing potential by indicating whether or not a sample was actively producing net acidity prior to sampling. If carbonate is the main neutralizing mineral and there is no active sulfide oxidation, paste pH values are typically buffered between 7 and 9. All three humidity cell sub-samples (Table 5-2) and the tailings sand (Bin 5) sub-sample (Table 5-3) have paste pH values greater than 7.3, suggesting that these materials currently contain sufficient NP to maintain circum-neutral pH. The tailings + organics (Bin 4) sub-sample (Table 5-3), on the other hand, has a slightly depressed paste pH value (paste pH = 6; Table 5-3), suggesting that while this material is not actively producing net acidity, there is not an abundance of NP in this material.

5.2.2.2 Sulfur Species and Acid Potential

The Mt. Nansen tailings kinetic test sub-samples were analyzed for their total, sulfate, and sulfide sulfur concentrations (Tables 5-2 and 5-3). Total sulfur values for the tailings kinetic (both humidity cells and field experiments) sub-samples are high, with concentrations ranging from 1.6 wt. %S in the tailings sand (Bin 5) (Table 5-3), up to 4.9 wt. %S in the sand-silt humidity cell sub-sample (T2 and T5; Table 5-2). The generation of acid is predominantly associated with the oxidation of sulfide minerals; therefore, it is important that the amount and form of sulfur-bearing mineralization be determined. Sulfide sulfur makes up a large proportion of the total sulfur budget for both field bin sub-samples and the sand-silt humidity cell sub-sample (T2 and T5); whereas sulfide sulfur in the clay (T1 and T4) and silt-clay (T3 and T6) humidity cell sub-samples comprise less than 50% of the total sulfur budget for these samples. A large proportion of the remaining sulfur budget for these humidity cell sub-samples is associated with sulfate mineralization (Table 5-2). To properly assess the AP of a sample, the content of acid producing sulfates should also be determined in addition to reactive sulfides. The presence of acid producing sulfates was assessed through SFEs, which are discussed in Section 5.2.4.

Notable concentrations of insoluble sulfur (= total S – (sulfate S + sulfide S)) are also measured within tailings kinetic sub-samples (Table 5-2 and Table 5-3). This is particularly evident for the silt-clay humidity cell sub-sample, where insoluble sulfur comprises nearly 20% of the total sulfur. The possibility of organic sulfur in the Mt. Nansen samples cannot be dismissed due to the intentional addition of organic matter in the tailings + organics (Bin 4) and the fact that sulfur occurs as both organic and inorganic forms in soils. Analyses conducted on the organic matter component of the field bin experiments (OR09-01, Table 5-3) indicate higher insoluble sulfur proportions for the organic matter samples relative to the mixed-bin sub-samples. These results suggest the presence of organic sulfur; however, analytical methods used to determine sulfide-sulfur for the Mt. Nansen investigation involved the leaching of samples with a 1:7 nitric acid solution, a method that is very effective at oxidizing Fe-sulfide minerals, such as pyrite; but not as effective at completely leaching other non-iron sulfide minerals, particularly from organic matter. The ore mineralization of the Brown-McDade deposit at Mt. Nansen consists of arsenopyrite, galena, sphalerite and sulfosalts (Altura, 2009). Therefore, it is possible that the resulting sulfide-sulfur values reported in Tables 5-2 and 5-3 underestimate the amount of acid generating sulfur in the samples. Furthermore, the humidity cells and tailings sand (Bin 5) are not expected to contain significant amounts of organic matter, yet still contain notable concentrations of insoluble sulfur.

Given the lack of mineralogical data and elevated concentrations of sulfate and insoluble sulfur in Mt. Nansen tailings samples, both sulfide-sulfur and non-sulfate sulfur (Total S – sulfate S) are conservatively used to calculate the AP of the tailings materials and associated NPR.

5.2.2.3 Neutralization Potential

Both siderite corrected NP (ScNP) and carbonate NP (CaNP) values were determined for the Mt. Nansen kinetic sub-samples. Siderite corrected NP provides information on the bulk NP of a sample and is not mineral specific. Carbonate NP, on the other hand, provides information on the specific contribution of carbonate minerals to the neutralization potential of a sample. Mt. Nansen tailings kinetic sub-samples generally contain low to moderate concentrations of ScNP with values of up to 42.1 kg $CaCO_3$/t in the clay humidity cell sub-sample (T1 & T4; Table 5-2) and up to 34.5 kg $CaCO_3$/t in the tailings + organics (Bin 4) sub-sample (Table 5-3). Slightly lower concentrations of CaNP are indicated for the humidity cell sub-samples relative to ScNP values suggesting that non-carbonate minerals may have a small contribution to the overall NP of these materials. The tailings field bin sub-samples contain similar values of ScNP and CaNP indicating that a majority of the measured ScNP is a result of calcite ($CaCO_3$) dissolution. In the absence of mineralogical data, total inorganic carbon is conservatively used to estimate NP (=CaNP) in subsequent NPR calculations.

5.2.2.4 Net Potential Ratio

The NPR, which is calculated by dividing the NP of a sample by its AP (NPR = NP/AP), is often used to assess the likelihood of a sample to generate acidic drainage, whereby samples with NPR values less than 1 are *likely* to generate ARD and samples with NPR values greater than 4 do not require any further ARD testing (Price, 1997). Samples with NPR values between 1 and 3 have an uncertain potential to generate ARD. Tables 5-2 and 5-3 indicate that a majority of the sub-samples collected from the tailings field bins and humidity cells have NPR values less than 1 (AP calculated with sulfide-S and non-sulfate S) and therefore have an elevated potential to generate acid. Only the clay humidity cell sub-sample has an NPR between 1 and 2 (T1 & 4; Table 5-2).

5.2.3 Solid Phase Metals

Summary statistics for solid phase elemental abundances from tailings humidity cell and field bin sub-samples are presented in Table 5-4 and Table 5-5, respectively. These tables also include summary statistics describing elemental abundances and include the minimum, maximum, median, 90th percentile, and 10th percentile values from the historic

data set. The solid phase elemental results for the tailings humidity cell and field bin sub-samples fall within the ranges reported for their respective component samples (Tables 5-4 and 5-5). Therefore, the tailings materials selected for kinetic are considered to be representative with respect to solid phase elemental concentrations. Overall, the humidity cell sub-samples, particularly the clay sub-sample (T1 & T4), have higher concentrations of solid phase metals compared to the field bin sub-samples, and the tailings + organics bin (Bin 4) has higher solid phase metals relative to the tailings sand bin (Bin 5) (Table 5-5).

Solid-phase elemental data are used to identify metals that are enriched in the various tailings materials. The degree of enrichment of an element over crustal abundance can be used as a general indicator of the elements that could be of potential concern, and which should be scrutinized further in kinetic leaching tests. However, solid-phase elemental concentrations well above crustal abundance do not conclusively indicate that the element will be leached at a high rate from the material. Rather, the rate of leaching is related to the element's mineralogical association and the aqueous geochemistry of the infiltrating waters.

As shown in Tables 5-4 and 5-5, an indicator of significant solid-phase enrichment is assigned to values greater than or equal to three times the average crustal abundance (light grey). Also highlighted in these tables are values indicated to be 10 times greater than the average crustal abundance (medium grey) and 100 times the average crustal abundance (dark grey).

Table 5-4:
Solid Phase Metals Results for Tailings Humidity Cell Sub-samples Compared to Statistics for Tailings Samples (2009)[1]

Metal	Unit	*Clay* (2009 Statistics, n = 7)			*Silty Clay* (2009 Statistics, n = 6)			*Sandy Silt* (2009 Statistics, n = 5)			*Lorax Humidity Cells*			Average Crust Values[2]
		Max	Median	Min	Max	Median	Min	Max	Median	Min	T1 &T4 Clay	T2 & T5 Sand Silt	T3 & T6 Silt Clay	
Ag	ppm	59	26.5	24.1	41.2	28.6	0.2	50.2	42.1	30	26.2	46.1	34.1	0.075
As	ppm	7081	3140	2648	3740	2559	19	4162	3459	2103	3428	3792	3170	1.8
Bi	ppm	86	36	18.7	38	19.4	0.2	47	24.4	9.8	35.4	33.9	24.3	*0.17*
Cd	ppm	53.7	40.2	12.7	45.6	18.1	0.3	42.8	38.7	16.4	46.3	36.3	36.3	0.15
Cu	ppm	660	398	157	683	181	16.7	492	430	133	427	433	479	60
Hg	ppm	683	503	212	392	150	9	316	218	174	0.43	0.26	0.23	*80*
Mn	ppm	3884	2888	674	2735	1279	161	3966	2368	1209	3490	2421	2095	950
Pb	ppm	6965	2690	1906	3187	1334	14.6	3407	1963	1585	2455	2234	1704	*12.5*
S	%	2.9	1.5	1.1	3	1.9	0	7.5	4.4	0.57	2.1	5	2.2	0.035
Sb	ppm	338	159	98.9	243	162	1.7	401	221	178	136	230	210	*0.2*
Se	ppm	0.9	0.55	0.5	0.6	0.4	0.1	1.2	0.7	0.2	0.6	1	0.7	*0.05*
Zn	ppm	3274	2460	631	2908	1226	35	2932	2479	863	2995	2364	2361	70

Notes: 1. *n* = number of samples used in statistical summary; values equal to or greater than 3 times the average continental crustal concentration are shaded in light grey values equal to or greater than 10 times the average continental crustal concentration are shaded in medium grey; and values equal to or greater than 100 times the average continental crustal concentration are shaded in dark grey
2. Average continental crust abundances according to Price (1997). Italic values are from CRC (1985)

Table 5-5:
Solid Phase Metals Results for Tailings Field Tests Sub-samples Compared to Statistics for Tailings Samples (2009)[1]

Metal	Unit	*2009 Tailings Samples Statistics*						*Lorax Field Tests*		Average Crust Values[2]
		Max	90th percentile	Median	10th percentile	Min	*n*	Tailings + Organics (Bin 4)	Tailings Sand (Bin 5)	
Ag	ppm	59	45.9	30.5	11.2	0.2	27	35.2	23.3	0.075
As	ppm	7081	4224	3027	1288	19	27	2875	2776	1.8
Bi	ppm	85.8	47.6	25.6	6.14	0.24	27	26.4	19.0	*0.17*
Cd	ppm	53.7	43.9	35.3	6.8	0.3	27	33.3	20.6	0.15
Cu	ppm	683	562	403	87.7	16.7	27	386	268	60
Hg	ppm	0.68	0.52	0.23	0.094	0.009	27	0.22	0.13	*80*
Mn	ppm	4378	3827	2369	488	161	27	2578	1187	950
Pb	ppm	6965	3275	2091	602	14.6	27	1774	1753	*12.5*
S	%	7.5	4.9	1.7	0.4	0	27	3.22	1.5	0.035
Sb	ppm	401	270	177	47.8	1.7	27	219	118	*0.2*
Se	ppm	1.2	0.9	0.6	0.2	0.1	27	0.5	0.4	*0.05*
Zn	ppm	3274	2918	2332	405	35	27	2334	1478	70

Notes:
1. *n* = number of samples used in statistical summary; values equal to or greater than 3 times the average continental crust concentration are shaded in light grey; values equal to or greater than 10 times the average continental crust concentration are shaded in medium grey; and values equal to or greater than 100 times the average continental crustal concentration are shaded in dark grey
2. Average continental crust abundances according to Price (1997). Italic values are from CRC (1985)

The results of the aqua regia digestion followed by elemental analyses indicate that silver (Ag), arsenic (As), bismuth (Bi), cadmium (Cd), copper (Cu), lead (Pb), antimony (Sb), selenium (Se) and zinc (Zn) are present in elevated concentrations with respect to average crustal concentrations in the tailings humidity cell and field bin sub-samples. In particular, Ag, As, Bi, Cd, Pb and Sb are elevated by more than 100 times the crustal concentrations. Additionally, solid phase concentrations of mercury (Hg) and manganese (Mn) are elevated with respect to average crustal concentrations in the tailings humidity cell sub-samples indicated.

5.2.4 Water Soluble Constituents (Shake Flask Extractions)

The water soluble constituents of the tailings field bin sub-samples were determined using the shake flask extraction (SFE) method. Shake flask extractions are particularly useful for materials which may contain readily leachable elemental constituents associated with non-sulfide mineral phases and/or partially weathered primary sulfide minerals that may host secondary oxidation products. Given the weathered nature of the Mt. Nansen deposit together with the weathering and oxidation that has occurred since placement of tailings materials, the dissolution of secondary minerals in the SFE will provide insight into the water soluble drainage chemistry that would be released from the Mt. Nansen tailings. Table 5-6 presents the results for SFE for the Mt. Nansen tailings field bin sub-samples. As well, the 90th and 10th percentile values and maximum, minimum and median values of SFE results are also presented, for comparative purposes. Parameters indicated to be consistently below the analytical detection limit were not included in these tables.

The SFE results for the tailings field bin sub-samples (Table 5-6), despite being notably different from each other, generally fall within the statistical distribution of the 2009 tailings SFE samples and are therefore considered to be consistent with the larger dataset. Notable differences exist for the tailings + organics Bin sub-sample, which has lower pH and alkalinity values relative to minimum values indicated for the 2009 tailings samples; and higher sulfate and Cd values compared to maximum values indicated for the 2009 tailings samples. On the other hand, the tailings impoundment sand Bin sub-sample has considerably lower sulfate values relative to the 2009 tailings samples.

Based on aqua regia solid-phase elemental data, Ag, As, Bi, Cd, Cu, Pb, Sb, Se and Zn are enriched in the tailings field bin sub-samples relative to average crustal concentrations (shaded grey in Table 5-5), with Ag, As, Cd, Pb and Sb indicated to be present in concentrations >100 times the average crustal values. Water soluble elemental concentrations exhibit similar trends to the aqua regia extractions. Based on SFE data, dissolved Ag, As, Cd, Cu, Sb and Zn were released from the tailings field bin

sub-samples in concentrations which exceed the CCME maximum water quality guidelines for the protection of aquatic life (shaded values in Table 5-6). Additionally, dissolved Hg from Bin 5 and dissolved Mn from Bin 4 were released in concentrations which exceeded CCME guidelines; neither of which were indicated to be present in elevated concentrations based on solid-phase analysis (Table 5-5). Shake flask extraction concentrations do not provide a direct measure of drainage chemistry and are compared to CCME guidelines as a reference only. The high concentrations observed in SFE from the Mt. Nansen field bin sub-samples are likely due to the abundant oxidation products that formed in these materials pre- and post-mining.

Table 5-6:
Results of Shake Flask Extractions for Mt. Nansen Tailings Field Tests Sub-samples

Parameter[1]	Unit	*2009 Tailings Sample Statistics*					*Lorax Field Bins*		CCME Max[2]
		Max	90th percentile	Median	10th percentile	Min	Tailings + Organics (Bin 4)	Tailings Sand (Bin 5)	
pH		8.4	8.1	7.8	7.5	7.5	6.9	7.8	
Redox	mV	315	292	274	252	247	338	312	
Conductivity	µS/cm	2309	2224	1808	1226	381	2392	248	
Acidity (pH 8.3)	mg/L	13	9.9	5.2	2.5	0	8.7	3.5	
Alkalinity	Mg/L	113.7	104.1	47.4	31.6	27.7	11.9	38.2	
Sulfate		1585	1519	1051	734	150	1750	92	*100*
Major Anions	meq/L	33.7	33.2	22.9	16.3	3.9	36.7	2.68	
Major Cations	meq/L	0.6	0.4	0.1	0	0	2.49	0	
Dissolved Metals									
Hardness	mg/L	1570	1538	953	709	183	1660	105	
Ag	mg/L	0.0077	0.0023	0.00006	0.00003	0.00001	**0.00021**	**0.00036**	0.0001
Al	mg/L	0.11	0.073	0.01	0.005	0.003	0.004	0.0199	0.1
As	mg/L	12.8	6.9	1.3	0.12	0.028	**0.099**	**0.121**	0.005
Bi	mg/L	<0.00005	<0.00005	<0.00003	<0.00003	<0.00003	**<0.00005**	**0.000012**	
Ca	mg/L	592	578.4	366	278.9	58.4	553	30.6	
Cd	mg/L	0.011	0.01	0.003	0.0004	0.0002	**0.0374**	**0.0011**	0.000017a
Co	mg/L	0.023	0.019	0.0038	0.001	0.0007	0.0104	0.00173	*0.11*
Cr	mg/L	<0.002	<0.0013	<0.0005	<0.0005	<0.0005	<0.001	<0.0001	0.001b
Cu	mg/L	3.31	0.749	0.0053	0.0035	0.0029	**0.0202**	**0.0108**	0.004c
Fe	mg/L	0.123	0.104	0.04	0.022	0.014	0.023	0.025	0.3
Hg	mg/L	0.0001	<0.0001	<0.0001	<0.00005	<0.00001	<0.0001	**0.00003**	0.000026
K	mg/L	33.1	26.9	14.9	4.9	3.8	13.4	3.75	
Mg	mg/L	93.6	37.4	9.6	3	1.5	67.3	6.9	*NP*
Mn	mg/L	8.6	3.6	0.22	0.026	0.008	**23.3**	**0.11**	0.2d
Mo	mg/L	0.044	0.023	0.004	0.003	0.002	0.0042	0.00511	0.073
Na	mg/L	96.7	78.4	11.2	3.4	0.8	6.14	5.65	
Ni	mg/L	0.011	0.008	0.003	0.002	0	0.011	0.00052	0.15c
P	mg/L	0.39	0.19	0.061	0.019	0.014	<0.02	0.012	
Pb	mg/L	0.0067	0.0047	0.0007	0.0004	0.0002	**0.00429**	**0.00117**	0.007c
S	mg/L	569	552	379	244	59	582	28	
Sb	mg/L	0.84	0.79	0.35	0.11	0.064	**0.319**	**0.257**	*0.02e*
Se	mg/L	0.0021	0.0018	<0.0008	<0.0002	0.0001	**<0.0004**	**0.00011**	0.001
Si	mg/L	10.6	10.5	5.1	3.3	2.8	2.34	3.01	
Sr	mg/L	1	0.94	0.54	0.35	0.1	0.968	0.069	
Tl	mg/L	0.001	0.001	0.0004	0.0001	0.0001	0.00016	0.00011	0.0008
U	mg/L	0.004	0.003	0.00037	0.00015	0.00014	<0.00002	0.00007	*0.3*
Zn	mg/L	0.297	0.181	0.017	0.002	0.001	**1.28**	**0.038**	0.03

Notes: 1. Acidity, alkalinity and hardness values are presented as units of $CaCO_3$; bold values are metals which were elevated in aqua regia digestion (Table 5-4); shaded values exceed CCME guidelines; 2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) interim guideline; b) criteria for the more toxic Cr(VI); c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L; d) irrigation guideline, none proposed for protection of aquatic life; e) working guideline based on proposed Ontario guideline for protection of aquatic life.

5.3 Native Substrate Static Characterization

Native substrate, including the native sand and organic layers, underlying the tailings impoundment was characterized to determine the extent of the downward migration of tailings-associated metals and potential associated contamination. Solid-phase elemental results for the native materials are summarized in Table 5-7 and are compared to the tailings and the CCME Contaminated Sites guidelines, for reference. Iron, As, Pb, Zn and S are present in the native materials but at lower concentrations than observed in the tailings. Copper, Zn, As, Cd, S and Fe are all more elevated in the organic native substrate compared to other native substrates. These elements are all effectively removed from groundwater via sulfide precipitation under reducing conditions (Huerta-Diaz *et al*., 1998; Benner *et al*., 1999; Nordstrom, 2000). The prevalence of these elements in the organic layer suggests that the organic layer promotes sulfide precipitation, and hence attenuation (discussed further in Section 5.5.3).

Table 5-7:
ABA and Metals Results for Native Substrate Samples

Sample ID	Total S	Sulfate -S	Sulfide -S	As	Cd	Cu	Fe	Mn	Pb	Zn
	%	%	%	Ppm	ppm	ppm	%	ppm	ppm	ppm
CCME Contaminated Sites				**5**	**0.5**	**30**			**25**	**60**
MP09-09 (13'1"-14'2")	0.62	0.41	0.18	**1122**	**5.7**	**93.9**	4.61	>10000	**802**	**389**
MP09-11 (11-12')	0.02	0.02	<0.01	**23.6**	0.36	9.28	1.54	298	15.7	59.5
MW09-01 (30-31')	0.16	0.09	0.05	**357**	**2.01**	29.9	1.54	240	**242**	**154**
MW09-01 (31-32')	0.04	0.03	<0.01	**99.2**	0.44	12.3	1.37	137	**81.1**	48.7
MW09-05 (17'3"-17'9")	0.17	0.12	0.03	**350**	**4.34**	**166**	4.07	211	**65**	**515**
MW09-05 (17'9"-18'3")	0.04	0.04	<0.01	**262**	**0.91**	**76.2**	1.11	124	21.8	45.8
MW09-05 (18'9"-21')	0.01	0.01	<0.01	**42**	0.24	**31.5**	1.28	154	15.2	42.7
MW09-07 (7'6"-7'11")	1.36	0.72	0.57	**5005**	**4.47**	**124**	2.16	350	**463**	**265**
MW09-07 (7'11"-8'5")	0.09	0.06	0.01	**187**	0.21	7.35	0.45	64	17.4	22.5

Notes: Values in bold exceed CCME contaminated sites guidelines, grey shaded rows are dense organic deposits

Most of the mining-related metals, including Cu, Pb, Zn, As, Cd and S are elevated in samples from 0 to 6" below the contact with the tailings, indicative of a downward migration, followed by adsorption or precipitation. Arsenic, cadmium, copper and sulfur are also elevated in MW09-05 6"-1' below the contact. Based on these results it appears as though the top 6" to 1 foot of native materials are contaminated and may require special management should the tailings be relocated (*e.g*., removal, covering, and/or monitoring).

5.4 Tailings Kinetic Program

Drainage quality from the Mt. Nansen tailings was assessed by laboratory humidity cell kinetic tests and field based kinetic tests. Results from these studies and salient observations are presented and discussed below.

5.4.1 Laboratory Humidity Cell Kinetic Tests

Six humidity cells were initiated for Mt. Nansen tailings in July/August of 2009 (Table 5-8). The fundamental purpose of humidity cells is to obtain reaction rates of primary (or original) minerals in a sample (Morin and Hutt, 1997). Specifically, the Mt. Nansen tailings humidity cells will assess the variation in leachate chemistry and reaction rates according to particle size differences and will assess the potential for non-carbonate NP and the capacity of these minerals to buffer acid.

Table 5-8:
Details of the Mt. Nansen Humidity Cell Test

HC	Sample ID	Start-up Date	End Date	No. Cycles	Dry Wt. of Sample (kg)	Volume of Initial Flushings (mL)	Flushing Rate / Weekly Input* (mL)	Temp (°C)
T1	tailings clay composite sample	28-Jul-09		93	1.0	750	500	20-22
T2	tailings sand silt composite sample	28-Jul-09		93	1.0	750	500	20-22
T3	tailings silt clay composite sample	28-Jul-09		93	1.0	750	500	20-22
T4	carbonate depleted sub-sample of T1	11-Aug-09	8-Sep-10	59	1.0	750	500	20-22
T5	carbonate depleted sub-sample of T2	11-Aug-09	8-Sep-10	59	1.0	750	500	20-22
T6	carbonate depleted sub-sample of T3	11-Aug-09	8-Sep-10	59	1.0	750	500	20-22

6. **Notes:** Sampling Frequency: Weekly
7. Operation Procedure: Flood Leach
8. Sample Preparation for Flushing: Stirred
9. Column description: perforated plexiglass, inner diameter 21 cm, length 20.5 cm
10. Method Reference: MEND

As previously discussed, split samples of humidity cells T1, T2 and T3 were each subjected to a sulfuric acid leach before commencing the laboratory experiments with the intention of removing carbonate minerals, and thereby CaNP, as well as secondary sulfate products. The removal of CaNP from tailings samples promotes the development of acidic conditions within these samples and provides the opportunity to observe the leaching behaviour of these materials under decreased pH conditions. In addition, removal of CaNP provides an opportunity to assess the ability of non-carbonate minerals

to neutralize acidity generated from sulfide oxidation. For example, copper sulfate was added during processing of ore at the Mt. Nansen mine. Therefore, removal of pre-existing secondary sulfate products allows the evaluation of the primary sulfide mineral reaction rates.

It should be noted that aqueous concentrations in the weekly rinse water should not be considered as direct predictions of on-site drainage chemistry due to the high water to solid ratio used in this type of testing (Sapsford *et al.,* 2009). In reality, conditions within actual waste stockpiles are much different, where lower water to solid ratios, incomplete flushing of particle surfaces and secondary minerals frequently reach saturation.

To date 59 (T4-T6) and 93 (T1-T3) leachate samples (cycles or weeks) have been collected and analyzed from the Mt. Nansen tailings humidity cell program. Similar to field kinetic tests, during the initial cycles, sulfate and metals often have highly variable release rates before stabilizing at a relatively constant rate (Sapsford *et al*., 2009). This variability is a geochemical response to surface exposure of freshly crushed samples and accelerated leaching/oxidizing conditions induced in a humidity cell. Once exposed mineral surfaces have equilibrated to this environment, stable reaction rates can be determined.

5.4.1.1 pH and Alkalinity

Weekly pH values provide insight to the state of competition between acid generating and acid neutralizing reactions in a humidity cell sample. If the leachate pH remains near 7, NP is derived from a reactive carbonate source and acid consuming reactions predominate. However, once the reactive NP is exhausted, pH will decrease rapidly if the sample maintains a source of acid production. When NP is derived from a less reactive source, a trend of gradually decreasing pH is observed as the NP is depleted and the equilibrium pH of the next most reactive mineral phase is reached. Temporal trends for pH and alkalinity for the Mt. Nansen humidity cells are provided in Figure 5-1. The pH values for samples T1, T2 and T3 remain between 7.2 and 8.0 for the extent of the humidity cell experiments, consistent with alkalinity levels. A rapid decease in pH from greater than 7 to approximately 2 was observed in leachate from humidity cell samples T4, T5 and T6. The low pH values for T4, T5 and T6 is consistent with a lack of alkalinity, reflecting the removal of carbonate in these samples (Figure 5-1).

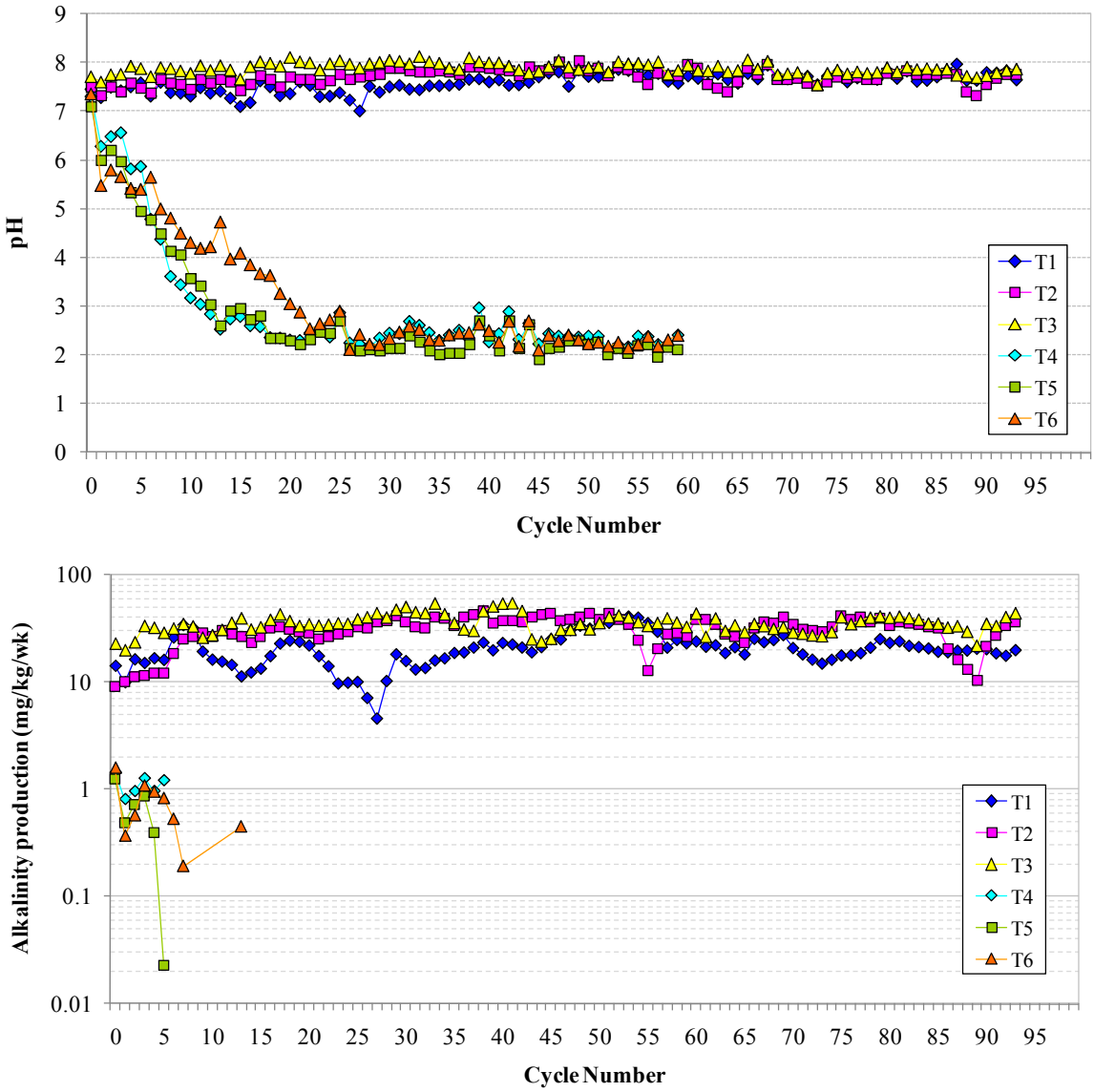


Figure 5-1: pH and Alkalinity Production in Tailings Humidity Cell Leachate

5.4.1.2 Sulfate Production and NP Depletion

The rates of sulfide oxidation and NP consumption are important parameters derived from the analysis of humidity cell leachate as they provide an indication to the timing to onset of ARD under the conditions of the laboratory kinetic tests. Humidity cell tests determine the rate of sulfide mineral oxidation by the concentration of sulfate in weekly leachate samples. Sulfide oxidation is typically the major source of acid production and metal loading in mine drainage. The rate of NP consumption resulting from leaching of the tailings can be calculated from the rate of sulfate production and release rates of major cations.

The consumption, or loss, of NP from geologic waste materials can occur via two important processes: 1) consumption through neutralization of acidity produced during sulfide oxidation; and, 2) consumption through simple carbonate dissolution from infiltration of meteoric water. When reactive sulfides are present, the dominant NP consumption reaction is that of acid neutralization.

The sulfide oxidation reaction for pyrite is typically represented as:

$$FeS_2 + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4H^+$$

Therefore, for each mole of sulfide-sulfur oxidized, two moles of acidity are produced. In the most simplistic scenario, when carbonate minerals are present, the oxidation-neutralization reaction is pH-dependent due to the pH-dependence of aqueous carbonate distribution. Assuming no calcium or sulfate is lost to secondary mineral precipitation, two carbonate consumption reactions can describe the neutralization process:

Eg. 1 (pH < 6.3)

$$FeS_2 + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O + 2\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 2H_2CO_3^0 + 2\left[Ca^{2+}, Mg^{2+}\right]$$

Eg. 2 (6.3 < pH < 10.3)

$$FeS_s + {}^{15}\!/_{4}\, O_2 + {}^{7}\!/_{2}\, H_2O + 4\left[Ca^{2+}, Mg^{2+}\right]CO_3 \longrightarrow Fe(OH)_3 + 2SO_4^{2-} + 4HCO_3^- + 4\left[Ca^{2+}, Mg^{2+}\right]$$

At pH values up to 6.3, $H_2CO_3^0$ is stable in solution, and the neutralization of acidity will produce one mole of Ca or Mg for each mole of SO_4 released, giving a 1:1 carbonate molar ratio. However, this case provides a simplification that does not consider the:

1) exsolution of carbon dioxide gas;
2) contribution of Ca and Mg from non-carbonate minerals; or,

3) dissolution of carbonates by dilute waters in the absence of significant sulfide oxidation.

Each of the neglected considerations listed above could increase the rate of Ca/Mg release relative to SO_4 production.

At circum-neutral pH (6.3 – 10.3), bicarbonate is the dominant form of aqueous carbonate and the neutralization of acidity within this pH range is less efficient, producing a 2:1 carbonate molar ratio (*e.g.,* 2).

Chemical analysis of the humidity cell leachate provides weekly leachate concentrations of Ca, Mg, Sr, and SO_4, which can be used to calculate the carbonate molar ratio (CMR):

$$CMR = \frac{[Ca^{2+}]+[Mg^{2+}]+[Sr^{2+}]}{[SO_4^{2-}]}$$

The CMR provides an indication of the actual rate of carbonate dissolution (carbonate NP consumption) and sulfide oxidation, and thus can be used in estimating the time to onset of acid generation under the appropriate laboratory conditions.

Sulfide Oxidation Rates – Sulfate Production

Humidity cell tests determine the rate of sulfide mineral oxidation by the presence of sulfate in weekly leachate samples. However, when kinetic tests are conducted on previously oxidized material such as waste rock stockpiles or tailings, it must be assumed that particle surfaces, including cracks and fissures, may contain water soluble oxidation products such as sulfates and/or hydroxyl-sulfates. These compounds dissolve as the kinetic test proceeds, and although the constituents measured in weekly leachate samples are products of ARD, they are not the products of sulfide oxidation during the kinetic test itself. Also, since most of these secondary products accumulate at the particle or grain boundaries of sulfide minerals, the secondary phases can protect, to varying degrees, the primary sulfide mineral grains from further oxidation. Therefore, kinetic tests on previously oxidized material will usually generate results that potentially show both the dissolution of oxidation products and the generation of oxidation products. As a result, the dissolution rates from oxidation products may mask generation rates from sulfide oxidation.

The weekly sulfate production and cumulative sulfate load in leachate from the Mt. Nansen tailings humidity cells are illustrated in Figure 5-2. Sulfate concentrations in leachate from humidity cells T4, T5 and T6 are initially low, reflecting the removal of soluble secondary sulfate minerals during pre-treatment of the samples. Over the first 20 weeks of the experiment, sulfate production for tests T4, T5 and T6 increase by two

orders of magnitude. The increase in sulfate production is consistent with decreasing pH and reflects the dissolution of primary sulfide minerals in the samples. Sample T5 (*i.e.,* sandy silt tailings) in particular is leaching sulfate at concentrations orders of magnitude higher than the other test cells.

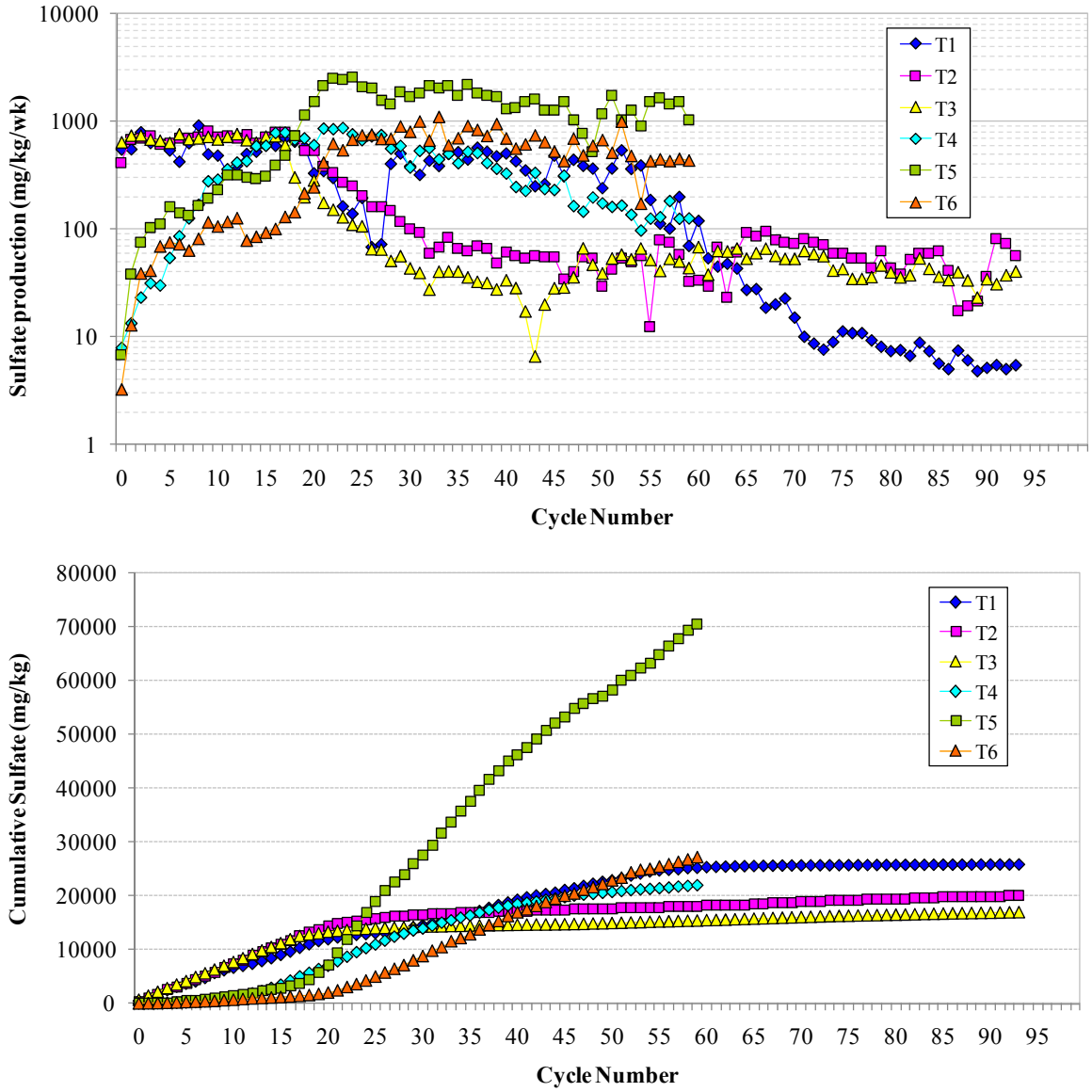


Figure 5-2: Weekly Sulfate Production and Cumulative Sulfate Loading from Tailings Humidity Cells

Concentrations of sulfate in leachate from T1, T2 and T3 are initially high (>500 mg/L), consistent with high initial sulfate-sulfur concentrations (Table 5-2) and, therefore, likely reflect the dissolution of pre-existing oxidation products (*i.e.,* gypsum and other sulfates). After cycle 16, concentrations of sulfate in leachate from T1, T2 and T3 begin to decrease. Sulfate production in leachate from T2 and T3 remains < 100 mg/kg/wk for the

rest of the test period. After cycle 28, sulfate production in leachate from T1 (clay tailings) increases again and remains between 250 and 500 mg/kg/wk until cycle 53 before gradually decreasing to concentrations of < 10 mg/kg/wk. Unlike the pretreated cells, there is no clear indication as to whether sulfate production from cells T1, T2 and T3 is predominantly reflecting sulfide oxidation rather than secondary sulfate mineral dissolution.

One way to assess whether the sulfate production from humidity cells is the result of sulfide oxidation is to assess the Fe:S ratios in leachate samples. The stoichiometric ratio of Fe:S in pyrite is 1:2; therefore, when the Fe:S ratio in leachate from humidity cell testwork is equal to 0.5 then pyrite oxidation is typically the dominant reaction contributing dissolved Fe and S to porewater (Sapsford *et al*., 2009). The Fe:S ratio of less than 0.5 is generally attributable to Fe-mineral precipitation, non-ferrous sulfide dissolution or sulfate mineral dissolution whereas an Fe:S ratio of 0.6 and greater can be interpreted as either a consequence of dissolution of Fe-bearing phases, and/or sulfate precipitation within the cells.

Figure 5-3 presents Fe:S molar ratios in leachate from the tailings humidity cell tests. Note that values indicated to be below detection were set at the analytical limit for calculation and plotting purposes. The data in Figure 5-3 indicates that the Fe:S ratios in leachate from the pre-treated cells (T4, T5 and T6) are initially low (< 0.01), suggesting that during early cycles of the experiment sulfate production was likely the result of residual sulfate dissolution in addition to sulfide oxidation. After cycle 20, the Fe:S ratio begins to approach 0.5, suggesting that sulfide (pyrite) oxidation is the dominant reaction contributing to Fe and S concentrations in solution (consistent with the removal of sulfate phases during pre-treatment).

The data in Figure 5-3 also indicates that Fe:S ratios for the untreated cells (T1, T2 and T3) are low (< 0.0001) and remain low for the extent of the experiment. Although primary sulfide (pyrite) oxidation may be taking place within these cells and although secondary Fe-mineral phases have probably contributed to the lower Fe concentrations in porewater, given the weathered nature of the tailings samples, it is likely that the dissolution of existing sulfate phases is the dominant reaction contributing to the higher sulfate concentrations in leachate from cells T1, T2 and T3. The increase in sulfate production from T1 after cycle 28 likely reflects further dissolution of existing oxidation products given the higher initial sulfate sulfur value and finer grain size of the sample (Table 5-4).

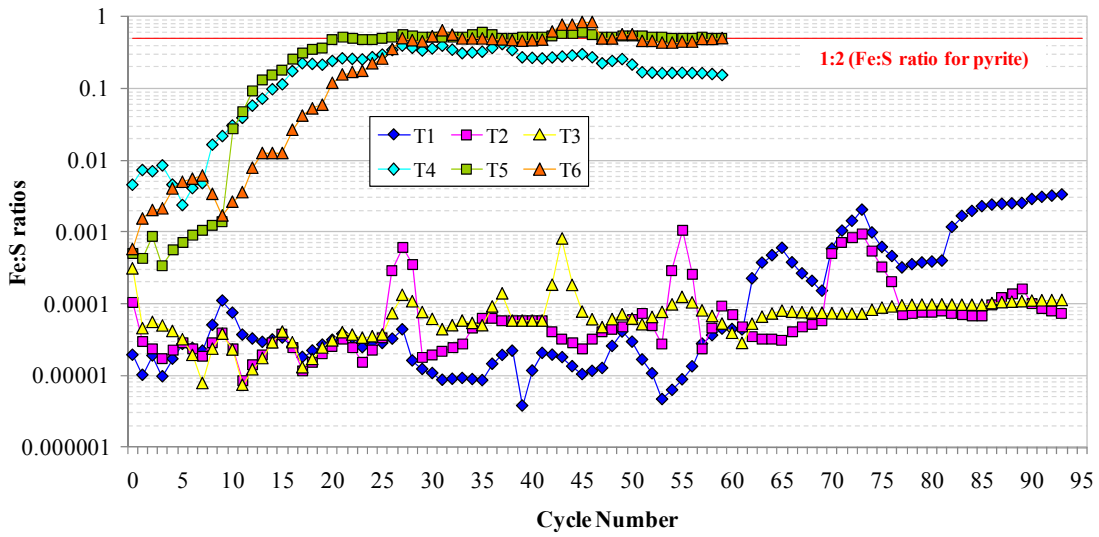


Figure 5-3: Fe:S (umol/kg) Ratios in Leachate from Tailings Humidity Cells

Table 5-9 provides the average sulfate production rates for the Mt. Nansen tailings humidity cell samples, based on leachate results from cycles when the sulphate production and CMR values have stabilized (*i.e.,* cycles 31 through 93 for cells T1, T2 and T3 and cycles 21 to 59 for cells T4, T5 and T6; Figures 5-2 and 5-4). In addition, the initial solid-phase non-sulfate sulfur (total S – sulfate S) concentrations are shown for comparative purposes. Sulfate-sulfur values are also provided in the table for comparison since cell samples T1, T2 and T3 were not pre-treated for removal of sulfate and initial sulfate values are substantial (> 0.72 wt. %S). The data in Table 5-9 indicate that the sulfate loading rates for the untreated tailings samples (T1, T2 and T3) appear to be reflective of the initial solid phase sulfate-S values whereas the more elevated sulfate loading rates for the pre-treated tailings samples (T4, T5 and T6) appear to be reflective of the initial sulfide and non-sulfate sulfur values.

Table 5-9:
Average of Final Five Sulfate Production Rates and Initial Solid-Phase Sulfide-Sulfur Content of Tailings Humidity Cell Samples

Humidity Cell	Cell Contents	Sulfate Production[1] (mg/kg/wk)	Initial Solid-Phase Non-Sulfate-S[2] (%)	Initial Solid-Phase Sulfate-S (%)
T1	clay composite	230.0	1.06	1.22
T2	sand-silt composite	55.5	4.13	0.72
T3	silt-clay composite	39.5	1.48	0.74
T4	NP depleted sub-sample of T1	391.6	1.06	1.22
T5	NP depleted sub-sample of T2	1600	4.13	0.72
T6	NP depleted sub-sample of T3	657.7	1.48	0.74

Notes: 1. Average value obtained from cycles 31-93 for cells T1, T2 and T3 and cycles 21-59 for cells T4, T5 and T6; and
2. Based on non-sulfate S value (total S – sulfate S) from Table 5-2.

The data in Table 5-9 and Figure 5-3 suggest that sulfate production from T1, T2 and T3 after more than 40 weeks of testing predominantly reflects the dissolution of pre-existing oxidation productions while the sulfate production from T4, T5 and T6 reflects the oxidation of primary sulfide phases.

Carbonate Molar Ratio

The rate of NP depletion is typically assessed using the CMR ((Ca + Mg + Sr) / sulfate production), which, as previously discussed, is the ratio of production of alkaline cations (Ca + Mg + Sr) to sulfate production. This ratio is most applicable when carbonate mineral dissolution is in direct response to neutralizing acidity produced by sulfide oxidation. However, laboratory artifacts, such as the high water-solid ratios, may complicate the situation and care must be taken when interpreting the humidity cell results.

The CMR values for each of the six tailings humidity cells for the duration of the tests are shown in Figure 5-4. The data in Figure 5-4 indicate that CMR values for cells T4, T5 and T6 decrease from 1 to approximately 0.01 during the test, consistent with pH trends (Figure 5-1) and the removal of available carbonate phases. CMR values for cells T1, T2 and T3 are also consistent with pH values, showing only a slight increase after the first 25 cycles, most notably in leachate from cell T1.

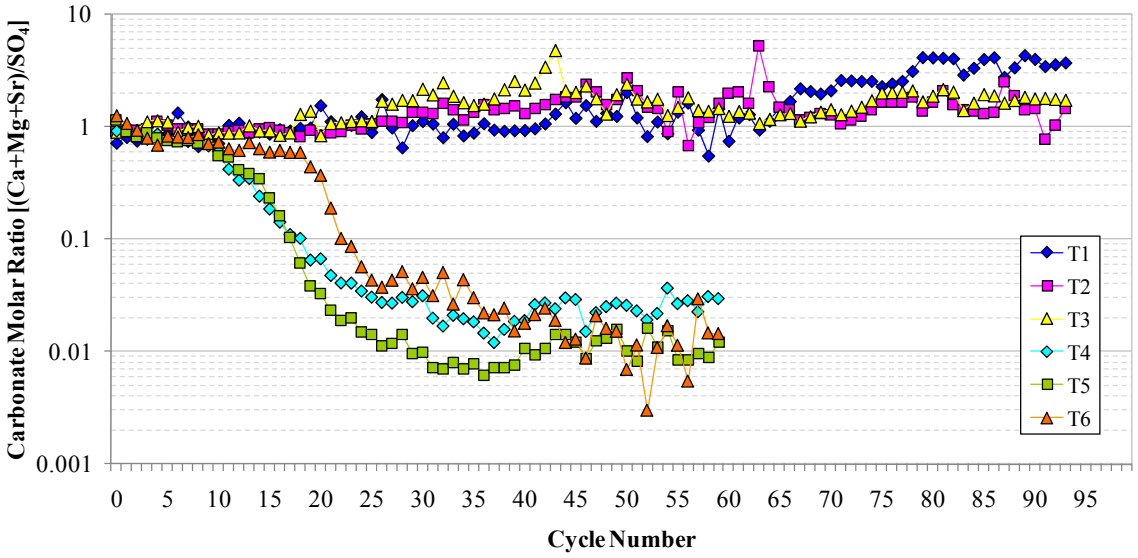


Figure 5-4: Carbonate Molar Ratios for Tailings Humidity Cell Leachate

The release rates for silicon and aluminum for the Mt. Nansen tailings humidity cells are presented in Figure 5-5. Aluminosilicate minerals have been shown to contribute to the neutralizing capacity of a sample. However, the elevated Si and Al release rates indicted for the T4, T5 and T6 tailings samples during low pH conditions suggest that the

dissolution of silicate phases is not sufficient to neutralize the generated acidity in the Mt. Nansen tailings samples following depletion of carbonate phases.

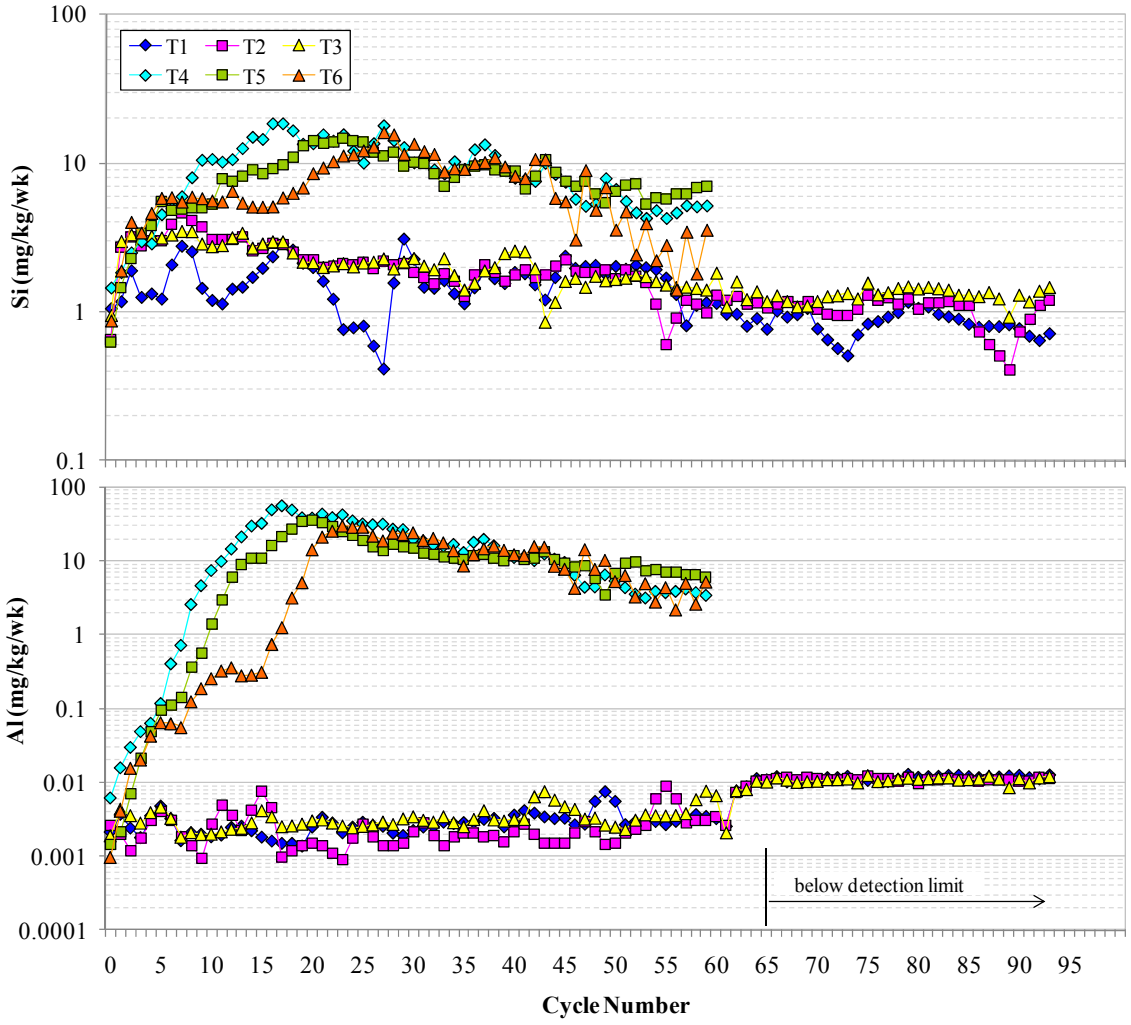


Figure 5-5: Silicon and Aluminum Production in Leachate from Tailings Humidity Cell Tests

Timing to Carbonate Depletion

One of the main goals of kinetic testing is to determine if a material will eventually generate acidic drainage. This is generally accomplished by comparing the rate at which sulfide minerals are oxidized, and thus producing acidity, and the rate at which the NP of a material is depleted. For the purposes of obtaining estimates on the timing to the onset of acidic conditions within the three Mt. Nansen tailings samples (clay, sand-silt and silt-clay) considered in this kinetic investigation, it is assumed that acidic drainage will be generated when all CaNP has been depleted from a sample; this tenet is confirmed by the leachate results of the pre-treated T4, T5 and T6 humidity cell test samples.

Table 5-10 provides the calculations used to determine the amount of time required to deplete the CaNP present in Mt. Nansen tailings humidity cell samples T1, T2 and T3. The data in Table 5-10 indicate that it will take <8 years for all the CaNP to be consumed in the Mt. Nansen tailings under the conditions of the experiments. However, it must be understood that comparisons between mineral weathering rates determined in the laboratory and those determined in the field generally reveal large discrepancies, with orders of magnitude lower rates commonly observed in the field (Evans and Banwart, 2006; Evans *et al.,* 2006). The complex oxidative dissolution kinetics of pyrite (and other sulfides) suggests that for the rates of oxidation to be the same in the laboratory and the field then the material must have experienced identical evolution in chemical, microbiological and physical environment (Sapsford *et al.,* 2009). Given the differences in flushing rates, flushing frequencies, pH, temperature, availability and rate of reactants, rate of accumulation of secondary-mineral precipitates, particle size distribution and mineral surface characteristics, it very unlikely that this evolution is the same. As a result, the laboratory based mineral weathering rates cannot be directly applied to rates expected in the field. Rather, humidity cell controlled weathering rates provide an understanding of the acid generating and neutralizing capacity as well as the metal leaching potential of the material under the specific advanced weathering conditions of the experiment.

Table 5-10:
Calculation of NP Depletion Time for Mt. Nansen Tailings Humidity Cells

Parameter	Units	T1 Clay Composite *cycles 31-93*	T2 Sand-Silt Composite *cycles 31-93*	T3 Silt-Clay Composite *cycles 31-93*
Total Sulphur[1]	%S	2.28	4.85	2.22
Sulphate Production Rate[2]	mg/kg/wk	230.0	55.5	39.5
CMR[3]	mol/mol	1.8	1.6	1.9
NP Depletion Rate[4]	kg $CaCO_3$/t/wk	0.26	0.09	0.07
NP (carbonate)[1]	kg $CaCO_3$/t	36.7	30.0	28.3
NP Depleted[5]	kg $CaCO_3$/t	24.2	8.4	6.5
NP Remaining[6]	kg $CaCO_3$/t	12.5	21.6	21.8
Time to Deplete NP	weeks	141	333	405
Time to Deplete NP	years	2.7	6.4	7.8

Notes: 1. Initial values derived from ABA analysis of solids;
2. Calculated from average of measured cycles 31 - 93 (when CMR and sulphate production rates have stabilized);
3. Calculated from average of measured cycles 31 - 93 ((when CMR and sulphate production rates have stabilized);
4. Calculated as sulphate production rate in mmol/kg * CMR (average of last 5 cycles) / 1000 to convert to kg $CaCO_3$/t;
5. Calculated as NP Depletion Rate * total number of measured test cycles; and
6. Calculated as Initial NP - NP Depleted after measured test cycles.

5.4.1.3 Dissolved Metal Release

Humidity cell leachate concentrations represent primary metal release rates with no consideration given to the influence of field conditions that govern actual metal concentrations in mine drainage. Therefore, concentrations obtained from weekly humidity cell leachate samples do not provide a strictly quantitative estimate of drainage chemistry. Rather, they provide a means to evaluate and compare the rate of sulfide oxidation and the rate of acid neutralization in a sample. As well, if a sample goes acid, humidity cell testing allows the evaluation of the leaching behaviour of elements under acidic conditions, which typically exerts a significant control on metal mobility in geologic materials.

To provide a more functional parameter which can be used to compare results between different humidity cells as well as inter-cycle comparison within a single humidity cell, metal concentrations in mine rock humidity cell leachate is normalized to the mass of sample in the cell and the volume of leachate collected each week, producing weekly mass loadings (mg solute/kg sample/wk). Note that, for the purposes of calculations, values that are reported to be below detection were set at half the value of detection.

Figure 5-6 presents the average metal release rates calculated for the same cycles used to calculate average sulphate production and NP depletion rates. Metals presented in Figure 5-6 are those which are indicated to exceed the Canadian water quality guidelines for the protection of aquatic life (CCME, 2007) in leachate from the field kinetic tests (Section 5.4.2).

Figures 5-7 through 5-16 present the weekly loads for dissolved Ag, As, Cd, Cu, Fe, Ni, Mn, Pb, Sb and Zn in Mt. Nansen tailings humidity cell leachate. Concentrations of As, Cd, Cu, Fe, Ni, Pb and Zn in leachate from T4, T5 and T6 are up to three orders of magnitude higher than their non-treated counterparts (T1, T2 and T3) and follow a similar general trend whereby concentrations increase during the first 20 – 25 cycles and then begin to slowly decrease until the end of the experiments. Concentrations of As (< 100 mg/kg/wk), Cu (< 10 mg/kg/wk), Fe (< 1000 mg/kg/wk) and Zn (< 100 mg/kg/wk) , in particular, are elevated in leachate from T4, T5 and T6. Note that unlike most metals in the leachate, As does not show an initial high influx (< 0.1 mg/L) and instead shows a slight decrease for the first approximately 10 cycles before increasing. Concentrations of As, Cd, Cu, Fe, Mn, Ni, Pb and Zn in leachate from T1, T2 and T3 are low (generally < 0.1 mg/L) and remain relatively constant or decrease over the extent of the experiment.

The increasing metal loads in T4, T5 and T6 is consistent with decreasing pH concentrations in leachate for these cells (Figure 5-1). The greatest metal loads are

observed in leachate from humidity cell T5 (weak acid leached sandy-silt tailings), which is consistent with higher solid phase total and non-sulfate-sulfur concentrations (4.85 mg/L and 4.13 mg/L, respectively, Table 5-2) and sulfate production rates (Figure 5-2) observed for this sample.

Concentrations of Sb in leachate from the tailings humidity cells show a different trend, with the highest concentrations indicated for the untreated tailings samples, particularly, T2 and T3. Concentrations from cells T2 and T3 increase during the first few cycles and then slowly decrease over the extent of the experiments. Dissolved Sb in leachate from the other tailings cells remain relatively low (< 0.1 mg/L), particularly for cell T4 (consistent with lower leached concentrations from its untreated counterpart, T1).

Of note is that concentrations of sulfate, Sb and Mn in leachate from T1 (*i.e.,* clay tailings) behave more like that of the carbonate and sulfate depleted cells (T4, T5 and T6). This may be due to the higher proportion of sulfate (Table 5-2) indicated for this sample relative to the other cell samples, enhanced by the finer particle size of cell sample T1.

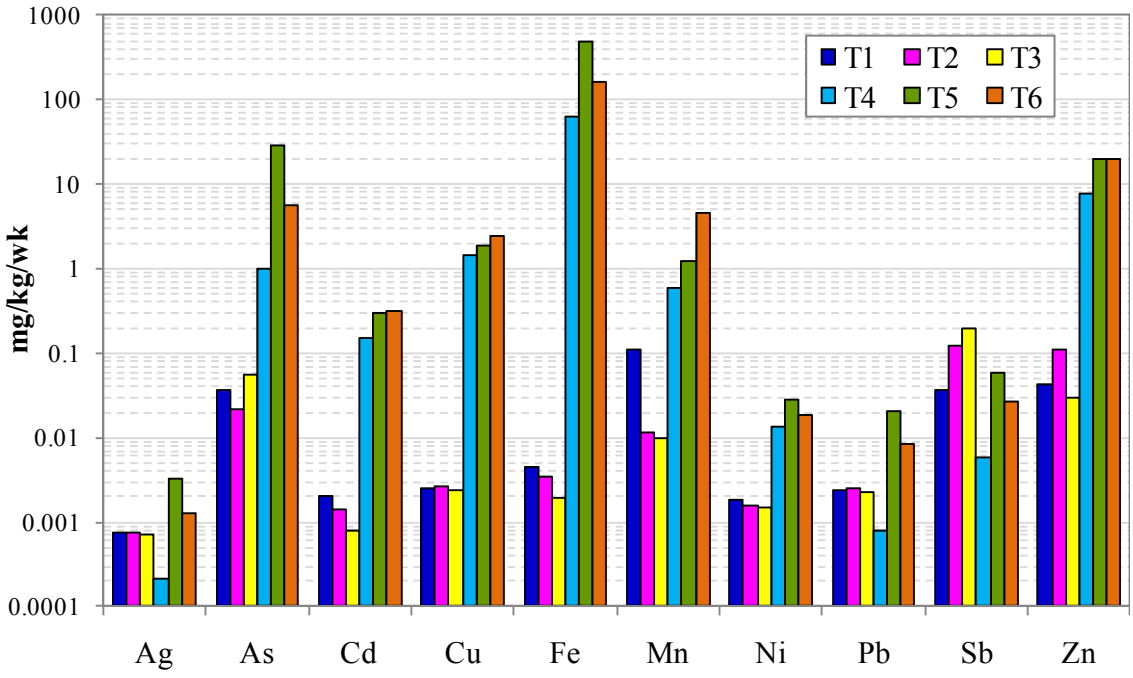


Figure 5-6: Average Metal (Ag, As, Cd, Cu, Fe, Mn, Pb, Ni, Sb and Zn) Release Rates from Final Five Weeks of Tailings Humidity Cell Testing

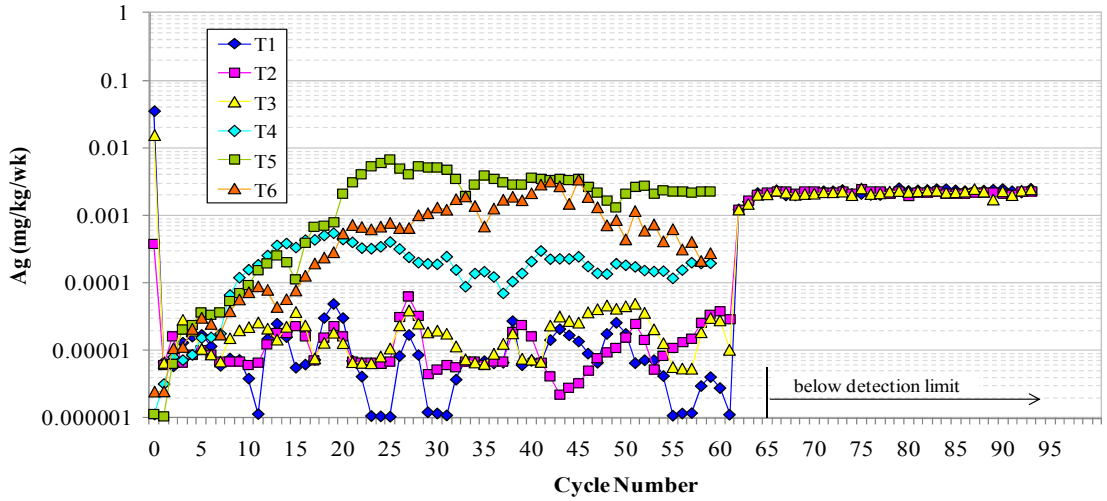


Figure 5-7: Weekly Silver Loads in Tailings Humidity Cell Leachate

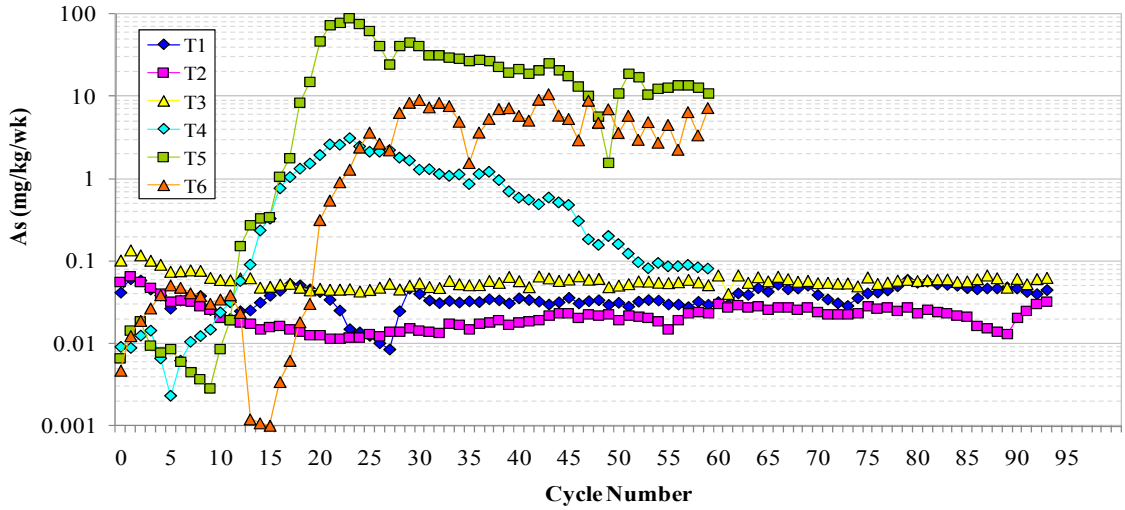


Figure 5-8: Weekly Arsenic Loads in Tailings Humidity Cell Leachate

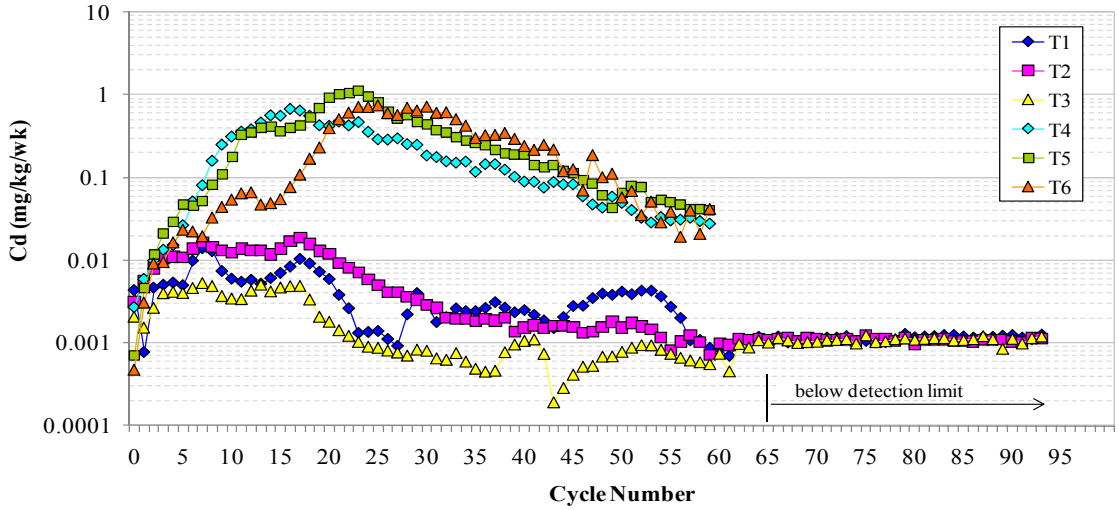


Figure 5-9: Weekly Cadmium Loads in Tailings Humidity Cell Leachate

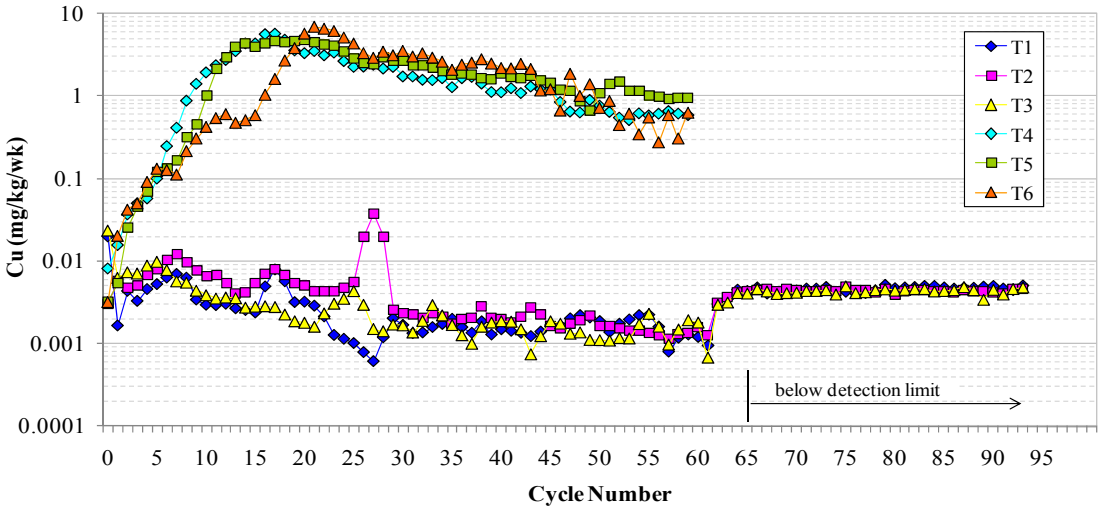


Figure 5-10: Weekly Copper Loads in Tailings Humidity Cell Leachate

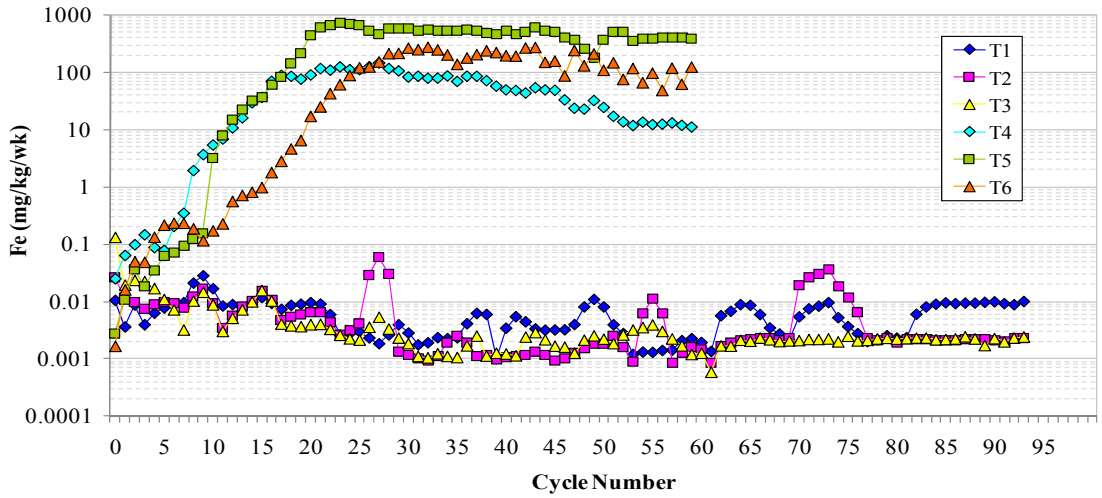


Figure 5-11: Weekly Iron Loads in Tailings Humidity Cell Leachate

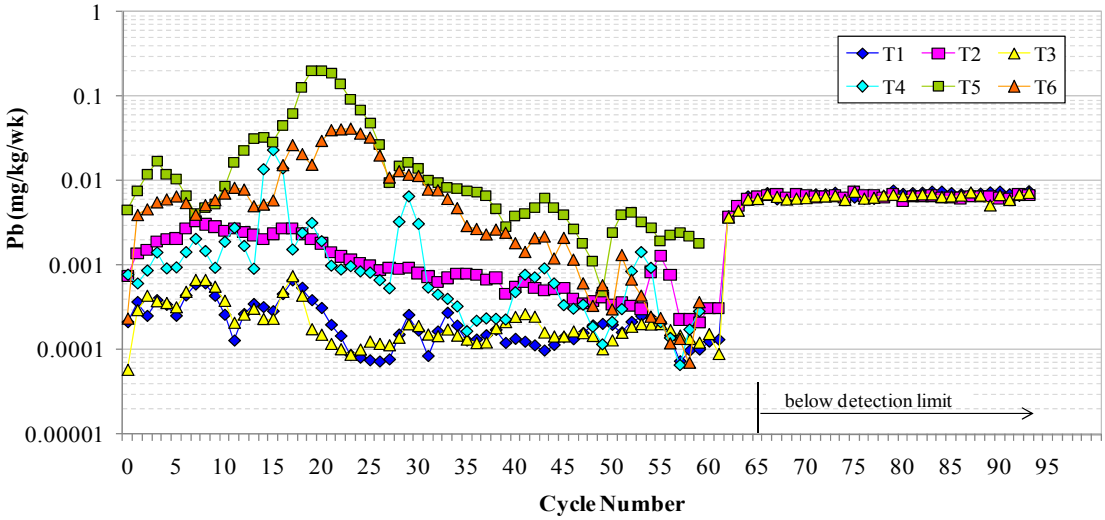


Figure 5-12: Weekly Lead Loads in Tailings Humidity Cell Leachate

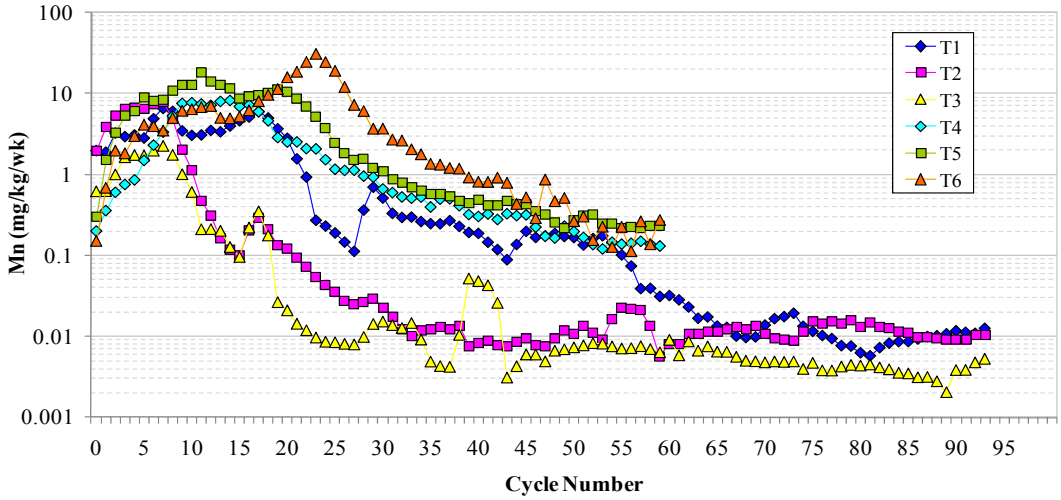


Figure 5-13: Weekly Manganese Loads in Tailings Humidity Cell Leachate

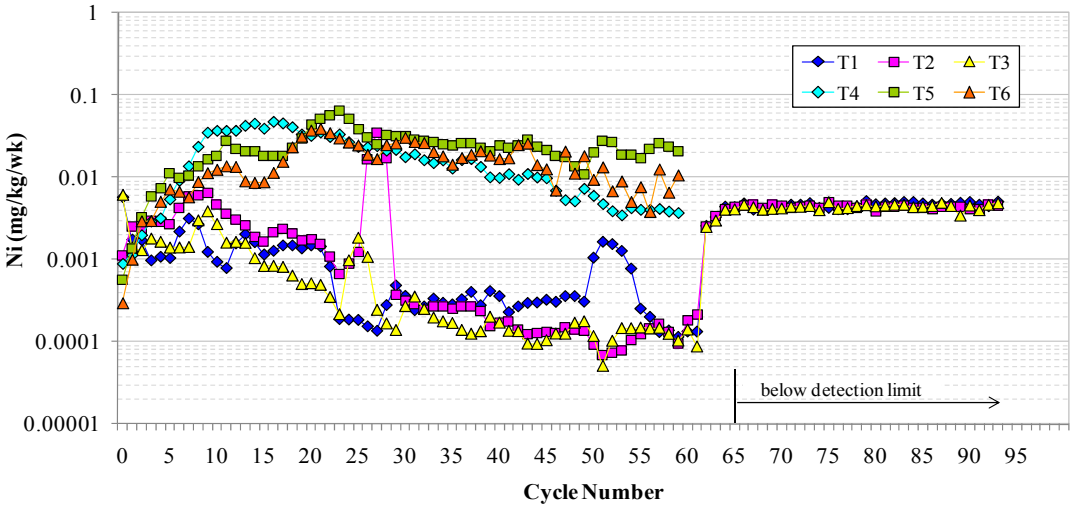


Figure 5-14: Weekly Nickel Loads in Tailings Humidity Cell Leachate

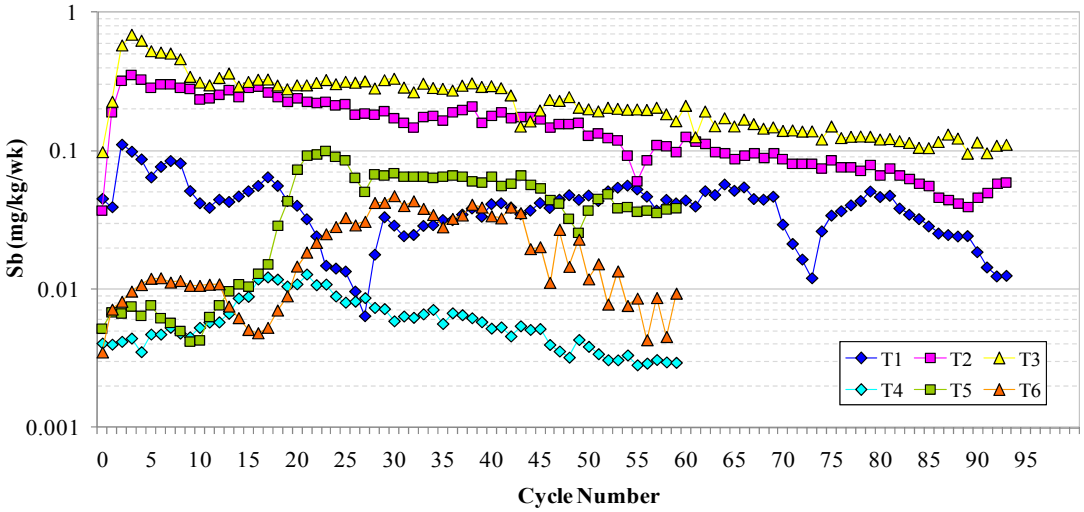


Figure 5-15: Weekly Antimony Loads in Tailings Humidity Cell Leachate

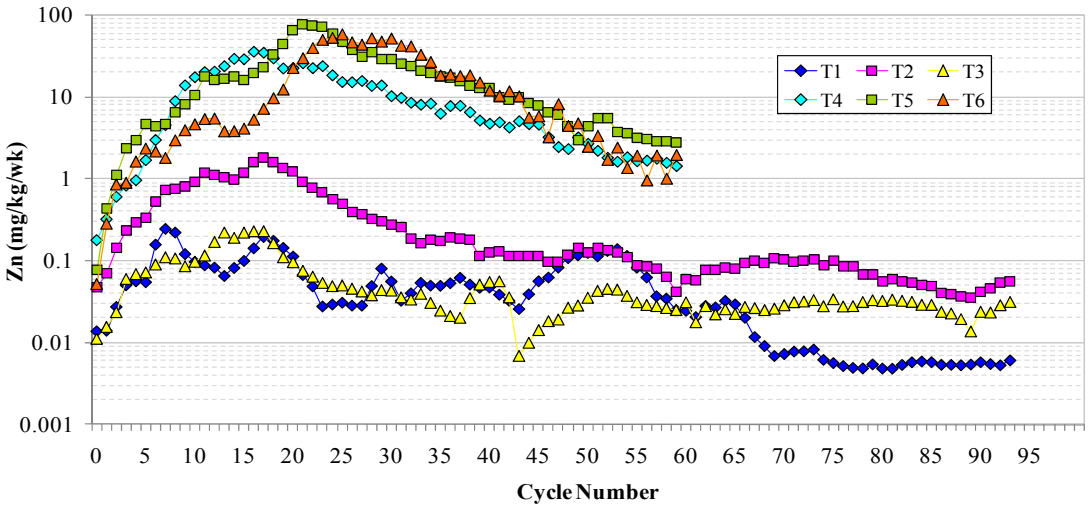


Figure 5-16: Weekly Zinc Loads in Tailings Humidity Cell Leachate

5.4.2 Field Bin Leachate

Two field kinetic tests were developed for the Mt. Nansen tailings. Table 5-11 presents the leachate results from the 2009 and 2010 tailings field bin sampling program. Also presented in Table 5-11 are the CCME maximum water quality guidelines for the protection of freshwater aquatic life. Parameters which are consistently below the analytical detection limit are not presented in this table. Complete results are available in Appendix B2 The results in Table 5-11 indicate neutral pH values in leachate from the tailings sand (Bin 5) and near neutral pH values in leachate from the tailings + organics (Bin 4). Alkalinity values for the tailings field bin leachate are low (< 135 mg $CaCO_3$/L), particularly for Bin 4 (< 29 mg $CaCO_3$/L).

Sulfate concentrations in leachate samples from the tailings field kinetic tests are high (1220 – 2570 mg/L), particularly in leachate from the tailings + organics (Table 5-11 and Figure 5-17). All leachate samples comprise sulfate concentrations well above leachate results from SFE tests on sub-samples from the kinetic test material. The highest sulfate concentrations were measured in the initial leachate samples, congruent with the initial flushing of pre-existing oxidation products typically observed from oxidized materials and with sulfate production rates in leachate from tailings humidity cell tests T1, T2 and T3 (Section 5.3.1.2).

Comparisons between mineral weathering rates determined in the laboratory and field reveal large discrepancies, with order(s)-of-magnitude lower rates commonly observed in the field (Malmstrom *et al.,* 2000). There are also cases where mineral weathering rates in the field are higher than those recorded under laboratory conditions. Field studies of weathering rates (*e.g.* White *et al.,* 1996) have found that laboratory weathering rates are up to five orders of magnitude faster than those observed in the field (Schnoor, 1990;

White *et al.,* 1996; White and Brantley, 2003). Laboratory derived mineral dissolution rates are often 2–4 orders of magnitude faster than those measured for minerals in the field (*e.g.*, Schnoor, 1990; White *et al.,* 1996).

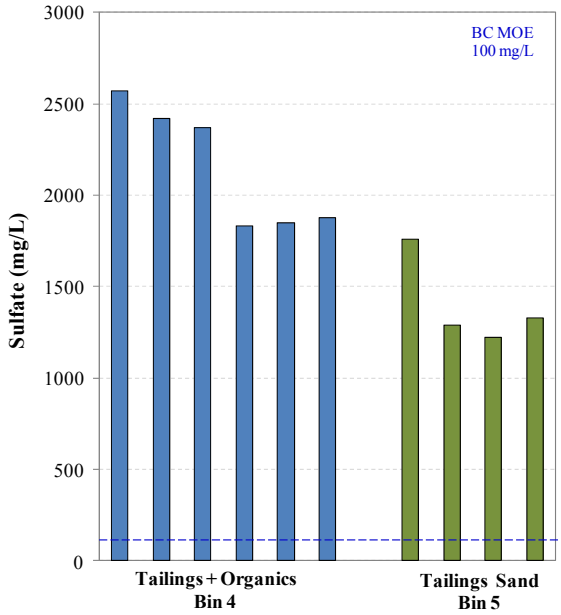


Figure 5-17: Concentrations of Sulfate in Leachate from the Tailings Field Bins

Dissolved Ag, Cd, Cu, Mn, Pb, Sb and Zn are leaching from both tailings field kinetic tests in concentrations higher than maximum CCME water quality guidelines (Table 5-11). Additionally, As, Fe and Ni are elevated in leachate samples from the tailings + organics field test. Elevated concentrations of dissolved metals in leachate from the tailings field kinetic tests are consistent with elevated concentrations measured in leachate from the tailings humidity cell tests (Section 5.3.1.3).

Consistent with sulfate levels, dissolved concentrations of Ag, Cd, Cu, Ni, Mn, Zn, As and Sb in leachate from both tailings field tests are initially higher and decrease in the subsequent samples (Figure 5-18 and 5-19). Unlike other dissolved metals in the Mt. Nansen tailings, concentrations of dissolved As in the initial few samples are low, with increases only observed in the May 2010 and June 2010 leachate samples from the saturated Tailings + Organics field test (Table 5-11; Figure 5-19). Note that As concentrations produced by the tailings humidity cell tests did not show an initial high influx (< 0.1 mg/L), but rather decreased slightly for the first approximately 10 cycles before increasing.

Given the mobility of As under natural environmental conditions, the proportion of oxidized (As^{V}) and reduced (As^{III}) species were determined. Arsenic speciation analyses

indicate that both the As^{V} and the more mobile and toxic As^{III} are present in leachate from the tailings field bins. Although As^{V} is indicated to be nearly an order of magnitude higher than As^{III} in leachate from the Tailings + Organics, inorganic species assessed in this investigation account for only 2.5% of the total arsenic budget. The other 97.5% is attributed to methylated and organic arsenic species (*i.e.,* monomethylarsonic acid (MMAA) and dimethylarsinic acid (DMAA)), which were not assessed in this study.

Concentrations of dissolved metals in leachate from the Tailings + Organics saturated field column are higher, by up to an order of magnitude, compared to concentrations in leachate from the tailings sand unsaturated field test (Table 5-11, Figures 5-18 and 5-19). In general, dissolved concentrations of metals in leachate from the tailings sand field test are relatively low and continue to decrease. Only dissolved Ag and Cu show an increase in the most recent leachate sample from the tailings sand field test. Dissolved concentrations of Cu and Zn in leachate from the tailings + organics field test increase to levels higher than the initial flush. Note that concentrations of dissolved Mn are consistently high (~100 mg/L) in 2009 and 2010 leachate samples from the tailings + organics Bin which is indicative of mild suboxia.

Concentrations of dissolved Sb are higher in leachate from the coarser unsaturated tailings sand field test compared to concentrations in leachate from the saturated tailings + organics field column. The same observation was made for the humidity cell experiments, which indicated higher concentrations of Sb in leachate from cells containing silty clay (T3 and T6) and sandy silt (T2 and T5) compared to cells containing clay (T1 and T4). However, higher concentrations of Sb in leachate from the sandy tailings sample is not consistent with solid phase analysis of the field test sub-samples, which indicate higher concentrations of Sb in the organic-rich field test sub-sample.

Overall, elevated parameters in field bin leachate samples are consistent with elevated concentrations identified in solid phase elemental determination (aqua regia) and SFE data for field tests and humidity cell sub-samples as well as leachate results from humidity cell tests.

Table 5-11:
Leachate Results for Mt. Nansen Tailings Field Kinetic Tests

Parameter	Unit	Detection Limit	Bin 4. Tailings + ORG Bin (Saturated)						Bin 5. Tailings Sand (Unsaturated)				CCME[1]
			23-Jul-09	5-Aug-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Max
Physical													
Field Temperature	°C		18.61	18.42		5.47	9.05	10.4		6.3	15.52	9.39	
Field pH			6.1	6.4		6.7	5.9	6.3		6.8	7.1	6.3	
Field conductivity	µS/cm		1869	3783		3025	3047	3006		2237	2448	2455	
pH (25°C)				6.8	6.8	6.7	6.7	6.7	7.0	7.0	7.0	7.8	
Conductivity (25°C)	µS/cm	1		3410		2940	3070	4670		2170	2310	3670	
Total Suspended Solids	mg/L	1				11	8	<2		3	<5	<2	
Total Dissolved Solids	mg/L	5		3550	3440	3300	3210	3150	2470	2300	2170	2440	
Anions and Nutrients													
T-Alkalinity	mg/L	5		129	135	86	67	65	17.9	10	12	29	
Bicarbonate	mg/L	5				100	80	80		10	20	40	
Carbonate	mg/L	6				<6	<6	<6		<6	<6	<6	
Hydroxide	mg/L	5				<5	<5	<5		<5	<5	<5	
Chloride	mg/L	0.02	<50	<50	<50	0.4	<0.2	0.25	<25	0.81	2.3	0.47	
Fluoride	mg/L	0.02	0.111	0.093	0.082				0.124				
Sulfate	mg/L	0.05	2570	2420	2370	1830	1850	1880	1760	1290	1220	1330	*100*
Ammonia-N	mg/L		1.92	1.92	2.12	1.2	<0.01	0.01	0.0328	<0.01	<0.01	<0.01	0.019a
Nitrate-N	mg/L	0.01	<0.50	0.74	<0.5	0.22	1.92	0.42	<0.25	0.41	<0.1	0.19	13
Nitrite-N	mg/L	0.01	<0.10	0.58	<0.1	<0.01	<0.1	<0.01	<0.05	<0.01	<0.1	<0.01	0.06
Orthophosphate-P	mg/L	0.002				0.002	0.007	0.005		0.005	0.007	<0.002	
Cyanides													
Cyanide Total	mg/L	0.001	0.045	0.029	0.041	0.008	0.001	<0.001	<0.001	0.004	0.003	0.003	0.005b
Cyanide (WAD)	mg/L	0.002	0.012	<0.005	<0.005	0.002	0.002	<0.002	0.008	0.006	0.004	<0.002	
Cyanate (CNO)	mg/L	0.2	<0.50	<0.50		<0.2	<0.2	<0.2		<0.2	<0.2	<0.2	
Thiocyanate	mg/L	0.1	1.33			<0.1	<0.1	<0.1		<0.1	<0.1	<0.1	
Total Organic Carbon	mg/L	0.5	39.3	30.2	24.2	21	16.4	12.5	3.05	3.2	4.2	4.8	
Hardness	mg/L	5	2380	2320	2320	1710	1970	1930	1810	1380	1570	1710	

Table 5-11:
Leachate Results for Mt. Nansen Tailings Field Kinetic Tests (continued)

Parameter[1]	Unit	Detection Limit	Bin 4. Tailings + ORG Bin (saturated)						Bin 5. Tailings Sand Pond (unsaturated)				CCME[2]
			23-Jul-09	5-Aug-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	Max
Dissolved Metal													
Ag	mg/L	0.00001	0.00134	0.00049	<0.0002	0.00004	0.00001	<0.00005	<0.0001	<0.00001	<0.00001	<0.00005	0.0001
Al	mg/L	0.005	<0.020	<0.020	<0.02	0.007	<0.005	<0.02	<0.01	<0.005	<0.005	<0.02	0.1
As	mg/L	0.0002	0.0056	0.011	0.008	0.0338	0.0494	0.0081	0.0035	0.001	0.0016	0.001	0.005
As^{III}	mg/L	0.00005				0.00111	0.00023	0.0010		0.00009	0.00030	0.00065	
As^{V}	mg/L	0.00005				0.00103	0.00099	0.0051		0.00044	0.00029	0.00062	
B	mg/L	0.004	<0.20	<0.20	<0.2	0.052	0.038	0.071	<0.1	0.018	0.014	0.03	
Ba	mg/L	0.001	0.0741	0.0714	0.0588	0.032	0.031	0.03	0.15	0.024	0.047	0.04	
Ca	mg/L	0.1	473	492	516	480	515	534	535	465	514	563	
Cd	mg/L	0.00001	0.0312	0.0138	0.0157	0.0234	0.0304	0.035	0.0146	0.00453	0.0044	0.0032	0.000017c
Co	mg/L	0.00002	0.11	0.0911	0.0871	0.0687	0.0626	0.0482	0.0363	0.0126	0.0158	0.013	
Cr	mg/L	0.0004	<0.010	<0.010	<0.01	0.0007	0.0009	<0.002	<0.005	<0.0004	<0.0004	<0.002	0.001d
Cu	mg/L	0.001	0.0466	0.0305	0.0153	0.005	0.008	0.008	0.008	0.002	0.002	<0.005	0.004e
Fe	mg/L	0.01	0.036	0.227	0.564	0.8	0.5	<0.05	<0.03	<0.01	<0.01	<0.05	0.3
K	mg/L	0.1	45.9	48	42.4	28.6	34	33	9.4	6.3	7	6	
Li	mg/L	0.001	<0.10	<0.10	<0.1	0.019	0.016	0.02	<0.05	0.005	0.004	0.005	
Mg	mg/L	0.1	292	266	250	125	166	144	116	54	71	75	
Mn	mg/L	0.0002	81	94	99.8	100	93.4	102	9.46	1.5	0.784	0.708	0.2f
Mo	mg/L	0.0001	<0.0010	0.0016	0.0016	0.0008	0.0008	0.0006	0.00065	0.0003	0.0005	0.0006	0.073
Na	mg/L	0.1	37.7	24.9	19.2	7.2	6	2	6.4	3.2	2	<1	
Ni	mg/L	0.001	0.167	0.106	0.093	0.065	0.058	0.05	0.0826	0.037	0.036	0.03	0.15e
Pb	mg/L	0.0001	<0.0010	<0.0010	<0.001	0.0002	0.0005	0.001	<0.0005	0.0003	0.0003	<0.0005	0.007e
S	mg/L	0.2				620	628	612		440	485	500	
Sb	mg/L	0.0002	0.024	0.0133	0.0126	0.0148	0.0398	0.047	0.0559	0.0311	0.0416	0.0554	*0.02g*
Se	mg/L	0.0006	0.00051	<0.00050	<0.0005	0.0008	<0.0006	<0.003	<0.0005	0.0008	<0.0006	<0.003	0.001
Si	mg/L	0.05	5.66	6.39	6.31	4.07	5.4	5.3	5.28	3.12	3.9	4.4	
Sr	mg/L	0.001	2.17	2.02	1.91	1.72	1.94	1.74	1.32	0.937	1.04	0.983	
Tl	mg/L	0.00001	<0.0020	<0.0020	<0.002	0.00019	0.00015	0.00016	<0.001	0.00006	0.00008	0.00008	
U	mg/L	0.0004	0.00033	0.00102	0.00198	0.001	0.0006	<0.002	<0.0001	<0.0004	<0.0004	<0.002	
V	mg/L	0.0001	<0.020	<0.020	<0.02	0.0003	0.0004	<0.0005	<0.01	0.0001	0.0002	<0.0005	
Zn	mg/L	0.001	2.62	1.49	1.7	2.31	3.01	3.17	1	0.327	0.228	0.13	0.03

Notes: 1. Alkalinity and hardness are expressed as units of $CaCO_3$; shaded values exceed CCME guidelines; 2. Canadian Council of Ministers of the Environment maximum guidelines for the protection of freshwater aquatic life (updated December 2007) for total metals; italic values are British Columbia maximum guidelines for protection of freshwater aquatic life (BC MOE, 2006) for total metals; a) criteria conservatively based on the unionized NH_3; b) criteria is for free cyanide; c) interim guideline; d) criteria is for the more toxic Cr(VI); e) guidelines are based on a hardness of > 180 mg $CaCO_3$/L; f) irrigation guideline, none proposed for protection of aquatic life; g) working guideline based on proposed Ontario guideline for protection of aquatic life.

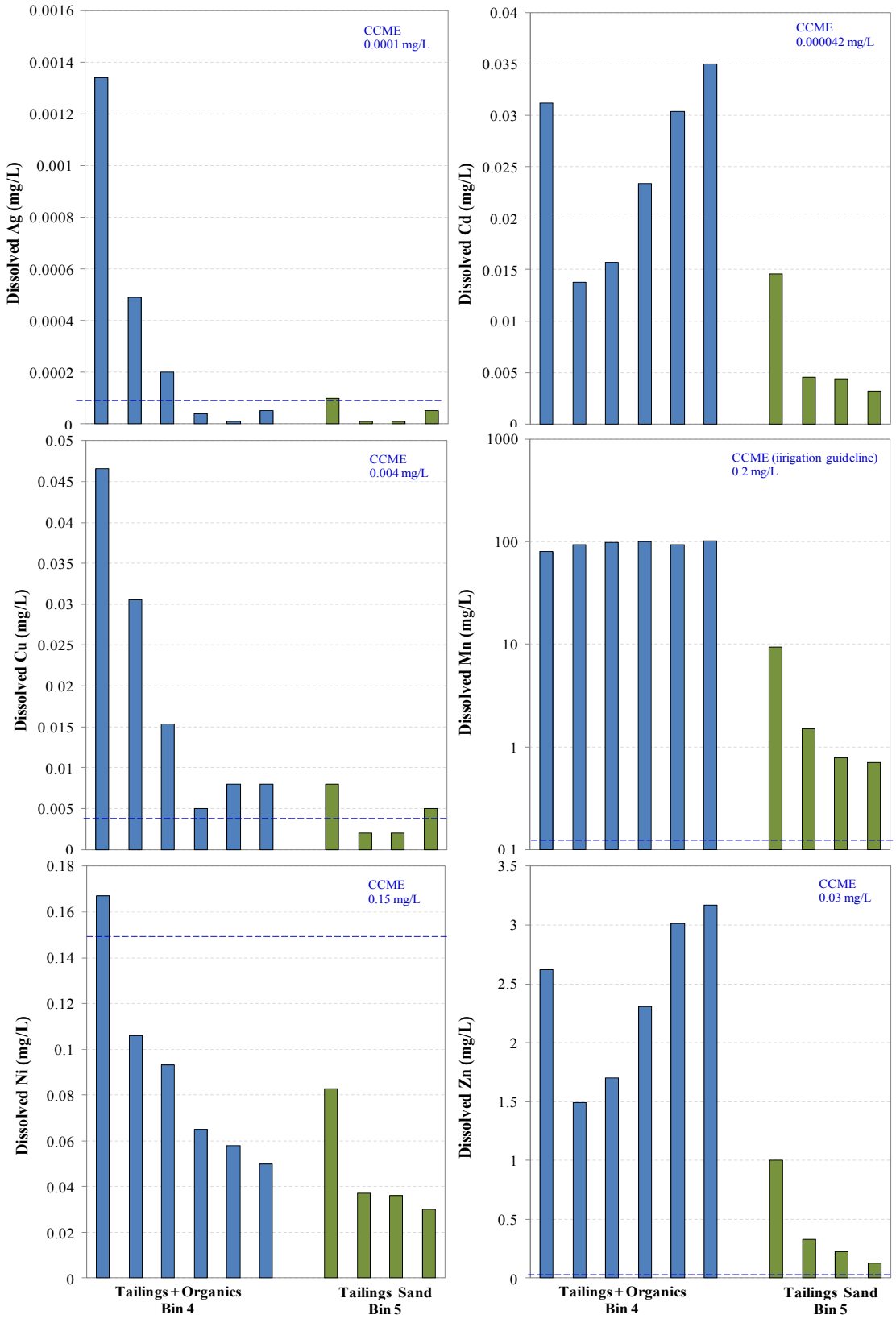


Figure 5-18: Dissolved Ag, Cd, Cu, Mn, Ni and Zn in Leachate from Tailings Field Kinetic Tests

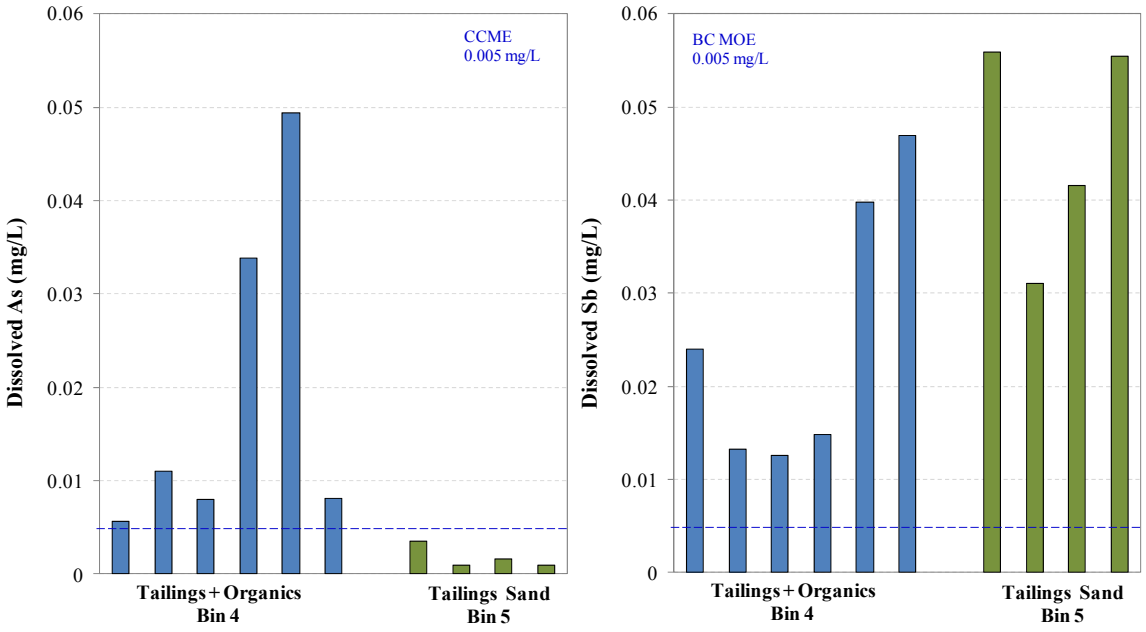


Figure 5-19: Dissolved As and Sb Concentrations in Leachate from Tailings Field Kinetic Tests

5.5 Tailings Drainage Chemistry

The following sections present surface water, porewater, and groundwater chemistry within and down-gradient of the tailings impoundment. Water quality results are presented and controls on the mobility and attenuation of arsenic and other metals associated with Mt. Nansen tailings are discussed.

5.5.1 Surface Water

In this section the concentration of parameters within the tailings pond and the seepage pond on the east side of the dam (Figure 2-5) are compared to evaluate the nature of the flowpath and the magnitude of metal release and/or attenuation along the flowpath from the tailings to the seepage pond.

During operations and immediately following mine closure parameters that were used in processing of the ore (*i.e.,* copper and cyanide; Figures 5-20 and 5-21) were elevated in tailings impoundment and seepage pond water. These concentrations have since declined by orders of magnitude, an indication that a large proportion of process water has flushed from the tailings. The relatively consistent concentrations of Cu and cyanide over the past five years suggest that the tailings mass has stabilized and the large metal releases observed in the first few years following closure are not expected to occur unless there are significant changes to site conditions.

The coincident rate and timing of Cu and cyanide depletion in the tailings and seepage collection pond (Figures 5-20 and 5-21) suggests that the tailings and seepage pond are intimately connected via a groundwater flow path. Further evidence of a connected groundwater flowpath is that the elevated sulfate concentrations in the seepage collection pond (700 mg/L) must be attributed to a tailings source. Sulfate concentrations in the tailings are approximately 1,450 mg/L, but depleted in all other waters reporting to the seepage collection pond: 85 mg/L in MW-24 (representing north slope geochemistry) and <500 mg/L in D1 (in Dome Creek, upstream of the tailings mass; Figure 5-22). Therefore, to attain the concentrations of sulfate observed in the seepage pond, seepage of porewater from the tailings must represent a dominant contribution.

It is also evident that there are geochemical mechanisms along the flow path between the tailings mass and the seepage collection pond that are attenuating and releasing certain parameters (Figures 5-23 and 5-24). For example, Fe and Mn (Figure 5-23) and alkalinity and ammonia (Figure 5-24) are all more elevated in the seepage pond compared to the tailings impoundment. Iron, Mn, alkalinity and ammonia are all redox sensitive parameters, suggesting that redox processes are occurring along the flow path from the tailings to the seepage collection pond.

A redox process is one in which the mineralization of organic matter causes electrons to be transferred from a reductant (organic matter) to an electron acceptor, or oxidant. Redox sensitive parameters include: sulfur, As, Fe, Mn, and N (*e.g.*, NO_3, and NH_3). In aerobic environments, oxygen is used preferentially as the electron acceptor in the oxidation of organic matter. Under oxic conditions As, Fe, Mn, sulfide (S^{2-}), and NH_3 are typically depleted in porewater (Table 5-12). Once oxygen is depleted, other electron acceptors are utilized. Thermodynamic theory predicts that electron acceptors are used in the following order: $O_2 > NO_3^- >$ Mn(IV) oxides > Fe(III) oxides > SO_4. In other words, once oxygen has been exhausted, nitrate will be utilized as the electron acceptor for organic matter oxidation, followed by Mn oxides, *etc*.

Under suboxic conditions (oxygen is depleted) nitrate is reduced to nitrite, and Fe and Mn are reduced and released from their respective oxides to the water column. Alkalinity is also elevated in suboxic waters as alkalinity is generated via the reduction of nitrate, Fe and Mn. Under reducing conditions nitrite is reduced to ammonia and sulfate is reduced to sulfide. Sulfide reacts quickly with metals such as As, Cd, Cu and Zn, precipitating these metals out of solution as secondary sulfides. As shown in Figures 5-25 and 5-26, As, Cd, Cu and Zn are all lower in the seepage collection pond compared to the tailings impoundment and suggests removal of these metals along the flow path. Elevated Fe, Mn, alkalinity and ammonia, and the depletion of metals from the tailings impoundment to the seepage collection pond suggests that the removal mechanism is sulfide precipitation owing to reducing conditions along the groundwater flow path. These mechanisms and their implications are discussed at length in Section 5.5.3.

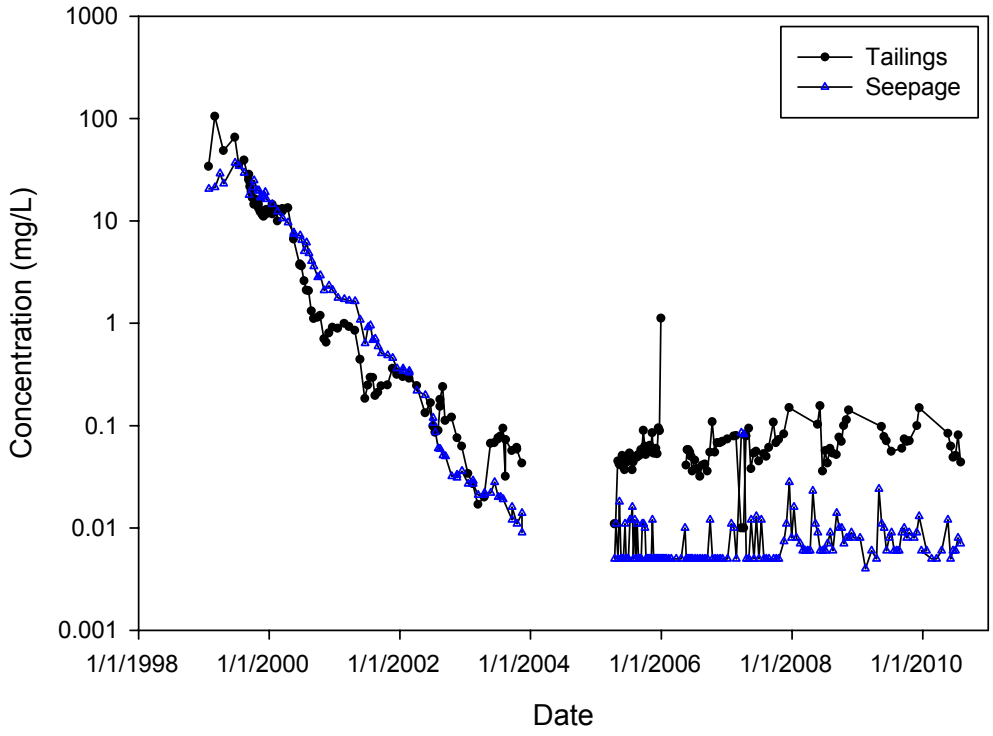


Figure 5-20: Time-series Copper Concentrations in Tailings and Seepage Ponds

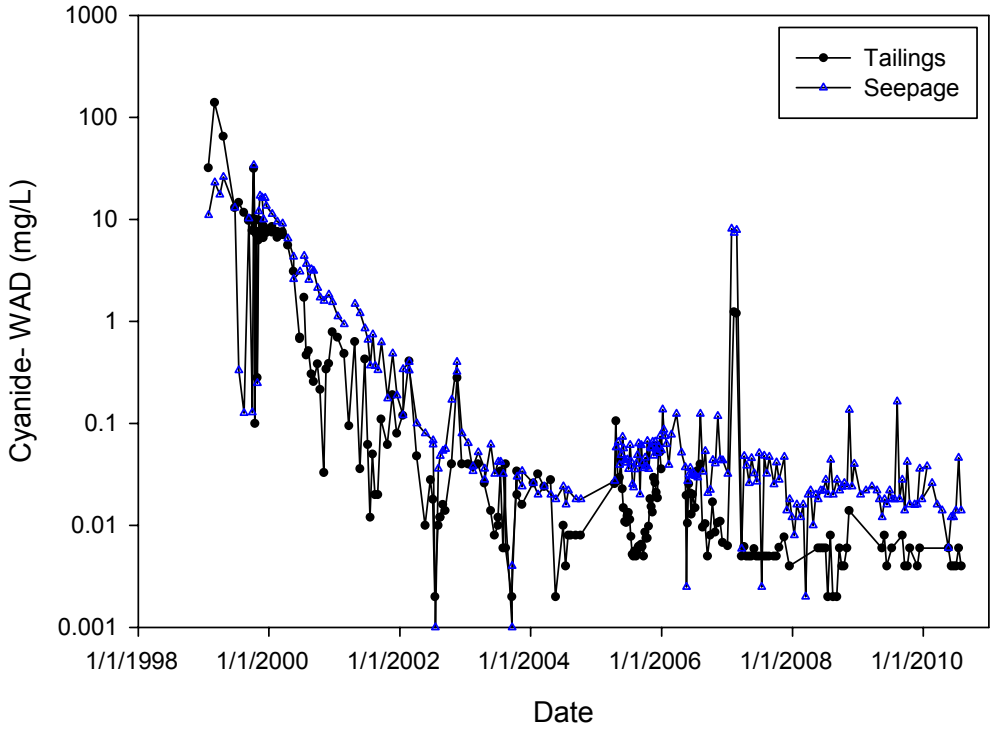


Figure 5-21: Time-series Cyanide Concentrations in Tailings and Seepage Ponds

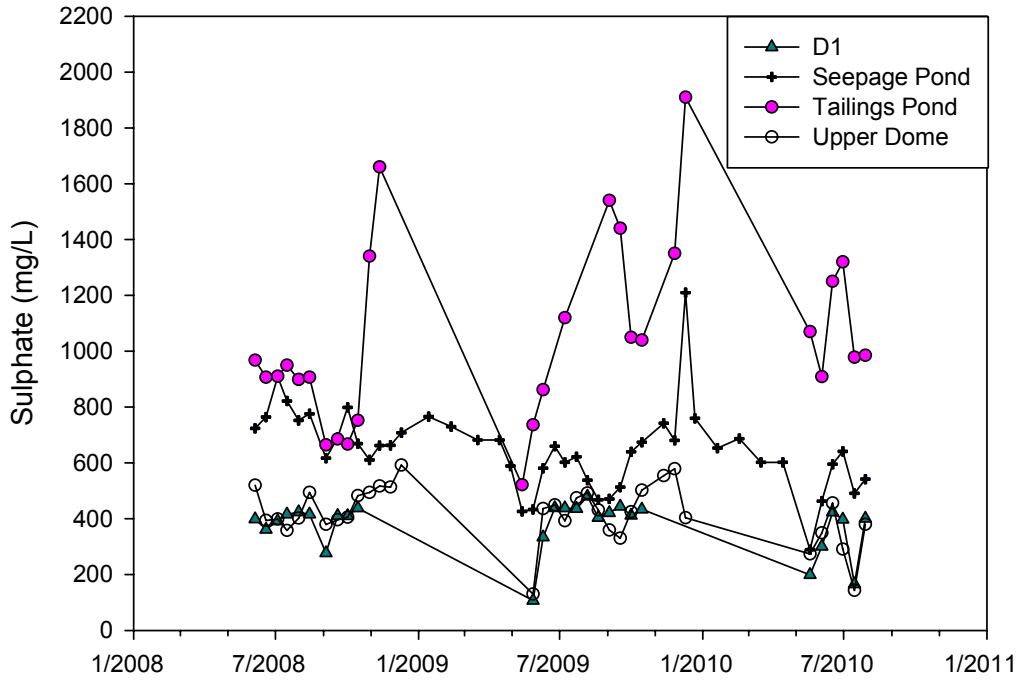


Figure 5-22: Time-series Sulfate Concentrations in the Tailings, Seepage Ponds and Dome Creek (D1)

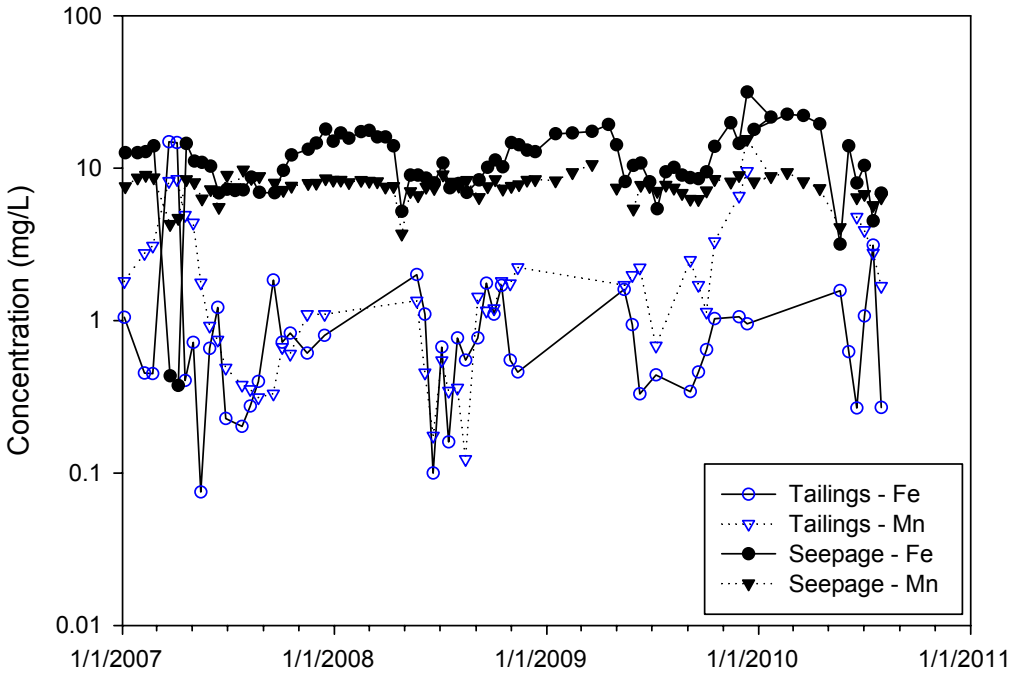


Figure 5-23: Time-series Iron and Manganese Concentrations in Tailings and Seepage Ponds

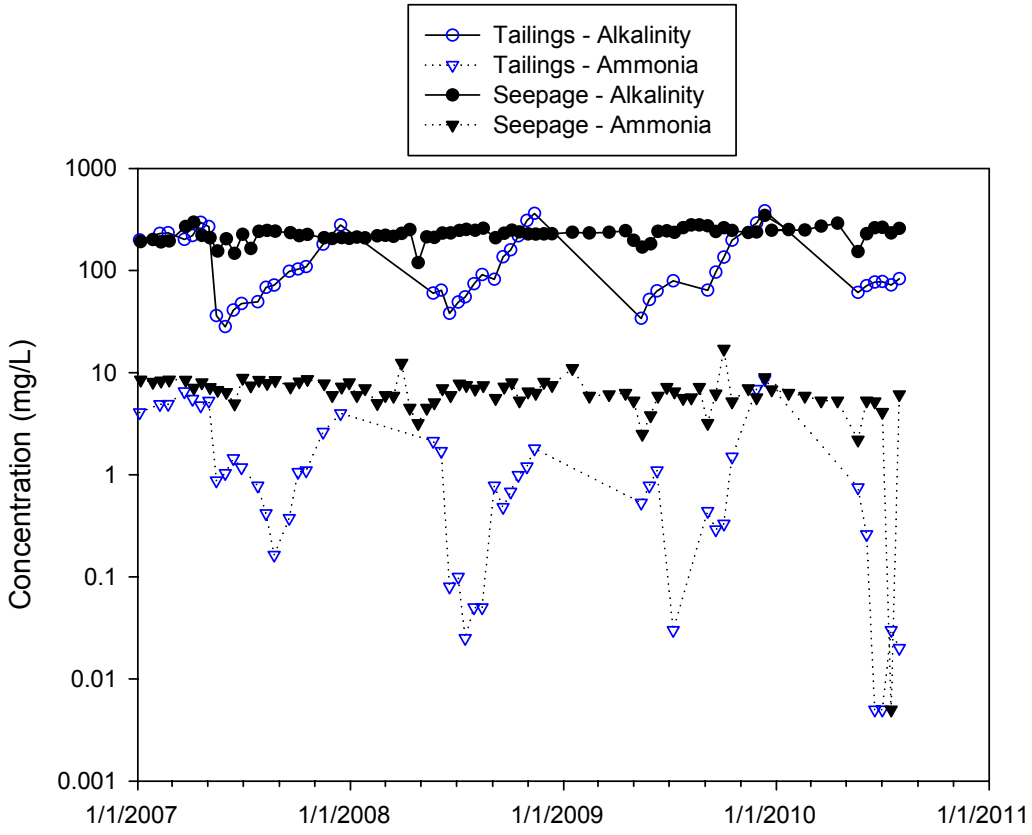


Figure 5-24: Time-series Alkalinity and Ammonia in Tailings and Seepage Ponds

Table 5-12:
Redox Sensitive Parameters and Occurrence

Redox-sensitive parameters	Oxic Water	Suboxic Water	Anoxic Water
Nitrate	X		
Nitrite		X	
Ammonia		X	X
Fe		X	X
Mn		X	X
Sulfide			X
As(III)		X	X
As(V)	X		

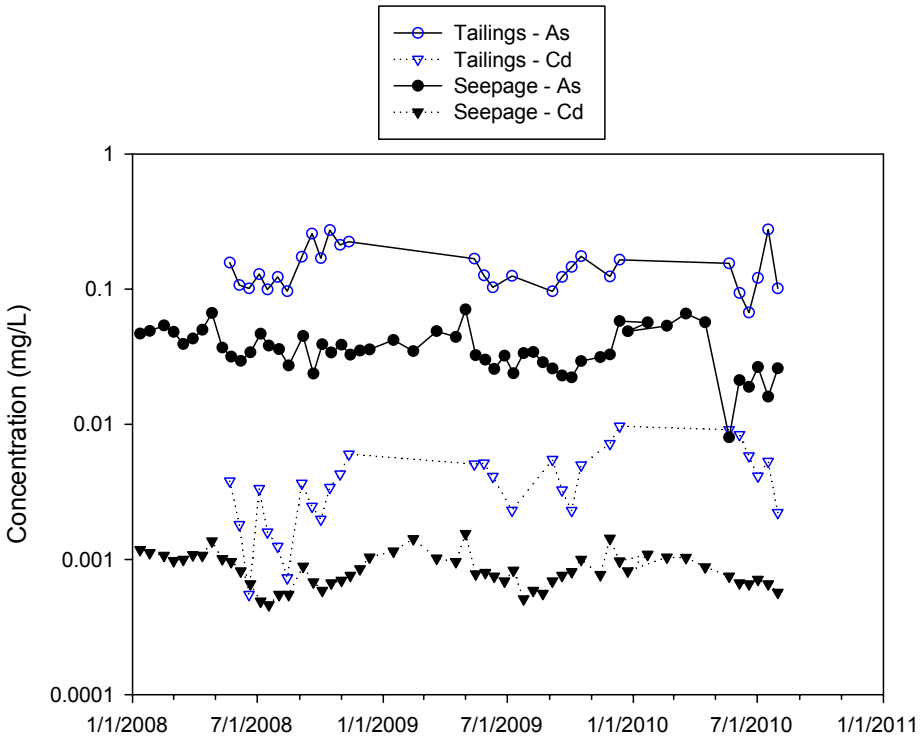


Figure 5-25: Time-series Arsenic and Cadmium Concentrations in Tailings and Seepage Ponds

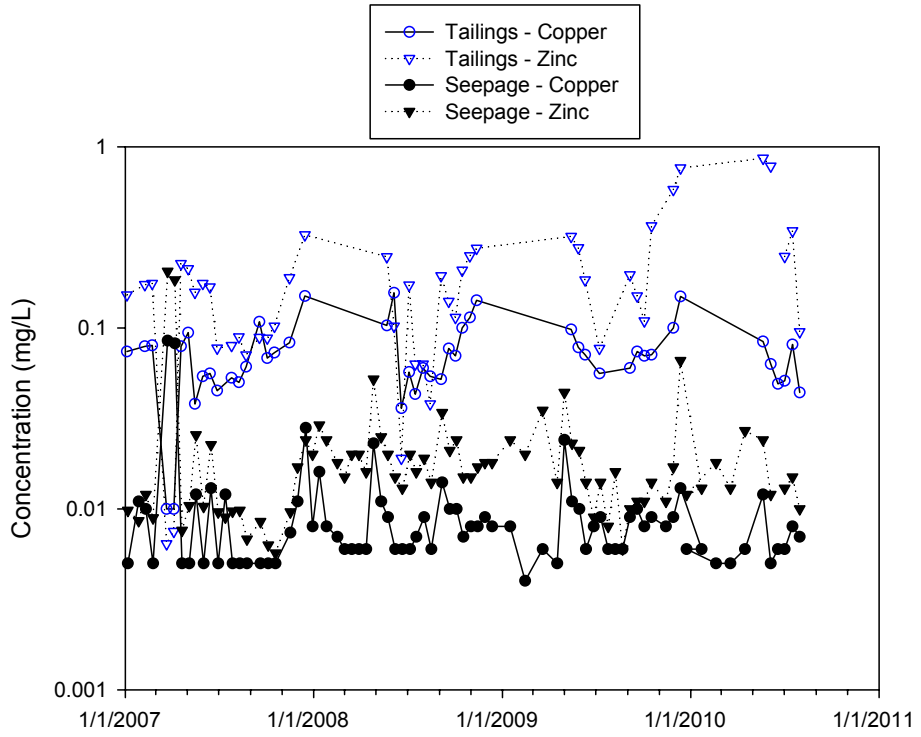


Figure 5-26: Time-series Copper and Zinc Concentrations in Tailings and Seepage Ponds

5.5.2 Tailings Porewater and Groundwater Quality

Groundwater wells were installed in 2009 to assess the geochemistry and variability within the tailings porewater, underlying native substrate, dam, and in groundwater on the east side of the dam (around the seepage pond). Four sets of nested wells (one shallow well screened over the tailings immediately adjacent to a deeper well screened over the underlying native substrate) were installed at the southeast and southwest ends of the impoundments to elucidate geochemical mechanisms occurring along the downward gradient from the tailings to the native substrate, and along the west-east groundwater flowpath. In total there are five wells screened over tailings, three wells in the underlying native substrate, three wells in the dam, and four around the seepage collection pond (Figure 2-5). Tailings porewater and associated groundwater quality are presented in Table 5-13.

Groundwater collected from all the tailings wells exceeded CCME guidelines for ammonia and arsenic (Table 5-13). Multiple exceedances were also observed for nitrate, nitrite, WAD CN, Cd, Cu, Fe and Zn. Porewater chemistry within the tailings is highly variable, consistent with previous study findings (Lorax, 2008). In fact, the minimum and maximum concentrations of ammonia, nitrate, nitrite, sulfate, WAD/total CN, As, Cd, Cu, Fe, Mn and Zn vary by several orders of magnitude. The significant variability in redox-sensitive parameters (nitrogen species, Fe, Mn, sulfate and As (Table 5-13) indicates that a range of redox conditions exist in the impoundment.

Metal mobility is strongly influenced by redox conditions. For example, in tailings and other environments where As is bound primarily to Fe and Mn-oxides As is found to be most mobile under suboxic conditions. This is due to the fact that adsorbed As is released when Fe and Mn are used as terminal electron acceptors resulting in the destabilization of their respective oxide phases. The dominant redox regime can be identified by the relative concentrations of redox-sensitive parameters as described in Section 5.4.1 and shown in Table 5-12.

Within the impoundment three wells represent typical suboxic conditions: MW09-02, MW09-04, and MP09-12. Specifically, mild suboxia is characterized as having depleted nitrate, elevated Mn, and low sulfide (the presence of sulfide indicates the development of reducing conditions). Monitoring wells MP09-12 and MW09-04 are typical of mild suboxia and show elevated Mn (~3.5 mg/L), depleted nitrate (<0.05 mg/L), and low sulfide (< 47 ug/L) concentrations. Arsenic concentrations in MP09-12 and MW09-04 range from 2.99 to 9.27 mg/L. Groundwater well MW09-02 best demonstrates strongly suboxic conditions within the tailings mass where Fe is the primary terminal electron

acceptor: Fe concentrations are 5-10 mg/L, Mn is 20-25 mg/L, nitrate is < 0.3 mg/L and sulfide is < 20 µg/L. Arsenic concentrations in MW09-02 range from 10.5-15.3 mg/L.

Arsenic is less mobile under reducing conditions where it reacts with the sulfide anion and precipitates as a discrete sulfide or with Fe-sulfides. MW09-01, screened over the organic layer underlying the impoundment, best represents a reduced groundwater: nitrate and nitrite have all been reduced to ammonia (12.3-13.9 mg/L) and sulfide concentrations are elevated (69.5 – 78.4 µg/L). Consequently, arsenic concentrations are two orders of magnitude lower than in the suboxic wells (0.092 to 0.22 mg/L) and the reduced species of As dominates (Table 5-14).

Similar to tailings groundwater, the chemistry of the wells screened over the native substrate underlying the tailings are also highly variable, likely reflective of a range of redox conditions as well as variable influence from the overlying tailings (Table 5-13).

All wells screened within native substrate below the tailings contain As and ammonia concentrations that exceed the CCME guidelines for the protection of freshwater aquatic life. The highest As concentration observed in a well screened over native material is 6.58 mg/L (MP09-09). Other parameters which exceeded guidelines include WAD CN, Fe, Cu, Zn, nitrate, and nitrite. These elevated constituents suggest that a downward migration of tailings-influenced groundwater is occurring. Dissolved organic carbon (DOC) concentrations are highest in the native substrate wells (32-164 mg/L).

The wells screened in the dam exhibit far less chemical variability. Also, the median As concentration for wells screened in the dam material are two orders of magnitude lower than in the tailings and underlying substrate. Similarly, the median As concentration in the wells screened around the seepage pond is three orders of magnitude lower than in the tailings and underlying native substrate. Hence, As appears to attenuate along the flow path from the tailings and through the dam, as discussed in the proceeding section and shown in Figure 5-27.

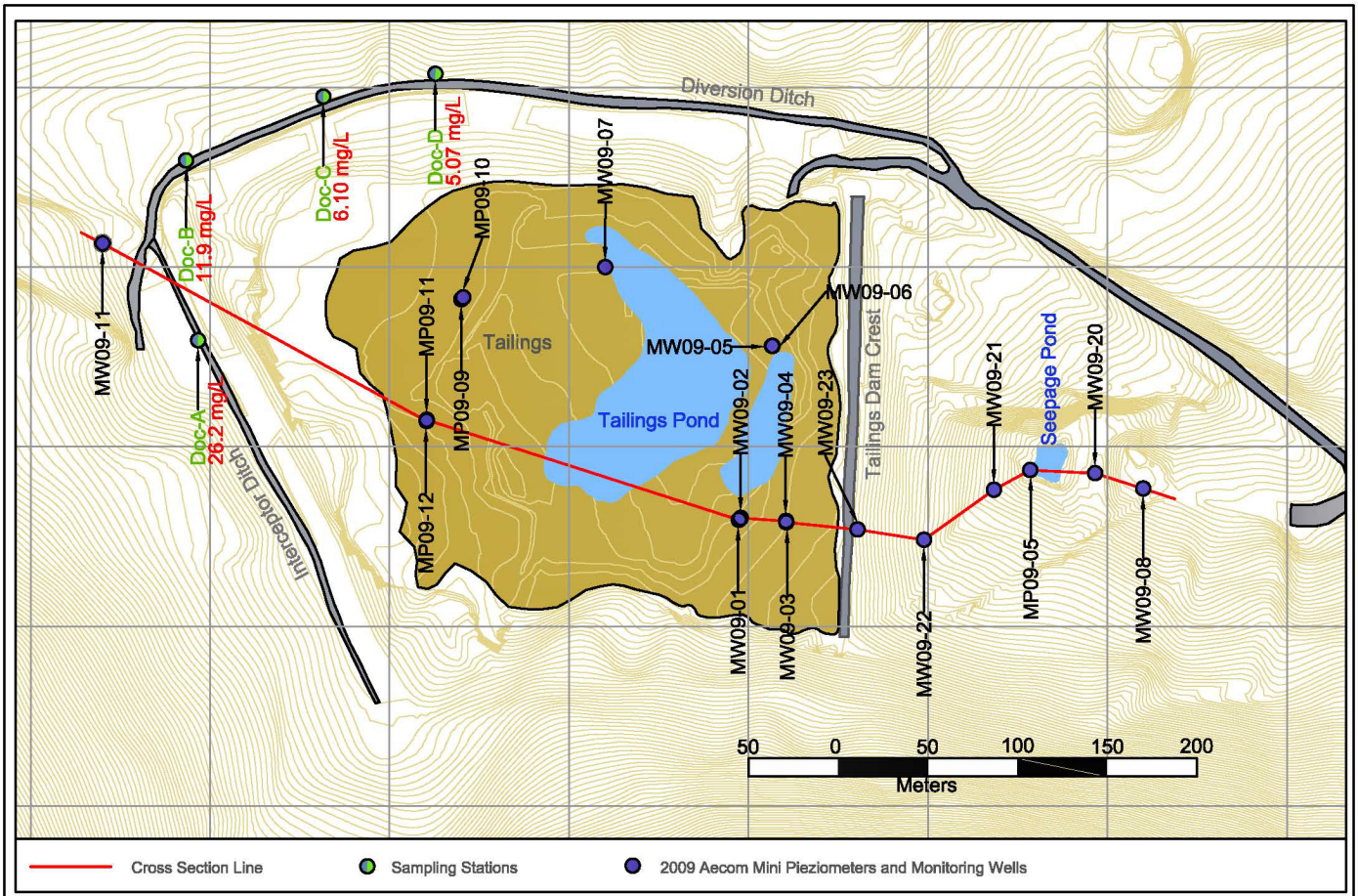
Table 5-13:
Porewater Chemistry Statistics

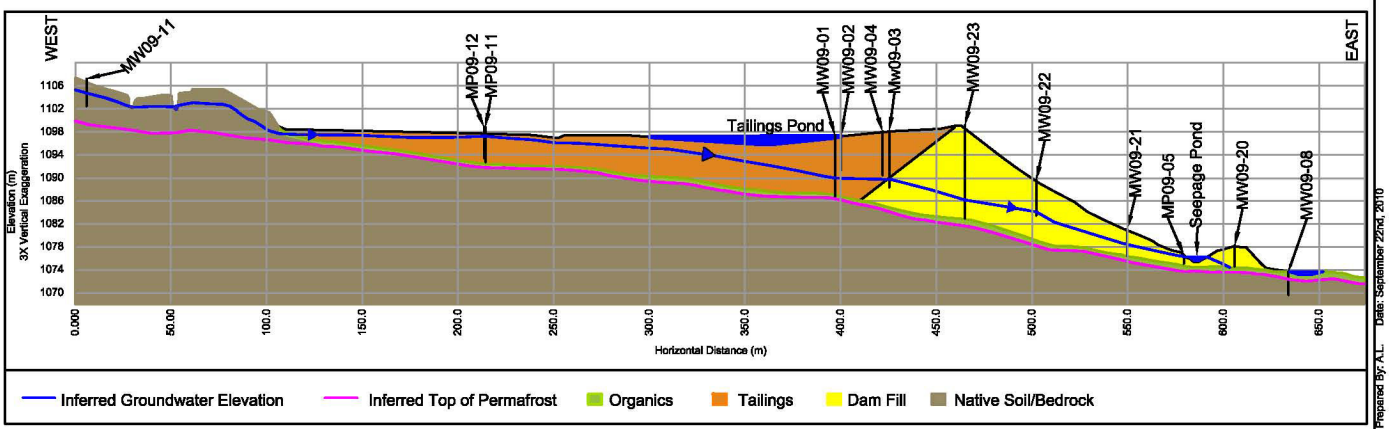
	pH	Ammonia (as N)	Nitrate (as N)	Nitrite (as N)	Sulfate (SO4)	Sulfide (µg/L)	Cyanide, WAD	Cyanide, Total	Cyanate (CNO)	Thiocyanate (SCN)	Dissolved Organic Carbon	Arsenic (As)	Cadmium (Cd)	Copper (Cu)	Iron (Fe)	Lead (Pb)	Manganese (Mn)	Zinc (Zn)
CCME Guidelines	6.5-9.0	0.019	2.9	0.06	-	-	0.005	-	-	-	-	0.005	0.000017	0.004	0.3	0.007	-	0.03
Tailings Wells																		
Min	**5.08**	**0.035**	0.026	0.0019	5.4	< 2	0.005	0.005	0.5	0.68	5.16	**0.221**	0.000085	0.0005	0.03	0.00025	0.26	0.005
Median (50th percentile)	8.06	**3.36**	0.075	0.02	1495	17.3	**0.0272**	0.11675	1.8	2.8	7.35	**6.98**	**0.00043**	0.00243	**0.359**	0.0005	3.91	**0.042**
Max	10.09	**15.5**	**2.95**	**0.548**	1960	46.9	**0.964**	2.96	5.9	7.13	55.9	**24.9**	**0.00894**	**0.845**	**14.8**	0.0053	23.7	**0.462**
Native Substrate Wells																		
Min	**6.79**	**1.6**	0.005	0.001	5	46.9	0.005	0.005	0.5	1.44	32	**0.0923**	0.000085	0.0005	0.16	0.00021	0.679	0.0028
Median (50th percentile)	7.84	**8.5**	-	-	136	69.5	**0.0168**	0.0591	0.6	4.3	46.5	**1.33**	0.00011	0.00107	**8.55**	0.00077	2.1	0.0073
Max	9.2	**13.9**	0.5	**0.1**	646	145	**0.0335**	0.125	5.1	35	164	**6.58**	**0.00046**	**0.0152**	**66.4**	0.00255	6.16	**0.031**
Wells in Dam																		
Min	6.67	**4.37**	0.05	0.01	126	-	0.005	0.0102	0.5	1.2	13.7	**0.006**	0.000085	0.0005	**3.46**	0.00025	3.2	0.005
Median (50th percentile)	7.12	**9.33**	0.175	0.035	848.5	-	**0.0211**	0.0311	3	1.98	18.45	**0.0156**	0.000144	**0.0045**	**16.3**	0.0015	6.38	0.005
Max	7.58	**18.9**	**22.3**	**0.0996**	1320	-	**0.107**	0.419	20.7	5.86	42.5	**0.0443**	**0.00065**	**0.005**	**66.4**	0.0025	11.2	0.0104
Seepage Pond area																		
Min	6.87	0.01	0.025	0.005	5	< 2	0.005	0.005	0.5	0.5	4.18	0.00102	0.000017	0.001	0.03	0.0001	0.00237	0.002
Median (50th percentile)	7.29	**2.98**	2.52	0.024	297	32.1	0.005	0.0119	0.5	1.08	14.5	0.00141	0.000055	**0.006**	0.03	0.00025	2.32	0.011
Max	7.96	**8.17**	**18**	**0.119**	634	476	**0.0171**	0.0542	3.42	5.8	24.3	**0.292**	**0.00674**	**0.0324**	**40.7**	0.0005	9.04	**0.081**

All values in mg/L unless stated otherwise. Values in bold exceed CCME guidelines for the protection of freshwater aquatic life.

Table 5-14:
Arsenic Speciation Results

Well	Date	As(III)	As(V)	As(III)/As(V)
Tailings Wells				
MW09-02	12-Jul-09	8720	356	24.5
	03-Sep-09	13500	649	20.8
	03-Sep-09	12800	209	61.2
	01-Jul-10	13400	772	17.4
MW09-04	11-Jul-09	7.52	2710	0.0028
	11-Jul-09	13.5	2720	0.0050
	03-Sep-09	26.5	3690	0.0072
	30-Jun-10	<0.050	3920	0.000013
MW09-06	13-Jul-09	3.41	240	0.014
	13-Jul-09	5.39	296	0.018
	03-Sep-09	8.37	641	0.013
	01-Jul-10	0.9	97.5	0.0092
MP09-10	12-Jul-09	125	19500	0.0064
	02-Sep-09	137	24200	0.0057
	04-Jul-10	85.6	17700	0.0048
MP09-12	12-Jul-09	3530	3000	1.18
	02-Sep-09	8540	2430	3.51
	03-Jul-10	3850	488	7.89
Native Substrate Wells				
MW09-01	12-Jul-09	46	6.54	7.03
	03-Sep-09	140	32.2	4.35
	01-Jul-10	67.6	1.56	43.3
MP09-09	12-Jul-09	152	4580	0.033
	02-Sep-09	223	4590	0.049
	04-Jul-10	122	5010	0.024
MP09-11	11-Jul-09	810	31.9	25.4
	02-Sep-09	1010	55.6	18.2
	03-Jul-10	1790	134	13.4
Wells screened in Dam Fill				
MW09-03	11-Jul-09	4.4	2930	0.0015
	03-Sep-09	220	2720	0.081
	30-Jun-10	206	2520	0.082
MW09-21	21-Jul-09	-	-	
	21-Jul-09	-	-	
	01-Sep-09	-	-	
	02-Jul-10	7.95	2.76	2.88
MW09-23	21-Jul-09	-	-	
	03-Sep-09	6.91	0.64	10.8
	01-Sep-09	-	-	
	01-Jul-10	6.71	2.02	3.32
Wells around Seepage Pond				
MW09-08	08-Jul-09	-	-	
	01-Sep-09	244	22.5	10.8
	03-Jul-10	161	46.2	3.48
MW09-24	22-Jul-09	-	-	
	01-Sep-09	-	-	
	02-Jul-10	0.21	1.08	0.19
MP09-04	13-Jul-09	0.07	1.22	0.057
	04-Jul-10	<0.050	10.9	0.0046
MP09-05	13-Jul-09	0.21	1.14	0.18
	03-Sep-09	0.43	0.68	0.63
	03-Jul-10	<0.050	0.52	0.10





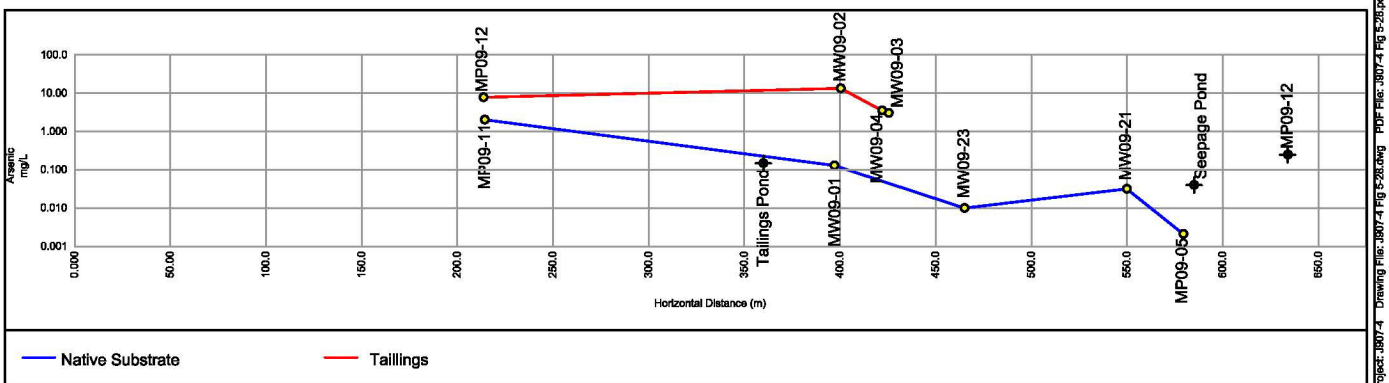


Figure 5-27 As concentrations along the groundwater flowpath from the tailings to the seepage collection pond

Project: 1807-4 Drawing File: 1807-4 Fig 5-28.dwg PDF File: 1807-4 Fig 5-28.pdf Prepared by: A.L. Date: September 22nd, 2010

5.5.3 Discussion

In previous geochemical studies of Mt. Nansen (Kwong *et al*, 2002; Lorax, 2008; 2009) arsenic was identified as the primary element of concern within the tailings impoundment. Arsenic concentrations within the tailings impoundment range from 0.10 mg/L to as high as 25 mg/L. In contrast, arsenic concentrations in the seepage collection pond are relatively low (<0.02 to 0.07 mg/L over the past 2 years) and appear to have stabilized. These data suggest that attenuation of As along the flowpath from the tailings to the seepage collection pond is occurring. The potential As attenuation mechanisms, as described in Lorax (2009), include:

- Adsorption onto Fe and Mn oxides;
- Adsorption onto clay surfaces;
- Adsorption of As onto the surfaces of sulfides; and,
- Precipitation of discrete arsenic sulfides.

Elucidating the mechanism of removal along the flowpath from the tailings to the seepage collection pond is important because some attenuation mechanisms are finite, such as adsorption mechanisms, while others infinite, such as precipitation as discrete arsenic sulfides. The finite nature of an adsorptive mechanism may be related to a limited number of sorption sites or a decrease in sorption sites due to mineral maturation, surface charge reversal due to changes in pH, and mineral destabilization due to changes in pH or redox.

Arsenic precipitation as discrete arsenic sulfides (*e.g.*, orpiment – As_2S_3) and via co-precipitation with iron sulfides (*e.g.*, pyrite – FeS_2) are effective attenuation mechanisms for As in tailings groundwater (Martin and Pedersen, 2002). Removal of metals via sulfide precipitation occurs when sulfate is reduced to sulfide followed by precipitation as a metal-sulfide. Sulfate reduction will only persist under reducing conditions and is often found to occur in organic-rich deposits. In mining environments, where sulfate is elevated in groundwater, the removal of metals via sulfide precipitation is an infinite process as long as there is a constant supply of DOC.

To refine the likely mechanisms of As attenuation, groundwater data from the tailings impoundment, the tailings dam, and around the seepage collection pond were analyzed and are interpreted in the following sections. An extended parameter list was developed to include redox-sensitive species (DOC, sulfide and arsenic species) to allow for the identification of likely redox mechanisms responsible for As behaviour in and around the tailings impoundment. In 2010, DOC was also measured within Dome Creek to the west of the impoundment and in seeps along to diversion channel to the north of the

impoundment to elucidate the potential infinite nature of a sulfide precipitation removal mechanism (Figure 5-27). In addition to the geochemical controls on As mobility, the physical controls on As mobility were also investigated and are discussed in the proceeding sections.

5.5.3.1 Physical Controls on Metal Mobility

Physical controls on metal mobility are primarily related to the flow regime throughout the impoundment. The tailings at Mt. Nansen are highly heterogeneous composed of sand material with high hydraulic conductivity and clay tailings with low hydraulic conductivities. During operations the porewater and tailings impoundment water is composed primarily of supernatant which is characterized by elevated Cu and cyanide added during processing, elevated As, and elevated pH. Following closure supernatant is no longer added to the impoundment and groundwater from the surrounding slopes, as well as meteoric water, will flush the supernatant from the tailings impoundment, as demonstrated in Figures 5-20 and 5-21. However, where the hydraulic conductivity through the tails is highly variable the rate of flushing of supernatant throughout the impoundment is also variable. Post-closure, the influence of variable flow rates becomes especially apparent and likely accounts for a significant degree of the chemical variability observed in the tailings porewater.

For example, the most elevated As concentration in tailings porewater (24.9 mg/L in MP09-10) correlates with the most elevated Cu concentration (0.732 mg/L). The median tailings porewater concentration of Cu is 0.0024 mg/L (Table 5-13), orders of magnitude lower than in MP09-10. Similar Cu concentrations were observed in the tailings and seepage ponds between 2001 and 2002 (Figure 5-20) suggesting that while the Cu added during processing and has since been exhausted in many areas of the tailings mass, it is trapped in the clay layer over which MP09-10 is screened, and likely in other clay-rich layers throughout the impoundment. The elevated cyanide and pH over the same screened interval further suggests that it represents trapped or slow-moving process water. Then, elevated As is also related to minimal groundwater movement and a lack of flushing in that specific area of the impoundment.

The heterogeneity of the tailings has resulted in incomplete flushing of process water such that different parts of the impoundment have reached different pseudo-equilibrium states. Because slow-moving process water does not represent long-term groundwater conditions (although slow, the supernatant trapped in the clay layers will eventually be flushed), it is important to distinguish between As concentrations resulting from physical controls and those governed by geochemical processes that may be representative of longer term conditions.

5.5.3.2 Geochemical Controls on Arsenic Mobility

A number of possible mechanisms for As attenuation were discussed in Section 5.4.3 as well as in Lorax (2009). Precipitation with and adsorption onto Fe and Mn oxides is a common As removal mechanism in mining environments but is not pertinent to the flowpath through the dam. To form Fe and Mn-oxides, the groundwater must be, or come into contact with, an oxygen-rich groundwater. The groundwater in the tailings and native substrate varies from mildly suboxic to reducing and is not sufficiently oxidized to precipitate Fe or Mn-oxides. Another attenuation mechanism that is common within tailings dams is adsorption onto clay particles. However, the Mt. Nansen tailings dam fill is composed of aeolian silica-rich sand which does not offer significant sorptive surfaces.

Based on the native substrate characterization, surface and porewater data, precipitation of arsenic-sulfides and/or adsorption onto precipitating sulfides is likely the mechanism attenuating As and other metals (Cd, Zn, Cu) along the flowpath from the tailings impoundment to the seepage pond. The influence of the flowpath on metal attenuation is significant. While the tailings groundwater is mostly suboxic with elevated concentrations of As, the groundwater in the underlying native substrate is more reducing. As mentioned in Section 5.4.3.1, there is strong evidence of a downward flow gradient through the tailings. There is also evidence of lateral flow from the tailings impoundment, through the tailings dam and into the seepage pond (Section 5.4.1). Therefore, suboxic groundwater flowing downward through the tailings must come into contact with the DOC-rich organic layer underlying the tailings. Flow further downward is impeded by the permafrost layer and flow proceeds laterally westward through the organic layer, under and through the tailings dam, and reports to the seepage collection pond (Figure 5-27). As groundwater flows through the organic layer and/or comes into contact with groundwaters containing high DOC concentrations it becomes reduced. Further geochemical evidence to support reduction of groundwater along the described flow path include:

- Water becomes more reduced as it moves from the tailings to the seepage pond (see Figures 5-23 and 5-24 and discussion in Section 5.4.1).
- The wells screened in the dam (MW09-21, MW09-22, and MW09-23) all have water chemistry consistent with reducing groundwater *i.e.,* elevated Fe (3.86-66.4 mg/L), and ammonia (4.37-18.9).
- MW09-01, screened in the organic-rich native substrate underlying the tailings is also characteristically reducing: elevated Fe (50.4-66.4 mg/L), ammonia (12.3-13.9 mg/L), and sulfide (69.5 µg/L);

- The dominant form of As in the tailings groundwater is As(V) (oxidized As). In contrast, the dominant form of aqueous As in native substrate and dam wells is As(III) (reduced As).

Geochemical evidence to support the attenuation of metals via sulfide precipitation along the described flow path include:

- Elements sensitive to sulfide precipitation, including As, Cd, Cu, and Zn, are lower in the seepage collection pond compared to the tailings impoundment (see Figures 5-25 and 5-26)
- Sulfur, and other metals that precipitate as sulfides under reducing flows (As, Cd, Cu, and Zn), are concentrated in the organic layer (solid phase, Section 5.3).
- Arsenic concentrations in MW09-01 (screened in the organic substrate underlying the tailings), and MW09-21, MW09-22, and MW09-23 (screened in the dam) are orders of magnitude lower than in the tailings wells (Table 5-13).

To sustain sulfide precipitation in perpetuity an endless supply of sulfate and DOC is required. In mining environments where water is in equilibrium with gypsum, as at Nansen, sulfate is expected is remain elevated far into the future. The source of DOC in groundwater throughout the impoundment includes the organic-rich substrate underlying the tailings, as well as groundwater flowing down the valley and through organic-rich valley substrate. Although the DOC in the organic layer underlying the impoundment may become exhausted at some point in the future, DOC originating from the expansively vegetated valley is limitless. To quantify the amount of DOC originating from the slopes DOC was measured in the interception ditches to the west and north of the impoundment, as well as in seeps to the north of the impoundment (see Figure 5-27). As shown in Figure 5-27 the concentrations of DOC in water from the north-slope range from 5.07 to 11.9 mg/L, enough to sustain sulfate reduction in perpetuity. DOC concentrations are even higher along the west slope: 26.2 mg/L.

5.6 Acidic Tailings Analog Evaluation

5.6.1 Introduction

Tailings from historic production at Mt. Nansen are presently stored in saturated conditions in a tailings impoundment. Two proposed closure options include the relocation of the tailings. One option is a dry facility, where tailings would be exposed to natural weathering conditions. As discussed in Section 5.2, ABA results demonstrate that the tailings are likely to generate acidic mine drainage if left exposed to oxygen. The potential geochemical behavior of tailings in an oxidizing environment is therefore of

interest. Comparable sites near Carcross, Yukon, were chosen as proxies for tailings at Mt. Nansen, namely the Venus Mine and the Arctic Gold and Silver Mine. These sites are abandoned historic mines where tailings are stored in dry facilities and have similar geologic and orogenic characteristics to Mt Nansen (C. Hart, Director Mineral Deposit Research Unit, UBC, personal communication, 15 September 2009). Geochemical characterization evaluations were completed at these two sites in the 1990s.

5.6.2 Site Background Comparison

5.6.2.1 Mt. Nansen

The Mount Nansen gold mine is hosted within an epithermal deposit, with mineralization consisting of structurally controlled veins and siliceous pipe-like structures. The Mount Nansen gold mine was operated between November 1997 and February 1999. The mine was abandoned in July 1999, leaving 250,000 tonnes of impounded tailings. The tailings are currently saturated and produce neutral drainage. Detailed geochemical characteristics of the Mt. Nansen tailings have been described previously in this chapter.

5.6.2.2 Venus

The Venus mine site is located 22 km south of Carcross, Yukon Territory. The mine operated from late 1970 to mid 1971, processed 54,400 tonnes of ore, and produced half a million ounces of silver, 12,000 ounces of gold, and approximately 39,000 m^3 of tailings. The tailings are deposited adjacent to Tagish Lake and are confined by a perimeter dike. The tailings are partially saturated due to their proximity to the lake. Some tailings have reportedly migrated into Windy Arm, a section of Tagish Lake.

The tailings are largely neutral with isolated areas of acidity and contain elevated concentrations of arsenic and zinc. Elevated concentrations of arsenic and zinc have been observed in adjacent lake water and sediments, however water quality from source seeps are not currently available.

5.6.2.3 Arctic

The Arctic mine site is located 4 km south of Carcross, Yukon Territory. The Arctic gold and silver mine went into production in 1968, operated for two years, processed 50,751 tonnes of ore and produced 27,200 m^3 of tailings. The tailings were deposited adjacent to an unnamed lake. The tailings are partially saturated at depth. The tailings at surface (approximately 2 hectares) are dry and exposed.

The Arctic tailings are largely oxidized, acid-generating and contain high levels of total and soluble arsenic. The characterization work discussed in this report was completed in 1998 by Public Works and Government Services Canada (PWGSC).

5.6.3 Comparison of Tailings Characteristics

5.6.3.1 Grain Size Distribution

Physical characteristics and storage setting play an important role in the weathering rate, acidification, and metal leaching of exposed tailings. The tailings at Mt. Nansen are comprised of 35% oxide silt, 29.8% oxide clay, 16.5% sulfidic silt, and 18.7% sulfidic clay (Kwong *et al*, 2002). The fine tailings account for nearly half of the impounded tailings by volume, and are concentrated in the middle part of the tailings impoundment where a water cover usually exists.

The Venus tailings are comprised of fine silt to sand. Due to deposition by pipes on the perimeter dikes, a beach of coarser tailings has been formed adjacent to the dike. The tailings range from sand/sandy silt at the dike down to very fine slimes near the impoundment. The fines reduce water infiltration and form a perched water table over the area. The tailings are largely unoxidized, although there are a few places where sulfides are seen on cracks exposed to air. Porewater samples and test pits show that saturated conditions and thus oxygen deprivation exist at depth.

The Arctic tailings consist of two layers delineated by oxidation characteristics. The upper layer is fine sand that is more oxidized. This layer is over 90% sand with 10% fines and is damp to moist with a water content of 10-15%. The lower layer is dark grey silt and sand and is relatively unoxidized. This layer is 10-85% sand with 15-90% fines and has a moisture content of 30-45%.

5.6.3.2 Acid-Base Accounting

Acid-base accounting (ABA) characteristics of Mt. Nansen tailings are compared to ABA data from the Venus and Arctic mines (Table 5-15).

Paste pH provides a measure of current acidity or alkalinity within the tailings mass. The Mt. Nansen and Venus tailings are neutral, while the Arctic tailings are very acidic (median paste pH = 2.9).

Table 5-15:
ABA Data for Mt. Nansen, Venus and Arctic Tailings

		Paste pH	S (T) %	S (SO4) %	S (S2) %	AP	Sobek NP	NNP	NPR
Mt Nansen Tailings	# samples	45	54	54	54	54	46	46	46
	min	6.8	0.04	0.01	0.02	0.63	7.4	-182	0.10
	max	9.1	7.3	1.6	6.7	209	58	22	14
	mean	7.8	2.3	0.60	1.6	51	27	-31	1.3
	median	7.7	2.2	0.53	1.3	41	24	-24	0.46
	std dev	0.54	1.5	0.37	1.5	45	13	43	2.6
Venus Tailings	# samples	27	27	27	27	27	27	27	27
	min	2.5	0.96	0.02	0.35	11	3.9	-207	0.36
	max	8.4	8.5	1.5	8.4	263	67	13.3	0.25
	mean	7.7	4.8	0.05	4.4	136	41	-101	0.30
	median	7.3	4.7	0.17	4.6	142	39	-103.4	0.27
	std dev	1.3	1.6	0.31	1.7	53	14	50.9	0.26
Arctic Tailings	# samples	17	17	17	17	17	17	17	17
	min	1.8	0.02	0.01	0.01	0.31	-38	-38.72	-123
	max	7.7	3.6	1.5	2.9	92	2.3	-89.58	0.03
	mean	2.5	0.88	0.52	0.57	18	-12	-29.51	-0.66
	median	2.9	1.2	0.59	0.77	24	-13	-36.67	-0.53
	std dev	1.4	0.96	0.41	0.94	29	9.4	-20.01	0.32

The acid generation potential of a sample is measured from the sulfur present in the sample. When considering the ARD potential, it is important to consider the amount and forms of sulfur present. Sulfur may be present in rock materials as: a) sulfide or pyritic sulfur; b) sulphate-sulfur; c) organic; and/or, d) elemental sulfur. Since acidic drainage at mine sites is typically generated from the oxidation of sulfide minerals, sulfide-sulfur has been used in the report to predict the acid generating potential of a sample. Mt. Nansen and Venus both show high AP due to their high sulfide sulfur contents. Venus has higher sulfide sulfur values and thus higher calculated AP. The presence of barite, a sulfur mineral that shows up as sulfide sulfur in ABA analysis, is a complicating factor here. Barite is not a sulfide mineral, but reportedly contributes to the calculated AP for Venus tailings. Therefore, the AP at Venus may be overestimated. Arctic is already acid generating, so the sulfide-sulfur and AP measurements taken there are an indication of further acid generation potential from the oxidation of sulfide minerals.

The NP of weathering materials is dependent on the composition of minerals that dissolve when exposed to acidic conditions and buffer acidity. Carbonate minerals are fast dissolving and are most typically responsible for acid neutralization, although some silicate minerals may contribute to the total neutralizing capacity. For the three sites discussed in this report, Sobek NP was used as a measure of NP. This method of analysis includes the neutralizing potential of all carbonate and silicate minerals. Carbonate NP (CaNP) is an indication of only carbonate minerals and is a more conservative metric of NP. While CaNP was not measured for the Arctic and Venus Tailings, it is reasonable to assume that the CaNP would be negative for the Arctic Tailings due to their acidic paste pH. Upon comparison of NP, Mt. Nansen tailings have less NP than Venus tailings. The NP at Arctic is negative, showing that any neutralization potential has been completely consumed, as indicated by low paste pH. The negative NP measurements at Arctic are actually measuring acidity.

Net Neutralization Potential (NNP) is calculated by subtracting the acid potential from the neutralization potential. The NNP is a forecast of future conditions. Negative NNP values indicate that more acid potential exists than neutralization potential, which is the case at Mt. Nansen, Venus and Arctic. At Arctic, where all the neutralization potential has been exhausted, NNP indicates long-term acid generation.

The NPR compares the relative proportions of NP to AP, and it can be used over a wide range of AP and NP values. The NPR is compared to criteria specified in the BC Ministry of Energy Mines and Petroleum Resources regulatory guidelines (Price, 1997, Table 5-16). These guidelines indicate that in the absence of any other information a sample with a NPR of less than 1 can be considered as PAG. For a sample with a NPR between 1 and 2, there is a possibility of the material to be considered acid generating if the sulfide oxidation is faster than NP dissolution or buffering. NPR values between 2 and 4 indicate a low risk of acid drainage, while NPR values greater than 4 have no potential of ARD.

Table 5-16:
British Columbia Acid-Base Accounting Screening Criteria (from Price, 1997)

Potential for ARD	Criteria	Comments
Likely	NPR < 1	Likely ARD generating unless sulfide minerals are non-reactive
Possibly	1 < NPR < 2	Possibly ARD generating if NP is insufficiently reactive or is depleted at a faster rate than sulfides
Low	2 < NPR < 4	Not potentially ARD generating unless significant preferential exposure of sulfides along fracture planes, or extremely reactive sulfides in combination with insufficiently reactive NP
None	NPR > 4	

Based on these criteria, Mt. Nansen and Venus are potentially acid generating. Mt. Nansen tailings have NPR values ranging from 0.1 to 3.2, with a mean of 0.4. The NPR values of the Venus tailings range from 0.03 to 2.22 with a mean of 0.25 and indicate that they are likely net acid generating (Table 5-16).

The Mt Nansen, Venus and Arctic tailings show similar ABA characteristics in that they are all classified as likely to be acid generating, as demonstrated by the NNP and NPR values. The Arctic tailings are exposed over a large surface area (2 hectares) and have become acid generating with a median paste pH of less than 3.0. The Mt Nansen and Venus tailings have not yet become acid generating as they have not been exposed to oxidation processes as they have been maintained under predominantly saturated conditions. Note that some Venus tailings have become acidic, as minimum paste pH values of ~2.5 have been measured (Table 5-16). Should the Mt. Nansen or Venus tailings be exposed to oxidation processes, they may evolve to become acid generating to a similar degree as the Arctic tailings.

5.6.3.3 Metals

Solid-phase elemental data are used to identify which elements are enriched in the sampled materials. This can be used as general indicator of the elements that could be of potential concern in drainage chemistry in the absence of drainage chemistry data. However, high solid-phase elemental concentrations do not conclusively indicate that the element will be leached at a high rate from the material. Rather, the rate of metal leaching is related to the metal's mineralogical association and the aqueous geochemistry of the infiltrating waters.

The Mt. Nansen, Arctic, and Venus site all exhibit elevated arsenic levels as well as other metals, as shown in Table 5-17. Concentrations of arsenic are variable across the three sites. Median concentrations at Mt Nansen, Venus and Arctic are approximately 2,800, 45,000, and >7,700 mg/kg, respectively. Concentrations of other metals are equally variable. Most metals are of the same order of magnitude at the three sites. The lone exception is zinc, which is relatively depleted at the Arctic site.

Table 5-17:
Solid Phase Metals Concentrations (mg/kg) for Mt. Nansen, Venus and Arctic

		As	Ag	Cd	Cr	Co	Cu	Pb	Sb	Zn
Mt Nansen Tailings	**# samples**	**29**	**29**	**29**	**29**	**29**	**29**	**29**	**29**	**29**
	min	349	7.5	5.0	12	2	66	419	77	355
	max	5494	56.0	45.0	52	8	679	6431	1112	2766
	mean	2419	42.3	22.9	20	5	312	1697	478	1525
	median	2825	38.0	22.1	24	5	315	2314	525	1602
	std dev	1420	14.0	10.1	11.2	1.7	136	1549	282	664
Venus Tailings	**# samples**	**27**	**27**	**27**	**27**	**27**	**27**	**27**	**27**	**27**
	min	25700	23.1	0.10	22.0	6	18.0	1660	39.0	502
	max	69200	85.8	100	430	15	220	6754	106	9956
	mean	45000	39.7	0.10	46.0	11	64.0	2898	66.0	2882
	median	45000	45.4	21.6	117	10.6	84.5	3701	72.6	3318
	std dev	0.94	17.7	39.7	126	1.95	57.0	1726	20.1	2284
Arctic Tailings	**# samples**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**
	min	194	0.90	0.10	19.0	1	15.0	27.0	6.0	33.0
	max	>10000	200	>100	184	26	1266	4222	468	643
	mean	>10000	74.0	>100	112	5	70.0	1386	163	112
	median	7733	91.2	64.7	92.1	6.12	160	1689	211	183
	std dev	3383	60.0	49.2	50.4	6.0	293	1070	134	166

5.6.3.4 Arctic Tailings Seepage Chemistry

The drainage chemistry from the Arctic tailings is examined as a proxy for potential drainage should the Mt Nansen tailings oxidize and become acidic. Arctic tailings seepage is highly acidic and has a pH of ~2.6, as summarized in Table 5-18. The seepage contains high dissolved metal concentrations, including arsenic, zinc, selenium, iron, lead, cobalt and copper.

Table 5-18:
Arctic Tailings Seepage Water Quality

pH	pH unit	2.55
electrical conductivity	µS/cm	3300
hardness	mg/L	852
alkalinity	mg/L	<1
TDS	mg/L	2800
sulfate	mg/L	2480
chloride	mg/L	0.7
bicarbonate	mg/L	<5
NO_2+NO_3-N	mg/L	<0.05
Dissolved Metals		
Aluminum	mg/L	27
Antimony	mg/L	0.048
Arsenic	mg/L	28.4
Cadmium	mg/L	0.0993
Calcium	mg/L	245
Chromium	mg/L	0.0153
Cobalt	mg/L	0.417
Copper	mg/L	1.44
Iron	mg/L	574
Lead	mg/L	0.358
Magnesium	mg/L	58.1
Manganese	mg/L	25.9
Mercury	mg/L	<0.0001
Molybdenum	mg/L	0.00257
Nickel	mg/L	0.204
Selenium	mg/L	0.233
Silver	mg/L	0.00227
Strontium	mg/L	0.527
Zinc	mg/L	9.76

5.6.3.5 Summary

Ore-deposit geology and ABA characteristics demonstrate that tailings from the Venus Mine and Arctic Gold and Silver Mine are potential analogs for Mt. Nansen tailings. Available characterization data shows the potential for acid generation at Nansen and Venus is likely. Acid generation is already occurring at Arctic. Under present storage conditions, the Nansen tailings appear to be stable. However, if they are relocated to an above ground storage facility, exposed to oxygen and allowed to oxidize, ABA data

suggest that acid mine drainage will occur. Acid mine drainage has been observed from the Arctic Gold and Silver tailings. Water quality of acid mine drainage from Arctic tailings is considered a proxy for acid mine drainage at Mt. Nansen (Table 5-18).

5.7 Source Term Derivation

Tailings source terms were derived for four closure options.

1. Tailings Management Area (TMA) is upgraded and tailings remain in place and saturated with a water cover.
2. TMA is upgraded and tailings remain in place and saturated with a soil cover.
3. Tailings are relocated to the pit with a high infiltration cover and remain near-saturation (>85%).
4. Tailings are relocated to the pit with a low-infiltration cover and are stored dry.

Table 5-20 contains the source terms developed for Mt. Nansen tailings for each option. The assumptions and methodology behind the tailings source term derivation are outlined in the following sections.

Table 5-19:
Tailings Source Term Estimates

Parameter	Options 1 and 2- TMA Upgrade			Option 3- Saturated Tailings in Pit		Option 4- Tailings in Pit Dry
	Conservative Best Estimate	Worst Case	Diffusive Flux- Option 1 (mg/m^2/day)	Conservative Best Estimate	Worst Case	Conservative Best Estimate
Ca	241	24	-	136	470	250
Mg	32.5	4.6	-	*50*	45	60
As	0.04	0.3	0.14	9.3	15	28.4
Cd	0.00089	0.0015	-	0.001	0.001	0.184
Cu	0.0087	0.015	-	0.002	0.002	1.4
Fe	12.8	40	-	3.2	15	574
Mn	7.75	10	0.12	5	24	28.6
Zn	0.02	0.1	-	0.045	0.45	26.2
Sulfate	663	1380	49	1700	2000	2500
Ammonia	6.4	12	-	15	15	6.5
CN (Tot)	0.7	0.5	-	0.04	0.9	0.07
WAD CN	0.025	0.15	-	0.03	0.2	0.03
Cyanate	1.6	18	-	6	6	2
Nitrate	3.1	10	-	0.1	0.1	3
Nitrite	0.25	0.6	-	0.085	0.085	0.3

5.7.1 Option 1- Tailings in Current Location with Water Cover

A number of assumptions were made in the derivation of source terms under option 1:

- At present, the tailings mass is stable (*i.e*., stable flow rates and loadings) and all geochemical mechanisms occurring currently within the impoundment will likely persist in the long term.
- The majority of loadings from the tailings impoundment reports to the seepage collection pond.
- Arsenic and other parameters are attenuated along the flow path from the tailings impoundment to the seepage collection pond. This mechanism of attenuation is presumed to be infinite.
- Dam upgrades and backfilling of the seepage collection pond will not alter the groundwater flow path in such a way to influence seepage water quality or related attenuation mechanisms.
- Currently, arsenic is removed along the flow path upgradient of the seepage collection pond. If the flow path is altered, groundwater quality represented by well MW09-08 (*e.g.,* elevated arsenic) is assumed to represent tailings seepage discharge to Dome Creek as a "Worst Case" scenario.

The tailings source terms for option 1 were developed using the long-term, year-round seepage collection pond dataset. Hence, source terms for options 1 and 2 correspond to total flow estimates currently measured for the entire seepage collection pond. In the event these flows change, tailings source terms may need to be revised. Under option 1 only, three source terms were developed: "Conservative Best Estimate" source term, "Worst Case" source term, and a diffusive flux source term assigned to the overlying water cover.

The "Conservative Best Estimate" tailings source terms were derived by averaging the concentration of each parameter in the seepage collection pond over the time interval from November 2007 to present. Prior to November 2007 many parameters are far from equilibrium and poor analytical detection limits prevent interpretation of the data.

"Worst Case" terms were developed using two approaches with the following assumptions: 1) infrequent yet consistent spikes observed in seepage pond data since January 1999 represent mechanisms that may dominate in the long term; and 2) groundwater quality from well MW09-08 is a proxy for groundwater that bypasses the seepage collection pond and may report to Dome Creek in the future. Surface water quality demonstrates that this bypass flow does not have a measurable impact on Dome

Creek. However, dam upgrades may change seepage flow paths. To assure conservatism is accounted for, the highest value determined under each approach, for each parameter, was selected to represent the source terms for the "Worst Case" scenario.

Exceptions to approaches described above include:

- Copper: Cu was added during processing and is a finite source. Cu concentrations have depleted significantly in the past 5 years. Therefore, only the past six years of data was considered for determination "Worst Case" source terms.
- Nitrate: nitrate has been increasing steadily in the seepage pond. Therefore, only the past three years of data was averaged to attain a "Conservative Best Estimate" source term. The "Worst Case" source term for nitrate was approached in two different ways. The first was to take the general approach and record consistent spikes in the seepage pond data. The second was to calculate the concentration of nitrate if nitrite and ammonia oxidized to nitrate. The values obtained using the two different approaches were consistent.
- Nitrite: similarly, the "Worst Case" source term for nitrite was determined by calculating the sum of the nitrogen species.
- Total Cyanide: Total cyanide was not analyzed in seepage pond water samples after November 2007. Therefore, data from January 1999 to November 2007 was used in the calculation of total cyanide source terms.
- Sulfate: similar to copper, concentrations of sulfate are decreasing over time, albeit more steadily than copper. Only the past four years of seepage pond data was utilized in the calculations of source terms for sulfate.

As shown in Table 5-19, the tailings source terms developed for option 1 exhibit a high range between the "Conservative Best Estimate" and "Worst Case" scenarios. The difference between As, Cd, Zn, sulfate, cyanide species and nitrite under the two scenarios is approximately an order of magnitude. The broad range reflects a high degree of geochemical and hydrogeological variability within the tailings mass itself.

The third source term provided for option 1 is the diffusive flux term for As, Mn and sulfate. The placement of a sand diffusion layer as part of option 1 will serve both to maintain the physical stability of the tailings as well as reduce the diffusive flux of constituents from tailings porewaters into the water cover. The upward diffusion of solutes from the tailings into the water cover has relevance to As, Mn and sulfate, all of which can be expected to show elevated concentrations in tailings porewater in comparison to surface inflows from Dome Creek. The storage of tailings under a permanent water cover and placement of a sand diffusion barrier will likely result in the

development of suboxic porewater conditions throughout the tailings mass. As shown by existing groundwater data for wells screened in suboxic zones, such conditions promote the increased solubility of dissolved As and Mn in porewaters. The diffusion of As, Mn and sulfate through the sand layer and into the water cover has relevance to the contaminant mass balance, since these constituents will report to Dome Creek via the discharge of surface waters from the tailings impoundment spillway.

In order to account for this potential loading to the water cover and downstream receptors, estimates of the diffusive flux from the tailings into the water cover were calculated. The rate of diffusive transport was estimated using Fick's First Law:

$$J_z = \frac{D^o_j \, \phi \, dc}{F \quad dz}$$

where J_z is the upward flux; D^o_j = temperature-dependent diffusion coefficient; F = formation factor which is a measure of tortuosity, and takes into account the convoluted path ions must follow as they diffuse around sediment particles; ϕ = porosity; and dc/dz = the concentration gradient across the sand diffusion layer. These variables were defined as follows:

- D^o_j = temperature-dependent diffusion coefficient for 10°C (Li and Gregory, 1974);
- F$^o_{rm}$ation factor (F) = 2 for sandy soil;
- P$^o_{ro}$sity (ϕ) = 0.4 for sandy soil;
- C$^o_{nc}$entration range (*dc*) = defined as the median concen*tr*ation in suboxic porewaters minus the median concentration in inflows to the tailings impoundment via Dome Creek; and,
- d^F = depth of the san*d* diffusion barrier (30 cm).

Based *o*n these inputs, respective diffusive flux estimates of 0.14, 0.12 and 49 mg/m^2/dayfor As, Mn and sulfate were calculated (Table 5-20). Assuming a water-covered tailings area of 60,000 m^2, such fluxes translate to total daily loadings for As, Mn and sulfate of approximately 9, 7 and 3,000 g/day, respectively (Table 5-20). These values were incorporated into the contaminant mass balance. The values for As and Mn represent conservative upper estimates of the diffusive flux since a proportion of the upward diffusing As and Mn can be expected to be removed from solution via adsorption and co-precipitation within aerobic zones of the sand layer.

Table 5-20:
Diffusive Flux Estimates for As, Mn and Sulfate (30 cm sand diffusion layer)

Concentration in Tailings Porewater	Concentration in Dome Creek Inflow	Sand Thickness	Dj	F	Porosity	dc/dz	Flux	Tailings Area	Daily Flux
(mg/L)	(mg/L)	(cm)	(cm^2/s)	(no unit)	(no unit)	(g/cm^4)	($mg/m^2/day$)	(m^2)	g/d
4.10	0.015	30	6.10E-06	2	0.4	1.36E-07	0.14	60,000	8.6
4.94	0.250	30	4.55E-06	2	0.4	1.56E-07	0.12	60,000	7.4
1,610	411	30	7.16E-06	2	0.4	4.00E-05	49	60,000	2,967

5.7.2 Option 2- Tailings in Current Location with a Soil Cover

The assumptions, approach and exceptions for "Conservative Best Estimate" and "Worst Case" source term derivation under option 2 are the same as for option 1. No diffusive flux term was developed as the soil cover is assumed to prevent the upward migration of contaminants from the tailings mass. Further, the soil cover layer will not include a water cover for most of the year.

5.7.3 Option 3- Saturated Tailings in the Pit

The main assumption made in deriving source terms under option 3 was that the tailings will be homogeneously placed in the pit (in terms of grain size and mixing with organics). Derivation of source terms under option 3 utilized the tailings groundwater well data and first, assumed that metal attenuation processes currently occurring along the groundwater path from the tailings to the seepage pond will not occur in the pit (see "no attenuation" columns in Table 5-19). This assumption is based on the fact that there is neither an underlying organic layer nor a significant source of DOC within the pit to invoke and maintain sulfide precipitation processes currently attenuating metals (arsenic) in tailings seepage.

In reality, some degree of attenuation is likely to occur. Loading reduction factors of 50% for arsenic were applied to the model to account for attenuation along groundwater flowpaths between the pit and receiving water courses. Some degree of arsenic attenuation in the subsurface environment can be expected through adsorption/co-precipitation mechanisms. Specific removal mechanisms for dissolved arsenic include sorption to Fe oxides (Bowel, 1994), sorption to clay minerals (Violante and Pigna, 2002), and arsenic precipitation as secondary sulphide minerals (Martin and Pedersen, 2002). The presence of silt-clay facies in the underlying deposits in the area certainly suggest that the sorption of arsenic to clay minerals may play a dominant role. Further, the ore-body surrounding the open pit is defined as an iron-oxide deposit. The oxidized, iron-rich nature of the bedrock is also expected to provide some attenuation of arsenic, as

described by Bowell (1994). The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented. After applying the loading reduction factor, the As source terms for conservative best estimate and worst case become 4.7 and 7.5 mg/L, respectively.

Upon relocation, native, organic-rich sediments will be combined with tailings into the open pit. Saturated conditions and the presence of organic matter will likely lead to the persistence of mild suboxia (as observed currently) or the development of strongly suboxic conditions within tailings impounded in the pit.

The "Conservative Best Estimate" scenario assumes that the currently observed, mildly suboxic conditions present within the tailings impoundment will persist throughout the tailings mass after they are moved to the pit. As discussed in Section 5.4.1, mild suboxia is characterized as having depleted nitrate, elevated Mn and low sulfide (the presence of sulfide indicates the development of reducing conditions). Monitoring wells MP09-12 and MW09-04 show elevated Mn (~3.5 mg/L), depleted nitrate (<0.05 mg/L), and low sulfide (< 47 ug/L) concentrations. Therefore, these wells are considered to be suitable proxies for seepage that would emanate from a mildly suboxic tailings mass and in the absence of attenuation via sulfide precipitation. For each parameter, the most conservative value from the two wells was selected. Hence, "Conservative Best Estimate" source terms represent a composite water of these two mildly suboxic wells.

"Worst Case" estimates are derived under the assumption that strongly suboxic conditions develop within the tailings in the long-term. Under strongly suboxic conditions the Fe associated with Fe-oxides is reduced and the Fe-oxide mineral phase dissolves. Because As and other metals are often strongly associated with Fe-oxides, they are released and remain highly mobile as the Fe-oxides dissolve. Groundwater well MW09-02 best demonstrates strongly suboxic conditions within the tailings mass. Iron concentrations are 5-10 mg/L, Mn is 20-25 mg/L, nitrate is < 0.3 mg/L and sulfide is < 20 μg/L. MW09-02 was used a proxy for "Worst Case" concentrations that may occur within the saturated tailings backfilled into the pit in the long term.

The difference between the "Conservative Best Estimate" and "Worst Case" source terms under closure option 3 is small compared to the two sets of source terms provided for options 1 and 2. The narrow range under option 3 is reflective of the more conservative approach to attaining the "Conservative Best Estimate" source terms, rather than being a product of certainty. Unlike under options 1 and 2, a long-term, historic, and seasonal

dataset was not available for use in the evaluation of source terms for option 3. Data used for these estimates were collected from groundwater wells that were sampled on three occasions: July 2009, September 2009 and July 2010. Although the data from the three sampling periods is similar, a number of inferences and conservative assumptions needed to be made.

Note that data from the tailings field bins were not utilized in the derivation of source terms as they do not appear to have reached an equilibrium state yet. It is recommended that the bin sampling program continue to validate source term estimates.

5.7.4 Option 4- Tailings in Pit Stored Dry

Three assumptions were made in the derivation of source terms under option 4:

- The tailings are readily exposed to oxygen, oxidize, and become acidic (supported by static data, Section 5.2.2.4, and kinetic data, Section 5.3.1.1);
- Acidic drainage from the tailings persists and dominates seepage quality emanating from the backfilled pit; and,
- Acid generation and metal leaching from the tailings is analogous to measured seepage from Arctic Gold and Silver Tailings.

The approach to derive source terms under option 4 uses the Arctic Gold and Silver tailings seepage as a proxy for dry and oxidizing Mt. Nansen tailings. As discussed in Section 5.6, the Arctic Gold and Silver tailings have similar geology and geochemical characteristics as the Mt. Nansen tailings. Seepage water quality from Arctic Gold and Silver tailings was compared to the humidity cell chemistry in cells T4-T6 (NP removed). Humidity cell tests represent primary release rates with no consideration given to the influence of field conditions that govern the actual metal concentrations in drainage. However, they do provide valuable information on the leaching behavior of metals under acidic conditions and were therefore used to support the source term development. The kinetic cell pH and leacheate chemistry was found to be within the same order of magnitude as the Arctic tailings seepage chemistry with the exception of Mn (0.27-0.73 mg/kg/week and 25.9 mg/L in Arctic tailings seepage). Therefore, the Mn source term is deemed very conservative. “Worst Case” source terms were not developed for option 4 as there is insufficient data to appropriately evaluate an upper bound.

As described in section 5.7.3 the source terms were first derived assuming no attenuation will occur along the flowpath from the pit to the receiving environment. However, attenuation of As along this flowpath is likely, therefore a 50% loading reduction factor was applied to the As source term giving a revised As source term of 14 mg/L.

6. Mill Area Characterization

6.1 Introduction

The following chapter is a collaboration between Altura Environmental Consulting (Diane Lister) and Lorax.

6.1.1 Overview

The main mill complex at Mount Nansen consists of several buildings constructed on a series of platforms as shown in Figure 6-1. The mill complex has been established over many decades of mining at Mt. Nansen.

Early mining began in the 1960's and 1970's around the Heustis Ore Zone and included at least two adits or mine portals (Figure 6-2). The mill complex was constructed around these original workings. The upper Heustis adit was located above the mill and has been backfilled and regraded. The existence of the lower Heustis adit was revealed by former BYG employee (E. Wheeler, personal communication with Diane Lister, 5 July 2010). The location of the lower Heustis adit is inferred from historic airphotos, which indicate a rail system emerging from an adit near the Heustis underground workings, to the northeast of the mill and a conveyor that was used to move the ore up to the crusher feed area at top of the mill complex (Figure 6-3). Historical records reveal that just over 22,000 tonnes of ore was milled during the two operating periods from 1968 to 1969, and from 1975 to 1976 (Conor Pacific, 2000).

In the 1990's ore from the Brown-McDade pit was processed on site. Ore was hauled directly to the upper mill platform by haul truck. The original lower ore transfer area, no longer required, was levelled and appears to have been used subsequently as a general storage area for materials and some reagents. It has been assumed that the lower Heustis adit was backfilled and regraded at this time.

The main watercourses within and around the millsite include Dome Creek, three ponds, and numerous springs at road cuts. Review of late 1980's aerial photograph images reveal that the three ponds (Figures 6-2 and 6-3) appear to have been used in some way during early mining, and a site drawing from the mid-1990's suggests tailings were stored in these ponds (Higgs, 1994). The eastern-most and centre ponds (ponds #1 and #2 respectively; Figure 6-2) are earthen berm structures and are presently overgrown with vegetation. Remnants of an equipment building, possibly used to house a pump for recovering process water, are still visible at Pond #1. The western-most Pond #3 is currently lined with a geomembrane and is thought to have been utilized during the

1990's mining phase and in the years following mine closure. Historic tailings from the 1960's and 1970's that were reportedly deposited in Pond #3 were to be reprocessed through the mill and/or relocated to the main tailings impoundment prior to lining of the dam in the 1990's (Brodie Consulting, 1998). It is not clear whether this work was in fact carried out. The small volume of tailings identified in this investigation suggests that this was partially completed.

Dome Creek flows west to east from the toe of the access road embankment to the lower mill platform (Figure 6-2). Thick willow-dominated vegetation spans the valley bottom. Ground conditions tend to be moist within a several metre wide zone surrounding the main Dome Creek channel. In some locations within the study area the creek consists of two or more small channels. Due to the thick brush it is difficult to determine if the main stream is bifurcating or is being fed by other tributaries.

Springs emerging from road cuts and trenches on the hillside above the mill complex are also significant sources of water and have caused water inundation to some of the buildings on the main mill level. Drainage control work in recent years has diverted much of the near-surface water flows from around the main platform area and little water is now seen in the buildings.

Figure 6-1: Mt. Nansen Mill Site (August 2008)

CLIENT:: Yukon Government

Legend

- Dome Ck WQ Sites
- Adit
- Mill Area
- Contoured Heustis Workings
- Dome Creek
- Mine Road

Meters
0 55 110 220

SCALE:	1:3,000
DATE:	OCT 6th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Mt. Nansen Mill Area

PROJECT No:	FIGURE No:
J907-4	**6-2**

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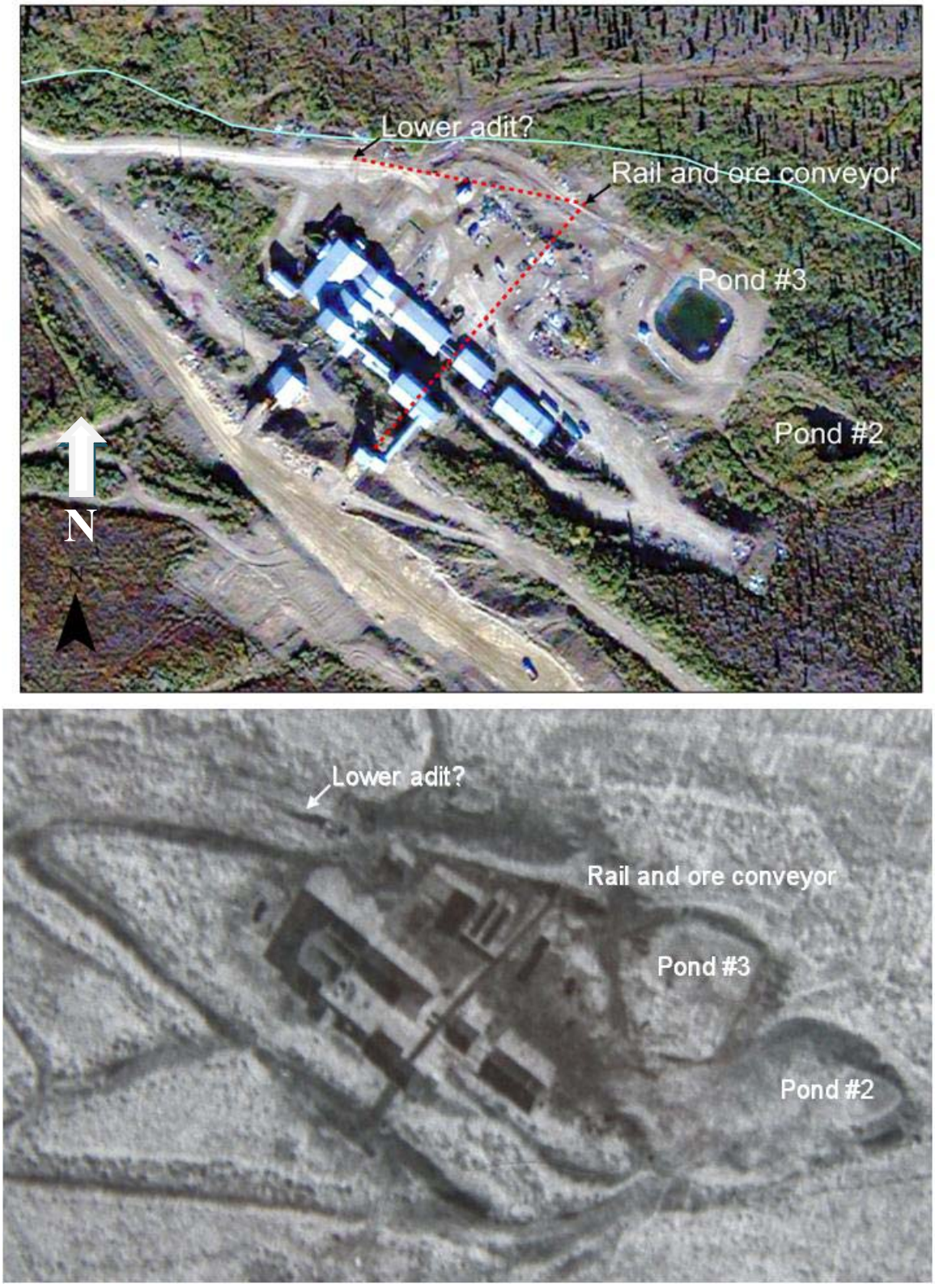

Figure 6-3: Earlier Mining Features Superimposed on 2008 Satellite Image and Lower Image is a Negative of an Aerial Photograph taken around 1986

6.1.2 Scope and Approach

The 2010 geochemical investigation of the mill area is preliminary in nature. Recommendations for further study are provided in Chapter 7. The principal objectives of the mill area geochemical characterization study were to:

- Identify the location, geochemical nature and extent of potential contaminant sources in the mill area that are likely contributing to dissolved metal concentrations in the Dome Creek basin; and,
- Improve understanding of water flow paths entering and exiting the mill area.

The study area (Figure 6-2) encompasses approximately 20 ha and comprises the main mill site and the area below the mill which was used to deposit tailings in the past (late 1960's and mid 1970's).

The approach to the preliminary geochemical characterization of the mill area included:

- A general field reconnaissance in an effort to:
    - locate and survey historic features such as the lower Heustis adit opening, ore transfer area and ponds; and,
    - understand the local surface and near-surface water flow regime;
- A detailed survey of conductivity/pH inflections within the main Dome Creek watercourse to better isolate potential contaminant source(s);
- Excavations to determine rock fill characteristics, with sampling for static characterization as merited; and,
- Water quality sampling of Dome Creek, selected seeps and ponds.

6.1.3 Previous Geochemical Investigations

Although a thorough and extensive investigation into contamination issues in the mill area has not been conducted to date, there have been several studies that provide relevant data:

- Altura (2009c) – excavated and sampled seven pits (HR1 to HR7; Figure 6-4) along the upper road (access to the crusher load out platform). This work formed part of a program to geochemically characterize the 1.5 km haul road from Brown-McDade pit to the mill;
- Water quality monitoring of Dome Creek has been routinely carried out by EDI at surface water stations DX, upstream of the mill area, and D1, just below the mill complex (Figure 6-5) since August 2007; and,

- Four shallow groundwater monitoring wells were installed in the lower platform areas of the mill complex (Figure 6-5) in 2009 as part of a site-wide groundwater investigation by AECOM, with groundwater sampling conducted in 2009 and 2010.

6.2 Static Characterization

Acid base accounting and aqua regia metals analyses were carried out on rock fill and pond sediments located within the study area. Results are summarized in the following sections.

6.2.1 Rock Fill

Nine test excavations were completed during the 2010 campaign on various platform levels of the study area. In 2009 seven test pits were completed in the upper mill platform (HR1 through HR7, Altura 2009c) and are shown in Figure 6-4. ABA results for the 2010 rock fill samples are given in Table 6-1, and metals results in Table 6-2. It is important to note that most samples were selected from zones of moderate to highly altered material, or where sulfides were visible in the rock samples examined. Thus, the tabulated results reflect the more geochemically reactive fill material within the mill area.

Seepage horizons and standing water were encountered in excavations MS-10-01, -02, -02A and -04. These sites are all located in the lower sectors of the mill site. Field measurements of intercepted water indicated circum-neutral to alkaline pH with electrical conductivities in the 1,500 to 2,000 μS/cm range. All other excavations, including the seven seepage sites sampled in 2009, were dry (Altura, 2009).

Excavations MS-10-02 and -02A were carried out in the area of Pond #2 to confirm the possible presence of tailings noted from the MW09-17 borehole log. Tailings were not encountered in the excavation but rather country rock fill material with a reddish sand-textured matrix (Note that this material when pulverized as drill cuttings could easily be mistaken for tailings).

Rock fill material from the main mill platform areas can be broadly classified into one of four categories: i) the local amphibolitic metamorphic suite (country rock); ii) remnant ore from either the original underground mining of the Heustis and possibly Webber zones which are locally concentrated in the lower platform area; iii) ore from the 90's era open pit production from the Brown-McDade zone; and, iv) mixed rock and refuse material.

387800 388000 388200

6881300

6881100

6880900

N

ROAD

HR7

HR6

HR5

HR4

HR3

HR2

HR1

MS 10-01

MS 10-02

MS 10-02A

MS 10-03

MS 10-04

MS 10-05

MS 10-06

MS 10-07

MS 10-08

MS 10-09

MS 10-10

CLIENT::

Yukon Government

Legend

- 2009 Mill Area Test Pits
- Trenches and Solid Samples
- Dome Creek
- Mine Road

Meters

0 35 70 140

SCALE: 1:2,000

DATE: OCT 6th, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE: **Excavations and solid sample collection sites, 2009 and 2010 investigations**

PROJECT No:	FIGURE No:
J907-4	**6-4**

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Lower Platform Ore Fill

A significant quantity of ore material was encountered in the lower platform area of the mill site (trenches MS-10-01, 04 and 05). The material in this area is likely spillage from the underground ore car loadout area during operations in the 1960's and 70's. Ore appears to have been transported from the Heustis workings by underground rail to this area where the cars dumped ore onto a conveyor system which carried the material to the crushing circuit on the upper platforms of the mill site (Figure 6-3). A small amount of old timbers and metal (rail and miscellaneous scrap) is mixed with the rock fill. Some zones and lenses of organic soil were encountered in trench MS-10-01 close to Dome Creek. This material exhibits orange-weathering and contains sulfides in varying quantities. Localized, patchy white to yellow weathering areas containing massive sulfide cobbles occur frequently. Within the six-sample set summarized in Tables 6-1 and 6-2, ABA and solid phase, multi-element results indicate localized zones of net acidity. In general, sulfide concentrations are above 0.50% and NPR ratios below 2.0. Elemental concentrations of Ag, As, Cd, Pb, S, Sb, Te and Tl are consistently 100 times average crustal concentrations. Concentrations of Zn are also elevated in most samples.

Ore Veneer – Brown McDade Ore

Several test pits indicate a 0.1 to 0.4 m thick veneer of mineralized material over older fill located within the mill area (the older fill in large part comprised of country rock). Due to its superposition over older fill, the veneer material is thought to be Brown-McDade mineralization (ore or low-grade ore). It should be noted that while a large quantity of Brown-McDade ore from the late 1990's operation of the mill was left stockpiled on the upper platform of the mill site at the time of mine closure, most of this material was excavated in 2008 and backfilled into the south end of the Brown-McDade pit.

Ore veneer is noted in excavations MS-10-07, HR-5 in the upper platforms of the mill area and in MS-10-03 on the main mill platform (Figure 6-4). The two ore veneer samples taken in 2010 characterize the material as having low NPR and variable sulfide content. The aqua regia metals signature is similar to the lower platform ore fill and is consistent with previous sampling of Brown-McDade mineralization (Altura, 2009b; 2009c).

Country Rock

Material primarily comprised of amphibolitic country rock was encountered in several excavations in the upper, mid, and main mill platforms, often underlying a veneer of clayey Brown-McDade ore or other fine surfacing material. This rock is often very blocky, but in some excavations was weathered to a sandy-textured soil. The 2009

excavations HR-1 through HR-7 on the uppermost platform consistently encountered country rock material, as did some of the 2010 excavations including MS-10-08 just northwest of the clarifier, MS-10-07 on the crusher platform, MS-10-02/02A in the area of Pond #2 and the deeper sections of MS-10-05 on the main mill platform (Figure 6-4).

Sulfide and sulfur content tend to be very low in country rock; however one sample (HR1) returned an ICP sulfur value of 0.52%. Nonetheless, based on NPR values, country rock material is considered to have low potential for net acidity, and metal leaching.

Mixed Rock and Refuse

The sector immediately southeast of the mill intersected by trench MS-10-06 is a combination of 1990's era refuse and mixed rock materials (mineralized and country rock). Refuse encountered in the excavation includes plastic, metal, wood and paper. Refuse, unused equipment, and used batteries are also scattered on the surface in this area. A white granular product that appears to have been in a 20 kg paper sack is likely ammonium nitrate (based on its appearance, pH 9 and high conductivity). A partial drum of another white caked product was also observed and is likely caustic soda (based on its pH value of 11 and the container specifications).

The one rock fill sample analyzed from this area returned results consistent with ore material: low NPR and the same suite of elevated metals. However field observations identify a variety of rock materials, including country rock.

Table 6-1:
Summary of Acid-Base Accounting Results for the 2010 Sampling of the Mill Area Rock Fill

	Material	Lower Platform Ore Fill						Ore Veneer		Country Rock		MRR[1]
	Sample ID #	MS-10-01A	MS-10-01B	MS-10-04A	MS-10-04B	MS-10-05A	MS-10-05B	MS-10-03A	MS-10-07A	MS-10-03B	MS-10-07B	MS-10-06
Paste pH		7.46	6.86	7.79	7.86	2.89	6.58	6.83	7.46	7.00	7.51	6.66
Fizz Rating		Slight	Slight	Moderate	Moderate	None	None	None	Slight	None	None	None
Paste Electrical Conductivity	uS/cm	603	828	866	749	2360	1267	678	1518	786	527	1759
Total Carbon	%	1.15	0.95	1.71	1.42	0.15	1.14	0.27	0.4	0.91	0.08	0.26
Total Inorganic Carbon	%	0.66	0.31	1.61	1.34	<0.01	0.05	0.02	0.26	0.06	<0.01	0.07
Total S	%	2.66	1.50	4.11	0.57	2.59	0.24	0.63	1.33	0.10	0.05	1.20
Sulfate-S	%	0.11	0.19	0.02	<0.01	1.17	0.04	0.29	0.27	0.02	0.01	0.59
Sulfide-S	%	2.12	1.25	4.00	0.52	0.68	0.15	0.05	0.92	0.07	0.03	0.25
Insoluble S	%	0.43	0.06	0.09	0.05	0.74	0.05	0.29	0.14	0.01	0.01	0.36
Non-Sulfate S	%	2.55	1.31	4.09	0.56	1.42	0.20	0.34	1.06	0.08	0.04	0.61
CaNP	$kgCaCO_3/t$	55.0	25.8	134.2	111.7	<0.8	4.2	1.7	21.7	5.0	<0.8	5.8
Bulk NP	$kgCaCO_3/t$	53.6	35.8	127.8	111.7	2.0	16.7	14.7	29.3	17.8	21.8	17.0
% CaNP of Bulk NP	%	103%	72%	105%	100%	<40%	25%	11%	74%	28%	4%	34%
SAP (sulfide AP)	$kgCaCO_3/t$	66.3	39.1	125.0	16.3	21.3	4.7	1.6	28.8	2.2	0.9	7.8
AP	$kgCaCO_3/t$	79.7	40.9	127.8	17.5	44.4	6.3	10.6	33.1	2.5	1.3	19.1
CaNPR		0.7	0.6	2.0	1.0	6.4	<0.02	0.7	0.2	0.7	0.3	<0.6
NPR		0.7	0.9	7.1	1.0	6.4	0.1	2.7	1.4	0.9	0.9	17.4

Notes:

1. MRR = Mixed Rock and Refuse
2. Gray shaded cells: <6.5 paste pH, ≥0.50% Sulfide-S, ≤2.0 NPR or CaNPR
3. See Appendix A.1.1, Altura, 2009a, for further details of analytical methodology
4. For calculation purposes, analytical results outside of minimum or maximum limits of detection are assigned a value equal to the respective detection limit
5. CaNP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne;
6. BulkNP = NP via siderite corrected neutralization potential
7. SAP calculated from sulfide S * 31.25
8. AP calculated from Non-Sulfate S * 31.25
9. CaNPR = CaNP/AP ; NPR = Bulk NP/AP

Table 6-2:
Solid Phase Metals Results for Mill Area Rock Fill and Pond Sediments

Metal[1]	Material	Lower Platform Ore Fill						Ore Veneer		Country Rock		MRR[2]	Pond Sediments			Av. Crust [3]
													Pond #1	Pond #2	Pond #2	
	Sample ID	MS-10-01A	MS-10-01B	MS-10-04A	MS-10-04B	MS-10-05A	MS-10-05B	MS-10-03A	MS-10-07A	MS-10-03B	MS-10-07B	MS-10-06	MS-10-09	MS-10-10A	MS-10-10B	
Ag	ppb	60956	84720	1870	1696	>100000	6324	2167	52841	2713	598	83886	>100000	564	514	75
As	ppm	6402	7933	6769	350	6394	973	283	2911	408	54.3	4404	>10000	74.9	74.3	1.8
Bi	ppm	1.35	0.92	0.30	0.12	3.94	0.15	0.88	21.9	0.31	0.11	28.2	2.28	0.12	0.11	*0.17*
Cd	ppm	96	62.8	7.06	30.2	40.4	3.42	2.45	25.4	2.91	0.44	22.25	97.35	0.45	0.41	0.15
Cu	ppm	222	216	28.4	39.0	587.5	49.9	33.4	516	38.7	51.6	255	685	32.42	33.72	60
Fe	%	5.02	4.17	5.06	4.1	3.6	2.89	4.25	4.5	3.01	3.73	4.5	4.5	2.2	2.21	5.63
Hg	ppb	209	245	60	114	507	74	26	371	68	45	385	251	43	34	*80*
Mn	ppm	1521	1559	2823	1898	172	571	305	2740	721	557	1083	1675	286	474	950
Pb	ppm	5277	3916	48.7	144	>10000	485	133	2079	192	27.04	3880	8216	34.25	25.62	*12.5*
S	%	2.62	1.49	4.09	0.55	2.61	0.24	0.61	1.34	0.12	0.04	1.22	2.82	0.10	0.18	0.035
Sb	ppm	461	537	35.6	24.09	1050	46.1	19.3	182	25.9	5.29	412	717	6.39	5.28	*0.2*
Se	ppm	1.5	1.6	1.3	0.7	2.6	0.6	0.8	0.4	0.8	0.7	0.6	1.2	0.3	0.4	*0.05*
Te	ppm	0.5	0.23	0.09	0.04	0.76	0.06	0.24	0.33	0.09	0.04	0.62	0.55	<0.02	<0.02	*0.005*
Tl	ppm	0.72	0.95	0.78	0.57	1.77	0.44	0.2	0.98	0.66	0.38	1.16	1.44	0.27	0.24	*0.001*
Zn	ppm	5901	3284	404	2438	2234	442	199	1681	212	94.7	1454	5835	78.1	68.6	70

Notes: 1. Values equal to or greater than 3 times the average continental crustal concentration are shaded in light grey; values equal to or greater than 10 times the average continental crustal concentration are shaded in medium grey; and values equal to or greater than 100 times the average continental crustal concentration are shaded in dark grey
2. MMR = Mixed Rock and Refuse
3. Average continental crust abundances according to Price (1997). Italic values are from CRC (1985)

6.2.2 Pond Sediments

Cores of sediments accumulated in ponds #1 and #2 (the two lower ponds; Figure 6-2) were collected using a manual hand auger. There was no significant accumulation of sediment noted in the geomembrane-lined Pond #3. Samples were analyzed for ABA, metals and moisture content.

It should be noted that the sediment samples collected from ponds #1 and #2 originate from only one site at the water's edge since available equipment did not permit safe ingress into the pond. ABA results for the pond sediments are given in Table 6-3 and metals results in Table 6-2 and are discussed below.

Pond #1 – Lower Pond

Sediments in Pond #1 are under less than a metre of water cover. The top 2 cm of sediment consists of organics and roots with a thin veneer of orange precipitate, likely accumulated from a small watercourse entering the pond. Below this surface layer is a thick horizon of very fine, amorphous grey-black clay to silt-textured substrate, which, based on geochemistry discussed below, are likely tailings slimes.

A 42-cm sample core was collected and submitted for analysis. ABA results reveal a sulfide content of 2.26%, a moderate NP value of 41 kg $CaCO_3$/t, and NPR and CaNPR ratios of 0.5. Concentrations of many metals are highly elevated including: 10,000 ppm As, 1,000 ppm Ag, 8,000 ppm Pb, and 5,000 ppm Zn. Gold is also elevated at over 8 g/t. The moisture content of the sample was 29%.

Pond #2 – Mid-Pond

The sediments collected from Pond #2 differ from those of Pond #1. In the accessible sectors of this pond, sediments are intercalated lenses of sandy-silt and organics, thus appearing to be relatively recent deposits accumulated from surface runoff.

The geochemical signature from samples MS-10-10A (16 to 45 cm depth) and MS-10-10B (45 to 75 cm depth) is consistent with what would be expected from surface runoff sediments. Sulfur and sulfide contents are low (less than 0.10%), carbon was largely present in organic form (2.5 to 4 percent total carbon with only trace levels of inorganic carbon) and heavy metal concentrations fall in the lower ranges of the suite of solids samples taken from the mill area. NPR and CaNPR values were 2.0 or greater, therefore these sediment samples are considered to have minimal net acid generation and/or metal leaching potential.

Additional characterization from the submerged area of Pond #2 is recommended. This pond is reportedly a water-retaining feature from the early mining phase. However, site drawings from the mid-1990's suggest that tailings were stored at this site

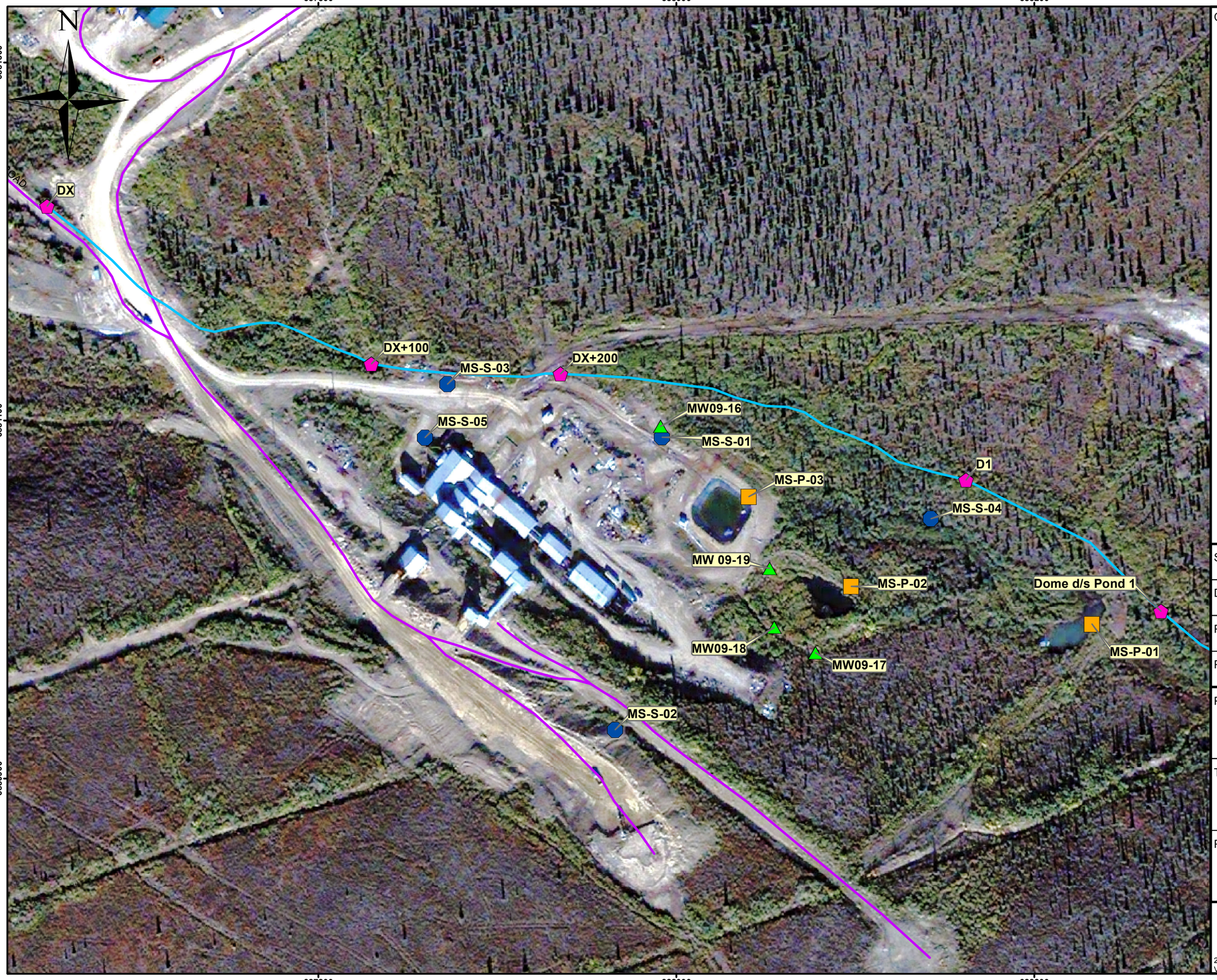
Table 6-3:
Summary of Acid Base Accounting Results for the 2010 Sampling of Pond #1 and Pond #2

	Sample #	MS-10-01A	MS-10-01B	MS-10-03A
	Site #	Pond #1	Pond #2	Pond #2
	Depth (cm)	5 - 40	16 - 45	45 - 75
Paste pH		7.53	6.65	6.62
Fizz Rating		Slight	None	None
Paste Electrical	uS/cm	1484	712	770
Total Carbon	%	0.86	2.59	3.96
Total Inorganic Carbon	%	0.53	0.03	0.07
Total S	%	2.96	0.10	0.19
Sulfate-S	%	0.16	0.02	0.09
Sulfide-S	%	2.26	0.04	0.06
Insoluble S	%	0.54	0.04	0.04
Non-Sulfate S	%	2.80	0.08	0.10
CaNP	$kgCaCO_3/t$	44.2	2.5	5.8
Bulk NP	$kgCaCO_3/t$	40.9	16.8	15.2
% CaNP of Bulk NP	%	108%	15%	38%
SAP (sulfide AP)	$kgCaCO_3/t$	70.6	1.3	1.9
AP	$kgCaCO_3/t$	87.5	2.5	3.1
CaNPR		0.5	1.0	1.9
NPR		0.5	6.7	4.9

Notes:
Gray shaded cells: <6.5 paste pH, ≥0.50% Sulfide-S, ≤2.0 NPR or CaNPR
See Appendix A.1.1, Altura, 2009a, for further details of analytical methodology
For calculation purposes, analytical results outside of minimum or maximum limits of detection are assigned a value equal to the respective detection limit
CaNP = Neutralization potential in tonnes $CaCO_3$ equivalent per 1000 tonnes of material, calculated from TIC originating from carbonates and is expressed in kg $CaCO_3$/tonne
BulkNP = NP via siderite corrected neutralization potential
SAP calculated from sulfide S * 31.25
AP calculated from Non-Sulfate S * 31.25
CaNPR = CaNP/AP

6.3 Drainage Characterization

Three of the main drainages within and around the mill area are characterized in the following sections including Dome Creek, seeps, and water management ponds (Figure 6-2). Additionally, monitoring well data from the mill area is presented in Section 6.3.4.



CLIENT:: Yukon Government

Legend

- 2009 MW Wells
- Pond WQ Sites
- Dome Ck WQ Sites
- Seepage WQ Sites
- Dome Creek
- Mine Road

Meters
0 35 70 140

SCALE: 1:2,000

DATE: OCT 6th, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Mill Area Water Quality Sampling Locations

PROJECT No:	FIGURE No:
J907-4	**6-5**

LORAX ENVIRONMENTAL
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6.3.1 Dome Creek

Water quality from stations immediately upstream and downstream of the mill complex (DX and D1, respectively; Figure 6-2) is documented in previous studies (EDI, 2008; AECOM, 2010). Table 6-4 clearly shows that significant metal and sulfate loading occurs in the 500 m reach from DX to D1. Below the mill complex, concentrations of Zn and Cd decrease along the 1,000 m reach between D1 and the Upper Dome station, located immediately upstream of the main tailings impoundment.

Table 6-4:
Summary of 3-year Median (2007-2009) Values for Key Modelling Points in Upper Dome Creek (mg/L) from AECOM (2010)

Parameter	Dome Creek, DX	Dome Creek, D1	Upper Dome
Sulfate	168	416	425
Arsenic (T)	0.0057	0.015	0.0145
Cadmium (T)	0.00004	0.00223	0.00022
Zinc (T)	0.009	0.509	0.019

Field pH and electrical conductivity measurements along the reach between DX and D1 indicated two significant upward inflection points in electrical conductivity, at approximately 100 m and 200 m downstream of station DX. Water quality samples were taken on July 5, 2010 from these two sites (stations DX+100 and DX+200) as well as from Dome Creek approximately 30m downstream of Pond #1 (Figure 6-2). Results from routine water quality sampling conducted at stations DX and D1 five days prior on June 30 were integrated with the July 5th sampling to depict a general water quality profile along this 700 m reach of Dome Creek that spans the mill area.

Dissolved sulfate, As, Cd, Fe and Zn concentrations along Dome Creek are presented in Figures 6-6 to 6-9. Arsenic, Cd and Zn concentrations exhibit a similar profile with a peak in the area of the mill complex (DX+200), followed by attenuation further downstream. Iron and Mn concentrations are also elevated at DX+200 (to 1.27 and 0.91 mg/L, respectively), relative to much lower concentrations at the two downstream stations.

Evidently, the substantial load of As, Cd, and Zn enters Dome Creek between DX+100 and DX+200. In general, Fe and Mn concentrations are low in oxygenated surface waters; elevated Fe and Mn concentrations in neutral pH waters can only be sustained by a suboxic, groundwater source. Downstream of DX+200 As, Cd, and Zn concentrations decrease. Conversely, sulfate increases steadily to 400 mg/L over the same interval. As a relatively conservative parameter, sulphate trends suggest that the decrease in metal

concentrations is not due to dilution in Dome Creek. Rather, the reddish precipitate that lines the creek at and downstream of DX+200 is a product of oxidizing Fe and Mn and their subsequent precipitation as Mn- and Fe-oxide solid phases. These Mn- and Fe-oxides have a high capacity to co-precipitate and/or absorb other metals. Likely, Fe, Mn, As, Cd, and Zn are all attenuated via the same geochemical mechanism, namely the precipitation of metal-bearing Mn- and Fe-oxides upon contact with oxygenated creek water.

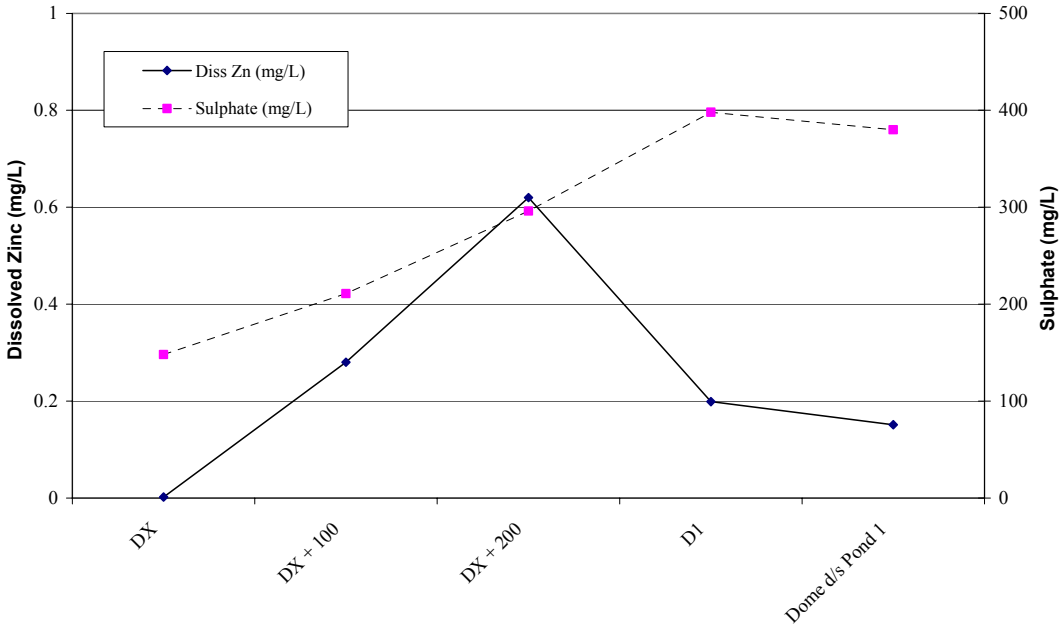

Figure 6-6: Dissolved Zinc and Sulfate in Upper Dome Creek

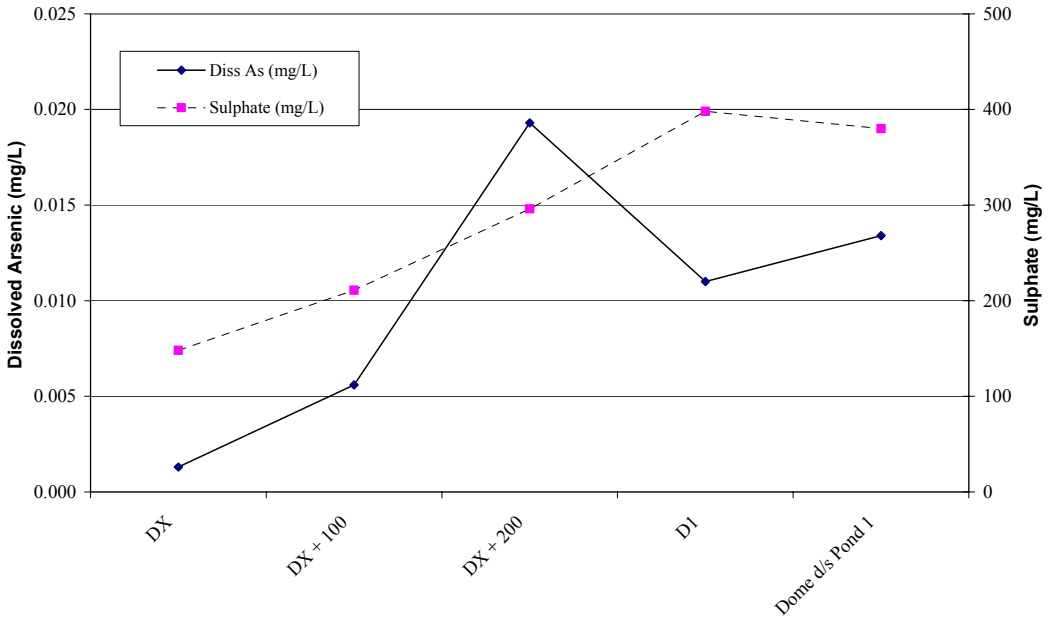

Figure 6-7: Dissolved Arsenic and Sulfate in Upper Dome Creek

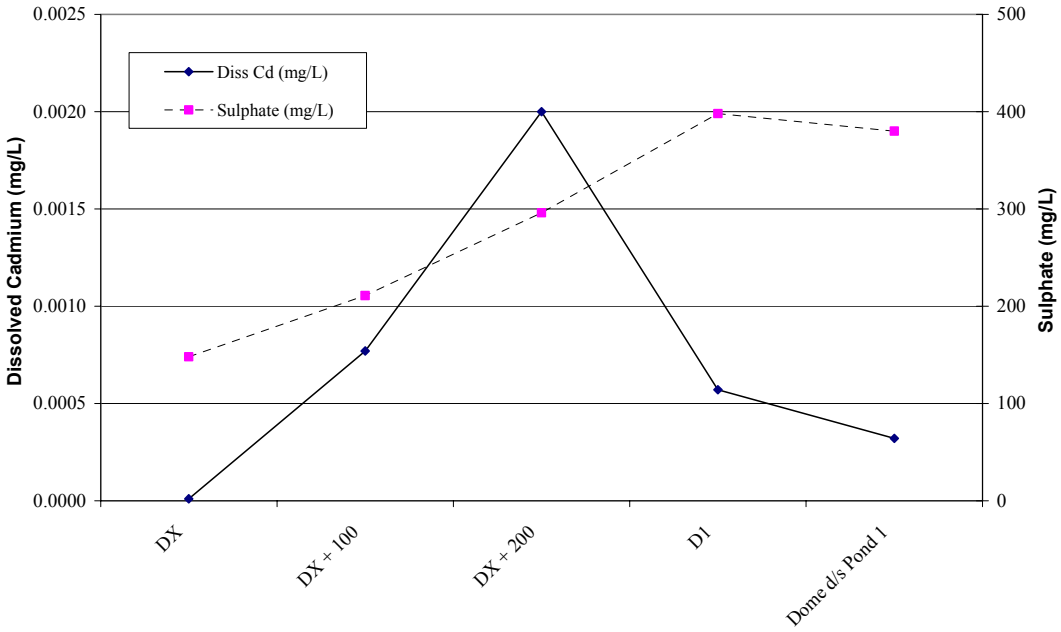

Figure 6-8: Dissolved Cadmium and Sulfate in Upper Dome Creek

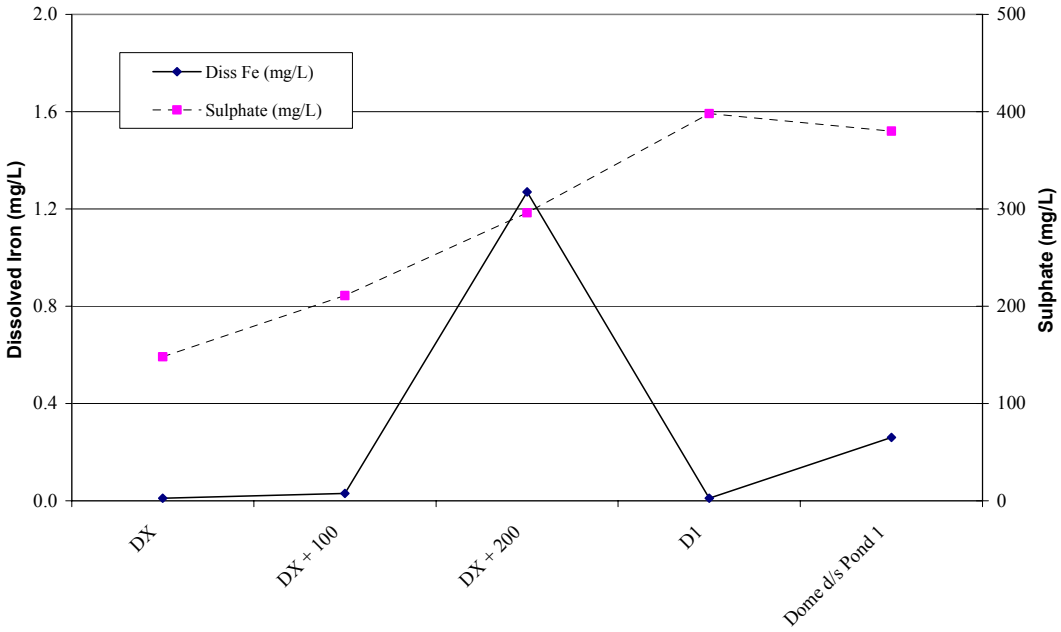

Figure 6-9: Dissolved Iron and Sulfate in Upper Dome Creek

In general, water quality results from Dome Creek suggest that the majority of loading to upper Dome Creek occurs between the between stations DX and D1. Peak concentrations of metals appears to occur between DX+100 and DX+200, or within the general vicinity of the lower Heustis adit (Figure 6-2). Total loading from the mill area appears to be limited to the drainage area above station D1, as indicated by measured sulphate concentrations.

6.3.2 Seeps

Five seeps (Figure 6-5) were sampled for water quality parameters, key results are tabulated in Table 6-5. Flow volumes were also visually estimated in order to evaluate approximate loadings for constituents of interest (Table 6-6). However it is important to note that some of the seeps discharge across a relatively wide zone, thus at times making it difficult to assess total flux visually.

Most seeps occur at lower elevations in the study area (MS-S-01, MS-S-04) and below the main mill platform, and throughout the vegetated zones below Pond #3, consistent with the local shallow groundwater system described in AECOM (2009). A few seeps were observed at higher elevations and were also sampled: i) MS-S-02, in the area where stockpiled Brown-McDade ore was removed in 2008; ii) MS-S-03, a high volume seep that emerges from the shoulder of the lower access road to the mill complex; and, iii) MS-S-05, a high-conductivity seep emerging on the northwest side of the mill building next to the thickener.

Water quality results returned variable concentrations of the main parameters of interest. Concentrations of dissolved Zn exceed the 0.03 mg/L CCME guideline at four of the five seeps sampled and the 0.3 mg/L Water License standard at three sites. The highest concentration of dissolved zinc was returned from seep MS-S-01 (3.71 mg/L), located within the area of lower platform ore fill and adjacent to Dome Creek. Significant loadings of Zn (0.7 mg/L) were also observed at seep MS-S-03, which discharges into Dome Creek just above station DX+200. Given the estimated flow of 75 L/min and a concentration of 0.7 mg/L Zn, the corresponding increase in zinc concentration along this sector of Dome Creek appears to reflect the contribution from MS-S-03. According to historic aerial photographs, this seep is located close to the lower HeustisHeustis adit (Figure 6-2), and thus could be related to the old underground workings.

Cadmium exceeds CCME guidelines at all five seeps sampled, and exceeds the Water License standard at seep MS-S-01 with a concentration of over 0.02 mg/L. Arsenic exceeds CCME guidelines at all five seeps sampled, with the highest value of 0.0592 mg/L returned from seep MS-S-04. Elevated concentrations of Fe and Mn were also obtained from this seep and considerable deposits of iron-rich precipitate were observed where the seep daylights suggestive of a suboxic groundwater source.

Seep MS-S-05, the high conductivity seep located beside the mill thickener, returned elevated sulfate concentrations but distinctly low metal levels relative to the other four seeps sampled. MS-S-02 from the old Brown-McDade ore stockpile area also returned relatively low concentrations of metals.

Table 6-5:
Water Quality Concentrations of Key Parameters in Seeps Located in Upper Dome Creek – Mill Area

Parameter	Units	MDL	CCME	Seep Location				
				S-01	S-02	S-03	S-04	S-05
Sulfate	mg/L	0.6	NP	874	112	291	469	1450
Arsenic	mg/L	0.0002	0.005	0.017	0.006	0.025	0.059	0.022
Cadmium	mg/L	0.00001	0.000017	0.0242	0.0011	0.0013	0.00061	0.00006
Iron	mg/L	0.01	0.3	0.01	0.01	0.24	5.83	0.05
Zinc	mg/L	0.001	0.03	3.71	0.063	0.734	0.404	0.006

Note: grey-shading indicates exceedences of CCME guidelines for freshwater aquatic life (total metals)

Table 6-6:
Loading Estimates of Key Parameters from Seeps in Upper Dome Creek – Mill Area

Parameter	Units	Seep Location				
		S-01	S-02	S-03	S-04	S-05
Est. Flow	L/min	40	2	75	250	10
Sulfate	g/min	35.0	0.2	21.8	117.3	14.5
Arsenic	mg/min	0.69	0.01	1.85	14.8	0.22
Cadmium	µg/min	968	2.2	101	153	0.6
Iron	mg/min	0.4	0.02	18	1458	0.5
Zinc	mg/min	148.4	0.126	55.05	101	0.06

6.3.3 Ponds

Results for key water quality parameters from the ponds are given in Table 6-7. The geomembrane-lined Pond #3 shows concentrations of metals and major ions that are markedly low relative to the other two ponds, and to most other sites sampled in the mill area. Nonetheless, low level exceedences of the CCME guideline values for As and Cd were recorded.

Ponds #1 and #2 show higher dissolved sulfate (294 to 592 mg/L) and arsenic concentrations (0.034 to 0.038 mg/L).

Table 6-7:
Water Quality Concentrations of Key Parameters from Ponds in Upper Dome Creek – Mill Area

Parameter	Units	MDL	CCME	Pond Location		
				P-01	P-02	P-03
Sulfate	mg/L	0.6	NP	592	294	140
Arsenic	mg/L	0.0002	0.005	0.034	0.038	0.006
Cadmium	mg/L	0.00001	0.000017	0.0001	0.0000	0.0002
Iron	mg/L	0.01	0.3	0.03	0.16	0.06
Zinc	mg/L	0.001	0.03	0.016	0.002	0.011

Note: grey-shading indicates exceedences of CCME guidelines for freshwater aquatic life (total metals)

6.3.4 Shallow Groundwater

Groundwater samples were collected from monitoring wells in 2009 and 2010 and are presented in Table 6-8. Similar to results from most of the water quality sites in this assessment, all four monitoring wells showed slightly elevated concentrations of As and sulfate. The chemistry from MW09-16 contained distinctly elevated concentrations of Zn and Cd, reflective of its location within the lower platform ore fill. These results are also similar to the chemistry observed at seep MS-S-01 which daylights approximately 7 m downgradient. Markedly elevated ammonia and sulfide concentrations at MW09-19 are reflective of a strongly reducing environment which may be related to its proximity to the refuse area on the above platforms. While sulfate concentrations are elevated in this well, Cd and Zn are very low, suggesting removal by sulfide precipitation.

Table 6-8:
Water Quality Concentrations of Key Parameters from Mill Area Piezometers

Parameter	Units	MW09-16		MW09-17		MW09-18			MW09-19	
		19-Jul-09	2-Jul-10	19-Jul-09	2-Jul-10	19-Jul-09	19-Jul-09	2-Jul-10	19-Jul-09	2-Jul-10
pH	pH	7.38	7.78	7.74	7.78	7.71	7.71	7.8	7.29	7.24
Ammonia (as N)	mg/L	0.079	0.023	0.229	<0.01	0.041	0.066	<0.01	3.24	2.45
Nitrate (as N)	mg/L	<0.25	0.134	<0.25	0.298	<0.25	<0.25	<0.05	<0.25	<0.05
Nitrite (as N)	mg/L	<0.05	<0.01	<0.05	<0.01	<0.05	<0.05	<0.01	<0.05	<0.01
Sulfate (SO_4)	mg/L	934	1040	1360	1240	1490	1470	1420	1390	1240
Sulfide	µg/L	-	<2.0	-	<2.0	-	-	<2.0	-	613
Cyanide, WAD	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanide, Total	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Cyanate (CNO)	mg/L	1.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4.26	<0.5
Thiocyanate (SCN)	mg/L	-	0.98	-	1.22	-	-	1.23	-	1.72
Arsenic (As)	mg/L	0.0506	0.0307	0.0119	0.016	0.0382	0.0423	0.0842	0.0769	0.0743
Cadmium (Cd)	mg/L	0.0558	0.0656	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085	<0.000085
Copper (Cu)	mg/L	0.010	0.0128	<0.005	0.0006	<0.005	<0.005	<0.0005	<0.005	<0.0005
Iron (Fe)	mg/L	0.389	0.194	<0.03	<0.03	<0.03	<0.03	0.164	40.6	33.6
Lead (Pb)	mg/L	0.036	0.035	0.0025	0.00025	0.0025	0.0025	0.00025	0.0025	0.00025
Manganese (Mn)	mg/L	0.389	0.592	0.0164	0.00038	0.349	0.409	0.767	2.39	2.38
Zinc (Zn)	mg/L	4.44	5.74	<0.005	<0.005	<0.005	<0.005	<0.005	0.0088	<0.005

Note: Note: Values in red type are less than the method detection limit (MDL).

6.4 Discussion and Data Summary

Reconnaissance, excavations, and previous studies indicate that zones below the main mill platform and the vegetated zones below Pond #3 are within a shallow groundwater zone and effectively discharged to the Dome Creek watershed. Above this zone, seep MS-S-03, possibly originating from the lower HeustisHeustis adit area, is the only significant flow identified in the study to be affecting Dome Creek water quality.

Mid-summer 2010 water quality sampling along the reach of Dome Creek adjacent to the mill area indicates a notable influx of dissolved As, Cd, Fe, Zn and other metals along the first 200 to 300 metres of the watercourse upstream of station D1. Results and field evidence indicates that some metal attenuation occurs at points downstream, likely due to the precipitation of metal-bearing Fe and Mn-oxides.

Four main material rock fill types are identified within the platforms underlying and surrounding the mill complex:

i) Country Rock - the local amphibolitic metamorphic suite;

ii) Lower Platform Ore Fill - remnant ore from 1960-1970 underground mining, primarily Heustis zone;

iii) Ore Veneer - ore from 90's era open pit production from the Brown-McDade zone, found as a thin veneer over platform fill; and,

iv) Mixed Rock and Refuse Material.

Static test results for the above-mentioned material types indicates that Country Rock may be considered to be effectively geochemically benign, but that the other material types, under certain conditions, may contribute to metal loading to Dome Creek through the generation of net acidity and/or leaching of metals.

This assessment also identified the existence of a deposit of tailings fines in Pond #1. A volumetric approximation using 1m topographic information indicates that up to 1,000 m^3 of tailings may be stored within Pond #1. While tailings were not present in the core sample of shoreline deposits from Pond #2, nor within the excavations carried out in the mill area, historical reports indicate that 20,000 to 25,000 tonnes of tailings were originally discharged below the mill area, and site drawings from the mid-1990's show the two upper ponds as containing tailings (Higgs, 1994). Other subsequent reports indicate that these stored tailings were slated for re-processing or relocation in the late 1990's, however this study reveals no tangible confirmation that this work was carried out to completion.

Areas of geochemical concern are considered to be those, which based on the results of this and previous investigations, show evidence of active and significant contributions of metal loading to Dome Creek; or present a significant risk of contributing to metal loading due to their physical location and/or composition. The following areas were identified:

- Lower Heustis Adit, which may be the source of seep MS-S-03 discharge to Dome Creek;
- Lower platform ore fill in the area of excavations MS-10-01, MS-10-04, and MS-10-05. This zone comprises an estimated 6,500 m^3 of material;
- Tailings accumulated in Pond #1. This zone comprises up to 1000 m^3 of material, however it is noted that further assessment for tailings is recommended for all historic pond areas, since available equipment only permitted core sampling of shoreline deposits; and
- A small amount of hazardous waste within the old refuse area. It is recommended that mitigation of this waste should be incorporated into the overall closure plan for Mt. Nansen.

7. Summary and Recommendations

7.1 Source Term Derivation and Uncertainties

Lorax Environmental Services Limited (Lorax) has conducted an investigation of mine materials (waste rock, tailings, ore, and pit wall rock) at the Mt. Nansen site with the ultimate objective of developing scientifically-defendable chemistry source term estimates for drainage from all geologic materials associated with mine features at closure. In order to achieve the objectives of this investigation, representative tailings, waste rock and ore samples from the Mt. Nansen mine site were collected during site visits conducted in 2008, 2009, and 2010. Static tests were conducted to evaluate geochemical stability, identify contaminants of concern, and to select material for longer-term kinetic testwork. Laboratory-based (humidity cells) and field-based (field weathering bins and saturated column experiments) kinetic programs were implemented in 2009, the results from which were used to derive realistic chemistry source terms that would be expected from Mt. Nansen waste materials under different closure scenarios. Further, an extensive groundwater study was conducted to characterize in-situ, geochemical processes that control the fate of constituents leaching from the tailings mass. This report provides a description of the rationale, methodology, analytical data and interpretation of test results used to derive source term estimates for the principal mine site components central to the various closure options being evaluated. The intended use of these source terms is their inclusion into a water quality model used to predict water quality impacts associated with the various closure options being considered for the Mt. Nansen site. Water quality modeling results are presented and discussed in detail in a separate report titled *Mount Nansen Closure Alternatives Assessment - Water Balance and Water Quality Model* (GEEC, 2010) and summarized in within *Mount Nansen Option for Closure – Technical Summary Report* (Lorax, 2010).

A short-list of closure options was considered in the design and approach taken to characterize mine features at Mt. Nansen. These options include the following:

- Option 1A – remediate tailings dam to maintain permanently saturated tailings under a water cover within the pre-existing impoundment, waste rock remains in its current location (subaerially exposed), and a pit lake;
- Option 1B – same as 1A with the exception that waste rock will be relocated to the pit. A portion of the waste rock will be below the water cover (saturated) and a portion will be above the water table (subaerially exposed);

- Option 2A - remediate tailings dam to maintain permanently saturated tailings under a soil cover within the pre-existing impoundment, waste rock remains in its current location (subaerially exposed), and a pit lake;
- Option 2B – same as 2A with the exception that waste rock will be relocated to the pit. A portion of the waste rock will be below the water cover (saturated) and a portion will be above the water table (subaerially exposed);
- Option 3 – tailings are relocated to the pit and stored under tension saturated conditions with a high infiltration cover, waste rock remains in its current location (subaerially exposed); and,
- Option 4 – tailings are relocated to the pit and maintained under dry conditions (hydraulically isolated) with a low infiltration cover. Waste rock will also be relocated and will be stored at the bottom of the pit (both above and below the water table) and at the surface (subaerially exposed).

The Brown-McDade pit lake, waste rock (and ore), and tailings which constituted the principal mine site components for which chemistry source terms were estimated are described in sections 7.1.1, 7.1.2 and 7.1.3, respectively.

7.1.1 Pit Lake

Options 1A and 2A most closely resemble the current environmental conditions at site. Specifically, the same geochemical mechanisms that are controlling the release and attenuation of metals currently will likely persist under options 1A and 2A. Under these options, there are no proposed changes in the configuration of the open pit lake. The main assumption under these options is that the all components (pit lake and adjacent waste rock) have reached equilibrium and shifts in this equilibrium state will be minimal.

The degree of uncertainty associated with the pit lake is relatively small for options 1A and 2A given the extent of the historic dataset. Furthermore, concentrations have remained relatively stable over the past two to three years, despite large variations in climate and pit lake elevation. The difference between the median maximum concentrations of pit lake constituents is generally within an order of magnitude. Pit wall ABA results suggest that while the pit walls are susceptible to acidic drainage, acid rock drainage has not been observed. Extreme fluctuations in the composition of pit lake waters are unlikely to occur. Significant fluctuations in the pit lake surface elevation may result in exposure of sulphide minerals prevalent in the deeper zone of the pit wall. Associated acid generation and concomitant increases in contaminant (principally metals and sulfate) loading to the pit lake water column (*i.e.,* increased sulphide oxidation rates during extremely low lake levels and flushing of soluble metal-bearing phases during

extremely high lake levels). Due to the relative stability of the pit lake elevation, it is unlikely that such conditions would persist in the longer-term.

7.1.2 Waste Rock

The options for waste rock management at closure include maintaining waste rock in its current location (subaerially exposed, options 1A, 2A, and 3) or relocation to the pit under a combination of saturated and unsaturated conditions (options 1B, 2B and 4). In support of the evaluation of these closure options, source term estimate of drainage quality were derived for both saturated and unsaturated waste rock.

Closure Options 1A, 2A, and 3 dictate that waste rock dumps will largely remain in their current form (except for minor regarding and revegetation). For the subaerially exposed waste rock, natural waste rock seep quality is used as a general benchmark against which source term estimations are evaluated. Seepage sites are limited and their quality may not necessarily represent the waste rock at Mt. Nansen as a whole. Given that only five lysimeter and natural seep locations were sampled throughout the site, there is uncertainty with regards to the representativeness of the chemistry results and their applicability to waste rock drainages at the whole site.

Large volumes of waste rock will be backfilled into the open pit and will remain under the water table (saturated). It is likely that the organic material underlying the waste rock piles will be relocated into the pit as well. Under these saturated conditions, suboxia may likely develop below the water table. In deriving source terms for the saturated waste rock it was assumed that the waste rock + organics field bin had fully evolved from oxic to suboxic conditions and therefore represents long-term drainage chemistry that will originate from the saturated waste rock in the pit. In fact, either suboxia has not fully developed within the bin or the redox-sensitive metals have yet to respond to the newly developed conditions. Arsenic, for example is expected to be significantly higher under pronounced suboxia than is being observed in the field bin. Either the bins have reached equilibria and reductive dissolution is not a mechanism of concern, or geochemical conditions within the bins are still evolving. Unfortunately, there is very limited data from which to evaluate this long-term behaviour and the uncertainty relating to the waste rock source terms under options 1B, 2B and 4 is significant.

Options 1B, 2B and 4 propose to place waste rock into the pit such that a portion will be above the water table and a portion below. Therefore, the chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both the unsaturated and saturated waste rock. To incorporate conservatism into the waste rock source terms under options 1B, 2B and 4, the saturated and unsaturated values for each parameter were compared and the highest value was selected.

7.1.3 Tailings

From a tailings geochemical standpoint Options 1A and 2A, and 1B and 2B are essentially the same with regards to the assumptions made and relative uncertainty. The only exception is that certain constituents (As, Mn and sulfate) are likely to diffuse from the tailings to the overlying water cover under options 1A and 2A. A diffusive flux source term has been developed for these options. Both tailings covers, water and soil, are designed to maintain a saturated state throughout the tailings in order to minimize acid mine drainage. Therefore, the release of metals via sulfide oxidation processes is assumed to be minimal under options 1 and 2.

Given the excess of sulfate and DOC within the impoundment, the currently observed attenuation of As, Cd, Cu and Zn along the flowpath from the tailings to the seepage collection pond, via precipitation as a sulfide phase, is assumed to persist in perpetuity. In addition to sulfate and DOC, the groundwater flow path is also required to remain relatively constant to maintain the level of attenuation currently observed. In deriving chemical source terms under options 1A, 1B, 2A, and 2B, it was assumed that the groundwater flow path is not altered over time by dam upgrades or degradation of the permafrost layer underlying the tailings impoundment.

The degree of uncertainty associated with the source terms derived for the tailings under Options 1 and 2 is low relative to long-term estimates derived for Options 3 and 4. Source terms estimates for options 1 and 2 are derived from a long-term historic dataset. However, if dam upgrades or degradation of permafrost alter the groundwater flow path such that it does not report to the seepage pond and/or does not come into contact with DOC-rich waters, metal-rich water may report to Dome Creek and subsequently to Victoria Creek.

Under option 3 the tailings are relocated to the pit and stored under tension saturated conditions. This option is designed to minimize acid mine drainage from the tailings by maintaining at least 85% water saturation to prevent the ingress of oxygen. It is therefore assumed that metal release via sulfide oxidation processes will be minimal and neutral pH conditions will persist in the long-term (*e.g.*, acid mine drainage will not occur). The organic layer underlying the tailings is also enriched in metals and will likely be moved along with the tailings. Even if the organic layer is not relocated intentionally it is likely that the process of excavation of the tailings will entrain a significant amount of organic material. Under tension-saturated conditions and in the presence of organic matter the tailings are likely to be mildly to strongly suboxic. Suboxic conditions throughout the tailings may promote the mobilization of the redox sensitive elements Fe and Mn, and metals that associate with their respective oxides (primarily arsenic, but also Zn, Cu and

Cd). It is assumed that redox mechanisms will be the dominant control on the release and attenuation of the metals of concern. It is also assumed that attenuation processes observed in the current tailings impoundment will not occur within the open pit due to the lack of a constant supply of DOC-rich waters (*e.g.*, bedrock water quality around the pit is low in DOC and is not strongly reducing). Although attenuation of metals via sulfide precipitation mechanisms is unlikely to occur within the pit, other attenuation mechanisms may occur within the pit and/or along the groundwater flowpath from the pit to Victoria Creek. Therefore, the assumption that no attenuation of metals will occur under option 3 is quite conservative.

Relative to options 1 and 2 there is significantly more uncertainty associated with the tailings source terms derived for option 3. Although it is very likely that the tailings porewater will be suboxic in nature, it is unknown whether Mn-reduction or Fe-reduction will dominate. Further, the rate of Mn or Fe-reduction that may occur within the pit is uncertain. If the rate is fairly slow the concentrations of metals observed in groundwater will be much lower than if reduction rates are higher. Further areas of uncertainty include the limited, short-term dataset (three sampling events over two summers, 2009 and 2010) upon which long-term water quality estimates are derived. Lastly, in-situ groundwater and porewater sampling may be biased. Groundwater sampling from the tailings mass is biased toward the more porous tailings intervals (*e.g.*, silt and sand). It is possible that porewater in the clay, which encompasses a large proportion of the tailings, has a different chemical signature compared to its sand and silt counterparts and is not adequately represented.

Similar to option 3, the tailings are excavated and relocated to the pit under option 4. However, rather than being stored under tension-saturated conditions, the design of option 4 will involve draining of the tailings and hydraulic isolation (stored dry and above the water table with a low-infiltration cover). Under this storage scenario, it is assumed that the tailings will produce acid mine drainage. Source terms were provided using two databases. The first dataset was derived from another site, Arctic Silver and Gold (Arctic) tailings, which serves as an analogue to Mt. Nansen. The Arctic Gold and Silver tailings have similar solid phase chemistry and geological origins as the Mt. Nansen tailings. The Arctic tailings have gone acid and currently produce drainage at a pH of approximately 2. The drainage chemistry from the Arctic site was compared to the lab-based kinetic experiments from Mt. Nansen tailing and suggest that Mt. Nansen tails will produce similar, low-pH drainage (2.4) with highly elevated metal concentrations typical of acid mine drainage (As, Cd, Cu Zn) if exposed to oxygen.

Option 4 presents the greatest amount of uncertainty due to the difficulties in extrapolating static and short-term kinetic tests into the distant future. The Arctic

Tailings provide a limited sense of certainty, particularly due to the similarities between the two sites, both geochemically and geographically. This certainty is limited by the lack of long-term data from the Arcitic Site, as it is represented by a single seepage quality sample. Evaluating temporal tends in data, such as seasonality of drainage chemistry or verification of chemical equilibrium in site drainages, is therefore not possible. Humidity cell tests were also used to constrain source terms. While these tests provide valuable information on the leaching behavior of metals from tailings under acidic conditions, they only represent primary release rates with no consideration given to the influence of field conditions that govern the actual metal concentrations in drainage. For this reason, laboratory-based kinetic tests are typically conducted in concert with field-based tests that better represent site-specific conditions.

7.2 Mill Area Characterization and Uncertainties

A mill area characterization study was conducted in 2010. Significant findings of this preliminary investigation include the following:

- There is significant loading of As, Cd, Fe, Mn, and Zn to Dome Creek from the mill area. The source appears to be groundwater flowing into Dome Creek between the sites DX+100 and DX+200, which may be in close proximity to a historic adit. Partial attenuation of these metals occurs downstream of DX+200 upon mixing with oxygenated Dome Creek waters.
- Approximately 1,000 m^3 of historic tailings were found in Pond #1. These tailings have elevated sulphide and metals contents.
- The ore fill located on the lower platform of the mill area may contribute to metal loading to Dome Creek through the generation of net acidity and/or leaching of metals.

Two main uncertainties arose from the mill area investigation:

- The location of the lower Huestis adit, which according to airphotos and site personnel, emerged from the hillside in Dome Creek adjacent to the mill. The potential for groundwater discharge from the adit loading metals to Dome Creek should be investigated.
- The location of historic tailings in the study area. Historical records indicate between 20,000 and 25,000 tonnes of tailings are stored on site, of which only 1,000 m^3 (2000 tonnes) has been located (Pond #1). Anecdotal evidence suggests that these tailings were relocated to the current impoundment.

7.3 Recommendations

To reduce geochemical uncertainties and refine specific aspects relating to the geochemical stability of the mine components under each option, the following future investigations are recommended:

1. Laboratory-based kinetic program – the NP-depleted kinetic cells (T4, T5, and T6) have been terminated as they have become acidic and peak metal release rates have been achieved (Appendix B1). Kinetic cells T1, T2 and T3 have not yet fully evolved and should continue to run, albeit at a reduced sampling schedule (*i.e.* pH and conductivity every week, sulfate every 2 weeks, and alkalinity, acidity and ICP-OES metals once a month). The data should be monitored continually for the development of acid mine drainage conditions. The program can then be assessed for termination or continuation.
2. Field-based kinetic program – field bins should continue to be maintained and serviced. Leachate should be collected and submitted for analysis on a monthly basis throughout the active season. Spring maintenance is recommended and field bin performance should be reevaluated at the end of each season.
3. Waste rock lysimeters – lysimeter water samples should be collected and submitted for analysis on a monthly basis during the active season, with a particularly emphasis on spring snowmelt.
4. Waste rock seeps – seeps should continue to be sampled from the waste rock dumps. Samples should be collected and submitted for analysis on a monthly basis when they are actively flowing.
5. Additional investigative work should be conducted on the Arctic Gold and Silver tailings, including seepage sample collection, for comparative purposes.
6. The location of the lower Huestis adit should be explored as it may be contributing significant metal loads to Dome Creek.
7. The location of historic tailings in the mill site area should be investigated.
8. The mill site area water quality surveys carried out in 2010 should be repeated in 2011 to confirm the initial results and to better elucidate potential attenuation mechanisms noted in the lower reaches of the mill area.

References

AECOM (2009) Hydrogeological Field Investigation Summary. Internal memorandum from Ryan Mills to Allistair Kent, December 3, 2009, 130 pp.

AECOM (2010) Overview of Mt. Nansen Closure Alternatives Characterization, *prepared for* Assessment and Abandoned Mines Branch, Government of Yukon, June 2010.

Altura Environmental Consulting (2009a) Brown McDade Waste Rock Pile Mount Nansen Mine Site, Yukon Geochemical Characterization, *prepared for* Assessment and Abandoned Mines Branch Energy, Mines and Resources Government of Yukon, March 2009.

Altura Environmental Consulting (2009b) Brown McDade Waste Rock Characterization Mount Nansen Mine Site, Yukon Summary of 2009 Work Program, *prepared for* Assessment and Abandoned Mines Branch Energy, Mines and Resources Government of Yukon, December 2009.

Altura Environmental Consulting (2009c) Mount Nansen Mine Closure: Mine to Mill Haul Road – Summary of Rock Characterization Studies. Technical Memo to AECOM dated December 22, 2009, 8 p.

Benner, S. G., D. W. Blowes, W. D. Gould, R. B. Herbert, and C. J. Ptacek (1999) Geochemistry of a permeable reactive barrier for metals and acid mine drainage, *Environ. Sci. Technol.*, *33*(16), 2793-2799.

Brodie Consulting Ltd., 1998. *Mt. Nansen Mine Closure Cost Assessment.* Report prepared for Water Resources Division, Indian and Northern Affairs Canada, 41 pp.

Cline, J.D. (1969). Spectrophotometric Determination of Hydrogen Sulfide in natural waters, *Limnology & Oceanography* 14(3), 454-458

Canadian Council of Ministers of the Environment (2007) Canadian Water Quality Guidelines for the Protection of Aquatic Life, updated December 2007.

Conor Pacific, 2000. *Mount Nansen Minesite – Historical Review, Site Assessment, and Field Sampling Program.* Final Report Version 2. Prepared for Indian and Northern Affairs Canada, 223 pp.

CRC (1985). CRC handbook of Chemistry and Physics. Robert C. Weast (Editor). CRC Press Inc., Boca Raton, Florida. Pp F-145.

Davison, W. and Woof, C. 1990. "The dynamics of alkalinity generation by an anoxic sediment exposed to acid water." Water Research. Volume 24, pp. 1537-1543.

EDI Environmental Dynamics, 2008. *Mt Nansen Site Specific Water Quality Investigation*. Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 139 pp.

Evans, K.A. and Banwart, S.A. (2006) Rate controls on the chemical weathering of natural polymineralic material. I. Dissolution behaviour of polymineralic assemblages determined using batch and unsaturated column experiments Applied Geochemistry 21: 352–376.

Evans, K.A., Watkins, D.C. and Banwart, S.A. (2006) Rate controls on the chemical weathering of natural polymineralic material. II. Rate-controlling mechanisms and mineral sources and sinks for element release from four UK mine sites, and implications for comparison of laboratory and field scale weathering studies, Applied Geochemistry 21: 377–403.

Filella, M., P. A. Williams, and N. Belzile (2009), Antimony in the environment: knowns and unknowns, *Environmental Chemistry*, *6*(2), 95-105.

GEEC (2010), Mount Nansen Closure Alternatives Assessment - Water Balance and Water Quality Model. Prepared for Prepared for Energy Mines and Resources, Yukon Government. Prepared by GEEC Consulting, Oct. 2010

Harvey, C. F., *et al*. (2002), Arsenic Mobility and Groundwater Extraction in Bangladesh, *Science*, *298*(5598), 1602-1606.

Hinkle, S. R., and D. J. Polette (1999), Arsenic in Ground Water of the Willamette Basin, Oregon, edited by U. S. D. o. t. I. U. S. G. Survey, USGS, Portland, Oregon.

Huerta-Diaz, M. A., A. Tessier, and R. Carignan (1998). Geochemistry of trace metals associated with reduced sulfur in freshwater sediments, *Applied Geochemistry*, *13*(2), 213-233.

Jambor, J (2005). Mineralogy of Tailings from the Mount Nansen Site, Yukon. Prepared for Energy and Mines Resources, Yukon Government. Prepared by John Jambor, Leslie Investments Ltd. November 2005.

Jambor, J.L., Blowes, D.W., and Ritchie, A.I.M. (eds.) (2003) Environmental Aspects of Mine Wastes. Mineralogical Association of Canada Short Course Vol. 31, 430 p.

Klohn-Crippen (1994). Venus Mine Tailngs, Study of Remedial Options. Prepared for Poushinsky Consulting, Whitehorse, Yukon. Prepared by Klohn-Crippen Consultants Ltd. March 1994.

Kohlmeyer, Ute, J. Kuballa, E. Jantzen (2002). Simultaneous separation of 17 inorganic and organic arsenic compounds in marine biota by means of high-performance liquid chromatography/inductively coupled plasma mass spectrometry, *Rapid Commun. Mass Spectrom., 16*, 965-974.

Kwong Y.T.J., A. Kapoor and J.-F. Fiset, (2002) Assessment of Chemical Stability of Impounded Tailings at Mt. Nansen, Yukon Territory. Prepared for Water Resources Division, Indian and Northern Affairs Canada, prepared by CANMET Mining and MineralSciences Laboratory, Natural Resources Canada. Project: 602345, Report MMSL 02-011(CR), June 2002.

Lapakko, K. A., (2003). Developments in humidity cell tests and their application, in: Jambor, J. L.; Blowes, D. W.; Ritchie, A. I. M., (Eds.), Environmental aspects of mine wastes, Minerals Association of Canada 147-164.

Li, Y.H and S. Gregory (1974) Diffusion of ions in sea water and deep-sea sediments. *Geochemica Cosmochimica Acta.* 308, 704-713.

Lorax (2008). Mount Nansen Tailings Porewater Assessment. Prepared for Energy Mines and Resources, Yukon Government. Prepared by Lorax Environmental Services Ltd. April 2008.

Lorax (2009). Mt Nansen Tailings – Long Term Storage Conditions Recommendations. Prepared for Energy Mines and Resources, Yukon Government. Prepared by Lorax Environmental Services Ltd. April 2009.

Lorax (2010). Mt Nansen Closure Plan Options Evaluation. Prepared for Energy Mines and Resources, Yukon Government. Prepared by Lorax Environmental Services Ltd. October 2010.

Malmstrom, M.E., Destouni, G., Banwart, S.A., Strömberg, B.H.E., 2000. Resolving the scale-dependence of mineral weathering rates. *Environmental Science and Technolog*y 34 (7), 1375–1378.

Martin, A.J. and Pedersen, T.F. (2002). Seasonal and interannual mobility of arsenic in a lake impacted by metal-mining. Environ. Sci. Tech., 36: 1516-1523.

Ministry of Environment (2006) British Columbia Approved Water Quality Guidelines 2006 Edition**,** Environmental Protection Division, Government of British Columbia, updated August 2006.

Ministry of Environment, L. a. P. (1998), Guidelines for Interpreting Water Quality Data, edited by R. I. Committee, Province of British Columbia.

Morin, K.A. and N.M. Hutt. 1997. Environmental geochemistry of minesite drainage: practical theory and case studies. MDAG Publishing, Vancouver, B.C.

Nordstrom, D.K. (2000). Thermodynamic properties of environmental arsenic species: Limitations and needs, *in* Young, C., ed., Minor elements 2000, processing and environmental aspects of As, Sb, Se, Te, and Bi: Society for Mining, Metallurgy, and Exploration, p. 325-331

Price, W.A. (1997) Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. Reclamation Section, Energy and Minerals Division, British Columbia Ministry of Employment and Investment.

Price, W.A. and J. Errington. 1998. Guidelines for Metal Leaching and Acid Rock Drainage at Minesites in British Columbia. British Columbia Ministry of Energy and Mines. p. 86.

PWGSC (1998). Phase III Environmental Assessment of the Arctic Gold and Silver Mill and Tailings Impoundment. Prepared for Waste Program, Indian and Northern Affairs Canada, Whitehorse, Yukon. Prepared by Environmental Services, Public Works and Government Services Canada, Western and Northern Region. March, 1998.

Sapsford, D.J., Bowell, R.J., Dey, M. And Williams, K.P. (2009). Humidity cell tests for the prediction of acid rock drainage, Minerals Engineering 22 (2009) 25–36.

Schnoor, J. (1990) Kinetics of Chemical Weathering: A Comparison of Laboratory and Field Weathering Rates. In: *Aquatic Chemical Kinetic* (ed. By W. Stumm), 475-504, John Wiley, New York.

T.W. Higgs Associates (1994). Initial Environmental Evaluation Mt. Nansen Development. Prepared for B.Y.G. Natural Resources Inc., November 1994, 2 Volumes.

Trainor, T. P., S. H. Mueller, V. Ritchie, and R. J. Goldfarb (2006), Controls on Antimony Speciation and Mobility in Legacy Mine Tailings Environments: A Case Study of Mineral Occurrences in the Tintina Gold Province, Alaska and Yukon, edited, U.S. Geological Survey.

White, A.F., Blum, A.E., Schulz, M.S., Bullen, T.D., Harden, J.W., Peterson, M.L., 1996. Chemical weathering rates of a soil chronosequence on granitic alluvium. 1. Quantification of mineralogical and surface area changes and calculation of primary silicate reaction rates. Geochim. Cosmochim. Acta 60, 2533–2550.

White, A.F. and Brantley, S.L. (2003) The effect of time on the weathering of silicate minerals: why do weathering rates differ in the laboratory and field? Chemical Geology 202, 479-506.

Yukon Government (2008). Options for Closure of the Mt. Nansen Mine. Technical Review Report by Energy, Mines, and Resources, Yukon Government. July 2008.

SGS CEMI Inc.

Static Testing Procedures

for

Lorax Environmental Services (Mt. Nansen Project)

November 10, 2009

1.0 Sample Receiving

Samples were received, logged-in and sample weights recorded.

2.0 Sample Preparation

Wet samples were air-dried at ambient temperatures and homogenized by breaking up lumps with a stainless steel rolling pin and mixing on a rolling mat. Representative splits of sample were made using a 12.7 mm opening splitter box. To produce a finely ground sample for analysis, 200 g was placed in a ring pulverizer to produce 80% -200 mesh.

3.0 Analysis

3.1 Paste pH

Paste pH was conducted at CEMI according to the procedure by Sobek, A. A., *et al.* 1978. "Field and Laboratory Methods Applicable to Overburdens and Minesoils", Report EPA-600/2-78-054.

3.2 Acid Base Accounting

The samples were analyzed at SGS CEMI according to the procedure outlined in Leavitt, B. J., *et al.* 1995. "Effects of Siderite on the Neutralization Potential in the Acid-base Account" In: Proc. 17th Annual West Virginia Surface Mine Drainage Task Force Symposium, 4-5 April, West Virginia Univ., Morgantown.

3.3 Total Sulphur

Total sulphur was determined by Assayers Canada using a Leco induction furnace.

3.4 Sulphate-Sulphur

Three hundred and two samples were sent to Assayers Canada and one hundred and forty-seven samples were sent to International Plasma Labs Ltd. (IPL) for acid-soluble sulphate analysis according to ASTM D2492-02 "Standard Test Method for Forms of Sulfur in Coal". In this procedure, the sample is digested with 20% hydrochloric acid and the sulphur content measured by ICP.

3.5 Sulphide-Sulphur

Sulphide-sulphur was determined by Assayers Canada on 302 samples. The procedure is based on a modified sulphide-sulphur method by Sobek, A. A., *et al.* 1978. "Field and Laboratory Methods Applicable to Overburdens And Minesoils", Report EPA-600/2-78-054. In this procedure, acid-soluble sulphate is first removed by treatment with 20% hydrochloric acid. The sulphide-sulphur in the residue is oxidized to sulphate in a 1:7 nitric acid to water solution, and the sulphur content is then measured by ICP.

3.6 Insoluble Sulphur

Insoluble sulphur is calculated as the difference between total sulphur and the sum of sulphate-sulphur and sulphide-sulphur (Total S – Sulphate S + Sulphide S). Insoluble sulphur is considered as acid-insoluble sulphur and is attributed to refractory sulphate compounds such as barite and alunite and to organic sulphur found in coal.

3.7 Inorganic Carbon

Total inorganic carbon was determined by Assayers Canada. In this procedure, a known weight of sample is placed into a glass test tube and acidified with 25% hydrochloric acid. The sample is boiled to evolve CO_2 which is measured by coulometric titration with a UIC Carbon Dioxide Analyzer.

3.8 Total Metals

Total metals were conducted by Acme Analytical Laboratories Ltd. (Acme) on a pulverized sample by digesting 0.500 g in aqua regia at 95°C for 1 hour. The extract is then diluted to 10.0 mL and analyzed for metals by ICP-MS.

3.9 Shake Flask Extraction

Samples were selected for analysis by shake flask extraction using a 3:1 liquid to solid ratio as described by W. A. Price "Draft Guidelines and Recommended Methods for the Prediction of Metal Leaching and Acid Rock Drainage at Minesites in British Columbia", British Columbia Ministry of Employment and Investment, Energy and Minerals Division.

The leachate was filtered through 0.45µm membrane filter paper and submitted for analysis. The pH was measured using a pH electrode; conductivity was measured with a conductivity probe; the oxidation-reduction potential was measured with an ORP electrode; acidity was determined by titration with base to an end point of either pH 4.5 (free acidity) and/or pH 8.3 (total acidity); alkalinity was determined by titration with an acid to an end point of pH 4.5; sulphate was measured by the turbidimetric method. Subsamples of the filtered leachate were sent to Maxxam Analytics Inc. for metals analysis by ICP-MS.

3.91 Particle Size

Particle size analysis was conducted according to ASTM E276 – 03; "Standard Test Method for Particle Size or Screen Analysis at No. 4 (4.75 mm) Sieve and Finer for Metal-Bearing Ores and Related Materials"

Appendix A1
Particle Size Distribution analyses of field bin material

Station ID		Ore Bin			Waste Rock Bin			Waste Rock + ORG Bin		
Sieve Designation	Aperture	Weight Retained								
				Cumulative			Cumulative			Cumulative
	(mm)	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)
+1/2"	12.5	56.4	0.09	0.09	59.08	0.10	0.10	65.25	0.11	0.11
-1/2" + 3/8"	9.5	78.3	0.13	0.22	82	0.14	0.24	72.48	0.12	0.23
-3/8" + 1/4"	6.3	98.85	0.17	0.39	112.27	0.19	0.42	81.27	0.14	0.37
-1/4" + 10	1.7	171.15	0.29	0.68	153.68	0.26	0.68	134.37	0.22	0.59
-10 + 35	0.425	114.13	0.19	0.87	113.48	0.19	0.87	132.55	0.22	0.81
-35 + 100	0.15	40.32	0.07	0.93	40.6	0.07	0.94	57.03	0.10	0.91
-100 + 270	0.053	19.17	0.03	0.97	18	0.03	0.97	25.85	0.04	0.95
-270	-0.053	20.76	0.03	1.00	20	0.03	1.00	29.69	0.05	1.00
TOTAL		599.08	1.00		599.11	1.00		598.49	1.00	

Station ID		Pile 09-01			Tailings + ORG Bin			Tailings Pond Sand			Tailings Sand		
Sieve Designation	Aperture	Weight Retained											
				Cumulative			Cumulative			Cumulative			Cumulative
	(mm)	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)	(g)	(%)	(%)
+60	0.25	21.34	0.22	0.22	14.1	0.14	0.14	9.01	0.09	0.09	5.22	0.05	0.05
-60 + 80	0.18	20.95	0.21	0.43	12.03	0.12	0.26	24.12	0.24	0.33	5.06	0.05	0.10
-80 + 100	0.15	8.79	0.09	0.52	6.16	0.06	0.33	12.66	0.13	0.46	3.92	0.04	0.14
-100 + 120	0.125	10.9	0.11	0.63	8.5	0.09	0.41	21.3	0.21	0.68	6.78	0.07	0.21
-120 + 200	0.075	20.59	0.21	0.84	21.46	0.22	0.63	22.45	0.23	0.90	24.82	0.25	0.46
-200 + 325	0.045	9.44	0.10	0.93	15.47	0.16	0.79	7.03	0.07	0.97	21.03	0.21	0.68
-325 + 400	0.038	1.73	0.02	0.95	6.36	0.06	0.85	0.7	0.01	0.98	12.38	0.13	0.80
-400	-0.038	4.8	0.05	1.00	14.76	0.15	1.00	1.97	0.02	1.00	19.63	0.20	1.00
TOTAL		98.54	1.00		98.84	1.00		99.24	1.00		98.84	1.00	

Station ID		Tailings Clayey Silt		
Sieve Designation	Aperture	Weight Retained		
				Cumulative
	(mm)	(g)	(%)	(%)
+60	0.25	5.54	0.06	0.06
-60 + 100	0.15	6.88	0.07	0.13
-100 + 200	0.075	21.43	0.22	0.35
-200 + 325	0.045	15.54	0.16	0.50
-325 + 400	0.038	14.07	0.14	0.65
-400	-0.038	34.58	0.35	1.00
TOTAL		98.04	1.00	

Appendix A1
ABA data for ore and waste rock test pits

Sample ID	Date	Paste pH	Paste EC_µS/cm	TIC % C	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	CalcS(-2) (i.e., non-sulfate S) %	CaNP kgCaCO3/t	NP kgCaCO3/t	SAP kgCaCO3/t	CalcSAP (non-sulfate S) AP kgCaCO3/t	Net NP	NPR (CaNP/SAP)	NPR (CaNP/AP)	NPR (ScNP/SAP)	Fizz Test
ORE																		
OB01 (-1/4")	2009	7.41	475	0.18	0.17	0.11	0.06	<0.01	0.06	15.0	17.3	1.9	1.9	15.4	8.0	8.00	9.2	Slight
OB02 (-1/4")	2009	6.35	1840	0.05	1.47	0.78	0.69	<0.01	0.69	4.2	4.4	21.6	21.6	-17.2	0.19	0.19	0.2	None
OB03 (-1/4")	2009	7.13	1651	0.07	0.58	0.41	0.17	<0.01	0.17	5.8	11.1	5.3	5.3	5.8	1.1	1.10	2.1	None
OB04 (-1/4")	2009	5.99	1792	0.09	1.72	1.01	0.71	<0.01	0.71	7.5	5.5	22.2	22.2	-16.7	0.34	0.34	0.2	None
OB05 (-1/4")	2009	6.77	1938	0.15	1.55	0.78	0.77	<0.01	0.77	12.5	11.4	24.1	24.1	-12.7	0.52	0.52	0.5	None
OB-07 (-1/4")	2009	6.07	1811	0.12	1.73	0.88	0.85	<0.01	0.85	10.0	7.1	26.6	26.6	-19.5	0.38	0.38	0.3	None
OB-08 (-1/4")	2009	6.42	1839	0.24	1.76	0.7	1.06	<0.01	1.06	20.0	15.3	33.1	33.1	-17.8	0.60	0.60	0.5	Slight
OB-09 (-1/4")	2009																	
OB-10 (-1/4")	2009																	
Mean		6.6	1620.9	0.1	1.3	0.7	0.6	0.01	0.6	10.7	10.3	19.2	19.2	-8.9	1.6	1.6	1.9	
Max		7.4	1938.0	0.2	1.8	1.0	1.1	0.01	1.1	20.0	17.3	33.1	33.1	15.4	8.0	8.0	9.2	
90th percentile		7.2	1879.2	0.2	1.7	0.9	0.9	0.01	0.9	17.0	16.1	29.2	29.2	9.6	3.9	3.9	4.9	
75th percentile		7.0	1839.5	0.2	1.7	0.8	0.8	0.01	0.8	13.8	13.4	25.3	25.3	-3.4	0.9	0.9	1.3	
Median (50th percentile)		6.4	1811.0	0.1	1.6	0.8	0.7	0.01	0.7	10.0	11.1	22.2	22.2	-16.7	0.5	0.5	0.5	
25th percentile		6.2	1721.5	0.1	1.0	0.6	0.4	0.01	0.4	6.7	6.3	13.4	13.4	-17.5	0.4	0.4	0.3	
10th percentile		6.0	1180.6	0.1	0.4	0.3	0.1	0.01	0.1	5.2	5.1	3.9	3.9	-18.5	0.3	0.3	0.23	
Min		6.0	475.0	0.1	0.17	0.1	0.06	0.01	0.06	4.17	4.40	1.88	1.88	-19.46	0.19	0.19	0.20	
Number of Samples		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	
WASTE ROCK																		
TP-22 (-1/4")	2009																	
TP-23 (-1/4")	2009																	
TP-24a (-1/4")	2009																	
TP-24b (-1/4")	2009	7.54	845	0.53	1.07	0.07	1.00	<0.01	1.0	44.2	39.5	31.3	31.3	8.3	1.4	1.4	1.3	Moderate
TP-25a (-1/4")	2009	7.74	1428	1.12	1.64	0.12	1.52	<0.01	1.5	93.3	77.5	47.5	47.5	30.0	2.0	2.0	1.6	Moderate
TP-25b (-1/4")	2009	7.75	1468	1.2	1.62	0.14	1.48	<0.01	1.5	100.0	81.3	46.3	46.3	35.1	2.2	2.2	1.8	Moderate
TP-26 (-1/4")	2009	5.40	2410	0.25	4.21	0.92	3.29	<0.01	3.3	20.8	11.8	102.8	102.8	-91.0	0.2	0.2	0.1	Slight
TP27 (-1/4")	2009	7.20	712	0.11	0.3	0.27	0.03	<0.01	0.03	9.2	11.5	0.9	0.9	10.6	9.8	9.8	12.3	Slight
TP28 (-1/4")	2009	7.17	1508	0.15	0.86	0.24	0.62	<0.01	0.6	12.5	15.8	19.4	19.4	-3.6	0.6	0.6	0.8	Slight
TP29 (-1/4")	2009	6.15	1724	0.1	2.09	0.77	1.32	<0.01	1.3	8.3	10.1	41.3	41.3	-31.2	0.2	0.2	0.2	None
Mean		7.0	1442.1	0.5	1.7	0.4	1.3	0.01	1.3	41.2	35.4	41.3	41.3	-6.0	2.3	2.3	2.6	
Max		7.8	2410.0	1.2	4.2	0.9	3.3	0.01	3.3	100.0	81.3	102.8	102.8	35.1	9.8	9.8	12.3	
90th percentile		7.7	1998.4	1.2	2.9	0.8	2.2	0.01	2.2	96.0	79.0	69.6	69.6	32.0	5.2	5.2	6.0	
75th percentile		7.6	1616.0	0.8	1.9	0.5	1.5	0.01	1.5	68.8	58.5	46.9	46.9	20.3	2.1	2.1	1.7	
Median (50th percentile)		7.2	1468.0	0.3	1.6	0.2	1.3	0.01	1.3	20.8	15.8	41.3	41.3	8.3	1.4	1.4	1.3	
25th percentile		6.7	1136.5	0.1	1.0	0.1	0.8	0.01	0.8	10.8	11.7	25.3	25.3	-17.4	0.4	0.4	0.5	
10th percentile		5.9	791.8	0.1	0.6	0.10	0.38	0.01	0.38	8.8	10.9	12.0	12.0	-55.1	0.2	0.2	0.2	
Min		5.4	712.0	0.10	0.30	0.07	0.03	0.01	0.03	8.3	10.1	0.9	0.9	-91.0	0.202	0.202	0.1	
Number of Samples		7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	

Appendix A1
ABA data for ore and w waste rock test pits

Sample ID	Ag	Al	As	Au	Ba	Be	Bi	Ca	Cd	Ce	Co	Cr	Cs	Cu	Fe	Ga	Ge	Hf	Hg	In	K	La	Li	Mg	Mn
	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	%	ppm
ORE																									
OB01 (-1/4")	5.2	0.51	1256.9	0.15	425	1	0.4	0.79	41.7	21	15.4	55	12.7	52.9	4.63	2	<0.1	0.1	0.132	0.26	0.21	10	1.7	0.1	6839
OB02 (-1/4")	7.5	0.47	521.8	0.22	265	<1	6.5	0.08	5.4	15	1.3	27	6.5	190.5	2.28	1	<0.1	0.1	0.199	0.49	0.21	8	2.1	0.06	102
OB03 (-1/4")	14.9	0.93	1380.6	1.83	256	1	14.7	0.67	14.8	31	9.8	53	6.6	121.5	4.57	3	<0.1	<0.1	1.042	0.36	0.31	16	5.5	0.32	2585
OB04 (-1/4")	29.5	0.59	2541.7	2.29	143	<1	32.1	0.58	17.7	16	4.7	57	4.2	220.6	5.21	2	<0.1	0.1	0.379	0.64	0.37	8	3.1	0.12	1758
OB05 (-1/4")	15.9	0.74	1241.7	1.28	218	1	14	0.68	17.8	23	8.5	50	6.6	130.8	4.35	3	<0.1	0.1	0.299	0.47	0.27	12	3.7	0.2	2235
OB-07 (-1/4")	43.5	0.53	2501.5	3.4	116	<1	42.1	0.83	19.8	14	4.8	48	4.6	292.4	5.75	2	<0.1	0.1	0.502	0.76	0.4	7	2.6	0.13	1686
OB-08 (-1/4")	19.6	0.51	2308.5	3.12	117	<1	16.4	0.95	25.2	17	6.6	39	5.1	232.4	4.59	2	<0.1	0.1	0.257	0.7	0.24	9	2.7	0.19	2142
OB-09 (-1/4")	42.9	0.61	3444	3.07	115	<1	35.9	0.96	17.5	15	4.9	47	4.1	285.1	5	2	<0.1	0.1	0.292	0.63	0.3	8	3.5	0.2	1291
OB-10 (-1/4")	24.3	0.63	1980.4	1.84	120	1	23.5	1.11	17.7	17	6.1	38	5.5	280.6	4.89	2	<0.1	0.1	0.3	0.57	0.28	9	3.3	0.3	1490
Mean	22.6	0.6	1908.6	1.9	197.2	1.0	20.6	0.7	19.7	18.8	6.9	46.0	6.2	200.8	4.6	2.1	0.1	0.1	0.4	0.5	0.3	9.7	3.1	0.2	2236.4
Max	43.5	0.9	3444.0	3.4	425.0	1.0	42.1	1.1	41.7	31.0	15.4	57.0	12.7	292.4	5.8	3.0	0.1	0.1	1.0	0.8	0.4	16.0	5.5	0.3	6839.0
90th percentile	43.0	0.8	2722.2	3.2	297.0	1.0	37.1	1.0	28.5	24.6	10.9	55.4	7.8	286.6	5.3	3.0	0.1	0.1	0.6	0.7	0.4	12.8	4.1	0.3	3435.8
75th percentile	29.5	0.6	2501.5	3.1	256.0	1.0	32.1	1.0	19.8	21.0	8.5	53.0	6.6	280.6	5.0	2.0	0.1	0.1	0.4	0.6	0.3	10.0	3.5	0.2	2235.0
Median (50th percentile)	19.6	0.6	1980.4	1.8	143.0	1.0	16.4	0.8	17.7	17.0	6.1	48.0	5.5	220.6	4.6	2.0	0.1	0.1	0.3	0.6	0.3	9.0	3.1	0.2	1758.0
25th percentile	14.9	0.5	1256.9	1.3	117.0	1.0	14.0	0.7	17.5	15.0	4.8	39.0	4.6	130.8	4.6	2.0	0.1	0.1	0.3	0.5	0.2	8.0	2.6	0.1	1490.0
10th percentile	7.0	0.5	1097.7	0.2	115.8	1.0	5.3	0.5	12.9	14.8	4.0	35.8	4.2	107.8	3.9	1.8	0.1	0.1	0.2	0.3	0.2	7.8	2.0	0.1	1053.2
Min	5.20	0.47	521.80	0.15	115.00	1.00	0.40	0.08	5.40	14.00	1.30	27.00	4.10	52.90	2.28	1.00	0.10	0.10	0.13	0.26	0.21	7.00	1.70	0.06	102.00
Number of Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
WASTE ROCK																									
TP-22 (-1/4")	13.7	1.09	861.1	0.41	342	1	10	0.9	24.5	21	12.4	45	7.9	109.7	5.15	3	<0.1	0.1	0.217	0.27	0.26	10	6.7	0.34	3648
TP-23 (-1/4")	1.7	0.64	493	0.08	209	1	0.5	2.68	6.8	33	14.4	27	25.2	32.6	4.96	3	<0.1	0.1	0.151	0.13	0.17	15	2.8	0.44	2603
TP-24a (-1/4")	11.9	0.98	1173.8	0.71	251	1	10.6	1.15	31	19	9.4	39	5.2	350.3	5.58	3	<0.1	0.1	0.271	0.61	0.24	10	6.6	0.42	2766
TP-24b (-1/4")	5.7	0.77	1205.1	0.48	161	1	6	1.49	29.2	18	10.5	46	4.7	184.8	4.43	2	<0.1	0.1	0.165	0.4	0.16	9	4.7	0.49	3153
TP-25a (-1/4")	3.7	0.23	544.4	0.21	108	<1	3.9	2.16	11.9	16	4.6	43	2.9	79.4	2.68	1	<0.1	0.2	0.054	0.2	0.14	8	0.8	0.62	2984
TP-25b (-1/4")	6.3	0.27	592	0.34	103	<1	8.6	2.3	20.3	16	5.6	47	3.1	73.6	2.98	1	<0.1	0.2	0.071	0.24	0.15	9	1.1	0.65	3223
TP-26 (-1/4")	22.2	0.52	1928.4	1.91	55	<1	36.6	1.09	22.6	16	8	55	4	619.5	6.84	2	<0.1	0.2	0.163	0.92	0.28	9	3.4	0.22	1972
TP27 (-1/4")	9.7	0.8	1822	1.11	262	1	7.2	0.68	24.1	23	11.2	46	9.6	136.9	5.63	3	<0.1	0.1	0.338	0.37	0.27	11	4.5	0.19	4116
TP28 (-1/4")	8.1	1.32	446.7	0.19	204	1	13	0.85	11.4	23	12	44	5.6	358.9	4.72	4	<0.1	0.1	0.084	0.25	0.2	11	10.5	0.54	1965
TP29 (-1/4")	71.4	0.72	1243.7	0.6	109	1	14.4	0.93	16.5	18	11.8	63	5.5	583.8	5.72	2	<0.1	0.1	0.302	0.37	0.27	9	4.7	0.17	3754
Mean	15.4	0.7	1031.0	0.6	180.4	1.0	11.1	1.4	19.8	20.3	10.0	45.5	7.4	253.0	4.9	2.4	0.1	0.1	0.18	0.4	0.2	10.1	4.6	0.4	3018.4
Max	71.4	1.3	1928.4	1.9	342.0	1.0	36.6	2.7	31.0	33.0	14.4	63.0	25.2	619.5	6.8	4.0	0.1	0.2	0.34	0.9	0.3	15.0	10.5	0.7	4116.0
90th percentile	27.1	1.1	1832.6	1.2	270.0	1.0	16.6	2.3	29.4	24.0	12.6	55.8	11.2	587.4	5.8	3.1	0.1	0.2	0.31	0.6	0.3	11.4	7.1	0.6	3790.2
75th percentile	13.3	0.9	1234.1	0.7	240.5	1.0	12.4	2.0	24.4	22.5	12.0	46.8	7.3	356.8	5.6	3.0	0.1	0.2	0.26	0.4	0.3	10.8	6.1	0.5	3541.8
Median (50th percentile)	8.9	0.7	1017.5	0.4	182.5	1.0	9.3	1.1	21.5	18.5	10.9	45.5	5.4	160.9	5.1	2.5	0.1	0.1	0.16	0.3	0.2	9.5	4.6	0.4	3068.5
25th percentile	5.9	0.6	556.3	0.2	108.3	1.0	6.3	0.9	13.1	16.5	8.4	43.3	4.2	87.0	4.5	2.0	0.1	0.1	0.10	0.2	0.2	9.0	3.0	0.3	2643.8
10th percentile	3.5	0.3	488.4	0.2	98.2	1.0	3.6	0.8	10.9	16.0	5.5	37.8	3.1	69.5	3.0	1.0	0.1	0.1	0.069	0.2	0.1	8.9	1.1	0.2	1971.3
Min	1.7	0.2	446.7	0.1	55.0	1.0	0.5	0.7	6.8	16.0	4.6	27.0	2.9	32.6	2.7	1.0	0.1	0.1	0.054	0.1	0.1	8.0	0.8	0.2	1965.0
Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Appendix A1
ABA data for ore and wwaste rock test pits

Sample ID	Mo	Na	Nb	Ni	P	Pb	Rb	Re	S	Sb	Sc	Se	Sn	Sr	Ta	Te	Th	Ti	Tl	U	V	W	Y	Zn	Zr
	ppm	%	ppm	ppm	%	ppm	ppm	ppb	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	%	ppm	ppm	ppm	ppm	ppm	ppm	ppm
ORE																									
OB01 (-1/4")	0.3	0.01	0.1	9	0.098	1381.1	14.8	<5	0.2	18.1	10.5	<0.5	0.5	28	<0.1	<0.1	2.1	<0.005	0.8	0.4	50	0.3	13.3	3330	2.2
OB02 (-1/4")	1.4	0.01	<0.1	3	0.031	602.3	11.4	<5	0.22	59.4	2.2	<0.5	0.4	35	<0.1	0.1	2.1	<0.005	0.4	0.7	10	0.1	1.6	578	4.3
OB03 (-1/4")	0.9	0.02	0.4	8.3	0.099	1355.5	16.9	<5	0.55	117.8	6.7	<0.5	0.8	36	<0.1	0.3	4.2	0.017	1.9	0.9	42	0.4	10.5	1206	1.8
OB04 (-1/4")	1.2	0.01	0.4	4.6	0.066	2525	19.9	<5	1.26	253.5	3.1	<0.5	0.9	49	<0.1	0.5	2.8	<0.005	1.5	0.9	18	0.3	5.4	1403	3.5
OB05 (-1/4")	0.8	0.02	0.8	7.5	0.086	1411.5	15.9	<5	0.62	119.6	5.4	<0.5	0.7	39	0.3	0.3	2.7	0.007	1	0.6	31	0.5	10.1	1435	1.8
OB-07 (-1/4")	1.7	0.01	0.1	4.7	0.064	2149.4	22.2	<5	1.74	311.3	3	<0.5	1.1	70	<0.1	0.8	2.9	<0.005	1.6	1	17	0.2	5.6	1543	5.3
OB-08 (-1/4")	1.2	0.01	<0.1	6.2	0.07	1751.6	14.4	<5	1.37	184.6	3.8	<0.5	0.9	45	<0.1	0.4	2.6	<0.005	1	1.2	21	0.4	8.2	2017	2.8
OB-09 (-1/4")	1.2	0.01	<0.1	5.4	0.067	2804.1	16.2	<5	1.67	441	3.4	<0.5	1.1	55	<0.1	0.7	2.8	<0.005	1.1	1	21	0.3	6.2	1361	3.6
OB-10 (-1/4")	1.2	0.01	0.1	5.5	0.067	2053.9	15.1	<5	1.72	233.7	3.7	<0.5	0.8	49	<0.1	0.4	2.9	0.005	1	1	22	0.3	6.8	1423	3
Mean	1.1	0.0	0.2	6.0	0.1	1781.6	16.3	5.0	1.0	193.2	4.6	0.5	0.8	45.1	0.1	0.4	2.8	0.0	1.1	0.9	25.8	0.3	7.5	1588.4	3.1
Max	1.7	0.0	0.8	9.0	0.1	2804.1	22.2	5.0	1.7	441.0	10.5	0.5	1.1	70.0	0.3	0.8	4.2	0.0	1.9	1.2	50.0	0.5	13.3	3330.0	5.3
90th percentile	1.5	0.0	0.5	8.4	0.1	2580.8	20.4	5.0	1.7	337.2	7.5	0.5	1.1	58.0	0.1	0.7	3.2	0.0	1.7	1.0	43.6	0.4	11.1	2279.6	4.5
75th percentile	1.2	0.0	0.4	7.5	0.1	2149.4	16.9	5.0	1.7	253.5	5.4	0.5	0.9	49.0	0.1	0.5	2.9	0.0	1.5	1.0	31.0	0.4	10.1	1543.0	3.6
Median (50th percentile)	1.2	0.0	0.1	5.5	0.1	1751.6	15.9	5.0	1.3	184.6	3.7	0.5	0.8	45.0	0.1	0.4	2.8	0.0	1.0	0.9	21.0	0.3	6.8	1423.0	3.0
25th percentile	0.9	0.0	0.1	4.7	0.1	1381.1	14.8	5.0	0.6	117.8	3.1	0.5	0.7	36.0	0.1	0.3	2.6	0.0	1.0	0.7	18.0	0.3	5.6	1361.0	2.2
10th percentile	0.7	0.0	0.1	4.3	0.1	1204.9	13.8	5.0	0.2	51.1	2.8	0.5	0.5	33.6	0.1	0.1	2.1	0.0	0.7	0.6	15.6	0.2	4.6	1080.4	1.8
Min	0.30	0.01	0.10	3.00	0.03	602.30	11.40	5.00	0.20	18.10	2.20	0.50	0.40	28.00	0.10	0.10	2.10	0.01	0.40	0.40	10.00	0.10	1.60	578.00	1.80
Number of Samples	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
WASTE ROCK																									
TP-22 (-1/4")	0.6	0.01	<0.1	11.4	0.1	2515.5	16.3	<5	0.3	52.5	7.1	<0.5	0.4	51	<0.1	0.2	2.1	0.006	1	0.8	43	0.4	12.8	2435	1.7
TP-23 (-1/4")	0.3	0.01	<0.1	7	0.162	349.9	17.2	<5	0.28	19.3	11.7	<0.5	0.6	65	<0.1	<0.1	2.5	0.005	0.6	0.5	67	1.3	17.1	841	1.5
TP-24a (-1/4")	1.3	0.02	<0.1	9.1	0.075	2401	14.6	<5	0.85	67.8	4.6	<0.5	0.5	64	<0.1	0.3	3	<0.005	0.9	1.1	31	0.3	10.3	2962	4.6
TP-24b (-1/4")	1.7	0.01	<0.1	11.3	0.072	1210.2	9	<5	1.12	49	4	<0.5	0.7	87	<0.1	0.2	3	<0.005	0.6	1.1	22	0.3	10.5	2726	5.1
TP-25a (-1/4")	1.4	0.01	0.1	5.7	0.054	333.8	7.6	<5	1.52	33.9	1.5	<0.5	0.2	39	<0.1	0.1	3.9	<0.005	0.3	1.2	6	0.2	6.7	1134	9.8
TP-25b (-1/4")	1.4	0.01	<0.1	6.6	0.055	513.6	8.6	<5	1.49	37.5	1.8	<0.5	0.3	51	<0.1	0.2	4	<0.005	0.3	1.2	9	0.2	7.6	1982	9.8
TP-26 (-1/4")	1.8	0.01	<0.1	5.1	0.059	1819.5	15.5	<5	3.9	192.6	2.6	<0.5	0.5	38	<0.1	1	5	<0.005	0.9	1	14	0.3	7.1	1942	6.9
TP27 (-1/4")	0.6	0.01	0.4	9.4	0.113	1860.7	19.1	<5	0.33	113.9	6.2	<0.5	0.5	60	<0.1	0.1	2.3	<0.005	1.6	0.7	31	0.3	12.9	1951	1.6
TP28 (-1/4")	0.7	0.03	0.2	6.3	0.094	472.8	12.1	<5	0.85	58	5.1	<0.5	0.4	48	<0.1	0.3	3.2	0.012	0.4	1.3	38	0.2	10.8	1095	2.3
TP29 (-1/4")	0.6	0.01	0.2	5.8	0.095	950.7	16.1	<5	1.92	287.4	5.3	<0.5	0.7	44	<0.1	0.3	2	<0.005	1.3	0.8	29	0.2	10.2	1382	1.8
Mean	1.0	0.0	0.2	7.8	0.1	1242.8	13.6	5.0	1.3	91.2	5.0	0.5	0.5	54.7	0.1	0.3	3.1	0.0	0.8	1.0	29.0	0.4	10.6	1845.0	4.5
Max	1.8	0.0	0.4	11.4	0.2	2515.5	19.1	5.0	3.9	287.4	11.7	0.5	0.7	87.0	0.1	1.0	5.0	0.0	1.6	1.3	67.0	1.3	17.1	2962.0	9.8
90th percentile	1.7	0.0	0.2	11.3	0.1	2412.5	17.4	5.0	2.1	202.1	7.6	0.5	0.7	67.2	0.1	0.4	4.1	0.0	1.3	1.2	45.4	0.5	13.3	2749.6	9.8
75th percentile	1.4	0.0	0.2	9.3	0.1	1850.4	16.3	5.0	1.5	102.4	6.0	0.5	0.6	63.0	0.1	0.3	3.7	0.0	1.0	1.2	36.3	0.3	12.3	2321.8	6.5
Median (50th percentile)	1.0	0.0	0.1	6.8	0.1	1080.5	15.1	5.0	1.0	55.3	4.9	0.5	0.5	51.0	0.1	0.2	3.0	0.0	0.8	1.1	30.0	0.3	10.4	1946.5	3.5
25th percentile	0.6	0.0	0.1	5.9	0.1	483.0	9.8	5.0	0.5	40.4	3.0	0.5	0.4	45.0	0.1	0.1	2.4	0.0	0.5	0.8	16.0	0.2	8.3	1196.0	1.7
10th percentile	0.6	0.0	0.1	5.6	0.1	348.3	8.5	5.0	0.3	32.4	1.8	0.5	0.3	38.9	0.1	0.1	2.1	0.0	0.3	0.7	8.7	0.2	7.1	1069.6	1.6
Min	0.3	0.0	0.1	5.1	0.1	333.8	7.6	5.0	0.3	19.3	1.5	0.5	0.2	38.0	0.1	0.1	2.0	0.0	0.3	0.5	6.0	0.2	6.7	841.0	1.5
Number of Samples	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Paste pH	TIC % C	Total C %	Organic C %	Total S %	Sulfate S %	Sulfide S %	Insoluble S %	Non-Sulfate S %	SAP $kgCaCO_3/t$	AP $kgCaCO_3/t$	CaNP $kgCaCO_3/t$	BulkNP $kgCaCO_3/t$	Net NP	NPR (CaNP/SAP)	NPR (CaNP/AP)	NPR (BulkNP/AP)
Tailings Samples																	
SL09-01					1.73	0.81	0.67	0.25	0.92	20.9	28.8						
UL09-01					1.13	0.31	0.73	0.09	0.82	22.8	25.6						
ClaySized Fractions																	
MW09-01 (10-13' Comp)					1.29	0.88	0.33	0.08	0.41	10.3	12.8						
MW09-04 (13'8"-14'2")					1.76	1.63	0.03	0.10	0.13	0.9	4.1						
MW09-05 (14-15')					1.13	1.01	0.07	0.05	0.12	2.2	3.8						
T1a-1	7.65	0.26			1.37	0.84	0.34	0.19	0.53	10.6	16.6	21.7	31.3	20.7	2.0	1.3	1.89
T1a-2	7.45	0.38			2.49	1.09	0.9	0.50	1.40	28.1	43.8	31.7	34.9	6.8	1.1	0.7	0.80
T1a-3	7.69	0.25			1.33	0.86	0.28	0.19	0.47	8.8	14.7	20.8	30.5	21.8	2.4	1.4	2.08
T1d-1	7.69	0.36			1.64	1.05	0.43	0.16	0.59	13.4	18.4	30.0	33.3	19.9	2.2	1.6	1.81
T1d-2	7.66	0.63			3.02	1.17	1.67	0.18	1.85	52.2	57.8	52.5	54.1	1.9	1.0	0.9	0.94
Clay Composite	7.97	0.44			2.28	1.22	0.98	0.08	1.06	30.6	33.1	36.7	42.1	11.5	1.2	1.1	1.27
Silty Clay Sized Fractions																	
MW09-05 (9-10')					1.98	1.54	0.4	0.04	0.44	12.5	13.8						
T1c-1	7.85	0.7			2.78	0.23	2.19	0.36	2.55	68.4	79.7	58.3	58.1	-10.3	0.9	0.7	0.73
T1c-2	7.86	0.32			2.62	0.53	1.48	0.61	2.09	46.3	65.3	26.7	33.1	-13.2	0.6	0.4	0.51
T2-1	7.36	0.44			3.26	1.1	1.69	0.47	2.16	52.8	67.5	36.7	37.8	-15.0	0.7	0.5	0.56
T3-1	7.03	0.05			0.04	<0.01	0.02	0.02	0.03	0.6	0.9	4.2	12.7	12.1	6.7	4.4	13.55
T3-2	7.39	0.06			0.07	<0.01	0.03	0.04	0.06	0.9	1.9	5.0	14.5	13.6	5.3	2.7	7.73
T3-3	7.49	0.06			0.06	0.01	0.03	0.02	0.05	0.9	1.6	5.0	14.9	14.0	5.3	3.2	9.54
Silt Clay Composite	8.06	0.34			2.22	0.74	1.06	0.42	1.48	33.1	46.3	28.3	34.3	1.2	0.9	0.6	0.74
Sand (sandy silt) Sized Fractions																	
MW09-04 (14'5"-15'5")					0.77	0.6	0.17	<0.01	0.17	5.3	5.3						
MW09-05 (5-6')					0.57	0.45	0.11	0.01	0.12	3.4	3.8						
T2-2	7.20	0.32			7.25	0.48	6.69	0.08	6.77	209.1	211.6	26.7	27.0	-182.1	0.1	0.1	0.13
T2-3	6.79	0.25			7.34	0.44	6.39	0.51	6.90	199.7	215.6	20.8	21.1	-178.6	0.1	0.1	0.10
T4-1	7.43	0.8			5.06	0.59	3.84	0.63	4.47	120.0	139.7	66.7	58.0	-62.0	0.6	0.5	0.42
T4-2	7.13	0.67			4.18	0.82	2.94	0.42	3.36	91.9	105.0	55.8	51.2	-40.7	0.6	0.5	0.49
Sand Silt Composite	7.51	0.36			4.85	0.72	3.84	0.29	4.13	120.0	129.1	30.0	31.5	-88.5	0.3	0.2	0.24

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Paste pH	TIC % C	Total C %	Organic C %	Total S %	Sulfate S %	Sulfide S %	Insoluble S %	Non-Sulfate S %	SAP $kgCaCO_3/t$	AP $kgCaCO_3/t$	CaNP $kgCaCO_3/t$	BulkNP $kgCaCO_3/t$	Net NP	NPR (CaNP/SAP)	NPR (CaNP/AP)	NPR (BulkNP/AP)
Statistical Summaries for Tailings Samples																	
ClaySized Fractions																	
Max	7.97	0.63			3.02	1.63	1.67	0.5	1.85	52.1875	57.8	52.5	54.1	21.75	2.38	1.63	2.1
Median (50th percentile)	7.675	0.37			1.64	1.05	0.34	0.16	0.53	10.625	16.6	30.8	34.1	15.6688	1.62	1.21	1.5
Min	7.45	0.25			1.13	0.84	0.03	0.05	0.12	0.9375	3.8	20.8	30.5	1.9125	1.01	0.72	0.8
Silty Clay Sized Fractions																	
Max	8.06	0.7			3.26	1.54	2.19	0.61	2.55	68.4375	79.7	58.3	58.1	13.9625	6.67	4.44	13.5
Median (50th percentile)	7.49	0.32			2.1	0.38	0.73	0.2	0.96	22.8125	30.0	26.7	33.1	1.175	0.86	0.73	0.7
Min	7.03	0.05			0.04	0.01	0.02	0.02	0.03	0.625	0.9	4.2	12.7	-15.013	0.58	0.41	0.5
Sand (sandy silt) Sized Fractions																	
Max	7.51	0.8			7.34	0.82	6.69	0.63	6.9	209.0625	215.6	66.7	58	-40.675	0.61	0.53	0.5
Median (50th percentile)	7.2	0.36			4.85	0.59	3.84	0.29	4.13	120	129.1	30.0	31.5	-88.5	0.25	0.23	0.2
Min	6.79	0.25			0.57	0.44	0.11	0.01	0.12	3.4375	3.8	20.8	21.1	-182.06	0.10	0.10	0.1
ALL Tailings Samples																	
Mean	7.5	0.4			2.4	0.7	1.4	0.2	1.7	44.8	51.8	31.0	34.5	-26.0	1.8	1.2	2.4
Max	8.1	0.8			7.3	1.6	6.7	0.6	6.9	209.1	215.6	66.7	58.1	21.8	6.7	4.4	13.5
90th percentile	7.9	0.7			5.0	1.2	3.8	0.5	4.3	120.0	134.4	56.6	55.3	20.1	5.3	2.8	8.3
75th percentile	7.7	0.4			3.0	1.0	1.7	0.4	2.1	52.7	67.0	36.7	41.0	13.2	2.2	1.4	1.9
Median (50th percentile)	7.5	0.4			1.9	0.8	0.7	0.2	0.9	21.9	27.2	29.2	33.2	1.5	0.9	0.7	0.8
25th percentile	7.4	0.3			1.2	0.5	0.2	0.1	0.2	6.2	7.2	21.0	27.9	-34.3	0.6	0.5	0.5
10th percentile	7.1	0.06			0.32	0.12	0.03	0.02	0.09	0.94	2.8	5.0	14.8	-115.5	0.2	0.2	0.2
Min	6.8	0.05			0.04	0.01	0.02	0.01	0.03	0.63	0.9	4.2	12.7	-182.1	0.1	0.1	0.1
Number of Samples	18	18			26	26	26	26	26	26	26	18	18	18	18	18	18
Tailings Field Bin Subsamples																	
Tailings + Org Bin	5.95	0.4	1.21	0.81	3.3	0.78	2.31	0.21	2.52	72.2	78.8	33.3	34.5	-37.7	0.46	0.42	0.44
Tailings Pond Sand	7.29	0.22	0.23	0.01	1.56	0.2	1.17	0.19	1.36	36.6	42.5	18.3	18.1	-18.5	0.50	0.43	0.43
Tailings Field Bin Component Samples																	
OR 09-01	4.35	0.25	23.3	23.05	1.96	0.18	0.77	1.01	1.78	24.1	55.6	20.8	4.8	-19.3	0.87	0.37	0.09
Pile 09-01	6.95	0.28	0.37	0.09	1.37	0.27	0.94	0.16	1.1	29.4	34.4	23.3	20.8	-8.6	0.79	0.68	0.61
Tailings Clayey Silt	6.15	0.29	0.37	0.08	3.14	0.7	1.56	0.88	2.44	48.8	76.3	24.2	27.5	-21.3	0.50	0.32	0.36
Tailings Sand	6.56	0.38	0.46	0.08	2.69	0.67	1.85	0.17	2.02	57.8	63.1	31.7	34.8	-23.0	0.55	0.50	0.55

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Ag ppm	Al %	As ppm	Au ppm	B ppm	Ba ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	Hg ppm	K %	La ppm
Tailings Samples																	
SL09-01	39.9	0.39	3027.4	2.26	<20	117	34.59	0.98	34.31	5.9	29.3	645.32	4.88	1.7	0.417	0.31	4.4
UL09-01	18.2	0.21	2433.9	1.42	<20	106.9	16.45	0.22	10.82	2.3	43.6	141.8	3.38	1	0.225	0.21	4
ClaySized Fractions																	
MW09-01 (10-13' Comp)	24.4	0.31	2818	0.48	<20	136	18.68	1.39	14.68	3.6	22.4	157.18	3.42	1.4	0.212	0.2	4.5
MW09-04 (13'8"-14'2")	59.0	0.51	7081.1	0.44	<20	222.1	85.8	0.69	12.68	2	26.6	175.28	7.61	3.9	0.648	0.86	6.2
MW09-05 (14-15')	42.6	0.6	4728.6	0.31	<20	208.6	47.84	1.08	25.59	3.7	22.3	216.44	6.46	2.7	0.683	0.54	6.9
T1a-1	24.1	0.52	2648	0.46	<20	116.7	30.83	1.17	40.42	5.6	14.9	394.03	5.55	1.7	0.511	0.34	6.9
T1a-2	44.7	0.54	3461.1	0.78	<20	66.9	51.88	1.51	40.58	4.7	17.7	660.34	5.85	2.1	0.495	0.36	5.9
T1a-3	24.3	0.53	2680.2	0.43	<20	111.1	31.25	1.16	41.33	5.8	17.5	402.67	5.78	1.8	0.444	0.32	7.2
T1d-1	26.4	0.65	2758.6	0.51	<20	105.2	36.24	1.36	39.92	5.4	26.9	476.32	5.98	2.1	0.529	0.38	7.4
T1d-2	26.7	0.56	4317.8	1.25	<20	63.6	35.4	2.15	53.67	5.7	28.9	420.12	5.57	1.8	0.432	0.3	5.2
Clay Composite	26.2	0.51	3428.3	0.81	<20	113.3	33.94	1.65	46.31	5.5	19.6	427.47	5.35	1.6	0.431	0.31	6
Silty Clay Sized Fractions																	
MW09-05 (9-10')	41.2	0.27	3740.2	0.73	<20	107.2	38.26	1.57	18.09	2.1	22.4	180.8	4.15	1.4	0.392	0.31	3.7
T1c-1	30.5	0.26	2580.6	0.83	<20	34.6	19.36	1.64	31.97	6	29.7	683.11	4.62	1	0.15	0.14	3.7
T1c-2	33.5	0.32	2937.8	1.15	<20	48	23.36	1.12	45.57	5.1	20.4	505.72	4.84	1.1	0.229	0.17	4.5
T2-1	28.6	0.3	2559	0.82	<20	43.7	23.91	1.88	35.26	6.1	12.6	408.88	4.81	1.1	0.198	0.18	3.9
T3-1	0.2	0.63	19	0.00	<20	78.7	0.24	0.43	0.3	3.6	40.6	16.69	1.14	2	0.011	0.07	8.2
T3-2	0.6	0.66	65.3	0.02	<20	84.9	0.58	0.51	0.68	4.3	46.4	18.89	1.37	2.3	0.009	0.08	9.1
T3-3	0.6	0.66	65.5	0.02	<20	84.7	0.63	0.54	0.67	4.1	47.7	19.61	1.39	2.2	0.009	0.09	9
Silt Clay Composite	46.1	0.27	3792.1	2.64	<20	36	35.41	1.17	36.34	6.6	20.7	432.73	6.56	1.1	0.262	0.17	3.3
Sand (sandy silt) Sized Fractions																	
MW09-04 (14'5"-15'5")	41.7	0.3	3619.4	0.46	<20	149.8	21.03	0.71	16.4	2.2	43.8	168.81	3.05	1.3	0.19	0.22	4.4
MW09-05 (5-6')	30.0	0.27	2102.8	0.52	<20	229.7	9.82	0.72	22.19	3.8	19.4	133.07	3.01	1.1	0.237	0.19	5.6
T2-2	45.8	0.26	4113.4	3.21	<20	11.7	40.16	0.91	42.69	9.3	34.5	464.67	9.29	1.1	0.316	0.16	3.5
T2-3	50.2	0.22	4162.2	8.07	<20	13.1	47.49	0.73	37.11	8.4	32.9	492	8.7	1.1	0.216	0.18	3
T4-1	42.5	0.22	3297.8	2.39	<20	21.1	23.29	1.99	42.8	7	20	472.78	5.58	0.8	0.174	0.11	2.7
T4-2	35.1	0.28	3115.7	1.90	<20	23.4	25.6	1.94	40.3	7.3	21.2	395.02	5.52	1	0.22	0.16	3.6
Sand Silt Composite	34.1	0.34	3169.8	0.75	<20	90.4	24.28	1.39	36.32	4.6	17.4	478.67	4.67	1.2	0.231	0.21	4.7
Statistical Summaries for Tailings Samples																	
ClaySized Fractions																	
Max	59.0	0.65	7081.1	1.25	20	222.1	85.8	2.15	53.67	5.8	28.9	660.34	7.61	3.9	0.683	0.86	7.4
Median (50th percentile)	26.4	0.53	3428.3	0.48	20	113.3	35.4	1.36	40.42	5.4	22.3	402.67	5.78	1.8	0.495	0.34	6.2
Min	24.1	0.31	2648	0.31	20	63.6	18.68	0.69	12.68	2	14.9	157.18	3.42	1.4	0.212	0.2	4.5
Silty Clay Sized Fractions																	
Max	46.1	0.66	3792.1	2.64	20	107.2	38.26	1.88	45.57	6.6	47.7	683.11	6.56	2.3	0.392	0.31	9.1
Median (50th percentile)	29.5	0.31	2569.8	0.78	20	63.35	21.36	1.145	25.03	4.7	26.05	294.84	4.385	1.25	0.174	0.155	4.2
Min	0.2	0.26	19	0.00	20	34.6	0.24	0.43	0.3	2.1	12.6	16.69	1.14	1	0.009	0.07	3.3
Sand (sandy silt) Sized Fractions																	
Max	50.2	0.34	4162.2	8.07	20	229.7	47.49	1.99	42.8	9.3	43.8	492	9.29	1.3	0.316	0.22	5.6
Median (50th percentile)	41.7	0.27	3297.8	1.90	20	23.4	24.28	0.91	37.11	7	21.2	464.67	5.52	1.1	0.22	0.18	3.6
Min	30.0	0.22	2102.8	0.46	20	11.7	9.82	0.71	16.4	2.2	17.4	133.07	3.01	0.8	0.174	0.11	2.7

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Ag ppm	Al %	As ppm	Au ppm	B ppm	Ba ppm	Bi ppm	Ca %	Cd ppm	Co ppm	Cr ppm	Cu ppm	Fe %	Ga ppm	Hg ppm	K %	La ppm
ALL Tailings Samples																	
Mean	31.4	0.4	3027.8	1.26	20.0	93.2	29.1	1.2	29.5	5.0	26.9	345.7	4.9	1.6	0.30	0.3	5.3
Max	59.0	0.7	7081.1	8.07	20.0	229.7	85.8	2.2	53.7	9.3	47.7	683.1	9.3	3.9	0.68	0.9	9.1
90th percentile	46.0	0.6	4240.0	2.52	20.0	179.2	47.7	1.9	44.2	7.2	43.7	575.5	7.1	2.3	0.52	0.4	7.8
75th percentile	42.3	0.5	3710.0	1.38	20.0	115.9	36.0	1.6	40.5	6.0	32.1	475.4	5.8	2.0	0.43	0.3	6.7
Median (50th percentile)	32.0	0.3	3071.6	0.76	20.0	87.7	28.2	1.2	35.8	5.3	22.4	405.8	5.1	1.4	0.23	0.2	4.6
25th percentile	24.8	0.3	2597.5	0.46	20.0	44.8	19.8	0.7	16.8	3.7	19.7	170.4	3.6	1.1	0.20	0.2	3.8
10th percentile	9.4	0.2	1084.2	0.17	20.0	22.3	5.2	0.5	5.8	2.3	17.5	76.3	2.2	1.0	0.08	0.1	3.4
Min	0.2	0.2	19.0	0.00	20.0	11.7	0.2	0.2	0.3	2.0	12.6	16.7	1.1	0.8	0.01	0.1	2.7
Number of Samples	26.0	26	26	26.00	26	26	26	26	26	26	26	26	26	26	26	26	26
Tailings Field Bin Subsamples																	
Tailings + Org Bin	35.163	0.38	2874.5	4.3597	<20	51.5	26.39	1.43	33.32	5.8	39.5	386.4	4.94	1.4	0.217	0.17	4.1
Tailings Pond Sand	23.285	0.31	2776.4	1.2457	<20	101.4	18.98	0.36	20.61	3.2	43.7	267.59	3.81	1	0.128	0.19	5.1
Tailings Field Bin Component Samples																	
OR 09-01	12.822	0.41	1563.8	0.7564	<20	80	11.78	0.87	14.45	3.6	15	462.27	4.01	1.1	0.266	0.09	4.1
Pile 09-01	25.449	0.34	2746.3	1.054	<20	115.6	21.47	0.44	23.56	4.1	43.3	290.15	3.93	1.2	0.148	0.21	5.4
Tailings Clayey Silt	43.954	0.41	2888.1	1.0243	<20	61.2	42.59	1.88	29.11	3.4	32.3	406.98	4.41	1.7	0.294	0.23	3.7
Tailings Sand	27.679	0.4	2515.5	1.4983	<20	63.3	23.31	1.29	40.11	5.4	34.7	441.26	4.94	1.2	0.223	0.2	4.7

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P %	Pb ppm	S %	Sb ppm	Sc ppm	Se ppm	Sr ppm	Te ppm	Th ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
Tailings Samples																				
SL09-01	0.18	4378	2.21	0.028	7.9	0.051	2761.97	1.6	158.96	2.2	0.7	79.8	0.63	2	<0.001	1.28	1.1	14	<0.1	2388
UL09-01	0.07	1096	0.94	0.007	2.8	0.032	981.55	1.1	75.95	1.2	0.6	32.5	0.32	1.3	<0.001	1.02	0.5	9	0.2	733
ClaySized Fractions																				
MW09-01 (10-13' Comp)	0.15	1289	1.07	0.007	3.5	0.05	1906.06	1.29	155.51	2.7	0.5	41	0.58	1.6	0.002	0.73	0.5	15	<0.1	1034
MW09-04 (13'8"-14'2")	0.08	674	2.14	0.049	4.2	0.065	6965.25	1.71	338.22	2.9	0.6	86.1	1.27	2.2	0.002	2.44	1	21	<0.1	631
MW09-05 (14-15')	0.09	1891	1.91	0.021	4.9	0.069	5162.33	1.14	261.82	3.3	0.5	77.3	0.87	2.5	0.001	1.74	1	22	<0.1	1718
T1a-1	0.17	3216	1.58	0.026	5.5	0.072	2210.59	1.32	105.25	3.3	0.6	63.4	0.43	3	0.001	1.37	1	20	<0.1	2457
T1a-2	0.25	2560	2	0.025	5.6	0.061	2827.44	2.32	162.02	3.1	0.9	86.4	0.71	2.8	0.001	1.52	1.3	18	<0.1	2462
T1a-3	0.18	3326	1.63	0.028	5.8	0.076	2313.73	1.32	102.42	3.3	0.5	65	0.41	3	0.001	1.44	1	21	<0.1	2652
T1d-1	0.2	3491	1.98	0.056	8.1	0.073	2551.79	1.59	98.92	3.1	0.5	73.3	0.46	3.3	0.002	1.51	1.1	22	<0.1	2627
T1d-2	0.39	3884	1.73	0.057	6	0.057	2829.15	2.89	177.15	2.7	0.7	69.4	0.46	2.5	0.002	1.41	1.1	17	0.1	3274
Clay Composite	0.29	3490	1.62	0.051	6.6	0.063	2455.44	2.09	135.99	3.4	0.6	72	0.47	2.7	0.002	1.25	1	19	<0.1	2995
Silty Clay Sized Fractions																				
MW09-05 (9-10')	0.08	1279	1.15	0.008	3.1	0.047	3186.56	1.9	205.15	1.8	0.6	47.5	0.71	1.9	<0.001	1.05	0.6	11	<0.1	1226
T1c-1	0.3	2735	1.09	0.011	6.6	0.045	1333.98	2.66	161.72	1.8	0.5	51.1	0.32	1.8	0.002	0.5	0.9	12	<0.1	2179
T1c-2	0.19	2584	1.22	0.014	4.1	0.052	1979.37	2.52	242.95	1.9	0.4	42.7	0.32	2.2	<0.001	0.89	0.8	12	<0.1	2908
T2-1	0.32	2369	1.2	0.006	5.2	0.056	1593.91	3.02	187.43	2.3	0.5	60.5	0.37	1.9	0.002	0.79	0.8	15	<0.1	2332
T3-1	0.26	161	0.36	0.039	7.4	0.045	14.56	0.02	1.71	1.6	0.1	28.1	<0.02	1.2	0.04	0.05	0.5	27	<0.1	35
T3-2	0.28	196	0.41	0.038	8.5	0.05	27.92	0.06	5.19	1.9	<0.1	32.5	<0.02	2.3	0.048	0.05	0.5	29	0.1	65
T3-3	0.3	208	0.4	0.041	8.9	0.049	32.56	0.06	5.5	2	<0.1	34.1	0.02	2.3	0.049	0.06	0.5	32	0.1	66
Silt Clay Composite	0.22	2421	1.52	0.006	4.3	0.041	2233.72	4.98	230.17	1.9	1	55	0.54	1.6	0.001	0.96	0.7	11	<0.1	2364
Sand (sandy silt) Sized Fractions																				
MW09-04 (14'5"-15'5")	0.09	1209	0.89	0.01	3.5	0.037	2090.7	0.78	400.96	1.6	0.2	33.8	0.34	1.6	0.002	0.69	0.6	14	<0.1	863
MW09-05 (5-6')	0.07	1988	0.96	0.005	3.8	0.05	1835.98	0.57	190.68	2.2	0.5	35.8	0.27	2	0.001	0.84	0.8	13	<0.1	1240
T2-2	0.18	2606	1.67	0.005	5.4	0.04	3407.02	7.47	223.52	1.6	1.2	42.2	0.73	1.8	0.002	1.27	0.8	9	<0.1	2649
T2-3	0.15	2129	1.7	0.004	4.3	0.035	2694.64	7.41	218.87	1.5	1.1	47.9	0.88	1.6	0.001	0.86	0.6	8	<0.1	2309
T4-1	0.41	3789	1.67	0.002	4.7	0.039	1584.56	4.86	283.01	1.4	0.7	51.2	0.41	1.5	<0.001	0.83	0.8	7	<0.1	2826
T4-2	0.38	3966	1.6	0.004	5.3	0.049	1646.78	4.03	178.02	1.8	0.7	58.4	0.35	1.8	<0.001	0.94	0.9	10	<0.1	2932
Sand Silt Composite	0.21	2095	1.37	0.016	4.5	0.055	1703.54	2.22	209.8	2.3	0.7	55.7	0.35	2	0.002	0.82	0.8	14	<0.1	2361
Statistical Summaries for Tailings Samples																				
ClaySized Fractions																				
Max	0.39	3884	2.14	0.057	8.1	0.076	6965.25	2.89	338.22	3.4	0.9	86.4	1.27	3.3	0.002	2.44	1.3	22	0.1	3274
Median (50th percentile)	0.18	3216	1.73	0.028	5.6	0.065	2551.79	1.59	155.51	3.1	0.6	72	0.47	2.7	0.002	1.44	1	20	0.1	2462
Min	0.08	674	1.07	0.007	3.5	0.05	1906.06	1.14	98.92	2.7	0.5	41	0.41	1.6	0.001	0.73	0.5	15	0.1	631
Silty Clay Sized Fractions																				
Max	0.32	2735	1.52	0.041	8.9	0.056	3186.56	4.98	242.95	2.3	1	60.5	0.71	2.3	0.049	1.05	0.9	32	0.1	2908
Median (50th percentile)	0.27	1824	1.12	0.0125	5.9	0.048	1463.945	2.21	174.58	1.9	0.45	45.1	0.32	1.9	0.002	0.645	0.65	13.5	0.1	1702
Min	0.08	161	0.36	0.006	3.1	0.041	14.56	0.02	1.71	1.6	0.1	28.1	0.02	1.2	0.001	0.05	0.5	11	0.1	35
Sand (sandy silt) Sized Fractions																				
Max	0.41	3966	1.7	0.016	5.4	0.055	3407.02	7.47	400.96	2.3	1.2	58.4	0.88	2	0.002	1.27	0.9	14	0.1	2932
Median (50th percentile)	0.18	2129	1.6	0.005	4.5	0.04	1835.98	4.03	218.87	1.6	0.7	47.9	0.35	1.8	0.001	0.84	0.8	10	0.1	2361
Min	0.07	1209	0.89	0.002	3.5	0.035	1584.56	0.57	178.02	1.4	0.2	33.8	0.27	1.5	0.001	0.69	0.6	7	0.1	863

Appendix A2
Tailings ABA and Elemental Abundance Results

Sample ID	Mg %	Mn ppm	Mo ppm	Na %	Ni ppm	P %	Pb ppm	S %	Sb ppm	Sc ppm	Se ppm	Sr ppm	Te ppm	Th ppm	Ti %	Tl ppm	U ppm	V ppm	W ppm	Zn ppm
ALL Tailings Samples																				
Mean	0.2	2270.4	1.4	0.0	5.4	0.1	2243.5	2.3	173.7	2.3	0.6	54.7	0.5	2.1	0.0	1.0	0.8	16.2	0.1	1897
Max	0.4	4378.0	2.2	0.1	8.9	0.1	6965.3	7.5	401.0	3.4	1.2	86.4	1.3	3.3	0.0	2.4	1.3	32.0	0.2	3274
90th percentile	0.4	3836.5	2.0	0.1	8.0	0.1	3296.8	4.9	272.4	3.3	1.0	78.6	0.8	2.9	0.0	1.5	1.1	24.5	0.1	2920
75th percentile	0.3	3298.5	1.7	0.0	6.5	0.1	2745.1	2.8	222.4	2.9	0.7	68.3	0.6	2.5	0.0	1.3	1.0	20.8	0.1	2644
Median (50th percentile)	0.2	2395.0	1.6	0.0	5.3	0.1	2150.6	1.8	177.6	2.1	0.6	53.1	0.4	2.0	0.0	1.0	0.8	14.5	0.1	2346
25th percentile	0.2	1281.5	1.1	0.0	4.2	0.0	1607.1	1.2	112.9	1.8	0.5	41.3	0.3	1.7	0.0	0.8	0.6	11.3	0.1	1082
10th percentile	0.1	441.0	0.7	0.0	3.5	0.0	507.1	0.3	40.7	1.6	0.2	33.2	0.1	1.6	0.0	0.3	0.5	9.0	0.1	348
Min	0.1	161.0	0.4	0.0	2.8	0.0	14.6	0.0	1.7	1.2	0.1	28.1	0.0	1.2	0.0	0.1	0.5	7.0	0.1	35
Number of Samples	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26
Tailings Field Bin Subsamples																				
Tailings + Org Bin	0.28	2578	1.44	0.006	5.2	0.044	1774.39	3.22	219.06	1.7	0.5	54.5	0.38	1.9	0.001	0.88	0.9	13	<0.1	2334
Tailings Pond Sand	0.13	1187	0.94	0.005	3.1	0.038	1753.3	1.5	118.2	1.5	0.4	31.5	0.32	1.9	<0.001	0.61	0.7	11	<0.1	1478
Tailings Field Bin Component Samples																				
OR 09-01	0.14	1479	2.38	0.009	11.9	0.051	811.94	1.87	114.73	1.4	0.5	55.3	0.18	0.9	0.003	0.57	1	12	0.1	1142
Pile 09-01	0.14	1782	1.06	0.006	3.7	0.041	1539.73	1.29	136.25	2	0.5	37.7	0.41	1.8	0.001	0.73	0.6	16	<0.1	1639
Tailings Clayey Silt	0.19	1730	1.39	0.005	3.2	0.041	1807.93	2.97	226.1	1.9	0.6	71.4	0.48	1.9	0.001	0.94	1.1	12	<0.1	1718
Tailings Sand	0.29	3030	1.4	0.007	4.8	0.051	1949.1	2.56	163.82	1.9	0.5	47.7	0.33	2.3	<0.001	0.93	0.8	14	0.1	2833

Appendix A3
Native Substrate Metals Results

Sample ID	Mo ppm	Cu ppm	Pb ppm	Zn ppm	Ag ppb	Ni ppm	Co ppm	Mn ppm	Fe %	As ppm	U ppm	Au ppb
CCME Contaminated Sites	**2**	**30**	**25**	**60**	**2000**	**20**	**10**			**5**		
MP09-09 (13'1"-14'2")	**4.73**	**93.9**	**802.11**	**389.2**	**10519**	11.7	**31**	>10000	4.61	**1122**	0.8	135.3
MP09-11 (11-12')	0.51	9.28	15.72	59.5	169	10.2	4.7	298	1.54	**23.6**	0.5	24.7
MW09-01 (30-31')	1.4	29.93	**242.02**	**153.6**	**2852**	8.2	3.1	240	1.54	**357.3**	0.4	58.9
MW09-01 (31-32')	0.86	12.25	**81.06**	48.7	722	8.5	3.4	137	1.37	**99.2**	0.4	15.8
MW09-05 (17'3"-17'9")	1.1	**165.75**	**65**	**515**	**39778**	7.6	6.3	211	4.07	**349.5**	0.5	239.5
MW09-05 (17'9"-18'3")	0.6	**76.18**	21.84	45.8	**13320**	6	3.2	124	1.11	**262.3**	0.3	73.7
MW09-05 (18'9"-21')	0.54	**31.54**	15.23	42.7	234	7.9	3.3	154	1.28	**42**	0.5	22.3
MW09-07 (7'6"-7'11")	1.76	**124.22**	**462.9**	**265**	**7790**	7.6	2.8	350	2.16	**5004.9**	0.4	292.6
MW09-07 (7'11"-8'5")	0.31	7.35	17.39	22.5	259	2.9	2.1	64	0.45	**187.2**	0.1	8.9

Bold values exceed CCME Contaminated sites guidelines, grey rows are organic-rich substrates

Native Substrate Metals Results cont.

Sample ID	Th ppm	Sr ppm	Cd ppm	Sb ppm	Bi ppm	V ppm	Ca %	P %	La ppm	Cr ppm	Mg %	Ba ppm
CCME Contaminated Sites	**0.5**		**0.5**	**20**		**25**				**20**		**200**
MP09-09 (13'1"-14'2")	**0.6**	67.5	**5.7**	**109.27**	17.81	**29**	1.13	0.085	7.2	**48.6**	0.14	**561.2**
MP09-11 (11-12')	**3**	54	0.36	2.01	0.31	**37**	1.36	0.048	10.5	**87.3**	0.4	114.6
MW09-01 (30-31')	**2.8**	26.7	**2.01**	**46.61**	2.94	**28**	0.38	0.051	10.1	**68.2**	0.21	107.7
MW09-01 (31-32')	**2.8**	21.3	0.44	12.76	1.12	**30**	0.25	0.039	9.3	**67**	0.22	106
MW09-05 (17'3"-17'9")	**1.5**	46.9	**4.34**	17.88	0.35	**47**	0.62	0.057	6.1	**91.2**	0.06	77.9
MW09-05 (17'9"-18'3")	**1.7**	26	**0.91**	4.71	0.15	**32**	0.32	0.043	7.1	**60.5**	0.19	76.3
MW09-05 (18'9"-21')	**2.8**	20.9	0.24	2.5	0.16	**30**	0.27	0.032	9.9	**64.7**	0.22	126.1
MW09-07 (7'6"-7'11")	0.2	52.4	**4.47**	**57.46**	6.14	5	1.62	0.052	1.3	8.1	0.1	134.6
MW09-07 (7'11"-8'5")	0.1	35.8	0.21	2.48	0.23	12	0.31	0.039	1.9	**36.2**	0.08	59.5

Bold values exceed CCME Contaminated sites guidelines, grey rows are organic-rich substrates

Appendix A3
Native Substrate Metals Results cont.

Sample ID	Ti %	B ppm	Al %	Na %	K %	W ppm	Sc ppm	Tl ppm	S %	Hg ppb	Se ppm	Te ppm	Ga ppm
CCME Contaminated Sites		**1**							**0.025***	**100**	**1**		
MP09-09 (13'1"-14'2")	0.013	<20	0.73	0.046	0.17	0.2	1.7	0.72	**0.67**	**145**	0.6	0.23	2.4
MP09-11 (11-12')	0.075	<20	0.75	0.064	0.11	0.1	2.4	0.06	<0.02	36	<0.1	<0.02	2.6
MW09-01 (30-31')	0.039	<20	0.57	0.04	0.1	0.2	1.8	0.14	**0.16**	29	<0.1	0.05	1.9
MW09-01 (31-32')	0.035	<20	0.58	0.036	0.1	0.2	1.6	0.08	**0.05**	13	0.2	0.03	2.1
MW09-05 (17'3"-17'9")	0.002	26	0.55	0.041	0.12	0.1	6.8	0.13	**0.14**	**520**	0.6	0.02	1.6
MW09-05 (17'9"-18'3")	0.044	<20	0.56	0.058	0.07	0.1	1.8	0.07	**0.05**	18	0.2	<0.02	2.3
MW09-05 (18'9"-21')	0.039	<20	0.62	0.042	0.09	0.1	2.2	0.07	<0.02	15	0.1	<0.02	2.1
MW09-07 (7'6"-7'11")	0.004	35	0.19	0.041	0.06	<0.1	0.7	0.19	**1.56**	**169**	0.4	0.13	0.5
MW09-07 (7'11"-8'5")	0.033	<20	0.26	0.108	0.05	<0.1	0.6	<0.02	**0.09**	12	<0.1	<0.02	1.2

Bold values exceed CCME Contaminated sites guidelines, grey rows are organic-rich substrates

Native Substrate Sulfide Results cont.

Sample ID	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %
MP09-09 (13'1"-14'2")	0.62	0.41	0.18	0.03
MP09-11 (11-12')	0.02	0.02	<0.01	<0.01
MW09-01 (30-31')	0.16	0.09	0.05	0.02
MW09-01 (31-32')	0.04	0.03	<0.01	0.01
MW09-05 (17'3"-17'9")	0.17	0.12	0.03	0.02
MW09-05 (17'9"-18'3")	0.04	0.04	<0.01	<0.01
MW09-05 (18'9"-21')	0.01	0.01	<0.01	<0.01
MW09-07 (7'6"-7'11")	1.36	0.72	0.57	0.07
MW09-07 (7'11"-8'5")	0.09	0.06	0.01	0.02

Grey rows are organic-rich substrates

Appendix A4

Shakeflask Extraction Results

Parameter	Method	Unit	*Waste Rock Composite Samples*					*Waste Rock Composite Sample Statistics (n = 5)*					Waste Rock Bin (-1/4")	WR + Org Bin (-1/4")
			TP24b	TP25a	TP25b	TP26	TP29	Max	90th percentile	Median	10th percentile	Min		
pH	meter		7.9	7.7	7.7	6.5	6.7	7.9	7.8	7.7	6.6	6.5	7.6	7.2
Redox	meter	mV	272	296	296	340	352	352	347	296	282	272	331	338
Conductivity	meter	uS/cm	422	794	794	2566	1855	2566	2282	794	571	422	2369	2347
Total Acidity (to pH 8.3)	titration	mg $CaCO_3$/L	3.2	3.3	3.3	117.6	10.0	117.6	74.5	3.3	3.2	3.2	7.3	12.3
Alkalinity	titration	mg $CaCO_3$/L	54.9	39.8	39.8	12.0	5.7	54.9	48.8	39.8	8.2	5.7	14.8	9.6
Sulfate			150	380	380	1803	1143	1803	1539	380	242	150	1690	1770
Ion Balance														
Major Anions	Calc	meq/L	4.22	8.71	8.71	37.80	23.93	37.8	32.3	8.7	6.0	4.2	35.50	37.07
Major Cations	Calc	meq/L	4.74	9.06	9.06	38.37	23.25	38.4	32.3	9.1	6.5	4.7	2.36	2.53
Difference	Calc	meq/L	-0.52	-0.35	-0.35	-0.57	0.68						33.14	34.53
Balance (%)	Calc	%	-5.8%	-2.0%	-2.0%	-0.7%	1.4%						87.5%	87.2%
Dissolved Metals														
Hardness ($CaCO_3$)		mg/L	231	447	447	1680	1140	1680	1464	447	317	231	1580	1540
Ag	ICP-MS	mg/L	<0.000005	<0.000005	<0.000005	0.00011	<0.00005	0.00011	0.000086	<0.000005	<0.000005	<0.000005	<0.00003	0.00004
Al	ICP-MS	mg/L	0.006	0.0056	0.0056	0.012	0.012	0.0120	0.0120	0.0060	0.0056	0.0056	0.003	0.004
As	ICP-MS	mg/L	0.00679	0.00242	0.00242	0.0129	0.0024	0.0129	0.0105	0.0024	0.0024	0.0024	0.0016	0.0039
B	ICP-MS	mg/L	<0.05	<0.05	<0.05	<0.5	<0.5	0.50	0.50	0.05	0.05	0.05	<0.3	<0.3
Ba	ICP-MS	mg/L	0.03	0.0207	0.0207	0.0045	0.0056	0.0300	0.0263	0.0207	0.0049	0.0045	0.0088	0.0192
Be	ICP-MS	mg/L	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001	<0.00010	<0.00010	<0.000010	<0.000010	<0.000010	<0.00005	<0.00005
Bi	ICP-MS	mg/L	<0.000005	<0.000005	<0.000005	<0.00005	<0.00005	<0.00005	<0.00005	<0.000005	<0.00005	<0.000005	<0.00003	<0.00003
Ca	ICP-MS	mg/L	70	160	160	481	405	481.0	450.6	160.0	106.0	70.0	527	507
Cd	ICP-MS	mg/L	0.00249	0.00638	0.00638	0.308	0.0363	0.3080	0.1993	0.0064	0.0040	0.0025	0.0416	0.0813
Co	ICP-MS	mg/L	0.00002	0.000074	0.000074	0.126	0.00121	0.13	0.076	0.00007	0.00004	0.00002	0.00071	0.00216
Cr	ICP-MS	mg/L	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005
Cu	ICP-MS	mg/L	0.00341	0.00262	0.00262	0.157	0.0133	0.157	0.100	0.003	0.003	0.003	0.0042	0.0169
Fe	ICP-MS	mg/L	0.003	0.006	0.006	0.03	<0.01	0.030	0.022	0.006	0.004	0.003	0.006	0.009
Hg	CVAA	ug/L	<0.01	<0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.01	<0.05	<0.05
K	ICP-MS	mg/L	3.64	3.6	3.6	1.53	2.94	3.6	3.6	3.6	2.1	1.5	6.56	8.33
Li	ICP-MS	mg/L	0.0036	0.0021	0.0021	0.035	0.01	0.0350	0.0250	0.0036	0.0021	0.0021	0.009	0.012
Mg	ICP-MS	mg/L	13.7	11.5	11.5	116	31.3	116.0	82.1	13.7	11.5	11.5	64.8	67.2
Mn	ICP-MS	mg/L	0.0269	0.207	0.207	91.5	7.82	91.5	58.0	0.21	0.10	0.027	6.14	15
Mo	ICP-MS	mg/L	0.00159	0.00258	0.00258	<0.0005	<0.0005	0.0026	0.0026	0.0016	<0.0005	<0.0005	<0.0003	<0.0003
Na	ICP-MS	mg/L	0.68	0.49	0.49	0.25	0.85	0.85	0.78	0.49	0.35	0.25	0.96	1.27
Ni	ICP-MS	mg/L	0.00038	0.00099	0.00099	0.0315	0.0048	0.0315	0.021	0.00099	0.00062	0.00038	0.0029	0.0072
P	ICP-MS	mg/L	0.005	0.004	0.004	<0.02	<0.02	<0.02	<0.02	0.005	0.004	0.004	<0.01	0.019
Pb	ICP-MS	mg/L	0.000482	0.000537	0.000537	0.00173	0.00021	0.0017	0.0013	0.0005	0.0003	0.0002	0.00021	0.00071
S	ICP-MS	mg/L	61	143	143	669	403	669	563	143	93.8	61.0	514	524
Sb	ICP-MS	mg/L	0.0128	0.0112	0.0112	0.0029	0.0057	0.0128	0.0122	0.0112	0.0040	0.0029	0.0027	0.0023
Se	ICP-MS	mg/L	0.00029	0.00006	0.00006	<0.0004	<0.0004	<0.0004	<0.0004	0.00029	0.00006	0.00006	0.0003	0.0003
Si	ICP-MS	mg/L	1.75	0.73	0.73	2.12	2.49	2.49	2.34	1.75	0.73	0.73	1.86	3.13
Sn	ICP-MS	mg/L	<0.00001	0.00002	0.00002	<0.0001	<0.0001	0.0001	0.0001	0.00002	<0.000014	<0.00001	<0.00005	<0.00005
Sr	ICP-MS	mg/L	0.211	0.206	0.206	0.333	0.482	0.48	0.42	0.21	0.21	0.21	0.673	0.773
Ti	ICP-MS	mg/L	<0.0005	<0.0005	<0.0005	<0.005	<0.005	<0.005	<0.005	<0.0005	<0.0005	<0.0005	<0.003	<0.003
Tl	ICP-MS	mg/L	0.000155	0.000124	0.000124	0.0002	0.00011	0.0002	0.0002	0.0001	0.0001	0.0001	0.00017	0.00022
U	ICP-MS	mg/L	0.000431	0.000822	0.000822	0.00002	<0.00002	0.0008	0.0008	0.0004	<0.00002	<0.00002	0.00004	0.00001
V	ICP-MS	mg/L	<0.0002	<0.0002	<0.0002	<0.002	<0.002	<0.002	<0.002	<0.0002	<0.0002	<0.0002	<0.001	<0.001
Zn	ICP-MS	mg/L	0.0653	0.183	0.183	47	1.77	47.0	28.9	0.2	0.1	0.1	0.645	2.6
Zr	ICP-MS	mg/L	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005

Notes: Shake Flask Extraction Leach Method 3:1 (750 mL de-ionized water: 250 mL solid sample)

TP24b: TP-24b (-1/4")

TP25a: TP-25a + TP-25b Composite (-1/4")

TP25b: TP-25a + TP-25b Composite (-1/4")

TP26: TP-26 (-1/4")

TP29: TP29 (-1/4")

Appendix A4

Shakeflask Extraction Results

Parameter	Method	Unit	*Ore Composite Samples*						*Ore Composite Sample Statistics (n = 6)*					Ore Bin (-1/4")
			OB04	OB05	OB07	OB08	OB09	OB10	Max	90th percentile	Median	10th percentile	Min	
pH	meter		6.7	7.5	6.7	6.7	7.3	7.3	7.5	7.4	7.0	6.7	6.7	6.8
Redox	meter	mV	338	332	347	347	315	315	347	347	335	315	315	363
Conductivity	meter	uS/cm	1609	1008	1742	1742	1861	1861	1861	1861	1742	1309	1008	2530
Total Acidity (to pH 8.3)	titration	mg $CaCO_3$/L	6.8	5.2	7.7	7.7	9.8	9.8	9.8	9.8	7.7	6.0	5.2	9.0
Alkalinity	titration	mg $CaCO_3$/L	5.7	26.3	8.5	8.5	10.1	10.1	26.3	18.2	9.3	7.1	5.7	11.5
Sulfate			1125	586	1101	1101	1240	1240	1240	1240	1113	844	586	1889
Ion Balance														
Major Anions	Calc	meq/L	23.55	12.74	23.11	23.11	26.04	26.04	26.0	26.0	23.3	17.9	12.7	39.58
Major Cations	Calc	meq/L	21.70	12.28	24.29	24.29	26.82	26.82	26.8	26.8	24.3	17.0	12.3	3.48
Difference	Calc	meq/L	1.86	0.46	-1.19	-1.19	-0.78	-0.78						36.11
Balance (%)	Calc	%	4.1%	1.8%	-2.5%	-2.5%	-1.5%	-1.5%						83.9%
Dissolved Metals														
Hardness ($CaCO_3$)		mg/L	1060	606	1190	1190	1300	1300	1300	1300	1190	833	606	1760
Ag	ICP-MS	mg/L	<0.00003	<0.000005	0.00004	0.00004	0.00005	0.00005	0.00005	0.00005	0.00004	0.00002	<0.000005	0.0005
Al	ICP-MS	mg/L	0.002	0.0038	0.006	0.006	0.005	0.005	0.006	0.006	0.005	0.003	0.002	0.006
As	ICP-MS	mg/L	0.0106	0.0387	0.0212	0.0212	0.0201	0.0201	0.039	0.030	0.021	0.015	0.011	0.0429
B	ICP-MS	mg/L	<0.3	<0.05	<0.3	<0.3	<0.3	<0.3	0.30	0.30	0.30	0.18	0.05	<0.5
Ba	ICP-MS	mg/L	0.0131	0.0193	0.0103	0.0103	0.0144	0.0144	0.019	0.017	0.014	0.010	0.010	0.0156
Be	ICP-MS	mg/L	<0.00005	<0.00001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<5E-05	<0.00003	<0.00001	<0.0001
Bi	ICP-MS	mg/L	<0.00003	0.000009	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<3E-05	<0.00002	<9E-06	<0.00005
Ca	ICP-MS	mg/L	337	205	365	365	394	394	394	394	365	271	205	551
Cd	ICP-MS	mg/L	0.0192	0.00195	0.0383	0.0383	0.0449	0.0449	0.045	0.045	0.038	0.011	0.002	0.0445
Co	ICP-MS	mg/L	0.00021	0.00002	0.00145	0.00145	0.00353	0.00353	0.0035	0.0035	0.0015	0.00012	0.00002	0.00444
Cr	ICP-MS	mg/L	<0.0005	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0001	<0.001
Cu	ICP-MS	mg/L	0.0027	0.00203	0.0031	0.0031	0.0055	0.0055	0.0055	0.0055	0.0031	0.0024	0.0020	0.0063
Fe	ICP-MS	mg/L	0.006	0.007	0.022	0.022	0.012	0.012	0.022	0.022	0.012	0.007	0.006	0.024
Hg	CVAA	ug/L	<0.05	<0.01	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.03	<0.01	0.3
K	ICP-MS	mg/L	5.49	5.02	3.94	3.94	4.12	4.12	5.49	5.26	4.12	3.94	3.94	7.81
Li	ICP-MS	mg/L	0.005	0.0013	0.0060	0.0060	0.0080	0.0080	0.0080	0.0080	0.0060	0.0032	0.0013	0.015
Mg	ICP-MS	mg/L	54.4	22.6	67.4	67.4	77.2	77.2	77.2	77.2	67.4	38.5	22.6	94.4
Mn	ICP-MS	mg/L	3.16	0.0065	9.24	9.24	15.6	15.6	15.6	15.6	9.2	1.6	0.01	20.4
Mo	ICP-MS	mg/L	<0.0003	0.00042	<0.0003	<0.0003	<0.0003	<0.0003	0.00042	<0.00036	<0.0003	<0.0003	<0.0003	<0.0005
Na	ICP-MS	mg/L	2.78	1.19	0.69	0.69	1	1	2.78	1.99	1.00	0.69	0.69	1.66
Ni	ICP-MS	mg/L	0.0016	0.00039	0.0042	0.0042	0.0073	0.0073	0.007	0.007	0.004	0.001	0.000	0.0081
P	ICP-MS	mg/L	<0.01	0.011	<0.01	<0.01	<0.01	<0.01	0.011	0.011	<0.01	<0.01	<0.01	<0.02
Pb	ICP-MS	mg/L	0.0009	0.00013	0.00054	0.00054	0.00174	0.00174	0.0017	0.0017	0.0007	0.00034	0.00013	0.00077
S	ICP-MS	mg/L	373	214	411	411	464	464	464.0	464.0	411.0	293.5	214.0	589
Sb	ICP-MS	mg/L	0.0132	0.0173	0.0228	0.0228	0.0359	0.0359	0.036	0.036	0.023	0.015	0.013	0.0595
Se	ICP-MS	mg/L	<0.0002	0.00008	0.0003	0.0003	0.0004	0.0004	0.0004	0.0004	0.0003	0.00014	0.00008	0.0007
Si	ICP-MS	mg/L	2.98	2.94	1.81	1.81	1.73	1.73	2.98	2.96	1.81	1.73	1.73	2.67
Sn	ICP-MS	mg/L	<0.00005	<0.00001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<5E-05	<0.00003	<0.00001	<0.0001
Sr	ICP-MS	mg/L	0.348	0.275	0.336	0.336	0.424	0.424	0.42	0.42	0.34	0.31	0.28	0.629
Ti	ICP-MS	mg/L	<0.003	<0.0005	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.003	<0.00175	<0.0005	<0.005
Tl	ICP-MS	mg/L	0.00011	0.000059	0.00014	0.00014	0.0002	0.0002	0.0002	0.0002	0.00014	0.000085	0.000059	0.00024
U	ICP-MS	mg/L	<0.00001	0.000085	<0.00001	<0.00001	<0.00001	<0.00001	0.000085	0.000048	<1E-05	<0.00001	<0.00001	0.00003
V	ICP-MS	mg/L	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0006	<0.0002	<0.002
Zn	ICP-MS	mg/L	0.591	0.0203	1.83	1.83	2.45	2.45	2.45	2.45	1.83	0.31	0.02	1.11
Zr	ICP-MS	mg/L	<0.0005	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0003	<0.0001	<0.001

Notes: Shake Flask Extraction Leach Method 3:1 (750 mL de-ionized water: 250 mL solid sample)

OB04: OB04 (-1/4")
OB05: OB05 (-1/4")
OB07: OB-07 + OB-08 Composite (-1/4")
OB08: OB-07 + OB-08 Composite (-1/4")
OB09: OB-09 + OB-10 Composite (-1/4")
OB10: OB-09 + OB-10 Composite (-1/4")

Appendix A4
Shakeflask extraction results

Parameter	Method	Unit	*Tailings Composite Samples*									*Tailings Composite Sample Statistics (n = 9)*					Tailings Pond Sand	Tailings + Org Bin
			Pile09-02	SL09-01	UL09-01	MW09-01	MW09-04	MW09-05	MW09-05	MW09-05	MW09-05	Max	90th percentile	Median	10th percentile	Min		
pH	meter		7.5	7.8	7.9	7.5	7.9	7.7	8.0	8.4	7.8	8.4	8.1	7.8	7.5	7.5	7.8	6.9
Redox	meter	mV	267	274	253	286	257	278	276	247	315	315	292	274	252	247	312	338
Conductivity	meter	uS/cm	1812	2309	381	2203	1437	1491	2160	1479	1808	2309	2224	1808	1226	381	248	2392
Total Acidity (to pH 8.3)	titration	mg $CaCO_3$/L	5.2	13.0	3.2	7.5	5.2	4.6	5.1	0.0	9.1	13.0	9.9	5.2	2.5	0.0	3.5	8.7
Alkalinity	titration	mg $CaCO_3$/L	27.7	113.7	39.9	32.6	47.4	40.0	68.6	101.7	98.1	113.7	104.1	47.4	31.6	27.7	38.2	11.9
Sulfate			1075	1478	150	1585	880	1001	1502	905	1051	1585	1519	1051	734	150	92	1750
Ion Balance																		
Major Anions	Calc	meq/L	22.95	33.07	3.92	33.72	19.34	21.65	32.85	21.11	24.37	33.7	33.2	22.9	16.3	3.9	2.68	36.70
Major Cations	Calc	meq/L	0.23	0.11	0.00	0.62	0.00	0.35	0.00	0.00	0.25	0.6	0.4	0.1	0.0	0.0	0.00	2.49
Difference	Calc	meq/L	22.72	32.96	3.92	33.10	19.34	21.30	32.85	21.11	24.12						2.68	34.20
Balance (%)	Calc	%	98.0%	99.4%	100.0%	96.4%	100.0%	96.8%	100.0%	100.0%	97.9%						100.0%	87.3%
Dissolved Metals																		
Hardness ($CaCO_3$)		mg/L	1270	1530	183	1510	882	953	1570	840	923	1570	1538	953	709	183	105	1660
Ag	ICP-MS	mg/L	0.00006	0.00094	0.000013	0.00056	0.00006	0.00004	0.00007	<0.00005	0.0077	0.0077	0.0023	0.00006	0.00003	0.00001	0.00036	0.00021
Al	ICP-MS	mg/L	0.008	0.01	0.0072	0.006	0.003	0.011	0.025	0.065	0.107	0.11	0.073	0.010	0.005	0.003	0.0199	0.004
As	ICP-MS	mg/L	0.0277	0.403	0.147	1.29	1.53	0.138	4.67	5.47	12.8	12.8	6.9	1.3	0.12	0.028	0.121	0.0987
B	ICP-MS	mg/L	<0.3	<0.3	<0.05	<0.3	<0.3	<0.3	<0.5	<0.5	2.94	2.9	1.0	0.3	0.3	0.1	<0.05	<0.5
Ba	ICP-MS	mg/L	0.007	0.0147	0.00141	0.0167	0.0109	0.0078	0.0048	0.0093	0.0517	0.1	0.0237	0.0093	0.0041	0.001	0.00438	0.0361
Be	ICP-MS	mg/L	<0.00005	<0.00005	<0.00001	<0.00005	<0.00005	<0.00005	<0.0001	<0.0001	<0.0002	<0.00020	<0.00013	<0.00005	<0.00005	<0.00005	<0.00001	<0.0001
Bi	ICP-MS	mg/L	<0.00003	<0.00003	<0.000005	<0.00003	<0.00003	<0.00003	<0.00005	<0.00005	<0.0001	<0.00005	<0.00005	<0.00003	<0.00003	<0.00003	0.000012	<0.00005
Ca	ICP-MS	mg/L	497	459	58.4	575	336	366	592	334	364	592.0	578.4	366.0	278.9	58.4	30.6	553
Cd	ICP-MS	mg/L	0.00995	0.0107	0.000482	0.00528	0.00071	0.00311	0.00053	0.00023	0.0041	0.011	0.010	0.003	0.0004	0.0002	0.0011	0.0374
Co	ICP-MS	mg/L	0.00909	0.00383	0.000682	0.00977	0.00267	0.00114	0.00226	0.0181	0.0229	0.023	0.019	0.0038	0.0010	0.0007	0.00173	0.0104
Cr	ICP-MS	mg/L	<0.0005	<0.0005	<0.0001	<0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.002	<0.002	<0.0013	<0.0005	<0.0005	<0.0005	<0.0001	<0.001
Cu	ICP-MS	mg/L	0.0029	3.31	0.00637	0.0053	0.0036	0.0045	0.0043	0.0058	0.109	3.310	0.749	0.0053	0.0035	0.0029	0.0108	0.0202
Fe	ICP-MS	mg/L	0.083	0.04	0.014	0.039	0.024	0.027	0.041	0.123	0.099	0.123	0.104	0.040	0.0220	0.0140	0.025	0.023
Hg	CVAA	ug/L	<0.05	0.09	<0.01	<0.05	<0.05	<0.05	<0.1	<0.1	<0.2	<0.2	<0.1	<0.1	<0.0	<0.01	0.03	<0.1
K	ICP-MS	mg/L	3.76	33.1	5.23	25.3	14.9	5.73	6.71	16.4	19.5	33.1	26.9	14.9	4.9	3.8	3.75	13.4
Li	ICP-MS	mg/L	0.006	0.012	0.0024	0.01	<0.003	0.007	<0.005	<0.005	<0.01	0.012	0.010	0.0060	<0.003	0.0024	0.003	0.019
Mg	ICP-MS	mg/L	6.23	93.6	9.12	17.1	10.7	9.62	23.3	1.5	3.4	93.6	37.4	9.6	3.0	1.5	6.9	67.3
Mn	ICP-MS	mg/L	2.33	0.751	0.0076	8.55	0.141	1.69	0.104	0.0308	0.22	8.6	3.6	0.22	0.026	0.008	0.11	23.3
Mo	ICP-MS	mg/L	0.0019	0.0135	0.00301	0.0177	0.0032	0.0071	0.0035	0.0035	0.044	0.044	0.023	0.004	0.003	0.002	0.00511	0.0042
Na	ICP-MS	mg/L	0.77	73.8	9.34	12.2	11.2	4.07	7.75	34.5	96.7	96.7	78.4	11.2	3.4	0.8	5.65	6.14
Ni	ICP-MS	mg/L	0.0027	0.0108	0.00026	0.0043	0.0025	0.0024	0.0029	0.0034	0.0079	0.011	0.008	0.003	0.002	0.000	0.00052	0.011
P	ICP-MS	mg/L	0.014	0.061	0.02	0.033	0.12	0.028	0.136	0.061	0.385	0.39	0.19	0.061	0.019	0.014	0.012	<0.02
Pb	ICP-MS	mg/L	0.00056	0.00042	0.000177	0.00072	0.00417	0.00053	0.00093	0.00089	0.0067	0.0067	0.0047	0.0007	0.0004	0.0002	0.00117	0.00429
S	ICP-MS	mg/L	433	569	59	548	311	323	522	290	379	569	552	379	244	59	28	582
Sb	ICP-MS	mg/L	0.0638	0.212	0.121	0.146	0.839	0.403	0.779	0.677	0.351	0.84	0.79	0.35	0.11	0.064	0.257	0.319
Se	ICP-MS	mg/L	<0.0002	0.0017	0.00013	0.0012	0.0006	0.0002	0.001	0.0021	<0.0008	0.0021	0.0018	<0.0008	<0.0002	0.0001	0.00011	<0.0004
Si	ICP-MS	mg/L	2.78	5.08	3.39	3.53	10.5	4.17	10.4	5.8	10.6	10.6	10.5	5.1	3.3	2.8	3.01	2.34
Sn	ICP-MS	mg/L	<0.00005	<0.00005	<0.00001	0.00011	<0.00005	<0.00005	<0.0001	<0.0001	<0.0002	<0.0002	<0.000155	<5E-05	<0.00005	<5E-05	0.00001	<0.0001
Sr	ICP-MS	mg/L	0.441	0.907	0.101	0.684	0.541	0.416	0.93	0.525	1	1.0	0.94	0.54	0.35	0.10	0.0692	0.968
Ti	ICP-MS	mg/L	<0.003	<0.003	<0.0005	0.004	0.005	0.003	<0.005	0.011	0.02	0.020	0.013	0.004	0.0025	<0.0005	<0.0005	<0.005
Tl	ICP-MS	mg/L	0.0001	0.00102	0.000121	0.00067	0.0004	0.00026	0.00042	0.00043	0.00008	0.001	0.001	0.0004	0.0001	0.0001	0.00011	0.00016
U	ICP-MS	mg/L	0.00015	0.00398	0.000138	0.00029	0.00037	0.00086	0.0016	0.0028	0.0002	0.004	0.003	0.00037	0.00015	0.00014	0.00007	<0.00002
V	ICP-MS	mg/L	<0.001	<0.001	<0.0002	<0.001	<0.001	<0.001	<0.002	<0.002	<0.004	<0.004	<0.0024	<0.001	<0.00084	<0.0002	<0.0002	<0.002
Zn	ICP-MS	mg/L	0.152	0.297	0.0132	0.0602	0.0037	0.017	0.002	0.001	0.035	0.297	0.181	0.017	0.002	0.001	0.0378	1.28
Zr	ICP-MS	mg/L	<0.0005	<0.0005	<0.0001	<0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.002	<0.002	<0.0013	<0.0005	<0.0005	<0.0005	<0.0001	<0.001

Notes: Shake Flask Extraction Leach Method 3:1 (750 mL de-ionized water: 250 mL solid sample)

Pile09-02: Partially saturated
SL09-01: Surface
UL09-01: Underlying
MW09-01: Tailings screen clay (10-13' Comp)
MW09-04: Tailings screen clay (14'5"-15'5")
MW09-05: Tailings screen sand (5-6')
MW09-05: Tailings screen sand (9-10')
MW09-05: Tailings screen silty clay (14-15')
MW09-05: Tailings screen clay (17'3"-17'9")

Appendix A4
Shakeflask extraction results

Parameter	Method	Unit	*Waste Rock and Tailings Components Samples*				
			WR Org	OR 09-01	Pile 09-01	Tailings Sand	Tailings Clayey Silt
pH	meter		4.5	6.0	7.6	7.5	6.9
Redox	meter	mV	426	289	301	333	334
Conductivity	meter	uS/cm	187	2137	938	2564	2221
Total Acidity (to pH 8.3)	titration	mg $CaCO_3$/L	88.8	38.1	5.1	7.8	7.3
Alkalinity	titration	mg $CaCO_3$/L	#N/A	4.5	29.2	29.0	22.0
Sulfate			20	1253	525	1908	1493
Ion Balance							
Major Anions	Calc	meq/L	0.42	26.19	11.52	40.33	31.54
Major Cations	Calc	meq/L	0.24	2.72	0.00	3.82	0.53
Difference	Calc	meq/L	0.17	23.47	11.52	36.51	31.02
Balance (%)	Calc	%	26.2%	81.2%	100.0%	82.7%	96.7%
Dissoved Metals							
Hardness ($CaCO_3$)		mg/L	31	1140	539	1800	1470
Ag	ICP-MS	mg/L	0.00027	0.0149	0.000037	0.00017	0.00197
Al	ICP-MS	mg/L	3.73	0.199	0.0059	0.006	0.012
As	ICP-MS	mg/L	0.0624	0.265	0.0621	0.0461	0.429
B	ICP-MS	mg/L	<0.05	<0.5	<0.05	<0.3	<0.3
Ba	ICP-MS	mg/L	0.0699	0.12	0.00966	0.0121	0.0099
Be	ICP-MS	mg/L	0.00023	<0.0001	<0.00001	<0.00005	<0.00005
Bi	ICP-MS	mg/L	0.000256	0.0004	<0.000005	<0.00003	<0.00003
Ca	ICP-MS	mg/L	7.84	358	205	551	564
Cd	ICP-MS	mg/L	0.0059	0.0558	0.00385	0.0271	0.00691
Co	ICP-MS	mg/L	0.00303	0.0549	0.00658	0.00678	0.00604
Cr	ICP-MS	mg/L	0.0023	<0.001	<0.0001	<0.0005	<0.0005
Cu	ICP-MS	mg/L	0.0921	0.283	0.00742	0.014	0.0089
Fe	ICP-MS	mg/L	0.738	2.55	0.042	0.015	0.057
Hg	CVAA	ug/L	0.07	0.1	0.02	<0.05	0.18
K	ICP-MS	mg/L	30.3	35.6	3.3	30.7	15.5
Li	ICP-MS	mg/L	0.0016	0.013	0.0064	0.021	0.006
Mg	ICP-MS	mg/L	2.77	58.7	6.52	103	14.4
Mn	ICP-MS	mg/L	0.856	58.9	0.774	9.05	5.52
Mo	ICP-MS	mg/L	0.00062	<0.0005	0.00322	0.007	0.0062
Na	ICP-MS	mg/L	1.86	22.8	2.02	11.1	1.04
Ni	ICP-MS	mg/L	0.00605	0.0705	0.00058	0.0031	0.0012
P	ICP-MS	mg/L	8.14	0.353	0.009	0.013	<0.01
Pb	ICP-MS	mg/L	0.00848	0.0237	0.000373	0.00212	0.00044
S	ICP-MS	mg/L	6	587	170	620	514
Sb	ICP-MS	mg/L	0.0007	0.0277	0.199	0.581	0.129
Se	ICP-MS	mg/L	0.00026	0.0007	0.0002	<0.0002	0.0007
Si	ICP-MS	mg/L	5.99	6.22	3.94	2.96	1.96
Sn	ICP-MS	mg/L	0.00019	0.0001	0.00002	<0.00005	<0.00005
Sr	ICP-MS	mg/L	0.0483	1.61	0.215	1.51	0.592
Ti	ICP-MS	mg/L	0.017	0.015	<0.0005	<0.003	<0.003
Tl	ICP-MS	mg/L	0.000086	0.0006	0.000073	0.00096	0.00013
U	ICP-MS	mg/L	0.000107	0.00012	0.000124	0.00039	0.00028
V	ICP-MS	mg/L	0.0061	<0.002	<0.0002	<0.001	<0.001
Zn	ICP-MS	mg/L	0.129	9.48	0.0643	0.329	0.052
Zr	ICP-MS	mg/L	0.0021	<0.001	<0.0001	<0.0005	<0.0005

Parameter	Method	Unit	Waste Rock Bin (-1/4")	WR + Org Bin (-1/4")	Ore Bin (-1/4")	Tailings Pond Sand	Tailings + Org Bin	CCME [2] Max Aquatic Life Guidelines
pH	meter		7.6	7.2	6.8	7.8	6.9	
Redox	meter	mV	331	338	363	312	338	
Conductivity	meter	uS/cm	2369	2347	2530	248	2392	
Total Acidity (to pH 8.3)	titration	mg $CaCO_3$/L	7.3	12.3	9.0	3.5	8.7	
Alkalinity	titration	mg $CaCO_3$/L	14.8	9.6	11.5	38.2	11.9	
Sulfate			1690	1770	1889	92	1750	
Ion Balance								
Major Anions	Calc	meq/L	35.50	37.07	39.58	2.68	36.70	
Major Cations	Calc	meq/L	2.36	2.53	3.48	0.0006	2.49	
Difference	Calc	meq/L	33.14	34.53	36.11	2.68	34.20	
Balance (%)	Calc	%	87.5%	87.2%	83.9%	100.0%	87.3%	
Dissoved Metals								
Hardness ($CaCO_3$)		mg/L	1580	1540	1760	105	1660	
Ag*	ICP-MS	mg/L	<0.00003	0.00004	0.0005	0.00036	0.00021	0.0001
Al	ICP-MS	mg/L	0.003	0.004	0.006	0.0199	0.004	0.1
As	ICP-MS	mg/L	0.0016	0.0039	0.0429	0.121	0.0987	0.005
B	ICP-MS	mg/L	<0.3	<0.3	<0.5	<0.05	<0.5	*1.2*
Ba	ICP-MS	mg/L	0.0088	0.0192	0.0156	0.00438	0.0361	*5*
Be	ICP-MS	mg/L	<0.00005	<0.00005	<0.0001	<0.00001	<0.0001	*0.0053*
Bi	ICP-MS	mg/L	<0.00003	<0.00003	<0.00005	0.000012	<0.00005	
Ca	ICP-MS	mg/L	527	507	551	30.6	553	
Cd*	ICP-MS	mg/L	0.0416	0.0813	0.0445	0.0011	0.0374	0.000017
Co	ICP-MS	mg/L	0.00071	0.00216	0.00444	0.00173	0.0104	*0.11*
Cr	ICP-MS	mg/L	<0.0005	<0.0005	<0.001	<0.0001	<0.001	0.001
Cu*	ICP-MS	mg/L	0.0042	0.0169	0.0063	0.0108	0.0202	0.004
Fe	ICP-MS	mg/L	0.006	0.009	0.024	0.025	0.023	0.3
Hg	CVAA	ug/L	<0.05	<0.05	0.3	0.03	<0.1	0.000026
K	ICP-MS	mg/L	6.56	8.33	7.81	3.75	13.4	
Li	ICP-MS	mg/L	0.009	0.012	0.015	0.003	0.019	*0.87*
Mg	ICP-MS	mg/L	64.8	67.2	94.4	6.9	67.3	*NP*
Mn*	ICP-MS	mg/L	6.14	15	20.4	0.11	23.3	*2.52*
Mo	ICP-MS	mg/L	<0.0003	<0.0003	<0.0005	0.00511	0.0042	0.073
Na	ICP-MS	mg/L	0.96	1.27	1.66	5.65	6.14	
Ni*	ICP-MS	mg/L	0.0029	0.0072	0.0081	0.00052	0.011	0.15
P	ICP-MS	mg/L	<0.01	0.019	<0.02	0.012	<0.02	
Pb*	ICP-MS	mg/L	0.00021	0.00071	0.00077	0.00117	0.00429	0.007
S	ICP-MS	mg/L	514	524	589	28	582	
Sb	ICP-MS	mg/L	0.0027	0.0023	0.0595	0.257	0.319	*0.02*
Se	ICP-MS	mg/L	0.0003	0.0003	0.0007	0.00011	<0.0004	0.001
Si	ICP-MS	mg/L	1.86	3.13	2.67	3.01	2.34	
Sn	ICP-MS	mg/L	<0.00005	<0.00005	<0.0001	0.00001	<0.0001	
Sr	ICP-MS	mg/L	0.673	0.773	0.629	0.0692	0.968	
Ti	ICP-MS	mg/L	<0.003	<0.003	<0.005	<0.0005	<0.005	
Tl	ICP-MS	mg/L	0.00017	0.00022	0.00024	0.00011	0.00016	0.0008
U	ICP-MS	mg/L	0.00004	0.00001	0.00003	0.00007	<0.00002	*0.3*
V	ICP-MS	mg/L	<0.001	<0.001	<0.002	<0.0002	<0.002	*0.006*
Zn*	ICP-MS	mg/L	0.645	2.6	1.11	0.038	1.28	0.03
Zr	ICP-MS	mg/L	<0.0005	<0.0005	<0.001	<0.0001	<0.001	

Notes:

Shading higlights metals which were elevated in aqua regia digestion (Tables

Bold indicates exceeds freshwater aquatic guidelines for total metals

* denotes hardness dependent parameters, presented guidelines based on median hardness value of 1580 mg CaCO/L

1. Metal Mining Effluent Regulations (2002) for total metals
   MMM: Maximum Authorized Monthly Mean Concentration
   MCS: Maximum Authorized Concentration in a Composite Sample
   MGS: Maximum Authorized Concentration in a Grab Sample
2. Canadian Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
   Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals (Be only has a 30-day criterion)
   Cd is an interim Guideline (Cd guideline = 10{0.86[log(hardness)] - 3.2})

SGS CEMI Inc.

Kinetic Testing Procedures

for

Lorax Environmental Services (Mt. Nansen Project)

October 8, 2010

1.0 Sample Receiving

Samples were received, logged-in and sample weights recorded.

2.0 Sample Preparation

Wet samples were air-dried at ambient temperature and homogenized by breaking up lumps with a stainless steel rolling pin and mixing on a rolling mat. For kinetic testing a 1.00 kg representative split of each sample was made using a 12.7 mm opening splitter box.

3.0 Kinetic Testing

3.1 Tailings Humidity Cell

The humidity cell is made from acrylic tubing, with height and diameter appropriate for the sample size. A 4 inch height and 8 inch diameter is suitable for a 1.00 kg sample.

The cell has a fixed base plate with a leachate drainage hole fitted with a tubing nipple. Approximately one inch above the base, a perforated plexiglas plate is fitted to support the sample. The plate is covered with one layer of 200 mesh nylon. A shark skin™ filter clothe is placed on top of the nylon mesh and siliconed around the circumference to prevent loss of fines. The cell is equipped with a removable lid with a central hose nipple for air inlet. The leachate drain is equipped with suitable pinch valves.

One kg was placed in the cell and an initial volume of 750 mL consisting of nanopure water was applied and allowed to stand quiescent for 1h. The cell was then drained and the leachate collected for analysis. The cell was operated on a 7 day cycle. For the first 3 days, dry air was passed over the sample. For the next 3 days, humid air from the humidifier was passed over the sample.

On the last day of the cycle, the air line was disconnected and 500 mL of nanopure water was added and allowed to soak for 1 hour (leachate drain closed). The cell was then drained and the leachate volume collected and recorded. The 7 day cycle was then re-started. The leachate was filtered through a 0.45 micron membrane filter and any solids recovered were returned to the cell. pH and other parameters, as required by the experimental design were measured. These included conductivity, acidity, alkalinity, sulphate and dissolved metals. Analysis of the leachate are described above in Section 3.9.

Source: Acid Rock Drainage Prediction Manual. March 1991

Appendix B.1-1
Humidity Cell T1 (Clay Composite)
Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
28-Jul-09	0	750	210	7.45	4548	#N/A	22.2	67.2	2640	340	1970	<0.02	0.215	0.199	0.034	<0.001	<0.0005	<5	0.0206	565	<0.01	0.0158	0.094	<0.1	0.001	<0.05	135
04-Aug-09	1	500	455	7.28	2019	#N/A	9.2	21.8	1224	18	1020	0.008	0.0862	0.134	0.0093	<0.00005	<0.00003	<0.3	0.00169	352	<0.0005	0.00395	0.0036	0.008	0.0008	0.011	35.3
11-Aug-09	2	500	395	7.49	2799	#N/A	12.4	41.0	2032	2.8	1580	0.006	0.282	0.149	0.0113	<0.00005	<0.00003	<0.3	0.0117	535	<0.0005	0.00439	0.0109	0.022	0.00063	0.017	59.6
18-Aug-09	3	500	440	7.42	2194	#N/A	9.8	34.1	1445	1.9	1290	0.004	0.225	0.104	0.0114	<0.00005	<0.00003	<0.3	0.0114	450	<0.0005	0.00267	0.0074	0.009	0.00087	0.014	40.2
25-Aug-09	4	500	465	7.50	2049				1361																		
01-Sep-09	5	500	430	7.58	1897	#N/A	9.0	37.3	1264	1	1130	0.011	0.15	0.0621	0.0136	<0.00005	<0.00003	<0.3	0.0115	393	<0.0005	0.00245	0.0121	0.018	0.00058	0.013	37.2
08-Sep-09	6	500	425	7.31	1518				1006																		
15-Sep-09	7	500	400	7.59	2560	#N/A	14.4	84.7	1587	0.9	1650	0.004	0.212	0.0953	0.0209	<0.00005	<0.00003	<0.3	0.0346	550	<0.0005	0.00738	0.0173	0.024	0.00147	0.025	66.4
22-Sep-09	8	500	515	7.38	2405				1798																		
29-Sep-09	9	500	490	7.37	1384	#N/A	7.6	39.1	1022	<0.5	850	0.004	0.105	0.0523	0.0108	<0.00005	<0.00003	<0.3	0.015	301	<0.0005	0.00869	0.0069	0.057	0.00088	0.01	24.3
06-Oct-09	10	500	445	7.31	1474				1094																		
13-Oct-09	11	500	465	7.48	1322	#N/A	4.8	33.2	713	<0.5	765	0.0041	0.0835	0.0431	0.0112	<0.00001	<0.000005	<0.05	0.0117	276	<0.0001	0.0185	0.00622	0.018	0.000273	0.0087	18.4
20-Oct-09	12	500	480	7.37	1218				817																		
27-Oct-09	13	500	420	7.41	1772	#N/A	4.9	26.7	1198	0.8	1070	0.006	0.102	0.0603	0.0098	<0.00005	<0.00003	<0.3	0.0123	392	<0.0005	0.0228	0.0063	0.019	0.00082	0.011	21.6
03-Nov-09	14	500	445	7.27	1765				1189																		
10-Nov-09	15	500	470	7.10	1802	#N/A	7.7	28.2	1290	1.5	1160	0.0038	0.109	0.0817	0.011	<0.00001	<0.000005	0.052	0.0148	424	<0.0001	0.0268	0.00501	0.025	0.000603	0.012	23.9
17-Nov-09	16	500	465	7.18	1876				1292																		
24-Nov-09	17	500	490	7.62	2165	#N/A	5.7	46.5	1444	1.4	1380	0.003	0.132	0.108	0.0116	<0.00005	<0.00003	<0.3	0.021	506	<0.0005	0.0272	0.016	0.015	0.00134	0.014	28.5
01-Dec-09	18	500	490	7.50	1970				1338																		
08-Dec-09	19	500	450	7.32	2047	#N/A	8.3	52.5	1305	<0.5	1330	0.003	0.0966	0.102	0.0105	<0.00005	<0.00003	<0.3	0.016	485	<0.0005	0.0241	0.007	0.02	0.00085	0.014	28
15-Dec-09	20	500	490	7.36	1085				680																		
22-Dec-09	21	500	475	7.60	1274	#N/A	4.0	36.6	737	<0.5	854	0.007	0.0676	0.0719	0.0097	<0.00005	<0.00003	<0.3	0.00795	310	<0.0005	0.0129	0.006	0.019	0.00041	0.01	19.2
29-Dec-09	22	500	475	7.53	1075				635																		
05-Jan-10	23	500	435	7.30	771	#N/A	3.8	22.2	378	<0.5	404	0.0047	0.034	0.0344	0.00715	<0.00001	<0.000005	<0.05	0.00301	145	<0.0001	0.00525	0.00289	0.006	0.000196	0.0047	10.3
12-Jan-10	24	500	430	7.31	641				326																		
19-Jan-10	25	500	425	7.38	791	#N/A	5.0	23.5	463	<0.5	431	0.0067	0.0316	0.0292	0.00847	<0.00001	<0.000005	<0.05	0.00325	153	0.0001	0.00521	0.00236	0.007	0.000174	0.0044	11.5
26-Jan-10	26	500	425	7.23	325				162																		
02-Feb-10	27	500	465	7.01	264	#N/A	2.9	9.8	157	<0.5	160	0.0054	0.0137	0.0182	0.00654	<0.00001	<0.000005	<0.05	0.00196	56.6	<0.0001	0.00165	0.0013	0.004	0.000163	0.0017	4.44
09-Feb-10	28	500	440	7.51	1466				927																		
16-Feb-10	29	500	495	7.39	1509	#N/A	6.0	36.5	1028	9.2	1100	0.0038	0.0671	0.0945	0.0103	<0.00001	<0.000005	<0.05	0.00801	389	<0.0001	0.00954	0.00405	0.008	0.000516	0.0095	30.6
23-Feb-10	30	500	475	7.50	1134				816																		
02-Mar-10	31	500	445	7.53	1208	#N/A	3.1	29.3	724	7.3	798	0.0055	0.0544	0.0753	0.00778	<0.00001	<0.000005	<0.05	0.00399	281	<0.0001	0.00792	0.00297	0.004	0.000187	0.0074	23.3
09-Mar-10	32	500	430	7.45	1508				1017																		
16-Mar-10	33	500	475	7.44	1336	#N/A	4.9	33.3	819	4.8	901	0.006	0.0605	0.0696	0.0078	<0.00005	<0.00003	<0.3	0.00546	320	<0.0005	0.00799	0.0033	0.005	0.00057	0.008	24.5
23-Mar-10	34	500	455	7.52	1551				1110																		
30-Mar-10	35	500	470	7.52	1627	#N/A	4.4	39.6	1114	3.3	1020	0.006	0.0675	0.0696	0.0089	<0.00005	<0.00003	<0.3	0.00511	364	<0.0005	0.00878	0.0042	0.005	0.00027	0.009	27
06-Apr-10	36	500	435	7.53	1729				1029																		
13-Apr-10	37	500	445	7.55	1883	#N/A	7.5	46.9	1297	2	1260	0.007	0.078	0.078	0.0115	<0.00005	<0.00003	<0.3	0.00694	454	<0.0005	0.0109	0.003	0.014	0.00033	0.009	31.7
20-Apr-10	38	500	460	7.65	1791	#N/A	5.6	50.6	1149	2	1090	0.007	0.0836	0.0732	0.0129	<0.00005	<0.00003	<0.3	0.00575	392	<0.0005	0.00898	0.004	0.013	0.00037	0.01	27.8
27-Apr-10	39	500	410	7.66	1774	#N/A	3.5	48.0	1169	1.6	1120	0.006	0.0817	0.0754	0.0111	<0.00005	<0.00003	<0.3	0.00568	405	<0.0005	0.00905	0.0031	<0.005	0.00029	0.009	27.2
04-May-10	40	500	475	7.60	1661				1073																		
11-May-10	41	500	455	7.64	1546	#N/A	5.6	49.1	949	1.3	950	0.009	0.0922	0.0748	0.0103	<0.00005	<0.00003	<0.3	0.00476	346	<0.0005	0.0061	0.0031	0.012	0.00027	0.007	20.8
18-May-10	42	500	445	7.53	1378				797																		
25-May-10	43	500	420	7.54	1289	#N/A	7.7	44.9	602	<0.5	813	0.008	0.0831	0.0714	0.0106	<0.00005	<0.00003	<0.3	0.00356	297	<0.0005	0.00533	0.0029	0.008	0.00023	0.006	17.4
01-Jun-10	44	500	425	7.59	1214				623																		
08-Jun-10	45	500	460	7.70	1594	#N/A	5.9	54.3	1058	0.8	1310	0.007	0.0914	0.0785	0.0139	<0.00005	<0.00003	<0.3	0.00602	481	<0.0005	0.00843	0.0036	0.007	0.0003	0.008	27
15-Jun-10	46	500	405	7.78	1607				771																		
22-Jun-10	47	500	445	7.80	1783	#N/A	5.9	68.5	1001	<0.5	1170	0.006	0.1	0.074	0.0136	<0.00005	<0.00003	<0.3	0.00778	430	<0.0005	0.00667	0.0045	0.009	0.00035	0.008	22.6
29-Jun-10	48	500	475	7.51	1717				823																		
06-Jul-10	49	500	435	7.84	1494	#N/A	4.9	72.2	848	<0.5	1090	0.017	0.102	0.0682	0.0129	<0.00005	<0.00003	<0.3	0.0087	404	<0.0005	0.00502	0.0047	0.025	0.00046	0.008	20.3
13-Jul-10	50	500	475	7.71	1351				511																		
20-Jul-10	51	500	440	7.70	1526	#N/A	8.4	80.8	840	2.9	1050	0.006	0.0989	0.0641	0.0129	<0.00005	<0.00003	<0.3	0.00874	392	<0.0005	0.00605	0.0031	0.009	0.00036	0.007	17.2
27-Jul-10	52	500	485	7.78	1644				1124																		
03-Aug-10	53	500	485	7.85	1290	#N/A	7.8	83.8	754	<0.5	867	0.006	0.112	0.0699	0.0128	<0.00005	<0.00003	<0.3	0.00876	324	<0.0005	0.00456	0.004	<0.005	0.00051	0.007	14.2
10-Aug-10	54	500	485	7.83	1223				813																		
17-Aug-10	55	500	440	7.92	960	#N/A	5.4	80.2	429	0.8	602	0.006	0.12	0.0682	0.0131	<0.00001	<0.000005	<0.05	0.00616	224	<0.0001	0.00305	0.00503	0.003	0.00046	0.0057	10.3
24-Aug-10	56	500	475	7.73	666				239																		
31-Aug-10	57	500	481	7.77	393	#N/A	7.8	43.3	212	<0.5	206	0.0063	0.0771	0.0578	0.00877	<0.00001	<0.000005	<0.05	0.00221	75.4	<0.0001	0.000812	0.00164	0.003	0.00015	0.0023	4.35
07-Sep-10	58	500	525	7.61	651				383																		
14-Sep-10	59	500	455	7.57	408	#N/A	4.3	50.4	155	<0.5	233	0.0075	0.092	0.0654	0.00943	<0.00001	0.000015	<0.05	0.0019	85.5	0.0001	0.00111	0.00279	0.005	0.000218	0.0028	4.66
21-Sep-10	60	500	490	7.72	418				246																		
28-Sep-10	61	500	455	7.67	310	#N/A	3.0	46.7	119	0.9	149	0.0055	0.0873	0.0654	0.00966	<0.00001	<0.000005	<0.05	0.00152	53.9	0.0002	0.000795	0.00206	0.003	0.000286	0.0021	3.39
05-Oct-10	62	500	495	7.57	325																						
12-Oct-10	63	500	430	7.76	239				112																		
19-Oct-10	64	500	495	7.64	227																						
26-Oct-10	65	500	430	7.57	194	#N/A	2.8	41.9	64	#N/A	96.3	<0.05	0.12	0.1	0.009	<0.003	<0.05	<0.01	<0.005	34.2	<0.01	<0.02	<0.02	0.02	<0.03	#N/A	2.61
02-Nov-10	66	500	475	7.77	219																						

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/l	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
09-Nov-10	67	500	400	7.66	199				47																		
16-Nov-10	68	500	400	7.94	389																						
23-Nov-10	69	500	425	7.72	220	#N/A	3.6	64.2	54	#N/A	110	<0.05	0.11	0.12	0.02	<0.003	<0.05	<0.01	<0.005	38.4	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	3.41
30-Nov-10	70	500	435	7.66	142																						
07-Dec-10	71	500	460	7.71	144				22																		
14-Dec-10	72	500	460	7.71	130																						
21-Dec-10	73	500	480	7.54	89	#N/A	5.1	30.8	16	#N/A	42.1	<0.05	<0.05	0.06	0.011	<0.003	<0.05	<0.01	<0.005	14.4	<0.01	<0.02	<0.02	0.02	<0.03	#N/A	1.5
28-Dec-10	74	500	420	7.72	102																						
04-Jan-11	75	500	420	7.79	128				27																		
11-Jan-11	76	500	405	7.60	109																						
18-Jan-11	77	500	405	7.68	143	#N/A	3.0	45.7	27	#N/A	71.1	<0.05	0.1	0.11	0.017	<0.003	<0.05	<0.01	<0.005	24.3	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	2.54
25-Jan-11	78	500	435	7.70	138																						
01-Feb-11	79	500	510	7.65	101				16																		
08-Feb-11	80	500	465	7.83	119																						
15-Feb-11	81	500	475	7.67	134	#N/A	3.1	50.2	16	#N/A	67.8	<0.05	0.1	0.12	0.017	<0.003	<0.05	<0.01	<0.005	22.9	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	2.55
22-Feb-11	82	500	480	7.82	115																						
01-Mar-11	83	500	495	7.61	87				18																		
08-Mar-11	84	500	495	7.63	78																						
15-Mar-11	85	500	475	7.70	104	#N/A	2.9	40.1	12	#N/A	49.5	<0.05	0.06	0.1	0.014	<0.003	<0.05	<0.01	<0.005	16.6	<0.01	<0.02	<0.02	0.02	<0.03	#N/A	1.94
22-Mar-11	86	500	460	7.82	127																						
29-Mar-11	87	500	470	7.96	145				16																		
05-Apr-11	88	500	470	7.63	111																						
12-Apr-11	89	500	485	7.63	95	#N/A	3.3	41.9	10	#N/A	44.5	<0.05	0.05	0.1	0.013	<0.003	<0.05	<0.01	<0.005	14.8	<0.01	<0.02	<0.02	0.02	<0.03	#N/A	1.85
19-Apr-11	90	500	495	7.79	82																						
26-Apr-11	91	500	460	7.78	107				12																		
03-May-11	92	500	440	7.82	191																						
10-May-11	93	500	500	7.64	85	#N/A	3.3	39.5	11	#N/A	42.4	<0.05	<0.05	0.09	0.013	<0.003	<0.05	<0.01	<0.005	13.8	<0.01	<0.02	<0.02	0.02	<0.03	#N/A	1.89
17-May-11	94	500	455	7.71	221																						
24-May-11	95	500	435	7.67	37				5																		
31-May-11	96	500	400	7.58	52																						

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Results of Leachate Analy

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
28-Jul-09	0	9.43	69	0.034	0.027	<0.2	85	0.004	<10	0.168	520	1.57	1500	0.0049	0.019	<0.05	0.0016	<0.02	0.065	<0.01
04-Aug-09	1	4.16	0.28	0.0082	0.0038	<0.01	26.9	0.0004	2.57	<0.00003	91.4	0.632	457	0.00217	0.00474	<0.003	0.00028	<0.001	0.0305	<0.0005
11-Aug-09	2	8.26	<0.05	0.0121	0.0043	<0.01	37.8	0.0005	4.76	<0.00003	136	1.05	675	0.00312	0.0071	<0.003	0.00066	<0.001	0.0688	<0.0005
18-Aug-09	3	6.72	<0.05	0.0076	0.0022	<0.01	29.4	0.0007	2.84	0.00003	73.7	0.77	539	0.00243	0.00444	<0.003	0.00033	<0.001	0.114	<0.0005
25-Aug-09	4																			
01-Sep-09	5	6.6	<0.05	0.0053	0.0024	<0.01	22.1	0.0003	2.83	0.00004	48.3	0.697	381	0.00199	0.00289	<0.003	0.00023	<0.001	0.127	<0.0005
08-Sep-09	6																			
15-Sep-09	7	16.5	0.12	0.0059	0.0078	<0.01	28.6	0.0006	6.86	<0.00003	56.1	1.18	631	0.00236	0.00512	<0.003	0.00039	<0.001	0.616	<0.0005
22-Sep-09	8																			
29-Sep-09	9	7.11	<0.05	0.003	0.0025	<0.01	10.4	0.0003	2.93	<0.00003	11.3	0.491	300	0.00062	0.00291	<0.003	0.00011	<0.001	0.247	<0.0005
06-Oct-09	10																			
13-Oct-09	11	6.66	0.01	0.00243	0.00168	0.004	7.89	0.00012	2.43	<0.000005	6.16	0.439	283	0.000398	0.00188	<0.0005	0.000105	<0.0002	0.189	<0.0001
20-Oct-09	12																			
27-Oct-09	13	8.06	0.09	0.0033	0.0048	<0.01	8.78	<0.0002	3.48	0.00006	5.79	0.578	377	0.00057	0.00391	<0.003	0.00013	<0.001	0.155	<0.0005
03-Nov-09	14																			
10-Nov-09	15	9.88	0.04	0.00327	0.00243	0.006	8.94	0.00017	4.16	0.000012	4.44	0.638	432	0.000489	0.00302	<0.0005	0.000155	<0.0002	0.212	<0.0001
17-Nov-09	16																			
24-Nov-09	17	12.3	<0.05	0.0033	0.003	<0.01	8.93	<0.0002	5.87	<0.00003	3.65	0.743	483	0.00059	0.00566	<0.003	0.00028	<0.001	0.4	<0.0005
01-Dec-09	18																			
08-Dec-09	19	8.19	0.08	0.0026	0.003	<0.01	7.56	0.0002	4.7	0.00011	2.3	0.679	433	0.00049	0.00144	0.004	0.00047	<0.001	0.32	<0.0005
15-Dec-09	20																			
22-Dec-09	21	3.3	<0.05	0.0015	0.003	<0.01	5.7	<0.0002	3.37	<0.00003	1.36	0.431	291	0.00032	0.003	<0.003	0.00027	<0.001	0.141	<0.0005
29-Dec-09	22																			
05-Jan-10	23	0.625	0.01	0.00067	0.00043	<0.002	2.88	0.00008	1.75	<0.000005	0.58	0.199	141	0.000161	0.00235	<0.0005	0.00017	<0.0002	0.0633	<0.0001
12-Jan-10	24																			
19-Jan-10	25	0.445	<0.01	0.00063	0.00043	0.007	2.92	0.00019	1.89	<0.000005	0.56	0.201	144	0.000151	0.00255	0.0006	0.000103	<0.0002	0.072	<0.0001
26-Jan-10	26																			
02-Feb-10	27	0.241	<0.01	0.00026	0.00029	<0.002	1.09	<0.00004	0.893	0.000037	0.26	0.07	53	0.000071	0.00132	<0.0005	0.000028	<0.0002	0.0606	<0.0001
09-Feb-10	28																			
16-Feb-10	29	1.41	0.01	0.0012	0.00097	0.002	5.85	0.00016	6.19	<0.000005	1.08	0.531	379	0.000358	0.00583	<0.0005	0.000391	<0.0002	0.162	<0.0001
23-Feb-10	30																			
02-Mar-10	31	0.744	0.01	0.00119	0.00054	0.004	4.6	0.00015	3.28	<0.000005	0.72	0.366	268	0.00024	0.00498	<0.0005	0.000299	<0.0002	0.0727	<0.0001
09-Mar-10	32																			
16-Mar-10	33	0.627	<0.05	0.0011	0.0007	<0.01	4.2	<0.0002	3.4	<0.00003	0.6	0.407	316	0.00027	0.00443	<0.003	0.0004	<0.001	0.113	<0.0005
23-Mar-10	34																			
30-Mar-10	35	0.525	<0.05	0.0034	0.0006	<0.01	4.3	<0.0002	2.41	<0.00003	0.61	0.432	339	0.00021	0.00757	<0.003	0.00054	<0.001	0.105	<0.0005
06-Apr-10	36																			
13-Apr-10	37	0.604	<0.05	0.0018	0.0009	<0.01	4.6	<0.0002	4.25	<0.00003	0.5	0.515	422	0.00027	0.0109	<0.003	0.00082	<0.001	0.139	<0.0005
20-Apr-10	38	0.496	<0.05	0.0018	0.0006	<0.01	4.2	<0.0002	3.62	0.00006	0.5	0.476	342	0.00027	0.0122	<0.003	0.00079	<0.001	0.111	<0.0005
27-Apr-10	39	0.469	<0.05	0.0016	0.001	<0.01	4.2	0.0003	3.77	<0.00003	0.5	0.446	383	0.00021	0.0103	<0.003	0.00079	<0.001	0.114	<0.0005
04-May-10	40																			
11-May-10	41	0.319	<0.05	0.0016	0.0005	<0.01	3.8	0.0007	3.95	<0.00003	0.4	0.389	339	0.00025	0.00942	<0.003	0.00071	<0.001	0.0844	<0.0005
18-May-10	42																			
25-May-10	43	0.21	<0.05	0.0023	0.0007	<0.01	3.2	<0.0002	2.86	0.00005	0.3	0.308	259	0.0002	0.00749	<0.003	0.00056	<0.001	0.0609	<0.0005
01-Jun-10	44																			
08-Jun-10	45	0.431	<0.05	0.002	0.0007	<0.01	4.1	<0.0002	5.12	0.00003	0.4	0.444	391	0.00027	0.0123	<0.003	0.00099	<0.001	0.122	<0.0005
15-Jun-10	46																			
22-Jun-10	47	0.392	<0.05	0.0016	0.0008	<0.01	3.6	<0.0002	4.52	<0.00003	0.3	0.457	413	0.00028	0.00876	<0.003	0.00112	<0.001	0.186	<0.0005
29-Jun-10	48																			
06-Jul-10	49	0.393	<0.05	0.0024	0.0007	<0.01	3.6	<0.0002	4.09	0.00006	0.4	0.413	356	0.00027	0.00777	<0.003	0.00107	<0.001	0.268	<0.0005
13-Jul-10	50																			
20-Jul-10	51	0.305	<0.05	0.0014	0.0037	<0.01	2.9	<0.0002	4.38	<0.00003	<0.3	0.373	314	0.00025	0.00844	<0.003	0.00118	<0.001	0.258	<0.0005
27-Jul-10	52																			
03-Aug-10	53	0.36	<0.05	0.0016	0.0026	<0.01	2.9	<0.0002	4.07	<0.00003	<0.3	0.329	311	0.00024	0.00734	<0.003	0.00103	<0.001	0.287	<0.0005
10-Aug-10	54																			
17-Aug-10	55	0.23	<0.01	0.00141	0.00057	0.004	2.39	0.0001	3.82	<0.000005	0.26	0.223	198	0.000196	0.00529	<0.0005	0.000709	<0.0002	0.187	<0.0001
24-Aug-10	56																			
31-Aug-10	57	0.0806	<0.01	0.00084	0.00027	0.004	1.11	0.00007	1.68	<0.000005	0.14	0.0795	63	0.000087	0.00098	<0.0005	0.000172	<0.0002	0.0763	<0.0001
07-Sep-10	58																			
14-Sep-10	59	0.0681	<0.01	0.00114	0.00025	0.003	1.28	0.00006	2.53	0.000009	0.18	0.0828	65	0.000092	0.00145	<0.0005	0.000218	<0.0002	0.0546	<0.0001
21-Sep-10	60																			
28-Sep-10	61	0.0617	<0.01	0.00119	0.00029	<0.002	0.98	0.00029	2.12	<0.000005	0.19	0.0589	40	0.000084	0.00109	<0.0005	0.000169	<0.0002	0.0448	<0.0001
05-Oct-10	62																			
12-Oct-10	63																			
19-Oct-10	64																			
26-Oct-10	65	0.031	#N/A	<0.02	<0.02	<0.05	0.7	<0.1	1.78	<0.01	0.2	0.04	19.4	#N/A	<0.03	<0.005	#N/A	<0.01	0.068	<0.02
02-Nov-10	66																			

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Results of Leachate Analy

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
09-Nov-10	67																			
16-Nov-10	68																			
23-Nov-10	69	0.023	#N/A	<0.02	<0.02	<0.05	0.8	<0.1	2.48	<0.01	0.2	0.049	19.2	#N/A	<0.03	<0.005	#N/A	<0.01	0.016	<0.02
30-Nov-10	70																			
07-Dec-10	71																			
14-Dec-10	72																			
21-Dec-10	73	0.04	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	1.06	<0.01	0.3	0.02	5.7	#N/A	<0.03	<0.005	#N/A	<0.01	0.017	<0.02
28-Dec-10	74																			
04-Jan-11	75																			
11-Jan-11	76																			
18-Jan-11	77	0.023	#N/A	<0.02	<0.02	<0.05	0.6	<0.1	2.28	<0.01	0.3	0.034	9.1	#N/A	<0.03	<0.005	#N/A	<0.01	0.012	<0.02
25-Jan-11	78																			
01-Feb-11	79																			
08-Feb-11	80																			
15-Feb-11	81	0.012	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.27	<0.01	<0.1	0.033	7.3	#N/A	<0.03	<0.005	#N/A	<0.01	0.01	<0.02
22-Feb-11	82																			
01-Mar-11	83																			
08-Mar-11	84																			
15-Mar-11	85	0.018	#N/A	<0.02	<0.02	<0.05	0.4	<0.1	1.74	<0.01	<0.1	0.024	5.1	#N/A	<0.03	<0.005	#N/A	<0.01	0.012	<0.02
22-Mar-11	86																			
29-Mar-11	87																			
05-Apr-11	88																			
12-Apr-11	89	0.022	#N/A	<0.02	<0.02	<0.05	0.4	<0.1	1.69	<0.01	<0.1	0.022	4.6	#N/A	<0.03	<0.005	#N/A	<0.01	0.011	<0.02
19-Apr-11	90																			
26-Apr-11	91																			
03-May-11	92																			
10-May-11	93	0.025	#N/A	<0.02	<0.02	<0.05	<0.3	<0.1	1.43	<0.01	0.3	0.021	3.5	#N/A	<0.03	<0.005	#N/A	<0.01	0.012	<0.02
17-May-11	94																			
24-May-11	95																			
31-May-11	96																			

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Weekly Production (mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/kg	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg
28-Jul-09	0	7.45	14.112	554.4	0.0021	0.04515	0.041790	0.0071	0.00010500	0.000052500	0.52500	0.00432600
04-Aug-09	1	7.28	9.90535	556.92	0.0036	0.03922	0.060970	0.0042	0.00001138	0.000006825	0.06825	0.00076895
11-Aug-09	2	7.49	16.2029	802.64	0.0024	0.11139	0.058855	0.0045	0.00000988	0.000005925	0.05925	0.00462150
18-Aug-09	3	7.42	14.9996	635.8	0.0018	0.09900	0.045760	0.0050	0.00001100	0.000006600	0.06600	0.00501600
25-Aug-09	4	7.5	16.58655	632.865	0.0035	0.08719	0.038618	0.0058	0.00001163	0.000006975	0.06975	0.00532425
01-Sep-09	5	7.58	16.0175	543.52	0.0047	0.06450	0.026703	0.0058	0.00001075	0.000006450	0.06450	0.00494500
08-Sep-09	6	7.31	25.905875	427.55	0.0032	0.07693	0.033448	0.0073	0.00001063	0.000006375	0.06375	0.00979625
15-Sep-09	7	7.59	33.864	634.8	0.0016	0.08480	0.038120	0.0084	0.00001000	0.000006000	0.06000	0.01384000
22-Sep-09	8	7.38	31.8785	925.97	0.0021	0.08163	0.038007	0.0082	0.00001288	0.000007725	0.07725	0.01277200
29-Sep-09	9	7.37	19.1786	500.78	0.0020	0.05145	0.025627	0.0053	0.00001225	0.000007350	0.07350	0.00735000
06-Oct-09	10	7.31	16.097875	486.83	0.0018	0.04194	0.021227	0.0049	0.00000668	0.000003894	0.03894	0.00594075
13-Oct-09	11	7.48	15.44265	331.545	0.0019	0.03883	0.020042	0.0052	0.00000233	0.000001163	0.01163	0.00544050
20-Oct-09	12	7.37	14.3856	392.16	0.0024	0.04452	0.024816	0.0050	0.00000720	0.000004200	0.04200	0.00576000
27-Oct-09	13	7.41	11.2266	503.16	0.0025	0.04284	0.025326	0.0041	0.00001050	0.000006300	0.06300	0.00516600
03-Nov-09	14	7.27	12.230825	529.105	0.0022	0.04695	0.031595	0.0046	0.00000668	0.000003894	0.04495	0.00602975
10-Nov-09	15	7.1	13.2728	606.3	0.0018	0.05123	0.038399	0.0052	0.00000235	0.000001175	0.02444	0.00695600
17-Nov-09	16	7.18	17.370075	600.78	0.0016	0.05603	0.044105	0.0053	0.00000698	0.000004069	0.04697	0.00832350
24-Nov-09	17	7.62	22.7703	707.56	0.0015	0.06468	0.052920	0.0057	0.00001225	0.000007350	0.07350	0.01029000
01-Dec-09	18	7.5	24.255	655.62	0.0015	0.05601	0.051450	0.0054	0.00001225	0.000007350	0.07350	0.00906500
08-Dec-09	19	7.32	23.6385	587.25	0.0014	0.04347	0.045900	0.0047	0.00001125	0.000006750	0.06750	0.00720000
15-Dec-09	20	7.36	21.84665	333.2	0.0025	0.04023	0.042606	0.0049	0.00001225	0.000007350	0.07350	0.00586775
22-Dec-09	21	7.6	17.404	350.075	0.0033	0.03211	0.034153	0.0046	0.00001188	0.000007125	0.07125	0.00377625
29-Dec-09	**22**	**7.53**	**13.965**	**301.625**	**0.0028**	**0.02413**	**0.025246**	**0.0040**	**0.00000713**	**0.000004156**	**0.04156**	**0.00260300**
05-Jan-10	23	7.3	9.6396	164.43	0.0020	0.01479	0.014964	0.0031	0.00000218	0.000001088	0.01088	0.00130935
12-Jan-10	24	7.31	9.81045	140.18	0.0025	0.01410	0.013674	0.0034	0.00000215	0.000001075	0.01075	0.00134590
19-Jan-10	25	7.38	9.97475	196.775	0.0028	0.01343	0.012410	0.0036	0.00000213	0.000001063	0.01063	0.00138125
26-Jan-10	26	7.23	7.0635	68.85	0.0026	0.00963	0.010073	0.0032	0.00000213	0.000001063	0.01063	0.00110713
02-Feb-10	27	7.01	4.54305	73.005	0.0025	0.00637	0.008463	0.0030	0.00000233	0.000001163	0.01163	0.00091140
09-Feb-10	28	7.51	10.175	407.88	0.0020	0.01778	0.024794	0.0037	0.00000220	0.000001100	0.01100	0.00219340
16-Feb-10	29	7.39	18.0576	508.86	0.0019	0.03321	0.046778	0.0051	0.00000248	0.000001238	0.01238	0.00396495
23-Feb-10	30	7.5	15.62275	387.6	0.0022	0.02886	0.040328	0.0043	0.00000238	0.000001188	0.01188	0.00285000
02-Mar-10	31	7.53	13.0385	322.18	0.0024	0.02421	0.033509	0.0035	0.00000223	0.000001113	0.01113	0.00177555
09-Mar-10	32	7.45	13.4547	437.31	0.0025	0.02470	0.031154	0.0033	0.00000645	0.000003763	0.03763	0.00203175
16-Mar-10	33	7.44	15.808	389.025	0.0029	0.02874	0.033060	0.0037	0.00001188	0.000007125	0.07125	0.00259350
23-Mar-10	34	7.52	16.5711	505.05	0.0027	0.02912	0.031668	0.0038	0.00001138	0.000006825	0.06825	0.00240468
30-Mar-10	35	7.52	18.5932	523.58	0.0028	0.03173	0.032712	0.0042	0.00001175	0.000007050	0.07050	0.00240170
06-Apr-10	36	7.53	18.8094	447.615	0.0028	0.03165	0.032103	0.0044	0.00001088	0.000006525	0.06525	0.00262088
13-Apr-10	37	7.55	20.8794	577.165	0.0031	0.03471	0.034710	0.0051	0.00001113	0.000006675	0.06675	0.00308830
20-Apr-10	38	7.65	23.2806	528.54	0.0032	0.03846	0.033672	0.0059	0.00001150	0.000006900	0.06900	0.00264500
27-Apr-10	39	7.66	19.6718	479.29	0.0025	0.03350	0.030914	0.0046	0.00001025	0.000006150	0.06150	0.00232880
04-May-10	40	7.6	23.047	509.675	0.0036	0.04130	0.035673	0.0051	0.00001188	0.000007125	0.07125	0.00247950
11-May-10	41	7.64	22.3223	431.795	0.0041	0.04195	0.034034	0.0047	0.00001138	0.000006825	0.06825	0.00216580
18-May-10	42	7.53	20.899425	354.665	0.0038	0.03900	0.032530	0.0047	0.00001113	0.000006675	0.06675	0.00185120
25-May-10	43	7.54	18.8454	252.84	0.0034	0.03490	0.029988	0.0045	0.00001050	0.000006300	0.06300	0.00149520
01-Jun-10	44	7.59	21.077875	264.775	0.0032	0.03708	0.031854	0.0052	0.00001063	0.000006375	0.06375	0.00203575
08-Jun-10	45	7.7	24.9872	486.68	0.0032	0.04204	0.036110	0.0064	0.00001150	0.000006900	0.06900	0.00276920
15-Jun-10	46	7.78	24.864975	312.255	0.0026	0.03876	0.030881	0.0056	0.00001013	0.000006075	0.06075	0.00279450
22-Jun-10	47	7.8	30.46915	445.445	0.0027	0.04450	0.032930	0.0061	0.00001113	0.000006675	0.06675	0.00346210
29-Jun-10	48	7.51	33.404375	390.925	0.0055	0.04798	0.033773	0.0063	0.00001188	0.000007125	0.07125	0.00391400
06-Jul-10	49	7.84	31.3983	368.88	0.0074	0.04437	0.029667	0.0056	0.00001088	0.000006525	0.06525	0.00378450
13-Jul-10	50	7.71	36.33275	242.725	0.0055	0.04771	0.031421	0.0061	0.00001188	0.000007125	0.07125	0.00414200
20-Jul-10	51	7.7	35.552	369.6	0.0026	0.04352	0.028204	0.0057	0.00001100	0.000006600	0.06600	0.00384560
27-Jul-10	52	7.78	39.91065	545.14	0.0029	0.05114	0.032495	0.0062	0.00001213	0.000007275	0.07275	0.00424375
03-Aug-10	53	7.85	40.6333	365.69	0.0029	0.05432	0.033902	0.0062	0.00001213	0.000007275	0.07275	0.00424860
10-Aug-10	54	7.83	39.767575	394.305	0.0029	0.05626	0.033489	0.0063	0.00000728	0.000004244	0.04244	0.00361810
17-Aug-10	55	7.92	35.2924	188.76	0.0026	0.05280	0.030008	0.0058	0.00000220	0.000001100	0.01100	0.00271040
24-Aug-10	56	7.73	29.33125	113.525	0.0029	0.04681	0.029925	0.0052	0.00000238	0.000001188	0.01188	0.00198788
31-Aug-10	57	7.77	20.82249	101.972	0.0030	0.03709	0.027802	0.0042	0.00000241	0.000001203	0.01203	0.00106301
07-Sep-10	58	7.61	24.58575	201.075	0.0036	0.04439	0.032340	0.0048	0.00000263	0.000004594	0.01313	0.00107888
14-Sep-10	59	7.57	22.91835	70.525	0.0034	0.04186	0.029757	0.0043	0.00000228	0.000006825	0.01138	0.00086450
21-Sep-10	60	7.72	23.79195	120.54	0.0032	0.04393	0.032046	0.0047	0.00000245	0.000004288	0.01225	0.00083790
28-Sep-10	61	7.67	21.2667	54.145	0.0025	0.03972	0.029757	0.0044	0.00000228	0.000001138	0.01138	0.00069160
05-Oct-10	62	7.57	21.940875	45.2925	0.0075	0.05131	0.040937	0.0046	0.00037249	0.006188119	0.00743	0.00099495
12-Oct-10	63	7.76	18.540525	48.16	0.0087	0.04808	0.039281	0.0039	0.00048429	0.008062769	0.00430	0.00096965
19-Oct-10	64	7.64	21.04430625	43.56	0.0112	0.05738	0.047359	0.0045	0.00065000	0.010828280	0.00371	0.00117686
26-Oct-10	65	7.57	18.0213	27.52	0.0108	0.05160	0.043000	0.0039	0.00064500	0.010750000	0.00215	0.00107500
02-Nov-10	66	7.77	25.194	28.025	0.0119	0.05463	0.052250	0.0069	0.00071250	0.011875000	0.00238	0.00118750
09-Nov-10	67	7.66	23.442	18.8	0.0100	0.04500	0.046000	0.0069	0.00060000	0.010000000	0.00200	0.00100000
16-Nov-10	68	7.94	24.555	20.2	0.0100	0.04450	0.047000	0.0075	0.00060000	0.010000000	0.00200	0.00100000
23-Nov-10	69	7.72	27.27225	22.95	0.0106	0.04675	0.051000	0.0085	0.00063750	0.010625000	0.00213	0.00106250
30-Nov-10	70	7.66	20.6625	15.225	0.0109	0.02936	0.039150	0.0067	0.00065250	0.010875000	0.00218	0.00108750
07-Dec-10	71	7.71	18.0159	10.12	0.0115	0.02128	0.034500	0.0061	0.00069000	0.011500000	0.00230	0.00115000
14-Dec-10	72	7.71	16.09885	8.74	0.0115	0.01639	0.031050	0.0056	0.00069000	0.011500000	0.00230	0.00115000
21-Dec-10	73	7.54	14.7984	7.68	0.0120	0.01200	0.028800	0.0053	0.00072000	0.012000000	0.00240	0.00120000
28-Dec-10	74	7.72	16.065	9.03	0.0105	0.02625	0.035700	0.0059	0.00063000	0.010500000	0.00210	0.00105000
04-Jan-11	75	7.79	17.6232	11.34	0.0105	0.03413	0.040950	0.0065	0.00063000	0.010500000	0.00210	0.00105000
11-Jan-11	76	7.6	17.745075	10.935	0.0101	0.03670	0.042019	0.0066	0.00060750	0.010125000	0.00203	0.00101250
18-Jan-11	77	7.68	18.49635	10.935	0.0101	0.04050	0.044550	0.0069	0.00060750	0.010125000	0.00203	0.00101250
25-Jan-11	78	7.7	20.84955	9.3525	0.0109	0.04350	0.050025	0.0074	0.00065250	0.010875000	0.00218	0.00108750
01-Feb-11	**79**	**7.65**	**25.0206**	**8.16**	**0.0128**	**0.05100**	**0.059925**	**0.0087**	**0.00076500**	**0.012750000**	**0.00255**	**0.00127500**
08-Feb-11	80	7.83	23.075625	7.44	0.0116	0.04650	0.055219	0.0079	0.00069750	0.011625000	0.00233	0.00116250
15-Feb-11	81	7.67	23.84025	7.6	0.0119	0.04750	0.057000	0.0081	0.00071250	0.011875000	0.00238	0.00118750
22-Feb-11	82	7.82	21.6792	6.72	0.0120	0.03840	0.052800	0.0074	0.00072000	0.012000000	0.00240	0.00120000
01-Mar-11	83	7.61	21.1129875	8.91	0.0124	0.03465	0.051975	0.0073	0.00074250	0.012375000	0.00248	0.00123750
08-Mar-11	84	7.63	20.49114375	7.425	0.0124	0.03218	0.050738	0.0071	0.00074250	0.012375000	0.00248	0.00123750
15-Mar-11	85	7.7	19.0665	5.7	0.0119	0.02850	0.047500	0.0067	0.00071250	0.011875000	0.00238	0.00118750
22-Mar-11	86	7.82	18.8692	5.06	0.0115	0.02530	0.046000	0.0062	0.00069000	0.011500000	0.00230	0.00115000
29-Mar-11	87	7.96	19.4862	7.52	0.0118	0.02468	0.047000	0.0062	0.00070500	0.011750000	0.00235	0.00117500
05-Apr-11	88	7.63	19.5896	6.11	0.0118	0.02409	0.047000	0.0062	0.00070500	0.011750000	0.00235	0.00117500
12-Apr-11	89	7.63	20.3215	4.85	0.0121	0.02425	0.048500	0.0063	0.00072750	0.012125000	0.00243	0.00121250
19-Apr-11	90	7.79	20.153925	5.1975	0.0124	0.01856	0.047025	0.0064	0.00074250	0.012375000	0.00248	0.00123750
26-Apr-11	91	7.78	18.45635	5.52	0.0115	0.01438	0.042550	0.0060	0.00069000	0.011500000	0.00230	0.00115000
03-May-11	92	7.82	17.52355	5.06	0.0110	0.01238	0.040150	0.0057	0.00066000	0.011000000	0.00220	0.00110000
10-May-11	93	7.64	19.765	5.5	0.0125	0.01250	0.045000	0.0065	0.00075000	0.012500000	0.00250	0.00125000

Date	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg
28-Jul-09	118.65	0.0010500	0.0033180	0.01974	0.01050	0.000210	0.005250	28.35	1.980300	0.01449000	0.00714	0.00567	0.021000	17.85000	0.00084
04-Aug-09	160.16	0.0001138	0.0017973	0.00164	0.00364	0.000364	0.005005	16.06	1.892800	0.00012740	0.00373	0.00173	0.002275	12.23950	0.00018
11-Aug-09	211.33	0.0000988	0.0017341	0.00431	0.00869	0.000249	0.006715	23.54	3.262700	0.00000988	0.00478	0.00170	0.001975	14.93100	0.00020
18-Aug-09	198.00	0.0001100	0.0011748	0.00326	0.00396	0.000383	0.006160	17.69	2.956800	0.00001100	0.00334	0.00097	0.002200	12.93600	0.00031
25-Aug-09	196.00	0.0001163	0.0011904	0.00453	0.00628	0.000337	0.006278	18.00	3.096900	0.00001163	0.00300	0.00107	0.002325	11.97375	0.00023
01-Sep-09	168.99	0.0001075	0.0010535	0.00520	0.00774	0.000249	0.005590	16.00	2.838000	0.00001075	0.00228	0.00103	0.002150	9.50300	0.00013
08-Sep-09	200.39	0.0001063	0.0020889	0.00625	0.00893	0.000436	0.008075	22.02	4.908750	0.00003081	0.00238	0.00217	0.002125	10.77375	0.00019
15-Sep-09	220.00	0.0001000	0.0029520	0.00692	0.00960	0.000588	0.010000	26.56	6.600000	0.00004800	0.00236	0.00312	0.002000	11.44000	0.00024
22-Sep-09	219.13	0.0001288	0.0041380	0.00623	0.02086	0.000605	0.009013	23.36	6.079575	0.00003734	0.00229	0.00265	0.002575	10.04250	0.00023
29-Sep-09	147.49	0.0001225	0.0042581	0.00338	0.02793	0.000431	0.004900	11.91	3.483900	0.00001225	0.00147	0.00123	0.002450	5.09600	0.00015
06-Oct-09	128.38	0.0000668	0.0060498	0.00292	0.01669	0.000257	0.004161	9.50	3.063825	0.00000779	0.00121	0.00093	0.002003	4.06953	0.00009
13-Oct-09	128.34	0.0000233	0.0086025	0.00289	0.00837	0.000127	0.004046	8.56	3.096900	0.00000465	0.00113	0.00078	0.001860	3.66885	0.00006
20-Oct-09	160.32	0.0000720	0.0099120	0.00300	0.00888	0.000262	0.004728	9.60	3.532800	0.00002400	0.00138	0.00156	0.002160	4.00080	0.00005
27-Oct-09	164.64	0.0001050	0.0095760	0.00265	0.00798	0.000344	0.004620	9.07	3.385200	0.00003780	0.00139	0.00202	0.002100	3.68760	0.00004
03-Nov-09	181.56	0.0000668	0.0110360	0.00252	0.00979	0.000317	0.005118	10.12	3.991650	0.00002893	0.00146	0.00161	0.002448	3.94270	0.00006
10-Nov-09	199.28	0.0000235	0.0125960	0.00235	0.01175	0.000283	0.005640	11.23	4.643600	0.00001880	0.00154	0.00114	0.002820	4.20180	0.00008
17-Nov-09	216.23	0.0000698	0.0125550	0.00488	0.00930	0.000452	0.006045	12.18	5.156850	0.00001511	0.00153	0.00126	0.002558	4.15478	0.00006
24-Nov-09	247.94	0.0001225	0.0133280	0.00784	0.00735	0.000657	0.006860	13.97	6.027000	0.00001225	0.00162	0.00147	0.002450	4.37570	0.00005
01-Dec-09	242.80	0.0001225	0.0125685	0.00564	0.00858	0.000537	0.006860	13.84	5.020050	0.00002573	0.00145	0.00147	0.002450	4.04005	0.00007
08-Dec-09	218.25	0.0001125	0.0108450	0.00315	0.00900	0.000383	0.006300	12.60	3.685500	0.00003600	0.00117	0.00135	0.002250	3.40200	0.00009
15-Dec-09	194.78	0.0001225	0.0090650	0.00319	0.00956	0.000309	0.005880	11.56	2.815050	0.00002573	0.00100	0.00147	0.002450	3.24870	0.00007
22-Dec-09	147.25	0.0001188	0.0061275	0.00285	0.00903	0.000195	0.004750	9.12	1.567500	0.00001188	0.00071	0.00143	0.002375	2.70750	0.00005
29-Dec-09	**108.06**	**0.0000713**	**0.0043106**	**0.00211**	**0.00594**	**0.000144**	**0.003491**	**7.01**	**0.932188**	**0.00000831**	**0.00052**	**0.00081**	**0.001425**	**2.03775**	**0.00004**
05-Jan-10	63.08	0.0000218	0.0022838	0.00126	0.00261	0.000085	0.002045	4.48	0.271875	0.00000435	0.00029	0.00019	0.000435	1.25280	0.00003
12-Jan-10	64.07	0.0000323	0.0022489	0.00113	0.00280	0.000080	0.001957	4.69	0.230050	0.00000323	0.00028	0.00018	0.001720	1.24700	0.00006
19-Jan-10	65.03	0.0000425	0.0022143	0.00100	0.00298	0.000074	0.001870	4.89	0.189125	0.00000213	0.00027	0.00018	0.002975	1.24100	0.00008
26-Jan-10	44.54	0.0000319	0.0014578	0.00078	0.00234	0.000072	0.001296	3.39	0.145775	0.00000213	0.00019	0.00015	0.001700	0.85213	0.00004
02-Feb-10	26.32	0.0000233	0.0007673	0.00060	0.00186	0.000076	0.000791	2.06	0.112065	0.00000233	0.00012	0.00013	0.000465	0.50685	0.00001
09-Feb-10	98.03	0.0000220	0.0024618	0.00118	0.00264	0.000149	0.002464	7.71	0.363220	0.00000330	0.00032	0.00028	0.000660	1.52680	0.00004
16-Feb-10	192.56	0.0000248	0.0047223	0.00200	0.00396	0.000255	0.004703	15.15	0.697950	0.00000495	0.00059	0.00048	0.000990	2.89575	0.00008
23-Feb-10	159.13	0.0000238	0.0041468	0.00167	0.00285	0.000167	0.004014	12.80	0.511575	0.00000475	0.00057	0.00036	0.001425	2.48188	0.00007
02-Mar-10	125.05	0.0000223	0.0035244	0.00132	0.00178	0.000083	0.003293	10.37	0.331080	0.00000445	0.00053	0.00024	0.001780	2.04700	0.00007
09-Mar-10	129.22	0.0000645	0.0034207	0.00135	0.00194	0.000163	0.003311	10.28	0.294765	0.00000753	0.00049	0.00027	0.001935	1.89200	0.00005
16-Mar-10	152.00	0.0001188	0.0037953	0.00157	0.00238	0.000271	0.003800	11.64	0.297825	0.00001188	0.00052	0.00033	0.002375	1.99500	0.00005
23-Mar-10	155.61	0.0001138	0.0038152	0.00171	0.00228	0.000191	0.003868	11.72	0.262080	0.00001138	0.00102	0.00030	0.002275	1.93375	0.00005
30-Mar-10	171.08	0.0001175	0.0041266	0.00197	0.00235	0.000127	0.004230	12.69	0.246750	0.00001175	0.00160	0.00028	0.002350	2.02100	0.00005
06-Apr-10	177.92	0.0001088	0.0042804	0.00157	0.00413	0.000131	0.003915	12.77	0.245558	0.00001088	0.00113	0.00033	0.002175	1.93575	0.00004
13-Apr-10	202.03	0.0001113	0.0048505	0.00134	0.00623	0.000147	0.004005	14.11	0.268780	0.00001113	0.00080	0.00040	0.002225	2.04700	0.00004
20-Apr-10	180.32	0.0001150	0.0041308	0.00184	0.00598	0.000170	0.004600	12.79	0.228160	0.00001150	0.00083	0.00028	0.002300	1.93200	0.00005
27-Apr-10	166.05	0.0001025	0.0037105	0.00127	0.00103	0.000119	0.003690	11.15	0.192290	0.00001025	0.00066	0.00041	0.002050	1.72200	0.00012
04-May-10	178.36	0.0001188	0.0035981	0.00147	0.00344	0.000133	0.003800	11.40	0.187150	0.00001188	0.00076	0.00036	0.002375	1.90000	0.00024
11-May-10	157.43	0.0001138	0.0027755	0.00141	0.00546	0.000123	0.003185	9.46	0.145145	0.00001138	0.00073	0.00023	0.002275	1.72900	0.00032
18-May-10	143.07	0.0001113	0.0025432	0.00134	0.00445	0.000111	0.002893	8.50	0.117703	0.00001113	0.00087	0.00027	0.002225	1.55750	0.00018
25-May-10	124.74	0.0001050	0.0022386	0.00122	0.00336	0.000097	0.002520	7.31	0.088200	0.00001050	0.00097	0.00029	0.002100	1.34400	0.00004
01-Jun-10	165.33	0.0001063	0.0029240	0.00138	0.00319	0.000113	0.002975	9.44	0.136213	0.00001063	0.00091	0.00030	0.002125	1.55125	0.00004
08-Jun-10	221.26	0.0001150	0.0038778	0.00166	0.00322	0.000138	0.003680	12.42	0.198260	0.00001150	0.00092	0.00032	0.002300	1.88600	0.00005
15-Jun-10	184.48	0.0001013	0.0030578	0.00164	0.00324	0.000132	0.003240	10.04	0.166658	0.00001013	0.00073	0.00030	0.002025	1.55925	0.00004
22-Jun-10	191.35	0.0001113	0.0029682	0.00200	0.00401	0.000156	0.003560	10.06	0.174440	0.00001113	0.00071	0.00036	0.002225	1.60200	0.00004
29-Jun-10	198.08	0.0001188	0.0027764	0.00219	0.00808	0.000192	0.003800	10.19	0.186438	0.00001188	0.00095	0.00036	0.002375	1.71000	0.00005
06-Jul-10	175.74	0.0001088	0.0021837	0.00204	0.01088	0.000200	0.003480	8.83	0.170955	0.00001088	0.00104	0.00030	0.002175	1.56600	0.00004
13-Jul-10	189.05	0.0001188	0.0026291	0.00185	0.00808	0.000195	0.003563	8.91	0.165775	0.00001188	0.00090	0.00105	0.002375	1.54375	0.00005
20-Jul-10	172.48	0.0001100	0.0026620	0.00136	0.00396	0.000158	0.003080	7.57	0.134200	0.00001100	0.00062	0.00163	0.002200	1.27600	0.00004
27-Jul-10	173.63	0.0001213	0.0025729	0.00172	0.00279	0.000211	0.003395	7.61	0.161263	0.00001213	0.00073	0.00153	0.002425	1.40650	0.00005
03-Aug-10	157.14	0.0001213	0.0022116	0.00194	0.00121	0.000247	0.003395	6.89	0.174600	0.00001213	0.00078	0.00126	0.002425	1.40650	0.00005
10-Aug-10	132.89	0.0000728	0.0018454	0.00219	0.00133	0.000235	0.003080	5.94	0.143075	0.00000728	0.00073	0.00077	0.002183	1.28283	0.00005
17-Aug-10	98.56	0.0000220	0.0013420	0.00221	0.00132	0.000202	0.002508	4.53	0.101200	0.00000220	0.00062	0.00025	0.001760	1.05160	0.00004
24-Aug-10	71.11	0.0000238	0.0009172	0.00158	0.00143	0.000145	0.001900	3.48	0.073768	0.00000238	0.00053	0.00020	0.001900	0.83125	0.00004
31-Aug-10	36.27	0.0000241	0.0003906	0.00079	0.00144	0.000072	0.001106	2.09	0.038769	0.00000241	0.00040	0.00013	0.001924	0.53391	0.00003
07-Sep-10	42.24	0.0000394	0.0005045	0.00116	0.00210	0.000097	0.001339	2.37	0.039034	0.00000263	0.00052	0.00014	0.001838	0.62738	0.00003
14-Sep-10	38.90	0.0000455	0.0005051	0.00127	0.00228	0.000099	0.001274	2.12	0.030986	0.00000228	0.00052	0.00011	0.001365	0.58240	0.00003
21-Sep-10	34.15	0.0000735	0.0004667	0.00119	0.00196	0.000123	0.001201	1.97	0.031801	0.00000245	0.00057	0.00013	0.000980	0.55370	0.00009
28-Sep-10	24.52	0.0000910	0.0003617	0.00094	0.00137	0.000130	0.000956	1.54	0.028074	0.00000228	0.00054	0.00013	0.000455	0.44590	0.00013
05-Oct-10	21.80	0.0012870	0.0026718	0.00298	0.00569	0.003783	#N/A	1.49	0.022943	#N/A	0.00277	0.00255	0.006435	0.41580	0.01245
12-Oct-10	16.82	0.0016340	0.0033105	0.00345	0.00677	0.004868	#N/A	1.21	0.016630	#N/A	0.00335	0.00326	0.008170	0.33110	0.01616
19-Oct-10	18.15	0.0021780	0.0043804	0.00446	0.00885	0.006515	#N/A	1.34	0.017245	#N/A	0.00440	0.00435	0.010890	0.36383	0.02167
26-Oct-10	14.71	0.0021500	0.0043000	0.00430	0.00860	0.006450	#N/A	1.12	0.013330	#N/A	0.00430	0.00430	0.010750	0.30100	0.02150
02-Nov-10	17.24	0.0023750	0.0047500	0.00475	0.00594	0.007125	#N/A	1.43	0.012825	#N/A	0.00475	0.00475	0.011875	0.35625	0.02375
09-Nov-10	14.94	0.0020000	0.0040000	0.00400	0.00350	0.006000	#N/A	1.28	0.010000	#N/A	0.00400	0.00400	0.010000	0.31000	0.02000
16-Nov-10	15.15	0.0020000	0.0040000	0.00400	0.00275	0.006000	#N/A	1.32	0.009600	#N/A	0.00400	0.00400	0.010000	0.31500	0.02000
23-Nov-10	16.32	0.0021250	0.0042500	0.00425	0.00213	0.006375	#N/A	1.45	0.009775	#N/A	0.00425	0.00425	0.010625	0.34000	0.02125
30-Nov-10	11.48	0.0021750	0.0043500	0.00435	0.00544	0.006525	#N/A	1.07	0.013703	#N/A	0.00435	0.00435	0.010875	0.28275	0.02175
07-Dec-10	9.38	0.0023000	0.0046000	0.00460	0.00748	0.006900	#N/A	0.91	0.016445	#N/A	0.00460	0.00460	0.011500	0.26450	0.02300
14-Dec-10	8.00	0.0023000	0.0046000	0.00460	0.00834	0.006900	#N/A	0.80	0.017423	#N/A	0.00460	0.00460	0.011500	0.24725	0.02300
21-Dec-10	6.91	0.0024000	0.0048000	0.00480	0.00960	0.007200	#N/A	0.72	0.019200	#N/A	0.00480	0.00480	0.012000	0.24000	0.02400
28-Dec-10	8.13	0.0021000	0.0042000	0.00420	0.00525	0.006300	#N/A	0.85	0.013230	#N/A	0.00420	0.00420	0.010500	0.23100	0.02100
04-Jan-11	9.17	0.0021000	0.0042000	0.00420	0.00368	0.006300	#N/A	0.96	0.011445	#N/A	0.00420	0.00420	0.010500	0.24150	0.02100
11-Jan-11	9.34	0.0020250	0.0040500	0.00405	0.00278	0.006075	#N/A	0.98	0.010176	#N/A	0.00405	0.00405	0.010125	0.23794	0.02025
18-Jan-11	9.84	0.0020250	0.0040500	0.00405	0.00203	0.006075	#N/A	1.03	0.009315	#N/A	0.00405	0.00405	0.010125	0.24300	0.02025
25-Jan-11	10.27	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	1.11	0.007613	#N/A	0.00435	0.00435	0.010875	0.23925	0.02175
01-Feb-11	**11.86**	**0.0025500**	**0.0051000**	**0.00510**	**0.00255**	**0.007650**	**#N/A**	**1.30**	**0.007523**	**#N/A**	**0.00510**	**0.00510**	**0.012750**	**0.26775**	**0.02550**
08-Feb-11	10.73	0.0023250	0.0046500	0.00465	0.00233	0.006975	#N/A	1.19	0.006219	#N/A	0.00465	0.00465	0.011625	0.23831	0.02325
15-Feb-11	10.88	0.0023750	0.0047500	0.00475	0.00238	0.007125	#N/A	1.21	0.005700	#N/A	0.00475	0.00475	0.011875	0.23750	0.02375
22-Feb-11	9.48	0.0024000	0.0048000	0.00480	0.00600	0.007200	#N/A	1.08	0.007200	#N/A	0.00480	0.00480	0.012000	0.21600	0.02400
01-Mar-11	9.00	0.0024750	0.0049500	0.00495	0.00804	0.007425	#N/A	1.04	0.008168	#N/A	0.00495	0.00495	0.012375	0.21038	0.02475
08-Mar-11	8.61	0.0024750	0.0049500	0.00495	0.00897	0.007425	#N/A	1.00	0.008539	#N/A	0.00495	0.00495	0.012375	0.20419	0.02475
15-Mar-11	7.89	0.0023750	0.0047500	0.00475	0.00950	0.007125	#N/A	0.92	0.008550	#N/A	0.00475	0.00475	0.011875	0.19000	0.02375
22-Mar-11	7.22	0.0023000	0.0046000	0.00460	0.00920	0.006900	#N/A	0.87	0.009200	#N/A	0.00460	0.00460	0.011500	0.18400	0.02300
29-Mar-11	7.17	0.0023500	0.0047000	0.00470	0.00940	0.007050	#N/A	0.88	0.009870	#N/A	0.00470	0.00470	0.011750	0.18800	0.02350
05-Apr-11	7.06	0.0023500	0.0047000	0.00470	0.00940	0.007050	#N/A	0.87	0.010105	#N/A	0.00470	0.00470	0.011750	0.18800	0.02350
12-Apr-11	7.18	0.0024250	0.0048500	0.00485	0.00970	0.007275	#N/A	0.90	0.010670	#N/A	0.00485	0.00485	0.012125	0.19400	0.02425
19-Apr-11	7.08	0.0024750	0.0049500	0.00495	0.00990	0.007425	#N/A	0.93	0.011633	#N/A	0.00495	0.00495	0.012375	0.13613	0.02475
26-Apr-11	6.46	0.0023000	0.0046000	0.00460	0.00920	0.006900	#N/A	0.86	0.011155	#N/A	0.00460	0.00460	0.011500	0.09775	0.02300
03-May-11	6.13	0.0022000	0.0044000	0.00440	0.00880	0.006600	#N/A	0.83	0.010835	#N/A	0.00440	0.00440	0.011000	0.07975	0.02200
10-May-11	6.90	0.0025000	0.0050000	0.00500	0.01000	0.007500	#N/A	0.95	0.012500	#N/A	0.00500	0.00500	0.012500	0.07500	0.02500

Date	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
28-Jul-09	1.050	0.035280000	109.2000	0.32970	315.00	0.00102900	0.0039900	0.0052500	0.000336	0.002100	0.01365	0.00105
04-Aug-09	1.169	0.000006825	41.5870	0.28756	207.94	0.00098735	0.0021567	0.0006825	0.000127	0.000228	0.01388	0.00011
11-Aug-09	1.880	0.000005925	53.7200	0.41475	266.63	0.00123240	0.0028045	0.0005925	0.000261	0.000198	0.02718	0.00010
18-Aug-09	1.250	0.000013200	32.4280	0.33880	237.16	0.00106920	0.0019536	0.0006600	0.000145	0.000220	0.05016	0.00011
25-Aug-09	1.318	0.000016275	28.3650	0.34108	213.90	0.00102765	0.0017042	0.0006975	0.000130	0.000233	0.05603	0.00012
01-Sep-09	1.217	0.000017200	20.7690	0.29971	163.83	0.00085570	0.0012427	0.0006450	0.000099	0.000215	0.05461	0.00011
08-Sep-09	2.059	0.000011688	22.1850	0.39886	215.05	0.00092438	0.0017021	0.0006375	0.000132	0.000213	0.15789	0.00011
15-Sep-09	2.744	0.000006000	22.4400	0.47200	252.40	0.00094400	0.0020480	0.0006000	0.000156	0.000200	0.24640	0.00010
22-Sep-09	2.521	0.000007725	17.3555	0.43028	239.73	0.00076735	0.0020677	0.0007725	0.000129	0.000258	0.22222	0.00013
29-Sep-09	1.436	0.000007350	5.5370	0.24059	147.00	0.00030380	0.0014259	0.0007350	0.000054	0.000245	0.12103	0.00012
06-Oct-09	1.193	0.000003894	3.8849	0.20693	129.72	0.00022651	0.0010658	0.0003894	0.000048	0.000134	0.09701	0.00007
13-Oct-09	1.130	0.000001163	2.8644	0.20414	131.60	0.00018507	0.0008742	0.0001163	0.000049	0.000047	0.08789	0.00002
20-Oct-09	1.418	0.000015000	2.8680	0.24408	158.40	0.00023232	0.0013896	0.0004200	0.000056	0.000144	0.08256	0.00007
27-Oct-09	1.462	0.000025200	2.4318	0.24276	158.34	0.00023940	0.0016422	0.0006300	0.000055	0.000210	0.06510	0.00011
03-Nov-09	1.700	0.000016020	2.2762	0.27056	180.00	0.00023563	0.0015419	0.0003894	0.000063	0.000134	0.08166	0.00007
10-Nov-09	1.955	0.000005640	2.0868	0.29986	203.04	0.00022983	0.0014194	0.0001175	0.000073	0.000047	0.09964	0.00002
17-Nov-09	2.332	0.000006278	1.8809	0.32108	212.74	0.00025087	0.0020181	0.0004069	0.000101	0.000140	0.14229	0.00007
24-Nov-09	2.876	0.000007350	1.7885	0.36407	236.67	0.00028910	0.0027734	0.0007350	0.000137	0.000245	0.19600	0.00012
01-Dec-09	2.590	0.000030625	1.4578	0.34839	224.42	0.00026460	0.0017395	0.0013475	0.000184	0.000245	0.17640	0.00012
08-Dec-09	2.115	0.000049500	1.0350	0.30555	194.85	0.00022050	0.0006480	0.0018000	0.000212	0.000225	0.14400	0.00011
15-Dec-09	1.977	0.000030625	0.8967	0.27195	177.38	0.00019845	0.0010878	0.0013475	0.000181	0.000245	0.11295	0.00012
22-Dec-09	1.601	0.000007125	0.6460	0.20473	138.23	0.00015200	0.0014250	0.0007125	0.000128	0.000238	0.06698	0.00012
29-Dec-09	**1.216**	**0.000004156**	**0.4608**	**0.14963**	**102.60**	**0.00011424**	**0.0012706**	**0.0004156**	**0.000105**	**0.000143**	**0.04852**	**0.00007**
05-Jan-10	0.761	0.000001088	0.2523	0.08657	61.34	0.00007004	0.0010223	0.0001088	0.000074	0.000044	0.02754	0.00002
12-Jan-10	0.783	0.000001075	0.2451	0.08600	61.28	0.00006708	0.0010535	0.0001828	0.000059	0.000043	0.02909	0.00002
19-Jan-10	0.803	0.000001063	0.2380	0.08543	61.20	0.00006418	0.0010838	0.0002550	0.000044	0.000043	0.03060	0.00002
26-Jan-10	0.591	0.000008394	0.1743	0.05759	41.86	0.00004718	0.0008224	0.0001806	0.000028	0.000043	0.02818	0.00002
02-Feb-10	0.415	0.000017205	0.1209	0.03255	24.65	0.00003302	0.0006138	0.0001163	0.000013	0.000047	0.02818	0.00002
09-Feb-10	1.558	0.000008690	0.2948	0.13222	95.04	0.00009438	0.0015730	0.0001100	0.000092	0.000044	0.04897	0.00002
16-Feb-10	3.064	0.000001238	0.5346	0.26285	187.61	0.00017721	0.0028859	0.0001238	0.000194	0.000050	0.08019	0.00002
23-Feb-10	2.249	0.000001188	0.4275	0.21304	153.66	0.00014203	0.0025674	0.0001188	0.000164	0.000048	0.05574	0.00002
02-Mar-10	1.460	0.000001113	0.3204	0.16287	119.26	0.00010680	0.0022161	0.0001113	0.000133	0.000045	0.03235	0.00002
09-Mar-10	1.436	0.000003763	0.2838	0.16620	125.56	0.00010965	0.0020232	0.0003763	0.000150	0.000129	0.03993	0.00006
16-Mar-10	1.615	0.000007125	0.2850	0.19333	150.10	0.00012825	0.0021043	0.0007125	0.000190	0.000238	0.05368	0.00012
23-Mar-10	1.322	0.000006825	0.2753	0.19087	149.01	0.00010920	0.0027300	0.0006825	0.000214	0.000228	0.04960	0.00011
30-Mar-10	1.133	0.000007050	0.2867	0.20304	159.33	0.00009870	0.0035579	0.0007050	0.000254	0.000235	0.04935	0.00012
06-Apr-10	1.449	0.000006525	0.2414	0.20597	165.52	0.00010440	0.0040172	0.0006525	0.000296	0.000218	0.05307	0.00011
13-Apr-10	1.891	0.000006675	0.2225	0.22918	187.79	0.00012015	0.0048505	0.0006675	0.000365	0.000223	0.06186	0.00011
20-Apr-10	1.665	0.000027600	0.2300	0.21896	157.32	0.00012420	0.0056120	0.0006900	0.000363	0.000230	0.05106	0.00012
27-Apr-10	1.546	0.000006150	0.2050	0.18286	157.03	0.00008610	0.0042230	0.0006150	0.000324	0.000205	0.04674	0.00010
04-May-10	1.834	0.000007125	0.2138	0.19831	171.48	0.00010925	0.0046835	0.0007125	0.000356	0.000238	0.04712	0.00012
11-May-10	1.797	0.000006825	0.1820	0.17700	154.25	0.00011375	0.0042861	0.0006825	0.000323	0.000228	0.03840	0.00011
18-May-10	1.515	0.000014463	0.1558	0.15508	133.06	0.00010013	0.0037625	0.0006675	0.000283	0.000223	0.03233	0.00011
25-May-10	1.201	0.000021000	0.1260	0.12936	108.78	0.00008400	0.0031458	0.0006300	0.000235	0.000210	0.02558	0.00011
01-Jun-10	1.696	0.000017000	0.1488	0.15980	138.13	0.00009988	0.0042054	0.0006375	0.000329	0.000213	0.03887	0.00011
08-Jun-10	2.355	0.000013800	0.1840	0.20424	179.86	0.00012420	0.0056580	0.0006900	0.000455	0.000230	0.05612	0.00012
15-Jun-10	1.952	0.000009113	0.1418	0.18245	162.81	0.00011138	0.0042647	0.0006075	0.000427	0.000203	0.06237	0.00010
22-Jun-10	2.011	0.000006675	0.1335	0.20337	183.79	0.00012460	0.0038982	0.0006675	0.000498	0.000223	0.08277	0.00011
29-Jun-10	2.045	0.000017813	0.1663	0.20663	182.64	0.00013063	0.0039259	0.0007125	0.000520	0.000238	0.10783	0.00012
06-Jul-10	1.779	0.000026100	0.1740	0.17966	154.86	0.00011745	0.0033800	0.0006525	0.000465	0.000218	0.11658	0.00011
13-Jul-10	2.012	0.000017813	0.1306	0.18668	159.13	0.00012350	0.0038499	0.0007125	0.000534	0.000238	0.12493	0.00012
20-Jul-10	1.927	0.000006600	0.0660	0.16412	138.16	0.00011000	0.0037136	0.0006600	0.000519	0.000220	0.11352	0.00011
27-Jul-10	2.049	0.000007275	0.0728	0.17024	151.56	0.00011883	0.0038267	0.0007275	0.000536	0.000243	0.13216	0.00012
03-Aug-10	1.974	0.000007275	0.0728	0.15957	150.84	0.00011640	0.0035599	0.0007275	0.000500	0.000243	0.13920	0.00012
10-Aug-10	1.913	0.000004244	0.0994	0.13386	123.43	0.00010573	0.0030628	0.0004244	0.000422	0.000146	0.11495	0.00007
17-Aug-10	1.681	0.000001100	0.1144	0.09812	87.12	0.00008624	0.0023276	0.0001100	0.000312	0.000044	0.08228	0.00002
24-Aug-10	1.306	0.000001188	0.0950	0.07184	61.99	0.00006721	0.0014891	0.0001188	0.000209	0.000048	0.06253	0.00002
31-Aug-10	0.808	0.000001203	0.0673	0.03824	30.30	0.00004185	0.0004714	0.0001203	0.000083	0.000048	0.03670	0.00002
07-Sep-10	1.105	0.000003019	0.0840	0.04260	33.60	0.00004699	0.0006379	0.0001313	0.000102	0.000053	0.03436	0.00003
14-Sep-10	1.151	0.000004095	0.0819	0.03767	29.58	0.00004186	0.0006598	0.0001138	0.000099	0.000046	0.02484	0.00002
21-Sep-10	1.139	0.000002818	0.0907	0.03472	25.73	0.00004312	0.0006223	0.0001225	0.000095	0.000049	0.02435	0.00002
28-Sep-10	0.965	0.000001138	0.0865	0.02680	18.20	0.00003822	0.0004960	0.0001138	0.000077	0.000046	0.02038	0.00002
05-Oct-10	0.965	0.001238119	0.0965	0.02448	14.70	#N/A	0.0039823	0.0006806	#N/A	0.001262	0.02792	0.00249
12-Oct-10	0.802	0.001612769	0.0849	0.01923	10.56	#N/A	0.0049547	0.0008331	#N/A	0.001623	0.02675	0.00323
19-Oct-10	0.902	0.002165780	0.0984	0.02097	10.88	#N/A	0.0065643	0.0010983	#N/A	0.002172	0.03222	0.00433
26-Oct-10	0.765	0.002150000	0.0860	0.01720	8.34	#N/A	0.0064500	0.0010750	#N/A	0.002150	0.02924	0.00430
02-Nov-10	1.012	0.002375000	0.0950	0.02114	9.17	#N/A	0.0071250	0.0011875	#N/A	0.002375	0.01995	0.00475
09-Nov-10	0.922	0.002000000	0.0800	0.01870	7.70	#N/A	0.0060000	0.0010000	#N/A	0.002000	0.01160	0.00400
16-Nov-10	0.957	0.002000000	0.0800	0.01915	7.69	#N/A	0.0060000	0.0010000	#N/A	0.002000	0.00900	0.00400
23-Nov-10	1.054	0.002125000	0.0850	0.02083	8.16	#N/A	0.0063750	0.0010625	#N/A	0.002125	0.00680	0.00425
30-Nov-10	0.770	0.002175000	0.1088	0.01501	5.42	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.00718	0.00435
07-Dec-10	0.651	0.002300000	0.1265	0.01254	4.17	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.00771	0.00460
14-Dec-10	0.569	0.002300000	0.1323	0.01087	3.40	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.00776	0.00460
21-Dec-10	0.509	0.002400000	0.1440	0.00960	2.74	#N/A	0.0072000	0.0012000	#N/A	0.002400	0.00816	0.00480
28-Dec-10	0.701	0.002100000	0.1260	0.01134	3.11	#N/A	0.0063000	0.0010500	#N/A	0.002100	0.00609	0.00420
04-Jan-11	0.830	0.002100000	0.1260	0.01281	3.47	#N/A	0.0063000	0.0010500	#N/A	0.002100	0.00557	0.00420
11-Jan-11	0.862	0.002025000	0.1215	0.01306	3.51	#N/A	0.0060750	0.0010125	#N/A	0.002025	0.00511	0.00405
18-Jan-11	0.923	0.002025000	0.1215	0.01377	3.69	#N/A	0.0060750	0.0010125	#N/A	0.002025	0.00486	0.00405
25-Jan-11	0.990	0.002175000	0.0761	0.01457	3.57	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.00479	0.00435
01-Feb-11	**1.159**	**0.002550000**	**0.0574**	**0.01696**	**3.95**	**#N/A**	**0.0076500**	**0.0012750**	**#N/A**	**0.002550**	**0.00536**	**0.00510**
08-Feb-11	1.056	0.002325000	0.0378	0.01540	3.50	#N/A	0.0069750	0.0011625	#N/A	0.002325	0.00477	0.00465
15-Feb-11	1.078	0.002375000	0.0238	0.01568	3.47	#N/A	0.0071250	0.0011875	#N/A	0.002375	0.00475	0.00475
22-Feb-11	0.962	0.002400000	0.0240	0.01368	2.98	#N/A	0.0072000	0.0012000	#N/A	0.002400	0.00528	0.00480
01-Mar-11	0.927	0.002475000	0.0248	0.01299	2.80	#N/A	0.0074250	0.0012375	#N/A	0.002475	0.00569	0.00495
08-Mar-11	0.894	0.002475000	0.0248	0.01244	2.66	#N/A	0.0074250	0.0012375	#N/A	0.002475	0.00582	0.00495
15-Mar-11	0.827	0.002375000	0.0238	0.01140	2.42	#N/A	0.0071250	0.0011875	#N/A	0.002375	0.00570	0.00475
22-Mar-11	0.789	0.002300000	0.0230	0.01058	2.23	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.00529	0.00460
29-Mar-11	0.800	0.002350000	0.0235	0.01058	2.22	#N/A	0.0070500	0.0011750	#N/A	0.002350	0.00529	0.00470
05-Apr-11	0.797	0.002350000	0.0235	0.01046	2.19	#N/A	0.0070500	0.0011750	#N/A	0.002350	0.00523	0.00470
12-Apr-11	0.820	0.002425000	0.0243	0.01067	2.23	#N/A	0.0072750	0.0012125	#N/A	0.002425	0.00534	0.00485
19-Apr-11	0.772	0.002475000	0.0866	0.01064	2.00	#N/A	0.0074250	0.0012375	#N/A	0.002475	0.00569	0.00495
26-Apr-11	0.688	0.002300000	0.1093	0.00978	1.74	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.00541	0.00460
03-May-11	0.644	0.002200000	0.1183	0.00930	1.60	#N/A	0.0066000	0.0011000	#N/A	0.002200	0.00523	0.00440
10-May-11	0.715	0.002500000	0.1500	0.01050	1.75	#N/A	0.0075000	0.0012500	#N/A	0.002500	0.00600	0.00500

<u>Appendix B.1-1</u>

Humidity Cell T1 (Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
28-Jul-09	0	554.4	0.0021	0.04515	0.04179	0.0071	0.0001050	0.0000525	0.525	0.004326	118.65	0.00105	0.0033	0.01974	0.01050	0.0002100	0.00525	28.35	1.98030	0.0144900	0.0071	0.00567	0.0210	17.85	0.0008	1.050	3.53E-02	109.200	0.3297	315.00	0.001029	0.00399	0.00525	0.000336	0.00210	0.01365	0.00105
04-Aug-09	1	1111.3	0.0057	0.08437	0.10276	0.0114	0.0001164	0.0000593	0.59325	0.00509495	278.8	0.0011638	0.0051	0.021378	0.0141	0.0005740	0.01026	44.41	3.87310	0.0146174	0.0109	0.00740	0.0233	30.09	0.0010	2.219	3.53E-02	150.787	0.6173	522.94	0.0020164	0.00615	0.0059325	0.0004634	0.00233	0.027528	0.00116
11-Aug-09	2	1914.0	0.0081	0.19576	0.16162	0.0158	0.0001263	0.0000653	0.6525	0.00971645	490.1	0.0012625	0.0068	0.0256835	0.0228	0.0008229	0.01697	67.95	7.13580	0.0146273	0.0157	0.00910	0.0253	45.02	0.0012	4.100	3.53E-02	204.507	1.0320	789.56	0.0032488	0.00895	0.006525	0.0007241	0.00253	0.054704	0.00126
18-Aug-09	3	2549.8	0.0099	0.29476	0.20738	0.0209	0.0001373	0.0000719	0.7185	0.01473245	688.1	0.0013725	0.008	0.0289395	0.0268	0.0012057	0.02313	85.64	10.09260	0.0146383	0.0190	0.01007	0.0275	57.96	0.0015	5.349	3.53E-02	236.935	1.3708	1026.72	0.004318	0.0109	0.007185	0.0008693	0.00275	0.104864	0.00137
25-Aug-09	4	3182.6	0.0134	0.38195	0.24599	0.0267	0.0001489	0.0000788	0.78825	0.0200567	884.1	0.0014888	0.0092	0.0334733	0.0331	0.0015428	0.02941	103.64	13.18950	0.0146499	0.0220	0.01114	0.0298	69.93	0.0018	6.667	3.53E-02	265.300	1.7119	1240.62	0.0053456	0.01261	0.0078825	0.0009995	0.00298	0.160896	0.00149
01-Sep-09	5	3726.1	0.0181	0.44645	0.27270	0.0325	0.0001596	0.0000853	0.85275	0.0250017	1053	0.0015963	0.0103	0.0386763	0.0408	0.0017922	0.03500	119.63	16.02750	0.0146607	0.0243	0.01217	0.0319	79.43	0.0019	7.884	3.53E-02	286.069	2.0116	1404.45	0.0062013	0.01385	0.0085275	0.0010984	0.00319	0.215506	0.00160
08-Sep-09	6	4153.7	0.0213	0.52337	0.30614	0.0398	0.0001703	0.0000917	0.9165	0.03479795	1254	0.0017025	0.0124	0.0449238	0.0497	0.0022278	0.04307	141.65	20.93625	0.0146915	0.0267	0.01433	0.0341	90.21	0.0021	9.943	3.54E-02	308.254	2.4105	1619.50	0.0071257	0.01555	0.009165	0.00123015	0.00341	0.373394	0.00170
15-Sep-09	7	4788.5	0.0229	0.60817	0.34426	0.0482	0.0001803	0.0000977	0.9765	0.04863795	1474	0.0018025	0.0153	0.0518438	0.0593	0.0028158	0.05307	168.21	27.53625	0.0147395	0.0290	0.01745	0.0361	101.65	0.0023	12.687	3.54E-02	330.694	2.8825	1871.90	0.0080697	0.0176	0.009765	0.00138615	0.00361	0.619794	0.00180
22-Sep-09	8	5714.5	0.0249	0.68980	0.38227	0.0564	0.0001931	0.0001054	1.05375	0.06140995	1693	0.0019313	0.0194	0.0580753	0.0802	0.0034209	0.06209	191.56	33.61583	0.0147768	0.0313	0.02011	0.0386	111.69	0.0026	15.208	3.54E-02	348.050	3.3127	2111.63	0.008837	0.01967	0.0105375	0.0015149	0.00386	0.842016	0.00193
29-Sep-09	9	6215.2	0.0269	0.74125	0.40790	0.0617	0.0002054	0.0001127	1.12725	0.06875995	1840	0.0020538	0.0237	0.0614563	0.1081	0.0038521	0.06699	203.47	37.09973	0.0147891	0.0328	0.02133	0.0411	116.79	0.0027	16.644	3.54E-02	353.587	3.5533	2258.63	0.0091408	0.0211	0.0112725	0.0015688	0.00411	0.963046	0.00205
06-Oct-09	10	6702.1	0.0287	0.78319	0.42912	0.0666	0.0002121	0.0001166	1.16619	0.0747007	1969	0.0021205	0.0298	0.0643755	0.1248	0.0041087	0.07115	212.97	40.16355	0.0147968	0.0340	0.02226	0.0431	120.86	0.0028	17.837	3.54E-02	357.471	3.7603	2388.35	0.0093673	0.02216	0.01166188	0.00161664	0.00424	1.060056	0.00212
13-Oct-09	11	7033.6	0.0306	0.82202	0.44917	0.0718	0.0002144	0.0001178	1.17781	0.0801412	2097	0.0021438	0.0384	0.0672678	0.1332	0.0042356	0.07519	221.53	43.26045	0.0148015	0.0351	0.02304	0.0449	124.52	0.0028	18.967	3.54E-02	360.336	3.9644	2519.95	0.0095524	0.02304	0.01177813	0.00166546	0.00429	1.147941	0.00214
20-Oct-09	12	7425.8	0.0330	0.86654	0.47398	0.0768	0.0002216	0.0001220	1.21981	0.0859012	2257	0.0022158	0.0483	0.0702726	0.1421	0.0044979	0.07992	231.13	46.79325	0.0148255	0.0365	0.02460	0.0471	128.52	0.0029	20.385	3.54E-02	363.204	4.2085	2678.35	0.0097847	0.02443	0.01219813	0.00172186	0.00443	1.230501	0.00222
27-Oct-09	13	7928.9	0.0355	0.90938	0.49931	0.0809	0.0002321	0.0001283	1.28281	0.0910672	2422	0.0023208	0.0578	0.0729186	0.1500	0.0048423	0.08454	240.20	50.17845	0.0148633	0.0379	0.02661	0.0492	132.21	0.0029	21.847	3.54E-02	365.636	4.4512	2836.69	0.0100241	0.02607	0.01282813	0.00177646	0.00464	1.295601	0.00232
03-Nov-09	14	8458.0	0.0377	0.95633	0.53090	0.0855	0.0002388	0.0001322	1.32776	0.09709695	2603	0.0023875	0.0689	0.075435	0.1598	0.0051590	0.08966	250.32	54.17010	0.0148922	0.0393	0.02822	0.0516	136.15	0.0030	23.547	3.54E-02	367.912	4.7218	3016.69	0.0102597	0.02761	0.0132175	0.00183988	0.00478	1.377259	0.00239
10-Nov-09	15	9064.3	0.0395	1.00756	0.56930	0.0907	0.0002411	0.0001334	1.3522	0.10405295	2803	0.002411	0.0815	0.0777897	0.1716	0.0054424	0.09530	261.56	58.81370	0.0149110	0.0409	0.02936	0.0545	140.36	0.0031	25.502	3.54E-02	369.999	5.0217	3219.73	0.0104896	0.02903	0.013335	0.00191273	0.00482	1.476899	0.00241
17-Nov-09	16	9665.1	0.0411	1.06359	0.61341	0.0960	0.0002481	0.0001374	1.39916	0.11237645	3019	0.0024808	0.094	0.0826746	0.1809	0.0058941	0.10134	273.74	63.97055	0.0149261	0.0424	0.03063	0.0570	144.51	0.0031	27.834	3.54E-02	371.879	5.3427	3432.47	0.0107404	0.03105	0.01374188	0.00201386	0.00496	1.619189	0.00248
24-Nov-09	17	10372.7	0.0426	1.12827	0.66633	0.1017	0.0002603	0.0001448	1.47266	0.12266645	3267	0.0026033	0.1074	0.0905146	0.1882	0.0065507	0.10820	287.70	69.99755	0.0149384	0.0440	0.03210	0.0595	148.89	0.0032	30.710	3.55E-02	373.668	5.7068	3669.14	0.0110295	0.03382	0.01447688	0.00215106	0.00521	1.815189	0.00260
01-Dec-09	18	11028.3	0.0440	1.18428	0.71778	0.1071	0.0002726	0.0001521	1.54616	0.13173145	3510	0.0027258	0.1199	0.0961496	0.1968	0.0070873	0.11506	301.55	75.01760	0.0149641	0.0455	0.03357	0.0619	152.93	0.0033	33.300	3.55E-02	375.126	6.0552	3893.56	0.0112941	0.03556	0.01582438	0.00233481	0.00545	1.991589	0.00273
08-Dec-09	19	11615.6	0.0454	1.22775	0.76368	0.1118	0.0002838	0.0001589	1.61366	0.13893145	3728	0.0028383	0.1308	0.0992996	0.2058	0.0074698	0.12136	314.15	78.70310	0.0150001	0.0466	0.03492	0.0642	156.33	0.0034	35.415	3.55E-02	376.161	6.3607	4088.41	0.0115146	0.03621	0.01762438	0.00254631	0.00568	2.135589	0.00284
15-Dec-09	20	11948.8	0.0478	1.26798	0.80628	0.1167	0.0002961	0.0001662	1.68716	0.1447992	3923	0.0029608	0.1398	0.1024846	0.2154	0.0077785	0.12724	325.71	81.51815	0.0150258	0.0476	0.03639	0.0666	159.58	0.0034	37.392	3.56E-02	377.057	6.6327	4265.79	0.0117131	0.0373	0.01897188	0.00272761	0.00592	2.248534	0.00296
22-Dec-09	21	12298.8	0.0512	1.30009	0.84044	0.1213	0.0003080	0.0001733	1.75841	0.14857545	4070	0.0030795	0.146	0.1053346	0.2244	0.0079732	0.13199	334.83	83.08565	0.0150377	0.0483	0.03781	0.0690	162.29	0.0035	38.993	3.56E-02	377.703	6.8374	4404.01	0.0118651	0.03872	0.01968438	0.00285586	0.00616	2.315509	0.00308
29-Dec-09	22	12600.5	0.0539	1.32422	0.86568	0.1254	0.0003151	0.0001775	1.79998	0.15117845	4178	0.0031508	0.1503	0.1074459	0.2303	0.0081171	0.13548	341.84	84.01784	0.0150460	0.0489	0.03863	0.0704	164.32	0.0035	40.209	3.56E-02	378.164	6.9870	4506.61	0.0119793	0.03999	0.0201	0.00296036	0.00630	2.36403	0.00315
05-Jan-10	23	12764.9	0.0560	1.33901	0.88065	0.1285	0.0003173	0.0001786	1.81085	0.1524878	4241	0.0031725	0.1526	0.1087031	0.2329	0.0082024	0.13753	346.32	84.28971	0.0150504	0.0492	0.03881	0.0709	165.58	0.0036	40.970	3.56E-02	378.416	7.0736	4567.95	0.0120494	0.04101	0.02020875	0.00303431	0.00635	2.391565	0.00317
12-Jan-10	24	12905.1	0.0584	1.35311	0.89432	0.1318	0.0003194	0.0001797	1.8216	0.1538337	4305	0.0032048	0.1548	0.1098318	0.2357	0.0082819	0.13948	351.00	84.51976	0.0150536	0.0494	0.03900	0.0726	166.82	0.0036	41.752	3.56E-02	378.662	7.1596	4629.22	0.0121164	0.04207	0.0203915	0.00309301	0.00639	2.420655	0.00319
19-Jan-10	25	13101.8	0.0613	1.36654	0.90673	0.1354	0.0003215	0.0001807	1.83223	0.15521495	4370	0.0032473	0.157	0.1108348	0.2387	0.0083559	0.14135	355.89	84.70889	0.0150557	0.0497	0.03918	0.0756	168.06	0.0037	42.556	3.56E-02	378.900	7.2450	4690.42	0.0121806	0.04315	0.0206465	0.00313678	0.00643	2.451255	0.00322
26-Jan-10	26	13170.7	0.0639	1.37617	0.91680	0.1386	0.0003237	0.0001818	1.84285	0.15632208	4415	0.0032791	0.1585	0.1116126	0.2410	0.0084275	0.14265	359.28	84.85466	0.0150578	0.0499	0.03933	0.0773	168.92	0.0037	43.147	3.56E-02	379.074	7.3026	4732.28	0.0122278	0.04397	0.02082713	0.00316462	0.00647	2.479432	0.00324
02-Feb-10	27	13243.7	0.0664	1.38254	0.92526	0.1416	0.0003260	0.0001830	1.85448	0.15723348	4441	0.0033024	0.1592	0.1122171	0.2429	0.0085033	0.14344	361.34	84.96673	0.0150602	0.0500	0.03947	0.0777	169.42	0.0037	43.562	3.56E-02	379.195	7.3352	4756.93	0.0122608	0.04459	0.02094338	0.00317764	0.00652	2.507611	0.00326
09-Feb-10	28	13651.6	0.0684	1.40031	0.95006	0.1454	0.0003282	0.0001841	1.86548	0.15942688	4539	0.0033244	0.1617	0.1133941	0.2455	0.0086527	0.14590	369.05	85.32995	0.0150635	0.0503	0.03975	0.0784	170.95	0.0038	45.121	3.56E-02	379.490	7.4674	4851.97	0.0123552	0.04616	0.02105338	0.00326982	0.00656	2.556583	0.00328
16-Feb-10	29	14160.4	0.0703	1.43353	0.99684	0.1505	0.0003307	0.0001853	1.87785	0.16339183	4732	0.0033491	0.1664	0.1153988	0.2495	0.0089081	0.15061	384.20	86.02790	0.0150684	0.0509	0.04023	0.0794	173.85	0.0039	48.185	3.56E-02	380.024	7.7302	5039.57	0.0125324	0.04905	0.02117713	0.00346337	0.00661	2.636773	0.00331
23-Feb-10	30	14548.0	0.0725	1.46238	1.03716	0.1547	0.0003330	0.0001865	1.88973	0.16624183	4891	0.0033729	0.1706	0.1170661	0.2523	0.0090751	0.15462	397.00	86.53947	0.0150732	0.0515	0.04059	0.0808	176.33	0.0039	50.434	3.56E-02	380.452	7.9433	5193.24	0.0126744	0.05161	0.02129588	0.00362724	0.00666	2.692515	0.00333
02-Mar-10	31	14870.2	0.0749	1.48659	1.07067	0.1582	0.0003353	0.0001876	1.90085	0.16801738	5016	0.0033951	0.1741	0.1183877	0.2541	0.0091583	0.15791	407.37	86.87055	0.0150776	0.0520	0.04083	0.0826	178.37	0.0040	51.893	3.56E-02	380.772	8.1061	5312.50	0.0127812	0.05383	0.02140713	0.0037603	0.00671	2.724866	0.00335
09-Mar-10	32	15307.5	0.0774	1.51129	1.10183	0.1616	0.0003417	0.0001914	1.93848	0.17004913	5145	0.0034596	0.1775	0.1197358	0.2561	0.0093210	0.16123	417.65	87.16532	0.0150851	0.0525	0.04109	0.0845	180.27	0.0041	53.330	3.56E-02	381.056	8.2723	5438.06	0.0128909	0.05585	0.02178338	0.00391058	0.00683	2.764792	0.00342
16-Mar-10	33	15696.6	0.0802	1.54003	1.13489	0.1653	0.0003536	0.0001985	2.00973	0.17264263	5297	0.0035784	0.1813	0.1213033	0.2584	0.0095918	0.16503	429.28	87.46314	0.0150970	0.0530	0.04143	0.0869	182.26	0.0041	54.945	3.56E-02	381.341	8.4657	5588.16	0.0130191	0.05796	0.02249588	0.00410058	0.00707	2.818467	0.00354
23-Mar-10	34	16201.6	0.0830	1.56915	1.16655	0.1691	0.0003650	0.0002053	2.07798	0.1750473	5453	0.0036921	0.1851	0.1230095	0.2607	0.0097829	0.16889	441.00	87.72522	0.0151084	0.0541	0.04172	0.0892	184.20	0.0042	56.266	3.56E-02	381.616	8.6565	5737.17	0.0131283	0.06069	0.02317838	0.00431443	0.00730	2.868062	0.00365
30-Mar-10	35	16725.2	0.0858	1.60088	1.19927	0.1732	0.0003767	0.0002124	2.14848	0.177449	5624	0.0038096	0.1893	0.1249835	0.2631	0.0099098	0.17312	453.69	87.97197	0.0151201	0.0557	0.04200	0.0915	186.22	0.0042	57.399	3.56E-02	381.903	8.8596	5896.50	0.013227	0.06424	0.02388338	0.00456823	0.00753	2.917412	0.00377
06-Apr-10	36	17172.8	0.0886	1.63252	1.23137	0.1777	0.0003876	0.0002189	2.21373	0.18006988	5802	0.0039184	0.1935	0.1265495	0.2672	0.0100403	0.17704	466.46	88.21753	0.0151310	0.0568	0.04233	0.0937	188.15	0.0042	58.848	3.56E-02	382.144	9.0656	6062.02	0.0133314	0.06826	0.02453588	0.00486403	0.00775	2.970482	0.00388
13-Apr-10	37	17750.0	0.0917	1.66723	1.26608	0.1828	0.0003987	0.0002256	2.28048	0.18315818	6004	0.0040296	0.1984	0.1278845	0.2734	0.0101871	0.18104	480.56	88.48631	0.0151421	0.0576	0.04273	0.0959	190.20	0.0043	60.739	3.57E-02	382.367	9.2947	6249.81	0.0134516	0.07311	0.02520338	0.00522893	0.00797	3.032337	0.00399
20-Apr-10	38	18278.5	0.0950	1.70569	1.29975	0.1887	0.0004102	0.0002325	2.34948	0.18580318	6184	0.0041446	0.2025	0.1297245	0.2794	0.0103573	0.18564	493.35	88.71447	0.0151536	0.0584	0.04301	0.0982	192.13	0.0043	62.404	3.57E-02	382.597	9.5137	6407.13	0.0135758	0.07872	0.02589338	0.00559233	0.00820	3.083397	0.00410
27-Apr-10	39	18757.8	0.0974	1.73919	1.33066	0.1933	0.0004205	0.0002386	2.41098	0.18813198	6350	0.0042471	0.2062	0.1309955	0.2804	0.0104762	0.18933	504.50	88.90676	0.0151639	0.0591	0.04342	0.1003	193.85	0.0045	63.950	3.57E-02	382.802	9.6965	6564.16	0.0136619	0.08295	0.02650838	0.00591623	0.00841	3.130137	0.00420
04-May-10	40	19267.5	0.1010	1.78049	1.36634	0.1984	0.0004323	0.0002457	2.48223	0.19061148	6528	0.0043659	0.2098	0.132468	0.2839	0.0106092	0.19313	515.90	89.09391	0.0151758	0.0598	0.04377	0.1026	195.75	0.0047	65.783	3.57E-02	383.015	9.8949	6735.63	0.0137711	0.08763	0.02722088	0.00627248	0.00865	3.177257	0.00432
11-May-10	41	19699.3	0.1051	1.82244	1.40037	0.2031	0.0004437	0.0002526	2.55048	0.19277728	6686	0.0044796	0.2126	0.1338785	0.2893	0.0107321	0.19632	525.37	89.23906	0.0151871	0.0606	0.04400	0.1049	197.48	0.0050	67.580	3.57E-02	383.197	10.0719	6889.88	0.0138849	0.09192	0.02790338	0.00659553	0.00887	3.215659	0.00444
18-May-10	42	20053.9	0.1089	1.86144	1.43290	0.2077	0.0004548	0.0002592	2.61723	0.19462848	6829	0.0045909	0.2152	0.1352135	0.2938	0.0108433	0.19921	533.87	89.35676	0.0151983	0.0614	0.04427	0.1071	199.04	0.0052	69.096	3.57E-02	383.353	10.2269	7022.93	0.013985	0.09568	0.02857088	0.00687811	0.00910	3.247988	0.00455
25-May-10	43	20306.8	0.1122	1.89635	1.46289	0.2122	0.0004653	0.0002655	2.68023	0.19612368	6954	0.0046959	0.2174	0.1364315	0.2971	0.0109399	0.20173	541.17	89.44496	0.0152088	0.0624	0.04456	0.1092	200.38	0.0052	70.297	3.57E-02	383.479	10.3563	7131.71	0.014069	0.09882	0.02920088	0.00711331	0.00931	3.273566	0.00465
01-Jun-10	44	20571.5	0.1154	1.93343	1.49474	0.2174	0.0004760	0.0002719	2.74398	0.19815943	7119	0.0048021	0.2203	0.1378128	0.3003	0.0110526	0.20471	550.61	89.58117	0.0152194	0.0633	0.04486	0.1114	201.93	0.0053	71.993	3.58E-02	383.628	10.5161	7269.84	0.0141689	0.10303	0.02983838	0.00744268	0.00952	3.312432	0.00476
08-Jun-10	45	21058.2	0.1186	1.97547	1.53085	0.2238	0.0004875	0.0002788	2.81298	0.20092863	7340	0.0049171	0.2242	0.1394688	0.3036	0.0111906	0.20839	563.03	89.77943	0.0152309	0.0642	0.04518	0.1137	203.82	0.0053	74.348	3.58E-02	383.812	10.7203	7449.70	0.0142931	0.10869	0.03052838	0.00789808	0.00975	3.368552	0.00487
15-Jun-10	46	21370.5	0.1213	2.01423	1.56173	0.2293	0.0004976	0.0002849	2.87373	0.20372313	7525	0.0050184	0.2272	0.141109	0.3068	0.0113222	0.21163	573.07	89.94609	0.0152410	0.0650	0.04548	0.1157	205.38	0.0054	76.300	3.58E-02	383.954	10.9028	7612.51	0.0144045	0.11295	0.03113588	0.00832536	0.00995	3.430922	0.00498
22-Jun-10	47	21815.9	0.1239	2.05873	1.59466	0.2354	0.0005087	0.0002916	2.94048	0.20718523	7716	0.0051296	0.2302	0.1431115	0.3108	0.0114779	0.21519	583.13	90.12053	0.0152521	0.0657	0.04584	0.1179	206.98	0.0054	78.311	3.58E-02	384.087	11.1062	7796.29	0.0145291	0.11685	0.03180338	0.00882376	0.01017	3.513692	0.00509
29-Jun-10	48	22206.8	0.1294	2.10670	1.62844	0.2417	0.0005206	0.0002987	3.01173	0.21109923	7914	0.0052484	0.233	0.1452965	0.3189	0.0116703	0.21899	593.32	90.30697	0.0152640	0.0666	0.04620	0.1203	208.69	0.0055	80.356	3.58E-02	384.253	11.3128	7978.93	0.0146597	0.12078	0.03251588	0.00934388	0.01041	3.621517	0.00521
06-Jul-10	49	22575.7	0.1368	2.15107	1.65810	0.2473	0.0005315	0.0003052	3.07698	0.21488373	8090	0.0053571	0.2352	0.147341	0.3297	0.0118704	0.22247	602.15	90.47792	0.0152749	0.0677	0.04650	0.1225	210.26	0.0055	82.135	3.58E-02	384.427	11.4924	8133.79	0.0147771	0.12416	0.03316838	0.00980933	0.01063	3.738097	0.00531
13-Jul-10	50	22818.5	0.1423	2.19879	1.68952	0.2534	0.0005433	0.0003123	3.14823	0.21902573	8279	0.0054759	0.2378	0.1491935	0.3378	0.0120652	0.22603	611.06	90.64370	0.0152868	0.0686	0.04755	0.1248	211.80	0.0055	84.147	3.58E-02	384.558	11.6791	8292.91	0.0149006	0.12801	0.03388088	0.01034371	0.01087	3.863022	0.00543
20-Jul-10	51	23188.1	0.1449	2.24230	1.71773	0.2591	0.0005543	0.0003189	3.21423	0.22287133	8451	0.0055859	0.2405	0.1505575	0.3418	0.0122236	0.22911	618.62	90.77790	0.0152978	0.0692	0.04917	0.1270	213.08	0.0056	86.074	3.59E-02	384.624	11.8432	8431.07	0.0150106	0.13172	0.03454088	0.01086291	0.01109	3.976542	0.00554
27-Jul-10	52	23733.2	0.1478	2.29345	1.75022	0.2653	0.0005665	0.0003262	3.28698	0.22711508	8625	0.0057071	0.243	0.1522793	0.3446	0.0124345	0.23250	626.24	90.93916	0.0153099	0.0699	0.05070	0.1295	214.48	0.0056	88.123	3.59E-02	384.697	12.0135	8582.64	0.0151295	0.13555	0.03526838	0.01139883	0.01133	4.108705	0.00566
03-Aug-10	53	24098.9	0.1507	2.34777	1.78413	0.2715	0.0005786	0.0003335	3.35973	0.23136368	8782	0.0058284	0.2453	0.1542193	0.3458	0.0126819	0.23590	633.13	91.11376	0.0153220	0.0707	0.05196	0.1319	215.89	0.0057	90.097	3.59E-02	384.770	12.1730	8733.47	0.0152459	0.13911	0.03599588	0.01189838	0.01157	4.2479	0.00579
10-Aug-10	54	24493.2	0.1536	2.40403	1.81761	0.2778	0.0005859	0.0003377	3.40216	0.23498178	8915	0.0059011	0.2471	0.1564091	0.3471	0.0129171	0.23898	639.07	91.25683	0.0153293	0.0714	0.05273	0.1341	217.17	0.0057	92.011	3.59E-02	384.869	12.3069	8856.90	0.0153516	0.14217	0.03642025	0.01232009	0.01172	4.362845	0.00586
17-Aug-10	55	24681.9	0.1563	2.45683	1.84762	0.2836	0.0005881	0.0003388	3.41316	0.23769218	9014	0.0059231	0.2484	0.1586223	0.3484	0.0131195	0.24149	643.60	91.35803	0.0153315	0.0720	0.05298	0.1358	218.23	0.0058	93.691	3.59E-02	384.983	12.4050	8944.02	0.0154378	0.1445	0.03653025	0.01263205	0.01176	4.445125	0.00588
24-Aug-10	56	24795.5	0.1592	2.50364	1.87755	0.2888	0.0005904	0.0003400	3.42504	0.23968005	9085	0.0059469	0.2494	0.1602064	0.3499	0.0132644	0.24339	647.08	91.43180	0.0153339	0.0726	0.05318	0.1377	219.06	0.0058	94.998	3.59E-02	385.078	12.4769	9006.01	0.015505	0.14599	0.036649	0.01284129	0.01181	4.507658	0.00590

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
31-Aug-10	57	24897.4	0.1622	2.54072	1.90535	0.2930	0.0005928	0.0003412	3.43706	0.24074306	9121	0.0059709	0.2497	0.1609952	0.3513	0.0133365	0.24449	649.17	91.47057	0.0153363	0.0730	0.05331	0.1396	219.59	0.0059	95.806	3.59E-02	385.146	12.5151	9036.31	0.0155469	0.14646	0.03676925	0.01292402	0.01186	4.544359	0.00593
07-Sep-10	58	25098.5	0.1658	2.58511	1.93769	0.2978	0.0005955	0.0003458	3.45019	0.24182194	9163	0.0060103	0.2503	0.1621581	0.3534	0.0134331	0.24583	651.54	91.50960	0.0153389	0.0735	0.05345	0.1415	220.22	0.0059	96.911	3.59E-02	385.230	12.5577	9069.91	0.0155939	0.1471	0.0369005	0.01302639	0.01191	4.57872	0.00595
14-Sep-10	59	25169.0	0.1692	2.62697	1.96745	0.3021	0.0005977	0.0003526	3.46156	0.24268644	9202	0.0060558	0.2508	0.1634275	0.3557	0.0135323	0.24710	653.66	91.54059	0.0153412	0.0740	0.05356	0.1429	220.80	0.0059	98.062	3.59E-02	385.312	12.5954	9099.49	0.0156357	0.14776	0.03701425	0.01312558	0.01195	4.603563	0.00598
21-Sep-10	60	25289.6	0.1724	2.67090	1.99949	0.3067	0.0006002	0.0003569	3.47381	0.24352434	9236	0.0061293	0.2512	0.1646158	0.3576	0.0136558	0.24830	655.63	91.57239	0.0153436	0.0746	0.05369	0.1438	221.35	0.0060	99.201	3.59E-02	385.402	12.6301	9125.21	0.0156788	0.14838	0.03713675	0.0132204	0.01200	4.627916	0.00600
28-Sep-10	61	25343.7	0.1749	2.71062	2.02925	0.3111	0.0006025	0.0003581	3.48519	0.24421594	9261	0.0062203	0.2516	0.1655531	0.3590	0.0137859	0.24926	657.17	91.60046	0.0153459	0.0751	0.05383	0.1443	221.80	0.0061	100.166	3.59E-02	385.489	12.6569	9143.41	0.0157171	0.14887	0.0372505	0.01329729	0.01205	4.6483	0.00602
05-Oct-10	62	25389.0	0.1825	2.76193	2.07019	0.3157	0.0009749	0.0065462	3.49261	0.24521089	9283	0.0075073	0.2543	0.1685379	0.3647	0.0175692	#N/A	658.66	91.62341	#N/A	0.0779	0.05637	0.1507	222.22	0.0186	101.131	3.71E-02	385.585	12.6814	9158.11	#N/A	0.15286	0.03793113	#N/A	0.01331	4.676218	0.00851
12-Oct-10	63	25437.2	0.1911	2.81001	2.10947	0.3197	0.0014592	0.0146089	3.49691	0.24618054	9299	0.0091413	0.2576	0.1719844	0.3715	0.0224375	#N/A	659.86	91.64004	#N/A	0.0813	0.05963	0.1589	222.55	0.0347	101.933	3.87E-02	385.670	12.7006	9168.67	#N/A	0.15781	0.03876425	#N/A	0.01493	4.702964	0.01174
19-Oct-10	64	25480.7	0.2023	2.86739	2.15683	0.3242	0.0021092	0.0254372	3.50063	0.2473574	9318	0.0113193	0.2619	0.1764431	0.3803	0.0289520	#N/A	661.20	91.65728	#N/A	0.0857	0.06398	0.1698	222.91	0.0564	102.835	4.09E-02	385.769	12.7216	9179.55	#N/A	0.16437	0.03986253	#N/A	0.01711	4.735188	0.01608
26-Oct-10	65	25508.3	0.2131	2.91899	2.19983	0.3280	0.0027542	0.0361872	3.50278	0.2484324	9332	0.0134693	0.2662	0.1807431	0.3889	0.0354020	#N/A	662.32	91.67061	#N/A	0.0900	0.06828	0.1805	223.21	0.0779	103.601	4.31E-02	385.855	12.7388	9187.89	#N/A	0.17082	0.04093753	#N/A	0.01926	4.764428	0.02038
02-Nov-10	66	25536.3	0.2249	2.97362	2.25208	0.3349	0.0034667	0.0480622	3.50515	0.2496199	9349	0.0158443	0.271	0.1854931	0.3949	0.0425270	#N/A	663.75	91.68344	#N/A	0.0947	0.07303	0.1924	223.57	0.1017	104.612	4.54E-02	385.950	12.7599	9197.06	#N/A	0.17795	0.04212503	#N/A	0.02163	4.784378	0.02513
09-Nov-10	67	25555.1	0.2349	3.01862	2.29808	0.3418	0.0040667	0.0580622	3.50715	0.2506199	9364	0.0178443	0.275	0.1894931	0.3984	0.0485270	#N/A	665.04	91.69344	#N/A	0.0987	0.07703	0.2024	223.88	0.1217	105.534	4.74E-02	386.030	12.7786	9204.76	#N/A	0.18395	0.04312503	#N/A	0.02363	4.795978	0.02913
16-Nov-10	68	25575.3	0.2449	3.06312	2.34508	0.3493	0.0046667	0.0680622	3.50915	0.2516199	9380	0.0198443	0.279	0.1934931	0.4011	0.0545270	#N/A	666.36	91.70304	#N/A	0.1027	0.08103	0.2124	224.19	0.1417	106.491	4.94E-02	386.110	12.7978	9212.45	#N/A	0.18995	0.04412503	#N/A	0.02563	4.804978	0.03313
23-Nov-10	69	25598.2	0.2556	3.10987	2.39608	0.3578	0.0053042	0.0786872	3.51128	0.2526824	9396	0.0219693	0.2832	0.1977431	0.4032	0.0609020	#N/A	667.81	91.71281	#N/A	0.1070	0.08528	0.2230	224.53	0.1629	107.545	5.16E-02	386.195	12.8186	9220.61	#N/A	0.19632	0.04518753	#N/A	0.02776	4.811778	0.03738
30-Nov-10	70	25613.5	0.2664	3.13923	2.43523	0.3645	0.0059567	0.0895622	3.51345	0.2537699	9407	0.0241443	0.2876	0.2020931	0.4087	0.0674270	#N/A	668.88	91.72651	#N/A	0.1113	0.08963	0.2339	224.82	0.1847	108.315	5.37E-02	386.303	12.8336	9226.02	#N/A	0.20285	0.04627503	#N/A	0.02993	4.818956	0.04173
07-Dec-10	71	25623.6	0.2779	3.16050	2.46973	0.3706	0.0066467	0.1010622	3.51575	0.2549199	9417	0.0264443	0.2922	0.2066931	0.4161	0.0743270	#N/A	669.79	91.74296	#N/A	0.1159	0.09423	0.2454	225.08	0.2077	108.966	5.60E-02	386.430	12.8461	9230.20	#N/A	0.20975	0.04742503	#N/A	0.03223	4.826661	0.04633
14-Dec-10	72	25632.3	0.2894	3.17689	2.50078	0.3762	0.0073367	0.1125622	3.51805	0.2560699	9425	0.0287443	0.2968	0.2112931	0.4245	0.0812270	#N/A	670.59	91.76038	#N/A	0.1205	0.09883	0.2569	225.33	0.2307	109.535	5.83E-02	386.562	12.8570	9233.60	#N/A	0.21665	0.04857503	#N/A	0.03453	4.834423	0.05093
21-Dec-10	73	25640.0	0.3014	3.18889	2.52958	0.3815	0.0080567	0.1245622	3.52045	0.2572699	9432	0.0311443	0.3016	0.2160931	0.4341	0.0884270	#N/A	671.31	91.77958	#N/A	0.1253	0.10363	0.2689	225.57	0.2547	110.044	6.07E-02	386.706	12.8666	9236.33	#N/A	0.22385	0.04977503	#N/A	0.03693	4.842583	0.05573
28-Dec-10	74	25649.0	0.3119	3.21514	2.56528	0.3874	0.0086867	0.1350622	3.52255	0.2583199	9440	0.0332443	0.3058	0.2202931	0.4393	0.0947270	#N/A	672.16	91.79281	#N/A	0.1295	0.10783	0.2794	225.80	0.2757	110.746	6.28E-02	386.832	12.8779	9239.44	#N/A	0.23015	0.05082503	#N/A	0.03903	4.848673	0.05993
04-Jan-11	75	25660.4	0.3224	3.24927	2.60623	0.3939	0.0093167	0.1455622	3.52465	0.2593699	9449	0.0353443	0.31	0.2244931	0.4430	0.1010270	#N/A	673.12	91.80426	#N/A	0.1337	0.11203	0.2899	226.04	0.2967	111.575	6.49E-02	386.958	12.8907	9242.91	#N/A	0.23645	0.05187503	#N/A	0.04113	4.854238	0.06413
11-Jan-11	76	25671.3	0.3326	3.28597	2.64824	0.4005	0.0099242	0.1556872	3.52668	0.2603824	9458	0.0373693	0.314	0.2285431	0.4458	0.1071020	#N/A	674.09	91.81443	#N/A	0.1378	0.11608	0.3000	226.28	0.3169	112.437	6.70E-02	387.080	12.9038	9246.42	#N/A	0.24252	0.05288753	#N/A	0.04316	4.859351	0.06818
18-Jan-11	77	25682.2	0.3427	3.32647	2.69279	0.4073	0.0105317	0.1658122	3.5287	0.2613949	9468	0.0393943	0.3181	0.2325931	0.4478	0.1131770	#N/A	675.12	91.82375	#N/A	0.1418	0.12013	0.3102	226.52	0.3372	113.360	6.90E-02	387.201	12.9176	9250.10	#N/A	0.2486	0.05390003	#N/A	0.04518	4.864211	0.07223
25-Jan-11	78	25691.6	0.3536	3.36997	2.74282	0.4147	0.0111842	0.1766872	3.53088	0.2624824	9478	0.0415693	0.3224	0.2369431	0.4500	0.1197020	#N/A	676.23	91.83136	#N/A	0.1462	0.12448	0.3210	226.76	0.3589	114.350	7.12E-02	387.277	12.9321	9253.67	#N/A	0.25512	0.05498753	#N/A	0.04736	4.868996	0.07658
01-Feb-11	79	25699.8	0.3663	3.42097	2.80274	0.4234	0.0119492	0.1894372	3.53343	0.2637574	9490	0.0441193	0.3275	0.2420431	0.4525	0.1273520	#N/A	677.53	91.83888	#N/A	0.1513	0.12958	0.3338	227.03	0.3844	115.509	7.37E-02	387.335	12.9491	9257.62	#N/A	0.26277	0.05626253	#N/A	0.04991	4.874351	0.08168
08-Feb-11	80	25707.2	0.3779	3.46747	2.85796	0.4313	0.0126467	0.2010622	3.53575	0.2649199	9501	0.0464443	0.3322	0.2466931	0.4549	0.1343270	#N/A	678.71	91.84510	#N/A	0.1559	0.13423	0.3454	227.27	0.4077	116.565	7.60E-02	387.372	12.9645	9261.12	#N/A	0.26975	0.05742503	#N/A	0.05223	4.879118	0.08633
15-Feb-11	81	25714.8	0.3898	3.51497	2.91496	0.4394	0.0133592	0.2129372	3.53813	0.2661074	9512	0.0488193	0.3369	0.2514431	0.4572	0.1414520	#N/A	679.92	91.85080	#N/A	0.1607	0.13898	0.3573	227.50	0.4314	117.643	7.84E-02	387.396	12.9802	9264.59	#N/A	0.27687	0.05861253	#N/A	0.05461	4.883868	0.09108
22-Feb-11	82	25721.5	0.4018	3.55337	2.96776	0.4468	0.0140792	0.2249372	3.54053	0.2673074	9521	0.0512193	0.3417	0.2562431	0.4632	0.1486520	#N/A	681.00	91.85800	#N/A	0.1655	0.14378	0.3693	227.72	0.4554	118.606	8.08E-02	387.420	12.9939	9267.57	#N/A	0.28407	0.05981253	#N/A	0.05701	4.889148	0.09588
01-Mar-11	83	25730.4	0.4142	3.58802	3.01974	0.4541	0.0148217	0.2373122	3.543	0.2685449	9530	0.0536943	0.3467	0.2611931	0.4713	0.1560770	#N/A	682.04	91.86617	#N/A	0.1704	0.14873	0.3817	227.93	0.4802	119.532	8.33E-02	387.445	13.0068	9270.36	#N/A	0.2915	0.06105003	#N/A	0.05948	4.89484	0.10083
08-Mar-11	84	25737.8	0.4266	3.62019	3.07048	0.4612	0.0155642	0.2496872	3.54548	0.2697824	9539	0.0561693	0.3516	0.2661431	0.4803	0.1635020	#N/A	683.03	91.87471	#N/A	0.1754	0.15368	0.3940	228.13	0.5049	120.427	8.58E-02	387.470	13.0193	9273.02	#N/A	0.29892	0.06228753	#N/A	0.06196	4.900656	0.10578
15-Mar-11	85	25743.5	0.4384	3.64869	3.11798	0.4679	0.0162767	0.2615622	3.54785	0.2709699	9547	0.0585443	0.3564	0.2708931	0.4898	0.1706270	#N/A	683.96	91.88326	#N/A	0.1801	0.15843	0.4059	228.32	0.5287	121.253	8.81E-02	387.493	13.0307	9275.45	#N/A	0.30605	0.06347503	#N/A	0.06433	4.906356	0.11053
22-Mar-11	86	25748.6	0.4499	3.67399	3.16398	0.4741	0.0169667	0.2730622	3.55015	0.2721199	9554	0.0608443	0.361	0.2754931	0.4990	0.1775270	#N/A	684.83	91.89246	#N/A	0.1847	0.16303	0.4174	228.51	0.5517	122.042	9.04E-02	387.516	13.0413	9277.68	#N/A	0.31295	0.06462503	#N/A	0.06663	4.911646	0.11513
29-Mar-11	87	25756.1	0.4617	3.69867	3.21098	0.4803	0.0176717	0.2848122	3.5525	0.2732949	9561	0.0631943	0.3657	0.2801931	0.5084	0.1845770	#N/A	685.71	91.90233	#N/A	0.1894	0.16773	0.4292	228.70	0.5752	122.842	9.28E-02	387.540	13.0518	9279.90	#N/A	0.32	0.06580003	#N/A	0.06898	4.916934	0.11983
05-Apr-11	88	25762.2	0.4734	3.72276	3.25798	0.4865	0.0183767	0.2965622	3.55485	0.2744699	9568	0.0655443	0.3704	0.2848931	0.5178	0.1916270	#N/A	686.58	91.91243	#N/A	0.1941	0.17243	0.4409	228.88	0.5987	123.639	9.51E-02	387.563	13.0623	9282.09	#N/A	0.32705	0.06697503	#N/A	0.07133	4.922163	0.12453
12-Apr-11	89	25767.1	0.4856	3.74701	3.30648	0.4928	0.0191042	0.3086872	3.55728	0.2756824	9575	0.0679693	0.3752	0.2897431	0.5275	0.1989020	#N/A	687.48	91.92310	#N/A	0.1990	0.17728	0.4530	229.08	0.6229	124.459	9.76E-02	387.588	13.0730	9284.32	#N/A	0.33432	0.06818753	#N/A	0.07376	4.927498	0.12938
19-Apr-11	90	25772.3	0.4979	3.76557	3.35350	0.4992	0.0198467	0.3210622	3.55975	0.2769199	9583	0.0704443	0.3802	0.2946931	0.5374	0.2063270	#N/A	688.40	91.93473	#N/A	0.2039	0.18223	0.4654	229.21	0.6477	125.231	1.00E-01	387.674	13.0836	9286.33	#N/A	0.34175	0.06942503	#N/A	0.07623	4.93319	0.13433
26-Apr-11	91	25777.8	0.5094	3.77994	3.39605	0.5052	0.0205367	0.3325622	3.56205	0.2780699	9589	0.0727443	0.3848	0.2992931	0.5466	0.2132270	#N/A	689.27	91.94589	#N/A	0.2085	0.18683	0.4769	229.31	0.6707	125.919	1.02E-01	387.783	13.0934	9288.06	#N/A	0.34865	0.07057503	#N/A	0.07853	4.938595	0.13893
03-May-11	92	25782.9	0.5204	3.79232	3.43620	0.5109	0.0211967	0.3435622	3.56425	0.2791699	9595	0.0749443	0.3892	0.3036931	0.5554	0.2198270	#N/A	690.10	91.95672	#N/A	0.2129	0.19123	0.4879	229.39	0.6927	126.562	1.05E-01	387.902	13.1027	9289.66	#N/A	0.35525	0.07167503	#N/A	0.08073	4.94382	0.14333
10-May-11	93	25788.4	0.5329	3.80482	3.48120	0.5174	0.0219467	0.3560622	3.56675	0.2804199	9602	0.0774443	0.3942	0.3086931	0.5654	0.2273270	#N/A	691.04	91.96922	#N/A	0.2179	0.19623	0.5004	229.47	0.7177	127.277	1.07E-01	388.052	13.1132	9291.41	#N/A	0.36275	0.07292503	#N/A	0.08323	4.94982	0.14833

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining	Fraction of Non-Sulphate Sulphur Leached	Fraction of Sulphate Sulphur Remaining	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO4	(Ca+Mg)/ Alk	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
28-Jul-09	0	4.664	14.1	14.1	554.4	554.4	5.771	0.00812	0.992	0.01888	0.981	0.01746	0.983	0.03	2.261	0.72	0.51	29.27	2.54	577.6	413.4	0.4134	413.4	0.4134	0.99	587.0	587.0	0.98
04-Aug-09	1	4.168	9.9	24.0	556.9	1111.3	11.569	0.01627	0.984	0.03786	0.962	0.03500	0.965	0.02	2.243	0.80	0.69	15.24	6.05	580.2	466.4	0.4664	879.8	0.8798	0.98	586.0	1173.0	0.97
11-Aug-09	2	4.886	16.2	40.2	802.6	1914.0	19.925	0.02802	0.972	0.06520	0.935	0.06028	0.940	0.02	2.216	0.75	0.63	23.53	5.44	836.2	625.1	0.6251	1504.9	1.5049	0.96	847.5	2020.6	0.94
18-Aug-09	3	4.290	15.0	55.2	635.8	2549.8	26.543	0.03733	0.963	0.08685	0.913	0.08030	0.920	0.02	2.195	0.86	0.75	19.19	6.79	662.4	567.6	0.5676	2072.6	2.0726	0.94	673.1	2693.7	0.93
25-Aug-09	4	4.364	16.6	71.8	632.9	3182.6	33.132	0.04660	0.953	0.10841	0.892	0.10023	0.900	0.03	2.174	0.86	0.74	18.03	6.61	659.3	563.9	0.5639	2636.5	2.6365	0.93	671.6	3365.2	0.91
01-Sep-09	5	3.879	16.0	87.8	543.5	3726.1	38.790	0.05456	0.945	0.12692	0.873	0.11735	0.883	0.03	2.156	0.86	0.75	16.88	6.41	566.3	488.2	0.4882	3124.7	3.1247	0.91	578.4	3943.6	0.89
08-Sep-09	6	4.966	25.9	113.7	427.6	4153.7	43.241	0.06082	0.939	0.14149	0.859	0.13081	0.869	0.06	2.141	1.33	1.12	20.69	5.52	445.4	591.5	0.5915	3716.2	3.7162	0.90	466.4	4410.0	0.88
15-Sep-09	7	5.740	33.9	147.6	634.8	4788.5	49.849	0.07011	0.930	0.16311	0.837	0.15080	0.849	0.05	2.120	1.00	0.83	24.51	5.02	661.4	659.3	0.6593	4375.4	4.3754	0.88	689.5	5099.5	0.86
22-Sep-09	8	5.639	31.9	179.5	926.0	5714.5	59.488	0.08367	0.916	0.19465	0.805	0.17996	0.820	0.03	2.089	0.67	0.57	18.59	5.69	964.7	643.9	0.6439	5019.3	5.0193	0.86	991.0	6090.5	0.83
29-Sep-09	9	3.700	19.2	198.7	500.8	6215.2	64.702	0.09100	0.909	0.21171	0.788	0.19573	0.804	0.04	2.073	0.80	0.71	12.67	7.51	521.7	417.6	0.4176	5436.9	5.4369	0.85	537.2	6627.7	0.82
06-Oct-09	10	2.752	16.1	214.7	486.8	6702.1	69.770	0.09813	0.902	0.22829	0.772	0.21106	0.789	0.03	2.056	0.71	0.63	12.03	8.19	507.2	359.9	0.3599	5796.9	5.7969	0.84	520.5	7148.2	0.81
13-Oct-09	11	2.241	15.4	230.2	331.5	7033.6	73.221	0.10298	0.897	0.23959	0.760	0.22151	0.778	0.05	2.045	1.03	0.93	11.38	9.10	345.4	355.9	0.3559	6152.8	6.1528	0.83	358.6	7506.8	0.80
20-Oct-09	12	2.330	14.4	244.6	392.2	7425.8	77.304	0.10872	0.891	0.25295	0.747	0.23386	0.766	0.04	2.032	1.08	0.98	13.64	10.13	408.6	440.1	0.4401	6592.9	6.5929	0.82	420.6	7927.5	0.78
27-Oct-09	13	2.054	11.2	255.8	503.2	7928.9	82.542	0.11609	0.884	0.27008	0.730	0.24970	0.750	0.02	2.015	0.86	0.78	15.89	11.01	524.2	448.8	0.4488	7041.7	7.0417	0.81	533.4	8460.9	0.77
03-Nov-09	14	2.792	12.2	268.0	529.1	8458.0	88.050	0.12384	0.876	0.28811	0.712	0.26636	0.734	0.02	1.998	0.90	0.82	16.56	10.88	551.2	495.4	0.4954	7537.1	7.5371	0.79	560.7	9021.5	0.75
10-Nov-09	15	3.600	13.3	281.3	606.3	9064.3	94.361	0.13271	0.867	0.30876	0.691	0.28546	0.715	0.02	1.977	0.86	0.79	17.22	10.76	631.7	544.2	0.5442	8081.3	8.0813	0.78	641.3	9662.9	0.74
17-Nov-09	16	3.109	17.4	298.7	600.8	9665.1	100.616	0.14151	0.858	0.32922	0.671	0.30438	0.696	0.03	1.957	0.94	0.86	18.88	10.76	625.9	590.5	0.5905	8671.8	8.6718	0.76	640.2	10303.1	0.72
24-Nov-09	17	2.798	22.8	321.4	707.6	10372.7	107.981	0.15187	0.848	0.35333	0.647	0.32666	0.673	0.03	1.934	0.92	0.84	20.55	10.77	737.2	677.1	0.6771	9348.8	9.3488	0.75	757.1	11060.2	0.70
01-Dec-09	18	3.420	24.3	345.7	655.6	11028.3	114.806	0.16147	0.839	0.37566	0.624	0.34731	0.653	0.04	1.912	0.97	0.89	20.14	10.64	683.1	663.7	0.6637	10012.5	10.0125	0.73	703.9	11764.1	0.68
08-Dec-09	19	3.713	23.6	369.3	587.3	11615.6	120.920	0.17007	0.830	0.39566	0.604	0.36580	0.634	0.04	1.892	0.98	0.89	19.74	10.50	611.8	597.2	0.5972	10609.7	10.6097	0.71	631.7	12395.8	0.66
15-Dec-09	20	2.999	21.8	391.2	333.2	11948.8	124.388	0.17494	0.825	0.40701	0.593	0.37629	0.624	0.07	1.881	1.54	1.40	16.22	10.21	347.1	534.3	0.5343	11144.0	11.1440	0.70	366.0	12761.8	0.65
22-Dec-09	21	1.895	17.4	408.6	350.1	12298.8	128.033	0.18007	0.820	0.41894	0.581	0.38732	0.613	0.05	1.869	1.11	1.01	12.70	9.79	364.7	405.5	0.4055	11549.5	11.5495	0.69	380.2	13142.1	0.64
29-Dec-09	22	1.838	14.0	422.6	301.6	12600.5	131.173	0.18449	0.816	0.42921	0.571	0.39682	0.603	0.05	1.859	0.95	0.86	9.36	9.35	314.2	298.9	0.2989	11848.4	11.8484	0.68	326.4	13468.4	0.63
05-Jan-10	23	1.631	9.6	432.2	164.4	12764.9	132.884	0.18689	0.813	0.43481	0.565	0.40200	0.598	0.06	1.854	1.03	0.92	6.02	8.54	171.3	176.1	0.1761	12024.4	12.0244	0.67	179.3	13647.8	0.63
12-Jan-10	24	1.877	9.8	442.0	140.2	12905.1	134.344	0.18895	0.811	0.43959	0.560	0.40641	0.594	0.07	1.849	1.23	1.10	6.20	8.29	146.0	179.4	0.1794	12203.8	12.2038	0.67	154.0	13801.7	0.62
19-Jan-10	25	2.117	10.0	452.0	196.8	13101.8	136.392	0.19183	0.808	0.44629	0.554	0.41261	0.587	0.05	1.843	0.89	0.79	6.39	8.07	205.0	182.6	0.1826	12386.4	12.3864	0.66	212.9	14014.6	0.62
26-Jan-10	26	1.681	7.1	459.0	68.9	13170.7	137.109	0.19283	0.807	0.44864	0.551	0.41478	0.585	0.10	1.840	1.75	1.55	4.38	7.97	71.7	125.2	0.1252	12511.7	12.5117	0.66	77.1	14091.7	0.62
02-Feb-10	27	1.362	4.5	463.6	73.0	13243.7	137.869	0.19390	0.806	0.45112	0.549	0.41708	0.583	0.06	1.838	0.98	0.86	2.38	7.73	76.1	74.3	0.0743	12585.9	12.5859	0.66	79.2	14171.0	0.61
09-Feb-10	28	1.962	10.2	473.8	407.9	13651.6	142.115	0.19988	0.800	0.46502	0.535	0.42992	0.570	0.02	1.824	0.65	0.58	9.35	7.71	424.9	276.7	0.2767	12862.6	12.8626	0.65	433.2	14604.1	0.60
16-Feb-10	29	2.965	18.1	491.8	508.9	14160.4	147.412	0.20733	0.793	0.48235	0.518	0.44595	0.554	0.04	1.807	1.03	0.91	16.33	7.71	530.2	543.5	0.5435	13406.1	13.4061	0.63	545.2	15149.4	0.59
23-Feb-10	30	2.157	15.6	507.4	387.6	14548.0	151.447	0.21300	0.787	0.49555	0.504	0.45815	0.542	0.04	1.794	1.12	0.98	14.10	7.54	403.8	450.3	0.4503	13856.4	13.8564	0.62	417.3	15566.6	0.58
02-Mar-10	31	1.375	13.0	520.5	322.2	14870.2	154.801	0.21772	0.782	0.50653	0.493	0.46830	0.532	0.04	1.784	1.06	0.93	11.87	7.31	335.7	355.1	0.3551	14211.6	14.2116	0.61	347.3	15914.0	0.57
09-Mar-10	32	1.707	13.5	533.9	437.3	15307.5	159.354	0.22412	0.776	0.52142	0.479	0.48207	0.518	0.03	1.769	0.80	0.71	12.63	7.62	455.6	365.2	0.3652	14576.7	14.5767	0.60	467.4	16381.3	0.55
16-Mar-10	33	2.304	15.8	549.7	389.0	15696.6	163.404	0.22982	0.770	0.53467	0.465	0.49432	0.506	0.04	1.756	1.06	0.94	13.39	7.92	405.3	427.7	0.4277	15004.4	15.0044	0.59	418.8	16800.1	0.54
23-Mar-10	34	2.102	16.6	566.3	505.1	16201.6	168.661	0.23721	0.763	0.55188	0.448	0.51023	0.490	0.03	1.739	0.83	0.74	14.29	8.05	526.2	437.0	0.4370	15441.5	15.4415	0.58	540.7	17340.8	0.53
30-Mar-10	35	2.063	18.6	584.9	523.6	16725.2	174.112	0.24488	0.755	0.56971	0.430	0.52672	0.473	0.04	1.722	0.88	0.78	15.18	8.18	545.5	479.7	0.4797	15921.2	15.9212	0.57	562.0	17902.8	0.51
06-Apr-10	36	2.577	18.8	603.7	447.6	17172.8	178.772	0.25143	0.749	0.58496	0.415	0.54081	0.459	0.04	1.707	1.07	0.95	17.00	8.45	466.3	497.1	0.4971	16418.3	16.4183	0.55	482.6	18385.4	0.50
13-Apr-10	37	3.320	20.9	624.6	577.2	17750.0	184.780	0.25988	0.740	0.60462	0.395	0.55899	0.441	0.04	1.687	0.94	0.84	18.81	8.69	601.3	562.8	0.5628	16981.1	16.9811	0.54	618.9	19004.3	0.48
20-Apr-10	38	2.585	23.3	647.9	528.5	18278.5	190.282	0.26762	0.732	0.62262	0.377	0.57563	0.424	0.04	1.670	0.91	0.82	16.27	8.55	550.7	503.2	0.5032	17484.3	17.4843	0.52	571.4	19575.6	0.47
27-Apr-10	39	1.447	19.7	667.6	479.3	18757.8	195.272	0.27464	0.725	0.63895	0.361	0.59073	0.409	0.04	1.654	0.92	0.83	16.72	9.03	499.3	460.8	0.4608	17945.1	17.9451	0.51	517.6	20093.2	0.45
04-May-10	40	2.157	23.0	690.6	509.7	19267.5	200.577	0.28210	0.718	0.65631	0.344	0.60678	0.393	0.05	1.637	0.93	0.84	15.42	9.49	531.0	492.6	0.4926	18437.6	18.4376	0.50	551.9	20645.1	0.44
11-May-10	41	2.525	22.3	712.9	431.8	19699.3	205.072	0.28842	0.712	0.67102	0.329	0.62038	0.380	0.05	1.622	0.96	0.87	14.13	10.09	449.9	432.3	0.4323	18869.9	18.8699	0.49	469.7	21114.7	0.42
18-May-10	42	2.953	20.9	733.8	354.7	20053.9	208.765	0.29361	0.706	0.68310	0.317	0.63155	0.368	0.06	1.611	1.06	0.97	13.12	10.21	369.5	392.4	0.3924	19262.3	19.2623	0.47	387.5	21502.2	0.41
25-May-10	43	3.242	18.8	752.7	252.8	20306.8	211.397	0.29732	0.703	0.69171	0.308	0.63951	0.360	0.07	1.602	1.30	1.18	12.10	10.35	263.4	341.7	0.3417	19604.1	19.6041	0.47	279.0	21781.2	0.41
01-Jun-10	44	2.901	21.1	773.7	264.8	20571.5	214.153	0.30119	0.699	0.70073	0.299	0.64785	0.352	0.08	1.593	1.64	1.50	15.82	10.63	275.9	451.9	0.4519	20055.9	20.0559	0.45	294.0	22075.2	0.40

Appendix B.1-1

Humidity Cell T1 (Clay Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining	Fraction of Non-Sulphate Sulphur Leached	Fraction of Sulphate Sulphur Remaining	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO4	(Ca+Mg)/ Alk	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
08-Jun-10	45	2.728	25.0	798.7	486.7	21058.2	219.219	0.30832	0.692	0.71731	0.283	0.66317	0.337	0.05	1.577	1.19	1.09	19.53	10.80	507.0	603.9	0.6039	20659.8	20.6598	0.44	529.3	22604.5	0.38
15-Jun-10	46	2.390	24.9	823.6	312.3	21370.5	222.470	0.31289	0.687	0.72795	0.272	0.67301	0.327	0.08	1.567	1.54	1.42	18.45	11.14	325.3	502.2	0.5022	21162.1	21.1621	0.42	347.8	22952.3	0.37
22-Jun-10	47	2.612	30.5	854.1	445.4	21815.9	227.107	0.31941	0.681	0.74312	0.257	0.68703	0.313	0.07	1.552	1.12	1.03	17.36	11.54	464.1	519.5	0.5195	21681.5	21.6815	0.41	491.9	23444.3	0.36
29-Jun-10	48	2.563	33.4	887.5	390.9	22206.8	231.177	0.32513	0.675	0.75644	0.244	0.69935	0.301	0.09	1.539	1.32	1.21	16.81	11.79	407.3	536.8	0.5368	22218.3	22.2183	0.39	438.1	23882.4	0.35
06-Jul-10	49	2.140	31.4	918.9	368.9	22575.7	235.017	0.33054	0.669	0.76900	0.231	0.71096	0.289	0.09	1.526	1.24	1.14	16.26	12.07	384.3	475.4	0.4754	22693.7	22.6937	0.38	413.6	24296.0	0.34
13-Jul-10	50	3.168	36.3	955.2	242.7	22818.5	237.544	0.33409	0.666	0.77727	0.223	0.71861	0.281	0.15	1.518	2.01	1.87	15.94	12.87	252.9	509.0	0.5090	23202.7	23.2027	0.37	286.0	24582.0	0.33
20-Jul-10	51	3.705	35.6	990.8	369.6	23188.1	241.391	0.33950	0.660	0.78986	0.210	0.73025	0.270	0.10	1.506	1.20	1.12	15.62	13.82	385.1	462.1	0.4621	23664.8	23.6648	0.35	416.9	24998.9	0.32
27-Jul-10	52	3.924	39.9	1030.7	545.1	23733.2	247.066	0.34748	0.653	0.80843	0.192	0.74741	0.253	0.07	1.488	0.82	0.76	14.27	13.83	568.0	465.1	0.4651	24129.9	24.1299	0.34	603.9	25602.9	0.30
03-Aug-10	53	3.764	40.6	1071.3	365.7	24098.9	250.873	0.35284	0.647	0.82088	0.179	0.75893	0.241	0.11	1.476	1.10	1.03	12.91	13.84	381.0	420.9	0.4209	24550.8	24.5508	0.33	417.9	26020.7	0.29
10-Aug-10	54	3.191	39.8	1111.1	394.3	24493.2	254.978	0.35861	0.641	0.83432	0.166	0.77135	0.229	0.10	1.462	0.87	0.81	10.93	13.56	410.8	356.5	0.3565	24907.3	24.9073	0.32	447.4	26468.1	0.28
17-Aug-10	55	2.376	35.3	1146.4	188.8	24681.9	256.943	0.36137	0.639	0.84075	0.159	0.77729	0.223	0.19	1.456	1.35	1.25	8.95	13.19	196.7	264.9	0.2649	25172.2	25.1722	0.31	229.6	26697.7	0.27
24-Aug-10	56	3.128	29.3	1175.7	113.5	24795.5	258.125	0.36304	0.637	0.84461	0.155	0.78087	0.219	0.26	1.452	1.62	1.50	6.01	12.39	118.3	192.0	0.1920	25364.1	25.3641	0.31	144.5	26842.2	0.27
31-Aug-10	57	3.737	20.8	1196.5	102.0	24897.4	259.186	0.36453	0.635	0.84809	0.152	0.78408	0.216	0.20	1.449	0.93	0.85	3.07	10.51	106.2	99.2	0.0992	25463.4	25.4634	0.31	123.3	26965.5	0.26
07-Sep-10	58	3.158	24.6	1221.1	201.1	25098.5	261.280	0.36747	0.633	0.85494	0.145	0.79041	0.210	0.12	1.442	0.55	0.50	3.27	10.83	209.5	115.3	0.1153	25578.6	25.5786	0.30	230.9	27196.4	0.26
14-Sep-10	59	1.938	22.9	1244.0	70.5	25169.0	262.014	0.36850	0.631	0.85734	0.143	0.79263	0.207	0.32	1.440	1.44	1.32	3.46	11.13	73.5	105.9	0.1059	25684.5	25.6845	0.30	94.5	27290.9	0.26
21-Sep-10	60	1.779	23.8	1267.8	120.5	25289.6	263.269	0.37027	0.630	0.86144	0.139	0.79643	0.204	0.20	1.436	0.74	0.68	2.84	10.50	125.6	93.4	0.0934	25778.0	25.7780	0.30	147.6	27438.5	0.25
28-Sep-10	61	1.365	21.3	1289.1	54.1	25343.7	263.832	0.37106	0.629	0.86329	0.137	0.79813	0.202	0.39	1.434	1.20	1.09	2.21	9.64	56.4	67.6	0.0676	25845.6	25.8456	0.30	76.3	27514.8	0.25
05-Oct-10	62	1.433	21.9	1311.0	45.3	25389.0	264.304	0.37173	0.628	0.86483	0.135	0.79956	0.200	0.48	1.432	1.28	1.15	1.82	8.90	47.2	60.6	0.0606	25906.2	25.9062	0.29	67.7	27582.5	0.25
12-Oct-10	63	1.222	18.5	1329.6	48.2	25437.2	264.805	0.37243	0.628	0.86647	0.134	0.80108	0.199	0.38	1.431	0.94	0.84	1.63	8.46	50.2	47.0	0.0470	25953.2	25.9532	0.29	67.5	27650.0	0.25
19-Oct-10	64	1.394	21.0	1350.6	43.6	25480.7	265.259	0.37307	0.627	0.86795	0.132	0.80245	0.198	0.48	1.429	1.12	1.00	1.53	8.21	45.4	50.9	0.0509	26004.1	26.0041	0.29	65.0	27715.0	0.24
26-Oct-10	65	1.200	18.0	1368.6	27.5	25508.3	265.545	0.37347	0.627	0.86889	0.131	0.80332	0.197	0.65	1.428	1.44	1.28	1.43	7.95	28.7	41.4	0.0414	26045.4	26.0454	0.29	45.5	27760.5	0.24
02-Nov-10	66	1.525	25.2	1393.8	28.0	25536.3	265.837	0.37388	0.626	0.86985	0.130	0.80420	0.196	0.90	1.428	1.68	1.47	1.53	7.31	29.2	49.0	0.0490	26094.4	26.0944	0.29	52.9	27813.4	0.24
09-Nov-10	67	1.368	23.4	1417.3	18.8	25555.1	266.033	0.37416	0.626	0.87049	0.130	0.80479	0.195	1.25	1.427	2.18	1.90	1.58	7.06	19.6	42.6	0.0426	26137.0	26.1370	0.29	41.7	27855.0	0.24
16-Nov-10	68	1.410	24.6	1441.8	20.2	25575.3	266.243	0.37445	0.626	0.87118	0.129	0.80543	0.195	1.22	1.426	2.06	1.80	1.61	6.94	21.0	43.3	0.0433	26180.3	26.1803	0.29	44.2	27899.2	0.24
23-Nov-10	69	1.543	27.3	1469.1	23.0	25598.2	266.482	0.37479	0.625	0.87196	0.128	0.80615	0.194	1.19	1.425	1.95	1.70	1.64	6.83	23.9	46.7	0.0467	26227.1	26.2271	0.28	49.6	27948.9	0.24
30-Nov-10	70	1.892	20.7	1489.7	15.2	25613.5	266.640	0.37501	0.625	0.87248	0.128	0.80663	0.193	1.36	1.425	2.09	1.81	1.13	6.52	15.9	33.1	0.0331	26260.1	26.2601	0.28	34.6	27983.5	0.24
07-Dec-10	71	2.167	18.0	1507.8	10.1	25623.6	266.746	0.37516	0.625	0.87282	0.127	0.80695	0.193	1.78	1.425	2.58	2.22	0.88	6.26	10.5	27.2	0.0272	26287.3	26.2873	0.28	26.4	28009.9	0.24
14-Dec-10	72	2.249	16.1	1523.9	8.7	25632.3	266.837	0.37529	0.625	0.87312	0.127	0.80722	0.193	1.84	1.424	2.56	2.19	0.75	6.07	9.1	23.3	0.0233	26310.6	26.3106	0.28	23.0	28032.8	0.24
21-Dec-10	73	2.434	14.8	1538.7	7.7	25640.0	266.917	0.37540	0.625	0.87338	0.127	0.80746	0.193	1.93	1.424	2.53	2.16	0.63	5.82	8.0	20.2	0.0202	26330.9	26.3309	0.28	20.4	28053.2	0.23
28-Dec-10	74	1.693	16.1	1554.7	9.0	25649.0	267.011	0.37553	0.624	0.87369	0.126	0.80775	0.192	1.78	1.424	2.53	2.16	0.84	5.81	9.4	23.8	0.0238	26354.7	26.3547	0.28	23.8	28077.0	0.23
04-Jan-11	75	1.474	17.6	1572.3	11.3	25660.4	267.129	0.37570	0.624	0.87407	0.126	0.80811	0.192	1.55	1.423	2.27	1.94	0.95	5.81	11.8	26.8	0.0268	26381.5	26.3815	0.28	28.0	28104.9	0.23
11-Jan-11	76	1.316	17.7	1590.1	10.9	25671.3	267.242	0.37586	0.624	0.87445	0.126	0.80845	0.192	1.62	1.423	2.40	2.05	1.00	5.80	11.4	27.4	0.0274	26408.9	26.4089	0.28	27.8	28132.8	0.23
18-Jan-11	77	1.211	18.5	1608.6	10.9	25682.2	267.356	0.37602	0.624	0.87482	0.125	0.80879	0.191	1.69	1.423	2.53	2.16	1.06	5.80	11.4	28.8	0.0288	26437.7	26.4377	0.28	28.7	28161.4	0.23
25-Jan-11	78	1.333	20.8	1629.4	9.4	25691.6	267.454	0.37616	0.624	0.87514	0.125	0.80909	0.191	2.23	1.422	3.10	2.63	1.03	5.62	9.7	30.2	0.0302	26467.9	26.4679	0.28	29.3	28190.7	0.23
01-Feb-11	79	1.582	25.0	1654.5	8.2	25699.8	267.539	0.37627	0.624	0.87542	0.125	0.80935	0.191	3.07	1.422	4.11	3.48	1.02	5.53	8.5	35.0	0.0350	26502.9	26.5029	0.28	31.9	28222.6	0.23
08-Feb-11	80	1.451	23.1	1677.5	7.4	25707.2	267.616	0.37638	0.624	0.87567	0.124	0.80958	0.190	3.10	1.422	4.09	3.46	1.01	5.49	7.8	31.7	0.0317	26534.6	26.5346	0.28	29.4	28252.0	0.23
15-Feb-11	81	1.492	23.8	1701.4	7.6	25714.8	267.695	0.37650	0.624	0.87593	0.124	0.80982	0.190	3.14	1.422	4.06	3.43	1.01	5.45	7.9	32.2	0.0322	26566.7	26.5667	0.28	30.3	28282.3	0.23
22-Feb-11	82	1.438	21.7	1723.1	6.7	25721.5	267.765	0.37659	0.623	0.87616	0.124	0.81003	0.190	3.23	1.421	4.02	3.38	0.87	5.34	7.0	28.1	0.0281	26594.9	26.5949	0.27	27.2	28309.5	0.23
01-Mar-11	83	1.447	21.1	1744.2	8.9	25730.4	267.858	0.37672	0.623	0.87646	0.124	0.81031	0.190	2.37	1.421	2.88	2.42	0.80	5.27	9.3	26.7	0.0267	26621.6	26.6216	0.27	28.9	28338.5	0.23
08-Mar-11	84	1.429	20.5	1764.7	7.4	25737.8	267.935	0.37683	0.623	0.87671	0.123	0.81055	0.189	2.76	1.421	3.31	2.78	0.77	5.23	7.7	25.6	0.0256	26647.2	26.6472	0.27	26.8	28365.3	0.23
15-Mar-11	85	1.354	19.1	1783.7	5.7	25743.5	267.994	0.37692	0.623	0.87691	0.123	0.81073	0.189	3.35	1.421	3.96	3.32	0.74	5.19	5.9	23.5	0.0235	26670.7	26.6707	0.27	23.7	28388.9	0.23
22-Mar-11	86	1.410	18.9	1802.6	5.1	25748.6	268.047	0.37699	0.623	0.87708	0.123	0.81088	0.189	3.73	1.420	4.10	3.42	0.70	5.02	5.3	21.6	0.0216	26692.4	26.6924	0.27	22.7	28411.7	0.23
29-Mar-11	87	1.491	19.5	1822.1	7.5	25756.1	268.125	0.37710	0.623	0.87734	0.123	0.81112	0.189	2.59	1.420	2.75	2.28	0.68	4.94	7.8	21.5	0.0215	26713.9	26.7139	0.27	25.8	28437.5	0.22
05-Apr-11	88	1.516	19.6	1841.7	6.1	25762.2	268.189	0.37719	0.623	0.87754	0.122	0.81131	0.189	3.21	1.420	3.34	2.77	0.67	4.90	6.4	21.2	0.0212	26735.2	26.7352	0.27	24.4	28461.9	0.22
12-Apr-11	89	1.591	20.3	1862.0	4.9	25767.1	268.240	0.37726	0.623	0.87771	0.122	0.81147	0.189	4.19	1.420	4.28	3.55	0.66	4.85	5.1	21.6	0.0216	26756.8	26.7568	0.27	23.8	28485.7	0.22
19-Apr-11	90	1.626	20.2	1882.1	5.2	25772.3	268.294	0.37734	0.623	0.87789	0.122	0.81163	0.188	3.88	1.420	3.97	3.26	0.65	4.64	5.4	21.5	0.0215	26778.3	26.7783	0.27	23.9	28509.7	0.22
26-Apr-11	91	1.512	18.5	1900.6	5.5	25777.8	268.351	0.37742	0.623	0.87807	0.122	0.81180	0.188	3.34	1.419	3.43	2.81	0.64	4.53	5.8	19.7	0.0197	26798.0	26.7980	0.27	22.7	28532.3	0.22
03-May-11	92	1.447	17.5	1918.1	5.1	25782.9	268.404	0.37749	0.623	0.87825	0.122	0.81196	0.188	3.46	1.419	3.55	2.90	0.63	4.48	5.3	18.7	0.0187	26816.7	26.8167	0.27	21.3	28553.7	0.22
10-May-11	93	1.645	19.8	1937.9	5.5	25788.4	268.461	0.37757	0.622	0.87843	0.122	0.81214	0.188	3.59	1.419	3.69	3.01	0.63	4.43	5.7	21.1	0.0211	26837.9	26.8379	0.27	23.9	28577.5	0.22
Average of Measured Cycles 31 - 93					*257.0*											*1.7*					*283.8*							

Appendix B.1-2

Humidity Cell T2 (Sand-Silt Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
28-Jul-09	0	750	440	7.49	1470	#N/A	8.0	20.4	936	6.3	882	0.0059	0.0843	0.126	0.011	<0.00001	<0.000005	<0.05	0.0071	315	<0.0001	0.00364	0.00695	0.059	0.00169	0.0047	23.2
04-Aug-09	1	500	400	7.33	2362	#N/A	6.7	24.9	1709	2.4	1630	0.005	0.472	0.163	0.0079	<0.00005	<0.00003	<0.3	0.014	551	<0.0005	0.00849	0.0143	0.029	0.00347	0.014	63
11-Aug-09	2	500	400	7.50	2364	#N/A	10.9	27.9	1748	0.5	1700	0.003	0.808	0.14	0.0076	<0.00005	<0.00003	<0.3	0.02	580	<0.0005	0.00832	0.0118	0.025	0.00379	0.016	61.8
18-Aug-09	3	500	440	7.39	2216	#N/A	7.9	26.3	1650	0.6	1640	0.004	0.805	0.109	0.0075	<0.00005	<0.00003	<0.3	0.0239	590	<0.0005	0.00786	0.0117	0.017	0.00436	0.015	40.1
25-Aug-09	4	500	430	7.57	2160				1441																		
01-Sep-09	5	500	400	7.48	2278	#N/A	12.0	30.3	1589	<0.5	1690	0.01	0.718	0.0812	0.0099	<0.0001	<0.00005	<0.5	0.0272	633	<0.001	0.00789	0.0202	0.025	0.00518	0.014	27.2
08-Sep-09	6	500	440	7.37	2232				1606																		
15-Sep-09	7	500	465	7.64	2209	#N/A	13.0	53.6	1508	<0.5	1490	0.004	0.649	0.0698	0.011	<0.00005	<0.00003	<0.3	0.0353	572	<0.0005	0.0105	0.026	0.017	0.00714	0.014	16.3
22-Sep-09	8	500	455	7.57	2132				1559																		
29-Sep-09	9	500	460	7.56	2147	#N/A	10.2	61.5	1783	<0.5	1580	0.002	0.604	0.0565	0.0099	<0.00005	<0.00003	<0.3	0.0286	594	<0.0005	0.00419	0.0168	0.037	0.00627	0.01	22.8
06-Oct-09	10	500	410	7.45	2299				1762																		
13-Oct-09	11	500	440	7.64	2282	#N/A	9.1	69.2	1676	<0.5	1580	0.011	0.542	0.0439	0.009	<0.00005	<0.00003	<0.3	0.0312	591	<0.0005	0.00188	0.0154	0.008	0.00626	0.009	25.1
20-Oct-09	12	500	440	7.58	2204				1601																		
27-Oct-09	13	500	450	7.64	2310	#N/A	8.5	58.8	1676	<0.5	1560	0.005	0.61	0.0392	0.0079	<0.00005	<0.00003	<0.3	0.029	580	<0.0005	0.00187	0.0091	0.018	0.00506	0.007	25.9
03-Nov-09	14	500	400	7.60	2275				1575																		
10-Nov-09	15	500	465	7.43	2180	#N/A	12.0	56.5	1529	<0.5	1560	0.016	0.608	0.0339	0.0096	<0.00005	<0.00003	<0.3	0.0296	590	<0.0005	0.00146	0.0115	0.033	0.0051	0.006	22
17-Nov-09	16	500	505	7.54	2262				1593																		
24-Nov-09	17	500	485	7.73	2216	#N/A	10.5	68.0	1649	<0.5	1500	0.002	0.546	0.0309	0.0099	<0.00005	<0.00003	<0.3	0.0384	575	<0.0005	0.00103	0.0166	0.01	0.00563	0.005	16.2
01-Dec-09	18	500	475	7.66	2078				1538																		
08-Dec-09	19	500	465	7.50	1823	#N/A	9.6	62.7	1163	<0.5	1140	0.003	0.489	0.0272	0.0069	<0.00005	<0.00003	<0.3	0.0279	434	<0.0005	0.001	0.0115	0.013	0.00435	0.004	13.6
15-Dec-09	20	500	490	7.69	1570				1086																		
22-Dec-09	21	500	455	7.65	1159	#N/A	6.3	54.9	836	<0.5	771	0.003	0.495	0.0249	0.0065	<0.00005	<0.00003	<0.3	0.0203	290	<0.0005	0.00083	0.0095	0.014	0.00312	0.003	11.7
29-Dec-09	22	500	440	7.65	1289				755																		
05-Jan-10	23	500	440	7.55	1157	#N/A	8.0	64.2	621	<0.5	662	0.002	0.516	0.0269	0.0077	<0.00005	<0.00003	<0.3	0.0163	242	<0.0005	0.00088	0.0099	0.006	0.00268	0.003	13.9
12-Jan-10	24	500	430	7.63	1033				590																		
19-Jan-10	25	500	450	7.76	915	#N/A	7.8	73.3	457	<0.5	500	0.006	0.48	0.0287	0.0105	<0.00005	<0.00003	<0.3	0.0112	178	<0.0005	0.00068	0.0125	0.009	0.00222	<0.003	13.5
26-Jan-10	26	500	410	7.66	727				390																		
02-Feb-10	27	500	455	7.69	619	#N/A	5.5	80.3	352	<0.5	409	0.003	0.41	0.0303	0.0118	<0.00005	<0.00003	<0.3	0.00895	143	<0.0005	0.00043	0.0829	0.133	0.00205	<0.003	13
09-Feb-10	28	500	440	7.72	693				341																		
16-Feb-10	29	500	455	7.75	592	#N/A	6.1	89.8	262	<0.5	362	0.0033	0.424	0.0334	0.0139	<0.00001	<0.000005	<0.05	0.0073	124	<0.0001	0.000877	0.00566	0.003	0.00204	0.0024	13.1
23-Feb-10	30	500	420	7.87	606				243																		
02-Mar-10	31	500	405	7.89	546	#N/A	3.5	81.4	233	<0.5	315	0.007	0.395	0.0341	0.0173	<0.00005	<0.00003	<0.3	0.00654	103	<0.0005	0.0007	0.0056	<0.005	0.00182	<0.003	14.4
09-Mar-10	32	500	375	7.82	457				159																		
16-Mar-10	33	500	455	7.80	425	#N/A	4.7	89.1	149	<0.5	218	0.003	0.382	0.0384	0.0162	<0.00005	<0.00003	<0.3	0.0043	68.3	<0.0005	0.00077	0.0052	<0.005	0.00157	<0.003	11.5
23-Mar-10	34	500	455	7.80	458				185																		
30-Mar-10	35	500	415	7.82	428	#N/A	4.1	81.7	161	<0.5	225	0.005	0.397	0.0363	0.0172	<0.00005	<0.00003	<0.3	0.00437	69.2	<0.0005	0.00085	0.0042	0.006	0.0019	<0.003	12.8
06-Apr-10	36	500	455	7.80	393				139																		
13-Apr-10	37	500	450	7.76	431	#N/A	6.0	94.3	155	<0.5	226	0.004	0.436	0.0404	0.0213	<0.00005	<0.00003	<0.3	0.00414	67.2	<0.0005	0.00079	0.0046	<0.005	0.00149	<0.003	14.1
20-Apr-10	38	500	470	7.91	443	#N/A	4.4	96.5	141	<0.5	215	0.004	0.447	0.0404	0.0329	<0.00005	<0.00003	<0.3	0.00434	62.6	<0.0005	0.00084	0.0061	<0.005	0.00152	<0.003	14.1
27-Apr-10	39	500	390	7.91	391	#N/A	2.6	89.7	124	<0.5	199	0.004	0.411	0.0432	0.0216	<0.00005	<0.00003	<0.3	0.00352	57.7	<0.0005	0.0007	0.0053	<0.005	0.00119	<0.003	13.3
04-May-10	40	500	425	7.88	430				143																		
11-May-10	41	500	445	7.86	395	#N/A	4.1	84.5	128	<0.5	192	0.006	0.428	0.0421	0.0223	<0.00005	<0.00003	<0.3	0.00368	55.8	<0.0005	0.00058	0.0041	<0.005	0.00142	<0.003	12.8
18-May-10	42	500	420	7.83	403				129																		
25-May-10	43	500	450	7.72	421	#N/A	6.0	88.9	127	<0.5	230	0.0033	0.388	0.0491	0.0233	<0.00001	0.000023	<0.05	0.00357	66.2	0.0001	0.000692	0.00606	0.003	0.00113	0.0017	15.6
01-Jun-10	44	500	465	7.91	416				120																		
08-Jun-10	45	500	465	7.84	415	#N/A	5.0	93.6	119	<0.5	226	0.0032	0.362	0.0497	0.0239	<0.00001	<0.000005	<0.05	0.00332	64.3	<0.0001	0.000646	0.00354	0.002	0.00115	0.0016	16
15-Jun-10	46	500	410	7.86	343				84																		
22-Jun-10	47	500	435	8.01	364	#N/A	2.9	87.3	92	<0.5	193	0.0067	0.361	0.0517	0.0244	<0.00001	<0.000005	<0.05	0.00315	53.8	0.0001	0.000509	0.004	0.003	0.000811	0.0016	14.2
29-Jun-10	48	500	440	7.78	368				125																		
06-Jul-10	49	500	460	8.03	371	#N/A	2.9	94.1	117	<0.5	211	0.0031	0.343	0.0489	0.026	<0.00001	<0.000005	<0.05	0.0039	58.3	<0.0001	0.000422	0.00472	0.004	0.000911	0.0017	15.9
13-Jul-10	50	500	415	7.83	291				71																		
20-Jul-10	51	500	495	7.89	353	#N/A	5.0	87.6	87	<0.5	188	0.0041	0.27	0.0441	0.0234	<0.00001	<0.000005	<0.05	0.00352	52.5	<0.0001	0.000413	0.00329	0.005	0.000728	0.0013	13.7
27-Jul-10	52	500	460	7.72	366				116																		
03-Aug-10	53	500	435	7.91	332	#N/A	4.3	79.0	115	<0.5	175	0.0059	0.271	0.0477	0.0222	<0.00001	<0.000005	<0.05	0.00334	47.9	<0.0001	0.000338	0.00331	0.002	0.000702	0.0013	13.4
10-Aug-10	54	500	450	7.86	314				125																		
17-Aug-10	55	500	435	7.70	134	#N/A	3.4	29.1	29	0.7	61.3	0.0205	0.137	0.0341	0.00992	<0.00001	0.000034	<0.05	0.00188	15.9	<0.0001	0.000094	0.00313	0.026	0.00301	<0.0005	5.22
24-Aug-10	56	500	435	7.55	590				183																		

Appendix B.1-2
Humidity Cell T2 (Sand-Silt Composite)
Results of Leachate Analysis

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
28-Jul-09	0	4.41	0.06	0.00392	0.00253	0.013	10.6	0.00037	1.49	0.000854	6.07	0.455	319	0.000483	0.00924	<0.0005	0.000055	<0.0002	0.109	<0.0001
04-Aug-09	1	9.64	<0.05	0.0151	0.0062	<0.01	19.8	0.0007	6.85	<0.00003	14.8	0.958	569	0.00061	0.00543	<0.003	0.0002	<0.001	0.177	<0.0005
11-Aug-09	2	13.4	<0.05	0.0144	0.0059	<0.01	18.3	0.0006	7.94	0.00004	9.79	0.985	607	0.00047	0.00532	<0.003	0.00016	<0.001	0.355	<0.0005
18-Aug-09	3	14.5	<0.05	0.0121	0.0068	<0.01	12.9	0.0002	6.29	<0.00003	4.29	0.934	567	0.00031	0.00482	<0.003	0.00014	<0.001	0.533	<0.0005
25-Aug-09	4																			
01-Sep-09	5	16.1	<0.1	0.0112	0.0067	<0.02	8.98	<0.0004	7.56	<0.00005	1.84	0.872	493	0.00016	0.0059	<0.005	0.00015	<0.002	0.827	<0.001
08-Sep-09	6																			
15-Sep-09	7	16.8	<0.05	0.008	0.0126	<0.01	7.23	0.0008	9.98	<0.00003	1.06	0.775	523	0.00013	0.0128	<0.003	0.00028	<0.001	1.57	<0.0005
22-Sep-09	8																			
29-Sep-09	9	4.42	<0.05	0.005	0.0141	<0.01	5.82	0.001	8.07	<0.00003	0.65	0.612	550	0.0001	0.0148	<0.003	0.00052	<0.001	1.77	<0.0005
06-Oct-09	10																			
13-Oct-09	11	1.06	<0.05	0.003	0.0083	<0.01	4.64	<0.0002	6.89	<0.00003	0.42	0.562	541	0.00006	0.0113	<0.003	0.00076	<0.001	2.68	<0.0005
20-Oct-09	12																			
27-Oct-09	13	0.365	<0.05	0.003	0.0057	<0.01	3.82	<0.0002	7.13	0.00004	0.31	0.545	526	0.00009	0.0106	<0.003	0.00065	<0.001	2.35	<0.0005
03-Nov-09	14																			
10-Nov-09	15	0.215	<0.05	0.0028	0.0036	<0.01	3.38	0.0003	5.74	0.00005	0.32	0.495	499	0.00009	0.0087	<0.003	0.0008	<0.001	2.55	<0.0005
17-Nov-09	16																			
24-Nov-09	17	0.598	<0.05	0.0029	0.0049	<0.01	2.68	<0.0002	5.8	<0.00003	0.28	0.455	503	0.00009	0.0101	<0.003	0.00079	<0.001	3.8	<0.0005
01-Dec-09	18																			
08-Dec-09	19	0.287	<0.05	0.0026	0.0037	<0.01	1.84	<0.0002	4.81	0.00005	0.19	0.332	368	0.00008	0.00812	0.003	0.00062	<0.001	2.94	<0.0005
15-Dec-09	20																			
22-Dec-09	21	0.206	<0.05	0.0024	0.0034	<0.01	1.48	<0.0002	4.37	<0.00003	0.31	0.241	253	0.00006	0.00767	<0.003	0.00042	<0.001	2.03	<0.0005
29-Dec-09	22																			
05-Jan-10	23	0.121	<0.05	0.0025	0.0015	<0.01	1.32	<0.0002	4.79	<0.00003	0.15	0.203	222	0.00004	0.00987	<0.003	0.00041	<0.001	1.54	<0.0005
12-Jan-10	24																			
19-Jan-10	25	0.078	<0.05	0.0027	0.0027	<0.01	1.23	<0.0002	4.77	<0.00003	0.2	0.156	156	0.00006	0.00865	<0.003	0.00034	<0.001	1.1	<0.0005
26-Jan-10	26																			
02-Feb-10	27	0.0547	<0.05	0.0027	0.0773	<0.01	1.13	<0.0002	4.83	0.00014	0.17	0.133	124	0.00006	0.00881	<0.003	0.00034	<0.001	0.819	<0.0005
09-Feb-10	28																			
16-Feb-10	29	0.0652	<0.01	0.00333	0.00082	0.002	1.13	0.00009	4.6	0.00001	0.2	0.131	96	0.000054	0.015	<0.0005	0.00031	<0.0002	0.657	<0.0001
23-Feb-10	30																			
02-Mar-10	31	0.0424	<0.05	0.0036	0.0007	<0.01	1.02	<0.0002	4.23	<0.00003	0.16	0.116	67	0.00006	0.00906	<0.003	0.00029	<0.001	0.634	<0.0005
09-Mar-10	32																			
16-Mar-10	33	0.0218	<0.05	0.0033	0.0006	<0.01	0.8	<0.0002	3.94	<0.00003	<0.3	0.085	52	0.00006	0.00856	<0.003	0.00027	<0.001	0.358	<0.0005
23-Mar-10	34																			
30-Mar-10	35	0.0295	<0.05	0.004	0.0006	<0.01	0.82	<0.0002	3.08	<0.00003	0.21	0.0873	54	0.00005	0.00994	<0.003	0.00038	<0.001	0.425	<0.0005
06-Apr-10	36																			
13-Apr-10	37	0.0273	<0.05	0.0037	0.0006	<0.01	0.8	<0.0002	4.62	<0.00003	<0.3	0.0918	<50	0.00005	0.00849	<0.003	0.00025	<0.001	0.407	<0.0005
20-Apr-10	38	0.0289	<0.05	0.0039	0.0005	<0.01	0.8	<0.0002	3.94	0.00004	<0.3	0.0939	<50	0.00007	0.00997	<0.003	0.00024	<0.001	0.379	<0.0005
27-Apr-10	39	0.0195	0.09	0.0037	0.0004	<0.01	0.8	0.0003	4.14	0.00006	<0.3	0.0829	<50	0.00008	0.0069	<0.003	0.0002	<0.001	0.288	<0.0005
04-May-10	40																			
11-May-10	41	0.0201	<0.05	0.0036	0.0004	<0.01	0.8	<0.0002	4.26	<0.00003	<0.3	0.0841	<50	0.00006	0.00688	<0.003	0.00019	<0.001	0.296	<0.0005
18-May-10	42																			
25-May-10	43	0.0169	<0.01	0.00403	0.00027	<0.002	0.81	0.00008	3.89	0.000005	0.13	0.0933	53	0.000061	0.00783	<0.0005	0.00025	<0.0002	0.251	<0.0001
01-Jun-10	44																			
08-Jun-10	45	0.0204	<0.01	0.00395	0.00028	<0.002	0.77	0.00007	4.8	0.000007	0.15	0.0884	48	0.000061	0.00737	<0.0005	0.000236	<0.0002	0.247	<0.0001
15-Jun-10	46																			
22-Jun-10	47	0.0172	<0.01	0.00346	0.00034	<0.002	0.71	0.00008	4.26	0.000018	0.12	0.0863	43	0.000062	0.00527	<0.0005	0.000224	<0.0002	0.224	<0.0001
29-Jun-10	48																			
06-Jul-10	49	0.0254	<0.01	0.00316	0.0003	<0.002	0.76	0.00007	4.16	0.000024	0.13	0.0916	48	0.000063	0.00478	<0.0005	0.00021	<0.0002	0.308	<0.0001
13-Jul-10	50																			
20-Jul-10	51	0.0268	<0.01	0.00282	0.00014	<0.002	0.63	0.00005	3.85	0.00005	0.1	0.0795	39	0.000055	0.00444	<0.0005	0.000175	<0.0002	0.294	<0.0001
27-Jul-10	52																			
03-Aug-10	53	0.021	<0.01	0.00259	0.00018	<0.002	0.62	<0.00004	3.63	0.000012	0.1	0.0766	41	0.000058	0.00377	<0.0005	0.000161	<0.0002	0.289	<0.0001
10-Aug-10	54																			
17-Aug-10	55	0.0513	<0.01	0.0009	0.00028	0.002	0.22	<0.00004	1.38	0.000025	0.21	0.0281	14	0.000012	0.0008	<0.0005	0.000028	<0.0002	0.202	<0.0001
24-Aug-10	56																			

Appendix B.1-2
Humidity Cell T2 (Sand-Silt Composite)
Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/I	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
31-Aug-10	57	500	430	7.79	363	#N/A	8.0	65.0	177	3.2	199	0.0066	0.255	0.0537	0.0209	<0.00001	<0.000005	<0.05	0.00292	53.2	<0.0001	0.000507	0.0027	0.002	0.000529	0.0012	16
07-Sep-10	58	500	430	7.73	341				135																		
14-Sep-10	59	500	395	7.72	249	#N/A	3.9	67.2	83	5.8	140	0.0077	0.246	0.0594	0.0151	<0.00001	0.000008	<0.05	0.0018	37.7	<0.0001	0.000405	0.00346	0.004	0.000534	0.001	11.1
21-Sep-10	60	500	485	7.96	266				69																		
28-Sep-10	61	500	420	7.88	297	#N/A	3.5	91.4	71	6.6	149	0.0062	0.276	0.0651	0.0231	<0.00001	<0.000005	<0.05	0.00225	40	0.0001	0.00042	0.00304	0.002	0.00074	0.0012	11.9
05-Oct-10	62	500	475	7.55	204																						
12-Oct-10	63	500	445	7.47	171				53																		
19-Oct-10	64	500	460	7.39	418																						
26-Oct-10	65	500	435	7.59	593	#N/A	3.9	53.1	215	#N/A	337	<0.05	0.2	0.06	0.032	<0.003	<0.05	<0.01	<0.005	89.2	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	27.7
02-Nov-10	66	500	450	7.87	410																						
09-Nov-10	67	500	460	7.75	603				210																		
16-Nov-10	68	500	425	7.96	267																						
23-Nov-10	69	500	460	7.64	421	#N/A	4.7	87.3	166	#N/A	223	<0.05	0.21	0.06	0.024	<0.003	<0.05	<0.01	<0.005	58.7	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	18.6
30-Nov-10	70	500	445	7.65	416																						
07-Dec-10	71	500	430	7.67	417				190																		
14-Dec-10	72	500	435	7.58	471																						
21-Dec-10	73	500	445	7.51	406	#N/A	7.3	66.3	162	#N/A	208	<0.05	0.18	0.05	0.021	<0.003	<0.05	<0.01	<0.005	53.3	<0.01	<0.02	<0.02	0.08	<0.03	#N/A	18.3
28-Dec-10	74	500	425	7.61	334																						
04-Jan-11	75	500	495	7.71	380				120																		
11-Jan-11	76	500	445	7.67	357																						
18-Jan-11	77	500	450	7.70	400	#N/A	5.6	88.5	120	#N/A	207	<0.05	0.17	0.06	0.025	<0.003	<0.05	<0.01	<0.005	53.6	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	17.7
25-Jan-11	78	500	420	7.66	415																						
01-Feb-11	79	500	460	7.66	382				136																		
08-Feb-11	80	500	390	7.77	355																						
15-Feb-11	81	500	435	7.75	361	#N/A	4.7	84.3	88	#N/A	190	<0.05	0.17	0.06	0.021	<0.003	<0.05	<0.01	<0.005	48.7	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	16.5
22-Feb-11	82	500	440	7.84	360																						
01-Mar-11	83	500	445	7.75	358				135																		
08-Mar-11	84	500	425	7.74	336																						
15-Mar-11	85	500	425	7.76	394	#N/A	4.2	75.0	150	#N/A	204	<0.05	0.13	0.05	0.024	<0.003	<0.05	<0.01	<0.005	52.4	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	17.7
22-Mar-11	86	500	415	7.77	372																						
29-Mar-11	87	500	440	7.74	153				40																		
05-Apr-11	88	500	435	7.40	300																						
12-Apr-11	89	500	435	7.31	159	#N/A	3.1	23.6	49	#N/A	72	<0.05	0.09	0.03	0.008	<0.003	<0.05	<0.01	<0.005	18.4	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	6.31
19-Apr-11	90	500	415	7.54	190																						
26-Apr-11	91	500	410	7.68	571				199																		
03-May-11	92	500	460	7.74	418																						
10-May-11	93	500	455	7.76	377	#N/A	4.8	80.7	125	#N/A	188	<0.05	0.13	0.07	0.02	<0.003	<0.05	<0.01	<0.005	48	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A	16.6
17-May-11	94	500	455	7.63	278																						
24-May-11	95	500	430	7.43	167				54																		
31-May-11	96	500	465	7.30	317																						

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-2
Humidity Cell T2 (Sand-Silt Composite)
Results of Leachate Analysis

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
31-Aug-10	57	0.0486	0.01	0.00313	0.00038	0.004	0.64	0.00007	2.77	0.000035	0.14	0.084	49	0.000063	0.00032	<0.0005	0.00019	<0.0002	0.188	<0.0001
07-Sep-10	58																			
14-Sep-10	59	0.0143	<0.01	0.00328	0.00024	<0.002	0.52	0.00007	2.49	0.000086	0.14	0.058	25	0.000043	0.00014	<0.0005	0.000134	<0.0002	0.104	<0.0001
21-Sep-10	60																			
28-Sep-10	61	0.019	<0.01	0.00365	0.00051	<0.002	0.6	0.00009	2.87	0.000069	0.13	0.0662	24	0.000064	0.00018	<0.0005	0.000214	<0.0002	0.139	<0.0001
05-Oct-10	62																			
12-Oct-10	63																			
19-Oct-10	64																			
26-Oct-10	65	0.026	#N/A	<0.02	<0.02	<0.05	0.7	<0.1	2.45	<0.01	0.2	0.138	91.8	#N/A	<0.03	<0.005	#N/A	<0.01	0.186	<0.02
02-Nov-10	66																			
09-Nov-10	67																			
16-Nov-10	68																			
23-Nov-10	69	0.029	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.57	<0.01	<0.1	0.098	49.9	#N/A	<0.03	<0.005	#N/A	<0.01	0.229	<0.02
30-Nov-10	70																			
07-Dec-10	71																			
14-Dec-10	72																			
21-Dec-10	73	0.02	#N/A	<0.02	<0.02	<0.05	0.6	<0.1	2.12	<0.01	0.3	0.095	48.6	#N/A	<0.03	<0.005	#N/A	<0.01	0.229	<0.02
28-Dec-10	74																			
04-Jan-11	75																			
11-Jan-11	76																			
18-Jan-11	77	0.034	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.78	<0.01	0.2	0.095	40.1	#N/A	<0.03	<0.005	#N/A	<0.01	0.189	<0.02
25-Jan-11	78																			
01-Feb-11	79																			
08-Feb-11	80																			
15-Feb-11	81	0.034	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.63	<0.01	<0.1	0.088	36.9	#N/A	<0.03	<0.005	#N/A	<0.01	0.136	<0.02
22-Feb-11	82																			
01-Mar-11	83																			
08-Mar-11	84																			
15-Mar-11	85	0.026	#N/A	<0.02	<0.02	<0.05	0.4	<0.1	2.61	<0.01	<0.1	0.094	42.3	#N/A	<0.03	<0.005	#N/A	<0.01	0.116	<0.02
22-Mar-11	86																			
29-Mar-11	87																			
05-Apr-11	88																			
12-Apr-11	89	0.021	#N/A	<0.02	<0.02	<0.05	<0.3	<0.1	0.94	<0.01	<0.1	0.034	17.8	#N/A	<0.03	<0.005	#N/A	<0.01	0.08	<0.02
19-Apr-11	90																			
26-Apr-11	91																			
03-May-11	92																			
10-May-11	93	0.023	#N/A	<0.02	<0.02	<0.05	0.4	<0.1	2.6	<0.01	0.1	0.087	39.2	#N/A	<0.03	<0.005	#N/A	<0.01	0.122	<0.02
17-May-11	94																			
24-May-11	95																			
31-May-11	96																			

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-2
Humidity Cell T2 (Sand-Silt Composite)
Weekly Production
(mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/kg	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
28-Jul-09	0	7.49	8.9804	411.84	0.0026	0.03709	0.055440	0.0048	0.00000220	0.000001100	0.01100	0.00312400	138.60	0.0000220	0.0016016	0.00306	0.02596	0.000744	0.002068	10.21	1.940400	0.00002640	0.00172	0.00111	0.005720	4.66400	0.00016	0.656	0.000375760	2.6708	0.20020	140.36	0.00021252	0.0040656	0.0001100	0.000024	0.000044	0.04796	0.00002
04-Aug-09	1	7.33	9.944	683.6	0.0020	0.18880	0.065200	0.0032	0.00001000	0.000006000	0.06000	0.00560000	220.40	0.0001000	0.0033960	0.00572	0.01160	0.001388	0.005600	25.20	3.856000	0.00001000	0.00604	0.00248	0.002000	7.92000	0.00028	2.740	0.000006000	5.9200	0.38320	227.60	0.00024400	0.0021720	0.0006000	0.000080	0.000200	0.07080	0.00010
11-Aug-09	2	7.5	11.172	699.2	0.0012	0.32320	0.056000	0.0030	0.00001000	0.000006000	0.06000	0.00800000	232.00	0.0001000	0.0033280	0.00472	0.01000	0.001516	0.006400	24.72	5.360000	0.00001000	0.00576	0.00236	0.002000	7.32000	0.00024	3.176	0.000016000	3.9160	0.39400	242.80	0.00018800	0.0021280	0.0006000	0.000064	0.000200	0.14200	0.00010
18-Aug-09	3	7.39	11.5808	726	0.0018	0.35420	0.047960	0.0033	0.00001100	0.000006600	0.06600	0.01051600	259.60	0.0001100	0.0034584	0.00515	0.00748	0.001918	0.006600	17.64	6.380000	0.00001100	0.00532	0.00299	0.002200	5.67600	0.00009	2.768	0.000006600	1.8876	0.41096	249.48	0.00013640	0.0021208	0.0006600	0.000062	0.000220	0.23452	0.00011
25-Aug-09	4	7.57	12.17975	619.63	0.0030	0.32745	0.040893	0.0037	0.00001613	0.000008600	0.08600	0.01098650	262.95	0.0001613	0.0033863	0.00686	0.00903	0.002051	0.006235	14.47	6.579000	0.00001613	0.00501	0.00290	0.003225	4.70420	0.00009	2.978	0.000008600	1.3180	0.38829	227.90	0.00010105	0.0023048	0.0008600	0.000062	0.000323	0.29240	0.00016
01-Sep-09	5	7.48	12.132	635.6	0.0040	0.28720	0.032480	0.0040	0.00002000	0.000010000	0.10000	0.01088000	253.20	0.0002000	0.0031560	0.00808	0.01000	0.002072	0.005600	10.88	6.440000	0.00002000	0.00448	0.00268	0.004000	3.59200	0.00008	3.024	0.000010000	0.7360	0.34880	197.20	0.00006400	0.0023600	0.0010000	0.000060	0.000400	0.33080	0.00020
08-Sep-09	6	7.37	18.458	706.64	0.0031	0.30074	0.033220	0.0046	0.00001650	0.000008800	0.08800	0.01375000	265.10	0.0001650	0.0040458	0.01016	0.00924	0.002710	0.006160	9.57	7.238000	0.00001650	0.00422	0.00425	0.003300	3.56620	0.00022	3.859	0.000008800	0.6380	0.36234	223.52	0.00006380	0.0041140	0.0008800	0.000095	0.000330	0.52734	0.00017
15-Sep-09	7	7.64	24.91005	701.22	0.0019	0.30179	0.032457	0.0051	0.00001163	0.000006975	0.06975	0.01641450	265.98	0.0001163	0.0048825	0.01209	0.00791	0.003320	0.006510	7.58	7.812000	0.00001163	0.00372	0.00586	0.002325	3.36195	0.00037	4.641	0.000006975	0.4929	0.36038	243.20	0.00006045	0.0059520	0.0006975	0.000130	0.000233	0.73005	0.00012
22-Sep-09	8	7.57	26.16705	709.345	0.0014	0.28506	0.028733	0.0048	0.00001138	0.000006825	0.06825	0.01453725	265.27	0.0001138	0.0033420	0.00974	0.01229	0.003051	0.005460	8.90	4.827550	0.00001138	0.00296	0.00607	0.002275	2.96888	0.00041	4.106	0.000006825	0.3890	0.31554	244.11	0.00005233	0.0062790	0.0006825	0.000182	0.000228	0.75985	0.00011
29-Sep-09	9	7.56	28.267	820.18	0.0009	0.27784	0.025990	0.0046	0.00001150	0.000006900	0.06900	0.01315600	273.24	0.0001150	0.0019274	0.00773	0.01702	0.002884	0.004600	10.49	2.033200	0.00001150	0.00230	0.00649	0.002300	2.67720	0.00046	3.712	0.000006900	0.2990	0.28152	253.00	0.00004600	0.0068080	0.0006900	0.000239	0.000230	0.81420	0.00012
06-Oct-09	10	7.45	26.7894	722.42	0.0027	0.23493	0.020582	0.0039	0.00001025	0.000006150	0.06150	0.01225900	242.93	0.0001025	0.0012444	0.00660	0.00923	0.002569	0.003895	9.82	1.123400	0.00001025	0.00164	0.00459	0.002050	2.14430	0.00023	3.067	0.000006150	0.2194	0.24067	223.66	0.00003280	0.0053505	0.0006150	0.000262	0.000205	0.91225	0.00010
13-Oct-09	11	7.64	30.4612	737.44	0.0048	0.23848	0.019316	0.0040	0.00001100	0.000006600	0.06600	0.01372800	260.04	0.0001100	0.0008272	0.00678	0.00352	0.002754	0.003960	11.04	0.466400	0.00001100	0.00132	0.00365	0.002200	2.04160	0.00004	3.032	0.000006600	0.1848	0.24728	238.04	0.00002640	0.0049720	0.0006600	0.000334	0.000220	1.17920	0.00011
20-Oct-09	12	7.58	28.1754	704.44	0.0035	0.25344	0.018282	0.0037	0.00001100	0.000006600	0.06600	0.01324400	257.62	0.0001100	0.0008250	0.00539	0.00572	0.002490	0.003520	11.22	0.313500	0.00001100	0.00132	0.00308	0.002200	1.86120	0.00004	3.084	0.000012100	0.1606	0.24354	234.74	0.00003300	0.0048180	0.0006600	0.000310	0.000220	1.10660	0.00011
27-Oct-09	13	7.64	26.478	754.2	0.0023	0.27450	0.017640	0.0036	0.00001125	0.000006750	0.06750	0.01305000	261.00	0.0001125	0.0008415	0.00410	0.00810	0.002277	0.003150	11.66	0.164250	0.00001125	0.00135	0.00257	0.002250	1.71900	0.00005	3.209	0.000018000	0.1395	0.24525	236.70	0.00004050	0.0047700	0.0006750	0.000293	0.000225	1.05750	0.00011
03-Nov-09	14	7.6	23.074	630	0.0042	0.24360	0.014620	0.0035	0.00001000	0.000006000	0.06000	0.01172000	234.00	0.0001000	0.0006660	0.00412	0.01020	0.002032	0.002600	9.58	0.116000	0.00001000	0.00116	0.00186	0.002000	1.44000	0.00008	2.574	0.000018000	0.1260	0.20800	205.00	0.00003600	0.0038600	0.0006000	0.000290	0.000200	0.98000	0.00010
10-Nov-09	15	7.43	26.28645	710.985	0.0074	0.28272	0.015764	0.0045	0.00001163	0.000006975	0.06975	0.01376400	274.35	0.0001163	0.0006789	0.00535	0.01535	0.002372	0.002790	10.23	0.099975	0.00001163	0.00130	0.00167	0.002325	1.57170	0.00014	2.669	0.000023250	0.1488	0.23018	232.04	0.00004185	0.0040455	0.0006975	0.000372	0.000233	1.18575	0.00012
17-Nov-09	16	7.54	31.44635	804.465	0.0045	0.29139	0.016362	0.0049	0.00001263	0.000007575	0.07575	0.01717000	294.16	0.0001263	0.0006287	0.00710	0.01086	0.002709	0.002778	9.65	0.205283	0.00001263	0.00144	0.00215	0.002525	1.53015	0.00010	2.914	0.000016413	0.1515	0.23988	253.01	0.00004545	0.0047470	0.0007575	0.000401	0.000253	1.60338	0.00013
24-Nov-09	17	7.73	32.98485	799.765	0.0010	0.26481	0.014987	0.0048	0.00001213	0.000007275	0.07275	0.01862400	278.88	0.0001213	0.0004996	0.00805	0.00485	0.002731	0.002425	7.86	0.290030	0.00001213	0.00141	0.00238	0.002425	1.29980	0.00005	2.813	0.000007275	0.1358	0.22068	243.96	0.00004365	0.0048985	0.0007275	0.000383	0.000243	1.84300	0.00012
01-Dec-09	18	7.66	31.048375	730.55	0.0012	0.24581	0.013799	0.0040	0.00001188	0.000007125	0.07125	0.01574625	239.64	0.0001188	0.0004821	0.00667	0.00546	0.002370	0.002138	7.08	0.210188	0.00001188	0.00131	0.00204	0.002375	1.07350	0.00005	2.520	0.000015438	0.1116	0.18691	206.86	0.00004038	0.0043273	0.0010688	0.000335	0.000238	1.60075	0.00012
08-Dec-09	19	7.5	29.1648	540.795	0.0014	0.22739	0.012648	0.0032	0.00001163	0.000006975	0.06975	0.01297350	201.81	0.0001163	0.0004650	0.00535	0.00605	0.002023	0.001860	6.32	0.133455	0.00001163	0.00121	0.00172	0.002325	0.85560	0.00005	2.237	0.000023250	0.0884	0.15438	171.12	0.00003720	0.0037758	0.0013950	0.000288	0.000233	1.36710	0.00012
15-Dec-09	20	7.69	28.812	532.14	0.0015	0.24108	0.012765	0.0033	0.00001225	0.000007350	0.07350	0.01180900	177.38	0.0001225	0.0004484	0.00515	0.00662	0.001830	0.001715	6.20	0.120785	0.00001225	0.00123	0.00174	0.002450	0.81340	0.00005	2.249	0.000015925	0.1225	0.14039	152.15	0.00003430	0.0038686	0.0011025	0.000255	0.000245	1.21765	0.00012
22-Dec-09	21	7.65	24.9704	380.38	0.0014	0.22523	0.011330	0.0030	0.00001138	0.000006825	0.06825	0.00923650	131.95	0.0001138	0.0003777	0.00432	0.00637	0.001420	0.001365	5.32	0.093730	0.00001138	0.00109	0.00155	0.002275	0.67340	0.00005	1.988	0.000006825	0.1411	0.10966	115.12	0.00002730	0.0034899	0.0006825	0.000191	0.000228	0.92365	0.00011
29-Dec-09	22	7.65	26.1998	332.2	0.0011	0.22242	0.011396	0.0031	0.00001100	0.000006600	0.06600	0.00805200	117.04	0.0001100	0.0003762	0.00427	0.00440	0.001276	0.001320	5.63	0.071940	0.00001100	0.00108	0.00108	0.002200	0.61600	0.00004	2.015	0.000006600	0.1012	0.09768	104.50	0.00002200	0.0038588	0.0006600	0.000183	0.000220	0.78540	0.00011
05-Jan-10	23	7.55	28.2524	273.24	0.0009	0.22704	0.011836	0.0034	0.00001100	0.000006600	0.06600	0.00717200	106.48	0.0001100	0.0003872	0.00436	0.00264	0.001179	0.001320	6.12	0.053240	0.00001100	0.00110	0.00066	0.002200	0.58080	0.00004	2.108	0.000006600	0.0660	0.08932	97.68	0.00001760	0.0043428	0.0006600	0.000180	0.000220	0.67760	0.00011
12-Jan-10	24	7.63	29.55605	253.7	0.0017	0.21414	0.011954	0.0039	0.00001075	0.000006450	0.06450	0.00591250	90.30	0.0001075	0.0003354	0.00482	0.00323	0.001054	0.000968	5.89	0.042785	0.00001075	0.00112	0.00090	0.002150	0.54825	0.00004	2.055	0.000006450	0.0753	0.07719	81.27	0.00002150	0.0039818	0.0006450	0.000161	0.000215	0.56760	0.00011
19-Jan-10	25	7.76	32.967	205.65	0.0027	0.21600	0.012915	0.0047	0.00001125	0.000006750	0.06750	0.00504000	80.10	0.0001125	0.0003060	0.00563	0.00405	0.000999	0.000675	6.08	0.035100	0.00001125	0.00122	0.00122	0.002250	0.55350	0.00005	2.147	0.000006750	0.0900	0.07020	70.20	0.00002700	0.0038925	0.0006750	0.000153	0.000225	0.49500	0.00011
26-Jan-10	26	7.66	31.4798	159.9	0.0018	0.18245	0.012095	0.0046	0.00001025	0.000006150	0.06150	0.00413075	65.81	0.0001025	0.0002276	0.01956	0.02911	0.000875	0.000615	5.43	0.027204	0.00001025	0.00111	0.01640	0.002050	0.48380	0.00004	1.968	0.000031775	0.0759	0.05925	57.40	0.00002460	0.0035793	0.0006150	0.000139	0.000205	0.39340	0.00010
02-Feb-10	27	7.69	36.5365	160.16	0.0014	0.18655	0.013787	0.0054	0.00001138	0.000006825	0.06825	0.00407225	65.07	0.0001138	0.0001957	0.03772	0.06052	0.000933	0.000683	5.92	0.024889	0.00001138	0.00123	0.03517	0.002275	0.51415	0.00005	2.198	0.000063700	0.0774	0.06052	56.42	0.00002730	0.0040086	0.0006825	0.000155	0.000228	0.37265	0.00011
09-Feb-10	28	7.72	37.422	150.04	0.0014	0.18348	0.014014	0.0057	0.00000660	0.000003850	0.03850	0.00357500	58.74	0.0000660	0.0002875	0.01948	0.02992	0.000900	0.000858	5.74	0.026378	0.00000660	0.00133	0.01719	0.001540	0.49720	0.00004	2.075	0.000033000	0.0814	0.05808	48.40	0.00002508	0.0052382	0.0003850	0.000143	0.000132	0.32472	0.00007
16-Feb-10	29	7.75	40.859	119.21	0.0015	0.19292	0.015197	0.0063	0.00000228	0.000001138	0.01138	0.00332150	56.42	0.0000228	0.0003990	0.00258	0.00137	0.000928	0.001092	5.96	0.029666	0.00000228	0.00152	0.00037	0.000910	0.51415	0.00004	2.093	0.000004550	0.0910	0.05961	43.68	0.00002457	0.0068250	0.0001138	0.000141	0.000046	0.29894	0.00002
23-Feb-10	30	7.87	35.9478	102.06	0.0022	0.17199	0.014175	0.0066	0.00000630	0.000003675	0.03675	0.00290640	47.67	0.0000630	0.0003312	0.00236	0.00116	0.000811	0.000819	5.78	0.022596	0.00000630	0.00146	0.00032	0.001470	0.45150	0.00004	1.854	0.000005250	0.0756	0.05187	34.23	0.00002394	0.0050526	0.0003675	0.000126	0.000126	0.27111	0.00006
02-Mar-10	31	7.89	32.9589	94.365	0.0028	0.15998	0.013811	0.0070	0.00001013	0.000006075	0.06075	0.00264870	41.72	0.0001013	0.0002835	0.00227	0.00101	0.000737	0.000608	5.83	0.017172	0.00001013	0.00146	0.00028	0.002025	0.41310	0.00004	1.713	0.000006075	0.0648	0.04698	27.14	0.00002430	0.0036693	0.0006075	0.000117	0.000203	0.25677	0.00010
09-Mar-10	32	7.82	31.955625	59.625	0.0019	0.14569	0.013594	0.0063	0.00000938	0.000005625	0.05625	0.00203250	32.12	0.0000938	0.0002756	0.00203	0.00094	0.000636	0.000563	4.86	0.012038	0.00000938	0.00129	0.00024	0.001875	0.34125	0.00004	1.532	0.000005625	0.0581	0.03769	22.31	0.00002250	0.0033038	0.0005625	0.000105	0.000188	0.18600	0.00009
16-Mar-10	33	7.8	40.51775	67.795	0.0014	0.17381	0.017472	0.0074	0.00001138	0.000006825	0.06825	0.00195650	31.08	0.0001138	0.0003504	0.00237	0.00114	0.000714	0.000683	5.23	0.009919	0.00001138	0.00150	0.00027	0.002275	0.36400	0.00005	1.793	0.000006825	0.0683	0.03868	23.66	0.00002730	0.0038948	0.0006825	0.000123	0.000228	0.16289	0.00011
23-Mar-10	34	7.8	38.850175	84.175	0.0018	0.17722	0.016994	0.0076	0.00001138	0.000006825	0.06825	0.00197243	31.28	0.0001138	0.0003686	0.00214	0.00193	0.000789	0.000683	5.53	0.011671	0.00001138	0.00166	0.00027	0.002275	0.36855	0.00005	1.597	0.000006825	0.0819	0.03920	24.12	0.00002503	0.0042088	0.0006825	0.000148	0.000228	0.17813	0.00011
30-Mar-10	35	7.82	33.9138	66.815	0.0021	0.16476	0.015065	0.0071	0.00001038	0.000006225	0.06225	0.00181355	28.72	0.0001038	0.0003528	0.00174	0.00249	0.000789	0.000623	5.31	0.012243	0.00001038	0.00166	0.00025	0.002075	0.34030	0.00004	1.278	0.000006225	0.0872	0.03623	22.41	0.00002075	0.0041251	0.0006225	0.000158	0.000208	0.17638	0.00010
06-Apr-10	36	7.8	40.037725	63.245	0.0020	0.18951	0.017449	0.0088	0.00001138	0.000006825	0.06825	0.00193603	31.03	0.0001138	0.0003731	0.00200	0.00193	0.000771	0.000683	6.12	0.012922	0.00001138	0.00175	0.00027	0.002275	0.36855	0.00005	1.752	0.000006825	0.0819	0.04075	17.97	0.00002275	0.0041928	0.0006825	0.000143	0.000228	0.18928	0.00011
13-Apr-10	37	7.76	42.4215	69.75	0.0018	0.19620	0.018180	0.0096	0.00001125	0.000006750	0.06750	0.00186300	30.24	0.0001125	0.0003555	0.00207	0.00113	0.000671	0.000675	6.35	0.012285	0.00001125	0.00167	0.00027	0.002250	0.36000	0.00005	2.079	0.000006750	0.0675	0.04131	11.25	0.00002250	0.0038205	0.0006750	0.000113	0.000225	0.18315	0.00011
20-Apr-10	38	7.91	45.3362	66.27	0.0019	0.21009	0.018988	0.0155	0.00001175	0.000007050	0.07050	0.00203980	29.42	0.0001175	0.0003948	0.00287	0.00118	0.000714	0.000705	6.63	0.013583	0.00001175	0.00183	0.00024	0.002350	0.37600	0.00005	1.852	0.000018800	0.0705	0.04413	11.75	0.00003290	0.0046859	0.0007050	0.000113	0.000235	0.17813	0.00012
27-Apr-10	39	7.91	34.9635	48.36	0.0016	0.16029	0.016848	0.0084	0.00000975	0.000005850	0.05850	0.00137280	22.50	0.0000975	0.0002730	0.00207	0.00098	0.000464	0.000585	5.19	0.007605	0.00003510	0.00144	0.00016	0.001950	0.31200	0.00012	1.615	0.000023400	0.0585	0.03233	9.75	0.00003120	0.0026910	0.0005850	0.000078	0.000195	0.11232	0.00010
04-May-10	40	7.88	37.015375	60.775	0.0021	0.17829	0.018126	0.0093	0.00001063	0.000006375	0.06375	0.00153000	24.12	0.0001063	0.0002720	0.00200	0.00106	0.000555	0.000638	5.55	0.008415	0.00002444	0.00155	0.00017	0.002125	0.34000	0.00009	1.785	0.000015938	0.0638	0.03549	10.63	0.00002975	0.0029283	0.0006375	0.000083	0.000213	0.12410	0.00011
11-May-10	41	7.86	37.6203	56.96	0.0027	0.19046	0.018735	0.0099	0.00001113	0.000006675	0.06675	0.00163760	24.83	0.0001113	0.0002581	0.00182	0.00111	0.000632	0.000668	5.70	0.008945	0.00001113	0.00160	0.00018	0.002225	0.35600	0.00004	1.896	0.000006675	0.0668	0.03742	11.13	0.00002670	0.0030616	0.0006675	0.000085	0.000223	0.13172	0.00011
18-May-10	42	7.83	36.4161	54.18	0.0020	0.17136	0.019152	0.0096	0.00000630	0.000007980	0.03675	0.00152250	25.62	0.0000735	0.0002671	0.00213	0.00116	0.000536	0.000672	5.96	0.007770	0.00000630	0.00160	0.00014	0.001260	0.33810	0.00004	1.712	0.000004200	0.0588	0.03725	16.38	0.00002541	0.0030891	0.0003675	0.000092	0.000126	0.11487	0.00006
25-May-10	43	7.72	39.9915	57.15	0.0015	0.17460	0.022095	0.0105	0.00000225	0.000010350	0.01125	0.00160650	29.79	0.0000450	0.0003114	0.00273	0.00135	0.000509	0.000765	7.02	0.007605	0.00000225	0.00181	0.00012	0.000450	0.36450	0.00004	1.751	0.000002250	0.0585	0.04199	23.85	0.00002745	0.0035235	0.0001125	0.000113	0.000045	0.11295	0.00002
01-Jun-10	44	7.91	42.42195	55.8	0.0015	0.17438	0.022971	0.0110	0.00000233	0.000005929	0.01163	0.00160193	30.34	0.0000349	0.0003111	0.00223	0.00116	0.000530	0.000767	7.35	0.008672	0.00000233	0.00186	0.00013	0.000465	0.36735	0.00003	2.020	0.000002790	0.0651	0.04225	23.48	0.00002837	0.0035340	0.0001163	0.000113	0.000047	0.11579	0.00002
08-Jun-10	45	7.84	43.51935	55.335	0.0015	0.16833	0.023111	0.0111	0.00000233	0.000001163	0.01163	0.00154380	29.90	0.0000233	0.0003004	0.00165	0.00093	0.000535	0.000744	7.44	0.009486	0.00000233	0.00184	0.00013	0.000465	0.35805	0.00003	2.232	0.000003255	0.0698	0.04111	22.32	0.00002837	0.0034271	0.0001163	0.000110	0.000047	0.11486	0.00002
15-Jun-10	46	7.86	37.07425	34.44	0.0020	0.14822	0.020787	0.0099	0.00000205	0.000001025	0.01025	0.00132635	24.21	0.0000308	0.0002368	0.00155	0.00103	0.000402	0.000656	6.19	0.007708	0.00000205	0.00152	0.00013	0.000410	0.30340	0.00003	1.857	0.000005125	0.0554	0.03581	18.66	0.00002522	0.0025912	0.0001025	0.000094	0.000041	0.09656	0.00002
22-Jun-10	47	8.01	37.9581	40.02	0.0029	0.15704	0.022490	0.0106	0.00000218	0.000001088	0.01088	0.00137025	23.40	0.0000435	0.0002214	0.00174	0.00131	0.000353	0.000696	6.18	0.007482	0.00000218	0.00151	0.00015	0.000435	0.30885	0.00003	1.853	0.000007830	0.0522	0.03754	18.71	0.00002697	0.0022925	0.0001088	0.000097	0.000044	0.09744	0.00002
29-Jun-10	48	7.78	39.9058	55	0.0022	0.15488	0.022132	0.0111	0.00000220	0.000001100	0.01100	0.00155100	24.66	0.0000330	0.0002048	0.00192	0.00154	0.000379	0.000726	6.62	0.009372	0.00000220	0.00146	0.00014	0.000440	0.32340	0.00003	1.852	0.000009240	0.0550	0.03914	20.02	0.00002750	0.0022110	0.0001100	0.000095	0.000044	0.11704	0.00002
06-Jul-10	49	8.03	43.2998	53.82	0.0014	0.15778	0.022494	0.0120	0.00000230	0.000001150	0.01150	0.00179400	26.82	0.0000230	0.0001941	0.00217	0.00184	0.000419	0.000782	7.31	0.011684	0.00000230	0.00145	0.00014	0.000460	0.34960	0.00003	1.914	0.000011040	0.0598	0.04214	22.08	0.00002898	0.0021988	0.0001150	0.000097	0.000046	0.14168	0.00002
13-Jul-10	50	7.83	37.71105	29.465	0.0015	0.12720	0.019298	0.0103	0.00000208	0.000001038	0.01038	0.00153965	22.99	0.0000208	0.0001733	0.00166	0.00187	0.000340	0.000623	6.14	0.010832	0.00000208	0.00124	0.00009	0.000415	0.28843	0.00002	1.662	0.000015355	0.0477	0.03550	18.05	0.00002449	0.0019132	0.0001038	0.000080	0.000042	0.12492	0.00002
20-Jul-10	51	7.89	43.36695	43.065	0.0020	0.13365	0.021830	0.0116	0.00000248	0.000001238	0.01238	0.00174240	25.99	0.0000248	0.0002044	0.00163	0.00248	0.000360	0.000644	6.78	0.013266	0.00000248	0.00140	0.00007	0.000495	0.31185	0.00002	1.906	0.000024750	0.0495	0.03935	19.31	0.00002723	0.0021978	0.0001238	0.000087	0.000050	0.14553	0.00002
27-Jul-10	52	7.72	38.3249	53.36	0.0023	0.12443	0.021114	0.0105	0.00000230	0.000001150	0.01150	0.00157780	23.09	0.0000230	0.0001727	0.00152	0.00161	0.000329	0.000598	6.23	0.010994	0.00000230	0.00124	0.00007	0.000460	0.28750	0.00002	1.720	0.000014260	0.0460	0.03590	18.40	0.00002599	0.0018883	0.0001150	0.000077	0.000046	0.13409	0.00002
03-Aug-10	53	7.91	34.3737	50.025	0.0026	0.11789	0.020750	0.0097	0.00000218	0.000001088	0.01088	0.00145290	20.84	0.0000218	0.0001470	0.00144	0.00087	0.000305	0.000566	5.83	0.009135	0.00000218	0.00113	0.00008	0.000435	0.26970	0.00001	1.579	0.000005220	0.0435	0.03332	17.84	0.00002523	0.0016400	0.0001088	0.000070	0.000044	0.12572	0.00002
10-Aug-10	54	7.86	24.32925	56.25	0.0059	0.09180	0.018405	0.0072	0.00000225	0.000008213	0.01125	0.00117450	14.36	0.0000225	0.0000972	0.00145	0.00630	0.000835	0.000349	4.19	0.016268	0.00000225	0.00079	0.00010	0.000675	0.18900	0.00001	1.127	0.000008325	0.0698	0.02356	12.38	0.00001575	0.0010283	0.0001125	0.000043	0.000045	0.11048	0.00002
17-Aug-10	55	7.7	12.66285	12.615	0.0089	0.05960	0.014834	0.0043	0.00000218	0.000014790	0.01088	0.00081780	6.92	0.0000218	0.0000409	0.00136	0.01131	0.001309	0.000109	2.27	0.022316	0.00000218	0.00039	0.00012	0.000870	0.09570	0.00001	0.600	0.000010875	0.0914	0.01222	6.09	0.00000522	0.0003480	0.0001088	0.000012	0.000044	0.08787	0.00002
24-Aug-10	56	7.55	20.47545	79.605	0.0059	0.08526	0.019097	0.0067	0.00000218	0.000007939	0.01088	0.00104400	15.03	0.0000218	0.0001307	0.00127	0.00609	0.000770	0.000315	4.62	0.021728	0.00000326	0.00088	0.00014	0.001305	0.18705	0.00002	0.903	0.000013050	0.0761	0.02438	13.70	0.00001631	0.0002436	0.0001088	0.000047	0.000044	0.08483	0.00002
31-Aug-10	57	7.79	27.9629	76.11	0.0028	0.10965	0.023091	0.0090	0.00000215	0.000001075	0.01075	0.00125560	22.88	0.0000215	0.0002180	0.00116	0.00086	0.000227	0.000516	6.88	0.020898	0.00000430	0.00135	0.00016	0.001720	0.27520	0.00003	1.191	0.000015050	0.0602	0.03612	21.07	0.00002709	0.0001376	0.0001075	0.000082	0.000043	0.08084	0.00002
07-Sep-10	58	7.73	28.4273	58.05	0.0031	0.10772	0.024317	0.0077	0.00000215	0.000002258	0.01075	0.00101480	19.54	0.0000215	0.0001961	0.00132	0.00129	0.000229	0.000473	5.83	0.013524	0.00000323	0.00138	0.00013	0.001075	0.24940	0.00003	1.131	0.000026015	0.0602	0.03053	15.91	0.00002279	0.0000989	0.0001075	0.000070	0.000043	0.06278	0.00002
14-Sep-10	59	7.72	26.54005	32.785	0.0030	0.09717	0.023463	0.0060	0.00000198	0.000003160	0.00988	0.00071100	14.89	0.0000198	0.0001600	0.00137	0.00158	0.000211	0.000395	4.38	0.005649	0.00000198	0.00130	0.00009	0.000395	0.20540	0.00003	0.984	0.000033970	0.0553	0.02291	9.88	0.00001699	0.0000553	0.0000988	0.000053	0.000040	0.04108	0.00002
21-Sep-10	60	7.96	38.45565	33.465	0.0034	0.12659	0.030191	0.0093	0.00000243	0.000002546	0.01213	0.00098213	18.84	0.0000364	0.0002001	0.00158	0.00146	0.000309	0.000534	5.58	0.008075	0.00000243	0.00168	0.00018	0.000485	0.27160	0.00004	1.300	0.000037588	0.0655	0.03012	11.88	0.00002595	0.0000776	0.0001213	0.000084	0.000049	0.05893	0.00002
28-Sep-10	61	7.88	38.3838	29.82	0.0026	0.11592	0.027342	0.0097	0.00000210	0.000001050	0.01050	0.00094500	16.80	0.0000420	0.0001764	0.00128	0.00084	0.000311	0.000504	5.00	0.007980	0.00000210	0.00153	0.00021	0.000420	0.25200	0.00004	1.205	0.000028980	0.0546	0.02780	10.08	0.00002688	0.0000756	0.0001050	0.000090	0.000042	0.05838	0.00002
05-Oct-10	62	7.55	34.3235	67.925	0.0074	0.11305	0.029711	0.0131	0.00035744	0.005938094	0.00713	0.00112813	30.69	0.0012113	0.0024748	0.00310	0.00166	0.003738	#N/A	9.41	0.010688	#N/A	0.00324	0.00250	0.006175	0.30875	0.01190	1.264	0.001203888	0.0784	0.04850	27.50	#N/A	0.0036053	0.0006531	#N/A	0.001211	0.07719	0.00239
12-Oct-10	63	7.47	27.899275	23.585	0.0090	0.09746	0.027267	0.0132	0.00050118	0.008344028	0.00445	0.00108469	34.22	0.0016799	0.0033842	0.00368	0.00189	0.005089	#N/A	10.57	0.010791	#N/A	0.00374	0.00339	0.008455	0.30038	0.01670	1.137	0.001676426	0.0812	0.05342	33.31	#N/A	0.0050263	0.0008622	#N/A	0.001680	0.07754	0.00334
19-Oct-10	64	7.39	26.63975	61.64	0.0104	0.09637	0.027893	0.0142	0.00060404	0.010062644	0.00345	0.00113563	38.20	0.0020183	0.0040492	0.00420	0.00213	0.006080	#N/A	11.83	0.011558	#N/A	0.00423	0.00405	0.010120	0.31625	0.02013	1.151	0.002016468	0.0880	0.05935	38.33	#N/A	0.0060479	0.0010206	#N/A	0.002018	0.08286	0.00403
26-Oct-10	65	7.59	23.11155	93.525	0.0109	0.08700	0.026100	0.0139	0.00065250	0.010875000	0.00218	0.00108750	38.80	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	12.05	0.011310	#N/A	0.00435	0.00435	0.010875	0.30450	0.02175	1.066	0.002175000	0.0870	0.06003	39.93	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.08091	0.00435
02-Nov-10	66	7.87	31.58775	85.725	0.0113	0.09225	0.027000	0.0126	0.00067500	0.011250000	0.00225	0.00112500	33.28	0.0022500	0.0045000	0.00450	0.00225	0.006750	#N/A	10.42	0.012375	#N/A	0.00450	0.00450	0.011250	0.27000	0.02250	1.130	0.002250000	0.0563	0.05310	31.88	#N/A	0.0067500	0.0011250	#N/A	0.002250	0.09338	0.00450
09-Nov-10	67	7.75	36.21465	96.6	0.0115	0.09545	0.027600	0.0120	0.00069000	0.011500000	0.00230	0.00115000	30.51	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	9.60	0.012995	#N/A	0.00460	0.00460	0.011500	0.25300	0.02300	1.168	0.002300000	0.0403	0.04968	27.77	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.10040	0.00460
16-Nov-10	68	7.96	35.27234375	79.9	0.0106	0.08872	0.025500	0.0106	0.00063750	0.010625000	0.00213	0.00106250	26.57	0.0021250	0.0042500	0.00425	0.00213	0.006375	#N/A	8.39	0.012166	#N/A	0.00425	0.00425	0.010625	0.22313	0.02125	1.086	0.002125000	0.0292	0.04378	23.43	#N/A	0.0063750	0.0010625	#N/A	0.002125	0.09504	0.00425
23-Nov-10	69	7.64	40.1396	76.36	0.0115	0.09660	0.027600	0.0110	0.00069000	0.011500000	0.00230	0.00115000	27.00	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	8.56	0.013340	#N/A	0.00460	0.00460	0.011500	0.23000	0.02300	1.182	0.002300000	0.0230	0.04508	22.95	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.10534	0.00460
30-Nov-10	70	7.65	34.16265	72.98	0.0111	0.08678	0.024475	0.0100	0.00066750	0.011125000	0.00223	0.00111250	24.92	0.0022250	0.0044500	0.00445	0.01891	0.006675	#N/A	8.21	0.010903	#N/A	0.00445	0.00445	0.011125	0.24475	0.02225	1.044	0.002225000	0.0779	0.04294	21.92	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.10191	0.00445
07-Dec-10	71	7.67	30.75575	81.7	0.0108	0.08063	0.022575	0.0094	0.00064500	0.010750000	0.00215	0.00107500	23.50	0.0021500	0.0043000	0.00430	0.02634	0.006450	#N/A	7.90	0.009568	#N/A	0.00430	0.00430	0.010750	0.24725	0.02150	0.960	0.002150000	0.1021	0.04117	21.04	#N/A	0.0064500	0.0010750	#N/A	0.002150	0.09847	0.00430
14-Dec-10	72	7.58	29.9725875	76.56	0.0109	0.07993	0.022294	0.0093	0.00065250	0.010875000	0.00218	0.00108750	23.48	0.0021750	0.0043500	0.00435	0.03072	0.006525	#N/A	7.98	0.009189	#N/A	0.00435	0.00435	0.010875	0.25556	0.02175	0.947	0.002175000	0.1169	0.04149	21.21	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.09962	0.00435
21-Dec-10	73	7.51	29.4946	72.09	0.0111	0.08010	0.022250	0.0093	0.00066750	0.011125000	0.00223	0.00111250	23.72	0.0022250	0.0044500	0.00445	0.03560	0.006675	#N/A	8.14	0.008900	#N/A	0.00445	0.00445	0.011125	0.26700	0.02225	0.943	0.002225000	0.1335	0.04228	21.63	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.10191	0.00445
28-Dec-10	74	7.61	32.89925	59.925	0.0106	0.07438	0.023375	0.0098	0.00063750	0.010625000	0.00213	0.00106250	22.72	0.0021250	0.0042500	0.00425	0.01806	0.006375	#N/A	7.65	0.011475	#N/A	0.00425	0.00425	0.010625	0.23375	0.02125	1.041	0.002125000	0.1063	0.04038	18.85	#N/A	0.0063750	0.0010625	#N/A	0.002125	0.08883	0.00425
04-Jan-11	75	7.71	41.072625	59.4	0.0124	0.08539	0.028463	0.0119	0.00074250	0.012375000	0.00248	0.00123750	26.49	0.0024750	0.0049500	0.00495	0.01176	0.007425	#N/A	8.84	0.015098	#N/A	0.00495	0.00495	0.012375	0.25988	0.02475	1.294	0.002475000	0.1114	0.04703	20.90	#N/A	0.0074250	0.0012375	#N/A	0.002475	0.09851	0.00495
11-Jan-11	76	7.67	38.1620875	53.4	0.0111	0.07621	0.026144	0.0109	0.00066750	0.011125000	0.00223	0.00111250	23.84	0.0022250	0.0044500	0.00445	0.00640	0.006675	#N/A	7.91	0.014351	#N/A	0.00445	0.00445	0.011125	0.22806	0.02225	1.200	0.002225000	0.0946	0.04228	18.32	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.08633	0.00445
18-Jan-11	77	7.7	39.843	54	0.0113	0.07650	0.027000	0.0113	0.00067500	0.011250000	0.00225	0.00112500	24.12	0.0022500	0.0045000	0.00450	0.00225	0.006750	#N/A	7.97	0.015300	#N/A	0.00450	0.00450	0.011250	0.22500	0.02250	1.251	0.002250000	0.0900	0.04275	18.05	#N/A	0.0067500	0.0011250	#N/A	0.002250	0.08505	0.00450
25-Jan-11	78	7.66	36.2922	43.68	0.0105	0.07140	0.025200	0.0097	0.00063000	0.010500000	0.00210	0.00105000	21.48	0.0021000	0.0042000	0.00420	0.00210	0.006300	#N/A	7.18	0.014280	#N/A	0.00420	0.00420	0.010500	0.21000	0.02100	1.136	0.002100000	0.0525	0.03843	16.17	#N/A	0.0063000	0.0010500	#N/A	0.002100	0.06825	0.00420
01-Feb-11	79	7.66	39.2587	62.56	0.0115	0.07820	0.027600	0.0101	0.00069000	0.011500000	0.00230	0.00115000	22.97	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	7.73	0.015640	#N/A	0.00460	0.00460	0.011500	0.23000	0.02300	1.227	0.002300000	0.0403	0.04129	17.34	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.06866	0.00460
08-Feb-11	80	7.77	33.076875	43.68	0.0098	0.06630	0.023400	0.0084	0.00058500	0.009750000	0.00195	0.00097500	19.23	0.0019500	0.0039000	0.00390	0.00195	0.005850	#N/A	6.49	0.013260	#N/A	0.00390	0.00390	0.009750	0.19500	0.01950	1.033	0.001950000	0.0268	0.03466	14.55	#N/A	0.0058500	0.0009750	#N/A	0.001950	0.05562	0.00390
15-Feb-11	81	7.75	36.6618	38.28	0.0109	0.07395	0.026100	0.0091	0.00065250	0.010875000	0.00218	0.00108750	21.18	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	7.18	0.014790	#N/A	0.00435	0.00435	0.010875	0.21750	0.02175	1.144	0.002175000	0.0218	0.03828	16.05	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.05916	0.00435
22-Feb-11	82	7.84	35.0416	52.36	0.0110	0.06600	0.024200	0.0099	0.00066000	0.011000000	0.00220	0.00110000	22.24	0.0022000	0.0044000	0.00440	0.00220	0.006600	#N/A	7.52	0.013200	#N/A	0.00440	0.00440	0.011000	0.19800	0.02200	1.153	0.002200000	0.0220	0.04004	17.42	#N/A	0.0066000	0.0011000	#N/A	0.002200	0.05544	0.00440
01-Mar-11	83	7.75	34.4074	60.075	0.0111	0.06230	0.023363	0.0103	0.00066750	0.011125000	0.00223	0.00111250	22.91	0.0022250	0.0044500	0.00445	0.00223	0.006675	#N/A	7.74	0.012460	#N/A	0.00445	0.00445	0.011125	0.18913	0.02225	1.164	0.002225000	0.0223	0.04116	18.22	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.05385	0.00445
08-Mar-11	84	7.74	32.368	60.5625	0.0106	0.05738	0.021781	0.0100	0.00063750	0.010625000	0.00213	0.00106250	22.07	0.0021250	0.0042500	0.00425	0.00213	0.006375	#N/A	7.46	0.011475	#N/A	0.00425	0.00425	0.010625	0.17531	0.02125	1.110	0.002125000	0.0213	0.03963	17.69	#N/A	0.0063750	0.0010625	#N/A	0.002125	0.05036	0.00425
15-Mar-11	85	7.76	31.875	63.75	0.0106	0.05525	0.021250	0.0102	0.00063750	0.010625000	0.00213	0.00106250	22.27	0.0021250	0.0042500	0.00425	0.00213	0.006375	#N/A	7.52	0.011050	#N/A	0.00425	0.00425	0.010625	0.17000	0.02125	1.109	0.002125000	0.0213	0.03995	17.98	#N/A	0.0063750	0.0010625	#N/A	0.002125	0.04930	0.00425
22-Mar-11	86	7.77	20.4595	41.2925	0.0104	0.04565	0.016600	0.0066	0.00062250	0.010375000	0.00208	0.00103750	14.69	0.0020750	0.0041500	0.00415	0.00208	0.006225	#N/A	4.98	0.009753	#N/A	0.00415	0.00415	0.010375	0.11413	0.02075	0.737	0.002075000	0.0208	0.02656	12.47	#N/A	0.0062250	0.0010375	#N/A	0.002075	0.04067	0.00415
29-Mar-11	87	7.74	16.038	17.6	0.0110	0.04400	0.015400	0.0053	0.00066000	0.011000000	0.00220	0.00110000	11.84	0.0022000	0.0044000	0.00440	0.00220	0.006600	#N/A	4.03	0.009790	#N/A	0.00440	0.00440	0.011000	0.09350	0.02200	0.597	0.002200000	0.0220	0.02156	10.53	#N/A	0.0066000	0.0011000	#N/A	0.002200	0.03916	0.00440
05-Apr-11	88	7.4	13.060875	19.3575	0.0109	0.04133	0.014138	0.0044	0.00065250	0.010875000	0.00218	0.00108750	9.85	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	3.36	0.009407	#N/A	0.00435	0.00435	0.010875	0.07884	0.02175	0.500	0.002175000	0.0218	0.01805	9.08	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.03676	0.00435
12-Apr-11	89	7.31	10.266	21.315	0.0109	0.03915	0.013050	0.0035	0.00065250	0.010875000	0.00218	0.00108750	8.00	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	2.74	0.009135	#N/A	0.00435	0.00435	0.010875	0.06525	0.02175	0.409	0.002175000	0.0218	0.01479	7.74	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.03480	0.00435
19-Apr-11	90	7.54	21.6381	36.105	0.0104	0.04565	0.020750	0.0058	0.00062250	0.010375000	0.00208	0.00103750	13.78	0.0020750	0.0041500	0.00415	0.00208	0.006225	#N/A	4.75	0.009130	#N/A	0.00415	0.00415	0.010375	0.11413	0.02075	0.735	0.002075000	0.0311	0.02511	11.83	#N/A	0.0062250	0.0010375	#N/A	0.002075	0.04192	0.00415
26-Apr-11	91	7.68	27.2281	81.59	0.0103	0.04920	0.024600	0.0070	0.00061500	0.010250000	0.00205	0.00102500	16.65	0.0020500	0.0041000	0.00410	0.00205	0.006150	#N/A	5.75	0.009225	#N/A	0.00410	0.00410	0.010250	0.13838	0.02050	0.896	0.002050000	0.0359	0.03024	13.88	#N/A	0.0061500	0.0010250	#N/A	0.002050	0.04572	0.00410
03-May-11	92	7.74	33.8307	74.52	0.0115	0.05750	0.029900	0.0085	0.00069000	0.011500000	0.00230	0.00115000	20.38	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	7.04	0.010465	#N/A	0.00460	0.00460	0.011500	0.16963	0.02300	1.101	0.002300000	0.0431	0.03697	16.80	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.05371	0.00460
10-May-11	93	7.76	36.7094	56.875	0.0114	0.05915	0.031850	0.0091	0.00068250	0.011375000	0.00228	0.00113750	21.84	0.0022750	0.0045500	0.00455	0.00228	0.006825	#N/A	7.55	0.010465	#N/A	0.00455	0.00455	0.011375	0.18200	0.02275	1.183	0.002275000	0.0455	0.03959	17.84	#N/A	0.0068250	0.0011375	#N/A	0.002275	0.05551	0.00455

Appendix B.1-2

Humidity Cell T2 (Sand-Silt Composite)

Cumulative Metal
Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg
28-Jul-09	0	411.8	0.0026	0.03709	0.05544	0.0048	0.0000022	0.0000011	0.011	0.003124	138.60
04-Aug-09	1	1095.4	0.0046	0.22589	0.12064	0.0080	0.0000122	0.0000071	0.071	0.008724	359.0
11-Aug-09	2	1794.6	0.0058	0.54909	0.17664	0.0110	0.0000222	0.0000131	0.131	0.016724	591.0
18-Aug-09	3	2520.6	0.0076	0.90329	0.22460	0.0143	0.0000332	0.0000197	0.197	0.02724	850.6
25-Aug-09	4	3140.3	0.0106	1.23074	0.26549	0.0181	0.0000493	0.0000283	0.283	0.0382265	1113.5
01-Sep-09	5	3775.9	0.0146	1.51794	0.29797	0.0220	0.0000693	0.0000383	0.383	0.0491065	1367
08-Sep-09	6	4482.5	0.0176	1.81868	0.33119	0.0266	0.0000858	0.0000471	0.471	0.0628565	1632
15-Sep-09	7	5183.7	0.0195	2.12046	0.36365	0.0318	0.0000975	0.0000541	0.54075	0.079271	1898
22-Sep-09	8	5893.1	0.0209	2.40552	0.39238	0.0365	0.0001088	0.0000609	0.609	0.09380825	2163
29-Sep-09	9	6713.3	0.0218	2.68336	0.41837	0.0411	0.0001203	0.0000678	0.678	0.10696425	2436
06-Oct-09	10	7435.7	0.0245	2.91829	0.43896	0.0449	0.0001306	0.0000740	0.7395	0.11922325	2679
13-Oct-09	11	8173.1	0.0293	3.15677	0.45827	0.0489	0.0001416	0.0000806	0.8055	0.13295125	2939
20-Oct-09	12	8877.6	0.0328	3.41021	0.47655	0.0526	0.0001526	0.0000872	0.8715	0.14619525	3197
27-Oct-09	13	9631.8	0.0351	3.68471	0.49419	0.0562	0.0001638	0.0000939	0.939	0.15924525	3458
03-Nov-09	14	10261.8	0.0393	3.92831	0.50881	0.0597	0.0001738	0.0000999	0.999	0.17096525	3692
10-Nov-09	15	10972.7	0.0467	4.21103	0.52458	0.0641	0.0001855	0.0001069	1.06875	0.18472925	3966
17-Nov-09	16	11777.2	0.0513	4.50241	0.54094	0.0691	0.0001981	0.0001145	1.1445	0.20189925	4260
24-Nov-09	17	12577.0	0.0522	4.76722	0.55593	0.0739	0.0002102	0.0001217	1.21725	0.22052325	4539
01-Dec-09	18	13307.5	0.0534	5.01304	0.56972	0.0778	0.0002221	0.0001289	1.2885	0.2362695	4779
08-Dec-09	19	13848.3	0.0548	5.24042	0.58237	0.0811	0.0002337	0.0001358	1.35825	0.249243	4981
15-Dec-09	20	14380.5	0.0563	5.48150	0.59514	0.0843	0.0002460	0.0001432	1.43175	0.261052	5158
22-Dec-09	21	14760.8	0.0576	5.70673	0.60647	0.0873	0.0002573	0.0001500	1.5	0.2702885	5290
29-Dec-09	22	15093.0	0.0587	5.92915	0.61786	0.0904	0.0002683	0.0001566	1.566	0.2783405	5407
05-Jan-10	23	15366.3	0.0596	6.15619	0.62970	0.0938	0.0002793	0.0001632	1.632	0.2855125	5514
12-Jan-10	24	15620.0	0.0613	6.37033	0.64165	0.0977	0.0002901	0.0001697	1.6965	0.291425	5604
19-Jan-10	25	15825.6	0.0640	6.58633	0.65457	0.1024	0.0003013	0.0001764	1.764	0.296465	5684
26-Jan-10	26	15985.5	0.0659	6.76878	0.66666	0.1070	0.0003116	0.0001826	1.8255	0.30059575	5750
02-Feb-10	27	16145.7	0.0672	6.95533	0.68045	0.1124	0.0003230	0.0001894	1.89375	0.304668	5815
09-Feb-10	28	16295.7	0.0686	7.13881	0.69446	0.1180	0.0003296	0.0001932	1.93225	0.308243	5874
16-Feb-10	29	16414.9	0.0701	7.33173	0.70966	0.1244	0.0003318	0.0001944	1.943625	0.3115645	5930
23-Feb-10	30	16517.0	0.0723	7.50372	0.72383	0.1309	0.0003381	0.0001980	1.980375	0.3144709	5978
02-Mar-10	31	16611.4	0.0751	7.66369	0.73765	0.1379	0.0003483	0.0002041	2.041125	0.3171196	6019
09-Mar-10	32	16671.0	0.0770	7.80938	0.75124	0.1442	0.0003576	0.0002097	2.097375	0.3191521	6052
16-Mar-10	33	16738.8	0.0784	7.98319	0.76871	0.1516	0.0003690	0.0002166	2.165625	0.3211086	6083
23-Mar-10	34	16823.0	0.0802	8.16041	0.78571	0.1592	0.0003804	0.0002234	2.233875	0.32308103	6114
30-Mar-10	35	16889.8	0.0823	8.32517	0.80077	0.1663	0.0003908	0.0002296	2.296125	0.32489458	6143
06-Apr-10	36	16953.0	0.0843	8.51467	0.81822	0.1751	0.0004021	0.0002364	2.364375	0.3268306	6174
13-Apr-10	37	17022.8	0.0861	8.71087	0.83640	0.1847	0.0004134	0.0002432	2.431875	0.3286936	6204
20-Apr-10	38	17089.0	0.0880	8.92096	0.85539	0.2001	0.0004251	0.0002502	2.502375	0.3307334	6233
27-Apr-10	39	17137.4	0.0896	9.08125	0.87223	0.2085	0.0004349	0.0002561	2.560875	0.3321062	6256
04-May-10	40	17198.2	0.0917	9.25954	0.89036	0.2179	0.0004455	0.0002625	2.624625	0.3336362	6280
11-May-10	41	17255.1	0.0944	9.45000	0.90910	0.2278	0.0004566	0.0002691	2.691375	0.3352738	6305
18-May-10	42	17309.3	0.0963	9.62136	0.92825	0.2374	0.0004629	0.0002771	2.728125	0.3367963	6330
25-May-10	43	17366.5	0.0978	9.79596	0.95034	0.2479	0.0004652	0.0002875	2.739375	0.3384028	6360
01-Jun-10	44	17422.3	0.0993	9.97034	0.97331	0.2588	0.0004675	0.0002934	2.751	0.34000473	6391
08-Jun-10	45	17477.6	0.1008	10.13867	0.99642	0.2699	0.0004698	0.0002946	2.762625	0.34154853	6420
15-Jun-10	46	17512.0	0.1028	10.28688	1.01721	0.2798	0.0004719	0.0002956	2.772875	0.34287488	6445
22-Jun-10	47	17552.1	0.1057	10.44392	1.03970	0.2905	0.0004741	0.0002967	2.78375	0.34424513	6468
29-Jun-10	48	17607.1	0.1079	10.59880	1.06183	0.3015	0.0004763	0.0002978	2.79475	0.34579613	6493
06-Jul-10	49	17660.9	0.1093	10.75658	1.08433	0.3135	0.0004786	0.0002989	2.80625	0.34759013	6519
13-Jul-10	50	17690.3	0.1108	10.88377	1.10362	0.3238	0.0004806	0.0003000	2.816625	0.34912978	6542
20-Jul-10	51	17733.4	0.1128	11.01742	1.12545	0.3353	0.0004831	0.0003012	2.829	0.35087218	6568
27-Jul-10	52	17786.8	0.1151	11.14185	1.14657	0.3458	0.0004854	0.0003023	2.8405	0.35244998	6592
03-Aug-10	53	17836.8	0.1177	11.25974	1.16732	0.3555	0.0004876	0.0003034	2.851375	0.35390288	6612
10-Aug-10	54	17893.0	0.1236	11.35154	1.18572	0.3627	0.0004898	0.0003116	2.862625	0.35507738	6627
17-Aug-10	55	17905.7	0.1326	11.41113	1.20056	0.3670	0.0004920	0.0003264	2.8735	0.35589518	6634
24-Aug-10	56	17985.3	0.1385	11.49639	1.21965	0.3737	0.0004942	0.0003344	2.884375	0.35693918	6649

Date	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg
28-Jul-09	0.000022	0.0016	0.003058	0.02596	0.0007436	0.00207	10.21	1.94040	0.0000264	0.0017	0.00111	0.0057	4.66	0.0002
04-Aug-09	0.000122	0.005	0.008778	0.0376	0.0021316	0.00767	35.41	5.79640	0.0000364	0.0078	0.00359	0.0077	12.58	0.0004
11-Aug-09	0.000222	0.00833	0.013498	0.0476	0.0036476	0.01407	60.13	11.15640	0.0000464	0.0135	0.00595	0.0097	19.90	0.0007
18-Aug-09	0.000332	0.01178	0.018646	0.0550	0.0055660	0.02067	77.77	17.53640	0.0000574	0.0188	0.00895	0.0119	25.58	0.0008
25-Aug-09	0.00049325	0.01517	0.0255045	0.0641	0.0076171	0.02690	92.24	24.11540	0.0000735	0.0239	0.01185	0.0151	30.28	0.0009
01-Sep-09	0.00069325	0.01833	0.0335845	0.0741	0.0096891	0.03250	103.12	30.55540	0.0000935	0.0283	0.01453	0.0191	33.88	0.0009
08-Sep-09	0.00085825	0.02237	0.0437485	0.0833	0.0123995	0.03866	112.69	37.79340	0.0001100	0.0326	0.01877	0.0224	37.44	0.0012
15-Sep-09	0.0009745	0.02725	0.0558385	0.0912	0.0157196	0.04517	120.27	45.60540	0.0001217	0.0363	0.02463	0.0248	40.80	0.0015
22-Sep-09	0.00108825	0.0306	0.0655755	0.1035	0.0187704	0.05063	129.17	50.43295	0.0001330	0.0392	0.03071	0.0270	43.77	0.0019
29-Sep-09	0.00120325	0.03252	0.0733035	0.1205	0.0216546	0.05523	139.65	52.46615	0.0001445	0.0415	0.03719	0.0293	46.45	0.0024
06-Oct-09	0.00130575	0.03377	0.0799045	0.1297	0.0242232	0.05913	149.47	53.58955	0.0001548	0.0432	0.04178	0.0314	48.59	0.0026
13-Oct-09	0.00141575	0.0346	0.0866805	0.1333	0.0269776	0.06309	160.52	54.05595	0.0001658	0.0445	0.04544	0.0336	50.64	0.0027
20-Oct-09	0.00152575	0.03542	0.0920705	0.1390	0.0294680	0.06661	171.74	54.36945	0.0001768	0.0458	0.04852	0.0358	52.50	0.0027
27-Oct-09	0.00163825	0.03626	0.0961655	0.1471	0.0317450	0.06976	183.39	54.53370	0.0001880	0.0472	0.05108	0.0380	54.22	0.0028
03-Nov-09	0.00173825	0.03693	0.1002855	0.1573	0.0337770	0.07236	192.97	54.64970	0.0001980	0.0483	0.05294	0.0400	55.66	0.0028
10-Nov-09	0.0018545	0.03761	0.105633	0.1726	0.0361485	0.07515	203.20	54.74968	0.0002097	0.0496	0.05462	0.0424	57.23	0.0030
17-Nov-09	0.00198075	0.03824	0.1127283	0.1835	0.0388579	0.07793	212.85	54.95496	0.0002223	0.0511	0.05676	0.0449	58.76	0.0031
24-Nov-09	0.002102	0.03874	0.1207793	0.1883	0.0415884	0.08035	220.71	55.24499	0.0002344	0.0525	0.05914	0.0473	60.06	0.0031
01-Dec-09	0.00222075	0.03922	0.127453	0.1938	0.0439587	0.08249	227.78	55.45518	0.0002463	0.0538	0.06118	0.0497	61.13	0.0032
08-Dec-09	0.002337	0.03968	0.1328005	0.1998	0.0459814	0.08435	234.11	55.58863	0.0002579	0.0550	0.06290	0.0520	61.99	0.0032
15-Dec-09	0.0024595	0.04013	0.1379455	0.2065	0.0478116	0.08606	240.31	55.70942	0.0002702	0.0562	0.06464	0.0545	62.80	0.0033
22-Dec-09	0.00257325	0.04051	0.142268	0.2128	0.0492312	0.08743	245.63	55.80315	0.0002815	0.0573	0.06619	0.0567	63.47	0.0033
29-Dec-09	0.00268325	0.04088	0.146536	0.2172	0.0505072	0.08875	251.26	55.87509	0.0002925	0.0584	0.06727	0.0589	64.09	0.0034
05-Jan-10	0.00279325	0.04127	0.150892	0.2199	0.0516864	0.09007	257.38	55.92833	0.0003035	0.0595	0.06793	0.0611	64.67	0.0034
12-Jan-10	0.00290075	0.04161	0.155708	0.2231	0.0527399	0.09104	263.27	55.97111	0.0003143	0.0606	0.06883	0.0633	65.22	0.0034
19-Jan-10	0.00301325	0.04191	0.161333	0.2271	0.0537389	0.09171	269.34	56.00621	0.0003255	0.0618	0.07004	0.0655	65.77	0.0035
26-Jan-10	0.00311575	0.04214	0.18089	0.2563	0.0546142	0.09233	274.78	56.03341	0.0003358	0.0629	0.08644	0.0676	66.26	0.0035
02-Feb-10	0.0032295	0.04234	0.2186095	0.3168	0.0555470	0.09301	280.69	56.05830	0.0003472	0.0642	0.12162	0.0699	66.77	0.0036
09-Feb-10	0.0032955	0.04262	0.2380927	0.3467	0.0564468	0.09387	286.43	56.08468	0.0003538	0.0655	0.13880	0.0714	67.27	0.0036
16-Feb-10	0.00331825	0.04302	0.240668	0.3481	0.0573750	0.09496	292.39	56.11435	0.0003560	0.0670	0.13918	0.0723	67.78	0.0037
23-Feb-10	0.00338125	0.04335	0.2430326	0.3492	0.0581856	0.09578	298.17	56.13694	0.0003623	0.0685	0.13949	0.0738	68.23	0.0037
02-Mar-10	0.0034825	0.04364	0.2453006	0.3502	0.0589227	0.09638	304.00	56.15411	0.0003725	0.0699	0.13978	0.0758	68.65	0.0037
09-Mar-10	0.00357625	0.04391	0.2473256	0.3512	0.0595583	0.09695	308.86	56.16615	0.0003818	0.0712	0.14002	0.0777	68.99	0.0038
16-Mar-10	0.00369	0.04426	0.2496916	0.3523	0.0602726	0.09763	314.09	56.17607	0.0003932	0.0727	0.14029	0.0800	69.35	0.0038
23-Mar-10	0.00380375	0.04463	0.2518301	0.3542	0.0610621	0.09831	319.62	56.18774	0.0004046	0.0744	0.14057	0.0822	69.72	0.0039
30-Mar-10	0.0039075	0.04498	0.2535731	0.3567	0.0618506	0.09893	324.93	56.19998	0.0004150	0.0760	0.14082	0.0843	70.06	0.0039
06-Apr-10	0.00402125	0.04536	0.2555751	0.3587	0.0626218	0.09962	331.05	56.21291	0.0004263	0.0778	0.14109	0.0866	70.43	0.0040
13-Apr-10	0.00413375	0.04571	0.2576451	0.3598	0.0632923	0.10029	337.39	56.22519	0.0004376	0.0794	0.14136	0.0888	70.79	0.0040
20-Apr-10	0.00425125	0.04611	0.2605121	0.3610	0.0640067	0.10100	344.02	56.23877	0.0004493	0.0813	0.14159	0.0912	71.17	0.0040
27-Apr-10	0.00434875	0.04638	0.2625791	0.3619	0.0644708	0.10158	349.21	56.24638	0.0004844	0.0827	0.14175	0.0931	71.48	0.0042
04-May-10	0.004455	0.04665	0.2645766	0.3630	0.0650254	0.10222	354.75	56.25479	0.0005089	0.0843	0.14192	0.0953	71.82	0.0042
11-May-10	0.00456625	0.04691	0.2664011	0.3641	0.0656573	0.10289	360.45	56.26374	0.0005200	0.0859	0.14210	0.0975	72.17	0.0043
18-May-10	0.00463975	0.04718	0.2685347	0.3653	0.0661928	0.10356	366.41	56.27151	0.0005263	0.0875	0.14224	0.0988	72.51	0.0043
25-May-10	0.00468475	0.04749	0.2712617	0.3666	0.0667013	0.10432	373.43	56.27911	0.0005285	0.0893	0.14236	0.0992	72.88	0.0044
01-Jun-10	0.00471963	0.0478	0.2734937	0.3678	0.0672314	0.10509	380.78	56.28779	0.0005309	0.0911	0.14249	0.0997	73.24	0.0044
08-Jun-10	0.00474288	0.0481	0.2751398	0.3687	0.0677662	0.10584	388.22	56.29727	0.0005332	0.0930	0.14262	0.1001	73.60	0.0044
15-Jun-10	0.00477363	0.04834	0.2766855	0.3697	0.0681682	0.10649	394.41	56.30498	0.0005352	0.0945	0.14275	0.1005	73.90	0.0045
22-Jun-10	0.00481713	0.04856	0.2784255	0.3710	0.0685209	0.10719	400.59	56.31246	0.0005374	0.0960	0.14289	0.1010	74.21	0.0045
29-Jun-10	0.00485013	0.04876	0.2803439	0.3726	0.0688998	0.10791	407.21	56.32183	0.0005396	0.0975	0.14303	0.1014	74.54	0.0045
06-Jul-10	0.00487313	0.04896	0.2825151	0.3744	0.0693188	0.10870	414.52	56.33352	0.0005419	0.0989	0.14317	0.1019	74.89	0.0046
13-Jul-10	0.00489388	0.04913	0.2841772	0.3763	0.0696589	0.10932	420.67	56.34435	0.0005440	0.1002	0.14326	0.1023	75.17	0.0046
20-Jul-10	0.00491863	0.04934	0.2858057	0.3788	0.0700193	0.10996	427.45	56.35762	0.0005465	0.1016	0.14333	0.1028	75.49	0.0046
27-Jul-10	0.00494163	0.04951	0.2873237	0.3804	0.0703482	0.11056	433.68	56.36861	0.0005488	0.1028	0.14341	0.1032	75.77	0.0046
03-Aug-10	0.00496338	0.04966	0.2887636	0.3812	0.0706536	0.11112	439.51	56.37774	0.0005509	0.1039	0.14349	0.1037	76.04	0.0046
10-Aug-10	0.00498588	0.04975	0.2902126	0.3875	0.0714888	0.11147	443.70	56.39401	0.0005532	0.1047	0.14359	0.1044	76.23	0.0046
17-Aug-10	0.00500763	0.04979	0.2915741	0.3988	0.0727981	0.11158	445.97	56.41633	0.0005554	0.1051	0.14371	0.1052	76.33	0.0047
24-Aug-10	0.00502938	0.04992	0.2928422	0.4049	0.0735678	0.11190	450.59	56.43806	0.0005586	0.1060	0.14385	0.1065	76.52	0.0047

Date	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
28-Jul-09	0.656	3.76E-04	2.671	0.2002	140.36	0.0002125	0.00407	0.00011	2.42E-05	0.00004	0.04796	0.00002
04-Aug-09	3.396	3.82E-04	8.591	0.5834	367.96	0.0004565	0.00624	0.00071	0.000104	0.00024	0.11876	0.00012
11-Aug-09	6.572	3.98E-04	12.507	0.9774	610.76	0.0006445	0.00837	0.00131	0.000168	0.00044	0.26076	0.00022
18-Aug-09	9.339	4.04E-04	14.394	1.3884	860.24	0.0007809	0.01049	0.00197	0.00023	0.00066	0.49528	0.00033
25-Aug-09	12.317	4.13E-04	15.712	1.7767	1088.14	0.000882	0.01279	0.00283	0.000292	0.00099	0.78768	0.00049
01-Sep-09	15.341	4.23E-04	16.448	2.1255	1285.34	0.000946	0.01515	0.00383	0.000352	0.00139	1.11848	0.00069
08-Sep-09	19.200	4.32E-04	17.086	2.4878	1508.86	0.0010098	0.01927	0.00471	0.000447	0.00172	1.64582	0.00086
15-Sep-09	23.840	4.39E-04	17.579	2.8482	1752.06	0.0010702	0.02522	0.0054075	0.000577	0.00195	2.37587	0.00097
22-Sep-09	27.947	4.46E-04	17.968	3.1637	1996.16	0.0011225	0.0315	0.00609	0.000759	0.00218	3.13572	0.00109
29-Sep-09	31.659	4.52E-04	18.267	3.4452	2249.16	0.0011685	0.0383	0.00678	0.000998	0.00241	3.94992	0.00120
06-Oct-09	34.726	4.59E-04	18.487	3.6859	2472.82	0.0012013	0.04365	0.007395	0.001261	0.00261	4.86217	0.00131
13-Oct-09	37.757	4.65E-04	18.671	3.9332	2710.86	0.0012277	0.04863	0.008055	0.001595	0.00283	6.04137	0.00142
20-Oct-09	40.842	4.77E-04	18.832	4.1767	2945.60	0.0012607	0.05344	0.008715	0.001905	0.00305	7.14797	0.00153
27-Oct-09	44.050	4.95E-04	18.972	4.4220	3182.30	0.0013012	0.05821	0.00939	0.002198	0.00328	8.20547	0.00164
03-Nov-09	46.624	5.13E-04	19.098	4.6300	3387.30	0.0013372	0.06207	0.00999	0.002488	0.00348	9.18547	0.00174
10-Nov-09	49.293	5.37E-04	19.246	4.8601	3619.33	0.0013791	0.06612	0.0106875	0.00286	0.00371	10.37122	0.00185
17-Nov-09	52.207	5.53E-04	19.398	5.1000	3872.34	0.0014245	0.07087	0.011445	0.003261	0.00396	11.9746	0.00198
24-Nov-09	55.020	5.60E-04	19.534	5.3207	4116.29	0.0014682	0.07577	0.0121725	0.003644	0.00420	13.8176	0.00210
01-Dec-09	57.540	5.76E-04	19.645	5.5076	4323.16	0.0015086	0.08009	0.01324125	0.003979	0.00444	15.41835	0.00222
08-Dec-09	59.777	5.99E-04	19.734	5.6620	4494.28	0.0015458	0.08387	0.01463625	0.004267	0.00467	16.78545	0.00234
15-Dec-09	62.026	6.15E-04	19.856	5.8024	4646.42	0.0015801	0.08774	0.01573875	0.004522	0.00492	18.0031	0.00246
22-Dec-09	64.014	6.22E-04	19.997	5.9120	4761.54	0.0016074	0.09123	0.01642125	0.004713	0.00515	18.92675	0.00257
29-Dec-09	66.029	6.28E-04	20.098	6.0097	4866.04	0.0016294	0.09509	0.01708125	0.004896	0.00537	19.71215	0.00268
05-Jan-10	68.137	6.35E-04	20.164	6.0990	4963.72	0.001647	0.09943	0.01774125	0.005076	0.00559	20.38975	0.00279
12-Jan-10	70.192	6.41E-04	20.240	6.1762	5044.99	0.0016685	0.10341	0.01838625	0.005238	0.00580	20.95735	0.00290
19-Jan-10	72.339	6.48E-04	20.330	6.2464	5115.19	0.0016955	0.1073	0.01906125	0.005391	0.00603	21.45235	0.00301
26-Jan-10	74.307	6.80E-04	20.405	6.3057	5172.59	0.0017201	0.11088	0.01967625	0.00553	0.00623	21.84574	0.00312
02-Feb-10	76.505	7.44E-04	20.483	6.3662	5229.01	0.0017474	0.11489	0.02035875	0.005685	0.00646	22.21839	0.00323
09-Feb-10	78.579	7.77E-04	20.564	6.4243	5277.41	0.0017725	0.12013	0.02074375	0.005828	0.00659	22.54311	0.00330
16-Feb-10	80.672	7.81E-04	20.655	6.4839	5321.09	0.001797	0.12695	0.0208575	0.005969	0.00664	22.84204	0.00332
23-Feb-10	82.527	7.86E-04	20.731	6.5357	5355.32	0.001821	0.13201	0.021225	0.006095	0.00676	23.11315	0.00338
02-Mar-10	84.240	7.92E-04	20.796	6.5827	5382.45	0.0018453	0.13568	0.0218325	0.006212	0.00697	23.36992	0.00348
09-Mar-10	85.772	7.98E-04	20.854	6.6204	5404.76	0.0018678	0.13898	0.022395	0.006317	0.00715	23.55592	0.00358
16-Mar-10	87.564	8.05E-04	20.922	6.6591	5428.42	0.0018951	0.14287	0.0230775	0.00644	0.00738	23.71881	0.00369
23-Mar-10	89.161	8.12E-04	21.004	6.6983	5452.54	0.0019201	0.14708	0.02376	0.006588	0.00761	23.89694	0.00380
30-Mar-10	90.439	8.18E-04	21.091	6.7345	5474.95	0.0019408	0.15121	0.0243825	0.006746	0.00782	24.07332	0.00391
06-Apr-10	92.191	8.25E-04	21.173	6.7752	5492.92	0.0019636	0.1554	0.025065	0.006889	0.00804	24.2626	0.00402
13-Apr-10	94.270	8.32E-04	21.240	6.8166	5504.17	0.0019861	0.15922	0.02574	0.007001	0.00827	24.44575	0.00413
20-Apr-10	96.122	8.50E-04	21.311	6.8607	5515.92	0.002019	0.16391	0.026445	0.007114	0.00850	24.62388	0.00425
27-Apr-10	97.737	8.74E-04	21.369	6.8930	5525.67	0.0020502	0.1666	0.02703	0.007192	0.00870	24.7362	0.00435
04-May-10	99.522	8.90E-04	21.433	6.9285	5536.30	0.0020799	0.16953	0.0276675	0.007275	0.00891	24.8603	0.00446
11-May-10	101.417	8.96E-04	21.500	6.9659	5547.42	0.0021066	0.17259	0.028335	0.00736	0.00913	24.99202	0.00457
18-May-10	103.129	9.01E-04	21.559	7.0032	5563.80	0.002132	0.17568	0.0287025	0.007452	0.00926	25.10689	0.00463
25-May-10	104.879	9.03E-04	21.617	7.0452	5587.65	0.0021595	0.1792	0.028815	0.007565	0.00930	25.21984	0.00465
01-Jun-10	106.900	9.06E-04	21.682	7.0874	5611.13	0.0021879	0.18274	0.02893125	0.007678	0.00935	25.33562	0.00468
08-Jun-10	109.132	9.09E-04	21.752	7.1285	5633.45	0.0022162	0.18616	0.0290475	0.007787	0.00940	25.45048	0.00470
15-Jun-10	110.989	9.14E-04	21.807	7.1643	5652.11	0.0022414	0.18875	0.02915	0.007882	0.00944	25.54703	0.00472
22-Jun-10	112.842	9.22E-04	21.860	7.2019	5670.81	0.0022684	0.19105	0.02925875	0.007979	0.00948	25.64447	0.00474
29-Jun-10	114.695	9.31E-04	21.915	7.2410	5690.83	0.0022959	0.19326	0.02936875	0.008075	0.00953	25.76151	0.00476
06-Jul-10	116.608	9.42E-04	21.974	7.2831	5712.91	0.0023249	0.19546	0.02948375	0.008171	0.00957	25.90319	0.00479
13-Jul-10	118.270	9.57E-04	22.022	7.3186	5730.97	0.0023494	0.19737	0.0295875	0.008251	0.00961	26.02811	0.00481
20-Jul-10	120.176	9.82E-04	22.072	7.3580	5750.27	0.0023766	0.19957	0.02971125	0.008338	0.00966	26.17364	0.00483
27-Jul-10	121.896	9.96E-04	22.118	7.3939	5768.67	0.0024026	0.20145	0.02982625	0.008415	0.00971	26.30773	0.00485
03-Aug-10	123.475	1.00E-03	22.161	7.4272	5786.51	0.0024278	0.20309	0.029935	0.008485	0.00975	26.43344	0.00488
10-Aug-10	124.603	1.01E-03	22.231	7.4508	5798.88	0.0024436	0.20412	0.0300475	0.008527	0.00980	26.54392	0.00490
17-Aug-10	125.203	1.02E-03	22.322	7.4630	5804.97	0.0024488	0.20447	0.03015625	0.00854	0.00984	26.63179	0.00492
24-Aug-10	126.106	1.03E-03	22.398	7.4874	5818.67	0.0024651	0.20471	0.030265	0.008587	0.00988	26.71661	0.00494

Appendix B.1-2

Humidity Cell T2 (Sand-Silt Composite)

Cumulative Metal
Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
31-Aug-10	57	18061.4	0.1413	11.60604	1.24274	0.3827	0.0004963	0.0003355	2.895125	0.35819478	6672	0.00505088	0.05014	0.2940032	0.4058	0.0737953	0.11241	457.47	56.45895	0.0005629	0.1073	0.14402	0.1083	76.79	0.0047	127.297	1.05E-03	22.459	7.5235	5839.74	0.0024922	0.20485	0.0303725	0.008669	0.00993	26.79745	0.00496
07-Sep-10	58	18119.4	0.1444	11.71376	1.26706	0.3905	0.0004985	0.0003377	2.905875	0.35920958	6691	0.00507238	0.05034	0.2953276	0.4071	0.0740239	0.11289	463.29	56.47248	0.0005662	0.1087	0.14415	0.1093	77.04	0.0047	128.428	1.07E-03	22.519	7.5540	5855.65	0.002515	0.20495	0.03048	0.008738	0.00997	26.86023	0.00498
14-Sep-10	59	18152.2	0.1474	11.81093	1.29052	0.3964	0.0005005	0.0003409	2.91575	0.35992058	6706	0.00509213	0.0505	0.2966943	0.4087	0.0742348	0.11328	467.68	56.47813	0.0005681	0.1100	0.14425	0.1097	77.25	0.0048	129.411	1.11E-03	22.574	7.5769	5865.53	0.002532	0.20501	0.03057875	0.008791	0.01001	26.90131	0.00500
21-Sep-10	60	18185.7	0.1508	11.93751	1.32071	0.4057	0.0005029	0.0003434	2.927875	0.3609027	6725	0.00513285	0.0507	0.2982705	0.4101	0.0745437	0.11382	473.25	56.48620	0.0005706	0.1117	0.14443	0.1102	77.52	0.0048	130.711	1.15E-03	22.640	7.6071	5877.41	0.0025579	0.20508	0.0307	0.008876	0.01006	26.96024	0.00503
28-Sep-10	61	18215.5	0.1534	12.05343	1.34806	0.4154	0.0005050	0.0003445	2.938375	0.3618477	6742	0.0051705	0.05088	0.2995473	0.4110	0.0748545	0.11432	478.25	56.49418	0.0005727	0.1132	0.14464	0.1106	77.77	0.0048	131.916	1.18E-03	22.694	7.6349	5887.49	0.0025848	0.20516	0.030805	0.008966	0.01010	27.01862	0.00505
05-Oct-10	62	18283.4	0.1608	12.16648	1.37777	0.4285	0.0008624	0.0062826	2.9455	0.36297583	6772	0.00638175	0.05335	0.3026443	0.4126	0.0785928	#N/A	487.66	56.50487	#N/A	0.1165	0.14714	0.1168	78.08	0.0167	133.180	2.38E-03	22.773	7.6834	5914.99	#N/A	0.20876	0.03145813	#N/A	0.01131	27.09581	0.00744
12-Oct-10	63	18307.0	0.1698	12.26394	1.40503	0.4417	0.0013636	0.0146266	2.94995	0.36406051	6807	0.00806163	0.05673	0.30632	0.4145	0.0836814	#N/A	498.23	56.51566	#N/A	0.1202	0.15053	0.1253	78.38	0.0334	134.317	4.06E-03	22.854	7.7368	5948.30	#N/A	0.21379	0.03232031	#N/A	0.01299	27.17335	0.01078
19-Oct-10	64	18368.6	0.1802	12.36031	1.43293	0.4559	0.0019676	0.0246892	2.9534	0.36519614	6845	0.01007988	0.06078	0.3105198	0.4166	0.0897614	#N/A	510.06	56.52722	#N/A	0.1244	0.15459	0.1354	78.69	0.0536	135.468	6.07E-03	22.942	7.7961	5986.63	#N/A	0.21984	0.03334094	#N/A	0.01501	27.25621	0.01481
26-Oct-10	65	18462.2	0.1911	12.44731	1.45903	0.4699	0.0026201	0.0355642	2.955575	0.36628364	6884	0.01225488	0.06513	0.3148698	0.4188	0.0962864	#N/A	522.11	56.53853	#N/A	0.1288	0.15894	0.1463	79.00	0.0753	136.534	8.25E-03	23.029	7.8562	6026.56	#N/A	0.22636	0.03442844	#N/A	0.01718	27.33712	0.01916
02-Nov-10	66	18547.9	0.2024	12.53956	1.48603	0.4825	0.0032951	0.0468142	2.957825	0.36740864	6917	0.01450488	0.06963	0.3193698	0.4211	0.1030364	#N/A	532.53	56.55090	#N/A	0.1333	0.16344	0.1575	79.27	0.0978	137.663	1.05E-02	23.085	7.9093	6058.45	#N/A	0.23311	0.03555344	#N/A	0.01943	27.43049	0.02366
09-Nov-10	67	18644.5	0.2139	12.63501	1.51363	0.4944	0.0039851	0.0583142	2.960125	0.36855864	6947	0.01680488	0.07423	0.3239698	0.4234	0.1099364	#N/A	542.13	56.56390	#N/A	0.1379	0.16804	0.1690	79.52	0.1208	138.832	1.28E-02	23.125	7.9590	6086.22	#N/A	0.24001	0.03670344	#N/A	0.02173	27.53089	0.02826
16-Nov-10	68	18724.4	0.2245	12.72373	1.53913	0.5050	0.0046226	0.0689392	2.96225	0.36962114	6974	0.01892988	0.07848	0.3282198	0.4255	0.1163114	#N/A	550.52	56.57606	#N/A	0.1421	0.17229	0.1796	79.75	0.1421	139.918	1.49E-02	23.154	8.0027	6109.65	#N/A	0.24639	0.03776594	#N/A	0.02386	27.62593	0.03251
23-Nov-10	69	18800.8	0.2360	12.82033	1.56673	0.5161	0.0053126	0.0804392	2.96455	0.37077114	7001	0.02122988	0.08308	0.3328198	0.4278	0.1232114	#N/A	559.07	56.58940	#N/A	0.1467	0.17689	0.1911	79.98	0.1651	141.100	1.72E-02	23.177	8.0478	6132.61	#N/A	0.25329	0.03891594	#N/A	0.02616	27.73127	0.03711
30-Nov-10	70	18873.7	0.2471	12.90710	1.59120	0.5261	0.0059801	0.0915642	2.966775	0.37188364	7026	0.02345488	0.08753	0.3372698	0.4467	0.1298864	#N/A	567.28	56.60030	#N/A	0.1512	0.18134	0.2023	80.22	0.1873	142.143	1.94E-02	23.255	8.0907	6154.52	#N/A	0.25996	0.04002844	#N/A	0.02838	27.83317	0.04156
07-Dec-10	71	18955.4	0.2579	12.98773	1.61378	0.5354	0.0066251	0.1023142	2.968925	0.37295864	7049	0.02560488	0.09183	0.3415698	0.4730	0.1363364	#N/A	575.18	56.60987	#N/A	0.1555	0.18564	0.2130	80.47	0.2088	143.103	2.16E-02	23.357	8.1319	6175.56	#N/A	0.26641	0.04110344	#N/A	0.03053	27.93164	0.04586
14-Dec-10	72	19032.0	0.2687	13.06766	1.63607	0.5447	0.0072776	0.1131892	2.9711	0.37404614	7073	0.02777988	0.09618	0.3459198	0.5038	0.1428614	#N/A	583.16	56.61906	#N/A	0.1598	0.18999	0.2239	80.72	0.2306	144.050	2.38E-02	23.474	8.1734	6196.77	#N/A	0.27294	0.04219094	#N/A	0.03271	28.03126	0.05021
21-Dec-10	73	19104.1	0.2799	13.14776	1.65832	0.5541	0.0079451	0.1243142	2.973325	0.37515864	7097	0.03000488	0.10063	0.3503698	0.5394	0.1495364	#N/A	591.31	56.62796	#N/A	0.1643	0.19444	0.2350	80.99	0.2528	144.993	2.60E-02	23.608	8.2157	6218.40	#N/A	0.27961	0.04330344	#N/A	0.03493	28.13316	0.05466
28-Dec-10	74	19164.0	0.2905	13.22213	1.68170	0.5639	0.0085826	0.1349392	2.97545	0.37622114	7119	0.03212988	0.10488	0.3546198	0.5574	0.1559114	#N/A	598.96	56.63944	#N/A	0.1685	0.19869	0.2456	81.22	0.2741	146.035	2.81E-02	23.714	8.2561	6237.25	#N/A	0.28599	0.04436594	#N/A	0.03706	28.22199	0.05891
04-Jan-11	75	19223.4	0.3029	13.30752	1.71016	0.5757	0.0093251	0.1473142	2.977925	0.37745864	7146	0.03460488	0.10983	0.3595698	0.5692	0.1633364	#N/A	607.79	56.65453	#N/A	0.1735	0.20364	0.2580	81.48	0.2988	147.329	3.06E-02	23.825	8.3031	6258.15	#N/A	0.29341	0.04560344	#N/A	0.03953	28.32049	0.06386
11-Jan-11	76	19276.8	0.3140	13.38373	1.73630	0.5866	0.0099926	0.1584392	2.98015	0.37857114	7170	0.03682988	0.11428	0.3640198	0.5756	0.1700114	#N/A	615.70	56.66889	#N/A	0.1779	0.20809	0.2691	81.71	0.3211	148.529	3.28E-02	23.920	8.3454	6276.47	#N/A	0.30009	0.04671594	#N/A	0.04176	28.40682	0.06831
18-Jan-11	77	19330.8	0.3252	13.46023	1.76330	0.5979	0.0106676	0.1696892	2.9824	0.37969614	7194	0.03907988	0.11878	0.3685198	0.5778	0.1767614	#N/A	623.67	56.68419	#N/A	0.1824	0.21259	0.2804	81.94	0.3436	149.780	3.51E-02	24.010	8.3881	6294.51	#N/A	0.30684	0.04784094	#N/A	0.04401	28.49187	0.07281
25-Jan-11	78	19374.5	0.3357	13.53163	1.78850	0.6076	0.0112976	0.1801892	2.9845	0.38074614	7215	0.04117988	0.12298	0.3727198	0.5799	0.1830614	#N/A	630.85	56.69847	#N/A	0.1866	0.21679	0.2909	82.15	0.3646	150.916	3.72E-02	24.063	8.4265	6310.68	#N/A	0.31314	0.04889094	#N/A	0.04611	28.56012	0.07701
01-Feb-11	79	19437.0	0.3472	13.60983	1.81610	0.6177	0.0119876	0.1916892	2.9868	0.38189614	7238	0.04347988	0.12758	0.3773198	0.5822	0.1899614	#N/A	638.58	56.71411	#N/A	0.1912	0.22139	0.3024	82.38	0.3876	152.143	3.95E-02	24.103	8.4678	6328.02	#N/A	0.32004	0.05004094	#N/A	0.04841	28.62878	0.08161
08-Feb-11	80	19480.7	0.3570	13.67613	1.83950	0.6261	0.0125726	0.2014392	2.98875	0.38287114	7257	0.04542988	0.13148	0.3812198	0.5842	0.1958114	#N/A	645.07	56.72737	#N/A	0.1951	0.22529	0.3121	82.57	0.4071	153.176	4.14E-02	24.130	8.5025	6342.57	#N/A	0.32589	0.05101594	#N/A	0.05036	28.6844	0.08551
15-Feb-11	81	19519.0	0.3679	13.75008	1.86560	0.6352	0.0132251	0.2123142	2.990925	0.38395864	7279	0.04760488	0.13583	0.3855698	0.5864	0.2023364	#N/A	652.25	56.74216	#N/A	0.1995	0.22964	0.3230	82.79	0.4288	154.321	4.36E-02	24.151	8.5408	6358.62	#N/A	0.33241	0.05210344	#N/A	0.05253	28.74356	0.08986
22-Feb-11	82	19571.4	0.3789	13.81608	1.88980	0.6451	0.0138851	0.2233142	2.993125	0.38505864	7301	0.04980488	0.14023	0.3899698	0.5886	0.2089364	#N/A	659.77	56.75536	#N/A	0.2039	0.23404	0.3340	82.99	0.4508	155.473	4.58E-02	24.173	8.5808	6376.05	#N/A	0.33901	0.05320344	#N/A	0.05473	28.799	0.09426
01-Mar-11	83	19631.4	0.3900	13.87838	1.91317	0.6554	0.0145526	0.2344392	2.99535	0.38617114	7324	0.05202988	0.14468	0.3944198	0.5908	0.2156114	#N/A	667.51	56.76782	#N/A	0.2083	0.23849	0.3451	83.18	0.4731	156.637	4.80E-02	24.196	8.6220	6394.27	#N/A	0.34569	0.05431594	#N/A	0.05696	28.85285	0.09871
08-Mar-11	84	19692.0	0.4006	13.93575	1.93495	0.6655	0.0151901	0.2450642	2.997475	0.38723364	7346	0.05415488	0.14893	0.3986698	0.5929	0.2219864	#N/A	674.97	56.77929	#N/A	0.2126	0.24274	0.3558	83.35	0.4943	157.747	5.01E-02	24.217	8.6616	6411.96	#N/A	0.35206	0.05537844	#N/A	0.05908	28.90321	0.10296
15-Mar-11	85	19755.8	0.4112	13.99100	1.95620	0.6757	0.0158276	0.2556892	2.9996	0.38829614	7368	0.05627988	0.15318	0.4029198	0.5950	0.2283614	#N/A	682.50	56.79034	#N/A	0.2168	0.24699	0.3664	83.52	0.5156	158.857	5.23E-02	24.238	8.7015	6429.94	#N/A	0.35844	0.05644094	#N/A	0.06121	28.95251	0.10721
22-Mar-11	86	19797.0	0.4216	14.03665	1.97280	0.6823	0.0164501	0.2660642	3.001675	0.38933364	7383	0.05835488	0.15733	0.4070698	0.5971	0.2345864	#N/A	687.48	56.80009	#N/A	0.2210	0.25114	0.3768	83.64	0.5363	159.593	5.43E-02	24.259	8.7281	6442.41	#N/A	0.36466	0.05747844	#N/A	0.06328	28.99318	0.11136
29-Mar-11	87	19814.6	0.4326	14.08065	1.98820	0.6876	0.0171101	0.2770642	3.003875	0.39043364	7395	0.06055488	0.16173	0.4114698	0.5993	0.2411864	#N/A	691.51	56.80988	#N/A	0.2254	0.25554	0.3878	83.73	0.5583	160.191	5.65E-02	24.281	8.7497	6452.93	#N/A	0.37126	0.05857844	#N/A	0.06548	29.03234	0.11576
05-Apr-11	88	19834.0	0.4435	14.12198	2.00233	0.6920	0.0177626	0.2879392	3.00605	0.39152114	7404	0.06272988	0.16608	0.4158198	0.6015	0.2477114	#N/A	694.87	56.81929	#N/A	0.2297	0.25989	0.3986	83.81	0.5801	160.690	5.87E-02	24.303	8.7677	6462.01	#N/A	0.37779	0.05966594	#N/A	0.06766	29.0691	0.12011
12-Apr-11	89	19855.3	0.4544	14.16113	2.01538	0.6954	0.0184151	0.2988142	3.008225	0.39260864	7412	0.06490488	0.17043	0.4201698	0.6037	0.2542364	#N/A	697.62	56.82842	#N/A	0.2341	0.26424	0.4095	83.87	0.6018	161.099	6.09E-02	24.324	8.7825	6469.75	#N/A	0.38431	0.06075344	#N/A	0.06983	29.1039	0.12446
19-Apr-11	90	19891.4	0.4647	14.20678	2.03613	0.7012	0.0190376	0.3091892	3.0103	0.39364614	7426	0.06697988	0.17458	0.4243198	0.6057	0.2604614	#N/A	702.37	56.83755	#N/A	0.2382	0.26839	0.4199	83.99	0.6226	161.834	6.30E-02	24.355	8.8076	6481.58	#N/A	0.39054	0.06179094	#N/A	0.07191	29.14581	0.12861
26-Apr-11	91	19973.0	0.4750	14.25598	2.06073	0.7082	0.0196526	0.3194392	3.01235	0.39467114	7443	0.06902988	0.17868	0.4284198	0.6078	0.2666114	#N/A	708.12	56.84678	#N/A	0.2423	0.27249	0.4301	84.13	0.6431	162.730	6.50E-02	24.391	8.8379	6495.46	#N/A	0.39669	0.06281594	#N/A	0.07396	29.19153	0.13271
03-May-11	92	20047.5	0.4865	14.31348	2.09063	0.7167	0.0203426	0.3309392	3.01465	0.39582114	7463	0.07132988	0.18328	0.4330198	0.6101	0.2735114	#N/A	715.17	56.85724	#N/A	0.2469	0.27709	0.4416	84.30	0.6661	163.830	6.73E-02	24.434	8.8748	6512.26	#N/A	0.40359	0.06396594	#N/A	0.07626	29.24523	0.13731

Appendix B.1-2

Humidity Cell T2 (Sand-Silt Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining (% of initial value)	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining (% of initial value)	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO 4	(Ca+Mg)/Al k	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
28-Jul-09	0	3.507	9.0	9.0	411.8	411.8	4.287	0.00283	0.997	0.00358	0.996	0.00333	0.997	0.02	4.836	0.91	0.81	43.22	8.23	429.1	388.4	0.3884	388.4	0.3884	0.99	434.5	434.5	0.99
04-Aug-09	1	2.668	9.9	9.9	683.6	1095.4	11.404	0.00754	0.992	0.00952	0.990	0.00885	0.991	0.01	4.813	0.92	0.77	80.12	5.30	712.2	654.6	0.6546	654.6	0.6546	0.98	719.5	719.5	0.98
11-Aug-09	2	4.368	11.2	11.2	699.2	1794.6	18.682	0.01235	0.988	0.01560	0.984	0.01451	0.985	0.02	4.790	0.94	0.80	83.43	5.69	728.5	681.6	0.6816	681.6	0.6816	0.98	735.3	735.3	0.98
18-Aug-09	3	3.485	11.6	11.6	726.0	2520.6	26.240	0.01735	0.983	0.02191	0.978	0.02037	0.980	0.02	4.766	0.95	0.86	80.28	8.92	756.4	721.4	0.7214	721.4	0.7214	0.98	764.5	764.5	0.97
25-Aug-09	4	4.274	12.2	12.2	619.6	3140.3	32.691	0.02161	0.978	0.02730	0.973	0.02538	0.975	0.02	4.745	1.11	1.02	81.60	11.02	645.6	716.6	0.7166	716.6	0.7166	0.98	653.5	653.5	0.98
01-Sep-09	5	4.784	12.1	12.1	635.6	3775.9	39.307	0.02599	0.974	0.03282	0.967	0.03052	0.969	0.02	4.724	1.02	0.95	82.93	14.11	662.2	677.5	0.6775	677.5	0.6775	0.98	669.5	669.5	0.98
08-Sep-09	6	5.482	18.5	18.5	706.6	4482.5	46.664	0.03085	0.969	0.03897	0.961	0.03623	0.964	0.03	4.700	0.95	0.90	78.10	16.80	736.2	701.8	0.7018	701.8	0.7018	0.98	749.2	749.2	0.98
15-Sep-09	7	6.026	24.9	24.9	701.2	5183.7	53.963	0.03568	0.964	0.04506	0.955	0.04190	0.958	0.04	4.677	0.95	0.91	73.27	21.28	730.6	695.8	0.6958	695.8	0.6958	0.98	749.4	749.4	0.98
22-Sep-09	8	5.260	26.2	26.2	709.3	5893.1	61.348	0.04056	0.959	0.05123	0.949	0.04763	0.952	0.04	4.653	0.95	0.90	75.27	18.08	739.0	699.4	0.6994	699.4	0.6994	0.98	759.9	759.9	0.97
29-Sep-09	9	4.674	28.3	28.3	820.2	6713.3	69.886	0.04621	0.954	0.05836	0.942	0.05426	0.946	0.03	4.626	0.85	0.80	77.27	15.80	854.5	725.8	0.7258	725.8	0.7258	0.98	878.1	878.1	0.97
06-Oct-09	10	3.946	26.8	26.8	722.4	7435.7	77.407	0.05118	0.949	0.06464	0.935	0.06010	0.940	0.04	4.602	0.86	0.81	77.32	15.00	752.6	647.3	0.6473	647.3	0.6473	0.98	775.5	775.5	0.97
13-Oct-09	11	4.000	30.5	30.5	737.4	8173.1	85.083	0.05625	0.944	0.07105	0.929	0.06606	0.934	0.04	4.577	0.90	0.85	77.37	14.28	768.3	695.1	0.6951	695.1	0.6951	0.98	794.8	794.8	0.97
20-Oct-09	12	3.874	28.2	28.2	704.4	8877.6	92.417	0.06110	0.939	0.07717	0.923	0.07176	0.928	0.04	4.554	0.94	0.88	76.78	13.92	733.9	689.8	0.6898	689.8	0.6898	0.98	758.2	758.2	0.97
27-Oct-09	13	3.834	26.5	26.5	754.2	9631.8	100.268	0.06629	0.934	0.08373	0.916	0.07785	0.922	0.04	4.528	0.89	0.83	76.19	13.58	785.8	700.0	0.7000	700.0	0.7000	0.98	808.4	808.4	0.97
03-Nov-09	14	4.112	23.1	23.1	630.0	10261.8	106.827	0.07063	0.929	0.08921	0.911	0.08294	0.917	0.04	4.507	0.95	0.89	76.41	14.81	656.4	624.0	0.6240	624.0	0.6240	0.98	675.3	675.3	0.98
10-Nov-09	15	5.599	26.3	26.3	711.0	10972.7	114.228	0.07552	0.924	0.09539	0.905	0.08869	0.911	0.04	4.484	0.98	0.92	76.62	16.26	740.7	727.5	0.7275	727.5	0.7275	0.98	761.4	761.4	0.97
17-Nov-09	16	5.699	31.4	31.4	804.5	11777.2	122.603	0.08106	0.919	0.10238	0.898	0.09519	0.905	0.04	4.457	0.92	0.88	75.12	18.49	838.1	774.5	0.7745	774.5	0.7745	0.97	863.9	863.9	0.97
24-Nov-09	17	5.107	33.0	33.0	799.8	12577.0	130.928	0.08657	0.913	0.10933	0.891	0.10166	0.898	0.04	4.430	0.87	0.84	73.62	21.52	833.2	729.0	0.7290	729.0	0.7290	0.98	861.1	861.1	0.97
01-Dec-09	18	4.779	31.0	31.0	730.6	13307.5	138.533	0.09159	0.908	0.11569	0.884	0.10756	0.892	0.04	4.406	0.82	0.79	64.73	20.53	761.1	627.8	0.6278	627.8	0.6278	0.98	787.4	787.4	0.97
08-Dec-09	19	4.459	29.2	29.2	540.8	13848.3	144.163	0.09532	0.905	0.12039	0.880	0.11193	0.888	0.05	4.388	0.94	0.89	55.84	19.35	563.4	530.2	0.5302	530.2	0.5302	0.98	588.1	588.1	0.98
15-Dec-09	20	3.893	28.8	28.8	532.1	14380.5	149.703	0.09898	0.901	0.12501	0.875	0.11623	0.884	0.05	4.370	0.85	0.80	46.84	17.35	554.4	468.6	0.4686	468.6	0.4686	0.98	579.3	579.3	0.98
22-Dec-09	21	2.867	25.0	25.0	380.4	14760.8	153.663	0.10160	0.898	0.12832	0.872	0.11931	0.881	0.07	4.357	0.89	0.83	37.84	15.03	396.3	351.5	0.3515	351.5	0.3515	0.99	418.4	418.4	0.99
29-Dec-09	22	3.144	26.2	26.2	332.2	15093.0	157.121	0.10388	0.896	0.13121	0.869	0.12199	0.878	0.08	4.346	0.91	0.84	35.13	12.60	346.1	315.6	0.3156	315.6	0.3156	0.99	369.2	369.2	0.99
05-Jan-10	23	3.516	28.3	28.3	273.2	15366.3	159.965	0.10576	0.894	0.13358	0.866	0.12420	0.876	0.10	4.337	1.02	0.93	32.41	10.56	284.7	291.2	0.2912	291.2	0.2912	0.99	309.4	309.4	0.99
12-Jan-10	24	3.384	29.6	29.6	253.7	15620.0	162.606	0.10751	0.892	0.13579	0.864	0.12625	0.874	0.12	4.329	0.95	0.85	28.46	9.30	264.3	249.8	0.2498	249.8	0.2498	0.99	290.5	290.5	0.99
19-Jan-10	25	3.488	33.0	33.0	205.7	15825.6	164.747	0.10893	0.891	0.13758	0.862	0.12792	0.872	0.16	4.322	1.05	0.93	24.50	8.00	214.3	225.1	0.2251	225.1	0.2251	0.99	243.7	243.7	0.99
26-Jan-10	26	2.722	31.5	31.5	159.9	15985.5	166.412	0.11003	0.890	0.13897	0.861	0.12921	0.871	0.20	4.316	1.12	0.99	22.31	7.35	166.6	186.8	0.1868	186.8	0.1868	0.99	195.3	195.3	0.99
02-Feb-10	27	2.516	36.5	36.5	160.2	16145.7	168.079	0.11113	0.889	0.14036	0.860	0.13050	0.869	0.23	4.311	1.12	0.97	20.12	6.67	166.9	186.9	0.1869	186.9	0.1869	0.99	200.9	200.9	0.99
09-Feb-10	28	2.565	37.4	37.4	150.0	16295.7	169.641	0.11216	0.888	0.14166	0.858	0.13171	0.868	0.25	4.306	1.09	0.94	18.97	6.20	156.3	170.4	0.1704	170.4	0.1704	0.99	191.2	191.2	0.99
16-Feb-10	29	2.789	40.9	40.9	119.2	16414.9	170.882	0.11298	0.887	0.14270	0.857	0.13268	0.867	0.34	4.302	1.33	1.13	17.81	5.74	124.2	165.5	0.1655	165.5	0.1655	0.99	162.3	162.3	0.99
23-Feb-10	30	2.012	35.9	35.9	102.1	16517.0	171.945	0.11368	0.886	0.14359	0.856	0.13350	0.866	0.35	4.299	1.34	1.12	16.66	5.01	106.3	142.9	0.1429	142.9	0.1429	1.00	140.3	140.3	1.00
02-Mar-10	31	1.397	33.0	33.0	94.4	16611.4	172.927	0.11433	0.886	0.14441	0.856	0.13427	0.866	0.35	4.295	1.30	1.06	15.51	4.34	98.3	128.2	0.1282	128.2	0.1282	1.00	129.9	129.9	1.00
09-Mar-10	32	1.534	32.0	32.0	59.6	16671.0	173.548	0.11474	0.885	0.14492	0.855	0.13475	0.865	0.54	4.293	1.61	1.29	13.09	4.01	62.1	100.2	0.1002	100.2	0.1002	1.00	92.5	92.5	1.00
16-Mar-10	33	2.152	40.5	40.5	67.8	16738.8	174.253	0.11521	0.885	0.14551	0.854	0.13530	0.865	0.60	4.291	1.40	1.10	10.68	3.60	70.6	99.2	0.0992	99.2	0.0992	1.00	109.0	109.0	1.00
23-Mar-10	34	2.011	38.9	38.9	84.2	16823.0	175.130	0.11579	0.884	0.14625	0.854	0.13598	0.864	0.46	4.288	1.15	0.89	10.86	3.43	87.7	100.9	0.1009	100.9	0.1009	1.00	124.5	124.5	1.00
30-Mar-10	35	1.706	33.9	33.9	66.8	16889.8	175.825	0.11625	0.884	0.14683	0.853	0.13652	0.863	0.51	4.286	1.35	1.03	11.05	3.28	69.6	93.6	0.0936	93.6	0.0936	1.00	101.8	101.8	1.00
06-Apr-10	36	2.298	40.0	40.0	63.2	16953.0	176.484	0.11669	0.883	0.14738	0.853	0.13703	0.863	0.63	4.284	1.56	1.18	11.06	3.08	65.9	102.7	0.1027	102.7	0.1027	1.00	103.6	103.6	1.00
13-Apr-10	37	2.696	42.4	42.4	69.8	17022.8	177.210	0.11717	0.883	0.14798	0.852	0.13759	0.862	0.61	4.282	1.40	1.04	11.07	2.89	72.7	101.7	0.1017	101.7	0.1017	1.00	112.4	112.4	1.00
20-Apr-10	38	2.073	45.3	45.3	66.3	17089.0	177.900	0.11762	0.882	0.14856	0.851	0.13813	0.862	0.68	4.280	1.46	1.06	10.50	2.69	69.0	100.8	0.1008	100.8	0.1008	1.00	112.3	112.3	1.00
27-Apr-10	39	1.026	35.0	35.0	48.4	17137.4	178.403	0.11795	0.882	0.14898	0.851	0.13852	0.861	0.72	4.278	1.54	1.12	9.74	2.63	50.4	77.6	0.0776	77.6	0.0776	1.00	84.3	84.3	1.00
04-May-10	40	1.439	37.0	37.0	60.8	17198.2	179.036	0.11837	0.882	0.14951	0.850	0.13901	0.861	0.61	4.276	1.31	0.95	9.58	2.64	63.3	83.1	0.0831	83.1	0.0831	1.00	98.9	98.9	1.00
11-May-10	41	1.842	37.6	37.6	57.0	17255.1	179.629	0.11876	0.881	0.15000	0.850	0.13947	0.861	0.66	4.274	1.44	1.04	9.41	2.64	59.3	85.5	0.0855	85.5	0.0855	1.00	95.1	95.1	1.00
18-May-10	42	2.136	36.4	36.4	54.2	17309.3	180.193	0.11914	0.881	0.15047	0.850	0.13991	0.860	0.67	4.272	1.57	1.13	10.33	2.61	56.4	88.6	0.0886	88.6	0.0886	1.00	90.7	90.7	1.00
25-May-10	43	2.714	40.0	40.0	57.2	17366.5	180.788	0.11953	0.880	0.15097	0.849	0.14037	0.860	0.70	4.270	1.74	1.25	11.25	2.57	59.5	103.3	0.1033	103.3	0.1033	1.00	96.8	96.8	1.00
01-Jun-10	44	2.567	42.4	42.4	55.8	17422.3	181.369	0.11992	0.880	0.15146	0.849	0.14082	0.859	0.76	4.268	1.82	1.30	11.17	2.50	58.1	106.1	0.1061	106.1	0.1061	1.00	98.0	98.0	1.00
08-Jun-10	45	2.330	43.5	43.5	55.3	17477.6	181.945	0.12030	0.880	0.15194	0.848	0.14127	0.859	0.79	4.267	1.83	1.30	11.09	2.44	57.7	105.3	0.1053	105.3	0.1053	1.00	98.8	98.8	1.00
15-Jun-10	46	1.615	37.1	37.1	34.4	17512.0	182.303	0.12053	0.879	0.15224	0.848	0.14155	0.858	1.08	4.265	2.40	1.68	10.27	2.37	35.9	86.0	0.0860	86.0	0.0860	1.00	71.3	71.3	1.00

Appendix B.1-2

Humidity Cell T2 (Sand-Silt Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining (% of initial value)	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining (% of initial value)	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO4	(Ca+Mg)/Alk	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
22-Jun-10	47	1.248	38.0	38.0	40.0	17552.1	182.720	0.12081	0.879	0.15258	0.847	0.14187	0.858	0.95	4.264	2.01	1.40	9.45	2.30	41.7	83.9	0.0839	83.9	0.0839	1.00	78.4	78.4	1.00
29-Jun-10	48	1.258	39.9	39.9	55.0	17607.1	183.292	0.12119	0.879	0.15306	0.847	0.14231	0.858	0.73	4.262	1.55	1.07	9.89	2.26	57.3	88.9	0.0889	88.9	0.0889	1.00	95.9	95.9	1.00
06-Jul-10	49	1.311	43.3	43.3	53.8	17660.9	183.853	0.12156	0.878	0.15353	0.846	0.14275	0.857	0.80	4.260	1.73	1.19	10.34	2.22	56.1	97.1	0.0971	97.1	0.0971	1.00	98.1	98.1	1.00
13-Jul-10	50	1.635	37.7	37.7	29.5	17690.3	184.159	0.12176	0.878	0.15379	0.846	0.14299	0.857	1.28	4.259	2.70	1.87	9.76	2.27	30.7	82.7	0.0827	82.7	0.0827	1.00	66.8	66.8	1.00
20-Jul-10	51	2.490	43.4	43.4	43.1	17733.4	184.608	0.12206	0.878	0.15416	0.846	0.14334	0.857	1.01	4.258	2.07	1.45	9.19	2.32	44.9	92.9	0.0929	92.9	0.0929	1.00	85.7	85.7	1.00
27-Jul-10	52	2.134	38.3	38.3	53.4	17786.8	185.163	0.12242	0.878	0.15462	0.845	0.14377	0.856	0.72	4.256	1.50	1.04	8.88	2.25	55.6	83.4	0.0834	83.4	0.0834	1.00	91.8	91.8	1.00
03-Aug-10	53	1.849	34.4	34.4	50.0	17836.8	185.684	0.12277	0.877	0.15506	0.845	0.14417	0.856	0.69	4.255	1.46	1.00	8.56	2.17	52.1	76.1	0.0761	76.1	0.0761	1.00	84.6	84.6	1.00
10-Aug-10	54	1.728	24.3	24.3	56.3	17893.0	186.269	0.12316	0.877	0.15555	0.844	0.14463	0.855	0.43	4.253	0.91	0.61	5.78	2.08	58.6	53.1	0.0531	53.1	0.0531	1.00	81.2	81.2	1.00
17-Aug-10	55	1.492	12.7	12.7	12.6	17905.7	186.401	0.12324	0.877	0.15566	0.844	0.14473	0.855	1.00	4.252	2.03	1.31	3.00	1.85	13.1	26.6	0.0266	26.6	0.0266	1.00	24.3	24.3	1.00
24-Aug-10	56	2.486	20.5	20.5	79.6	17985.3	187.229	0.12379	0.876	0.15635	0.844	0.14537	0.855	0.26	4.250	0.68	0.45	6.37	1.97	82.9	56.6	0.0566	56.6	0.0566	1.00	100.9	100.9	1.00
31-Aug-10	57	3.440	28.0	28.0	76.1	18061.4	188.022	0.12431	0.876	0.15701	0.843	0.14599	0.854	0.37	4.247	1.08	0.72	9.74	2.02	79.3	85.5	0.0855	85.5	0.0855	1.00	103.8	103.8	1.00
07-Sep-10	58	2.565	28.4	28.4	58.1	18119.4	188.626	0.12471	0.875	0.15752	0.842	0.14646	0.854	0.49	4.245	1.20	0.81	8.29	2.03	60.5	72.8	0.0728	72.8	0.0728	1.00	86.3	86.3	1.00
14-Sep-10	59	1.552	26.5	26.5	32.8	18152.2	188.967	0.12494	0.875	0.15780	0.842	0.14672	0.853	0.81	4.244	1.62	1.09	6.85	2.06	34.2	55.3	0.0553	55.3	0.0553	1.00	59.1	59.1	1.00
21-Sep-10	60	1.797	38.5	38.5	33.5	18185.7	189.316	0.12517	0.875	0.15809	0.842	0.14699	0.853	1.15	4.243	2.01	1.35	7.07	2.05	34.9	70.1	0.0701	70.1	0.0701	1.00	71.5	71.5	1.00
28-Sep-10	61	1.462	38.4	38.4	29.8	18215.5	189.626	0.12537	0.875	0.15835	0.842	0.14723	0.853	1.29	4.242	2.01	1.35	7.29	2.04	31.1	62.6	0.0626	62.6	0.0626	1.00	68.0	68.0	1.00
05-Oct-10	62	1.753	34.3	34.3	67.9	18283.4	190.333	0.12584	0.874	0.15894	0.841	0.14778	0.852	0.51	4.240	1.63	1.08	11.90	1.98	70.8	115.4	0.1154	115.4	0.1154	1.00	103.3	103.3	1.00
12-Oct-10	63	1.689	27.9	27.9	23.6	18307.0	190.579	0.12600	0.874	0.15915	0.841	0.14797	0.852	1.18	4.239	5.25	3.48	14.20	1.96	24.6	129.0	0.1290	129.0	0.1290	1.00	50.8	50.8	1.00
19-Oct-10	64	1.770	26.6	26.6	61.6	18368.6	191.220	0.12643	0.874	0.15968	0.840	0.14847	0.852	0.43	4.237	2.25	1.49	15.35	1.96	64.2	144.2	0.1442	144.2	0.1442	1.00	89.1	89.1	1.00
26-Oct-10	65	1.697	23.1	23.1	93.5	18462.2	192.194	0.12707	0.873	0.16050	0.840	0.14923	0.851	0.25	4.234	1.50	0.99	16.50	1.95	97.4	146.6	0.1466	146.6	0.1466	1.00	118.9	118.9	1.00
02-Nov-10	66	1.935	31.6	31.6	85.7	18547.9	193.087	0.12766	0.872	0.16124	0.839	0.14992	0.850	0.37	4.231	1.41	0.93	13.72	1.94	89.3	126.1	0.1261	126.1	0.1261	1.00	119.0	119.0	1.00
09-Nov-10	67	2.070	36.2	36.2	96.6	18644.5	194.092	0.12833	0.872	0.16208	0.838	0.15070	0.849	0.37	4.228	1.15	0.76	12.33	1.93	100.6	115.8	0.1158	115.8	0.1158	1.00	134.8	134.8	1.00
16-Nov-10	68	1.955	35.3	35.3	79.9	18724.4	194.924	0.12888	0.871	0.16277	0.837	0.15135	0.849	0.44	4.225	1.21	0.80	11.63	1.92	83.2	100.9	0.1009	100.9	0.1009	1.00	116.6	116.6	1.00
23-Nov-10	69	2.162	40.1	40.1	76.4	18800.8	195.719	0.12940	0.871	0.16344	0.837	0.15196	0.848	0.53	4.222	1.29	0.85	10.93	1.91	79.6	102.7	0.1027	102.7	0.1027	1.00	117.5	117.5	1.00
30-Nov-10	70	2.659	34.2	34.2	73.0	18873.7	196.479	0.12991	0.870	0.16407	0.836	0.15255	0.847	0.47	4.220	1.26	0.82	10.57	1.84	76.0	96.1	0.0961	96.1	0.0961	1.00	107.5	107.5	1.00
07-Dec-10	71	2.843	30.8	30.8	81.7	18955.4	197.329	0.13047	0.870	0.16478	0.835	0.15321	0.847	0.38	4.217	1.07	0.69	10.39	1.80	85.1	91.3	0.0913	91.3	0.0913	1.00	113.0	113.0	1.00
14-Dec-10	72	3.015	30.0	30.0	76.6	19032.0	198.126	0.13099	0.869	0.16545	0.835	0.15383	0.846	0.39	4.215	1.15	0.74	10.30	1.79	79.8	91.5	0.0915	91.5	0.0915	1.00	106.7	106.7	1.00
21-Dec-10	73	3.226	29.5	29.5	72.1	19104.1	198.877	0.13149	0.869	0.16608	0.834	0.15441	0.846	0.41	4.212	1.24	0.79	10.21	1.77	75.1	92.8	0.0928	92.8	0.0928	1.00	101.4	101.4	1.00
28-Dec-10	74	2.731	32.9	32.9	59.9	19164.0	199.500	0.13190	0.868	0.16660	0.833	0.15490	0.845	0.55	4.210	1.41	0.91	10.17	1.80	62.4	88.3	0.0883	88.3	0.0883	1.00	92.6	92.6	1.00
04-Jan-11	75	2.976	41.1	41.1	59.4	19223.4	200.119	0.13231	0.868	0.16711	0.833	0.15538	0.845	0.69	4.208	1.66	1.07	10.15	1.82	61.9	102.6	0.1026	102.6	0.1026	1.00	100.0	100.0	1.00
11-Jan-11	76	2.584	38.2	38.2	53.4	19276.8	200.675	0.13268	0.867	0.16758	0.832	0.15581	0.844	0.71	4.207	1.66	1.07	10.14	1.83	55.6	92.1	0.0921	92.1	0.0921	1.00	91.2	91.2	1.00
18-Jan-11	77	2.520	39.8	39.8	54.0	19330.8	201.237	0.13305	0.867	0.16805	0.832	0.15625	0.844	0.74	4.205	1.65	1.07	10.13	1.84	56.3	93.1	0.0931	93.1	0.0931	1.00	93.6	93.6	1.00
25-Jan-11	78	2.169	36.3	36.3	43.7	19374.5	201.691	0.13335	0.867	0.16843	0.832	0.15660	0.843	0.83	4.203	1.83	1.18	9.71	1.81	45.5	83.3	0.0833	83.3	0.0833	1.00	79.6	79.6	1.00
01-Feb-11	79	2.276	39.3	39.3	62.6	19437.0	202.343	0.13378	0.866	0.16897	0.831	0.15711	0.843	0.63	4.201	1.37	0.88	9.50	1.80	65.2	89.2	0.0892	89.2	0.0892	1.00	102.2	102.2	1.00
08-Feb-11	80	1.887	33.1	33.1	43.7	19480.7	202.797	0.13408	0.866	0.16935	0.831	0.15746	0.843	0.76	4.200	1.64	1.06	9.39	1.80	45.5	74.8	0.0748	74.8	0.0748	1.00	76.7	76.7	1.00
15-Feb-11	81	2.058	36.7	36.7	38.3	19519.0	203.196	0.13435	0.866	0.16968	0.830	0.15777	0.842	0.96	4.198	2.07	1.33	9.29	1.79	39.9	82.5	0.0825	82.5	0.0825	1.00	74.5	74.5	1.00
22-Feb-11	82	1.962	35.0	35.0	52.4	19571.4	203.741	0.13471	0.865	0.17014	0.830	0.15819	0.842	0.67	4.197	1.59	1.02	9.63	1.79	54.6	86.6	0.0866	86.6	0.0866	1.00	87.6	87.6	1.00
01-Mar-11	83	1.925	34.4	34.4	60.1	19631.4	204.366	0.13512	0.865	0.17066	0.829	0.15868	0.841	0.57	4.195	1.42	0.91	9.81	1.79	62.6	89.1	0.0891	89.1	0.0891	1.00	95.1	95.1	1.00
08-Mar-11	84	1.809	32.4	32.4	60.6	19692.0	204.997	0.13554	0.864	0.17119	0.829	0.15917	0.841	0.53	4.193	1.36	0.87	9.90	1.79	63.1	85.9	0.0859	85.9	0.0859	1.00	93.7	93.7	1.00
15-Mar-11	85	1.781	31.9	31.9	63.8	19755.8	205.661	0.13598	0.864	0.17174	0.828	0.15968	0.840	0.50	4.191	1.30	0.84	9.98	1.80	66.4	86.6	0.0866	86.6	0.0866	1.00	96.5	96.5	1.00
22-Mar-11	86	1.515	20.5	20.5	41.3	19797.0	206.090	0.13626	0.864	0.17210	0.828	0.16002	0.840	0.50	4.189	1.33	0.85	6.75	1.79	43.0	57.2	0.0572	57.2	0.0572	1.00	62.0	62.0	1.00
29-Mar-11	87	1.487	16.0	16.0	17.6	19814.6	206.274	0.13638	0.864	0.17225	0.828	0.16016	0.840	0.91	4.189	2.52	1.61	5.14	1.78	18.3	46.2	0.0462	46.2	0.0462	1.00	32.9	32.9	1.00
05-Apr-11	88	1.412	13.1	13.1	19.4	19834.0	206.475	0.13651	0.863	0.17242	0.828	0.16031	0.840	0.67	4.188	1.91	1.22	4.33	1.78	20.2	38.5	0.0385	38.5	0.0385	1.00	31.8	31.8	1.00
12-Apr-11	89	1.353	10.3	10.3	21.3	19855.3	206.697	0.13666	0.863	0.17261	0.827	0.16049	0.840	0.48	4.187	1.41	0.90	3.52	1.77	22.2	31.3	0.0313	31.3	0.0313	1.00	31.1	31.1	1.00
19-Apr-11	90	1.650	21.6	21.6	36.1	19891.4	207.073	0.13691	0.863	0.17292	0.827	0.16078	0.839	0.60	4.186	1.44	0.91	6.37	1.76	37.6	54.0	0.0540	54.0	0.0540	1.00	57.6	57.6	1.00
26-Apr-11	91	1.807	27.2	27.2	81.6	19973.0	207.922	0.13747	0.863	0.17363	0.826	0.16144	0.839	0.33	4.183	0.77	0.49	7.80	1.76	85.0	65.3	0.0653	65.3	0.0653	1.00	110.4	110.4	1.00
03-May-11	92	2.127	33.8	33.8	74.5	20047.5	208.698	0.13798	0.862	0.17428	0.826	0.16204	0.838	0.45	4.181	1.03	0.66	8.51	1.75	77.6	79.9	0.0799	79.9	0.0799	1.00	109.3	109.3	1.00
10-May-11	93	2.202	36.7	36.7	56.9	20104.4	209.290	0.13838	0.862	0.17477	0.825	0.16250	0.838	0.65	4.179	1.45	0.92	9.22	1.75	59.3	85.7	0.0857	85.7	0.0857	1.00	93.8	93.8	1.00
Average of Measured Cycles 31 - 93					*55.5*											*1.6*					*87.3*							

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/I	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L
28-Jul-09	0	750	380	7.70	2790	#N/A	11.8	60.2	1685	68	1580	<0.01	0.26	0.266	0.031	<0.0005	<0.0003	<3	0.0055	539	<0.005	0.0186	0.062	0.352	<0.0003	<0.03
04-Aug-09	1	500	435	7.59	2522	#N/A	8.4	45.6	1698	3.1	1630	0.01	0.52	0.308	0.0107	<0.00005	<0.00003	<0.3	0.00354	571	<0.0005	0.0199	0.0144	0.045	0.00067	0.011
11-Aug-09	2	500	445	7.74	2374	#N/A	9.7	52.9	1667	0.9	1600	0.008	1.3	0.262	0.0088	<0.00005	<0.00003	<0.3	0.00602	568	<0.0005	0.0141	0.0165	0.053	0.00097	0.012
18-Aug-09	3	500	470	7.75	2227	#N/A	8.5	71.0	1445	0.8	1670	0.006	1.47	0.214	0.0099	<0.00005	<0.00003	<0.3	0.00859	607	<0.0005	0.0146	0.0151	0.048	0.00079	0.012
25-Aug-09	4	500	460	7.92	2139				1441																	
01-Sep-09	5	500	420	7.87	2288	#N/A	10.8	68.5	1507	0.7	1740	0.011	1.25	0.176	0.0114	<0.0001	<0.00005	<0.5	0.00968	648	<0.001	0.0136	0.0234	0.026	0.00075	0.013
08-Sep-09	6	500	435	7.70	2221				1751																	
15-Sep-09	7	500	455	7.89	2209	#N/A	10.7	76.3	1508	<0.5	1550	0.004	1.11	0.169	0.0108	<0.00005	<0.00003	<0.3	0.0118	590	<0.0005	0.0122	0.0125	0.007	0.00146	0.012
22-Sep-09	8	500	465	7.87	2132				1500																	
29-Sep-09	9	500	395	7.82	2158	#N/A	8.0	65.6	1824	<0.5	1610	0.005	0.87	0.158	0.0098	<0.00005	<0.00003	<0.3	0.00943	621	<0.0005	0.00861	0.0111	0.037	0.0014	0.01
06-Oct-09	10	500	400	7.77	2270				1703																	
13-Oct-09	11	500	430	7.93	2262	#N/A	5.6	71.3	1676	<0.5	1540	0.005	0.69	0.136	0.0092	<0.00005	<0.00003	<0.3	0.00796	594	<0.0005	0.00526	0.0082	0.007	0.00048	0.009
20-Oct-09	12	500	465	7.83	2173				1642																	
27-Oct-09	13	500	480	7.93	2220	#N/A	6.6	81.8	1398	<0.5	1490	0.005	0.75	0.129	0.009	<0.00005	<0.00003	<0.3	0.0107	577	<0.0005	0.00343	0.0074	0.015	0.00063	0.009
03-Nov-09	14	500	405	7.84	2222				1567																	
10-Nov-09	15	500	460	7.65	2138	#N/A	11.2	70.5	1574	0.8	1520	0.009	0.68	0.106	0.0104	<0.00005	<0.00003	<0.3	0.0103	590	<0.0005	0.003	0.0061	0.034	0.0005	0.008
17-Nov-09	16	500	490	7.91	2151				1489																	
24-Nov-09	17	500	505	8.01	1763	#N/A	6.2	84.4	1197	<0.5	1100	0.005	0.65	0.105	0.0094	<0.00005	<0.00003	<0.3	0.0098	431	<0.0005	0.00214	0.0055	0.008	0.00146	0.006
01-Dec-09	18	500	470	7.98	1075				643																	
08-Dec-09	19	500	455	7.92	1088	#N/A	6.1	73.1	435	<0.5	625	0.006	0.61	0.097	0.0084	<0.00005	<0.00003	<0.3	0.00459	242	<0.0005	0.00157	0.0041	0.008	0.00038	0.004
15-Dec-09	20	500	465	8.10	983				609																	
22-Dec-09	21	500	445	8.01	732	#N/A	3.4	75.2	394	<0.5	441	0.007	0.67	0.101	0.0101	<0.00005	<0.00003	<0.3	0.00322	170	<0.0005	0.00128	0.0036	0.009	0.00026	0.003
29-Dec-09	22	500	435	7.99	777				348																	
05-Jan-10	23	500	430	7.84	685	#N/A	5.6	82.1	299	<0.5	348	0.006	0.76	0.106	0.0124	<0.00005	<0.00003	<0.3	0.0024	133	<0.0005	0.00102	0.0071	0.006	0.0002	0.003
12-Jan-10	24	500	405	7.97	646				271																	
19-Jan-10	25	500	425	8.03	598	#N/A	5.8	90.3	250	<0.5	290	0.006	0.74	0.105	0.0156	<0.0001	<0.00005	<0.5	0.00206	110	<0.001	0.00075	0.0102	<0.01	0.00029	<0.005
26-Jan-10	26	500	445	7.96	414				146																	
02-Feb-10	27	500	485	7.88	354	#N/A	4.1	90.0	133	<0.5	220	0.006	0.66	0.109	0.0174	<0.00005	<0.00003	<0.3	0.00158	82.3	<0.0005	0.00048	0.0031	0.011	0.00023	<0.003
09-Feb-10	28	500	415	7.97	428				122																	
16-Feb-10	29	500	460	8.00	387	#N/A	3.8	102.4	122	<0.5	216	0.007	0.7	0.109	0.0232	<0.00005	<0.00003	<0.3	0.00181	80	<0.0005	0.00045	0.0037	0.005	0.00043	<0.003
23-Feb-10	30	500	490	8.04	352				88																	
02-Mar-10	31	500	440	8.02	338	#N/A	3.3	101.6	89	<0.5	177	0.007	0.65	0.11	0.0422	<0.00005	<0.00003	<0.3	0.00148	65	<0.0005	0.00063	0.0031	<0.005	0.00034	0.003
09-Mar-10	32	500	415	7.97	309				66																	
16-Mar-10	33	500	490	8.12	352	#N/A	2.4	109.7	82	<0.5	159	0.007	0.62	0.117	0.028	<0.00005	<0.00003	<0.3	0.00154	57.8	<0.0005	0.00038	0.006	<0.005	0.00035	<0.003
23-Mar-10	34	500	440	8.01	315				92																	
30-Mar-10	35	500	420	7.98	299	#N/A	2.6	84.5	96	<0.5	154	0.006	0.67	0.121	0.0255	<0.00005	<0.00003	<0.3	0.00116	56	<0.0005	0.00054	0.004	<0.005	0.00031	<0.003
06-Apr-10	36	500	395	7.88	285				90																	
13-Apr-10	37	500	415	7.85	287	#N/A	4.0	72.3	78	<0.5	143	0.01	0.71	0.138	0.025	<0.00005	<0.00003	<0.3	0.00111	51.5	<0.0005	0.00059	0.0024	0.006	0.00029	<0.003
20-Apr-10	38	500	445	8.09	330	#N/A	3.1	102.9	71	<0.5	157	0.007	0.69	0.122	0.0359	<0.00005	<0.00003	<0.3	0.00174	56.1	<0.0005	0.00043	0.0036	<0.005	0.0004	<0.003
27-Apr-10	39	500	500	8.01	284	#N/A	2.5	101.1	55	<0.5	144	0.006	0.58	0.128	0.0323	<0.00005	<0.00003	<0.3	0.00192	51.2	<0.0005	0.0003	0.0036	<0.005	0.00042	<0.003
04-May-10	40	500	485	7.99	301				69																	
11-May-10	41	500	450	7.99	325	#N/A	4.1	120.2	63	<0.5	160	0.007	0.63	0.107	0.0407	<0.00005	<0.00003	<0.3	0.00246	57	<0.0005	0.00034	0.0041	<0.005	0.00058	<0.003
18-May-10	42	500	505	7.92	289				34																	
25-May-10	43	500	410	7.84	160	#N/A	4.3	61.1	16	<0.5	78.3	0.0183	0.37	0.15	0.0172	<0.00001	<0.000005	<0.05	0.00046	28.2	0.0004	0.00031	0.00181	0.007	0.000385	0.001
01-Jun-10	44	500	390	7.78	240				51																	
08-Jun-10	45	500	415	7.81	283	#N/A	3.6	61.2	68	<0.5	143	0.0113	0.47	0.144	0.0319	<0.00001	<0.000005	<0.05	0.00099	51.1	0.0002	0.0007	0.0045	0.004	0.000342	0.0017
15-Jun-10	46	500	455	7.91	289				63																	
22-Jun-10	47	500	415	8.04	322	#N/A	2.4	74.1	86	<0.5	159	0.0077	0.55	0.143	0.0358	<0.00001	<0.000005	<0.05	0.00127	55.8	<0.0001	0.00064	0.00318	0.003	0.000374	0.0017
29-Jun-10	48	500	470	7.90	401				141																	
06-Jul-10	49	500	420	7.85	393	#N/A	3.6	73.9	111	<0.5	222	0.0063	0.49	0.115	0.0408	<0.00001	<0.000005	<0.05	0.00164	79.4	0.0003	0.00064	0.00264	0.006	0.000238	0.0021
13-Jul-10	50	500	440	7.89	380				88																	
20-Jul-10	51	500	460	7.91	391	#N/A	4.6	87.5	116	<0.5	213	0.005	0.42	0.114	0.0418	<0.00001	<0.000005	<0.05	0.00191	75.6	<0.0001	0.00061	0.00237	0.004	0.000341	0.0023
27-Jul-10	52	500	475	7.80	382				122																	

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L
03-Aug-10	53	500	455	8.01	408	#N/A	4.1	87.5	115	<0.5	210	0.008	0.44	0.124	0.0415	<0.00001	<0.000005	<0.05	0.00206	74.2	0.0001	0.00063	0.00254	0.007	0.000437	0.0021
10-Aug-10	54	500	440	7.97	366				150																	
17-Aug-10	55	500	435	7.98	356	#N/A	3.7	76.7	119	<0.5	184	0.0081	0.46	0.124	0.0346	<0.00001	<0.000005	<0.05	0.0017	64.7	<0.0001	0.00054	0.00529	0.009	0.000457	0.0019
24-Aug-10	56	500	430	7.95	346				95																	
31-Aug-10	57	500	445	8.01	322	#N/A	7.3	88.1	119	<0.5	173	0.0085	0.46	0.133	0.0352	<0.00001	<0.000005	<0.05	0.00138	60.4	<0.0001	0.00046	0.00219	0.005	0.000327	0.0018
07-Sep-10	58	500	420	7.75	334				119																	
14-Sep-10	59	500	395	7.83	294	#N/A	4.3	82.6	110	<0.5	167	0.0193	0.41	0.129	0.0307	<0.00001	0.00002	<0.05	0.0014	58.4	0.0001	0.00051	0.00487	0.003	0.000303	0.0017
21-Sep-10	60	500	500	7.94	284				136																	
28-Sep-10	61	500	290	7.83	288	#N/A	4.4	91.1	130	0.8	185	0.0072	0.43	0.138	0.0363	<0.00001	<0.000005	<0.05	0.00156	64.6	<0.0001	0.00065	0.00233	0.002	0.000303	0.0019
05-Oct-10	62	500	480	7.82	336																					
12-Oct-10	63	500	390	7.92	355				159																	
19-Oct-10	64	500	455	7.80	344																					
26-Oct-10	65	500	405	7.83	321	#N/A	3.3	71.9	131	#N/A	175	<0.05	0.37	0.14	0.031	<0.003	<0.05	<0.01	<0.005	60.7	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
02-Nov-10	66	500	460	8.05	341																					
09-Nov-10	67	500	430	7.86	319				153																	
16-Nov-10	68	500	400	8.02	347																					
23-Nov-10	69	500	410	7.74	354	#N/A	4.4	79.2	129	#N/A	181	<0.05	0.36	0.14	0.033	<0.003	<0.05	<0.01	<0.005	62.5	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
30-Nov-10	70	500	415	7.76	352																					
07-Dec-10	71	500	435	7.79	370				144																	
14-Dec-10	72	500	435	7.71	411																					
21-Dec-10	73	500	445	7.53	666	#N/A	7.9	60.2	126	#N/A	196	<0.05	0.31	0.12	0.04	<0.003	<0.05	<0.01	<0.005	66.8	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
28-Dec-10	74	500	395	7.77	349																					
04-Jan-11	75	500	495	7.84	317				86																	
11-Jan-11	76	500	410	7.76	284																					
18-Jan-11	77	500	420	7.80	340	#N/A	5.2	88.1	82	#N/A	172	<0.05	0.3	0.13	0.034	<0.003	<0.05	<0.01	<0.005	59.2	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
25-Jan-11	78	500	445	7.77	357																					
01-Feb-11	79	500	455	7.79	354				101																	
08-Feb-11	80	500	440	7.89	334																					
15-Feb-11	81	500	450	7.80	335	#N/A	4.4	90.5	79	#N/A	175	<0.05	0.27	0.13	0.035	<0.003	<0.05	<0.01	<0.005	60.2	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
22-Feb-11	82	500	460	7.90	342																					
01-Mar-11	83	500	460	7.85	362				116																	
08-Mar-11	84	500	430	7.87	352																					
15-Mar-11	85	500	435	7.85	329	#N/A	3.6	80.5	83	#N/A	167	<0.05	0.24	0.13	0.032	<0.003	<0.05	<0.01	<0.005	57.2	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
22-Mar-11	86	500	445	7.86	332																					
29-Mar-11	87	500	485	7.73	323				82																	
05-Apr-11	88	500	445	7.71	350																					
12-Apr-11	89	500	340	7.68	267	#N/A	4.3	64.2	68	#N/A	129	<0.05	0.28	0.14	0.024	<0.003	<0.05	<0.01	<0.005	44.3	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
19-Apr-11	90	500	450	7.72	287																					
26-Apr-11	91	500	395	7.78	302				78																	
03-May-11	92	500	460	7.83	320																					
10-May-11	93	500	480	7.86	309	#N/A	5.1	90.9	84	#N/A	150	<0.05	0.23	0.13	0.033	<0.003	<0.05	<0.01	<0.005	50.8	<0.01	<0.02	<0.02	<0.01	<0.03	#N/A
17-May-11	94	500	475	7.85	348																					
24-May-11	95	500	450	7.64	333				104																	
31-May-11	96	500	450	7.74	329																					

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
28-Jul-09	0	56.4	1.64	1.8	0.033	0.016	<0.1	43.5	0.003	<5	0.0401	135	1.04	658	0.0016	0.0285	<0.03	0.0021	<0.01	0.029	<0.005
04-Aug-09	1	49.3	1.44	0.06	0.0371	0.0032	0.015	30.8	0.0011	6.8	<0.00003	46.5	0.974	574	0.00122	0.00749	<0.003	0.00185	<0.001	0.0355	<0.0005
11-Aug-09	2	45.2	2.27	<0.05	0.0268	0.0029	0.01	21.9	0.0005	7.36	<0.00003	23.5	0.972	553	0.00089	0.00667	<0.003	0.00164	<0.001	0.0526	<0.0005
18-Aug-09	3	36.8	3.5	<0.05	0.0213	0.0038	<0.01	16.5	0.0006	6.53	0.00006	9.5	0.936	561	0.00058	0.0134	<0.003	0.00186	<0.001	0.127	<0.0005
25-Aug-09	4																				
01-Sep-09	5	28.5	4.13	<0.1	0.0167	0.0033	<0.02	11.4	<0.0004	7.44	<0.00005	3.65	0.899	473	0.00042	0.0138	0.007	0.00176	<0.002	0.171	<0.001
08-Sep-09	6																				
15-Sep-09	7	19.6	5	<0.05	0.014	0.0031	<0.01	8.72	<0.0002	7.59	<0.00003	1.78	0.813	520	0.00038	0.0146	<0.003	0.00158	<0.001	0.242	<0.0005
22-Sep-09	8																				
29-Sep-09	9	14.9	2.57	<0.05	0.0094	0.0097	<0.01	7.15	0.0007	7.21	0.00005	1.14	0.683	564	0.00029	0.0113	<0.003	0.00137	<0.001	0.216	<0.0005
06-Oct-09	10																				
13-Oct-09	11	14.7	0.492	<0.05	0.0048	0.0037	<0.01	5.85	<0.0002	6.47	0.00006	0.79	0.617	550	0.00022	0.00862	<0.003	0.00162	<0.001	0.269	<0.0005
20-Oct-09	12																				
27-Oct-09	13	12	0.422	<0.05	0.0048	0.0033	<0.01	5	<0.0002	7	0.00003	0.56	0.595	500	0.0002	0.00882	<0.003	0.0017	<0.001	0.461	<0.0005
03-Nov-09	14																				
10-Nov-09	15	10.3	0.209	<0.05	0.0041	0.0018	<0.01	4.47	<0.0002	6.19	0.00008	0.49	0.547	484	0.00021	0.00631	<0.003	0.00179	<0.001	0.48	<0.0005
17-Nov-09	16																				
24-Nov-09	17	6.58	0.697	<0.05	0.0047	0.0016	<0.01	3.23	<0.0002	5.83	<0.00003	0.43	0.393	358	0.00024	0.00811	<0.003	0.00127	<0.001	0.455	<0.0005
01-Dec-09	18																				
08-Dec-09	19	4.84	0.0582	<0.05	0.0035	0.0011	<0.01	2.2	<0.0002	4.73	0.00004	0.31	0.228	190	0.00012	0.00473	0.004	0.00084	<0.001	0.242	<0.0005
15-Dec-09	20																				
22-Dec-09	21	3.99	0.0322	<0.05	0.0038	0.0011	<0.01	1.79	<0.0002	4.46	<0.00003	0.44	0.168	131	0.00009	0.00456	<0.003	0.00058	<0.001	0.169	<0.0005
29-Dec-09	22																				
05-Jan-10	23	3.91	0.0225	<0.05	0.0045	0.0005	<0.01	1.57	<0.0002	4.9	<0.00003	0.27	0.134	104	0.00006	0.00587	<0.003	0.00052	<0.001	0.124	<0.0005
12-Jan-10	24																				
19-Jan-10	25	4.03	0.0199	<0.1	0.0045	0.0043	<0.02	1.54	0.0005	5.01	<0.00005	0.36	0.117	78	0.0001	0.005	0.007	0.00054	<0.002	0.117	<0.001
26-Jan-10	26																				
02-Feb-10	27	3.5	0.0164	<0.05	0.004	0.0005	<0.01	1.34	<0.0002	4.67	0.00008	0.27	0.0904	48	0.00008	0.00538	<0.003	0.00041	<0.001	0.0865	<0.0005
09-Feb-10	28																				
16-Feb-10	29	4.05	0.031	<0.05	0.0049	0.0003	<0.01	1.36	<0.0002	4.69	0.00004	0.28	0.0982	38	0.00007	0.00818	<0.003	0.00045	<0.001	0.0949	<0.0005
23-Feb-10	30																				
02-Mar-10	31	3.71	0.0313	<0.05	0.0048	0.0008	<0.01	1.23	0.0003	4.61	0.00004	0.26	0.0868	33	0.00008	0.00626	<0.003	0.00043	<0.001	0.0808	<0.0005
09-Mar-10	32																				
16-Mar-10	33	3.6	0.0299	<0.05	0.0044	0.0004	<0.01	1.1	<0.0002	4.64	<0.00003	<0.3	0.0803	<50	0.00008	0.00804	<0.003	0.00032	<0.001	0.0801	<0.0005
23-Mar-10	34																				
30-Mar-10	35	3.51	0.0116	<0.05	0.0047	0.0004	<0.01	1.03	<0.0002	3.34	<0.00003	0.24	0.0743	29	0.00006	0.0038	<0.003	0.00038	<0.001	0.0582	<0.0005
06-Apr-10	36																				
13-Apr-10	37	3.6	0.0101	<0.05	0.0047	0.0003	<0.01	1	<0.0002	4.54	0.00003	<0.3	0.0687	<50	0.00006	0.00347	<0.003	0.00029	<0.001	0.0481	<0.0005
20-Apr-10	38	4.2	0.0235	<0.05	0.0043	0.0003	<0.01	1.1	<0.0002	4.45	0.00004	<0.3	0.0848	<50	0.00007	0.00469	<0.003	0.00034	<0.001	0.0782	<0.0005
27-Apr-10	39	3.9	0.104	<0.05	0.0046	0.0004	<0.01	1	<0.0002	4.92	<0.00003	<0.3	0.0699	<50	0.00006	0.00456	<0.003	0.00029	<0.001	0.102	<0.0005
04-May-10	40																				
11-May-10	41	4.2	0.0953	<0.05	0.0038	0.0003	<0.01	1	<0.0002	5.61	<0.00003	<0.3	0.0833	<50	0.00007	0.00537	<0.003	0.00029	<0.001	0.124	<0.0005
18-May-10	42																				
25-May-10	43	1.9	0.00754	<0.01	0.00217	0.00023	0.011	0.54	0.00008	2.09	0.000077	0.22	0.0392	<10	0.00003	0.00235	<0.0005	0.000192	<0.0002	0.0166	<0.0001
01-Jun-10	44																				
08-Jun-10	45	3.64	0.0144	<0.01	0.00327	0.00025	0.005	0.95	0.00007	3.86	0.000062	0.33	0.0671	30	0.000065	0.00053	<0.0005	0.000319	<0.0002	0.034	<0.0001
15-Jun-10	46																				
22-Jun-10	47	4.75	0.0118	<0.01	0.00379	0.0003	0.007	1.07	0.00006	3.53	0.000098	0.29	0.0831	37	0.000079	0.00012	<0.0005	0.000394	<0.0002	0.0458	<0.0001
29-Jun-10	48																				
06-Jul-10	49	5.83	0.0165	<0.01	0.00303	0.00042	0.002	0.97	0.00048	3.85	0.000098	0.4	0.0997	49	0.000045	0.00016	<0.0005	0.000377	<0.0002	0.0671	<0.0001
13-Jul-10	50																				
20-Jul-10	51	5.85	0.0168	<0.01	0.00257	0.00011	0.004	1	0.00007	3.66	0.000106	0.24	0.102	45	0.000062	0.00016	<0.0005	0.000397	<0.0002	0.0927	<0.0001
27-Jul-10	52																				

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
03-Aug-10	53	5.98	0.0179	<0.01	0.00306	0.00032	0.005	1.05	0.00006	3.79	0.000045	0.23	0.102	53	0.000077	0.00014	<0.0005	0.000414	<0.0002	0.0972	<0.0001
10-Aug-10	54																				
17-Aug-10	55	5.46	0.0163	<0.01	0.00298	0.00034	0.003	0.84	0.00009	3.48	0.000013	0.27	0.0874	42	0.00006	0.0001	<0.0005	0.000364	<0.0002	0.071	<0.0001
24-Aug-10	56																				
31-Aug-10	57	5.4	0.017	<0.01	0.00336	0.00033	0.005	0.83	0.00028	3.3	0.000012	0.25	0.0868	36	0.000062	0.00005	<0.0005	0.00034	<0.0002	0.0624	<0.0001
07-Sep-10	58																				
14-Sep-10	59	5.05	0.0161	<0.01	0.00285	0.00026	0.006	0.78	0.00008	3.55	0.000076	0.27	0.0778	33	0.000044	0.00009	<0.0005	0.000329	<0.0002	0.0629	<0.0001
21-Sep-10	60																				
28-Sep-10	61	5.77	0.0201	<0.01	0.00313	0.0003	0.005	0.85	0.00012	3.73	0.000035	0.28	0.0913	41	0.000051	0.00012	<0.0005	0.0232	<0.0002	0.0606	<0.0001
05-Oct-10	62																				
12-Oct-10	63																				
19-Oct-10	64																				
26-Oct-10	65	5.66	0.016	#N/A	<0.02	<0.02	<0.05	0.6	<0.1	2.9	<0.01	0.2	0.081	36.3	#N/A	<0.03	<0.005	#N/A	<0.01	0.055	<0.02
02-Nov-10	66																				
09-Nov-10	67																				
16-Nov-10	68																				
23-Nov-10	69	6.06	0.012	#N/A	<0.02	<0.02	<0.05	0.6	<0.1	2.68	<0.01	0.2	0.085	38.9	#N/A	<0.03	<0.005	#N/A	<0.01	0.063	<0.02
30-Nov-10	70																				
07-Dec-10	71																				
14-Dec-10	72																				
21-Dec-10	73	7.01	0.011	#N/A	<0.02	<0.02	<0.05	0.9	<0.1	2.99	<0.01	0.3	0.097	40.1	#N/A	<0.03	<0.005	#N/A	<0.01	0.074	<0.02
28-Dec-10	74																				
04-Jan-11	75																				
11-Jan-11	76																				
18-Jan-11	77	5.99	0.009	#N/A	<0.02	<0.02	<0.05	0.7	<0.1	3.21	<0.01	0.4	0.084	30.5	#N/A	<0.03	<0.005	#N/A	<0.01	0.066	<0.02
25-Jan-11	78																				
01-Feb-11	79																				
08-Feb-11	80																				
15-Feb-11	81	6.12	0.01	#N/A	<0.02	<0.02	<0.05	0.6	<0.1	3.25	<0.01	<0.1	0.085	29.7	#N/A	<0.03	<0.005	#N/A	<0.01	0.074	<0.02
22-Feb-11	82																				
01-Mar-11	83																				
08-Mar-11	84																				
15-Mar-11	85	5.74	0.008	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.98	<0.01	0.1	0.078	30.1	#N/A	<0.03	<0.005	#N/A	<0.01	0.066	<0.02
22-Mar-11	86																				
29-Mar-11	87																				
05-Apr-11	88																				
12-Apr-11	89	4.49	0.006	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	2.72	<0.01	<0.1	0.061	26.8	#N/A	<0.03	<0.005	#N/A	<0.01	0.04	<0.02
19-Apr-11	90																				
26-Apr-11	91																				
03-May-11	92																				
10-May-11	93	5.71	0.011	#N/A	<0.02	<0.02	<0.05	0.5	<0.1	3.04	<0.01	0.2	0.072	25.8	#N/A	<0.03	<0.005	#N/A	<0.01	0.065	<0.02
17-May-11	94																				
24-May-11	95																				
31-May-11	96																				

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Weekly Production (mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/kg	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg
28-Jul-09	0	7.7	22.8798	640.3	0.0019	0.09766	0.101080	0.0118	0.00009500	0.000057000	0.57000
04-Aug-09	1	7.59	19.84035	738.63	0.0044	0.22620	0.133980	0.0047	0.00001088	0.000006525	0.06525
11-Aug-09	2	7.74	23.5316	741.815	0.0036	0.57850	0.116590	0.0039	0.00001113	0.000006675	0.06675
18-Aug-09	3	7.75	33.3653	679.15	0.0028	0.69090	0.100580	0.0047	0.00001175	0.000007050	0.07050
25-Aug-09	4	7.92	32.0919	662.86	0.0039	0.62560	0.089700	0.0049	0.00001725	0.000009200	0.09200
01-Sep-09	5	7.87	28.7868	632.94	0.0046	0.52500	0.073920	0.0048	0.00002100	0.000010500	0.10500
08-Sep-09	6	7.7	31.5114	761.685	0.0033	0.51330	0.075038	0.0048	0.00001631	0.000008700	0.08700
15-Sep-09	7	7.89	34.7347	686.14	0.0018	0.50505	0.076895	0.0049	0.00001138	0.000006825	0.06825
22-Sep-09	8	7.87	33.0057	697.5	0.0021	0.45965	0.076028	0.0048	0.00001163	0.000006975	0.06975
29-Sep-09	9	7.82	25.9199	720.48	0.0020	0.34247	0.062410	0.0039	0.00000988	0.000005925	0.05925
06-Oct-09	10	7.77	27.374	681.2	0.0020	0.31160	0.058800	0.0038	0.00001000	0.000006000	0.06000
13-Oct-09	11	7.93	30.6375	720.68	0.0022	0.29713	0.058480	0.0040	0.00001075	0.000006450	0.06450
20-Oct-09	12	7.83	35.579475	763.53	0.0023	0.33596	0.061613	0.0042	0.00001163	0.000006975	0.06975
27-Oct-09	13	7.93	39.2544	671.04	0.0024	0.36192	0.061920	0.0043	0.00001200	0.000007200	0.07200
03-Nov-09	14	7.84	30.83265	634.635	0.0028	0.29120	0.047588	0.0039	0.00001013	0.000006075	0.06075
10-Nov-09	15	7.65	32.4208	724.04	0.0041	0.31464	0.048760	0.0048	0.00001150	0.000006900	0.06900
17-Nov-09	16	7.91	37.9554	729.61	0.0034	0.32659	0.051695	0.0049	0.00001225	0.000007350	0.07350
24-Nov-09	17	8.01	42.6422	604.485	0.0025	0.32775	0.053025	0.0047	0.00001263	0.000007575	0.07575
01-Dec-09	18	7.98	37.02895	302.21	0.0026	0.29634	0.047470	0.0042	0.00001175	0.000007050	0.07050
08-Dec-09	19	7.92	33.27415	197.925	0.0027	0.27846	0.044135	0.0038	0.00001138	0.000006825	0.06825
15-Dec-09	20	8.1	34.496025	283.185	0.0030	0.29760	0.046035	0.0043	0.00001163	0.000006975	0.06975
22-Dec-09	21	8.01	33.4818	175.33	0.0031	0.29726	0.044945	0.0045	0.00001113	0.000006675	0.06675
29-Dec-09	22	7.99	34.219275	151.38	0.0028	0.30950	0.045023	0.0049	0.00001088	0.000006525	0.06525
05-Jan-10	23	7.84	35.2987	128.57	0.0026	0.32465	0.045580	0.0053	0.00001075	0.000006450	0.06450
12-Jan-10	24	7.97	34.911	109.755	0.0024	0.30314	0.042728	0.0057	0.00001519	0.000008100	0.08100
19-Jan-10	25	8.03	38.38175	106.25	0.0026	0.31535	0.044625	0.0066	0.00002125	0.000010625	0.10625
26-Jan-10	26	7.96	40.11675	64.97	0.0027	0.31083	0.047615	0.0073	0.00001669	0.000008900	0.08900
02-Feb-10	27	7.88	43.64515	64.505	0.0029	0.31768	0.052865	0.0084	0.00001213	0.000007275	0.07275
09-Feb-10	28	7.97	39.912625	50.63	0.0027	0.28199	0.045235	0.0084	0.00001038	0.000006225	0.06225
16-Feb-10	29	8	47.0856	56.12	0.0032	0.32384	0.050140	0.0107	0.00001150	0.000006900	0.06900
23-Feb-10	30	8.04	49.9702	43.12	0.0034	0.33198	0.053655	0.0160	0.00001225	0.000007350	0.07350
02-Mar-10	31	8.02	44.704	39.16	0.0031	0.28644	0.048400	0.0186	0.00001100	0.000006600	0.06600
09-Mar-10	32	7.97	43.8489	27.39	0.0029	0.26456	0.047103	0.0146	0.00001038	0.000006225	0.06225
16-Mar-10	33	8.12	53.7628	40.18	0.0034	0.30576	0.057330	0.0137	0.00001225	0.000007350	0.07350
23-Mar-10	34	8.01	42.7284	40.48	0.0029	0.28424	0.052360	0.0118	0.00001100	0.000006600	0.06600
30-Mar-10	35	7.98	35.49	40.32	0.0025	0.28056	0.050820	0.0107	0.00001050	0.000006300	0.06300
06-Apr-10	36	7.88	30.962075	35.55	0.0032	0.27255	0.051153	0.0100	0.00000988	0.000005925	0.05925
13-Apr-10	37	7.85	29.99205	32.37	0.0042	0.29548	0.057270	0.0104	0.00001038	0.000006225	0.06225
20-Apr-10	38	8.09	45.7727	31.595	0.0031	0.30750	0.054290	0.0160	0.00001113	0.000006675	0.06675
27-Apr-10	39	8.01	50.55	27.5	0.0030	0.28950	0.064000	0.0162	0.00001250	0.000007500	0.07500
04-May-10	40	7.99	53.6604	33.465	0.0032	0.29318	0.056988	0.0177	0.00001213	0.000007275	0.07275
11-May-10	41	7.99	54.081	28.35	0.0032	0.28350	0.048150	0.0183	0.00001125	0.000006750	0.06750
18-May-10	42	7.92	45.760575	17.17	0.0064	0.25124	0.064893	0.0146	0.00000758	0.000004419	0.04419
25-May-10	43	7.84	25.0305	6.56	0.0075	0.14965	0.061500	0.0071	0.00000205	0.000001025	0.01025
01-Jun-10	44	7.78	23.83485	19.89	0.0058	0.16302	0.057330	0.0096	0.00000195	0.000000975	0.00975
08-Jun-10	45	7.81	25.3897	28.22	0.0047	0.19547	0.059760	0.0132	0.00000208	0.000001038	0.01038
15-Jun-10	**46**	**7.91**	**30.778475**	**28.665**	**0.0043**	**0.23296**	**0.065293**	**0.0154**	**0.00000228**	**0.000001138**	**0.01138**
22-Jun-10	47	8.04	30.75565	35.69	0.0032	0.22950	0.059345	0.0149	0.00000208	0.000001038	0.01038
29-Jun-10	48	7.9	34.79175	66.27	0.0033	0.24440	0.060630	0.0180	0.00000235	0.000001175	0.01175
06-Jul-10	49	7.85	31.0548	46.62	0.0026	0.20454	0.048300	0.0171	0.00000210	0.000001050	0.01050
13-Jul-10	50	7.89	35.5124	38.72	0.0025	0.19932	0.050380	0.0182	0.00000220	0.000001100	0.01100
20-Jul-10	51	7.91	40.2408	53.36	0.0023	0.19274	0.052440	0.0192	0.00000230	0.000001150	0.01150
27-Jul-10	52	7.8	41.564875	57.95	0.0031	0.20449	0.056525	0.0198	0.00000238	0.000001188	0.01188
03-Aug-10	53	8.01	39.82615	52.325	0.0036	0.20111	0.056420	0.0189	0.00000228	0.000001138	0.01138
10-Aug-10	54	7.97	36.1372	66	0.0035	0.19778	0.054560	0.0167	0.00000220	0.000001100	0.01100
17-Aug-10	55	7.98	33.37755	51.765	0.0035	0.19880	0.053940	0.0151	0.00000218	0.000001088	0.01088
24-Aug-10	56	7.95	35.432	40.85	0.0036	0.19716	0.055255	0.0150	0.00000215	0.000001075	0.01075
31-Aug-10	57	8.01	39.19115	52.955	0.0038	0.20470	0.059185	0.0157	0.00000223	0.000001113	0.01113
07-Sep-10	58	7.75	35.8428	49.98	0.0058	0.18354	0.055020	0.0138	0.00000210	0.000004725	0.01050
14-Sep-10	59	7.83	32.63095	43.45	0.0076	0.16353	0.050955	0.0121	0.00000198	0.000007900	0.00988
21-Sep-10	60	7.94	43.435	68	0.0066	0.21125	0.066750	0.0168	0.00000250	0.000005625	0.01250
28-Sep-10	61	7.83	26.4277	37.7	0.0021	0.12499	0.040020	0.0105	0.00000145	0.000000725	0.00725
05-Oct-10	62	7.82	39.1344	62.64	0.0077	0.19224	0.066720	0.0162	0.00036120	0.006000600	0.00720
12-Oct-10	63	7.92	29.9247	62.01	0.0080	0.15025	0.054405	0.0126	0.00043924	0.007312744	0.00390
19-Oct-10	64	7.8	33.82015	65.975	0.0104	0.17182	0.063586	0.0144	0.00059747	0.009953267	0.00341
26-Oct-10	65	7.83	29.13165	53.055	0.0101	0.14985	0.056700	0.0126	0.00060750	0.010125000	0.00203
02-Nov-10	66	8.05	34.7622	59.8	0.0115	0.16790	0.064400	0.0147	0.00069000	0.011500000	0.00230
09-Nov-10	67	7.86	33.2777	65.79	0.0108	0.15588	0.060200	0.0140	0.00064500	0.010750000	0.00215
16-Nov-10	68	8.02	31.32	56.4	0.0100	0.14450	0.056000	0.0131	0.00060000	0.010000000	0.00200
23-Nov-10	69	7.74	32.4761	52.89	0.0103	0.14760	0.057400	0.0135	0.00061500	0.010250000	0.00205
30-Nov-10	70	7.76	28.9172	52.9125	0.0104	0.13903	0.053950	0.0151	0.00062250	0.010375000	0.00208
07-Dec-10	71	7.79	28.238025	62.64	0.0109	0.14029	0.054375	0.0166	0.00065250	0.010875000	0.00218
14-Dec-10	72	7.71	27.2016375	58.725	0.0109	0.13757	0.053288	0.0170	0.00065250	0.010875000	0.00218
21-Dec-10	73	7.53	26.76675	56.07	0.0111	0.13795	0.053400	0.0178	0.00066750	0.011125000	0.00223
28-Dec-10	74	7.77	29.287275	41.08	0.0099	0.12048	0.049375	0.0146	0.00059250	0.009875000	0.00198
04-Jan-11	75	7.84	40.1655375	42.57	0.0124	0.14974	0.063113	0.0176	0.00074250	0.012375000	0.00248
11-Jan-11	76	7.76	34.7029125	34.44	0.0103	0.12351	0.052788	0.0142	0.00061500	0.010250000	0.00205
18-Jan-11	77	7.8	37.0188	34.44	0.0105	0.12600	0.054600	0.0143	0.00063000	0.010500000	0.00210
25-Jan-11	78	7.77	39.7385	35.8225	0.0111	0.12683	0.057850	0.0154	0.00066750	0.011125000	0.00223
01-Feb-11	79	7.79	40.8954	45.955	0.0114	0.12626	0.059150	0.0158	0.00068250	0.011375000	0.00228
08-Feb-11	80	7.89	39.6748	39.6	0.0110	0.12045	0.057200	0.0153	0.00066000	0.011000000	0.00220
15-Feb-11	81	7.8	40.707	35.55	0.0113	0.12150	0.058500	0.0158	0.00067500	0.011250000	0.00225
22-Feb-11	82	7.9	39.3093	37.26	0.0115	0.11730	0.059800	0.0154	0.00069000	0.011500000	0.00230
01-Mar-11	83	7.85	38.15815	53.36	0.0115	0.11385	0.059800	0.0151	0.00069000	0.011500000	0.00230
08-Mar-11	84	7.87	35.1315375	42.785	0.0108	0.10481	0.055900	0.0139	0.00064500	0.010750000	0.00215
15-Mar-11	85	7.85	34.99575	36.105	0.0109	0.10440	0.056550	0.0139	0.00065250	0.010875000	0.00218
22-Mar-11	86	7.86	32.184625	33.5975	0.0111	0.11570	0.060075	0.0125	0.00066750	0.011125000	0.00223
29-Mar-11	87	7.73	33.1073125	39.77	0.0121	0.13095	0.066688	0.0126	0.00072750	0.012125000	0.00243
05-Apr-11	88	7.71	29.47290625	33.375	0.0111	0.12238	0.061744	0.0111	0.00066750	0.011125000	0.00223
12-Apr-11	89	7.68	21.828	23.12	0.0085	0.09520	0.047600	0.0082	0.00051000	0.008500000	0.00170
19-Apr-11	90	7.72	34.902	34.2	0.0113	0.11475	0.060750	0.0128	0.00067500	0.011250000	0.00225
26-Apr-11	91	7.78	33.2748	30.81	0.0099	0.09579	0.052338	0.0121	0.00059250	0.009875000	0.00198
03-May-11	92	7.83	40.2868	37.26	0.0115	0.10868	0.060375	0.0147	0.00069000	0.011500000	0.00230
10-May-11	93	7.86	43.6416	40.32	0.0120	0.11040	0.062400	0.0158	0.00072000	0.012000000	0.00240

Date	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg
28-Jul-09	0.00209000	204.82	0.0009500	0.0070680	0.02356	0.13376	0.000057	0.005700	21.43	0.623200	0.00068400	0.01254	0.00608	0.019000
04-Aug-09	0.00153990	248.39	0.0001088	0.0086565	0.00626	0.01958	0.000291	0.004785	21.45	0.626400	0.00002610	0.01614	0.00139	0.006525
11-Aug-09	0.00267890	252.76	0.0001113	0.0062745	0.00734	0.02359	0.000432	0.005340	20.11	1.010150	0.00001113	0.01193	0.00129	0.004450
18-Aug-09	0.00403730	285.29	0.0001175	0.0068620	0.00710	0.02256	0.000371	0.005640	17.30	1.645000	0.00001175	0.01001	0.00179	0.002350
25-Aug-09	0.00420210	288.65	0.0001725	0.0064860	0.00886	0.01702	0.000354	0.005750	15.02	1.754900	0.00001725	0.00874	0.00163	0.003450
01-Sep-09	0.00406560	272.16	0.0002100	0.0057120	0.00983	0.01092	0.000315	0.005460	11.97	1.734600	0.00002100	0.00701	0.00139	0.004200
08-Sep-09	0.00467190	269.27	0.0001631	0.0056115	0.00781	0.00718	0.000481	0.005438	10.46	1.985775	0.00001631	0.00668	0.00139	0.003263
15-Sep-09	0.00536900	268.45	0.0001138	0.0055510	0.00569	0.00319	0.000664	0.005460	8.92	2.275000	0.00001138	0.00637	0.00141	0.002275
22-Sep-09	0.00493598	281.56	0.0001163	0.0048383	0.00549	0.01023	0.000665	0.005115	8.02	1.760025	0.00001163	0.00544	0.00298	0.002325
29-Sep-09	0.00372485	245.30	0.0000988	0.0034010	0.00438	0.01462	0.000553	0.003950	5.89	1.015150	0.00000988	0.00371	0.00383	0.001975
06-Oct-09	0.00347800	243.00	0.0001000	0.0027740	0.00386	0.00880	0.000376	0.003800	5.92	0.612400	0.00001000	0.00284	0.00268	0.002000
13-Oct-09	0.00342280	255.42	0.0001075	0.0022618	0.00353	0.00301	0.000206	0.003870	6.32	0.211560	0.00001075	0.00206	0.00159	0.002150
20-Oct-09	0.00433845	272.26	0.0001163	0.0020204	0.00363	0.00512	0.000258	0.004185	6.21	0.212505	0.00001163	0.00223	0.00163	0.002325
27-Oct-09	0.00513600	276.96	0.0001200	0.0016464	0.00355	0.00720	0.000302	0.004320	5.76	0.202560	0.00001200	0.00230	0.00158	0.002400
03-Nov-09	0.00425250	236.32	0.0001013	0.0013021	0.00273	0.00992	0.000229	0.003443	4.52	0.127778	0.00001013	0.00180	0.00103	0.002025
10-Nov-09	0.00473800	271.40	0.0001150	0.0013800	0.00281	0.01564	0.000230	0.003680	4.74	0.096140	0.00001150	0.00189	0.00083	0.002300
17-Nov-09	0.00492450	250.15	0.0001225	0.0012593	0.00284	0.01029	0.000480	0.003430	4.14	0.221970	0.00001225	0.00216	0.00083	0.002450
24-Nov-09	0.00494900	217.66	0.0001263	0.0010807	0.00278	0.00404	0.000737	0.003030	3.32	0.351985	0.00001263	0.00237	0.00081	0.002525
01-Dec-09	0.00338165	158.16	0.0001175	0.0008719	0.00226	0.00376	0.000432	0.002350	2.68	0.177472	0.00001175	0.00193	0.00063	0.002350
08-Dec-09	0.00208845	110.11	0.0001138	0.0007144	0.00187	0.00364	0.000173	0.001820	2.20	0.026481	0.00001138	0.00159	0.00050	0.002275
15-Dec-09	0.00181583	95.79	0.0001163	0.0006626	0.00179	0.00395	0.000149	0.001628	2.05	0.021018	0.00001163	0.00170	0.00051	0.002325
22-Dec-09	0.00143290	75.65	0.0001113	0.0005696	0.00160	0.00401	0.000116	0.001335	1.78	0.014329	0.00001113	0.00169	0.00049	0.002225
29-Dec-09	0.00122235	65.90	0.0001088	0.0005003	0.00233	0.00326	0.000100	0.001305	1.72	0.011897	0.00001088	0.00181	0.00035	0.002175
05-Jan-10	0.00103200	57.19	0.0001075	0.0004386	0.00305	0.00258	0.000086	0.001290	1.68	0.009675	0.00001075	0.00194	0.00022	0.002150
12-Jan-10	0.00090315	49.21	0.0001519	0.0003584	0.00350	0.00223	0.000099	0.001114	1.61	0.008586	0.00001519	0.00182	0.00097	0.003038
19-Jan-10	0.00087550	46.75	0.0002125	0.0003188	0.00434	0.00213	0.000123	0.001063	1.71	0.008458	0.00002125	0.00191	0.00183	0.004250
26-Jan-10	0.00080990	42.79	0.0001669	0.0002737	0.00296	0.00356	0.000116	0.000890	1.68	0.008077	0.00001669	0.00189	0.00107	0.003338
02-Feb-10	0.00076630	39.92	0.0001213	0.0002328	0.00150	0.00534	0.000112	0.000728	1.70	0.007954	0.00001213	0.00194	0.00024	0.002425
09-Feb-10	0.00070343	33.68	0.0001038	0.0001930	0.00141	0.00332	0.000137	0.000623	1.57	0.009836	0.00001038	0.00185	0.00017	0.002075
16-Feb-10	0.00083260	36.80	0.0001150	0.0002070	0.00170	0.00230	0.000198	0.000690	1.86	0.014260	0.00001150	0.00225	0.00014	0.002300
23-Feb-10	0.00080605	35.53	0.0001225	0.0002646	0.00167	0.00184	0.000189	0.001103	1.90	0.015264	0.00001225	0.00238	0.00027	0.002450
02-Mar-10	0.00065120	28.60	0.0001100	0.0002772	0.00136	0.00110	0.000150	0.001320	1.63	0.013772	0.00001100	0.00211	0.00035	0.002200
09-Mar-10	0.00062665	25.48	0.0001038	0.0002096	0.00189	0.00104	0.000143	0.000934	1.52	0.012699	0.00001038	0.00191	0.00025	0.002075
16-Mar-10	0.00075460	28.32	0.0001225	0.0001862	0.00294	0.00123	0.000172	0.000735	1.76	0.014651	0.00001225	0.00216	0.00020	0.002450
23-Mar-10	0.00059400	25.04	0.0001100	0.0002024	0.00220	0.00110	0.000145	0.000660	1.56	0.009130	0.00001100	0.00200	0.00018	0.002200
30-Mar-10	0.00048720	23.52	0.0001050	0.0002268	0.00168	0.00105	0.000130	0.000630	1.47	0.004872	0.00001050	0.00197	0.00017	0.002100
06-Apr-10	0.00044833	21.23	0.0000988	0.0002232	0.00126	0.00168	0.000119	0.000593	1.40	0.004286	0.00000988	0.00186	0.00014	0.001975
13-Apr-10	0.00046065	21.37	0.0001038	0.0002449	0.00100	0.00249	0.000120	0.000623	1.49	0.004192	0.00001038	0.00195	0.00012	0.002075
20-Apr-10	0.00077430	24.96	0.0001113	0.0001914	0.00160	0.00111	0.000178	0.000668	1.87	0.010458	0.00001113	0.00191	0.00013	0.002225
27-Apr-10	0.00096000	25.60	0.0001250	0.0001500	0.00180	0.00125	0.000210	0.000750	1.95	0.052000	0.00001250	0.00230	0.00020	0.002500
04-May-10	0.00106215	26.24	0.0001213	0.0001552	0.00187	0.00121	0.000243	0.000728	1.96	0.048330	0.00001213	0.00204	0.00017	0.002425
11-May-10	0.00110700	25.65	0.0001125	0.0001530	0.00185	0.00113	0.000261	0.000675	1.89	0.042885	0.00001125	0.00171	0.00014	0.002250
18-May-10	0.00073831	21.51	0.0001641	0.0001646	0.00149	0.00240	0.000244	0.000631	1.54	0.025967	0.00000758	0.00151	0.00013	0.004040
25-May-10	0.00019024	11.56	0.0001640	0.0001279	0.00074	0.00287	0.000158	0.000410	0.78	0.003091	0.00000205	0.00089	0.00009	0.004510
01-Jun-10	0.00028431	15.46	0.0001170	0.0001964	0.00123	0.00215	0.000142	0.000527	1.08	0.004278	0.00000195	0.00106	0.00009	0.003120
08-Jun-10	0.00041251	21.21	0.0000830	0.0002884	0.00187	0.00166	0.000142	0.000706	1.51	0.005976	0.00000208	0.00136	0.00010	0.002075
15-Jun-10	**0.00051506**	**24.32**	**0.0000569**	**0.0003033**	**0.00175**	**0.00159**	**0.000163**	**0.000774**	**1.91**	**0.005961**	**0.00000228**	**0.00161**	**0.00013**	**0.002730**
22-Jun-10	0.00052705	23.16	0.0000208	0.0002648	0.00132	0.00125	0.000155	0.000706	1.97	0.004897	0.00000208	0.00157	0.00012	0.002905
29-Jun-10	0.00068385	31.77	0.0000823	0.0002992	0.00137	0.00212	0.000144	0.000893	2.49	0.006651	0.00000235	0.00160	0.00017	0.002115
06-Jul-10	0.00068880	33.35	0.0001260	0.0002667	0.00111	0.00252	0.000100	0.000882	2.45	0.006930	0.00000210	0.00127	0.00018	0.000840
13-Jul-10	0.00078100	34.10	0.0000770	0.0002746	0.00110	0.00220	0.000127	0.000968	2.57	0.007326	0.00000220	0.00123	0.00012	0.001320
20-Jul-10	0.00087860	34.78	0.0000230	0.0002820	0.00109	0.00184	0.000157	0.001058	2.69	0.007728	0.00000230	0.00118	0.00005	0.001840
27-Jul-10	0.00094288	35.58	0.0000356	0.0002947	0.00117	0.00261	0.000185	0.001045	2.81	0.008241	0.00000238	0.00134	0.00010	0.002138
03-Aug-10	0.00093730	33.76	0.0000455	0.0002857	0.00116	0.00319	0.000199	0.000956	2.72	0.008145	0.00000228	0.00139	0.00015	0.002275
10-Aug-10	0.00082720	30.56	0.0000330	0.0002565	0.00172	0.00352	0.000197	0.000880	2.52	0.007524	0.00000220	0.00133	0.00015	0.001760
17-Aug-10	0.00073950	28.14	0.0000218	0.0002340	0.00230	0.00392	0.000199	0.000827	2.38	0.007091	0.00000218	0.00130	0.00015	0.001305
24-Aug-10	0.00066220	26.90	0.0000215	0.0002152	0.00161	0.00301	0.000169	0.000796	2.33	0.007160	0.00000215	0.00136	0.00014	0.001720
31-Aug-10	0.00061410	26.88	0.0000223	0.0002060	0.00097	0.00223	0.000146	0.000801	2.40	0.007565	0.00000223	0.00150	0.00015	0.002225
07-Sep-10	0.00058380	24.95	0.0000315	0.0002035	0.00148	0.00168	0.000132	0.000735	2.19	0.006951	0.00000210	0.00130	0.00012	0.002310
14-Sep-10	0.00055300	23.07	0.0000395	0.0001999	0.00192	0.00119	0.000120	0.000672	1.99	0.006360	0.00000198	0.00113	0.00010	0.002370
21-Sep-10	0.00074000	30.75	0.0000375	0.0002885	0.00180	0.00125	0.000152	0.000900	2.71	0.009050	0.00000250	0.00150	0.00014	0.002750
28-Sep-10	0.00045240	18.73	0.0000145	0.0001879	0.00068	0.00058	0.000088	0.000551	1.67	0.005829	0.00000145	0.00091	0.00009	0.001450
05-Oct-10	0.00097440	30.07	0.0012120	0.0025555	0.00296	0.00168	0.003673	#N/A	2.74	0.008664	#N/A	0.00315	0.00247	0.007200
12-Oct-10	0.00088335	24.05	0.0014674	0.0029882	0.00315	0.00166	0.004417	#N/A	2.22	0.006640	#N/A	0.00323	0.00295	0.007800
19-Oct-10	0.00108404	27.84	0.0019935	0.0040181	0.00411	0.00210	0.005989	#N/A	2.58	0.007513	#N/A	0.00416	0.00400	0.010238
26-Oct-10	0.00101250	24.58	0.0020250	0.0040500	0.00405	0.00203	0.006075	#N/A	2.29	0.006480	#N/A	0.00405	0.00405	0.010125
02-Nov-10	0.00115000	28.34	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	2.70	0.006440	#N/A	0.00460	0.00460	0.011500
09-Nov-10	0.00107500	26.68	0.0021500	0.0043000	0.00430	0.00215	0.006450	#N/A	2.56	0.005590	#N/A	0.00430	0.00430	0.010750
16-Nov-10	0.00100000	24.91	0.0020000	0.0040000	0.00400	0.00200	0.006000	#N/A	2.40	0.005000	#N/A	0.00400	0.00400	0.010000
23-Nov-10	0.00102500	25.63	0.0020500	0.0041000	0.00410	0.00205	0.006150	#N/A	2.48	0.004920	#N/A	0.00410	0.00410	0.010250
30-Nov-10	0.00103750	26.83	0.0020750	0.0041500	0.00415	0.00208	0.006225	#N/A	2.71	0.004773	#N/A	0.00415	0.00415	0.010375
07-Dec-10	0.00108750	28.59	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	2.95	0.004894	#N/A	0.00435	0.00435	0.010875
14-Dec-10	0.00108750	28.82	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	3.00	0.004839	#N/A	0.00435	0.00435	0.010875
21-Dec-10	0.00111250	29.73	0.0022250	0.0044500	0.00445	0.00223	0.006675	#N/A	3.12	0.004895	#N/A	0.00445	0.00445	0.011125
28-Dec-10	0.00098750	24.89	0.0019750	0.0039500	0.00395	0.00198	0.005925	#N/A	2.57	0.003950	#N/A	0.00395	0.00395	0.009875
04-Jan-11	0.00123750	30.24	0.0024750	0.0049500	0.00495	0.00248	0.007425	#N/A	3.09	0.004703	#N/A	0.00495	0.00495	0.012375
11-Jan-11	0.00102500	24.66	0.0020500	0.0041000	0.00410	0.00205	0.006150	#N/A	2.51	0.003793	#N/A	0.00410	0.00410	0.010250
18-Jan-11	0.00105000	24.86	0.0021000	0.0042000	0.00420	0.00210	0.006300	#N/A	2.52	0.003780	#N/A	0.00420	0.00420	0.010500
25-Jan-11	0.00111250	26.57	0.0022250	0.0044500	0.00445	0.00223	0.006675	#N/A	2.69	0.004228	#N/A	0.00445	0.00445	0.011125
01-Feb-11	0.00113750	27.28	0.0022750	0.0045500	0.00455	0.00228	0.006825	#N/A	2.77	0.004436	#N/A	0.00455	0.00455	0.011375
08-Feb-11	0.00110000	26.43	0.0022000	0.0044000	0.00440	0.00220	0.006600	#N/A	2.69	0.004345	#N/A	0.00440	0.00440	0.011000
15-Feb-11	0.00112500	27.09	0.0022500	0.0045000	0.00450	0.00225	0.006750	#N/A	2.75	0.004500	#N/A	0.00450	0.00450	0.011250
22-Feb-11	0.00115000	27.00	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	2.73	0.004140	#N/A	0.00460	0.00460	0.011500
01-Mar-11	0.00115000	26.66	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	2.68	0.003910	#N/A	0.00460	0.00460	0.011500
08-Mar-11	0.00107500	24.76	0.0021500	0.0043000	0.00430	0.00215	0.006450	#N/A	2.49	0.003548	#N/A	0.00430	0.00430	0.010750
15-Mar-11	0.00108750	24.88	0.0021750	0.0043500	0.00435	0.00218	0.006525	#N/A	2.50	0.003480	#N/A	0.00435	0.00435	0.010875
22-Mar-11	0.00111250	22.58	0.0022250	0.0044500	0.00445	0.00223	0.006675	#N/A	2.28	0.003115	#N/A	0.00445	0.00445	0.011125
29-Mar-11	0.00121250	23.05	0.0024250	0.0048500	0.00485	0.00243	0.007275	#N/A	2.33	0.003153	#N/A	0.00485	0.00485	0.012125
05-Apr-11	0.00111250	20.43	0.0022250	0.0044500	0.00445	0.00223	0.006675	#N/A	2.07	0.002781	#N/A	0.00445	0.00445	0.011125
12-Apr-11	0.00085000	15.06	0.0017000	0.0034000	0.00340	0.00170	0.005100	#N/A	1.53	0.002040	#N/A	0.00340	0.00340	0.008500
19-Apr-11	0.00112500	21.40	0.0022500	0.0045000	0.00450	0.00225	0.006750	#N/A	2.30	0.003825	#N/A	0.00450	0.00450	0.011250
26-Apr-11	0.00098750	19.42	0.0019750	0.0039500	0.00395	0.00198	0.005925	#N/A	2.13	0.003851	#N/A	0.00395	0.00395	0.009875
03-May-11	0.00115000	22.99	0.0023000	0.0046000	0.00460	0.00230	0.006900	#N/A	2.56	0.004773	#N/A	0.00460	0.00460	0.011500
10-May-11	0.00120000	24.38	0.0024000	0.0048000	0.00480	0.00240	0.007200	#N/A	2.74	0.005280	#N/A	0.00480	0.00480	0.012000

Date	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
28-Jul-09	16.53000	0.00114	0.950	0.015238000	51.3000	0.39520	250.04	0.00060800	0.0108300	0.0057000	0.000798	0.001900	0.01102	0.00095
04-Aug-09	13.39800	0.00048	2.958	0.000006525	20.2275	0.42369	249.69	0.00053070	0.0032582	0.0006525	0.000805	0.000218	0.01544	0.00011
11-Aug-09	9.74550	0.00022	3.275	0.000006675	10.4575	0.43254	246.09	0.00039605	0.0029682	0.0006675	0.000730	0.000223	0.02341	0.00011
18-Aug-09	7.75500	0.00028	3.069	0.000028200	4.4650	0.43992	263.67	0.00027260	0.0062980	0.0007050	0.000874	0.000235	0.05969	0.00012
25-Aug-09	6.41700	0.00018	3.213	0.000019550	3.0245	0.42205	237.82	0.00023000	0.0062560	0.0019550	0.000833	0.000345	0.06854	0.00017
01-Sep-09	4.78800	0.00008	3.125	0.000010500	1.5330	0.37758	198.66	0.00017640	0.0057960	0.0029400	0.000739	0.000420	0.07182	0.00021
08-Sep-09	4.37610	0.00007	3.269	0.000008700	1.1810	0.37236	215.98	0.00017400	0.0061770	0.0018488	0.000726	0.000326	0.08983	0.00016
15-Sep-09	3.96760	0.00005	3.453	0.000006825	0.8099	0.36992	236.60	0.00017290	0.0066430	0.0006825	0.000719	0.000228	0.11011	0.00011
22-Sep-09	3.68978	0.00019	3.441	0.000015113	0.6789	0.34782	252.03	0.00015578	0.0060218	0.0006975	0.000686	0.000233	0.10649	0.00012
29-Sep-09	2.82425	0.00028	2.848	0.000019750	0.4503	0.26979	222.78	0.00011455	0.0044635	0.0005925	0.000541	0.000198	0.08532	0.00010
06-Oct-09	2.60000	0.00016	2.736	0.000022000	0.3860	0.26000	222.80	0.00010200	0.0039840	0.0006000	0.000598	0.000200	0.09700	0.00010
13-Oct-09	2.51550	0.00004	2.782	0.000025800	0.3397	0.26531	236.50	0.00009460	0.0037066	0.0006450	0.000697	0.000215	0.11567	0.00011
20-Oct-09	2.52263	0.00005	3.132	0.000020925	0.3139	0.28179	244.13	0.00009765	0.0040548	0.0006975	0.000772	0.000233	0.16973	0.00012
27-Oct-09	2.40000	0.00005	3.360	0.000014400	0.2688	0.28560	240.00	0.00009600	0.0042336	0.0007200	0.000816	0.000240	0.22128	0.00012
03-Nov-09	1.91768	0.00004	2.671	0.000022275	0.2126	0.23126	199.26	0.00008303	0.0030638	0.0006075	0.000707	0.000203	0.19055	0.00010
10-Nov-09	2.05620	0.00005	2.847	0.000036800	0.2254	0.25162	222.64	0.00009660	0.0029026	0.0006900	0.000823	0.000230	0.22080	0.00012
17-Nov-09	1.88650	0.00005	2.945	0.000023275	0.2254	0.23030	206.29	0.00011025	0.0035329	0.0007350	0.000750	0.000245	0.22908	0.00012
24-Nov-09	1.63115	0.00005	2.944	0.000007575	0.2172	0.19847	180.79	0.00012120	0.0040956	0.0007575	0.000641	0.000253	0.22978	0.00013
01-Dec-09	1.27605	0.00005	2.482	0.000012925	0.1739	0.14594	128.78	0.00008460	0.0030174	0.0012925	0.000496	0.000235	0.16380	0.00012
08-Dec-09	1.00100	0.00005	2.152	0.000018200	0.1411	0.10374	86.45	0.00005460	0.0021522	0.0018200	0.000382	0.000228	0.11011	0.00011
15-Dec-09	0.92768	0.00005	2.137	0.000012788	0.1744	0.09207	74.63	0.00004883	0.0021599	0.0012788	0.000330	0.000233	0.09556	0.00012
22-Dec-09	0.79655	0.00004	1.985	0.000006675	0.1958	0.07476	58.30	0.00004005	0.0020292	0.0006675	0.000258	0.000223	0.07521	0.00011
29-Dec-09	0.73080	0.00004	2.036	0.000006525	0.1544	0.06569	51.11	0.00003263	0.0022685	0.0006525	0.000239	0.000218	0.06373	0.00011
05-Jan-10	0.67510	0.00004	2.107	0.000006450	0.1161	0.05762	44.72	0.00002580	0.0025241	0.0006450	0.000224	0.000215	0.05332	0.00011
12-Jan-10	0.62978	0.00012	2.007	0.000008100	0.1276	0.05083	36.86	0.00003240	0.0022012	0.0017213	0.000215	0.000304	0.04880	0.00015
19-Jan-10	0.65450	0.00021	2.129	0.000010625	0.1530	0.04973	33.15	0.00004250	0.0021250	0.0029750	0.000230	0.000425	0.04973	0.00021
26-Jan-10	0.64080	0.00013	2.154	0.000023363	0.1402	0.04615	28.04	0.00004005	0.0023096	0.0018913	0.000211	0.000334	0.04528	0.00017
02-Feb-10	0.64990	0.00005	2.265	0.000038800	0.1310	0.04384	23.28	0.00003880	0.0026093	0.0007275	0.000199	0.000243	0.04195	0.00012
09-Feb-10	0.56025	0.00004	1.942	0.000024900	0.1141	0.03913	17.85	0.00003113	0.0028137	0.0006225	0.000178	0.000208	0.03764	0.00010
16-Feb-10	0.62560	0.00005	2.157	0.000018400	0.1288	0.04517	17.48	0.00003220	0.0037628	0.0006900	0.000207	0.000230	0.04365	0.00012
23-Feb-10	0.63455	0.00010	2.279	0.000019600	0.1323	0.04533	17.40	0.00003675	0.0035378	0.0007350	0.000216	0.000245	0.04305	0.00012
02-Mar-10	0.54120	0.00013	2.028	0.000017600	0.1144	0.03819	14.52	0.00003520	0.0027544	0.0006600	0.000189	0.000220	0.03555	0.00011
09-Mar-10	0.48348	0.00008	1.919	0.000011413	0.0851	0.03467	12.04	0.00003320	0.0029673	0.0006225	0.000156	0.000208	0.03339	0.00010
16-Mar-10	0.53900	0.00005	2.274	0.000007350	0.0735	0.03935	12.25	0.00003920	0.0039396	0.0007350	0.000157	0.000245	0.03925	0.00012
23-Mar-10	0.46860	0.00004	1.756	0.000006600	0.0858	0.03401	11.88	0.00003080	0.0026048	0.0006600	0.000154	0.000220	0.03043	0.00011
30-Mar-10	0.43260	0.00004	1.403	0.000006300	0.1008	0.03121	12.18	0.00002520	0.0015960	0.0006300	0.000160	0.000210	0.02444	0.00011
06-Apr-10	0.40093	0.00004	1.556	0.000008888	0.0770	0.02824	10.67	0.00002370	0.0014358	0.0005925	0.000132	0.000198	0.02099	0.00010
13-Apr-10	0.41500	0.00004	1.884	0.000012450	0.0623	0.02851	10.38	0.00002490	0.0014401	0.0006225	0.000120	0.000208	0.01996	0.00010
20-Apr-10	0.48950	0.00004	1.980	0.000017800	0.0668	0.03774	11.13	0.00003115	0.0020871	0.0006675	0.000151	0.000223	0.03480	0.00011
27-Apr-10	0.50000	0.00005	2.460	0.000007500	0.0750	0.03495	12.50	0.00003000	0.0022800	0.0007500	0.000145	0.000250	0.05100	0.00013
04-May-10	0.48500	0.00005	2.554	0.000007275	0.0728	0.03715	12.13	0.00003153	0.0024080	0.0007275	0.000141	0.000243	0.05481	0.00012
11-May-10	0.45000	0.00005	2.525	0.000006750	0.0675	0.03749	11.25	0.00003150	0.0024165	0.0006750	0.000131	0.000225	0.05580	0.00011
18-May-10	0.38885	0.00005	1.944	0.000023230	0.0934	0.03093	7.58	0.00002525	0.0019493	0.0004419	0.000122	0.000152	0.03550	0.00008
25-May-10	0.22140	0.00003	0.857	0.000031570	0.0902	0.01607	2.05	0.00001230	0.0009635	0.0001025	0.000079	0.000041	0.00681	0.00002
01-Jun-10	0.29055	0.00003	1.160	0.000027105	0.1073	0.02073	6.83	0.00001853	0.0005616	0.0000975	0.000100	0.000039	0.00987	0.00002
08-Jun-10	0.39425	0.00003	1.602	0.000025730	0.1370	0.02785	12.45	0.00002698	0.0002200	0.0001038	0.000132	0.000042	0.01411	0.00002
15-Jun-10	**0.45955**	**0.00003**	**1.681**	**0.000036400**	**0.1411**	**0.03417**	**15.24**	**0.00003276**	**0.0001479**	**0.0001138**	**0.000162**	**0.000046**	**0.01815**	**0.00002**
22-Jun-10	0.44405	0.00002	1.465	0.000040670	0.1204	0.03449	15.36	0.00003279	0.0000498	0.0001038	0.000164	0.000042	0.01901	0.00002
29-Jun-10	0.47940	0.00013	1.734	0.000046060	0.1622	0.04296	20.21	0.00002914	0.0000658	0.0001175	0.000181	0.000047	0.02653	0.00002
06-Jul-10	0.40740	0.00020	1.617	0.000041160	0.1680	0.04187	20.58	0.00001890	0.0000672	0.0001050	0.000158	0.000042	0.02818	0.00002
13-Jul-10	0.43340	0.00012	1.652	0.000044880	0.1408	0.04437	20.68	0.00002354	0.0000704	0.0001100	0.000170	0.000044	0.03516	0.00002
20-Jul-10	0.46000	0.00003	1.684	0.000048760	0.1104	0.04692	20.70	0.00002852	0.0000736	0.0001150	0.000183	0.000046	0.04264	0.00002
27-Jul-10	0.48688	0.00003	1.769	0.000035863	0.1116	0.04845	23.28	0.00003301	0.0000713	0.0001188	0.000193	0.000048	0.04510	0.00002
03-Aug-10	0.47775	0.00003	1.724	0.000020475	0.1047	0.04641	24.12	0.00003504	0.0000637	0.0001138	0.000188	0.000046	0.04423	0.00002
10-Aug-10	0.41580	0.00003	1.599	0.000012760	0.1100	0.04167	20.90	0.00003014	0.0000528	0.0001100	0.000171	0.000044	0.03700	0.00002
17-Aug-10	0.36540	0.00004	1.514	0.000005655	0.1175	0.03802	18.27	0.00002610	0.0000435	0.0001088	0.000158	0.000044	0.03089	0.00002
24-Aug-10	0.35905	0.00008	1.458	0.000005375	0.1118	0.03745	16.77	0.00002623	0.0000323	0.0001075	0.000151	0.000043	0.02868	0.00002
31-Aug-10	0.36935	0.00012	1.469	0.000005340	0.1113	0.03863	16.02	0.00002759	0.0000223	0.0001113	0.000151	0.000045	0.02777	0.00002
07-Sep-10	0.33810	0.00008	1.439	0.000018480	0.1092	0.03457	14.49	0.00002226	0.0000294	0.0001050	0.000140	0.000042	0.02631	0.00002
14-Sep-10	0.30810	0.00003	1.402	0.000030020	0.1067	0.03073	13.04	0.00001738	0.0000356	0.0000988	0.000130	0.000040	0.02485	0.00002
21-Sep-10	0.40750	0.00005	1.820	0.000027750	0.1375	0.04228	18.50	0.00002375	0.0000525	0.0001250	0.005882	0.000050	0.03088	0.00003
28-Sep-10	0.24650	0.00003	1.082	0.000010150	0.0812	0.02648	11.89	0.00001479	0.0000348	0.0000725	0.006728	0.000029	0.01757	0.00001
05-Oct-10	0.34800	0.01203	1.591	0.001208400	0.1152	0.04135	18.55	#N/A	0.0036288	0.0006600	#N/A	0.001224	0.02774	0.00241
12-Oct-10	0.25838	0.01464	1.212	0.001465913	0.0858	0.03259	14.62	#N/A	0.0043992	0.0007556	#N/A	0.001472	0.02200	0.00293
19-Oct-10	0.28722	0.01991	1.367	0.001992616	0.0956	0.03744	16.78	#N/A	0.0059787	0.0010095	#N/A	0.001996	0.02534	0.00398
26-Oct-10	0.24300	0.02025	1.175	0.002025000	0.0810	0.03281	14.70	#N/A	0.0060750	0.0010125	#N/A	0.002025	0.02228	0.00405
02-Nov-10	0.27600	0.02300	1.283	0.002300000	0.0920	0.03818	17.30	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.02714	0.00460
09-Nov-10	0.25800	0.02150	1.176	0.002150000	0.0860	0.03612	16.45	#N/A	0.0064500	0.0010750	#N/A	0.002150	0.02623	0.00430
16-Nov-10	0.24000	0.02000	1.083	0.002000000	0.0800	0.03380	15.43	#N/A	0.0060000	0.0010000	#N/A	0.002000	0.02480	0.00400
23-Nov-10	0.24600	0.02050	1.099	0.002050000	0.0820	0.03485	15.95	#N/A	0.0061500	0.0010250	#N/A	0.002050	0.02583	0.00410
30-Nov-10	0.31125	0.02075	1.177	0.002075000	0.1038	0.03777	16.39	#N/A	0.0062250	0.0010375	#N/A	0.002075	0.02843	0.00415
07-Dec-10	0.35888	0.02175	1.267	0.002175000	0.1196	0.04089	17.31	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.03099	0.00435
14-Dec-10	0.37519	0.02175	1.284	0.002175000	0.1251	0.04154	17.38	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.03159	0.00435
21-Dec-10	0.40050	0.02225	1.331	0.002225000	0.1335	0.04317	17.84	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.03293	0.00445
28-Dec-10	0.31600	0.01975	1.225	0.001975000	0.1383	0.03575	13.94	#N/A	0.0059250	0.0009875	#N/A	0.001975	0.02765	0.00395
04-Jan-11	0.37125	0.02475	1.562	0.002475000	0.1856	0.04319	16.29	#N/A	0.0074250	0.0012375	#N/A	0.002475	0.03366	0.00495
11-Jan-11	0.29725	0.02050	1.305	0.002050000	0.1589	0.03511	13.00	#N/A	0.0061500	0.0010250	#N/A	0.002050	0.02747	0.00410
18-Jan-11	0.29400	0.02100	1.348	0.002100000	0.1680	0.03528	12.81	#N/A	0.0063000	0.0010500	#N/A	0.002100	0.02772	0.00420
25-Jan-11	0.28925	0.02225	1.437	0.002225000	0.1001	0.03760	13.39	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.03115	0.00445
01-Feb-11	0.28438	0.02275	1.474	0.002275000	0.0626	0.03856	13.60	#N/A	0.0068250	0.0011375	#N/A	0.002275	0.03276	0.00455
08-Feb-11	0.26950	0.02200	1.428	0.002200000	0.0413	0.03735	13.11	#N/A	0.0066000	0.0011000	#N/A	0.002200	0.03212	0.00440
15-Feb-11	0.27000	0.02250	1.463	0.002250000	0.0225	0.03825	13.37	#N/A	0.0067500	0.0011250	#N/A	0.002250	0.03330	0.00450
22-Feb-11	0.25300	0.02300	1.433	0.002300000	0.0345	0.03749	13.75	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.03220	0.00460
01-Mar-11	0.24150	0.02300	1.402	0.002300000	0.0403	0.03669	13.80	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.03128	0.00460
08-Mar-11	0.22038	0.02150	1.296	0.002150000	0.0403	0.03392	12.92	#N/A	0.0064500	0.0010750	#N/A	0.002150	0.02881	0.00430
15-Mar-11	0.21750	0.02175	1.296	0.002175000	0.0435	0.03393	13.09	#N/A	0.0065250	0.0010875	#N/A	0.002175	0.02871	0.00435
22-Mar-11	0.22250	0.02225	1.268	0.002225000	0.0334	0.03093	12.66	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.02359	0.00445
29-Mar-11	0.24250	0.02425	1.351	0.002425000	0.0303	0.03165	13.40	#N/A	0.0072750	0.0012125	#N/A	0.002425	0.02255	0.00485
05-Apr-11	0.22250	0.02225	1.225	0.002225000	0.0250	0.02809	12.11	#N/A	0.0066750	0.0011125	#N/A	0.002225	0.01925	0.00445
12-Apr-11	0.17000	0.01700	0.925	0.001700000	0.0170	0.02074	9.11	#N/A	0.0051000	0.0008500	#N/A	0.001700	0.01360	0.00340
19-Apr-11	0.22500	0.02250	1.296	0.002250000	0.0563	0.02993	11.84	#N/A	0.0067500	0.0011250	#N/A	0.002250	0.02363	0.00450
26-Apr-11	0.19750	0.01975	1.169	0.001975000	0.0642	0.02735	10.29	#N/A	0.0059250	0.0009875	#N/A	0.001975	0.02321	0.00395
03-May-11	0.23000	0.02300	1.380	0.002300000	0.0834	0.03249	11.93	#N/A	0.0069000	0.0011500	#N/A	0.002300	0.02846	0.00460
10-May-11	0.24000	0.02400	1.459	0.002400000	0.0960	0.03456	12.38	#N/A	0.0072000	0.0012000	#N/A	0.002400	0.03120	0.00480

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
28-Jul-09	0	640.3	0.0019	0.09766	0.10108	0.0118	0.0000950	0.0000570	0.57	0.00209	204.82	0.00095	0.00707	0.02356	0.13376	0.0000570	0.00570	21.43	0.62320	0.0006840	0.0125	0.00608	0.0190	16.53	0.0011	0.950	1.52E-02	51.300	0.3952	250.04	0.000608	0.01083	0.0057	0.000798	0.00190	0.01102	0.00095
04-Aug-09	1	1378.9	0.0063	0.32386	0.23506	0.0164	0.0001059	0.0000635	0.63525	0.0036299	453.2	0.00105875	0.01572	0.029824	0.1533	0.0003485	0.01049	42.88	1.24960	0.0007101	0.0287	0.00747	0.0255	29.93	0.0016	3.908	1.52E-02	71.528	0.8189	499.73	0.001139	0.01409	0.0063525	0.001603	0.00212	0.0264625	0.00106
11-Aug-09	2	2120.7	0.0098	0.90236	0.35165	0.0204	0.0001170	0.0000702	0.702	0.0063088	706.0	0.00117	0.022	0.0371665	0.1769	0.0007801	0.01583	62.99	2.25975	0.0007212	0.0406	0.00876	0.0300	39.67	0.0018	7.183	1.53E-02	81.985	1.2514	745.82	0.001535	0.01706	0.00702	0.002333	0.00234	0.0498695	0.00117
18-Aug-09	3	2799.9	0.0126	1.59326	0.45223	0.0250	0.0001288	0.0000773	0.7725	0.0103461	991.3	0.0012875	0.02886	0.0442635	0.1995	0.0011514	0.02147	80.29	3.90475	0.0007330	0.0506	0.01055	0.0323	47.43	0.0021	10.252	1.53E-02	86.450	1.6914	1009.49	0.001807	0.02335	0.007725	0.003207	0.00258	0.1095595	0.00129
25-Aug-09	4	3462.8	0.0165	2.21886	0.54193	0.0299	0.0001460	0.0000865	0.8645	0.0145482	1279.9	0.00146	0.03535	0.0531185	0.2165	0.0015056	0.02722	95.31	5.65965	0.0007502	0.0594	0.01218	0.0358	53.85	0.0023	13.465	1.53E-02	89.475	2.1134	1247.31	0.002037	0.02961	0.00968	0.004039	0.00292	0.1780995	0.00146
01-Sep-09	5	4095.7	0.0212	2.74386	0.61585	0.0347	0.0001670	0.0000970	0.9695	0.0186138	1552	0.00167	0.04106	0.0629465	0.2274	0.0018206	0.03268	107.28	7.39425	0.0007712	0.0664	0.01357	0.0400	58.63	0.0024	16.590	1.53E-02	91.008	2.4910	1445.97	0.002214	0.03541	0.01262	0.004779	0.00334	0.2499195	0.00167
08-Sep-09	6	4857.4	0.0244	3.25716	0.69089	0.0395	0.0001833	0.0001057	1.0565	0.0232857	1821	0.00183313	0.04667	0.0707548	0.2346	0.0023013	0.03811	117.74	9.38003	0.0007875	0.0730	0.01496	0.0432	63.01	0.0025	19.859	1.53E-02	92.189	2.8633	1661.94	0.002388	0.04158	0.0144688	0.005505	0.00367	0.339747	0.00183
15-Sep-09	7	5543.5	0.0262	3.76221	0.76778	0.0444	0.0001947	0.0001125	1.12475	0.0286547	2090	0.00194688	0.05222	0.0764423	0.2378	0.0029656	0.04357	126.66	11.65503	0.0007989	0.0794	0.01637	0.0455	66.98	0.0025	23.313	1.53E-02	92.998	3.2333	1898.54	0.002561	0.04823	0.0151513	0.006224	0.00389	0.449857	0.00195
22-Sep-09	8	6241.0	0.0283	4.22186	0.84381	0.0492	0.0002063	0.0001195	1.1945	0.0335590675	2371	0.00206313	0.05706	0.0819293	0.2480	0.0036305	0.04869	134.68	13.41505	0.0008105	0.0849	0.01935	0.0478	70.67	0.0027	26.754	1.53E-02	93.677	3.5811	2150.57	0.002716	0.05425	0.0158488	0.00691	0.00413	0.556342	0.00206
29-Sep-09	9	6961.5	0.0303	4.56433	0.90622	0.0531	0.0002162	0.0001254	1.25375	0.037315525	2617	0.00216188	0.06046	0.0863138	0.2626	0.0041835	0.05264	140.56	14.43020	0.0008204	0.0886	0.02318	0.0498	73.49	0.0030	29.602	1.54E-02	94.128	3.8509	2373.35	0.002831	0.05871	0.0164413	0.007451	0.00432	0.641662	0.00216
06-Oct-09	10	7642.7	0.0323	4.87593	0.96502	0.0569	0.0002262	0.0001314	1.31375	0.040793525	2860	0.00226188	0.06323	0.0901738	0.2714	0.0045595	0.05644	146.48	15.04260	0.0008304	0.0914	0.02586	0.0518	76.09	0.0031	32.338	1.54E-02	94.514	4.1109	2596.15	0.002933	0.0627	0.0170413	0.008049	0.00452	0.738662	0.00226
13-Oct-09	11	8363.4	0.0345	5.17306	1.02350	0.0608	0.0002369	0.0001378	1.37825	0.044216325	3115	0.00236938	0.0655	0.0936998	0.2744	0.0047659	0.06031	152.80	15.25416	0.0008412	0.0935	0.02745	0.0540	78.61	0.0032	35.120	1.54E-02	94.853	4.3762	2832.65	0.003028	0.0664	0.0176863	0.008746	0.00474	0.854332	0.00237
20-Oct-09	12	9126.9	0.0368	5.50902	1.08511	0.0651	0.0002486	0.0001448	1.448	0.048554775	3387	0.00248563	0.06752	0.0973268	0.2796	0.0050240	0.06449	159.01	15.46667	0.0008528	0.0957	0.02908	0.0563	81.13	0.0032	38.252	1.54E-02	95.167	4.6580	3076.78	0.003125	0.07046	0.0183838	0.009517	0.00497	1.024057	0.00249
27-Oct-09	13	9798.0	0.0392	5.87094	1.14703	0.0694	0.0002606	0.0001520	1.52	0.053690775	3664	0.00260563	0.06916	0.1008788	0.2868	0.0053264	0.06881	164.77	15.66923	0.0008648	0.0980	0.03066	0.0587	83.53	0.0033	41.612	1.54E-02	95.436	4.9436	3316.78	0.003221	0.07469	0.0191038	0.010333	0.00521	1.245337	0.00261
03-Nov-09	14	10432.6	0.0420	6.16214	1.19462	0.0733	0.0002707	0.0001581	1.58075	0.057943275	3901	0.00270688	0.07047	0.1036125	0.2967	0.0055552	0.07226	169.29	15.79700	0.0008749	0.0998	0.03169	0.0607	85.45	0.0033	44.282	1.55E-02	95.649	5.1748	3516.04	0.003304	0.07775	0.0197113	0.01104	0.00541	1.4358895	0.00271
10-Nov-09	15	11156.6	0.0462	6.47678	1.24338	0.0781	0.0002822	0.0001650	1.64975	0.062681275	4172	0.00282188	0.07185	0.1064185	0.3123	0.0057852	0.07594	174.03	15.89314	0.0008864	0.1017	0.03252	0.0630	87.50	0.0033	47.130	1.55E-02	95.874	5.4264	3738.68	0.003401	0.08066	0.0204013	0.011864	0.00564	1.6566895	0.00282
17-Nov-09	16	11886.2	0.0496	6.80336	1.29508	0.0830	0.0002944	0.0001723	1.72325	0.067605775	4422	0.00294438	0.0731	0.1092605	0.3226	0.0062654	0.07937	178.16	16.11511	0.0008987	0.1039	0.03335	0.0655	89.39	0.0034	50.075	1.55E-02	96.099	5.6567	3944.97	0.003511	0.08419	0.0211363	0.012613	0.00589	1.8857645	0.00294
24-Nov-09	17	12490.7	0.0521	7.13111	1.34810	0.0877	0.0003071	0.0001799	1.799	0.072554775	4640	0.00307063	0.07419	0.112038	0.3266	0.0070027	0.08240	181.48	16.46710	0.0009113	0.1062	0.03416	0.0680	91.02	0.0034	53.019	1.55E-02	96.317	5.8552	4125.76	0.003632	0.08829	0.0218938	0.013255	0.00614	2.1155395	0.00307
01-Dec-09	18	12792.9	0.0547	7.42744	1.39557	0.0919	0.0003188	0.0001870	1.8695	0.075936425	4798	0.00318813	0.07506	0.114294	0.3304	0.0074351	0.08475	184.17	16.64457	0.0009230	0.1082	0.03480	0.0703	92.30	0.0035	55.501	1.55E-02	96.490	6.0011	4254.54	0.003717	0.0913	0.0231863	0.01375	0.00638	2.2793345	0.00319
08-Dec-09	19	12990.9	0.0574	7.70590	1.43971	0.0957	0.0003302	0.0001938	1.93775	0.078024875	4908	0.00330188	0.07577	0.1161595	0.3340	0.0076080	0.08657	186.37	16.67105	0.0009344	0.1097	0.03530	0.0726	93.30	0.0035	57.653	1.56E-02	96.632	6.1049	4340.99	0.003772	0.09345	0.0250063	0.014133	0.00660	2.3894445	0.00330
15-Dec-09	20	13274.0	0.0605	8.00350	1.48574	0.1000	0.0003418	0.0002008	2.0075	0.0798407	5004	0.00341813	0.07643	0.1179498	0.3380	0.0077568	0.08819	188.42	16.69207	0.0009460	0.1114	0.03581	0.0749	94.23	0.0036	59.789	1.56E-02	96.806	6.1969	4415.62	0.00382	0.09561	0.026285	0.014463	0.00684	2.485002	0.00342
22-Dec-09	21	13449.4	0.0636	8.30076	1.53069	0.1045	0.0003529	0.0002074	2.07425	0.0812736	5079	0.00352938	0.077	0.1195518	0.3420	0.0078725	0.08953	190.20	16.70640	0.0009572	0.1131	0.03630	0.0772	95.02	0.0036	61.774	1.56E-02	97.002	6.2717	4473.92	0.00386	0.09764	0.0269525	0.014721	0.00706	2.560207	0.00353
29-Dec-09	22	13600.8	0.0664	8.61026	1.57571	0.1094	0.0003638	0.0002140	2.1395	0.08249595	5145	0.00363813	0.0775	0.121879	0.3453	0.0079726	0.09083	191.92	16.71829	0.0009680	0.1149	0.03665	0.0793	95.75	0.0037	63.810	1.56E-02	97.156	6.3374	4525.03	0.003893	0.09991	0.027605	0.01496	0.00728	2.6239345	0.00364
05-Jan-10	23	13729.3	0.0690	8.93491	1.62129	0.1147	0.0003746	0.0002204	2.204	0.08352795	5203	0.00374563	0.07794	0.124932	0.3478	0.0080586	0.09212	193.60	16.72797	0.0009788	0.1169	0.03686	0.0815	96.43	0.0037	65.917	1.56E-02	97.272	6.3950	4569.75	0.003919	0.10244	0.02825	0.015184	0.00749	2.6772545	0.00375
12-Jan-10	24	13839.1	0.0714	9.23806	1.66402	0.1204	0.0003898	0.0002285	2.285	0.0844311	5252	0.0038975	0.0783	0.1284353	0.3501	0.0081578	0.09324	195.21	16.73656	0.0009940	0.1187	0.03783	0.0845	97.06	0.0038	67.924	1.56E-02	97.400	6.4458	4606.60	0.003951	0.10464	0.0299713	0.015398	0.00780	2.726057	0.00390
19-Jan-10	25	13945.3	0.0740	9.55341	1.70864	0.1270	0.0004110	0.0002391	2.39125	0.0853066	5299	0.00411	0.07862	0.1327703	0.3522	0.0082811	0.09430	196.92	16.74501	0.0010152	0.1206	0.03966	0.0888	97.71	0.0041	70.053	1.56E-02	97.553	6.4956	4639.75	0.003994	0.10676	0.0329463	0.015628	0.00822	2.775782	0.00411
26-Jan-10	26	14010.3	0.0766	9.86424	1.75626	0.1344	0.0004277	0.0002480	2.48025	0.0861165	5341	0.00427688	0.07889	0.1357295	0.3558	0.0083968	0.09519	198.59	16.75309	0.0010319	0.1225	0.04073	0.0921	98.35	0.0042	72.207	1.56E-02	97.693	6.5417	4667.79	0.004034	0.10907	0.0348375	0.015839	0.00855	2.8210608	0.00428
02-Feb-10	27	14074.8	0.0795	10.18191	1.80912	0.1428	0.0004398	0.0002553	2.553	0.0868828	5381	0.00439813	0.07913	0.137233	0.3611	0.0085083	0.09592	200.29	16.76104	0.0010440	0.1244	0.04097	0.0945	99.00	0.0042	74.472	1.57E-02	97.824	6.5856	4691.07	0.004073	0.11168	0.035565	0.016038	0.00880	2.8630133	0.00440
09-Feb-10	28	14125.4	0.0822	10.46391	1.85436	0.1512	0.0004502	0.0002615	2.61525	0.087586225	5415	0.00450188	0.07932	0.138644	0.3644	0.0086453	0.09654	201.86	16.77088	0.0010544	0.1263	0.04114	0.0966	99.56	0.0043	76.414	1.57E-02	97.938	6.6247	4708.91	0.004104	0.1145	0.0361875	0.016217	0.00900	2.9006538	0.00450
16-Feb-10	29	14181.6	0.0855	10.78775	1.90450	0.1619	0.0004617	0.0002684	2.68425	0.088418825	5452	0.00461688	0.07953	0.140346	0.3667	0.0088431	0.09723	203.72	16.78514	0.0010659	0.1285	0.04127	0.0989	100.19	0.0043	78.571	1.57E-02	98.067	6.6699	4726.39	0.004136	0.11826	0.0368775	0.016424	0.00923	2.9443078	0.00462
23-Feb-10	30	14224.7	0.0889	11.11972	1.95815	0.1779	0.0004739	0.0002758	2.75775	0.089224875	5487	0.00473938	0.07979	0.142012	0.3686	0.0090317	0.09833	205.62	16.80040	0.0010782	0.1309	0.04154	0.1014	100.82	0.0044	80.850	1.57E-02	98.199	6.7152	4743.79	0.004173	0.1218	0.0376125	0.016639	0.00948	2.9873543	0.00474
02-Mar-10	31	14263.8	0.0920	11.40616	2.00655	0.1965	0.0004849	0.0002824	2.82375	0.089876075	5516	0.00484938	0.08007	0.143376	0.3697	0.0091813	0.09965	207.25	16.81418	0.0010892	0.1330	0.04190	0.1036	101.36	0.0046	82.878	1.58E-02	98.314	6.7534	4758.31	0.004208	0.12455	0.0382725	0.016828	0.00970	3.0229063	0.00485
09-Mar-10	32	14291.2	0.0949	11.67072	2.05365	0.2111	0.0004953	0.0002886	2.886	0.090502725	5541	0.00495313	0.08028	0.1452643	0.3707	0.0093245	0.10059	208.77	16.82687	0.0010995	0.1349	0.04215	0.1056	101.85	0.0046	84.798	1.58E-02	98.399	6.7880	4770.34	0.004241	0.12752	0.038895	0.016984	0.00991	3.056293	0.00495
16-Mar-10	33	14331.4	0.0983	11.97648	2.11098	0.2248	0.0005076	0.0002960	2.9595	0.091257325	5570	0.00507563	0.08046	0.1482043	0.3719	0.0094960	0.10132	210.54	16.84153	0.0011118	0.1371	0.04234	0.1081	102.39	0.0047	87.071	1.58E-02	98.472	6.8274	4782.59	0.00428	0.13146	0.03963	0.017141	0.01015	3.095542	0.00508
23-Mar-10	34	14371.9	0.1012	12.26072	2.16334	0.2366	0.0005186	0.0003026	3.0255	0.091851325	5595	0.00518563	0.08067	0.1504043	0.3730	0.0096412	0.10198	212.10	16.85066	0.0011228	0.1391	0.04252	0.1103	102.86	0.0047	88.827	1.58E-02	98.558	6.8614	4794.47	0.004311	0.13406	0.04029	0.017295	0.01037	3.125968	0.00519
30-Mar-10	35	14412.2	0.1037	12.54128	2.21416	0.2473	0.0005291	0.0003089	3.0885	0.092338525	5618	0.00529063	0.08089	0.1520843	0.3741	0.0097714	0.10261	213.57	16.85553	0.0011333	0.1411	0.04269	0.1124	103.29	0.0048	90.230	1.58E-02	98.659	6.8926	4806.65	0.004336	0.13566	0.04092	0.017454	0.01058	3.150412	0.00529
06-Apr-10	36	14447.8	0.1068	12.81383	2.26532	0.2572	0.0005389	0.0003148	3.14775	0.09278685	5639	0.00538938	0.08112	0.1533483	0.3757	0.0098899	0.10320	214.98	16.85981	0.0011432	0.1429	0.04282	0.1144	103.69	0.0048	91.786	1.58E-02	98.736	6.9209	4817.32	0.00436	0.13709	0.0415125	0.017587	0.01078	3.1714063	0.00539
13-Apr-10	37	14480.1	0.1110	13.10931	2.32259	0.2676	0.0005493	0.0003210	3.21	0.0932475	5661	0.00549313	0.08136	0.1543443	0.3782	0.0100102	0.10383	216.47	16.86400	0.0011535	0.1449	0.04295	0.1164	104.10	0.0049	93.670	1.58E-02	98.798	6.9494	4827.69	0.004385	0.13853	0.042135	0.017707	0.01099	3.1913678	0.00549
20-Apr-10	38	14511.7	0.1141	13.41681	2.37688	0.2836	0.0005604	0.0003277	3.27675	0.0940218	5686	0.00560438	0.08155	0.1559463	0.3793	0.0101882	0.10449	218.34	16.87446	0.0011647	0.1468	0.04308	0.1187	104.59	0.0049	95.650	1.58E-02	98.865	6.9871	4838.82	0.004416	0.14062	0.0428025	0.017858	0.01121	3.2261668	0.00560
27-Apr-10	39	14539.2	0.1171	13.70631	2.44088	0.2997	0.0005729	0.0003352	3.35175	0.0949818	5711	0.00572938	0.0817	0.1577463	0.3806	0.0103982	0.10524	220.29	16.92646	0.0011772	0.1491	0.04328	0.1212	105.09	0.0049	98.110	1.58E-02	98.940	7.0221	4851.32	0.004446	0.1429	0.0435525	0.018003	0.01146	3.2771668	0.00573
04-May-10	40	14572.7	0.1203	13.99949	2.49786	0.3175	0.0005851	0.0003425	3.4245	0.09604395	5738	0.00585063	0.08186	0.1596135	0.3818	0.0106407	0.10597	222.26	16.97479	0.0011893	0.1511	0.04345	0.1236	105.58	0.0050	100.664	1.58E-02	99.013	7.0592	4863.44	0.004478	0.14531	0.04428	0.018144	0.01170	3.3319718	0.00585
11-May-10	41	14601.0	0.1234	14.28299	2.54601	0.3358	0.0005963	0.0003492	3.492	0.09715095	5763	0.00596313	0.08201	0.1614585	0.3829	0.0109017	0.10665	224.15	17.01768	0.0012005	0.1528	0.04359	0.1258	106.03	0.0050	103.188	1.59E-02	99.080	7.0967	4874.69	0.004509	0.14773	0.044955	0.018275	0.01193	3.3877718	0.00596
18-May-10	42	14618.2	0.1298	14.53423	2.61091	0.3504	0.0006039	0.0003536	3.536188	0.09788926	5785	0.00612725	0.08218	0.1629508	0.3853	0.0111454	0.10728	225.69	17.04364	0.0012081	0.1543	0.04372	0.1299	106.42	0.0051	105.132	1.59E-02	99.173	7.1276	4882.27	0.004534	0.14967	0.0453969	0.018396	0.01208	3.4232733	0.00604
25-May-10	43	14624.8	0.1373	14.68388	2.67241	0.3574	0.0006059	0.0003546	3.546438	0.0980795	5796	0.00629125	0.0823	0.1636929	0.3882	0.0113032	0.10769	226.46	17.04674	0.0012102	0.1552	0.04381	0.1344	106.64	0.0051	105.989	1.59E-02	99.264	7.1437	4884.32	0.004547	0.15064	0.0454994	0.018475	0.01212	3.4300793	0.00606
01-Jun-10	44	14644.7	0.1431	14.84690	2.72974	0.3670	0.0006079	0.0003556	3.556188	0.09836381	5812	0.00640825	0.0825	0.1649233	0.3903	0.0114450	0.10821	227.54	17.05101	0.0012121	0.1563	0.04391	0.1375	106.93	0.0051	107.150	1.59E-02	99.371	7.1644	4891.14	0.004565	0.1512	0.0455969	0.018575	0.01216	3.4399463	0.00608
08-Jun-10	45	14672.9	0.1478	15.04236	2.78950	0.3803	0.0006100	0.0003567	3.566563	0.09877632	5833	0.00649125	0.08279	0.1667908	0.3920	0.0115869	0.10892	229.06	17.05699	0.0012142	0.1577	0.04401	0.1396	107.32	0.0052	108.751	1.60E-02	99.508	7.1923	4903.59	0.004592	0.15142	0.0457006	0.018707	0.01220	3.4540563	0.00610
15-Jun-10	46	14701.5	0.1521	15.27532	2.85479	0.3957	0.0006122	0.0003578	3.577938	0.09929138	5857	0.00654813	0.08309	0.168538	0.3936	0.0117498	0.10969	230.96	17.06295	0.0012165	0.1593	0.04414	0.1423	107.78	0.0052	110.433	1.60E-02	99.649	7.2264	4918.84	0.004625	0.15157	0.0458144	0.018869	0.01224	3.4722108	0.00612

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
22-Jun-10	47	14737.2	0.1553	15.50482	2.91413	0.4105	0.0006143	0.0003588	3.588313	0.09981843	5880	0.00656888	0.08336	0.1698577	0.3948	0.0119050	0.11040	232.94	17.06785	0.0012185	0.1608	0.04426	0.1452	108.23	0.0052	111.898	1.60E-02	99.769	7.2609	4934.19	0.004658	0.15162	0.0459181	0.019033	0.01229	3.4912178	0.00614
29-Jun-10	48	14803.5	0.1586	15.74922	2.97476	0.4285	0.0006167	0.0003600	3.600063	0.10050228	5912	0.00665113	0.08366	0.1712254	0.3970	0.0120489	0.11129	235.42	17.07450	0.0012209	0.1624	0.04443	0.1473	108.71	0.0054	113.632	1.61E-02	99.931	7.3039	4954.40	0.004687	0.15168	0.0460356	0.019214	0.01233	3.5177493	0.00617
06-Jul-10	49	14850.1	0.1612	15.95376	3.02306	0.4456	0.0006188	0.0003611	3.610563	0.10119108	5946	0.00677713	0.08392	0.1723342	0.3995	0.0121488	0.11217	237.87	17.08143	0.0012230	0.1637	0.04461	0.1482	109.11	0.0056	115.249	1.61E-02	100.099	7.3458	4974.98	0.004706	0.15175	0.0461406	0.019372	0.01238	3.5459313	0.00619
13-Jul-10	50	14888.8	0.1637	16.15308	3.07344	0.4638	0.0006210	0.0003622	3.621563	0.10197208	5980	0.00685413	0.0842	0.1734364	0.4017	0.0122762	0.11314	240.44	17.08875	0.0012252	0.1649	0.04472	0.1495	109.55	0.0057	116.901	1.62E-02	100.240	7.3901	4995.66	0.004729	0.15182	0.0462506	0.019543	0.01242	3.5810873	0.00621
20-Jul-10	51	14942.2	0.1660	16.34582	3.12588	0.4830	0.0006233	0.0003633	3.633063	0.10285068	6014	0.00687713	0.08448	0.1745266	0.4035	0.0124331	0.11420	243.13	17.09648	0.0012275	0.1661	0.04477	0.1513	110.01	0.0057	118.585	1.62E-02	100.351	7.4371	5016.36	0.004758	0.15189	0.0463656	0.019725	0.01247	3.6237293	0.00623
27-Jul-10	52	15000.1	0.1691	16.55031	3.18241	0.5028	0.0006256	0.0003645	3.644938	0.103793555	6050	0.00691275	0.08477	0.1756928	0.4061	0.0126178	0.11524	245.94	17.10472	0.0012299	0.1675	0.04488	0.1535	110.49	0.0057	120.354	1.63E-02	100.462	7.4855	5039.64	0.004791	0.15197	0.0464844	0.019918	0.01251	3.6688305	0.00626
03-Aug-10	53	15052.5	0.1727	16.75142	3.23883	0.5217	0.0006279	0.0003656	3.656313	0.104730855	6084	0.00695825	0.08506	0.1768485	0.4093	0.0128167	0.11620	248.66	17.11287	0.0012321	0.1689	0.04502	0.1557	110.97	0.0058	122.079	1.63E-02	100.567	7.5319	5063.75	0.004826	0.15203	0.0465981	0.020106	0.01256	3.7130565	0.00628
10-Aug-10	54	15118.5	0.1763	16.94920	3.29339	0.5385	0.0006301	0.0003667	3.667313	0.105558055	6114	0.00699125	0.08532	0.1785711	0.4128	0.0130133	0.11708	251.18	17.12039	0.0012343	0.1702	0.04517	0.1575	111.39	0.0058	123.678	1.63E-02	100.677	7.5736	5084.65	0.004856	0.15208	0.0467081	0.020277	0.01260	3.7500605	0.00630
17-Aug-10	55	15170.2	0.1798	17.14799	3.34733	0.5535	0.0006323	0.0003678	3.678188	0.106297555	6143	0.007013	0.08555	0.1808722	0.4168	0.0132121	0.11791	253.55	17.12748	0.0012365	0.1715	0.04531	0.1588	111.75	0.0058	125.192	1.63E-02	100.794	7.6116	5102.92	0.004882	0.15213	0.0468169	0.020436	0.01265	3.7809455	0.00632
24-Aug-10	56	15211.1	0.1834	17.34515	3.40258	0.5685	0.0006344	0.0003689	3.688938	0.106959755	6169	0.0070345	0.08576	0.1824804	0.4198	0.0133807	0.11870	255.89	17.13464	0.0012387	0.1728	0.04546	0.1605	112.11	0.0059	126.649	1.63E-02	100.906	7.6491	5119.69	0.004908	0.15216	0.0469244	0.020587	0.01269	3.8096265	0.00634
31-Aug-10	57	15264.0	0.1871	17.54985	3.46177	0.5842	0.0006367	0.0003700	3.700063	0.107573855	6196	0.00705675	0.08597	0.183455	0.4220	0.0135262	0.11950	258.29	17.14221	0.0012409	0.1743	0.04561	0.1628	112.48	0.0060	128.118	1.63E-02	101.017	7.6877	5135.71	0.004936	0.15218	0.0470356	0.020738	0.01273	3.8373945	0.00637
07-Sep-10	58	15314.0	0.1930	17.73339	3.51679	0.5980	0.0006388	0.0003747	3.710563	0.108157655	6221	0.00708825	0.08617	0.1849376	0.4237	0.0136585	0.12024	260.49	17.14916	0.0012430	0.1756	0.04573	0.1651	112.82	0.0061	129.556	1.63E-02	101.127	7.7222	5150.20	0.004958	0.15221	0.0471406	0.020879	0.01278	3.8637075	0.00639
14-Sep-10	59	15357.5	0.2006	17.89692	3.56774	0.6101	0.0006407	0.0003826	3.720438	0.108710655	6244	0.00712775	0.08637	0.1868612	0.4249	0.0137782	0.12091	262.48	17.15552	0.0012450	0.1768	0.04583	0.1674	113.13	0.0062	130.959	1.63E-02	101.233	7.7530	5163.24	0.004975	0.15225	0.0472394	0.021009	0.01281	3.888553	0.00641
21-Sep-10	60	15425.5	0.2072	18.10817	3.63449	0.6269	0.0006432	0.0003883	3.732938	0.109450655	6275	0.00716525	0.08666	0.1886612	0.4261	0.0139297	0.12181	265.19	17.16457	0.0012475	0.1783	0.04597	0.1702	113.54	0.0062	132.779	1.64E-02	101.371	7.7952	5181.74	0.004999	0.1523	0.0473644	0.026891	0.01286	3.919428	0.00643
28-Sep-10	61	15463.2	0.2093	18.23316	3.67451	0.6374	0.0006447	0.0003890	3.740188	0.109903055	6294	0.00717975	0.08685	0.1893369	0.4267	0.0140176	0.12236	266.86	17.17040	0.0012489	0.1792	0.04606	0.1716	113.78	0.0062	133.860	1.64E-02	101.452	7.8217	5193.63	0.005014	0.15233	0.0474369	0.033619	0.01289	3.937002	0.00645
05-Oct-10	62	15525.8	0.2170	18.42540	3.74123	0.6536	0.0010059	0.0063896	3.747388	0.110877455	6324	0.00839175	0.08941	0.1922961	0.4284	0.0176903	#N/A	269.60	17.17906	#N/A	0.1823	0.04853	0.1788	114.13	0.0183	135.452	1.76E-02	101.567	7.8631	5212.18	#N/A	0.15596	0.0480969	#N/A	0.01412	3.964746	0.00886
12-Oct-10	63	15587.8	0.2251	18.57564	3.79564	0.6662	0.0014451	0.0137023	3.751288	0.111760805	6348	0.00985913	0.09239	0.1954483	0.4300	0.0221073	#N/A	271.82	17.18570	#N/A	0.1856	0.05149	0.1866	114.39	0.0329	136.664	1.91E-02	101.653	7.8957	5226.79	#N/A	0.16036	0.0488525	#N/A	0.01559	3.986742	0.01179
19-Oct-10	64	15653.8	0.2354	18.74746	3.85922	0.6806	0.0020426	0.0236556	3.7547	0.112844843	6376	0.01185259	0.09641	0.199562	0.4321	0.0280964	#N/A	274.40	17.19321	#N/A	0.1897	0.05548	0.1969	114.68	0.0528	138.030	2.11E-02	101.748	7.9331	5243.58	#N/A	0.16634	0.049862	#N/A	0.01759	4.0120855	0.01577
26-Oct-10	65	15706.9	0.2455	18.89731	3.91592	0.6931	0.0026501	0.0337806	3.756725	0.113857343	6400	0.01387759	0.10046	0.203612	0.4341	0.0341714	#N/A	276.69	17.19969	#N/A	0.1938	0.05953	0.2070	114.92	0.0731	139.205	2.31E-02	101.829	7.9659	5258.28	#N/A	0.17241	0.0508745	#N/A	0.01961	4.0343605	0.01982
02-Nov-10	66	15766.7	0.2570	19.06521	3.98032	0.7079	0.0033401	0.0452806	3.759025	0.115007343	6429	0.01617759	0.10506	0.208212	0.4364	0.0410714	#N/A	279.39	17.20613	#N/A	0.1984	0.06413	0.2185	115.19	0.0961	140.488	2.54E-02	101.921	8.0041	5275.57	#N/A	0.17931	0.0520245	#N/A	0.02191	4.0615005	0.02442
09-Nov-10	67	15832.4	0.2678	19.22109	4.04052	0.7218	0.0039851	0.0560306	3.761175	0.116082343	6455	0.01832759	0.10936	0.212512	0.4386	0.0475214	#N/A	281.95	17.21172	#N/A	0.2027	0.06843	0.2292	115.45	0.1176	141.664	2.75E-02	102.007	8.0402	5292.02	#N/A	0.18576	0.0530995	#N/A	0.02406	4.0877305	0.02872
16-Nov-10	68	15888.8	0.2778	19.36559	4.09652	0.7349	0.0045851	0.0660306	3.763175	0.117082343	6480	0.02032759	0.11336	0.216512	0.4406	0.0535214	#N/A	284.36	17.21672	#N/A	0.2067	0.07243	0.2392	115.69	0.1376	142.747	2.95E-02	102.087	8.0740	5307.45	#N/A	0.19176	0.0540995	#N/A	0.02606	4.1125305	0.03272
23-Nov-10	69	15941.7	0.2880	19.51319	4.15392	0.7485	0.0052001	0.0762806	3.765225	0.118107343	6506	0.02237759	0.11746	0.220612	0.4426	0.0596714	#N/A	286.84	17.22164	#N/A	0.2108	0.07653	0.2495	115.94	0.1581	143.846	3.16E-02	102.169	8.1089	5323.40	#N/A	0.19791	0.0551245	#N/A	0.02811	4.1383605	0.03682
30-Nov-10	70	15994.6	0.2984	19.65221	4.20787	0.7636	0.0058226	0.0866556	3.7673	0.119144843	6533	0.02445259	0.12161	0.224762	0.4447	0.0658964	#N/A	289.55	17.22642	#N/A	0.2149	0.08068	0.2599	116.25	0.1788	145.023	3.37E-02	102.273	8.1466	5339.79	#N/A	0.20414	0.056162	#N/A	0.03019	4.166788	0.04097
07-Dec-10	71	16057.3	0.3093	19.79250	4.26225	0.7802	0.0064751	0.0975306	3.769475	0.120232343	6561	0.02662759	0.12596	0.229112	0.4469	0.0724214	#N/A	292.50	17.23131	#N/A	0.2193	0.08503	0.2707	116.61	0.2006	146.289	3.58E-02	102.393	8.1875	5357.11	#N/A	0.21066	0.0572495	#N/A	0.03236	4.1977818	0.04532
14-Dec-10	72	16116.0	0.3202	19.93007	4.31554	0.7973	0.0071276	0.1084056	3.77165	0.121319843	6590	0.02880259	0.13031	0.233462	0.4491	0.0789464	#N/A	295.50	17.23615	#N/A	0.2236	0.08938	0.2816	116.98	0.2223	147.573	3.80E-02	102.518	8.2291	5374.48	#N/A	0.21719	0.058337	#N/A	0.03454	4.2293736	0.04967
21-Dec-10	73	16172.1	0.3313	20.06802	4.36894	0.8151	0.0077951	0.1195306	3.773875	0.122432343	6620	0.03102759	0.13476	0.237912	0.4513	0.0856214	#N/A	298.62	17.24104	#N/A	0.2281	0.09383	0.2927	117.38	0.2446	148.904	4.02E-02	102.651	8.2722	5392.33	#N/A	0.22386	0.0594495	#N/A	0.03676	4.2623036	0.05412
28-Dec-10	74	16213.2	0.3412	20.18849	4.41831	0.8297	0.0083876	0.1294056	3.77585	0.123419843	6645	0.03300259	0.13871	0.241862	0.4533	0.0915464	#N/A	301.18	17.24499	#N/A	0.2320	0.09778	0.3026	117.70	0.2643	150.128	4.22E-02	102.790	8.3080	5406.27	#N/A	0.22979	0.060437	#N/A	0.03874	4.2899536	0.05807
04-Jan-11	75	16255.7	0.3535	20.33823	4.48142	0.8473	0.0091301	0.1417806	3.778325	0.124657343	6675	0.03547759	0.14366	0.246812	0.4557	0.0989714	#N/A	304.28	17.24970	#N/A	0.2370	0.10273	0.3150	118.07	0.2891	151.690	4.47E-02	102.975	8.3512	5422.56	#N/A	0.23721	0.0616745	#N/A	0.04121	4.3236136	0.06302
11-Jan-11	76	16290.2	0.3638	20.46174	4.53421	0.8615	0.0097451	0.1520306	3.780375	0.125682343	6700	0.03752759	0.14776	0.250912	0.4578	0.1051214	#N/A	306.78	17.25349	#N/A	0.2411	0.10683	0.3252	118.37	0.3096	152.995	4.67E-02	103.134	8.3863	5435.55	#N/A	0.24336	0.0626995	#N/A	0.04326	4.3510836	0.06712
18-Jan-11	77	16324.6	0.3743	20.58774	4.58881	0.8758	0.0103751	0.1625306	3.782475	0.126732343	6725	0.03962759	0.15196	0.255112	0.4599	0.1114214	#N/A	309.30	17.25727	#N/A	0.2453	0.11103	0.3357	118.66	0.3306	154.343	4.88E-02	103.302	8.4216	5448.36	#N/A	0.24966	0.0637495	#N/A	0.04536	4.3788036	0.07132
25-Jan-11	78	16360.4	0.3854	20.71457	4.64666	0.8911	0.0110426	0.1736556	3.7847	0.127844843	6751	0.04185259	0.15641	0.259562	0.4621	0.1180964	#N/A	311.99	17.26150	#N/A	0.2497	0.11548	0.3469	118.95	0.3528	155.780	5.11E-02	103.402	8.4592	5461.76	#N/A	0.25634	0.064862	#N/A	0.04759	4.4099536	0.07577
01-Feb-11	79	16406.4	0.3968	20.84083	4.70581	0.9069	0.0117251	0.1850306	3.786975	0.128982343	6778	0.04412759	0.16096	0.264112	0.4644	0.1249214	#N/A	314.76	17.26593	#N/A	0.2543	0.12003	0.3582	119.24	0.3756	157.255	5.33E-02	103.465	8.4977	5475.36	#N/A	0.26316	0.0659995	#N/A	0.04986	4.4427136	0.08032
08-Feb-11	80	16446.0	0.4078	20.96128	4.76301	0.9223	0.0123851	0.1960306	3.789175	0.130082343	6805	0.04632759	0.16536	0.268512	0.4666	0.1315214	#N/A	317.45	17.27028	#N/A	0.2587	0.12443	0.3692	119.51	0.3976	158.682	5.55E-02	103.506	8.5351	5488.48	#N/A	0.26976	0.0670995	#N/A	0.05206	4.4748336	0.08472
15-Feb-11	81	16481.5	0.4190	21.08278	4.82151	0.9380	0.0130601	0.2072806	3.791425	0.131207343	6832	0.04857759	0.16986	0.273012	0.4688	0.1382714	#N/A	320.20	17.27478	#N/A	0.2632	0.12893	0.3805	119.78	0.4201	160.145	5.78E-02	103.529	8.5733	5501.84	#N/A	0.27651	0.0682245	#N/A	0.05431	4.5081336	0.08922
22-Feb-11	82	16518.8	0.4305	21.20008	4.88131	0.9535	0.0137501	0.2187806	3.793725	0.132357343	6859	0.05087759	0.17446	0.277612	0.4711	0.1451714	#N/A	322.93	17.27892	#N/A	0.2678	0.13353	0.3920	120.03	0.4431	161.578	6.01E-02	103.563	8.6108	5515.59	#N/A	0.28341	0.0693745	#N/A	0.05661	4.5403336	0.09382
01-Mar-11	83	16572.2	0.4420	21.31393	4.94111	0.9685	0.0144401	0.2302806	3.796025	0.133507343	6886	0.05317759	0.17906	0.282212	0.4734	0.1520714	#N/A	325.61	17.28283	#N/A	0.2724	0.13813	0.4035	120.27	0.4661	162.980	6.24E-02	103.603	8.6475	5529.39	#N/A	0.29031	0.0705245	#N/A	0.05891	4.5716136	0.09842
08-Mar-11	84	16614.9	0.4528	21.41874	4.99701	0.9824	0.0150851	0.2410306	3.798175	0.134582343	6910	0.05532759	0.18336	0.286512	0.4756	0.1585214	#N/A	328.10	17.28637	#N/A	0.2767	0.14243	0.4142	120.49	0.4876	164.276	6.45E-02	103.644	8.6814	5542.32	#N/A	0.29676	0.0715995	#N/A	0.06106	4.6004236	0.10272
15-Mar-11	85	16651.0	0.4637	21.52314	5.05356	0.9964	0.0157376	0.2519056	3.80035	0.135669843	6935	0.05750259	0.18771	0.290862	0.4778	0.1650464	#N/A	330.60	17.28985	#N/A	0.2810	0.14678	0.4251	120.71	0.5093	165.572	6.67E-02	103.687	8.7153	5555.41	#N/A	0.30329	0.072687	#N/A	0.06324	4.6291336	0.10707
22-Mar-11	86	16684.6	0.4748	21.63884	5.11364	1.0088	0.0164051	0.2630306	3.802575	0.136782343	6958	0.05972759	0.19216	0.295312	0.4800	0.1717214	#N/A	332.88	17.29297	#N/A	0.2855	0.15123	0.4362	120.93	0.5316	166.840	6.89E-02	103.721	8.7463	5568.07	#N/A	0.30996	0.0737995	#N/A	0.06546	4.6527186	0.11152
29-Mar-11	87	16724.4	0.4869	21.76979	5.18032	1.0214	0.0171326	0.2751556	3.805	0.137994843	6981	0.06215259	0.19701	0.300162	0.4824	0.1789964	#N/A	335.21	17.29612	#N/A	0.2903	0.15608	0.4484	121.17	0.5558	168.191	7.14E-02	103.751	8.7779	5581.47	#N/A	0.31724	0.075012	#N/A	0.06789	4.6752711	0.11637
05-Apr-11	88	16757.8	0.4980	21.89217	5.24207	1.0326	0.0178001	0.2862806	3.807225	0.139107343	7001	0.06437759	0.20146	0.304612	0.4846	0.1856714	#N/A	337.27	17.29890	#N/A	0.2948	0.16053	0.4595	121.40	0.5781	169.416	7.36E-02	103.776	8.8060	5593.58	#N/A	0.32391	0.0761245	#N/A	0.07011	4.6945174	0.12082
12-Apr-11	89	16780.9	0.5065	21.98737	5.28967	1.0407	0.0183101	0.2947806	3.808925	0.139957343	7016	0.06607759	0.20486	0.308012	0.4863	0.1907714	#N/A	338.80	17.30094	#N/A	0.2982	0.16393	0.4680	121.57	0.5951	170.341	7.53E-02	103.793	8.8267	5602.69	#N/A	0.32901	0.0769745	#N/A	0.07181	4.7081174	0.12422
19-Apr-11	90	16815.1	0.5178	22.10212	5.35042	1.0535	0.0189851	0.3060306	3.811175	0.141082343	7038	0.06832759	0.20936	0.312512	0.4886	0.1975214	#N/A	341.09	17.30477	#N/A	0.3027	0.16843	0.4792	121.79	0.6176	171.637	7.75E-02	103.849	8.8567	5614.52	#N/A	0.33576	0.0780995	#N/A	0.07406	4.7317424	0.12872
26-Apr-11	91	16845.9	0.5277	22.19791	5.40276	1.0657	0.0195776	0.3159056	3.81315	0.142069843	7057	0.07030259	0.21331	0.316462	0.4906	0.2034464	#N/A	343.23	17.30862	#N/A	0.3066	0.17238	0.4891	121.99	0.6373	172.806	7.95E-02	103.913	8.8840	5624.81	#N/A	0.34169	0.079087	#N/A	0.07604	4.7549486	0.13267
03-May-11	92	16883.2	0.5392	22.30658	5.46313	1.0803	0.0202676	0.3274056	3.81545	0.143219843	7080	0.07260259	0.21791	0.321062	0.4929	0.2103464	#N/A	345.79	17.31339	#N/A	0.3112	0.17698	0.5006	122.22	0.6603	174.186	8.18E-02	103.997	8.9165	5636.74	#N/A	0.34859	0.080237	#N/A	0.07834	4.7834111	0.13727
10-May-11	93	16923.5	0.5512	22.41698	5.52553	1.0962	0.0209876	0.3394056	3.81785	0.144419843	7105	0.07500259	0.22271	0.325862	0.4953	0.2175464	#N/A	348.53	17.31867	#N/A	0.3160	0.18178	0.5126	122.46	0.6843	175.645	8.42E-02	104.093	8.9511	5649.12	#N/A	0.35579	0.081437	#N/A	0.08074	4.8146111	0.14207

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining	Fraction of Non-Sulphate Sulphur Leached	Fraction of Sulphate Sulphur Remaining	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO4	(Ca+Mg)/Alk	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
28-Jul-09	0	4.480	22.9	22.9	640.3	640.3	6.666	0.00963	0.990	0.02016	0.980	0.01444	0.986	0.04	2.199	0.90	0.77	26.21	5.80	667.1	600.2	0.6002	600.2	0.6002	0.98	685.5	685.5	0.98
04-Aug-09	1	3.650	19.8	42.7	738.6	1378.9	14.355	0.02073	0.979	0.04343	0.957	0.03110	0.969	0.03	2.174	0.92	0.81	27.05	7.02	769.5	709.0	0.7090	1309.2	1.3092	0.95	785.7	1471.2	0.95
11-Aug-09	2	4.312	23.5	66.3	741.8	2120.7	22.077	0.03189	0.968	0.06679	0.933	0.04783	0.952	0.03	2.149	0.92	0.82	26.65	7.62	772.9	714.5	0.7145	2023.7	2.0237	0.93	792.1	2263.3	0.92
18-Aug-09	3	4.004	33.4	99.6	679.2	2799.9	29.147	0.04210	0.958	0.08818	0.912	0.06315	0.937	0.05	2.127	1.11	1.01	27.69	10.00	707.6	784.1	0.7841	2807.8	2.8078	0.90	736.9	3000.2	0.89
25-Aug-09	4	4.441	32.1	131.7	662.9	3462.8	36.048	0.05207	0.948	0.10905	0.891	0.07810	0.922	0.05	2.104	1.13	1.04	28.26	11.66	690.6	783.1	0.7831	3590.9	3.5909	0.87	718.2	3718.5	0.87
01-Sep-09	5	4.532	28.8	160.5	632.9	4095.7	42.637	0.06159	0.938	0.12898	0.871	0.09238	0.908	0.05	2.083	1.11	1.03	28.82	13.79	659.4	729.3	0.7293	4320.3	4.3203	0.85	683.7	4402.2	0.84
08-Sep-09	6	4.676	31.5	192.0	761.7	4857.4	50.566	0.07304	0.927	0.15297	0.847	0.10956	0.890	0.04	2.058	0.90	0.85	27.32	15.61	793.6	715.9	0.7159	5036.2	5.0362	0.82	820.4	5222.5	0.82
15-Sep-09	7	4.873	34.7	226.7	686.1	5543.5	57.709	0.08336	0.917	0.17458	0.825	0.12504	0.875	0.05	2.035	0.99	0.94	25.81	18.26	714.9	707.5	0.7075	5743.7	5.7437	0.80	744.7	5967.3	0.79
22-Sep-09	8	4.348	33.0	259.7	697.5	6241.0	64.970	0.09385	0.906	0.19654	0.803	0.14077	0.859	0.05	2.012	1.01	0.97	26.29	21.29	726.7	736.5	0.7365	6480.2	6.4802	0.77	755.3	6722.6	0.76
29-Sep-09	9	3.156	25.9	285.7	720.5	6961.5	72.470	0.10468	0.895	0.21923	0.781	0.15702	0.843	0.04	1.988	0.85	0.82	26.77	25.28	750.6	637.1	0.6371	7117.2	7.1172	0.75	773.4	7496.0	0.74
06-Oct-09	10	2.708	27.4	313.0	681.2	7642.7	79.562	0.11492	0.885	0.24069	0.759	0.17238	0.828	0.04	1.965	0.89	0.86	26.21	24.89	709.7	631.5	0.6315	7748.7	7.7487	0.73	734.4	8230.4	0.71
13-Oct-09	11	2.387	30.6	343.7	720.7	8363.4	87.064	0.12576	0.874	0.26338	0.737	0.18864	0.811	0.04	1.941	0.88	0.85	25.64	24.51	750.8	664.1	0.6641	8412.9	8.4129	0.70	779.1	9009.5	0.68
20-Oct-09	12	2.834	35.6	379.3	763.5	9126.9	95.013	0.13724	0.863	0.28743	0.713	0.20586	0.794	0.05	1.915	0.89	0.85	25.20	26.60	795.5	705.7	0.7057	9118.6	9.1186	0.68	828.2	9837.7	0.65
27-Oct-09	13	3.187	39.3	418.5	671.0	9798.0	101.998	0.14733	0.853	0.30856	0.691	0.22100	0.779	0.06	1.893	1.02	0.99	24.75	29.16	699.1	715.6	0.7156	9834.2	9.8342	0.65	735.2	10572.9	0.63
03-Nov-09	14	3.611	30.8	449.3	634.6	10432.6	108.605	0.15687	0.843	0.32855	0.671	0.23531	0.765	0.05	1.872	0.92	0.89	24.96	31.74	661.2	609.0	0.6090	10443.2	10.4432	0.63	688.4	11261.3	0.60
10-Nov-09	15	5.147	32.4	481.8	724.0	11156.6	116.142	0.16776	0.832	0.35135	0.649	0.25164	0.748	0.04	1.848	0.92	0.90	25.17	34.74	754.3	697.5	0.6975	11140.7	11.1407	0.61	781.6	12042.9	0.57
17-Nov-09	16	4.253	38.0	519.7	729.6	11886.2	123.738	0.17873	0.821	0.37433	0.626	0.26810	0.732	0.05	1.823	0.84	0.82	21.75	36.68	760.1	641.9	0.6419	11782.7	11.7827	0.58	793.8	12836.7	0.55
24-Nov-09	17	3.116	42.6	562.4	604.5	12490.7	130.030	0.18782	0.812	0.39336	0.607	0.28173	0.718	0.07	1.803	0.89	0.86	18.33	39.72	629.8	557.4	0.5574	12340.1	12.3401	0.56	669.3	13506.0	0.52
01-Dec-09	18	2.891	37.0	599.4	302.2	12792.9	133.176	0.19237	0.808	0.40288	0.597	0.28855	0.711	0.12	1.793	1.29	1.25	14.35	35.74	314.9	406.1	0.4061	12746.2	12.7462	0.55	349.0	13855.0	0.51
08-Dec-09	19	2.789	33.3	632.7	197.9	12990.9	135.237	0.19534	0.805	0.40911	0.591	0.29301	0.707	0.17	1.786	1.38	1.33	10.37	30.32	206.2	284.1	0.2841	13030.4	13.0304	0.54	236.7	14091.7	0.50
15-Dec-09	20	2.204	34.5	667.2	283.2	13274.0	138.185	0.19960	0.800	0.41803	0.582	0.29940	0.701	0.12	1.777	0.84	0.81	8.85	28.30	295.0	247.8	0.2478	13278.1	13.2781	0.53	327.3	14419.0	0.49
22-Dec-09	21	1.491	33.5	700.6	175.3	13449.4	140.010	0.20224	0.798	0.42355	0.576	0.30336	0.697	0.19	1.771	1.07	1.03	7.32	25.84	182.7	196.3	0.1963	13474.4	13.4744	0.52	214.7	14633.7	0.48
29-Dec-09	22	1.951	34.2	734.9	151.4	13600.8	141.586	0.20451	0.795	0.42832	0.572	0.30677	0.693	0.23	1.766	1.09	1.04	6.55	23.26	157.7	171.7	0.1717	13646.2	13.6462	0.52	190.0	14823.7	0.48
05-Jan-10	23	2.417	35.3	770.2	128.6	13729.3	142.924	0.20645	0.794	0.43237	0.568	0.30967	0.690	0.27	1.762	1.12	1.07	5.78	20.63	133.9	149.8	0.1498	13796.0	13.7960	0.51	166.8	14990.5	0.47
12-Jan-10	24	2.315	34.9	805.1	109.8	13839.1	144.067	0.20810	0.792	0.43583	0.564	0.31215	0.688	0.32	1.758	1.13	1.07	5.31	18.56	114.3	129.6	0.1296	13925.5	13.9255	0.51	146.9	15137.5	0.47
19-Jan-10	25	2.469	38.4	843.5	106.3	13945.3	145.173	0.20969	0.790	0.43917	0.561	0.31454	0.685	0.36	1.754	1.12	1.05	4.84	16.55	110.7	123.8	0.1238	14049.4	14.0494	0.50	146.6	15284.1	0.46
26-Jan-10	26	2.207	40.1	883.6	65.0	14010.3	145.849	0.21067	0.789	0.44122	0.559	0.31601	0.684	0.62	1.752	1.68	1.58	4.25	15.49	67.7	113.8	0.1138	14163.2	14.1632	0.50	105.6	15389.7	0.46
02-Feb-10	27	1.993	43.6	927.2	64.5	14074.8	146.521	0.21164	0.788	0.44325	0.557	0.31746	0.683	0.68	1.750	1.59	1.48	3.65	14.26	67.2	106.7	0.1067	14269.9	14.2699	0.50	108.9	15498.5	0.45
09-Feb-10	28	1.650	39.9	967.1	50.6	14125.4	147.048	0.21240	0.788	0.44484	0.555	0.31860	0.681	0.79	1.748	1.72	1.59	3.62	13.04	52.7	90.6	0.0906	14360.5	14.3605	0.49	91.0	15589.5	0.45
16-Feb-10	29	1.766	47.1	1014.2	56.1	14181.6	147.632	0.21325	0.787	0.44661	0.553	0.31987	0.680	0.84	1.747	1.70	1.57	3.59	11.98	58.5	99.6	0.0996	14460.1	14.4601	0.49	103.8	15693.3	0.45
23-Feb-10	30	1.752	50.0	1064.2	43.1	14224.7	148.081	0.21389	0.786	0.44797	0.552	0.32084	0.679	1.16	1.745	2.15	1.97	3.27	11.33	44.9	96.6	0.0966	14556.7	14.5567	0.49	93.1	15786.5	0.44
02-Mar-10	31	1.456	44.7	1108.9	39.2	14263.8	148.489	0.21448	0.786	0.44920	0.551	0.32173	0.678	1.14	1.744	1.92	1.75	2.95	10.63	40.8	78.2	0.0782	14634.8	14.6348	0.48	84.0	15870.5	0.44
09-Mar-10	32	1.191	43.8	1152.7	27.4	14291.2	148.774	0.21490	0.785	0.45006	0.550	0.32234	0.678	1.60	1.743	2.45	2.23	2.80	10.19	28.5	69.9	0.0699	14704.8	14.7048	0.48	71.2	15941.7	0.44
16-Mar-10	33	1.191	53.8	1206.5	40.2	14331.4	149.192	0.21550	0.785	0.45133	0.549	0.32325	0.677	1.34	1.742	1.86	1.69	2.64	9.74	41.9	78.0	0.0780	14782.8	14.7828	0.48	94.4	16036.1	0.43
23-Mar-10	34	1.109	42.7	1249.2	40.5	14371.9	149.614	0.21611	0.784	0.45260	0.547	0.32416	0.676	1.06	1.740	1.64	1.48	2.60	9.71	42.2	69.0	0.0690	14851.8	14.8518	0.48	83.8	16119.9	0.43
30-Mar-10	35	1.096	35.5	1284.7	40.3	14412.2	150.033	0.21671	0.783	0.45387	0.546	0.32507	0.675	0.88	1.739	1.54	1.40	2.56	9.68	42.0	64.8	0.0648	14916.6	14.9166	0.47	76.4	16196.3	0.43
06-Apr-10	36	1.298	31.0	1315.7	35.6	14447.8	150.403	0.21725	0.783	0.45499	0.545	0.32587	0.674	0.87	1.738	1.59	1.43	2.47	9.17	37.0	58.8	0.0588	14975.5	14.9755	0.47	66.7	16263.0	0.43
13-Apr-10	37	1.643	30.0	1345.7	32.4	14480.1	150.740	0.21774	0.782	0.45601	0.544	0.32660	0.673	0.93	1.737	1.77	1.58	2.38	8.68	33.7	59.6	0.0596	15035.0	15.0350	0.47	62.1	16325.1	0.42
20-Apr-10	38	1.371	45.8	1391.4	31.6	14511.7	151.069	0.21821	0.782	0.45701	0.543	0.32732	0.673	1.45	1.736	2.13	1.89	2.61	8.10	32.9	70.1	0.0701	15105.1	15.1051	0.47	77.3	16402.4	0.42
27-Apr-10	39	1.270	50.6	1442.0	27.5	14539.2	151.356	0.21862	0.781	0.45787	0.542	0.32794	0.672	1.84	1.735	2.51	2.23	2.39	7.96	28.7	72.0	0.0720	15177.1	15.1771	0.46	77.9	16480.4	0.42
04-May-10	40	1.598	53.7	1495.7	33.5	14572.7	151.704	0.21913	0.781	0.45893	0.541	0.32869	0.671	1.60	1.734	2.11	1.88	2.52	8.10	34.9	73.7	0.0737	15250.7	15.2507	0.46	86.9	16567.3	0.42
11-May-10	41	1.823	54.1	1549.7	28.4	14601.0	151.999	0.21955	0.780	0.45982	0.540	0.32933	0.671	1.91	1.733	2.43	2.17	2.65	8.23	29.5	71.9	0.0719	15322.6	15.3226	0.46	81.8	16649.1	0.41
18-May-10	42	2.118	45.8	1595.5	17.2	14618.2	152.178	0.21981	0.780	0.46036	0.540	0.32972	0.670	2.67	1.732	3.36	3.00	1.98	8.47	17.9	60.1	0.0601	15382.7	15.3827	0.46	61.5	16710.6	0.41
25-May-10	43	1.779	25.0	1620.5	6.6	14624.8	152.246	0.21991	0.780	0.46057	0.539	0.32987	0.670	3.82	1.732	4.70	4.22	1.30	9.00	6.8	32.1	0.0321	15414.8	15.4148	0.46	30.1	16740.7	0.41
01-Jun-10	44	1.554	23.8	1644.4	19.9	14644.7	152.453	0.22021	0.780	0.46119	0.539	0.33032	0.670	1.20	1.731	2.08	1.86	1.83	8.68	20.7	43.1	0.0431	15457.9	15.4579	0.45	43.0	16783.7	0.41
08-Jun-10	45	1.506	25.4	1669.8	28.2	14672.9	152.747	0.22063	0.779	0.46208	0.538	0.33095	0.669	0.90	1.730	2.01	1.80	2.37	8.51	29.4	59.2	0.0592	15517.1	15.5171	0.45	53.3	16837.0	0.41
15-Jun-10	46	1.363	30.8	1700.5	28.7	14701.5	153.045	0.22107	0.779	0.46299	0.537	0.33160	0.668	1.07	1.729	2.30	2.03	2.50	7.73	29.9	68.6	0.0686	15585.7	15.5857	0.45	59.3	16896.3	0.40
22-Jun-10	47	0.979	30.8	1731.3	35.7	14737.2	153.417	0.22160	0.778	0.46411	0.536	0.33240	0.668	0.86	1.728	1.77	1.56	2.64	7.12	37.2	66.0	0.0660	15651.7	15.6517	0.45	67.0	16963.2	0.40
29-Jun-10	48	1.401	34.8	1766.1	66.3	14803.5	154.107	0.22260	0.777	0.46620	0.534	0.33390	0.666	0.53	1.726	1.30	1.15	3.17	7.75	69.0	89.6	0.0896	15741.3	15.7413	0.44	102.4	17065.7	0.40
06-Jul-10	49	1.512	31.1	1797.1	46.6	14850.1	154.592	0.22330	0.777	0.46767	0.532	0.33495	0.665	0.67	1.724	1.92	1.71	3.69	8.26	48.6	93.4	0.0934	15834.7	15.8347	0.44	78.1	17143.8	0.39
13-Jul-10	50	1.813	35.5	1832.6	38.7	14888.8	154.995	0.22388	0.776	0.46888	0.531	0.33582	0.664	0.92	1.723	2.37	2.11	3.61	8.05	40.3	95.8	0.0958	15930.5	15.9305	0.44	74.0	17217.8	0.39
20-Jul-10	51	2.134	40.2	1872.9	53.4	14942.2	155.551	0.22468	0.775	0.47057	0.529	0.33703	0.663	0.75	1.721	1.76	1.56	3.54	7.84	55.6	98.0	0.0980	16028.5	16.0285	0.43	93.7	17311.5	0.39
27-Jul-10	52	2.064	41.6	1914.5	58.0	15000.1	156.154	0.22556	0.774	0.47239	0.528	0.33833	0.662	0.72	1.719	1.66	1.47	3.51	7.68	60.4	100.5	0.1005	16129.0	16.1290	0.43	99.9	17411.4	0.39
03-Aug-10	53	1.843	39.8	1954.3	52.3	15052.5	156.699	0.22634	0.774	0.47404	0.526	0.33951	0.660	0.76	1.718	1.75	1.55	3.49	7.52	54.5	95.6	0.0956	16224.5	16.2245	0.43	92.5	17503.9	0.38
10-Aug-10	54	1.707	36.1	1990.4	66.0	15118.5	157.386	0.22733	0.773	0.47612	0.524	0.34100	0.659	0.55	1.715	1.26	1.11	3.27	7.36	68.8	86.7	0.0867	16311.3	16.3113	0.42	103.2	17607.1	0.38
17-Aug-10	55	1.614	33.4	2023.8	51.8	15170.2	157.925	0.22811	0.772	0.47775	0.522	0.34217	0.658	0.64	1.714	1.49	1.30	3.06	7.19	53.9	80.1	0.0801	16391.4	16.3914	0.42	85.7	17692.8	0.38
24-Aug-10	56	2.361	35.4	2059.2	40.9	15211.1	158.350	0.22873	0.771	0.47903	0.521	0.34309	0.657	0.87	1.712	1.81	1.58	2.97	6.99	42.6	76.8	0.0768	16468.2	16.4682	0.42	75.6	17768.4	0.37

Appendix B.1-3

Humidity Cell T3 (Silt-Clay Composite)

Production Rates and Depletion | *Ratios* | *NP Consumption Rates*

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining	Fraction of Non-Sulphate Sulphur Leached	Fraction of Sulphate Sulphur Remaining	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	CMR	Ca/SO4	(Ca+Mg)/Alk	Ca/Mg	Theoretical NP Consumption at pH 6	Carbonate NP Consumption (kg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
31-Aug-10	57	3.235	39.2	2098.4	53.0	15264.0	158.901	0.22952	0.770	0.48070	0.519	0.34429	0.656	0.74	1.710	1.40	1.22	2.87	6.78	55.2	77.1	0.0771	16545.2	16.5452	0.42	91.1	17859.5	0.37
07-Sep-10	58	2.428	35.8	2134.3	50.0	15314.0	159.421	0.23028	0.770	0.48227	0.518	0.34541	0.655	0.72	1.709	1.37	1.20	2.82	6.89	52.1	71.4	0.0714	16616.6	16.6166	0.41	85.5	17945.0	0.37
14-Sep-10	59	1.695	32.6	2166.9	43.5	15357.5	159.874	0.23093	0.769	0.48364	0.516	0.34639	0.654	0.75	1.707	1.45	1.27	2.77	7.01	45.3	65.9	0.0659	16682.5	16.6825	0.41	76.2	18021.2	0.36
21-Sep-10	60	2.178	43.4	2210.3	68.0	15425.5	160.582	0.23195	0.768	0.48578	0.514	0.34793	0.652	0.64	1.705	1.24	1.08	2.92	6.89	70.8	88.0	0.0880	16770.4	16.7704	0.41	112.1	18133.3	0.36
28-Sep-10	61	1.282	26.4	2236.8	37.7	15463.2	160.974	0.23252	0.767	0.48697	0.513	0.34878	0.651	0.70	1.704	1.37	1.19	3.07	6.79	39.3	53.7	0.0537	16824.1	16.8241	0.41	64.4	18197.8	0.36
05-Oct-10	62	1.860	39.1	2275.9	62.6	15525.8	161.626	0.23346	0.767	0.48894	0.511	0.35019	0.650	0.62	1.702	1.32	1.15	2.99	6.65	65.3	86.4	0.0864	16910.6	16.9106	0.40	102.5	18300.3	0.35
12-Oct-10	63	1.405	29.9	2305.8	62.0	15587.8	162.272	0.23439	0.766	0.49090	0.509	0.35159	0.648	0.48	1.700	1.07	0.93	2.95	6.58	64.6	69.2	0.0692	16979.8	16.9798	0.40	93.1	18393.4	0.35
19-Oct-10	64	1.577	33.8	2339.6	66.0	15653.8	162.959	0.23538	0.765	0.49298	0.507	0.35308	0.647	0.51	1.697	1.17	1.01	2.93	6.54	68.7	80.2	0.0802	17060.0	17.0600	0.40	101.0	18494.4	0.35
26-Oct-10	65	1.349	29.1	2368.8	53.1	15706.9	163.511	0.23618	0.764	0.49465	0.505	0.35427	0.646	0.55	1.696	1.28	1.11	2.90	6.50	55.3	70.9	0.0709	17130.9	17.1309	0.40	83.1	18577.4	0.34
02-Nov-10	66	1.778	34.8	2403.5	59.8	15766.7	164.133	0.23708	0.763	0.49653	0.503	0.35562	0.644	0.58	1.694	1.31	1.14	2.96	6.37	62.3	81.9	0.0819	17212.8	17.2128	0.39	95.3	18672.7	0.34
09-Nov-10	67	1.777	33.3	2436.8	65.8	15832.4	164.818	0.23807	0.762	0.49860	0.501	0.35711	0.643	0.51	1.691	1.13	0.97	2.98	6.31	68.5	77.2	0.0772	17290.0	17.2900	0.39	100.0	18772.8	0.34
16-Nov-10	68	1.707	31.3	2468.1	56.4	15888.8	165.405	0.23892	0.761	0.50038	0.500	0.35838	0.642	0.56	1.690	1.23	1.06	2.99	6.28	58.8	72.1	0.0721	17362.1	17.3621	0.39	88.4	18861.2	0.33
23-Nov-10	69	1.804	32.5	2500.6	52.9	15941.7	165.956	0.23971	0.760	0.50204	0.498	0.35957	0.640	0.61	1.688	1.35	1.16	3.01	6.25	55.1	74.3	0.0743	17436.4	17.4364	0.38	85.8	18946.9	0.33
30-Nov-10	70	2.554	28.9	2529.5	52.9	15994.6	166.507	0.24051	0.759	0.50371	0.496	0.36076	0.639	0.55	1.686	1.42	1.22	3.13	6.00	55.1	78.2	0.0782	17514.6	17.5146	0.38	81.5	19028.4	0.33
07-Dec-10	71	3.059	28.2	2557.8	62.6	16057.3	167.159	0.24145	0.759	0.50568	0.494	0.36218	0.638	0.45	1.684	1.28	1.09	3.19	5.89	65.3	83.6	0.0836	17598.2	17.5982	0.38	90.4	19118.9	0.33
14-Dec-10	72	3.250	27.2	2585.0	58.7	16116.0	167.770	0.24233	0.758	0.50753	0.492	0.36350	0.636	0.46	1.682	1.38	1.18	3.22	5.83	61.2	84.4	0.0844	17682.5	17.6825	0.38	85.1	19204.0	0.32
21-Dec-10	73	3.520	26.8	2611.7	56.1	16172.1	168.354	0.24318	0.757	0.50930	0.491	0.36477	0.635	0.48	1.680	1.49	1.27	3.25	5.78	58.4	87.1	0.0871	17769.7	17.7697	0.37	81.7	19285.7	0.32
28-Dec-10	74	2.579	29.3	2641.0	41.1	16213.2	168.782	0.24380	0.756	0.51059	0.489	0.36569	0.634	0.71	1.679	1.70	1.45	3.06	5.88	42.8	72.8	0.0728	17842.4	17.8424	0.37	69.5	19355.2	0.32
04-Jan-11	75	2.891	40.2	2681.2	42.6	16255.7	169.225	0.24444	0.756	0.51193	0.488	0.36665	0.633	0.94	1.677	1.99	1.70	2.96	5.93	44.4	88.3	0.0883	17930.7	17.9307	0.37	81.6	19436.8	0.31
11-Jan-11	76	2.253	34.7	2715.9	34.4	16290.2	169.583	0.24495	0.755	0.51302	0.487	0.36743	0.633	1.01	1.676	2.01	1.72	2.91	5.96	35.9	72.0	0.0720	18002.7	18.0027	0.36	68.3	19505.1	0.31
18-Jan-11	77	2.163	37.0	2752.9	34.4	16324.6	169.942	0.24547	0.755	0.51410	0.486	0.36821	0.632	1.07	1.675	2.02	1.73	2.86	5.99	35.9	72.5	0.0725	18075.1	18.0751	0.36	70.7	19575.9	0.31
25-Jan-11	78	2.127	39.7	2792.6	35.8	16360.4	170.315	0.24601	0.754	0.51523	0.485	0.36902	0.631	1.11	1.674	2.08	1.78	2.89	5.98	37.3	77.5	0.0775	18152.6	18.1526	0.36	74.9	19650.8	0.31
01-Feb-11	79	2.091	40.9	2833.5	46.0	16406.4	170.793	0.24670	0.753	0.51668	0.483	0.37005	0.630	0.89	1.672	1.66	1.42	2.90	5.97	47.9	79.6	0.0796	18232.2	18.2322	0.36	86.7	19737.5	0.30
08-Feb-11	80	1.981	39.7	2873.2	39.6	16446.0	171.205	0.24730	0.753	0.51792	0.482	0.37094	0.629	1.00	1.671	1.87	1.60	2.91	5.97	41.3	77.1	0.0771	18309.3	18.3093	0.35	79.0	19816.4	0.30
15-Feb-11	81	1.985	40.7	2913.9	35.6	16481.5	171.575	0.24783	0.752	0.51904	0.481	0.37175	0.628	1.15	1.670	2.13	1.83	2.92	5.97	37.0	79.0	0.0790	18388.3	18.3883	0.35	75.8	19892.2	0.30
22-Feb-11	82	1.847	39.3	2953.2	37.3	16518.8	171.963	0.24839	0.752	0.52022	0.480	0.37259	0.627	1.06	1.669	2.03	1.74	2.84	6.00	38.8	78.7	0.0787	18467.0	18.4670	0.35	76.3	19968.5	0.30
01-Mar-11	83	1.756	38.2	2991.4	53.4	16572.2	172.519	0.24919	0.751	0.52190	0.478	0.37379	0.626	0.72	1.667	1.40	1.20	2.80	6.02	55.6	77.7	0.0777	18544.7	18.5447	0.35	92.0	20060.5	0.29
08-Mar-11	84	1.599	35.1	3026.5	42.8	16614.9	172.964	0.24984	0.750	0.52324	0.477	0.37476	0.625	0.82	1.665	1.62	1.39	2.78	6.03	44.6	72.1	0.0721	18616.8	18.6168	0.34	78.1	20138.6	0.29
15-Mar-11	85	1.575	35.0	3061.5	36.1	16651.0	173.340	0.25038	0.750	0.52438	0.476	0.37557	0.624	0.97	1.664	1.93	1.65	2.76	6.04	37.6	72.5	0.0725	18689.3	18.6893	0.34	71.0	20209.6	0.29
22-Mar-11	86	1.751	32.2	3093.7	33.6	16684.6	173.690	0.25089	0.749	0.52544	0.475	0.37633	0.624	0.96	1.663	1.88	1.61	2.45	6.02	35.0	65.8	0.0658	18755.1	18.7551	0.34	65.4	20275.0	0.28
29-Mar-11	87	1.985	33.1	3126.8	39.8	16724.4	174.104	0.25148	0.749	0.52669	0.473	0.37722	0.623	0.83	1.662	1.62	1.39	2.30	6.00	41.4	67.2	0.0672	18822.2	18.8222	0.34	72.6	20347.6	0.28
05-Apr-11	88	1.856	29.5	3156.3	33.4	16757.8	174.451	0.25199	0.748	0.52774	0.472	0.37798	0.622	0.88	1.661	1.71	1.47	2.22	5.99	34.8	59.6	0.0596	18881.8	18.8818	0.33	62.4	20410.0	0.28
12-Apr-11	89	1.445	21.8	3178.1	23.1	16780.9	174.692	0.25233	0.748	0.52847	0.472	0.37850	0.622	0.94	1.660	1.82	1.56	2.14	5.98	24.1	43.9	0.0439	18925.7	18.9257	0.33	44.5	20454.5	0.28
19-Apr-11	90	2.113	34.9	3213.0	34.2	16815.1	175.048	0.25285	0.747	0.52955	0.470	0.37927	0.621	1.02	1.659	1.77	1.50	2.32	5.65	35.6	62.9	0.0629	18988.6	18.9886	0.33	68.4	20522.9	0.28
26-Apr-11	91	1.942	33.3	3246.3	30.8	16845.9	175.369	0.25331	0.747	0.53052	0.469	0.37997	0.620	1.08	1.658	1.79	1.51	2.41	5.52	32.1	57.3	0.0573	19046.0	19.0460	0.33	63.4	20586.3	0.27
03-May-11	92	2.313	40.3	3286.6	37.3	16883.2	175.757	0.25387	0.746	0.53169	0.468	0.38081	0.619	1.08	1.656	1.75	1.48	2.45	5.45	38.8	68.0	0.0680	19113.9	19.1139	0.33	76.8	20663.1	0.27
10-May-11	93	2.467	43.6	3330.2	40.3	16923.5	176.176	0.25448	0.746	0.53296	0.467	0.38172	0.618	1.08	1.655	1.72	1.45	2.50	5.40	42.0	72.2	0.0722	19186.2	19.1862	0.32	83.2	20746.3	0.27
Average of Measured Cycles 31 - 93		*39.5*														*1.9*				*71.6*							

Appendix B.1-4

Humidity Cell T4 (CaNP depleted Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L	Mn mg/L	Hg ug/L
11-Aug-09	0	500	445	7.29	55	#N/A	5.6	3.2	18	0.7	17	0.0139	0.00914	0.0204	0.0661	0.00003	<0.000005	<0.05	0.00617	5.94	<0.0001	0.000459	0.0181	0.056	0.00172	0.0019	0.53	0.447	<0.01
18-Aug-09	1	500	450	6.27	88	#N/A	6.3	1.8	30	0.9	28.2	0.0352	0.00887	0.0196	0.0915	0.00007	<0.000005	<0.05	0.0133	10	<0.0001	0.000811	0.0345	0.141	0.00134	0.0033	0.77	0.791	<0.01
25-Aug-09	2	500	440	6.47	131	#N/A	9.4	2.2	53	<0.5	44.7	0.068	0.00951	0.0283	0.101	0.00012	<0.000005	<0.05	0.0226	15.7	<0.0001	0.0015	0.0832	0.222	0.00195	0.0049	1.34	1.36	<0.01
01-Sep-09	3	500	445	6.55	166	#N/A	12.9	2.9	71	0.8	56.6	0.11	0.00993	0.0322	0.0784	0.00016	<0.000005	<0.05	0.0303	19.9	<0.0001	0.00201	0.112	0.327	0.00315	0.0061	1.69	1.68	0.01
08-Sep-09	4	500	355	5.81	207				85																				
15-Sep-09	5	500	475	5.86	272	#N/A	19.9	2.6	114	<0.5	93.9	0.248	0.00994	0.00486	0.0506	0.0003	<0.000005	<0.05	0.056	32.8	<0.0001	0.00404	0.21	0.163	0.00197	0.01	2.93	3.12	<0.01
22-Sep-09	6	500	430	4.78	395				200																				
29-Sep-09	7	500	440	4.37	577	13.9	59.3	#N/A	286	<0.5	218	1.64	0.012	0.0238	0.0301	0.00154	<0.000005	<0.05	0.183	76.6	0.0006	0.0127	0.939	0.785	0.00462	0.0142	6.57	7.52	<0.01
06-Oct-09	8	500	440	3.61	703				381																				
13-Oct-09	9	500	460	3.44	1159	49.6	192.0	#N/A	601	<0.5	421	10.1	0.0098	0.032	0.0114	0.00504	<0.00003	<0.3	0.54	147	0.0048	0.0334	3.07	7.91	0.00201	0.023	12.8	16.3	<0.05
20-Oct-09	10	500	475	3.17	1068				603																				
27-Oct-09	11	500	465	3.04	1336	133.7	377.7	#N/A	768	<0.5	333	21.3	0.0124	0.0682	0.0031	0.0087	<0.0001	<1	0.767	117	0.019	0.0412	5.11	14.6	0.0059	0.019	10	15.8	<0.2
03-Nov-09	12	500	425	2.84	1664				968																				
10-Nov-09	13	500	450	2.53	1572	389.1	640.2	#N/A	943	<0.5	338	47.3	0.0148	0.202	0.0021	0.014	<0.0001	<1	1.02	117	0.049	0.0579	7.84	35.2	0.002	0.023	11.3	17.6	<0.2
17-Nov-09	14	500	480	2.74	2142				1217																				
24-Nov-09	15	500	420	2.79	2277	517.7	1200	#N/A	1403	<0.5	270	77.2	0.021	0.787	0.002	0.017	<0.0003	<3	1.32	91.8	0.122	0.0724	10.4	86	0.0546	<0.03	10	16.3	<0.5
01-Dec-09	16	500	480	2.60	2512				1612																				
08-Dec-09	17	500	435	2.58	2210	600.0	1225	#N/A	1791	<0.5	205	129	0.028	2.43	0.002	0.0193	<0.0003	<3	1.47	65	0.246	0.101	13.2	201	0.0035	<0.03	10.3	13.6	<0.5
15-Dec-09	18	500	460	2.36	2610				1454																				
22-Dec-09	19	500	455	2.35	2980	987.5	1438	#N/A	1515	<0.5	103	84.9	0.023	3.39	0.001	0.0115	<0.0003	<3	0.935	28.2	0.198	0.0689	7.91	165	0.0069	<0.03	7.9	6.24	<0.5
29-Dec-09	20	500	420	2.31	2990				1419																				
05-Jan-10	21	500	445	2.30	3910	987.5	1475	#N/A	1908	<0.5	95.1	97.5	0.0287	5.94	0.0023	0.0122	<0.0001	<1	1.06	20	0.26	0.087	7.94	258	0.0022	0.026	10.9	5.64	<0.2
12-Jan-10	22	500	410	2.45	4590				2044																				
19-Jan-10	23	500	460	2.49	4740	1375	1800	#N/A	1867	<0.5	79.2	92.1	0.0235	6.84	0.002	0.0109	<0.0001	<1	1.01	14.6	0.266	0.0892	7.36	267	0.0021	0.025	10.4	4.47	<0.2
26-Jan-10	24	500	430	2.37	4120				1748																				
02-Feb-10	25	500	450	2.87	3390	1175	1325	#N/A	1475	<0.5	47.1	70.9	0.0178	4.78	0.0022	0.0068	<0.0001	<1	0.641	7.6	0.179	0.0687	5.04	244	0.0018	0.017	6.8	2.56	<0.2
09-Feb-10	26	500	455	2.25	3470				1581																				
16-Feb-10	27	500	480	2.23	3270	975.0	1450	#N/A	1540	<0.5	43.5	66.1	0.018	4.69	0.002	0.0063	<0.0003	<3	0.617	7.5	0.172	0.0692	5.01	299	0.0011	<0.03	6	2.34	<0.5
23-Feb-10	28	500	445	2.19	2980				1246																				
02-Mar-10	29	500	480	2.35	3340	1275	1475	#N/A	1222	<0.5	35.7	55.8	0.015	3.51	0.002	0.0052	<0.0003	<3	0.516	6.3	0.149	0.0648	4.72	218	0.0135	<0.03	4.8	1.92	<0.5
09-Mar-10	30	500	420	2.45	3520				882																				
16-Mar-10	31	500	490	2.44	3250	975.0	1475	#N/A	1078	<0.5	22.5	38.2	0.013	2.69	0.002	0.0042	<0.0003	<3	0.359	4	0.101	0.0502	3.54	172	0.0011	<0.03	3	1.21	<0.5
23-Mar-10	32	500	445	2.69	4310				1257																				
30-Mar-10	33	500	440	2.61	3680	1275	1450	#N/A	1000	<0.5	22.3	36.2	0.015	2.49	0.0032	0.0036	<0.0001	<1	0.342	4.2	0.103	0.0518	3.56	178	0.0009	0.012	2.8	1.15	<0.2
06-Apr-10	34	500	500	2.46	3630				992																				
13-Apr-10	35	500	420	2.30	3510	775.0	1200	#N/A	968	<0.5	18.5	31.1	0.0134	2.07	0.0032	0.003	<0.00005	<0.5	0.279	3.5	0.087	0.0463	3.06	163	0.00039	0.012	2.4	0.94	<0.1
20-Apr-10	36	500	490	2.41	3120				1057																				
27-Apr-10	37	500	465	2.51	3710	800.0	1225	#N/A	1085	<0.5	20.2	42.4	0.014	2.64	0.005	0.0028	<0.0003	<3	0.312	3	0.094	0.0547	3.68	181	0.0005	<0.03	<3	1.07	<0.5
04-May-10	38	500	465	2.33	2930				878																				
11-May-10	39	500	460	2.97	2520	725.0	1050	#N/A	785	<0.5	15.5	27	0.0126	1.54	0.0031	0.00228	<0.00003	<0.3	0.222	3.3	0.0637	0.037	2.44	123	0.00049	0.01	1.7	0.691	<0.05
18-May-10	40	500	415	2.27	2430				786																				
25-May-10	41	500	425	2.44	2340	675.0	1075	#N/A	576	<0.5	15.6	26.8	0.0125	1.32	0.0037	0.0025	<0.0001	<1	0.209	3	0.068	0.0408	2.94	112	0.0018	0.01	2	0.761	<0.2
01-Jun-10	42	500	375	2.89	2510				600																				
08-Jun-10	43	500	455	2.32	2590	575.0	725.0	#N/A	727	<0.5	16.8	27.4	0.0119	1.31	0.0041	0.0025	<0.0001	<1	0.194	4	0.064	0.0382	2.88	117	0.002	0.011	2	0.715	<0.2
15-Jun-10	44	500	445	2.65	2320				527																				
22-Jun-10	45	500	470	2.23	2230	600.0	775.0	#N/A	489	<0.5	15	20.4	0.011	1.03	0.0047	0.00202	<0.00003	<0.3	0.176	3.3	0.0531	0.0348	2.57	102	0.00071	0.009	1.6	0.671	<0.05
29-Jun-10	46	500	445	2.44	2400				701																				
06-Jul-10	47	500	520	2.39	1510	325.0	425.0	#N/A	314	<0.5	7.3	8.51	0.00685	0.356	0.00433	0.00116	<0.000005	<0.05	0.091	1.69	0.0242	0.0166	1.25	44.9	0.00065	0.0058	0.74	0.33	<0.01
13-Jul-10	48	500	425	2.38	2130				341																				
20-Jul-10	49	500	520	2.37	2110	375.0	525.0	#N/A	377	<0.5	10.6	12.5	0.0083	0.39	0.0038	0.00125	<0.00003	<0.3	0.113	2.6	0.0286	0.0212	1.73	61.3	0.00022	0.007	1	0.439	<0.05
27-Jul-10	50	500	500	2.39	1890				346																				
03-Aug-10	51	500	480	2.39	1710	350.0	450.0	#N/A	334	<0.5	8	9.09	0.0071	0.258	0.00308	0.00106	0.000028	<0.05	0.0845	1.99	0.022	0.0164	1.34	35.2	0.000624	0.0061	0.74	0.346	<0.01
10-Aug-10	52	500	440	2.13	1554				375																				
17-Aug-10	53	500	445	2.21	1531	325.0	450.0	#N/A	305	2.5	6.9	7.11	0.00692	0.185	0.0028	0.00086	0.00001	<0.05	0.0643	1.71	0.0167	0.0129	1.15	26.2	0.00319	0.0059	0.65	0.269	<0.01
24-Aug-10	54	500	505	2.17	1380				192																				
31-Aug-10	55	500	450	2.39	1360	325.0	425.0	#N/A	278	<0.5	7.7	8.29	0.0063	0.193	0.00387	0.00101	<0.000005	<0.05	0.0676	1.91	0.019	0.0146	1.3	26.9	0.000466	0.0065	0.72	0.305	<0.01
07-Sep-10	56	500	450	2.38	1263				287																				
14-Sep-10	57	500	465	2.22	1421	300.0	400.0	#N/A	391	<0.5	9.2	9.01	0.00666	0.194	0.003	0.00093	<0.000005	<0.05	0.0705	2.36	0.0199	0.0152	1.42	27.9	0.00014	0.007	0.81	0.32	<0.01
21-Sep-10	58	500	455	2.19	1310				274																				
28-Sep-10	59	500	460	2.41	1270	275.0	400.0	#N/A	273	<0.5	8.5	7.46	0.00642	0.177	0.00248	0.00095	<0.000005	<0.05	0.0604	2.17	0.0165	0.0131	1.28	23.9	0.000613	0.0071	0.73	0.283	<0.01

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-4

Humidity Cell T4 (CaNP depleted Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11-Aug-09	0	<0.00005	0.00201	0.004	0.8	0.00009	3.25	<0.000005	0.87	0.0147	7	0.00008	0.00383	<0.0005	0.000003	<0.0002	0.398	<0.0001
18-Aug-09	1	<0.00005	0.00254	0.003	0.82	0.00019	4.07	0.000007	0.62	0.0241	11	0.000055	0.00472	<0.0005	0.000009	<0.0002	0.709	<0.0001
25-Aug-09	2	<0.00005	0.00453	<0.002	1.08	0.00021	5.66	0.000018	0.79	0.0364	18	0.000078	0.00559	<0.0005	0.000026	<0.0002	1.36	<0.0001
01-Sep-09	3	<0.00005	0.00656	<0.002	1.16	0.00027	6.65	0.000016	0.76	0.0454	22	0.000095	0.00745	<0.0005	0.000026	<0.0002	1.84	<0.0001
08-Sep-09	4																	
15-Sep-09	5	<0.00005	0.0114	0.003	1.64	0.00042	9.46	0.000032	0.87	0.0682	39	0.000147	0.012	<0.0005	0.000076	<0.0002	3.53	<0.0001
22-Sep-09	6																	
29-Sep-09	7	<0.00005	0.0311	0.002	2.69	0.00043	13.5	0.00004	0.91	0.136	93	0.000249	0.0304	<0.0005	0.000612	<0.0002	10.2	<0.0001
06-Oct-09	8																	
13-Oct-09	9	<0.0003	0.0759	<0.01	3.31	0.0004	22.7	0.00026	0.99	0.244	208	0.00027	0.065	<0.003	0.00223	<0.001	29.8	<0.0005
20-Oct-09	10																	
27-Oct-09	11	<0.001	0.079	<0.04	1.8	<0.0008	21.8	0.0004	0.6	0.196	214	0.00024	0.105	<0.01	0.00586	<0.004	42.9	<0.002
03-Nov-09	12																	
10-Nov-09	13	<0.001	0.0942	<0.04	1.5	<0.0008	27.8	0.0008	0.6	0.166	280	0.00023	0.0909	<0.01	0.0114	0.01	52.3	<0.002
17-Nov-09	14																	
24-Nov-09	15	<0.003	0.093	<0.1	0.7	<0.002	34.3	0.0008	0.8	0.101	431	0.0002	0.109	<0.03	0.024	<0.01	68.1	<0.005
01-Dec-09	16																	
08-Dec-09	17	<0.003	0.104	0.195	0.6	<0.002	42.2	0.001	<0.5	0.07	513	0.0002	0.112	<0.03	0.0489	0.03	79	<0.005
15-Dec-09	18																	
22-Dec-09	19	<0.003	0.073	0.145	<0.5	<0.002	29.4	0.0012	1.2	0.034	441	0.0001	0.097	<0.03	0.0399	<0.01	48.5	<0.005
29-Dec-09	20																	
05-Jan-10	21	0.001	0.079	0.392	<0.2	0.0009	34.8	0.0009	0.4	0.029	563	0.00005	0.106	<0.01	0.0495	0.03	57.4	<0.002
12-Jan-10	22																	
19-Jan-10	23	0.007	0.0723	0.538	<0.2	<0.0008	33.7	0.0007	0.5	0.026	603	0.00009	0.0876	0.012	0.0373	0.026	51.2	<0.002
26-Jan-10	24																	
02-Feb-10	25	<0.001	0.0521	0.497	0.3	<0.0008	22.2	0.0009	0.5	0.024	472	0.00011	0.057	<0.01	0.0242	0.016	33.5	<0.002
09-Feb-10	26																	
16-Feb-10	27	<0.003	0.05	0.288	<0.5	<0.002	37.1	0.0005	<0.5	0.028	434	<0.0001	0.0702	<0.03	0.0217	0.015	32.3	<0.005
23-Feb-10	28																	
02-Mar-10	29	<0.003	0.045	0.172	<0.5	<0.002	26.5	0.0004	<0.5	0.03	371	<0.0001	0.0636	<0.03	0.0166	<0.01	28.5	<0.005
09-Mar-10	30																	
16-Mar-10	31	<0.003	0.039	0.103	<3	<0.002	21.2	0.0005	<3	0.025	<500	<0.0001	0.0605	<0.03	0.0105	<0.01	19.7	<0.005
23-Mar-10	32																	
30-Mar-10	33	<0.001	0.0339	0.215	<0.2	<0.0008	19.2	0.0002	0.6	0.03	329	0.00008	0.0601	<0.01	0.00999	0.006	18.1	<0.002
06-Apr-10	34																	
13-Apr-10	35	<0.0005	0.0305	0.188	<0.5	<0.0004	21.6	0.00035	0.5	0.0273	288	0.00007	0.0438	<0.005	0.00848	0.007	14.7	<0.001
20-Apr-10	36																	
27-Apr-10	37	<0.003	0.036	0.2	<3	<0.002	28.5	<0.0003	<3	0.035	<500	<0.0001	0.0635	<0.03	0.0087	<0.01	16.6	<0.005
04-May-10	38																	
11-May-10	39	<0.0003	0.0218	0.135	<0.3	0.0004	19.9	0.0003	0.6	0.0298	260	0.00005	0.0455	<0.003	0.0057	0.003	11.1	<0.0005
18-May-10	40																	
25-May-10	41	0.001	0.0258	0.107	<1	<0.0008	18.2	0.0007	<1	0.032	245	0.00008	0.0344	<0.01	0.00585	<0.004	11.4	<0.002
01-Jun-10	42																	
08-Jun-10	43	<0.001	0.0242	0.14	<1	<0.0008	21.9	0.0005	<1	0.03	241	0.00006	0.0306	<0.01	0.0055	<0.004	11	<0.002
15-Jun-10	44																	
22-Jun-10	45	0.0017	0.0208	0.115	<0.3	<0.0002	15.8	0.00052	0.7	0.0329	195	0.00005	0.0341	<0.003	0.00499	0.003	9.69	<0.0005
29-Jun-10	46																	
06-Jul-10	47	0.00008	0.0102	0.033	0.08	0.00005	9.84	0.000267	0.46	0.02	115	0.000051	0.0173	<0.0005	0.0026	0.0014	4.66	<0.0001
13-Jul-10	48																	
20-Jul-10	49	<0.0003	0.014	0.043	<0.3	<0.0002	15.1	0.00037	0.7	0.0298	137	0.00004	0.0272	<0.003	0.00264	0.003	6.1	<0.0005
27-Jul-10	50																	
03-Aug-10	51	0.00007	0.0099	0.036	<0.05	0.00005	11.5	0.000361	0.55	0.0235	120	0.000044	0.0183	<0.0005	0.00201	0.001	4.54	<0.0001
10-Aug-10	52																	
17-Aug-10	53	<0.00005	0.0078	0.023	0.05	0.00005	9.54	0.000332	0.57	0.0192	92	0.000054	0.0132	<0.0005	0.00182	0.0008	3.6	<0.0001
24-Aug-10	54																	
31-Aug-10	55	0.00008	0.009	0.026	<0.05	<0.00004	9.42	0.00026	0.6	0.0228	93	0.000046	0.0141	<0.0005	0.00183	0.0007	3.61	<0.0001
07-Sep-10	56																	
14-Sep-10	57	0.00006	0.00893	0.036	<0.05	0.00006	11.1	0.000429	0.63	0.023	98	0.000043	0.0183	<0.0005	0.00212	0.001	3.75	<0.0001
21-Sep-10	58																	
28-Sep-10	59	0.00052	0.00805	0.032	<0.05	0.00007	11.2	0.000424	0.64	0.0219	89	0.000045	0.0148	<0.0005	0.00184	0.0008	3.08	<0.0001

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-4

Humidity Cell T4 (CaNP depleted Clay Composite)

Weekly Production (mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/k	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg
11-Aug-09	0	7.29	1.4418	8.01	0.0062	0.00407	0.009078	0.0294	0.00001335	0.000001113	0.01113
18-Aug-09	1	6.27	0.8055	13.5	0.0158	0.00399	0.008820	0.0412	0.00003150	0.000001125	0.01125
25-Aug-09	2	6.47	0.9592	23.32	0.0299	0.00418	0.012452	0.0444	0.00005280	0.000001100	0.01100
01-Sep-09	3	6.55	1.2727	31.595	0.0490	0.00442	0.014329	0.0349	0.00007120	0.000001113	0.01113
08-Sep-09	4	5.81		30.175	0.0635	0.00353	0.006578	0.0229	0.00008165	0.000000888	0.00888
15-Sep-09	5	5.86	1.216	54.15	0.1178	0.00472	0.002309	0.0240	0.00014250	0.000001188	0.01188
22-Sep-09	6	4.78		86	0.4059	0.00472	0.006162	0.0174	0.00039560	0.000001075	0.01075
29-Sep-09	7	4.37	#N/A	125.84	0.7216	0.00528	0.010472	0.0132	0.00067760	0.000001100	0.01100
06-Oct-09	8	3.61		167.64	2.5828	0.00480	0.012276	0.0091	0.00144760	0.000003850	0.03850
13-Oct-09	9	3.44	#N/A	276.46	4.6460	0.00451	0.014720	0.0052	0.00231840	0.000006900	0.06900
20-Oct-09	10	3.17		286.43	7.4575	0.00527	0.023798	0.0034	0.00326325	0.000015438	0.15438
27-Oct-09	11	3.04	#N/A	357.12	9.9045	0.00577	0.031713	0.0014	0.00404550	0.000023250	0.23250
03-Nov-09	12	2.84		411.4	14.5775	0.00578	0.057418	0.0011	0.00482375	0.000021250	0.21250
10-Nov-09	13	2.53	#N/A	424.35	21.2850	0.00666	0.090900	0.0009	0.00630000	0.000022500	0.22500
17-Nov-09	14	2.74		584.16	29.8800	0.00859	0.237360	0.0010	0.00744000	0.000048000	0.48000
24-Nov-09	15	2.79	#N/A	589.26	32.4240	0.00882	0.330540	0.0008	0.00714000	0.000063000	0.63000
01-Dec-09	16	2.6		773.76	49.4880	0.01176	0.772080	0.0010	0.00871200	0.000072000	0.72000
08-Dec-09	17	2.58	#N/A	779.09	56.1150	0.01218	1.057050	0.0009	0.00839550	0.000065250	0.65250
15-Dec-09	18	2.36		668.84	49.1970	0.01173	1.338600	0.0007	0.00708400	0.000069000	0.69000
22-Dec-09	19	2.35	#N/A	689.33	38.6295	0.01047	1.542450	0.0005	0.00523250	0.000068250	0.68250
29-Dec-09	20	2.31		595.98	38.3040	0.01086	1.959300	0.0007	0.00497700	0.000042000	0.42000
05-Jan-10	21	2.3	#N/A	849.06	43.3875	0.01277	2.643300	0.0010	0.00542900	0.000022250	0.22250
12-Jan-10	22	2.45		838.04	38.8680	0.01070	2.619900	0.0009	0.00473550	0.000020500	0.20500
19-Jan-10	23	2.49	#N/A	858.82	42.3660	0.01081	3.146400	0.0009	0.00501400	0.000023000	0.23000
26-Jan-10	24	2.37		751.64	35.0450	0.00888	2.498300	0.0009	0.00380550	0.000021500	0.21500
02-Feb-10	25	2.87	#N/A	663.75	31.9050	0.00801	2.151000	0.0010	0.00306000	0.000022500	0.22500
09-Feb-10	26	2.25		719.36	31.1675	0.00814	2.154425	0.0010	0.00298025	0.000045500	0.45500
16-Feb-10	27	2.23	#N/A	739.2	31.7280	0.00864	2.251200	0.0010	0.00302400	0.000072000	0.72000
23-Feb-10	28	2.19		554.47	27.1228	0.00734	1.824500	0.0009	0.00255875	0.000066750	0.66750
02-Mar-10	29	2.35	#N/A	586.56	26.7840	0.00720	1.684800	0.0010	0.00249600	0.000072000	0.72000
09-Mar-10	30	2.45		370.44	19.7400	0.00588	1.302000	0.0008	0.00197400	0.000063000	0.63000
16-Mar-10	31	2.44	#N/A	528.22	18.7180	0.00637	1.318100	0.0010	0.00205800	0.000073500	0.73500
23-Mar-10	32	2.69		559.37	16.5540	0.00623	1.152550	0.0012	0.00173550	0.000044500	0.44500
30-Mar-10	33	2.61	#N/A	440	15.9280	0.00660	1.095600	0.0014	0.00158400	0.000022000	0.22000
06-Apr-10	34	2.46		496	16.8250	0.00710	1.140000	0.0016	0.00165000	0.000018750	0.18750
13-Apr-10	35	2.3	#N/A	406.56	13.0620	0.00563	0.869400	0.0013	0.00126000	0.000010500	0.10500
20-Apr-10	36	2.41		517.93	18.0075	0.00671	1.153950	0.0020	0.00142100	0.000042875	0.42875
27-Apr-10	37	2.51	#N/A	504.53	19.7160	0.00651	1.227600	0.0023	0.00130200	0.000069750	0.69750
04-May-10	38	2.33		408.27	16.1355	0.00618	0.971850	0.0019	0.00118110	0.000038363	0.38363
11-May-10	39	2.97	#N/A	361.1	12.4200	0.00580	0.708400	0.0014	0.00104880	0.000006900	0.06900
18-May-10	40	2.27		326.19	11.1635	0.00521	0.593450	0.0014	0.00099185	0.000013488	0.13488
25-May-10	41	2.44	#N/A	244.8	11.3900	0.00531	0.561000	0.0016	0.00106250	0.000021250	0.21250
01-Jun-10	42	2.89		225	10.1625	0.00458	0.493125	0.0015	0.00093750	0.000018750	0.18750
08-Jun-10	43	2.32	#N/A	330.79	12.4670	0.00541	0.596050	0.0019	0.00113750	0.000022750	0.22750
15-Jun-10	44	2.65		234.52	10.6355	0.00510	0.520650	0.0020	0.00100570	0.000014463	0.14463
22-Jun-10	45	2.23		229.83	9.5880	0.00517	0.484100	0.0022	0.00094940	0.000007050	0.07050
29-Jun-10	46	2.44		311.95	6.4325	0.00397	0.308385	0.0020	0.00070755	0.000003894	0.03894
06-Jul-10	47	2.39		163.28	4.4252	0.00356	0.185120	0.0023	0.00060320	0.000001300	0.01300
13-Jul-10	48	2.38		144.93	4.4646	0.00322	0.158525	0.0017	0.00051213	0.000003719	0.03719
20-Jul-10	49	2.37		196.04	6.5000	0.00432	0.202800	0.0020	0.00065000	0.000007800	0.07800
27-Jul-10	50	2.39		173	5.3975	0.00385	0.162000	0.0017	0.00057750	0.000010750	0.04375
03-Aug-10	51	2.39		160.32	4.3632	0.00341	0.123840	0.0015	0.00050880	0.000013440	0.01200
10-Aug-10	52	2.13		165	3.5640	0.00308	0.097460	0.0013	0.00042240	0.000008360	0.01100
17-Aug-10	53	2.21		135.73	3.1640	0.00308	0.082325	0.0012	0.00038270	0.000004450	0.01113
24-Aug-10	54	2.17		96.96	3.8885	0.00334	0.095445	0.0017	0.00047218	0.000003156	0.01263
31-Aug-10	55	2.39		125.1	3.7305	0.00284	0.086850	0.0017	0.00045450	0.000001125	0.01125
07-Sep-10	56	2.38		129.15	3.8925	0.00292	0.087075	0.0015	0.00043650	0.000001125	0.01125
14-Sep-10	57	2.22		181.82	4.1897	0.00310	0.090210	0.0014	0.00043245	0.000001163	0.01163
21-Sep-10	58	2.19		124.67	3.7469	0.00298	0.084403	0.0012	0.00042770	0.000001138	0.01138
28-Sep-10	59	2.41		125.58	3.4316	0.00295	0.081420	0.0011	0.00043700	0.000001150	0.01150

Date	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg
11-Aug-09	0.00274565	2.64	0.0000223	0.0002043	0.00805	0.02492	0.000765	0.000846	0.24	0.198915	0.00000223	0.00001	0.00089	0.001780	0.35600
18-Aug-09	0.00598500	4.50	0.0000225	0.0003650	0.01553	0.06345	0.000603	0.001485	0.35	0.355950	0.00000225	0.00001	0.00114	0.001350	0.36900
25-Aug-09	0.00994400	6.91	0.0000220	0.0006600	0.03661	0.09768	0.000858	0.002156	0.59	0.598400	0.00000220	0.00001	0.00199	0.000440	0.47520
01-Sep-09	0.01348350	8.86	0.0000223	0.0008945	0.04984	0.14552	0.001402	0.002715	0.75	0.747600	0.00000445	0.00001	0.00292	0.000445	0.51620
08-Sep-09	0.01531825	9.35	0.0000178	0.0010739	0.05716	0.08698	0.000909	0.002858	0.82	0.852000	0.00000266	0.00001	0.00319	0.000710	0.49700
15-Sep-09	0.02660000	15.58	0.0000238	0.0019190	0.09975	0.07743	0.000936	0.004750	1.39	1.482000	0.00000238	0.00001	0.00542	0.001425	0.77900
22-Sep-09	0.05138500	23.52	0.0001398	0.0035991	0.24704	0.20382	0.001417	0.005203	2.04	2.287600	0.00000215	0.00001	0.00914	0.001075	0.93095
29-Sep-09	0.08052000	33.70	0.0002640	0.0055880	0.41316	0.34540	0.002033	0.006248	2.89	3.308800	0.00000220	0.00001	0.01368	0.000880	1.18360
06-Oct-09	0.15906000	49.19	0.0011880	0.0101420	0.88198	1.91290	0.001459	0.008184	4.26	5.240400	0.00000660	0.00004	0.02354	0.001540	1.32000
13-Oct-09	0.24840000	67.62	0.0022080	0.0153640	1.41220	3.63860	0.000925	0.010580	5.89	7.498000	0.00001150	0.00007	0.03491	0.002300	1.52260
20-Oct-09	0.31041250	62.70	0.0056525	0.0177175	1.94275	5.34613	0.001879	0.009975	5.42	7.623750	0.00002969	0.00015	0.03679	0.005938	1.21363
27-Oct-09	0.35665500	54.41	0.0088350	0.0191580	2.37615	6.78900	0.002744	0.008835	4.65	7.347000	0.00004650	0.00023	0.03674	0.009300	0.83700
03-Nov-09	0.37973750	49.73	0.0144500	0.0210588	2.75188	10.58250	0.001679	0.008925	4.53	7.097500	0.00004250	0.00021	0.03681	0.008500	0.70125
10-Nov-09	0.45900000	52.65	0.0220500	0.0260550	3.52800	15.84000	0.000900	0.010350	5.09	7.920000	0.00004500	0.00023	0.04239	0.009000	0.67500
17-Nov-09	0.56160000	50.11	0.0410400	0.0312720	4.37760	29.08800	0.013584	0.009120	5.11	8.136000	0.00008400	0.00048	0.04493	0.016800	0.52800
24-Nov-09	0.55440000	38.56	0.0512400	0.0304080	4.36800	36.12000	0.022932	0.006300	4.20	6.846000	0.00010500	0.00063	0.03906	0.021000	0.29400
01-Dec-09	0.66960000	37.63	0.0883200	0.0416160	5.66400	68.88000	0.013944	0.007200	4.87	7.176000	0.00012000	0.00072	0.04728	0.058800	0.31200
08-Dec-09	0.63945000	28.28	0.1070100	0.0439350	5.74200	87.43500	0.001523	0.006525	4.48	5.916000	0.00010875	0.00065	0.04524	0.084825	0.26100
15-Dec-09	0.55315000	21.44	0.1021200	0.0390770	4.85530	84.18000	0.002392	0.006900	4.19	4.563200	0.00011500	0.00069	0.04071	0.078200	0.19550
22-Dec-09	0.42542500	12.83	0.0900900	0.0313495	3.59905	75.07500	0.003140	0.006825	3.59	2.839200	0.00011375	0.00068	0.03322	0.065975	0.11375
29-Dec-09	0.41895000	10.12	0.0961800	0.0327390	3.32850	88.83000	0.001911	0.008610	3.95	2.494800	0.00007350	0.00053	0.03192	0.112770	0.07350
05-Jan-10	0.47170000	8.90	0.1157000	0.0387150	3.53330	114.81000	0.000979	0.011570	4.85	2.509800	0.00004450	0.00045	0.03516	0.174440	0.04450
12-Jan-10	0.42435000	7.09	0.1078300	0.0361210	3.13650	107.62500	0.000882	0.010455	4.37	2.072550	0.00004100	0.00164	0.03102	0.190650	0.04100
19-Jan-10	0.46460000	6.72	0.1223600	0.0410320	3.38560	122.82000	0.000966	0.011500	4.78	2.056200	0.00004600	0.00322	0.03326	0.247480	0.04600
26-Jan-10	0.35496500	4.77	0.0956750	0.0339485	2.66600	109.86500	0.000839	0.009030	3.70	1.511450	0.00004300	0.00161	0.02675	0.222525	0.08600
02-Feb-10	0.28845000	3.42	0.0805500	0.0309150	2.26800	109.80000	0.000810	0.007650	3.06	1.152000	0.00004500	0.00023	0.02345	0.223650	0.13500
09-Feb-10	0.28619500	3.44	0.0798525	0.0313723	2.28638	123.53250	0.000660	0.007280	2.91	1.114750	0.00007963	0.00046	0.02323	0.178588	0.12513
16-Feb-10	0.29616000	3.60	0.0825600	0.0332160	2.40480	143.52000	0.000528	0.007200	2.88	1.123200	0.00012000	0.00072	0.02400	0.138240	0.12000
23-Feb-10	0.25209250	3.07	0.0714225	0.0298150	2.16493	115.03250	0.003249	0.006675	2.40	0.947850	0.00011125	0.00067	0.02114	0.102350	0.11125
02-Mar-10	0.24768000	3.02	0.0715200	0.0311040	2.26560	104.64000	0.006480	0.007200	2.30	0.921600	0.00012000	0.00072	0.02160	0.082560	0.12000
09-Mar-10	0.18375000	2.16	0.0525000	0.0241500	1.73460	81.90000	0.003066	0.006300	1.64	0.657300	0.00010500	0.00063	0.01764	0.057750	0.36750
16-Mar-10	0.17591000	1.96	0.0494900	0.0245980	1.73460	84.28000	0.000539	0.007350	1.47	0.592900	0.00012250	0.00074	0.01911	0.050470	0.73500
23-Mar-10	0.15597250	1.82	0.0453900	0.0226950	1.57975	77.87500	0.000445	0.006008	1.29	0.525100	0.00007788	0.00045	0.01622	0.070755	0.35600
30-Mar-10	0.15048000	1.85	0.0453200	0.0227920	1.56640	78.32000	0.000396	0.005280	1.23	0.506000	0.00004400	0.00022	0.01492	0.094600	0.04400
06-Apr-10	0.15525000	1.93	0.0475000	0.0245250	1.65500	85.25000	0.000323	0.006000	1.30	0.522500	0.00003750	0.00019	0.01610	0.100750	0.08750
13-Apr-10	0.11718000	1.47	0.0365400	0.0194460	1.28520	68.46000	0.000164	0.005040	1.01	0.394800	0.00002100	0.00011	0.01281	0.078960	0.10500
20-Apr-10	0.14479500	1.59	0.0443450	0.0247450	1.65130	84.28000	0.000218	0.006615	0.96	0.492450	0.00007350	0.00043	0.01629	0.095060	0.42875
27-Apr-10	0.14508000	1.40	0.0437100	0.0254355	1.71120	84.16500	0.000233	0.006975	0.70	0.497550	0.00011625	0.00070	0.01674	0.093000	0.69750
04-May-10	0.12415500	1.46	0.0366653	0.0213203	1.42290	70.68000	0.000230	0.005813	0.74	0.409433	0.00006394	0.00038	0.01344	0.077888	0.38363
11-May-10	0.10212000	1.52	0.0293020	0.0170200	1.12240	56.58000	0.000225	0.004600	0.78	0.317860	0.00001150	0.00007	0.01003	0.062100	0.06900
18-May-10	0.08943250	1.31	0.0273278	0.0161435	1.11635	48.76250	0.000475	0.004150	0.77	0.301290	0.00002594	0.00024	0.00988	0.050215	0.13488
25-May-10	0.08882500	1.28	0.0289000	0.0173400	1.24950	47.60000	0.000765	0.004250	0.85	0.323425	0.00004250	0.00043	0.01097	0.045475	0.21250
01-Jun-10	0.07556250	1.31	0.0247500	0.0148125	1.09125	42.93750	0.000713	0.003938	0.75	0.276750	0.00003750	0.00028	0.00938	0.046313	0.18750
08-Jun-10	0.08827000	1.82	0.0291200	0.0173810	1.31040	53.23500	0.000910	0.005005	0.91	0.325325	0.00004550	0.00023	0.01101	0.063700	0.22750
15-Jun-10	0.08232500	1.62	0.0260548	0.0162425	1.21263	48.72750	0.000603	0.004450	0.80	0.308385	0.00002781	0.00049	0.01001	0.056738	0.14463
22-Jun-10	0.08272000	1.55	0.0249570	0.0163560	1.20790	47.94000	0.000334	0.004230	0.75	0.315370	0.00001175	0.00080	0.00978	0.054050	0.07050
29-Jun-10	0.05940750	1.11	0.0171993	0.0114365	0.84995	32.68525	0.000303	0.003293	0.52	0.222723	0.00000668	0.00040	0.00690	0.032930	0.05118
06-Jul-10	0.04732000	0.88	0.0125840	0.0086320	0.65000	23.34800	0.000338	0.003016	0.38	0.171600	0.00000260	0.00004	0.00530	0.017160	0.04160
13-Jul-10	0.04335000	0.91	0.0112200	0.0080325	0.63325	22.56750	0.000185	0.002720	0.37	0.163413	0.00000638	0.00005	0.00514	0.016150	0.04888
20-Jul-10	0.05876000	1.35	0.0148720	0.0110240	0.89960	31.87600	0.000114	0.003640	0.52	0.228280	0.00001300	0.00008	0.00728	0.022360	0.07800
27-Jul-10	0.04937500	1.15	0.0126500	0.0094000	0.76750	24.12500	0.000211	0.003275	0.44	0.196250	0.00000750	0.00006	0.00598	0.019750	0.04375
03-Aug-10	0.04056000	0.96	0.0105600	0.0078720	0.64320	16.89600	0.000300	0.002928	0.36	0.166080	0.00000240	0.00003	0.00475	0.017280	0.01200
10-Aug-10	0.03273600	0.81	0.0085140	0.0064460	0.54780	13.50800	0.000839	0.002640	0.31	0.135300	0.00000220	0.00002	0.00389	0.012980	0.01650
17-Aug-10	0.02861350	0.76	0.0074315	0.0057405	0.51175	11.65900	0.001420	0.002626	0.29	0.119705	0.00000223	0.00001	0.00347	0.010235	0.02225
24-Aug-10	0.03330475	0.91	0.0090143	0.0069438	0.61863	13.40775	0.000923	0.003131	0.35	0.144935	0.00000253	0.00003	0.00424	0.012373	0.01894
31-Aug-10	0.03042000	0.86	0.0085500	0.0065700	0.58500	12.10500	0.000210	0.002925	0.32	0.137250	0.00000225	0.00004	0.00405	0.011700	0.01125
07-Sep-10	0.03107250	0.96	0.0087525	0.0067050	0.61200	12.33000	0.000136	0.003038	0.34	0.140625	0.00000225	0.00003	0.00403	0.013950	0.01125
14-Sep-10	0.03278250	1.10	0.0092535	0.0070680	0.66030	12.97350	0.000065	0.003255	0.38	0.148800	0.00000233	0.00003	0.00415	0.016740	0.01163
21-Sep-10	0.02977975	1.03	0.0082810	0.0064383	0.61425	11.78450	0.000171	0.003208	0.35	0.137183	0.00000228	0.00013	0.00386	0.015470	0.01138
28-Sep-10	0.02778400	1.00	0.0075900	0.0060260	0.58880	10.99400	0.000282	0.003266	0.34	0.130180	0.00000230	0.00024	0.00370	0.014720	0.01150

Date	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
11-Aug-09	0.00004	1.446	0.000001113	0.3872	0.00654	3.12	0.00003560	0.0017044	0.0001113	0.000001	0.000045	0.17711	0.00002
18-Aug-09	0.00009	1.832	0.000003150	0.2790	0.01085	4.95	0.00002475	0.0021240	0.0001125	0.000004	0.000045	0.31905	0.00002
25-Aug-09	0.00009	2.490	0.000007920	0.3476	0.01602	7.92	0.00003432	0.0024596	0.0001100	0.000011	0.000044	0.59840	0.00002
01-Sep-09	0.00012	2.959	0.000007120	0.3382	0.02020	9.79	0.00004228	0.0033153	0.0001113	0.000012	0.000045	0.81880	0.00002
08-Sep-09	0.00012	2.860	0.000008520	0.2893	0.02016	10.83	0.00004296	0.0034524	0.0000888	0.000018	0.000036	0.95318	0.00002
15-Sep-09	0.00020	4.494	0.000015200	0.4133	0.03240	18.53	0.00006983	0.0057000	0.0001188	0.000036	0.000048	1.67675	0.00002
22-Sep-09	0.00018	4.936	0.000015480	0.3827	0.04390	28.38	0.00008514	0.0091160	0.0001075	0.000148	0.000043	2.95195	0.00002
29-Sep-09	0.00019	5.940	0.000017600	0.4004	0.05984	40.92	0.00010956	0.0133760	0.0001100	0.000269	0.000044	4.48800	0.00002
06-Oct-09	0.00018	7.964	0.000066000	0.4180	0.08360	66.22	0.00011418	0.0209880	0.0003850	0.000625	0.000132	8.80000	0.00007
13-Oct-09	0.00018	10.442	0.000119600	0.4554	0.11224	95.68	0.00012420	0.0299000	0.0006900	0.001026	0.000230	13.70800	0.00012
20-Oct-09	0.00019	10.569	0.000156750	0.3776	0.10450	100.23	0.00012113	0.0403750	0.0015438	0.001921	0.000594	17.26625	0.00030
27-Oct-09	0.00019	10.137	0.000186000	0.2790	0.09114	99.51	0.00011160	0.0488250	0.0023250	0.002725	0.000930	19.94850	0.00047
03-Nov-09	0.00017	10.540	0.000255000	0.2550	0.07693	104.98	0.00009988	0.0416288	0.0021250	0.003668	0.002550	20.23000	0.00043
10-Nov-09	0.00018	12.510	0.000360000	0.2700	0.07470	126.00	0.00010350	0.0409050	0.0022500	0.005130	0.004500	23.53500	0.00045
17-Nov-09	0.00034	14.904	0.000384000	0.3360	0.06408	170.64	0.00010320	0.0479760	0.0048000	0.008496	0.003600	28.89600	0.00084
24-Nov-09	0.00042	14.406	0.000336000	0.3360	0.04242	181.02	0.00008400	0.0457800	0.0063000	0.010080	0.002100	28.60200	0.00105
01-Dec-09	0.00048	18.360	0.000432000	0.2520	0.04104	226.56	0.00009600	0.0530400	0.0072000	0.017496	0.008400	35.30400	0.00120
08-Dec-09	0.00044	18.357	0.000435000	0.1088	0.03045	223.16	0.00008700	0.0487200	0.0065250	0.021272	0.013050	34.36500	0.00109
15-Dec-09	0.00046	16.468	0.000506000	0.3335	0.02392	219.42	0.00006900	0.0480700	0.0069000	0.020424	0.008050	29.32500	0.00115
22-Dec-09	0.00046	13.377	0.000546000	0.5460	0.01547	200.66	0.00004550	0.0441350	0.0068250	0.018155	0.002275	22.06750	0.00114
29-Dec-09	0.00040	13.482	0.000441000	0.3360	0.01323	210.84	0.00003150	0.0426300	0.0042000	0.018774	0.007350	22.23900	0.00074
05-Jan-10	0.00040	15.486	0.000400500	0.1780	0.01291	250.54	0.00002225	0.0471700	0.0022250	0.022028	0.013350	25.54300	0.00045
12-Jan-10	0.00027	14.043	0.000328000	0.1845	0.01128	239.03	0.00002870	0.0396880	0.0034850	0.017794	0.011480	22.26300	0.00041
19-Jan-10	0.00018	15.502	0.000322000	0.2300	0.01196	277.38	0.00004140	0.0402960	0.0055200	0.017158	0.011960	23.55200	0.00046
26-Jan-10	0.00017	12.019	0.000344000	0.2150	0.01075	231.13	0.00004300	0.0310890	0.0036550	0.013223	0.009030	18.21050	0.00043
02-Feb-10	0.00018	9.990	0.000405000	0.2250	0.01080	212.40	0.00004950	0.0256500	0.0022500	0.010890	0.007200	15.07500	0.00045
09-Feb-10	0.00032	13.491	0.000318500	0.1706	0.01183	206.12	0.00003640	0.0289380	0.0045500	0.010442	0.007053	14.96950	0.00080
16-Feb-10	0.00048	17.808	0.000240000	0.1200	0.01344	208.32	0.00002400	0.0336960	0.0072000	0.010416	0.007200	15.50400	0.00120
23-Feb-10	0.00045	14.151	0.000200250	0.1113	0.01291	179.11	0.00002225	0.0297705	0.0066750	0.008522	0.004450	13.52800	0.00111
02-Mar-10	0.00048	12.720	0.000192000	0.1200	0.01440	178.08	0.00002400	0.0305280	0.0072000	0.007968	0.002400	13.68000	0.00120
09-Mar-10	0.00042	10.017	0.000189000	0.3675	0.01155	130.41	0.00002100	0.0260610	0.0063000	0.005691	0.002100	10.12200	0.00105
16-Mar-10	0.00049	10.388	0.000245000	0.7350	0.01225	122.50	0.00002450	0.0296450	0.0073500	0.005145	0.002450	9.65300	0.00123
23-Mar-10	0.00031	8.989	0.000155750	0.4673	0.01224	128.83	0.00002893	0.0268335	0.0044500	0.004559	0.002448	8.41050	0.00078
30-Mar-10	0.00018	8.448	0.000088000	0.2640	0.01320	144.76	0.00003520	0.0264440	0.0022000	0.004396	0.002640	7.96400	0.00044
06-Apr-10	0.00015	10.200	0.000137500	0.2750	0.01433	154.25	0.00003750	0.0259750	0.0018750	0.004618	0.003250	8.20000	0.00038
13-Apr-10	0.00008	9.072	0.000147000	0.2100	0.01147	120.96	0.00002940	0.0183960	0.0010500	0.003562	0.002940	6.17400	0.00021
20-Apr-10	0.00029	12.275	0.000122500	0.4900	0.01526	131.81	0.00002940	0.0262885	0.0042875	0.004209	0.002940	7.66850	0.00074
27-Apr-10	0.00047	13.253	0.000069750	0.6975	0.01628	116.25	0.00002325	0.0295275	0.0069750	0.004046	0.002325	7.71900	0.00116
04-May-10	0.00033	11.253	0.000104625	0.4883	0.01507	118.58	0.00002325	0.0253425	0.0038363	0.003348	0.001860	6.44025	0.00064
11-May-10	0.00018	9.154	0.000138000	0.2760	0.01371	119.60	0.00002300	0.0209300	0.0006900	0.002622	0.001380	5.10600	0.00012
18-May-10	0.00017	7.906	0.000207500	0.2283	0.01282	104.79	0.00002698	0.0165793	0.0013488	0.002397	0.001038	4.66875	0.00026
25-May-10	0.00017	7.735	0.000297500	0.2125	0.01360	104.13	0.00003400	0.0146200	0.0021250	0.002486	0.000850	4.84500	0.00043
01-Jun-10	0.00015	7.519	0.000225000	0.1875	0.01163	91.13	0.00002625	0.0121875	0.0018750	0.002128	0.000750	4.20000	0.00038
08-Jun-10	0.00018	9.965	0.000227500	0.2275	0.01365	109.66	0.00002730	0.0139230	0.0022750	0.002503	0.000910	5.00500	0.00046
15-Jun-10	0.00011	8.388	0.000226950	0.2670	0.01400	97.01	0.00002448	0.0143958	0.0014463	0.002334	0.001113	4.60353	0.00028
22-Jun-10	0.00005	7.426	0.000244400	0.3290	0.01546	91.65	0.00002350	0.0160270	0.0007050	0.002345	0.001410	4.55430	0.00012
29-Jun-10	0.00003	5.705	0.000175108	0.2581	0.01177	68.98	0.00002247	0.0114365	0.0003894	0.001689	0.000979	3.19288	0.00007
06-Jul-10	0.00003	5.117	0.000138840	0.2392	0.01040	59.80	0.00002652	0.0089960	0.0001300	0.001352	0.000728	2.42320	0.00003
13-Jul-10	0.00003	5.300	0.000135363	0.2465	0.01058	53.55	0.00001934	0.0094563	0.0003719	0.001114	0.000935	2.28650	0.00006
20-Jul-10	0.00005	7.852	0.000192400	0.3640	0.01550	71.24	0.00002080	0.0141440	0.0007800	0.001373	0.001560	3.17200	0.00013
27-Jul-10	0.00004	6.650	0.000182750	0.3125	0.01333	64.25	0.00002100	0.0113750	0.0004375	0.001163	0.001000	2.66000	0.00008
03-Aug-10	0.00002	5.520	0.000173280	0.2640	0.01128	57.60	0.00002112	0.0087840	0.0001200	0.000965	0.000480	2.17920	0.00002
10-Aug-10	0.00002	4.629	0.000152460	0.2464	0.00939	46.64	0.00002156	0.0069300	0.0001100	0.000843	0.000396	1.79080	0.00002
17-Aug-10	0.00002	4.245	0.000147740	0.2537	0.00854	40.94	0.00002403	0.0058740	0.0001113	0.000810	0.000356	1.60200	0.00002
24-Aug-10	0.00002	4.787	0.000149480	0.2954	0.01061	46.71	0.00002525	0.0068933	0.0001263	0.000922	0.000379	1.82053	0.00003
31-Aug-10	0.00001	4.239	0.000117000	0.2700	0.01026	41.85	0.00002070	0.0063450	0.0001125	0.000824	0.000315	1.62450	0.00002
07-Sep-10	0.00002	4.617	0.000155025	0.2768	0.01031	42.98	0.00002003	0.0072900	0.0001125	0.000889	0.000383	1.65600	0.00002
14-Sep-10	0.00003	5.162	0.000199485	0.2930	0.01070	45.57	0.00002000	0.0085095	0.0001163	0.000986	0.000465	1.74375	0.00002
21-Sep-10	0.00003	5.073	0.000194058	0.2889	0.01021	42.54	0.00002002	0.0075303	0.0001138	0.000901	0.000410	1.55383	0.00002
28-Sep-10	0.00003	5.152	0.000195040	0.2944	0.01007	40.94	0.00002070	0.0068080	0.0001150	0.000846	0.000368	1.41680	0.00002

Appendix B.1-4

Humidity Cell T4 (CaNP depleted Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg
11-Aug-09	0	8.0	0.0062	0.00407	0.00908	0.0294	0.0000134	0.0000011	0.011125	0.00274565	2.64
18-Aug-09	1	21.5	0.0220	0.00806	0.01790	0.0706	0.0000449	0.0000022	0.022375	0.00873065	7.1
25-Aug-09	2	44.8	0.0519	0.01224	0.03035	0.1150	0.0000977	0.0000033	0.033375	0.01867465	14.1
01-Sep-09	3	76.4	0.1009	0.01666	0.04468	0.1499	0.0001689	0.0000045	0.0445	0.03215815	22.9
08-Sep-09	4	106.6	0.1644	0.02019	0.05126	0.1728	0.0002505	0.0000053	0.053375	0.0474764	32.3
15-Sep-09	5	160.8	0.2822	0.02491	0.05357	0.1969	0.0003930	0.0000065	0.06525	0.0740764	48
22-Sep-09	6	246.8	0.6882	0.02963	0.05973	0.2142	0.0007886	0.0000076	0.076	0.1254614	71
29-Sep-09	7	372.6	1.4098	0.03491	0.07020	0.2274	0.0014662	0.0000087	0.087	0.2059814	105
06-Oct-09	8	540.2	3.9926	0.03970	0.08248	0.2366	0.0029138	0.0000126	0.1255	0.3650414	154
13-Oct-09	9	816.7	8.6386	0.04421	0.09720	0.2418	0.0052322	0.0000195	0.1945	0.6134414	222
20-Oct-09	10	1103.1	16.0961	0.04948	0.12099	0.2453	0.0084955	0.0000349	0.348875	0.9238539	285
27-Oct-09	11	1460.2	26.0006	0.05525	0.15271	0.2467	0.0125410	0.0000581	0.581375	1.2805089	339
03-Nov-09	12	1871.6	40.5781	0.06103	0.21012	0.2478	0.0173647	0.0000794	0.793875	1.6602464	389
10-Nov-09	13	2296.0	61.8631	0.06769	0.30102	0.2488	0.0236647	0.0001019	1.018875	2.1192464	441
17-Nov-09	14	2880.1	91.7431	0.07628	0.53838	0.2497	0.0311047	0.0001499	1.498875	2.6808464	491
24-Nov-09	15	3469.4	124.1671	0.08510	0.86892	0.2506	0.0382447	0.0002129	2.128875	3.2352464	530
01-Dec-09	16	4243.2	173.6551	0.09686	1.64100	0.2515	0.0469567	0.0002849	2.848875	3.9048464	568
08-Dec-09	17	5022.3	229.7701	0.10904	2.69805	0.2524	0.0553522	0.0003501	3.501375	4.5442964	596
15-Dec-09	18	5691.1	278.9671	0.12077	4.03665	0.2531	0.0624362	0.0004191	4.191375	5.0974464	617
22-Dec-09	19	6380.4	317.5966	0.13124	5.57910	0.2536	0.0676687	0.0004874	4.873875	5.5228714	630
29-Dec-09	20	6976.4	355.9006	0.14209	7.53840	0.2542	0.0726457	0.0005294	5.293875	5.9418214	640
05-Jan-10	21	7825.5	399.2881	0.15487	10.18170	0.2553	0.0780747	0.0005516	5.516375	6.4135214	649
12-Jan-10	22	8663.5	438.1561	0.16557	12.80160	0.2562	0.0828102	0.0005721	5.721375	6.8378714	656
19-Jan-10	23	9522.3	480.5221	0.17638	15.94800	0.2571	0.0878242	0.0005951	5.951375	7.3024714	663
26-Jan-10	24	10274.0	515.5671	0.18526	18.44630	0.2580	0.0916297	0.0006166	6.166375	7.6574364	668
02-Feb-10	25	10937.7	547.4721	0.19327	20.59730	0.2590	0.0946897	0.0006391	6.391375	7.9458864	671
09-Feb-10	26	11657.1	578.6396	0.20141	22.75173	0.2599	0.0976700	0.0006846	6.846375	8.2320814	675
16-Feb-10	27	12396.3	610.3676	0.21005	25.00293	0.2609	0.1006940	0.0007566	7.566375	8.5282414	678
23-Feb-10	28	12950.7	637.4903	0.21739	26.82743	0.2618	0.1032527	0.0008234	8.233875	8.7803339	681
02-Mar-10	29	13537.3	664.2743	0.22459	28.51223	0.2627	0.1057487	0.0008954	8.953875	9.0280139	684
09-Mar-10	30	13907.7	684.0143	0.23047	29.81423	0.2636	0.1077227	0.0009584	9.583875	9.2117639	687
16-Mar-10	31	14436.0	702.7323	0.23684	31.13233	0.2645	0.1097807	0.0010319	10.318875	9.3876739	688
23-Mar-10	32	14995.3	719.2863	0.24307	32.28488	0.2657	0.1115162	0.0010764	10.763875	9.5436464	690
30-Mar-10	33	15435.3	735.2143	0.24967	33.38048	0.2671	0.1131002	0.0010984	10.983875	9.6941264	692
06-Apr-10	34	15931.3	752.0393	0.25677	34.52048	0.2687	0.1147502	0.0011171	11.171375	9.8493764	694
13-Apr-10	35	16337.9	765.1013	0.26240	35.38988	0.2701	0.1160102	0.0011276	11.276375	9.9665564	696
20-Apr-10	36	16855.8	783.1088	0.26911	36.54383	0.2721	0.1174312	0.0011705	11.705125	10.1113514	697
27-Apr-10	37	17360.3	802.8248	0.27562	37.77143	0.2744	0.1187332	0.0012403	12.402625	10.2564314	699
04-May-10	38	17768.6	818.9603	0.28181	38.74328	0.2763	0.1199143	0.0012786	12.78625	10.3805864	700
11-May-10	39	18129.7	831.3803	0.28760	39.45168	0.2777	0.1209631	0.0012855	12.85525	10.4827064	702
18-May-10	40	18455.9	842.5438	0.29281	40.04513	0.2791	0.1219550	0.0012990	12.990125	10.5721389	703
25-May-10	41	18700.7	853.9338	0.29813	40.60613	0.2807	0.1230175	0.0013203	13.202625	10.6609639	704
01-Jun-10	42	18925.7	864.0963	0.30270	41.09925	0.2821	0.1239550	0.0013390	13.390125	10.7365264	705
08-Jun-10	43	19256.5	876.5633	0.30811	41.69530	0.2840	0.1250925	0.0013618	13.617625	10.8247964	707
15-Jun-10	44	19491.0	887.1988	0.31321	42.21595	0.2860	0.1260982	0.0013762	13.76225	10.9071214	709
22-Jun-10	45	19720.8	896.7868	0.31838	42.70005	0.2882	0.1270476	0.0013833	13.83275	10.9898414	710
29-Jun-10	46	20032.8	903.2193	0.32235	43.00844	0.2902	0.1277551	0.0013872	13.8716875	11.0492489	712
06-Jul-10	47	20196.0	907.6445	0.32591	43.19356	0.2924	0.1283583	0.0013885	13.8846875	11.0965689	712
13-Jul-10	48	20341.0	912.1091	0.32913	43.35208	0.2942	0.1288704	0.0013922	13.921875	11.1399189	713
20-Jul-10	49	20537.0	918.6091	0.33345	43.55488	0.2961	0.1295204	0.0014000	13.999875	11.1986789	715
27-Jul-10	50	20710.0	924.0066	0.33730	43.71688	0.2979	0.1300979	0.0014107	14.043625	11.2480539	716
03-Aug-10	51	20870.3	928.3698	0.34071	43.84072	0.2993	0.1306067	0.0014242	14.055625	11.2886139	717
10-Aug-10	52	21035.3	931.9338	0.34379	43.93818	0.3006	0.1310291	0.0014325	14.066625	11.3213499	718
17-Aug-10	53	21171.1	935.0978	0.34687	44.02051	0.3019	0.1314118	0.0014370	14.07775	11.3499634	718
24-Aug-10	54	21268.0	938.9863	0.35021	44.11595	0.3036	0.1318840	0.0014401	14.090375	11.3832682	719
31-Aug-10	55	21393.1	942.7168	0.35304	44.20280	0.3053	0.1323385	0.0014413	14.101625	11.4136882	720
07-Sep-10	56	21522.3	946.6093	0.35596	44.28988	0.3069	0.1327750	0.0014424	14.112875	11.4447607	721
14-Sep-10	57	21704.1	950.7989	0.35906	44.38009	0.3082	0.1332075	0.0014436	14.1245	11.4775432	722
21-Sep-10	58	21828.8	954.5458	0.36203	44.46449	0.3095	0.1336352	0.0014447	14.135875	11.5073229	723
28-Sep-10	59	21954.3	957.9774	0.36499	44.54591	0.3106	0.1340722	0.0014458	14.147375	11.5351069	724

Date	Cycle No.	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg
11-Aug-09	0	0.00002225	0.0002	0.0080545	0.02492	0.0007654	0.00085	0.24	0.19892	0.0000022	0.0000	0.00089	0.0018	0.36	0.0000
18-Aug-09	1	0.00004475	0.0006	0.0235795	0.0884	0.0013684	0.00233	0.58	0.55487	0.0000045	0.0000	0.00204	0.0031	0.73	0.0001
25-Aug-09	2	0.00006675	0.0012	0.0601875	0.1861	0.0022264	0.00449	1.17	1.15327	0.0000067	0.0000	0.00403	0.0036	1.20	0.0002
01-Sep-09	3	0.000089	0.0021	0.1100275	0.3316	0.0036282	0.00720	1.92	1.90087	0.0000111	0.0000	0.00695	0.0040	1.72	0.0003
08-Sep-09	4	0.00010675	0.0032	0.1671825	0.4185	0.0045370	0.01006	2.74	2.75287	0.0000138	0.0001	0.01014	0.0047	2.21	0.0005
15-Sep-09	5	0.0001305	0.0051	0.2669325	0.4960	0.0054727	0.01481	4.14	4.23487	0.0000162	0.0001	0.01555	0.0062	2.99	0.0007
22-Sep-09	6	0.00027025	0.0087	0.5139675	0.6998	0.0068896	0.02001	6.18	6.52247	0.0000183	0.0001	0.02469	0.0072	3.92	0.0008
29-Sep-09	7	0.00053425	0.0143	0.9271275	1.0452	0.0089224	0.02626	9.07	9.83127	0.0000205	0.0001	0.03837	0.0081	5.11	0.0010
06-Oct-09	8	0.00172225	0.0244	1.8091075	2.9581	0.0103810	0.03444	13.33	15.07167	0.0000271	0.0001	0.06191	0.0096	6.43	0.0012
13-Oct-09	9	0.00393025	0.0398	3.2213075	6.5967	0.0113056	0.04502	19.22	22.56967	0.0000386	0.0002	0.09683	0.0119	7.95	0.0014
20-Oct-09	10	0.00958275	0.0575	5.1640575	11.9428	0.0131842	0.05500	24.63	30.19342	0.0000683	0.0003	0.13362	0.0179	9.16	0.0016
27-Oct-09	11	0.01841775	0.0767	7.5402075	18.7318	0.0159277	0.06383	29.28	37.54042	0.0001148	0.0006	0.17035	0.0272	10.00	0.0018
03-Nov-09	12	0.03286775	0.0977	10.292083	29.3143	0.0176064	0.07276	33.81	44.63792	0.0001573	0.0008	0.20716	0.0357	10.70	0.0019
10-Nov-09	13	0.05491775	0.1238	13.820083	45.1543	0.0185064	0.08311	38.89	52.55792	0.0002023	0.0010	0.24955	0.0447	11.38	0.0021
17-Nov-09	14	0.09595775	0.1551	18.197683	74.2423	0.0320904	0.09223	44.01	60.69392	0.0002863	0.0015	0.29448	0.0615	11.90	0.0025
24-Nov-09	15	0.14719775	0.1855	22.565683	110.3623	0.0550224	0.09853	48.21	67.53992	0.0003913	0.0021	0.33354	0.0825	12.20	0.0029
01-Dec-09	16	0.23551775	0.2271	28.229683	179.2423	0.0689664	0.10573	53.08	74.71592	0.0005113	0.0028	0.38082	0.1413	12.51	0.0034
08-Dec-09	17	0.34252775	0.271	33.971683	266.6773	0.0704889	0.11225	57.56	80.63192	0.0006201	0.0035	0.42606	0.2261	12.77	0.0038
15-Dec-09	18	0.44464775	0.3101	38.826983	350.8573	0.0728809	0.11915	61.75	85.19512	0.0007351	0.0042	0.46677	0.3043	12.97	0.0043
22-Dec-09	19	0.53473775	0.3415	42.426033	425.9323	0.0760204	0.12598	65.34	88.03432	0.0008488	0.0049	0.49998	0.3703	13.08	0.0047
29-Dec-09	20	0.63091775	0.3742	45.754533	514.7623	0.0779314	0.13459	69.29	90.52912	0.0009223	0.0054	0.53190	0.4831	13.15	0.0051
05-Jan-10	21	0.74661775	0.4129	49.287833	629.5723	0.0789104	0.14616	74.14	93.03892	0.0009668	0.0058	0.56706	0.6575	13.20	0.0055
12-Jan-10	22	0.85444775	0.449	52.424333	737.1973	0.0797919	0.15661	78.50	95.11147	0.0010078	0.0075	0.59807	0.8481	13.24	0.0058
19-Jan-10	23	0.97680775	0.4901	55.809933	860.0173	0.0807579	0.16811	83.29	97.16767	0.0010538	0.0107	0.63133	1.0956	13.29	0.0060
26-Jan-10	24	1.07248275	0.524	58.475933	969.8823	0.0815964	0.17714	86.99	98.67912	0.0010968	0.0123	0.65808	1.3181	13.37	0.0061
02-Feb-10	25	1.15303275	0.5549	60.743933	1079.6823	0.0824064	0.18479	90.05	99.83112	0.0011418	0.0125	0.68152	1.5418	13.51	0.0063
09-Feb-10	26	1.23288525	0.5863	63.030308	1203.2148	0.0830662	0.19207	92.96	100.94587	0.0012214	0.0130	0.70475	1.7204	13.63	0.0066
16-Feb-10	27	1.31544525	0.6195	65.435108	1346.7348	0.0835942	0.19927	95.84	102.06907	0.0013414	0.0137	0.72875	1.8586	13.75	0.0071
23-Feb-10	28	1.38686775	0.6493	67.600033	1461.7673	0.0868427	0.20595	98.24	103.01692	0.0014527	0.0144	0.74989	1.9610	13.86	0.0076
02-Mar-10	29	1.45838775	0.6804	69.865633	1566.4073	0.0933227	0.21315	100.55	103.93852	0.0015727	0.0151	0.77149	2.0435	13.98	0.0080
09-Mar-10	30	1.51088775	0.7046	71.600233	1648.3073	0.0963887	0.21945	102.18	104.59582	0.0016777	0.0157	0.78913	2.1013	14.35	0.0085
16-Mar-10	31	1.56037775	0.7292	73.334833	1732.5873	0.0969277	0.22680	103.65	105.18872	0.0018002	0.0165	0.80824	2.1518	15.09	0.0089
23-Mar-10	32	1.60576775	0.7519	74.914583	1810.4623	0.0973727	0.23281	104.94	105.71382	0.0018781	0.0169	0.82446	2.2225	15.44	0.0093
30-Mar-10	33	1.65108775	0.7747	76.480983	1888.7823	0.0977687	0.23809	106.18	106.21982	0.0019221	0.0171	0.83937	2.3171	15.49	0.0094
06-Apr-10	34	1.69858775	0.7992	78.135983	1974.0323	0.0980912	0.24409	107.48	106.74232	0.0019596	0.0173	0.85547	2.4179	15.57	0.0096
13-Apr-10	35	1.73512775	0.8186	79.421183	2042.4923	0.0982550	0.24913	108.48	107.13712	0.0019806	0.0174	0.86828	2.4968	15.68	0.0097
20-Apr-10	36	1.77947275	0.8434	81.072483	2126.7723	0.0984730	0.25574	109.44	107.62957	0.0020541	0.0179	0.88457	2.5919	16.11	0.0100
27-Apr-10	37	1.82318275	0.8688	82.783683	2210.9373	0.0987055	0.26272	110.14	108.12712	0.0021703	0.0186	0.90131	2.6849	16.80	0.0104
04-May-10	38	1.859848	0.8901	84.206583	2281.6173	0.0989357	0.26853	110.88	108.53655	0.0022342	0.0189	0.91475	2.7628	17.19	0.0108
11-May-10	39	1.88915	0.9072	85.328983	2338.1973	0.0991611	0.27313	111.66	108.85441	0.0022457	0.0190	0.92478	2.8249	17.26	0.0109
18-May-10	40	1.91647775	0.9233	86.445333	2386.9598	0.0996363	0.27728	112.43	109.15570	0.0022717	0.0192	0.93466	2.8751	17.39	0.0111
25-May-10	41	1.94537775	0.9406	87.694833	2434.5598	0.1004013	0.28153	113.28	109.47912	0.0023142	0.0197	0.94562	2.9206	17.60	0.0113
01-Jun-10	42	1.97012775	0.9555	88.786083	2477.4973	0.1011138	0.28547	114.03	109.75587	0.0023517	0.0200	0.95500	2.9669	17.79	0.0114
08-Jun-10	43	1.99924775	0.9728	90.096483	2530.7323	0.1020238	0.29047	114.94	110.08120	0.0023972	0.0202	0.96601	3.0306	18.02	0.0116
15-Jun-10	44	2.0253025	0.9891	91.309108	2579.4598	0.1026268	0.29492	115.74	110.38958	0.0024250	0.0207	0.97602	3.0873	18.16	0.0117
22-Jun-10	45	2.0502595	1.0054	92.517008	2627.3998	0.1029605	0.29915	116.49	110.70495	0.0024367	0.0215	0.98580	3.1414	18.23	0.0118
29-Jun-10	46	2.06745875	1.0169	93.366958	2660.0851	0.1032631	0.30244	117.01	110.92768	0.0024434	0.0219	0.99270	3.1743	18.29	0.0118
06-Jul-10	47	2.08004275	1.0255	94.016958	2683.4331	0.1036011	0.30546	117.40	111.09928	0.0024460	0.0219	0.99800	3.1914	18.33	0.0118
13-Jul-10	48	2.09126275	1.0335	94.650208	2706.0006	0.1037859	0.30818	117.77	111.26269	0.0024524	0.0220	1.00314	3.2076	18.38	0.0119
20-Jul-10	49	2.10613475	1.0446	95.549808	2737.8766	0.1039003	0.31182	118.29	111.49097	0.0024654	0.0220	1.01042	3.2300	18.45	0.0119
27-Jul-10	50	2.11878475	1.054	96.317308	2762.0016	0.1041113	0.31510	118.72	111.68722	0.0024729	0.0221	1.01640	3.2497	18.50	0.0119
03-Aug-10	51	2.12934475	1.0618	96.960508	2778.8976	0.1044108	0.31802	119.08	111.85330	0.0024753	0.0221	1.02115	3.2670	18.51	0.0120
10-Aug-10	52	2.13785875	1.0683	97.508308	2792.4056	0.1052499	0.32066	119.39	111.98860	0.0024775	0.0221	1.02504	3.2800	18.53	0.0120
17-Aug-10	53	2.14529025	1.074	98.020058	2804.0646	0.1066695	0.32329	119.67	112.10830	0.0024797	0.0222	1.02851	3.2902	18.55	0.0120
24-Aug-10	54	2.1543045	1.081	98.638683	2817.4723	0.1075926	0.32642	120.02	112.25324	0.0024822	0.0222	1.03276	3.3026	18.57	0.0120
31-Aug-10	55	2.1628545	1.0875	99.223683	2829.5773	0.1078023	0.32934	120.34	112.39049	0.0024845	0.0222	1.03681	3.3143	18.58	0.0120
07-Sep-10	56	2.171607	1.0942	99.835683	2841.9073	0.1079387	0.33238	120.69	112.53111	0.0024867	0.0222	1.04084	3.3282	18.59	0.0121
14-Sep-10	57	2.1808605	1.1013	100.49598	2854.8808	0.1080038	0.33564	121.07	112.67991	0.0024891	0.0223	1.04499	3.3450	18.60	0.0121
21-Sep-10	58	2.1891415	1.1077	101.11023	2866.6653	0.1081751	0.33885	121.42	112.81710	0.0024913	0.0224	1.04886	3.3604	18.61	0.0121
28-Sep-10	59	2.1967315	1.1138	101.69903	2877.6593	0.1084571	0.34211	121.75	112.94728	0.0024936	0.0226	1.05256	3.3752	18.62	0.0121

Date	Cycle No.	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
11-Aug-09	0	1.446	1.11E-06	0.387	0.0065	3.12	4E-05	0.0017	0.0001113	1.335E-06	0.00004	0.17711	0.00002
18-Aug-09	1	3.278	4.26E-06	0.666	0.0174	8.07	6E-05	0.0038	0.0002238	5.385E-06	0.00009	0.49616	0.00004
25-Aug-09	2	5.768	1.22E-05	1.014	0.0334	15.99	9E-05	0.0063	0.0003338	1.683E-05	0.00013	1.09456	0.00007
01-Sep-09	3	8.727	1.93E-05	1.352	0.0536	25.78	0.0001	0.0096	0.000445	2.84E-05	0.00018	1.91336	0.00009
08-Sep-09	4	11.587	2.78E-05	1.641	0.0738	36.60	0.0002	0.0131	0.0005338	0.0000465	0.00021	2.86654	0.00011
15-Sep-09	5	16.080	4.30E-05	2.055	0.1062	55.13	0.0002	0.0188	0.0006525	0.0000826	0.00026	4.54329	0.00013
22-Sep-09	6	21.017	5.85E-05	2.437	0.1501	83.51	0.0003	0.0279	0.00076	0.0002305	0.00030	7.49524	0.00015
29-Sep-09	7	26.957	7.61E-05	2.838	0.2099	124.43	0.0004	0.0412	0.00087	0.0004998	0.00035	11.9832	0.00017
06-Oct-09	8	34.921	1.42E-04	3.256	0.2935	190.65	0.0006	0.0622	0.001255	0.001125	0.00048	20.7832	0.00024
13-Oct-09	9	45.363	2.62E-04	3.711	0.4057	286.33	0.0007	0.0921	0.001945	0.0021508	0.00071	34.4912	0.00036
20-Oct-09	10	55.932	4.18E-04	4.089	0.5102	386.55	0.0008	0.1325	0.0034888	0.0040722	0.00130	51.7575	0.00065
27-Oct-09	11	66.069	6.04E-04	4.368	0.6014	486.06	0.0009	0.1813	0.0058138	0.0067971	0.00223	71.706	0.00112
03-Nov-09	12	76.609	8.59E-04	4.623	0.6783	591.04	0.001	0.223	0.0079388	0.0104649	0.00478	91.936	0.00154
10-Nov-09	13	89.119	1.22E-03	4.893	0.7530	717.04	0.0011	0.2639	0.0101888	0.0155949	0.00928	115.471	0.00199
17-Nov-09	14	104.023	1.60E-03	5.229	0.8171	887.68	0.0012	0.3118	0.0149888	0.0240909	0.01288	144.367	0.00283
24-Nov-09	15	118.429	1.94E-03	5.565	0.8595	1068.70	0.0013	0.3576	0.0212888	0.0341709	0.01498	172.969	0.00388
01-Dec-09	16	136.789	2.37E-03	5.817	0.9006	1295.26	0.0014	0.4107	0.0284888	0.0516669	0.02338	208.273	0.00508
08-Dec-09	17	155.146	2.81E-03	5.925	0.9310	1518.41	0.0015	0.4594	0.0350138	0.0729384	0.03643	242.638	0.00617
15-Dec-09	18	171.614	3.31E-03	6.259	0.9549	1737.83	0.0016	0.5075	0.0419138	0.0933624	0.04448	271.963	0.00732
22-Dec-09	19	184.991	3.86E-03	6.805	0.9704	1938.49	0.0016	0.5516	0.0487388	0.1115169	0.04676	294.03	0.00846
29-Dec-09	20	198.473	4.30E-03	7.141	0.9836	2149.33	0.0016	0.5942	0.0529388	0.1302909	0.05411	316.269	0.00919
05-Jan-10	21	213.959	4.70E-03	7.319	0.9965	2399.86	0.0017	0.6414	0.0551638	0.1523184	0.06746	341.812	0.00964
12-Jan-10	22	228.001	5.03E-03	7.503	1.0078	2638.89	0.0017	0.6811	0.0586488	0.1701124	0.07894	364.075	0.01005
19-Jan-10	23	243.503	5.35E-03	7.733	1.0198	2916.27	0.0017	0.7214	0.0641688	0.1872704	0.09090	387.627	0.01051
26-Jan-10	24	255.522	5.69E-03	7.948	1.0305	3147.40	0.0018	0.7525	0.0678238	0.2004929	0.09993	405.838	0.01094
02-Feb-10	25	265.512	6.10E-03	8.173	1.0413	3359.80	0.0018	0.7781	0.0700738	0.2113829	0.10713	420.913	0.01139
09-Feb-10	26	279.002	6.42E-03	8.344	1.0531	3565.91	0.0019	0.8071	0.0746238	0.2218251	0.11418	435.882	0.01218
16-Feb-10	27	296.810	6.66E-03	8.464	1.0666	3774.23	0.0019	0.8407	0.0818238	0.2322411	0.12138	451.386	0.01338
23-Feb-10	28	310.961	6.86E-03	8.575	1.0795	3953.35	0.0019	0.8705	0.0884988	0.2407629	0.12583	464.914	0.01450
02-Mar-10	29	323.681	7.05E-03	8.695	1.0939	4131.43	0.0019	0.901	0.0956988	0.2487309	0.12823	478.594	0.01570
09-Mar-10	30	333.698	7.24E-03	9.063	1.1054	4261.84	0.0019	0.9271	0.1019988	0.2544219	0.13033	488.716	0.01675
16-Mar-10	31	344.086	7.48E-03	9.798	1.1177	4384.34	0.002	0.9568	0.1093488	0.2595669	0.13278	498.369	0.01797
23-Mar-10	32	353.075	7.64E-03	10.265	1.1299	4513.16	0.002	0.9836	0.1137988	0.2641259	0.13523	506.78	0.01875
30-Mar-10	33	361.523	7.73E-03	10.529	1.1431	4657.92	0.002	1.01	0.1159988	0.2685215	0.13787	514.744	0.01919
06-Apr-10	34	371.723	7.86E-03	10.804	1.1575	4812.17	0.0021	1.036	0.1178738	0.273139	0.14112	522.944	0.01956
13-Apr-10	35	380.795	8.01E-03	11.014	1.1689	4933.13	0.0021	1.0544	0.1189238	0.2767006	0.14406	529.118	0.01977
20-Apr-10	36	393.070	8.13E-03	11.504	1.1842	5064.94	0.0021	1.0807	0.1232113	0.2809097	0.14700	536.786	0.02051
27-Apr-10	37	406.322	8.20E-03	12.202	1.2005	5181.19	0.0022	1.1102	0.1301863	0.2849552	0.14932	544.505	0.02167
04-May-10	38	417.575	8.31E-03	12.690	1.2155	5299.77	0.0022	1.1356	0.1340225	0.2883032	0.15118	550.946	0.02231
11-May-10	39	426.729	8.45E-03	12.966	1.2292	5419.37	0.0022	1.1565	0.1347125	0.2909252	0.15256	556.052	0.02243
18-May-10	40	434.635	8.65E-03	13.194	1.2421	5524.16	0.0022	1.1731	0.1360613	0.2933218	0.15360	560.72	0.02269
25-May-10	41	442.370	8.95E-03	13.407	1.2557	5628.28	0.0023	1.1877	0.1381863	0.2958081	0.15445	565.565	0.02311
01-Jun-10	42	449.889	9.18E-03	13.594	1.2673	5719.41	0.0023	1.1999	0.1400613	0.2979362	0.15520	569.765	0.02349
08-Jun-10	43	459.853	9.40E-03	13.822	1.2809	5829.06	0.0023	1.2138	0.1423363	0.3004387	0.15611	574.77	0.02394
15-Jun-10	44	468.242	9.63E-03	14.089	1.2949	5926.07	0.0023	1.2282	0.1437825	0.3027727	0.15722	579.374	0.02422
22-Jun-10	45	475.668	9.88E-03	14.418	1.3104	6017.72	0.0024	1.2442	0.1444875	0.305118	0.15863	583.928	0.02434
29-Jun-10	46	481.372	1.01E-02	14.676	1.3222	6086.70	0.0024	1.2557	0.1448769	0.3068068	0.15961	587.121	0.02440
06-Jul-10	47	486.489	1.02E-02	14.915	1.3326	6146.50	0.0024	1.2647	0.1450069	0.3081588	0.16034	589.544	0.02443
13-Jul-10	48	491.789	1.03E-02	15.161	1.3431	6200.05	0.0024	1.2741	0.1453788	0.3092723	0.16128	591.831	0.02449
20-Jul-10	49	499.641	1.05E-02	15.525	1.3586	6271.29	0.0025	1.2883	0.1461588	0.3106451	0.16284	595.003	0.02462
27-Jul-10	50	506.291	1.07E-02	15.838	1.3720	6335.54	0.0025	1.2996	0.1465963	0.3118076	0.16384	597.663	0.02470
03-Aug-10	51	511.811	1.09E-02	16.102	1.3832	6393.14	0.0025	1.3084	0.1467163	0.3127724	0.16432	599.842	0.02472
10-Aug-10	52	516.440	1.10E-02	16.348	1.3926	6439.78	0.0025	1.3153	0.1468263	0.313615	0.16471	601.633	0.02474
17-Aug-10	53	520.685	1.12E-02	16.602	1.4012	6480.72	0.0025	1.3212	0.1469375	0.3144249	0.16507	603.235	0.02477
24-Aug-10	54	525.473	1.13E-02	16.897	1.4118	6527.43	0.0026	1.3281	0.1470638	0.3153465	0.16545	605.055	0.02479
31-Aug-10	55	529.712	1.14E-02	17.167	1.4220	6569.28	0.0026	1.3345	0.1471763	0.31617	0.16576	606.68	0.02481
07-Sep-10	56	534.329	1.16E-02	17.444	1.4323	6612.25	0.0026	1.3417	0.1472888	0.3170588	0.16614	608.336	0.02484
14-Sep-10	57	539.490	1.18E-02	17.737	1.4430	6657.82	0.0026	1.3503	0.147405	0.3180446	0.16661	610.08	0.02486
21-Sep-10	58	544.563	1.20E-02	18.026	1.4533	6700.37	0.0026	1.3578	0.1475188	0.3189455	0.16702	611.633	0.02488
28-Sep-10	59	549.715	1.22E-02	18.320	1.4633	6741.31	0.0027	1.3646	0.1476338	0.3197919	0.16739	613.05	0.02491

Appendix B.1-4

Humidity Cell T4 (CaNP depleted Clay Composite)

Production Rates and Depletion

Date	Cycle	Acidity (mg $CaCO_3$/kg/wk)	Alkalinity (mg $CaCO_3$/kg/wk)	Cumulative Alkalinity (mg/$CaCO_3$/wk)	Sulphate (mg/kg/wk)	Cumulative Sulphate (mg/kg)	Cumulative Sulphate (mmol/kg)	Fraction of total S Leached	Fraction of Total S remaining	Fraction of Sulphide Sulphur Leached	Fraction of Sulphide Sulphur Remaining	Alkalinity/ Sulphate Production	Total S Conc Remaining (%)	*Ratios* CMR	Ca/SO4	(Ca+Mg)/ Alk	Ca/Mg	*NP Consumption Rates* Theoretical NP Consumption at pH 6	Carbonate NP Consumption (mg CaCO3/kg/wk)	Carbonate NP Consumption (kg CaCO3/t/wk)	Cum. Carb NP Consum. (mg CaCO3/kg/wk)	Cum. Carb NP Consum. (kg CaCO3/t/wk)	Remaining Carbonate NP	Open System NP Consumption	Cumulative NP Consumption	Remaining NP
11-Aug-09	0	2.505	1.4	1.4	8.0	8.0	0.083	0.00012	1.000	0.00027	1.000	0.18	2.280	0.91	0.79	5.25	6.80	8.3	7.6	0.0076	7.6	0.0076	1.00	7.3	7.3	1.00
18-Aug-09	1	2.844	0.8	2.2	13.5	21.5	0.224	0.00031	1.000	0.00073	0.999	0.06	2.279	0.90	0.80	8.69	7.88	14.1	12.7	0.0127	20.3	0.0203	1.00	12.0	19.3	1.00
25-Aug-09	2	4.118	1.0	3.2	23.3	44.8	0.467	0.00066	0.999	0.00153	0.998	0.04	2.279	0.81	0.71	13.80	7.11	24.3	19.7	0.0197	40.0	0.0400	1.00	21.1	40.4	1.00
01-Sep-09	3	5.718	1.3	4.5	31.6	76.4	0.796	0.00112	0.999	0.00260	0.997	0.04	2.277	0.77	0.67	17.49	7.14	32.9	25.2	0.0252	65.2	0.0652	1.00	28.5	68.9	1.00
08-Sep-09	4	5.820	1.0	5.4	30.2	106.6	1.110	0.00156	0.998	0.00363	0.996	0.03	2.276	0.85	0.74	23.24	6.92	31.4	26.8	0.0268	91.9	0.0919	1.00	26.6	95.5	1.00
15-Sep-09	5	9.472	1.2	6.7	54.2	160.8	1.673	0.00235	0.998	0.00548	0.995	0.02	2.275	0.79	0.69	29.00	6.79	56.4	44.7	0.0447	136.6	0.1366	1.00	48.2	143.7	1.00
22-Sep-09	6	17.028	#N/A	#N/A	86.0	246.8	2.569	0.00361	0.996	0.00841	0.992	#N/A	2.272	0.75	0.66	48.20	6.98	89.6	67.2	0.0672	203.8	0.2038	0.99	#N/A	#N/A	#N/A
29-Sep-09	7	26.074	#N/A	#N/A	125.8	372.6	3.879	0.00546	0.995	0.01269	0.987	#N/A	2.268	0.73	0.64	67.39	7.07	131.1	96.1	0.0961	299.9	0.2999	0.99	#N/A	#N/A	#N/A
06-Oct-09	8	55.282	#N/A	#N/A	167.6	540.2	5.624	0.00791	0.992	0.01840	0.982	#N/A	2.262	0.80	0.70	98.47	7.00	174.7	140.5	0.1405	440.4	0.4404	0.99	#N/A	#N/A	#N/A
13-Oct-09	9	88.329	#N/A	#N/A	276.5	816.7	8.502	0.01196	0.988	0.02782	0.972	#N/A	2.253	0.67	0.59	129.56	6.96	288.0	193.2	0.1932	633.7	0.6337	0.98	#N/A	#N/A	#N/A
20-Oct-09	10	135.311	#N/A	#N/A	286.4	1103.1	11.484	0.01615	0.984	0.03758	0.962	#N/A	2.243	0.60	0.52	116.22	7.02	298.4	179.0	0.1790	812.6	0.8126	0.98	#N/A	#N/A	#N/A
27-Oct-09	11	175.635	#N/A	#N/A	357.1	1460.2	15.201	0.02138	0.979	0.04974	0.950	#N/A	2.231	0.42	0.37	102.88	7.10	372.1	155.1	0.1551	967.7	0.9677	0.97	#N/A	#N/A	#N/A
03-Nov-09	12	216.297	#N/A	#N/A	411.4	1871.6	19.484	0.02740	0.973	0.06375	0.936	#N/A	2.218	0.33	0.29	103.71	6.66	428.6	142.9	0.1429	1110.6	1.1106	0.97	#N/A	#N/A	#N/A
10-Nov-09	13	288.072	#N/A	#N/A	424.4	2296.0	23.902	0.03362	0.966	0.07821	0.922	#N/A	2.203	0.34	0.30	104.54	6.28	442.1	152.5	0.1525	1263.1	1.2631	0.97	#N/A	#N/A	#N/A
17-Nov-09	14	441.638	#N/A	#N/A	584.2	2880.1	29.983	0.04217	0.958	0.09811	0.902	#N/A	2.184	0.24	0.21	94.00	5.94	608.6	146.3	0.1463	1409.4	1.4094	0.96	#N/A	#N/A	#N/A
24-Nov-09	15	504.000	#N/A	#N/A	589.3	3469.4	36.117	0.05080	0.949	0.11818	0.882	#N/A	2.164	0.19	0.16	83.46	5.57	613.9	113.6	0.1136	1523.0	1.5230	0.96	#N/A	#N/A	#N/A
01-Dec-09	16	582.000	#N/A	#N/A	773.8	4243.2	44.172	0.06212	0.938	0.14454	0.855	#N/A	2.138	0.14	0.12	73.32	4.68	806.1	114.1	0.1141	1637.1	1.6371	0.96	#N/A	#N/A	#N/A
08-Dec-09	17	532.875	#N/A	#N/A	779.1	5022.3	52.282	0.07353	0.926	0.17107	0.829	#N/A	2.112	0.11	0.09	63.19	3.83	811.7	89.1	0.0891	1726.2	1.7262	0.95	#N/A	#N/A	#N/A
15-Dec-09	18	612.375	#N/A	#N/A	668.8	5691.1	59.245	0.08332	0.917	0.19386	0.806	#N/A	2.090	0.10	0.08	47.48	3.11	696.8	70.8	0.0708	1797.0	1.7970	0.95	#N/A	#N/A	#N/A
22-Dec-09	19	654.063	#N/A	#N/A	689.3	6380.4	66.421	0.09342	0.907	0.21734	0.783	#N/A	2.067	0.07	0.04	31.77	2.16	718.2	46.9	0.0469	1843.8	1.8438	0.95	#N/A	#N/A	#N/A
29-Dec-09	20	611.625	#N/A	#N/A	596.0	6976.4	72.625	0.10214	0.898	0.23764	0.762	#N/A	2.047	0.07	0.04	30.52	1.55	620.9	41.5	0.0415	1885.4	1.8854	0.95	#N/A	#N/A	#N/A
05-Jan-10	21	656.375	#N/A	#N/A	849.1	7825.5	81.464	0.11457	0.885	0.26656	0.733	#N/A	2.019	0.05	0.03	29.27	1.11	884.6	42.2	0.0422	1927.6	1.9276	0.95	#N/A	#N/A	#N/A
12-Jan-10	22	671.375	#N/A	#N/A	838.0	8663.5	90.188	0.12684	0.873	0.29511	0.705	#N/A	1.991	0.04	0.02	26.87	0.99	873.1	35.7	0.0357	1963.3	1.9633	0.95	#N/A	#N/A	#N/A
19-Jan-10	23	828.000	#N/A	#N/A	858.8	9522.3	99.129	0.13942	0.861	0.32436	0.676	#N/A	1.962	0.04	0.02	24.47	0.85	894.8	36.5	0.0365	1999.8	1.9998	0.95	#N/A	#N/A	#N/A
26-Jan-10	24	671.875	#N/A	#N/A	751.6	10274.0	106.954	0.15042	0.850	0.34996	0.650	#N/A	1.937	0.03	0.02	19.48	0.78	783.1	27.2	0.0272	2026.9	2.0269	0.94	#N/A	#N/A	#N/A
02-Feb-10	25	596.250	#N/A	#N/A	663.8	10937.7	113.863	0.16014	0.840	0.37257	0.627	#N/A	1.915	0.03	0.01	14.50	0.68	691.5	21.2	0.0212	2048.1	2.0481	0.94	#N/A	#N/A	#N/A
09-Feb-10	26	631.313	#N/A	#N/A	719.4	11657.1	121.352	0.17067	0.829	0.39708	0.603	#N/A	1.891	0.03	0.01	13.95	0.72	749.5	20.6	0.0206	2068.7	2.0687	0.94	#N/A	#N/A	#N/A
16-Feb-10	27	696.000	#N/A	#N/A	739.2	12396.3	129.047	0.18150	0.819	0.42226	0.578	#N/A	1.866	0.03	0.01	13.41	0.76	770.1	20.9	0.0209	2089.5	2.0895	0.94	#N/A	#N/A	#N/A
23-Feb-10	28	650.813	#N/A	#N/A	554.5	12950.7	134.819	0.18961	0.810	0.44114	0.559	#N/A	1.848	0.03	0.01	12.18	0.77	577.7	17.6	0.0176	2107.1	2.1071	0.94	#N/A	#N/A	#N/A
02-Mar-10	29	708.000	#N/A	#N/A	586.6	13537.3	140.925	0.19820	0.802	0.46112	0.539	#N/A	1.828	0.03	0.01	10.96	0.80	611.1	17.1	0.0171	2124.2	2.1242	0.94	#N/A	#N/A	#N/A
09-Mar-10	30	619.500	#N/A	#N/A	370.4	13907.7	144.782	0.20363	0.796	0.47374	0.526	#N/A	1.816	0.03	0.01	8.93	0.80	385.9	12.2	0.0122	2136.3	2.1363	0.94	#N/A	#N/A	#N/A
16-Mar-10	31	722.750	#N/A	#N/A	528.2	14436.0	150.281	0.21136	0.789	0.49173	0.508	#N/A	1.798	0.02	0.01	6.90	0.81	550.3	11.0	0.0110	2147.3	2.1473	0.94	#N/A	#N/A	#N/A
23-Mar-10	32	650.813	#N/A	#N/A	559.4	14995.3	156.104	0.21955	0.780	0.51079	0.489	#N/A	1.779	0.02	0.01	6.85	0.86	582.8	9.9	0.0099	2157.2	2.1572	0.94	#N/A	#N/A	#N/A
30-Mar-10	33	638.000	#N/A	#N/A	440.0	15435.3	160.684	0.22599	0.774	0.52578	0.474	#N/A	1.765	0.02	0.01	6.80	0.91	458.4	9.7	0.0097	2166.9	2.1669	0.94	#N/A	#N/A	#N/A
06-Apr-10	34	662.500	#N/A	#N/A	496.0	15931.3	165.848	0.23325	0.767	0.54267	0.457	#N/A	1.748	0.02	0.01	6.27	0.90	516.8	10.2	0.0102	2177.1	2.1771	0.94	#N/A	#N/A	#N/A
13-Apr-10	35	504.000	#N/A	#N/A	406.6	16337.9	170.080	0.23921	0.761	0.55652	0.443	#N/A	1.735	0.02	0.01	5.75	0.88	423.6	7.8	0.0078	2184.9	2.1849	0.94	#N/A	#N/A	#N/A
20-Apr-10	36	594.125	#N/A	#N/A	517.9	16855.8	175.472	0.24679	0.753	0.57416	0.426	#N/A	1.717	0.01	0.01	4.98	1.01	539.6	7.9	0.0079	2192.8	2.1928	0.94	#N/A	#N/A	#N/A
27-Apr-10	37	569.625	#N/A	#N/A	504.5	17360.3	180.724	0.25418	0.746	0.59135	0.409	#N/A	1.700	0.01	0.01	4.22	1.21	525.6	6.4	0.0064	2199.2	2.1992	0.94	#N/A	#N/A	#N/A
04-May-10	38	528.938	#N/A	#N/A	408.3	17768.6	184.974	0.26015	0.740	0.60525	0.395	#N/A	1.687	0.02	0.01	4.46	1.19	425.4	6.7	0.0067	2205.9	2.2059	0.94	#N/A	#N/A	#N/A
11-May-10	39	483.000	#N/A	#N/A	361.1	18129.7	188.733	0.26544	0.735	0.61756	0.382	#N/A	1.675	0.02	0.01	4.70	1.18	376.2	7.0	0.0070	2213.0	2.2130	0.94	#N/A	#N/A	#N/A
18-May-10	40	440.938	#N/A	#N/A	326.2	18455.9	192.129	0.27022	0.730	0.62867	0.371	#N/A	1.664	0.02	0.01	4.78	1.03	339.8	6.4	0.0064	2219.4	2.2194	0.94	#N/A	#N/A	#N/A
25-May-10	41	456.875	#N/A	#N/A	244.8	18700.7	194.677	0.27380	0.726	0.63700	0.363	#N/A	1.656	0.03	0.01	4.85	0.91	255.0	6.7	0.0067	2226.1	2.2261	0.94	#N/A	#N/A	#N/A
01-Jun-10	42	337.500	#N/A	#N/A	225.0	18925.7	197.019	0.27709	0.723	0.64467	0.355	#N/A	1.648	0.03	0.01	5.24	1.06	234.4	6.4	0.0064	2232.5	2.2325	0.94	#N/A	#N/A	#N/A
08-Jun-10	43	329.875	#N/A	#N/A	330.8	19256.5	200.463	0.28194	0.718	0.65594	0.344	#N/A	1.637	0.02	0.01	5.62	1.21	344.6	8.3	0.0083	2240.8	2.2408	0.94	#N/A	#N/A	#N/A
15-Jun-10	44	333.750	#N/A	#N/A	234.5	19491.0	202.904	0.28537	0.715	0.66392	0.336	#N/A	1.629	0.03	0.02	5.10	1.23	244.3	7.4	0.0074	2248.2	2.2482	0.94	#N/A	#N/A	#N/A
22-Jun-10	45	364.250	#N/A	#N/A	229.8	19720.8	205.297	0.28874	0.711	0.67175	0.328	#N/A	1.622	0.03	0.02	4.58	1.25	239.4	7.0	0.0070	2255.1	2.2551	0.94	#N/A	#N/A	#N/A
29-Jun-10	46	267.000	#N/A	#N/A	311.9	20032.8	208.544	0.29330	0.707	0.68238	0.318	#N/A	1.611	0.02	0.01	3.41	1.29	325.0	4.9	0.0049	2260.1	2.2601	0.94	#N/A	#N/A	#N/A
06-Jul-10	47	221.000	#N/A	#N/A	163.3	20196.0	210.244	0.29569	0.704	0.68794	0.312	#N/A	1.606	0.02	0.01	2.24	1.38	170.1	3.8	0.0038	2263.9	2.2639	0.94	#N/A	#N/A	#N/A
13-Jul-10	48	201.875	#N/A	#N/A	144.9	20341.0	211.753	0.29782	0.702	0.69288	0.307	#N/A	1.601	0.03	0.02	2.76	1.50	151.0	3.8	0.0038	2267.7	2.2677	0.94	#N/A	#N/A	#N/A
20-Jul-10	49	273.000	#N/A	#N/A	196.0	20537.0	213.794	0.30069	0.699	0.69956	0.300	#N/A	1.594	0.03	0.02	3.27	1.58	204.2	5.5	0.0055	2273.2	2.2732	0.94	#N/A	#N/A	#N/A
27-Jul-10	50	243.750	#N/A	#N/A	173.0	20710.0	215.595	0.30322	0.697	0.70545	0.295	#N/A	1.589	0.03	0.02	2.87	1.60	180.2	4.7	0.0047	2277.9	2.2779	0.94	#N/A	#N/A	#N/A
03-Aug-10	51	216.000	#N/A	#N/A	160.3	20870.3	217.263	0.30557	0.694	0.71091	0.289	#N/A	1.583	0.02	0.01	2.47	1.63	167.0	3.9	0.0039	2281.7	2.2817	0.94	#N/A	#N/A	#N/A
10-Aug-10	52	198.000	#N/A	#N/A	165.0	21035.3	218.981	0.30798	0.692	0.71653	0.283	#N/A	1.578	0.02	0.01	2.31	1.61	171.9	3.3	0.0033	2285.0	2.2850	0.94	#N/A	#N/A	#N/A
17-Aug-10	53	200.250	#N/A	#N/A	135.7	21171.1	220.394	0.30997	0.690	0.72115	0.279	#N/A	1.573	0.02	0.01	2.14	1.60	141.4	3.1	0.0031	2288.1	2.2881	0.94	#N/A	#N/A	#N/A
24-Aug-10	54	220.938	#N/A	#N/A	97.0	21268.0	221.403	0.31139	0.689	0.72446	0.276	#N/A	1.570	0.04	0.02	2.27	1.60	101.0	3.7	0.0037	2291.9	2.2919	0.94	#N/A	#N/A	#N/A
31-Aug-10	55	191.250	#N/A	#N/A	125.1	21393.1	222.706	0.31322	0.687	0.72872	0.271	#N/A	1.566	0.03	0.02	2.39	1.61	130.3	3.5	0.0035	2295.4	2.2954	0.94	#N/A	#N/A	#N/A
07-Sep-10	56	185.625	#N/A	#N/A	129.2	21522.3	224.050	0.31511	0.685	0.73312	0.267	#N/A	1.562	0.03	0.02	2.62	1.69	134.6	3.8	0.0038	2299.2	2.2992	0.94	#N/A	#N/A	#N/A
14-Sep-10	57	186.000	#N/A	#N/A	181.8	21704.1	225.943	0.31777	0.682	0.73931	0.261	#N/A	1.555	0.02	0.01	2.85	1.77	189.4	4.3	0.0043	2303.5	2.3035	0.94	#N/A	#N/A	#N/A
21-Sep-10	58	182.000	#N/A	#N/A	124.7	21828.8	227.241	0.31960	0.680	0.74356	0.256	#N/A	1.551	0.03	0.02	2.72	1.78	129.9	4.0	0.0040	2307.5	2.3075	0.94	#N/A	#N/A	#N/A
28-Sep-10	59	184.000	#N/A	#N/A	125.6	21954.3	228.548	0.32144	0.679	0.74783	0.252	#N/A	1.547	0.03	0.02	2.60	1.80	130.8	3.9	0.0039	2311.4	2.3114	0.94	#N/A	#N/A	#N/A

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L
11-Aug-09	0	500	455	7.08	49	#N/A	4.6	2.7	15	<0.5	18.1	0.0032	0.0114	0.0146	0.0241	<0.00001	<0.000005	<0.05	0.00155	5.89	<0.0001	0.000487	0.00709	0.006	0.0098
18-Aug-09	1	500	420	5.99	207	#N/A	6.9	1.2	92	1.2	87.1	0.005	0.0162	0.0346	0.0927	0.00001	<0.000005	<0.05	0.011	27.9	<0.0001	0.00229	0.0128	0.025	0.0179
25-Aug-09	2	500	375	6.19	391	#N/A	12.9	1.9	202	<0.5	174	0.0185	0.0179	0.0491	0.108	0.00006	<0.000005	<0.05	0.0312	55.2	<0.0001	0.00649	0.0687	0.097	0.0319
01-Sep-09	3	500	415	5.96	518	#N/A	25.1	2.1	251	0.6	231	0.051	0.018	0.0228	0.0614	0.00012	<0.00003	<0.3	0.0514	70.8	<0.0005	0.0115	0.111	0.044	0.0417
08-Sep-09	4	500	370	5.32	601				306																
15-Sep-09	5	500	450	4.94	677	#N/A	43.1	<0.1	357	<0.5	278	0.212	0.0169	0.0193	0.0162	0.00042	<0.00003	<0.3	0.105	80.1	<0.0005	0.0212	0.266	0.141	0.0231
22-Sep-09	6	500	420	4.77	638				336																
29-Sep-09	7	500	460	4.48	568	2.7	41.2	#N/A	292	<0.5	231	0.309	0.0125	0.0097	0.009	0.00059	<0.00003	<0.3	0.113	60.3	<0.0005	0.0203	0.356	0.201	0.00905
06-Oct-09	8	500	455	4.13	682				369																
13-Oct-09	9	500	440	4.05	826	8.8	74.2	#N/A	440	<0.5	316	1.26	0.0095	0.0064	0.0056	0.00183	<0.00003	<0.3	0.248	76.2	<0.0005	0.0344	1.02	0.35	0.0122
20-Oct-09	10	500	400	3.57	1000				577																
27-Oct-09	11	500	520	3.41	1102	51.1	211.9	#N/A	611	<0.5	338	5.74	0.012	0.0366	0.004	0.0078	<0.0001	<1	0.639	75.2	<0.002	0.0463	4.05	15.5	0.0313
03-Nov-09	12	500	435	3.03	1323				729																
10-Nov-09	13	500	420	2.60	1315	219.5	459.9	#N/A	720	<0.5	287	21.6	0.023	0.657	0.006	0.015	<0.0003	<3	0.956	57.2	0.02	0.0484	9.4	54.3	0.0749
17-Nov-09	14	500	470	2.89	1419				624																
24-Nov-09	15	500	450	2.95	1440	194.4	525.9	#N/A	694	<0.5	165	24.1	0.023	0.769	0.006	0.011	<0.0005	<5	0.795	27	0.027	0.0349	8.85	80.7	0.0631
01-Dec-09	16	500	475	2.73	1647				821																
08-Dec-09	17	500	485	2.79	1189	550.0	875.0	#N/A	1000	<0.5	106	44	0.031	3.64	0.006	0.009	<0.0005	<5	0.88	15	0.069	0.0463	9.43	175	0.13
15-Dec-09	18	500	455	2.34	3310				1618																
22-Dec-09	19	500	460	2.35	4150	1700	3425	#N/A	2522	1.6	102	75	0.094	32.5	0.013	0.006	0.0011	<5	1.49	9	0.207	0.0866	10.2	465	0.432
29-Dec-09	20	500	465	2.29	5290				3276																
05-Jan-10	21	500	425	2.21	7750	1875	2588	#N/A	4999	<0.5	123	77.6	0.217	169	0.009	0.007	0.0133	<5	2.41	9	0.333	0.155	10.4	1430	0.445
12-Jan-10	22	500	430	2.30	9930				5905																
19-Jan-10	23	500	450	2.46	9210	1975	3325	#N/A	5425	<0.5	114	56	0.22	197	0.005	0.006	0.0102	<5	2.51	9	0.381	0.179	9.04	1600	0.206
26-Jan-10	24	500	445	2.45	8040				5860																
02-Feb-10	25	500	450	2.69	8180	1875	2375	#N/A	4608	<0.5	66.7	42.1	0.188	137	0.005	0.005	0.0049	<5	1.81	9	0.292	0.142	6.32	1480	0.108
09-Feb-10	26	500	415	2.14	7200				4880																
16-Feb-10	27	500	425	2.09	6000	2800	3350	#N/A	3707	<0.5	45.1	32.1	0.118	57.8	0.002	0.0038	0.0007	<3	1.22	7.5	0.216	0.112	5.8	1070	0.0222
23-Feb-10	28	500	480	2.10	4840				3043																
02-Mar-10	29	500	410	2.09	7940	2950	3050	#N/A	4571	<0.5	43	37.3	0.163	110	0.004	0.004	0.003	<5	1.14	10	0.238	0.142	6.58	1400	0.0401
09-Mar-10	30	500	450	2.14	110500				3736																
16-Mar-10	31	500	455	2.13	8020	2750	3450	#N/A	4033	<0.5	20.6	27.7	0.142	69.2	0.014	0.003	0.0014	<5	0.828	8	0.169	0.123	5.22	1180	0.0222
23-Mar-10	32	500	460	2.39	10500				4699																
30-Mar-10	33	500	450	2.27	10660	2850	3450	#N/A	4505	<0.5	37.5	25	0.143	66.2	0.004	0.0022	0.0011	<3	0.678	10.6	0.153	0.127	4.85	1180	0.0187

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L
06-Apr-10	34	500	450	2.09	10880				4728																
13-Apr-10	35	500	455	2.01	10630	2800	3450	#N/A	3880	<0.5	34.9	22.9	0.142	58.8	0.003	0.0021	0.0016	<3	0.568	10	0.134	0.124	4.03	1170	0.0169
20-Apr-10	36	500	455	2.02	10130				4828																
27-Apr-10	37	500	440	2.03	10960	2800	3550	#N/A	4186	<0.5	35.7	28.3	0.147	61.4	0.004	0.0019	0.0015	<3	0.492	10	0.14	0.132	4.16	1220	0.0153
04-May-10	38	500	420	2.21	6970				4157																
11-May-10	39	500	425	2.69	3700	2750	3400	#N/A	3948	<0.5	25	23.8	0.139	45.2	0.002	0.0022	0.0006	<3	0.44	10	0.108	0.119	3.72	1080	0.0067
18-May-10	40	500	490	2.39	6290				2687																
25-May-10	41	500	445	2.09	6780	2700	3450	#N/A	2986	<0.5	23.6	23.3	0.126	42.4	0.003	0.0017	0.0011	<3	0.32	9	0.107	0.128	3.86	1060	0.0092
01-Jun-10	42	500	410	2.69	8900				3720																
08-Jun-10	43	500	425	2.13	7120	3150	3800	#N/A	3744	<0.5	56.3	30.7	0.155	59.6	0.006	0.0024	0.0019	<3	0.33	17	0.141	0.162	4.13	1440	0.0145
15-Jun-10	44	500	410	2.61	7130				3078																
22-Jun-10	45	500	440	1.91	6950	2700	3450	#N/A	2864	<0.5	41.3	20.7	0.121	39.7	0.003	0.0014	0.0009	<3	0.257	12	0.096	0.129	3.31	1130	0.0089
29-Jun-10	46	500	420	2.14	7170				3629																
06-Jul-10	47	500	465	2.16	5550	2550	3300	#N/A	2238	<0.5	22.5	18.1	0.089	22	0.003	0.0013	<0.0003	<3	0.184	9	0.069	0.0953	2.45	788	0.0039
13-Jul-10	48	500	455	2.28	6680				1706																
20-Jul-10	49	500	495	2.29	4650	2600	3350	#N/A	1070	<0.5	17.8	7	0.0516	3.17	0.0015	0.0007	<0.00005	<0.5	0.0866	5.1	0.026	0.0421	1.33	364	0.00096
27-Jul-10	50	500	455	2.21	6160				2556																
03-Aug-10	51	500	410	2.27	7650	2550	3350	#N/A	4225	<0.5	30.9	22.2	0.11	45	0.003	0.0018	0.0011	<3	0.195	12	0.091	0.15	3.41	1240	0.0098
10-Aug-10	52	500	495	2.01	4890				2078																
17-Aug-10	53	500	435	2.14	6570	2650	3300	#N/A	2901	<0.5	32.2	17	0.0878	24.2	0.0031	0.0012	0.0005	<1	0.117	10	0.059	0.106	2.66	813	0.0075
24-Aug-10	54	500	460	2.02	6490				1986																
31-Aug-10	55	500	435	2.19	6250	2600	3250	#N/A	3477	<0.5	30.6	16.1	0.0837	28.9	0.0026	0.0011	0.0006	<1	0.114	9	0.056	0.11	2.32	890	0.0045
07-Sep-10	56	500	445	2.21	6890				3707																
14-Sep-10	57	500	430	1.95	6250	2550	3200	#N/A	3409	<0.5	28.4	15.2	0.082	31.4	0.002	0.001	0.0009	<3	0.0961	11	0.058	0.113	2.11	959	0.0057
21-Sep-10	58	500	460	2.16	7180				3358																
28-Sep-10	59	500	465	2.10	6000	2500	3100	#N/A	2247	0.8	30.3	13	0.083	23.4	0.002	0.0008	0.0004	<3	0.0858	9	0.049	0.105	2.05	837	0.0039

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Results of Leachate Analysis

Date	Cycle No.	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11-Aug-09	0	<0.0005	0.83	0.649	<0.01	<0.00005	0.00123	0.003	0.21	0.00004	1.38	<0.000005	0.55	0.0103	7	0.000012	0.00311	<0.0005	0.000003	<0.0002	0.17	<0.0001
18-Aug-09	1	0.0014	4.24	3.64	<0.01	<0.00005	0.00321	0.003	0.55	0.00015	3.44	<0.000005	0.94	0.0484	33	0.00002	0.00549	<0.0005	0.000002	<0.0002	1.02	<0.0001
25-Aug-09	2	0.0027	8.69	8.6	<0.01	<0.00005	0.00867	0.003	0.88	0.00032	6.1	0.000017	1.16	0.0867	65	0.000034	0.00799	<0.0005	0.000011	<0.0002	2.96	<0.0001
01-Sep-09	3	0.004	13.1	12.8	<0.05	<0.0003	0.0143	<0.01	1.16	0.0004	8.11	0.00005	1.17	0.112	76	0.00007	0.0102	<0.003	0.00002	<0.001	5.65	<0.0005
08-Sep-09	4																					
15-Sep-09	5	0.007	18.9	20.1	<0.05	<0.0003	0.0248	<0.01	1.35	0.0003	12.3	0.00008	0.8	0.127	112	0.00006	0.0273	<0.003	0.00011	<0.001	10.5	<0.0005
22-Sep-09	6																					
29-Sep-09	7	0.006	19.7	18.3	<0.05	<0.0003	0.0225	<0.01	1.29	<0.0002	10.7	0.00008	0.51	0.0996	108	0.00005	0.0407	<0.003	0.00018	<0.001	10.2	<0.0005
06-Oct-09	8																					
13-Oct-09	9	0.007	30.6	28.5	<0.05	<0.0003	0.0375	<0.01	1.25	<0.0002	11.4	0.00016	0.42	0.135	145	0.00007	0.0612	<0.003	0.00069	<0.001	18.4	<0.0005
20-Oct-09	10																					
27-Oct-09	11	<0.01	36.6	34.9	<0.2	<0.001	0.0527	<0.04	1	<0.0008	15.2	0.0003	0.4	0.174	185	0.0001	0.139	<0.01	0.00394	<0.004	33.8	<0.002
03-Nov-09	12																					
10-Nov-09	13	<0.03	35.1	30.4	<0.5	<0.003	0.049	<0.1	1.5	<0.002	19.3	0.0006	<0.5	0.169	242	0.0001	0.208	<0.03	0.0117	0.012	39.3	<0.005
17-Nov-09	14																					
24-Nov-09	15	<0.05	24	19.2	<1	<0.005	0.04	<0.2	<1	<0.004	18.9	<0.0005	<1	0.112	255	<0.0002	0.243	<0.05	0.0121	<0.02	35.8	<0.01
01-Dec-09	16																					
08-Dec-09	17	<0.05	17	19.3	<1	<0.005	0.037	<0.2	<1	<0.004	20	0.0014	<1	0.097	319	0.0002	0.251	<0.05	0.0194	0.035	47.4	<0.01
15-Dec-09	18																					
22-Dec-09	19	<0.05	19	24.6	<1	<0.005	0.064	<0.2	<1	<0.004	28.5	0.0017	2	0.094	735	0.0003	0.267	<0.05	0.0408	0.048	96.8	<0.01
29-Dec-09	20																					
05-Jan-10	21	<0.05	24	20.4	<1	0.005	0.122	2.08	<1	<0.004	32	0.0072	<1	0.084	1560	<0.0002	0.281	<0.05	0.0404	0.116	182	<0.01
12-Jan-10	22																					
19-Jan-10	23	<0.05	22	11.5	<1	0.017	0.145	4	<1	<0.004	32.6	0.012	1	0.062	1940	0.0003	0.212	0.077	0.0249	0.122	162	<0.01
26-Jan-10	24																					
02-Feb-10	25	<0.05	11	5.36	<1	<0.005	0.086	3.97	<1	<0.004	30.6	0.0147	2	0.058	1700	0.0004	0.158	<0.05	0.0174	0.094	106	<0.01
09-Feb-10	26																					
16-Feb-10	27	<0.03	6.4	3.6	<0.5	<0.003	0.06	1.87	<0.5	<0.002	26.1	0.0094	0.5	0.05	1080	0.0003	0.152	<0.03	0.0128	0.095	73	<0.005
23-Feb-10	28																					
02-Mar-10	29	<0.05	5	2.9	<1	<0.005	0.078	4.14	<1	<0.004	23.4	0.0124	<1	0.057	1540	0.0003	0.158	<0.05	0.0117	0.086	71.4	<0.01
09-Mar-10	30																					
16-Mar-10	31	<0.05	<5	1.91	<1	<0.005	0.063	2.57	<5	<0.004	21.6	0.0106	<5	0.05	1290	0.0003	0.131	<0.05	0.0087	0.07	55.9	<0.01
23-Mar-10	32																					
30-Mar-10	33	<0.03	2.7	1.54	<0.5	<0.003	0.059	3.77	<0.5	<0.002	15.6	0.0043	0.6	0.048	1310	0.0002	0.115	<0.03	0.0076	0.062	47	<0.005

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite

Results of Leachate Analysis

Date	Cycle No.	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	mg/L	mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
06-Apr-10	34																					
13-Apr-10	35	<0.03	<3	1.25	<0.5	<0.003	0.054	3.7	<3	<0.002	19.9	0.0085	<3	0.045	1090	0.0004	0.0953	<0.03	0.0064	0.059	39.5	<0.005
20-Apr-10	36																					
27-Apr-10	37	<0.03	<3	1.23	0.5	<0.003	0.06	4.52	<3	<0.002	22.3	0.007	<3	0.043	1410	0.0002	0.0988	<0.03	0.0064	0.067	35.2	<0.005
04-May-10	38																					
11-May-10	39	<0.03	<3	1.04	<0.5	<0.003	0.049	3.2	<3	<0.002	20.9	0.0066	<3	0.041	1200	0.0002	0.112	<0.03	0.0057	0.051	30.5	<0.005
18-May-10	40																					
25-May-10	41	<0.03	<3	0.922	<0.5	<0.003	0.052	3.45	<3	<0.002	15.2	0.0079	<3	0.045	1200	0.0002	0.0917	<0.03	0.005	0.045	21.9	<0.005
01-Jun-10	42																					
08-Jun-10	43	<0.03	3	1.1	<0.5	<0.003	0.067	5.81	<3	<0.002	24.8	0.0082	<3	0.054	1440	0.0002	0.0947	<0.03	0.0067	0.069	23.2	<0.005
15-Jun-10	44																					
22-Jun-10	45	<0.03	<3	0.963	<0.5	0.004	0.049	4.17	<3	<0.002	17.3	0.0078	<3	0.047	1080	0.0002	0.0834	<0.03	0.0051	0.05	17.9	<0.005
29-Jun-10	46																					
06-Jul-10	47	<0.03	<3	0.691	<0.5	<0.003	0.038	2.39	<3	<0.002	16.1	0.0047	<3	0.04	870	0.0001	0.0642	<0.03	0.0033	0.034	13.1	<0.005
13-Jul-10	48																					
20-Jul-10	49	<0.005	1.2	0.434	<0.1	<0.0005	0.0216	0.288	<0.5	<0.0004	10.9	0.00265	<0.5	0.0239	394	0.00021	0.0408	<0.005	0.00205	0.03	5.92	<0.001
27-Jul-10	50																					
03-Aug-10	51	<0.03	<3	0.749	<0.5	<0.003	0.067	5.56	<3	<0.002	17.3	0.0064	<3	0.048	1340	0.0002	0.0868	<0.03	0.0043	0.037	13.4	<0.005
10-Aug-10	52																					
17-Aug-10	53	<0.01	2	0.562	<0.2	0.001	0.0426	3.39	<1	0.0008	12.1	0.0049	<1	0.04	912	0.00016	0.0606	<0.01	0.0037	0.031	8.42	<0.002
24-Aug-10	54																					
31-Aug-10	55	<0.01	2	0.499	<0.2	0.001	0.0387	3.91	<1	<0.0008	13.3	0.0053	<1	0.036	1040	0.00011	0.0554	<0.01	0.00274	0.029	7.28	<0.002
07-Sep-10	56																					
14-Sep-10	57	<0.03	<3	0.509	<0.5	<0.003	0.06	4.79	<3	<0.002	14.4	0.005	<3	0.036	1080	<0.0001	0.0522	<0.03	0.0047	0.029	6.6	<0.005
21-Sep-10	58																					
28-Sep-10	59	<0.03	<3	0.502	<0.5	<0.003	0.044	3.57	<3	<0.002	15.1	0.0049	<3	0.034	970	<0.0001	0.0534	<0.03	0.003	0.021	6.01	<0.005

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

<u>Appendix B.1-5</u>
Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Weekly Production
(mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/kg	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg
11-Aug-09	0	7.08	1.23305	6.825	0.0015	0.00519	0.006643	0.0110	0.00000228	0.000001138	0.01138
18-Aug-09	1	5.99	0.4872	38.64	0.0021	0.00680	0.014532	0.0389	0.00000420	0.000001050	0.01050
25-Aug-09	2	6.19	0.72375	75.75	0.0069	0.00671	0.018413	0.0405	0.00002250	0.000000938	0.00938
01-Sep-09	3	5.96	0.85905	104.165	0.0212	0.00747	0.009462	0.0255	0.00004980	0.000006225	0.06225
08-Sep-09	4	5.32	0.3922	113.22	0.0487	0.00646	0.007789	0.0144	0.00009990	0.000005550	0.05550
15-Sep-09	5	4.94	0.0225	160.65	0.0954	0.00761	0.008685	0.0073	0.00018900	0.000006750	0.06750
22-Sep-09	6	4.77	#N/A	141.12	0.1094	0.00617	0.006090	0.0053	0.00021210	0.000006300	0.06300
29-Sep-09	7	4.48	#N/A	134.32	0.1421	0.00575	0.004462	0.0041	0.00027140	0.000006900	0.06900
06-Oct-09	8	4.13	#N/A	167.895	0.3569	0.00501	0.003663	0.0033	0.00055055	0.000006825	0.06825
13-Oct-09	9	4.05	#N/A	193.6	0.5544	0.00418	0.002816	0.0025	0.00080520	0.000006600	0.06600
20-Oct-09	10	3.57	#N/A	230.8	1.4000	0.00430	0.008600	0.0019	0.00192600	0.000013000	0.13000
27-Oct-09	11	3.41	#N/A	317.72	2.9848	0.00624	0.019032	0.0021	0.00405600	0.000026000	0.26000
03-Nov-09	12	3.03	#N/A	317.115	5.9465	0.00761	0.150858	0.0022	0.00495900	0.000043500	0.43500
10-Nov-09	13	2.6	#N/A	302.4	9.0720	0.00966	0.275940	0.0025	0.00630000	0.000063000	0.63000
17-Nov-09	14	2.89	#N/A	293.28	10.7395	0.01081	0.335110	0.0028	0.00611000	0.000094000	0.94000
24-Nov-09	15	2.95	#N/A	312.3	10.8450	0.01035	0.346050	0.0027	0.00495000	0.000112500	1.12500
01-Dec-09	16	2.73	#N/A	389.975	16.1738	0.01283	1.047138	0.0029	0.00475000	0.000118750	1.18750
08-Dec-09	17	2.79	#N/A	485	21.3400	0.01504	1.765400	0.0029	0.00436500	0.000121250	1.21250
15-Dec-09	18	2.34	#N/A	736.19	27.0725	0.02844	8.221850	0.0043	0.00341250	0.000307125	1.13750
22-Dec-09	19	2.35	#N/A	1160.12	34.5000	0.04324	14.950000	0.0060	0.00276000	0.000506000	1.15000
29-Dec-09	20	2.29	#N/A	1523.34	35.4795	0.07231	46.848750	0.0051	0.00302250	0.003348000	1.16250
05-Jan-10	21	2.21	#N/A	2124.58	32.9800	0.09223	71.825000	0.0038	0.00297500	0.005652500	1.06250
12-Jan-10	22	2.3	#N/A	2539.15	28.7240	0.09396	78.690000	0.0030	0.00279500	0.005052500	1.07500
19-Jan-10	23	2.46	#N/A	2441.25	25.2000	0.09900	88.650000	0.0023	0.00270000	0.004590000	1.12500
26-Jan-10	24	2.45	#N/A	2607.7	21.8273	0.09078	74.315000	0.0022	0.00244750	0.003359750	1.11250
02-Feb-10	25	2.69	#N/A	2073.6	18.9450	0.08460	61.650000	0.0023	0.00225000	0.002205000	1.12500
09-Feb-10	26	2.14	#N/A	2025.2	15.3965	0.06350	40.421000	0.0015	0.00182600	0.001162000	0.83000
16-Feb-10	27	2.09	#N/A	1575.48	13.6425	0.05015	24.565000	0.0009	0.00161500	0.000297500	0.63750
23-Feb-10	28	2.1	#N/A	1460.64	16.6560	0.06744	40.272000	0.0014	0.00187200	0.000888000	0.96000
02-Mar-10	29	2.09	#N/A	1874.11	15.2930	0.06683	45.100000	0.0016	0.00164000	0.001230000	1.02500
09-Mar-10	30	2.14	#N/A	1681.2	14.6250	0.06863	40.320000	0.0041	0.00157500	0.000990000	1.12500
16-Mar-10	31	2.13	#N/A	1835.02	12.6035	0.06461	31.486000	0.0064	0.00136500	0.000637000	1.13750
23-Mar-10	32	2.39	#N/A	2161.54	12.1210	0.06555	31.142000	0.0041	0.00119600	0.000575000	0.92000
30-Mar-10	33	2.27	#N/A	2027.25	11.2500	0.06435	29.790000	0.0018	0.00099000	0.000495000	0.67500
06-Apr-10	34	2.09	#N/A	2127.6	10.7775	0.06413	28.125000	0.0016	0.00096750	0.000607500	0.67500
13-Apr-10	35	2.01	#N/A	1765.4	10.4195	0.06461	26.754000	0.0014	0.00095550	0.000728000	0.68250
20-Apr-10	36	2.02	#N/A	2196.74	11.6480	0.06575	27.345500	0.0016	0.00091000	0.000705250	0.68250
27-Apr-10	37	2.03	#N/A	1841.84	12.4520	0.06468	27.016000	0.0018	0.00083600	0.000660000	0.66000
04-May-10	38	2.21	#N/A	1745.94	10.9410	0.06006	22.386000	0.0013	0.00086100	0.000441000	0.63000
11-May-10	39	2.69	#N/A	1677.9	10.1150	0.05908	19.210000	0.0009	0.00093500	0.000255000	0.63750
18-May-10	40	2.39	#N/A	1316.63	11.5395	0.06493	21.462000	0.0012	0.00095550	0.000416500	0.73500
25-May-10	41	2.09	#N/A	1328.77	10.3685	0.05607	18.868000	0.0013	0.00075650	0.000489500	0.66750
01-Jun-10	42	2.69	#N/A	1525.2	11.0700	0.05761	20.910000	0.0018	0.00084050	0.000615000	0.61500
08-Jun-10	43	2.13	#N/A	1591.2	13.0475	0.06588	25.330000	0.0026	0.00102000	0.000807500	0.63750
15-Jun-10	44	2.61	#N/A	1261.98	10.5370	0.05658	20.356500	0.0018	0.00077900	0.000574000	0.61500
22-Jun-10	45	1.91	#N/A	1260.16	9.1080	0.05324	17.468000	0.0013	0.00061600	0.000396000	0.66000
29-Jun-10	46	2.14	#N/A	1524.18	8.1480	0.04410	12.957000	0.0013	0.00056700	0.000220500	0.63000
06-Jul-10	47	2.16	#N/A	1040.67	8.4165	0.04139	10.230000	0.0014	0.00060450	0.000069750	0.69750
13-Jul-10	48	2.28	#N/A	776.23	5.7103	0.03199	5.726175	0.0010	0.00045500	0.000039813	0.39813
20-Jul-10	49	2.29	#N/A	529.65	3.4650	0.02554	1.569150	0.0007	0.00034650	0.000012375	0.12375
27-Jul-10	50	2.21	#N/A	1162.98	6.6430	0.03676	10.958675	0.0010	0.00056875	0.000255938	0.39813
03-Aug-10	51	2.27	#N/A	1732.25	9.1020	0.04510	18.450000	0.0012	0.00073800	0.000451000	0.61500
10-Aug-10	52	2.01	#N/A	1028.61	9.7020	0.04896	17.127000	0.0015	0.00074250	0.000396000	0.49500
17-Aug-10	53	2.14	#N/A	1261.94	7.3950	0.03819	10.527000	0.0013	0.00052200	0.000217500	0.21750
24-Aug-10	54	2.02	#N/A	913.56	7.6130	0.03945	12.213000	0.0013	0.00052900	0.000253000	0.23000
31-Aug-10	55	2.19	#N/A	1512.5	7.0035	0.03641	12.571500	0.0011	0.00047850	0.000261000	0.21750
07-Sep-10	56	2.21	#N/A	1649.62	6.9643	0.03687	13.416750	0.0010	0.00046725	0.000333750	0.44500
14-Sep-10	57	1.95	#N/A	1465.87	6.5360	0.03526	13.502000	0.0009	0.00043000	0.000387000	0.64500
21-Sep-10	58	2.16	#N/A	1544.68	6.4860	0.03795	12.604000	0.0009	0.00041400	0.000299000	0.69000
28-Sep-10	59	2.1	#N/A	1044.86	6.0450	0.03860	10.881000	0.0009	0.00037200	0.000186000	0.69750

Date	Cd mg/kg	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg	Si mg/kg
11-Aug-09	0.00070525	2.68	0.0000228	0.0002216	0.00323	0.00273	0.004459	0.000114	0.38	0.295295	0.00000228	0.00001	0.00056	0.001365	0.09555	0.00002	0.628
18-Aug-09	0.00462000	11.72	0.0000210	0.0009618	0.00538	0.01050	0.007518	0.000588	1.78	1.528800	0.00000210	0.00001	0.00135	0.001260	0.23100	0.00006	1.445
25-Aug-09	0.01170000	20.70	0.0000188	0.0024338	0.02576	0.03638	0.011963	0.001013	3.26	3.225000	0.00000188	0.00001	0.00325	0.001125	0.33000	0.00012	2.288
01-Sep-09	0.02133100	29.38	0.0001038	0.0047725	0.04607	0.01826	0.017306	0.001660	5.44	5.312000	0.00001038	0.00006	0.00593	0.002075	0.48140	0.00017	3.366
08-Sep-09	0.02893400	27.92	0.0000925	0.0060495	0.06975	0.03423	0.011988	0.002035	5.92	6.086500	0.00000925	0.00006	0.00723	0.001850	0.46435	0.00013	3.776
15-Sep-09	0.04725000	36.05	0.0001125	0.0095400	0.11970	0.06345	0.010395	0.003150	8.51	9.045000	0.00001125	0.00007	0.01116	0.002250	0.60750	0.00014	5.535
22-Sep-09	0.04578000	29.48	0.0001050	0.0087150	0.13062	0.07182	0.006752	0.002730	8.11	8.064000	0.00001050	0.00006	0.00993	0.002100	0.55440	0.00008	4.830
29-Sep-09	0.05198000	27.74	0.0001150	0.0093380	0.16376	0.09246	0.004163	0.002760	9.06	8.418000	0.00001150	0.00007	0.01035	0.002300	0.59340	0.00005	4.922
06-Oct-09	0.08212750	31.05	0.0001138	0.0124443	0.31304	0.12535	0.004834	0.002958	11.44	10.647000	0.00001138	0.00007	0.01365	0.002275	0.57785	0.00005	5.028
13-Oct-09	0.10912000	33.53	0.0001100	0.0151360	0.44880	0.15400	0.005368	0.003080	13.46	12.540000	0.00001100	0.00007	0.01650	0.002200	0.55000	0.00004	5.016
20-Oct-09	0.17740000	30.28	0.0002500	0.0161400	1.01400	3.17000	0.008700	0.002400	13.44	12.680000	0.00002500	0.00013	0.01804	0.005000	0.45000	0.00010	5.320
27-Oct-09	0.33228000	39.10	0.0005200	0.0240760	2.10600	8.06000	0.016276	0.002600	19.03	18.148000	0.00005200	0.00026	0.02740	0.010400	0.52000	0.00021	7.904
03-Nov-09	0.34691250	28.80	0.0045675	0.0205973	2.92538	15.18150	0.023099	0.004350	15.59	14.202750	0.00007613	0.00044	0.02212	0.015225	0.54375	0.00030	7.504
10-Nov-09	0.40152000	24.02	0.0084000	0.0203280	3.94800	22.80600	0.031458	0.006300	14.74	12.768000	0.00010500	0.00063	0.02058	0.021000	0.63000	0.00042	8.106
17-Nov-09	0.41148500	19.79	0.0110450	0.0195755	4.28875	31.72500	0.032430	0.009400	13.89	11.656000	0.00017625	0.00094	0.02092	0.035250	0.47000	0.00071	8.977
24-Nov-09	0.35775000	12.15	0.0121500	0.0157050	3.98250	36.31500	0.028395	0.011250	10.80	8.640000	0.00022500	0.00113	0.01800	0.045000	0.22500	0.00090	8.505
01-Dec-09	0.39781250	9.98	0.0228000	0.0192850	4.34150	60.72875	0.045861	0.011875	9.74	9.143750	0.00023750	0.00119	0.01829	0.047500	0.23750	0.00095	9.239
08-Dec-09	0.42680000	7.28	0.0334650	0.0224555	4.57355	84.87500	0.063050	0.012125	8.25	9.360500	0.00024250	0.00121	0.01795	0.048500	0.24250	0.00097	9.700
15-Dec-09	0.53917500	5.46	0.0627900	0.0302348	4.46583	145.60000	0.127855	0.011375	8.19	9.987250	0.00022750	0.00114	0.02298	0.045500	0.22750	0.00091	11.034
22-Dec-09	0.68540000	4.14	0.0952200	0.0398360	4.69200	213.90000	0.198720	0.011500	8.74	11.316000	0.00023000	0.00115	0.02944	0.046000	0.23000	0.00092	13.110
29-Dec-09	0.90675000	4.19	0.1255500	0.0561720	4.78950	440.58750	0.203903	0.011625	10.00	10.462500	0.00023250	0.00174	0.04325	0.506850	0.23250	0.00093	14.066
05-Jan-10	1.02425000	3.83	0.1415250	0.0658750	4.42000	607.75000	0.189125	0.010625	10.20	8.670000	0.00021250	0.00213	0.05185	0.884000	0.21250	0.00085	13.600
12-Jan-10	1.05780000	3.87	0.1535100	0.0718100	4.17960	651.45000	0.139965	0.010750	9.89	6.858500	0.00021500	0.00473	0.05741	1.307200	0.21500	0.00086	13.889
19-Jan-10	1.12950000	4.05	0.1714500	0.0805500	4.06800	720.00000	0.092700	0.011250	9.90	5.175000	0.00022500	0.00765	0.06525	1.800000	0.22500	0.00090	14.670
26-Jan-10	0.96120000	4.01	0.1497425	0.0714225	3.41760	685.30000	0.069865	0.011125	7.34	3.751350	0.00022250	0.00434	0.05140	1.773325	0.22250	0.00089	14.062
02-Feb-10	0.81450000	4.05	0.1314000	0.0639000	2.84400	666.00000	0.048600	0.011250	4.95	2.412000	0.00022500	0.00113	0.03870	1.786500	0.22500	0.00090	13.770
09-Feb-10	0.62872500	3.42	0.1054100	0.0527050	2.51490	529.12500	0.027017	0.008300	3.61	1.859200	0.00015563	0.00083	0.03030	1.211800	0.15563	0.00062	11.765
16-Feb-10	0.51850000	3.19	0.0918000	0.0476000	2.46500	454.75000	0.009435	0.006375	2.72	1.530000	0.00010625	0.00064	0.02550	0.794750	0.10625	0.00043	11.093
23-Feb-10	0.56640000	4.20	0.1089600	0.0609600	2.97120	592.80000	0.014952	0.009600	2.74	1.560000	0.00018000	0.00096	0.03312	1.442400	0.18000	0.00072	11.880
02-Mar-10	0.46740000	4.10	0.0975800	0.0582200	2.69780	574.00000	0.016441	0.010250	2.05	1.189000	0.00020500	0.00103	0.03198	1.697400	0.20500	0.00082	9.594
09-Mar-10	0.44280000	4.05	0.0915750	0.0596250	2.65500	580.50000	0.014018	0.011250	1.69	1.082250	0.00022500	0.00113	0.03173	1.509750	0.67500	0.00090	10.125
16-Mar-10	0.37674000	3.64	0.0768950	0.0559650	2.37510	536.90000	0.010101	0.011375	1.14	0.869050	0.00022750	0.00114	0.02867	1.169350	1.13750	0.00091	9.828
23-Mar-10	0.34638000	4.28	0.0740600	0.0575000	2.31610	542.80000	0.009407	0.009200	1.20	0.793500	0.00017250	0.00092	0.02806	1.458200	0.63250	0.00069	8.556
30-Mar-10	0.30510000	4.77	0.0688500	0.0571500	2.18250	531.00000	0.008415	0.006750	1.22	0.693000	0.00011250	0.00068	0.02655	1.696500	0.11250	0.00045	7.020
06-Apr-10	0.28035000	4.64	0.0645750	0.0564750	1.99800	528.75000	0.008010	0.006750	0.95	0.627750	0.00011250	0.00068	0.02543	1.680750	0.39375	0.00045	7.988
13-Apr-10	0.25844000	4.55	0.0609700	0.0564200	1.83365	532.35000	0.007690	0.006825	0.68	0.568750	0.00011375	0.00068	0.02457	1.683500	0.68250	0.00046	9.055
20-Apr-10	0.24115000	4.55	0.0623350	0.0582400	1.86323	543.72500	0.007326	0.006825	0.68	0.564200	0.00017063	0.00068	0.02594	1.870050	0.68250	0.00046	9.601
27-Apr-10	0.21648000	4.40	0.0616000	0.0580800	1.83040	536.80000	0.006732	0.006600	0.66	0.541200	0.00022000	0.00066	0.02640	1.988800	0.66000	0.00044	9.812
04-May-10	0.19572000	4.20	0.0520800	0.0527100	1.65480	483.00000	0.004620	0.006300	0.63	0.476700	0.00015750	0.00063	0.02289	1.621200	0.63000	0.00042	9.072
11-May-10	0.18700000	4.25	0.0459000	0.0505750	1.58100	459.00000	0.002848	0.006375	0.64	0.442000	0.00010625	0.00064	0.02083	1.360000	0.63750	0.00043	8.883
18-May-10	0.18620000	4.66	0.0526750	0.0605150	1.85710	524.30000	0.003896	0.007350	0.74	0.480690	0.00012250	0.00074	0.02475	1.629250	0.73500	0.00049	8.845
25-May-10	0.14240000	4.01	0.0476150	0.0569600	1.71770	471.70000	0.004094	0.006675	0.67	0.410290	0.00011125	0.00067	0.02314	1.535250	0.66750	0.00045	6.764
01-Jun-10	0.13325000	5.33	0.0508400	0.0594500	1.63795	512.50000	0.004859	0.006150	0.92	0.414510	0.00010250	0.00062	0.02440	1.898300	0.61500	0.00041	8.200
08-Jun-10	0.14025000	7.23	0.0599250	0.0688500	1.75525	612.00000	0.006163	0.006375	1.28	0.467500	0.00010625	0.00064	0.02848	2.469250	0.63750	0.00043	10.540
15-Jun-10	0.12033500	5.95	0.0485850	0.0596550	1.52520	526.85000	0.004797	0.006150	0.92	0.422915	0.00010250	0.00113	0.02378	2.045900	0.61500	0.00041	8.631
22-Jun-10	0.11308000	5.28	0.0422400	0.0567600	1.45640	497.20000	0.003916	0.006600	0.66	0.423720	0.00011000	0.00176	0.02156	1.834800	0.66000	0.00044	7.612
29-Jun-10	0.09261000	4.41	0.0346500	0.0471030	1.20960	402.78000	0.002688	0.006300	0.63	0.347340	0.00010500	0.00116	0.01827	1.377600	0.63000	0.00042	7.014
06-Jul-10	0.08556000	4.19	0.0320850	0.0443145	1.13925	366.42000	0.001814	0.006975	0.70	0.321315	0.00011625	0.00070	0.01767	1.111350	0.69750	0.00047	7.487
13-Jul-10	0.06156150	3.21	0.0216125	0.0312585	0.85995	262.08000	0.001106	0.003981	0.61	0.255938	0.00006825	0.00040	0.01356	0.609245	0.39813	0.00027	6.143
20-Jul-10	0.04286700	2.52	0.0128700	0.0208395	0.65835	180.18000	0.000475	0.001238	0.59	0.214830	0.00002475	0.00012	0.01069	0.142560	0.12375	0.00010	5.396
27-Jul-10	0.06406400	3.89	0.0266175	0.0437028	1.07835	364.91000	0.002448	0.003981	0.61	0.269133	0.00006825	0.00040	0.02016	1.330420	0.39813	0.00027	6.416
03-Aug-10	0.07995000	4.92	0.0373100	0.0615000	1.39810	508.40000	0.004018	0.006150	0.62	0.307090	0.00010250	0.00062	0.02747	2.279600	0.61500	0.00041	7.093
10-Aug-10	0.07722000	5.45	0.0371250	0.0633600	1.50233	508.11750	0.004282	0.004950	0.87	0.324473	0.00008663	0.00062	0.02713	2.215125	0.49500	0.00045	7.277
17-Aug-10	0.05089500	4.35	0.0256650	0.0461100	1.15710	353.65500	0.003263	0.002175	0.87	0.244470	0.00004350	0.00044	0.01853	1.474650	0.21750	0.00035	5.264
24-Aug-10	0.05313000	4.37	0.0264500	0.0496800	1.14540	391.69000	0.002760	0.002300	0.92	0.244030	0.00004600	0.00046	0.01870	1.679000	0.23000	0.00028	5.842
31-Aug-10	0.04959000	3.92	0.0243600	0.0478500	1.00920	387.15000	0.001958	0.002175	0.87	0.217065	0.00004350	0.00044	0.01683	1.700850	0.21750	0.00017	5.786
07-Sep-10	0.04674725	4.45	0.0253650	0.0496175	0.98568	411.40250	0.002270	0.004450	0.78	0.224280	0.00007788	0.00056	0.02196	1.935750	0.44500	0.00031	6.163
14-Sep-10	0.04132300	4.73	0.0249400	0.0485900	0.90730	412.37000	0.002451	0.006450	0.65	0.218870	0.00010750	0.00065	0.02580	2.059700	0.64500	0.00043	6.192
21-Sep-10	0.04183700	4.60	0.0246100	0.0501400	0.95680	413.08000	0.002208	0.006900	0.69	0.232530	0.00011500	0.00069	0.02392	1.922800	0.69000	0.00046	6.785
28-Sep-10	0.03989700	4.19	0.0227850	0.0488250	0.95325	389.20500	0.001814	0.006975	0.70	0.233430	0.00011625	0.00070	0.02046	1.660050	0.69750	0.00047	7.022

Date	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
11-Aug-09	0.000001138	0.2503	0.00469	3.19	0.00000546	0.0014151	0.0001138	0.000001	0.000046	0.07735	0.00002
18-Aug-09	0.000001050	0.3948	0.02033	13.86	0.00000840	0.0023058	0.0001050	0.000001	0.000042	0.42840	0.00002
25-Aug-09	0.000006375	0.4350	0.03251	24.38	0.00001275	0.0029963	0.0000938	0.000004	0.000038	1.11000	0.00002
01-Sep-09	0.000020750	0.4856	0.04648	31.54	0.00002905	0.0042330	0.0006225	0.000008	0.000208	2.34475	0.00010
08-Sep-09	0.000024050	0.3645	0.04422	34.78	0.00002405	0.0069375	0.0005550	0.000024	0.000185	2.98775	0.00009
15-Sep-09	0.000036000	0.3600	0.05715	50.40	0.00002700	0.0122850	0.0006750	0.000050	0.000225	4.72500	0.00011
22-Sep-09	0.000033600	0.2751	0.04759	46.20	0.00002310	0.0142800	0.0006300	0.000061	0.000210	4.34700	0.00011
29-Sep-09	0.000036800	0.2346	0.04582	49.68	0.00002300	0.0187220	0.0006900	0.000083	0.000230	4.69200	0.00012
06-Oct-09	0.000054600	0.2116	0.05337	57.56	0.00002730	0.0231823	0.0006825	0.000198	0.000228	6.50650	0.00011
13-Oct-09	0.000070400	0.1848	0.05940	63.80	0.00003080	0.0269280	0.0006600	0.000304	0.000220	8.09600	0.00011
20-Oct-09	0.000092000	0.1640	0.06180	66.00	0.00003400	0.0400400	0.0013000	0.000926	0.000500	10.44000	0.00025
27-Oct-09	0.000156000	0.2080	0.09048	96.20	0.00005200	0.0722800	0.0026000	0.002049	0.001040	17.57600	0.00052
03-Nov-09	0.000195750	0.1414	0.07460	92.87	0.00004350	0.0754725	0.0043500	0.003402	0.003045	15.89925	0.00076
10-Nov-09	0.000252000	0.1050	0.07098	101.64	0.00004200	0.0873600	0.0063000	0.004914	0.005040	16.50600	0.00105
17-Nov-09	0.000199750	0.1763	0.06604	116.80	0.00004700	0.1059850	0.0094000	0.005593	0.005170	17.64850	0.00176
24-Nov-09	0.000112500	0.2250	0.05040	114.75	0.00004500	0.1093500	0.0112500	0.005445	0.004500	16.11000	0.00225
01-Dec-09	0.000391875	0.2375	0.04964	136.33	0.00007125	0.1173250	0.0118750	0.007481	0.010688	19.76000	0.00238
08-Dec-09	0.000679000	0.2425	0.04705	154.72	0.00009700	0.1217350	0.0121250	0.009409	0.016975	22.98900	0.00243
15-Dec-09	0.000705250	0.5688	0.04345	239.79	0.00011375	0.1178450	0.0113750	0.013696	0.018883	32.80550	0.00228
22-Dec-09	0.000782000	0.9200	0.04324	338.10	0.00013800	0.1228200	0.0115000	0.018768	0.022080	44.52800	0.00230
29-Dec-09	0.002069250	0.5813	0.04139	533.59	0.00009300	0.1274100	0.0116250	0.018879	0.038130	64.82100	0.00233
05-Jan-10	0.003060000	0.2125	0.03570	663.00	0.00004250	0.1194250	0.0106250	0.017170	0.049300	77.35000	0.00213
12-Jan-10	0.004128000	0.3225	0.03139	752.50	0.00008600	0.1059950	0.0219300	0.014040	0.051170	73.96000	0.00215
19-Jan-10	0.005400000	0.4500	0.02790	873.00	0.00013500	0.0954000	0.0346500	0.011205	0.054900	72.90000	0.00225
26-Jan-10	0.005940750	0.6675	0.02670	809.90	0.00015575	0.0823250	0.0226950	0.009412	0.048060	59.63000	0.00223
02-Feb-10	0.006615000	0.9000	0.02610	765.00	0.00018000	0.0711000	0.0112500	0.007830	0.042300	47.70000	0.00225
09-Feb-10	0.005000750	0.5188	0.02241	576.85	0.00014525	0.0643250	0.0083000	0.006267	0.039218	37.14250	0.00156
16-Feb-10	0.003995000	0.2125	0.02125	459.00	0.00012750	0.0646000	0.0063750	0.005440	0.040375	31.02500	0.00106
23-Feb-10	0.005232000	0.2400	0.02568	628.80	0.00014400	0.0744000	0.0096000	0.005880	0.043440	34.65600	0.00180
02-Mar-10	0.005084000	0.2050	0.02337	631.40	0.00012300	0.0647800	0.0102500	0.004797	0.035260	29.27400	0.00205
09-Mar-10	0.005175000	0.6750	0.02408	636.75	0.00013500	0.0650250	0.0112500	0.004590	0.035100	28.64250	0.00225
16-Mar-10	0.004823000	1.1375	0.02275	586.95	0.00013650	0.0596050	0.0113750	0.003959	0.031850	25.43450	0.00228
23-Mar-10	0.003427000	0.7130	0.02254	598.00	0.00011500	0.0565800	0.0092000	0.003749	0.030360	23.66700	0.00173
30-Mar-10	0.001935000	0.2700	0.02160	589.50	0.00009000	0.0517500	0.0067500	0.003420	0.027900	21.15000	0.00113
06-Apr-10	0.002880000	0.4725	0.02093	540.00	0.00013500	0.0473175	0.0067500	0.003150	0.027225	19.46250	0.00113
13-Apr-10	0.003867500	0.6825	0.02048	495.95	0.00018200	0.0433615	0.0068250	0.002912	0.026845	17.97250	0.00114
20-Apr-10	0.003526250	0.6825	0.02002	568.75	0.00013650	0.0441578	0.0068250	0.002912	0.028665	16.99425	0.00114
27-Apr-10	0.003080000	0.6600	0.01892	620.40	0.00008800	0.0434720	0.0066000	0.002816	0.029480	15.48800	0.00110
04-May-10	0.002856000	0.6300	0.01764	548.10	0.00008400	0.0442680	0.0063000	0.002541	0.024780	13.79700	0.00105
11-May-10	0.002805000	0.6375	0.01743	510.00	0.00008500	0.0476000	0.0063750	0.002423	0.021675	12.96250	0.00106
18-May-10	0.003552500	0.7350	0.02107	588.00	0.00009800	0.0499065	0.0073500	0.002622	0.023520	12.83800	0.00123
25-May-10	0.003515500	0.6675	0.02003	534.00	0.00008900	0.0408065	0.0066750	0.002225	0.020025	9.74550	0.00111
01-Jun-10	0.003300500	0.6150	0.02030	541.20	0.00008200	0.0382120	0.0061500	0.002399	0.023370	9.24550	0.00103
08-Jun-10	0.003485000	0.6375	0.02295	612.00	0.00008500	0.0402475	0.0063750	0.002848	0.029325	9.86000	0.00106
15-Jun-10	0.003280000	0.6150	0.02071	516.60	0.00008200	0.0365105	0.0061500	0.002419	0.024395	8.42550	0.00103
22-Jun-10	0.003432000	0.6600	0.02068	475.20	0.00008800	0.0366960	0.0066000	0.002244	0.022000	7.87600	0.00110
29-Jun-10	0.002625000	0.6300	0.01827	409.50	0.00006300	0.0309960	0.0063000	0.001764	0.017640	6.51000	0.00105
06-Jul-10	0.002185500	0.6975	0.01860	404.55	0.00004650	0.0298530	0.0069750	0.001535	0.015810	6.09150	0.00116
13-Jul-10	0.001672125	0.3981	0.01454	287.56	0.00007053	0.0238875	0.0039813	0.001217	0.014560	4.32705	0.00068
20-Jul-10	0.001311750	0.1238	0.01183	195.03	0.00010395	0.0201960	0.0012375	0.001015	0.014850	2.93040	0.00025
27-Jul-10	0.002058875	0.3981	0.01636	394.49	0.00009328	0.0290290	0.0039813	0.001445	0.015243	4.39530	0.00068
03-Aug-10	0.002624000	0.6150	0.01968	549.40	0.00008200	0.0355880	0.0061500	0.001763	0.015170	5.49400	0.00103
10-Aug-10	0.002796750	0.4950	0.02178	557.37	0.00008910	0.0364815	0.0049500	0.001980	0.016830	5.40045	0.00087
17-Aug-10	0.002131500	0.2175	0.01740	396.72	0.00006960	0.0263610	0.0021750	0.001610	0.013485	3.66270	0.00044
24-Aug-10	0.002346000	0.2300	0.01748	448.96	0.00006210	0.0266800	0.0023000	0.001481	0.013800	3.61100	0.00046
31-Aug-10	0.002305500	0.2175	0.01566	452.40	0.00004785	0.0240990	0.0021750	0.001192	0.012615	3.16680	0.00044
07-Sep-10	0.002291750	0.4450	0.01602	471.70	0.00003560	0.0239410	0.0044500	0.001655	0.012905	3.08830	0.00078
14-Sep-10	0.002150000	0.6450	0.01548	464.40	0.00002150	0.0224460	0.0064500	0.002021	0.012470	2.83800	0.00108
21-Sep-10	0.002277000	0.6900	0.01610	471.50	0.00002300	0.0242880	0.0069000	0.001771	0.011500	2.90030	0.00115
28-Sep-10	0.002278500	0.6975	0.01581	451.05	0.00002325	0.0248310	0.0069750	0.001395	0.009765	2.79465	0.00116

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle	SO4	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu	Fe	Pb	Li	Mg	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
	No.	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
11-Aug-09	0	6.8	0.0015	0.00519	0.00664	0.0110	0.0000023	0.0000011	0.011375	0.00070525	2.68	2.275E-05	2E-04	0.003226	0.00273	0.0044590	0.00011	0.38	0.29530	0.0000023	0.0000	0.00056	0.0014	0.10	0.0000	0.628	1.14E-06	0.250	0.0047	3.19	5.5E-06	0.0014	0.00011375	1.365E-06	0.00005	0.07735	0.00002
18-Aug-09	1	45.5	0.0036	0.01199	0.02118	0.0499	0.0000065	0.0000022	0.021875	0.00532525	14.4	4.375E-05	0.001	0.008602	0.0132	0.0119770	0.00070	2.16	1.82410	0.0000044	0.0000	0.00191	0.0026	0.33	0.0001	2.073	2.19E-06	0.645	0.0250	17.05	1.4E-05	0.0037	0.00021875	2.205E-06	0.00009	0.50575	0.00004
25-Aug-09	2	121.2	0.0105	0.01870	0.03959	0.0904	0.0000290	0.0000031	0.03125	0.01702525	35.1	0.0000625	0.004	0.034364	0.0496	0.0239395	0.00171	5.42	5.04910	0.0000063	0.0000	0.00516	0.0038	0.66	0.0002	4.360	8.56E-06	1.080	0.0575	41.42	2.7E-05	0.0067	0.0003125	6.33E-06	0.00013	1.61575	0.00006
01-Sep-09	3	225.4	0.0317	0.02617	0.04905	0.1159	0.0000788	0.0000094	0.0935	0.03835625	64.5	0.0001663	0.008	0.080429	0.0679	0.0412450	0.00337	10.85	10.36110	0.0000166	0.0001	0.01109	0.0058	1.14	0.0004	7.726	2.93E-05	1.566	0.1040	72.96	5.6E-05	0.011	0.000935	1.463E-05	0.00033	3.9605	0.00017
08-Sep-09	4	338.6	0.0803	0.03263	0.05684	0.1302	0.0001787	0.0000149	0.149	0.06729025	92.4	0.0002588	0.014	0.150174	0.1021	0.0532330	0.00541	16.77	16.44760	0.0000259	0.0001	0.01833	0.0077	1.60	0.0005	11.502	5.34E-05	1.930	0.1482	107.74	8E-05	0.0179	0.00149	3.868E-05	0.00052	6.94825	0.00026
15-Sep-09	5	499.3	0.1757	0.04024	0.06552	0.1375	0.0003677	0.0000217	0.2165	0.11454025	128	0.0003713	0.024	0.269874	0.1655	0.0636280	0.00856	25.28	25.49260	0.0000371	0.0002	0.02949	0.0099	2.21	0.0006	17.037	8.94E-05	2.290	0.2054	158.14	0.00011	0.0302	0.002165	8.818E-05	0.00074	11.67325	0.00037
22-Sep-09	6	640.4	0.2851	0.04641	0.07161	0.1428	0.0005798	0.0000280	0.2795	0.16032025	158	0.0004763	0.033	0.400494	0.2374	0.0703795	0.01129	33.38	33.55660	0.0000476	0.0003	0.03942	0.0120	2.76	0.0007	21.867	1.23E-04	2.565	0.2530	204.34	0.00013	0.0445	0.002795	0.0001491	0.00095	16.02025	0.00048
29-Sep-09	7	774.7	0.4273	0.05216	0.07608	0.1470	0.0008512	0.0000349	0.3485	0.21230025	186	0.0005913	0.042	0.564254	0.3298	0.0745425	0.01405	42.45	41.97460	0.0000591	0.0003	0.04977	0.0143	3.36	0.0008	26.789	1.60E-04	2.800	0.2988	254.02	0.00015	0.0632	0.003485	0.0002319	0.00118	20.71225	0.00059
06-Oct-09	8	942.6	0.7842	0.05716	0.07974	0.1503	0.0014017	0.0000417	0.41675	0.29442775	217	0.000705	0.054	0.877294	0.4552	0.0793769	0.01701	53.89	52.62160	0.0000705	0.0004	0.06342	0.0166	3.94	0.0008	31.816	2.14E-04	3.011	0.3521	311.58	0.00018	0.0864	0.0041675	0.0004298	0.00141	27.21875	0.00071
13-Oct-09	9	1136.2	1.3386	0.06134	0.08255	0.1527	0.0022069	0.0000483	0.48275	0.40354775	250	0.000815	0.07	1.326094	0.6092	0.0847449	0.02009	67.35	65.16160	0.0000815	0.0005	0.07992	0.0188	4.49	0.0009	36.832	2.85E-04	3.196	0.4115	375.38	0.00021	0.1133	0.0048275	0.0007334	0.00163	35.31475	0.00082
20-Oct-09	10	1367.0	2.7386	0.06564	0.09115	0.1547	0.0041329	0.0000613	0.61275	0.58094775	281	0.001065	0.086	2.340094	3.7792	0.0934449	0.02249	80.79	77.84160	0.0001065	0.0006	0.09796	0.0238	4.94	0.0010	42.152	3.77E-04	3.360	0.4733	441.38	0.00024	0.1533	0.0061275	0.0016594	0.00213	45.75475	0.00107
27-Oct-09	11	1684.7	5.7234	0.07188	0.11019	0.1567	0.0081889	0.0000873	0.87275	0.91322775	320	0.001585	0.11	4.446094	11.8392	0.1097209	0.02509	99.83	95.98960	0.0001585	0.0009	0.12536	0.0342	5.46	0.0012	50.056	5.33E-04	3.568	0.5638	537.58	0.0003	0.2256	0.0087275	0.0037082	0.00317	63.33075	0.00159
03-Nov-09	12	2001.8	11.6699	0.07950	0.26104	0.1589	0.0131479	0.0001308	1.30775	1.26014025	348	0.0061525	0.13	7.371469	27.0207	0.1328194	0.02944	115.42	110.19235	0.0002346	0.0013	0.14748	0.0494	6.00	0.0015	57.560	7.29E-04	3.710	0.6384	630.45	0.00034	0.3011	0.0130775	0.0071099	0.00622	79.23	0.00235
10-Nov-09	13	2304.2	20.7419	0.08916	0.53698	0.1614	0.0194479	0.0001938	1.93775	1.66166025	372	0.0145525	0.151	11.31947	49.8267	0.1642774	0.03574	130.16	122.96035	0.0003396	0.0019	0.16806	0.0704	6.63	0.0019	65.666	9.81E-04	3.815	0.7094	732.09	0.00038	0.3884	0.0193775	0.0120239	0.01126	95.736	0.00340
17-Nov-09	14	2597.5	31.4814	0.09997	0.87209	0.1643	0.0255579	0.0002878	2.87775	2.07314525	392	0.0255975	0.17	15.60822	81.5517	0.1967074	0.04514	144.05	134.61635	0.0005159	0.0029	0.18898	0.1057	7.10	0.0026	74.643	1.18E-03	3.991	0.7754	848.89	0.00043	0.4944	0.0287775	0.0176169	0.01643	113.3845	0.00516
24-Nov-09	15	2909.8	42.3264	0.11032	1.21814	0.1670	0.0305079	0.0004003	4.00275	2.43089525	404	0.0377475	0.186	19.59072	117.8667	0.2251024	0.05639	154.85	143.25635	0.0007409	0.0040	0.20698	0.1507	7.32	0.0035	83.148	1.29E-03	4.216	0.8258	963.64	0.00047	0.6038	0.0400275	0.0230619	0.02093	129.4945	0.00741
01-Dec-09	16	3299.8	58.5001	0.12314	2.26528	0.1698	0.0352579	0.0005190	5.19025	2.82870775	414	0.0605475	0.205	23.93222	178.5954	0.2709636	0.06826	164.59	152.40010	0.0009784	0.0052	0.22527	0.1982	7.56	0.0044	92.387	1.68E-03	4.453	0.8755	1099.96	0.00055	0.7211	0.0519025	0.0305432	0.03161	149.2545	0.00978
08-Dec-09	17	3784.8	79.8401	0.13818	4.03068	0.1727	0.0396229	0.0006403	6.40275	3.25550775	422	0.0940125	0.228	28.50577	263.4704	0.3340136	0.08039	172.83	161.76060	0.0012209	0.0064	0.24321	0.2467	7.80	0.0054	102.087	2.36E-03	4.696	0.9225	1254.68	0.00064	0.8428	0.0640275	0.0399522	0.04859	172.2435	0.01221
15-Dec-09	18	4521.0	106.9126	0.16661	12.25253	0.1770	0.0430354	0.0009474	7.54025	3.79468275	427	0.1568025	0.258	32.97159	409.0704	0.4618686	0.09176	181.02	171.74785	0.0014484	0.0075	0.26619	0.2922	8.03	0.0063	113.121	3.07E-03	5.265	0.9660	1494.46	0.00076	0.9607	0.0754025	0.0536477	0.06747	205.049	0.01448
22-Dec-09	19	5681.1	141.4126	0.20985	27.20253	0.1830	0.0457954	0.0014534	8.69025	4.48008275	431	0.2520225	0.298	37.66359	622.9704	0.6605886	0.10326	189.76	183.06385	0.0016784	0.0087	0.29563	0.3382	8.26	0.0072	126.231	3.85E-03	6.185	1.0092	1832.56	0.00089	1.0835	0.0869025	0.0724157	0.08955	249.577	0.01678
29-Dec-09	20	7204.4	176.8921	0.28216	74.05128	0.1881	0.0488179	0.0048014	9.85275	5.38683275	435	0.3775725	0.354	42.45309	1063.5579	0.8644911	0.11489	199.76	193.52635	0.0019109	0.0104	0.33887	0.8450	8.49	0.0082	140.297	5.92E-03	6.766	1.0506	2366.15	0.00099	1.2109	0.0985275	0.0912947	0.12768	314.398	0.01911
05-Jan-10	21	9329.0	209.8721	0.37439	145.87628	0.1920	0.0517929	0.0104539	10.91525	6.41108275	439	0.5190975	0.42	46.87309	1671.3079	1.0536161	0.12551	209.96	202.19635	0.0021234	0.0126	0.39072	1.7290	8.71	0.0090	153.897	8.98E-03	6.978	1.0863	3029.15	0.00103	1.3303	0.1091525	0.1084647	0.17698	391.748	0.02123
12-Jan-10	22	11868.2	238.5961	0.46834	224.56628	0.1950	0.0545879	0.0155064	11.99025	7.46888275	443	0.6726075	0.492	51.05269	2322.7579	1.1935811	0.13626	219.85	209.05485	0.0023384	0.0173	0.44813	3.0362	8.92	0.0099	167.786	1.31E-02	7.301	1.1177	3781.65	0.00112	1.4363	0.1310825	0.1225042	0.22815	465.708	0.02338
19-Jan-10	23	14309.4	263.7961	0.56734	313.21628	0.1972	0.0572879	0.0200964	13.11525	8.59838275	447	0.8440575	0.572	55.12069	3042.7579	1.2862811	0.14751	229.75	214.22985	0.0025634	0.0249	0.51338	4.8362	9.15	0.0108	182.456	1.85E-02	7.751	1.1456	4654.65	0.00125	1.5317	0.1657325	0.1337092	0.28305	538.608	0.02563
26-Jan-10	24	16917.1	285.6234	0.65812	387.53128	0.1994	0.0597354	0.0234562	14.22775	9.55958275	451	0.9938	0.644	58.53829	3728.0579	1.3561461	0.15864	237.09	217.98120	0.0027859	0.0293	0.56478	6.6096	9.37	0.0117	196.518	2.44E-02	8.418	1.1723	5464.55	0.00141	1.6141	0.1884275	0.1431209	0.33111	598.238	0.02786
02-Feb-10	25	18990.7	304.5684	0.74272	449.18128	0.2017	0.0619854	0.0256612	15.35275	10.37408275	455	1.1252	0.708	61.38229	4394.0579	1.4047461	0.16989	242.04	220.39320	0.0030109	0.0304	0.60348	8.3961	9.59	0.0126	210.288	3.11E-02	9.318	1.1984	6229.55	0.00159	1.6852	0.1996775	0.1509509	0.37341	645.938	0.03011
09-Feb-10	26	21015.9	319.9649	0.80622	489.60228	0.2031	0.0638114	0.0268232	16.18275	11.00280775	459	1.23061	0.76	63.89719	4923.1829	1.4317626	0.17819	245.65	222.25240	0.0031665	0.0312	0.63377	9.6079	9.75	0.0132	222.053	3.61E-02	9.837	1.2208	6806.40	0.00173	1.7495	0.2079775	0.1572174	0.41263	683.0805	0.03167
16-Feb-10	27	22591.4	333.6074	0.85637	514.16728	0.2040	0.0654264	0.0271207	16.82025	11.52130775	462	1.32241	0.808	66.36219	5377.9329	1.4411976	0.18456	248.37	223.78240	0.0032728	0.0319	0.65927	10.4026	9.86	0.0136	233.146	4.01E-02	#####	1.2421	7265.40	0.00186	1.8141	0.2143525	0.1626574	0.45300	714.1055	0.03273
23-Feb-10	28	24052.0	350.2634	0.92381	554.43928	0.2054	0.0672984	0.0280087	17.78025	12.08770775	466	1.43137	0.869	69.33339	5970.7329	1.4561496	0.19416	251.11	225.34240	0.0034528	0.0328	0.69239	11.8450	10.04	0.0143	245.026	4.53E-02	#####	1.2677	7894.20	0.002	1.8885	0.2239525	0.1685374	0.49644	748.7615	0.03453
02-Mar-10	29	25926.1	365.5564	0.99064	599.53928	0.2071	0.0689384	0.0292387	18.80525	12.55510775	470	1.52895	0.927	72.03119	6544.7329	1.4725906	0.20441	253.16	226.53140	0.0036578	0.0339	0.72437	13.5424	10.24	0.0152	254.620	5.04E-02	#####	1.2911	8525.60	0.00213	1.9533	0.2342025	0.1733344	0.53170	778.0355	0.03658
09-Mar-10	30	27607.3	380.1814	1.05926	639.85928	0.2111	0.0705134	0.0302287	19.93025	12.99790775	474	1.620525	0.987	74.68619	7125.2329	1.4866081	0.21566	254.85	227.61365	0.0038828	0.0350	0.75610	15.0522	10.92	0.0161	264.745	5.56E-02	#####	1.3152	9162.35	0.00226	2.0183	0.2454525	0.1779244	0.56680	806.678	0.03883
16-Mar-10	31	29442.3	392.7849	1.12387	671.34528	0.2175	0.0718784	0.0308657	21.06775	13.37464775	478	1.69742	1.043	77.06129	7662.1329	1.4967091	0.22704	255.99	228.48270	0.0041103	0.0361	0.78476	16.2215	12.05	0.0170	274.573	6.04E-02	#####	1.3379	9749.30	0.0024	2.0779	0.2568275	0.1818829	0.59865	832.1125	0.04110
23-Mar-10	32	31603.9	404.9059	1.18942	702.48728	0.2216	0.0730744	0.0314407	21.98775	13.72102775	482	1.77148	1.1	79.37739	8204.9329	1.5061161	0.23624	257.18	229.27620	0.0042828	0.0370	0.81282	17.6797	12.69	0.0177	283.129	6.38E-02	#####	1.3605	10347.30	0.00251	2.1345	0.2660275	0.1856319	0.62901	855.7795	0.04283
30-Mar-10	33	33631.1	416.1559	1.25377	732.27728	0.2234	0.0740644	0.0319357	22.66275	14.02612775	487	1.84033	1.157	81.55989	8735.9329	1.5145311	0.24299	258.40	229.96920	0.0043953	0.0377	0.83937	19.3762	12.80	0.0181	290.149	6.57E-02	#####	1.3821	10936.80	0.0026	2.1862	0.2727775	0.1890519	0.65691	876.9295	0.04395
06-Apr-10	34	35758.7	426.9334	1.31790	760.40228	0.2250	0.0750319	0.0325432	23.33775	14.30647775	492	1.904905	1.214	83.55789	9264.6829	1.5225411	0.24974	259.34	230.59695	0.0045078	0.0384	0.86480	21.0570	13.19	0.0186	298.136	6.86E-02	#####	1.4030	11476.80	0.00274	2.2335	0.2795275	0.1922019	0.68414	896.392	0.04508
13-Apr-10	35	37524.1	437.3529	1.38251	787.15628	0.2264	0.0759874	0.0332712	24.02025	14.56491775	496	1.965875	1.27	85.39154	9797.0329	1.5302306	0.25656	260.02	231.16570	0.0046215	0.0391	0.88937	22.7405	13.87	0.0190	307.191	7.25E-02	#####	1.4235	11972.75	0.00292	2.2769	0.2863525	0.1951139	0.71098	914.3645	0.04622
20-Apr-10	36	39720.9	449.0009	1.44825	814.50178	0.2280	0.0768974	0.0339764	24.70275	14.80606775	501	2.02821	1.328	87.25477	10340.7579	1.5375561	0.26339	260.71	231.72990	0.0047921	0.0398	0.91530	24.6105	14.56	0.0195	316.791	7.60E-02	#####	1.4435	12541.50	0.00306	2.3211	0.2931775	0.1980259	0.73965	931.3588	0.04735
27-Apr-10	37	41562.7	461.4529	1.51293	841.51778	0.2297	0.0777334	0.0346364	25.36275	15.02254775	505	2.08981	1.387	89.08517	10877.5579	1.5442881	0.26999	261.37	232.27110	0.0050121	0.0404	0.94170	26.5993	15.22	0.0199	326.603	7.91E-02	#####	1.4624	13161.90	0.00314	2.3645	0.2997775	0.2008419	0.76913	946.8468	0.04845
04-May-10	38	43308.7	472.3939	1.57299	863.90378	0.2310	0.0785944	0.0350774	25.99275	15.21826775	509	2.14189	1.439	90.73997	11360.5579	1.5489081	0.27629	262.00	232.74780	0.0051696	0.0410	0.96459	28.2205	15.85	0.0203	335.675	8.19E-02	#####	1.4800	13710.00	0.00323	2.4088	0.3060775	0.2033829	0.79391	960.6438	0.04950
11-May-10	39	44986.6	482.5089	1.63207	883.11378	0.2318	0.0795294	0.0353324	26.63025	15.40526775	513	2.18779	1.49	92.32097	11819.5579	1.5517556	0.28266	262.63	233.18980	0.0052759	0.0417	0.98542	29.5805	16.48	0.0208	344.558	8.48E-02	#####	1.4975	14220.00	0.00331	2.4564	0.3124525	0.2058054	0.81558	973.6063	0.05057
18-May-10	40	46303.2	494.0484	1.69699	904.57578	0.2331	0.0804849	0.0357489	27.36525	15.59146775	518	2.240465	1.55	94.17807	12343.8579	1.5556511	0.29001	263.37	233.67049	0.0053984	0.0424	1.01016	31.2098	17.22	0.0212	353.402	8.83E-02	#####	1.5185	14808.00	0.00341	2.5063	0.3198025	0.2084269	0.83910	986.4443	0.05179
25-May-10	41	47632.0	504.4169	1.75306	923.44378	0.2344	0.0812414	0.0362384	28.03275	15.73386775	522	2.28808	1.607	95.89577	12815.5579	1.5597451	0.29669	264.04	234.08078	0.0055096	0.0431	1.03330	32.7450	17.89	0.0217	360.166	9.18E-02	#####	1.5386	15342.00	0.0035	2.5471	0.3264775	0.2106519	0.85913	996.1898	0.05290
01-Jun-10	42	49157.2	515.4869	1.81067	944.35378	0.2362	0.0820819	0.0368534	28.64775	15.86711775	527	2.33892	1.667	97.53372	13328.0579	1.5646036	0.30284	264.96	234.49529	0.0056121	0.0437	1.05770	34.6433	18.50	0.0221	368.366	9.51E-02	#####	1.5589	15883.20	0.00358	2.5853	0.3326275	0.2130504	0.88250	1005.435	0.05393
08-Jun-10	43	50748.4	528.5344	1.87654	969.68378	0.2388	0.0831019	0.0376609	29.28525	16.00736775	535	2.398845	1.736	99.28897	13940.0579	1.5707661	0.30921	266.23	234.96279	0.0057184	0.0443	1.08617	37.1126	19.14	0.0225	378.906	9.86E-02	#####	1.5818	16495.20	0.00367	2.6256	0.3390025	0.2158979	0.91182	1015.295	0.05499
15-Jun-10	44	52010.3	539.0714	1.93312	990.04028	0.2406	0.0838809	0.0382349	29.90025	16.12770275	541	2.44743	1.795	100.8142	14466.9079	1.5755631	0.31536	267.16	235.38570	0.0058209	0.0455	1.10995	39.1585	19.75	0.0229	387.537	1.02E-01	#####	1.6025	17011.80	0.00375	2.6621	0.3451525	0.2183169	0.93622	1023.721	0.05602
22-Jun-10	45	53270.5	548.1794	1.98636	#########	0.2420	0.0844969	0.0386309	30.56025	16.24078275	546	2.48967	1.852	102.2706	14964.1079	1.5794791	0.32196	267.82	235.80942	0.0059309	0.0472	1.13151	40.9933	20.41	0.0234	395.149	1.05E-01	#####	1.6232	17487.00	0.00384	2.6988	0.3517525	0.2205609	0.95822	1031.597	0.05712
29-Jun-10	46	54794.7	556.3274	2.03046	#########	0.2432	0.0850639	0.0388514	31.19025	16.33339275	550	2.52432	1.899	103.4802	15366.8879	1.5821671	0.32826	268.45	236.15676	0.0060359	0.0484	1.14978	42.3709	21.04	0.0238	402.163	1.08E-01	#####	1.6415	17896.50	0.0039	2.7298	0.3580525	0.2223249	0.97586	1038.107	0.05817
06-Jul-10	47	55835.3	564.7439	2.07185	#########	0.2446	0.0856684	0.0389212	31.88775	16.41895275	554	2.556405	1.943	104.6194	15733.3079	1.5839806	0.33524	269.14	236.47808	0.0061521	0.0491	1.16745	43.4822	21.74	0.0243	409.649	1.10E-01	#####	1.6601	18301.05	0.00395	2.7596	0.3650275	0.2238594	0.99167	1044.198	0.05933
13-Jul-10	48	56611.6	570.4541	2.10384	#########	0.2456	0.0861234	0.0389610	32.285875	16.48051425	558	2.5780175	1.975	105.4794	15995.3879	1.5850863	0.33922	269.76	236.73401	0.0062204	0.0495	1.18101	44.0914	22.14	0.0245	415.792	1.12E-01	#####	1.6746	18588.61	0.00402	2.7835	0.36900875	0.2250765	1.00623	1048.525	0.06001
20-Jul-10	49	57141.2	573.9191	2.12938	#########	0.2464	0.0864699	0.0389733	32.409625	16.52338125	560	2.5908875	1.996	106.1377	16175.5679	1.5855615	0.34046	270.35	236.94884	0.0062451	0.0496	1.19170	44.2340	22.26	0.0246	421.187	1.13E-01	#####	1.6864	18783.64	0.00412	2.8037	0.37024625	0.2260913	1.02108	1051.456	0.06026
27-Jul-10	50	58304.2	580.5621	2.16614	#########	0.2474	0.0870387	0.0392293	32.80775	16.58744525	564	2.617505	2.039	107.2161	16540.4779	1.5880094	0.34444	270.97	237.21798	0.0063134	0.0500	1.21186	45.5644	22.66	0.0249	427.603	1.15E-01	#####	1.7028	19178.12	0.00421	2.8327	0.3742275	0.2275359	1.03632	1055.851	0.06094
03-Aug-10	51	60036.5	589.6641	2.21124	#########	0.2486	0.0877767	0.0396803	33.42275	16.66739525	569	2.654815	2.101	108.6142	17048.8779	1.5920274	0.35059	271.58	237.52507	0.0064159	0.0506	1.23933	47.8440	23.28	0.0253	434.696	1.18E-01	#####	1.7225	19727.52	0.0043	2.8683	0.3803775	0.2292989	1.05149	1061.345	0.06197
10-Aug-10	52	61065.1	599.3661	2.26020	#########	0.2501	0.0885192	0.0400763	33.91775	16.74461525	574	2.69194	2.164	110.1165	17556.9954	1.5963091	0.35554	272.45	237.84954	0.0065025	0.0512	1.26645	50.0592	23.77	0.0258	441.972	1.21E-01	#####	1.7443	20284.89	0.00439	2.9048	0.3853275	0.2312789	1.06832	1066.745	0.06283
17-Aug-10	53	62327.0	606.7611	2.29839	#########	0.2515	0.0890412	0.0402938	34.13525	16.79551025	579	2.717605	2.21	111.2736	17910.6504	1.5995716	0.35771	273.32	238.09401	0.0065460	0.0517	1.28499	51.5338	23.99	0.0261	447.236	1.23E-01	#####	1.7617	20681.61	0.00446	2.9312	0.3875025	0.2328884	1.08181	1070.408	0.06327
24-Aug-10	54	63240.6	614.3741	2.33784	#########	0.2528	0.0895702	0.0405468	34.36525	16.84864025	583	2.744055	2.26	112.419	18302.3404	1.6023316	0.36001	274.24	238.33804	0.0065920	0.0521	1.30368	53.2128	24.22	0.0264	453.078	1.25E-01	#####	1.7791	21130.57	0.00452	2.9578	0.3898025	0.2343696	1.09561	1074.019	0.06373
31-Aug-10	55	64753.1	621.3776	2.37424	#########	0.2539	0.0900487	0.0408078	34.58275	16.89823025	587	2.768415	2.308	113.4282	18689.4904	1.6042891	0.36219	275.11	238.55510	0.0066355	0.0526	1.32052	54.9137	24.44	0.0266	458.863	1.27E-01	#####	1.7948	21582.97	0.00457	2.9819	0.3919775	0.2355615	1.10822	1077.186	0.06416
07-Sep-10	56	66402.7	628.3419	2.41111	#########	0.2550	0.0905159	0.0411415	35.02775	16.9449775	592	2.79378	2.357	114.4139	19100.8929	1.6065586	0.36664	275.89	238.77938	0.0067134	0.0531	1.34248	56.8494	24.88	0.0269	465.026	1.30E-01	#####	1.8108	22054.67	0.0046	3.0059	0.3964275	0.2372169	1.12113	1080.274	0.06494
14-Sep-10	57	67868.5	634.8779	2.44637	#########	0.2558	0.0909459	0.0415285	35.67275	16.9863005	596	2.81872	2.406	115.3212	19513.2629	1.6090096	0.37309	276.53	238.99825	0.0068209	0.0538	1.36828	58.9091	25.53	0.0273	471.218	1.32E-01	#####	1.8263	22519.07	0.00462	3.0283	0.4028775	0.2392379	1.13360	1083.112	0.06602
21-Sep-10	58	69413.2	641.3639	2.48432	#########	0.2567	0.0913599	0.0418275	36.36275	17.0281375	601	2.84333	2.456	116.278	19926.3429	1.6112176	0.37999	277.22	239.23078	0.0069359	0.0545	1.39220	60.8319	26.22	0.0278	478.003	1.34E-01	#####	1.8424	22990.57	0.00465	3.0526	0.4097775	0.2410089	1.14510	1086.013	0.06717
28-Sep-10	59	70458.1	647.4089	2.52292	#########	0.2577	0.0917319	0.0420135	37.06025	17.0680345	605	2.866115	2.505	117.2312	20315.5479	1.6130311	0.38696	277.92	239.46421	0.0070521	0.0551	1.41266	62.4920	26.91	0.0282	485.025	1.36E-01	#####	1.8582	23441.62	0.00467	3.0775	0.4167525	0.2424039	1.15486	1088.807	0.06833

Appendix B.1-5

Humidity Cell T5 (CaNP depleted Sand-Silt Composite)

Production Rates and Depletion

													Ratios				*NP Consumption Rates*							
Date	**Cycle**	**Acidity (mg $CaCO_3$/kg/wk)**	**Alkalinity (mg $CaCO_3$/kg/wk)**	**Cumulative Alkalinity (mg/$CaCO_3$/wk)**	**Sulphate (mg/kg/wk)**	**Cumulative Sulphate (mg/kg)**	**Cumulative Sulphate (mmol/kg)**	**Fraction of total S Leached**	**Fraction of Total S remaining**	**Fraction of Sulphide Sulphur Leached**	**Fraction of Sulphide Sulphur Remaining**	**Alkalinity/ Sulphate Production**	**Total S Conc Remaining (%)**	**CMR**	**Ca/SO4**	**Ca+Mg)/Al**	**Ca/Mg**	**Theoretical NP Consumption at pH 6**	**Carbonate NP Consumption (mg CaCO3/kg/wk)**	**Carbonate NP Consumption (kg CaCO3/t/wk)**	**Cum. Carb NP Consum. (mg CaCO3/kg/wk)**	**Cum. Carb NP Consum. (kg CaCO3/t/wk)**	**Remaining Carbonate NP**	**Open System NP Consumption**	**Cumulative NP Consumption**	**Remaining NP**
11-Aug-09	0	2.075	1.2	1.2	6.8	6.8	0.071	0.00005	1.000	0.00006	1.000	0.18	4.850	1.16	0.94	6.69	4.30	7.1	8.3	0.0083	8.3	0.0083	1.00	6.3	6.3	1.00
18-Aug-09	1	2.894	0.5	1.7	38.6	45.5	0.473	0.00031	1.000	0.00040	1.000	0.01	4.848	0.91	0.73	32.15	3.99	40.3	36.6	0.0366	44.9	0.0449	1.00	37.9	44.1	1.00
25-Aug-09	2	4.841	0.7	2.4	75.8	121.2	1.262	0.00083	0.999	0.00105	0.999	0.01	4.846	0.83	0.65	64.07	3.85	78.9	65.1	0.0651	110.0	0.1100	1.00	74.8	118.9	1.00
01-Sep-09	3	10.421	0.9	3.3	104.2	225.4	2.346	0.00155	0.998	0.00196	0.998	0.01	4.842	0.88	0.68	85.14	3.28	108.5	95.8	0.0958	205.8	0.2058	0.99	99.0	217.9	0.99
08-Sep-09	4	12.613	0.4	3.7	113.2	338.6	3.525	0.00233	0.998	0.00294	0.997	0.00	4.839	0.80	0.59	93.83	2.86	118.0	94.1	0.0941	300.0	0.3000	0.99	105.7	323.6	0.99
15-Sep-09	5	19.382	0.0	3.7	160.7	499.3	5.197	0.00344	0.997	0.00434	0.996	0.00	4.833	0.75	0.54	102.53	2.57	167.4	125.1	0.1251	425.1	0.4251	0.99	148.0	471.6	0.98
22-Sep-09	6	17.705	#N/A	#N/A	141.1	640.4	6.666	0.00441	0.996	0.00557	0.994	#N/A	4.829	0.73	0.50	94.01	2.21	147.0	107.1	0.1071	532.1	0.5321	0.98	#N/A	#N/A	#N/A
29-Sep-09	7	18.970	#N/A	#N/A	134.3	774.7	8.065	0.00533	0.995	0.00673	0.993	#N/A	4.824	0.76	0.49	85.50	1.86	139.9	106.6	0.1066	638.7	0.6387	0.98	#N/A	#N/A	#N/A
06-Oct-09	8	26.269	#N/A	#N/A	167.9	942.6	9.812	0.00649	0.994	0.00819	0.992	#N/A	4.819	0.71	0.44	101.10	1.65	174.9	124.7	0.1247	763.5	0.7635	0.97	#N/A	#N/A	#N/A
13-Oct-09	9	32.661	#N/A	#N/A	193.6	1136.2	11.828	0.00782	0.992	0.00988	0.990	#N/A	4.812	0.69	0.42	116.71	1.51	201.7	139.2	0.1392	902.7	0.9027	0.97	#N/A	#N/A	#N/A
20-Oct-09	10	57.228	#N/A	#N/A	230.8	1367.0	14.231	0.00941	0.991	0.01188	0.988	#N/A	4.804	0.54	0.31	120.81	1.37	240.5	131.0	0.1310	1033.7	1.0337	0.97	#N/A	#N/A	#N/A
27-Oct-09	11	110.193	#N/A	#N/A	317.7	1684.7	17.538	0.01160	0.988	0.01465	0.985	#N/A	4.794	0.53	0.29	124.90	1.25	331.0	176.1	0.1761	1209.8	1.2098	0.96	#N/A	#N/A	#N/A
03-Nov-09	12	146.127	#N/A	#N/A	317.1	2001.8	20.839	0.01378	0.986	0.01740	0.983	#N/A	4.783	0.41	0.22	115.47	1.12	330.4	136.2	0.1362	1346.1	1.3461	0.96	#N/A	#N/A	#N/A
10-Nov-09	13	193.175	#N/A	#N/A	302.4	2304.2	23.987	0.01586	0.984	0.02003	0.980	#N/A	4.773	0.38	0.19	106.04	0.99	315.1	120.8	0.1208	1466.8	1.4668	0.95	#N/A	#N/A	#N/A
17-Nov-09	14	231.668	#N/A	#N/A	293.3	2597.5	27.040	0.01788	0.982	0.02258	0.977	#N/A	4.763	0.35	0.16	83.69	0.86	305.6	106.7	0.1067	1573.5	1.5735	0.95	#N/A	#N/A	#N/A
24-Nov-09	15	236.646	#N/A	#N/A	312.3	2909.8	30.291	0.02003	0.980	0.02530	0.975	#N/A	4.753	0.23	0.09	61.35	0.68	325.4	74.9	0.0749	1648.4	1.6484	0.95	#N/A	#N/A	#N/A
01-Dec-09	16	332.709	#N/A	#N/A	390.0	3299.8	34.351	0.02271	0.977	0.02869	0.971	#N/A	4.740	0.16	0.06	50.50	0.62	406.3	65.1	0.0651	1713.4	1.7134	0.94	#N/A	#N/A	#N/A
08-Dec-09	17	424.375	#N/A	#N/A	485.0	3784.8	39.400	0.02605	0.974	0.03290	0.967	#N/A	4.724	0.10	0.04	39.65	0.54	505.3	52.2	0.0522	1765.6	1.7656	0.94	#N/A	#N/A	#N/A
15-Dec-09	18	978.250	#N/A	#N/A	736.2	4521.0	47.064	0.03112	0.969	0.03930	0.961	#N/A	4.699	0.06	0.02	38.41	0.40	767.0	47.4	0.0474	1813.0	1.8130	0.94	#N/A	#N/A	#N/A
22-Dec-09	19	1575.500	#N/A	#N/A	1160.1	5681.1	59.141	0.03910	0.961	0.04939	0.951	#N/A	4.660	0.04	0.01	37.16	0.29	1208.7	46.4	0.0464	1859.4	1.8594	0.94	#N/A	#N/A	#N/A
29-Dec-09	20	1397.906	#N/A	#N/A	1523.3	7204.4	74.999	0.04959	0.950	0.06263	0.937	#N/A	4.610	0.03	0.01	40.96	0.25	1587.1	51.7	0.0517	1911.0	1.9110	0.94	#N/A	#N/A	#N/A
05-Jan-10	21	1099.688	#N/A	#N/A	2124.6	9329.0	97.116	0.06421	0.936	0.08110	0.919	#N/A	4.539	0.02	0.00	44.76	0.23	2213.5	51.6	0.0516	1962.6	1.9626	0.93	#N/A	#N/A	#N/A
12-Jan-10	22	1271.188	#N/A	#N/A	2539.2	11868.2	123.549	0.08169	0.918	0.10317	0.897	#N/A	4.454	0.02	0.00	43.24	0.24	2645.4	50.4	0.0504	2013.1	2.0131	0.93	#N/A	#N/A	#N/A
19-Jan-10	23	1496.250	#N/A	#N/A	2441.3	14309.4	148.963	0.09849	0.902	0.12439	0.876	#N/A	4.372	0.02	0.00	41.72	0.25	2543.4	50.9	0.0509	2064.0	2.0640	0.93	#N/A	#N/A	#N/A
26-Jan-10	24	1268.250	#N/A	#N/A	2607.7	16917.1	176.110	0.11644	0.884	0.14706	0.853	#N/A	4.285	0.01	0.00	33.36	0.33	2716.8	40.3	0.0403	2104.2	2.1042	0.93	#N/A	#N/A	#N/A
02-Feb-10	25	1068.750	#N/A	#N/A	2073.6	18990.7	197.696	0.13071	0.869	0.16509	0.835	#N/A	4.216	0.01	0.00	25.01	0.50	2160.4	30.5	0.0305	2134.8	2.1348	0.93	#N/A	#N/A	#N/A
09-Feb-10	26	1187.938	#N/A	#N/A	2025.2	21015.9	218.779	0.14465	0.855	0.18270	0.817	#N/A	4.148	0.01	0.00	20.82	0.58	2109.9	23.4	0.0234	2158.2	2.1582	0.93	#N/A	#N/A	#N/A
16-Feb-10	27	1423.750	#N/A	#N/A	1575.5	22591.4	235.180	0.15549	0.845	0.19639	0.804	#N/A	4.096	0.01	0.00	16.64	0.71	1641.4	19.2	0.0192	2177.4	2.1774	0.93	#N/A	#N/A	#N/A
23-Feb-10	28	1536.000	#N/A	#N/A	1460.6	24052.0	250.385	0.16555	0.834	0.20909	0.791	#N/A	4.047	0.01	0.01	16.72	0.93	1521.8	21.8	0.0218	2199.2	2.1992	0.93	#N/A	#N/A	#N/A
02-Mar-10	29	1250.500	#N/A	#N/A	1874.1	25926.1	269.895	0.17845	0.822	0.22538	0.775	#N/A	3.985	0.01	0.01	16.81	1.21	1952.5	18.7	0.0187	2217.9	2.2179	0.93	#N/A	#N/A	#N/A
09-Mar-10	30	1462.500	#N/A	#N/A	1681.2	27607.3	287.397	0.19002	0.810	0.24000	0.760	#N/A	3.928	0.01	0.01	13.99	1.46	1751.5	17.1	0.0171	2235.0	2.2350	0.93	#N/A	#N/A	#N/A
16-Mar-10	31	1569.750	#N/A	#N/A	1835.0	29442.3	306.499	0.20265	0.797	0.25595	0.744	#N/A	3.867	0.01	0.00	11.17	1.94	1911.8	13.8	0.0138	2248.8	2.2488	0.93	#N/A	#N/A	#N/A
23-Mar-10	32	1587.000	#N/A	#N/A	2161.5	31603.9	329.001	0.21753	0.782	0.27474	0.725	#N/A	3.795	0.01	0.00	12.52	2.17	2252.0	15.6	0.0156	2264.4	2.2644	0.92	#N/A	#N/A	#N/A
30-Mar-10	33	1552.500	#N/A	#N/A	2027.3	33631.1	350.105	0.23148	0.769	0.29236	0.708	#N/A	3.727	0.01	0.01	13.87	2.38	2112.1	16.9	0.0169	2281.3	2.2813	0.92	#N/A	#N/A	#N/A
06-Apr-10	34	1552.500	#N/A	#N/A	2127.6	35758.7	372.254	0.24612	0.754	0.31086	0.689	#N/A	3.656	0.01	0.01	12.68	2.97	2216.6	15.5	0.0155	2296.8	2.2968	0.92	#N/A	#N/A	#N/A
13-Apr-10	35	1569.750	#N/A	#N/A	1765.4	37524.1	390.632	0.25827	0.742	0.32620	0.674	#N/A	3.597	0.01	0.01	11.49	4.04	1839.3	14.2	0.0142	2311.0	2.3110	0.92	#N/A	#N/A	#N/A
20-Apr-10	36	1592.500	#N/A	#N/A	2196.7	39720.9	413.501	0.27339	0.727	0.34530	0.655	#N/A	3.524	0.01	0.00	11.49	4.04	2288.7	14.2	0.0142	2325.2	2.3252	0.92	#N/A	#N/A	#N/A
27-Apr-10	37	1562.000	#N/A	#N/A	1841.8	41562.7	432.674	0.28607	0.714	0.36131	0.639	#N/A	3.463	0.01	0.01	11.49	4.04	1918.9	13.7	0.0137	2338.9	2.3389	0.92	#N/A	#N/A	#N/A
04-May-10	38	1459.500	#N/A	#N/A	1745.9	43308.7	450.850	0.29809	0.702	0.37649	0.624	#N/A	3.404	0.01	0.01	11.49	4.04	1819.0	13.1	0.0131	2352.0	2.3520	0.92	#N/A	#N/A	#N/A
11-May-10	39	1445.000	#N/A	#N/A	1677.9	44986.6	468.317	0.30964	0.690	0.39108	0.609	#N/A	3.348	0.01	0.01	11.49	4.04	1748.1	13.3	0.0133	2365.3	2.3653	0.92	#N/A	#N/A	#N/A
18-May-10	40	1678.250	#N/A	#N/A	1316.6	46303.2	482.024	0.31870	0.681	0.40252	0.597	#N/A	3.304	0.01	0.01	11.03	3.84	1371.7	14.7	0.0147	2380.0	2.3800	0.92	#N/A	#N/A	#N/A
25-May-10	41	1535.250	#N/A	#N/A	1328.8	47632.0	495.856	0.32784	0.672	0.41407	0.586	#N/A	3.260	0.01	0.01	10.57	3.64	1384.4	12.8	0.0128	2392.8	2.3928	0.92	#N/A	#N/A	#N/A
01-Jun-10	42	1486.250	#N/A	#N/A	1525.2	49157.2	511.734	0.33834	0.662	0.42733	0.573	#N/A	3.209	0.01	0.01	15.40	3.50	1589.0	17.1	0.0171	2409.9	2.4099	0.92	#N/A	#N/A	#N/A
08-Jun-10	43	1615.000	#N/A	#N/A	1591.2	50748.4	528.298	0.34929	0.651	0.44117	0.559	#N/A	3.156	0.01	0.01	20.22	3.44	1657.8	23.3	0.0233	2433.2	2.4332	0.92	#N/A	#N/A	#N/A
15-Jun-10	44	1486.250	#N/A	#N/A	1262.0	52010.3	541.436	0.35798	0.642	0.45214	0.548	#N/A	3.114	0.01	0.01	16.78	3.91	1314.8	18.7	0.0187	2451.9	2.4519	0.92	#N/A	#N/A	#N/A
22-Jun-10	45	1518.000	#N/A	#N/A	1260.2	53270.5	554.554	0.36665	0.633	0.46309	0.537	#N/A	3.072	0.01	0.01	13.34	4.85	1312.9	15.9	0.0159	2467.8	2.4678	0.92	#N/A	#N/A	#N/A
29-Jun-10	46	1417.500	#N/A	#N/A	1524.2	54794.7	570.421	0.37714	0.623	0.47634	0.524	#N/A	3.021	0.01	0.01	11.95	4.25	1588.0	13.6	0.0136	2481.4	2.4814	0.92	#N/A	#N/A	#N/A
06-Jul-10	47	1534.500	#N/A	#N/A	1040.7	55835.3	581.255	0.38431	0.616	0.48539	0.515	#N/A	2.986	0.01	0.01	10.57	3.64	1084.2	13.3	0.0133	2494.8	2.4948	0.92	#N/A	#N/A	#N/A
13-Jul-10	48	1512.875	#N/A	#N/A	776.2	56611.6	589.336	0.38965	0.610	0.49214	0.508	#N/A	2.960	0.01	0.01	8.55	3.17	808.7	10.6	0.0106	2505.3	2.5053	0.92	#N/A	#N/A	#N/A
20-Jul-10	49	1658.250	#N/A	#N/A	529.7	57141.2	594.849	0.39330	0.607	0.49674	0.503	#N/A	2.943	0.02	0.01	6.52	2.58	551.8	8.8	0.0088	2514.1	2.5141	0.92	#N/A	#N/A	#N/A
27-Jul-10	50	1524.250	#N/A	#N/A	1163.0	58304.2	606.956	0.40130	0.599	0.50685	0.493	#N/A	2.904	0.01	0.01	9.93	3.84	1211.6	12.3	0.0123	2526.4	2.5264	0.92	#N/A	#N/A	#N/A
03-Aug-10	51	1373.500	#N/A	#N/A	1732.3	60036.5	624.989	0.41322	0.587	0.52191	0.478	#N/A	2.846	0.01	0.01	13.34	4.85	1804.7	14.8	0.0148	2541.2	2.5412	0.92	#N/A	#N/A	#N/A
10-Aug-10	52	1645.875	#N/A	#N/A	1028.6	61065.1	635.697	0.42030	0.580	0.53085	0.469	#N/A	2.812	0.02	0.01	12.79	3.81	1071.7	17.2	0.0172	2558.4	2.5584	0.91	#N/A	#N/A	#N/A
17-Aug-10	53	1435.500	#N/A	#N/A	1261.9	62327.0	648.834	0.42899	0.571	0.54182	0.458	#N/A	2.769	0.01	0.01	12.25	3.03	1314.7	14.5	0.0145	2572.8	2.5728	0.91	#N/A	#N/A	#N/A
24-Aug-10	54	1506.500	#N/A	#N/A	913.6	63240.6	658.344	0.43528	0.565	0.54976	0.450	#N/A	2.739	0.02	0.01	11.79	2.88	951.8	14.7	0.0147	2587.6	2.5876	0.91	#N/A	#N/A	#N/A
31-Aug-10	55	1413.750	#N/A	#N/A	1512.5	64753.1	674.090	0.44569	0.554	0.56291	0.437	#N/A	2.688	0.01	0.01	11.33	2.73	1575.8	13.4	0.0134	2600.9	2.6009	0.91	#N/A	#N/A	#N/A
07-Sep-10	56	1435.125	#N/A	#N/A	1649.6	66402.7	691.262	0.45704	0.543	0.57725	0.423	#N/A	2.633	0.01	0.01	11.87	3.47	1718.6	14.3	0.0143	2615.3	2.6153	0.91	#N/A	#N/A	#N/A
14-Sep-10	57	1376.000	#N/A	#N/A	1465.9	67868.5	706.522	0.46713	0.533	0.59000	0.410	#N/A	2.584	0.01	0.01	12.42	4.45	1527.2	14.5	0.0145	2629.8	2.6298	0.91	#N/A	#N/A	#N/A
21-Sep-10	58	1449.000	#N/A	#N/A	1544.7	69413.2	722.603	0.47776	0.522	0.60342	0.397	#N/A	2.533	0.01	0.01	11.49	4.04	1609.3	14.3	0.0143	2644.1	2.6441	0.91	#N/A	#N/A	#N/A
28-Sep-10	59	1441.500	#N/A	#N/A	1044.9	70458.1	733.480	0.48495	0.515	0.61251	0.387	#N/A	2.498	0.01	0.01	10.57	3.64	1088.6	13.3	0.0133	2657.5	2.6575	0.91	#N/A	#N/A	#N/A

Appendix B.1-6
Humidity Cell T6 (CaNP depleted Silt-Clay Composite)
Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
11-Aug-09	0	500	405	7.35	33	#N/A	4.4	3.9	8	0.7	10.3	0.0024	0.00866	0.0117	0.0313	<0.00001	<0.000005	<0.05	0.00118	3.23	<0.0001	0.000291	0.00795	0.004	0.000574	0.0006	0.55
18-Aug-09	1	500	490	5.47	87	#N/A	5.7	0.8	26	0.6	28.7	0.0084	0.0146	0.0254	0.0729	0.00002	<0.000005	<0.05	0.0063	9.05	<0.0001	0.00109	0.0415	0.032	0.00802	0.0017	1.47
25-Aug-09	2	500	410	5.79	234	#N/A	11.3	1.4	94	<0.5	90	0.0382	0.0199	0.0464	0.12	0.00007	<0.000005	<0.05	0.0223	27.7	<0.0001	0.00414	0.103	0.119	0.0112	0.0041	5.03
01-Sep-09	3	500	445	5.65	205	#N/A	13.5	2.4	92	0.9	75.2	0.0456	0.0217	0.0605	0.0666	0.00007	<0.000005	<0.05	0.0214	22.7	<0.0001	0.00385	0.113	0.107	0.0125	0.0035	4.48
08-Sep-09	4	500	435	5.41	335				158																		
15-Sep-09	5	500	430	5.39	394	#N/A	26.1	1.9	174	<0.5	148	0.151	0.0278	0.119	0.0495	0.00019	<0.00003	<0.3	0.0543	43	<0.0005	0.00956	0.307	0.493	0.0152	0.006	9.91
22-Sep-09	6	500	445	5.64	340				162																		
29-Sep-09	7	500	425	4.99	319	#N/A	21.0	0.5	148	<0.5	122	0.131	0.0264	0.0967	0.0267	0.00019	<0.000005	<0.05	0.0459	34.5	<0.0001	0.00896	0.264	0.539	0.00932	0.0064	8.8
06-Oct-09	8	500	470	4.80	335				172																		
13-Oct-09	9	500	470	4.49	460	2.0	32.4	#N/A	245	<0.5	179	0.4	0.0226	0.0654	0.0292	0.00049	<0.00003	<0.3	0.0936	48.3	<0.0005	0.0153	0.652	0.241	0.0126	0.007	14.1
20-Oct-09	10	500	450	4.30	460				234																		
27-Oct-09	11	500	440	4.18	523	6.1	50.1	#N/A	264	<0.5	173	0.742	0.0246	0.0885	0.0214	0.001	<0.0001	<1	0.146	45	<0.002	0.0188	1.23	0.508	0.0188	<0.01	14.8
03-Nov-09	12	500	520	4.21	476				242																		
10-Nov-09	13	500	435	4.72	336	#N/A	33.0	1.0	179	<0.5	133	0.645	0.0173	0.0028	0.0158	0.001	<0.0001	<1	0.108	32.8	<0.002	0.0155	1.09	1.61	0.0115	<0.01	12.5
17-Nov-09	14	500	455	3.96	442				186																		
24-Nov-09	15	500	510	4.08	383	8.4	41.4	#N/A	181	0.6	111	0.614	0.01	0.002	0.016	0.0008	<0.0003	<3	0.107	25.8	<0.005	0.0153	1.15	1.89	0.0115	<0.03	11.3
01-Dec-09	16	500	460	3.84	477				217																		
08-Dec-09	17	500	480	3.66	579	24.3	97.9	#N/A	269	<0.5	164	2.63	0.011	0.013	0.014	0.0028	<0.0003	<3	0.225	35.3	<0.005	0.0273	3.35	5.77	0.0553	<0.03	18.4
15-Dec-09	18	500	470	3.62	652				304																		
22-Dec-09	19	500	470	3.25	816	60.0	206.9	#N/A	455	<0.5	207	10.9	0.019	0.065	0.013	0.007	<0.0005	<5	0.489	43	<0.01	0.0463	8.08	13.6	0.033	<0.05	24
29-Dec-09	20	500	465	3.04	1253				522																		
05-Jan-10	21	500	420	2.87	1927	382.2	905.9	#N/A	981	<0.5	193	50.6	0.044	1.3	0.01	0.015	<0.0005	<5	1.2	37	0.044	0.0844	16.4	58.9	0.095	<0.05	24
12-Jan-10	22	500	430	2.53	2345				1432																		
19-Jan-10	23	500	440	2.63	3290	675.0	1075	#N/A	1219	<0.5	108	68.2	0.057	2.94	0.008	0.0137	<0.0003	<3	1.61	18.4	0.093	0.112	13.9	137	0.0946	<0.03	15.1
26-Jan-10	24	500	435	2.71	2900				1545																		
02-Feb-10	25	500	450	2.89	3190	800.0	1275	#N/A	1636	<0.5	72.9	64.4	0.073	8.09	0.007	0.0086	<0.0003	<3	1.64	7.4	0.115	0.0919	9.6	266	0.0725	<0.03	13.2
09-Feb-10	26	500	415	2.10	3400				1803																		
16-Feb-10	27	500	460	2.41	2790	850.0	1375	#N/A	1483	<0.5	68	41	0.067	4.82	0.003	0.005	<0.0005	<5	1.23	5	0.082	0.0602	6.3	328	0.0238	<0.05	13
23-Feb-10	28	500	485	2.21	2410				1415																		
02-Mar-10	29	500	395	2.20	2430	1450	2375	#N/A	2254	<0.5	87.2	58.2	0.107	21.2	0.004	0.006	<0.0005	<5	1.62	4	0.14	0.0961	7.87	540	0.0299	<0.05	18
09-Mar-10	30	500	480	2.33	4170				1656																		
16-Mar-10	31	500	445	2.46	3190	1050	1775	#N/A	2225	<0.5	67	43	0.09	16.6	0.014	0.005	<0.0005	<5	1.35	<5	0.114	0.0859	6.76	556	0.0177	<0.05	16
23-Mar-10	32	500	485	2.58	3840				1357																		
30-Mar-10	33	500	430	2.51	3710	1100	1725	#N/A	2538	<0.5	68.2	41.3	0.089	17.8	0.013	0.004	<0.0005	<5	1.17	3	0.107	0.0903	6.78	570	0.0142	<0.05	15
06-Apr-10	34	500	470	2.30	3700				1266																		

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
11-Aug-09	0	0.373	<0.01	<0.00005	0.00073	0.002	0.27	<0.00004	2.12	0.000006	0.75	0.00837	4	0.00002	0.0035	<0.0005	<0.000002	0.0002	0.128	<0.0001
18-Aug-09	1	1.39	<0.01	<0.00005	0.00204	<0.002	0.46	0.00005	3.8	0.000005	0.75	0.0226	12	0.000075	0.00682	<0.0005	0.000002	<0.0002	0.579	<0.0001
25-Aug-09	2	4.77	<0.01	<0.00005	0.00711	0.004	0.9	0.00022	9.68	0.000026	1.44	0.0602	34	0.000062	0.009	<0.0005	0.000016	<0.0002	2.08	<0.0001
01-Sep-09	3	4.07	<0.01	<0.00005	0.0066	<0.002	1.07	0.00017	7.56	0.000025	1.1	0.0474	29	0.00013	0.00804	<0.0005	0.000012	<0.0002	2.01	<0.0001
08-Sep-09	4																			
15-Sep-09	5	9.49	<0.05	<0.0003	0.0165	<0.01	1.28	0.0002	13.4	0.00007	0.93	0.0899	57	0.00012	0.028	<0.003	0.00004	<0.001	5.45	<0.0005
22-Sep-09	6																			
29-Sep-09	7	8.14	<0.01	<0.00005	0.0134	0.002	1.26	0.00014	12.8	0.00004	0.59	0.0695	51	0.000106	0.0323	<0.0005	0.000032	<0.0002	4.23	<0.0001
06-Oct-09	8																			
13-Oct-09	9	12.9	<0.05	<0.0003	0.0238	<0.01	1.39	<0.0002	12.2	0.00012	0.47	0.101	82	0.00009	0.0395	<0.003	0.00008	<0.001	8.36	<0.0005
20-Oct-09	10																			
27-Oct-09	11	15.3	<0.2	<0.001	0.0308	<0.04	1.5	<0.0008	12.4	0.0002	0.5	0.114	82	0.0001	0.073	<0.01	0.00022	<0.004	12.2	<0.002
03-Nov-09	12																			
10-Nov-09	13	11.4	<0.2	0.002	0.0205	<0.04	1.7	<0.0008	12.3	0.0001	0.4	0.084	74	0.00011	0.0777	<0.01	0.00021	0.006	8.74	<0.002
17-Nov-09	14																			
24-Nov-09	15	10.1	<0.5	<0.003	0.017	<0.1	1.2	<0.002	9.85	<0.0003	<0.5	0.068	87	<0.0001	0.0568	<0.03	0.0002	<0.01	8.04	<0.005
01-Dec-09	16																			
08-Dec-09	17	16.6	<0.5	<0.003	0.032	<0.1	1.8	<0.002	12.1	0.0004	<0.5	0.11	80	0.0002	0.108	<0.03	0.0009	<0.01	14.9	<0.005
15-Dec-09	18																			
22-Dec-09	19	23.9	<1	<0.005	0.066	<0.2	2	<0.004	14.4	0.0006	2	0.155	133	0.0002	0.169	<0.05	0.004	<0.02	26.2	<0.01
29-Dec-09	20																			
05-Jan-10	21	43.7	<1	<0.005	0.092	<0.2	1	<0.004	22	0.0017	<1	0.18	218	<0.0002	0.278	<0.05	0.0214	<0.02	70.8	<0.01
12-Jan-10	22																			
19-Jan-10	23	69.3	<0.5	0.008	0.067	<0.1	1	<0.002	25.3	0.0014	0.8	0.145	452	0.0002	0.309	<0.03	0.0294	<0.01	113	<0.005
26-Jan-10	24																			
02-Feb-10	25	41.9	<0.5	<0.003	0.054	<0.1	0.8	<0.002	26.8	0.0017	0.9	0.098	592	0.0002	0.266	<0.03	0.0284	0.019	129	<0.005
09-Feb-10	26																			
16-Feb-10	27	15.6	<1	<0.005	0.036	<0.2	<1	<0.004	34.8	0.0014	<1	0.052	380	<0.0002	0.205	<0.05	0.0164	<0.02	94.3	<0.01
23-Feb-10	28																			
02-Mar-10	29	9.22	<1	<0.005	0.065	0.274	<1	<0.004	28.9	0.0027	<1	0.05	692	<0.0002	0.22	<0.05	0.0179	0.049	120	<0.01
09-Mar-10	30																			
16-Mar-10	31	6.01	<1	<0.005	0.06	0.285	<5	<0.004	26.8	0.0027	<5	0.04	<1000	<0.0002	0.207	<0.05	0.0125	0.057	94.8	<0.01
23-Mar-10	32																			
30-Mar-10	33	4.73	<1	<0.005	0.047	0.51	<1	<0.004	20.2	0.0044	<1	0.044	665	<0.0002	0.203	<0.05	0.0117	0.051	76	<0.01
06-Apr-10	34																			

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Volume mL Input	Volume mL Output	pH	Cond. umhos/cm	Acidity (pH 4.5) mg $CaCO_3$/L	Acidity (pH 8.3) mg $CaCO_3$/L	Alkalinity mg $CaCO_3$/L	Sulphate mg/L	Chloride mg/L	Hardness mg $CaCO_3$/L	Al mg/L	Sb mg/L	As mg/L	Ba mg/L	Be mg/L	Bi mg/L	B mg/L	Cd mg/L	Ca mg/L	Cr mg/L	Co mg/L	Cu mg/L	Fe mg/L	Pb mg/L	Li mg/L	Mg mg/L
13-Apr-10	35	500	485	2.29	3680	825.0	1775	#N/A	1430	<0.5	43.3	17.8	0.058	3.21	0.004	0.0024	<0.0001	<1	0.616	3	0.053	0.0462	4.28	282	0.006	<0.01	9
20-Apr-10	36	500	480	2.40	4160				1875																		
27-Apr-10	37	500	445	2.44	4370	850.0	1725	#N/A	1862	<0.5	35.8	33.2	0.077	12	0.004	0.0028	<0.0003	<3	0.731	<3	0.085	0.0756	5.69	456	0.0052	<0.03	9
04-May-10	38	500	485	2.45	3120				1501																		
11-May-10	39	500	425	2.62	2930	1225	1700	#N/A	2205	<0.5	36.1	33.1	0.092	17	0.003	0.0029	<0.0003	<3	0.685	4	0.087	0.0839	5.81	518	0.0057	<0.03	6
18-May-10	40	500	405	2.49	3240				1704																		
25-May-10	41	500	435	2.25	3350	1450	1775	#N/A	1277	<0.5	27.1	27.5	0.075	11.7	0.003	0.0022	<0.0003	<3	0.494	3	0.075	0.0763	4.96	438	0.0033	<0.03	5
01-Jun-10	42	500	480	2.68	3890				1266																		
08-Jun-10	43	500	405	2.17	4740	1775	2225	#N/A	1818	0.7	36.8	38.4	0.088	26.3	0.006	0.003	<0.0005	<5	0.535	6	0.105	0.105	5.25	666	0.0054	<0.05	5
15-Jun-10	44	500	445	2.69	3360				1432																		
22-Jun-10	45	500	430	2.09	2380	1100	1275	#N/A	1215	<0.5	19.3	18.1	0.047	12.4	0.003	0.0012	<0.0003	<3	0.292	4	0.058	0.0596	2.81	362	0.0049	<0.03	<3
29-Jun-10	46	500	475	2.39	2450				895																		
06-Jul-10	47	500	435	2.28	3660	1675	1925	#N/A	1582	<0.5	32.9	33	0.062	20.4	0.002	0.0022	<0.0003	<3	0.427	7	0.093	0.0933	4.26	550	0.0014	<0.03	4
13-Jul-10	48	500	470	2.40	3840				1023																		
20-Jul-10	49	500	445	2.30	4390	975.0	1300	#N/A	1325	<0.5	21.8	23.1	0.0515	15.7	0.0024	0.0017	<0.0001	<1	0.249	5	0.067	0.0774	3.12	469	0.0013	<0.01	2
27-Jul-10	50	500	460	2.22	3970				1449																		
03-Aug-10	51	500	425	2.25	3270	1025	1325	#N/A	1196	<0.5	14.8	15.1	0.0358	13.7	0.0016	0.0011	<0.0001	<1	0.161	4	0.048	0.0588	2.05	344	0.0031	<0.01	1
10-Aug-10	52	500	435	2.17	4580				2273																		
17-Aug-10	53	500	440	2.25	3150	1050	1325	#N/A	1080	<0.5	12.3	11.3	0.0307	11.1	0.0011	0.00088	<0.00003	<0.3	0.116	3.2	0.0335	0.0445	1.39	264	0.00099	0.004	1
24-Aug-10	54	500	495	2.13	1940				346																		
31-Aug-10	55	500	430	2.21	2120	1025	1300	#N/A	989	<0.5	11.5	10.2	0.02	10.5	0.0006	0.0008	<0.00005	<0.5	0.0894	3	0.034	0.0399	1.28	223	0.00055	<0.005	1
07-Sep-10	56	500	430	2.37	2570				1029																		
14-Sep-10	57	500	445	2.17	2260	1000	1275	#N/A	957	<0.5	30.3	11.3	0.0195	14.5	<0.0004	0.0009	<0.0001	<1	0.0895	10	0.039	0.0445	1.32	264	0.0003	<0.01	1
21-Sep-10	58	500	465	2.30	2590				960																		
28-Sep-10	59	500	455	2.39	2420	1025	1275	#N/A	946	0.7	15.5	11.5	0.0205	15.9	0.0005	0.001	<0.0001	<1	0.0914	4	0.042	0.0451	1.38	270	0.0008	<0.01	1

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

Results of Leachate Analysis

Date	Cycle No.	Mn	Hg	Mo	Ni	P	K	Se	Si	Ag	Na	Sr	S	Tl	Sn	Ti	U	V	Zn	Zr
		mg/L	ug/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
13-Apr-10	35	2.78	<0.2	<0.001	0.0292	0.075	<1	<0.0008	18.6	0.0014	<1	0.031	329	0.00033	0.107	0.011	0.00609	0.037	37.7	<0.002
20-Apr-10	36																			
27-Apr-10	37	2.69	<0.5	<0.003	0.042	0.424	<3	<0.002	22.6	0.0038	<3	0.037	549	0.0001	0.153	<0.03	0.0078	0.043	40.4	<0.005
04-May-10	38																			
11-May-10	39	2.15	<0.5	<0.003	0.043	0.562	<3	<0.002	22.1	0.0039	<3	0.041	651	<0.0001	0.147	<0.03	0.0072	0.031	35.2	<0.005
18-May-10	40																			
25-May-10	41	1.85	<0.5	<0.003	0.039	0.471	<3	<0.002	18	0.0065	<3	0.038	531	0.0001	0.112	<0.03	0.007	0.032	23.7	<0.005
01-Jun-10	42																			
08-Jun-10	43	1.94	<1	<0.005	0.063	1.3	<5	<0.004	25.9	0.0066	<5	0.041	<1000	<0.0002	0.126	<0.05	0.0076	0.041	25.1	<0.01
15-Jun-10	44																			
22-Jun-10	45	1.21	<0.5	<0.003	0.029	0.642	<3	<0.002	12.7	0.0078	<3	0.023	<500	0.0001	0.0699	<0.03	0.0045	0.02	13.5	<0.005
29-Jun-10	46																			
06-Jul-10	47	1.98	<0.5	<0.003	0.047	1.31	<3	<0.002	20.4	0.003	<3	0.042	643	<0.0001	0.104	<0.03	0.0065	0.03	18.8	<0.005
13-Jul-10	48																			
20-Jul-10	49	1.15	<0.2	<0.001	0.0404	0.918	<1	<0.0008	15.3	0.0019	<1	0.033	479	0.00007	0.0936	<0.01	0.0046	0.024	10.7	<0.002
27-Jul-10	50																			
03-Aug-10	51	0.709	<0.2	<0.001	0.031	0.872	<1	<0.0008	11	0.0027	<1	0.023	434	0.00013	0.0599	<0.01	0.00299	0.011	7.85	<0.002
10-Aug-10	52																			
17-Aug-10	53	0.513	<0.05	0.0006	0.0202	0.804	<0.3	0.0002	8.84	0.00165	<0.3	0.0179	352	0.00006	0.0426	<0.003	0.00209	0.009	5.47	<0.0005
24-Aug-10	54																			
31-Aug-10	55	0.524	<0.1	<0.0005	0.0176	0.836	<0.5	<0.0004	6.45	0.00144	<0.5	0.0135	288	0.00005	0.0342	<0.005	0.00197	0.006	4.45	<0.001
07-Sep-10	56																			
14-Sep-10	57	0.591	<0.2	<0.001	0.0279	1.32	<1	<0.0008	7.66	0.0009	<1	0.014	313	0.00006	0.0408	0.023	0.00325	0.007	4.32	<0.002
21-Sep-10	58																			
28-Sep-10	59	0.601	<0.2	<0.001	0.0231	1.41	<1	<0.0008	7.72	0.0006	<1	0.013	312	<0.00004	0.0409	<0.01	0.00271	0.006	4.3	<0.002

Notes: Values in red are below the detection limit. For calculation purposes, values below detection were set at half the value of the analytical limit.

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

Weekly Production

(mg/kg/wk)

Date	Cycle	pH	Alkalinity mg $CaCO_3$/kg	SO_4 mg/kg	Al mg/kg/wk	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg
11-Aug-09	0	7.35	1.5876	3.24	0.0010	0.00351	0.004739	0.0127	0.00000203	0.000001013	0.01013	0.00047790
18-Aug-09	1	5.47	0.3675	12.74	0.0041	0.00715	0.012446	0.0357	0.00000980	0.000001225	0.01225	0.00308700
25-Aug-09	2	5.79	0.5699	38.54	0.0157	0.00816	0.019024	0.0492	0.00002870	0.000001025	0.01025	0.00914300
01-Sep-09	3	5.65	1.08135	40.94	0.0203	0.00966	0.026923	0.0296	0.00003115	0.000001113	0.01113	0.00952300
08-Sep-09	4	5.41	0.946125	68.73	0.0428	0.01077	0.039041	0.0253	0.00005655	0.000003806	0.03806	0.01646475
15-Sep-09	5	5.39	0.8256	74.82	0.0649	0.01195	0.051170	0.0213	0.00008170	0.000006450	0.06450	0.02334900
22-Sep-09	6	5.64	0.527325	72.09	0.0627	0.01206	0.047993	0.0170	0.00008455	0.000003894	0.03894	0.02229450
29-Sep-09	7	4.99	0.19125	62.9	0.0557	0.01122	0.041098	0.0113	0.00008075	0.000001063	0.01063	0.01950750
06-Oct-09	8	4.8	#N/A	80.84	0.1248	0.01152	0.038094	0.0131	0.00015980	0.000004113	0.04113	0.03278250
13-Oct-09	9	4.49	#N/A	115.15	0.1880	0.01062	0.030738	0.0137	0.00023030	0.000007050	0.07050	0.04399200
20-Oct-09	10	4.3	#N/A	105.3	0.2570	0.01062	0.034628	0.0114	0.00033525	0.000014625	0.14625	0.05391000
27-Oct-09	11	4.18	#N/A	116.16	0.3265	0.01082	0.038940	0.0094	0.00044000	0.000022000	0.22000	0.06424000
03-Nov-09	12	4.21	#N/A	125.84	0.3606	0.01089	0.023738	0.0097	0.00052000	0.000026000	0.26000	0.06604000
10-Nov-09	13	4.72	0.44805	77.865	0.2806	0.00753	0.001218	0.0069	0.00043500	0.000021750	0.21750	0.04698000
17-Nov-09	14	3.96	#N/A	84.63	0.2864	0.00621	0.001092	0.0072	0.00040950	0.000045500	0.45500	0.04891250
24-Nov-09	15	4.08	#N/A	92.31	0.3131	0.00510	0.001020	0.0082	0.00040800	0.000076500	0.76500	0.05457000
01-Dec-09	16	3.84	#N/A	99.82	0.7461	0.00483	0.003450	0.0069	0.00082800	0.000069000	0.69000	0.07636000
08-Dec-09	17	3.66	#N/A	129.12	1.2624	0.00528	0.006240	0.0067	0.00134400	0.000072000	0.72000	0.10800000
15-Dec-09	18	3.62	#N/A	142.88	3.1796	0.00705	0.018330	0.0063	0.00230300	0.000094000	0.94000	0.16779000
22-Dec-09	19	3.25	#N/A	213.85	5.1230	0.00893	0.030550	0.0061	0.00329000	0.000117500	1.17500	0.22983000
29-Dec-09	20	3.04	#N/A	242.73	14.2988	0.01465	0.317363	0.0053	0.00511500	0.000116250	1.16250	0.39269250
05-Jan-10	21	2.87	#N/A	412.02	21.2520	0.01848	0.546000	0.0042	0.00630000	0.000105000	1.05000	0.50400000
12-Jan-10	22	2.53	#N/A	615.76	25.5420	0.02172	0.911600	0.0039	0.00617050	0.000086000	0.86000	0.60415000
19-Jan-10	23	2.63	#N/A	536.36	30.0080	0.02508	1.293600	0.0035	0.00602800	0.000066000	0.66000	0.70840000
26-Jan-10	24	2.71	#N/A	672.075	28.8405	0.02828	2.399025	0.0033	0.00485025	0.000065250	0.65250	0.70687500
02-Feb-10	25	2.89	#N/A	736.2	28.9800	0.03285	3.640500	0.0032	0.00387000	0.000067500	0.67500	0.73800000
09-Feb-10	26	2.1	#N/A	748.245	21.8705	0.02905	2.678825	0.0021	0.00282200	0.000083000	0.83000	0.59552500
16-Feb-10	27	2.41	#N/A	682.18	18.8600	0.03082	2.217200	0.0014	0.00230000	0.000115000	1.15000	0.56580000
23-Feb-10	28	2.21	#N/A	686.275	24.0560	0.04220	6.309850	0.0017	0.00266750	0.000121250	1.21250	0.69112500
02-Mar-10	29	2.2	#N/A	890.33	22.9890	0.04227	8.374000	0.0016	0.00237000	0.000098750	0.98750	0.63990000
09-Mar-10	30	2.33	#N/A	794.88	24.2880	0.04728	9.072000	0.0043	0.00264000	0.000120000	1.20000	0.71280000
16-Mar-10	31	2.46	#N/A	990.125	19.1350	0.04005	7.387000	0.0062	0.00222500	0.000111250	1.11250	0.60075000
23-Mar-10	32	2.58	#N/A	658.145	20.4428	0.04341	8.342000	0.0065	0.00218250	0.000121250	1.21250	0.61110000
30-Mar-10	33	2.51	#N/A	1091.34	17.7590	0.03827	7.654000	0.0056	0.00172000	0.000107500	1.07500	0.50310000
06-Apr-10	34	2.3	#N/A	595.02	13.8885	0.03455	4.937350	0.0040	0.00150400	0.000070500	0.70500	0.41971000
13-Apr-10	35	2.29	#N/A	693.55	8.6330	0.02813	1.556850	0.0019	0.00116400	0.000024250	0.24250	0.29876000
20-Apr-10	36	2.4	#N/A	900	12.2400	0.03240	3.650400	0.0019	0.00124800	0.000048000	0.48000	0.32328000
27-Apr-10	37	2.44	#N/A	828.59	14.7740	0.03427	5.340000	0.0018	0.00124600	0.000066750	0.66750	0.32529500
04-May-10	38	2.45	#N/A	727.985	16.0778	0.04098	7.032500	0.0017	0.00138225	0.000072750	0.72750	0.34338000
11-May-10	39	2.62	#N/A	937.125	14.0675	0.03910	7.225000	0.0013	0.00123250	0.000063750	0.63750	0.29112500
18-May-10	40	2.49	#N/A	690.12	12.2715	0.03382	5.811750	0.0012	0.00103275	0.000060750	0.60750	0.23874750
25-May-10	41	2.25	#N/A	555.495	11.9625	0.03263	5.089500	0.0013	0.00095700	0.000065250	0.65250	0.21489000
01-Jun-10	42	2.68	#N/A	607.68	15.8160	0.03912	9.120000	0.0022	0.00124800	0.000096000	0.96000	0.24696000
08-Jun-10	43	2.17	#N/A	736.29	15.5520	0.03564	#######	0.0024	0.00121500	0.000101250	1.01250	0.21667500
15-Jun-10	44	2.69	#N/A	637.24	8.5440	0.01958	5.851750	0.0013	0.00066750	0.000055625	0.55625	0.11903750
22-Jun-10	45	2.09	#N/A	522.45	7.7830	0.02021	5.332000	0.0013	0.00051600	0.000064500	0.64500	0.12556000
29-Jun-10	46	2.39	#N/A	425.125	4.2988	0.01116	2.945000	0.0007	0.00028500	0.000035625	0.35625	0.06935000
06-Jul-10	47	2.28	#N/A	688.17	14.3550	0.02697	8.874000	0.0009	0.00095700	0.000065250	0.65250	0.18574500
13-Jul-10	48	2.4	#N/A	480.81	7.7550	0.01457	4.794000	0.0005	0.00051700	0.000035250	0.35250	0.10034500
20-Jul-10	49	2.3	#N/A	589.625	10.2795	0.02292	6.986500	0.0011	0.00075650	0.000022250	0.22250	0.11080500
27-Jul-10	50	2.22	#N/A	666.54	5.3130	0.01185	3.611000	0.0006	0.00039100	0.000011500	0.11500	0.05727000
03-Aug-10	51	2.25	#N/A	508.3	6.4175	0.01522	5.822500	0.0007	0.00046750	0.000021250	0.21250	0.06842500
10-Aug-10	52	2.17	#N/A	988.755	3.2843	0.00779	2.979750	0.0003	0.00023925	0.000010875	0.10875	0.03501750
17-Aug-10	53	2.25	#N/A	475.2	4.9720	0.01351	4.884000	0.0005	0.00038720	0.000006600	0.06600	0.05104000
24-Aug-10	54	2.13	#N/A	171.27	2.7968	0.00760	2.747250	0.0003	0.00021780	0.000003713	0.03713	0.02871000
31-Aug-10	55	2.21	#N/A	425.27	4.3860	0.00860	4.515000	0.0003	0.00034400	0.000010750	0.10750	0.03844200
07-Sep-10	56	2.37	#N/A	442.47	2.1930	0.00430	2.257500	0.0001	0.00017200	0.000005375	0.05375	0.01922100
14-Sep-10	57	2.17	#N/A	425.865	5.0285	0.00868	6.452500	0.0001	0.00040050	0.000022250	0.22250	0.03982750
21-Sep-10	58	2.3	#N/A	446.4	2.6273	0.00453	3.371250	0.0000	0.00020925	0.000011625	0.11625	0.02080875
28-Sep-10	59	2.39	#N/A	430.43	5.2325	0.00933	7.234500	0.0002	0.00045500	0.000022750	0.22750	0.04158700

Date	Cycle	Ca mg/kg	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg
11-Aug-09	0	1.31	0.0000203	0.0001179	0.00322	0.00162	0.000232	0.000243	0.22	0.151065	0.00000203	0.00001	0.00030	0.000810	0.10935
18-Aug-09	1	4.43	0.0000245	0.0005341	0.02034	0.01568	0.003930	0.000833	0.72	0.681100	0.00000245	0.00001	0.00100	0.000490	0.22540
25-Aug-09	2	11.36	0.0000205	0.0016974	0.04223	0.04879	0.004592	0.001681	2.06	1.955700	0.00000205	0.00001	0.00292	0.001640	0.36900
01-Sep-09	3	10.10	0.0000223	0.0017133	0.05029	0.04762	0.005563	0.001558	1.99	1.811150	0.00000223	0.00001	0.00294	0.000445	0.47615
08-Sep-09	4	14.29	0.0000653	0.0029167	0.09135	0.13050	0.006025	0.002066	3.13	2.949300	0.00000653	0.00004	0.00502	0.001305	0.51113
15-Sep-09	5	18.49	0.0001075	0.0041108	0.13201	0.21199	0.006536	0.002580	4.26	4.080700	0.00001075	0.00006	0.00710	0.002150	0.55040
22-Sep-09	6	17.24	0.0000668	0.0041207	0.12705	0.22962	0.005456	0.002759	4.16	3.922675	0.00000668	0.00004	0.00665	0.001558	0.56515
29-Sep-09	7	14.66	0.0000213	0.0038080	0.11220	0.22908	0.003961	0.002720	3.74	3.459500	0.00000213	0.00001	0.00570	0.000850	0.53550
06-Oct-09	8	19.46	0.0000705	0.0057011	0.21526	0.18330	0.005151	0.003149	5.38	4.944400	0.00000705	0.00004	0.00874	0.001645	0.62275
13-Oct-09	9	22.70	0.0001175	0.0071910	0.30644	0.11327	0.005922	0.003290	6.63	6.063000	0.00001175	0.00007	0.01119	0.002350	0.65330
20-Oct-09	10	20.99	0.0002813	0.0076725	0.42345	0.16853	0.007065	0.002700	6.50	6.345000	0.00002813	0.00015	0.01229	0.005625	0.65025
27-Oct-09	11	19.80	0.0004400	0.0082720	0.54120	0.22352	0.008272	0.002200	6.51	6.732000	0.00004400	0.00022	0.01355	0.008800	0.66000
03-Nov-09	12	20.23	0.0005200	0.0089180	0.60320	0.55068	0.007878	0.002600	7.10	6.942000	0.00005200	0.00065	0.01334	0.010400	0.83200
10-Nov-09	13	14.27	0.0004350	0.0067425	0.47415	0.70035	0.005003	0.002175	5.44	4.959000	0.00004350	0.00087	0.00892	0.008700	0.73950
17-Nov-09	14	13.33	0.0007963	0.0070070	0.50960	0.79625	0.005233	0.004550	5.41	4.891250	0.00007963	0.00080	0.00853	0.015925	0.65975
24-Nov-09	15	13.16	0.0012750	0.0078030	0.58650	0.96390	0.005865	0.007650	5.76	5.151000	0.00012750	0.00077	0.00867	0.025500	0.61200
01-Dec-09	16	14.05	0.0011500	0.0097980	1.03500	1.76180	0.015364	0.006900	6.83	6.141000	0.00011500	0.00069	0.01127	0.023000	0.69000
08-Dec-09	17	16.94	0.0012000	0.0131040	1.60800	2.76960	0.026544	0.007200	8.83	7.968000	0.00012000	0.00072	0.01536	0.024000	0.86400
15-Dec-09	18	18.40	0.0017625	0.0172960	2.68605	4.55195	0.020751	0.009400	9.96	9.517500	0.00017625	0.00094	0.02303	0.035250	0.89300
22-Dec-09	19	20.21	0.0023500	0.0217610	3.79760	6.39200	0.015510	0.011750	11.28	11.233000	0.00023500	0.00118	0.03102	0.047000	0.94000
29-Dec-09	20	18.60	0.0113925	0.0303878	5.69160	16.85625	0.029760	0.011625	11.16	15.717000	0.00023250	0.00116	0.03674	0.046500	0.69750
05-Jan-10	21	15.54	0.0184800	0.0354480	6.88800	24.73800	0.039900	0.010500	10.08	18.354000	0.00021000	0.00105	0.03864	0.042000	0.42000
12-Jan-10	22	11.91	0.0294550	0.0422260	6.51450	42.11850	0.040764	0.008600	8.41	24.295000	0.00016125	0.00226	0.03419	0.032250	0.43000
19-Jan-10	23	8.10	0.0409200	0.0492800	6.11600	60.28000	0.041624	0.006600	6.64	30.492000	0.00011000	0.00352	0.02948	0.022000	0.44000
26-Jan-10	24	5.61	0.0452400	0.0443483	5.11125	87.65250	0.036344	0.006525	6.16	24.186000	0.00010875	0.00207	0.02632	0.021750	0.39150
02-Feb-10	25	3.33	0.0517500	0.0413550	4.32000	119.70000	0.032625	0.006750	5.94	18.855000	0.00011250	0.00068	0.02430	0.022500	0.36000
09-Feb-10	26	2.57	0.0408775	0.0315608	3.29925	123.25500	0.019982	0.008300	5.44	11.931250	0.00015563	0.00083	0.01868	0.031125	0.26975
16-Feb-10	27	2.30	0.0377200	0.0276920	2.89800	150.88000	0.010948	0.011500	5.98	7.176000	0.00023000	0.00115	0.01656	0.046000	0.23000
23-Feb-10	28	2.18	0.0538350	0.0379028	3.43623	210.49000	0.013022	0.012125	7.52	6.018850	0.00024250	0.00121	0.02449	0.090695	0.24250
02-Mar-10	29	1.58	0.0553000	0.0379595	3.10865	213.30000	0.011811	0.009875	7.11	3.641900	0.00019750	0.00099	0.02568	0.108230	0.19750
09-Mar-10	30	1.56	0.0609600	0.0436800	3.51120	263.04000	0.011424	0.012000	8.16	3.655200	0.00024000	0.00120	0.03000	0.134160	0.72000
16-Mar-10	31	1.11	0.0507300	0.0382255	3.00820	247.42000	0.007877	0.011125	7.12	2.674450	0.00022250	0.00111	0.02670	0.126825	1.11250
23-Mar-10	32	1.33	0.0535925	0.0427285	3.28345	273.05500	0.007736	0.012125	7.52	2.604450	0.00024250	0.00121	0.02595	0.192788	0.72750
30-Mar-10	33	1.29	0.0460100	0.0388290	2.91540	245.10000	0.006106	0.010750	6.45	2.033900	0.00021500	0.00108	0.02021	0.219300	0.21500
06-Apr-10	34	1.41	0.0376000	0.0320775	2.59910	200.22000	0.004747	0.007050	5.64	1.764850	0.00014100	0.00071	0.01791	0.137475	0.23500
13-Apr-10	35	1.46	0.0257050	0.0224070	2.07580	136.77000	0.002910	0.002425	4.37	1.348300	0.00004850	0.00024	0.01416	0.036375	0.24250
20-Apr-10	36	1.08	0.0331200	0.0292320	2.39280	177.12000	0.002688	0.004800	4.32	1.312800	0.00008400	0.00048	0.01709	0.119760	0.48000
27-Apr-10	37	0.67	0.0378250	0.0336420	2.53205	202.92000	0.002314	0.006675	4.01	1.197050	0.00011125	0.00067	0.01869	0.188680	0.66750
04-May-10	38	1.33	0.0417100	0.0386788	2.78875	236.19500	0.002643	0.007275	3.64	1.173700	0.00012125	0.00073	0.02061	0.239105	0.72750
11-May-10	39	1.70	0.0369750	0.0356575	2.46925	220.15000	0.002423	0.006375	2.55	0.913750	0.00010625	0.00064	0.01828	0.238850	0.63750
18-May-10	40	1.42	0.0328050	0.0324405	2.18093	193.59000	0.001823	0.006075	2.23	0.810000	0.00010125	0.00061	0.01661	0.209183	0.60750
25-May-10	41	1.31	0.0326250	0.0331905	2.15760	190.53000	0.001436	0.006525	2.18	0.804750	0.00010875	0.00065	0.01697	0.204885	0.65250
01-Jun-10	42	2.16	0.0432000	0.0435120	2.45040	264.96000	0.002088	0.009600	2.40	0.909600	0.00018000	0.00096	0.02448	0.425040	0.96000
08-Jun-10	43	2.43	0.0425250	0.0425250	2.12625	269.73000	0.002187	0.010125	2.03	0.785700	0.00020250	0.00101	0.02552	0.526500	1.01250
15-Jun-10	44	1.34	0.0233625	0.0233625	1.16813	148.18500	0.001202	0.005563	1.11	0.431650	0.00011125	0.00056	0.01402	0.289250	0.55625
22-Jun-10	45	1.72	0.0249400	0.0256280	1.20830	155.66000	0.002107	0.006450	0.65	0.520300	0.00010750	0.00065	0.01247	0.276060	0.64500
29-Jun-10	46	0.95	0.0137750	0.0141550	0.66738	85.97500	0.001164	0.003563	0.36	0.287375	0.00005938	0.00036	0.00689	0.152475	0.35625
06-Jul-10	47	3.05	0.0404550	0.0405855	1.85310	239.25000	0.000609	0.006525	1.74	0.861300	0.00010875	0.00065	0.02045	0.569850	0.65250
13-Jul-10	48	1.65	0.0218550	0.0219255	1.00110	129.25000	0.000329	0.003525	0.94	0.465300	0.00005875	0.00035	0.01105	0.307850	0.35250
20-Jul-10	49	2.23	0.0298150	0.0344430	1.38840	208.70500	0.000579	0.002225	0.89	0.511750	0.00004450	0.00022	0.01798	0.408510	0.22250
27-Jul-10	50	1.15	0.0154100	0.0178020	0.71760	107.87000	0.000299	0.001150	0.46	0.264500	0.00002300	0.00012	0.00929	0.211140	0.11500
03-Aug-10	51	1.70	0.0204000	0.0249900	0.87125	146.20000	0.001318	0.002125	0.43	0.301325	0.00004250	0.00021	0.01318	0.370600	0.21250
10-Aug-10	52	0.87	0.0104400	0.0127890	0.44588	74.82000	0.000674	0.001088	0.22	0.154208	0.00002175	0.00011	0.00674	0.189660	0.10875
17-Aug-10	53	1.41	0.0147400	0.0195800	0.61160	116.16000	0.000436	0.001760	0.44	0.225720	0.00001100	0.00026	0.00889	0.353760	0.06600
24-Aug-10	54	0.79	0.0082913	0.0110138	0.34403	65.34000	0.000245	0.000990	0.25	0.126968	0.00000619	0.00015	0.00500	0.198990	0.03713
31-Aug-10	55	1.29	0.0146200	0.0171570	0.55040	95.89000	0.000237	0.001075	0.43	0.225320	0.00002150	0.00011	0.00757	0.359480	0.10750
07-Sep-10	56	0.65	0.0073100	0.0085785	0.27520	47.94500	0.000118	0.000538	0.22	0.112660	0.00001075	0.00005	0.00378	0.179740	0.05375
14-Sep-10	57	4.45	0.0173550	0.0198025	0.58740	117.48000	0.000134	0.002225	0.45	0.262995	0.00004450	0.00022	0.01242	0.587400	0.22250
21-Sep-10	58	2.33	0.0090675	0.0103463	0.30690	61.38000	0.000070	0.001163	0.23	0.137408	0.00002325	0.00012	0.00649	0.306900	0.11625
28-Sep-10	59	1.82	0.0191100	0.0205205	0.62790	122.85000	0.000364	0.002275	0.46	0.273455	0.00004550	0.00023	0.01051	0.641550	0.22750

Date	Cycle	Se mg/kg	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
11-Aug-09	0	0.00001	0.859	0.000002430	0.3038	0.00339	1.62	0.00000810	0.0014175	0.0001013	0.000000	0.000081	0.05184	0.00002
18-Aug-09	1	0.00002	1.862	0.000002450	0.3675	0.01107	5.88	0.00003675	0.0033418	0.0001225	0.000001	0.000049	0.28371	0.00002
25-Aug-09	2	0.00009	3.969	0.000010660	0.5904	0.02468	13.94	0.00002542	0.0036900	0.0001025	0.000007	0.000041	0.85280	0.00002
01-Sep-09	3	0.00008	3.364	0.000011125	0.4895	0.02109	12.91	0.00005785	0.0035778	0.0001113	0.000005	0.000045	0.89445	0.00002
08-Sep-09	4	0.00008	4.559	0.000020663	0.4415	0.02986	18.71	0.00005438	0.0078387	0.0003806	0.000011	0.000131	1.62255	0.00007
15-Sep-09	5	0.00009	5.762	0.000030100	0.3999	0.03866	24.51	0.00005160	0.0120400	0.0006450	0.000017	0.000215	2.34350	0.00011
22-Sep-09	6	0.00008	5.830	0.000024475	0.3382	0.03547	24.03	0.00005029	0.0134168	0.0003894	0.000016	0.000134	2.15380	0.00007
29-Sep-09	7	0.00006	5.440	0.000017000	0.2508	0.02954	21.68	0.00004505	0.0137275	0.0001063	0.000014	0.000043	1.79775	0.00002
06-Oct-09	8	0.00006	5.875	0.000037600	0.2491	0.04007	31.26	0.00004606	0.0168730	0.0004113	0.000026	0.000141	2.95865	0.00007
13-Oct-09	9	0.00005	5.734	0.000056400	0.2209	0.04747	38.54	0.00004230	0.0185650	0.0007050	0.000038	0.000235	3.92920	0.00012
20-Oct-09	10	0.00011	5.535	0.000072000	0.2183	0.04838	36.90	0.00004275	0.0253125	0.0014625	0.000068	0.000563	4.62600	0.00028
27-Oct-09	11	0.00018	5.456	0.000088000	0.2200	0.05016	36.08	0.00004400	0.0321200	0.0022000	0.000097	0.000880	5.36800	0.00044
03-Nov-09	12	0.00021	6.422	0.000078000	0.2340	0.05148	40.56	0.00005460	0.0391820	0.0026000	0.000112	0.002080	5.44440	0.00052
10-Nov-09	13	0.00017	5.351	0.000043500	0.1740	0.03654	32.19	0.00004785	0.0337995	0.0021750	0.000091	0.002610	3.80190	0.00044
17-Nov-09	14	0.00032	5.039	0.000056875	0.1479	0.03458	36.63	0.00003640	0.0305988	0.0045500	0.000093	0.002503	3.81745	0.00080
24-Nov-09	15	0.00051	5.024	0.000076500	0.1275	0.03468	44.37	0.00002550	0.0289680	0.0076500	0.000102	0.002550	4.10040	0.00128
01-Dec-09	16	0.00046	5.049	0.000126500	0.1150	0.04094	38.41	0.00005750	0.0379040	0.0069000	0.000253	0.002300	5.27620	0.00115
08-Dec-09	17	0.00048	5.808	0.000192000	0.1200	0.05280	38.40	0.00009600	0.0518400	0.0072000	0.000432	0.002400	7.15200	0.00120
15-Dec-09	18	0.00071	6.228	0.000235000	0.5288	0.06228	50.06	0.00009400	0.0650950	0.0094000	0.001152	0.003525	9.65850	0.00176
22-Dec-09	19	0.00094	6.768	0.000282000	0.9400	0.07285	62.51	0.00009400	0.0794300	0.0117500	0.001880	0.004700	12.31400	0.00235
29-Dec-09	20	0.00093	8.463	0.000534750	0.5813	0.07789	81.61	0.00006975	0.1039275	0.0116250	0.005906	0.004650	22.55250	0.00233
05-Jan-10	21	0.00084	9.240	0.000714000	0.2100	0.07560	91.56	0.00004200	0.1167600	0.0105000	0.008988	0.004200	29.73600	0.00210
12-Jan-10	22	0.00065	10.170	0.000666500	0.2795	0.06988	144.05	0.00006450	0.1262050	0.0086000	0.010922	0.003225	39.51700	0.00161
19-Jan-10	23	0.00044	11.132	0.000616000	0.3520	0.06380	198.88	0.00008800	0.1359600	0.0066000	0.012936	0.002200	49.72000	0.00110
26-Jan-10	24	0.00044	11.332	0.000674250	0.3698	0.05285	227.07	0.00008700	0.1250625	0.0065250	0.012572	0.005220	52.63500	0.00109
02-Feb-10	25	0.00045	12.060	0.000765000	0.4050	0.04410	266.40	0.00009000	0.1197000	0.0067500	0.012780	0.008550	58.05000	0.00113
09-Feb-10	26	0.00062	12.782	0.000643250	0.2905	0.03113	201.69	0.00006225	0.0977325	0.0083000	0.009296	0.006018	46.33475	0.00156
16-Feb-10	27	0.00092	16.008	0.000644000	0.2300	0.02392	174.80	0.00004600	0.0943000	0.0115000	0.007544	0.004600	43.37800	0.00230
23-Feb-10	28	0.00097	15.447	0.000994250	0.2425	0.02474	259.96	0.00004850	0.1030625	0.0121250	0.008318	0.014308	51.96775	0.00243
02-Mar-10	29	0.00079	11.416	0.001066500	0.1975	0.01975	273.34	0.00003950	0.0869000	0.0098750	0.007071	0.019355	47.40000	0.00198
09-Mar-10	30	0.00096	13.368	0.001296000	0.7200	0.02160	286.08	0.00004800	0.1024800	0.0120000	0.007296	0.025440	51.55200	0.00240
16-Mar-10	31	0.00089	11.926	0.001201500	1.1125	0.01780	222.50	0.00004450	0.0921150	0.0111250	0.005563	0.025365	42.18600	0.00223
23-Mar-10	32	0.00097	11.398	0.001721750	0.7275	0.02037	282.51	0.00004850	0.0994250	0.0121250	0.005869	0.026190	41.41900	0.00243
30-Mar-10	33	0.00086	8.686	0.001892000	0.2150	0.01892	285.95	0.00004300	0.0872900	0.0107500	0.005031	0.021930	32.68000	0.00215
06-Apr-10	34	0.00056	9.118	0.001363000	0.2350	0.01763	233.59	0.00010105	0.0728500	0.0084600	0.004181	0.020680	26.71950	0.00141
13-Apr-10	35	0.00019	9.021	0.000679000	0.2425	0.01504	159.57	0.00016005	0.0518950	0.0053350	0.002954	0.017945	18.28450	0.00049
20-Apr-10	36	0.00034	9.888	0.001248000	0.4800	0.01632	210.72	0.00010320	0.0624000	0.0062400	0.003334	0.019200	18.74400	0.00084
27-Apr-10	37	0.00045	10.057	0.001691000	0.6675	0.01647	244.31	0.00004450	0.0680850	0.0066750	0.003471	0.019135	17.97800	0.00111
04-May-10	38	0.00049	10.840	0.001867250	0.7275	0.01892	291.00	0.00003638	0.0727500	0.0072750	0.003638	0.017945	18.33300	0.00121
11-May-10	39	0.00043	9.393	0.001657500	0.6375	0.01743	276.68	0.00002125	0.0624750	0.0063750	0.003060	0.013175	14.96000	0.00106
18-May-10	40	0.00041	8.120	0.002106000	0.6075	0.01600	239.36	0.00003038	0.0524475	0.0060750	0.002876	0.012758	11.92725	0.00101
25-May-10	41	0.00044	7.830	0.002827500	0.6525	0.01653	230.99	0.00004350	0.0487200	0.0065250	0.003045	0.013920	10.30950	0.00109
01-Jun-10	42	0.00072	10.536	0.003144000	0.9600	0.01896	247.44	0.00004800	0.0571200	0.0096000	0.003504	0.017520	11.71200	0.00180
08-Jun-10	43	0.00081	10.490	0.002673000	1.0125	0.01661	202.50	0.00004050	0.0510300	0.0101250	0.003078	0.016605	10.16550	0.00203
15-Jun-10	44	0.00045	5.763	0.001468500	0.5563	0.00912	111.25	0.00002225	0.0280350	0.0055625	0.001691	0.009123	5.58475	0.00111
22-Jun-10	45	0.00043	5.461	0.003354000	0.6450	0.00989	107.50	0.00004300	0.0300570	0.0064500	0.001935	0.008600	5.80500	0.00108
29-Jun-10	46	0.00024	3.016	0.001852500	0.3563	0.00546	59.38	0.00002375	0.0166013	0.0035625	0.001069	0.004750	3.20625	0.00059
06-Jul-10	47	0.00044	8.874	0.001305000	0.6525	0.01827	279.71	0.00002175	0.0452400	0.0065250	0.002828	0.013050	8.17800	0.00109
13-Jul-10	48	0.00024	4.794	0.000705000	0.3525	0.00987	151.11	0.00001175	0.0244400	0.0035250	0.001528	0.007050	4.41800	0.00059
20-Jul-10	49	0.00018	6.809	0.000845500	0.2225	0.01469	213.16	0.00003115	0.0416520	0.0022250	0.002047	0.010680	4.76150	0.00045
27-Jul-10	50	0.00009	3.519	0.000437000	0.1150	0.00759	110.17	0.00001610	0.0215280	0.0011500	0.001058	0.005520	2.46100	0.00023
03-Aug-10	51	0.00017	4.675	0.001147500	0.2125	0.00978	184.45	0.00005525	0.0254575	0.0021250	0.001271	0.004675	3.33625	0.00043
10-Aug-10	52	0.00009	2.393	0.000587250	0.1088	0.00500	94.40	0.00002828	0.0130283	0.0010875	0.000650	0.002393	1.70738	0.00022
17-Aug-10	53	0.00009	3.890	0.000726000	0.0660	0.00788	154.88	0.00002640	0.0187440	0.0006600	0.000920	0.003960	2.40680	0.00011
24-Aug-10	54	0.00005	2.188	0.000408375	0.0371	0.00443	87.12	0.00001485	0.0105435	0.0003713	0.000517	0.002228	1.35383	0.00006
31-Aug-10	55	0.00009	2.774	0.000619200	0.1075	0.00581	123.84	0.00002150	0.0147060	0.0010750	0.000847	0.002580	1.91350	0.00022
07-Sep-10	56	0.00004	1.387	0.000309600	0.0538	0.00290	61.92	0.00001075	0.0073530	0.0005375	0.000424	0.001290	0.95675	0.00011
14-Sep-10	57	0.00018	3.409	0.000400500	0.2225	0.00623	139.29	0.00002670	0.0181560	0.0102350	0.001446	0.003115	1.92240	0.00045
21-Sep-10	58	0.00009	1.781	0.000209250	0.1163	0.00326	72.77	0.00001395	0.0094860	0.0053475	0.000756	0.001628	1.00440	0.00023
28-Sep-10	59	0.00018	3.513	0.000273000	0.2275	0.00592	141.96	0.00000910	0.0186095	0.0022750	0.001233	0.002730	1.95650	0.00046

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

Cumulative Metal Production (mg/kg)

Date	Cycle No.	SO4 mg/kg	Al mg/kg	Sb mg/kg	As mg/kg	Ba mg/kg	Be mg/kg	Bi mg/kg	B mg/kg	Cd mg/kg	Ca mg/kg
11-Aug-09	0	3.2	0.0010	0.00351	0.00474	0.0127	0.0000020	0.0000010	0.010125	0.0004779	1.31
18-Aug-09	1	16.0	0.0051	0.01066	0.01718	0.0484	0.0000118	0.0000022	0.022375	0.0035649	5.7
25-Aug-09	2	54.5	0.0208	0.01882	0.03621	0.0976	0.0000405	0.0000033	0.032625	0.0127079	17.1
01-Sep-09	3	95.5	0.0410	0.02848	0.06313	0.1272	0.0000717	0.0000044	0.04375	0.0222309	27.2
08-Sep-09	4	164.2	0.0838	0.03924	0.10217	0.1525	0.0001282	0.0000082	0.0818125	0.0386957	41.5
15-Sep-09	5	239.0	0.1487	0.05120	0.15334	0.1738	0.0002099	0.0000146	0.1463125	0.0620447	60
22-Sep-09	6	311.1	0.2115	0.06326	0.20134	0.1907	0.0002945	0.0000185	0.18525	0.0843392	77
29-Sep-09	7	374.0	0.2672	0.07448	0.24243	0.2021	0.0003752	0.0000196	0.195875	0.1038467	92
06-Oct-09	8	454.8	0.3919	0.08599	0.28053	0.2152	0.0005350	0.0000237	0.237	0.1366292	111
13-Oct-09	9	570.0	0.5799	0.09661	0.31126	0.2289	0.0007653	0.0000308	0.3075	0.1806212	134
20-Oct-09	10	675.3	0.8369	0.10723	0.34589	0.2403	0.0011006	0.0000454	0.45375	0.2345312	155
27-Oct-09	11	791.5	1.1634	0.11806	0.38483	0.2497	0.0015406	0.0000674	0.67375	0.2987712	175
03-Nov-09	12	917.3	1.5240	0.12895	0.40857	0.2594	0.0020606	0.0000934	0.93375	0.3648112	195
10-Nov-09	13	995.2	1.8046	0.13648	0.40979	0.2663	0.0024956	0.0001151	1.15125	0.4117912	209
17-Nov-09	14	1079.8	2.0910	0.14269	0.41088	0.2735	0.0029051	0.0001606	1.60625	0.4607037	223
24-Nov-09	15	1172.1	2.4041	0.14779	0.41190	0.2817	0.0033131	0.0002371	2.37125	0.5152737	236
01-Dec-09	16	1271.9	3.1502	0.15262	0.41535	0.2886	0.0041411	0.0003061	3.06125	0.5916337	250
08-Dec-09	17	1401.0	4.4126	0.15790	0.42159	0.2953	0.0054851	0.0003781	3.78125	0.6996337	267
15-Dec-09	18	1543.9	7.5922	0.16495	0.43992	0.3016	0.0077881	0.0004721	4.72125	0.8674237	285
22-Dec-09	19	1757.8	12.7152	0.17388	0.47047	0.3077	0.0110781	0.0005896	5.89625	1.0972537	305
29-Dec-09	20	2000.5	27.0139	0.18853	0.78783	0.3131	0.0161931	0.0007059	7.05875	1.4899462	324
05-Jan-10	21	2412.5	48.2659	0.20701	1.33383	0.3173	0.0224931	0.0008109	8.10875	1.9939462	340
12-Jan-10	22	3028.3	73.8079	0.22872	2.24543	0.3212	0.0286636	0.0008969	8.96875	2.5980962	351
19-Jan-10	23	3564.6	103.8159	0.25380	3.53903	0.3247	0.0346916	0.0009629	9.62875	3.3064962	360
26-Jan-10	24	4236.7	132.6564	0.28208	5.93806	0.3279	0.0395418	0.0010281	10.28125	4.0133712	365
02-Feb-10	25	4972.9	161.6364	0.31493	9.57856	0.3311	0.0434118	0.0010956	10.95625	4.7513712	369
09-Feb-10	26	5721.2	183.5069	0.34398	12.25738	0.3332	0.0462338	0.0011786	11.78625	5.3468962	371
16-Feb-10	27	6403.3	202.3669	0.37480	14.47458	0.3346	0.0485338	0.0012936	12.93625	5.9126962	373
23-Feb-10	28	7089.6	226.4229	0.41699	20.78443	0.3363	0.0512013	0.0014149	14.14875	6.6038212	376
02-Mar-10	29	7979.9	249.4119	0.45926	29.15843	0.3378	0.0535713	0.0015136	15.13625	7.2437212	377
09-Mar-10	30	8774.8	273.6999	0.50654	38.23043	0.3422	0.0562113	0.0016336	16.33625	7.9565212	379
16-Mar-10	31	9764.9	292.8349	0.54659	45.61743	0.3484	0.0584363	0.0017449	17.44875	8.5572712	380
23-Mar-10	32	10423.1	313.2777	0.58999	53.95943	0.3549	0.0606188	0.0018661	18.66125	9.1683712	381
30-Mar-10	33	11514.4	331.0367	0.62826	61.61343	0.3605	0.0623388	0.0019736	19.73625	9.6714712	382
06-Apr-10	34	12109.5	344.9252	0.66281	66.55078	0.3645	0.0638428	0.0020441	20.44125	10.091181	384
13-Apr-10	35	12803.0	353.5582	0.69094	68.10763	0.3665	0.0650068	0.0020684	20.68375	10.389941	385
20-Apr-10	36	13703.0	365.7982	0.72334	71.75803	0.3684	0.0662548	0.0021164	21.16375	10.713221	386
27-Apr-10	37	14531.6	380.5722	0.75760	77.09803	0.3702	0.0675008	0.0021831	21.83125	11.038516	387
04-May-10	38	15259.6	396.6499	0.79859	84.13053	0.3719	0.0688831	0.0022559	22.55875	11.381896	388
11-May-10	39	16196.7	410.7174	0.83769	91.35553	0.3731	0.0701156	0.0023196	23.19625	11.673021	390
18-May-10	40	16886.8	422.9889	0.87150	97.16728	0.3743	0.0711483	0.0023804	23.80375	11.911769	392
25-May-10	41	17442.3	434.9514	0.90413	102.25678	0.3756	0.0721053	0.0024456	24.45625	12.126659	393
01-Jun-10	42	18050.0	450.7674	0.94325	111.37678	0.3778	0.0733533	0.0025416	25.41625	12.373619	395
08-Jun-10	43	18786.3	466.3194	0.97889	122.02828	0.3802	0.0745683	0.0026429	26.42875	12.590294	397
15-Jun-10	44	19423.5	474.8634	0.99847	127.88003	0.3816	0.0752358	0.0026985	26.985	12.709331	399
22-Jun-10	45	19946.0	482.6464	1.01868	133.21203	0.3829	0.0757518	0.0027630	27.63	12.834891	400
29-Jun-10	46	20371.1	486.9452	1.02984	136.15703	0.3836	0.0760368	0.0027986	27.98625	12.904241	401
06-Jul-10	47	21059.3	501.3002	1.05681	145.03103	0.3844	0.0769938	0.0028639	28.63875	13.089986	404
13-Jul-10	48	21540.1	509.0552	1.07138	149.82503	0.3849	0.0775108	0.0028991	28.99125	13.190331	406
20-Jul-10	49	22129.7	519.3347	1.09430	156.81153	0.3860	0.0782673	0.0029214	29.21375	13.301136	408
27-Jul-10	50	22796.2	524.6477	1.10614	160.42253	0.3865	0.0786583	0.0029329	29.32875	13.358406	409
03-Aug-10	51	23304.5	531.0652	1.12136	166.24503	0.3872	0.0791258	0.0029541	29.54125	13.426831	411
10-Aug-10	52	24293.3	534.3494	1.12914	169.22478	0.3876	0.0793651	0.0029650	29.65	13.461849	412
17-Aug-10	53	24768.5	539.3214	1.14265	174.10878	0.3880	0.0797523	0.0029716	29.716	13.512889	413
24-Aug-10	54	24939.8	542.1182	1.15025	176.85603	0.3883	0.0799701	0.0029753	29.753125	13.541599	414
31-Aug-10	55	25365.0	546.5042	1.15885	181.37103	0.3886	0.0803141	0.0029861	29.860625	13.580041	416
07-Sep-10	56	25807.5	548.6972	1.16315	183.62853	0.3887	0.0804861	0.0029914	29.914375	13.599262	416
14-Sep-10	57	26233.4	553.7257	1.17183	190.08103	0.3888	0.0808866	0.0030137	30.136875	13.639089	421
21-Sep-10	58	26679.8	556.3529	1.17636	193.45228	0.3888	0.0810958	0.0030253	30.253125	13.659898	423
28-Sep-10	59	27110.2	561.5854	1.18569	200.68678	0.3891	0.0815508	0.0030481	30.480625	13.701485	425

Date	Cr mg/kg	Co mg/kg	Cu mg/kg	Fe mg/kg	Pb mg/kg	Li mg/kg	Mg mg/kg	Mn mg/kg	Hg mg/kg	Mo mg/kg	Ni mg/kg	P mg/kg	K mg/kg	Se mg/kg
11-Aug-09	0.00002025	0.0001	0.00321975	0.00162	0.0002325	0.00024	0.22	0.15107	0.0000020	0.0000	0.00030	0.0008	0.11	0.0000
18-Aug-09	0.00004475	0.0007	0.02355475	0.0173	0.0041623	0.00108	0.94	0.83217	0.0000045	0.0000	0.00130	0.0013	0.33	0.0000
25-Aug-09	0.00006525	0.0023	0.06578475	0.0661	0.0087543	0.00276	3.01	2.78787	0.0000065	0.0000	0.00421	0.0029	0.70	0.0001
01-Sep-09	0.0000875	0.0041	0.11606975	0.1137	0.0143168	0.00431	5.00	4.59902	0.0000088	0.0000	0.00715	0.0034	1.18	0.0002
08-Sep-09	0.00015275	0.007	0.20741975	0.2442	0.0203415	0.00638	8.13	7.54832	0.0000153	0.0001	0.01217	0.0047	1.69	0.0003
15-Sep-09	0.00026025	0.0111	0.33942975	0.4562	0.0268775	0.00896	12.39	11.62902	0.0000260	0.0001	0.01927	0.0068	2.24	0.0004
22-Sep-09	0.000327	0.0152	0.46647725	0.6858	0.0323332	0.01172	16.55	15.55169	0.0000327	0.0002	0.02592	0.0084	2.81	0.0004
29-Sep-09	0.00034825	0.019	0.57867725	0.9149	0.0362942	0.01444	20.29	19.01119	0.0000348	0.0002	0.03161	0.0092	3.34	0.0005
06-Oct-09	0.00041875	0.0247	0.79393725	1.0982	0.0414454	0.01759	25.67	23.95559	0.0000419	0.0002	0.04036	0.0109	3.96	0.0006
13-Oct-09	0.00053625	0.0319	1.10037725	1.2115	0.0473674	0.02088	32.30	30.01859	0.0000536	0.0003	0.05154	0.0132	4.62	0.0006
20-Oct-09	0.0008175	0.0396	1.52382725	1.3800	0.0544324	0.02358	38.80	36.36359	0.0000818	0.0005	0.06383	0.0189	5.27	0.0007
27-Oct-09	0.0012575	0.0479	2.06502725	1.6035	0.0627044	0.02578	45.32	43.09559	0.0001258	0.0007	0.07738	0.0277	5.93	0.0009
03-Nov-09	0.0017775	0.0568	2.66822725	2.1542	0.0705824	0.02838	52.41	50.03759	0.0001778	0.0013	0.09072	0.0381	6.76	0.0011
10-Nov-09	0.0022125	0.0635	3.14237725	2.8545	0.0755849	0.03055	57.85	54.99659	0.0002213	0.0022	0.09963	0.0468	7.50	0.0013
17-Nov-09	0.00300875	0.0705	3.65197725	3.6508	0.0808174	0.03510	63.27	59.88784	0.0003009	0.0030	0.10817	0.0627	8.16	0.0016
24-Nov-09	0.00428375	0.0783	4.23847725	4.6147	0.0866824	0.04275	69.03	65.03884	0.0004284	0.0038	0.11684	0.0882	8.77	0.0021
01-Dec-09	0.00543375	0.0881	5.27347725	6.3765	0.1020464	0.04965	75.86	71.17984	0.0005434	0.0044	0.12811	0.1112	9.46	0.0026
08-Dec-09	0.00663375	0.1012	6.88147725	9.1461	0.1285904	0.05685	84.69	79.14784	0.0006634	0.0052	0.14347	0.1352	10.33	0.0030
15-Dec-09	0.00839625	0.1185	9.56752725	13.6980	0.1493409	0.06625	94.66	88.66534	0.0008396	0.0061	0.16650	0.1704	11.22	0.0037
22-Dec-09	0.01074625	0.1403	13.3651273	20.0900	0.1648509	0.07800	105.94	99.89834	0.0010746	0.0073	0.19752	0.2174	12.16	0.0047
29-Dec-09	0.02213875	0.1707	19.0567273	36.9463	0.1946109	0.08963	117.10	115.61534	0.0013071	0.0084	0.23425	0.2639	12.86	0.0056
05-Jan-10	0.04061875	0.2061	25.9447273	61.6843	0.2345109	0.10013	127.18	133.96934	0.0015171	0.0095	0.27289	0.3059	13.28	0.0065
12-Jan-10	0.07007375	0.2483	32.4592273	103.8028	0.2752749	0.10873	135.58	158.26434	0.0016784	0.0118	0.30708	0.3382	13.71	0.0071
19-Jan-10	0.11099375	0.2976	38.5752273	164.0828	0.3168989	0.11533	142.23	188.75634	0.0017884	0.0153	0.33656	0.3602	14.15	0.0075
26-Jan-10	0.15623375	0.342	43.6864773	251.7353	0.3532432	0.12185	148.38	212.94234	0.0018971	0.0173	0.36287	0.3819	14.54	0.0080
02-Feb-10	0.20798375	0.3833	48.0064773	371.4353	0.3858682	0.12860	154.32	231.79734	0.0020096	0.0180	0.38717	0.4044	14.90	0.0084
09-Feb-10	0.24886125	0.4149	51.3057273	494.6903	0.4058504	0.13690	159.76	243.72859	0.0021653	0.0188	0.40585	0.4356	15.17	0.0090
16-Feb-10	0.28658125	0.4426	54.2037273	645.5703	0.4167984	0.14840	165.74	250.90459	0.0023953	0.0200	0.42241	0.4816	15.40	0.0100
23-Feb-10	0.34041625	0.4805	57.6399523	856.0603	0.4298207	0.16053	173.26	256.92344	0.0026378	0.0212	0.44690	0.5723	15.64	0.0109
02-Mar-10	0.39571625	0.5184	60.7486023	1069.3603	0.4416312	0.17040	180.37	260.56534	0.0028353	0.0222	0.47258	0.6805	15.84	0.0117
09-Mar-10	0.45667625	0.5621	64.2598023	1332.4003	0.4530552	0.18240	188.53	264.22054	0.0030753	0.0234	0.50258	0.8147	16.56	0.0127
16-Mar-10	0.50740625	0.6004	67.2680023	1579.8203	0.4609317	0.19353	195.65	266.89499	0.0032978	0.0245	0.52928	0.9415	17.67	0.0136
23-Mar-10	0.56099875	0.6431	70.5514523	1852.8753	0.4686674	0.20565	203.16	269.49944	0.0035403	0.0257	0.55522	1.1343	18.40	0.0145
30-Mar-10	0.60700875	0.6819	73.4668523	2097.9753	0.4747734	0.21640	209.61	271.53334	0.0037553	0.0268	0.57543	1.3536	18.61	0.0154
06-Apr-10	0.64460875	0.714	76.0659523	2298.1953	0.4795204	0.22345	215.25	273.29819	0.0038963	0.0275	0.59334	1.4910	18.85	0.0160
13-Apr-10	0.67031375	0.7364	78.1417523	2434.9653	0.4824304	0.22588	219.62	274.64649	0.0039448	0.0277	0.60750	1.5274	19.09	0.0162
20-Apr-10	0.70343375	0.7656	80.5345523	2612.0853	0.4851184	0.23068	223.94	275.95929	0.0040288	0.0282	0.62459	1.6472	19.57	0.0165
27-Apr-10	0.74125875	0.7993	83.0666023	2815.0053	0.4874324	0.23735	227.94	277.15634	0.0041400	0.0289	0.64328	1.8359	20.24	0.0169
04-May-10	0.78296875	0.8379	85.8553523	3051.2003	0.4900757	0.24463	231.58	278.33004	0.0042613	0.0296	0.66389	2.0750	20.96	0.0174
11-May-10	0.81994375	0.8736	88.3246023	3271.3503	0.4924982	0.25100	234.13	279.24379	0.0043675	0.0303	0.68217	2.3138	21.60	0.0179
18-May-10	0.85274875	0.906	90.5055273	3464.9403	0.4943207	0.25708	236.36	280.05379	0.0044688	0.0309	0.69877	2.5230	22.21	0.0183
25-May-10	0.88537375	0.9392	92.6631273	3655.4703	0.4957562	0.26360	238.53	280.85854	0.0045775	0.0315	0.71574	2.7279	22.86	0.0187
01-Jun-10	0.92857375	0.9827	95.1135273	3920.4303	0.4978442	0.27320	240.93	281.76814	0.0047575	0.0325	0.74022	3.1529	23.82	0.0194
08-Jun-10	0.97109875	1.0253	97.2397773	4190.1603	0.5000312	0.28333	242.96	282.55384	0.0049600	0.0335	0.76573	3.6794	24.83	0.0202
15-Jun-10	0.99446125	1.0486	98.4079023	4338.3453	0.5012327	0.28889	244.07	282.98549	0.0050713	0.0340	0.77975	3.9687	25.39	0.0207
22-Jun-10	1.01940125	1.0743	99.6162023	4494.0053	0.5033397	0.29534	244.72	283.50579	0.0051788	0.0347	0.79222	4.2447	26.04	0.0211
29-Jun-10	1.03317625	1.0884	100.283577	4579.9803	0.5045034	0.29890	245.07	283.79317	0.0052381	0.0350	0.79911	4.3972	26.39	0.0213
06-Jul-10	1.07363125	1.129	102.136677	4819.2303	0.5051124	0.30543	246.81	284.65447	0.0053469	0.0357	0.81955	4.9671	27.04	0.0218
13-Jul-10	1.09548625	1.1509	103.137777	4948.4803	0.5054414	0.30895	247.75	285.11977	0.0054056	0.0360	0.83060	5.2749	27.40	0.0220
20-Jul-10	1.12530125	1.1854	104.526177	5157.1853	0.5060199	0.31118	248.64	285.63152	0.0054501	0.0363	0.84858	5.6834	27.62	0.0222
27-Jul-10	1.14071125	1.2032	105.243777	5265.0553	0.5063189	0.31233	249.10	285.89602	0.0054731	0.0364	0.85787	5.8946	27.73	0.0223
03-Aug-10	1.16111125	1.2282	106.115027	5411.2553	0.5076364	0.31445	249.53	286.19734	0.0055156	0.0366	0.87104	6.2652	27.95	0.0225
10-Aug-10	1.17155125	1.241	106.560902	5486.0753	0.5083107	0.31554	249.74	286.35155	0.0055374	0.0367	0.87779	6.4548	28.06	0.0225
17-Aug-10	1.18629125	1.2605	107.172502	5602.2353	0.5087463	0.31730	250.18	286.57727	0.0055484	0.0370	0.88667	6.8086	28.12	0.0226
24-Aug-10	1.1945825	1.2715	107.516527	5667.5753	0.5089913	0.31829	250.43	286.70424	0.0055546	0.0371	0.89167	7.0076	28.16	0.0227
31-Aug-10	1.2092025	1.2887	108.066927	5763.4653	0.5092278	0.31937	250.86	286.92956	0.0055761	0.0372	0.89924	7.3670	28.27	0.0228
07-Sep-10	1.2165125	1.2973	108.342127	5811.4103	0.5093460	0.31990	251.08	287.04222	0.0055868	0.0373	0.90303	7.5468	28.32	0.0228
14-Sep-10	1.2338675	1.3171	108.929527	5928.8903	0.5094795	0.32213	251.52	287.30521	0.0056313	0.0375	0.91544	8.1342	28.54	0.0230
21-Sep-10	1.242935	1.3274	109.236427	5990.2703	0.5095493	0.32329	251.75	287.44262	0.0056546	0.0376	0.92193	8.4411	28.66	0.0231
28-Sep-10	1.262045	1.3479	109.864327	6113.1203	0.5099133	0.32557	252.21	287.71607	0.0057001	0.0378	0.93244	9.0826	28.89	0.0233

Date	Si mg/kg	Ag mg/kg	Na mg/kg	Sr mg/kg	S mg/kg	Tl mg/kg	Sn mg/kg	Ti mg/kg	U mg/kg	V mg/kg	Zn mg/kg	Zr mg/kg
11-Aug-09	0.859	2.43E-06	0.304	0.0034	1.62	8.1E-06	0.001418	0.00010125	4.05E-07	0.00008	0.05184	0.00002
18-Aug-09	2.721	4.88E-06	0.671	0.0145	7.50	4.5E-05	0.004759	0.00022375	1.385E-06	0.00013	0.33555	0.00004
25-Aug-09	6.689	1.55E-05	1.262	0.0391	21.44	7E-05	0.008449	0.00032625	7.945E-06	0.00017	1.18835	0.00007
01-Sep-09	10.054	2.67E-05	1.751	0.0602	34.35	0.00013	0.012027	0.0004375	1.329E-05	0.00022	2.0828	0.00009
08-Sep-09	14.612	4.73E-05	2.193	0.0901	53.05	0.00018	0.019866	0.000818125	2.46E-05	0.00035	3.70535	0.00015
15-Sep-09	20.374	7.74E-05	2.593	0.1288	77.56	0.00023	0.031906	0.001463125	4.18E-05	0.00056	6.04885	0.00026
22-Sep-09	26.204	1.02E-04	2.931	0.1642	101.59	0.00028	0.045323	0.0018525	5.782E-05	0.00069	8.20265	0.00033
29-Sep-09	31.644	1.19E-04	3.182	0.1938	123.27	0.00033	0.05905	0.00195875	7.142E-05	0.00074	10.0004	0.00035
06-Oct-09	37.519	1.57E-04	3.431	0.2338	154.52	0.00038	0.075923	0.00237	9.774E-05	0.00088	12.95905	0.00042
13-Oct-09	43.253	2.13E-04	3.652	0.2813	193.06	0.00042	0.094488	0.003075	0.0001353	0.00111	16.88825	0.00054
20-Oct-09	48.788	2.85E-04	3.870	0.3297	229.96	0.00046	0.119801	0.0045375	0.0002028	0.00168	21.51425	0.00082
27-Oct-09	54.244	3.73E-04	4.090	0.3798	266.04	0.0005	0.151921	0.0067375	0.0002996	0.00256	26.88225	0.00126
03-Nov-09	60.666	4.51E-04	4.324	0.4313	306.60	0.00056	0.191103	0.0093375	0.0004114	0.00464	32.32665	0.00178
10-Nov-09	66.016	4.94E-04	4.498	0.4679	338.79	0.00061	0.224902	0.0115125	0.0005028	0.00725	36.12855	0.00221
17-Nov-09	71.056	5.51E-04	4.646	0.5024	375.42	0.00064	0.255501	0.0160625	0.0005961	0.00975	39.946	0.00301
24-Nov-09	76.079	6.28E-04	4.773	0.5371	419.79	0.00067	0.284469	0.0237125	0.0006981	0.01230	44.0464	0.00428
01-Dec-09	81.128	7.54E-04	4.888	0.5781	458.20	0.00073	0.322373	0.0306125	0.0009511	0.01460	49.3226	0.00543
08-Dec-09	86.936	9.46E-04	5.008	0.6309	496.60	0.00082	0.374213	0.0378125	0.0013831	0.01700	56.4746	0.00663
15-Dec-09	93.163	1.18E-03	5.537	0.6931	546.65	0.00092	0.439308	0.0472125	0.0025346	0.02052	66.1331	0.00840
22-Dec-09	99.931	1.46E-03	6.477	0.7660	609.16	0.00101	0.518738	0.0589625	0.0044146	0.02522	78.4471	0.01075
29-Dec-09	108.394	2.00E-03	7.058	0.8439	690.77	0.00108	0.622665	0.0705875	0.0103201	0.02987	100.9996	0.01307
05-Jan-10	117.634	2.71E-03	7.268	0.9195	782.33	0.00112	0.739425	0.0810875	0.0193081	0.03407	130.7356	0.01517
12-Jan-10	127.804	3.38E-03	7.548	0.9893	926.38	0.00119	0.86563	0.0896875	0.0302301	0.03730	170.2526	0.01678
19-Jan-10	138.936	3.99E-03	7.900	1.0531	1125.26	0.00127	1.00159	0.0962875	0.0431661	0.03950	219.9726	0.01788
26-Jan-10	150.267	4.67E-03	8.269	1.1060	1352.33	0.00136	1.126653	0.1028125	0.0557376	0.04472	272.6076	0.01897
02-Feb-10	162.327	5.43E-03	8.674	1.1501	1618.73	0.00145	1.246353	0.1095625	0.0685176	0.05327	330.6576	0.02010
09-Feb-10	175.109	6.08E-03	8.965	1.1812	1820.42	0.00151	1.344085	0.1178625	0.0778136	0.05929	376.9924	0.02165
16-Feb-10	191.117	6.72E-03	9.195	1.2051	1995.22	0.00156	1.438385	0.1293625	0.0853576	0.06389	420.3704	0.02395
23-Feb-10	206.565	7.72E-03	9.437	1.2299	2255.18	0.00161	1.541448	0.1414875	0.0936753	0.07819	472.3381	0.02638
02-Mar-10	217.980	8.78E-03	9.635	1.2496	2528.52	0.00165	1.628348	0.1513625	0.1007458	0.09755	519.7381	0.02835
09-Mar-10	231.348	1.01E-02	10.355	1.2712	2814.60	0.0017	1.730828	0.1633625	0.1080418	0.12299	571.2901	0.03075
16-Mar-10	243.274	1.13E-02	11.467	1.2890	3037.10	0.00174	1.822943	0.1744875	0.1136043	0.14835	613.4761	0.03298
23-Mar-10	254.672	1.30E-02	12.195	1.3094	3319.61	0.00179	1.922368	0.1866125	0.1194728	0.17454	654.8951	0.03540
30-Mar-10	263.358	1.49E-02	12.410	1.3283	3605.56	0.00183	2.009658	0.1973625	0.1245038	0.19647	687.5751	0.03755
06-Apr-10	272.476	1.63E-02	12.645	1.3459	3839.15	0.00193	2.082508	0.2058225	0.1286845	0.21715	714.2946	0.03896
13-Apr-10	281.497	1.69E-02	12.887	1.3610	3998.72	0.00209	2.134403	0.2111575	0.1316381	0.23510	732.5791	0.03945
20-Apr-10	291.385	1.82E-02	13.367	1.3773	4209.44	0.0022	2.196803	0.2173975	0.1349717	0.25430	751.3231	0.04029
27-Apr-10	301.442	1.99E-02	14.035	1.3938	4453.74	0.00224	2.264888	0.2240725	0.1384427	0.27343	769.3011	0.04140
04-May-10	312.281	2.17E-02	14.762	1.4127	4744.74	0.00228	2.337638	0.2313475	0.1420802	0.29138	787.6341	0.04261
11-May-10	321.674	2.34E-02	15.400	1.4301	5021.42	0.0023	2.400113	0.2377225	0.1451402	0.30455	802.5941	0.04368
18-May-10	329.794	2.55E-02	16.007	1.4461	5260.77	0.00233	2.45256	0.2437975	0.1480157	0.31731	814.5214	0.04469
25-May-10	337.624	2.83E-02	16.660	1.4626	5491.76	0.00237	2.50128	0.2503225	0.1510607	0.33123	824.8309	0.04578
01-Jun-10	348.160	3.15E-02	17.620	1.4816	5739.20	0.00242	2.5584	0.2599225	0.1545647	0.34875	836.5429	0.04758
08-Jun-10	358.650	3.41E-02	18.632	1.4982	5941.70	0.00246	2.60943	0.2700475	0.1576427	0.36536	846.7084	0.04960
15-Jun-10	364.412	3.56E-02	19.189	1.5073	6052.95	0.00248	2.637465	0.27561	0.1593337	0.37448	852.2931	0.05071
22-Jun-10	369.873	3.90E-02	19.834	1.5172	6160.45	0.00253	2.667522	0.28206	0.1612687	0.38308	858.0981	0.05179
29-Jun-10	372.890	4.08E-02	20.190	1.5227	6219.82	0.00255	2.684124	0.2856225	0.1623375	0.38783	861.3044	0.05238
06-Jul-10	381.764	4.21E-02	20.842	1.5409	6499.53	0.00257	2.729364	0.2921475	0.165165	0.40088	869.4824	0.05347
13-Jul-10	386.558	4.28E-02	21.195	1.5508	6650.63	0.00258	2.753804	0.2956725	0.1666925	0.40793	873.9004	0.05406
20-Jul-10	393.366	4.37E-02	21.417	1.5655	6863.79	0.00261	2.795456	0.2978975	0.1687395	0.41861	878.6619	0.05450
27-Jul-10	396.885	4.41E-02	21.532	1.5731	6973.96	0.00263	2.816984	0.2990475	0.1697975	0.42413	881.1229	0.05473
03-Aug-10	401.560	4.53E-02	21.745	1.5829	7158.41	0.00269	2.842441	0.3011725	0.1710682	0.42880	884.4591	0.05516
10-Aug-10	403.953	4.59E-02	21.854	1.5879	7252.80	0.00271	2.855469	0.30226	0.1717185	0.43120	886.1665	0.05537
17-Aug-10	407.842	4.66E-02	21.920	1.5957	7407.68	0.00274	2.874213	0.30292	0.1726381	0.43516	888.5733	0.05548
24-Aug-10	410.030	4.70E-02	21.957	1.6002	7494.80	0.00276	2.884757	0.30329125	0.1731554	0.43738	889.9271	0.05555
31-Aug-10	412.804	4.76E-02	22.064	1.6060	7618.64	0.00278	2.899463	0.30436625	0.1740025	0.43996	891.8406	0.05576
07-Sep-10	414.190	4.79E-02	22.118	1.6089	7680.56	0.00279	2.906816	0.30490375	0.1744261	0.44125	892.7974	0.05587
14-Sep-10	417.599	4.83E-02	22.341	1.6151	7819.85	0.00281	2.924972	0.31513875	0.1758723	0.44437	894.7198	0.05631
21-Sep-10	419.380	4.85E-02	22.457	1.6184	7892.62	0.00283	2.934458	0.32048625	0.1766279	0.44600	895.7242	0.05655
28-Sep-10	422.893	4.88E-02	22.684	1.6243	8034.58	0.00284	2.953067	0.32276125	0.177861	0.44873	897.6807	0.05700

Appendix B.1-6

Humidity Cell T6 (CaNP depleted Silt-Clay Composite)

		Production Rates and Depletion											*Ratios*				*NP Consumption Rates*							
Date	**Cycle**	**Acidity (mg $CaCO_3$/kg/wk)**	**Alkalinity (mg $CaCO_3$/kg/wk)**	**Cumulative Alkalinity (mg/$CaCO_3$/wk)**	**Sulphate (mg/kg/wk)**	**Cumulative Sulphate (mg/kg)**	**Cumulative Sulphate (mmol/kg)**	**Fraction of total S Leached**	**Fraction of Total S remaining**	**Fraction of Sulphide Sulphur Leached**	**Fraction of Sulphide Sulphur Remaining**	**Alkalinity/ Sulphate Production**	**Total S Conc Remaining (%)**	**CMR**	**Ca/SO4**	**(Ca+Mg)/Alk**	**Ca/Mg**	**Theoretical NP Consumption at pH 6**	**Carbonate NP Consumption (mg CaCO3/kg/wk)**	**Carbonate NP Consumption (kg CaCO3/t/wk)**	**Cum. Carb NP Consum. (mg CaCO3/kg/wk)**	**Cum. Carb NP Consum. (kg CaCO3/t/wk)**	**Remaining Carbonate NP**	**Open System NP Consumption**	**Cumulative NP Consumption**	**Remaining NP**
11-Aug-09	0	1.794	1.6	1.6	3.2	3.2	0.034	0.00005	1.000	0.00010	1.000	0.49	2.220	1.24	0.97	2.64	3.56	3.4	4.2	0.0042	4.2	0.0042	1.00	3.2	3.2	1.00
18-Aug-09	1	2.769	0.4	2.0	12.7	16.0	0.166	0.00024	1.000	0.00050	0.999	0.03	2.219	1.06	0.83	7.31	3.73	13.3	14.1	0.0141	18.2	0.0182	1.00	10.9	14.0	1.00
25-Aug-09	2	4.621	0.6	2.5	38.5	54.5	0.568	0.00082	0.999	0.00172	0.998	0.01	2.218	0.92	0.71	22.93	3.34	40.2	36.9	0.0369	55.1	0.0551	1.00	36.1	50.1	1.00
01-Sep-09	3	5.999	1.1	3.6	40.9	95.5	0.994	0.00144	0.999	0.00301	0.997	0.03	2.217	0.78	0.59	19.17	3.07	42.7	33.5	0.0335	88.6	0.0886	1.00	37.7	87.9	1.00
08-Sep-09	4	8.600	0.9	4.6	68.7	164.2	1.709	0.00247	0.998	0.00517	0.995	0.01	2.215	0.68	0.50	28.48	2.77	71.6	48.6	0.0486	137.2	0.1372	1.00	64.0	151.8	0.99
15-Sep-09	5	11.206	0.8	5.4	74.8	239.0	2.488	0.00359	0.996	0.00753	0.992	0.01	2.212	0.82	0.59	37.80	2.63	78.0	63.8	0.0638	200.9	0.2009	0.99	67.6	219.4	0.99
22-Sep-09	6	10.469	0.5	5.9	72.1	311.1	3.239	0.00468	0.995	0.00980	0.990	0.01	2.210	0.80	0.57	34.51	2.51	75.1	60.2	0.0602	261.2	0.2612	0.99	65.2	284.6	0.99
29-Sep-09	7	8.921	0.2	6.1	62.9	374.0	3.893	0.00562	0.994	0.01178	0.988	0.00	2.208	0.79	0.56	31.22	2.38	65.5	52.0	0.0520	313.2	0.3132	0.99	56.8	341.4	0.99
06-Oct-09	8	12.542	#N/A	#N/A	80.8	454.8	4.735	0.00684	0.993	0.01432	0.986	#N/A	2.205	0.84	0.58	38.40	2.19	84.2	70.8	0.0708	384.0	0.3840	0.99	#N/A	#N/A	#N/A
13-Oct-09	9	15.219	#N/A	#N/A	115.2	570.0	5.934	0.00857	0.991	0.01795	0.982	#N/A	2.201	0.70	0.47	45.58	2.08	120.0	84.0	0.0840	468.1	0.4681	0.98	#N/A	#N/A	#N/A
20-Oct-09	10	18.547	#N/A	#N/A	105.3	675.3	7.030	0.01015	0.990	0.02127	0.979	#N/A	2.197	0.72	0.48	44.90	1.96	109.7	79.3	0.0793	547.3	0.5473	0.98	#N/A	#N/A	#N/A
27-Oct-09	11	22.022	#N/A	#N/A	116.2	791.5	8.239	0.01190	0.988	0.02492	0.975	#N/A	2.194	0.63	0.41	44.21	1.84	121.0	76.3	0.0763	623.6	0.6236	0.98	#N/A	#N/A	#N/A
03-Nov-09	12	21.588	#N/A	#N/A	125.8	917.3	9.549	0.01379	0.986	0.02889	0.971	#N/A	2.189	0.61	0.39	39.12	1.73	131.1	79.8	0.0798	703.4	0.7034	0.98	#N/A	#N/A	#N/A
10-Nov-09	13	14.346	0.4	#N/A	77.9	995.2	10.360	0.01496	0.985	0.03134	0.969	0.01	2.187	0.72	0.44	34.02	1.59	81.1	58.1	0.0581	761.5	0.7615	0.97	67.2	#N/A	#N/A
17-Nov-09	14	16.921	#N/A	#N/A	84.6	1079.8	11.241	0.01624	0.984	0.03400	0.966	#N/A	2.184	0.63	0.38	31.16	1.49	88.2	55.6	0.0556	817.1	0.8171	0.97	#N/A	#N/A	#N/A
24-Nov-09	15	21.114	#N/A	#N/A	92.3	1172.1	12.202	0.01762	0.982	0.03691	0.963	#N/A	2.181	0.59	0.34	28.31	1.38	96.2	56.6	0.0566	873.7	0.8737	0.97	#N/A	#N/A	#N/A
01-Dec-09	16	32.032	#N/A	#N/A	99.8	1271.9	13.241	0.01913	0.981	0.04006	0.960	#N/A	2.178	0.61	0.34	35.06	1.25	104.0	63.3	0.0633	937.0	0.9370	0.97	#N/A	#N/A	#N/A
08-Dec-09	17	46.978	#N/A	#N/A	129.1	1401.0	14.585	0.02107	0.979	0.04412	0.956	#N/A	2.173	0.59	0.31	41.81	1.16	134.5	78.7	0.0787	1015.7	1.0157	0.96	#N/A	#N/A	#N/A
15-Dec-09	18	71.609	#N/A	#N/A	142.9	1543.9	16.072	0.02322	0.977	0.04862	0.951	#N/A	2.168	0.58	0.31	47.21	1.12	148.9	87.0	0.0870	1102.8	1.1028	0.96	#N/A	#N/A	#N/A
22-Dec-09	19	97.220	#N/A	#N/A	213.9	1757.8	18.299	0.02643	0.974	0.05536	0.945	#N/A	2.161	0.44	0.23	52.60	1.09	222.8	97.0	0.0970	1199.8	1.1998	0.96	#N/A	#N/A	#N/A
29-Dec-09	20	258.721	#N/A	#N/A	242.7	2000.5	20.825	0.03008	0.970	0.06300	0.937	#N/A	2.153	0.37	0.18	50.69	1.01	252.9	92.5	0.0925	1292.3	1.2923	0.95	#N/A	#N/A	#N/A
05-Jan-10	21	380.491	#N/A	#N/A	412.0	2412.5	25.115	0.03628	0.964	0.07598	0.924	#N/A	2.139	0.19	0.09	48.78	0.93	429.3	80.4	0.0804	1372.7	1.3727	0.95	#N/A	#N/A	#N/A
12-Jan-10	22	425.900	#N/A	#N/A	615.8	3028.3	31.525	0.04554	0.954	0.09537	0.905	#N/A	2.119	0.10	0.05	38.18	0.86	641.5	64.4	0.0644	1437.1	1.4371	0.95	#N/A	#N/A	#N/A
19-Jan-10	23	473.000	#N/A	#N/A	536.4	3564.6	37.108	0.05360	0.946	0.11226	0.888	#N/A	2.101	0.09	0.04	27.58	0.74	558.8	47.6	0.0476	1484.8	1.4848	0.95	#N/A	#N/A	#N/A
26-Jan-10	24	511.125	#N/A	#N/A	672.1	4236.7	44.105	0.06371	0.936	0.13342	0.867	#N/A	2.079	0.06	0.02	23.08	0.55	700.2	39.4	0.0394	1524.2	1.5242	0.95	#N/A	#N/A	#N/A
02-Feb-10	25	573.750	#N/A	#N/A	736.2	4972.9	51.769	0.07478	0.925	0.15661	0.843	#N/A	2.054	0.04	0.01	18.58	0.34	767.0	32.8	0.0328	1557.0	1.5570	0.95	#N/A	#N/A	#N/A
09-Feb-10	26	549.875	#N/A	#N/A	748.2	5721.2	59.558	0.08603	0.914	0.18017	0.820	#N/A	2.029	0.04	0.01	17.71	0.29	779.6	28.8	0.0288	1585.8	1.5858	0.94	#N/A	#N/A	#N/A
16-Feb-10	27	632.500	#N/A	#N/A	682.2	6403.3	66.660	0.09629	0.904	0.20166	0.798	#N/A	2.006	0.04	0.01	16.84	0.23	710.7	30.4	0.0304	1616.2	1.6162	0.94	#N/A	#N/A	#N/A
23-Feb-10	28	909.375	#N/A	#N/A	686.3	7089.6	73.804	0.10661	0.893	0.22327	0.777	#N/A	1.983	0.05	0.01	19.15	0.18	715.0	36.4	0.0364	1652.7	1.6527	0.94	#N/A	#N/A	#N/A
02-Mar-10	29	938.125	#N/A	#N/A	890.3	7979.9	83.072	0.11999	0.880	0.25131	0.749	#N/A	1.954	0.04	0.00	21.46	0.13	927.6	33.2	0.0332	1685.9	1.6859	0.94	#N/A	#N/A	#N/A
09-Mar-10	30	996.000	#N/A	#N/A	794.9	8774.8	91.347	0.13195	0.868	0.27634	0.724	#N/A	1.927	0.05	0.00	19.93	0.12	828.1	37.5	0.0375	1723.4	1.7234	0.94	#N/A	#N/A	#N/A
16-Mar-10	31	789.875	#N/A	#N/A	990.1	9764.9	101.655	0.14683	0.853	0.30752	0.692	#N/A	1.894	0.03	0.00	18.40	0.09	1031.6	32.1	0.0321	1755.6	1.7556	0.94	#N/A	#N/A	#N/A
23-Mar-10	32	848.750	#N/A	#N/A	658.1	10423.1	108.506	0.15673	0.843	0.32825	0.672	#N/A	1.872	0.05	0.00	18.03	0.11	685.7	34.3	0.0343	1789.9	1.7899	0.94	#N/A	#N/A	#N/A
30-Mar-10	33	741.750	#N/A	#N/A	1091.3	11514.4	119.867	0.17314	0.827	0.36262	0.637	#N/A	1.836	0.03	0.00	17.67	0.12	1137.0	29.8	0.0298	1819.7	1.8197	0.94	#N/A	#N/A	#N/A
06-Apr-10	34	822.500	#N/A	#N/A	595.0	12109.5	126.061	0.18209	0.818	0.38136	0.619	#N/A	1.816	0.04	0.01	14.52	0.15	619.9	26.8	0.0268	1846.4	1.8464	0.93	#N/A	#N/A	#N/A
13-Apr-10	35	860.875	#N/A	#N/A	693.6	12803.0	133.281	0.19252	0.807	0.40320	0.597	#N/A	1.793	0.03	0.01	11.36	0.20	722.6	21.6	0.0216	1868.0	1.8680	0.93	#N/A	#N/A	#N/A
20-Apr-10	36	840.000	#N/A	#N/A	900.0	13703.0	142.650	0.20605	0.794	0.43154	0.568	#N/A	1.763	0.02	0.00	10.89	0.15	937.7	20.5	0.0205	1888.6	1.8886	0.93	#N/A	#N/A	#N/A
27-Apr-10	37	767.625	#N/A	#N/A	828.6	14531.6	151.276	0.21851	0.781	0.45763	0.542	#N/A	1.735	0.02	0.00	10.41	0.10	863.3	18.2	0.0182	1906.7	1.9067	0.93	#N/A	#N/A	#N/A
04-May-10	38	830.563	#N/A	#N/A	728.0	15259.6	158.855	0.22946	0.771	0.48056	0.519	#N/A	1.711	0.02	0.00	9.63	0.22	758.4	18.3	0.0183	1925.1	1.9251	0.93	#N/A	#N/A	#N/A
11-May-10	39	722.500	#N/A	#N/A	937.1	16196.7	168.610	0.24355	0.756	0.51007	0.490	#N/A	1.679	0.02	0.00	8.85	0.40	976.3	14.8	0.0148	1939.8	1.9398	0.93	#N/A	#N/A	#N/A
18-May-10	40	703.688	#N/A	#N/A	690.1	16886.8	175.795	0.25393	0.746	0.53181	0.468	#N/A	1.656	0.02	0.00	8.01	0.39	719.0	12.7	0.0127	1952.6	1.9526	0.93	#N/A	#N/A	#N/A
25-May-10	41	772.125	#N/A	#N/A	555.5	17442.3	181.577	0.26228	0.738	0.54930	0.451	#N/A	1.638	0.02	0.01	7.16	0.36	578.7	12.2	0.0122	1964.8	1.9648	0.93	#N/A	#N/A	#N/A
01-Jun-10	42	960.000	#N/A	#N/A	607.7	18050.0	187.903	0.27142	0.729	0.56844	0.432	#N/A	1.617	0.02	0.01	8.12	0.55	633.1	15.3	0.0153	1980.1	1.9801	0.93	#N/A	#N/A	#N/A
08-Jun-10	43	901.125	#N/A	#N/A	736.3	18786.3	195.568	0.28249	0.718	0.59162	0.408	#N/A	1.593	0.02	0.01	9.07	0.73	767.1	14.4	0.0144	1994.5	1.9945	0.93	#N/A	#N/A	#N/A
15-Jun-10	44	495.063	#N/A	#N/A	637.2	19423.5	202.202	0.29207	0.708	0.61169	0.388	#N/A	1.572	0.01	0.01	4.54	0.73	663.9	7.9	0.0079	2002.4	2.0024	0.93	#N/A	#N/A	#N/A
22-Jun-10	45	548.250	#N/A	#N/A	522.5	19946.0	207.641	0.29993	0.700	0.62815	0.372	#N/A	1.554	0.01	0.01	4.12	1.62	544.3	7.0	0.0070	2009.4	2.0094	0.93	#N/A	#N/A	#N/A
29-Jun-10	46	302.813	#N/A	#N/A	425.1	20371.1	212.066	0.30632	0.694	0.64153	0.358	#N/A	1.540	0.01	0.01	2.06	1.62	442.9	3.8	0.0038	2013.2	2.0132	0.93	#N/A	#N/A	#N/A
06-Jul-10	47	837.375	#N/A	#N/A	688.2	21059.3	219.230	0.31667	0.683	0.66321	0.337	#N/A	1.517	0.02	0.01	8.66	1.06	717.0	14.8	0.0148	2028.0	2.0280	0.93	#N/A	#N/A	#N/A
13-Jul-10	48	452.375	#N/A	#N/A	480.8	21540.1	224.236	0.32390	0.676	0.67835	0.322	#N/A	1.501	0.02	0.01	4.33	1.06	500.9	8.0	0.0080	2036.0	2.0360	0.93	#N/A	#N/A	#N/A
20-Jul-10	49	578.500	#N/A	#N/A	589.6	22129.7	230.374	0.33276	0.667	0.69692	0.303	#N/A	1.481	0.02	0.01	5.29	1.52	614.3	9.2	0.0092	2045.3	2.0453	0.93	#N/A	#N/A	#N/A
27-Jul-10	50	299.000	#N/A	#N/A	666.5	22796.2	237.313	0.34278	0.657	0.71791	0.282	#N/A	1.459	0.01	0.00	2.64	1.52	694.4	4.8	0.0048	2050.0	2.0500	0.93	#N/A	#N/A	#N/A
03-Aug-10	51	563.125	#N/A	#N/A	508.3	23304.5	242.604	0.35043	0.650	0.73392	0.266	#N/A	1.442	0.01	0.01	3.60	2.43	529.6	6.0	0.0060	2056.0	2.0560	0.93	#N/A	#N/A	#N/A
10-Aug-10	52	288.188	#N/A	#N/A	988.8	24293.3	252.897	0.36530	0.635	0.76505	0.235	#N/A	1.409	0.00	0.00	1.80	2.43	1030.1	3.1	0.0031	2059.1	2.0591	0.93	#N/A	#N/A	#N/A
17-Aug-10	53	583.000	#N/A	#N/A	475.2	24768.5	257.844	0.37244	0.628	0.78002	0.220	#N/A	1.393	0.01	0.01	3.09	1.94	495.1	5.3	0.0053	2064.5	2.0645	0.93	#N/A	#N/A	#N/A
24-Aug-10	54	327.938	#N/A	#N/A	171.3	24939.8	259.627	0.37502	0.625	0.78541	0.215	#N/A	1.387	0.02	0.01	1.54	1.94	178.4	3.0	0.0030	2067.5	2.0675	0.93	#N/A	#N/A	#N/A
31-Aug-10	55	559.000	#N/A	#N/A	425.3	25365.0	264.054	0.38141	0.619	0.79881	0.201	#N/A	1.373	0.01	0.01	2.96	1.82	443.1	5.0	0.0050	2072.5	2.0725	0.93	#N/A	#N/A	#N/A
07-Sep-10	56	279.500	#N/A	#N/A	442.5	25807.5	268.660	0.38806	0.612	0.81274	0.187	#N/A	1.358	0.01	0.00	1.48	1.82	461.0	2.5	0.0025	2075.0	2.0750	0.93	#N/A	#N/A	#N/A
14-Sep-10	57	567.375	#N/A	#N/A	425.9	26233.4	273.094	0.39447	0.606	0.82615	0.174	#N/A	1.344	0.03	0.03	7.42	6.06	443.7	13.0	0.0130	2087.9	2.0879	0.93	#N/A	#N/A	#N/A
21-Sep-10	58	296.438	#N/A	#N/A	446.4	26679.8	277.741	0.40118	0.599	0.84021	0.160	#N/A	1.329	0.01	0.01	3.71	6.06	465.1	6.8	0.0068	2094.7	2.0947	0.93	#N/A	#N/A	#N/A
28-Sep-10	59	580.125	#N/A	#N/A	430.4	27110.2	282.222	0.40765	0.592	0.85376	0.146	#N/A	1.315	0.01	0.01	3.60	2.43	448.4	6.4	0.0064	2101.1	2.1011	0.93	#N/A	#N/A	#N/A

Appendix B-2

Field parameters and notes

Date	Field Bin	pH	Conductivity (uS/cm)	Temperature (°C)	Leachate Volume (L)	Notes
20-May-10	Waste Rock Bin	7.35	2268	4.84	3	Irrigated with 8 L of water
20-May-10	Ore Bin	7.08	2839	3.95	2.9	Metals Split, irrigated with 8 L of water
20-May-10	Waste Rock and Org Bin	6.72	3393	3.90	N/A	Head space 0.16 m, B Bin taken here
20-May-10	Tailings and Org Bin	6.74	3025	5.47	N/A	Head space 0.175 m, D Bin taken from this one
20-May-10	Tailings Sand Bin	6.80	2237	6.30	2.5	Metals Split from this bin, 28 L of water added
17-Jun-10	Waste Rock Bin	5.21	2454	7.59	2.5	Irrigated with 6 L water (4+2), B Bin filled here
17-Jun-10	Ore Bin	5.58	3026	7.66	3	Irrigated with 8 L (4+4)
17-Jun-10	Waste Rock and Org Bin	5.50	3456	8.36	N/A	Refilled to fill line, required 16 L
17-Jun-10	Tailings and Org Bin	5.88	3047	9.05	N/A	D Bin sampled here
17-Jun-10	Tailings Sand Bin	7.12	2448	15.52	2.5	Irrigated with 4+6+4+2+4+4-4+2 = 26 L, Time of sampling 11:35
15-Jul-10	Waste Rock Bin	7.30	3158	8.79	5	No irrigation required due to precip over past month
15-Jul-10	Ore Bin	7.03	3762	8.73	~4.75	No irrigation required, B Bin sample filled following ore bin
15-Jul-10	Waste Rock and Org Bin	6.48	3332	8.58	N/A	Bins filled to saturation line before sampling began, less than 4 L added following sampling, metals split sample taken from this bin
15-Jul-10	Tailings and Org Bin	6.25	3006	10.40	N/A	Bin also filled to sat line before sampling by precip, added only ~2 L following sampling to top up bin
15-Jul-10	Tailings Sand Bin	6.30	2455	9.39	21	~21 L all due to precip., no irrigation required, metals split taken from Tailings Sand Bin sample, D Bin sample taken following Tailings Sand Bin sample
12-Aug-10	Waste Rock Bin	6.50	3017	9.86	4	Had to add 4 L of distilled water on site, there was only ~1 L originally
12-Aug-10	Ore Bin	6.50	3894	9.84	3.75	Had added 4 L of distilled water as there was <2 L of leachate in the bin, B Bin sampled
12-Aug-10	Waste Rock and Org Bin	7.50	3482	12.11	N/A	
12-Aug-10	Tailings and Org Bin	6.50	3162	12.50	N/A	D Bin sampled
12-Aug-10	Tailings Sand Bin	6.50	2390	10.03	7	No artificial irrigation was required
8-Sep-10	Waste Rock Bin	5.95	3034	5.66	5.25	All leachate volume from precipiration (natural), weeks of precipitation since last sampling, Time of sampling 07:36
8-Sep-10	Ore Bin	6.07	3429	6.53	5.25	All leachate volume from natural precipitation, weeks of precipitation since last sampling, Time 08:00
8-Sep-10	Waste Rock and Org Bin	5.80	3222	7.50	N/A	Added 1 L to fill line, Time 08:25, B Bin sample time 08:40
8-Sep-10	Tailings and Org Bin	6.06	2888	8.12	N/A	Added 4 L of water to fill line, Time 09:10, D Bin sampled Time 09:18
8-Sep-10	Tailings Sand Bin	6.21	2165	7.24	12.1	All leachate volume from natural precipitation, Time 09:25

Appendix B-2
Field Bin Results

Parameter		Unit	Detection Limit	Bin 1. Waste Rock Bin								CCME[1]
				23-Jul-09	6-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	max
Notes												
Field Parameters												
Temperature		C		15.99	12.34	8.17	4.84	7.59	8.79	9.86	5.66	
pH				6.29	7.43	6.47	7.35	5.21	7.3	6.50	5.95	
Conductivity		uS/cm		2759	-	2314	2268	2454	3158	3017	3034	
Leachate Volume		L		7	1	2	2	2.5	5	4	5.25	
Added Volume		L			4	4	8	6	0	4	0	
Physical												
pH @ 25 °C					6.84	7.24	7.2	7.05	7.47	7.45	7.61	
Conductivity @ 25 °C		µS/cm	1		2600		2220	2460	5030	2740	2800	
Total Suspended Solids		mg/L	1				<2	<2	<2	5	3	
Total Dissolved Solids		mg/L	5		2650	1970	2320	2460	3280	3150	3740	
Turbidity		NTU			<0.1							
Anions and Nutrients												
T-Alkalinity as CaCO3		mg/L	5.0		39.6	34	16	24	47	47	48	
Bicarbonate		mg/L	5				20	30	60	60	60	
Carbonate		mg/L	6				<6	<6	<6	<6	<6	
Hydroxide		mg/L	5				<5	<5	<5	<5	<5	
Bromide		mg/L	0.05	<5.0	<5.0	<2.5						
Chloride		mg/L	0.02	<50	<50	<25	0.45	2.3	0.58	0.52	1.7	
Fluoride		mg/L	0.02	0.152	0.167	0.165						
Sulfate (SO4)		mg/L	0.05	***1890***	***1710***	***1360***	***1280***	***1410***	***1870***	***1690***	93	*100*
Ammonia - N		mg/L		0.005	***0.044***	0.0079	<0.01	<0.01	<0.01	<0.01	<0.01	0.019
Nitrate - N		mg/L	0.01	<0.50	0.75	6.24	0.15	<0.1	<0.01	0.11	1.19	13
Nitrite - N		mg/L	0.01	<0.10	***0.32***	<0.050	<0.01	<0.1	<0.01	<0.01	<0.01	0.06
Orthophosphate-P		mg/L	0.002				<0.002	0.002	<0.002	0.002	<0.002	
Cyanides												
Cyanide Total		mg/L	0.001									
Cyanide (WAD)		mg/L	0.002									
Cyanate (digested sample)		mg/L	0.2									
Thiocyanate		mg/L	0.1									
Org-C (total nonpurgeable)		mg/L	0.5	1.29	1.79	1.1	1.6	1.8	1.8	2	1.8	
Dissolved Metal												
Hardness as CaCO3		mg/L	5	1920	1890	1410	1340	1690	2270	1990	2440	
Aluminum	Al	mg/L	0.005	<0.0050	<0.0050	0.0116	<0.005	0.008	<0.005	<0.05	<0.050	
Antimony	Sb	mg/L	0.0002	0.00077	0.00072	0.0005	0.0005	0.0008	0.0011	<0.002	<0.002	*0.02f*
Arsenic	As	mg/L	0.0002	0.00138	0.00152	0.00095	0.0011	0.0013	0.0019	0.003	0.004	0.005
Arsenic, Trivalent		mg/L	0.00005									
Arsenic, Pentavalent		mg/L	0.00005									
check												
notes												
Barium	Ba	mg/L	0.001	0.00631	0.00922	0.00459	0.01	0.013	0.004	<0.01	<0.01	
Beryllium	Be	mg/L	0.00004	0.0025	0.0025	0.0025	<0.00004	<0.00004	<0.00004	<0.0004	<0.0004	
Bismuth	Bi	mg/L	0.001	0.0025	0.0025	0.0025	<0.001	<0.001	<0.001	<0.01	<0.01	
Boron	B	mg/L	0.004	0.05	0.05	0.05	<0.004	<0.004	0.005	<0.04	<0.04	
Cadmium	Cd	mg/L	0.00001	***0.13***	***0.0468***	***0.0174***	***0.0094***	***0.0112***	***0.00984***	***0.0102***	***0.00742***	0.000017b
Calcium	Ca	mg/L	0.1	456	442	337	355	416	496	446	542	
Chromium	Cr	mg/L	0.0004	***0.0025***	***0.0025***	***0.0025***	***0.0054***	<0.0004	0.0008	<0.004	<0.004	0.001g
Cobalt	Co	mg/L	0.00002	0.00108	0.0005	0.0005	0.00021	0.00042	0.00026	<0.0002	0.0003	
Copper	Cu	mg/L	0.001	***0.0167***	***0.0085***	***0.00614***	<0.001	0.002	<0.001	<0.01	<0.01	0.004c
Iron	Fe	mg/L	0.01	0.03	0.03	0.03	<0.01	<0.01	<0.01	<0.10	<0.1	0.3d
Lead	Pb	mg/L	0.0001	0.00025	0.00025	0.00025	0.0001	0.0004	<0.0001	<0.001	<0.001	0.007c
Lithium	Li	mg/L	0.001	0.025	0.025	0.025	0.004	0.003	0.005	<0.01	<0.01	
Magnesium	Mg	mg/L	0.1	191	191	139	110	159	250	212	265	
Manganese	Mn	mg/L	0.0002	***17.1***	1.79	0.242	0.0669	0.167	0.0538	0.119	0.075	*3.8e*
Molybdenum	Mo	mg/L	0.0001	0.00025	0.00025	0.00025	<0.0001	<0.0001	0.0008	<0.001	<0.001	0.073
Nickel	Ni	mg/L	0.001	0.0144	0.0037	0.0025	0.004	0.006	0.006	<0.01	<0.01	0.15c
Phosphorus	P	mg/L	0.01	0.3	0.3	0.3	<0.01	<0.10	<0.10	<0.01	<0.1	
Potassium	K	mg/L	0.1	6.4	5.9	3.5	3	4	4	4.6	8	
Selenium	Se	mg/L	0.0006	0.00093	***0.00117***	0.00075	0.0009	***0.001***	***0.0018***	<0.006	<0.006	0.001
Silicon	Si	mg/L	0.05	2.92	2.32	1.3	0.71	1.2	1.1	1.23	1.6	
Silver	Ag	mg/L	0.00001	0.00005	0.00005	0.00005	<0.00001	<0.00001	<0.00001	<0.0001	<0.0001	
Sodium	Na	mg/L	0.1	2.3	2	2	0.8	<1	2	1.8	6	
Strontium	Sr	mg/L	0.001	1.02	0.799	0.546	0.615	0.705	0.936	0.74	0.76	
Sulfur	S	mg/L	0.2				440	516	670	628	683	
Tellurium	Te	mg/L	0.0001				<0.0001	<0.0001	<0.0001	<0.001	<0.001	
Thallium	Tl	mg/L	0.00001	<0.00050	<0.00050	<0.00050	0.00006	0.00008	0.0001	<0.0001	<0.0001	
Thorium	Th	mg/L	0.0004				<0.0004	<0.0004	<0.0004	<0.004	<0.004	
Tin	Sn	mg/L	0.0001	<0.00050	<0.00050	<0.00050	0.0001	<0.0001	0.0001	<0.001	<0.001	
Titanium	Ti	mg/L	0.01	<0.010	<0.010	<0.010	<0.01	<0.1	<0.1	<0.01	<0.1	
Uranium	U	mg/L	0.0004	<0.000050	0.000096	0.000176	<0.0004	<0.0004	0.0006	<0.004	<0.004	
Vanadium	V	mg/L	0.0001	<0.0050	<0.0050	<0.0050	<0.0001	<0.0001	0.0001	<0.001	<0.001	
Zinc	Zn	mg/L	0.001	***9.88***	***1.88***	***1***	***0.361***	***0.367***	***0.365***	***0.33***	***0.27***	0.03
Zirconium	Zr	mg/L	0.0001				<0.0001	<0.0001	0.0001	<0.001	<0.001	

Notes:
1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals
a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C,
b) working guideline based on a hardness >210 mg CaCO3/L (10 exp (0.86[log{hardness}]-3.2));
c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L;
d) guideline is for dissolved Fe;
e) guideline based on a water hardness of > 300 mg $CaCO_3$/L;
f) working guideline, based on proposed Ontario guideline
g) criteria for Cr(VI)
Bold italic values: exceeds CCME guidelines

Appendix B-2
Field Bin Results

Parameter		Unit	Detection Limit	Bin 2. Ore Bin unsaturated								CCME[1]
				23-Jul-09	6-Aug-09	20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	max
Field Parameters												
Temperature		C		15.31	12.55		3.95	7.66	8.73	9.84	6.53	
pH				6.28	7.21		7.08	5.58	7.03	6.5	6.07	
Conductivity		uS/cm		3619	-		2839	3026	3762	3894	3429	
Leachate Volume		L		3.5	1		2.9	3	~4.75	3.75	5.25	
Irrigated Volume		L			4		8	8	0	4	0	
Physical												
pH @ 25 °C					6.5	6.8	6.7	6.6	7.0	7.03	7.18	
Conductivity @ 25 °C		µS/cm	1		3460		2890	3020	6020	3610	3220	
Total Suspended Solids		mg/L	1				3	6	<2	6	<2	
Total Dissolved Solids		mg/L	5		3790	2890	3080	3410	4120	4300	3560	
Turbidity		NTU			0.13							
Anions and Nutrients												
T-Alkalinity as CaCO3		mg/L	5.0		22.8	22.8	5.0	8.0	32.0	44	36	
Bicarbonate		mg/L	5				<5	<5	40	50	40	
Carbonate		mg/L	6				6	10	<6	<6	<6	
Hydroxide		mg/L	5				<5	<5	<5	<5	<5	
Bromide		mg/L	0.05	<5.0	<5.0	<2.5						
Chloride		mg/L	0.02	<50	<50	<25	2.2	2.4	0.86	0.8	1.8	
Fluoride		mg/L	0.02	0.125	0.113	0.09						
Sulfate (SO4)		mg/L	0.05	***2680***	***2620***	***1930***	***1840***	***1780***	***2600***	***2480***	***101***	*100*
Ammonia - N		mg/L		0.0147	***0.093***	***0.0242***	<0.01	<0.01	<0.01	<0.01	<0.01	0.019
Nitrate - N		mg/L	0.01	<0.50	0.85	<0.25	0.14	<0.1	0.12	<0.01	<0.1	13
Nitrite - N		mg/L	0.01	<0.10	<0.10	<0.05	<0.01	***<0.1***	<0.01	<0.01	<0.01	0.06
Orthophosphate-P		mg/L	0.002				0.007	0.007	0.01	0.015	0.014	
Cyanides												
Cyanide Total		mg/L	0.001	-	-	-						
Cyanide (WAD)		mg/L	0.002	-	-	-						
Cyanate (digested sample)		mg/L	0.2	-	-							
Thiocyanate		mg/L	0.1	-								
Org-C (total nonpurgeable)		mg/L	0.5	2.64	3.16	1.69	1.3	2	2.4	2.5	2.1	
Dissolved Metal												
Hardness as CaCO3		mg/L	5	2530	2520	1830	1970	2170	2920	2710	2810	
Aluminum	Al	mg/L	0.005	<0.020	<0.020	<0.01	<0.005	<0.005	<0.02	<0.05	<0.05	
Antimony	Sb	mg/L	0.0002	***0.0332***	***0.0335***	***0.0219***	***0.0226***	***0.0229***	***0.031***	***0.028***	***0.024***	*0.02f*
Arsenic	As	mg/L	0.0002	***0.0173***	***0.0321***	***0.0227***	***0.0173***	***0.0279***	***0.038***	***0.04***	***0.041***	0.005
Arsenic, Trivalent		mg/L	0.00005									
Arsenic, Pentavalent		mg/L	0.00005									
check												
notes												
Barium	Ba	mg/L	0.001	0.0157	0.0146	0.00803	0.008	0.01	0.01	<0.01	<0.01	
Beryllium	Be	mg/L	0.00004	<0.010	<0.010	<0.005	<0.00004	<0.00004	<0.0002	<0.0004	<0.0004	
Bismuth	Bi	mg/L	0.001	<0.010	<0.010	<0.005	<0.001	<0.001	<0.005	<0.01	<0.01	
Boron	B	mg/L	0.004	<0.20	<0.20	<0.1	<0.004	<0.004	<0.02	<0.04	<0.040	
Cadmium	Cd	mg/L	0.00001	***0.201***	***0.108***	***0.0702***	***0.0452***	***0.0457***	***0.0716***	***0.0671***	***0.0391***	0.000017b
Calcium	Ca	mg/L	0.1	462	432	358	384	442	507	462	505	
Chromium	Cr	mg/L	0.0004	<0.010	<0.010	<0.005	<0.0004	0.0005	<0.002	<0.004	<0.004	0.001g
Cobalt	Co	mg/L	0.00002	0.0272	0.0116	0.0072	0.00289	0.00248	0.003	0.0022	0.0017	
Copper	Cu	mg/L	0.001	***0.0364***	***0.0216***	***0.0159***	0.003	***0.005***	***0.006***	<0.01	<0.01	0.004c
Iron	Fe	mg/L	0.01	<0.030	<0.030	<0.03	<0.01	0.02	<0.05	<0.10	<0.1	0.3d
Lead	Pb	mg/L	0.0001	0.0043	0.0054	0.00261	0.0011	0.0035	0.0009	<0.001	<0.001	0.007c
Lithium	Li	mg/L	0.001	<0.10	<0.10	<0.05	0.009	0.008	0.02	0.02	<0.01	
Magnesium	Mg	mg/L	0.1	334	350	229	246	259	402	377	376	
Manganese	Mn	mg/L	0.0002	***97.4***	***64.9***	***45***	***28.7***	***21.6***	***36.4***	2	***12.8***	*3.8e*
Molybdenum	Mo	mg/L	0.0001	<0.0010	<0.0010	<0.0005	<0.0001	<0.0001	0.001	<0.001	<0.001	0.073
Nickel	Ni	mg/L	0.001	0.058	0.028	0.0183	0.013	0.013	0.02	0.02	<0.01	0.15c
Phosphorus	P	mg/L	0.01	<0.30	<0.30	<0.3	<0.01	<0.1	<0.1	<0.01	<0.1	
Potassium	K	mg/L	0.1	8	7.7	5	4.6	7	7	7.9	11	
Selenium	Se	mg/L	0.0006	***0.00211***	***0.00188***	0.00092	***0.001***	0.0006	<0.003	<0.006	<0.006	0.001
Silicon	Si	mg/L	0.05	4.23	2.93	2.28	1.32	2.6	4.2	3.58	4.3	
Silver	Ag	mg/L	0.00001	0.00095	<0.00020	<0.0001	<0.00001	0.00001	<5E-05	<0.0001	<0.0001	
Sodium	Na	mg/L	0.1	4	3.1	2.4	1.3	1	<1	2.9	6	
Strontium	Sr	mg/L	0.001	1.13	0.855	0.656	0.758	0.82	1	0.9	0.78	
Sulfur	S	mg/L	0.2				605	698	832	920	784	
Tellurium	Te	mg/L	0.0001				<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Thallium	Tl	mg/L	0.00001	<0.0020	<0.0020	<0.001	0.00012	0.00014	0.00027	0.0002	<0.0001	
Thorium	Th	mg/L	0.0004				<0.0004	<0.0004	<0.002	<0.004	<0.004	
Tin	Sn	mg/L	0.0001	<0.0020	<0.0020	<0.001	<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Titanium	Ti	mg/L	0.01	<0.010	<0.010	<0.01	<0.01	<0.1	<0.1	<0.01	<0.1	
Uranium	U	mg/L	0.0004	<0.00020	<0.00020	<0.0001	<0.0004	<0.0004	<0.002	<0.004	<0.004	
Vanadium	V	mg/L	0.0001	<0.020	<0.020	<0.01	<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Zinc	Zn	mg/L	0.001	***31.2***	***8.39***	***8.28***	***4.02***	***4.03***	***6.34***	***5.89***	***3.48***	0.03
Zirconium	Zr	mg/L	0.0001				<0.0001	<0.0001	<0.0005	<0.001	<0.001	

Notes:
1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals
a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C,
b) working guideline based on a hardness >210 mg CaCO3/L (10 exp (0.86[log{hardness}]-3.2));
c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L;
d) guideline is for dissolved Fe;
e) guideline based on a water hardness of > 300 mg $CaCO_3$/L;
f) working guideline, based on proposed Ontario guideline
g) criteria for Cr(VI)
Bold italic values: exceeds CCME guidelines

Appendix B-2
Field Bin Results

Parameter		Unit	Detection Limit	Bin 3. Waste Rock + ORG Bin								CCME[1]
				23-Jul-09	8-May-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	max
				CN not filtered								
Field Parameters												
Temperature		C		18.65	18.9		3.9	8.36	8.58	12.11	7.5	
pH				5.62	6.05		6.72	5.5	6.48	7.5	5.8	
Conductivity		uS/cm		1344	3528		3393	3456	3332	3482	3222	
Leachate Volume		L					N/A	N/A	N/A	-	-	
Irrigated Volume		L					head space 0.16 m	16L to fill line	*	<4	1	
Physical												
pH @ 25 °C					6.31	6.69	6.48	6.55	6.4	6.19	6.37	
Conductivity @ 25 °C		µS/cm	1		3150		3470	3470	5140	3200	3070	
Total Suspended Solids		mg/L	1				10	8	<2	4	<2	
Total Dissolved Solids		mg/L	5		3320	3310	3950	3460	3540	3680	3460	
Turbidity		NTU			2.39							
Anions and Nutrients												
T-Alkalinity as CaCO3		mg/L	5.0		280	390	237	249	167	131	118	
Bicarbonate		mg/L	5				290	300	200	160	140	
Carbonate		mg/L	6				<6	<6	<6	<6	<6	
Hydroxide		mg/L	5				<5	<5	<5	<5	<5	
Bromide		mg/L	0.05	<5.0	<5.0	<5						
Chloride		mg/L	0.02	<50	<50	<50	4.48	5.3	2.08	1.93	3.8	
Fluoride		mg/L	0.02	0.064	0.054	0.065						
Sulfate (SO4)		mg/L	0.05	***1890***	***2040***	***2140***	***2180***	***2040***	***1920***	***1940***	81	*100*
Ammonia - N		mg/L		<0.354	<0.978	<1.29	***1.4***	***1.2***	***1.54***	***1.6***	***1.8***	0.019
Nitrate - N		mg/L	0.01	<0.50	0.58	<0.5	0.13	<0.1	<0.01	<0.01	1.12	13
Nitrite - N		mg/L	0.01	<0.10	0.34	<0.1	<0.01	<0.1	<0.01	<0.01	<0.01	0.06
Orthophosphate-P		mg/L	0.002				0.014	0.005	0.01	0.003	0.004	
Cyanides												
Cyanide Total		mg/L	0.001	0.0067	<0.0050	-						
Cyanide (WAD)		mg/L	0.002	<0.0050	<0.0050	-						
Cyanate (digested sample)		mg/L	0.2	<0.50	0.59							
Thiocyanate		mg/L	0.1	0.97								
Org-C (total nonpurgeable)		mg/L	0.5	17.3	38.1	37.5	24.2	36.3	15.4	12.1	17.3	
Dissolved Metal												
Hardness as CaCO3		mg/L	5	1860	2290	2320	2250	2170	2170	1840	2350	
Aluminum	Al	mg/L	0.005	0.034	<0.020	<0.05	0.009	0.012	<0.050	<0.050	<0.05	
Antimony	Sb	mg/L	0.0002	0.0014	0.0154	0.005	0.0007	0.0009	0.003	<0.002	<0.002	*0.02f*
Arsenic	As	mg/L	0.0002	0.0017	***0.0397***	***0.007***	***0.0197***	***0.0098***	0.004	***0.007***	***0.008***	0.005
Arsenic, Trivalent		mg/L	0.00005									
Arsenic, Pentavalent		mg/L	0.00005									
check												
notes												
Barium	Ba	mg/L	0.001	0.0808	0.0654	0.0728	0.032	0.036	0.04	0.03	0.02	
Beryllium	Be	mg/L	0.00004	<0.005	<0.01	<0.025	<0.00004	<0.00004	<0.0004	<0.0004	<0.0004	
Bismuth	Bi	mg/L	0.001	<0.005	<0.01	<0.025	<0.001	<0.001	<0.01	<0.01	<0.01	
Boron	B	mg/L	0.004	<0.1	<0.2	<0.5	<0.004	<0.004	0.05	<0.04	<0.040	
Cadmium	Cd	mg/L	0.00001	***0.0521***	***0.015***	***0.00085***	***0.00917***	***0.0357***	***0.0244***	***0.0679***	***0.0553***	0.000017b
Calcium	Ca	mg/L	0.1	496	499	558	487	500	524	503	583	
Chromium	Cr	mg/L	0.0004	<0.005	<0.01	<0.025	***0.0029***	***0.0035***	<0.004	<0.004	<0.004	0.001g
Cobalt	Co	mg/L	0.00002	0.0933	0.0778	0.174	0.156	0.154	0.107	0.0224	0.0216	
Copper	Cu	mg/L	0.001	0.0028	***0.0165***	***0.005***	0.003	***0.007***	<0.01	<0.01	<0.01	0.004c
Iron	Fe	mg/L	0.01	<0.03	<0.08	<5.28		0.17	<0.1	<0.1	<0.1	0.3d
Lead	Pb	mg/L	0.0001	0.0005	0.001	0.0025	0.0007	0.0001	<0.001	<0.001	<0.001	0.007c
Lithium	Li	mg/L	0.001	0.05	0.1	0.25	0.009	0.01	0.01	0.02	0.02	
Magnesium	Mg	mg/L	0.1	151	253	226	251	224	209	141	218	
Manganese	Mn	mg/L	0.0002	***29.4***	***91.3***	***134***		***181***	***152***	2	***97***	*3.8e*
Molybdenum	Mo	mg/L	0.0001	0.0005	0.0015	0.0025	0.0005	0.0005	0.001	<0.001	<0.001	0.073
Nickel	Ni	mg/L	0.001	***0.301***	0.085	***0.194***	0.119	0.108	0.1	0.12	0.1	0.15c
Phosphorus	P	mg/L	0.01	<0.3	<0.3	<0.3	<0.1	<0.10	<0.10	<0.01	<0.1	
Potassium	K	mg/L	0.1	8.2	50.6	11	13	15	15	16.7	25	
Selenium	Se	mg/L	0.0006	<0.00069	<0.0005	<0.0005	***0.001***	***0.0011***	<0.006	<0.0060	<0.006	0.001
Silicon	Si	mg/L	0.05	7.73	6.7	8.65	6.7	7	7.2	5.86	9.2	
Silver	Ag	mg/L	0.00001	<0.0001	<0.0002	<0.0005	0.00002	<0.00001	<0.00010	<0.0001	<0.0001	
Sodium	Na	mg/L	0.1	<7.2	<24	<5.8	5	4	5	3.7	8	
Strontium	Sr	mg/L	0.001	1.24	1.89	1.21	1.27	1.34	1.23	1.26	1.21	
Sulfur	S	mg/L	0.2				696	715	711	700	704	
Tellurium	Te	mg/L	0.0001				<0.0001	<0.0001	<0.001	<0.001	<0.001	
Thallium	Tl	mg/L	0.00001	<0.0010	<0.0020	<0.005	0.00028	0.00046	0.00034	0.00049	0.0003	
Thorium	Th	mg/L	0.0004				<0.0004	<0.0004	<0.004	<0.004	<0.004	
Tin	Sn	mg/L	0.0001	<0.0010	<0.0020	<0.005	<0.0001	<0.0001	<0.001	<0.001	<0.001	
Titanium	Ti	mg/L	0.01	<0.010	<0.010	<0.01	<0.1	<0.1	<0.1	<0.01	<0.1	
Uranium	U	mg/L	0.0004	0.00024	0.00124	0.00783	0.0039	0.0037	<0.004	<0.004	<0.004	
Vanadium	V	mg/L	0.0001	<0.010	<0.020	<0.05	0.0025	0.0029	0.002	0.002	0.002	
Zinc	Zn	mg/L	0.001	***7.89***	***1.96***	***0.576***	***2.04***	***4.92***	***4.64***	***9.26***	***9.06***	0.03
Zirconium	Zr	mg/L	0.0001				0.0003	0.0002	<0.001	<0.001	<0.001	

Notes:
1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals
a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C,
b) working guideline based on a hardness >210 mg CaCO3/L (10 exp (0.86[log{hardness}]-3.2));
c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L;
d) guideline is for dissolved Fe;
e) guideline based on a water hardness of > 300 mg $CaCO_3$/L;
f) working guideline, based on proposed Ontario guideline
g) criteria for Cr(VI)
Bold italic values: exceeds CCME guidelines

Appendix B-2
Field Bin Results

Parameter		Unit	Detection Limit	Bin 4. Tailings + ORG Bin saturated								CCME[1]
				23-Jul-09	8-May-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	max
Field Parameters												
Temperature		C		18.61	18.42		5.47	9.05	10.4	12.5	8.12	
pH				6.07	6.37		6.74	5.88	6.25	6.5	6.06	
Conductivity		uS/cm		1869	3783		3025	3047	3006	3162	2888	
Leachate Volume		L					N/A	N/A	N/A	-	-	
Irrigated Volume		L					head space 0.175 m		**		4	
Physical												
pH @ 25 °C					6.8	6.8	6.7	6.7	6.7	6.71	6.73	
Conductivity @ 25 °C		µS/cm	1		3410		2940	3070	4670	2850	2670	
Total Suspended Solids		mg/L	1				11	8	<2	8	<2	
Total Dissolved Solids		mg/L	5		3550	3440	3300	3210	3150	3050	2940	
Turbidity		NTU			6.2							
Anions and Nutrients												
T-Alkalinity as CaCO3		mg/L	5.0		129.0	135.0	86.0	67.0	65.0	62	83	
Bicarbonate		mg/L	5				100	80	80	80	100	
Carbonate		mg/L	6				<6	<6	<6	<6	<6	
Hydroxide		mg/L	5				<5	<5	<5	<5	<5	
Bromide		mg/L	0.05	<5.0	<5.0	<5						
Chloride		mg/L	0.02	<50	<50	<50	0.4	<0.2	0.25	1.94	<0.2	
Fluoride		mg/L	0.02	0.111	0.093	0.082						
Sulfate (SO4)		mg/L	0.05	***2570***	***2420***	***2370***	***1830***	***1850***	***1880***	***1730***	80	*100*
Ammonia - N		mg/L		***1.92***	***1.92***	***2.12***	***1.2***	<0.01	0.01	***0.03***	***0.1***	0.019
Nitrate - N		mg/L	0.01	<0.50	0.74	<0.5	0.22	1.92	0.42	<0.01	1.18	13
Nitrite - N		mg/L	0.01	<0.10	***0.58***	<0.1	<0.01	<0.1	<0.01	<0.01	***0.19***	0.06
Orthophosphate-P		mg/L	0.002				0.002	0.007	0.005	0.009	0.004	
Cyanides												
Cyanide Total		mg/L	0.001	0.0454	0.0287	0.0413	0.008	0.001	<0.001	0.001	0.002	
Cyanide (WAD)		mg/L	0.002	0.0115	<0.0050	<0.005	0.002	0.002	<0.002	<0.002	0.002	
Cyanate (digested sample)		mg/L	0.2	<0.50	<0.50		<0.2	<0.2	<0.2	0.2	<0.2	
Thiocyanate		mg/L	0.1	1.33			<0.1	<0.1	<0.1	<0.1	0.4	
Org-C (total nonpurgeable)		mg/L	0.5	39.3	30.2	24.2	21	16.4	12.5	10.7	9.9	
Dissolved Metal												
Hardness as CaCO3		mg/L	5	2380	2320	2320	1710	1970	1930	1540	1910	
Aluminum	Al	mg/L	0.005	<0.020	<0.020	<0.02	0.007	<0.005	<0.02	<0.05	<0.05	
Antimony	Sb	mg/L	0.0002	***0.024***	0.0133	0.0126	0.0148	***0.0398***	***0.047***	***0.046***	***0.042***	*0.02f*
Arsenic	As	mg/L	0.0002	***0.0056***	***0.011***	***0.008***	***0.0338***	***0.0494***	***0.0081***	***0.077***	***0.149***	0.005
Arsenic, Trivalent		mg/L	0.00005				0.00111	0.00023	0.001			
Arsenic, Pentavalent		mg/L	0.00005				0.00103	0.00099	0.00512			
check							0.00214	0.00122	0.00612			
notes							methylated /organic species?	methylated /organic species?				
Barium	Ba	mg/L	0.001	0.0741	0.0714	0.0588	0.032	0.031	0.03	0.03	0.02	
Beryllium	Be	mg/L	0.00004	<0.010	<0.010	<0.01	<0.00004	<0.00004	<0.0002	<0.0004	<0.0004	
Bismuth	Bi	mg/L	0.001	<0.010	<0.010	<0.01	<0.001	<0.001	<0.005	<0.01	<0.01	
Boron	B	mg/L	0.004	<0.20	<0.20	<0.2	0.052	0.038	0.071	<0.04	<0.04	
Cadmium	Cd	mg/L	0.00001	***0.0312***	***0.0138***	***0.0157***	***0.0234***	***0.0304***	***0.035***	***0.0413***	***0.0396***	0.000017b
Calcium	Ca	mg/L	0.1	473	492	516	480	515	534	480	567	
Chromium	Cr	mg/L	0.0004	<0.010	<0.010	<0.01	0.0007	0.0009	<0.002	<0.004	<0.004	0.001g
Cobalt	Co	mg/L	0.00002	0.11	0.0911	0.0871	0.0687	0.0626	0.0482	0.0355	0.041	
Copper	Cu	mg/L	0.001	***0.0466***	***0.0305***	***0.0153***	***0.005***	***0.008***	***0.008***	<0.01	<0.01	0.004c
Iron	Fe	mg/L	0.01	0.036	0.227	***0.564***	***0.8***	***0.5***	<0.05	0.17	***2.54***	0.3d
Lead	Pb	mg/L	0.0001	<0.0010	<0.0010	<0.001	0.0002	0.0005	0.001	<0.001	<0.001	0.007c
Lithium	Li	mg/L	0.001	<0.10	<0.10	<0.1	0.019	0.016	0.02	0.02	0.02	
Magnesium	Mg	mg/L	0.1	292	266	250	125	166	144	82.8	121	
Manganese	Mn	mg/L	0.0002	***81***	***94***	***99.8***	***100***	***93.4***	***102***	2	***101***	*3.8e*
Molybdenum	Mo	mg/L	0.0001	<0.0010	0.0016	0.0016	0.0008	0.0008	0.0006	<0.001	<0.001	0.073
Nickel	Ni	mg/L	0.001	***0.167***	0.106	0.093	0.065	0.058	0.05	0.05	0.04	0.15c
Phosphorus	P	mg/L	0.01	<0.30	<0.30	<0.3	<0.01	<0.1	<0.1	<0.01	<0.1	
Potassium	K	mg/L	0.1	45.9	48	42.4	28.6	34	33	24.9	34	
Selenium	Se	mg/L	0.0006	0.00051	<0.00050	<0.0005	0.0008	<0.0006	<0.003	<0.006	<0.006	0.001
Silicon	Si	mg/L	0.05	5.66	6.39	6.31	4.07	5.4	5.3	3.28	5.9	
Silver	Ag	mg/L	0.00001	0.00134	0.00049	<0.0002	0.00004	0.00001	<5E-05	<0.0001	<0.0001	
Sodium	Na	mg/L	0.1	37.7	24.9	19.2	7.2	6	2	3.2	7	
Strontium	Sr	mg/L	0.001	2.17	2.02	1.91	1.72	1.94	1.74	1.6	1.61	
Sulfur	S	mg/L	0.2				620	628	612	583	588	
Tellurium	Te	mg/L	0.0001				<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Thallium	Tl	mg/L	0.00001	<0.0020	<0.0020	<0.002	0.00019	0.00015	0.00016	0.00012	<0.0001	
Thorium	Th	mg/L	0.0004				<0.0004	<0.0004	<0.002	<0.004	<0.004	
Tin	Sn	mg/L	0.0001	<0.0020	<0.0020	<0.002	<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Titanium	Ti	mg/L	0.01	<0.010	<0.010	<0.01	<0.01	<0.1	<0.1	<0.01	<0.1	
Uranium	U	mg/L	0.0004	0.00033	0.00102	0.00198	0.001	0.0006	<0.002	<0.004	<0.004	
Vanadium	V	mg/L	0.0001	<0.020	<0.020	<0.02	0.0003	0.0004	<0.0005	<0.001	<0.001	
Zinc	Zn	mg/L	0.001	***2.62***	***1.49***	***1.7***	***2.31***	***3.01***	***3.17***	***3.49***	***4.12***	0.03
Zirconium	Zr	mg/L	0.0001				0.0001	<0.0001	<0.0005	<0.001	<0.001	

Notes:
1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals
a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C,
b) working guideline based on a hardness >210 mg CaCO3/L (10 exp (0.86[log{hardness}]-3.2));
c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L;
d) guideline is for dissolved Fe;
e) guideline based on a water hardness of > 300 mg $CaCO_3$/L;
f) working guideline, based on proposed Ontario guideline
g) criteria for Cr(VI)
Bold italic values: exceeds CCME guidelines

Appendix B-2
Field Bin Results

Parameter		Unit	Detection Limit	Bin 5. Tailings Sand Pond unsaturated						CCME[1]
				20-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	max
Field Parameters										
Temperature		C			6.3	15.52	9.39	10.03	7.24	
pH					6.8	7.12	6.3	6.5	6.21	
Conductivity		uS/cm			2237	2448	2455	2390	2165	
Leachate Volume		L			2.5	2.5	21	7	12.1	
Irrigated Volume		L			28	26			0	
Physical										
pH @ 25 °C				7.0	7.0	7.0	7.8	7.77	7.07	
Conductivity @ 25 °C		µS/cm	1		2170	2310	3670	2180	2050	
Total Suspended Solids		mg/L	1		3	<5	<2	<3	<2	
Total Dissolved Solids		mg/L	5	2470	2300	2170	2440	2300	2050	
Turbidity		NTU								
Anions and Nutrients										
T-Alkalinity as CaCO3		mg/L	5.0	17.9	10.0	12.0	29.0	32	11	
Bicarbonate		mg/L	5		10	20	40	40	10	
Carbonate		mg/L	6		<6	<6	<6	<6	<6	
Hydroxide		mg/L	5		<5	<5	<5	<5	<5	
Bromide		mg/L	0.05	<2.5						
Chloride		mg/L	0.02	<25	0.81	2.3	0.47	0.24	<0.2	
Fluoride		mg/L	0.02	0.124						
Sulfate (SO4)		mg/L	0.05	***1760***	***1290***	***1220***	***1330***	***1230***	85	*100*
Ammonia - N		mg/L		***0.0328***	<0.01	<0.01	<0.01	<0.01	<0.01	0.019
Nitrate - N		mg/L	0.01	<0.25	0.41	<0.1	0.19	<0.01	<0.1	13
Nitrite - N		mg/L	0.01	<0.05	<0.01	<0.1	<0.01	<0.01	<0.1	0.06
Orthophosphate-P		mg/L	0.002		0.005	0.007	<0.002	<0.002	<0.002	
Cyanides										
Cyanide Total		mg/L	0.001					0.003	0.005	
Cyanide (WAD)		mg/L	0.002	<0.001	0.004	0.003	0.003	<0.002	0.004	
Cyanate (digested sample)		mg/L	0.2	0.0077	0.006	0.004	<0.002	<0.2	<0.2	
Thiocyanate		mg/L	0.1		<0.2	<0.2	<0.2	<0.1	0.3	
Org-C (total nonpurgeable)		mg/L	0.5	3.05	3.2	4.2	4.8	2.4	1.7	
Dissolved Metal										
Hardness as CaCO3		mg/L	5	1810	1380	1570	1710	1040	1620	
Aluminum	Al	mg/L	0.005	<0.01	<0.005	<0.005	<0.02	<0.05	<0.050	
Antimony	Sb	mg/L	0.0002	***0.0559***	***0.0311***	***0.0416***	***0.0554***	***0.057***	***0.056***	*0.02f*
Arsenic	As	mg/L	0.0002	0.0035	0.001	0.0016	0.001	<0.002	<0.002	0.005
Arsenic, Trivalent		mg/L	0.00005		0.00009	0.00030	0.00065			
Arsenic, Pentavalent		mg/L	0.00005		0.00044	0.00029	0.00062			
check					0.00053	0.00059	0.00127			
notes					possibly small amount of methylated	possibly small amount of methylated				
Barium	Ba	mg/L	0.001	0.15	0.024	0.047	0.04	0.03	0.06	
Beryllium	Be	mg/L	0.00004	<0.005	<0.00004	<0.00004	<0.0002	<0.0004	<0.0004	
Bismuth	Bi	mg/L	0.001	<0.005	<0.001	<0.001	<0.005	<0.01	<0.01	
Boron	B	mg/L	0.004	<0.1	0.018	0.014	0.03	<0.04	<0.04	
Cadmium	Cd	mg/L	0.00001	***0.0146***	***0.00453***	***0.0044***	***0.0032***	***0.00167***	***0.00083***	0.000017b
Calcium	Ca	mg/L	0.1	535	465	514	563	382	605	
Chromium	Cr	mg/L	0.0004	<0.005	<0.0004	<0.0004	<0.002	<0.004	<0.004	0.001g
Cobalt	Co	mg/L	0.00002	0.0363	0.0126	0.0158	0.013	0.0072	0.006	
Copper	Cu	mg/L	0.001	***0.008***	0.002	0.002	<0.005	<0.01	<0.01	0.004c
Iron	Fe	mg/L	0.01	<0.03	<0.01	<0.01	<0.05	<0.10	<0.1	0.3d
Lead	Pb	mg/L	0.0001	<0.0005	0.0003	0.0003	<0.0005	<0.001	<0.001	0.007c
Lithium	Li	mg/L	0.001	<0.05	0.005	0.004	0.005	<0.01	<0.01	
Magnesium	Mg	mg/L	0.1	116	54	71	75	21.2	28	
Manganese	Mn	mg/L	0.0002	***9.46***	1.5	0.784	0.708	0.293	0.204	*3.8e*
Molybdenum	Mo	mg/L	0.0001	0.00065	0.0003	0.0005	0.0006	<0.001	<0.001	0.073
Nickel	Ni	mg/L	0.001	0.0826	0.037	0.036	0.03	0.02	0.01	0.15c
Phosphorus	P	mg/L	0.01	<0.3	<0.01	<0.1	<0.1	<0.01	<0.1	
Potassium	K	mg/L	0.1	9.4	6.3	7	6	5.4	6	
Selenium	Se	mg/L	0.0006	<0.0005	0.0008	<0.0006	<0.003	<0.006	<0.006	0.001
Silicon	Si	mg/L	0.05	5.28	3.12	3.9	4.4	2.4	3.4	
Silver	Ag	mg/L	0.00001	<0.0001	<0.00001	<0.00001	<0.00005	<0.0001	<0.0001	
Sodium	Na	mg/L	0.1	6.4	3.2	2	<1	0.8	3	
Strontium	Sr	mg/L	0.001	1.32	0.937	1.04	0.983	0.8	0.67	
Sulfur	S	mg/L	0.2		440	485	500	326	445	
Tellurium	Te	mg/L	0.0001		<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Thallium	Tl	mg/L	0.00001	<0.001	0.00006	0.00008	0.00008	<0.0001	<0.00010	
Thorium	Th	mg/L	0.0004		<0.0004	<0.0004	<0.002	<0.004	<0.004	
Tin	Sn	mg/L	0.0001	<0.001	<0.0001	<0.0001	<0.0005	<0.001	<0.001	
Titanium	Ti	mg/L	0.01	<0.01	<0.01	<0.1	<0.1	<0.01	<0.1	
Uranium	U	mg/L	0.0004	<0.0001	<0.0004	<0.0004	<0.002	<0.004	<0.004	
Vanadium	V	mg/L	0.0001	<0.01	0.0001	0.0002	<0.0005	<0.001	<0.001	
Zinc	Zn	mg/L	0.001	***1***	***0.327***	***0.228***	***0.13***	***0.06***	***0.04***	0.03
Zirconium	Zr	mg/L	0.0001		<0.0001	<0.0001	<0.0005	<0.001	<0.001	

Notes:
1. Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines for the Protection of Aquatic Life (updated December 2007) for total metals,
Values listed in italics are Maximum B.C. Provincial Guidelines for Protection of Freshwater Aquatic Life for total metals
a) ammonia (as N) criteria is based on a median pH of 7.5 and a conservative temperature of 20°C,
b) working guideline based on a hardness >210 mg CaCO3/L (10 exp (0.86[log{hardness}]-3.2));
c) guidelines are based on a hardness of > 180 mg $CaCO_3$/L;
d) guideline is for dissolved Fe;
e) guideline based on a water hardness of > 300 mg $CaCO_3$/L;
f) working guideline, based on proposed Ontario guideline
g) criteria for Cr(VI)
Bold italic values: exceeds CCME guidelines

Appendix B2
Field Bin Results - QA/QC

Parameter		Unit	Detection Limit	Tailings + Org	Tailings + Org	Tailings + Org	Tailings + Org	Tailings Sand Bin	Tailings Sand Bin	Tailings + Org	Tailings + Org	Tailings + Org	Tailings + Org	Blanks	Blanks	Blanks	Blanks	Blanks
				D Bin	D Bin	D Bin	D Bin	D Bin	D Bin	D Bin	D Bin	D Bin	D Bin	B Bin	B Bin	B Bin	B Bin	B Bin
				20-May-10	20-May-10	17-Jun-10	17-Jun-10	15-Jul-10	15-Jul-10	12-Aug-10	12-Aug-10	8-Sep-10	8-Sep-10	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10
Physical																		
pH @ 25 °C				6.7	6.6	6.7	6.8	7.8	7.9	6.71	7.86	6.73	6.68	5.9	6.1	6.2	6.16	6.46
Conductivity @ 25 °C		µS/cm	1	2940	2960	3070	2970	3670	3350	2850	2160	2670	2590	2	1	2	2	2
Total Suspended Solids		mg/L	1	11	26	8	11	<2	<2	8	<3	<2	14	<2	<4	<2	<3	<2
Total Dissolved Solids		mg/L	5	3300	3170	3210	2630	2440	2430	3050	2310	2940	2900	16	8	14	24	22
Turbidity		NTU																
Anions and Nutrients																		
T-Alkalinity as CaCO3		mg/L	5.0	86.0	102.0	67.0	84.0	29.0	29.0	62	32	83	87	5.0	5.0	5.0	<5	<5
Bicarbonate		mg/L	5	100	120	80	100	40	40	80	40	100	100	<5	<5	<5	<5	<5
Carbonate		mg/L	6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
Hydroxide		mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Bromide		mg/L	0.05															
Chloride		mg/L	0.02	0.4	0.43	<0.2	<0.2	0.47	0.46	1.94	0.24	<0.2	<0.2	<0.02	<0.02	0.22	<0.02	5.3
Fluoride		mg/L	0.02															
Sulfate (SO4)		mg/L	0.05	1830	1840	1850	1690	1330	1320	1730	1260	80	85	0.6	0.53	0.25	0.29	1.08
Ammonia - N		mg/L		1.2	2.3	<0.01	0.88	<0.01	<0.01	0.03	<0.01	0.1	0.3	0.02	<0.01	<0.01	<0.01	<0.01
Nitrate - N		mg/L	0.01	0.22	0.14	1.92	1.97	0.19	0.2	<0.01	<0.01	1.18	1.05	<0.01	<0.01	<0.01	<0.01	<0.01
Nitrite - N		mg/L	0.01	<0.01	<0.01	<0.1	<0.1	<0.01	<0.01	<0.01	<0.01	0.19	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
Orthophosphate-P		mg/L	0.002	0.002	<0.002	0.007	0.002	<0.002	<0.002	0.009	0.002	0.004	0.002	<0.002	0.002	<0.002	<0.002	<0.002
Cyanides																		
Cyanide Total		mg/L	0.001	0.008		0.001				0.001	0.003	0.002	0.004	<0.001	<0.001	<0.001	<0.001	0.001
Cyanide (WAD)		mg/L	0.002	0.002	0.024	0.002	0.004	0.003	0.003	<0.002	<0.002	0.002	0.002	0.004	0.002	<0.002	<0.002	0.002
Cyanate (digested sample)		mg/L	0.2	<0.2	0.002	<0.2	0.002	<0.002	<0.002	0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Thiocyanate		mg/L	0.1	<0.1	<0.2	<0.1	0.2	<0.2	<0.2	<0.1	<0.1	0.4	0.3	<0.1	<0.1	<0.1	<0.1	0.2
Org-C (total nonpurgeable)		mg/L	0.5	21	23.2	16.4	19.1	4.8	4	10.7	2.5	9.9	11.3	0.6	2.1	2.1	0.5	<0.5
Dissolved Metal																		
Hardness as CaCO3		mg/L	5	1710	640	1970	1870	1710	1600	1540	1340	1910	1830	<5	<5	<7	<5	<5
Aluminum	Al	mg/L	0.005	0.007	<0.005	<0.005	<0.005	<0.02	<0.02	<0.05	<0.05	<0.05	<0.05	<0.005	<0.005	<0.025	<0.005	<0.005
Antimony	Sb	mg/L	0.0002	0.0148	0.0184	0.0398	0.0406	0.0554	0.0565	0.046	0.058	0.042	0.04	<0.0002	<0.0002	<0.001	<0.0002	<0.0002
Arsenic	As	mg/L	0.0002	0.0338	0.504	0.0494	0.329	0.001	<0.001	0.077	0.002	0.149	0.237	<0.0002	<0.0002	<0.001	<0.0002	<0.0002
Arsenic, Trivalent		mg/L	0.00005	0.00111	0.169	0.00023	0.085	0.00065	0.00031					<0.00005	0.00028	<0.00005		
Arsenic, Pentavalent		mg/L	0.00005	0.00103	0.00477	0.00099	0.0044	0.00062	0.00067					0.00011	0.00011	0.0002		
check				0.00214	0.174	0.00122	0.089	0.00127	0.001					0.00011	0.00039	0.0002		
notes				methylated /organic species?	methylated /organic species?	methylated /organic species?	methylated /organic species?								?			
Barium	Ba	mg/L	0.001	0.032	0.029	0.031	0.028	0.04	0.04	0.03	0.03	0.02	0.02	<0.001	<0.001	<0.005	<0.001	<0.001
Beryllium	Be	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.0002	<0.0002	<0.0004	<0.0004	<0.0004	<0.0004	<0.00004	<0.00004	<0.0002	<0.00004	<0.00004
Bismuth	Bi	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.005	<0.005	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.005	<0.001	<0.001
Boron	B	mg/L	0.004	0.052	0.044	0.038	0.038	0.03	0.03	<0.04	<0.04	<0.04	<0.04	<0.004	<0.004	<0.02	<0.004	<0.004
Cadmium	Cd	mg/L	0.00001	0.0234	0.0279	0.0304	0.0374	0.0032	0.00332	0.0413	0.00153	0.0396	0.0399	<0.00001	0.00006	<5E-05	<0.00001	<0.00001
Calcium	Ca	mg/L	0.1	480	156	515	503	563	525	480	514	567	554	<0.1	<0.1	<1	<0.1	<0.1
Chromium	Cr	mg/L	0.0004	0.0007	0.006	0.0009	0.0048	<0.002	<0.002	<0.004	<0.004	<0.004	<0.004	0.0004	<0.0004	<0.002	<0.0004	<0.0004
Cobalt	Co	mg/L	0.00002	0.0687	0.0665	0.0626	0.0584	0.013	0.0132	0.0355	0.0074	0.041	0.0501	<0.00002	<0.00002	<0.0001	<0.00002	<0.00002
Copper	Cu	mg/L	0.001	0.005	0.006	0.008	0.01	<0.005	<0.005	<0.01	<0.01	<0.01	<0.01	<0.001	<0.001	<0.005	<0.001	<0.001
Iron	Fe	mg/L	0.01	0.8	7.64	0.5	4.87	<0.05	<0.05	0.17	<0.1	2.54	9.23	<0.01	<0.01	<0.05	<0.01	<0.01
Lead	Pb	mg/L	0.0001	0.0002	0.0006	0.0005	0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	0.0003	0.0004	<0.0005	<0.0001	<0.0001
Lithium	Li	mg/L	0.001	0.019	0.023	0.016	0.022	0.005	0.005	0.02	<0.01	0.02	0.02	<0.001	<0.001	<0.005	<0.001	<0.001
Magnesium	Mg	mg/L	0.1	125	61	166	149	75	69	82.8	14.6	121	109	<0.1	<0.1	<1	<0.1	<0.1
Manganese	Mn	mg/L	0.0002	100	43.8	93.4	97.7	0.708	0.712	2	0.279	101	98	0.0006	0.0044	<0.001	<0.0002	0.0004
Molybdenum	Mo	mg/L	0.0001	0.0008	0.0009	0.0008	0.0007	0.0006	0.0007	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001
Nickel	Ni	mg/L	0.001	0.065	0.047	0.058	0.045	0.03	0.03	0.05	0.02	0.04	0.04	<0.001	<0.001	<0.005	<0.001	<0.001
Phosphorus	P	mg/L	0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.01	<0.01	<0.1	<0.01	<0.01
Potassium	K	mg/L	0.1	28.6	16	34	34	6	6	24.9	4.7	34	32	<0.1	<0.1	<1	<0.1	<0.1
Selenium	Se	mg/L	0.0006	0.0008	<0.0006	<0.0006	<0.0006	<0.003	<0.003	<0.006	<0.006	<0.006	<0.006	<0.0006	<0.0006	<0.003	<0.0006	<0.0006
Silicon	Si	mg/L	0.05	4.07	3.4	5.4	6	4.4	4.2	3.28	1.2	5.9	5.6	<0.05	<0.05	<0.5	<0.05	<0.05
Silver	Ag	mg/L	0.00001	0.00004	0.00006	0.00001	0.00007	<0.00005	<0.00005	<0.0001	<0.0001	<0.0001	0.00015	<0.00001	<0.00001	<5E-05	<0.00001	<0.00001
Sodium	Na	mg/L	0.1	7.2	<1	6	5	<1	<1	3.2	0.5	7	6	<0.1	<0.1	<1	<0.1	<0.1
Strontium	Sr	mg/L	0.001	1.72	1.77	1.94	2.02	0.983	0.98	1.6	0.77	1.61	1.54	<0.001	<0.001	<0.005	<0.001	<0.001
Sulfur	S	mg/L	0.2	620	541	628	608	500	483	583	456	588	584	1.3	<0.2	<2	1.1	0.3
Tellurium	Te	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001
Thallium	Tl	mg/L	0.00001	0.00019	0.00024	0.00015	0.00022	0.00008	0.00008	0.00012	<0.0001	<0.0001	<0.0001	<0.00001	<0.00001	<5E-05	<0.00001	<0.00001
Thorium	Th	mg/L	0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.002	<0.002	<0.004	<0.004	<0.004	<0.004	<0.0004	<0.0004	<0.002	<0.0004	<0.0004
Tin	Sn	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0001	0.0001	<0.0005	<0.0001	<0.0001
Titanium	Ti	mg/L	0.01	<0.01	<0.1	<0.1	<0.1	<0.1	<0.1	<0.01	<0.01	<0.1	<0.1	<0.01	<0.01	<0.1	<0.01	<0.01
Uranium	U	mg/L	0.0004	0.001	0.0014	0.0006	0.0008	<0.002	<0.002	<0.004	<0.004	<0.004	<0.004	<0.0004	<0.0004	<5E-02	<0.0004	<0.0004
Vanadium	V	mg/L	0.0001	0.0003	0.0005	0.0004	0.0005	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001
Zinc	Zn	mg/L	0.001	2.31	4.01	3.01	4.47	0.13	0.13	3.49	0.06	4.12	4.35	<0.001	0.003	0.01	0.003	<0.001
Zirconium	Zr	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001

Appendix C
Waste Rock Lysimeter and Seep Chemistry Results

		Sample ID	L1						CCME
		Date Sampled	14-May-09	28-May-09	20-Aug-09	3-Sep-09	20-May-10	15-Jul-10	
	Units	Detection Limit							
Field Parameters									
F-pH			7.11	7					
F-cond	uS/cm		3788	4720					
F-Temp	°C		2.55	4.38					
Leachate Volume	L								
Irrigated Volume	L								
Lab Parameters									
Conductivity	uS/cm		3680	3480	1820	2740	2780	4660	
Hardness (as CaCO3)	mg/L	1	2750		1240	2380	1810	2480	
pH	pH	0.1	6.99	7.29	7.27	7.25	7.48	7.49	
TSS				145		8	40	10	
Total Dissolved Solids	mg/L	10		3600	1910	2770	2700	2870	
Turbidity	NTU	0.1							
Acidity			12						
Alkalinity, Total (as CaCO3)	mg/L	2	52	75	32	30	48	45	
Bicarbonate Alkalinity			60	90	40	40	60	50	
Carbonate Alkalinity			<6	<6	<6	<6	<6	<6	
Hydroxide Alkalinity			<5	<5	<5	<5	<5	<5	
Ammonia as N	mg/L	0.005		0.04		<0.01	<0.09	<0.04	0.019
Bromide (Br)	mg/L	0.05							
Chloride (Cl)	mg/L	0.5		0.79	1.57	1.25	1.14	0.95	
Fluoride (F)	mg/L	0.02							
Nitrate (as N)	mg/L	0.005	0.94	0.48	1.17	0.27	0.62	0.47	
Nitrite (as N)	mg/L	0.001		0.01	0.25	0.33	<0.01	<0.01	?
Sulfate (SO4)	mg/L	0.5	2940	2650	1340	1990	2120	2030	*100*
Total Phosphate									
Cyanide, Weak Acid Diss	mg/L	0.005							
Cyanide, Total	mg/L	0.005							
Cyanate (CNO)	mg/L	0.5							
Thiocyanate (SCN)	mg/L	0.5							
CN SAD									
Total Organic Carbon	mg/L	0.5							
Ag	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.0001	<0.00001	<1E-05	
Al	mg/L	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	
As	mg/L	0.0001	0.0027	0.0056	0.0028	0.0031	0.0038	0.0048	0.005
B	mg/L	0.01	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	
Ba	mg/L	0.00005	0.002	0.004	0.004	0.004	0.003	0.004	
Be	mg/L	0.0005	<0.00004	<0.00004	<0.00004	<4E-05	<0.00004	<4E-05	
Bi	mg/L	0.0005	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	
Ca	mg/L	0.05	319	402	449	456	271	514	
Cd	mg/L	0.000017	0.0287	0.0323	0.00736	0.00759	0.00666	0.00673	1.7E-05
Co	mg/L	0.0001	0.00101	0.00065	0.00017	0.00011	0.00018	0.0002	
Cr	mg/L	0.0005	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.0089/0.
Cu	mg/L	0.0001	0.006	0.01	0.005	<0.001	<0.002	<0.002	0.004
Fe	mg/L	0.03	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Hg				<0.01	<0.01	<0.01	<0.01	<1E-05	2.6E-05
K	mg/L	2	5.9	6.1	3.4	1.8	3.8	7	
Li	mg/L	0.005	0.012	0.013	0.003	0.006	0.004	0.008	
Mg	mg/L	0.1	475	488	95.5	301	275	290	
Mn	mg/L	0.00005	3.78	4.64	0.114	0.0613	0.0435	0.0141	0.2
Mo	mg/L	0.00005	0.00006	0.00003	<0.0001	<0.0001	<0.0001	<0.0001	0.073
Na	mg/L	2	1.2	1.4	0.6	0.4	0.7	<1	
Ni	mg/L	0.0005	0.007	0.008	0.003	0.002	0.003	0.003	0.15
P	mg/L	0.3	<0.01	0.02	<0.01	0.02	<0.01	<0.1	
Pb	mg/L	0.00005	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.007
S			831		445	664	705	676	
Sb	mg/L	0.0001	0.001	0.0012	0.0014	0.0016	0.0012	0.0022	0.006
Se	mg/L	0.0005	0.0044	0.0039	<0.0006	0.0011	0.0018	0.0011	0.001
Si	mg/L	0.05	1.35	1.92	0.94	0.45	1.03	1.6	
Sn	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Sr	mg/L	0.0001	1.04	1.01	0.443	0.784	0.643	0.89	
Te			<0.0001						
Th			<0.0001	<0.0001	<0.0004	<0.0004	<0.0004	<0.0004	
Ti	mg/L	0.01	0.0006	0.031	<0.0004	<0.0004	<0.0004	<0.0004	
Tl	mg/L	0.0001	0.00013	0.00014	0.00009	0.00009	0.00009	0.00015	
U	mg/L	0.00001	0.0006	0.0009	<0.0004	0.0007	0.0013	0.0011	
V	mg/L	0.001	0.00014	0.00013	<0.0001	<0.0001	<0.0001	<0.0001	
Zn	mg/L	0.001	2.15	2.39	0.154	0.311	0.415	0.276	0.03
Zr			0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Appendix C
Waste Rock Lysimeter and Seep Chemistry Results

	Sample ID	L2					CCME
	Date Sampled	14-May-09	28-May-09	3-Sep-09	20-May-10	15-Jul-10	
Field Parameters							
F-pH		7.7	7.57				
F-cond	uS/cm	1310	1563				
F-Temp	°C		3.74				
Leachate Volume	L						
Irrigated Volume	L						
Lab Parameters							
Conductivity	uS/cm	1390	1190	1370	414	2910	
Hardness (as CaCO3)	mg/L	838		665	176	1450	
pH	pH	7.59	7.71	7.73	7.52	7.74	
TSS			32	19	<2	3	
Total Dissolved Solids	mg/L		938	738	227	1780	
Turbidity	NTU						
Acidity		5					
Alkalinity, Total (as CaCO3)	mg/L	62	64	59	25	79	
Bicarbonate Alkalinity		80	80	70	30	100	
Carbonate Alkalinity		<6	<6	<6	<6	<6	
Hydroxide Alkalinity		<5	<5	<5	<5	<5	
Ammonia as N	mg/L		0.02	0.12	0.04	0.01	0.019
Bromide (Br)	mg/L						
Chloride (Cl)	mg/L		0.4	0.66	0.39	0.55	
Fluoride (F)	mg/L						
Nitrate (as N)	mg/L	0.14	0.16	0.25	0.18	0.41	
Nitrite (as N)	mg/L		<0.01	0.1	<0.01	<0.01	?
Sulfate (SO4)	mg/L	746	642	467	146	1220	*100*
Total Phosphate							
Cyanide, Weak Acid Diss	mg/L						
Cyanide, Total	mg/L						
Cyanate (CNO)	mg/L						
Thiocyanate (SCN)	mg/L						
CN SAD							
Total Organic Carbon	mg/L						
Ag	mg/L	<0.00001	<0.00001	<0.0001	<0.00001	<1E-05	
Al	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	
As	mg/L	0.0075	0.0077	0.0088	0.0057	0.0084	0.005
B	mg/L	<0.004	<0.004	<0.004	<0.004	<0.005	
Ba	mg/L	0.01	0.011	0.022	0.005	0.016	
Be	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<4E-05	
Bi	mg/L	<0.0001	<0.0001	<0.001	<0.001	<0.001	
Ca	mg/L	212	171	161	46.9	363	
Cd	mg/L	0.0013	0.00137	0.00141	0.00073	0.00237	0.000017
Co	mg/L	0.00012	0.00014	0.00007	0.00012	0.00016	
Cr	mg/L	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.0089/0.00
Cu	mg/L	<0.001	<0.001	<0.001	<0.002	<0.001	0.004
Fe	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Hg			<0.01	<0.01	<0.01	<1E-05	0.000026
K	mg/L	4.7	3.8	3.7	1.4	7	
Li	mg/L	0.004	0.004	0.005	0.001	0.009	
Mg	mg/L	75.2	75.9	63.8	14.4	131	
Mn	mg/L	0.0074	0.018	0.005	0.051	0.0007	0.2
Mo	mg/L	0.00006	<0.00002	<0.0001	<0.0001	<0.0001	0.073
Na	mg/L	1.4	1.1	1	0.2	<1	
Ni	mg/L	0.003	0.002	0.001	<0.001	0.002	0.15
P	mg/L	<0.01	<0.01	0.08	<0.01	<0.1	
Pb	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.007
S		256		156	48.8	408	
Sb	mg/L	0.0009	0.0013	0.0015	0.001	0.0015	0.006
Se	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	0.001
Si	mg/L	1.37	1.33	1.19	0.52	2.2	
Sn	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Sr	mg/L	0.689	0.61	0.694	0.15	1.09	
Te		<0.0001					
Th		<0.0001	<0.0001	<0.0004	<0.0004	<0.0004	
Ti	mg/L	0.0003	0.0068	<0.0004	<0.0004	<0.0004	
Tl	mg/L	0.00002	0.00002	<0.0001	<0.00001	<4E-05	
U	mg/L	0.0012	0.0011	0.001	<0.0004	0.0019	
V	mg/L	0.00008	0.00007	<0.0001	<0.0001	<0.0001	
Zn	mg/L	0.038	0.042	0.032	0.034	0.08	0.03
Zr		0.0001	<0.0001	<0.0001	<0.0001	<0.0001	

Appendix C
Waste Rock Lysimeter and Seep Chemistry Results

	Sample ID	NW Seep-01											CCME
	Date Sampled	28-May-09	10-Jun-09	25-Jun-09	8-Jul-09	23-Jul-09	6-Aug-09	20-Aug-09	3-Sep-09	20-May-10	3-Jun-10	15-Jul-10	
Field Parameters													
F-pH				7.44									
F-cond	uS/cm			1296									
F-Temp	°C			11.3									
Leachate Volume	L												
Irrigated Volume	L												
Lab Parameters													
Conductivity	uS/cm	1120	1800	1900	1940	2120	2400	1850	1780	1500	1950	2170	
Hardness (as CaCO3)	mg/L		1140	1280	1220	1400	1650	1290	1210	708	1210	1000	
pH	pH	7.3	7.91	8.13	7.82	7.89	7.88	7.72	7.75	7.57	7.63	7.54	
TSS		4	<2		3	4	6	4	<2	<2	<2	<2	
Total Dissolved Solids	mg/L	784	1320	1660	1610	1850	1940	1580	1530	1180	1360	1230	
Turbidity	NTU												
Acidity													
Alkalinity, Total (as CaCO3)	mg/L	46	54	51	64	59	63	58	62	44	47	47	
Bicarbonate Alkalinity		60	60	60	80	70	80	70	80	50	60	60	
Carbonate Alkalinity		<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	
Hydroxide Alkalinity		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	
Ammonia as N	mg/L	<0.01	<0.01	<0.01	<0.01	0.04	0.01	0.05	0.04	0.08	<0.01	<0.01	0.019
Bromide (Br)	mg/L												
Chloride (Cl)	mg/L	0.63	3.7	0.17	0.07	0.17	0.36	0.11	0.11	0.48	0.35	0.32	
Fluoride (F)	mg/L												
Nitrate (as N)	mg/L	0.32	0.55	<0.01	0.06	<0.01	<0.01	0.14	0.31	0.48	0.4	0.49	
Nitrite (as N)	mg/L	<0.01	<0.1	<0.01	<0.01	0.1	<0.01	<0.01	0.08	<0.01	<0.01	<0.01	?
Sulfate (SO4)	mg/L	515	863	1150	1120	1290	1300	1070	1040	887	883	820	*100*
Total Phosphate													
Cyanide, Weak Acid Diss	mg/L												
Cyanide, Total	mg/L												
Cyanate (CNO)	mg/L												
Thiocyanate (SCN)	mg/L												
CN SAD													
Total Organic Carbon	mg/L												
Ag	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00001	<0.00001	<0.0001	<0.00001	<0.00001	<0.00001	
Al	mg/L	<0.005	0.007	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.016	
As	mg/L	0.0047	0.0112	0.0105	0.0117	0.0129	0.0227	0.01	0.0085	0.0072	0.0112	0.0068	0.005
B	mg/L	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.005	<0.004	
Ba	mg/L	0.015	0.01	0.008	0.011	0.011	0.016	0.009	0.008	0.008	0.006	0.005	
Be	mg/L	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	
Bi	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	
Ca	mg/L	185	313	367	353	407	463	373	343	201	359	294	
Cd	mg/L	0.00259	0.00295	0.00199	0.00241	0.00186	0.00185	0.00189	0.00237	0.00316	0.0024	0.0032	1.7E-05
Co	mg/L	0.00033	0.00022	0.00025	0.00017	0.00033	0.00041	0.00017	0.00009	0.00021	0.00017	0.00021	
Cr	mg/L	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	0.0089/0
Cu	mg/L	0.005	0.002	0.002	0.002	0.003	0.013	0.004	0.002	0.01	0.003	0.024	0.004
Fe	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	0.06	<0.01	<0.01	<0.01	<0.01	<0.01	0.3
Hg		<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.00001	<0.00001	2.6E-05
K	mg/L	3.1	3.6	3.8	3.8		5.2	3.8	3.3	3	3.6	2	
Li	mg/L	0.002	0.006	0.005	0.006	0.006	0.006	0.005	0.006	0.004	0.005	0.006	
Mg	mg/L	41.6	86.1	88.2	82.9	93.6	121	92.7	86.8	49.8	75.2	70	
Mn	mg/L	0.208	0.0194	0.0058	0.0043	0.0021	0.0156	0.0083	0.0056	0.143	0.0096	0.124	0.2
Mo	mg/L	0.00007	0.00016	0.00009	0.00009	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.073
Na	mg/L	2.6	4.3	4.8	4.6	4.4	5.7	4.6	4.2	2.2	3.7	2	
Ni	mg/L	0.003	0.003	0.003	0.001	0.003	0.009	0.002	0.001	0.003	0.002	0.002	0.15
P	mg/L	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.1	
Pb	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.007
S						3.7	433	356	348	296	294	273	
Sb	mg/L	0.0017	0.0021	0.0019	0.0031	0.0027	0.0036	0.0026	0.0024	0.0017	0.0018	0.0016	0.006
Se	mg/L	<0.0006	0.0008	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	0.001
Si	mg/L	2.6	3.36	2.95	3.42	3.35	3.73	2.75	2.89	2.52	3.55	3.5	
Sn	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Sr	mg/L	0.423	0.854	0.911	0.874	1.13	1.21	0.814	0.826	0.673	0.939	0.647	
Te													
Th		0.0007	<0.0001	0.0001	<0.0001	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	
Ti	mg/L	0.0066	0.0008	0.0006	0.0005	0.0004	0.0005	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	
Tl	mg/L	0.00004	0.00006	0.00005	0.00005	0.00002	0.00005	0.00002	0.00003	0.00005	0.00005	0.00005	
U	mg/L	0.0004	0.0008	0.0009	0.0008	0.0008	0.0008	0.0006	0.0009	0.0006	0.001	0.0007	
V	mg/L	0.00006	0.00021	0.00013	0.00005	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	
Zn	mg/L	0.119	0.114	0.088	0.115	0.074	0.055	0.098	0.142	0.128	0.131	0.182	0.03
Zr		0.0003	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0002	<0.0001	<0.0001	

Appendix C
Waste Rock Lysimeter and Seep Chemistry Results

	Sample ID	LW Seep-01										CCME
	Date Sampled	28-May-09	10-Jun-09	25-Jun-09	8-Jul-09	23-Jul-09	6-Aug-09	20-Aug-09	3-Sep-09	20-May-10	3-Jun-10	15-Jul-10	
Field Parameters													
F-pH		6.22											
F-cond	uS/cm	2955											
F-Temp	ºC	2.62											
Leachate Volume	L												
Irrigated Volume	L												
Lab Parameters													
Conductivity	uS/cm	2240			2630	2580	2520	2420	2550	2550		3410	
Hardness (as CaCO3)	mg/L				1300	1760	1740	1790	1820	1950		1630	
pH	pH	6.96			6.7	6.66	6.62	6.66	6.62	6.49		6.86	
TSS		36			4	762	1810	514	948	346		96	
Total Dissolved Solids	mg/L	1690			2250	2410	2120	2110	2290	2390		1950	
Turbidity	NTU												
Acidity													
Alkalinity, Total (as CaCO3)	mg/L	58			41	38	41	36	31	28		54	
Bicarbonate Alkalinity		70			50	50	50	40	40	30		60	
Carbonate Alkalinity		<6			<6	<6	<6	<6	<6	<6		<6	
Hydroxide Alkalinity		<5			<5	<5	<5	<5	<5	<5		<5	
Ammonia as N	mg/L	0.03			<0.01	0.02	0.04	0.06	0.06	0.08		0.01	0.019
Bromide (Br)	mg/L												
Chloride (Cl)	mg/L	0.53			0.83	1.1	1.25	1.38	1.03	0.91		1.04	
Fluoride (F)	mg/L												
Nitrate (as N)	mg/L	8.19			9.96	9.13	9.86	9.55	8.16	8.09		6.35	
Nitrite (as N)	mg/L	<0.01			<0.01	<0.01	<0.01	0.2	0.36	<0.01		<0.01	?
Sulfate (SO4)	mg/L	1120			1690	1740	1450	1450	1610	1680		1330	*100*
Total Phosphate													
Cyanide, Weak Acid Diss	mg/L												
Cyanide, Total	mg/L												
Cyanate (CNO)	mg/L												
Thiocyanate (SCN)	mg/L												
CN SAD													
Total Organic Carbon	mg/L												
Ag	mg/L	<0.00001			<1E-05	<0.00001	0.00003	<0.00001	<0.0001	<0.00004		<0.00001	
Al	mg/L	0.016			0.008	<0.005	<0.005	<0.005	<0.005	<0.005		<0.005	
As	mg/L	0.001			0.0005	0.0008	0.0012	0.0007	0.0009	0.0004		0.0007	0.005
B	mg/L	<0.004			<0.004	<0.004	<0.004	<0.004	<0.004	<0.004		<0.004	
Ba	mg/L	0.012			0.008	0.008	0.01	0.007	0.012	0.007		0.007	
Be	mg/L	<0.00004			<4E-05	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004		<0.00004	
Bi	mg/L	<0.0001			<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001		<0.001	
Ca	mg/L	346			371	370	377	385	395	420		368	
Cd	mg/L	0.184			0.138	0.127	0.137	0.127	0.148	0.173		0.11	0.000017
Co	mg/L	0.0194			0.00628	0.0135	0.00737	0.00913	0.00419	0.0107		0.00199	
Cr	mg/L	<0.0004			<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		<0.0004	0.0089/0.0
Cu	mg/L	0.223			0.184	0.169	0.175	0.201	0.11	0.225		0.118	0.004
Fe	mg/L	<0.01			<0.01	<0.01	0.05	<0.01	<0.01	<0.01		<0.01	0.3
Hg		<0.01			<0.01	<0.01	<0.01	0.01	0.02	<0.01		<0.00001	0.000026
K	mg/L	2			1.5		1.9	1.6	1.1	1.9		<1	
Li	mg/L	0.005			0.005	0.005	0.005	0.004	0.005	0.006		0.005	
Mg	mg/L	125			90.5	203	194	182	201	219		173	
Mn	mg/L	19.8			24.2	28.6	23.2	24.4	17.4	28.3		16.6	0.2
Mo	mg/L	<0.00002			<2E-05	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	0.073
Na	mg/L	8.8			10.1	9.9	12.9	11.5	7.3	8.8		11	
Ni	mg/L	0.024			0.028	0.039	0.04	0.037	0.03	0.031		0.026	0.15
P	mg/L	0.02			<0.01	<0.01	0.04	0.02	0.04	<0.01		<0.1	
Pb	mg/L	0.0002			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0012	0.007
S						1.4	482	483	538	560		442	
Sb	mg/L	0.001			0.0011	0.0009	0.001	0.00143	0.0009	0.0006		0.0006	0.006
Se	mg/L	<0.0006			<0.0006	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006		<0.0006	0.001
Si	mg/L	4.44			4.43	5.09	6.31	5.92	4.1	4.22		5.4	
Sn	mg/L	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001	0.0009	<0.0001		<0.0001	
Sr	mg/L	0.92			0.972	0.963	1.11	0.892	0.951	0.958		0.884	
Te													
Th		0.0002			<0.0001	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		<0.0004	
Ti	mg/L	0.0175			0.0008	0.0007	0.0009	0.0006	<0.0004	<0.0005		<0.0006	
Tl	mg/L	0.0001			0.00005	0.00005	0.00008	0.00006	0.00006	0.00009		0.00005	
U	mg/L	0.001			<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004		<0.0004	
V	mg/L	0.00011			0.00006	<0.0001	0.0001	<0.0001	<0.0001	<0.0001		<0.0001	
Zn	mg/L	26.2			17.7	25.8	23.1	25.9	22.8	34.2		18.8	0.03
Zr		0.0002			0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001		<0.0001	

Appendix D
Groundwater Chemistry Results

Porewater Analyses Parameters	**Guidelines**	**Tailings Wells**								
Sample ID	CCME Freshwater	MW09-02	MW09-2	MW09-200	MW09-02	MW09-04		MW09-4	MW09-04	MW09-06
Date Sampled	Aquatic Life Guidelines	12-Jul-09	03-Sep-09	03-Sep-09	01-Jul-10	11-Jul-09	11-Jul-09	03-Sep-09	30-Jun-10	13-Jul-09
Field Tests										
pH		8.11	7.37	-	6.19	7.99	-	8.38	8.35	8
Conductivity		4.05	1.86	-	1.774	2.25	-	1.64	2.69	3.4
Dissolved Oxygen		0	1.52	-	4.94	-	-	0.33	1.58	1.35
Temperature (°C)		-5	3.66	-	2.53	5.8	-	3.53	4.66	-5
Physical Tests										
Conductivity		-	-	-	3140	-	-	-	2610	-
Hardness (as CaCO3)		1390	1440	1470	1360	1410	1420	1480	1510	1480
pH	6.5-9.0	-	-	-	5.08	-	-	-	8.11	-
Total Dissolved Solids		-	-	-	2730	-	-	-	2370	-
Anions and Nutrients										
Acidity (as CaCO3)		-	-	-	-	-	-	-	-	-
Alkalinity, Total (as CaCO3)		-	-	-	-	-	-	-	-	-
Ammonia as N	0.02	**15.5**	**14**	**15.4**	**14.2**	**13.6**	**13.7**	**14.7**	**11.8**	**0.47**
Bromide (Br)		<0.50	<2.5	<1.0	<1.0	<0.50	<0.50	<1.0	<1.0	<0.50
Chloride (Cl)		<5.0	<25	<10	<10	<5.0	<5.0	<10	<10	<5.0
Fluoride (F)	0.12	**0.43**	**0.729**	**0.64**	**0.94**	**0.4**	**0.53**	**0.68**	**0.66**	<0.20
Nitrate (as N)	2.90	<0.050	<0.25	<0.10	<0.10	<0.050	<0.050	<0.10	<0.10	0.401
Nitrite (as N)	0.06	<0.010	<0.050	<0.020	<0.020	0.058	**0.085**	<0.020	**0.087**	**0.335**
Sulfate (SO4)		1730	1690	1750	1960	1680	1650	1610	1720	1400
Sulfide (ug/L)		-	18.2	11.25	0	-	-	24.29	-0.99	-
Cyanides										
Cyanide, Weak Acid Diss	0.01	**0.326**	**0.0281**	**0.128**	**0.207**	**0.207**	**0.295**	**0.0239**	**0.0263**	<0.0050
Cyanide, Total		0.547	0.361	0.857	0.191	0.654	0.812	0.0425	0.0266	0.0083
Cyanate (CNO)		3	4.7	<1.8	<1.8	<1.8	<1.8	5.9	<1.8	<0.50
Thiocyanate (SCN)		5.56	3.11	2.67	7.13	3.05	2.99	1.21	2.22	0.69
Organic / Inorganic Carbon										
Total Organic Carbon		7.48	6.23	6.76	8.01	7.67	7.22	5.16	5.66	6.05

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	**Guidelines**	**Tailings Wells**								
Sample ID	CCME Freshwater	MW09-02	MW09-2	MW09-200	MW09-02	MW09-04		MW09-4	MW09-04	MW09-06
Date Sampled	Aquatic Life Guidelines	12-Jul-09	03-Sep-09	03-Sep-09	01-Jul-10	11-Jul-09	11-Jul-09	03-Sep-09	30-Jun-10	13-Jul-09
Dissolved Metals										
Aluminum (Al)-Dissolved	0.10	<0.0050	<0.010	<0.010	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.010
Antimony (Sb)-Dissolved		0.0235	0.0068	0.0045	0.0014	0.434	0.486	0.484	0.438	0.72
Arsenic (As)-Dissolved	0.005	**10.5**	**15.3**	**13.5**	**13.8**	**2.99**	**3.42**	**4.06**	**3.63**	**0.274**
Barium (Ba)-Dissolved		0.0165	0.0138	0.0142	0.0119	0.0105	0.011	0.00834	0.0045	0.00531
Beryllium (Be)-Dissolved		<0.0025	<0.0050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0050
Bismuth (Bi)-Dissolved		<0.0025	<0.0050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0050
Boron (B)-Dissolved		<0.050	<0.10	<0.10	<0.050	0.151	0.152	0.23	0.211	0.24
Cadmium (Cd)-Dissolved	0.000017	**0.000278**	**0.00019**	<0.00017	<0.000085	**0.000549**	**0.000364**	<0.00017	<0.000085	**0.00835**
Calcium (Ca)-Dissolved		487	488	504	470	484	484	489	481	528
Chromium (Cr)-Dissolved	0.0089	<0.0025	<0.0050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0050
Cobalt (Co)-Dissolved		0.02	0.0122	0.0117	0.00745	0.00819	0.00875	0.0051	0.00447	0.0056
Copper (Cu)-Dissolved	0.00	<0.00050	<0.0010	<0.0010	<0.0030	0.0006	0.00286	<0.0010	<0.00090	**0.0052**
Iron (Fe)-Dissolved	0.30	**4.85**	**9.46**	**8.12**	**14.8**	<0.030	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	0.01	<0.00025	<0.00050	<0.00050	<0.00025	<0.00025	<0.00025	<0.00050	<0.00025	<0.00050
Lithium (Li)-Dissolved		<0.025	<0.050	<0.050	<0.025	<0.025	<0.025	<0.050	<0.025	<0.050
Magnesium (Mg)-Dissolved		43.3	53.2	50.6	45.1	50.2	50.6	62.7	75.1	38.6
Manganese (Mn)-Dissolved		21.8	23.7	20	15	4.94	3.31	3.32	1.1	12.6
Molybdenum (Mo)-Dissolved	0.073	0.0135	0.00974	0.0108	0.00772	0.0122	0.0116	0.0105	0.011	0.0075
Nickel (Ni)-Dissolved	0.15	0.0029	<0.0050	<0.0050	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	0.006
Phosphorus (P)-Dissolved		<0.60	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved		43.9	51.8	49.6	85.8	40.6	44	44	43.8	10.7
Selenium (Se)-Dissolved	0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Silicon (Si)-Dissolved		5.19	5.36	4.88	3.68	10.2	10.1	9.61	10.3	7.58
Silver (Ag)-Dissolved	0.0001	<0.000050	**0.00014**	<0.00010	<0.000050	<0.000050	0.000071	<0.00010	<0.000050	<0.00010
Sodium (Na)-Dissolved		183	123	158	248	101	109	55.9	80	24.6
Strontium (Sr)-Dissolved		0.9	1.08	1.03	1	1.03	1.06	1.14	1.04	0.847
Thallium (Tl)-Dissolved	0.0008	<0.00050	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	<0.0010
Tin (Sn)-Dissolved		<0.00050	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	<0.0010
Titanium (Ti)-Dissolved		0.026	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved		0.000658	0.00048	0.00042	0.000082	0.000486	0.000501	0.00015	0.000097	0.00489
Vanadium (V)-Dissolved		<0.0050	<0.010	<0.010	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.010
Zinc (Zn)-Dissolved	0.03	**0.197**	**0.462**	**0.244**	**0.061**	<0.0050	<0.0050	<0.010	<0.0050	**0.123**
Speciated Metals										
Arsenic, Trivalent (ug/L)		8720	13500	12800	13400	7.52	13.5	26.5	<0.050	3.41
Arsenic, Pentavalent (ug/L)		356	649	209	772	2710	2720	3690	3920	240

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Tailings Wells								
Sample ID	CCME Freshwater	MW09-06	MW09-6	MW09-06	MP09-10	MP09-10	MP09-10	MP09-12	MP09-12	MP09-12
Date Sampled	Aquatic Life Guidelines	13-Jul-09	03-Sep-09	01-Jul-10	12-Jul-09	02-Sep-09	04-Jul-10	12-Jul-09	02-Sep-09	03-Jul-10
Field Tests										
pH		8.06	7.73	6.7	10.09	8.53	8.5	8.26	7.39	7.68
Conductivity		3.3	1.65	1.603	1.16	0.48	0.845	1.31	0.682	1.045
Dissolved Oxygen		1.4	1.17	0.25	0	0.3	0.27	0.58	0.83	0.88
Temperature (°C)		-5	6.12	6.28	-5	4.8	1.27	1.11	6.35	4.06
Physical Tests										
Conductivity		-	-	2450	-	-	790	-	-	-
Hardness (as CaCO3)		1490	1550	1580	210	-	260	709	-	652
pH	6.5-9.0	-	-	7.97	-	-	8.56	-	-	-
Total Dissolved Solids		-	-	2430	-	-	656	-	-	-
Anions and Nutrients										
Acidity (as CaCO3)		-	-	-	-	-	-	-	-	-
Alkalinity, Total (as CaCO3)		-	-	-	-	-	-	-	-	-
Ammonia as N	0.02	**0.743**	**1.96**	**0.035**	**2.94**	**2.65**	**3.52**	**1.92**	**1.98**	**3.2**
Bromide (Br)		<0.50	<1.0	<1.0	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50
Chloride (Cl)		<5.0	<10	<10	1.6	<5.0	<5.0	<5.0	6.3	<5.0
Fluoride (F)	0.12	<0.20	<0.40	<0.40	**1.5**	**1.67**	**1.44**	<0.20	**0.2**	**0.31**
Nitrate (as N)	2.90	0.197	<0.10	**2.95**	0.026	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrite (as N)	0.06	**0.375**	<0.020	**0.548**	0.0019	<0.010	<0.010	<0.010	<0.010	<0.010
Sulfate (SO4)		1430	1450	1540	263	237	249	79	59.9	5.4
Sulfide (ug/L)		-	-	0	-	17.33	-	-	46.89	-
Cyanides										
Cyanide, Weak Acid Diss	0.01	<0.0050	<0.0050	**0.0106**	**0.627**	**0.964**	**0.432**	<0.0050	<0.0050	<0.0050
Cyanide, Total		0.0062	<0.0050	0.0101	2.69	2.96	1.62	0.0326	0.0387	0.0205
Cyanate (CNO)		<0.50	<0.50	<0.50	2.1	0.54	1.56	<0.50	<0.50	-
Thiocyanate (SCN)		0.68	0.71	0.77	3.39	3.2	2.8	2.37	2.89	-
Organic / Inorganic Carbon										
Total Organic Carbon		5.87	6.05	7.07	49.2	48.5	44	45.2	55.9	38.8

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	**Guidelines**	**Tailings Wells**								
Sample ID	CCME Freshwater	MW09-6	MW09-6	MW09-06	MP09-10	MP09-10	MP09-10	MP09-12	MP09-12	MP09-12
Date Sampled	Aquatic Life Guidelines	13-Jul-09	03-Sep-09	01-Jul-10	12-Jul-09	02-Sep-09	04-Jul-10	12-Jul-09	02-Sep-09	03-Jul-10
Dissolved Metals										
Aluminum (Al)-Dissolved	0.10	<0.010	<0.010	<0.010	<0.0050	<0.010	<0.0050	0.0058	0.0052	0.0073
Antimony (Sb)-Dissolved		0.838	0.591	0.276	0.163	0.178	0.149	0.0653	0.0707	0.0118
Arsenic (As)-Dissolved	0.005	**0.353**	**0.868**	**0.221**	**24.9**	**24.2**	**19.4**	**7.56**	**9.27**	**6.39**
Barium (Ba)-Dissolved		0.00598	0.00564	0.00445	0.00475	0.00361	0.0053	0.053	0.047	0.147
Beryllium (Be)-Dissolved		<0.0050	<0.0050	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0010
Bismuth (Bi)-Dissolved		<0.0050	<0.0050	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0010
Boron (B)-Dissolved		0.28	0.36	0.2	<0.050	<0.10	<0.050	0.119	0.114	0.055
Cadmium (Cd)-Dissolved	0.000017	**0.00894**	**0.00827**	**0.00876**	**0.000489**	**0.00089**	**0.000273**	**0.00091**	**0.000546**	**0.000079**
Calcium (Ca)-Dissolved		527	548	534	80.6	76	100	195	185	136
Chromium (Cr)-Dissolved	0.0089	<0.0050	<0.0050	<0.0050	<0.0025	<0.0050	<0.0025	<0.0035	<0.0025	<0.0040
Cobalt (Co)-Dissolved		0.0057	0.0038	0.0068	0.0834	0.0896	0.0549	0.00215	0.00208	0.00105
Copper (Cu)-Dissolved	0.00	**0.0055**	**0.0045**	**0.0083**	**0.732**	**0.725**	**0.845**	0.00199	0.00102	0.00114
Iron (Fe)-Dissolved	0.30	<0.030	<0.030	<0.030	**0.381**	**0.496**	**0.337**	**0.661**	**1.03**	**3.24**
Lead (Pb)-Dissolved	0.01	<0.00050	0.00087	0.0008	0.00212	0.00311	0.00268	0.00285	0.00404	0.00534
Lithium (Li)-Dissolved		<0.050	<0.050	<0.050	<0.025	<0.050	<0.025	<0.025	<0.025	<0.010
Magnesium (Mg)-Dissolved		41.4	44	59.7	2.05	1.49	2.37	53.7	50.1	76
Manganese (Mn)-Dissolved		17.1	14	3.98	0.349	0.26	0.336	3.83	3.3	2.32
Molybdenum (Mo)-Dissolved	0.073	0.00899	0.00899	0.00164	0.0139	0.0123	0.0132	0.021	0.0235	0.0174
Nickel (Ni)-Dissolved	0.15	0.0077	0.0059	0.0053	0.0413	0.0367	0.0368	0.0127	0.0133	0.0074
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	0.56	0.54	0.57	<0.30	<0.30	<0.30
Potassium (K)-Dissolved		11.2	11.4	14.3	12.9	12.6	16.1	6.3	6.6	4.2
Selenium (Se)-Dissolved	0.001	<0.00050	<0.00050	<0.00050	**0.00191**	**0.00259**	**0.00159**	<0.00050	0.00065	<0.00050
Silicon (Si)-Dissolved		7.42	7.43	10.6	16.2	15.9	20.9	16.1	16.7	12.7
Silver (Ag)-Dissolved	0.0001	<0.00010	<0.00010	<0.00010	**0.0196**	**0.0285**	**0.00799**	<0.000050	<0.000050	<0.000020
Sodium (Na)-Dissolved		26.9	28.4	45	105	106	92.3	41.4	40.1	28.5
Strontium (Sr)-Dissolved		0.892	1.02	0.81	0.253	0.233	0.252	0.655	0.633	0.718
Thallium (Tl)-Dissolved	0.0008	<0.0010	<0.0010	<0.0010	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00020
Tin (Sn)-Dissolved		<0.0010	<0.0010	<0.0010	<0.00050	<0.0010	<0.00050	<0.00050	<0.00050	<0.00020
Titanium (Ti)-Dissolved		<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved		0.00501	0.00309	0.00401	0.00111	0.00077	0.00123	0.0042	0.00384	0.000761
Vanadium (V)-Dissolved		<0.010	<0.010	<0.010	<0.0050	<0.010	<0.0050	0.0053	<0.0050	0.0112
Zinc (Zn)-Dissolved	0.03	**0.129**	**0.121**	**0.239**	0.0225	**0.033**	**0.0104**	**0.0451**	**0.038**	**0.0172**
Speciated Metals										
Arsenic, Trivalent (ug/L)		5.39	8.37	0.9	125	137	85.6	3530	8540	3850
Arsenic, Pentavalent (ug/L)		296	641	97.5	19500	24200	17700	3000	2430	488

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	**Guidelines**	**Native Substrate Wells**								
Sample ID	CCME Freshwater	MW09-01	MW09-1	MW09-01	MP09-09	MP09-09	MP09-09	MP09-11	MP09-11	MP09-11
Date Sampled	Aquatic Life Guidelines	12-Jul-09	03-Sep-09	01-Jul-10	12-Jul-09	02-Sep-09	04-Jul-10	11-Jul-09	02-Sep-09	03-Jul-10
Field Tests										
pH		7.73	7.1	6.63	9.2	8.16	7.75	7.84	6.79	7.67
Conductivity		2.49	1.24	1.013	1.15	0.567	0.984	1.55	0.576	0.47
Dissolved Oxygen		0	0.61	4.58	0	0.26	0.38	0	6.56?	0.25
Temperature (°C)		-0.98	1.9	2.85	-4.36	5.28	1.14	0.85	3.99	0.47
Physical Tests										
Conductivity		-	-	1630	-	-	879	-	-	1110
Hardness (as CaCO3)		923	943	907	415	382	582	722	-	750
pH	6.5-9.0	-	-	7.8	-	-	8.25	-	-	7.91
Total Dissolved Solids		-	-	1270	-	-	648	-	-	943
Anions and Nutrients										
Acidity (as CaCO3)		-	-	-	-	-	-	-	-	-
Alkalinity, Total (as CaCO3)		-	-	-	-	-	-	-	-	-
Ammonia as N	0.02	**13.9**	**13.5**	**12.3**	**9.6**	**8.5**	**8.41**	**1.7**	**1.6**	**1.78**
Bromide (Br)		<0.50	<5.0	<1.0	<0.050	<0.50	<0.50	<0.50	<0.50	<0.50
Chloride (Cl)		5.3	<50	<10	1.96	6.5	<5.0	11.2	8.5	<5
Fluoride (F)	0.12	<0.20	0.076	<0.40	**0.568**	**0.64**	**0.49**	**0.197**	**0.218**	**0.25**
Nitrate (as N)	2.90	<0.050	<0.50	<0.10	<0.0050	<0.050	<0.050	<0.050	<0.050	<0.050
Nitrite (as N)	0.06	<0.010	<0.10	<0.020	<0.0010	<0.010	<0.010	<0.010	<0.010	<0.010
Sulfate (SO4)		646	531	445	136	179	123	<5.0	<5.0	<5.0
Sulfide (ug/L)		69.49	-	-	-	46.89	-	-	145.11	-
Cyanides										
Cyanide, Weak Acid Diss	0.01	**0.0261**	**0.0209**	**0.0222**	<0.0050	**0.0335**	**0.0168**	**0.0124**	**0.0099**	**0.0054**
Cyanide, Total		0.0401	0.0525	0.0207	<0.0050	0.125	0.0738	0.0591	0.0747	0.0667
Cyanate (CNO)		<1.8	5.1	<1.8	<0.50	<0.60	3.5	<0.50	0.54	<0.50
Thiocyanate (SCN)		35	27.1	20.1	1.6	1.96	1.44	4.3	4.46	3.64
Organic / Inorganic Carbon										
Total Organic Carbon		41.4	66.8	46.5	32	35.4	37.2	164	142	144

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Native Substrate Wells								
Sample ID	CCME Freshwater	MW09-01	MW09-1	MW09-01	MP09-09	MP09-09	MP09-09	MP09-11	MP09-11	MP09-11
Date Sampled	Aquatic Life Guidelines	12-Jul-09	03-Sep-09	01-Jul-10	12-Jul-09	02-Sep-09	04-Jul-10	11-Jul-09	02-Sep-09	03-Jul-10
Dissolved Metals										
Aluminum (Al)-Dissolved	0.10	0.0696	0.0812	0.0647	0.0045	0.0023	0.0031	0.0353	0.0244	0.0102
Antimony (Sb)-Dissolved		0.0124	0.00404	0.00071	0.108	0.109	0.0691	0.00148	0.00098	0.00212
Arsenic (As)-Dissolved	0.005	**0.0923**	**0.215**	**0.0968**	**6.58**	**5.73**	**5.76**	**1.16**	**1.33**	**3.65**
Barium (Ba)-Dissolved		0.117	0.163	0.135	0.0137	0.013	0.0216	0.139	0.158	0.161
Beryllium (Be)-Dissolved		<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Dissolved		<0.0025	<0.0025	<0.0025	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Boron (B)-Dissolved		0.055	0.051	0.054	<0.020	<0.020	<0.020	0.027	0.027	0.03
Cadmium (Cd)-Dissolved	0.000017	<0.000085	<0.000085	**0.000102**	**0.000134**	**0.000166**	**0.000087**	**0.000458**	**0.000229**	**0.00011**
Calcium (Ca)-Dissolved		274	293	280	122	115	171	147	129	151
Chromium (Cr)-Dissolved	0.0089	0.0036	<0.0070	<0.0080	<0.0010	<0.0010	<0.0020	<0.0080	<0.0070	<0.0050
Cobalt (Co)-Dissolved		0.011	0.011	0.0084	0.00828	0.00954	0.0057	0.0033	0.00276	0.00177
Copper (Cu)-Dissolved	0.00	0.00164	<0.00050	<0.00050	**0.0152**	<0.015	0.00271	0.00107	0.00075	0.0005
Iron (Fe)-Dissolved	0.30	**57.1**	**66.4**	**50.4**	0.192	0.16	**3.07**	**8.55**	**8.1**	**11.9**
Lead (Pb)-Dissolved	0.01	0.00255	0.00044	0.00149	0.00104	0.00077	0.00047	0.00166	0.00023	0.00021
Lithium (Li)-Dissolved		<0.025	<0.025	<0.025	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Magnesium (Mg)-Dissolved		57.9	51.7	50.5	26.7	23	37.7	86.3	69	90.4
Manganese (Mn)-Dissolved		6.16	6.05	5.15	0.81	0.679	1.98	2.67	2.03	2.1
Molybdenum (Mo)-Dissolved	0.073	0.00292	0.00121	0.00127	0.0148	0.0151	0.0166	0.0223	0.0246	0.0205
Nickel (Ni)-Dissolved	0.15	0.0038	0.0033	0.003	0.0049	0.0084	0.0045	0.0151	0.016	0.0116
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	0.73	0.68	0.52	0.43	0.41	0.48
Potassium (K)-Dissolved		8.4	9	8.7	34.3	32	42.3	2.5	2.5	3.6
Selenium (Se)-Dissolved	0.001	<0.00050	<0.00050	<0.00050	0.00053	0.0006	<0.00050	**0.00124**	**0.00111**	**0.00067**
Silicon (Si)-Dissolved		5.79	6.65	8.21	22.8	22.7	26	13.5	12	10.8
Silver (Ag)-Dissolved	0.0001	<0.000050	<0.000050	<0.000050	**0.000166**	0.000079	0.000065	0.000061	0.000068	0.000027
Sodium (Na)-Dissolved		76.2	81.9	66	34.8	36.8	33.9	44.6	39.1	42.2
Strontium (Sr)-Dissolved		0.968	1.03	0.853	0.766	0.731	0.835	0.694	0.582	0.659
Thallium (Tl)-Dissolved	0.0008	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Tin (Sn)-Dissolved		<0.00050	<0.00050	<0.00050	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Titanium (Ti)-Dissolved		0.01	<0.010	<0.010	<0.010	<0.010	<0.010	0.014	<0.010	<0.010
Uranium (U)-Dissolved		0.00209	0.0012	0.000866	0.00587	0.00337	0.00477	0.000697	0.000211	0.000103
Vanadium (V)-Dissolved		0.0083	0.0125	0.0114	<0.0020	<0.0020	<0.0020	0.0716	0.0507	0.0197
Zinc (Zn)-Dissolved	0.03	**0.0307**	0.0094	0.0279	0.0073	0.0044	0.0047	0.0158	0.0048	0.0028
Speciated Metals										
Arsenic, Trivalent (ug/L)		46	140	67.6	152	223	122	810	1010	1790
Arsenic, Pentavalent (ug/L)		6.54	32.2	1.56	4580	4590	5010	31.9	55.6	134

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Wells screened in Dam Fill									
Sample ID	CCME Freshwater	MW09-03	MW09-3	MW09-03	MW09-21		MW09-21	MW09-21	MW09-22	MW09-22	MW09-23
Date Sampled	Aquatic Life Guidelines	11-Jul-09	03-Sep-09	30-Jun-10	21-Jul-09	21-Jul-09	01-Sep-09	02-Jul-10	22-Jul-09	01-Sep-09	21-Jul-09
											AECOM
Field Tests											
pH		8.82	7.96	8.11	-	-	-	5.83	-	-	-
Conductivity		3.15	1.27	2.931	-	-	-	2.261	-	-	-
Dissolved Oxygen		0	0.77	4.88	-	-	-	0.45	-	-	-
Temperature (°C)		3.85	2.7	0.79	-	-	-	3.24	-	-	-
Physical Tests											
Conductivity		-	-	2760	1630	1640	1790	-	630	543	1930
Hardness (as CaCO3)		1470	1510	1750	711	710	838	986	248	244	1020
pH	6.5-9.0	-	-	8.12	7.1	7.17	6.67	-	7.12	6.92	7.5
Total Dissolved Solids		-	-	2710	1230	1280	1420	-	389	378	1630
Anions and Nutrients											
Acidity (as CaCO3)		-	-	-	38.8	31.9	143	-	21.1	27.2	21
Alkalinity, Total (as CaCO3)		-	-	-	266	269	231	-	176	122	269
Ammonia as N	0.02	**14.4**	**10.7**	**8.02**	**6.3**	**12.1**	**17.9**	**18.9**	**6.65**	**4.37**	**9.49**
Bromide (Br)		<0.50	<1.0	<1.0	<2.5	<2.5	<1.0	<0.50	<0.25	<0.50	<2.5
Chloride (Cl)		<5.0	<10	<10	<25	<25	<10	<5.0	<2.5	<5.0	<25
Fluoride (F)	0.12	**0.57**	**0.56**	**0.51**	0.057	0.059	<0.40	<0.20	0.075	<0.20	0.058
Nitrate (as N)	2.90	**7.07**	**7.15**	**13.3**	1.44	1.37	<0.10	**22.3**	**4.79**	<0.050	<0.25
Nitrite (as N)	0.06	**0.694**	**1.14**	**0.886**	0.058	<0.050	<0.020	**0.063**	**0.0996**	<0.010	<0.050
Sulfate (SO4)		1700	1570	1720	617	617	818	1000	126	156	879
Sulfide (ug/L)		-	-	0	-	-	-	-	-	-	-
Cyanides											
Cyanide, Weak Acid Diss	0.01	**0.0305**	**0.0107**	**0.0292**	**0.0331**	**0.0209**	**0.0169**	**0.0313**	<0.0050	<0.0050	**0.107**
Cyanide, Total		0.254	0.298	0.231	0.0504	0.0465	0.0293	0.0298	0.0165	0.0102	0.419
Cyanate (CNO)		<1.8	1.74	<1.8	5	6.9	20.7	-	<1.6	1.14	3.5
Thiocyanate (SCN)		1	1.1	1.01	-	-	1.98	-	-	1.2	-
Organic / Inorganic Carbon											
Total Organic Carbon		10.2	8.8	7.31	-	-	42.5	20.7	-	13.7	-

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	**Guidelines**	**Wells screened in Dam Fill**									
Sample ID	CCME Freshwater	MW09-03	MW09-3	MW09-03	MW09-21		MW09-21	MW09-21	MW09-22	MW09-22	MW09-23
Date Sampled	Aquatic Life Guidelines	11-Jul-09	03-Sep-09	30-Jun-10	21-Jul-09	21-Jul-09	01-Sep-09	02-Jul-10	22-Jul-09	01-Sep-09	21-Jul-09
Dissolved Metals											
Aluminum (Al)-Dissolved	0.10	0.0116	<0.010	<0.010	**0.158**	**0.15**	**0.152**	**0.0565**	0.0332	0.0982	0.033
Antimony (Sb)-Dissolved		0.33	0.439	0.356	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.00050	<0.0025
Arsenic (As)-Dissolved	0.005	**3.08**	**3.29**	**2.77**	**0.0329**	**0.0341**	**0.0443**	**0.0172**	**0.014**	**0.0368**	**0.01**
Barium (Ba)-Dissolved		0.0652	0.0523	0.0348	0.3	0.294	0.426	0.244	0.157	0.115	0.089
Beryllium (Be)-Dissolved		<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0025	<0.0010	<0.0010	<0.0050
Bismuth (Bi)-Dissolved		<0.0025	<0.0050	<0.0050	<0.20	<0.20	<0.20	<0.0025	<0.20	<0.20	<0.20
Boron (B)-Dissolved		0.231	0.28	0.24	<0.10	<0.10	<0.10	0.051	<0.10	<0.10	0.14
Cadmium (Cd)-Dissolved	0.000017	**0.000194**	**0.00018**	**0.00019**	**0.000196**	**0.000188**	**0.000162**	**0.000647**	**0.000109**	**0.000077**	**0.000184**
Calcium (Ca)-Dissolved		477	493	556	247	247	293	348	91.6	89.9	327
Chromium (Cr)-Dissolved	0.0089	<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0027	<0.0010	<0.0020	<0.0050
Cobalt (Co)-Dissolved		0.0123	0.0091	0.0111	0.0268	0.0272	0.026	0.0307	0.0134	0.0123	0.0189
Copper (Cu)-Dissolved	0.00	0.0006	0.0018	0.0017	<0.0050	<0.0050	<0.0050	0.00398	0.0036	0.0015	<0.0050
Iron (Fe)-Dissolved	0.30	0.118	0.126	0.116	**19**	**18.7**	**66.4**	**18.7**	**3.46**	**14.6**	**3.86**
Lead (Pb)-Dissolved	0.01	0.00041	<0.00050	<0.00050	<0.0025	<0.0025	<0.0025	<0.00025	<0.00050	<0.00050	<0.0025
Lithium (Li)-Dissolved		<0.025	<0.050	<0.050	<0.025	<0.025	<0.025	<0.025	<0.0050	<0.0050	<0.025
Magnesium (Mg)-Dissolved		68.9	69	86.9	22.9	22.5	26.1	28.5	4.57	4.84	50.1
Manganese (Mn)-Dissolved		0.555	0.761	1.89	7.52	7.66	6.73	5.06	3.88	3.2	6.69
Molybdenum (Mo)-Dissolved	0.073	0.0229	0.0128	0.0114	<0.0050	<0.0050	<0.0050	0.00067	0.0017	<0.0010	<0.0050
Nickel (Ni)-Dissolved	0.15	<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0025	0.0096	0.0092	<0.0050
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved		28.5	31	33.9	8.2	8.1	9.4	14	5.7	4.4	15.5
Selenium (Se)-Dissolved	0.001	<0.00050	<0.00050	<0.00050	<0.0050	<0.0050	<0.0050	<0.00050	<0.0010	<0.0010	<0.0050
Silicon (Si)-Dissolved		4.62	5.29	7.2	5.69	5.61	5.69	4.44	4.69	5.51	5.35
Silver (Ag)-Dissolved	0.0001	<0.000050	**0.00012**	<0.00010	<0.00010	<0.00010	<0.00010	<0.000050	<0.000020	<0.000020	<0.00010
Sodium (Na)-Dissolved		149	72.7	58.2	102	99.4	73.1	128	25.6	15.4	59.5
Strontium (Sr)-Dissolved		1.08	1.18	1.3	0.927	0.906	1	0.939	0.341	0.286	0.736
Thallium (Tl)-Dissolved	0.0008	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.00020	<0.00020	<0.0010
Tin (Sn)-Dissolved		<0.00050	<0.0010	<0.0010	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.00050	<0.0025
Titanium (Ti)-Dissolved		<0.010	<0.010	<0.010	0.019	0.018	0.019	<0.010	<0.010	0.011	0.015
Uranium (U)-Dissolved		0.00514	0.00513	0.00405	0.0016	0.0016	0.001	0.0014	0.00067	0.00071	0.0023
Vanadium (V)-Dissolved		<0.0050	<0.010	<0.010	0.0052	0.0051	0.0064	<0.0050	0.0019	0.0044	<0.0050
Zinc (Zn)-Dissolved	0.03	<0.0050	<0.010	<0.010	0.0099	0.0104	0.0076	<0.0050	<0.0050	<0.0050	<0.0050
Speciated Metals											
Arsenic, Trivalent (ug/L)		4.4	220	206	-	-	-	7.95	-	-	-
Arsenic, Pentavalent (ug/L)		2930	2720	2520	-	-	-	2.76	-	-	-

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Wells screened in Dam Fill			Wells around Seepage Pond						
Sample ID	CCME Freshwater	MW09-23	MW09-23	MW09-23	MW09-08	MW09-08	MW09-08	MW09-24	MW09-24	MW09-24	MP09-04
Date Sampled	Aquatic Life Guidelines	03-Sep-09	01-Sep-09	01-Jul-10	08-Jul-09	01-Sep-09	03-Jul-10	22-Jul-09	01-Sep-09	02-Jul-10	13-Jul-09
		LORAX	AECOM								
Field Tests											
pH		7.01	-	6.77	-	-	5.9	-	6.91	6.29	6.91
Conductivity		1.2	-	2.546	-	-	0.253	-	1.3	1.039	1.3
Dissolved Oxygen		10.24	-	6.18	-	-	6.97	-	0	0.74	0
Temperature (°C)		1.03	-	1.6	-	-	2.54	-	-	3.18	-
Physical Tests											
Conductivity		-	1890	2380	187	222	176	564	378	965	-
Hardness (as CaCO3)		-	1030	1230	72.2	99.5	79.1	297	197	555	377
pH	6.5-9.0	-	7.3	7.58	7.5	6.92	7.64	7.75	7.69	7.96	-
Total Dissolved Solids		-	1610	2090	189	233	189	364	255	727	-
Anions and Nutrients											
Acidity (as CaCO3)		-	24.4	-	13.9	26.6	-	7.5	5.9	-	-
Alkalinity, Total (as CaCO3)		-	247	-	91.1	88.3	-	210	107	-	-
Ammonia as N	0.02	**9.27**	**8.73**	**9.38**	**3.27**	**3.77**	**2.98**	**0.032**	<0.020	<0.010	**0.843**
Bromide (Br)		<1.0	<0.50	<1.0	<0.50	<0.25	<0.50	<0.050	<0.050	<0.50	<0.050
Chloride (Cl)		<10	<5.0	<10	<5.0	<2.5	<5.0	0.76	<0.50	<5.0	<0.50
Fluoride (F)	0.12	<0.40	<0.20	<0.40	<0.20	<0.10	<0.20	<0.020	0.032	<0.20	<0.020
Nitrate (as N)	2.90	<0.10	<0.050	<0.10	<0.050	<0.025	<0.050	2.2	2.52	1.8	**9.55**
Nitrite (as N)	0.06	<0.020	<0.010	<0.020	<0.010	<0.0050	<0.010	0.0092	0.0016	0.036	0.0264
Sulfate (SO4)		976	916	1320	16	14.9	<5.0	86.6	81.7	384	297
Sulfide (ug/L)		-	-	15.88	-	476.27	165.72	24.29	-	0	-
Cyanides											
Cyanide, Weak Acid Diss	0.01	**0.0583**	**0.019**	**0.0212**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cyanide, Total		0.0729	0.0324	0.0265	0.0542	0.0104	0.0144	0.012	0.0119	0.0082	<0.0050
Cyanate (CNO)		3	2.34	<0.50	<1.6	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50
Thiocyanate (SCN)		5.86	3.72	1.34	-	5.8	<5.0	-	<0.50	0.68	0.5
Organic / Inorganic Carbon											
Total Organic Carbon		18.1	18.8	16.8	-	23.3	24.2	-	4.18	6.05	5.24

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Wells screened in Dam Fill			Wells around Seepage Pond						
Sample ID	CCME Freshwater	MW09-23	MW09-23	MW09-23	MW09-08	MW09-08	MW09-08	MW09-24	MW09-24	MW09-24	MP09-04
Date Sampled	Aquatic Life Guidelines	03-Sep-09	01-Sep-09	01-Jul-10	08-Jul-09	01-Sep-09	03-Jul-10	22-Jul-09	01-Sep-09	02-Jul-10	13-Jul-09
Dissolved Metals											
Aluminum (Al)-Dissolved	0.10	0.0215	0.037	0.0352	**0.118**	0.098	**0.104**	<0.0050	<0.0050	<0.0020	0.0037
Antimony (Sb)-Dissolved		-	<0.0025	0.00065	<0.00050	<0.00050	0.00032	<0.00050	<0.00050	<0.00020	0.00055
Arsenic (As)-Dissolved	0.005	**0.00599**	**0.0137**	**0.0115**	**0.178**	**0.284**	**0.292**	0.00117	0.00102	0.00141	0.00105
Barium (Ba)-Dissolved		0.0373	0.064	0.0798	0.102	0.126	0.0867	0.077	0.056	0.0977	0.0435
Beryllium (Be)-Dissolved		<0.0025	<0.0050	<0.0025	<0.0010	<0.0010	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010
Bismuth (Bi)-Dissolved		<0.0025	<0.20	<0.0025	<0.20	<0.20	<0.00050	<0.20	<0.20	<0.0010	<0.0010
Boron (B)-Dissolved		0.077	0.14	0.145	<0.10	<0.10	<0.010	<0.10	<0.10	<0.020	0.076
Cadmium (Cd)-Dissolved	0.000017	<0.000085	**0.000126**	<0.000085	<0.000017	<0.000017	<0.000017	**0.000055**	**0.000034**	**0.000051**	**0.0028**
Calcium (Ca)-Dissolved		353	332	405	21.8	30.9	24.1	88.7	60.4	160	121
Chromium (Cr)-Dissolved	0.0089	<0.0025	<0.0050	<0.0025	0.0017	<0.0020	<0.0020	<0.0010	<0.0010	<0.0010	<0.0010
Cobalt (Co)-Dissolved		0.00874	0.0171	0.0168	0.00145	0.00147	0.00109	0.00063	0.00063	0.00026	0.00153
Copper (Cu)-Dissolved	0.00	<0.00050	<0.0050	<0.00050	<0.0010	<0.0010	0.00014	**0.0085**	**0.0057**	**0.00645**	**0.00513**
Iron (Fe)-Dissolved	0.30	**5.55**	**7.93**	**17.9**	**31.9**	**40.7**	**29.2**	<0.030	<0.030	<0.030	<0.030
Lead (Pb)-Dissolved	0.01	<0.00025	<0.0025	<0.00025	<0.00050	<0.00050	0.000143	<0.00050	<0.00050	<0.00010	<0.00010
Lithium (Li)-Dissolved		<0.025	<0.025	<0.025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.010
Magnesium (Mg)-Dissolved		47.2	47.8	53.7	4.3	5.45	4.61	18.4	11.3	37.8	18
Manganese (Mn)-Dissolved		3.9	6.06	11.2	2.09	2.32	1.95	0.0115	0.00267	0.00237	5.25
Molybdenum (Mo)-Dissolved	0.073	0.00135	<0.0050	0.00242	<0.0010	<0.0010	0.000173	<0.0010	<0.0010	0.00016	0.00035
Nickel (Ni)-Dissolved	0.15	<0.0025	<0.0050	<0.0025	<0.0010	<0.0010	0.00057	<0.0010	<0.0010	<0.0010	0.0064
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved		15.6	14.4	20.5	<2.0	<2.0	<2.0	<2.0	<2.0	2.2	4.1
Selenium (Se)-Dissolved	0.001	<0.00050	<0.0050	<0.00050	<0.0010	<0.0010	<0.00050	<0.0010	<0.0010	<0.00050	<0.00050
Silicon (Si)-Dissolved		5.33	5.69	6.31	8.28	8.72	9.06	5.74	5.62	5.51	9.19
Silver (Ag)-Dissolved	0.0001	<0.000050	<0.00010	<0.000050	<0.000020	<0.000020	<0.000010	<0.000020	<0.000020	<0.000020	<0.000020
Sodium (Na)-Dissolved		80.9	56.9	136	4.1	3.8	3.6	9.2	8.7	11.5	21.2
Strontium (Sr)-Dissolved		0.4	0.698	0.946	0.106	0.14	0.105	0.467	0.295	0.582	0.299
Thallium (Tl)-Dissolved	0.0008	<0.00050	<0.0010	<0.00050	<0.00020	<0.00020	<0.00010	<0.00020	<0.00020	<0.00020	<0.00020
Tin (Sn)-Dissolved		<0.00050	<0.0025	<0.00050	<0.00050	<0.00050	<0.00010	<0.00050	<0.00050	<0.00020	<0.00020
Titanium (Ti)-Dissolved		<0.010	0.016	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Uranium (U)-Dissolved		0.000803	0.0015	0.00115	<0.00020	<0.00020	0.000129	0.00252	0.00058	0.00319	0.000252
Vanadium (V)-Dissolved		<0.0050	<0.0050	<0.0050	0.0059	0.0048	0.0050	<0.0010	<0.0010	<0.0020	<0.0020
Zinc (Zn)-Dissolved	0.03	<0.0050	<0.0050	<0.0050	<0.0050	0.0117	0.0010	<0.0050	<0.0050	<0.0020	0.011
Speciated Metals											
Arsenic, Trivalent (ug/L)		6.91	-	6.71	-	244	161	-	-	0.21	0.07
Arsenic, Pentavalent (ug/L)		0.64	-	2.02	-	22.5	46.2	-	-	1.08	1.22

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Wells around Seepage Pond				Millsite				Background	
Sample ID	CCME Freshwater	MP09-04	MP09-05	MP09-5	MP09-05	MW09-16	MW09-17	MW09-18	MW09-19	MW09-11	MW09-11
Date Sampled	Aquatic Life Guidelines	04-Jul-10	13-Jul-09	03-Sep-09	03-Jul-10	02-Jul-10	02-Jul-10	02-Jul-10	02-Jul-10	22-Jul-09	02-Sep-09
Field Tests											
pH		6.15	7.33	6.87	5.97	6.73	6.42	6.15	5.73	-	-
Conductivity		1.123	2.1	1.01	1.466	2	2.513	2.691	2.439	-	-
Dissolved Oxygen		0.87	2.6	0.66	11.07	1.66	1.02	2.4-4.2	12.15	-	-
Temperature (°C)		1.33	-4.9	5.01	5.12	5.73	-0.83	0.9	2.05	-	-
Physical Tests											
Conductivity		1030	-	-	1380	1880	2360	2590	2310	433	659
Hardness (as CaCO3)		625	684	693	697	1210	1710	1950	1630	209	352
pH	6.5-9.0	7.29	-	-	7.48	7.78	7.78	7.8	7.24	7.96	7.78
Total Dissolved Solids		863	-	-	1050	1670	2180	2640	2090	262	445
Anions and Nutrients											
Acidity (as CaCO3)		-	-	-	-	-	-	-	-	5.3	10.9
Alkalinity, Total (as CaCO3)		-	-	-	-	-	-	-	-	227	325
Ammonia as N	0.02	**0.231**	**8.17**	**8.06**	**6.98**	**0.023**	<0.010	<0.010	**2.45**	**1.85**	**2.48**
Bromide (Br)		<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	<0.050	0.05
Chloride (Cl)		<5.0	<5.0	6.6	<5.0	<5.0	<5.0	<5.0	<5.0	3.23	4.9
Fluoride (F)	0.12	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	**0.723**	**0.697**
Nitrate (as N)	2.90	**4.17**	**15.2**	**5.7**	**18**	0.134	0.298	<0.050	<0.050	0.283	0.495
Nitrite (as N)	0.06	0.03	0.028	**0.119**	**0.024**	<0.010	<0.010	<0.010	<0.010	0.0059	0.0277
Sulfate (SO4)		504	634	530	529	1040	1240	1420	1240	11	50.2
Sulfide (ug/L)		-	-	32.11	-	0	0	0	613.28	-	-
Cyanides											
Cyanide, Weak Acid Diss	0.01	<0.0050	**0.0149**	**0.0171**	**0.0139**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Cyanide, Total		<0.0050	0.02	0.0219	0.0111	<0.0050	<0.0050	<0.0050	0.005	<0.0050	<0.0050
Cyanate (CNO)		<0.50	0.87	3.42	1.17	<0.50	<0.50	<0.50	<0.50	<1.6	<0.50
Thiocyanate (SCN)		0.64	1.11	1.62	1.08	0.98	1.22	1.23	1.72	-	1.03
Organic / Inorganic Carbon											
Total Organic Carbon		5.17	15.2	24.3	14.5	3.44	2.38	2.56	11.2	-	26.2

Bold indicates that the value exceeds the CCME guideline

Appendix D
Groundwater Chemistry Results

Parameters	Guidelines	Wells around Seepage Pond				Millsite				Background	
Sample ID	CCME Freshwater	MP09-04	MP09-05	MP09-5	MP09-05	MW09-16	MW09-17	MW09-18	MW09-19	MW09-11	MW09-11
Date Sampled	Aquatic Life Guidelines	04-Jul-10	13-Jul-09	03-Sep-09	03-Jul-10	02-Jul-10	02-Jul-10	02-Jul-10	02-Jul-10	22-Jul-09	02-Sep-09
Dissolved Metals											
Aluminum (Al)-Dissolved	0.10	<0.0050	0.015	0.0198	0.0119	<0.0050	<0.0050	<0.0050	0.0129	<0.0050	<0.0050
Antimony (Sb)-Dissolved		0.00104	<0.00050	<0.00050	<0.00050	0.14	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Arsenic (As)-Dissolved	0.005	0.00111	0.00132	0.00355	0.00152	**0.0307**	**0.016**	**0.0842**	**0.0743**	**0.0182**	**0.0239**
Barium (Ba)-Dissolved		0.0157	0.0441	0.044	0.0341	0.0162	0.00878	0.00788	0.0716	0.169	0.311
Beryllium (Be)-Dissolved		<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0010	<0.0010
Bismuth (Bi)-Dissolved		<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.20	<0.20
Boron (B)-Dissolved		<0.050	0.073	0.071	0.09	0.195	0.23	<0.050	0.404	<0.10	<0.10
Cadmium (Cd)-Dissolved	0.000017	**0.00674**	**0.00227**	**0.00239**	**0.00176**	**0.0656**	<0.000085	<0.000085	<0.000085	**0.000082**	**0.000038**
Calcium (Ca)-Dissolved		204	237	232	239	284	322	353	349	39.3	65.5
Chromium (Cr)-Dissolved	0.0089	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0030	<0.0010	<0.0010
Cobalt (Co)-Dissolved		0.00144	0.0214	0.0211	0.018	0.00177	<0.00050	<0.00050	0.00153	0.00169	0.00096
Copper (Cu)-Dissolved	0.00	**0.00595**	**0.0267**	**0.0324**	**0.0273**	**0.0128**	0.0006	<0.00050	<0.00050	<0.0010	<0.0010
Iron (Fe)-Dissolved	0.30	<0.030	<0.030	**0.346**	<0.030	**0.194**	<0.030	**0.164**	**33.6**	**0.596**	**1.52**
Lead (Pb)-Dissolved	0.01	<0.00025	<0.00025	<0.00025	<0.00025	**0.0346**	<0.00025	<0.00025	<0.00025	<0.00050	<0.00050
Lithium (Li)-Dissolved		<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.0050	<0.0050
Magnesium (Mg)-Dissolved		28	22.5	28	24.4	123	219	259	185	26.9	45.8
Manganese (Mn)-Dissolved		7.48	8.6	9.04	6.83	0.592	0.00038	0.767	2.38	0.987	1.42
Molybdenum (Mo)-Dissolved	0.073	<0.00025	0.00049	0.00034	0.00033	0.00027	<0.00025	<0.00025	<0.00025	0.01	0.0079
Nickel (Ni)-Dissolved	0.15	0.0129	0.0068	0.0097	0.0068	0.0055	<0.0025	<0.0025	<0.0025	0.0033	0.0027
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.46	<0.30	<0.30
Potassium (K)-Dissolved		5.3	7.2	7.4	8	6.6	7.4	7.4	5.7	3.2	4.2
Selenium (Se)-Dissolved	0.001	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	0.001	<0.0010
Silicon (Si)-Dissolved		10.1	3.94	5.07	4.72	4.88	5.29	5.58	8.81	5.5	6.03
Silver (Ag)-Dissolved	0.0001	<0.000050	<0.000050	<0.000050	<0.000050	**0.000127**	<0.000050	<0.000050	<0.000050	<0.000020	<0.000020
Sodium (Na)-Dissolved		14.8	92.8	79	73.4	8.4	11.6	11.5	14.9	15.3	20.1
Strontium (Sr)-Dissolved		0.401	0.706	0.679	0.637	0.619	0.916	0.977	0.985	0.376	0.637
Thallium (Tl)-Dissolved	0.0008	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00020	<0.00020
Tin (Sn)-Dissolved		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<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
Uranium (U)-Dissolved		0.000319	0.00125	0.00133	0.00115	0.00235	0.00657	0.00737	0.000257	0.00273	0.00346
Vanadium (V)-Dissolved		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0015	0.0018
Zinc (Zn)-Dissolved	0.03	**0.081**	0.0286	**0.0354**	**0.0232**	**5.74**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Speciated Metals											
Arsenic, Trivalent (ug/L)		<0.050	0.21	0.43	<0.050	-	-	-	-	-	-
Arsenic, Pentavalent (ug/L)		10.9	1.14	0.68	0.52	-	-	-	-	-	-

Bold indicates that the value exceeds the CCME guideline

E-1
Mill Area % Moisture Results

Sample ID	Wet Wt. (g)	Dry Wt. (g)	% Moisture
MS-10-09	100	70.92	29.08
MS-10-10A	100	73.65	26.35
MS-10-10B	100	73.36	26.64

E-1
Mill Area ABA Results

Sample ID	Paste pH	Paste EC µS/cm	TIC %	CaCO3 NP	C(T) %	S(T) %	S(SO4) %	S(S-2) %	Insoluble S %	AP	NP	Net NP	Fizz Test
MS-10-01A	7.46	603	0.66	55.0	1.15	2.66	0.11	2.12	0.43	66.3	53.6	-12.7	Slight
MS-10-01B	6.86	828	0.31	25.8	0.95	1.5	0.19	1.25	0.06	39.1	35.8	-3.3	Slight
MS-10-03A	6.83	678	0.02	1.7	0.27	0.63	0.29	0.05	0.29	1.6	14.7	13.1	None
MS-10-03B	7.00	786	0.06	5.0	0.91	0.1	0.02	0.07	0.01	2.2	17.8	15.6	None
MS-10-04A	7.79	866	1.61	134.2	1.71	4.11	0.02	4.00	0.09	125.0	127.8	2.8	Moderate
MS-10-04B	7.86	749	1.34	111.7	1.42	0.57	<0.01	0.52	0.05	16.3	111.7	111.7	Moderate
MS-10-05A	2.89	2360	<0.01	<0.8	0.15	2.59	1.17	0.68	0.74	21.3	2.0	-19.3	None
MS-10-05B	6.58	1267	0.05	4.2	1.14	0.24	0.04	0.15	0.05	4.7	16.7	12.0	None
MS-10-06	6.66	1759	0.07	5.8	0.26	1.2	0.59	0.25	0.36	7.8	17.0	9.2	None
MS-10-07A	7.46	1518	0.26	21.7	0.4	1.33	0.27	0.92	0.14	28.8	29.3	0.6	Slight
MS-10-07B	7.51	527	<0.01	<0.8	0.08	0.05	0.01	0.03	0.01	0.9	21.8	20.9	None
MS-10-09	7.53	1484	0.53	44.2	0.86	2.96	0.16	2.26	0.54	70.6	40.9	-29.7	Slight
MS-10-10A	6.65	712	0.03	2.5	2.59	0.1	0.02	0.04	0.04	1.3	16.8	15.6	None
MS-10-10B	6.62	770	0.07	5.8	3.96	0.19	0.09	0.06	0.04	1.9	15.2	13.3	None
Duplicates													
MS-10-01A	7.64	601	0.67		1.16	2.68	0.11	2.12			53.2		Slight
MS-10-07A			0.26		0.39	1.35	0.26	0.91					

Note:

AP = Acid potential in tonnes CaCO3 equivalent per 1000 tonnes of material. AP is determined from the sulphide sulphur content.

NP = Neutralization potential in tonnes CaCO3 equivalent per 1000 tonnes of material.

NET NP = NP - AP

Carbonate NP is calculated from TIC originating from carbonate minerals and is expressed in kg CaCO3/tonne.

E-1
Mill Area Elemental Abundance Results

Parameters	Units	MS-10-01A	MS-10-01B	MS-10-03A	MS-10-03B	MS-10-04A	MS-10-04B	MS-10-05A	MS-10-05B	MS-10-06	MS-10-07A	MS-10-07B	MS-10-09	MS-10-10A	MS-10-10B
Ag	**ppb**	60956	84720	2167	2713	1870	1696	>100000	6324	83886	52841	598	>100000	564	514
Al	**%**	0.56	0.6	1.04	0.99	0.36	1.1	0.3	0.95	0.58	0.6	1.36	0.57	1.02	0.97
As	**ppm**	6402.3	7933	283.4	408.1	6769	350.1	6393.5	972.6	4404	2910.7	54.3	>10000.0	74.9	74.3
Au	**ppb**	3676.2	4994.3	108.9	198.5	450.7	136.2	9092.2	477.1	4373.5	3601.9	21.5	8120.8	49	41.3
B	**ppm**	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20
Ba	**ppm**	102.7	141.7	155.2	181.2	68.9	251	98.4	154.1	207.8	130.4	281.1	97.9	162.4	163.8
Bi	**ppm**	1.35	0.92	0.88	0.31	0.3	0.12	3.94	0.15	28.22	21.86	0.11	2.28	0.12	0.11
Ca	**%**	1.49	0.87	0.28	0.53	3.7	2.34	0.58	0.59	0.8	0.67	0.61	1.08	0.64	0.71
Cd	**ppm**	96	62.82	2.45	2.91	7.06	30.21	40.36	3.42	22.25	25.44	0.44	97.35	0.45	0.41
Co	**ppm**	9.4	8.7	5.3	9.6	15.6	15.5	2.4	11.5	5.9	6.8	17.1	7	9.6	11
Cr	**ppm**	49.1	51	69.2	48.6	30.6	36.5	60.5	62.1	43.2	55.7	79.7	40.4	62.9	61.1
Cu	**ppm**	221.73	215.93	33.39	38.69	28.39	39.01	587.46	49.92	255.38	515.59	51.58	684.93	32.42	33.72
Fe	**%**	5.02	4.17	4.25	3.01	5.06	4.1	3.6	2.89	4.5	4.5	3.73	4.5	2.2	2.21
Ga	**ppm**	2	2.3	7.8	3.7	1.1	3.8	1.1	3.6	2.4	2	4.8	1.8	3.7	3.3
Hg	**ppb**	209	245	26	68	60	114	507	74	385	371	45	251	43	34
K	**%**	0.17	0.22	0.21	0.17	0.2	0.36	0.24	0.16	0.37	0.27	0.38	0.21	0.16	0.14
La	**ppm**	8	10.4	17.6	12.1	6.4	12.2	4.8	13.3	7.4	7.8	13.2	5.3	10.4	10.9
Mg	**%**	0.54	0.41	0.65	0.5	0.91	1.01	0.04	0.46	0.21	0.29	0.73	0.3	0.54	0.51
Mn	**ppm**	1521	1559	305	721	2823	1898	172	571	1083	2740	557	1675	286	474
Mo	**ppm**	1.32	1.48	1.3	1.08	0.55	2.32	1.71	0.82	2.94	1.46	0.73	2.41	0.62	0.55
Na	**%**	0.01	0.01	0.132	0.031	0.002	0.004	0.005	0.027	0.015	0.009	0.03	0.006	0.039	0.036
Ni	**ppm**	10.9	9.9	9.8	12.1	6.7	8.2	4.7	13.7	7.4	7.8	21.7	15	12	12.1
P	**%**	0.075	0.073	0.081	0.078	0.155	0.085	0.043	0.079	0.057	0.056	0.114	0.046	0.077	0.073
Pb	**ppm**	5276.73	3916.31	133.13	192.41	48.67	144.38	>10000.00	484.95	3879.9	2079.01	27.04	8215.8	34.25	25.62
S	**%**	2.62	1.49	0.61	0.12	4.09	0.55	2.61	0.24	1.22	1.34	0.04	2.82	0.1	0.18
Sb	**ppm**	460.7	537.31	19.28	25.89	35.62	24.09	1049.99	46.13	411.53	181.88	5.29	716.84	6.39	5.28
Sc	**ppm**	5.8	5.5	5.4	6.8	6.1	11.3	2.1	6.7	3.6	3.6	10.7	4.6	5.2	4.6
Se	**ppm**	1.5	1.6	0.8	0.8	1.3	0.7	2.6	0.6	0.6	0.4	0.7	1.2	0.3	0.4
Sr	**ppm**	38.4	35	75.8	26.7	40.6	60.6	57.5	24.9	47.2	41.8	33.1	42	29.7	30.3
Te	**ppm**	0.5	0.23	0.24	0.09	0.09	0.04	0.76	0.06	0.62	0.33	0.04	0.55	<0.02	<0.02
Th	**ppm**	4.4	6.1	5.3	2.9	2.1	3	2.5	3.1	2.7	2.4	3.5	2.7	2	2
Ti	**%**	0.012	0.012	0.037	0.045	0.001	0.034	<0.001	0.054	0.009	0.008	0.092	0.003	0.075	0.072
Tl	**ppm**	0.72	0.95	0.2	0.66	0.78	0.57	1.77	0.44	1.16	0.98	0.38	1.44	0.27	0.24
U	**ppm**	0.9	1.1	1.2	0.7	0.6	0.8	1	0.7	1	1	0.5	1.5	0.6	0.8
V	**ppm**	32	32	55	55	18	57	11	54	27	26	90	18	57	53
W	**ppm**	1.1	0.7	0.2	0.2	0.1	<0.1	0.2	0.1	<0.1	<0.1	<0.1	0.5	0.1	0.1
Zn	**ppm**	5901.3	3283.6	199.3	212.1	404.3	2437.6	2233.5	441.7	1454.4	1681	94.7	5835.4	78.1	68.6

Appendix E-2
Drainage Characterization Results

Parameter Name	Parameter Description	Units	Sample Site	Pond			Seep					Dome Creek				
				MS-P-01	MS-P-02	MS-P-03	MS-S-01	MS-S-02	MS-S-03	MS-S-04	MS-S-05	DX	DX + 100	DX + 200	D1	Dome d/s Pond 1
			Sampled Date	04/07/2010	04/07/2010	04/07/2010	04/07/2010	04/07/2010	04/07/2010	05/07/2010	05/07/2010	30/06/2010	05/07/2010	05/07/2010	30/06/2010	05/07/2010
			Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
			Detection Limit	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text	Result Text
Aluminum	Dissolved	mg/L	0.005	0.007	<0.005	0.006	<0.005	0.007	<0.005	0.006	<0.005	0.006	0.015	0.01	<0.005	0.008
Antimony	Dissolved	mg/L	0.0002	0.013	0.0024	0.0077	0.0624	0.0016	0.0127	0.0035	0.0005	0.0007	0.0055	0.0111	0.0088	0.0063
Arsenic	Dissolved	mg/L	0.0002	0.0344	0.0384	0.0061	0.0173	0.0061	0.0246	0.0592	0.0218	0.0013	0.0056	0.0193	0.011	0.0134
Barium	Dissolved	mg/L	0.001	0.021	0.019	0.01	0.014	0.06	0.016	0.026	0.012	0.038	0.029	0.021	0.018	0.02
Beryllium	Dissolved	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004
Bismuth	Dissolved	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	Dissolved	mg/L	0.004	0.137	1.86	0.158	0.308	0.016	0.013	0.146	0.013	<0.004	0.007	0.01	0.004	0.07
Cadmium	Dissolved	mg/L	0.00001	0.00007	<0.00001	0.00015	0.0242	0.0011	0.00134	0.00061	0.00006	0.00001	0.00077	0.002	0.00057	0.00032
Chromium	Dissolved	mg/L	0.0004	0.0025	0.0015	0.0009	0.0031	0.0025	0.0024	0.0024	0.0044	<0.0004	0.002	0.0024	0.0007	0.002
Cobalt	Dissolved	mg/L	0.00002	0.0002	0.0003	0.00007	0.0004	0.00026	0.00047	0.00088	0.00023	0.00005	0.0003	0.00056	0.00008	0.00029
Copper	Dissolved	mg/L	0.001	0.002	<0.001	0.011	0.008	0.002	<0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001	0.001
Iron	Dissolved	mg/L	0.01	0.03	0.16	0.06	<0.01	<0.01	0.24	5.83	0.05	<0.01	0.03	1.27	<0.01	0.26
Lead	Dissolved	mg/L	0.0001	0.0002	0.0003	0.0004	0.0107	0.0001	<0.0001	0.0002	0.0002	<0.0001	0.0001	0.0003	<0.0001	0.0001
Lithium	Dissolved	mg/L	0.001	0.011	0.005	0.002	0.01	0.007	0.009	0.005	0.021	<0.001	0.005	0.008	0.007	0.007
Manganese	Dissolved	mg/L	0.0002	0.0711	0.146	0.0014	0.0794	0.269	0.652	3.09	0.0673	0.0043	0.512	0.971	0.0099	0.618
Molybdenum	Dissolved	mg/L	0.0001	0.0002	0.0004	0.001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	0.0002	0.0001
Nickel	Dissolved	mg/L	0.001	0.002	0.001	<0.001	0.004	0.001	0.002	0.002	0.002	<0.001	0.001	0.002	0.001	0.002
Selenium	Dissolved	mg/L	0.0006	<0.0006	<0.0006	<0.0006	<0.0006	0.0007	<0.0006	<0.0006	0.001	<0.0006	<0.0006	<0.0006	<0.0006	<0.0006
Silver	Dissolved	mg/L	0.00001	<0.00001	<0.00001	0.00006	0.00002	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Strontium	Dissolved	mg/L	0.001	0.646	0.344	0.178	0.628	0.306	0.414	0.594	1.08	0.194	0.294	0.402	0.421	0.453
Sulfur	Dissolved	mg/L	0.2	197	98	46.6	291	37.2	97	156	482	49.2	70.2	98.8	133	127
Thallium	Dissolved	mg/L	0.00001	0.00002	<0.00001	0.00002	0.00026	0.00004	0.00009	0.00002	0.00018	<0.00001	0.00005	0.00007	0.00003	0.00002
Thorium	Dissolved	mg/L	0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004	<0.0004
Tin	Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Titanium	Dissolved	mg/L	0.0004	0.0004	<0.0004	<0.0004	0.0005	0.0005	0.0007	0.0008	0.0005	0.0005	0.0007	0.0008	0.0005	0.0006
Uranium	**Dissolved**	**mg/L**	**0.0004**	**0.0034**	**0.001**	**0.0005**	**0.0031**	**0.0012**	**0.0044**	**0.0011**	**0.0131**	**<0.0004**	**0.0027**	**0.0036**	**0.003**	**0.0024**
Vanadium	Dissolved	mg/L	0.0001	0.0007	0.0003	0.0001	0.0008	0.0008	0.0008	0.0006	0.0012	0.0001	0.0005	0.0006	0.0003	0.0006
Zinc	Dissolved	mg/L	0.001	0.016	0.002	0.011	3.71	0.063	0.734	0.404	0.006	0.002	0.28	0.62	0.199	0.151
Zirconium	Dissolved	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Mercury	Total Dissolved	mg/L	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
pH	@ 25 °C			8.05	8.05	7.95	6.98	7.55	7.12	7.44	7.21	7.27	7.17	7.59	8.01	7.93
Electrical Conductivity	@ 25 °C	µS/cm	1	1730	974	479	1820	755	1120	1490	2920	414	788	1060	1090	1220
Calcium	Dissolved	mg/L	0.1	196	130	60.3	249	95.2	158	204	465	56	109	152	170	162
Magnesium	Dissolved	mg/L	0.1	136	51.4	14.6	109	37.1	50.9	82.6	283	13.5	33.8	48.8	48.5	70.1
Phosphorus	Dissolved	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.1	0.01	<0.01	<0.01	<0.01	0.01
Potassium	Dissolved	mg/L	0.1	9.8	7.2	2.7	8.1	4.7	5	5.4	8	4.9	4.3	4.6	4.1	5
Silicon	Dissolved	mg/L	0.05	2.75	2.71	0.71	4.46	4.06	5.45	6.04	4.8	4.47	5.26	5.62	5.06	4.92
Sodium	Dissolved	mg/L	0.1	12	8.7	13.1	11.4	5.8	6.4	11.2	15	4.3	5.2	6.1	5.3	8.3
Bicarbonate		mg/L	5	300	170	50	330	330	290	290	660	70	200	270	280	250
Carbonate		mg/L	6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6	<6
Hydroxide		mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
P-Alkalinity	as CaCO3	mg/L	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
T-Alkalinity	as CaCO3	mg/L	5	250	141	43	268	270	239	241	545	54	164	220	226	208
Chloride	Dissolved	mg/L	0.02	1.07	0.85	0.53	0.78	0.47	0.74	0.68	0.82	<0.02	0.39	0.78	0.78	0.69
Nitrate - N	Dissolved	mg/L	0.01	0.09	<0.01	<0.01	0.3	0.71	0.12	0.27	0.16	<0.01	0.11	0.12	<0.01	0.19
Nitrite - N	Dissolved	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01	<0.01
Sulfate (SO4)	Dissolved	mg/L	0.6	592	294	140	874	112	291	469	1450	148	211	296	398	380
Hardness	as CaCO3	mg/L	5	1050	536	211	1070	391	605	850	2330	196	412	581	623	694
Total Dissolved Solids	Calculated Value	mg/L	1	1100	584	259	1430	431	671	936	2560	271	476	657	776	766
Ammonia - N		mg/L			<0.01				<0.01		<0.01	<0.01			<0.01	
Cyanide	Strong Acid Dissociable	mg/L										0.02			0.008	
Cyanide	Weak Acid Dissociable	mg/L										0.002			0.002	
Cyanate	Digested Sample	mg/L										<0.2			<0.2	
Thiocyanate		mg/L										0.2			0.1	

Appendix E-3
Mill Area Groundwater Chemistry Results

Sample ID	CCME Freshwater	MW09-16		MW09-17		MW09-18			MW09-19	
Date Sampled	Aquatic Life Guidelines	19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10	19-JUL-09	19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10
Field Tests										
pH			6.73		6.42			6.15		5.73
Conductivity			2		2.513			2.691		2.439
Dissolved Oxygen			1.66		1.02			2.4-4.2		12.15
Temperature (°C)			5.73		-0.83			0.9		2.05
Physical Tests										
Conductivity		1930	1880	2570	2360	2660	2660	2590	2570	2310
Hardness (as CaCO3)		1210	1210	1760	1710	1830	1860	1950	1740	1630
pH	6.5-9.0	7.38	7.78	7.74	7.78	7.71	7.71	7.8	7.29	7.24
Total Dissolved Solids		1650	1670	2380	2180	2490	2440	2640	2260	2090
Anions and Nutrients										
Acidity (as CaCO3)		35.4	-	28.5	-	30.3	29.7	-	52.7	-
Alkalinity, Total (as CaCO3)		298	-	435	-	427	425	-	389	-
Ammonia as N	0.02	0.079	0.023	**0.229**	**<0.010**	0.041	0.066	**<0.010**	**3.24**	**2.45**
Bromide (Br)		<2.5	<0.50	<2.5	<0.50	<2.5	<2.5	<0.50	<2.5	<0.50
Chloride (Cl)		<25	<5.0	<25	<5.0	<25	<25	<5.0	<25	<5.0
Fluoride (F)	0.12	0.152	<0.20	**0.144**	<0.20	0.143	0.122	<0.20	**0.095**	<0.20
Nitrate (as N)	2.90	<0.25	0.134	**<0.25**	**0.298**	<0.25	<0.25	**<0.050**	**<0.25**	**<0.050**
Nitrite (as N)	0.06	<0.050	<0.010	**<0.050**	<0.010	<0.050	<0.050	<0.010	**<0.050**	<0.010
Sulfate (SO4)		934	1040	1360	1240	**1490**	**1470**	1420	1390	1240
Sulfide		-	<2	-	<2	-	-	<2	-	613.28
Cyanides										
Cyanide, Weak Acid Diss	0.01	<0.0050	<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	<0.0050	0.005
Cyanate (CNO)		<1.8	<0.50	<0.50	<0.50	**<0.50**	**<0.50**	<0.50	4.26	<0.50
Thiocyanate (SCN)		-	0.98	-	1.22	-	-	1.23	-	1.72
Organic / Inorganic Carbon										
Total Organic Carbon		-	3.44	-	2.38	-	-	2.56	-	11.2

Appendix E-3
Mill Area Groundwater Chemistry Results

Sample ID	CCME Freshwater	MW09-16		MW09-17		MW09-18			MW09-19	
Date Sampled	Aquatic Life Guidelines	19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10	19-JUL-09	19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10
Dissolved Metals										
Aluminum (Al)-Dissolved	0.10	<0.025	<0.0050	<0.025	<0.0050	<0.025	<0.025	<0.0050	<0.025	0.0129
Antimony (Sb)-Dissolved		0.175	0.14	<0.0025	<0.00050	<0.0025	<0.0025	<0.00050	<0.0025	<0.00050
Arsenic (As)-Dissolved	0.005	0.0506	**0.0307**	**0.0119**	**0.016**	0.0382	0.0423	**0.0842**	0.0769	**0.0743**
Barium (Ba)-Dissolved		0.034	0.0162	**<0.020**	0.00878	<0.020	<0.020	0.00788	**0.082**	0.0716
Beryllium (Be)-Dissolved		<0.0050	<0.0025	<0.0050	<0.0025	<0.0050	<0.0050	<0.0025	<0.0050	<0.0025
Bismuth (Bi)-Dissolved		<0.20	<0.0025	<0.20	<0.0025	<0.20	<0.20	<0.0025	<0.20	<0.0025
Boron (B)-Dissolved		0.27	0.195	0.27	0.23	<0.10	<0.10	<0.050	0.32	0.404
Cadmium (Cd)-Dissolved	0.000017	0.0558	0.0656	<0.000085	**<0.000085**	<0.000085	<0.000085	**<0.000085**	<0.000085	**<0.000085**
Calcium (Ca)-Dissolved		276	284	327	322	352	355	353	**368**	349
Chromium (Cr)-Dissolved	0.0089	<0.0050	<0.0025	<0.0050	<0.0025	**<0.0050**	**<0.0050**	<0.0025	<0.0050	**<0.0030**
Cobalt (Co)-Dissolved		0.0020	0.00177	<0.0015	<0.00050	<0.0015	<0.0015	<0.00050	**0.0024**	0.00153
Copper (Cu)-Dissolved	0.004	0.0100	0.0128	<0.0050	0.0006	<0.0050	<0.0050	**<0.00050**	<0.0050	**<0.00050**
Iron (Fe)-Dissolved	0.30	**0.389**	**0.194**	**<0.030**	**<0.030**	<0.030	<0.030	**0.164**	**40.6**	**33.6**
Lead (Pb)-Dissolved	0.007	0.0364	0.0346	**<0.0025**	**<0.00025**	<0.0025	<0.0025	**<0.00025**	**<0.0025**	**<0.00025**
Lithium (Li)-Dissolved		<0.025	<0.025	**<0.025**	<0.025	**<0.025**	**<0.025**	<0.025	**<0.025**	<0.025
Magnesium (Mg)-Dissolved		126	123	230	219	231	236	259	200	185
Manganese (Mn)-Dissolved		0.389	0.592	0.0164	0.00038	**0.349**	**0.409**	0.767	2.39	2.38
Molybdenum (Mo)-Dissolved	0.073	<0.0050	0.00027	<0.000020	**<0.00025**	<0.000020	<0.000020	**<0.00025**	<0.000020	**<0.00025**
Nickel (Ni)-Dissolved	0.15	0.0071	0.0055	**<0.0050**	**<0.0025**	**<0.0050**	**<0.0050**	**<0.0025**	**<0.0050**	**<0.0025**
Phosphorus (P)-Dissolved		<0.30	<0.30	<0.30	<0.30	**<0.30**	**<0.30**	<0.30	0.46	0.46
Potassium (K)-Dissolved		6.5	6.6	7.2	7.4	6.9	7.1	7.4	4.4	5.7
Selenium (Se)-Dissolved	0.001	<0.0050	<0.00050	**<0.0050**	<0.00050	<0.0050	<0.0050	<0.00050	**<0.0050**	<0.00050
Silicon (Si)-Dissolved		5.29	4.88	4.74	5.29	4.80	4.87	5.58	7.88	8.81
Silver (Ag)-Dissolved	0.0001	<0.00010	0.000127	**<0.00010**	**<0.000050**	**<0.00010**	**<0.00010**	**<0.000050**	**<0.00010**	**<0.000050**
Sodium (Na)-Dissolved		18.9	8.4	10.8	11.6	**10.0**	**10.2**	11.5	20.5	14.9
Strontium (Sr)-Dissolved		0.670	0.619	0.972	0.916	0.981	1.00	0.977	0.973	0.985
Thallium (Tl)-Dissolved	0.0008	<0.0010	<0.00050	**<0.0010**	<0.00050	<0.0010	<0.0010	<0.00050	**<0.0010**	<0.00050
Tin (Sn)-Dissolved		<0.0025	<0.00050	<0.0025	<0.00050	**<0.0025**	**<0.0025**	<0.00050	<0.0025	<0.00050
Titanium (Ti)-Dissolved		0.013	<0.010	0.014	<0.010	0.015	0.014	<0.010	0.015	<0.010
Uranium (U)-Dissolved		0.0037	0.00235	0.0070	0.00657	**0.0068**	**0.0070**	0.00737	<0.0010	0.000257
Vanadium (V)-Dissolved		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Zinc (Zn)-Dissolved	0.03	4.44	**5.74**	**<0.0050**	**<0.0050**	<0.0050	<0.0050	**<0.0050**	**0.0088**	**<0.0050**

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01**
LOCATION: Tailings Dam Crest, near TH-03 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): 1101.44

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/m^3)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	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					1101.44
1								1100.44
2								1099.44
3			- moist with dry lenses		S-1	10-14-15		1098.44
4								1097.44
5	FILL							1096.44
6								1095.44
7								1094.44
8								1093.44
9	FILL		- SAND and GRAVEL		S-2	7-14-15		1092.44
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					1091.44
11								1090.44
12	FILL							1089.44
13								1088.44
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		1087.44
15	FILL							1086.44

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01**
LOCATION: Tailings Dam Crest, near TH-03 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): 1101.44

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
15	FILL	- wet, dense to very dense - GRAVEL (fill), sandy					320
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		319
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					318
18		- clast supported - wet, very loose		S-5	2-1-2		317
19		SAND (native soil), trace to some silt, trace organics - dark grey - fine sand, sub-rounded - wet, very loose					
20	SA	- sand coarsens with depth - some gravel					316
21							315
22	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		314
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					313
24							312
25	SA						311
26		- fine sand content decreases with depth		S-7	31-61-		310
27							309
28		- some gravel SAND and GRAVEL - light grey-brown - fine grained to medium-coarse sand, sub-rounded - sub-angular gravel, <1 cm					308
29	GRSA	- coarsening downward sequences		G-8			307
30							306

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: 7/19/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-01**
LOCATION: Tailings Dam Crest, near TH-03 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): 1101.44

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

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

DEPTH (m)	USC	SOIL SYMBOL	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 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						305
31									304
32									303
33									302
34									301
35									300
36									299
37									298
38									297
39									296
40									295
41									294
42									293
43									292
44									291
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: 7/19/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02**
LOCATION: Tailings Dam, on Road from South Abutment 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): 1090.41

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 (fill), trace silt - medium brown - fine grained to medium grained sand, sub-rounded - moist, loose					332
1							331
2				S-1	5-7-10		
3		- some gravel below 2.13 m below ground surface		S-2	5-6-6		330
4							329
5	SA	SAND, trace silt, trace organics - wood debris, <2 cm - dark grey - sub-rounded - permafrost at 5.64 m below ground surface, Nbn, 1.6°C - gravel content increases with depth to "gravelly"		S-3	1-1-1		328
6				S-4	28-34-61		327
7	GRSA	GRAVEL, sandy, trace silt - dark grey - medium to coarse sand, sub-angular - sub-angular gravel, >0.5 cm to 2 cm					326
8		SAND, trace silt - dark grey - medium grained sand, sub-rounded		S-5	25-42-35		325
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		324
10							323
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		322
12							321
13		- fine grained to medium grained sand below 12.19 m below ground surface		S-8	38-47-56		320
14		- some gravel below 13.41 m below ground surface		S-9	37-45-47		319
15							318

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/17/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-02**
LOCATION: Tailings Dam, on Road from South Abutment 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): 1090.41

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

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

DEPTH (m)	USC	SOIL SYMBOL	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		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	>> ◆		317
16	GRSA		END OF DRILLING at 16.77 m in permafrost (refusal)						316
17			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)						315
18			Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.77 m below ground surface						314
19									313
20									312
21									311
22									310
23									309
24									308
25									307
26									306
27									305
28									304
29									303
30									

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/17/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace 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): 1092.33

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	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					
1							332
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		331
3				S-2	4-5-5		330
4	SA						329
5				S-3	3-4-5		328
6		- some gravel below 5.33 m below ground surface		S-4	6-7-7		327
7		- trace gravel below 6.10 m below ground surface					326
8	GRSA	- some gravel below 7.32 m below ground surface SAND and GRAVEL, trace silt - light brown-orange - moist, compact		S-5	4-7-5		325
9	SA	- medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - iron staining on gravel SAND, trace gravel, trace silt (Aeolian)		S-6	3-7-9		324
10	GRSA	- orange-brown - moist, compact - medium grained sand, sub-rounded - sub-rounded gravel, 1 cm to 1.5 cm - matrix supported					323
11		SAND and GRAVEL, trace silt SAND, trace gravel, trace silt		S-7	6-8-4		322
12	SA						321
13		- some gravel below 12.19 m below ground surface		S-8	4-5-10		320
14	GRSA	SAND and GRAVEL, trace silt - coarsening downward sequence		S-9	3-7-2		319
15							

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/19/09
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 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): 1092.33

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
15	GRSA	GRAVEL, sandy, trace silt - coarsening downward sequence		S-10	5-24-16		
16	GRSA						317
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 - permarfrost at 16.52 m below ground surface		S-11	25-52-34		316
18	SA						315
19							314
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					313
21							312
22							311
23							310
24							309
25							308
26							307
27							306
28							305
29							304
30							

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/19/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04**
LOCATION: Seepage Dam Crest 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): 1080.81

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 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					329
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		328
3		- permafrost at 2.8 m below ground surface, -0.3°C, Nbn		S-2	30-40-42		327
4		SAND (Native soil), trace to some silt, trace to some organic - dark grey-brown - mediumgrained to coarse grained sand, sub-rounded					326
5				S-3	14-19-20		325
6	SA						324
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		323
8		SAND and GRAVEL, some silt - dark brown - coarse sand - sub-angular gravel - sub-angular sand		G-5			322
9				G-6			321
10	GRSA						320
11				G-7			319
12		- gravel content decreases to become SAND, gravelly, trace of silt					318
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			317
14	SA	- SAND, gravelly, trace of silt below 13.41 m below ground surface		S-9	41-71-51		316
15							315

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

AECOM

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

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-04**
LOCATION: Seepage Dam Crest 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): 1080.81

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15	SA		SAND and GRAVEL, trace of silt	SPLIT SPOON	S-10	67--			314
16	GRSA		- 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 oC description: Nbn						313
17			END OF DRILLING at16.23 m in permafrost (refusal)						312
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)						311
19			Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.10 m below ground surface						310
20									309
21									308
22									307
23									306
24									305
25									304
26									303
27									302
28									301
29									300
30									

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-05**
LOCATION: North terrace, near Seepage Dam 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): 1089.60

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	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					332
1								331
2					S-1	1-3-3		330
3			- fine sand content decreases with depth - coarsening downward sequence		S-2	3-4-4		329
4								328
5			- moist with dry lenses		S-3	4-9-8		327
6			- coarsening downward sequence		S-4	5-8-10		326
7								325
8	SA		- some dark brown sand between 4.1 and 4.4 m below ground surface - moist, dense		S-5	10-18-18		324
9			- some gravel below 8.38 m below ground surface - coarsening downward sequence - wet, loose		S-6	2-3-5		323
10								322
11			- Permafrost at approximately 11.28 m below ground surface, Nbn		S-7	5-9-23		321
12								320
13					S-8	23-32-41		319
14	GRSA		SAND AND GRAVEL, trace silt (description from dill cuttings)					318
15	SA		- SAND, some gravel, trace silt (description from dill cuttings)					

AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/21/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-05**
LOCATION: North terrace, near Seepage Dam 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): 1089.60

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15	SASI		SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth						317
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						316
17	SA				S-9	21-26-23			315
18									314
19	GRSA		SAND and GRAVEL, trace silt - gravel content increases with depth - sub-angular gravel, < 2 cm - coarse sand, sub-rounded						313
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						312
21									311
22									310
23									309
24									308
25									307
26									306
27									305
28									304
29									303
30									

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: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/21/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1103 (est.)

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/m^3)
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	DEPTH
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded					0
1							1
2	SA	SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					2
3	SM	SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand		S-1			3
4							4
5	CI	CLAY TAILINGS - dark yellow brown - wet, medium stiff, cohesive, medium plasticity, slow dilatency - minor silt, fining downward and finely laminated					5
6				S-2			6
7		- damp from 7.62 m to 9.14 m					7
8				S-3			8
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					9
10	SA	SAND - brown - wet, very loose, non-cohesive, non-plastic - coarse subrounded sand with minor angular gravel inferred to be colluvium					10
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					11
12		END OF DRILLING at 10.66 m					12
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)					13
14							14
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 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1103 (est.)

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/m^3)
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
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded				
2	SA	SAND TAILINGS - dark reddish brown - wet, very loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded				
3	SM	SILTY SAND TAILINGS - dark yellow brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine grained sand		S-1		
4.57		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)				

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 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-03**
LOCATION: South side of tailings empoundment 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): 1103 (est.)

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/m^3)
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	DEPTH
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					0
1				S-1			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					
2	SM						2
3				S-2			3
4	SASI SICL	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded					4
5		SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency					5
6	SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded					6
7	CL	CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, high plasticity, slow dilatency		S-3			7
8	CB	COBBLES AND SAND AND SILT - brown - wet, dense, non-cohesive, non-plastic		S-4			8
9	SA	- loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill					9
10		END OF DRILLING at 9.14 m					10
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)					11
12							12
13							13
14							14
15							

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1103 (est.)

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 / Total Unit Wt / Plastic MC Liquid	COMMENTS	DEPTH
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded						0
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						1
2	SM							2
3				S-1				3
4	SASI SICL	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded						4
5		SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency		S-2				5
6	SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded						6
7		END OF DRILLING at 7.01 m 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)						7
8								8
9								9
10								10
11								11
12								12
13								13
14								14
15								

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-05**
LOCATION: North side of tailings empoundment 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): 1103 (est.)

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	DEPTH
0			SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency						0
1	SICL								1
2	SM		SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded						2
3			CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency						3
4	CL								4
5									5
6	OR SM		ORGANICS - dark brown - wet - primarily moss						6
7	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						7
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						8
9			END OF DRILLING at 6.71 m						9
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)						10
11									11
12									12
13									13
14									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: 6.71 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/9/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR		TESTHOLE NO: **MW09-06**
LOCATION: North side of tailings empoundment 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): 1103 (est.)

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	DEPTH
0	SICL	SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency					0
1							1
2	SM	SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded					2
3	CL	CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency					3
4							4
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)					5
6							6
7							7
8							8
9							9
10							10
11							11
12							12
13							13
14							14
15							

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1103 (est.)

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/m^3)
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	DEPTH
0		SILTY SAND FILL - brown - dry, loose, non-cohesive, non-plastic - native fill used for drill pad construction					0
1	SM						1
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					2
3		ORGANICS - dark brown to black - moist - fibrous roots and moss becoming more decomposed with depth					3
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					4
5		CLAY - light grey - moist, very dense, cohesive, non-plastic - clay sized volcanic ash sediments					5
6		SILTY SAND - dark grey to black - moist, dense, cohesive, non-plastic - fine sand, sub-rounded, organic rich, grading coarser with depth					6
7		END OF DRILLING at 4.57 m					7
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)					8
9							9
10							10
11							11
12							12
13							13
14							14
15							

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-08**
LOCATION: Downstream of Seepage Dam N 2,097,199.8 E 118,756.2		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary - 114 mm	ELEVATION (m): 1076.03

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

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

DEPTH (m)	USC	SOIL SYMBOL	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)						1076
1									327
2	SA		SAND, some silt, some organic - dark grey - moist to wet, loose - fine grained to medium grained sand - presence of roots						326
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						325
4	SA		SAND, trace silt - dark brown and grey - very dense - medium grained sand - presence of wood debris - permafrost, Nbn						324
5									323
6			END OF DRILLING at 3.66 m in permafrost (refusal)						322
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)						321
8									320
9									319
10									318
11									317
12									316
13									315
14									314
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: 3.66 m
REVIEWED BY: Ryan Mills	COMPLETION DATE: 7/15/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-11**
LOCATION: South of Dome Creek and west of Diversion Channel 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): 1102.24

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0			SAND (Aeolian) - grey brown - dry, loose, non-cohesive - uniform fine to medium grained sand, sub-rounded, minor silt						335
1									
2	SA		- 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						334
3			- saturated at 3.25 m, dense, sandy silt interbed <1 cm thick						333
4			- occasional nugget of frozen sand between 3.66 m and 4.11 m - 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)		S-1				332
5			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)						331
6									330
7									329
8									328
9									327
10									326
11									325
12									324
13									323
14									322
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: 7/8/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit 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): 1209.35

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 / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0		CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet						
1	CL			S-1				368
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				367 366
3				S-5				365
4	BE			S-6				
5		- casing to 4.57 m		S-7 S-8				364
6		- borehole producing approx. 1-2 L/min during air development		S-9 S-10				363 362
7		GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11 S-12				361
8				S-13				
9		- chips coarser from 8.53 m to 10.46 m		S-14				360
10	BE			S-15 S-16				359
11				S-17				358
12				S-18 S-19				357
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				356
14	BE			S-22 S-23				355
15								354

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: 7/12/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit 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): 1209.35

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15					S-24				
					S-25				353
16					S-26				
					S-27				352
17					S-28				
	BE								351
18					S-29				
					S-30				350
19					S-31				
					S-32				349
20			HORNEBLENDE DIORITE - dark grey - dry, potassium feldspar and horneblende mildly weathered, chips fine		S-33				
									348
21					S-34				
					S-35				347
22					S-36				
									346
23					S-37				
					S-38				345
24					S-39				
					S-40				344
25	BE				S-41				
									343
26					S-42				
					S-43				342
27					S-44				
					S-45				341
28					S-46				
									340
29					S-47				
					S-48				339
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: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/12/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-13**
LOCATION: Northeast of Brown-McDade pit 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): 1209.35

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

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

DEPTH (m)	USC	SOIL SYMBOL	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				338
31					S-50				
32	BE				S-51				337
33					S-52				
34					S-53				336
35	BE		GRANODIORITE - light grey - dry, high quartz content with minor amount of highly weathered potassium feldspar		S-54				335
36					S-55				
37			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)		S-56				334
38					S-57				
39					S-58				333
40									332
41									331
42									330
43									329
44									328
45									327
									326
									325
									324

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: 7/12/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1209 (est.)

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/m^3)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	DEPTH
0			CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet					0
1	CL				S-1			1
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			2
3					S-4 S-5			3
4	BE				S-6			4
5			- casing to 4.57 m		S-7 S-8			5
6			- borehole producing approx. 1-2 L/min during air development		S-9 S-10			6
7			GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole		S-11 S-12			7
8					S-13			8
9	BE		- chips coarser from 8.53 m to 10.46 m		S-14			9
10					S-15 S-16			10
11								11
12								12
13								13
14								14
15								

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/12/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1209 (est.)

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

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

DEPTH (m)	USC	SOIL SYMBOL	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	DEPTH
15									15
16									16
17									17
18									18
19									19
20									20
21									21
22									22
23									23
24									24
25									25
26									26
27									27
28									28
29									29
30									

AECOM

LOGGED BY: Ryan Mills	COMPLETION DEPTH: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/12/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1209 (est.)

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	DEPTH
30									30
31									31
32									32
33									33
34									34
35									35
36			END OF DRILLING at 10.67 m						36
37			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)						37
38									38
39									39
40									40
41									41
42									42
43									43
44									44
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: 10.67 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/12/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit 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): 1208 (est.)

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	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	DEPTH
0			CLAY (minor SAND and some GRAVEL) - brown - dry, loose, cohesive, non-plastic, rapid dilatency when wet					0
1					S-1			1
2	CL							2
3					S-2			3
4								4
					S-3			
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			5
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			6
7	BE				S-9			7
					S-10			
8					S-11			8
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			9
					S-13			
10					S-14			10
					S-15			
11			- quartz vein 10.97 m to 11.58 m		S-16			11
12					S-17			12
					S-18			
13					S-19			13
					S-20			
14					S-21			14
15	BE		GRANODIORITE					

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit 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): 1208 (est.)

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

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

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

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-15**
LOCATION: North of Brown-McDade pit 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): 1208 (est.)

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

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

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	COMMENTS	DEPTH
30	BE		DIORITE - light grey - dry, soft, moderately weathered, minor iron staining		S-47				30
31					S-48				31
32					S-49				32
33					S-50				33
34	BE				S-51				34
35			- highly weathered from 34.14 m to end of hole at 38.10 m		S-52				35
36					S-53				36
37			- moist from 35.36 m to 35.38 m		S-54				37
38					S-55				38
39			- wet from 35.38 m to end of hole at 38.10 m		S-56				39
40					S-57				40
41					S-58				41
42					S-59				42
43					S-60				43
44									44
45									

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)

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1187 (est.)

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	DEPTH
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					0
1	GR						1
2				S-1			2
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					3
4							4
4.5	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		END OF DRILLING at 4.57 m					5
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)					6
7							7
8							8
9							9
10							10
11							11
12							12
13							13
14							14
15							

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

AECOM

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

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-17**
LOCATION: Downgradient of Mill 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): 1179.40

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 / Total Unit Wt / Plastic MC Liquid	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						359
1	SICL	- becomes moist at 1.37 m						358
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				357
3		GRAVEL with some CLAY, SILT and SAND filling interstices - yellow-brown - wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered		S-2				356
4	GR	- gravel to 10 cm along long axis - inferred to be colluvium						355
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						354
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)						353
7								352
8								351
9								350
10								349
11								348
12								347
13								346
14								345
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: 4.88 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/14/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-18**
LOCATION: Downgradient of Mill 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): 1181.06

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	SASI	SANDY SILT - brown with red staining - dry, loose, non-cohesive, non-plastic - organic rich with pervasive roots, mild unknown odour		S-1			359
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					
2							358
3	SM						357
4		- dry from 3.81 m to 4.88 m; loose					356
5		SILTY SAND TAILINGS - yellow-orange - dry, medium dense, cohesive, low plasticity, rapid dilatency - minor subangular gravel		S-2			355
6	SM			S-3			354
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 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)					353
8							352
9							351
10							350
11							349
12							348
13							347
14							346
15							

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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): 1182 (est.)

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/m^3) 16 17 18 19 20 21 | Plastic MC Liquid 20 40 60 80 100

DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	DEPTH
0			No recovery					0
	SM		SAND, silty - orange-brown - dry, loose - fine grained to medium grained sand					
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)					1
2	OR SA		- clast supported		G-1 G-2			2
3	OR		- presence of wood debris (waste rock?)		G-3			3
			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					4
5					G-4			5
			ORGANIC, some silt, trace sand - dark brown - moist, loose - presence of roots					
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					6
7								7
8			END OF DRILLING at 5.11 m in permafrost (refusal)					8
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)					9
10								10
11								11
12								12
13								13
14								14
15								

AECOM

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

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-21**
LOCATION: Tailings Dam 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): 1082.77

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	G-1			329
2			S	S-1	19-32-50		328
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	S-2	41-50-		327
4		SILT, sandy, trace organic - dark brown					326
5		SAND, some silt, trace gravel - dark brown - medium sand, sub-rounded - sub-angular gravel, >0.5 cm to <1 cm - matrix supported					325
6		SAND, some silt, trace to some organic (volcanic ash marker) - light grey					324
7		END OF DRILLING at 3.20 m in permafrost (refusal)					323
8		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)					322
9							321
10							320
11							319
12							318
13							317
14							316
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: 7/17/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

LOG OF TEST HOLE 112359 BOREHOLE LOGS OCT 5 2009 RDM.GPJ UMA WINN.GDT 10/6/09

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Appendix C-9: Compilation of Closure Costing (AECOM)

Appendix C-10: Tailings Relocation Considerations (AECOM)

Yukon

Environment

Yukon Government

Assessment and Abandoned Mines Branch

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

draft for discussion

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60159089 (402.19.1.1)

Date:

November, 2010

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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.

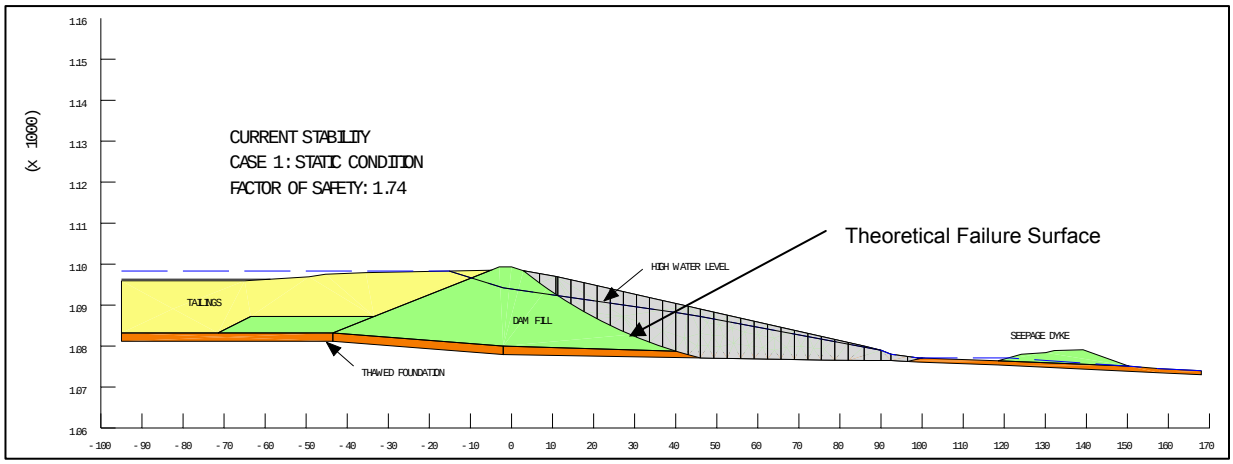

Figure 1 Cross Section for Slope stability Analysis

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.

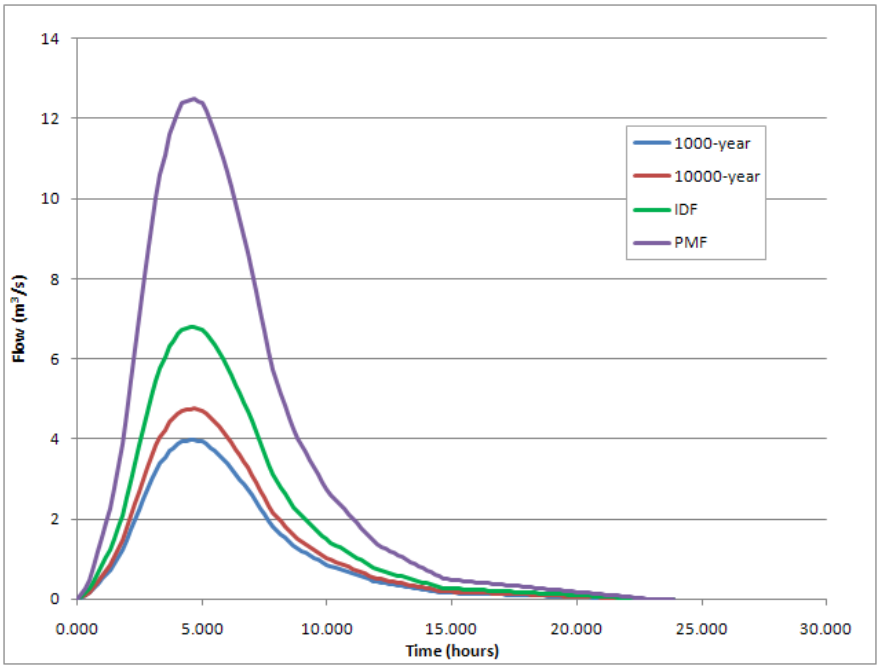

Figure 2. 1000-year, 10000-year, IDF, and PMF Event Hydrographs

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.

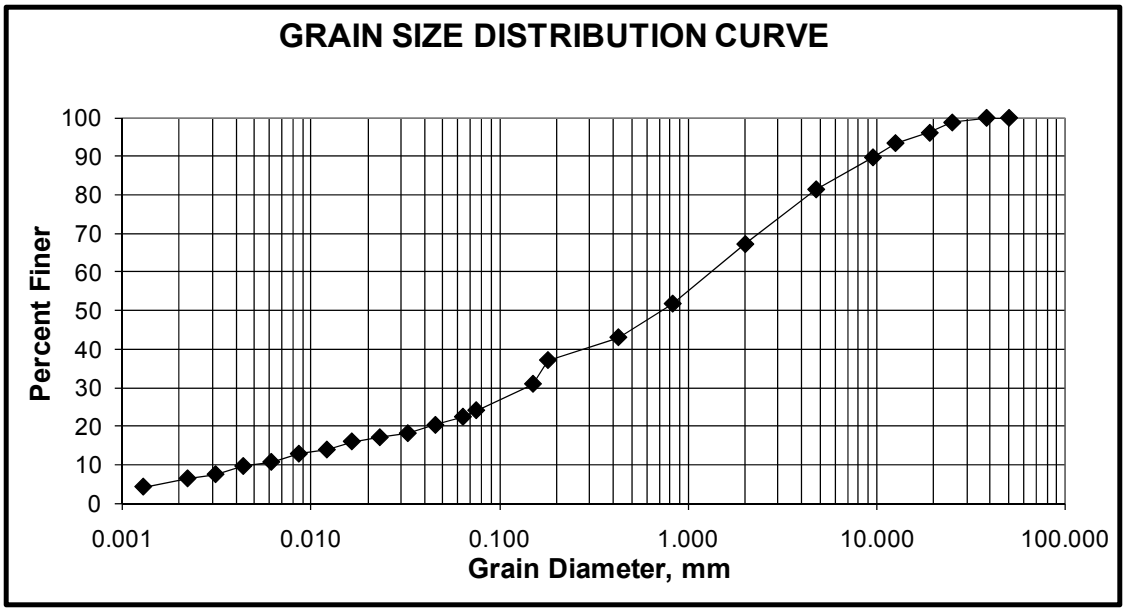

Figure 3. Grain Size Distribution from Victoria Creek Borrow Source

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

AECOM, 2009:
Mt. Nansen Mine Water Treatment Study

Altura, 2009:
Brown McDade Waste Rock Pile: Mount Nansen Mine Site, Yukon

AECOM 2008:
Mt. Nansen Tailings Dam: 2008 Geotechnical Inspections

EBA, 2002:
Mt. Nansen Summary Data Report

EBA 2009:
2009 Instrumentation Data Review: Tailings and Seepage Collection Dams, Mt. Nansen Mine, Carmacks, YT.

Gomm Environmental Engineering Consulting (GEEC) 2010
Mount Nansen Closure Alternatives Assessment - Water Balance and Water Quality Model, *prepared for* Assessment and Abandoned Mines Branch Energy, Mines and Resources Government of Yukon

Golder and Associates 2010A:
Assessment of Closure Options and Cover Water Balance for the Mt. Nansen Project, Yukon

Golder and Associates 2010B:
Conceptual Assessment of Low Infiltration Cover Options for the Mt. Nansen Project, Yukon

Naviq, 2010:
Mt Mansen Mine Reclamation Thermosyphon Screening Study

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

Drawings

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CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT GRADED TO FIT NATURAL TOPOGRAPHY
0+400
0+385 FIG-07
DOME CREEK
PLACE ADDITIONAL ARMOURING AT CREEK CHANNEL OUTLET
ACCESS ROAD
0+300
ENTRANCE CHANNEL
APRON
BORROW AREA TO BE RE-VEGETATED
ARMOURED DRAINAGE SWALES
CREEK CHANNEL
DRY CHANNEL
0+200
CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT REMOVED TO FIT NATURAL TOPOGRAPHY
DRY CHANNEL
0+105 FIG-06
ARMOURED DRAINAGE SWALES
SEEPAGE
SEEPAGE
SEEPAGE
0+000
CREEK
0+600
0+500
ACCESS ROAD
REMOVE BRIDGE
SPILLWAY CONTROL
RECONSTRUCT EMERGENCY SPILLWAY
Y4170
CP4001
ACCESS ROAD
0+715 FIG-08
FORD CROSSING
0+256.047
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
0+200
0+100
0+000
A
-
DIVERSION CHANNEL
0+600
DROP STRUCTURE (TYP)
#1
#2
#3
#4
#5
#6
#7
#8
#9
#10
#11
#12
#13
0+900
1+000
ACCESS ROAD
NORTH TERRACE
PLACE ADDITIONAL ARMOURING AS REQUIRED
ROCK FILL TOE BERM 7% SLOPE
ROCK FILL TOE BERM 10% SLOPE
END OF DIVERSION CHANNEL
1+066.771
DOME CREEK
ZONE OF GROUND FREEZING WITH THERMOSYPHONS
DRAINAGE DITCH
1095
1097.5
1092.5
1090
1087.5
1085
1082.5
1080
1077.5
1075
1100
1102.5
1105
1107.5
1110
1112.5
1115
1117.5
1120

MOUNT NANSEN

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LEGEND

SURVEY BENCH MARK

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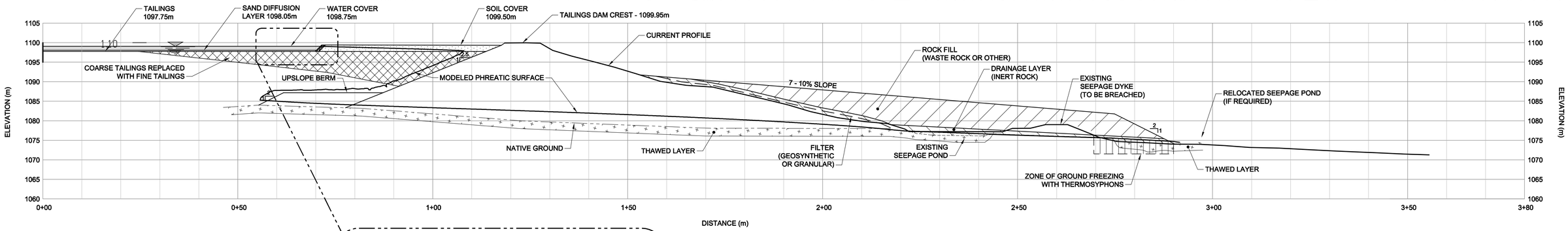

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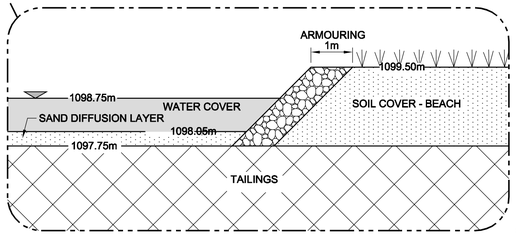

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Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 1
Site Plan & Profile
Drawing - 01

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MOUNT NANSEN

0 12.5 25 37.5 m

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

LEGEND
- SURVEY BENCH MARK

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
PRIMARY DRAINAGE SWALE
ARMOURED DRAINAGE SWALES
CREEK CHANNEL
DRY CHANNEL
CHANNEL TO BE BACKFILLED AND ROAD EMBANKMENT REMOVED TO FIT NATURAL TOPOGRAPHY
SEEPAGE
CREEK
SWALE
REGRADED TAILINGS AREA:
TAILINGS ELEV. 1097.75m
SOIL COVER ELEV. ±1098.75m
WATER COVER ELEV. ±1098.90m
SPILLWAY ELEV. 1098.90m
SOIL COVER AREA 6.0ha
SOIL COVER BEACH
AREA 1.26ha
ELEV. 1099.65m
TAILINGS DAM CREST
SPILLWAY CONTROL
RECONSTRUCT EMERGENCY SPILLWAY
Y4170
CP4001
ACCESS ROAD
REMOVE BRIDGE
DROP STRUCTURE (TYP)
NORTH TERRACE
ROCK FILL TOE BERM 7% SLOPE
ROCK FILL TOE BERM 10% SLOPE
ZONE OF GROUND FREEZING WITH THERMOSYPHONS
DRAINAGE DITCH
END OF DIVERSION CHANNEL
DOME CREEK
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0+200
0+100
0+000
1+098.771

PROFILE A

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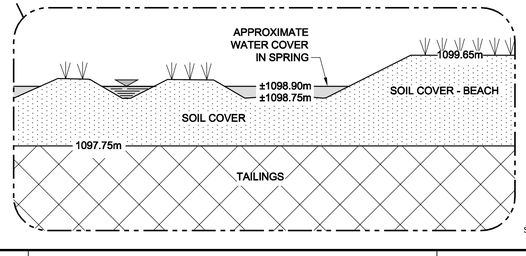

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Government of Yukon
Mt. Nansen Closure Alternatives Characterization

Option 2
Site Plan & Profile
Drawing 02

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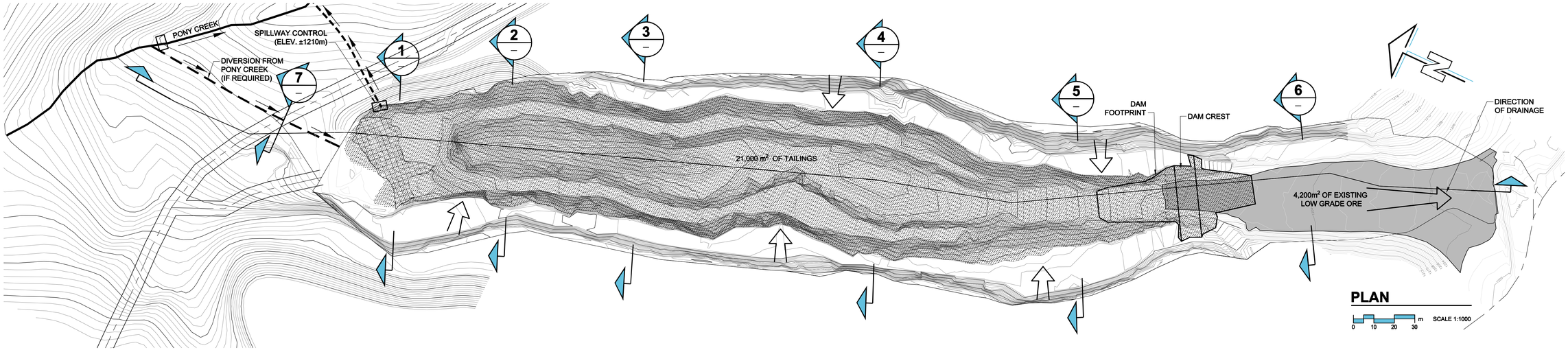

PLAN

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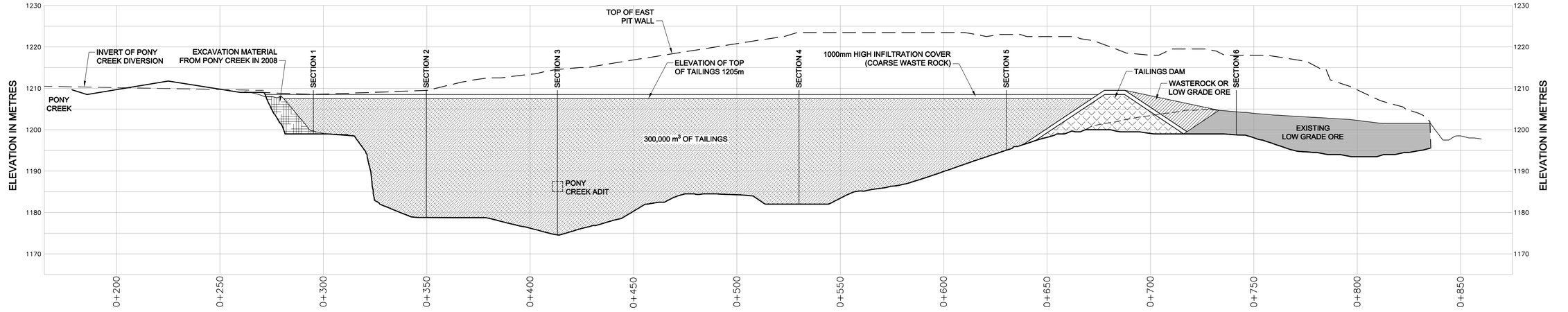

DISTANCE IN METRES
PROFILE THROUGH OPEN PIT

PROFILE

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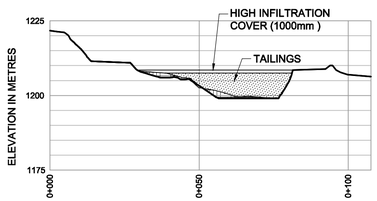

SECTION 1

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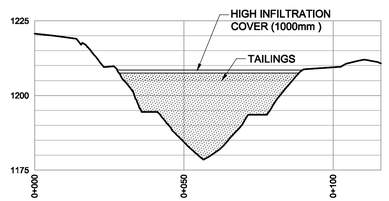

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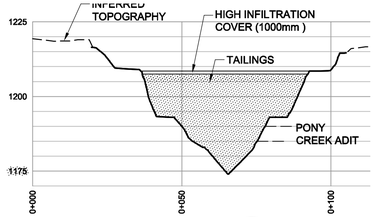

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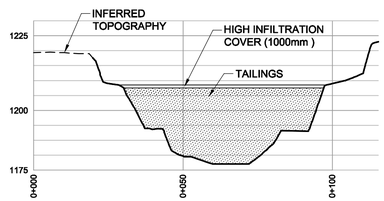

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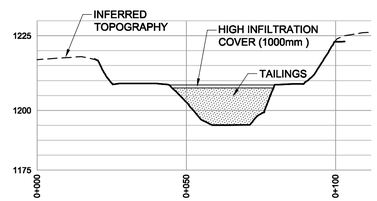

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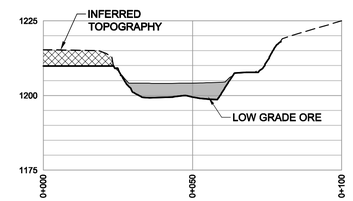

SECTION 6

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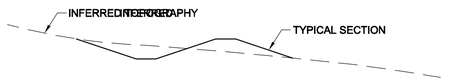

SECTION 7

0 1.5 3 4.5 m SCALE 1:150

TYPICAL DIVERSION DITCH

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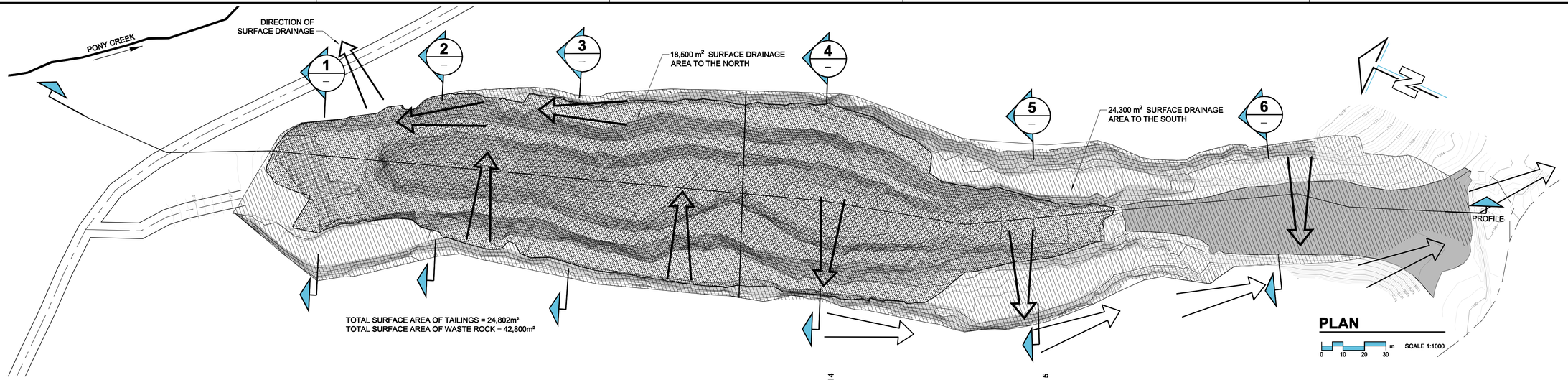
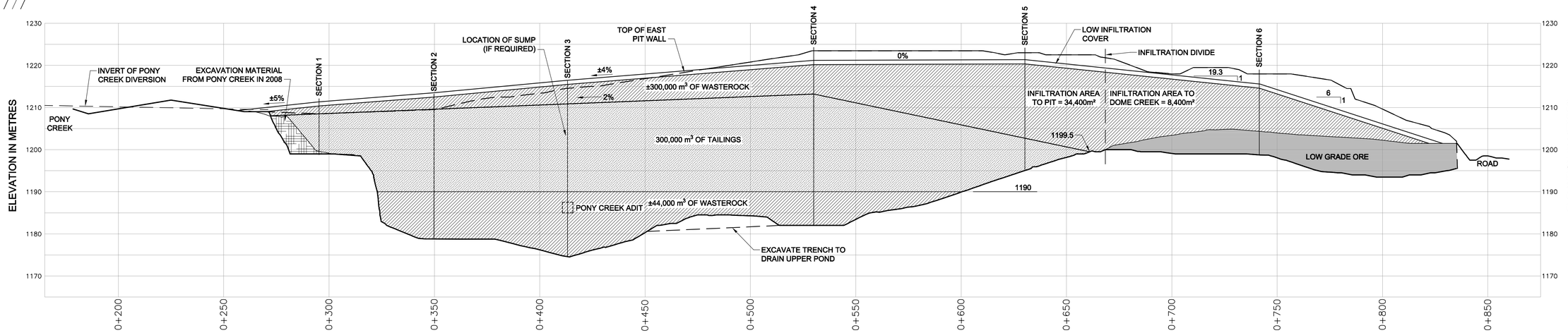
Mt. Nansen Closure Alternatives Characterization

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



PLAN

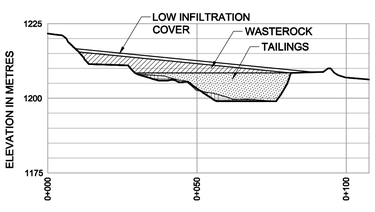
SCALE 1:1000



PROFILE

H=1:1000

V=1:500



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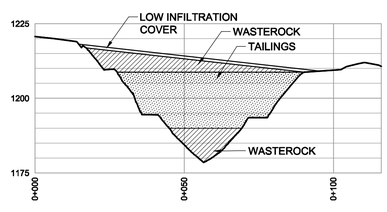
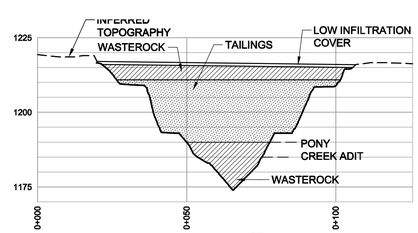


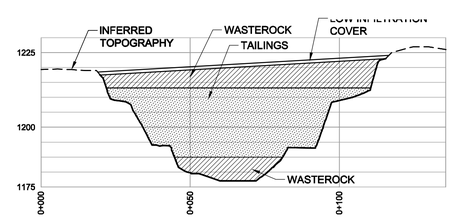
SECTION 2

SCALE 1:1000



SECTION 3

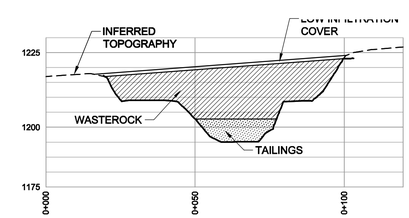
SCALE 1:1000



SECTION 4

SCALE 1:1000

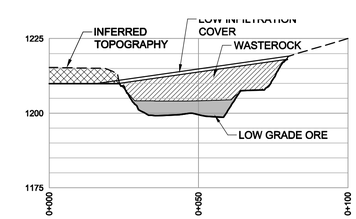
LOW INFILTRATION



SECTION 5

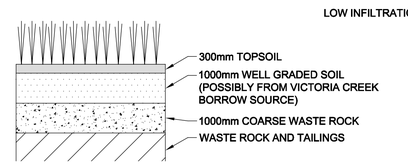
SCALE 1:1000

LOW INFILTRATION



SECTION 6

SCALE 1:1000



COVER

SCALE 1:200

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

D SIZE 22" x 34" (558.8mm x 863.6mm)

PLOT: 10/10/15 4:46:20 PM

ISS/REV: 0A
AECOM FILE NAME: 60159089-05-B-F06-R0X.dwg Saved By: cloustonc

D SIZE(22" x 34" (558.8mm x 863.6mm)
PLOT: 10/10/15 4:45:38 PM
[SOURCE]: 0A
AECOM FILE NAME: 60159089-05-B-F07-R0X.dwg Saved By: cbeatonc
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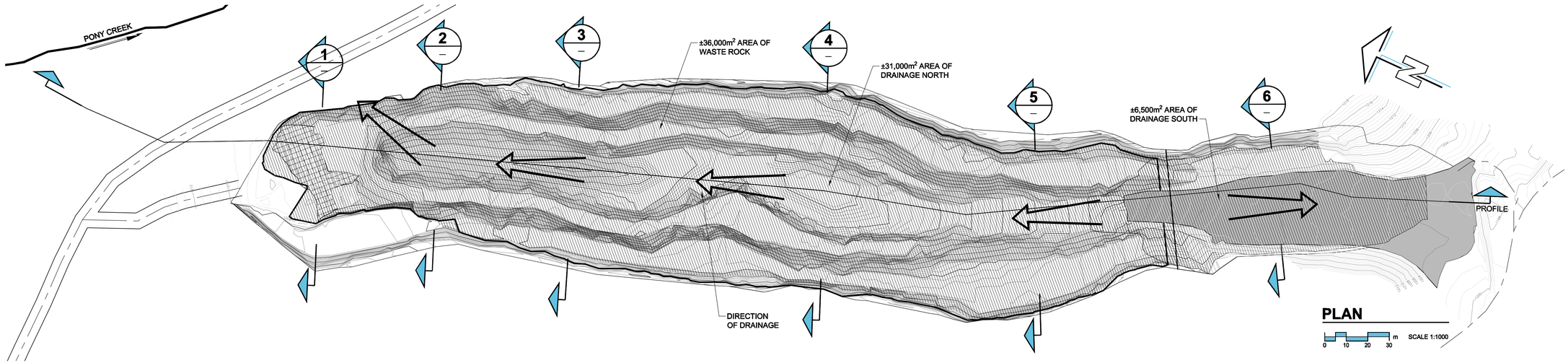

PLAN

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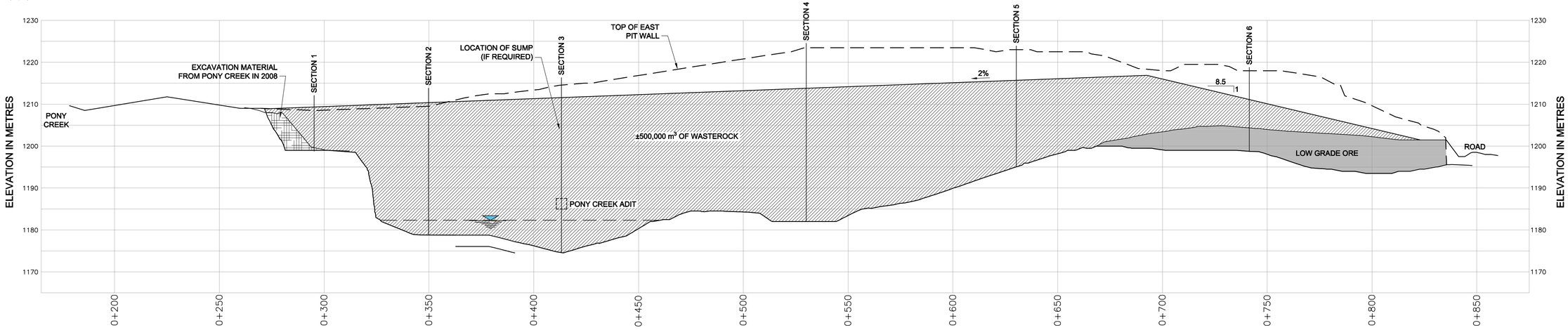
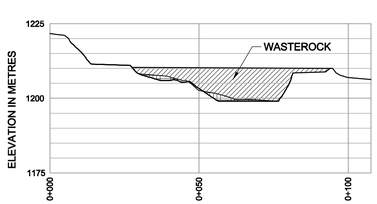


DISTANCE IN METRES
PROFILE THROUGH OPEN PIT

PROFILE

0 10 20 30 m H=1:1000
0 5 10 15 V=1:500



SECTION 1

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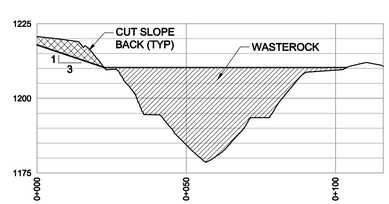

SECTION 2

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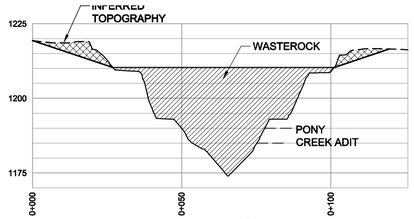

SECTION 3

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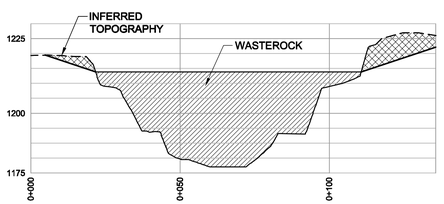

SECTION 4

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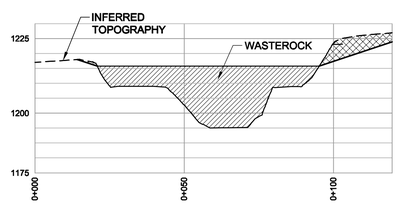

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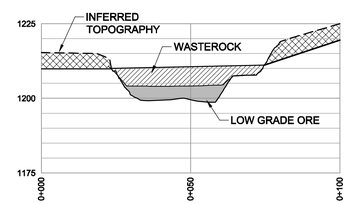

SECTION 6

0 10 20 30 m SCALE 1:1000

NOTE: REFER TO DRAWING 01 AND 02 FOR DAM UPGRADING

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

Drawing - 05

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 10/09/22 1:29:30 PM
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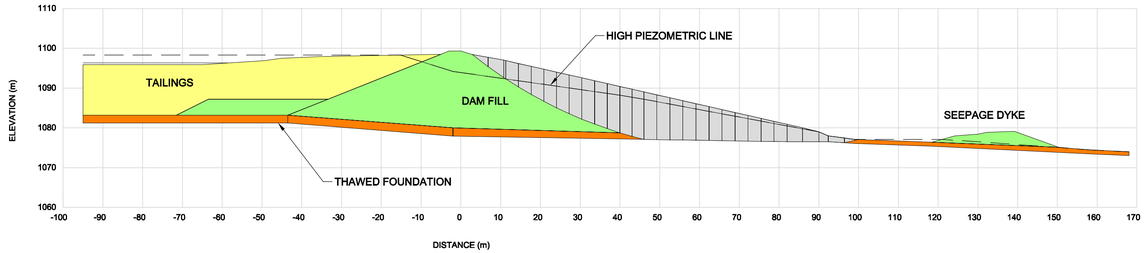
ISSUED/: GA
AECOM FILE NAME: 60159089-05-B-F04-R0X.dwg Saved By: cdeatonc

CURRENT STABILITY

CASE 1: STATIC CONDITION

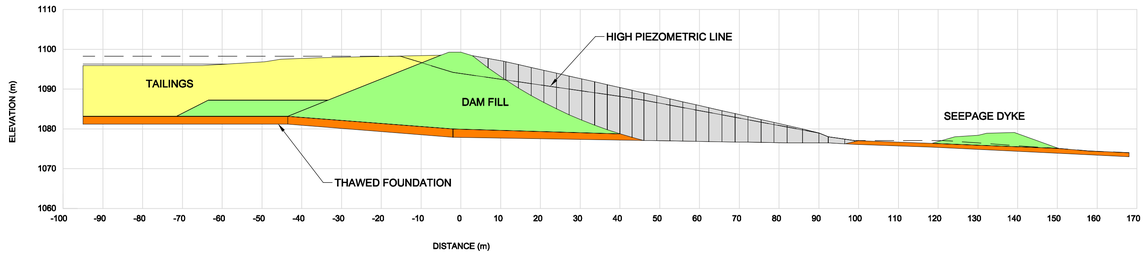
FACTOR OF SAFETY: 1.74



CURRENT STABILITY

CASE 2: PSEUDO-STATIC

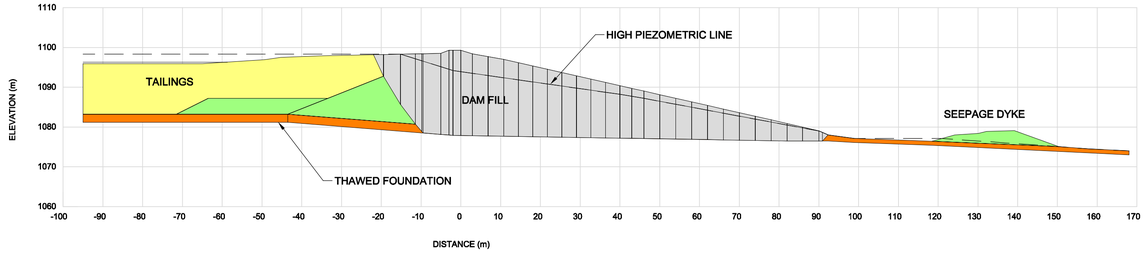
FACTOR OF SAFETY: 1.12



CURRENT STABILITY

CASE 3: POST EARTHQUAKE - RESIDUAL STRENGTH

FACTOR OF SAFETY: 0.56



SECTIONS

SCALE: NTS

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Option 1 & 2 - Stability Analysis

Drawing - 06

D SIZE 22" x 34" (558.8mm x 863.6mm)
PLOT: 10/09/22 1:28:58 PM
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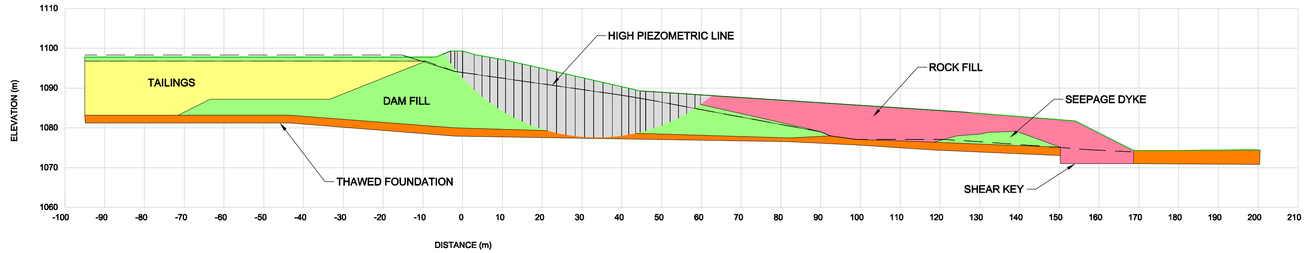
ISSUED BY: GA
AECOM FILE NAME: 60159089-05-B-F12-R0X.dwg Saved By: cloeatonc

STABILIZED

CASE 1: STATIC CONDITION

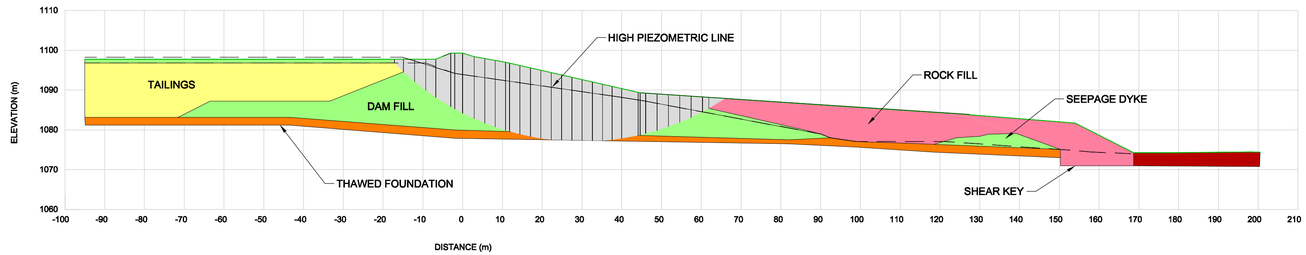
FACTOR OF SAFETY: 2.62



CURRENT STABILITY

CASE 2: PSEUDO-STATIC

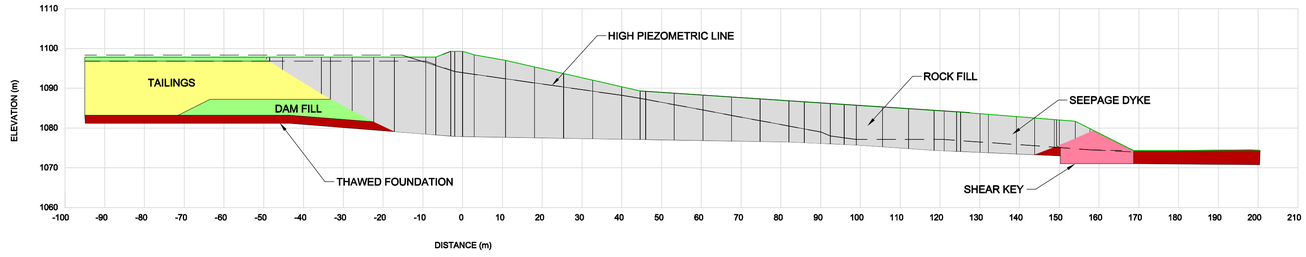
FACTOR OF SAFETY: 1.60



CURRENT STABILITY

CASE 3: POST EARTHQUAKE - RESIDUAL STRENGTH

FACTOR OF SAFETY: 1.26



SECTIONS

SCALE: NTS

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Mt. Nansen Closure Alternatives Characterization

Option 1 & 2 - Stability Analysis

Drawing - 07

B SIZE 11" x 17" (279.4mm x 431.8mm)
PLOT: 10/09/22 1:46:10 PM
Saved By: cloustonc
ISS/REV: 0A
AECOM FILE NAME: 60159089-05-B-F11-R0X.dwg
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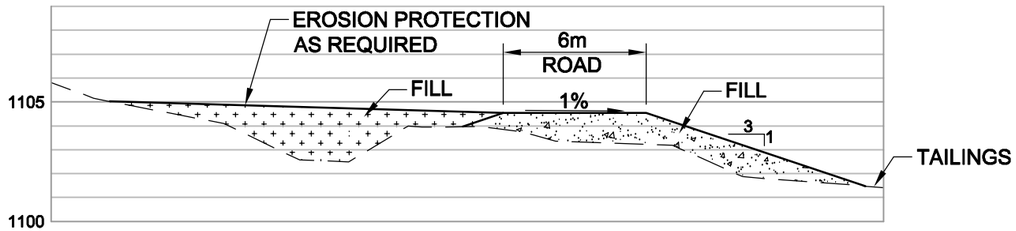
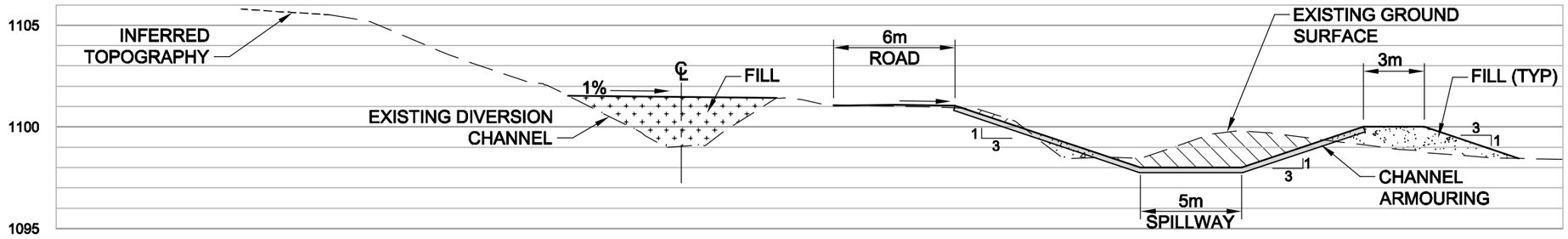


SECTION 0+105

0 2.5 5 m SCALE 1:250

INCEPTOR DITCH & DIVERSION CHANNEL



SECTION 0+715

0 2.5 5 m SCALE 1:250

SPILLWAY

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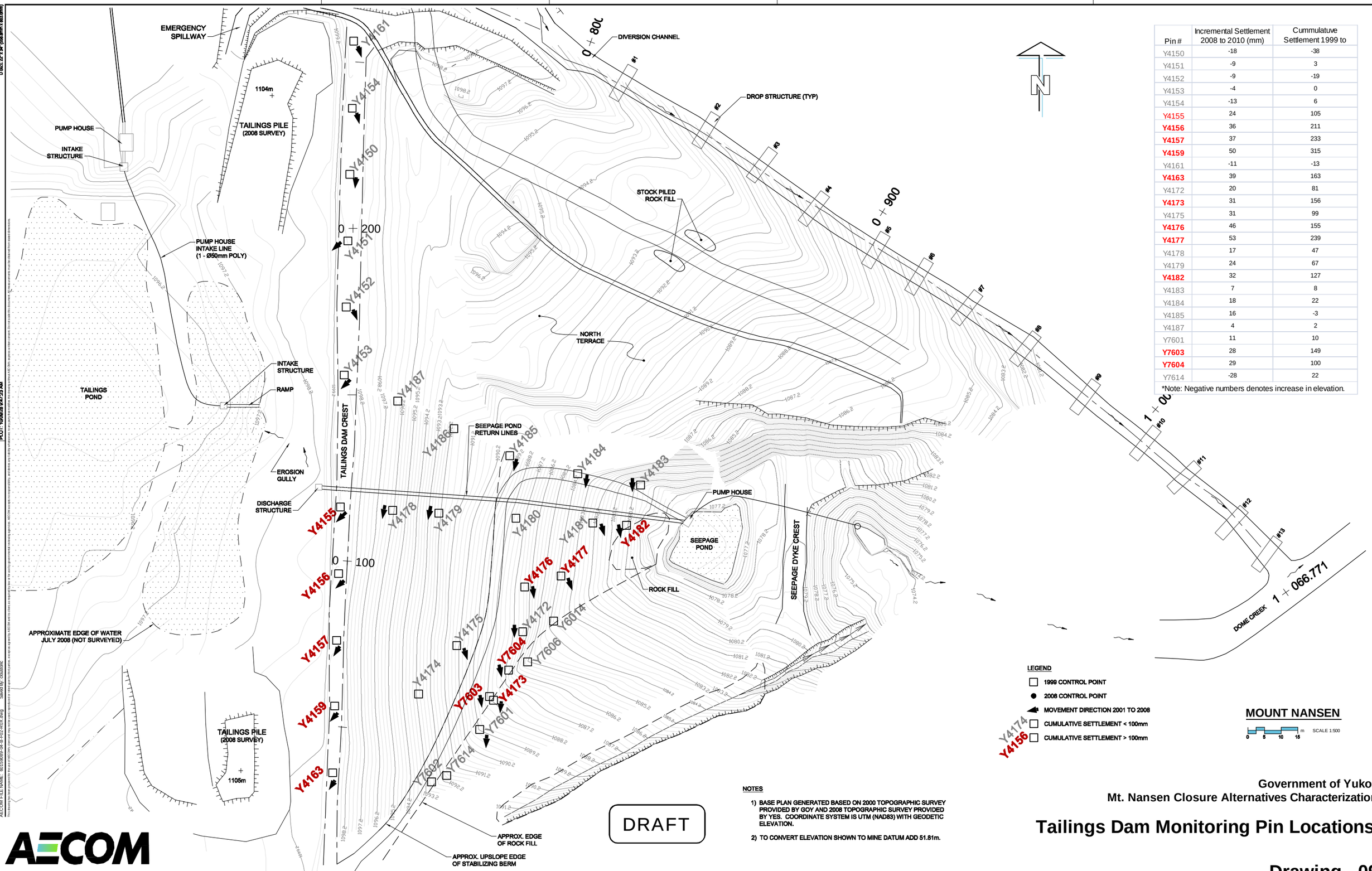
Mt. Nansen Closure Alternatives Characterization

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.

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.

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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 / MW09-23**
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 DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0	FILL	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							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							1088
12							1087
13							1086
14	FILL	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
15							

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: 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 / MW09-23**
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)	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					1082
18					- clast supported - 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					1080
20					- some gravel					1079
21	GRSA				SAND and GRAVEL, trace silt - dark grey-brown					1078
22					- 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		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					1076
24	SA				- SAND and GRAVEL until approx. 27.4 m below ground surface					1075
25										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					1071
29	GRSA				- coarsening downward sequences		G-8			1070
30										

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: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
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: **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 / 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 / MW09-22**
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 / Total Unit Wt / Plastic MC Liquid	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					SAND, trace silt, trace organics - wood debris, <2 cm - dark grey - sub-rounded - permafrost at 5.64 m below ground surface, Nbn, 1.6°C - gravel content increases with depth to "gravelly"		S-3	1-1-1			1083
6	SA						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											

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 / MW09-22**
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: ✳ 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	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) 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) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.77 m below ground surface						1071
18											1070
19											1069
20											1068
21											1067
22											1066
23											1065
24											1064
25											1063
26											1062
27											1061
28											1060
29											1059
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: 16.77 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 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
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						S-3	3-4-5			1085
6				- some gravel below 5.33 m below ground surface		S-4	6-7-7			1084
7				- trace gravel below 6.10 m below ground surface						1083
8	GRSA			- some gravel below 7.32 m below ground surface 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 / Total Unit Wt / 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 - permarfrost 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										

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

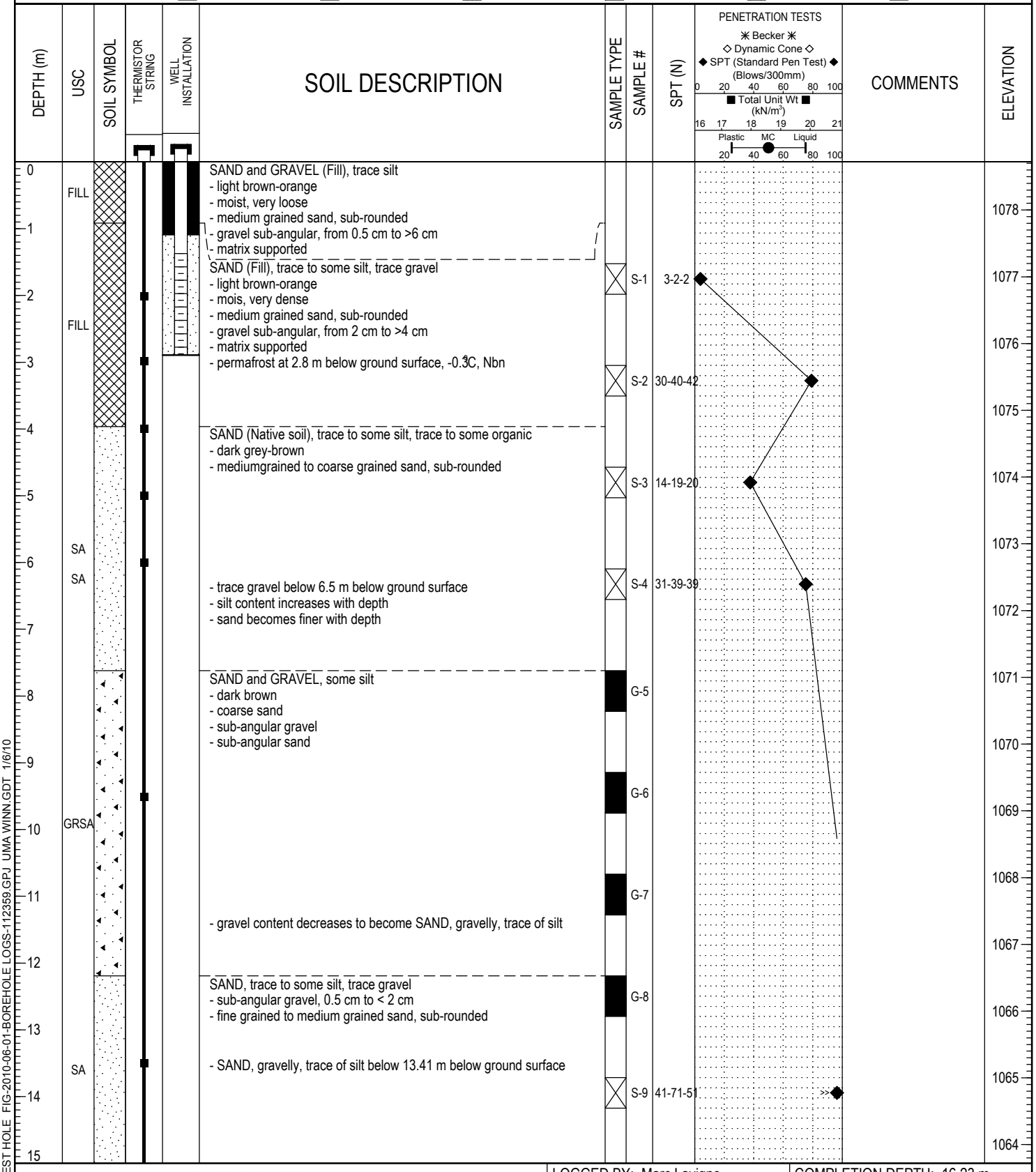
AECOM	LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.87 m
	REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
	PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

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



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 / Plastic MC Liquid	COMMENTS	ELEVATION
15	SA				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	GRSA				END OF DRILLING at16.23 m in permafrost (refusal) 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) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.10 m below ground surface						1062
17											1061
18											1060
19											1059
20											1058
21											1057
22											1056
23											1055
24											1054
25											1053
26											1052
27											1051
28											1050
29											1049
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: 16.23 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

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, 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											1086
2							S-1	1-3-3			1085
3					- fine sand content decreases with depth - coarsening downward sequence		S-2	3-4-4			1084
4											1083
5					- moist with dry lenses		S-3	4-9-8			1082
6					- coarsening downward sequence		S-4	5-8-10			1081
7											1080
8	SA				- some dark brown sand between 4.1 and 4.4 m below ground surface - moist, dense		S-5	10-18-18			1079
9					- some gravel below 8.38 m below ground surface						1078
10					- coarsening downward sequence - wet, loose		S-6	2-3-5			1077
11							S-7	5-9-23			1076
12					- Permafrost at approximately 11.28 m below ground surface, Nbn						1075
13							S-8	23-32-41			1074
14	GRSA				SAND AND GRAVEL, trace silt (description from dill cuttings)						1073
15	SA				- SAND, some gravel, trace silt (description from dill cuttings)						

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 1 of 2

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)	PENETRATION TESTS	COMMENTS	ELEVATION
15					SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth						1072
16	SASI				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/m^3)
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/m^3)
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 - 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									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 / 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		S-1				1093
4	SM									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/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: 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 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, 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						1088
9	SA			- loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill		S-4				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										1082
15										

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

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: 9.14 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: **MW09-04**
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

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, non-plastic, slow dilatency - fine grained sand, sub-rounded						
1										1095
2	SM			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						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 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)						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/m^3) 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: 7.01 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

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 / 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										1091
6	OR SM			ORGANICS - dark brown - wet - primarily moss						1090
7	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
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						1088
9				END OF DRILLING at 6.71 m						1087
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)						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/m^3) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

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/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: 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 / Total Unit Wt / 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									
2										1094
	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						
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/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: 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

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

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	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			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 / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0				SAND (Aeolian) - grey brown - dry, loose, non-cohesive - uniform fine to medium grained sand, sub-rounded, minor silt						1107
1										1106
2	SA			- 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 - 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)		S-1				1103
5				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										1093
15										

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: 4.22 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 / Total Unit Wt / Plastic MC Liquid	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 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										

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/m^3)
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								
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
						S-44			
27						S-45			1181
28						S-46			1180
						S-47			
29						S-48			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 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										1168
41										1167
42										1166
43										1165
44										1164
45										

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)

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 / Total Unit Wt / Plastic MC Liquid	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

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

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0				CLAY (minor SAND and some GRAVEL) - brown - dry, loose, cohesive, non-plastic, rapid dilatency when wet					
1									1206
						S-1			
2	CL								1205
						S-2			
3									1204
4									1203
						S-3			
						S-4			
5	BE			DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer		S-5			1202
						S-6			
				- wet 4.88 m to 6.01 m		S-7			
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
						S-9			
7	BE								1200
						S-10			
8						S-11			1199
				- 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					
9						S-12			1198
				- slightly weathered from 9.14 m to 14.63 m - dry, light grey		S-13			
10						S-14			1197
						S-15			
11				- quartz vein 10.97 m to 11.58 m		S-16			1196
						S-17			
12						S-18			1195
13						S-19			1194
						S-20			
14						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										1191
						S-24				
	BE					S-25				1190
17										
						S-26				
18										1189
						S-27				
				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor potassium feldspar, chips fine		S-28				
19										1188
						S-29				
	BE					S-30				1187
20										
						S-31				
21										1186
						S-32				
				GRANODIORITE - grey-brown - moist, highly weathered, heavily fractured and iron stained, rapid drilling rates		S-33				
22	BE									1185
						S-34				
				DIORITE - light grey - dry, moderately weathered, trace feldspar		S-35				1184
23	BE									
						S-36				
				GRANODIORITE - orange-brown - moist, highly weathered with high clay mineral content inferred to be fault gouge - potentially conductive fracture zone		S-37				1183
24	BE									
						S-38				1182
25				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor iron staining, chips fine		S-39				
						S-40				1181
26										
						S-41				
27										1180
	BE					S-42				
						S-43				1179
28										
						S-44				
29				- less than 1 m of water in borehole after sitting overnight without rods in hole		S-45				1178
						S-46				
30										1177

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 / Total Unit Wt / Plastic MC Liquid	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
						S-53				
34	BE			- highly weathered from 34.14 m to end of hole at 38.10 m		S-54				1173
						S-55				
35				- moist from 35.36 m to 35.38 m		S-56				1172
36						S-57				
				- wet from 35.38 m to end of hole at 38.10 m		S-58				1171
37						S-59				
38						S-60				1170
				END OF DRILLING at 38.10 m						1169
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

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 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 / Total Unit Wt / Plastic MC Liquid	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									1181
2						S-1				1180
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						1179
4										1178
5	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 END OF DRILLING at 4.57 m						1177
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

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: 14/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

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 / Total Unit Wt / Plastic MC Liquid	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				GRAVEL with some CLAY, SILT and SAND filling interstices - yellow-brown - wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered						1175
4	GR			- gravel to 10 cm along long axis - inferred to be colluvium		S-2				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										

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: 4.88 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	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 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)		S-3				1171
8										1170
9										1169
10										1168
11										1167
12										1166
13										1165
14										
15										

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: 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 SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS	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										1175
	OR			- clast supported		G-1				
	SA					G-2				
3	OR			- presence of wood debris (waste rock?)		G-3				1174
				ORGANIC, some silt, trace sand - black - moist, loose - presence of roots						
4	SA									1173
				SAND, gravelly, trace of silt - orange-brown - moist, dense - fine grained sand, sub-rounded - volcanic ash marker		G-4				
5										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
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/m^3)
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					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	G-1			1079
2			S	S-1	19-32-50		
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	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					1075
7		END OF DRILLING at 3.20 m in permafrost (refusal)					1074
8		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
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

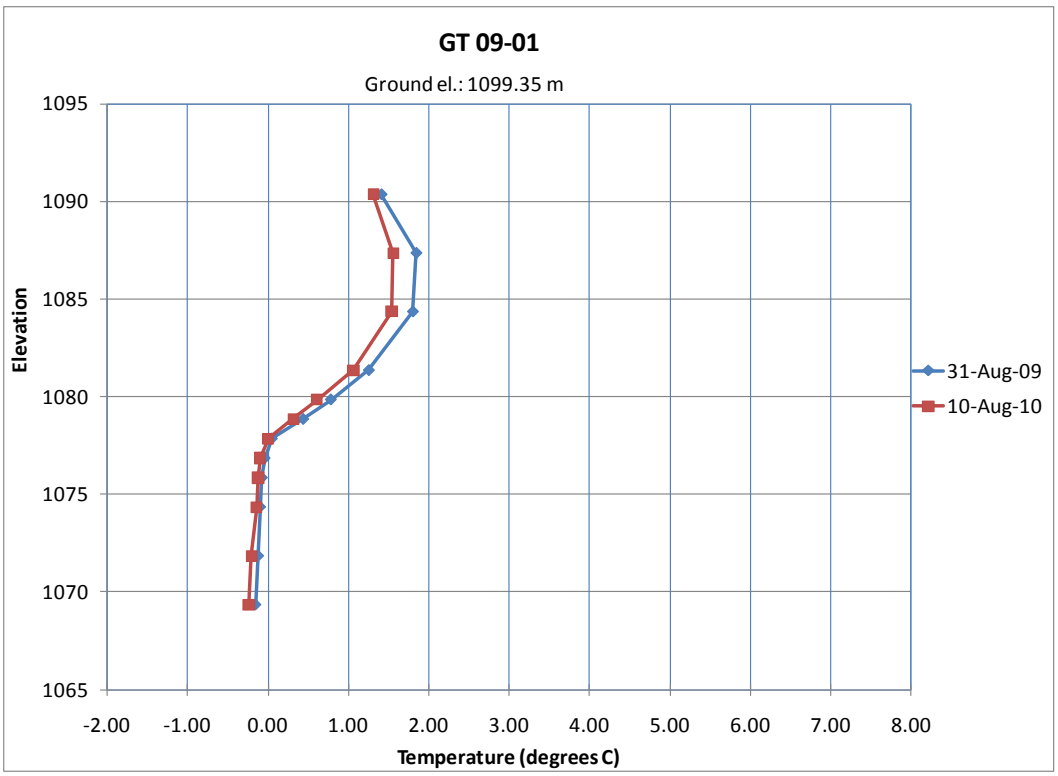
AECOM

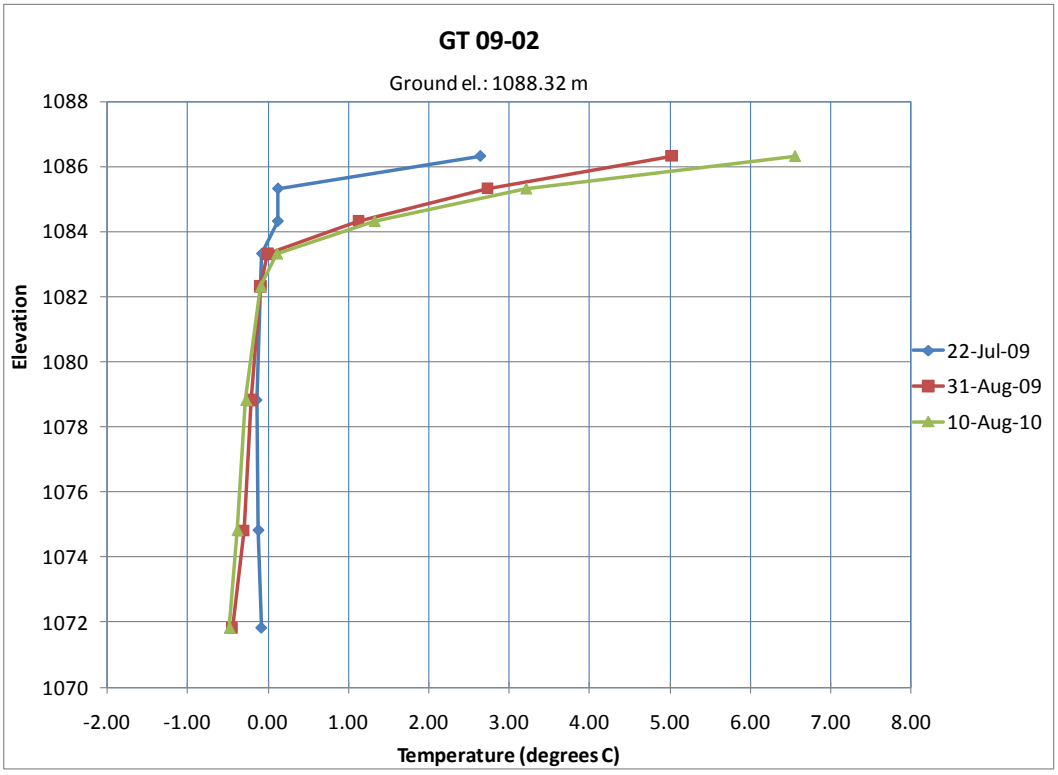
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 3.20 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 17/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

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

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
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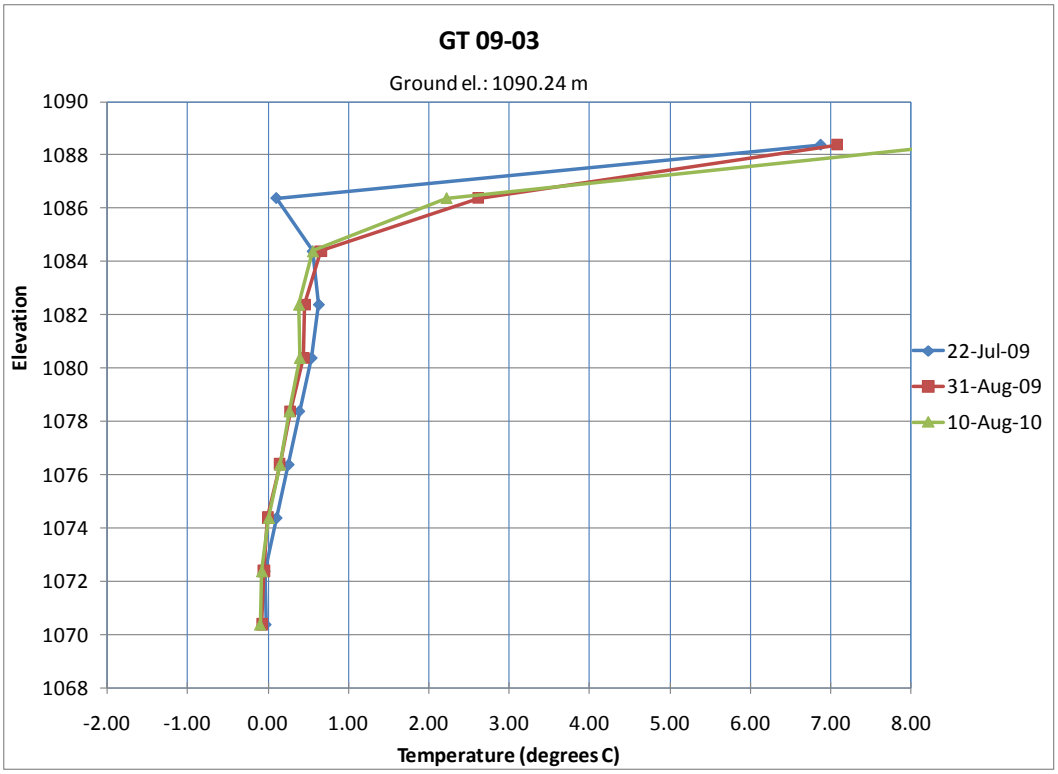
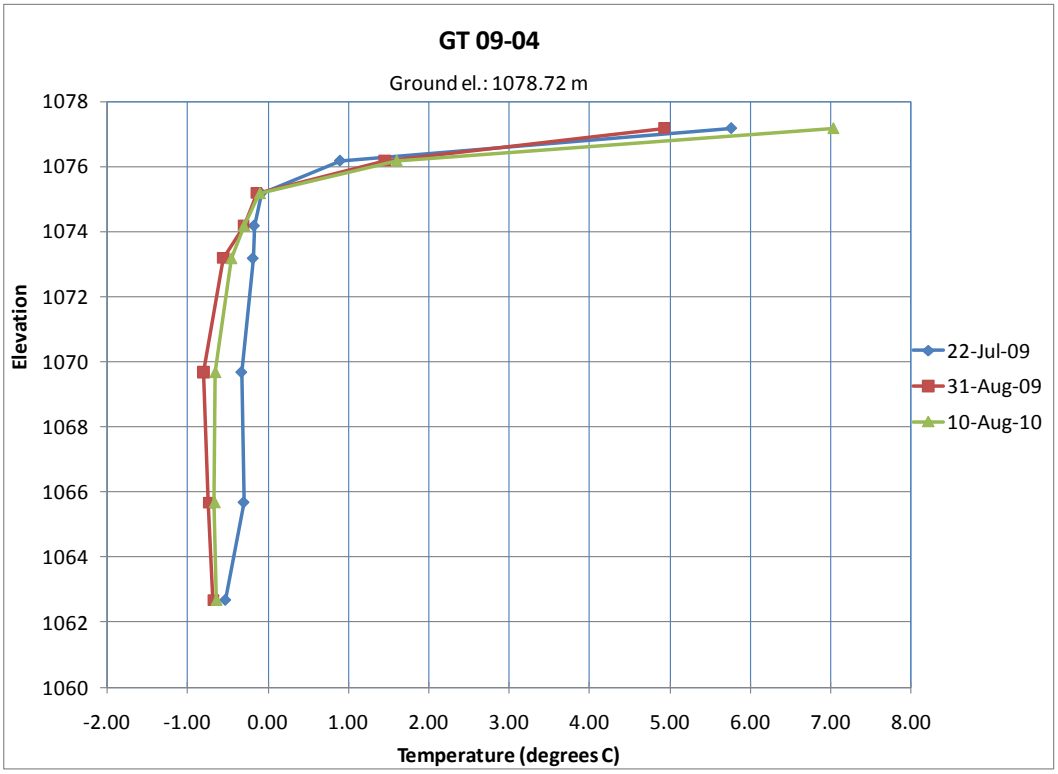
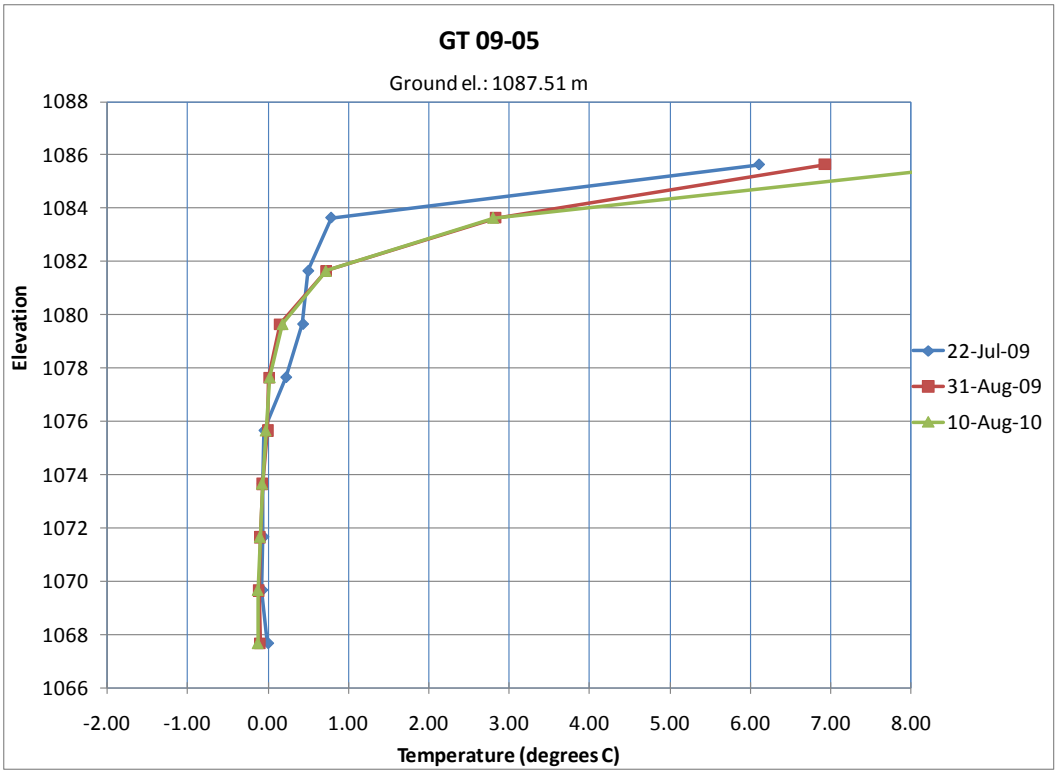
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10


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
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Elevation
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1086
1084
1082
1080
1078
1076
1074
1072
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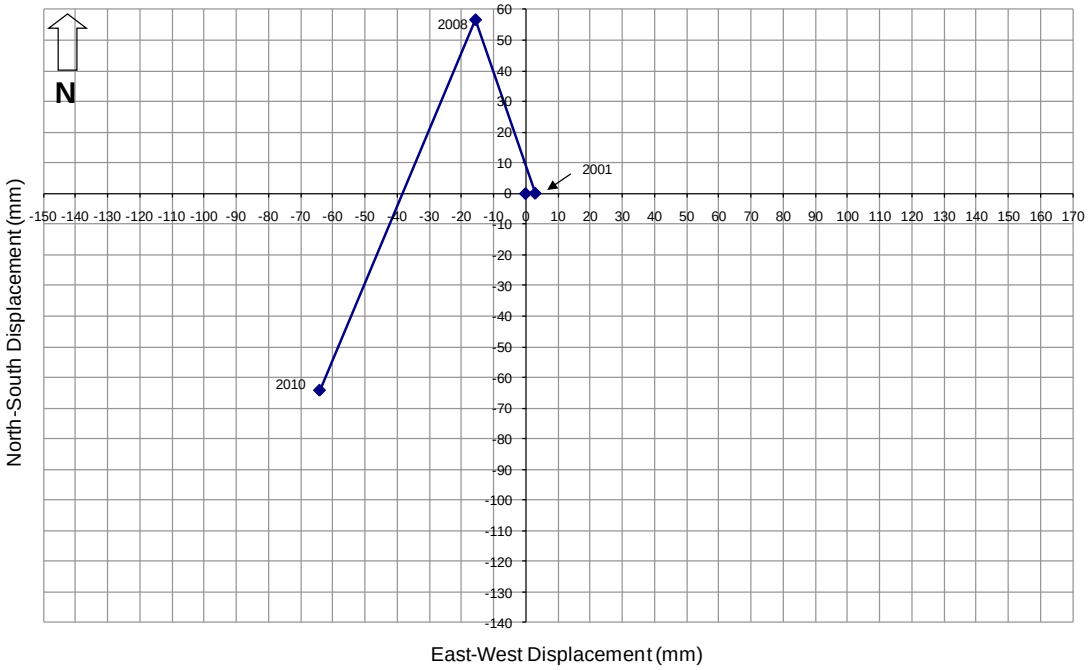
1068
1066
-2.00
-1.00
0.00
1.00
2.00
3.00
4.00
5.00
6.00
7.00
8.00
Temperature (degrees C)
22-Jul-09
31-Aug-09
10-Aug-10

Mount Nansen - Deformation Survey
Pin Number Y4151



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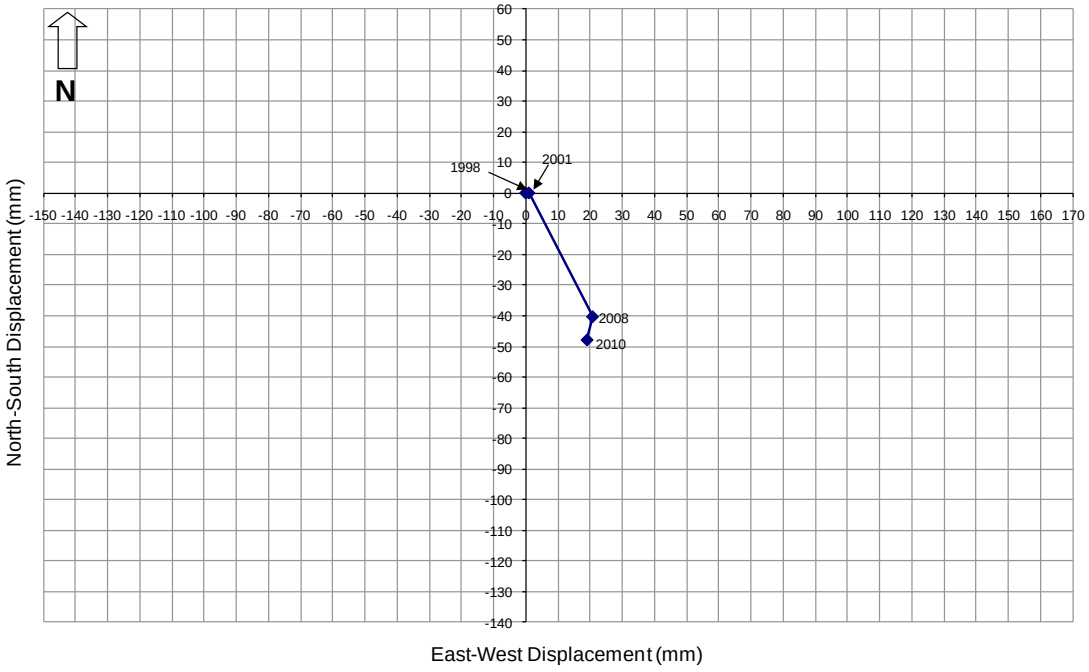

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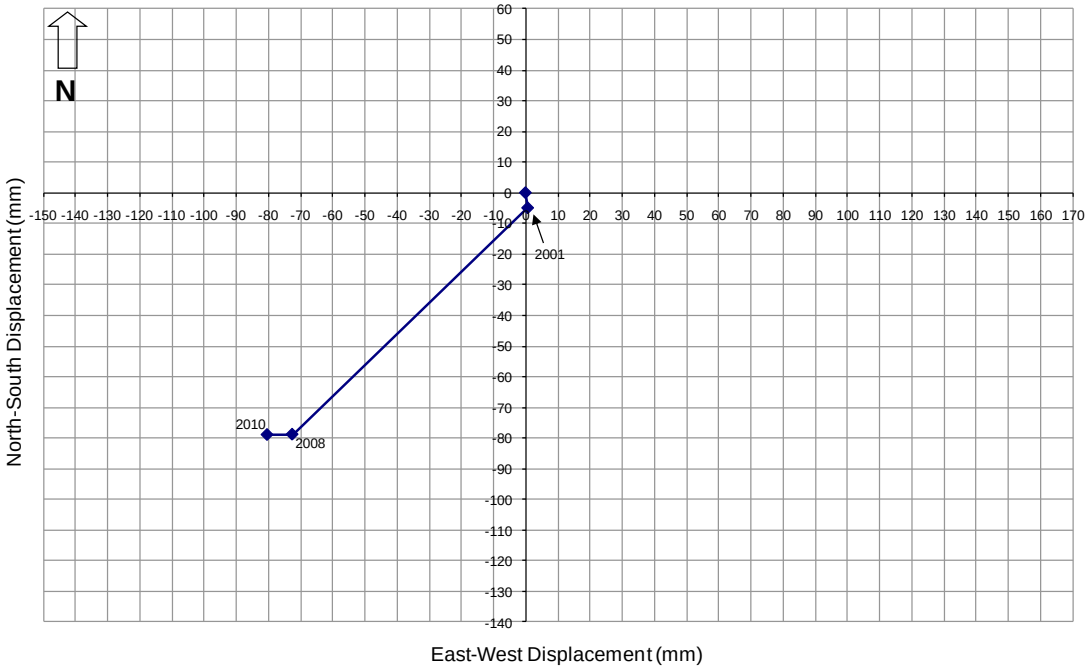

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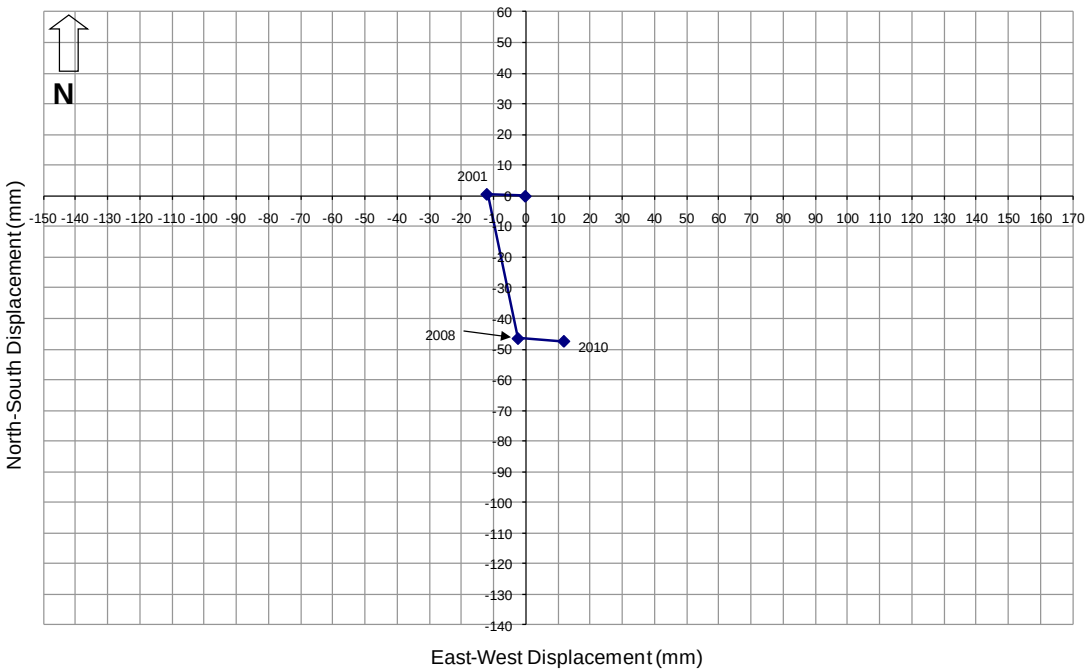

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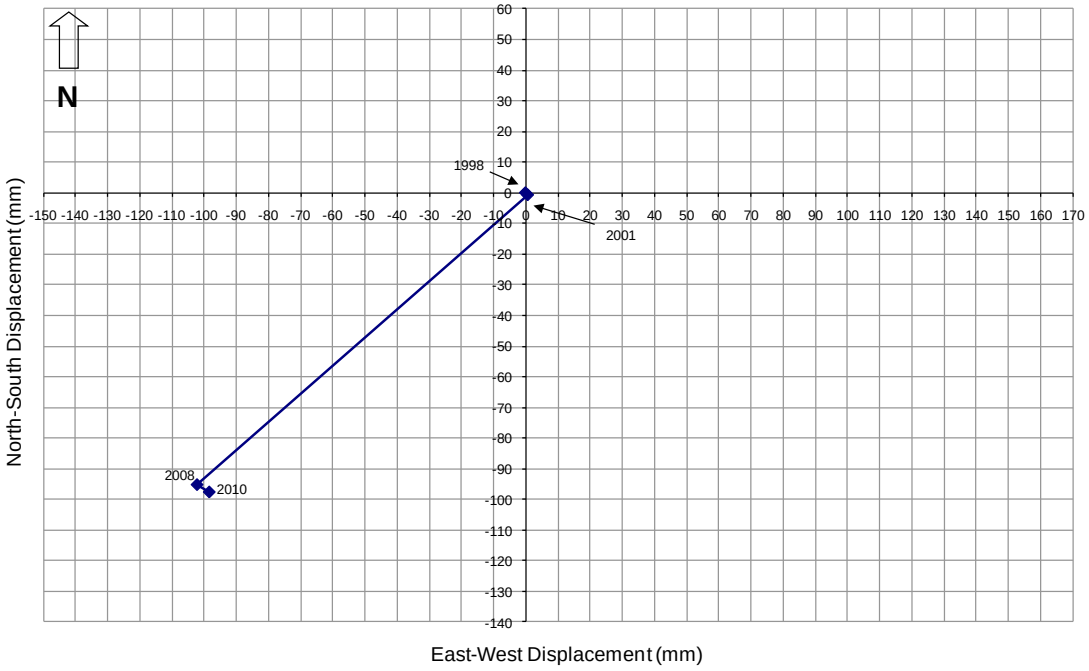

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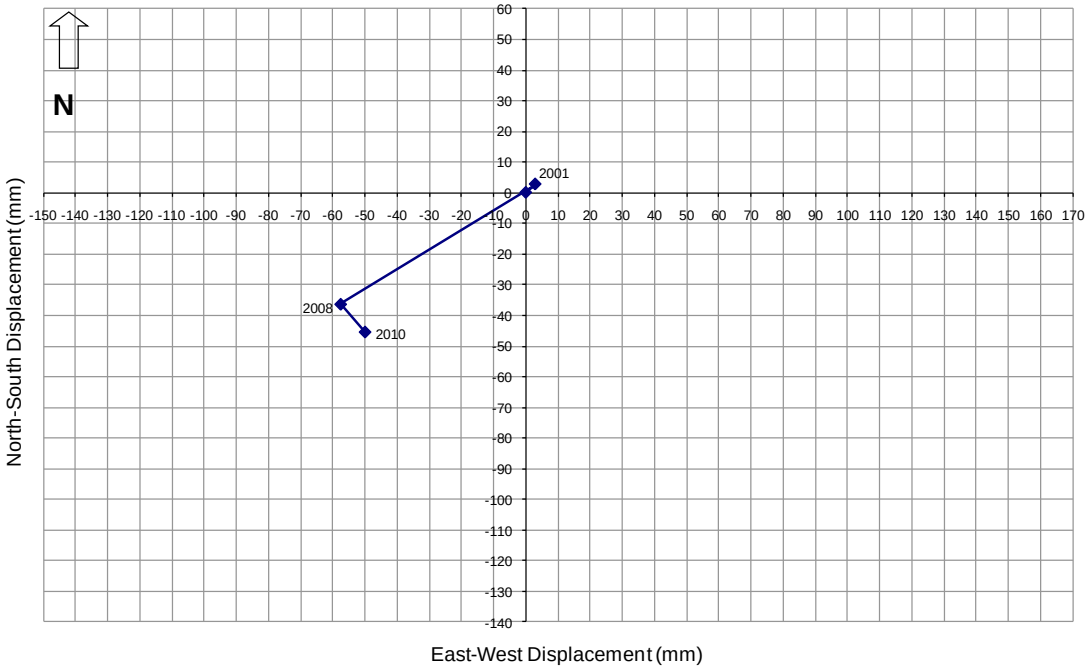

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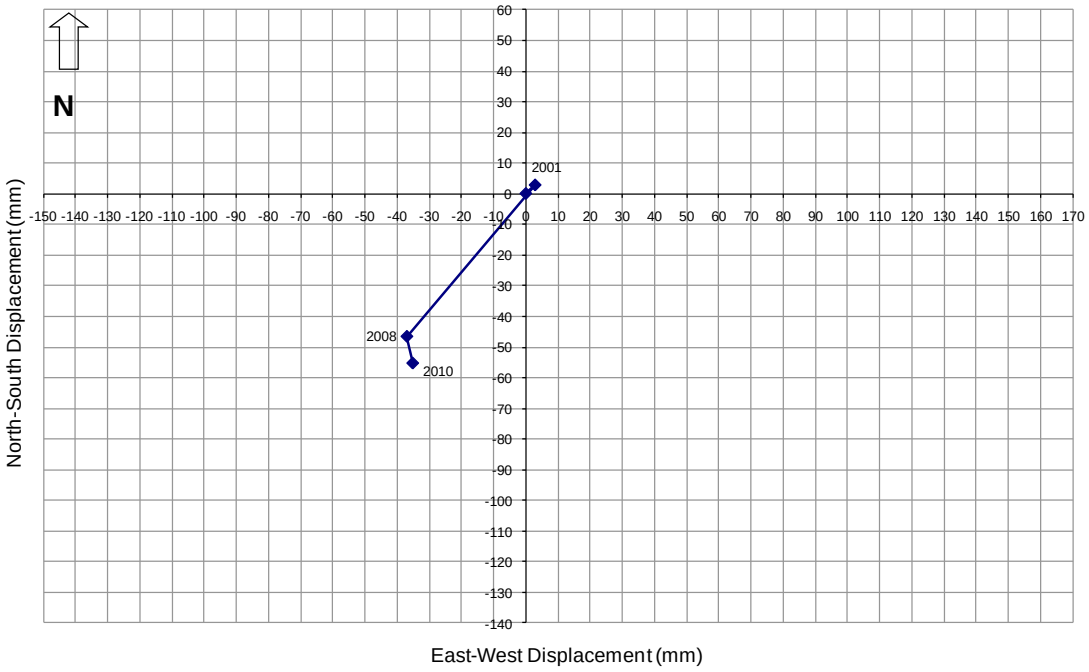

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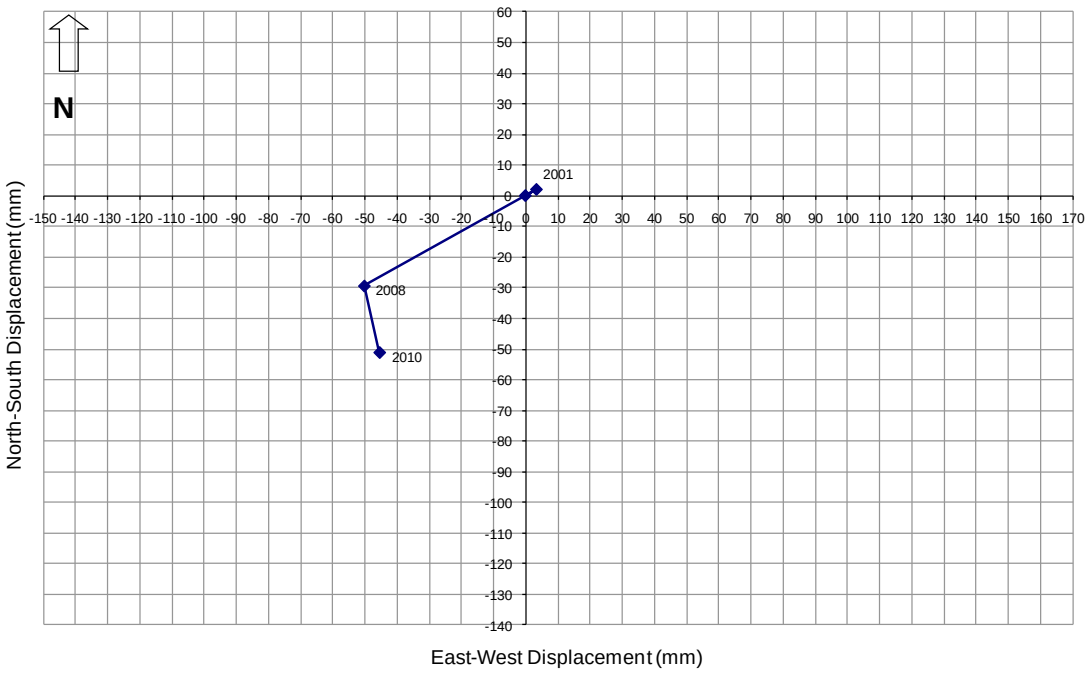

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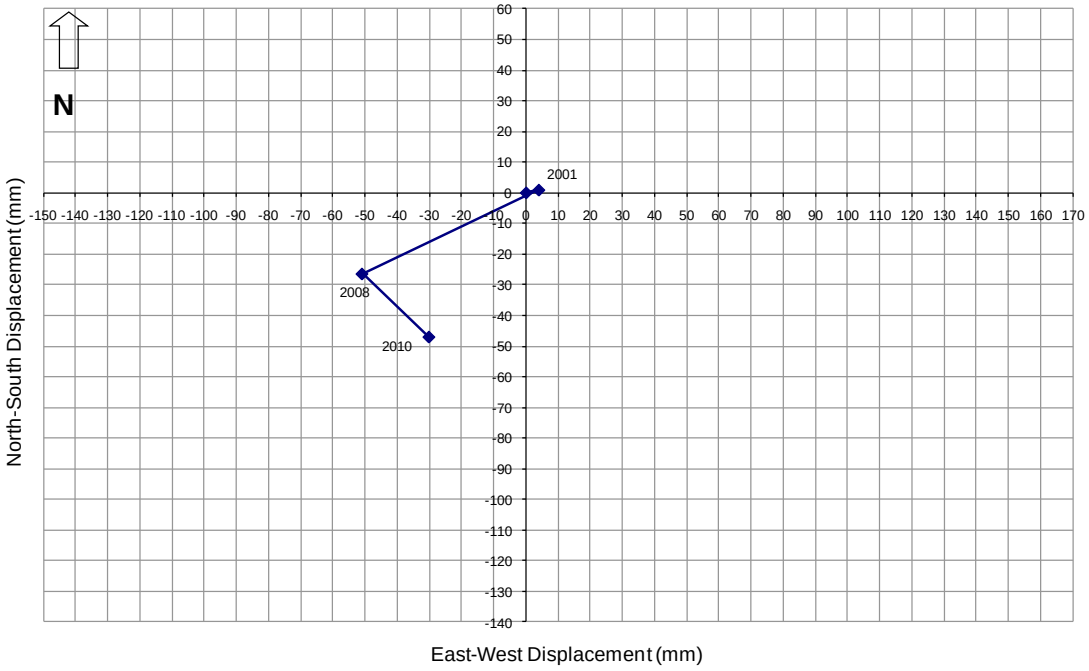

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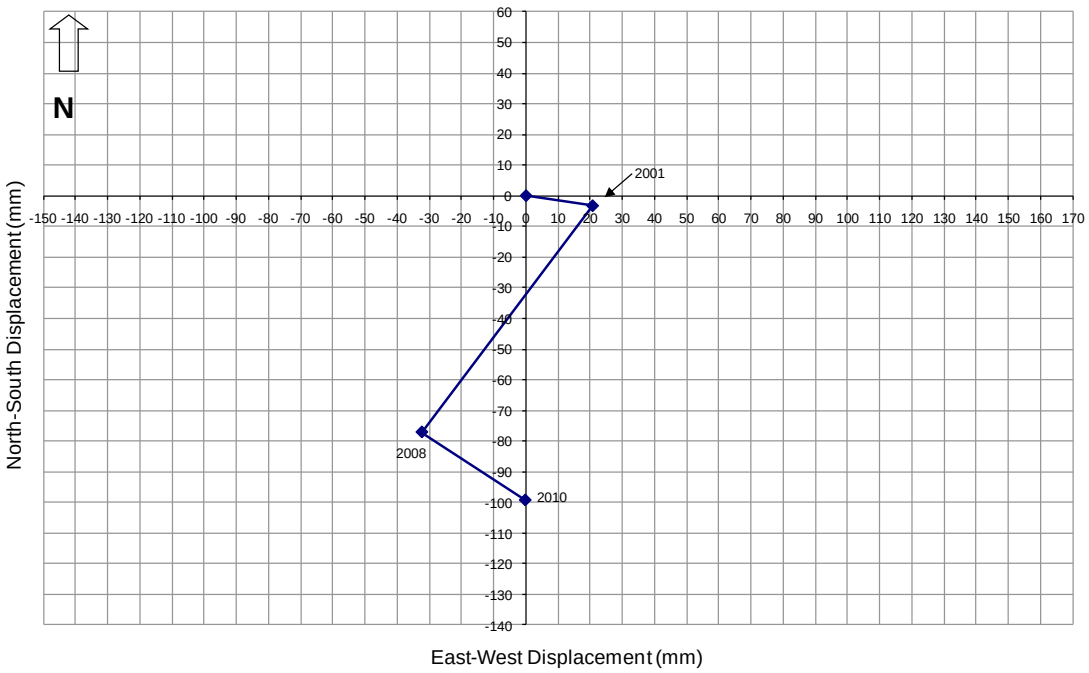

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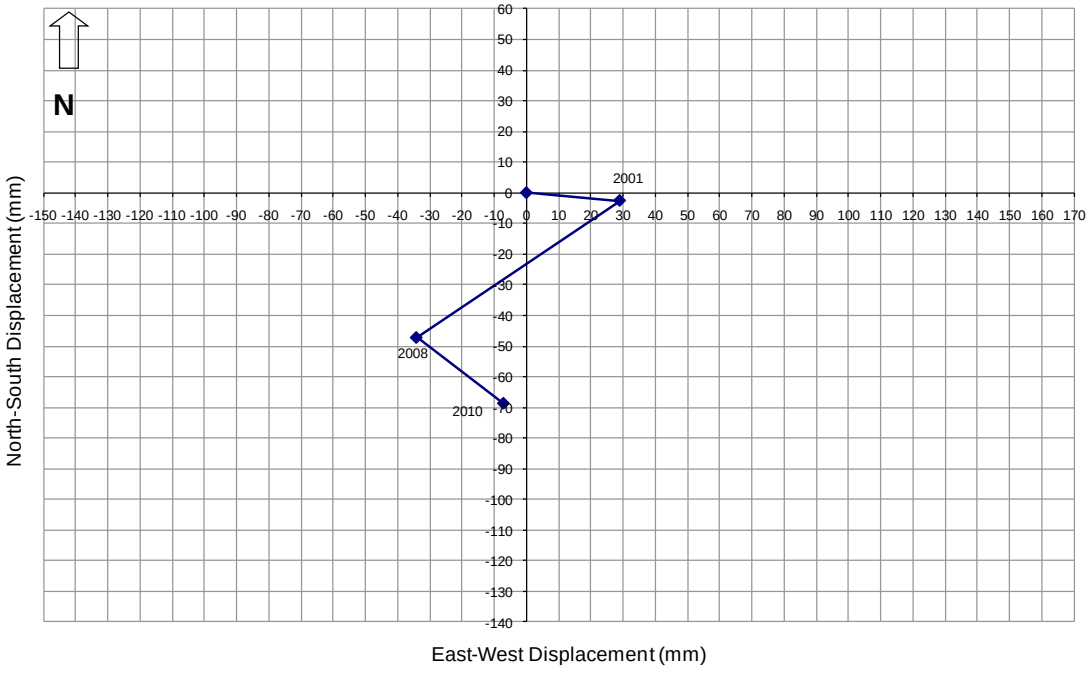

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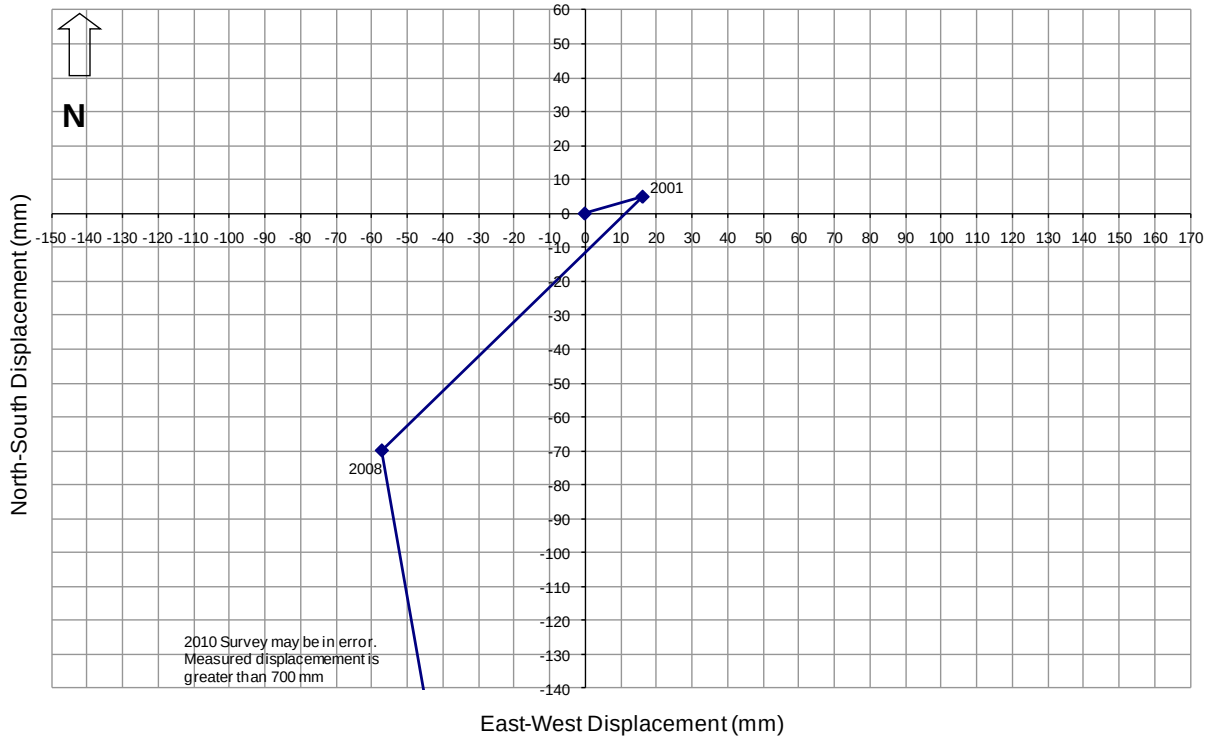

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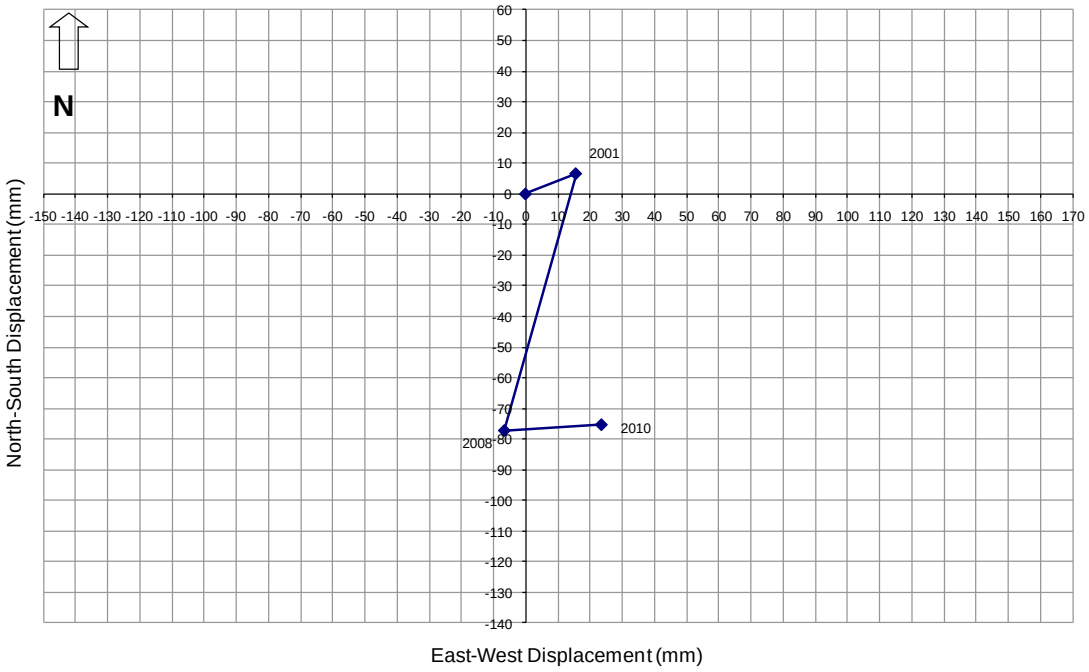

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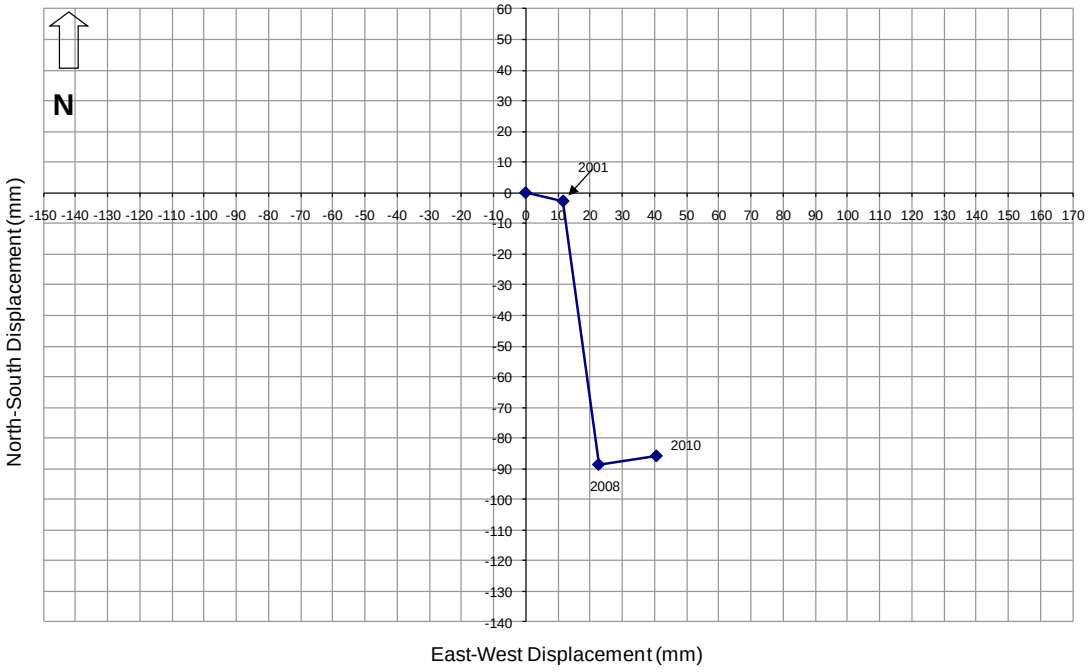

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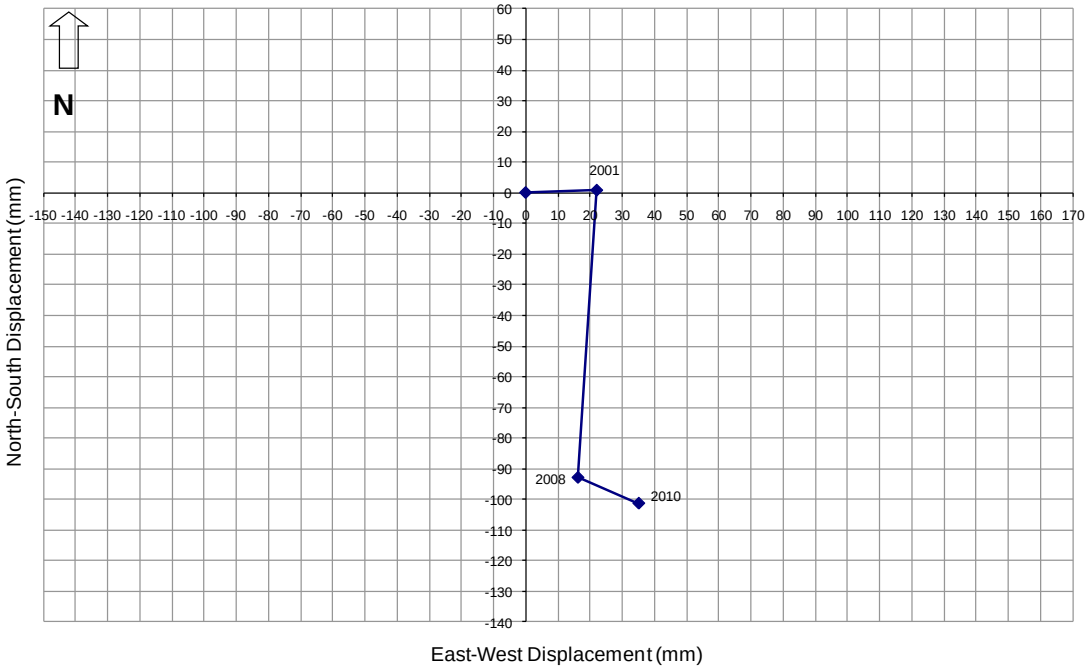

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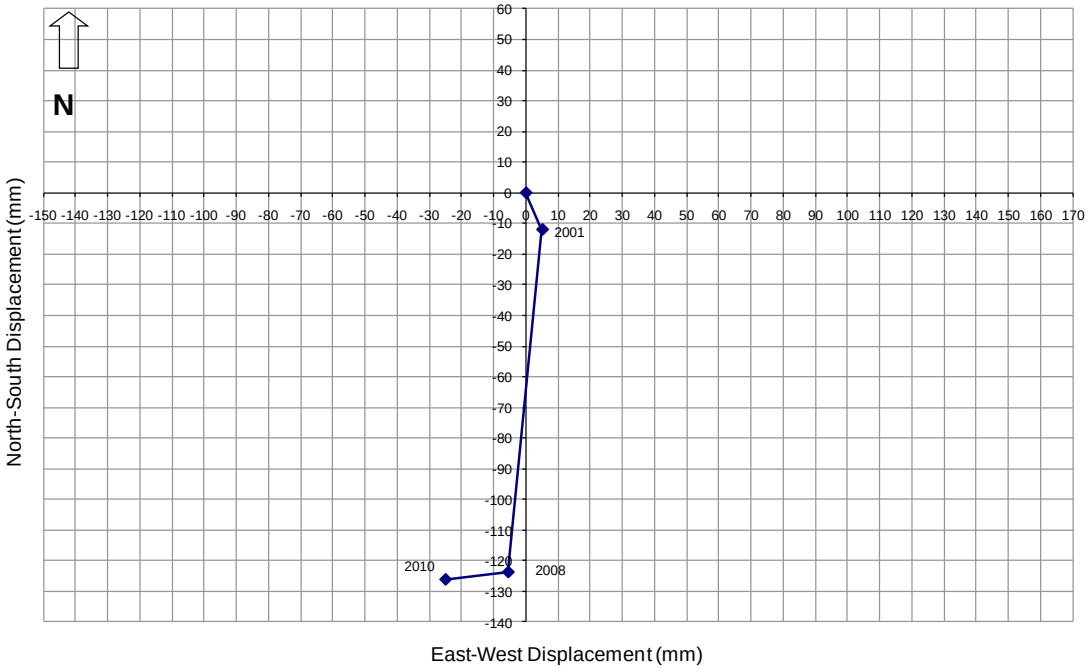

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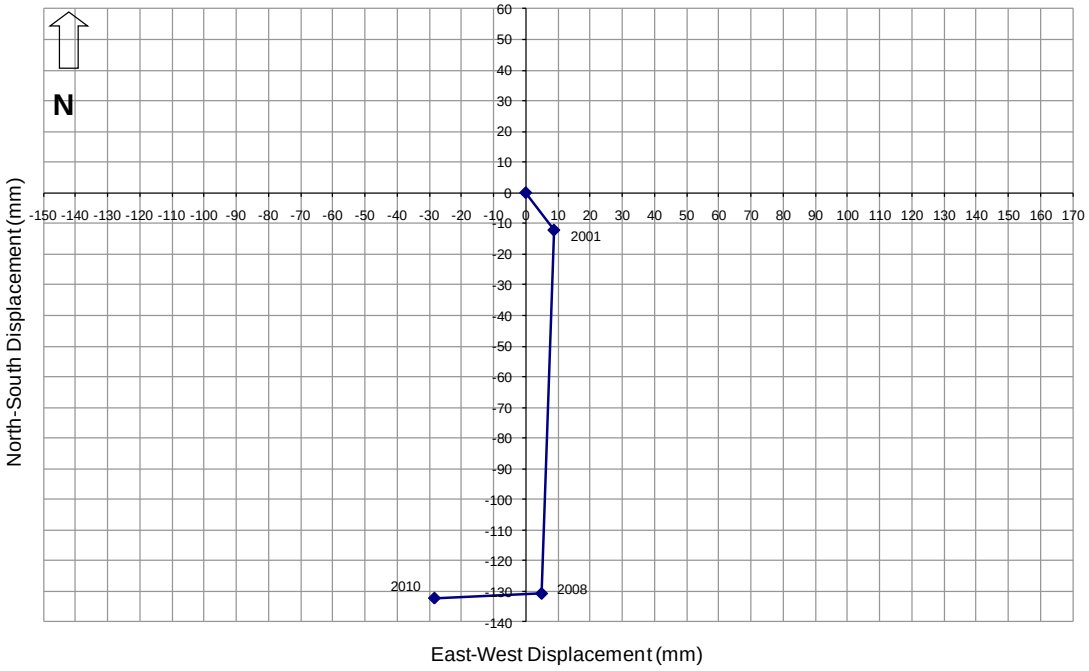

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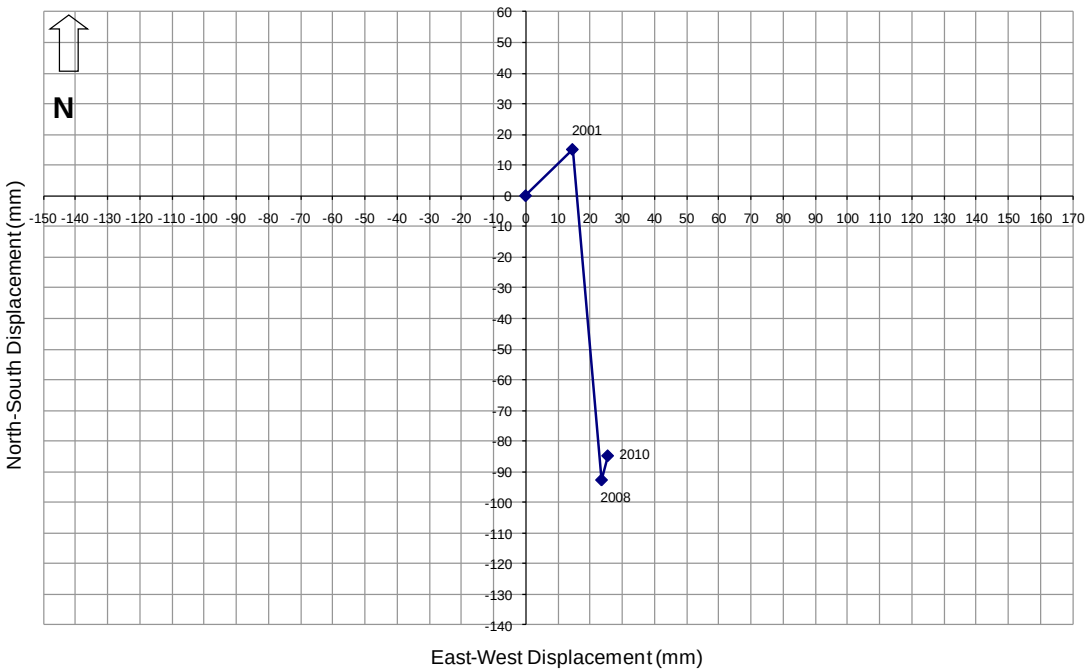

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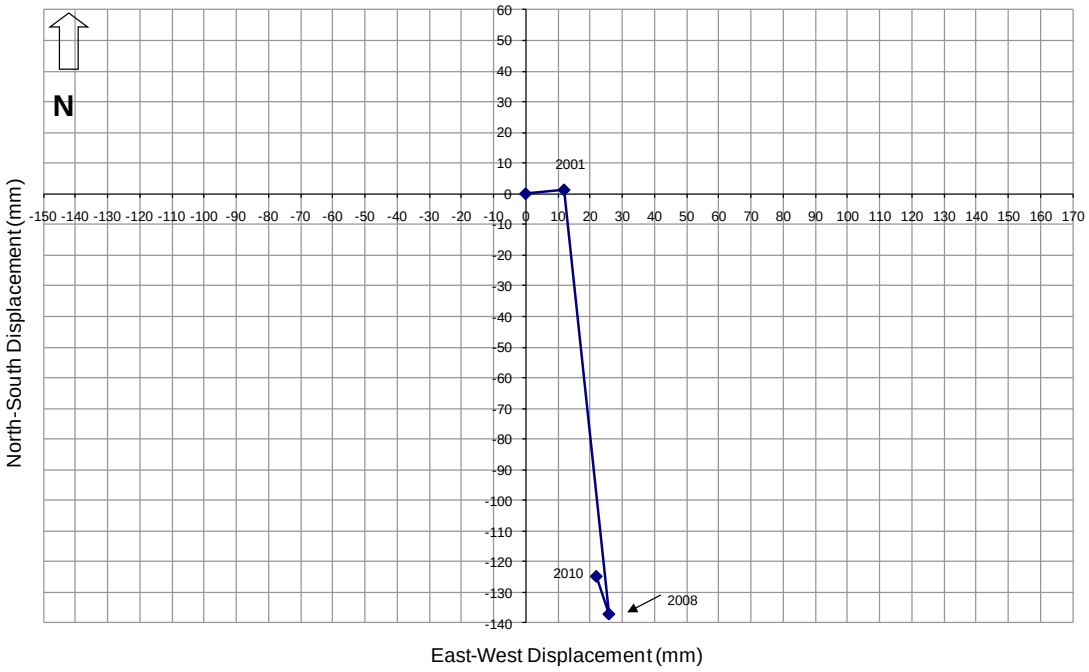

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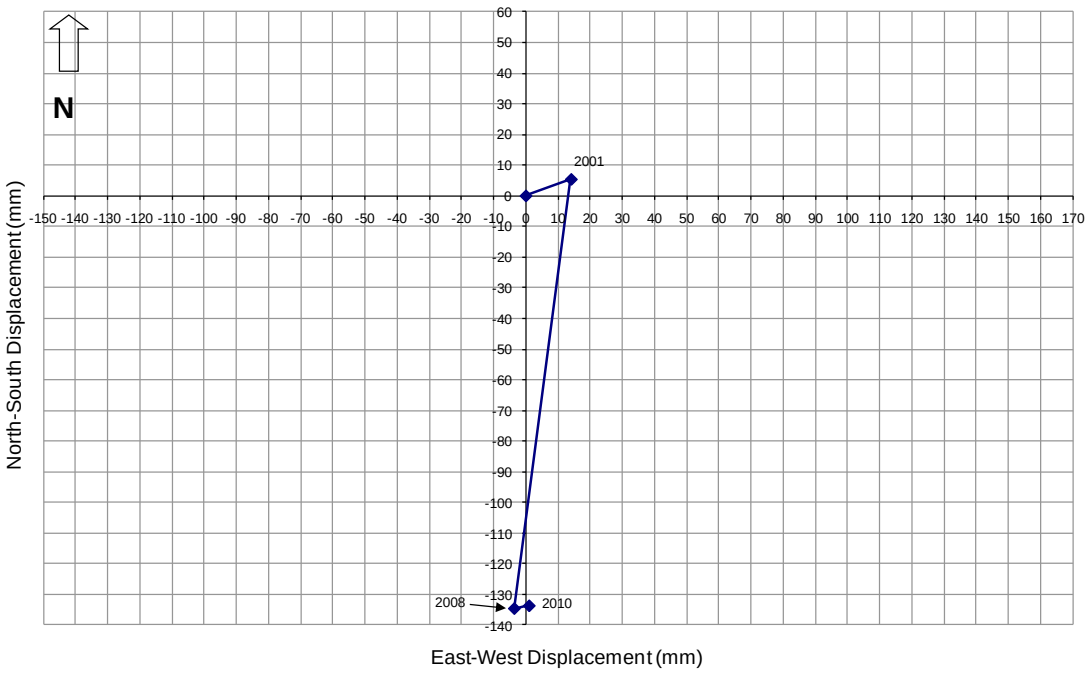

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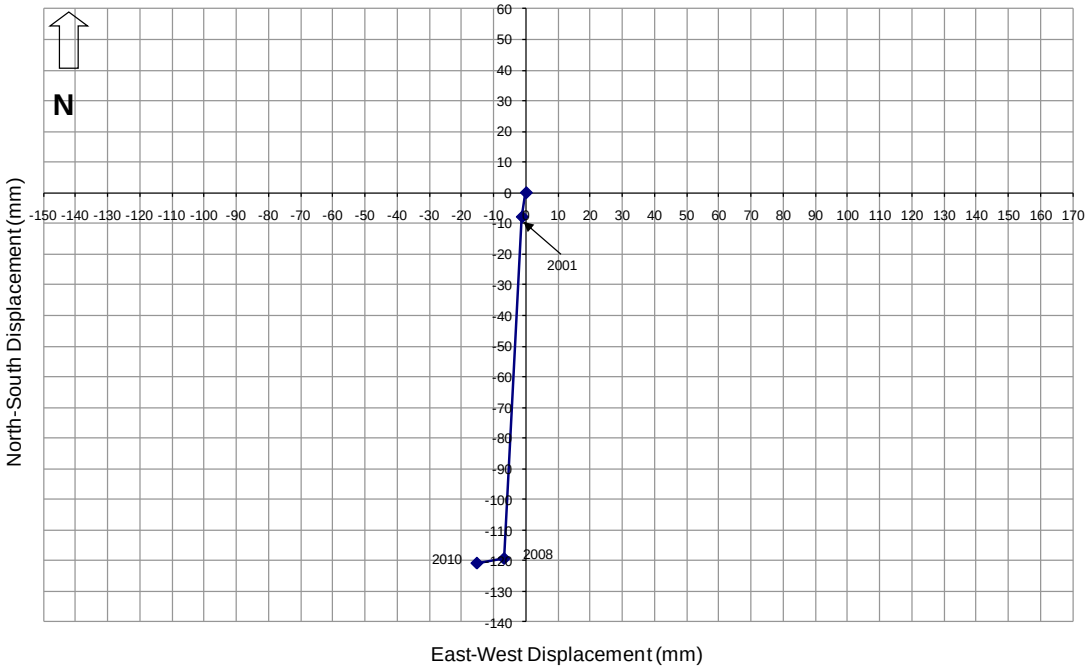

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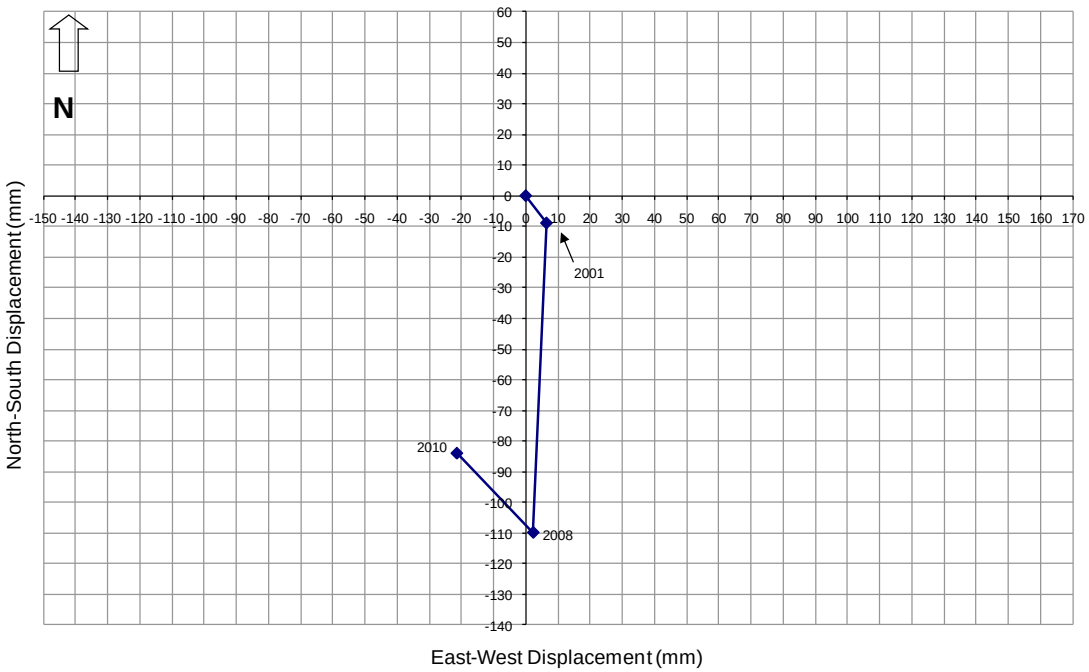

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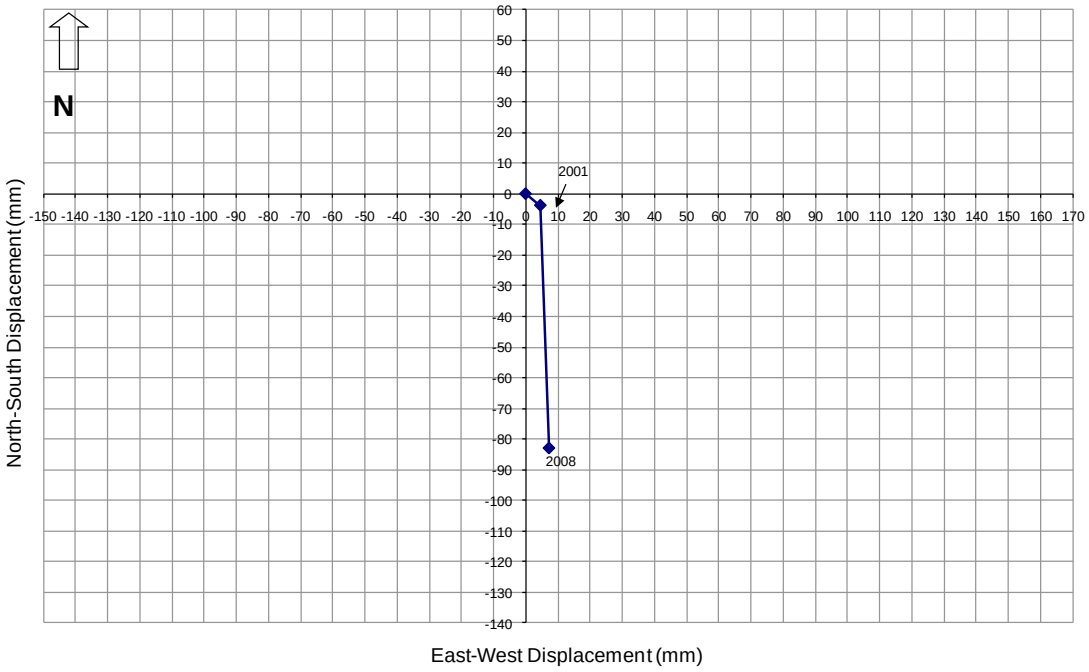

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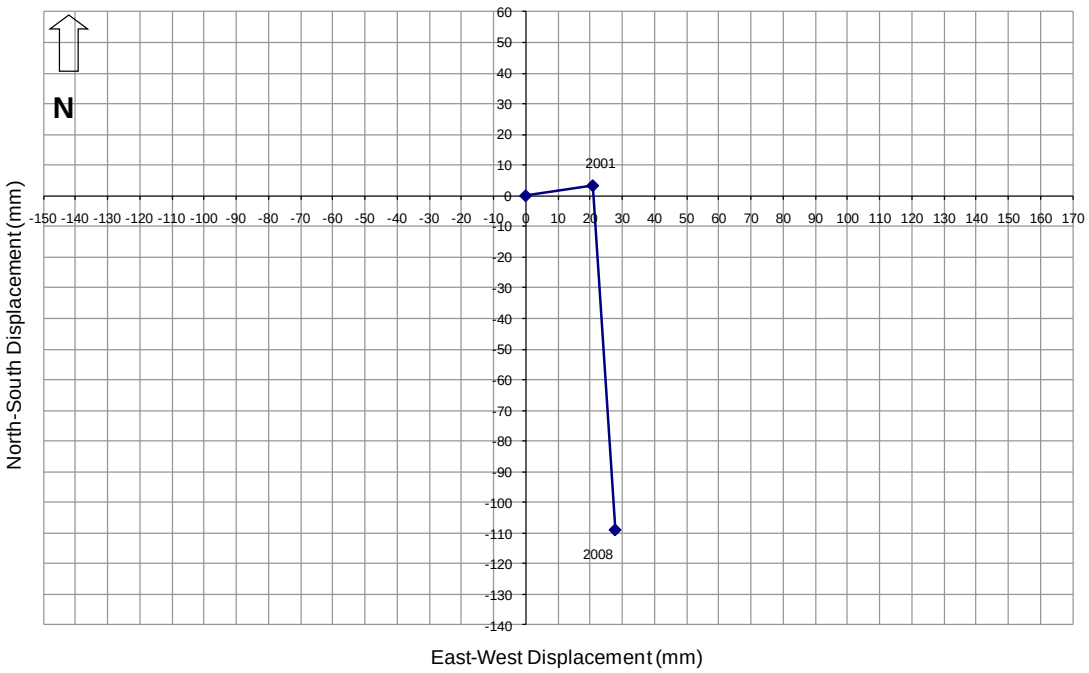

Mount Nansen - Deformation Survey
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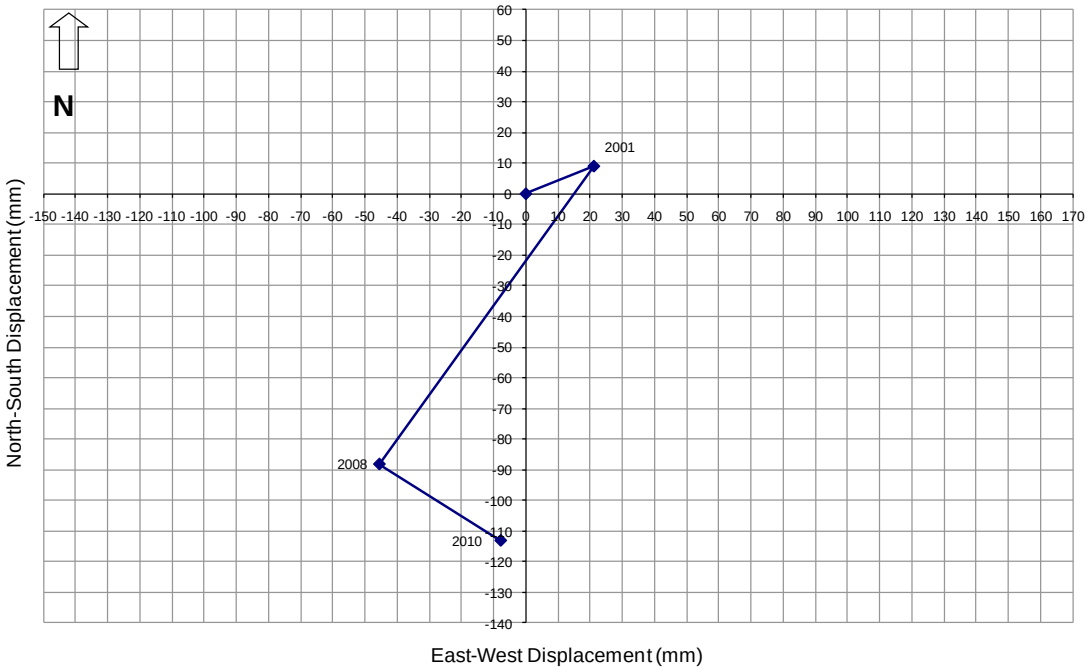
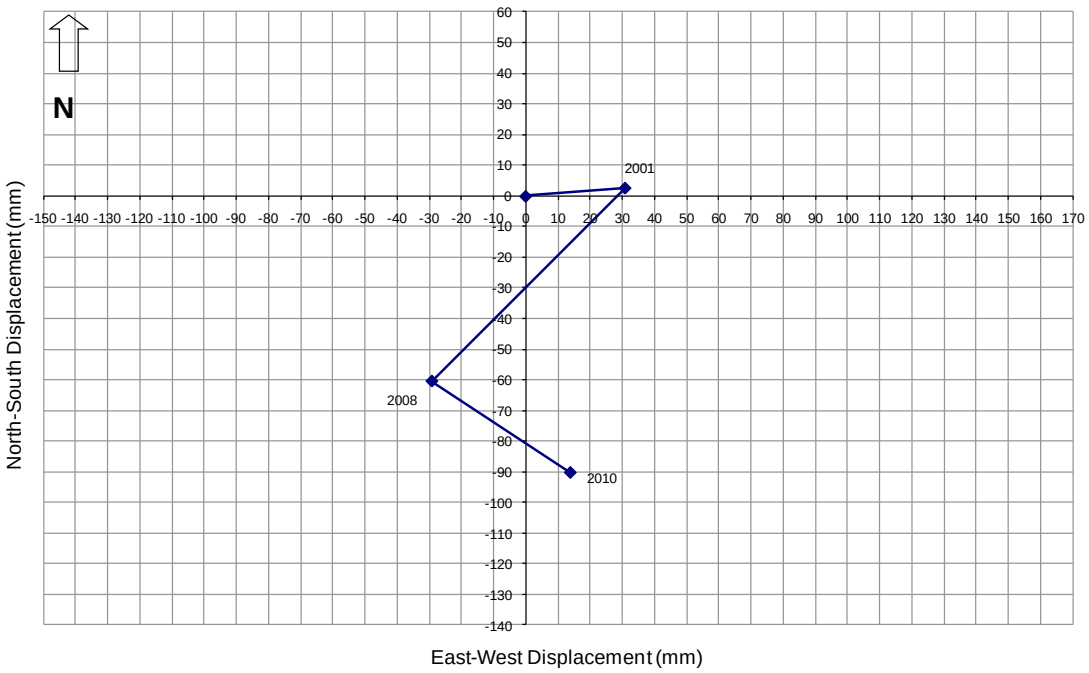
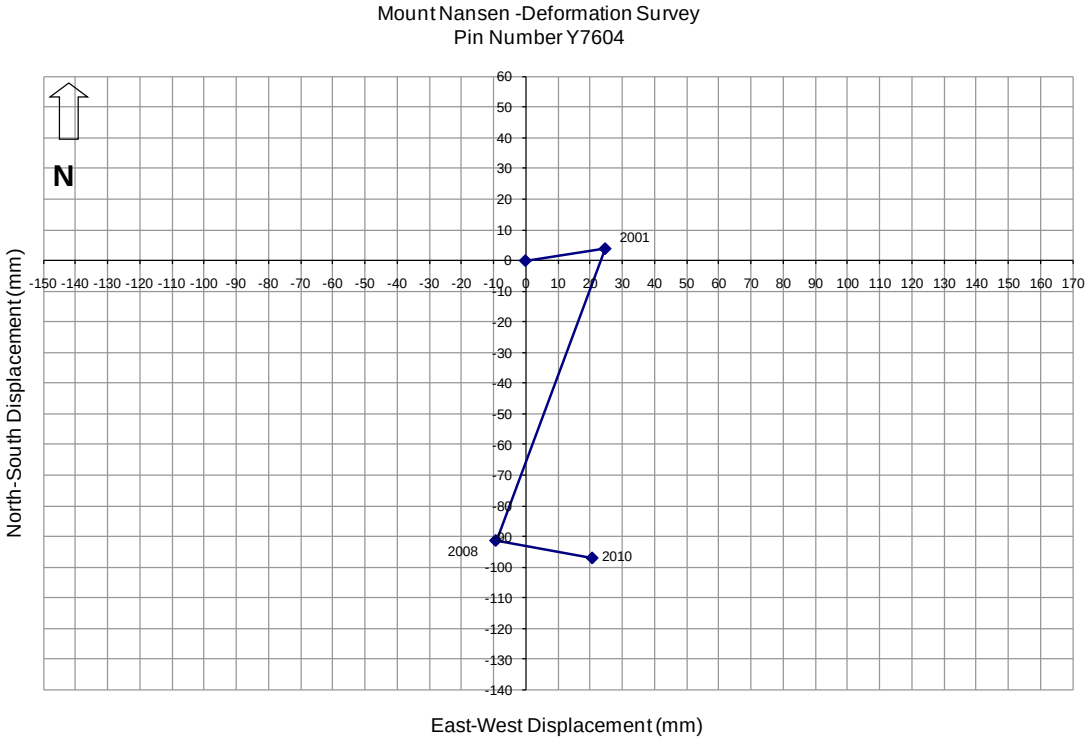


Mount Nansen - Deformation Survey
Pin Number Y7603




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 Dam

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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.

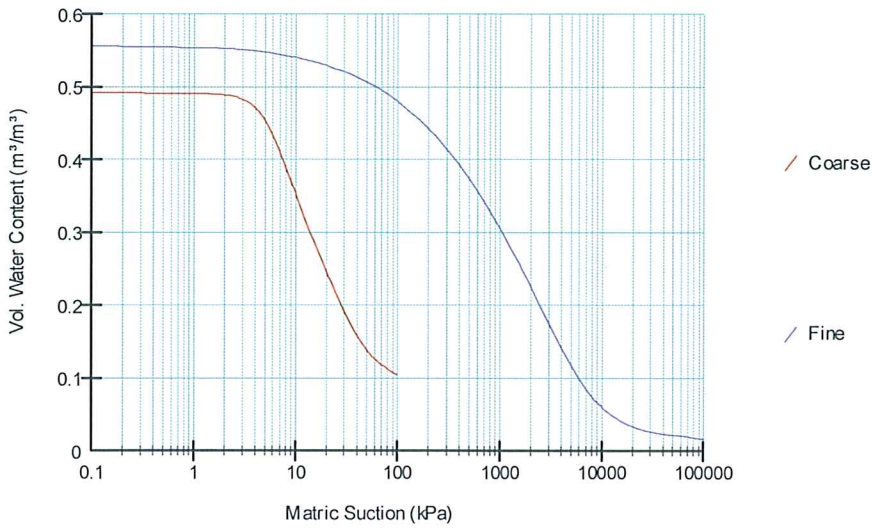

Figure 1. Soil water characteristic curve for coarse and fine tailings

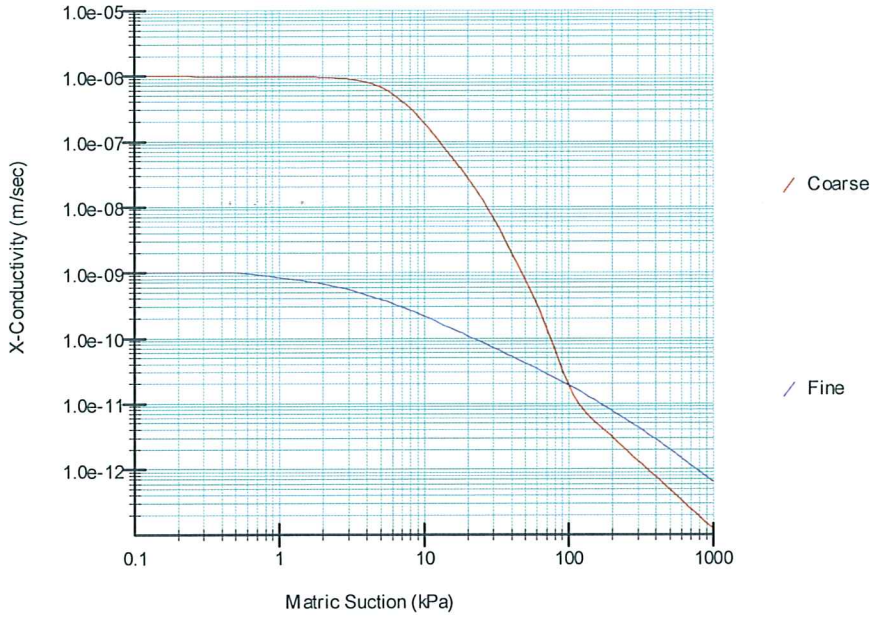

Figure 2. Hydraulic conductivity functions for coarse and fine tailings

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.

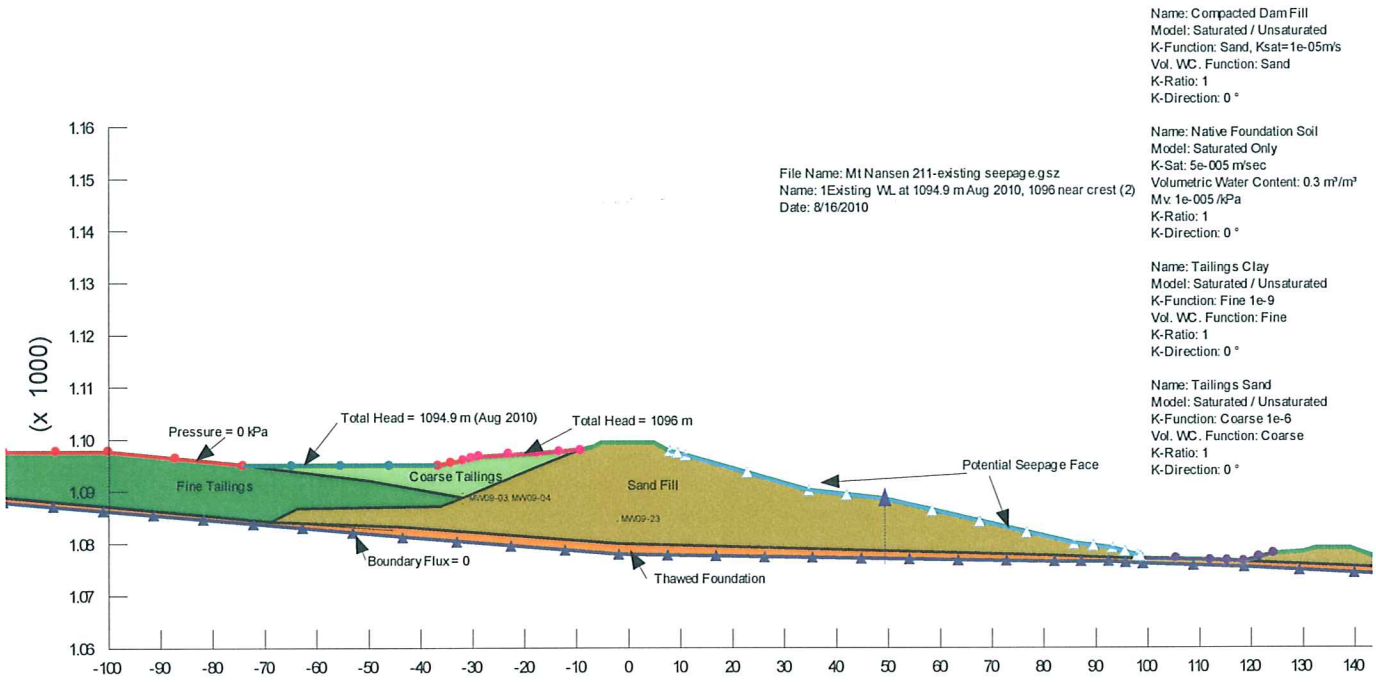

Figure 3. Cross section of tailings dam.

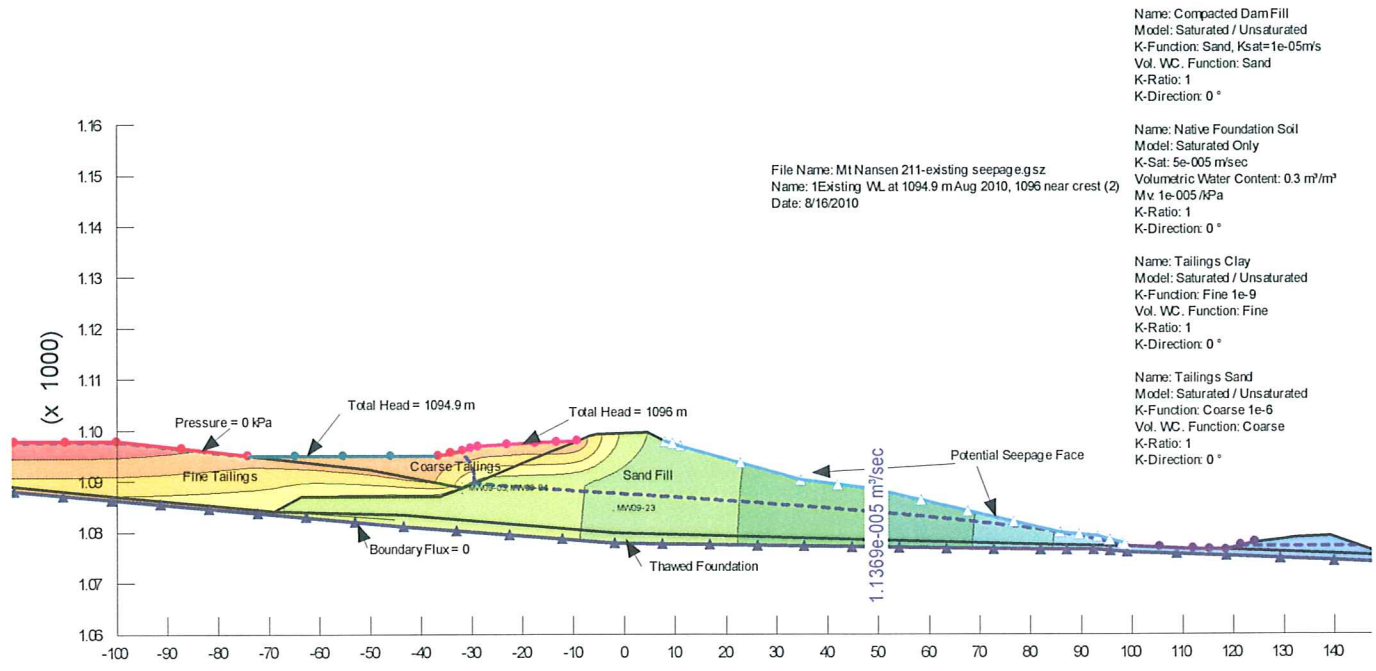

Figure 4. Existing conditions, with contours of total head and piezometric surface plotted.

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.

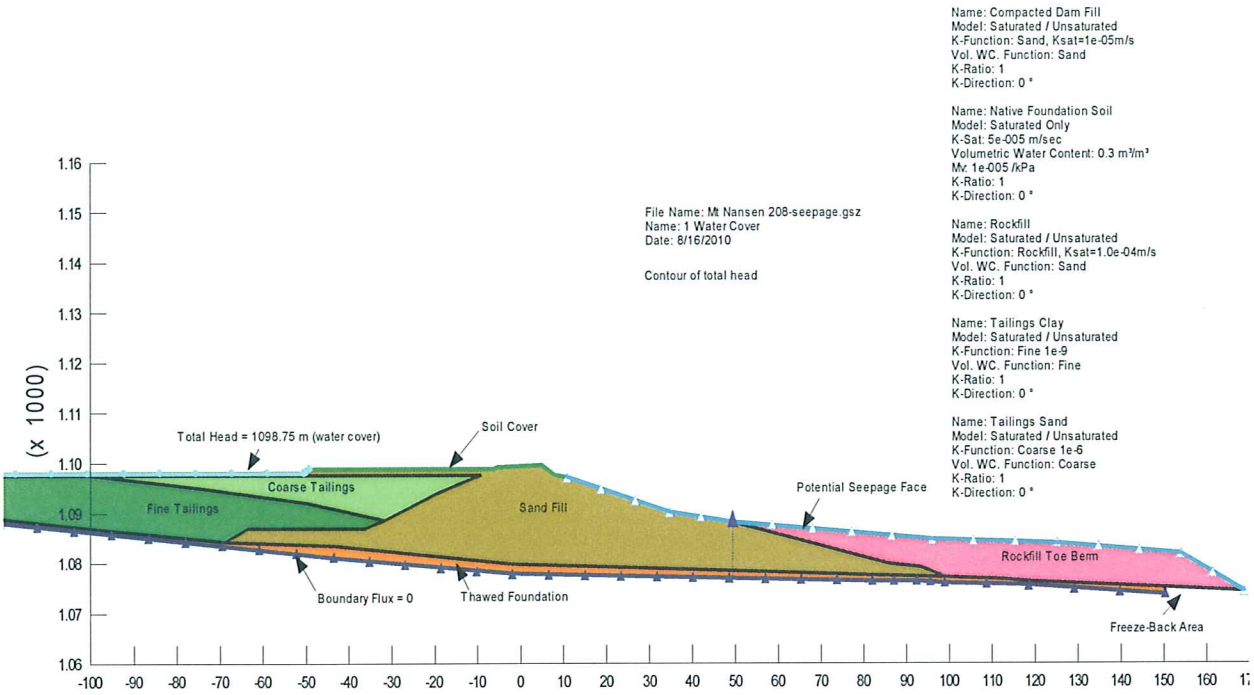

Figure 5. Option 1 (Water cover) modeled section .

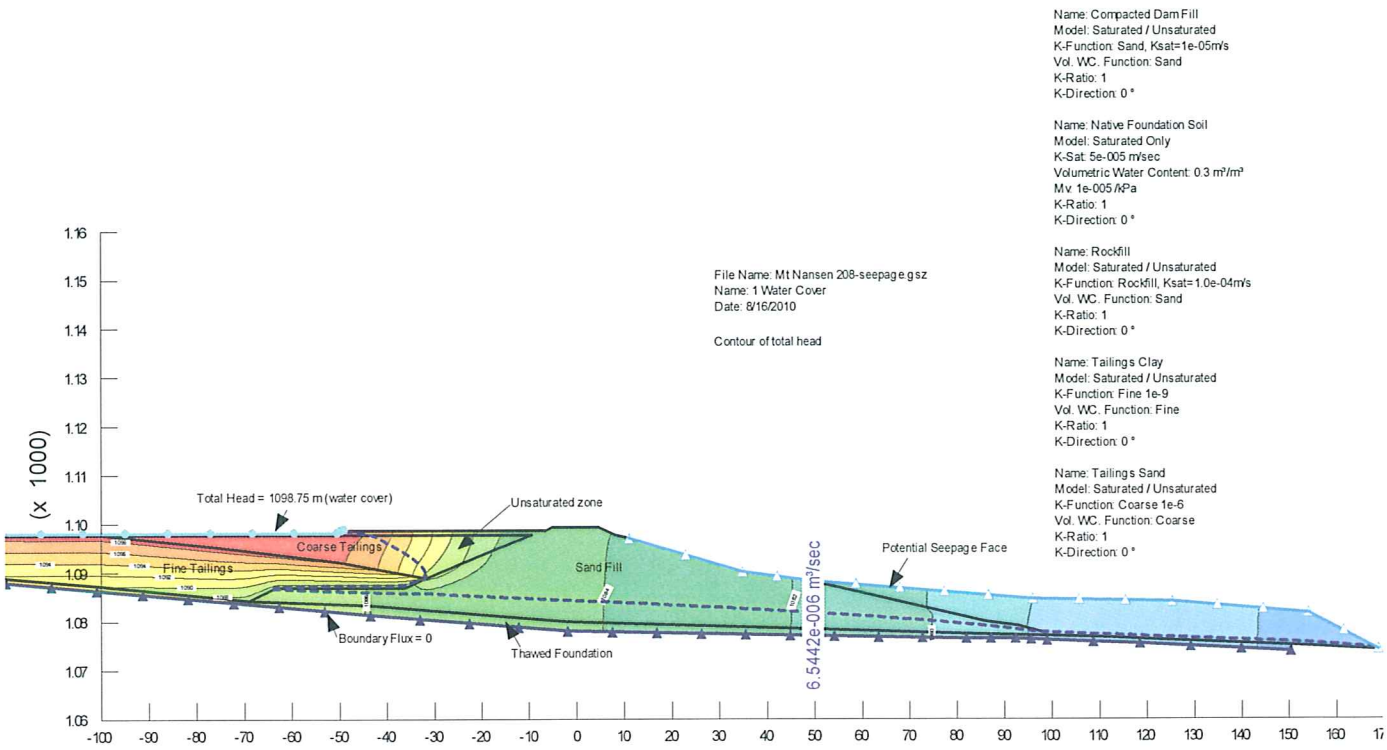

Figure 6. Total head through tailings dam.

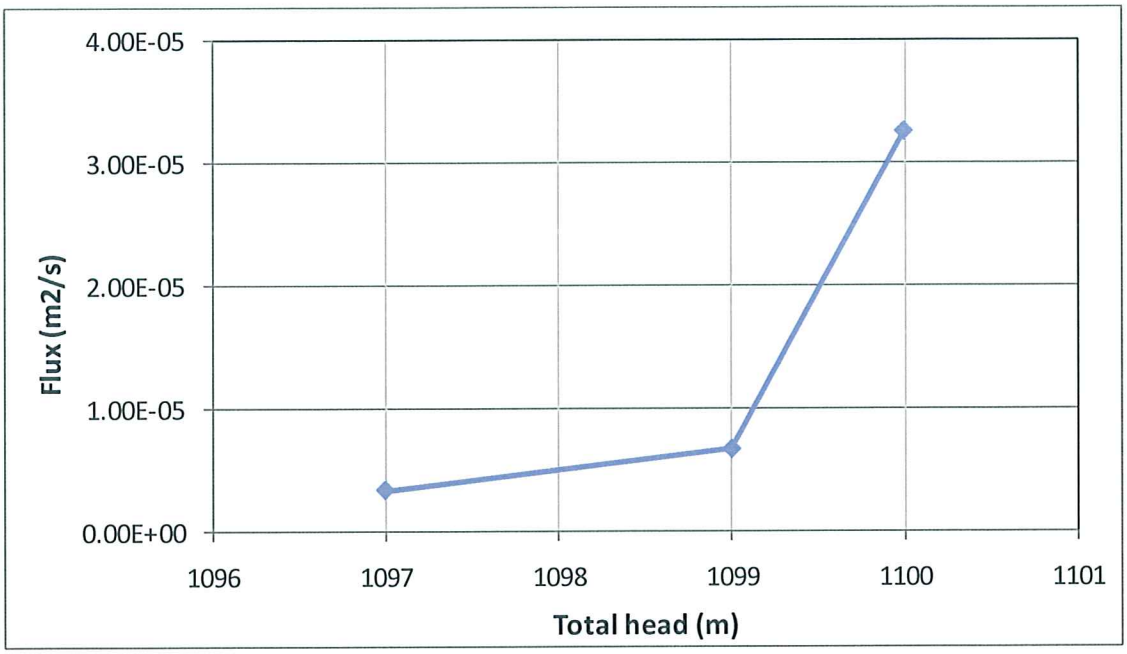

Figure 7. Seepage flux plotted vs. total head

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)

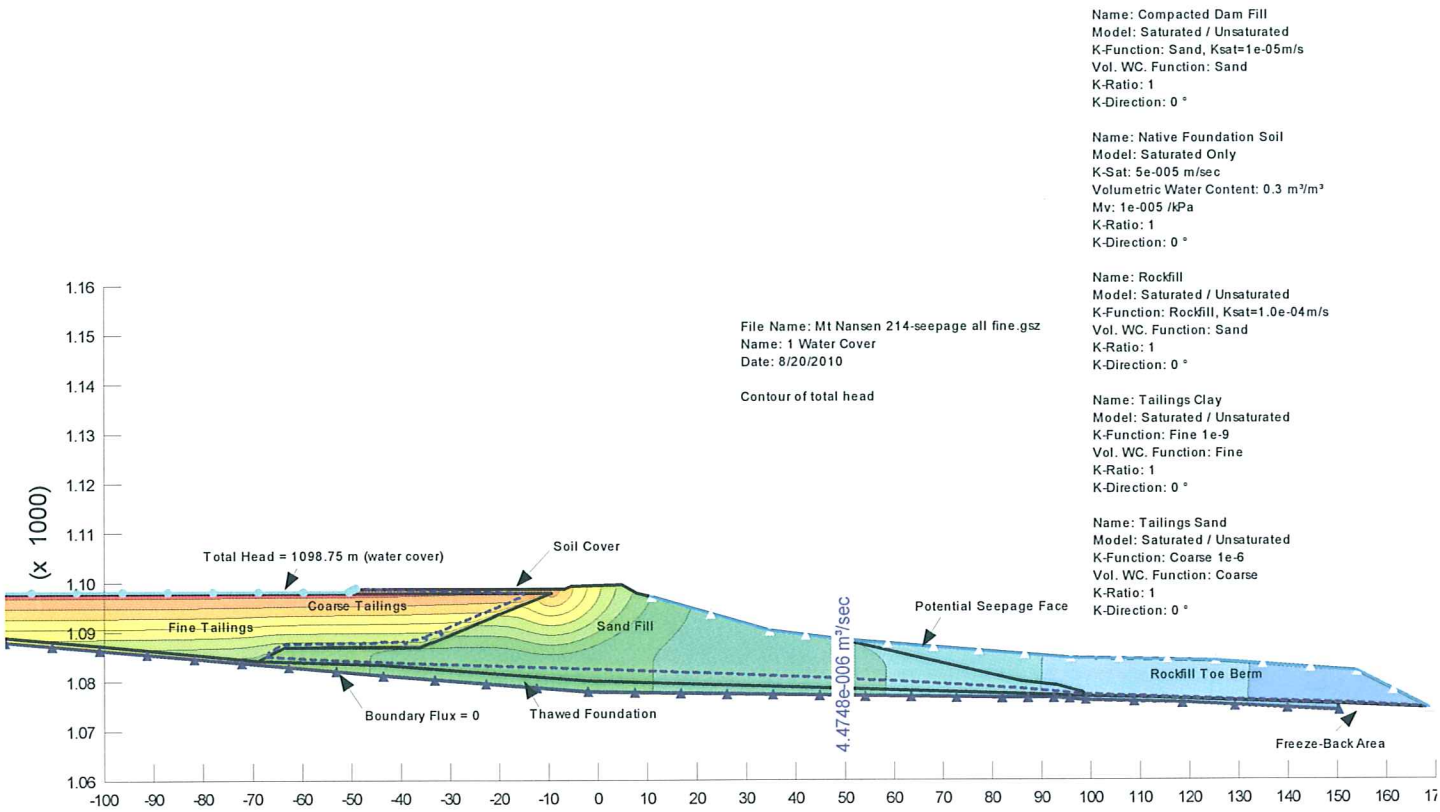

Figure 8. Total head with fine grained tailings against dam.

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.

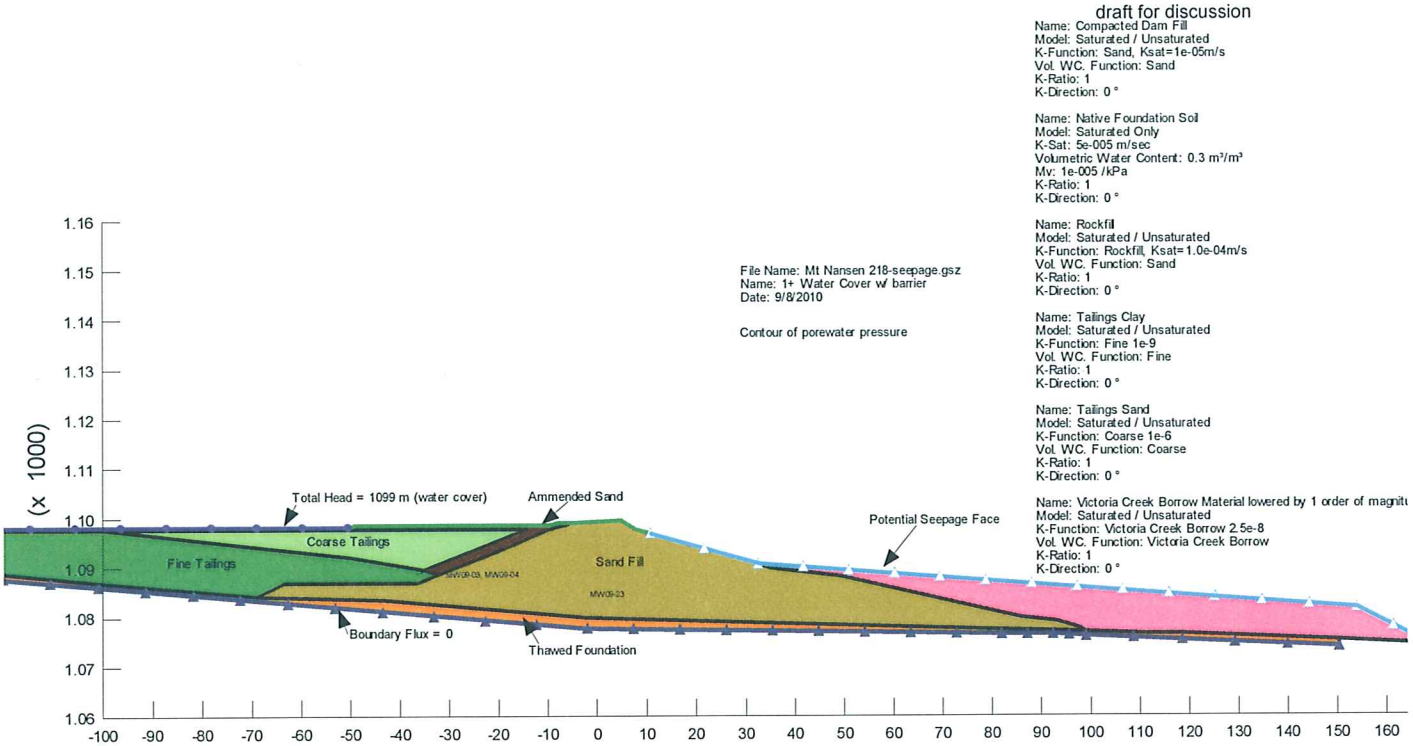

Figure 9: Cross section showing proposed amended sand barrier against upslope face of dam.

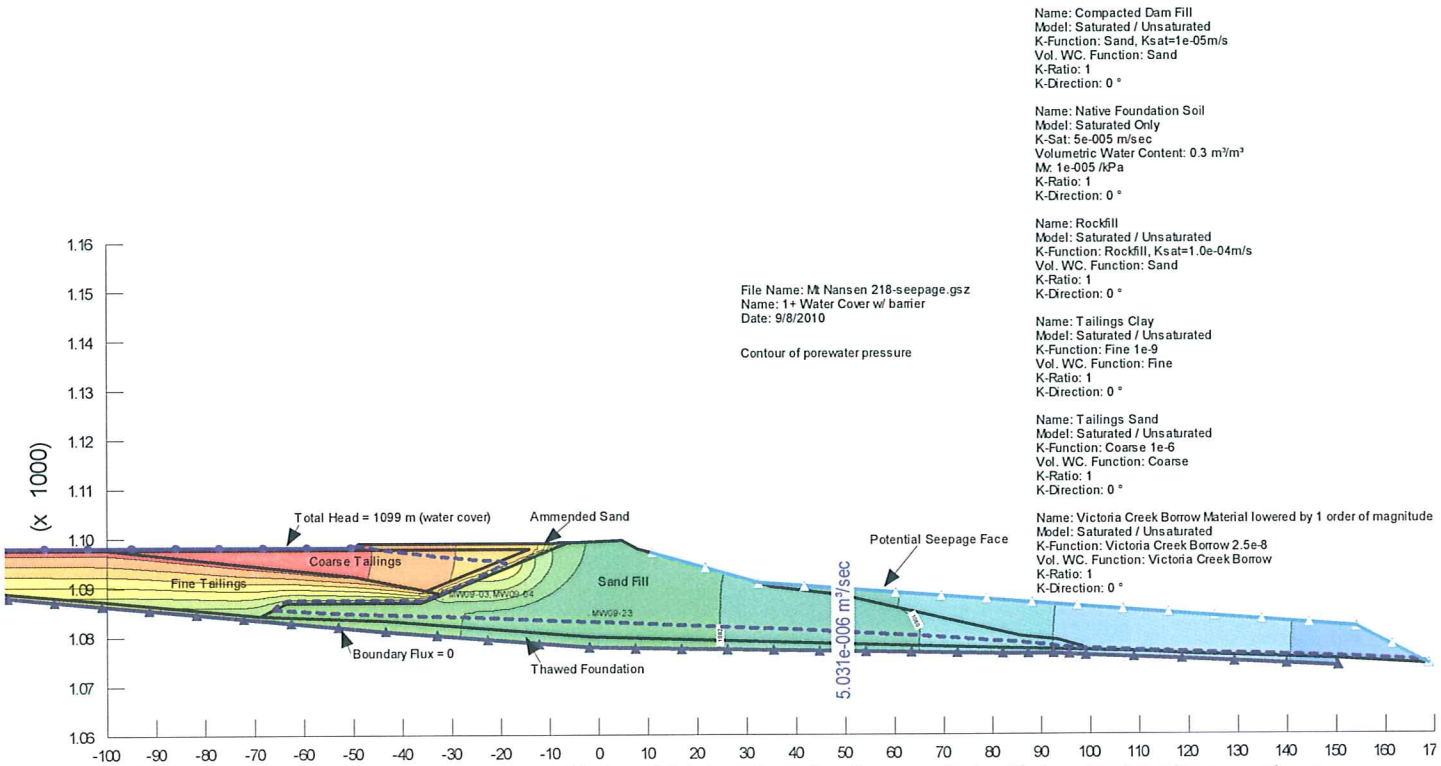

Figure 10: Total head through dam with 2m thick barrier of soil amended with bentonite along upslope face of dam.

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.

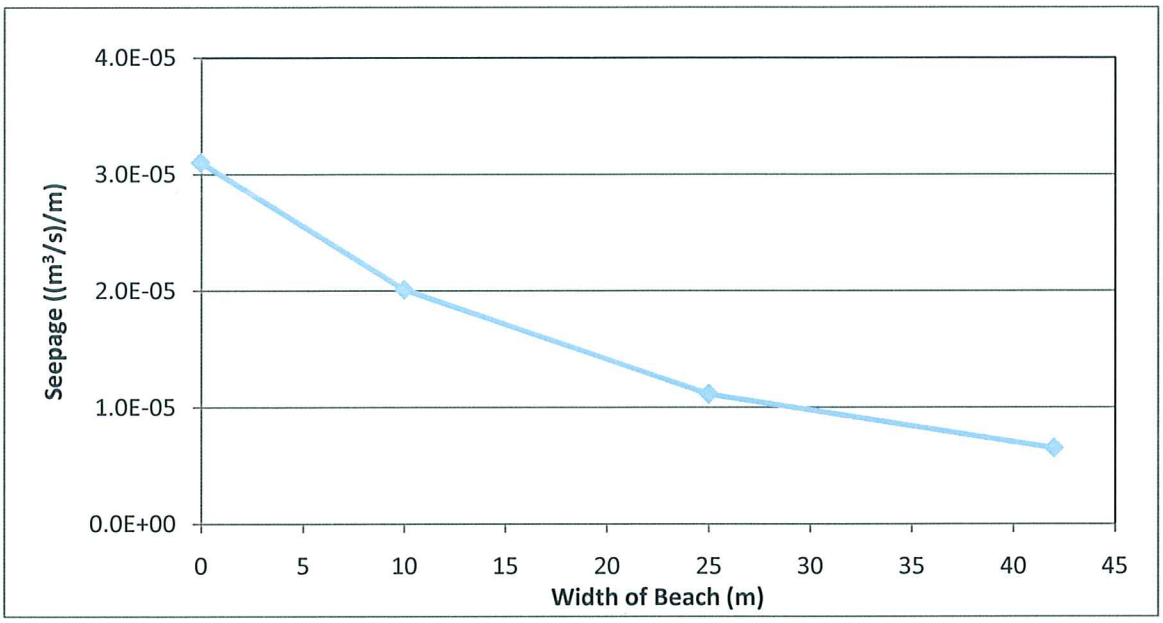

Figure 8. Seepage rate through dam vs. width of beach.

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.

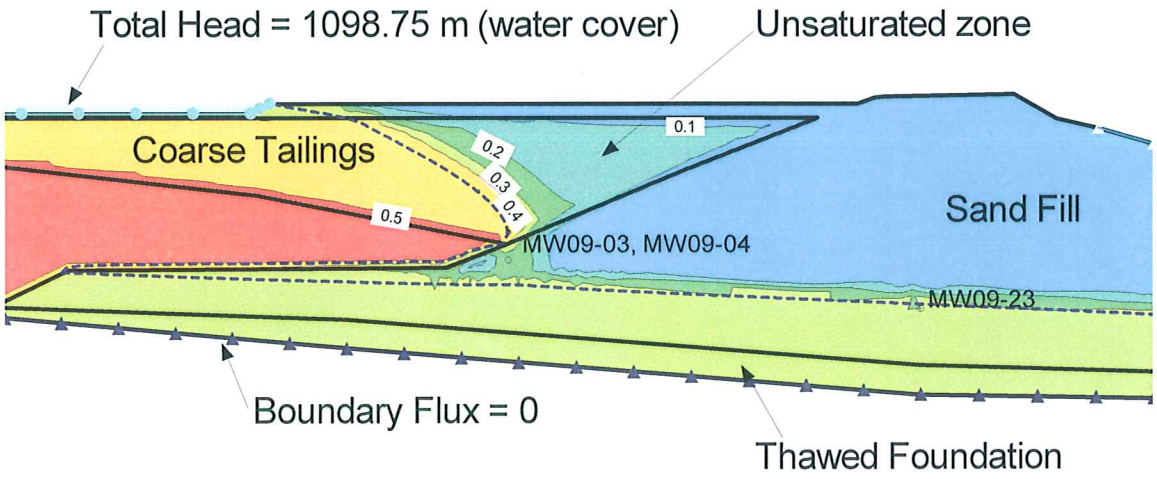

Figure 9. Unsaturated wedge of soil against upslope dam face. Contours showing volumetric water content.

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,

AECOM Canada Ltd.

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Lead Geotechnical Engineer

Appendix C-2

Thermal Analysis of Toe-Berm

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.

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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.

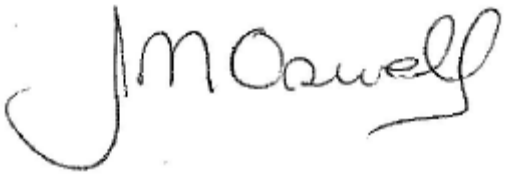
While multiple rows may provide some additional benefit, it is likely that the geothermal effect will be moderate, rather than significant.

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.



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Senior Permafrost Engineer

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Northern Engineering and Scientific Limited

FIGURES

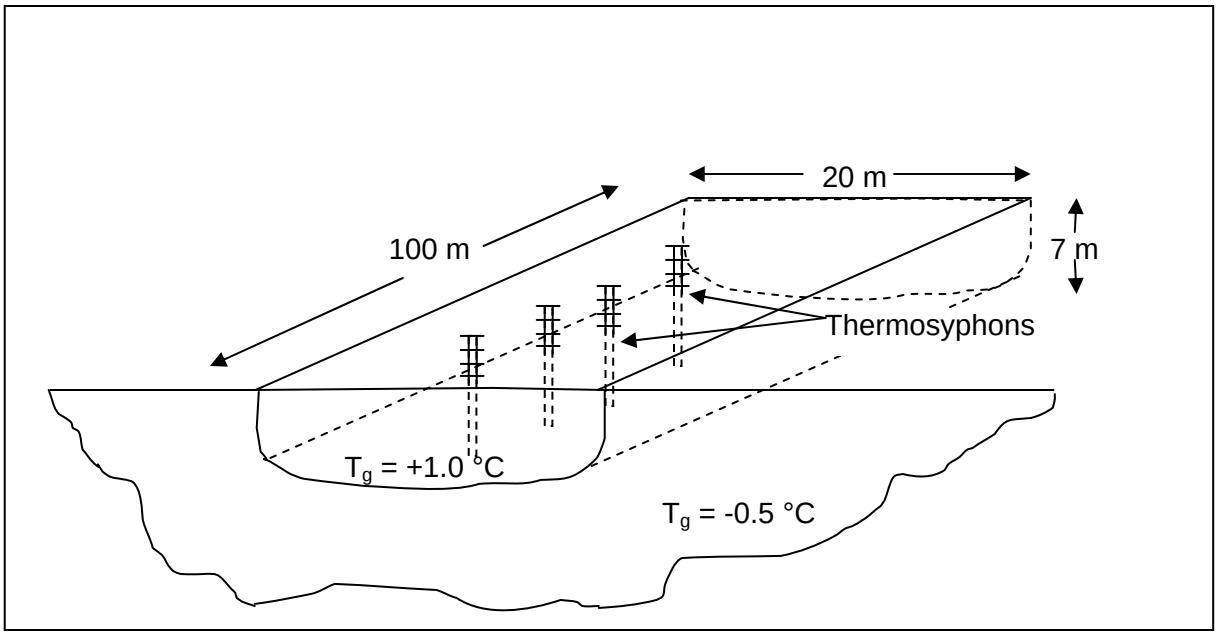


Figure 1. Schematic of the idealized soil geometry for thermosyphon feasibility assessment with closed unfrozen zone, the so-called “closed geometry”.

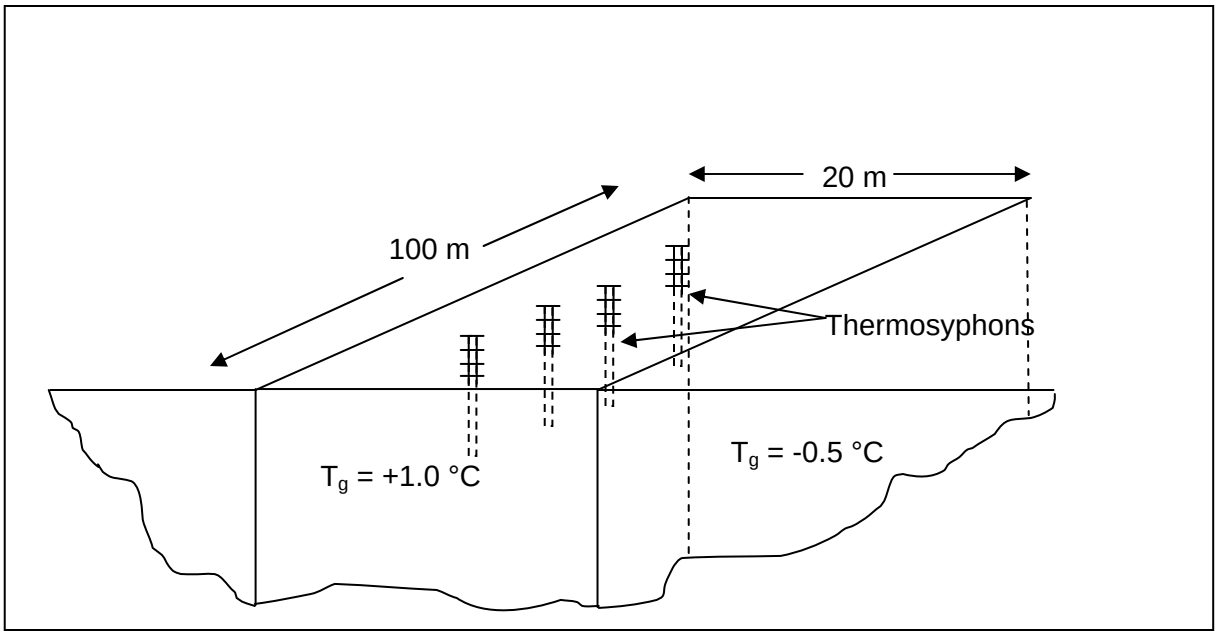


Figure 2. Schematic of the idealized soil geometry for thermosyphon feasibility assessment with open unfrozen zone, the so-called “open geometry”.

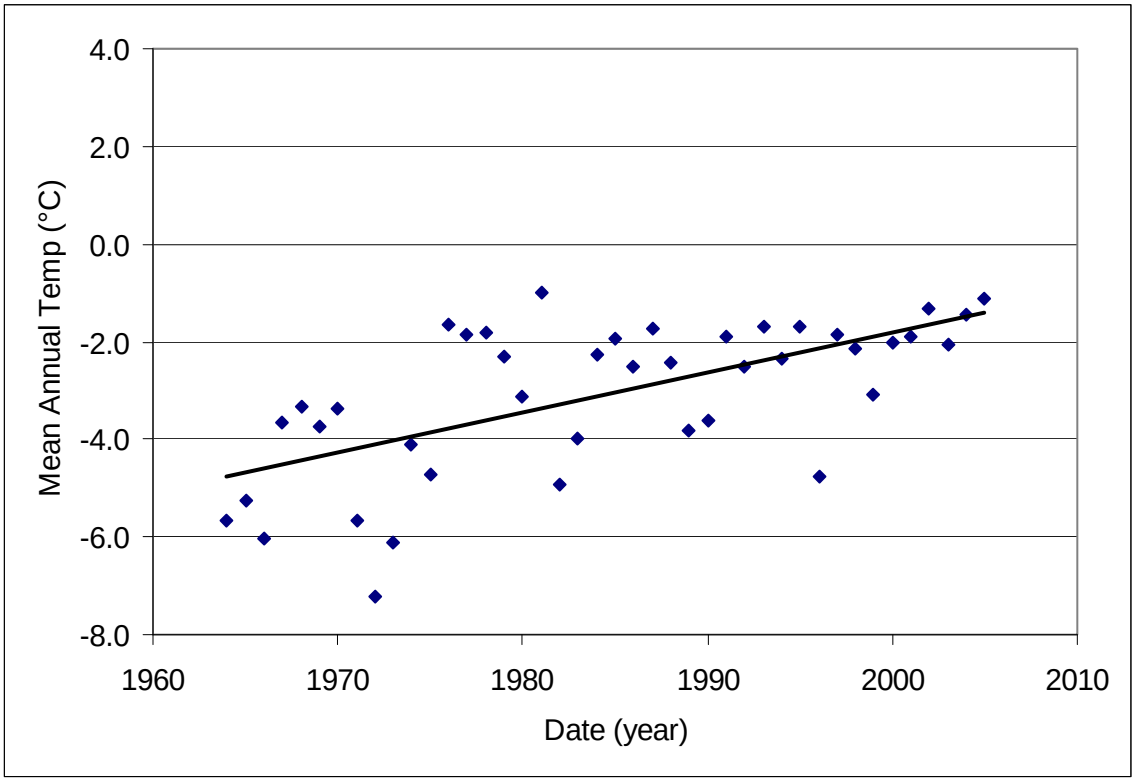


Figure 3. Mean annual air temperature for Mount Nansen mine site. The slope of the solid line represents the historical climate warming rate of the plotted time period. Raw monthly data provided by AECOM.

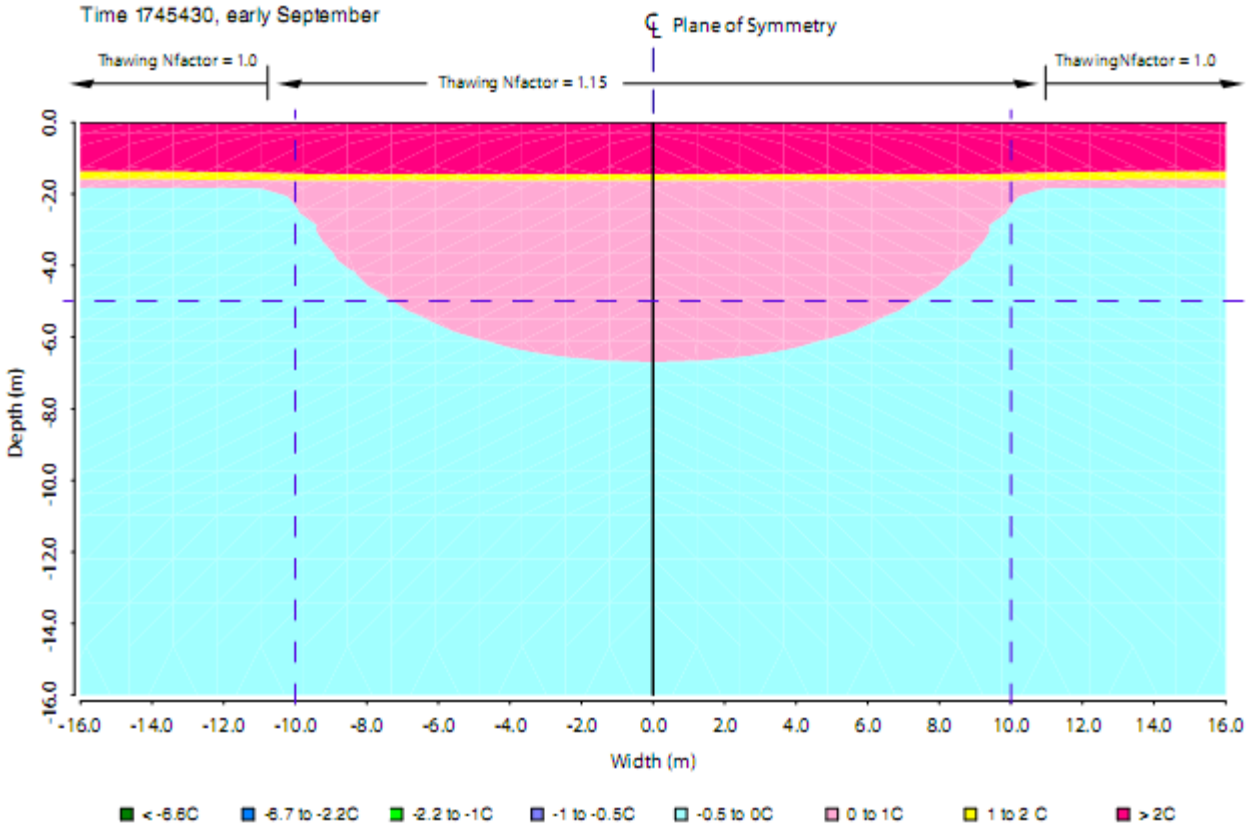


Figure 4. Initial cross section of closed geometry showing temperature regime, in September of Year 1.

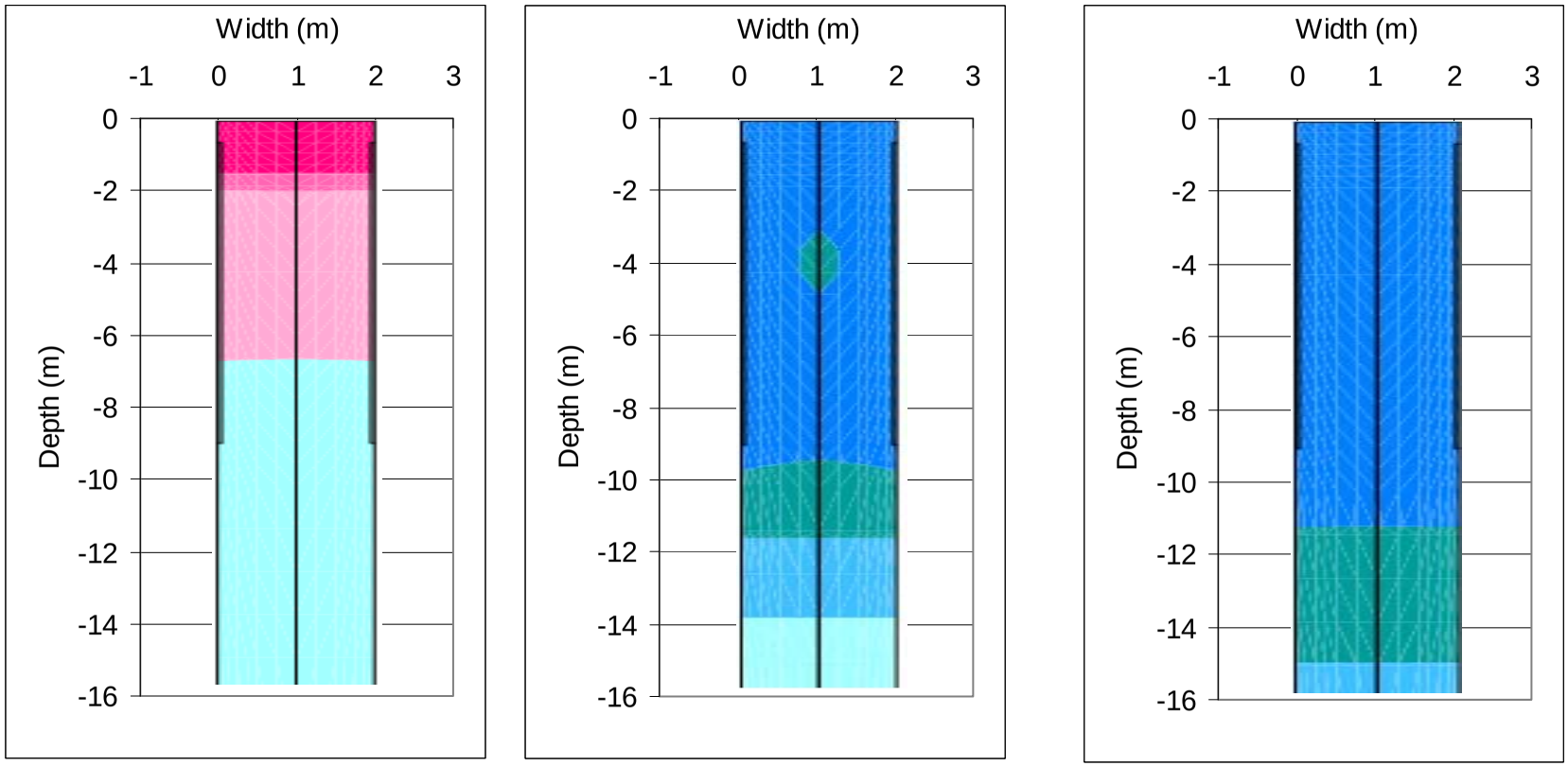
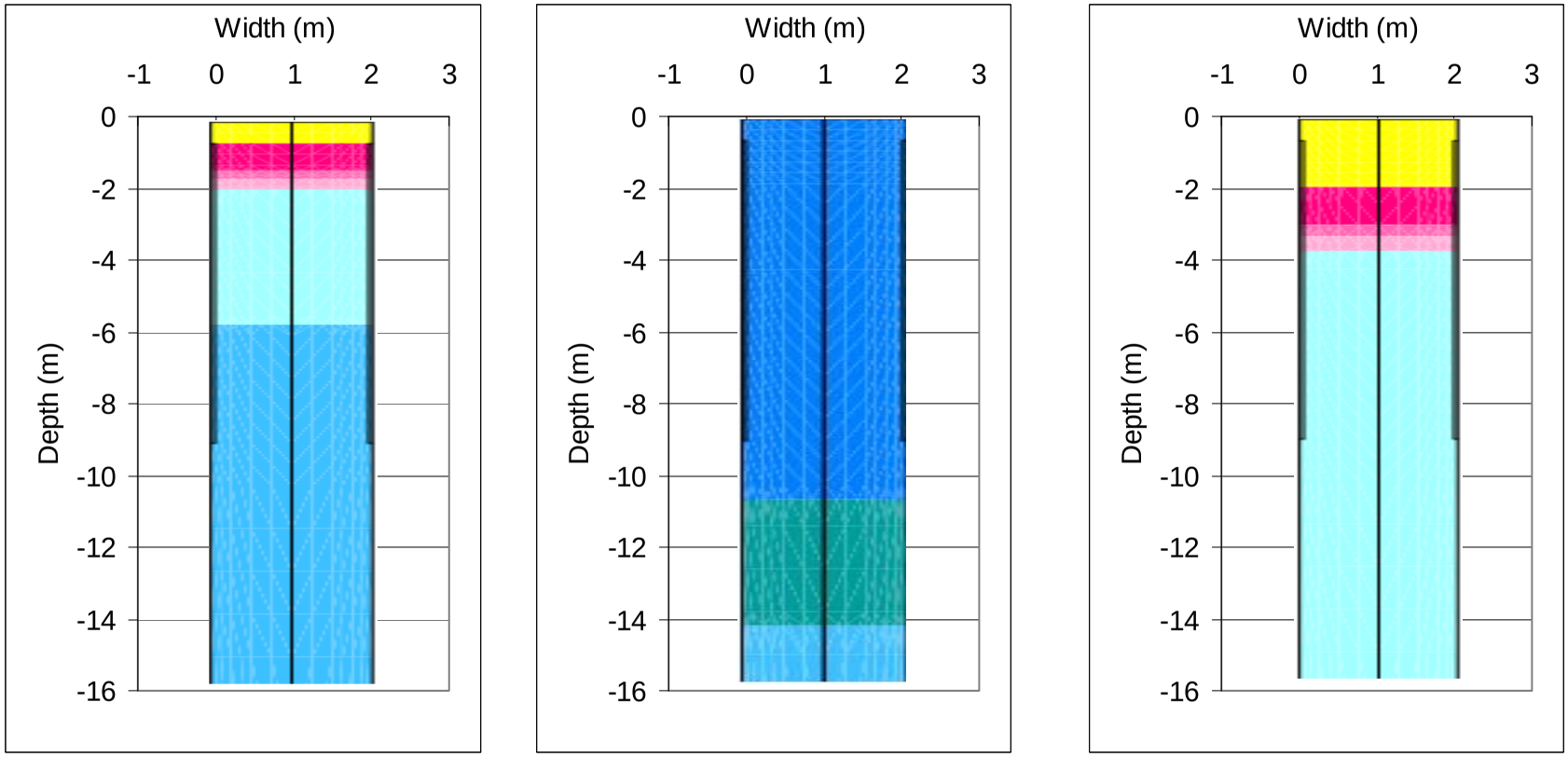


Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry.

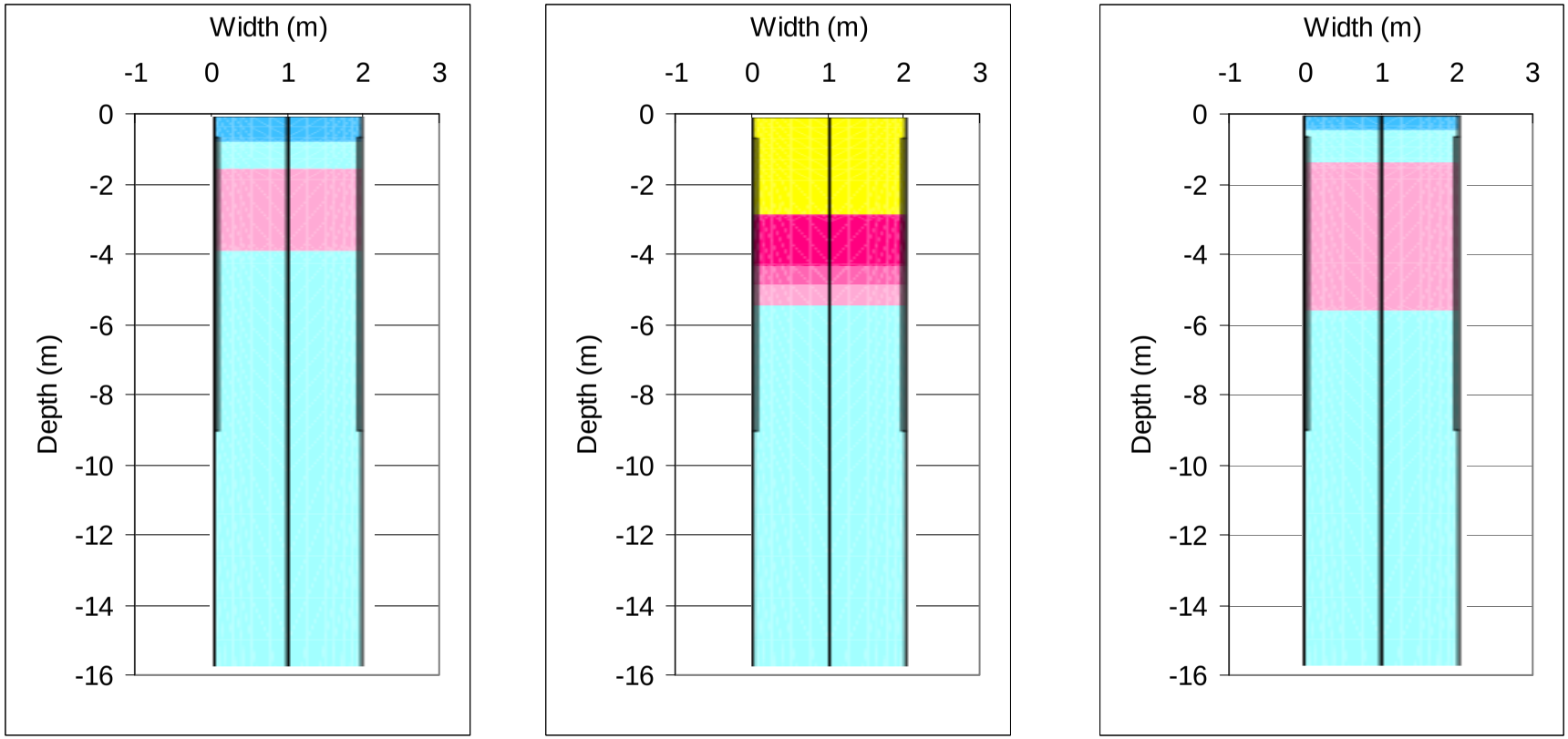


(d) September, Year 25 (e) March, Year 25 (f) September, Year 30

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

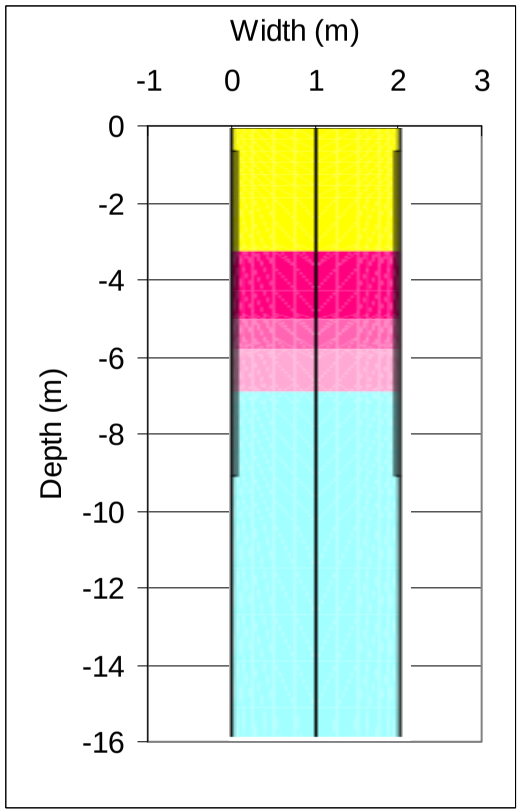


(g) March, Year 30 (h) September, Year 35 (i) March, Year 35

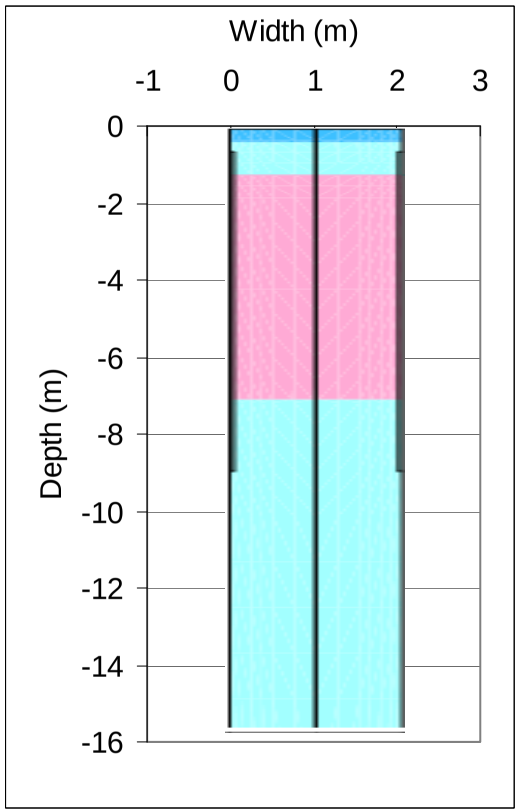
Figure 5. Geothermal results for thermosyphon spacing at 2 m, in closed geometry, continued.

< - 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

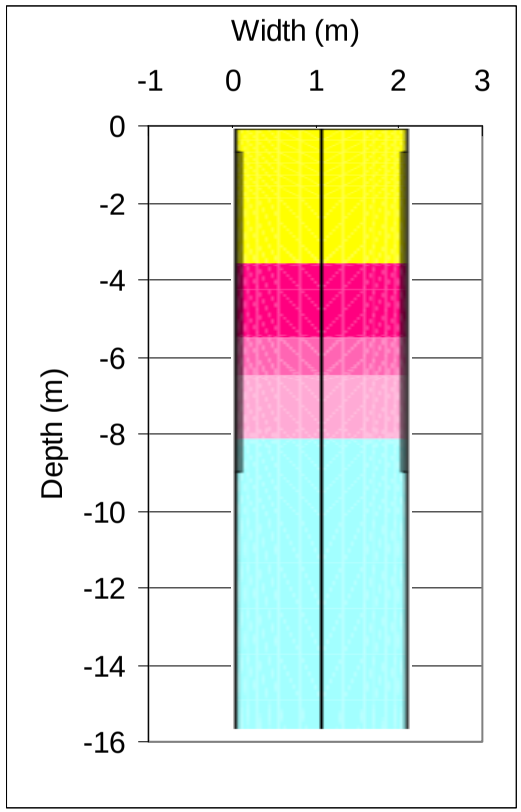
+2 °C to +5 °C > + 5 °C



(j) September Year 40



(k) March, Year 40

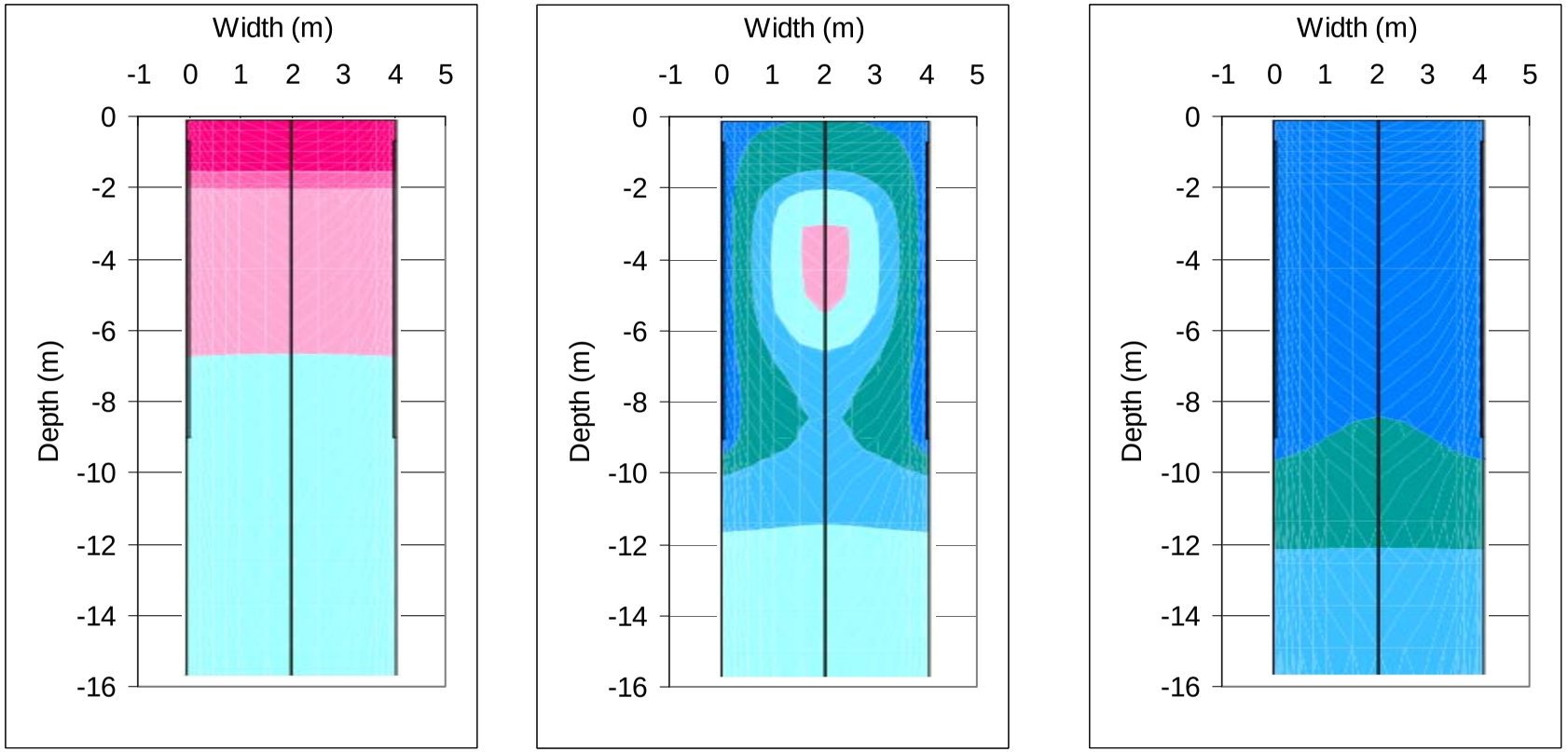


(l) September, Year 45

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

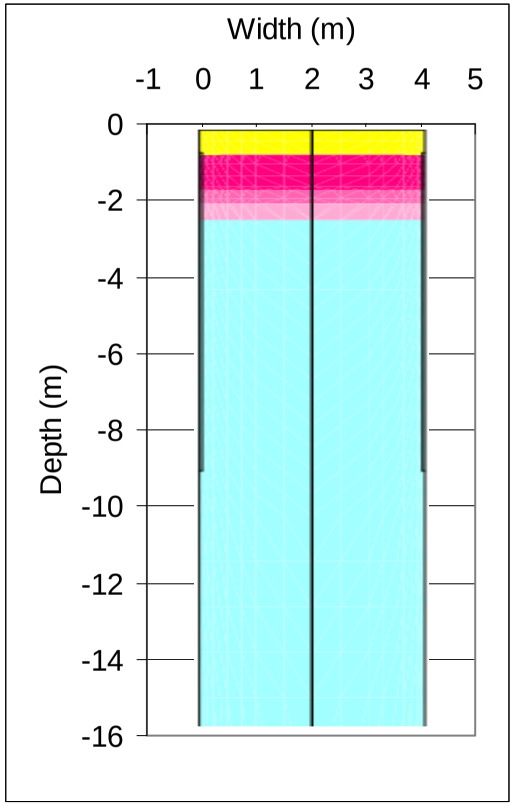


(a) September Year 1 (b) March, Year 1 (c) March, Year 15

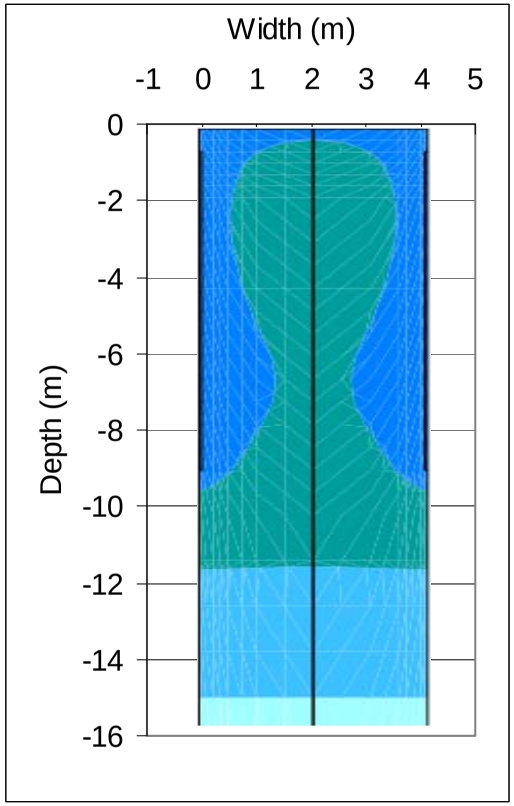
Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry.

< - 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

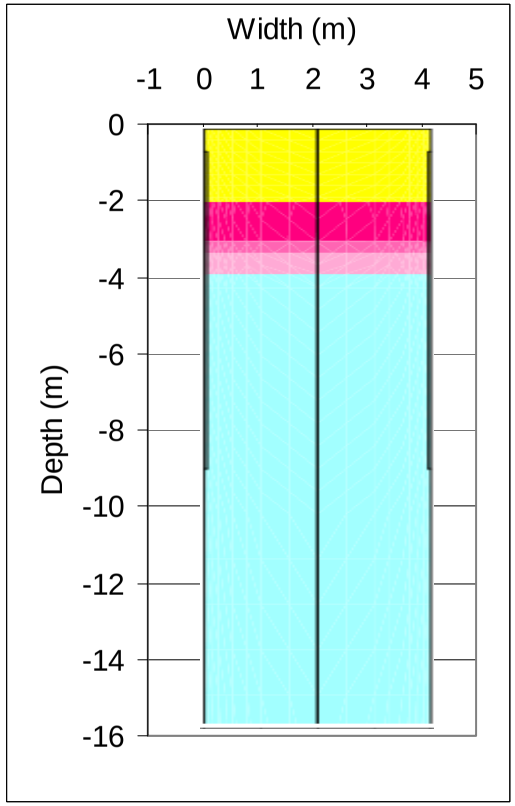
+2 °C to +5 °C > + 5 °C



(d) September, Year 25



(e) March, Year 25

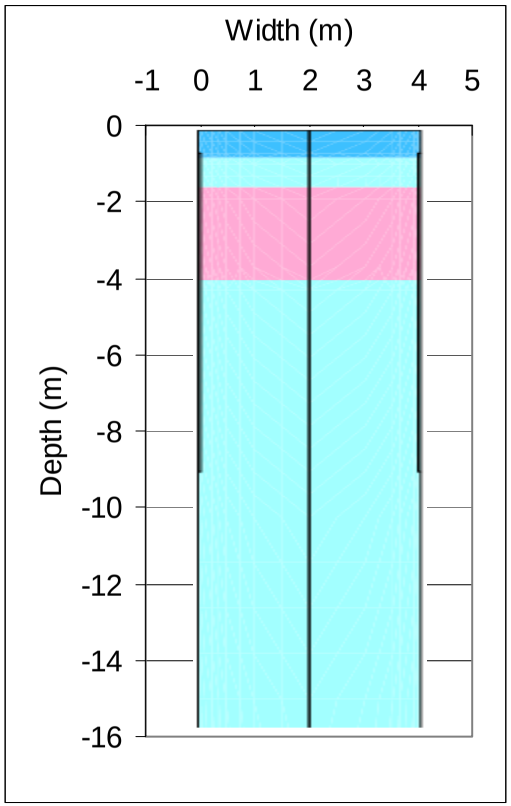


(f) September, Year 30

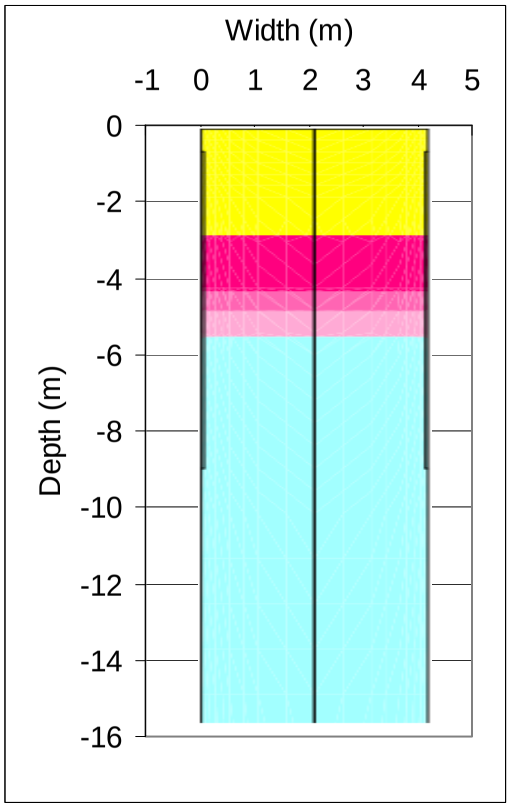
Figure 6. Geothermal results for thermosyphon spacing at 4 m, in closed geometry, continued.

< - 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

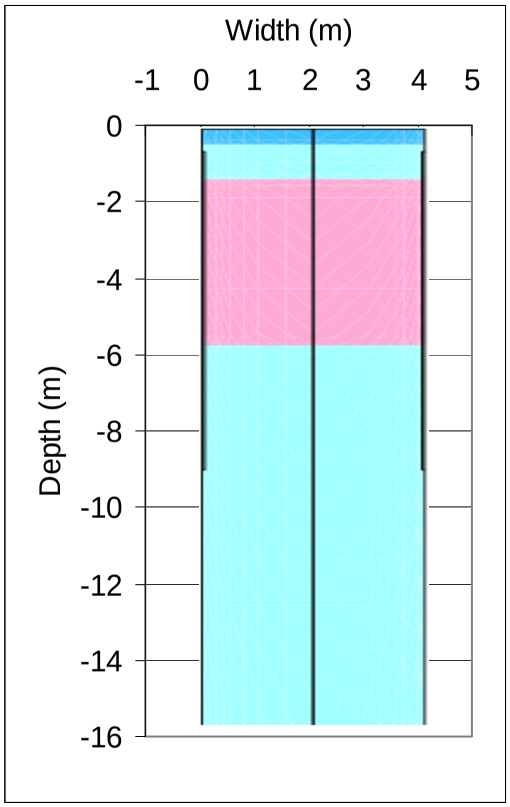
+2 °C to +5 °C > + 5 °C



(g) March, Year 30



(h) September, Year 35

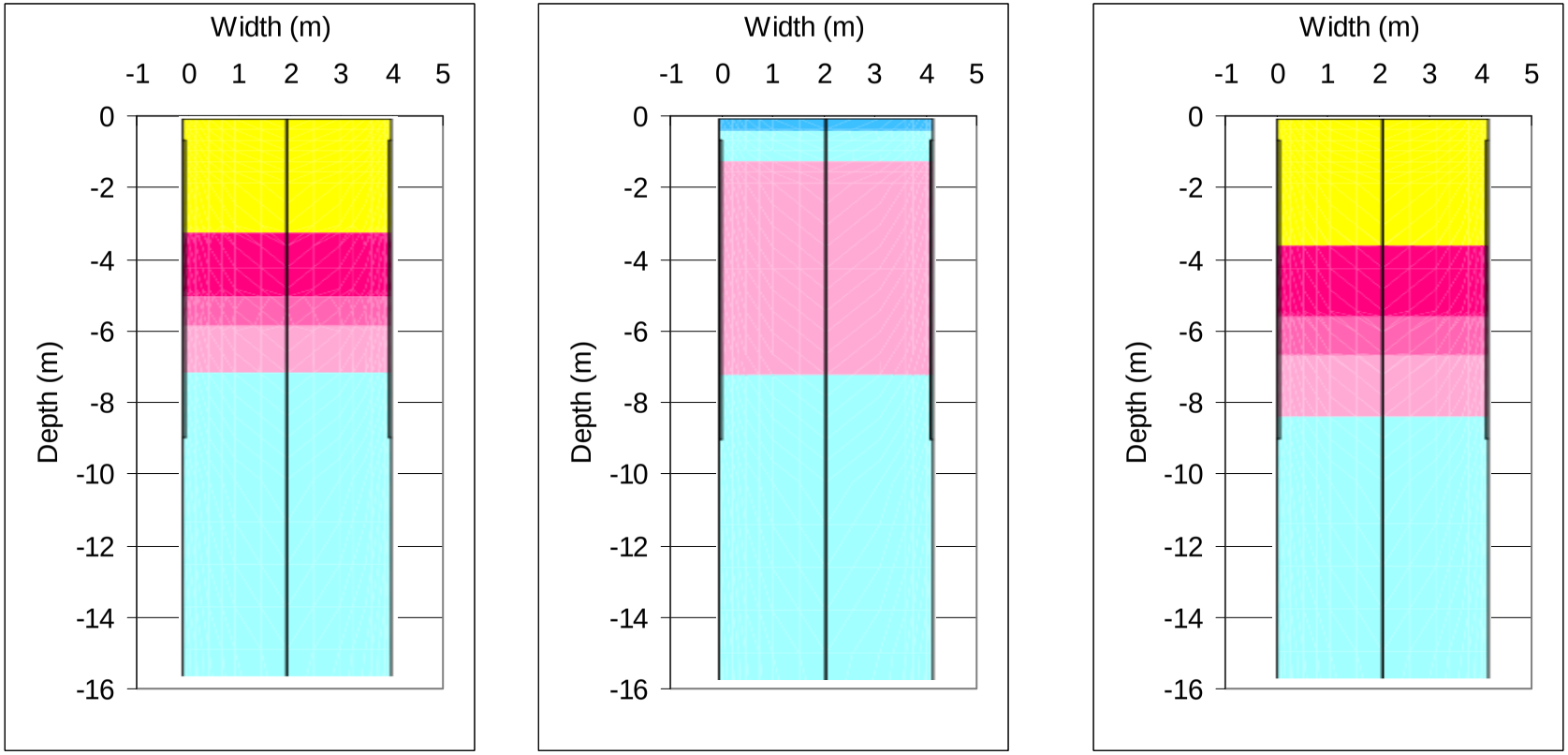


(i) March, Year 35

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

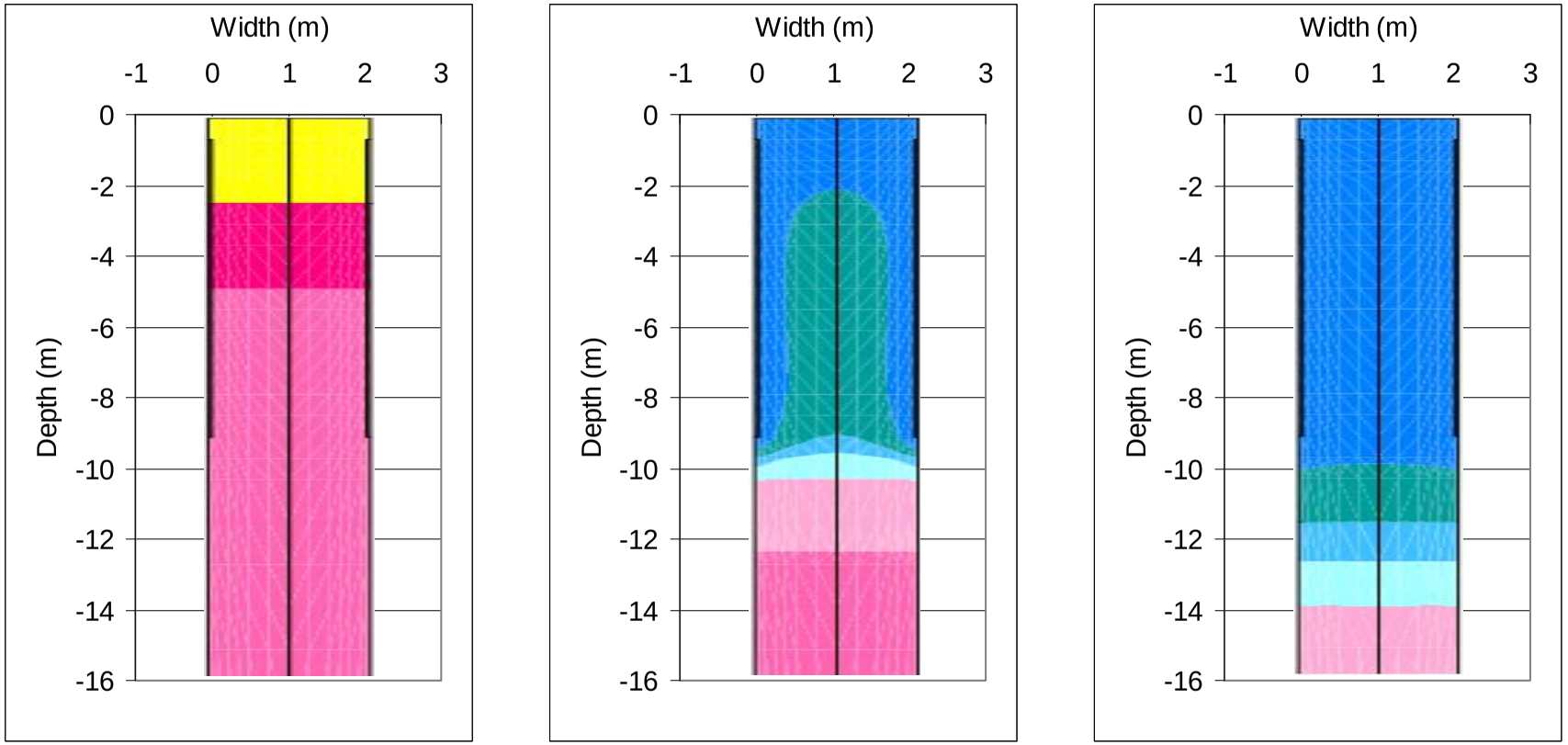
+2 °C to +5 °C > + 5 °C



(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.

< - 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

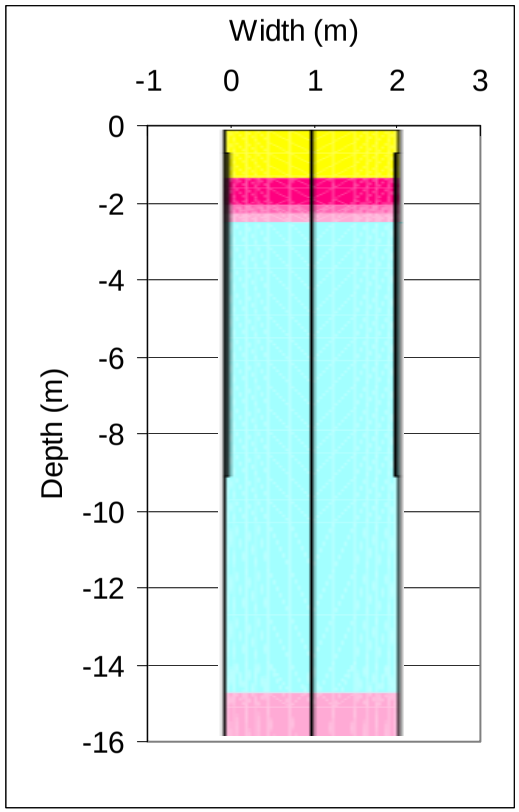


(a) September Year 1 (b) March, Year 1 (c) March, Year 15

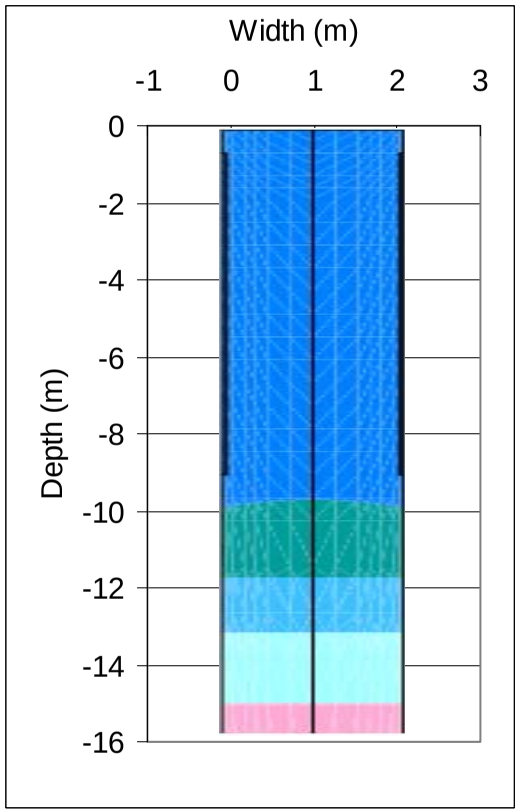
Figure 7. Geothermal results for thermosyphon spacing at 2 m, in open geometry.

< - 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

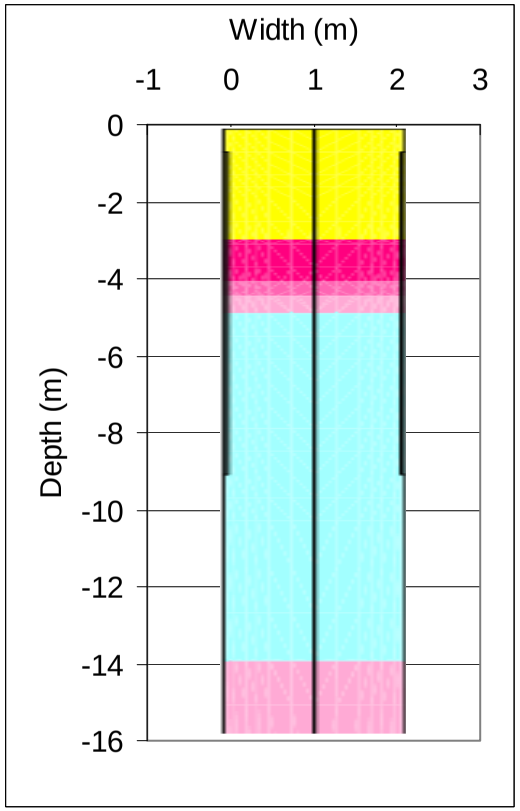
+2 °C to +5 °C > + 5 °C



(d) September Year 25



(e) March, Year 25

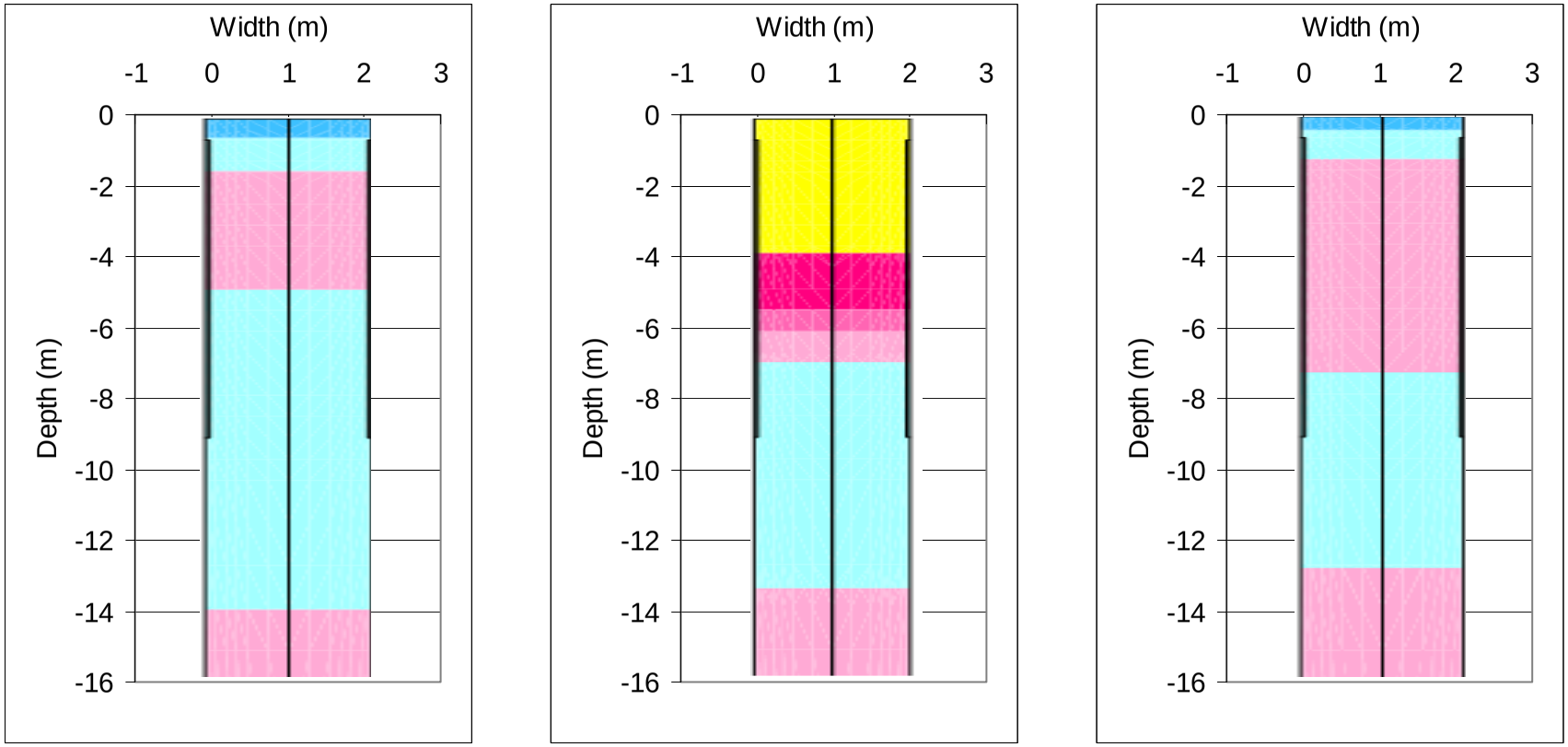


(f) September, 30

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

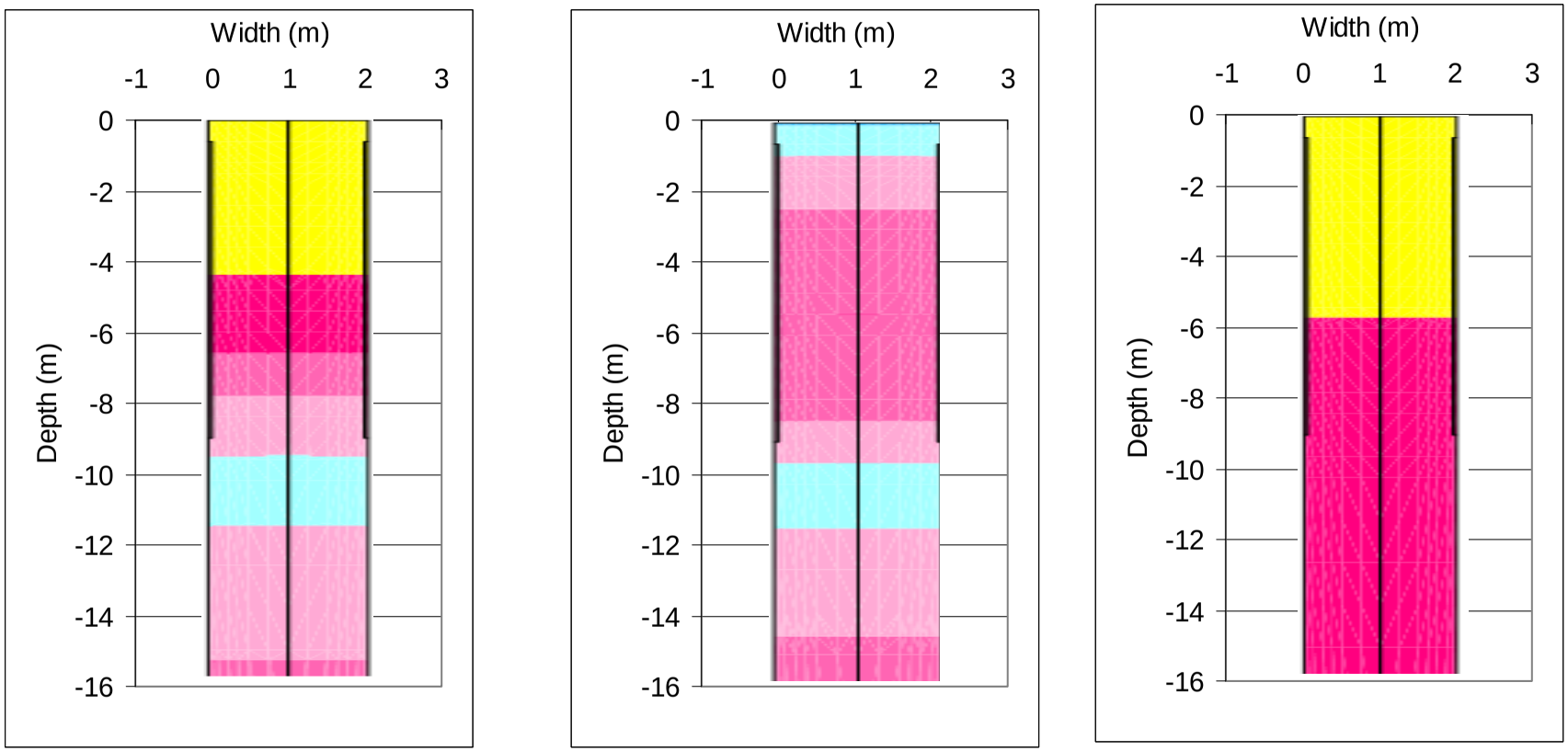


(g) March, Year 30 (h) September, Year 35 (i) March, Year 35

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.

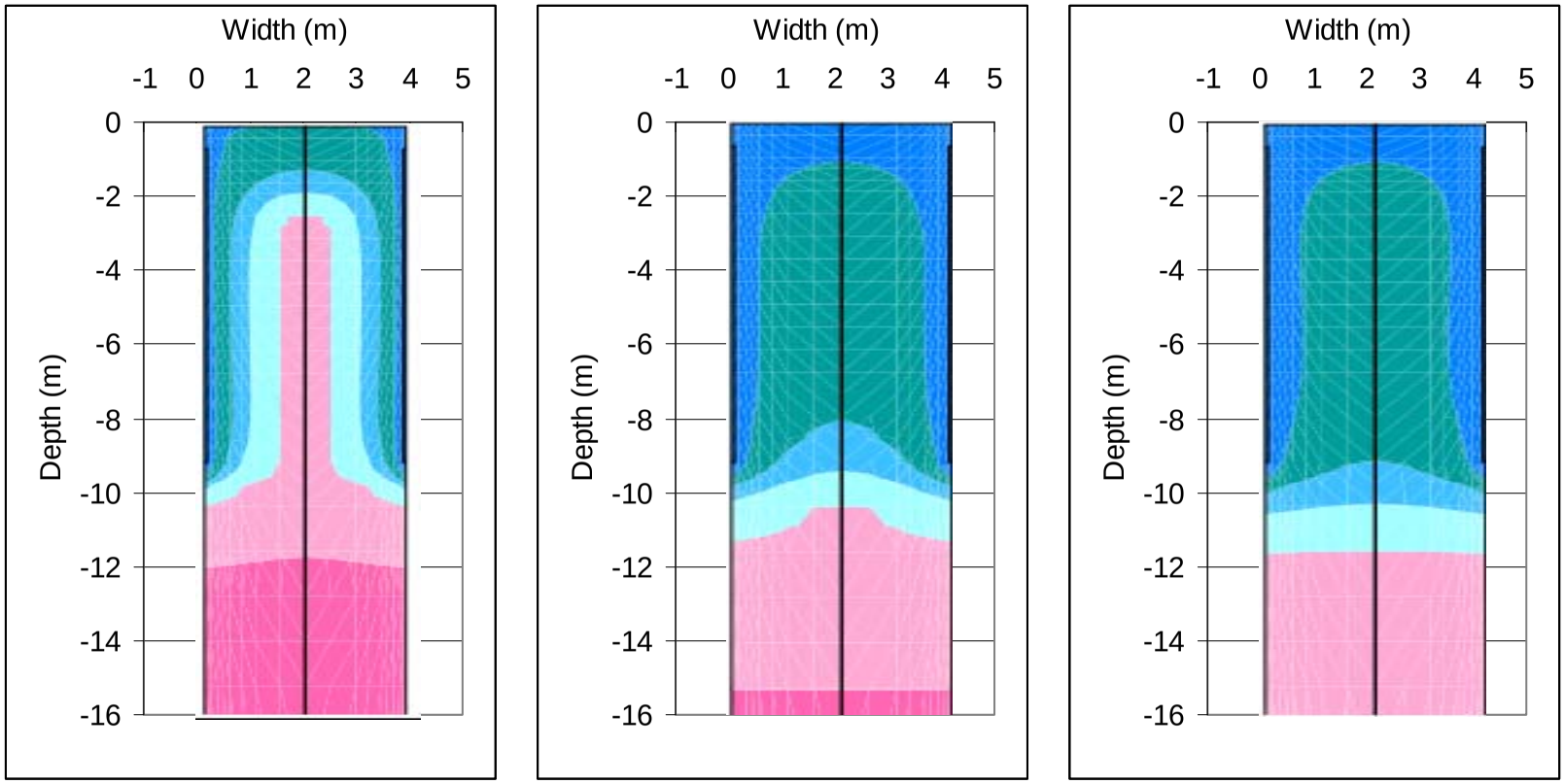
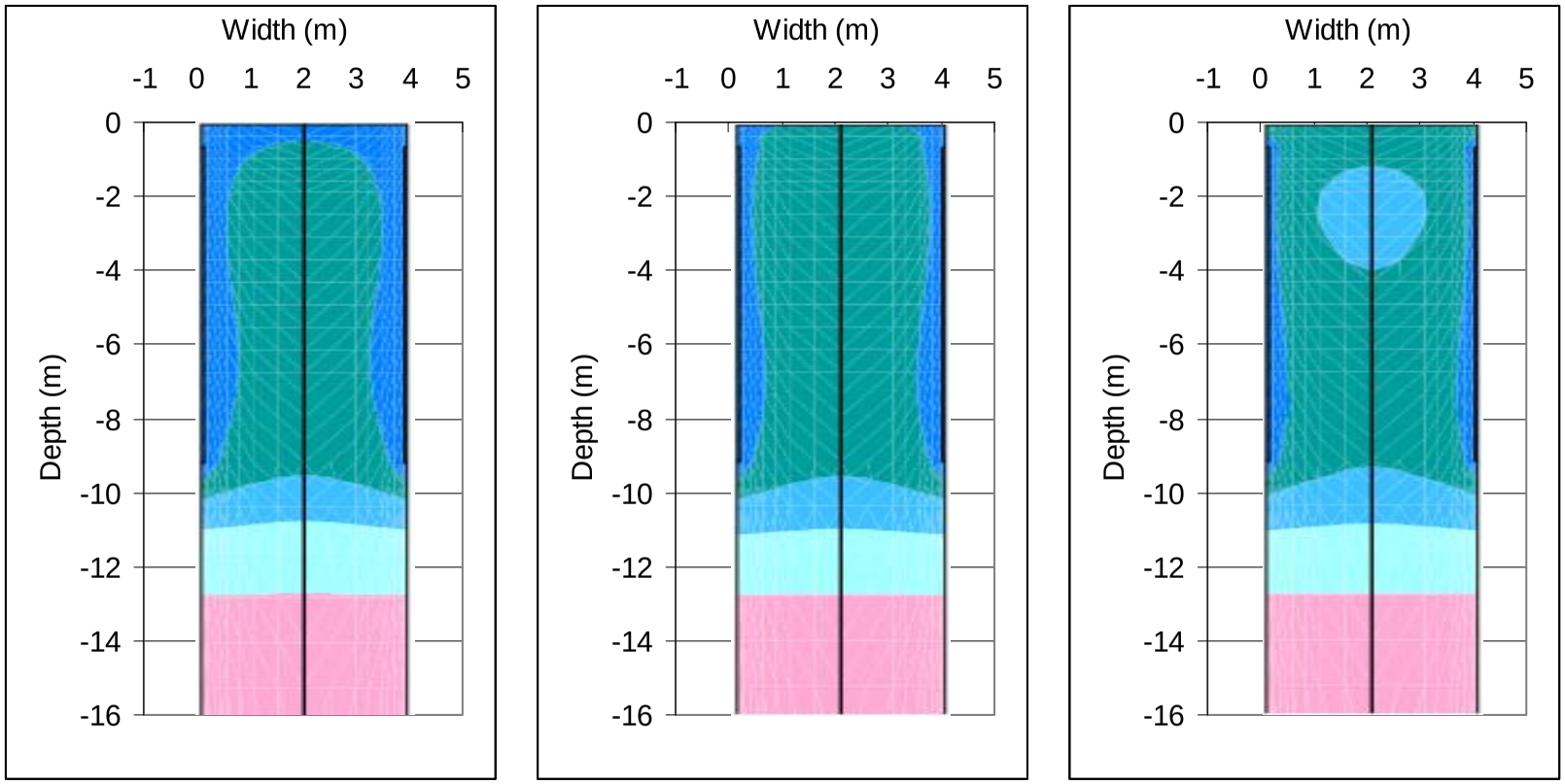


Figure 8. Geothermal results for thermosyphon spacing at 4 m, in open geometry.

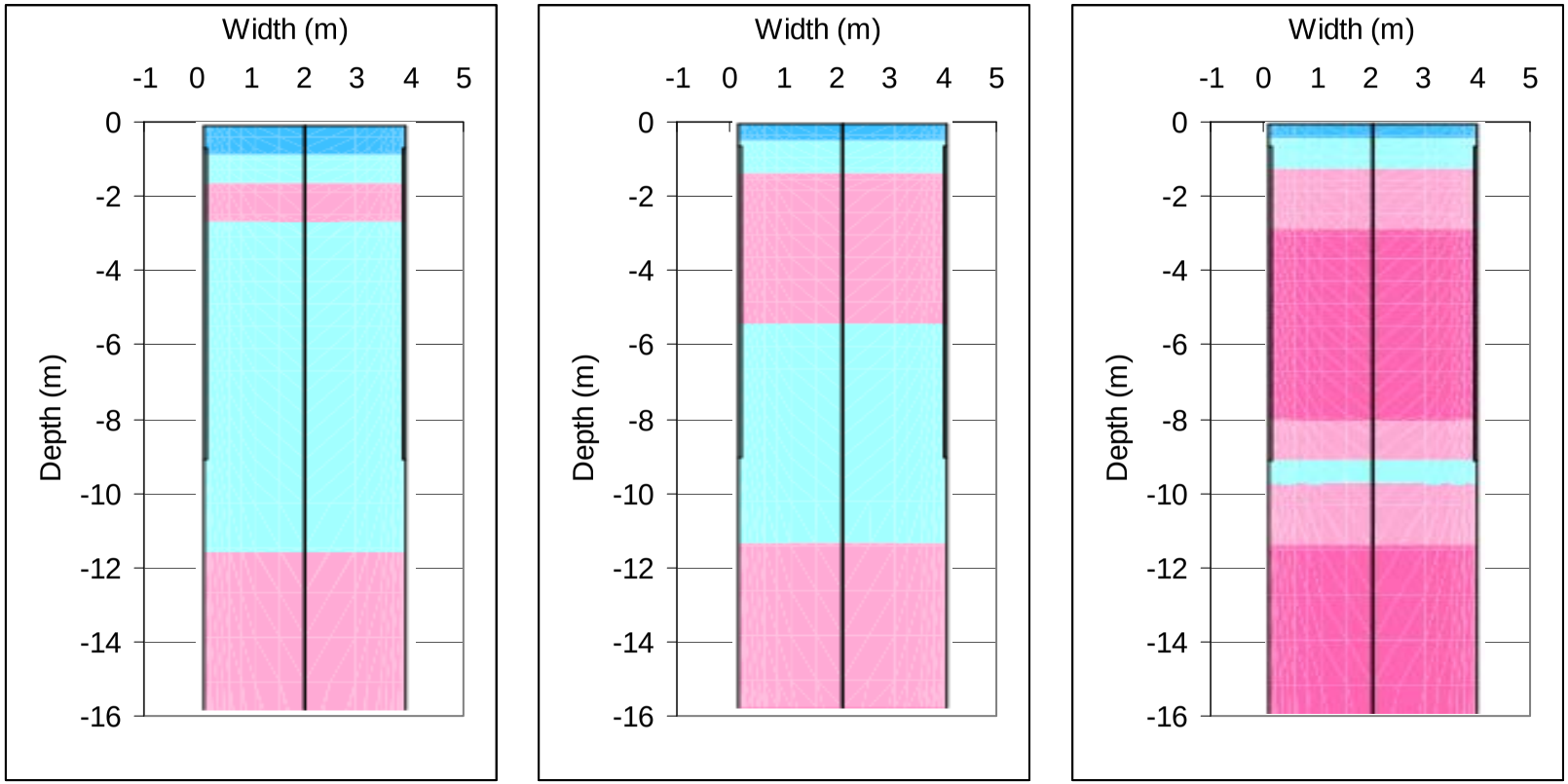


(d) March, Year 15 (e) March, Year 20 (f) March, Year 25

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

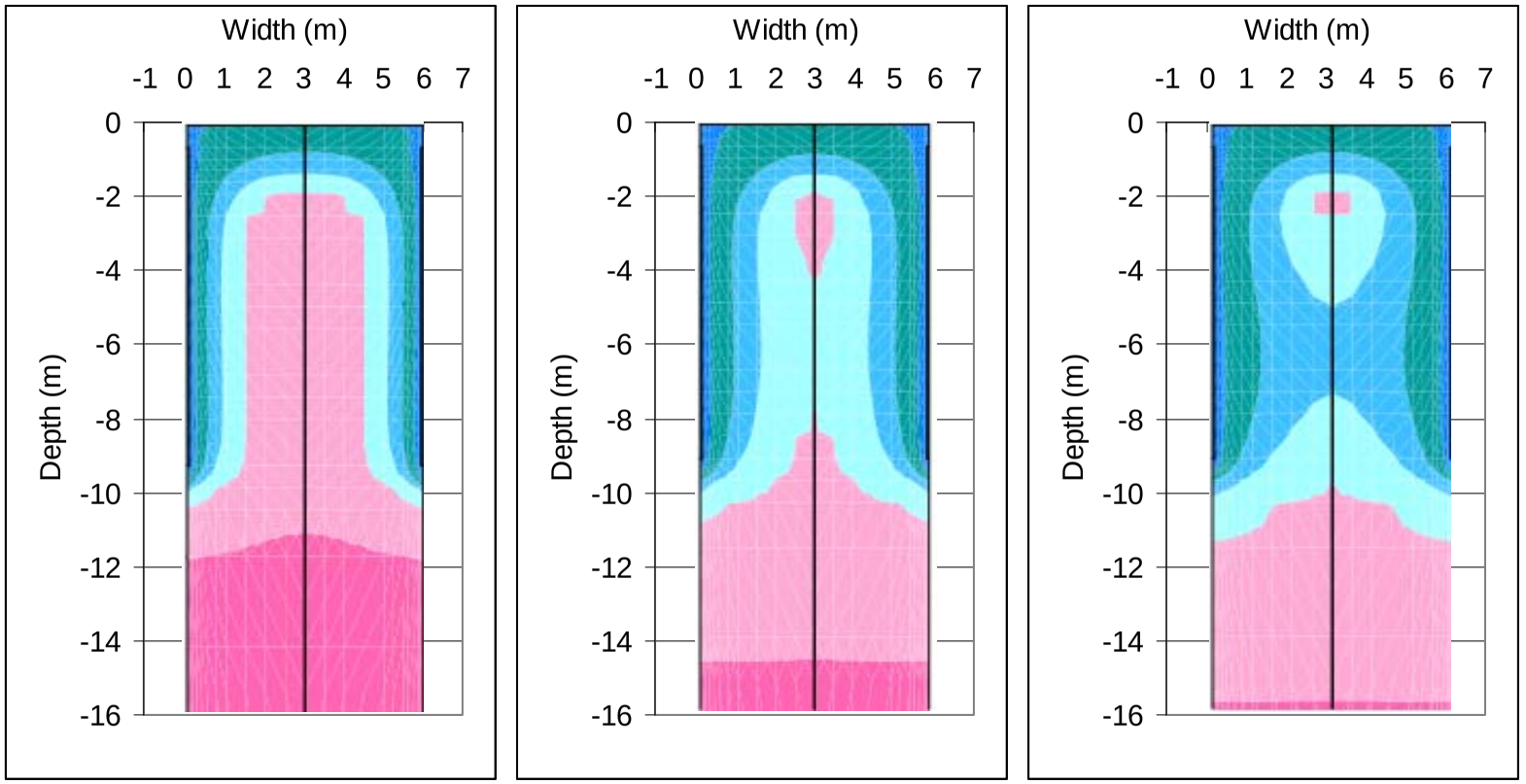


(g) March, Year 26 (h) March, Year 30 (i) March, Year 35

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

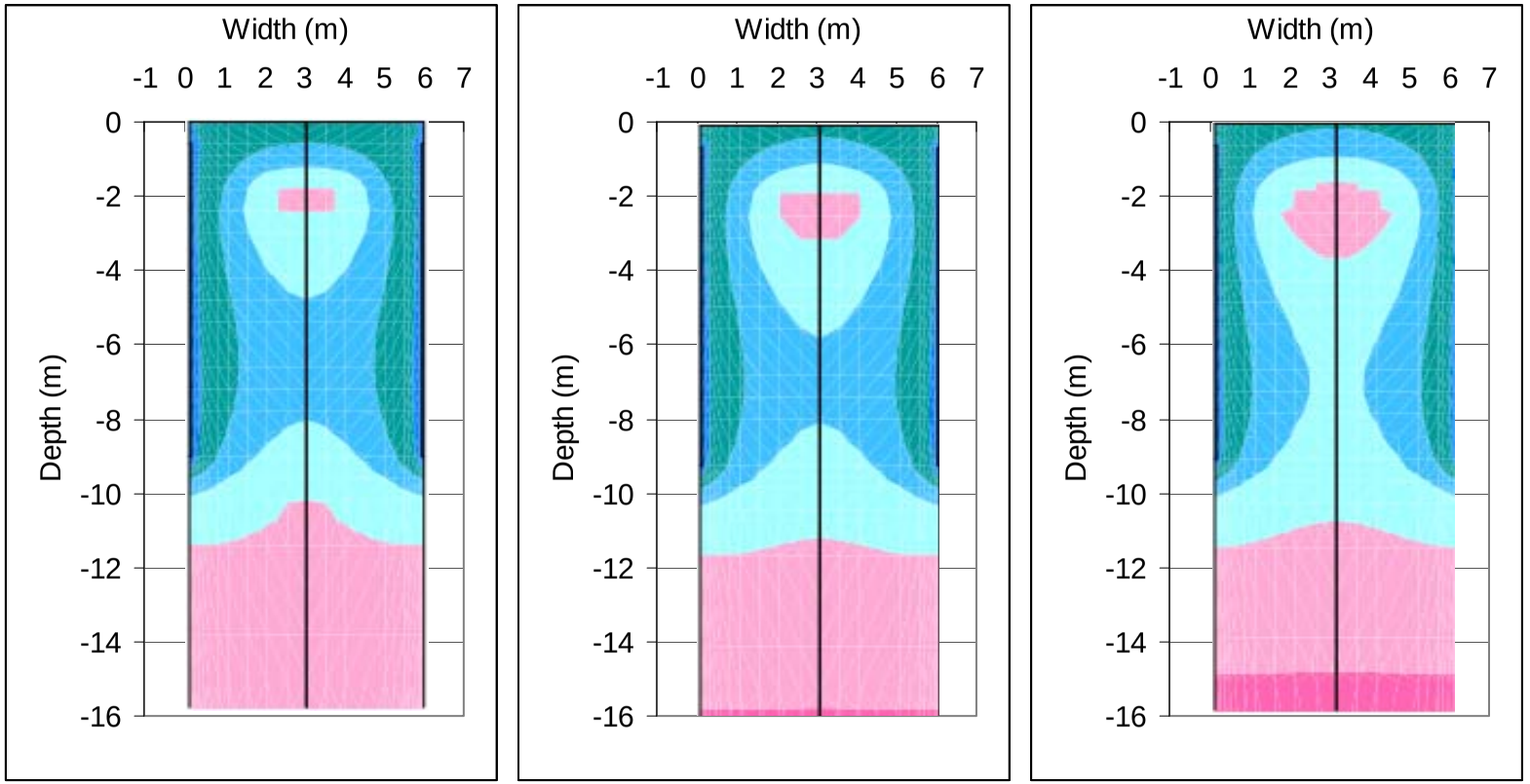


(a) March, Year1 (b) March, Year 5 (c) March, Year 10

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

< - 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

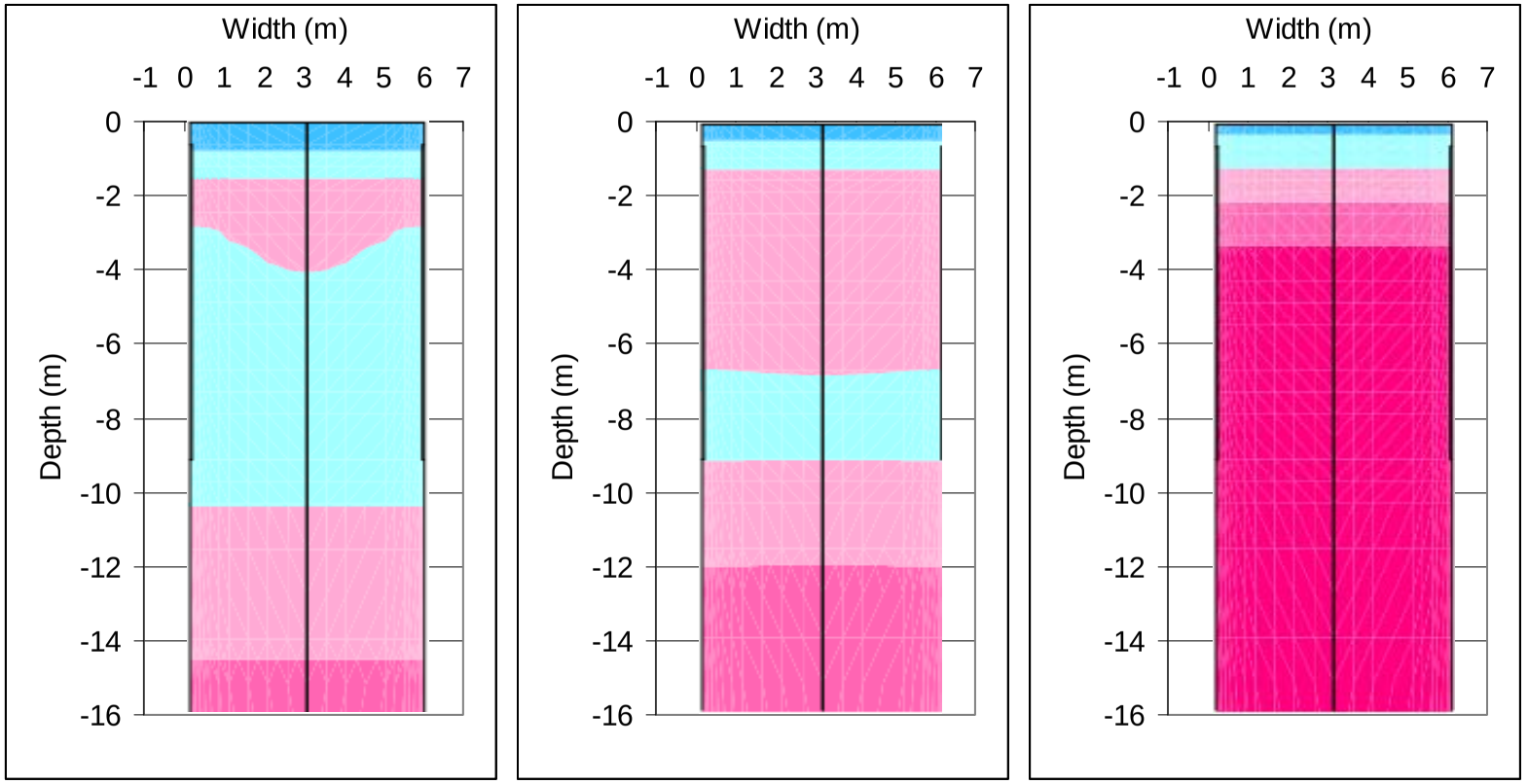
+2 °C to +5 °C > + 5 °C



(d) 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

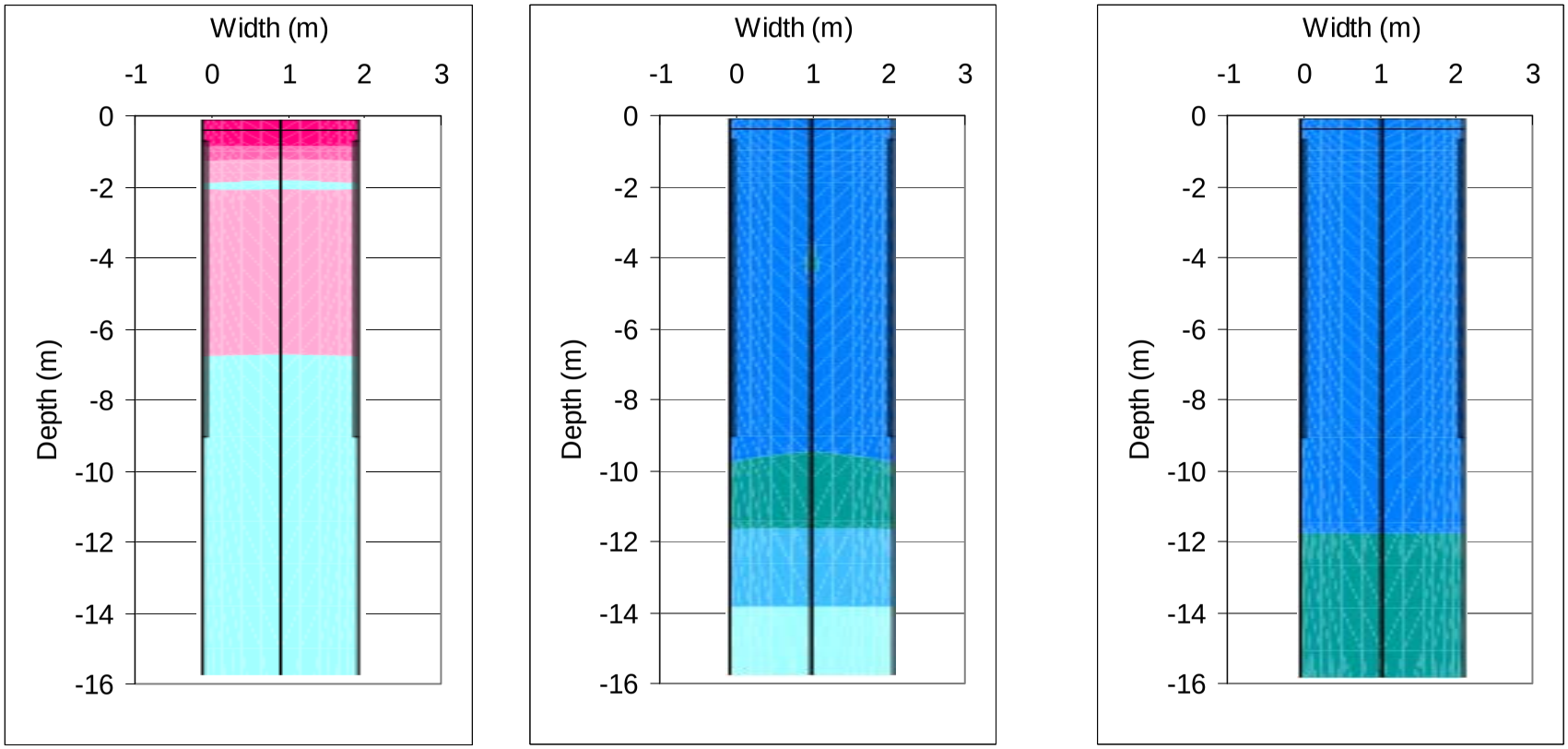


(g) March, Year 26 (h) March, Year 30 (i) March, Year 35

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

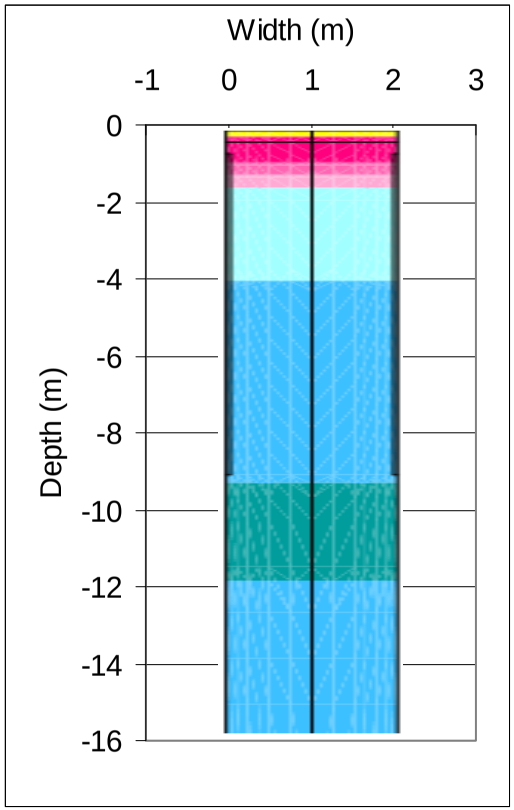


(a) September Year 1 (b) March, Year 1 (c) March, Year 15

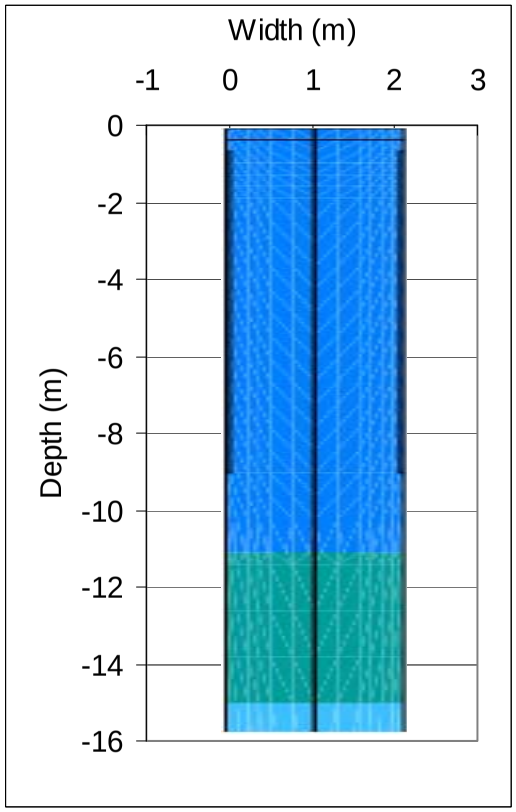
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation.

< - 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

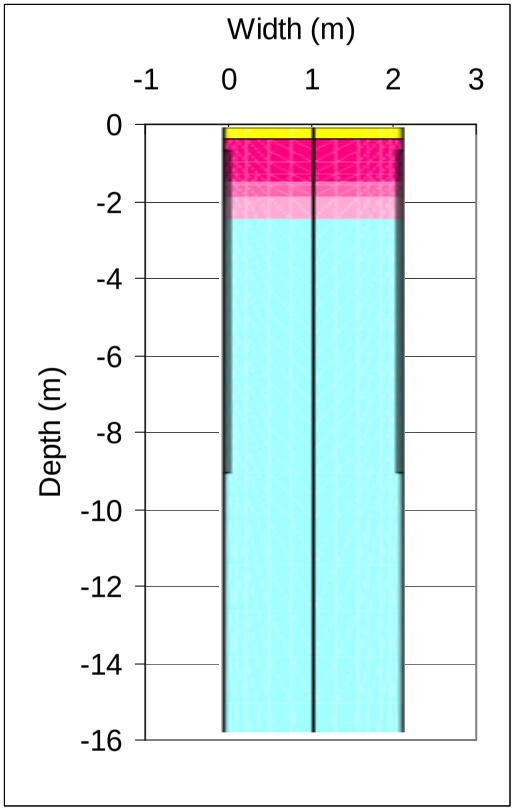
+2 °C to +5 °C > + 5 °C



(d) September Year 25



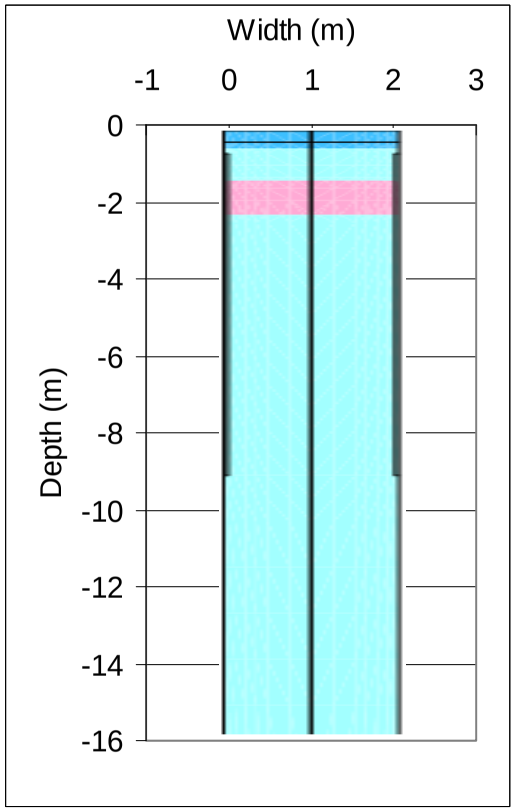
(e) March, Year 25



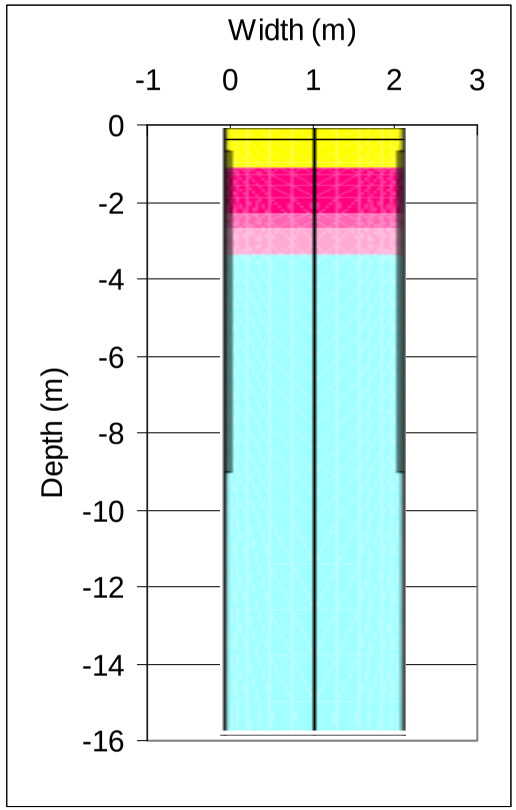
(f) September, Year 30

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

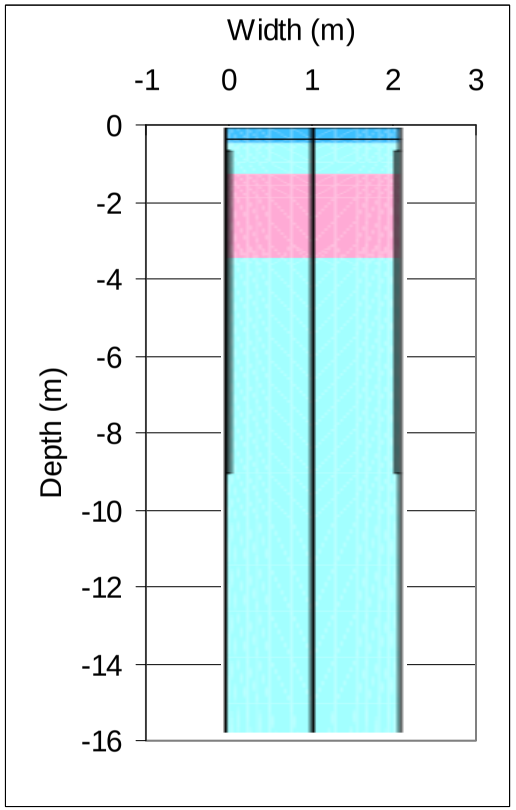
< - 4 °C - 4 °C to – 2 °C - 2 °C to -1 °C - 1 °C to 0 °C 0 °C to +1 °C +1 °C to +2 °C +2 °C to +5 °C > + 5 °C



(g) March, Year 30



(h) September, Year 35

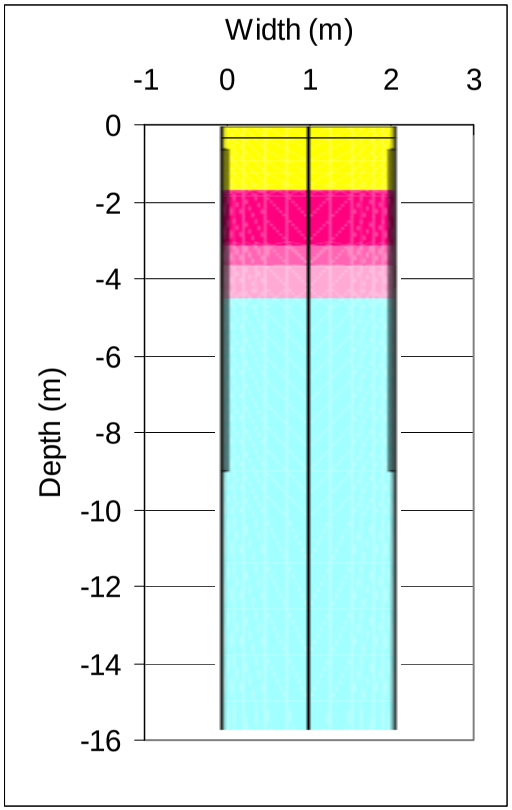


(i) March, Year 35

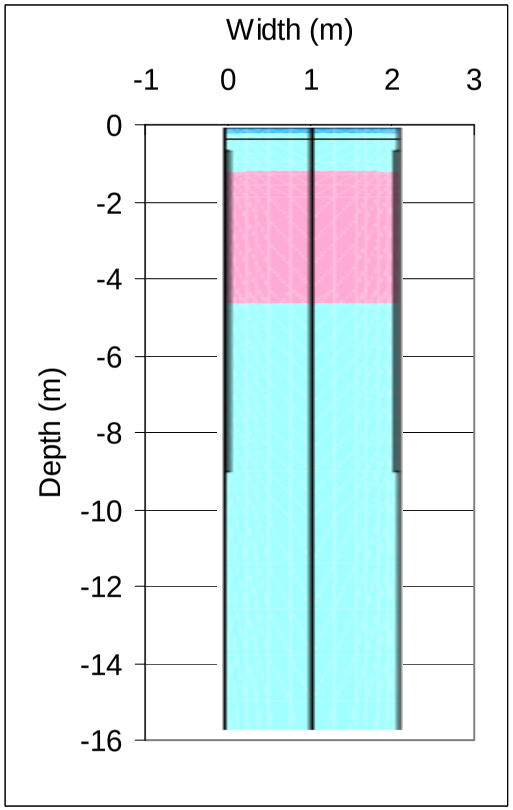
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation, continued.

< - 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

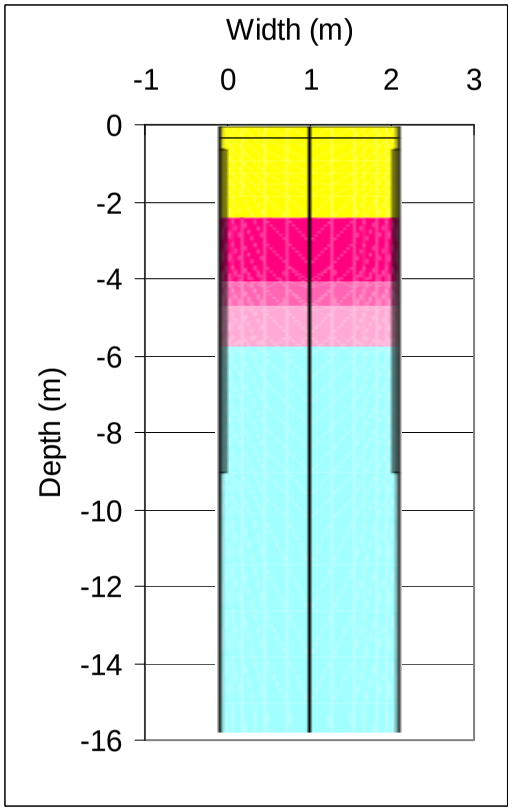
+2 °C to +5 °C > + 5 °C



(j) September, Year 40



(k) March, Year 40

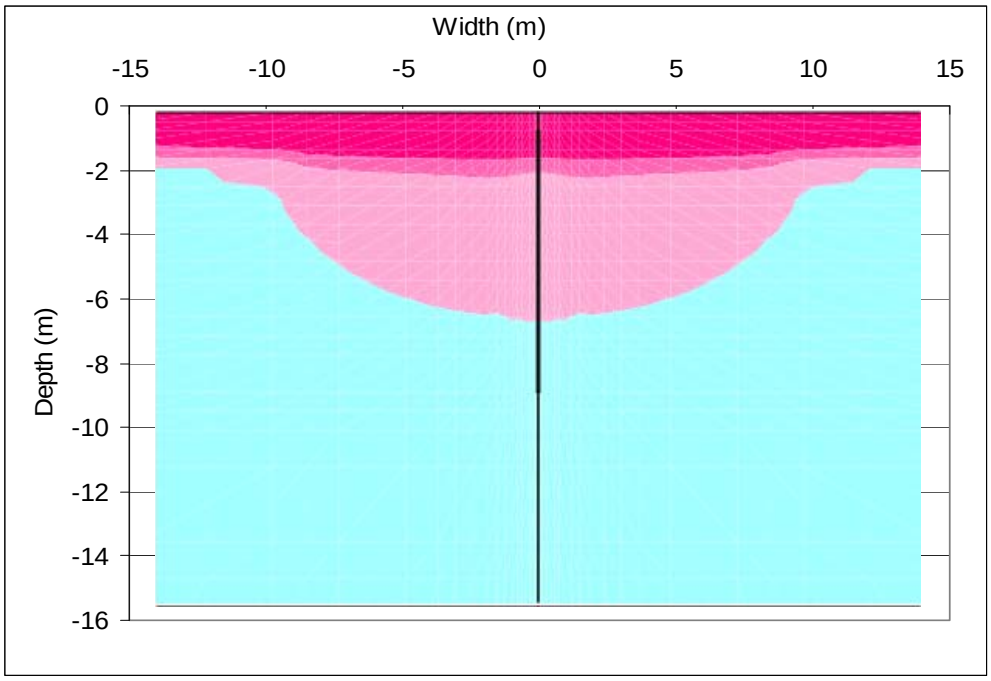


(l) September, Year 45

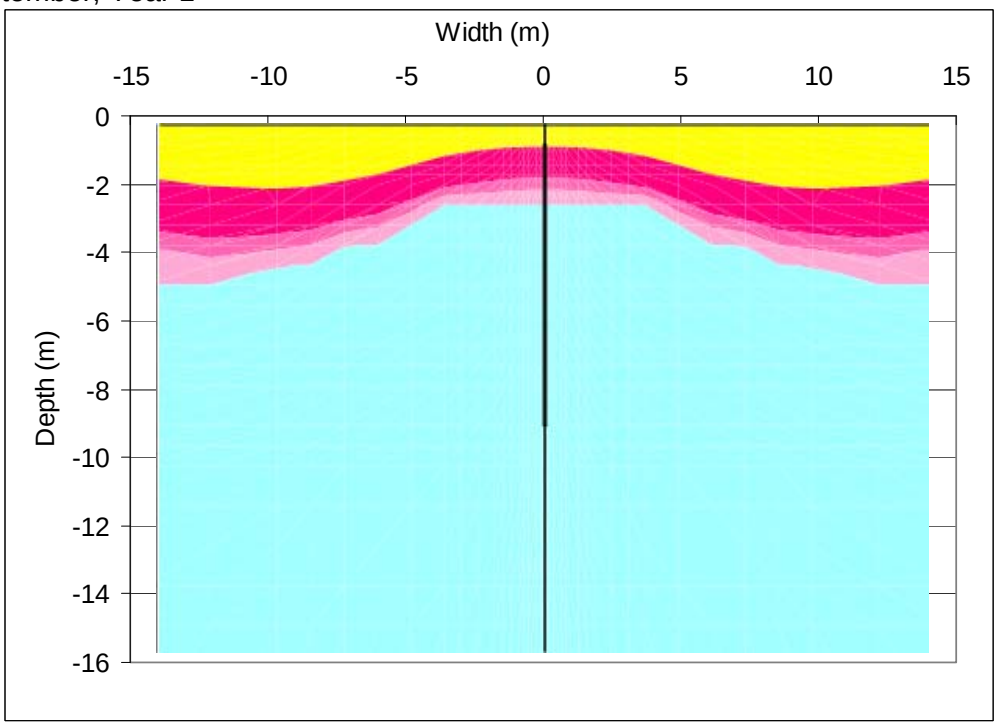
Figure 10. Geothermal results for thermosyphon spacing at 2 m, in closed geometry with surface organic layer for insulation, continued.

< - 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

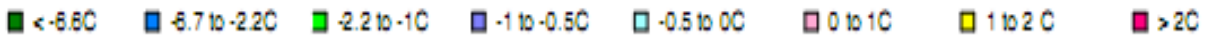


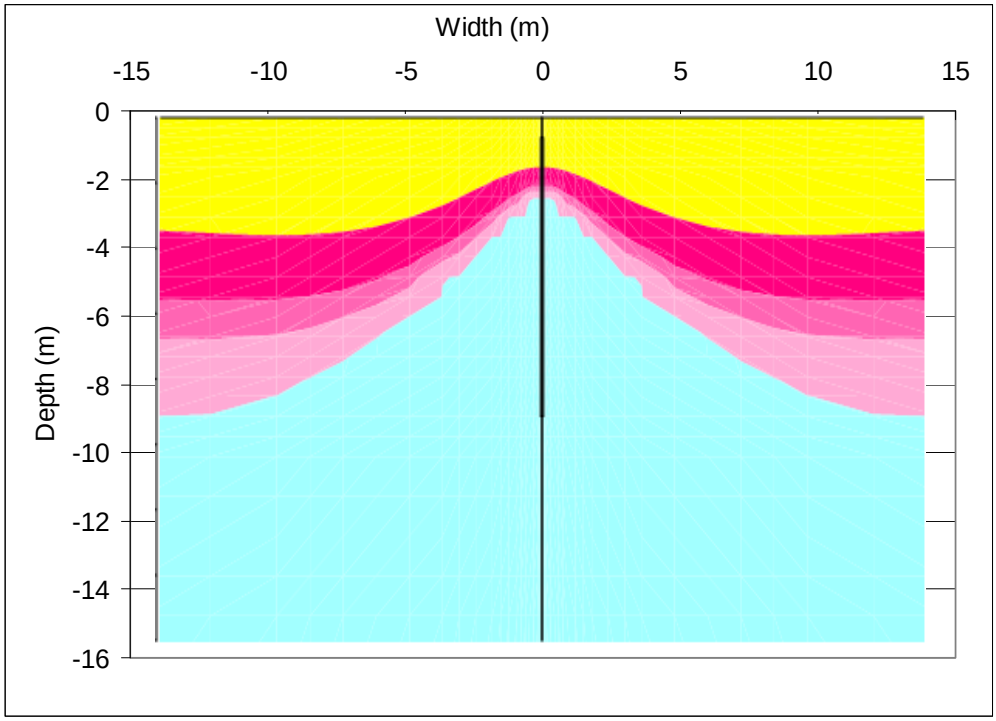
(a) September, Year 1



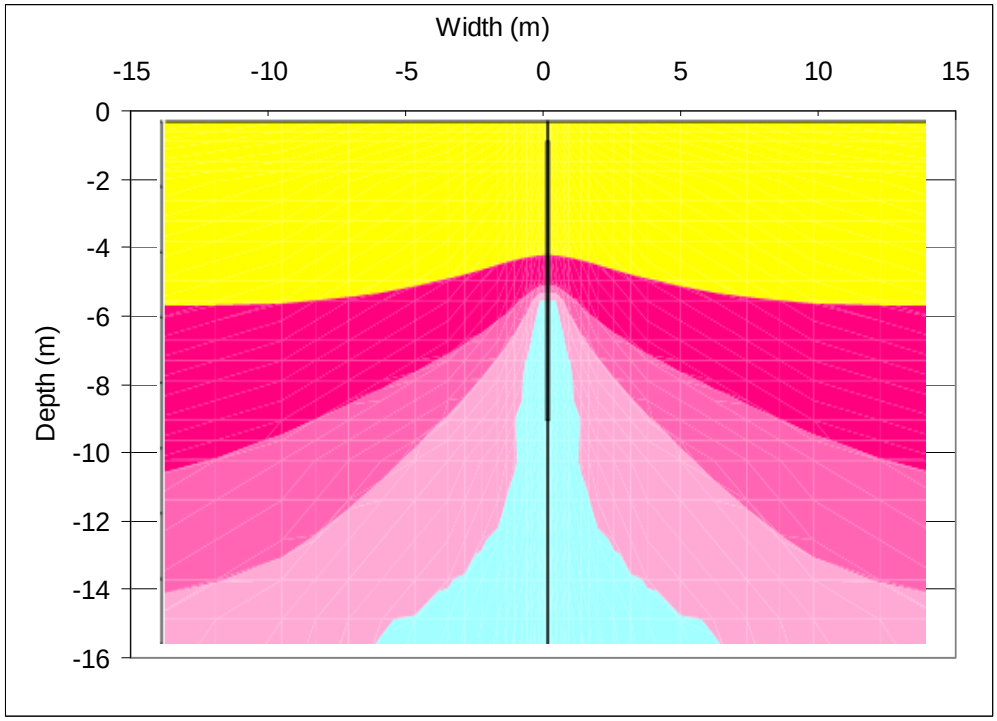
(b) September, Year 25

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



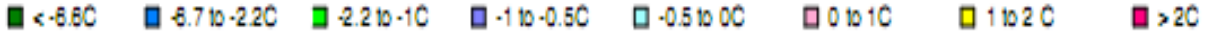


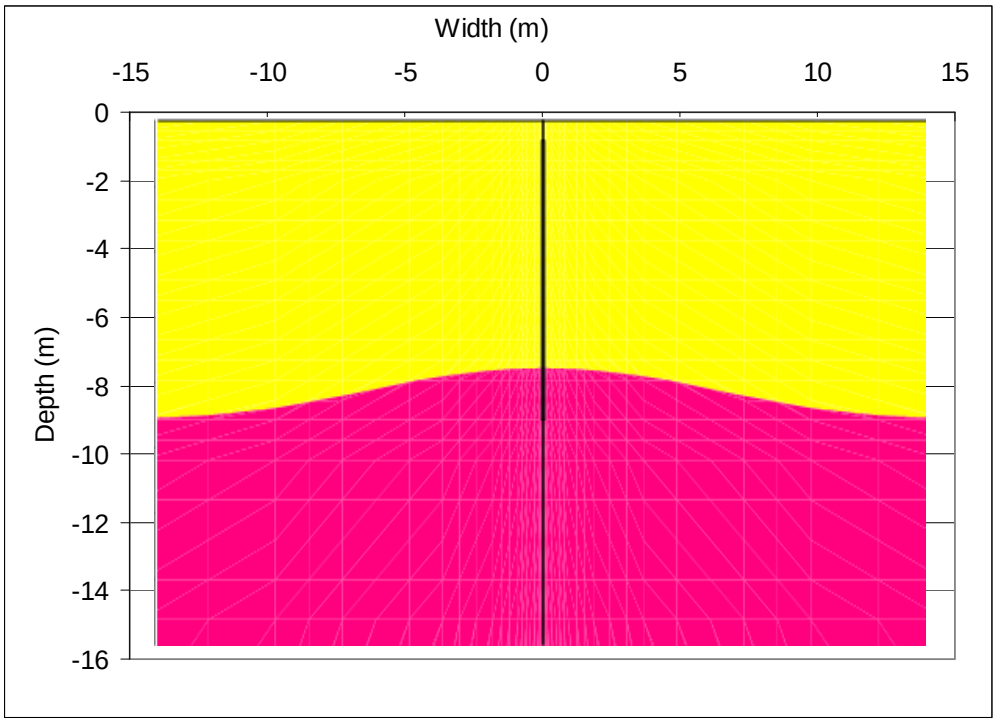
(c) September, Year 50



(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 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).

Mount Nansen Mine Site, Yukon

COMMON ELEMENT and SUPPLEMENTAL COST ESTIMATES

FOR CONCEPTUAL CLOSURE PLANNING

Prepared for:
Lorax Environmental Services Ltd.

November 2010

DRAFT

Altura
Environmental
Consulting

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Appendices

Appendix A Details of Supplemental Costs for Short-Listed Options

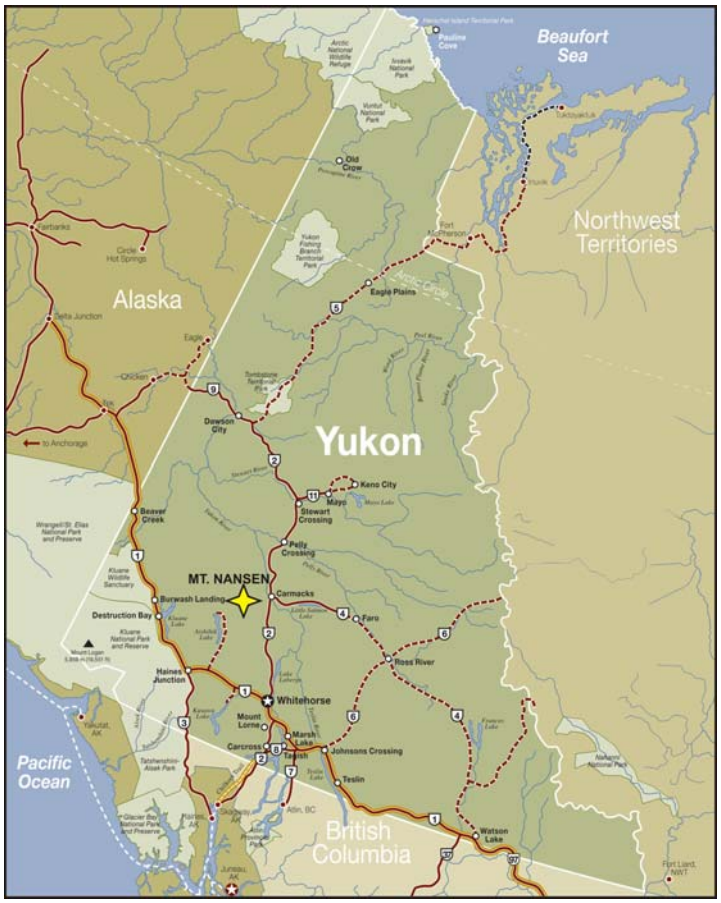
Appendix B Details of Common Elements Closure Costs

1. Overview

1.1 Introduction

The Mount Nansen Mine (Mt. Nansen) is a former gold and silver mine located in central Yukon, approximately 60 km west of Carmacks (Figure 1-1). The site was abandoned by the owner in 1999 with inadequate funding to implement an environmentally-responsible mine closure plan or the requisite post-closure monitoring program. Mt. Nansen is now classified as an Abandoned Type II site and is under the care of the Government of Yukon (Lorax, 2010a). Currently Assessment and Abandoned Mines Branch of the Department of Energy Mines and Resources is implementing a process to evaluate and develop a closure plan for the Mt. Nansen site.

Figure 1-1: Location of Mount Nansen Mine Site



Altura Environmental Consulting (Altura) was requested by Lorax Environmental Services Ltd. (Lorax) to provide conceptual closure strategies and associated cost estimates for certain aspects of the Mt. Nansen Closure Planning project.

Altura has been involved in site assessments at the Mt. Nansen site since 2008 including waste rock and pit geochemical characterization, mill area geochemical characterization, and conceptual ecological restoration planning for the waste rock area. Altura's principal Diane Lister, P.Eng. also spent several field seasons working at the Mt. Nansen project in the late 1980's and is familiar with much of the exploration activity that occurred during that era.

1.2 Scope

The information presented in this report specifically addresses conceptual closure strategies and associated cost estimates for the following closure aspects of the Mt. Nansen Mine site:

- final surface remediation and revegetation of the Short-Listed Options for tailings, pit and waste rock areas
- closure of the Common Elements of the Mt. Nansen site, including the Mill Area, Camp and Site Ancillary Buildings, Roads, Exploration Trenches, Miscellaneous Infrastructure, and Other Areas such as clearings.

1.3 General Assumptions

The following sections discuss general assumptions for the cost estimates. Specific premises for the Supplemental and Common Elements costs are given in Section 2 and 3 respectively.

1.3.1 Closure Objectives

The over-arching objectives for the Mt. Nansen site closure are described in Section 3.2 of the "*Mount Nansen: Options for Closure*" report in preparation by Lorax (2010b). Further site-specific objectives are provided for consideration in this costing report as applicable, typically in cases where a specific risk aspect has been identified for a given area.

1.3.2 Approach

The costing approach involved development of a conceptual strategy for each element. The strategy incorporated generally accepted best management practices and proven

techniques to meet the closure objectives established for the Mt. Nansen site. Reasonable costs were then applied. Earthworks tasks were typically calculated using appropriate heavy equipment cost rates and typical equipment time requirements based on Altura's experience and on comparison with available closure costing at a selection of similar sites (Access Consulting Group, 2009, SRK Consulting, 2009). Revegetation and surface preparation cost rates were derived based on the approach described below in Section 1.3.5. In most cases a general allowance was included for tasks not involving earthworks or revegetation, such as hazardous product removal or building demolition.

1.3.3 Accuracy

Closure costs described in this report are preliminary and conceptual. While Altura is familiar with many aspects of the Mt. Nansen site, Altura did not carry out site work specifically supporting this closure costing task. The estimates are thus based on limited site investigation, consultations with Lorax and Assessment and Abandoned Mines, and a review of certain documents, conceptual design drawings and digital map information available to Altura. This estimate should be regarded as a low precision level Class "D" estimate (INAC contaminated sites protocol (CSP)) and is considered to provide an accuracy range of -25% to +75%. Additional field investigation, systematic document review, detailed site inventory, personnel interviews, volume surveys and in-depth costing are required to fully determine the required scope of closure activities and to improve the accuracy of these cost estimates.

1.3.4 Exclusions

Unless otherwise stated, costing considers only direct costs associated with the specified works to be carried out, and do not include:

- Post-Closure monitoring, inspection, or follow-up remediation costs. Although it is recognized that some post-closure activities such as field assessments for erosion control, general physical stability, and certain ongoing water quality monitoring will be required for some aspects of the work. It is assumed that these activities will form a part of the comprehensive, site-wide closure plan for the mine site.
- Salvage credits.
- Mobilization and demobilization costs.
- Indirect costs such as management and supervision, contract administration, camp accommodation, general field and site support, and insurance.

1.3.5 Revegetation and Surface Preparation

The overall conceptual revegetation approach for the Mt. Nansen site is to achieve closure objectives by encouraging natural revegetation through use of appropriate surface preparation methods and locally-sourced materials. In general, surface preparation will be carried out not only to integrate the disturbances into the surrounding landscape and control erosion, but to also favour moisture accumulation and provide plant shelter and seed trap locations. No placement of 'topsoil' material over disturbances is assumed, since there are virtually no stockpiles of stripped organics available at the Mt. Nansen site. Typical surface preparation rates used are 25 heavy equipment hours (an assumed combination of Cat D9 bulldozer or Cat 300-series excavator) per hectare, although higher or lower rates are assumed in several cases as existing information warrants. A heavy equipment rate of $250 per hour is assumed.

Active, hands-on revegetation work considers use of locally-sourced seed and other materials such as coarse woody debris and live cuttings, and propagation of select local species as appropriate and cost-effective. The active revegetation work is intended to focus on areas of specific physical stability concern, and on establishment of 'native species islands' and habitat sites across larger disturbances. These islands would ultimately serve as nuclei for self-propagation of species and encourage wildlife use (Altura, 2009a). Given that the site disturbances at Mt. Nansen tend to be discrete and not overly expansive, it is generally not considered necessary to use non-locally derived seed and plant materials such as grass and/or legume mixes.

Unless otherwise stated in the cost estimation tables, the active revegetation work described above is assumed to be applied to 25 percent of a given disturbance area, at $16,000 per full vegetated hectare (eg. for a 1 hectare disturbance, 0.25 hectares will see active revegetation for a total revegetation cost of $4,000). Narrow linear disturbances (8m or less) would receive surface preparation but in general would be left to naturally revegetate.

2. Supplemental Costs for Short-Listed Options

2.1 Scope

Altura understands that cost estimates for the short-listed closure option combinations for the tailings, open pit and waste rock piles completed by AECOM have considered all activities up to but not including: final surface preparation, revegetation, and safety signage and berming for any remaining open pit wall exposures. Lorax therefore requested Altura to complete a preliminary cost estimate for these above-mentioned aspects.

In addition, Altura was requested by Lorax to provide the following:

- an estimate of cost for partial pit backfill with waste rock as a supplemental activity for Options 1A and 2A. The partial waste rock backfill would serve to cover the exposed water in the pit bottom, improve pit wall stability, and reduce the amount of exposed pit walls; and
- a conceptual strategy and associated cost estimate for restoration of Dome Creek valley following tailings removal, to substantiate the general allowance provided by AECOM in their costing of Options 3 and 4.

Costs for field monitoring and reporting are assumed to be included within the main activity costs estimated by AECOM. Therefore with the exception of the Dome Creek valley restoration task, allowances for these activities have not been included in these supplemental costs.

2.2 Approach

The costing approach is described in Section 1.3.2 and relied largely on: i) the conceptual design drawings for the short-listed closure options and the information derived from them, ii) general geometry and field knowledge of the tailings, waste rock and pit areas and surrounding areas, and iii) measurements from the 2008 geo-referenced site image.

It is important to note that in order to provide the clearest comparative data, attributable costs in this section include only those physical areas that see a material variance in surface preparation and revegetation across the four Short-Listed closure options. While the cost of remediating the peripheral areas has been calculated as part of this exercise, the expenditure is considered as a 'Common Element' and results incorporated in Section 3 of this report. For example, the tailings management area closure options see their

major variations over: i) the body of stored tailings and ii) the tailings dam. Therefore, the surface preparation and revegetation for only these areas are included in each option's comparative cost. Costs for peripheral areas such as the existing diversion channel and perimeter road as well as the upstream and downstream borrow areas are given as a separate line item, and incorporated into Common Elements results in Section 3.7.

Key points and results of the costing exercise are summarized in the following sections. Further supporting detail is given in the spreadsheet tabulations in Appendix A.

2.3 Results

Table 2-1 summarizes the main aspects of the supplemental tasks, and their associated costs.

Figures 2-1 through 2-6 depict the main site elements post-closure for each of the Short-Listed Options.

Table 2-1: Summary of Supplemental Costs for Short-Listed Closure Options

Option	Description	Tailings Management Area		Waste Rock Storage Area		Pit Area		Supplemental Backfill Option A[2]	Supplemental Backfill Option B[3]
		Aspect	Est Cost	Aspect	Est Cost	Aspect	Est Cost		
1A	tailings dam upgrade with water cover, waste rock in place, open pit lake	Final site prep and revegetation	$ 34,000	Re-slope angle of repose faces, re-grade, surface preparation and revegetation	$ 142,000	Safety berm and signage	$ 24,000	$ 1,779,000	$ 575,000
1B	same as option 1A with waste rock relocation into the open pit, covering the pit lake	Final site prep and revegetation	$ 34,000	Re-grade, surface preparation and revegetation	$ 123,000	Re-grade and revegetate pit fill, safety berm and signage	$ 53,000	NA	NA
2A	tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake	Final site prep and revegetation	$ 124,000	Re-slope angle of repose faces, re-grade, surface preparation and revegetation	$ 142,000	Safety berm and signage	$ 24,000	$ 1,779,000	$ 575,000
2B	same as option 2A with waste rock relocation into the open pit, covering the pit lake	Final site prep and revegetation	$ 124,000	Re-grade, surface preparation and revegetation	$ 123,000	Re-grade and revegetate pit fill, safety berm and signage	$ 53,000	NA	NA
3	tailings backfill into open pit (covering the pit lake) with high infiltration cover, waste rock in place, Dome Creek reclaimed	Final site prep and revegetation; Dome Ck valley restoration	$ 1,670,000	Re-slope angle of repose faces, re-grade, surface preparation and revegetation	$ 142,000	Re-grade and revegetate pit fill, safety berm and signage	$ 49,000	NA	NA
4	tailings and waste rock backfill into open pit (covering the pit lake) with low infiltration cover, waste rock in place, Dome Creek reclaimed	Final site prep and revegetation; Dome Ck valley restoration	$ 1,670,000	Re-grade, surface preparation and revegetation	$ 123,000	Re-grade and revegetate pit fill, safety berm and signage	$ 46,000	NA	NA

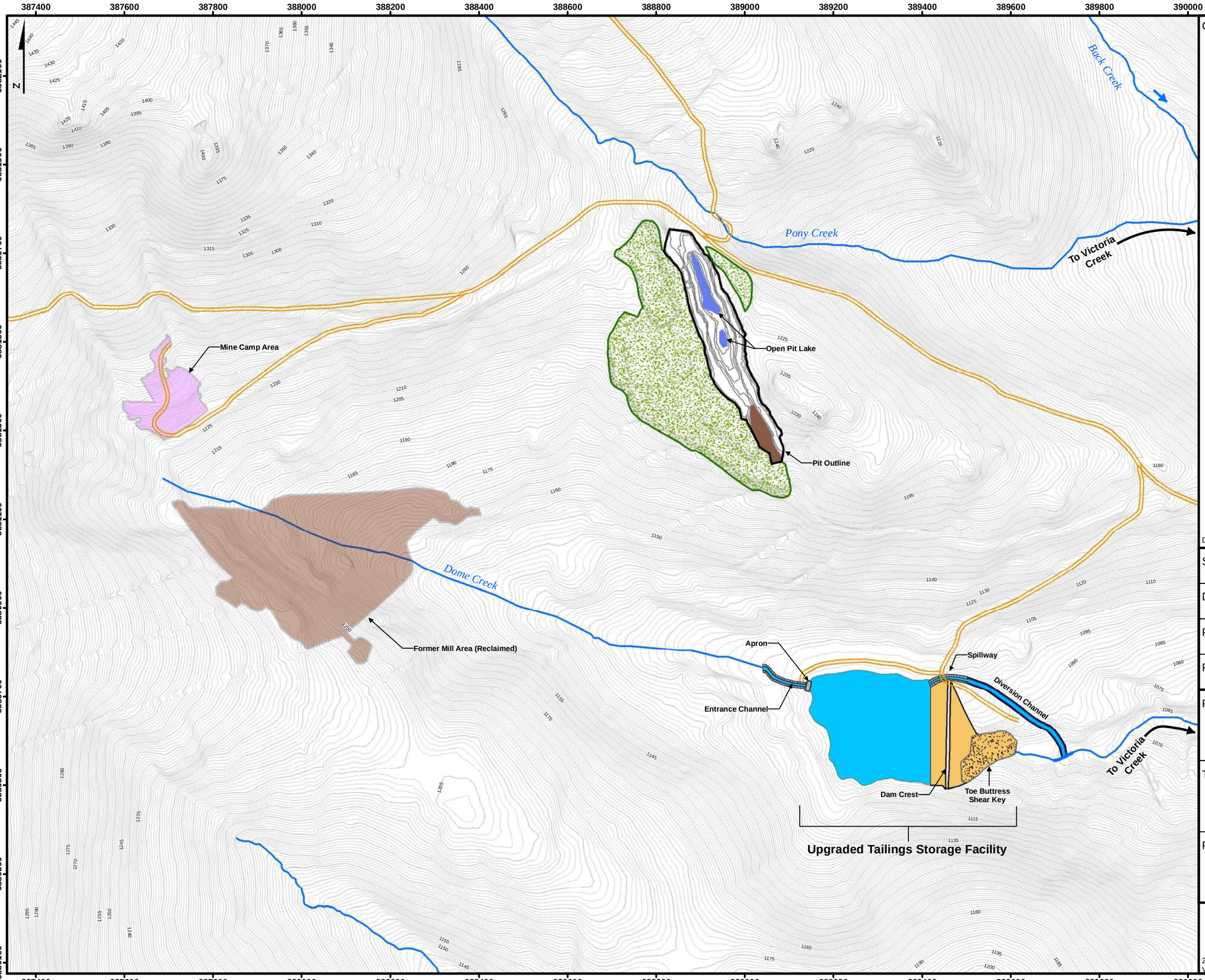
Table 2-1, Supplemental Notes:

1 Costs are rounded to nearest $1,000 of the detailed estimates presented in Appendix A

2 Supplemental Backfill Option A: Estimated cost to cover pit lake and improve pit wall stability; and revegetate (300,000m^3 waste rock backfill, to approximately 1205 masl level of open pit)

3 Supplemental Backfill Option B: As for Supplemental Backfill Option A, but 155,000m^3 waste rock backfill to approximately 1200 masl level of open pit.

4 Tailings Peripheral Areas are larger on options 1 and 2 than for options 3 and 4 (8.8ha versus 5.9ha) due to options 3 and 4 incorporating a stream restoration corridor and a slightly larger tailings management facility excavation footprint than soil and water cover placement.



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Water Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

TITLE: **Closure Option 1A: Tailings Dam Upgrade with Water Cover, Waste Rock in Place**

PROJECT No:	FIGURE No:
J907-4	**2-1**

LORAX ENVIRONMENTAL
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Vancouver, BC, V6J 3H9
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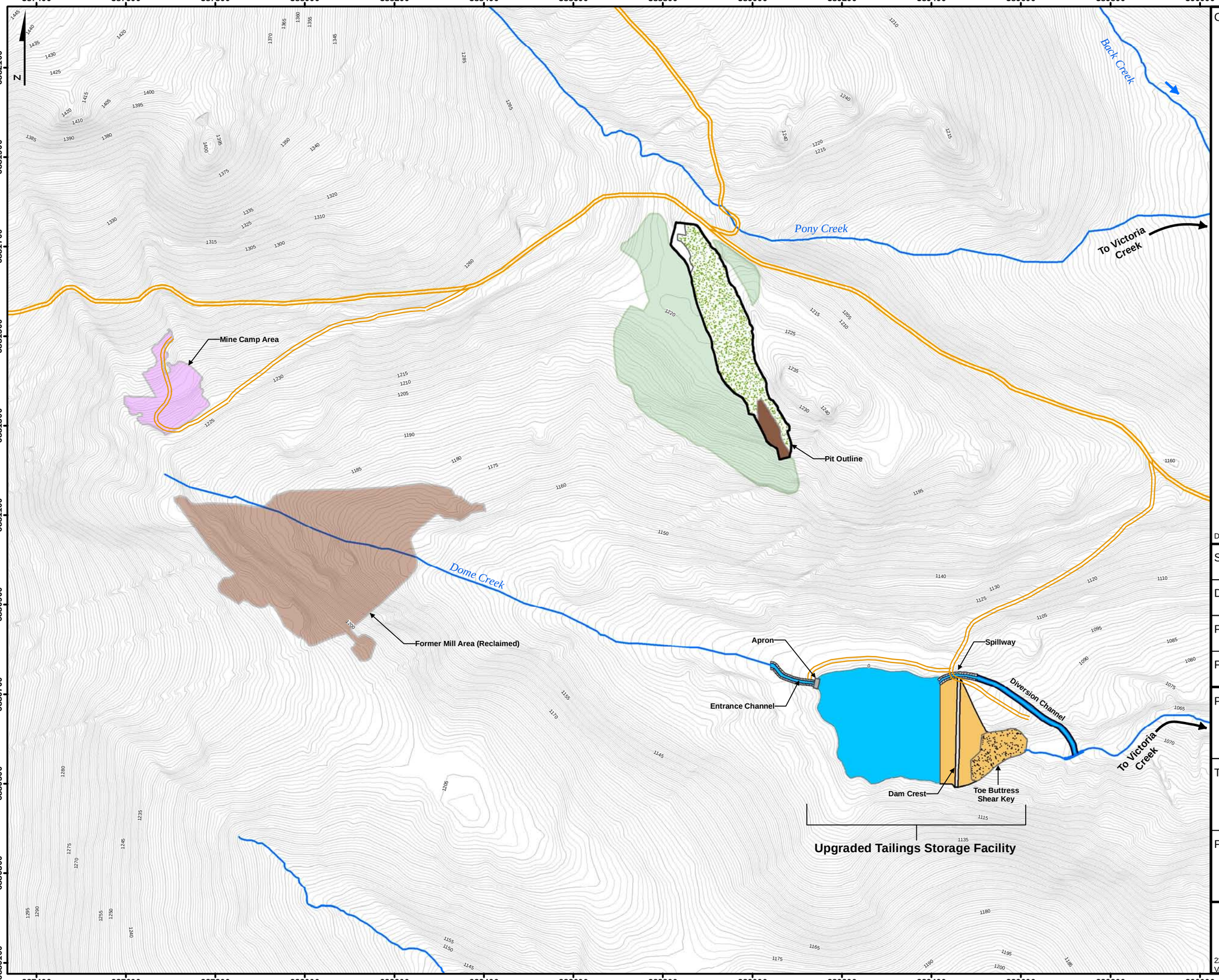
Website: www.lorax.ca



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit_Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Water Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:8,000

DATE: OCT 22nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE:
Closure Option 1B: Tailings Dam Upgrade with Water Cover, Waste Rock Backfill into Pit

PROJECT No:	FIGURE No:
J907-4	**2-2**

LORAX ENVIRONMENTAL
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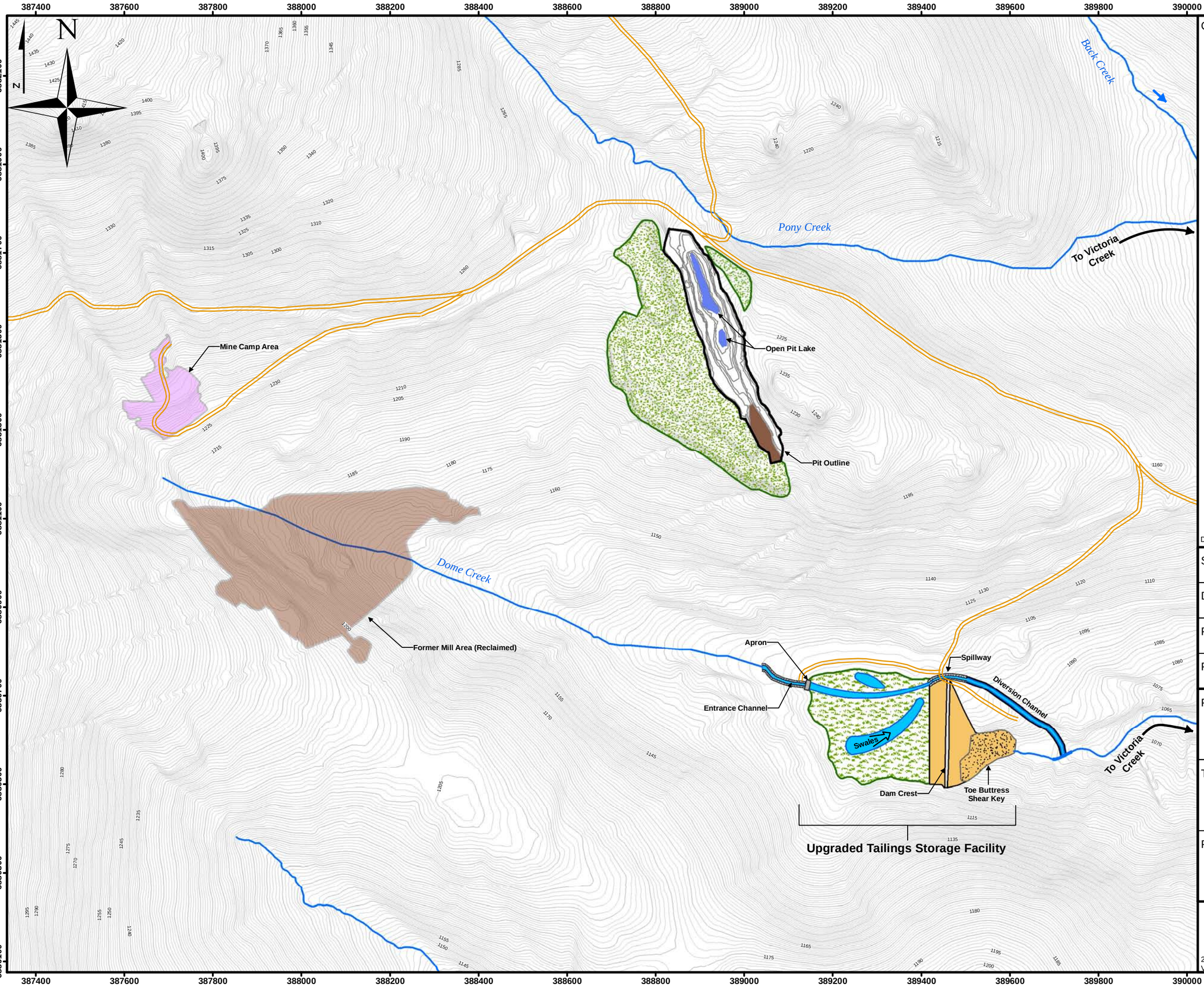

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Saturated Soil Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data Courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

TITLE: **Closure Option 2A: Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock in Place**

PROJECT No:	FIGURE No:
J907-4	**2-3**

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2289 Burrard St.
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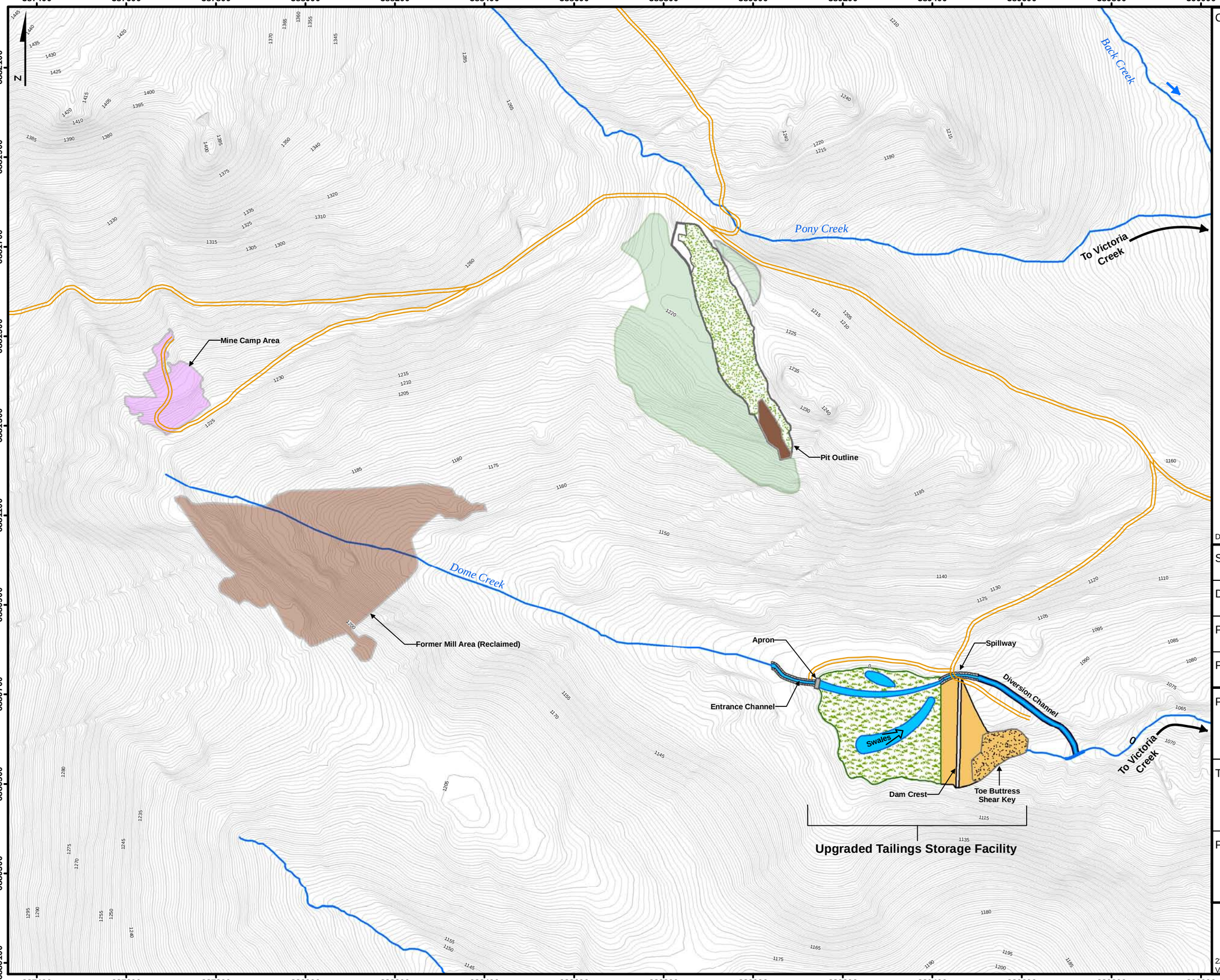
Website: www.lorax.ca



CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Dam Area
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Saturated Soil Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:8,000

DATE: OCT 22th, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:
Mount Nansen Options for Closure

TITLE: **Closure Option 2B: Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock Backfill into Pit**

PROJECT No:	FIGURE No:
J907-4	**2-4**

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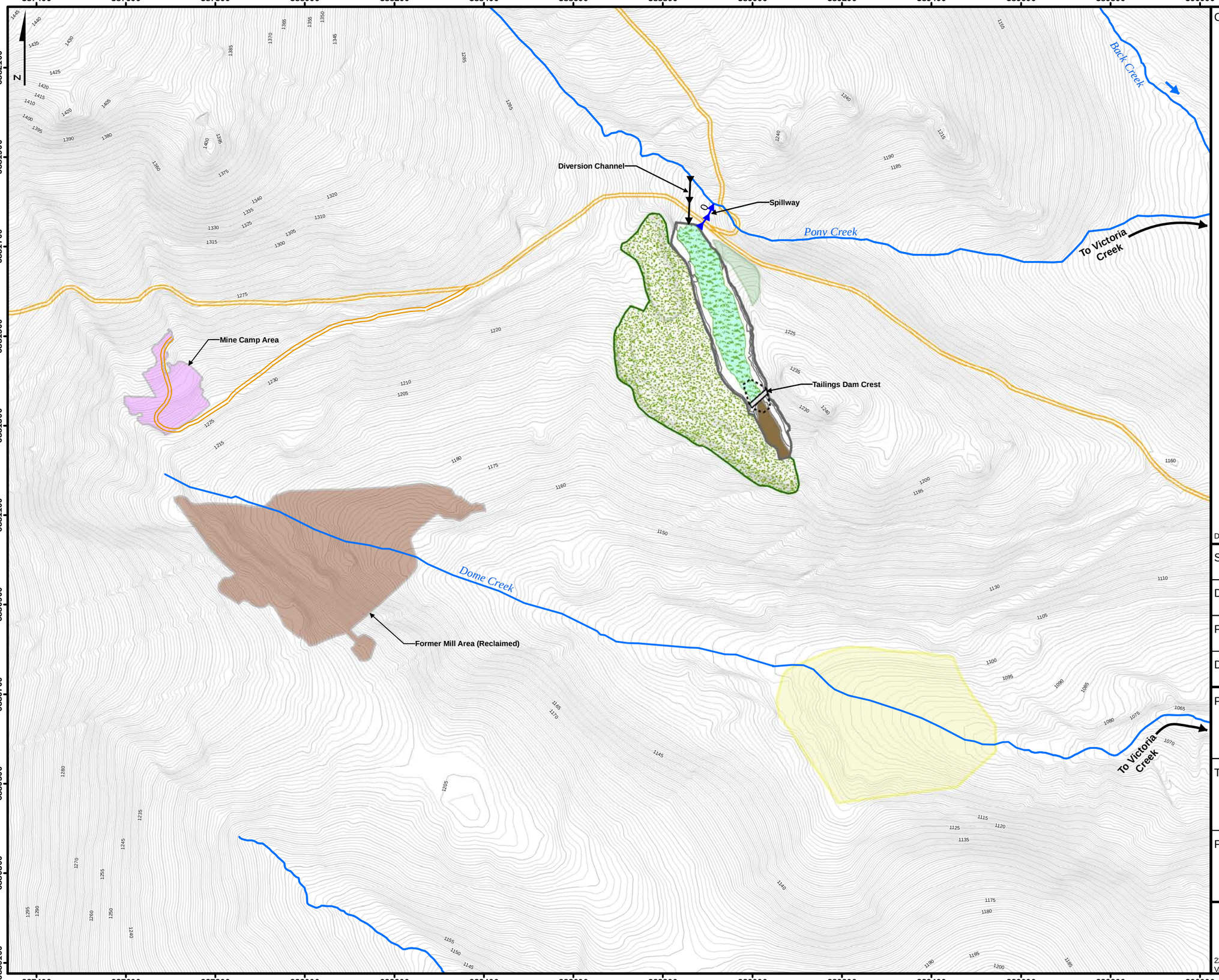

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Tailings Dam Footprint
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings with High Infiltration Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
DATA SOURCE:	J.S.

PROJECT:

Mount Nansen Options for Closure

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

PROJECT No:	FIGURE No:
J907-4	**2-5**

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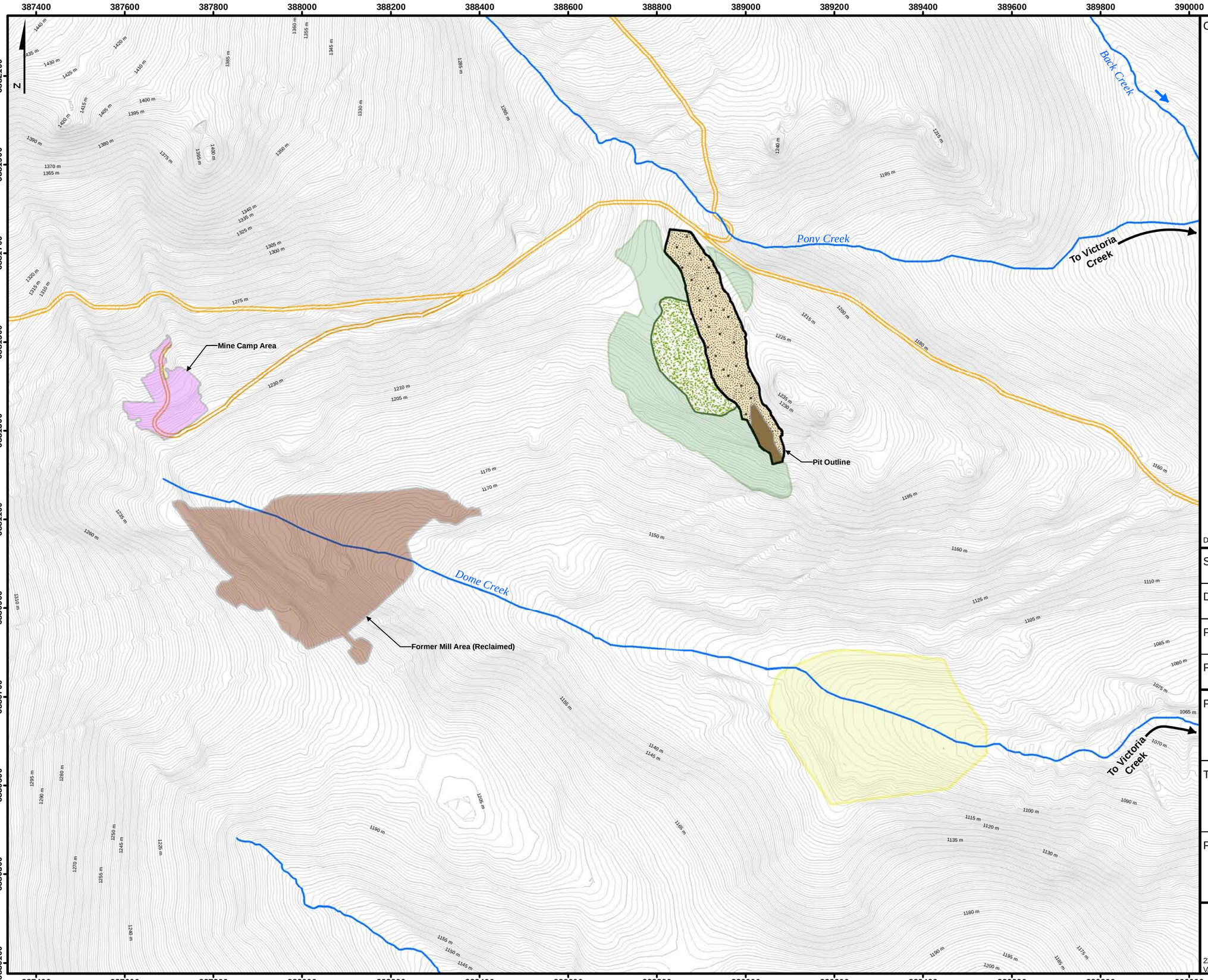

CLIENT:: Yukon Government

Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings + Waste Rock with Low Infiltration Cover)

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOMM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mount Nansen Options for Closure

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

PROJECT No:	FIGURE No:
J907-4	**2-6**

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2.3.1 Tailings Management Area

Options 1 and 2

Costing of final closure measures for options 1A and 1B considers five major areas: i) water cover, ii) beach soil cover, iii) dam crest and upstream face, iv) downstream dam face, and v) rock fill toe berm.

No site preparation nor revegetation costs were assumed for the water cover. Conventional surface preparation and revegetation measures described in section 1.3.5 are assumed in varying degrees for the remaining areas. Given its exposure and importance of minimizing erosion, the 0.5ha beach soil cover is assumed to require relatively intensive revegetation work (75% revegetation cover); conversely due to the anticipated coarseness of material, minimal site preparation and revegetation costs area assumed for the rock fill toe berm.

Options 2A and 2B consider a similar costing framework as 1A/1B, with the exception that the water cover in the first option is largely replaced with a soil cover. The soil cover is assumed to require relatively intensive revegetation work similar to the tailings beach soil cover area.

Options 3 and 4: Dome Creek Valley Restoration

The removal of the stored tailings and dam in Options 3 and 4 calls for a more complex restoration strategy for the exposed tailings management area (TMA) footprint and for the Dome Creek watercourse.

The closure concept assumes restoration of: i) Dome Creek flow through the central 'Watercourse' zone, and ii) the tailings management area 'Footprint' zone, both shown in Figure 2-7. Costs for restoring the north and south Peripheral zones shown in the Figure are considered in the Common Elements section of the Closure Plan.

As noted in AECOM (2010), 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. The two principal challenges and uncertainties associated with the Dome Creek valley restoration task are:

- the degree of permafrost degradation and its associated effects, particularly along the southern margin of the impoundment footprint where based on vegetation characteristics, the north aspect hill slope above is likely also underlain by permafrost; and
- magnitude of groundwater and seepage influx, and its associated effects.

To in part address these uncertainties, costs assume: i) an allowance for detailed site characterization and design once the majority of the footprint surface is exposed, ii) a significant allowance for water management and physical stabilization throughout the project, and iii) an aggressive revegetation program for exposed surfaces within the Footprint and Watercourse zones.

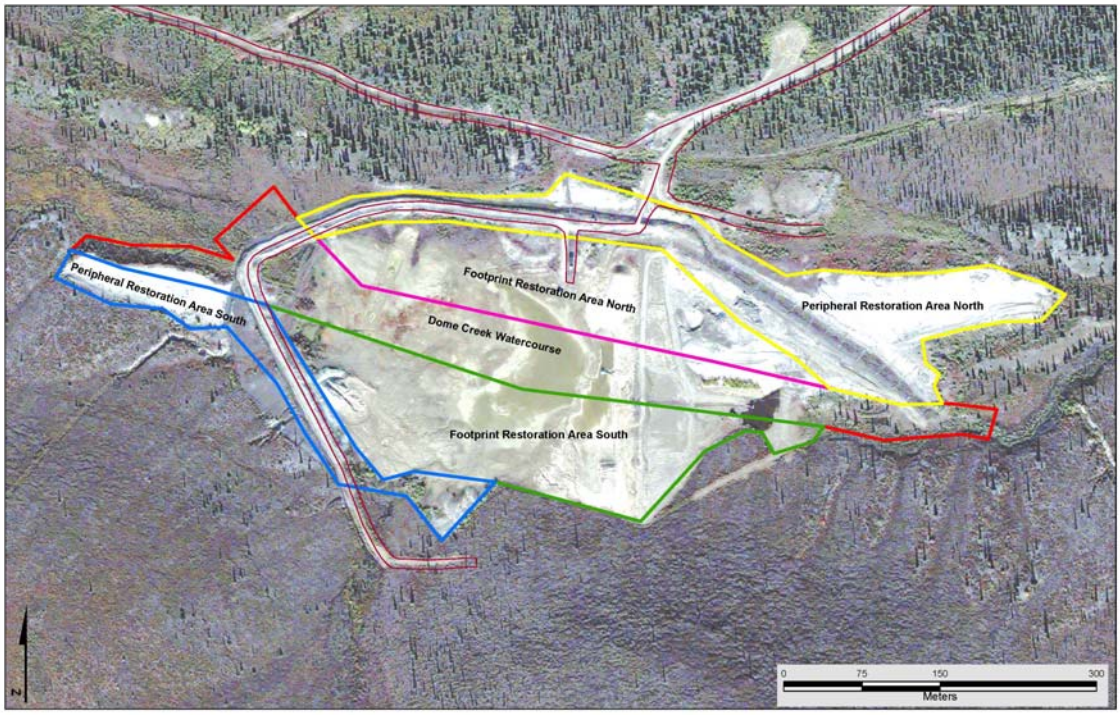
Following detailed site characterization and design, the conceptual closure concept assumes three distinct project phases which are summarized below. Further details of the conceptual work plan and associated costs are given in Appendices B.3 to B.5.

Phase 1, the major work phase, would commence after excavation of tailings mass and of the majority of the dam structures, and would be carried out over an assumed 80 percent of the total excavated footprint. Upstream diversion structures and a small part of the dam structure would be left in place to retain and control drainage in the work area. Costing assumes that material placement, re-contouring, and surface hummocking would be carried out to restore topography, improve water management and control general physical stability. Allowances for temporary water management works, temporary accesses, and localized measures to stabilize/terrace surface and install basic drain structures are also included. While there is a cost allowance for excavation of a main channel for Dome Creek, it is recognized that based on site investigations and characterization, an alterative design may be to incorporate one or more retaining structures to allow formation of a wetland corridor through the TMA. Final surface preparation considers extensive coarse woody debris dispersal and cutting establishment / direct seeding over 100% of the central Watercourse zone and 50% of surface in the Footprint zones.

Phase 2 would begin the following season after completion of Phase 1. In this phase it is assumed that the remaining tailings dam structures are removed while the upstream diversion of Dome Creek is maintained. Restoration work, similar to Phase 1 is then carried out over the remaining 20 percent of the total excavated footprint, including tie-in's to the original Dome Creek channel downstream and upstream of the TMA disturbance.

During Phase 3, Dome Creek flow is introduced into the restored watercourse in a staged fashion and the upstream tailings diversion structure decommissioned. Allowances have been included for remedial earthworks and revegetation work to address localized stability issues that may arise during this period. It is also assumed that temporary accesses will be removed, leaving only a basic trail system for ongoing inspection and monitoring.

Figure 2-7: Zones for Dome Creek Valley Restoration, Options 3 and 4



2.3.2 Waste Rock Pile Area

Final closure measures for the waste rock pile area assume the following main activities:

- re-sloping of remaining angle of repose faces for landscape integration, long term stability, and to improve access for revegetation work;
- de-compaction of platform areas, roads and other running surfaces; and
- surface preparation, coarse woody debris dispersal and revegetation as outlined in Section 1.3.5.

Approximately 2400m of crest length within the waste rock pile has been measured from the site satellite image (see Appendix A.6). By conservatively assigning a 20m horizontally projected slope length, it is considered that up to 4.8ha of the 12ha rock pile is comprised of angle of repose slopes.

Costs assume that to the extent feasible, slopes that 'toe' into undisturbed areas (eg. the lower south margin of the Brown McDade waste rock pile) will be re-sloped using an excavator to pull material from the crest. This measure is intended to minimize expansion of the existing waste rock pile footprint, given the demonstrated metal

mobilization from certain areas of the rock pile (Lorax 2010a). Other slopes internal to the rock pile will be re-sloped using a conventional dozer push. A heavy equipment rate of 50 hours per hectare assumed for the 'excavator pull' re-sloping, and 35 hours per hectare for the 'dozer push' re-sloping.

All other areas of the rock pile will require only conventional surface preparation or re-grading (de-compaction, roughening) at the rate of 25 heavy equipment hours per hectare.

No soil cover placement is considered in the costing.

As seen in Figures 2-1 through 2-6 and in Appendix A.6, the amount of re-sloping and re-grading of the remnant pile is dependent on the amount of waste rock used in open pit backfill operations for the various options. Nonetheless, costs for the entirety of this work do not vary substantially across the options.

2.3.3 Open Pit Area

Final closure measures for the open pit area assumes two major activities:

- regrading, surface preparation, and revegetation of backfill; and
- berming and signage of pit rim where exposed pit wall areas may present a public safety hazard

The degree to which each activity is carried out is a function of the amount of pit backfill carried out in each of the short-listed closure options. Details of the costing assumptions used for each option are provided in Appendix A.7, and are based on surface area data provided by Lorax, as well as the conceptual closure design drawings showing the remnant exposed pit walls.

Costing for relocation of part of the waste rock pile into the open pit was carried out as a supplemental consideration for Options 1A and 2A. Backfill to both elevation 1205 masl and 1200 masl (300,000m^3 and 155,000m^3 waste rock respectively) was costed. Using rough volume estimates of available waste rock in the various zones of the pile (Altura 2009b), the costing exercise illustrates that at most, 100,000m^3 of material is relatively inexpensive to relocate to the pit via direct bulldozer push. Relocation of the balance of waste rock material would likely require a loader/excavator and rock truck fleet, hence the substantially higher unit cost for the 300,000m^3 relocation.

3. Closure Costing of Common Elements

3.1 Overview and Summary

3.1.1 Scope

This chapter describes common closure elements to the Mt. Nansen Mine Site and as illustrated in Figure 3-1, include the following:

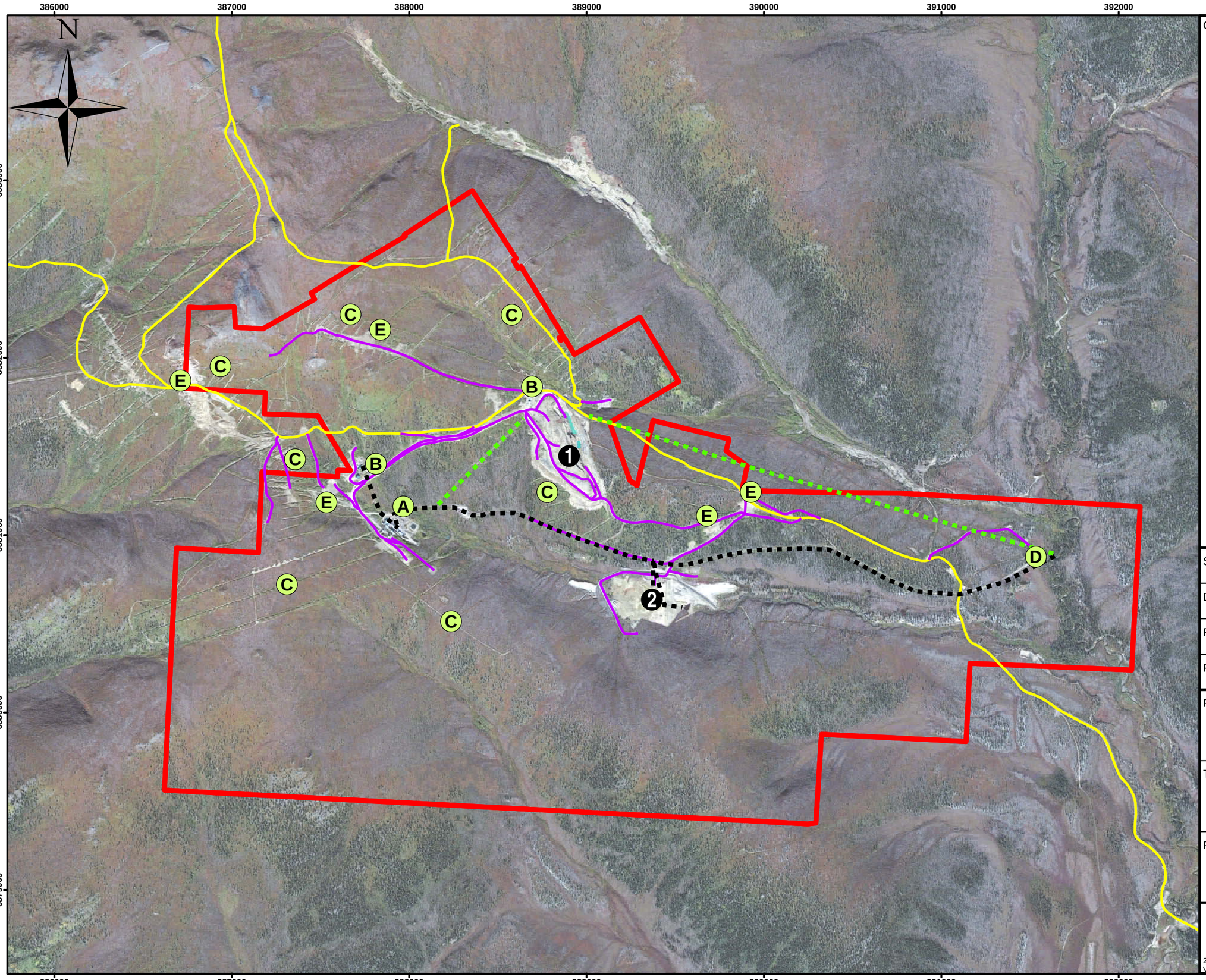
- Mill Area;
- Camp and Site Ancillary Buildings (camp, mine shop, water storage tank building above camp);
- Roads;
- Exploration Trenches;
- Miscellaneous infrastructure (e.g., power supply infrastructure, pipelines, Victoria Creek pump house, core storage areas); and
- Other Areas requiring revegetation and site restoration (eg. exploration clearings and adit disturbance areas, borrow areas, etc.)

Each of the following sections provide an overview, general inventory, and 'Class D' cost estimate (see Section 1.3.3) for each of these six Common Elements at closure.

3.1.2 Assumptions

In addition to the general assumptions discussed in section 1.3, cost determination for Common Elements assume the following:

- Only those facilities, installations, and significant ground disturbances within the 'Mt. Nansen OIC Boundary' are considered. This limit, shown in Figure 3-1, is defined as the area bounded by existing quartz claims held by others, coupled with the perimeter identified in the 2006 Yukon Order in Council (O.I.C.) 2006/205. This Order in Council prohibits entry for the prospecting or for the purposes of placer and quartz claim staking in order "to facilitate reclamation of the lands as a result of mining activity."



CLIENT::

Yukon Government

Legend

- 1 Open Pit and Waste Rock
- 2 Tailings
- Mine Road
- Public Road
- Mt. Nansen OIC Boundary

Powerlines

- Active
- Inactive / Cond'n. Unknown

Common Elements

- A Mill
- B Camp and Ancillary Buildings
- C Exploration Trenches
- D Pump House
- E Clearings

Meters
0 350 700 1,400

SCALE:	1:20,000
DATE:	OCT 6th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Mt. Nansen Mine Area

PROJECT No:	FIGURE No:
J907-4	**3-1**

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- All facilities and workings will be fully decommissioned and will no longer see any use; hence buildings will be removed or demolished. Powerlines, pipelines, tanks and other ancillary equipment will be removed from service. Non-public exploration and mine roads will be decommissioned. It is recognized that it may be deemed appropriate to maintain or re-purpose certain buildings or infrastructure in support of on-going care and maintenance, or to provide services to other interested parties (e.g., Little Salmon Carmacks First Nation).
- Assessments considered integral to carrying out the closure activity have been included in some areas as 'Pre-Closure' activities. It is important to note that these investigations are limited in scope and their assigned costs are not intended to include any required engineering, design, or detailed planning.
- Road and trail differentiation is based on information provided by Government of Yukon. Trails have been defined to require no specific closure measures.

3.1.3 Summary of Results

Table 3-1 gives a summary of the estimated closure costs for the six Common Elements. Further details for each element are given in the following sections.

Table 3-1: Summary of Estimated Closure Costs for Common Elements

		Pre-Closure Phase	**Active Closure Phase**
#	**Component**	**Estimated Cost**	**Estimated Cost**
1	**Mill Area**	$ 78,000	$ 2,190,000
2	**Camp and Ancillary Buildings**	$ 40,000	$ 390,000
3	**Roads**	$ 25,000	$ 210,000
4	**Exploration Trenches**	$ 15,000	$ 210,000
5	**Miscellaneous Infrastructure**	$ 15,000	$ 210,000
6	**Revegetation and Site Restoration of Other Areas**	$ 5,000	$ 210,000
	Subtotal	$ 178,000	$ 3,420,000
	TOTAL ESTIMATED COST		**$ 3,600,000**

3.2 Mill Area

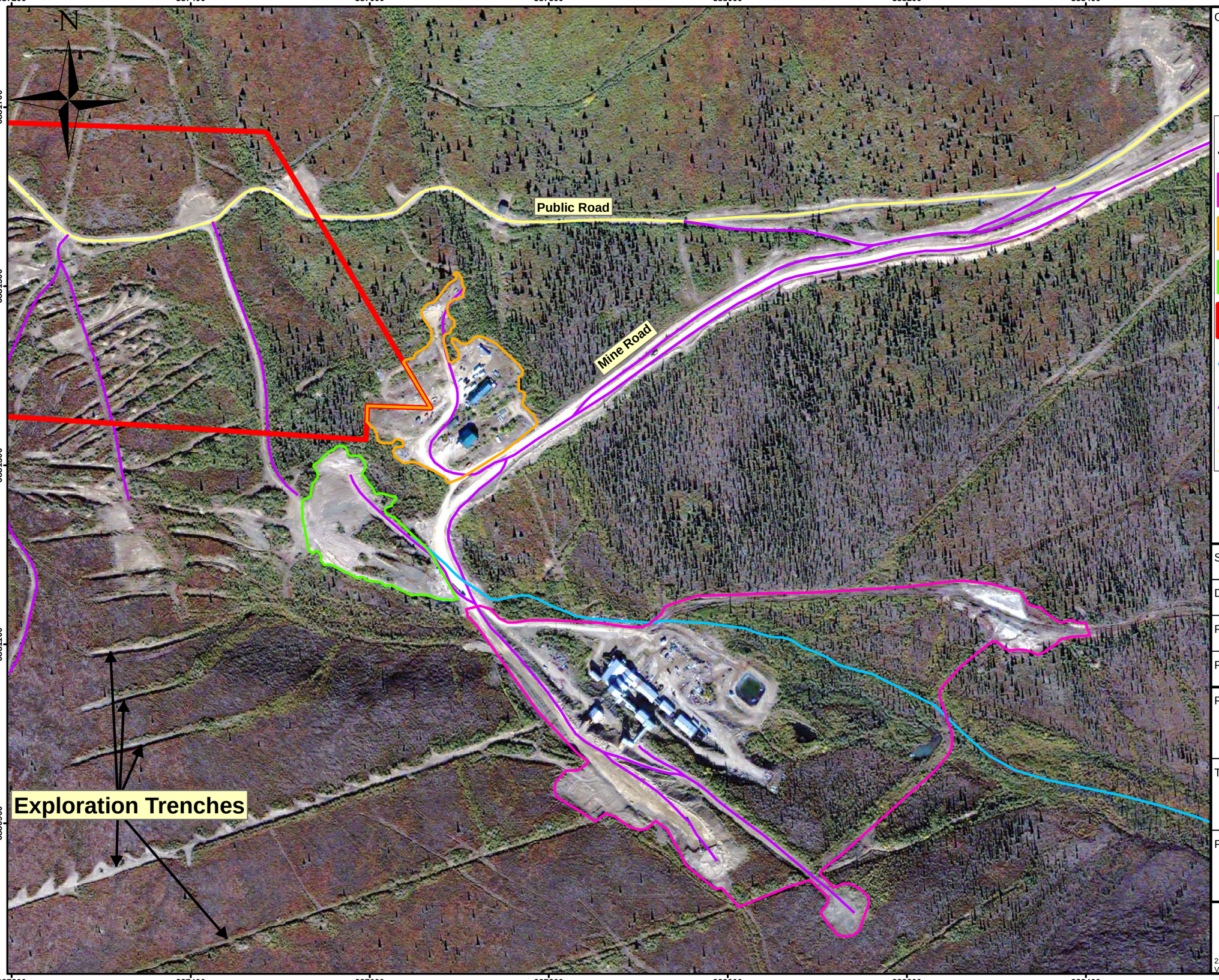
3.2.1 Overview

The Mill Area is shown in Figure 3-2 and includes mill buildings, ponds, roads, platforms, equipment laydown areas, miscellaneous products, pipelines, and powerlines.

According to reports the Mill Area first saw significant use during two brief mining campaigns in the 1960's and 1970's (Conor Pacific, 2000). During that time at least 22,000 tonnes of ore mined from the nearby Huestis workings was transported to the mill area, and processed via froth flotation to produce a sulphide concentrate. Airphotos and company personnel report that at least some ore was brought to the mill via a lower adit which at one time daylighted just northwest of the mill buildings (Figure 3-1). Tailings were reportedly discharged below the mill, and two remnant decant structures remain mainly intact in the naturally revegetated area downhill from the main mill platform (Pond #1 and #2). A third decant structure is visible in old air photographs and is now the site of a geomembrane-lined pond on the lower mill platform (Pond #3). This newer pond was used during and after the 1990's mining phase.

During preparation for mining in the 1990's, the old ore transfer area on the lower levels of the mill site appears to have been levelled out and the conveyor to transport ore up to the crushing circuit removed. The mill underwent retrofitting to accommodate a cyanidation circuit, thickener, and other updated process equipment. A set of diesel-powered generators was installed in part of the old warehouse building and remain in operation today. Conor Pacific (2000) reported that a well was installed in 1997 and used for temporary supply of process make-up water until there was sufficient inventory in the tailings impoundment. The location of this well is not shown in any of the site reports reviewed.

East of the mill buildings is an area which saw ongoing refuse disposal during the life of the mine. A small amount of hazardous products (likely ammonium nitrate and sodium hydroxide) has been noted in this area during 2010 surface reconnaissance and test excavations.



CLIENT::

Yukon Government

Legend

- Mill Area
- Mine Camp
- Contoured Heustis Workings
- Mt. Nansen OIC Boundary
- Dome Creek
- Mine Road
- Public Road

Meters
0 70 140 280

SCALE:	1:4,000
DATE:	OCT 6th, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:

Mt. Nansen 2010 Planning

TITLE:

Mt. Nansen Mill and Camp Area

PROJECT No:	FIGURE No:
J907-4	**3-2**

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Closure-related studies specific to the Mill Area include a site-wide Historical Review, Site Assessment, and Field Sampling Program (Conor Pacific, 2000), a Limited Phase 2 Environmental Site Assessment (Kearah & WERI, 2008), preliminary geochemical investigations (Altura 2009b, Lorax 2010a), and installation and monitoring of four shallow piezometers (AECOM, 2009). Water quality monitoring has been routinely conducted at stations DX, upstream of the mill area, and D1, just below the mill complex (EDI Environmental Dynamics, 2008).

With respect to potential environmental liabilities, salient conclusions from the aforementioned studies include the following:

- Hazardous Products: most hazardous products inside mill and in main laydown areas have been removed, however residual amounts remain in some tanks and vessels within the mill. Minor amounts have been observed outside in the main refuse area. A rail tanker just west of the mill is reportedly under pressure and contains residual amounts of sulphur dioxide. Surveys indicate asbestos products and PCB's do not exist or have been removed. A minor amount of lead-containing paint has been identified from the ball mill. Groundwater monitoring of four Mill Area wells installed during 2009 has not identified detectable hydrocarbon concentrations.
- Tailings: Some tailings are stored in the Mill Area. Of the 20,000+ tonnes of tailings reportedly discharged below the mill area during the 1960's and 1970's, approximately 1000 m^3 (~2,000 tonnes) has been identified in the easternmost pond (Pond #1) in the Mill Area, and anecdotal evidence (Brodie, 1998) that the tailings may have been removed in the late 1990's has not been verified. It is noted that a soil sample taken during 2009 piezometer installation in the area of Pond #2 bears a geochemical signature similar to the known tailings in Pond #1, but the piezometer's drill logs are unclear as to the nature of this material nor the thickness sampled.
- Water Flow Paths: Reconnaissance, excavations, and previous studies indicate that zones below the main mill platform and the vegetated zones below Pond #3 are within a shallow groundwater zone and effectively discharge to the Dome Creek watershed. Above this zone, a seep, possibly originating from the lower Huestis adit area, is the only significant flow identified in the study to be affecting Dome Creek water quality.
- Water Quality: Dome Creek water quality shows increased Cd, Zn, As, and sulphate concentrations along the reach transecting the Mill Area. A deposit of mineralized material presumed from an old ore rail transfer area is likely contributing to flux of metals to Dome Creek. Preliminary assessments suggest that the mineralized fill and

a high-volume seep just west of the mill (possibly associated with the historic adit opening in this area as described above) are likely the primary contributors to Dome Creek metal loading in the vicinity of the mill. Investigations indicate that metal concentrations are partially attenuated downstream, possibly through co-precipitation with Fe-Mn oxide compounds (Lorax, 2010a).

3.2.2 Assumptions

Objectives

Specific objectives to Mill Area closure are:

- reduce zinc and cadmium loading to Dome Creek
- minimize surface and near surface water flow through mill platform area
- ensure that the location of older tailings deposits is identified and where feasible, the old tailings are stored in a location offering long term physical and chemical stability (e.g., open pit or in tailings impoundment)
- restore upper Dome Creek watercourse for long term physical stability
- remove hazardous products
- ensure treatment of hydrocarbon contaminated soil
- decommission and recycle/dispose of buildings

Main Components

Based on site evaluations conducted to date, closure costing for the Mill Area considers the following main components and key assumptions given in Table 3-2. Items not included in the closure cost estimate are as follows:

- Powerlines and associated transformers and switchgear, roads, pipelines, and exploration trenches are discussed separately in Section 3.6;
- Remediation of underground workings, including adit plugging if relevant;
- Water treatment costs. Costs for temporary sediment control measures have been assumed where potentially applicable, but since sampling of ponds indicates compliance with existing water license levels for metals, there is no allowance for additional water treatment.

Table 3-2: Main Components and Key Assumptions for Closure Costing of the Mill Area

Component	Key Assumptions
Mill buildings	Minor amounts of residual hazardous products No asbestos, no PCB's Minor amounts of lead-containing paint
Old refuse disposal area principally containing non-hazardous waste with some hazardous waste	Minor amounts of hazardous products Remaining waste can be landfilled in-situ
Laydown areas containing metal, pipes, abandoned equipment, miscellaneous waste and consumables	Minor amounts of hazardous products
Three Ponds #1, #2, #3 (two earthen, one geomembrane lined). Pond #1 (earthen) confirmed to contain sulphide and metal-rich tailings	Apart from tailings identified in Pond #1, no other deposits of recoverable tailings Water in all ponds meets Water License effluent discharge requirements
Fuel and miscellaneous petroleum product storage in concrete containment and fuel dispensing area	2 X 10,000 gallon (45,500L) diesel tanks Likelihood of hydrocarbon-contaminated soil and concrete
Mill Disturbance Area: rock fill platforms	4 ha, in a series of 5 platforms. Lower platform contains approximately 6500 m^3 of potentially ARD/ML material within or near the saturated zone and will require relocation
Dome Creek watercourse, some sectors with platforms and scrap metal pushed to the edge of the stream	Culvert, scrap metal to be removed from watercourse
Rail tanker reportedly with residual pressure and containing a minor amount of sulphur dioxide	0.08 L sulphur dioxide (Kearah and WERI, 2008)

3.2.3 Inventory and Cost

Closure activities for the Mill Area are divided into ten main tasks. Pre- and Active Closure phase aspects are summarized in Table 3-3 along with estimated costs. Further cost details are given in Appendices B.1 and B.2.

Table 3-3: Main Closure Tasks and Estimated Costs for the Mill Area

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Control of water flow through mill disturance area**	additional investigation above and at the north corner of the mill to source the high volume seep (possibly old adit?)	$ 10,000	- improve cut-off ditching to direct drainage around millsite area - armour and stabilize any permanent water diversion structures	$ 20,000
2	**Removal of reactive rock fill from old ore transfer site**	no specific assessments identified	$ -	- remove rock fill in lower platform area that is demonstrably leachable and within or near the saturated zone (eg. old ore transfer area that has been re-worked) - estimate up to 6500m3; - adjustment of excavation based on material and flowpath characteristics	$ 100,000
3	**Decomissioning of Pond #1 - Accumulation of Old Tailings**	additional field and document investigation and sampling to determine extent of tailings	$ 7,500	-removal of accumulation tailings fines in Pond #1 (roughly estimated at up to 1000m3) - watercourse restoration and revegetation	$ 200,000
4	**Decomissioning of Pond #2**	additional field and document investigation and sampling to determine presence/absence of tailings	$ 7,500	- dewater impounded water via pump, recontour and ditch to ensure no water impoundment, encourage revegetation	$ 20,000
5	**Decomissioning of Pond #3**	additional field and document investigation and sampling to determine presence/absence of tailings (note some of this assessment is deferred to active closure phase once pond liner is removed)	$ 3,000	- dewater impounded water via pump. Characterize any accumulated solids at pond bottom. Remove liner and dispose with non-hazardous waste. - assess fill below and in immediate area of pond to identify any significant amounts of old tailings	$ 20,000
6	**Watercourse restoration**	no specific assessments identified	$ -	- removal of culvert and road crossing at start of reclaim line road - estimate 500m3 - removal of other rockfill within 5 metres of Dome Creek watercourse - estimate 500m3 - recontour and encourage natural revegetation	$ 40,000

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
7	**Removal of fuel storage equipment and hydrocarbon contaminated soil / concrete**	soil investigation for local hydrocarbon contaminaton	$ 10,000	- remove tanks and appurtenances; remove contaminated soils and contaminated concrete as required	$ 50,000
8	**Removal of mill buildings and other structures**	final assessment for hazardous products and local soil contamination	$ 20,000	- remove any remaining hazardous products, remove contaminated soil if required, salvage/recycle material as feasible, landfill remainder in place - drainage control to reduce seepage through excavation	$ 1,550,000
9	**Removal of hazardous products and refuse around mill**	assess for hazardous products, and as required, local soil assessment	$ 20,000	- remove any remaining hazardous products, remove contaminated soil if required - remove any surface-exposed non-hazardous refuse	$ 70,000
10	**Recontouring and revegetating mill disturbance area**	no specific assessments identified	$ -	- recontour to a stable configuration; create small scale undulations (±0.5m) to encourage natural recolonization - de-compact all exposed roads and platforms to 0.8m depth - assumes no placement of cover material - encourage natural revegetation	$ 120,000
	Subtotal		$ 78,000		$ 2,190,000
	TOTAL ESTIMATED COST				**$ 2,268,000**

3.2.4 Uncertainty

Main uncertainties affecting the Mill Area closure cost estimate include, in approximate order of cost implication:

- **Existence and location of tailings in the study area**. Historical records indicate between 20,000 and 25,000 tonnes of tailings generated from earlier mining phases, of which only approximately 1000 m^3 (2000 tonnes) has been confirmed as stored in Pond #1. There is unverified and anecdotal evidence (Brodie, 1998) that tailings were relocated in the late 1990's. *Cost estimate assumes only removal of up to 1000m^3 of tailings.*
- **Water treatment requirements.** Metal concentrations of water in ponds indicates compliance with existing water license standards, however some seeps in the Mill Area show concentrations exceeding these standards. *Cost estimate has no allowance for water treatment other than temporary sediment control measures.*
- **Availability of sufficient cover material for in-place landfilling of mill demolition refuse.** Detailed volume surveys of mill platform material have not been completed. *Cost estimate assumes that no additional cover material is required.*
- **Location of the lower Huestis adit.** According to airphotos and site personnel, the lower Huestis adit emerged from the hillside in Dome Creek adjacent to the mill. Field investigations identified a high-volume seep in the immediate area of the adit that appears to be significantly contributing to metal loading in Dome Creek. *Cost estimate does not include remediation of the adit or its supposed discharge.*
- **Final volume of mineralized material to be relocated from lower mill platform.** This volume is estimated to be up to 6500 m^3, and the actual volume will be field-determined during the relocation phase. *Cost estimate assumes removal of 6500 m^3 of mineralized material; this is considered a conservative approximation.*
- **Quantity of remaining hazardous materials within and outside of mill.** Limited assessments have been conducted which indicate that most products have been removed from site. *Cost estimate assumes minor amounts of remaining hazardous products.*

3.3 Camp and Site Ancillary Buildings

3.3.1 Overview

The Camp and Site Ancillary Buildings include the main camp area along with the mine shop, adjacent bone-yard, and laydown areas, as well as the water storage tank above the camp. The main camp area is shown in Figure 3-2. Note that this area lies in close proximity to the OIC boundary, with some of the camp clearing lying outside of these limits.

It is understood that the main camp area was constructed in the 1960-70's mining era and then upgraded during the mid-1990's when several Atco®-style camp trailers were used to house mine employees. These trailers have since been removed from site.

The remaining camp kitchen, office/bunkhouse, and workshop are currently in use to support ongoing care and maintenance activities, and their upkeep is funded by the Government of Yukon. Water for camp use is supplied by a stand-alone water tank that is filled by water truck. A power line runs from the mill site for electricity. It is understood that there are buried and on-surface water lines in the camp area, most inactive. It is also understood that domestic sewage is disposed of in a tank and drain field system, with the tank contents periodically pumped and transported off-site. The specific location of the system has not been confirmed for this estimate. Other materials in the vicinity of the camp include core storage areas, at least one shed in disrepair, and miscellaneous consumables. Propane and gasoline tanks are located in the lower platform of the camp area and are still in use.

The mine shop is unheated, and sees occasional use in supporting ongoing care and maintenance activities. Miscellaneous consumables, tools and components, the majority no longer in use, are stored within and around the building.

Conor Pacific (2000) included review of the Camp and Site Ancillary Building areas as part of their Historical Review, Site Assessment, and Field Sampling Program, however from review of other available documents it is not clear what aspects have since been remediated during the current care and maintenance phase. The Conor Pacific document notes above-ground fuel storage at both the camp area and the mine shop complex, and the existence of an old transformer (of vintage to potentially house PCB-containing oil) at the mine shop, however it is understood from Yukon Government Assessment and Abandoned Mines that all PCBs have been removed from the site at large. A review of documents indicates that there have been no other closure-related studies specific to the Camp and Ancillary Buildings Area. Altura (2009c) noted a strong hydrocarbon odour in

a geochemical investigation test pit in the road bed immediately below the camp, however to date no follow-up work has been completed to determine the source.

The Camp and Ancillary Building sites are assumed to have relatively low levels of potential environmental liability, nonetheless the following aspects are considered to apply to these areas: i) presence of localized hydrocarbon-contaminated soil, ii) presence of minor amounts of lead-containing paint, and iii) presence of minor amounts of hazardous products. It is understood from communication with Yukon Government Assessment and Abandoned Mines that no PCB-containing fixtures remain on site. It is also assumed that no asbestos products are present (consistent with site assessment findings for the mill complex).

3.3.2 Assumptions

Objectives

Specific objectives to the Camp and Site Ancillary Buildings are:

- remove hazardous products
- ensure treatment of hydrocarbon contaminated soil
- decommission and recycle/dispose of buildings

Main Components

Based on site understanding review of available documents and map information, closure costing for the Camp and Site Ancillary Buildings considers the main components and key assumptions given in Table 3-4. Items not included in the closure cost estimate are as follows:

- Powerlines and associated transformers and switchgear, pipelines, and roads are described separately in Section 3.6.
- Portion of the Camp Area clearing outside of the OIC boundary (see Figure 3-2).

Since it is desirable to continue using the camp facilities while the major site work is being undertaken, the camp area would likely be decommissioned as late in the active closure phase as is feasible. Further, as mentioned previously it has been acknowledged that the camp facilities ultimately may not be decommissioned should a local or private party show interest in using, buying, and/or assuming liability for it (e.g., Little Salmon Carmacks First Nation).

Table 3-4: Main Components and Key Assumptions for Closure Costing of the Camp and Site Ancillary Buildings

Component	Key Assumptions
Camp Buildings: Kitchen, office/bunkhouse, workshop/garage	Minor amounts of residual hazardous products No asbestos, no PCB's Minor amounts of lead-containing paint (some buildings pre-date late 1970's ban)
Clearings, Camp area	2 ha, in a series of 4 platforms connected by roads Minor amounts of residual hazardous products, minor refuse to be removed Minor laydowns of supplies and small equipment Core storage in various areas
Fuel and Propane storage, lower camp platform	Gasoline in one 2000 gallon (4,550L) 'enviro tank', fuel dispensing equipment in current use - potential for hydrocarbon soil contamination from fuel dispensing 4 – 1000 lb. propane tanks, in current use
Water Tank Building, above camp adjacent to main Nansen road	35,500 gallon (161,500L) wood stave water tank housed in stand-alone building (T.W. Higgs, 1994), not in use; clearing 500 m^2
Mine Shop and laydown ('Ketza Construction Yard')	Metal clad building approximately 250m^2, Minor laydowns of supplies and small equipment, 1500m^2 metal and miscellaneous scrap yard to southeast, equipment parking platform to north, potential for hydrocarbon soil contamination due to maintenance activities and fuel tanks during mining; total 0.8ha area.

3.3.3 Inventory and Cost

Closure activities for the Camp and Site Ancillary Buildings are divided into three main tasks. Pre- and Active Closure phase aspects are summarized in Table 3-5, along with estimated costs. Further cost details are given in Appendices B.1 and B.2.

Table 3-5: Main Closure Tasks and Estimated Costs for the Camp and Site Ancillary Buildings

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Camp Area**	- hazardous product inventory - hydrocarbon contaminated soil assessment	$ 20,000	- remove refuse and stored material, remove hazardous products - remediate hydrocarbon soil contamination as required - remove propane and gasoline storage tanks - dismantle buildings, recycle and salvage as feasible. - platform decompaction, regrade and encourage natural revegetation	$ 220,000
2	**Water Tank**	no specific assessments identified	$ -	- remove tank and building, remove surface-exposed piping, re-grade	$ 40,000
3	**Mine Shop and Laydown**	- hazardous product inventory - hydrocarbon contaminated soil assessment	$ 20,000	-remove refuse and stored material, remove hazardous products - remediate hydrocarbon soil contamination as required - dismantle buildings, recycle and salvage as feasible. - regrade and encourage natural revegetation	$ 130,000
	Subtotal		$ 40,000		$ 390,000
	TOTAL ESTIMATED COST				**$ 430,000**

3.3.4 Uncertainty

Main uncertainties affecting the Camp and Site Ancillary Buildings closure cost estimate include:

- **Ultimate disposition of the camp:** in the event of a requirement for continuous site presence following active closure or a decision to cede the facility to a third party, much of the camp facility would remain intact.
- **Quantity of remaining hazardous materials and/or hydrocarbon-contaminated soil within the camp and mine shop area.** Limited assessments have been conducted which indicate that most products have been removed from site, however there appears to have been no systematic assessment for hydrocarbon-contaminated soil.

3.4 Roads

3.4.1 Overview

As shown in Figure 3-1, there is an extensive network of roads in over the Mt. Nansen site, developed over the last 70 years to support mineral exploration as well as quartz and placer mining needs. The roads range from narrow temporary accesses for trenching campaigns to an approximately 15m-wide thoroughfare at one time used by mine haul trucks. The roads are in various states of repair and currently see different levels of use.

Certain thoroughfares through the Mt. Nansen site are used by other operations in the area and are designated as 'Public', and shown in Figure 3-1. These sections will remain active and will not be decommissioned and reclaimed as part of the Mt. Nansen site closure.

Conceptual closure and cost estimates for road decommissioning are based on Altura's general site familiarity as well as preliminary mapping information provided by Assessment and Abandoned Mines. No detailed mapping or ground-truthing of the more remote roads has been conducted to date, and their state of repair and environmental liability issues are largely unknown.

Roads are surfaced with locally-sourced material, have a highly compacted running surface, were typically constructed with cut and fill method, and in some sections are ditched with culverts installed. It is understood that there are no bridge crossings to be removed.

The 1.2 km mine haul road merits specific consideration in that the original road, a cut and fill structure, was substantially widened, straightened, and bermed in the late 1990's by dumping waste rock hauled from the Brown McDade pit (Altura, 2009c, 2009d). As a result, several sections of the haul road have long angle of repose slopes that cannot readily be resloped and integrated with the surrounding terrain. Haul road test pit characterization by Altura (2009c) indicated that:

- berm material, particularly along the eastern sector towards the mine, exhibits mixing with potentially reactive highly altered and sulphidic material;
- excess road bed could be suitable for use elsewhere as low-reactivity construction material (providing that there is field quality control and avoidance of berm material and zones near the mill); and
- soil and rock with a strong hydrocarbon odour were encountered in a test pit in the haul road bed below the camp, and it is considered likely that a minor amount of roadbed material will require soil remediation.

Many trails exist throughout the Mt. Nansen site. Trails are considered thoroughfares that are not passable by regular vehicle, have little or no constructed roadbed, and are largely vegetated.

3.4.2 Assumptions

Objectives

Specific objectives to closure of site Roads are:

- prevent future ingress by light vehicles or equipment
- minimize erosion
- encourage natural revegetation

Main Components

Closure costing for the site Roads considers the main components and key assumptions given in Table 3-6. Items not included in the closure cost estimate are as follows:

- Trails (as noted in Section 3.1.2);and
- Public roads (Figure 3-1) – these are thoroughfares within the Mt. Nansen OIC boundary that are utilized by other parties such as placer miners and hunters for accessing areas within and beyond the immediate Mt. Nansen site. Public roads will not be decommissioned as part of Mt. Nansen closure activities.

Table 3-6: Main Components and Key Assumptions for Closure Costing of Roads

Component	Key Assumptions
Public Roads	6.5 km within OIC Boundary No closure activities on these roads
Mine Roads	Total 11.6 km within OIC Boundary, not including haul road described below All Mine Roads to be ultimately decommissioned Minor amount of roadbed material will require hydrocarbon remediation All material geochemically stable
Haul Road	1.2 km of 15m-width haul road from mine shop to mill A portion of the berms (up to 1000m^3) potentially leachable material; all other haul road material insitu is considered to have minimal potential effect to water quality. Minor amount of roadbed material will require hydrocarbon remediation
Trails	No closure activities on trails

In general, road surfaces will be de-compacted to 0.8m depth and recontoured to integrate with the surrounding terrain. Culverts will be removed, and water bars or other control structures will be created as required to minimize erosion and direct surface water and seepage through the disturbance. The surface will be left undulating and non-compacted, and as available, materials such as organics, natural coarse woody debris will distributed over the final surface.

A blanket rate equivalent of 25 heavy equipment hours per kilometre of road (assuming CatD9, Cat 300-series excavator or equivalent) is assumed for site preparation of the Mine roads. Due to its substantially larger width and longer fill slopes, 75 equipment hours per kilometre rate has been applied to the 1.2 km haul road from the mine shop to

the mill. These rates are reasonably consistent with those utilized for the closure costing for the nearby Western Copper project (Access Consulting Group, 2009), and for the Red Dog Mine in Alaska (SRK Consulting, 2009). It is recognized that other equipment or support such as labour, loader or dump truck may be substituted for certain areas and tasks such as culvert removal and relocation of material.

Revegetation is assumed over approximately 10 percent of the narrower roads (15m disturbance width), and concentrated in larger disturbances and those areas requiring physical stabilization. Revegetation on the haul road is assumed to take place over 25 percent of the disturbance owing to its slope and size.

3.4.3 Inventory and Cost

Closure activities for the Roads are divided into two main tasks. Pre- and Active Closure phase aspects are summarized in Table 3-7 along with estimated costs, and further cost details are given in Appendices B.1 and B.2.

Table 3-7: Main Closure Tasks and Estimated Costs for Roads

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Mine Roads (all non-public roads within OIC boundary)**	- hydrocarbon contaminated soil assessment; ground-truthing to evaluate decommissioning requirements	$ 15,000	- site preparation: decompaction and recontouring, culvert removal, drainage control, coarse woody debris dispersal as available - remediate soil hydrocarbon contamination - encourage natural re-vegetation	$ 120,000
2	**Haul Road**	- hydrocarbon contaminated soil assessment	$ 10,000	- site preparation: decompaction and recontouring, relocation of potentially reactive berm material, drainage control, coarse woody debris dispersal as available - remediate soil hydrocarbon contamination - encourage natural re-vegetation	$ 90,000
3	**Trails**	no closure activities	$ -	no closure activities	$ -
	Subtotal		$ 25,000		$ 210,000
	TOTAL ESTIMATED COST				**$ 235,000**

3.4.4 Uncertainty

Main uncertainties affecting the Roads closure cost estimate include:

- **Detailed inventory**. An on-ground inventory of roads to be reclaimed has not yet been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge, which can not take into account local occurrences potentially complex conditions such as permafrost, seepage areas, or acid rock drainage and/or metal leaching.

3.5 Exploration Trenches

3.5.1 Overview

There are numerous exploration trenches over the Mt. Nansen site that were not reclaimed by previous operators, largely due to absence of mining land use legislation at the time. Trenches are visible as long linear features, typically clustered around a mineralized zone of interest (Figures 3-1 and 3-2). Many trenches at the Mt. Nansen site are several hundred metres in length.

Most of the trenching was carried out from the mid-1980's through to the late 1990's. In general, trenching programs during this period entailed initial pre-stripping of the top 0.5m of vegetation and sub-soil with a bulldozer to allow for any permafrost to thaw. Several weeks later (or the following field season), trenching to approximately 1 to 2m depth by 1m width was completed with a large excavator, leaving a slot excavation in the order of 2m overall depth, with sidecast material piled on one or both sides. The Huestis zone trenches above the mill present a special reclamation challenge. They are very long and generally well over 3m deep due to being initially trenched with a dozer to about 1.5 m depth (in the 1970's), and in the mid 1980's deepened with an excavator. Some sections of these trenches were recently filled in as part of the care and maintenance activities and thus provide valuable field-verified cost estimate data.

No detailed mapping or ground-truthing of the Mt. Nansen exploration trenches has been conducted to date, and their current condition and environmental liability issues are largely unknown. However, in general open trenches can present a public safety hazard in those areas frequented for animal, plant and berry harvesting, and as well can cause alterations to wildlife movement patterns. Some trenches alter the drainage characteristics of the area, and some may present ongoing erosion concerns. In rare cases, local water quality may be affected due to acid rock drainage and/or metal leaching.

Due to mine development and other later workings, some trenched areas at Mt. Nansen are no longer easily accessible for heavy equipment to carry out reclamation activities. Thus, the decision to carry out trench-filling work should be weighed against the potential for those additional impacts created by developing new trails to these areas.

3.5.2 Assumptions

Objectives

Specific objectives to the closure of site Exploration Trenches are:

- protect public safety
- minimize erosion
- restore natural drainage characteristics as feasible
- encourage natural revegetation

Main Components

Closure costing for the site Exploration Trenches considers the main components and key assumptions given in Table 3-8. A more detailed inventory of trenches is given in Appendix B.3.

Table 3-8: Main Components and Key Assumptions for Closure Costing of Trenches

Component	Key Assumptions
Trenches	Approximately 15 lineal km within OIC Boundary 2 lineal km of deep trenches already backfilled during care and maintenance; 2 lineal km of deep trenches remaining 80% of outstanding 11km are feasible be backfilled Field verification required

As previously mentioned, trench backfilling was carried out in 2008 on approximately 1.7km of trenches in the Huestis zone above the mill. Based on information provided by Assessment and Abandoned Mines, a total of 125 hours was required to complete the work, yielding in the order of 75 equipment hours per kilometre. As noted in Section 3.5.1, these particular trenches present considerable challenge due to their significant depth, and it is expected that other areas will require less effort. For the approximately 2km of trenching remaining in the Huestis area above the mill the 75 equipment hours per kilometre is assumed. As noted in Table 3-8, due to potential impacts created by re-accessing some trenches, it is assumed that only 80 percent of the remaining 11km of trenches will be filled. A rate of 60 equipment hours per kilometre is applied to these areas.

In general, trenches will be accessed via a temporary trail, utilizing existing trails and roads where possible. The trenches will be backfilled using available sidecast material, and recontoured to integrate as possible with the surrounding terrain. Water bars or other control features will be created as required to minimize erosion and direct surface water and seepage across the trenching disturbance into natural depressions or drainages. The backfilled surface will be left undulating and non-compacted, and as available, materials such as organics, natural coarse woody debris will distributed over the final surface. Due to the narrow linear nature of the disturbance, no re-vegetation activities are assumed, except in those areas requiring additional erosion control. For the purposes of costing, revegetation is assumed to take place over 2 percent of the trenches backfilled.

3.5.3 Inventory and Cost

Closure activities for the Exploration Trenches is assumed as one single task. Pre- and Active Closure phase aspects are summarized in Table 3-9, along with estimated costs. Further cost details are given in Appendices B.1 and B.2.

Table 3-9: Main Closure Tasks and Estimated Costs for Exploration Trenches

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Backfill Trenches**	- ground-truthing survey to assess state of trenches, confirm conceptual estimates, and assess viability of access for reclamation	$ 15,000	- access trenches via existing roads/trails, or create temporary trails, backfill using available sidecast material, contour to integrate with surrounding terrain, drainage control and erosion prevention, coarse woody debris dispersal as available, limited re-vegetation	$ 210,000
	Subtotal		$ 15,000		$ 210,000
	TOTAL ESTIMATED COST				**$ 225,000**

3.5.4 Uncertainty

Main uncertainties affecting the Trenches closure cost estimate include:

- **Detailed inventory.** Similar to the Road Common Element, an on-ground inventory of exploration trenches to be reclaimed has not yet been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge, which can not take into account local occurrences potentially complex conditions such as permafrost, seepage areas, or acid rock drainage and/or metal leaching.

3.6 Miscellaneous Infrastructure

3.6.1 Overview

Other Common Element infrastructure and facilities include power supply infrastructure, pipelines and other specific facilities described in the following paragraphs.

Power Supply Infrastructure: these are existing line routes, both active and inactive, across the property, along with associated transformers and switchgear. The lines known to be active transmit power generated from the site generator facility located at the millsite and it is understood that they include: i) mill site to camp, ii) mill site to tailings pond and seepage pond, and iii) tailings pond to Victoria Creek pumphouse. Other lines, understood to be inactive and in unknown condition include: i) mill site to mine shop, ii) camp to water tank, and iii) Pony Creek to Victoria Creek pumphouse. There is no systematic inventory of remaining powerline infrastructure nor switchgear, and it is understood that all remaining transformers on site are in service and located at the mill site, camp or Victoria Creek pumphouse areas.

Pipelines: main pipeline routes include those from Victoria Creek pumphouse to the tailings area, tailings area to the mill, and from the mill to camp and water tank areas. There are several intermediate pump shacks in the tailings area in various states of repair. There has been no systematic inventory of pipelines completed, and at least one, and in many cases two or three partial lines of pipes may be located along these routes. There are several other minor pipeline sections noted remaining within the mine, tailings, and camp areas; as well, there is potentially an older pipeline originally installed along the old powerline route from Victoria Creek to Pony Creek.

Victoria Creek Pumphouse: Victoria Creek pumphouse is located adjacent to Victoria Creek and approximately 2km east of the tailings impoundment. The facility was originally commissioned and used during the 1960's to 1970's mining periods for supply of fresh water for processing and for the camp. The facility is still used for filling the site

water truck for supply of camp water. It is understood that water is supplied from a single artesian well with multi-staged submersible pump, and housed in a wood frame pumphouse (F. Patch, pers. comm., 2010, T.W. Higgs, 1994). The pumphouse is located in a clearing covering an approximately 1000 m^2 area.

Core Storage Areas: diamond drill core is stored in several locations at the old Pony Creek exploration camp, and at the mine camp area. The majority of the core storage areas have core boxes are well-labelled and intact. The boxes are either stacked or on racks that have fallen into disrepair.

3.6.2 Assumptions

Objectives

Objectives for closure of the Miscellaneous Infrastructure components are consistent with the over-arching site-wide criteria, and no specific objectives have been identified.

Main Components

Closure costing for Miscellaneous Infrastructure considers the main components and key assumptions given in Table 3-10.

Power supply infrastructure will be deactivated by qualified industrial electricians. Remnant power cable and switchgear will be removed, and disposed of along with general site waste, with recycling and salvage as feasible. It is assumed that older power poles may be cut down at the base and bucked up to remain in the field. Newer power poles may be salvageable, may be creosote-containing, and are assumed to be cut off at the base and transported out of the field. Transformers will be salvaged or disposed of in accordance with applicable regulations. It is understood that most powerline right-of-ways are narrow and infrequently used, and thus, minimal re-vegetation requirements are assumed. There is insufficient information to allow for further development of a closure strategy, in particular with respect to vehicular access to power line right-of-ways, and details on infrastructure remaining in the field. Thus for preliminary costing purposes a blanket allowance has been assumed.

Table 3-10: Main Components and Key Assumptions for Miscellaneous Infrastructure

Component	Key Assumptions
Power Supply Infrastructure	Active lines: approximately 5km Historical lines, condition unknown: approximately 4km No hazardous products Limited vehicular access Field verification required
Pipelines	5km of main pipeline routes plus 4 km of miscellaneous pipeline sections in other areas Multiple and/or partial segments of pipeline, majority above ground Pump shacks in various states of repair No hazardous products Limited vehicular access Field verification required
Victoria Creek Pumphouse	One artesian well (characteristics unknown), submersible multi-stage pump, pumphouse 1000 m^2 clearing
Core Storage Areas	Vehicular and heavy equipment access

Above-surface pipelines along with remnant insulation and debris will be removed from the field to be disposed of or salvaged. Usable equipment in pump shacks will be salvaged, and the buildings removed from site and dismantled or salvaged. Minimal re-vegetation requirements are assumed. Due to insufficient information on remaining infrastructure and access, a blanket allowance has been assumed for preliminary costing purposes.

It is assumed that the down-hole pump and piping will be removed from the artesian well at Victoria Creek and the well sealed. The pumphouse equipment will be removed form the site and salvaged or disposed of, along with the pumphouse building. The clearing will be re-graded and left in a state conducive to promoting natural revegetation, and a minor allowance for active re-vegetation is included.

Given its high scientific value for both the Mt. Nansen region in general and for potential future questions concerning decommissioning of the site, it is considered important that sufficient core be archived for future use. Nonetheless, there are limited resources for on-site storage of large quantities of drill core. Where possible, intact drill core will initially be amalgamated to a common storage area. Options to consider for closure include: i) construction of a open, roofed storage shelter for long term preservation of the core on site, and/or ii) transfer of representative intervals to the H. S. Bostock Core Library for long term archiving. Core that is to be no longer stored may be emptied from the boxes and placed in the Brown McDade waste rock pile. The boxes may then be disposed of along with other site wood refuse.

3.6.3 Inventory and Cost

Closure activities for Miscellaneous Infrastructure are divided into four main tasks. Pre- and Active Closure phase aspects are summarized in Table 3-11 along with estimated costs. Further cost details are given in Appendices B.1 and B.2.

Table 3-11: Main Closure Tasks and Estimated Costs for Miscellaneous Infrastructure

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Power Supply Infrastructure**	- field assessment and inventory	$ 5,000	- deactivate powerlines - remove remnant cable and switchgear, salvage/recycle/dispose as feasible; remove transformer and dispose/salvage - remove newer power poles and salvage as feasible - no re-vegetation allowance assumed	$ 50,000
2	**Pipelines**	- field assessment and inventory	$ 5,000	- remove above-surface pipelines along with remnant insulation and debris, salvage/recycle/dispose as feasible - remove pump shacks and equipment; salvage/recycle/dispose as feasible - no re-vegetation allowance assumed	$ 50,000
3	**Victoria Creek Pump House**	-assess artesian well and develop decommissioning strategy	$ 5,000	- decommission and seal artesian well - remove pump house and equipment; salvage/recycle/dispose as feasible - surface preparation of clearing, minor re-vegetation allowance assumed	$ 80,000
4	**Core Storage Areas**	- no specific assessments identified	$ -	- archive representative drill holes, disposal of remaining drill core	$ 30,000
	Subtotal		$ 15,000		$ 210,000
	TOTAL ESTIMATED COST				**$ 225,000**

3.6.4 Uncertainty

Main uncertainties affecting the Miscellaneous Infrastructure closure cost estimate include:

- **Detailed inventory**. An on-ground inventory of power lines and pipelines has not yet been completed. All costing assumptions are based on satellite photo interpretation, general site knowledge, and other limited information. Degree of access to these sites and the actual amount of cable and other infrastructure remaining in the field will greatly influence decommissioning cost. Additional site information is required.
- **Well Characteristics.** It is understood that the water supply well at Victoria Creek is artesian, however no further details are available. The specific well decommissioning strategy and associated cost will greatly depend on the nature of the aquifer and of the actual well configuration.

3.7 Revegetation and Site Restoration of Other Areas

Given the long mining and exploration history in the area, there are numerous clearings and minor disturbances within the Mt. Nansen OIC boundary for which site restoration is expected to be relatively simple, requiring: minimal stabilization, re-contouring and re-vegetation. Restoration and revegetation of these areas is addressed in this section.

3.7.1 Miscellaneous Clearings

Based on available information there are several sizeable clearings ($\geq$1000m^2) at the Mt. Nansen site. While most sites will require surface preparation, a few have been previously re-contoured, with or without some re-vegetation efforts.

Over 8ha of clearing disturbance has been identified across the exploration and mining areas (see Appendix B.4), nonetheless there are likely numerous other minor clearings in existence that will require these basic remediation efforts.

For costing purposes, 16ha of small clearing disturbance is assumed.

Surface preparation (removal of minor debris, erosion and runoff control measures, de-compaction, re-contouring, surface roughening) is assumed at an average of 20 heavy equipment hours per hectare.

Revegetation measures assume that owing to their small size that certain clearings will require minimal revegetation effort, at an assumed average of 15% of the disturbance area.

3.7.2 Tailings Peripheral Areas

For the purposes of costing, the Tailings Management Area disturbance was divided into two zones:

i) *The main tailings storage area and dam.* Closure approach and cost for remediation of these areas are addressed in section 2.1: Supplemental Costs for Short-Listed Options.

ii) *The tailings diversion system and upstream and downstream borrow disturbances.* Closure approach and cost for remediation of these 'Tailings Peripheral Areas' is considered a Common Element and is discussed in this section.

Costing assumes 9ha of Tailings Peripheral Area, with the standard 25 heavy equipment hours allocated for surface preparation, and active revegetation over 25% of the surface. See Appendix A.1 and A.2 for further details of cost estimation for this area.

3.7.3 Waste Rock and Open Pit Areas

Closure approach and cost for remediation of the waste rock and open pit disturbances is addressed in section 2.1: Supplemental Costs for Short-Listed Options.

3.7.4 Other Borrow Areas

It is recognized that closure work will likely require development or re-development of borrow areas. However, due to the conceptual nature of the closure design options, there is insufficient information to determine borrow pit requirements or locations of such sites. Thus, no specific allowance for remediation of these areas has been included in this cost estimate, but it is noted that the Miscellaneous Clearings (section 3.7.1) has a generous contingency for additional clearing areas (16ha versus 8ha measured).

3.7.5 Inventory and Cost

Closure activities for Revegetation and Site Restoration of Other Areas is divided into the three main areas of Miscellaneous Clearings, Tailings Peripheral Areas, and Waste Rock Pile (note that at present, all costs for waste rock and open pit activities are addressed in Supplemental Costs for Short-Listed Options). Pre- and Active Closure phase aspects are summarized in Table 3-12 along with estimated costs. Further cost details are given in Appendices B.1 and B.2.

Table 3-12: Main Closure Tasks and Estimated Costs for Revegetation and Site Restoration of Other Areas

#	Component	Pre-Closure Phase	Est. Cost	Active Closure Phase	Est. Cost
1	**Miscellaneous clearings**	- field assessment and inventory	$ 5,000	- surface preparation - revegetation (assume of 15 percent of disturbance)	$ 120,000
2	**Tailings Peripheral Areas**	- no specific assessments identified	$ -	see Appendix A.1 and A.2 for supporting data (Option 1 and 2 Tailings Peripheral Area Cost)	$ 90,000
3	**Waste Rock Pile and Open Pit Areas**	- costs for this element addressed in Supplemental Costs for Short-Listed Options	$ -	- costs for this element addressed in Supplemental Costs for Short-Listed Options	$ -
4					
	Subtotal		$ 5,000		$ 210,000
	TOTAL ESTIMATED COST				**$ 215,000**

3.7.6 Uncertainty

Main uncertainties affecting the Revegetation and Site Restoration of Other Areas closure cost estimate include:

- **Detailed inventory**. An on-ground inventory of clearings to be reclaimed has not yet been completed. All costing assumptions are based on satellite photo interpretation and general site knowledge, and assume that remediation of these sites will be straightforward. The existing information does not permit identification of potentially complex conditions such as permafrost, seepage areas, or acid rock drainage and/or metal leaching. It is unknown if any of these clearings contain refuse or hazardous waste, or if there are any significant soil hydrocarbon-contamination issues.
- **Borrow Area Requirements for Closure.** The amount of projected disturbance for new or expanded borrow areas to be used for closure work is not available. While some conservatism is built into the current estimates, any significant additional borrow disturbance will require an added allowance for remediation.

4. Report Closure

This report was prepared for Lorax Environmental Services Ltd. on behalf of their Client – the Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources of the Government of Yukon. The report, which specifically includes all text, figures, tables and appendices, is based on information provided by Lorax or by the Client, and on data interpreted from available mapping and report information.

The work described in this report was conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Altura Environmental Consulting sincerely appreciates the opportunity to participate in and contribute to the decommissioning phase of the Mount Nansen site. Please direct any questions regarding the contents of this report to the undersigned at 867-335-2006.

Prepared by:

ALTURA ENVIRONMENTAL CONSULTING

Diane Lister, M.A.Sc., P.Eng.

5. References

Access Consulting Group, 2009. *Carmacks Copper Project, Yukon Territory. Preliminary Detailed Closure and Reclamation Plan.* Report prepared for Western Copper Corporation, 136 pp. http://www.emr.gov.yk.ca/mining/pdf/mml_cc_preliminary_detailed_closure_and_reclamation_plan.pdf, accessed Oct 1/10.

AECOM, 2009. *Hydrogeological Field Investigation Summary.* Internal memorandum froom Ryan Mills to Allistair Kent, December 3, 2009, 130 pp.

AECOM, 2010. *Overview of Mt. Nansen Closure Alternatives Characterization.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 164 pp.

Altura Environmental Consulting, 2009a. *Brown McDade Waste Rock Pile, Mount Nansen Mine Site, Yukon, Ecological Restoration Strategy.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 54 pp.

Altura Environmental Consulting, 2009b. *Brown McDade Waste Rock Pile, Mount Nansen Mine Site, Yukon – Geochemical Characterization.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 237 pp.

Altura Environmental Consulting, 2009c. *Mount Nansen Mine Closure: Mine to Mill Haul Road – Summary of Rock Characterization Studies.* Technical Memo to AECOM dated December 22, 2009, 8 p.

Altura Environmental Consulting, 2009d. *Brown McDade Waste Rock Characterization Mount Nansen Mine Site, Yukon, Summary of 2009 Work Program.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 116 pp.

Brodie Consulting Ltd., 1998. *Mt. Nansen Mine Closure Cost Assessment.* Report prepared for Water Resources Division, Indian and Northern Affairs Canada, 41 pp.

EDI Environmental Dynamics, 2008. *Mt Nansen Site Specific Water Quality Investigation.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 139 pp.

Conor Pacific, 2000. *Mount Nansen Minesite – Historical Review, Site Assessment, and Field Sampling Program.* Final Report Version 2. Prepared for Indian and Northern Affairs Canada, 223 pp.

Government of British Columbia, 2004. *Mine Reclamation Costing and Spreadsheet, Version 3.5.1.* Ministry of Energy and Mines, January 2004, 21pp. http://www.minem.gob.pe/minem/archivos/file/dgaam/publicaciones/curso_cierreminas/02_T%C3%A9cnico/12_Costos/TecCost-L5_Manual%20BC%20Revegetation.pdf, accessed October 15, 2010.

Kearah & WERI Environmental Contracting Ltd., 2008. *Limited Phase 2 Environmntal Site Assessment, Mount Nansen Mine Site, Yukon Territory, Draft Report.* Report prepared for Yukon Government Department of Energy Mines & Resources, May 2008, 59 pp.

Lorax Environmental Services Ltd., 2010a. *Mt. Nansen Mine, Geochemical Assessment in Support of Evaluating Closure Options – September 2010 Draft.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, 338 pp.

Lorax Environmental Services Ltd., 2010b. *Mt. Nansen Options for Closure.* Report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, in press.

SRK Consulting, 2009. *Basis of Estimate – Closure Costs, Red Dog Mine, Alaska.* Report prepared for Teck Alaska Incorporated, 54 pp. http://dnr.alaska.gov/mlw/mining/largemine/reddog/publicnotice/pdf/sdj2.pdf, accessed Oct. 1/10.

APPENDIX A

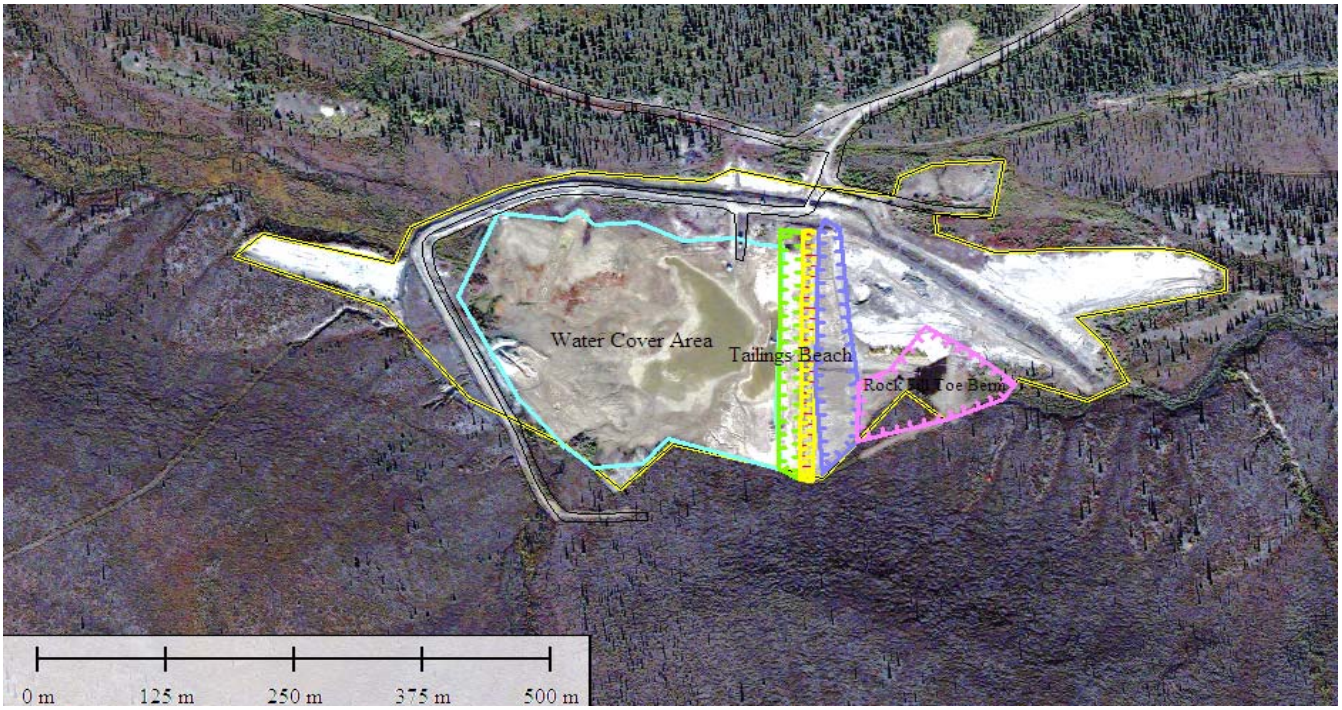
Details of Supplemental Costs for Short-Listed Options

A.1 Tailings Option 1A and 1B
A.2 Tailings Option 2A and 2B
A.3 Dome Creek Valley Restoration Summary
A.4 Dome Creek Valley Restoration Tasks
A.5 Dome Creek Valley Restoration Cost Details
A.6 Waste Rock Pile Cost Details
A.7 Open Pit Cost Details

Option **1A** **tailings dam upgrade with water cover, waste rock in place, open pit lake**

Site Preparation	$	250	/hr
Active Revegetation	$	16,000	/ha

Tailings Sector	Area (ha)	Revegetation	Site Preparation (hr/ha)	Active Revegetation	Site Preparation Cost	Active Revegetation Cost	Subtotal for Component
Water Cover	6.5	None (water cover)	0	0%	$ -	$ -	$ -
Beach Soil Cover	0.5	Intensive	25	75%	$ 3,125	$ 6,000	$ 9,125
Dam Crest and u/s face	0.4	Moderate	25	25%	$ 2,500	$ 1,600	$ 4,100
D/s dam face	0.8	Intensive	40	50%	$ 8,000	$ 6,400	$ 14,400
Rock Fill Toe Berm	1.0	Minor (assume coarse rock fill)	15	15%	$ 3,750	$ 2,400	$ 6,150
Subtotal for Option	*9.2*				*$ 17,375*	*$ 16,400*	***$ 33,775***
Peripheral Area (Common Elements)	8.8	Moderate	25	25%	$ 55,000	$ 35,200	**$ 90,200**



Option **2A** **tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake**

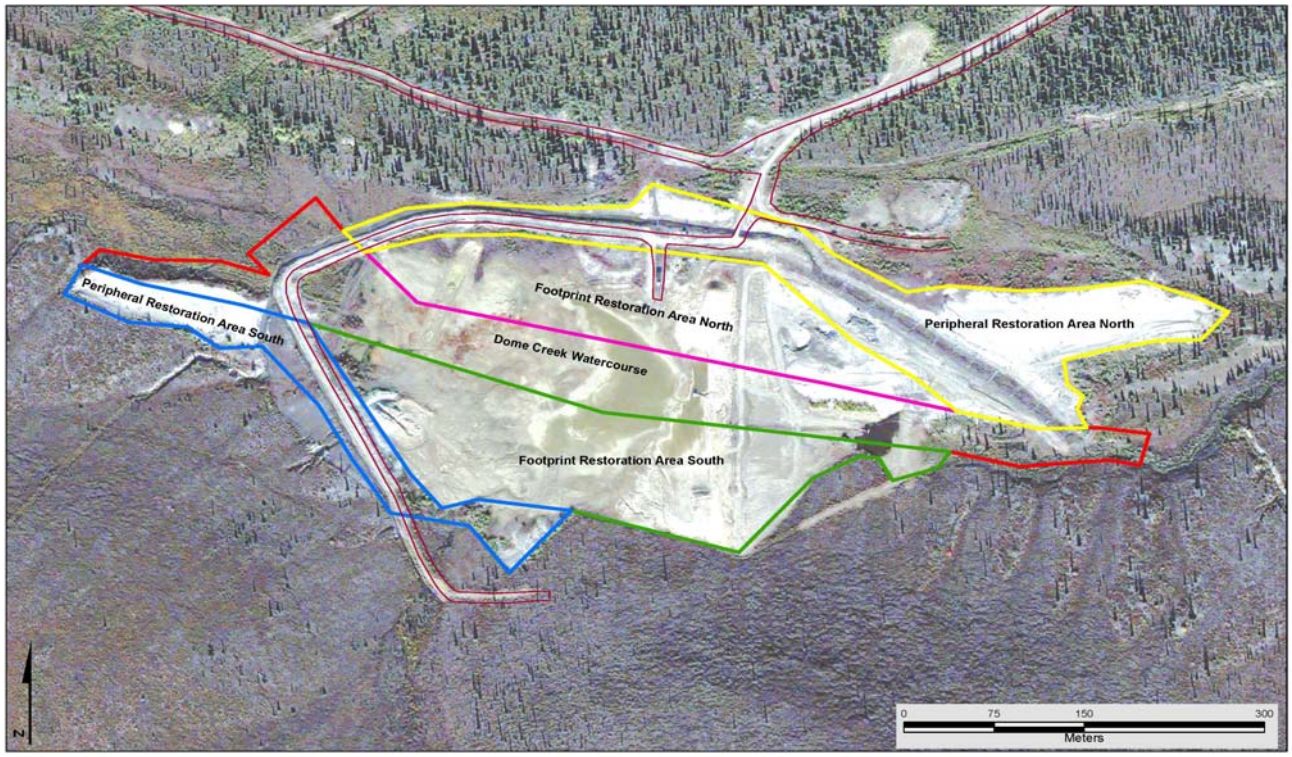
Site Preparation	$	250	/hr
Active Revegetation	$	16,000	/ha

Tailings Sector	Area (ha)	Revegetation	Site Preparation (hr/ha)	Active Revegetation	Site Preparation Cost	Active Revegetation Cost	Subtotal for Component
Soil Cover, Main Tailings Mass	6.5	Intensive	25	50%	$ 40,625	$ 52,000	$ 92,625
Soil Cover, Beach Area	0.5	Intensive	25	50%	$ 3,125	$ 4,000	$ 7,125
Dam Crest and u/s face	0.4	Moderate	25	25%	$ 2,500	$ 1,600	$ 4,100
D/s dam face	0.8	Intensive	40	50%	$ 8,000	$ 6,400	$ 14,400
Rock Fill Toe Berm	1.0	Minor (assume coarse rock fill)	15	15%	$ 3,750	$ 2,400	$ 6,150
Subtotal for Option	*9.2*				*$ 58,000*	*$ 66,400*	***$ 124,400***
Peripheral Area (Common Elements)	8.8	Moderate	25	25%	$ 55,000	$ 35,200	**$ 90,200**

	Est. Area (ha)	Design (once majority of dam footprint exposed)	Phase 1 Activities (After excavation of tailings mass and majority of dam; upstream diversion structures and small part of dam structure left in place to retain and control drainage)	Phase 2 Activities (following season after completion of Phase 1, and subsequent excavation of remaining dam structures)	Phase 3 Activities (following season after completion of Phase 2)	TOTAL
Footprint Restoration Areas (tailings mass and dam)	7.4	$ 50,000	$ 280,000	$ 140,000	$ 120,000	*$ 590,000*
Dome Creek Watercourse Restoration Area	4.4	$ 50,000	$ 390,000	$ 170,000	$ 190,000	*$ 800,000*
Subtotal						*$ 1,390,000*
Field Monitoring, Quality Control, Reporting (20% of subtotal)						$ 280,000
TOTAL FOR TAILINGS CLOSURE OPTION 3 or 4						**$ 1,670,000**

Common Elements Component:

Peripheral Restoration Areas	5.9	$ -	$ 40,000	$ 20,000	$ 20,000	**$ 80,000**



			Design Phase (following tailings excavation)	**Phase 1 Activities** (After excavation of tailings mass and majority of dam; upstream diversion structures and small part of dam structure left in place to retain and control drainage)		
Zone	**Est. Area** (ha)	**Main Characteristics**	**Investigation and Engineering**	**Earthworks**	**Physical Works and Controls**	**Revegetation**
Footprint Restoration Areas (tailings mass and dam)	7.4	topographic restoration likely required; potential issues of permafrost degradation resulting in water management and physical stability issues	topographic survey, subsurface investigations, soil mapping, design	- within excavated footprint (assume 80% of total): material placement, re-contouring, surface hummocking to restore topography, improve water management and control physical stability - establish temporary accesses	- temporary water control works (silt fences, bypass pumping of water) - rock and/or bio-engineering to stabilize/terrace surface as required; installation of drain structures as required - coarse woody debris over entire surface	- cuttings and direct seeding over 50% of surface
Dome Creek Watercourse Restoration Area	4.4	issues as per remnant footprint, plus necessity to provide suitable long term armouring/stabilization, as suited to watercourse	topographic survey, subsurface investigations, soil mapping, design	- within excavated footprint (assume 80% of total): material placement, re-contouring, surface hummocking to restore topography, improve water management and control physical stability - excavate channel - establish temporary accesses	- rock and/or bio-engineering to stabilize/terrace surface and install drain structures as required; - armouring and/or bio-engineering to create stable creek structure - coarse woody debris over entire area	- cuttings and direct seeding over 100% of surface
Peripheral Restoration Areas	5.9	surface-disturbed, general re-grading/site preparation required	no specific design phase required	- general re-grading and surface roughening; assume 50% of area to be done during Phase 1	-coarse woody debris over 25% of area	- cuttings and direct seeding over 25% of surface
Total	17.7					

			Phase 2 Activities (following season after completion of Phase 1, and subsequent excavation of remaining dam structures)			**Phase 3 Activities** (following season after completion of Phase 2)		
Zone	**Est. Area** (ha)	**Main Characteristics**	**Earthworks**	**Physical Works and Controls**	**Revegetation**	**Earthworks**	**Physical Works and Controls**	**Revegetation**
Footprint Restoration Areas (tailings mass and dam)	7.4	topographic restoration likely required; potential issues of permafrost degradation resulting in water management and physical stability issues	- maintain diversion structures - within excavated footprint (assume 20% of total): material placement, re-contouring, surface hummocking to restore topography, improve water management and control physical stability	- temporary water control works (silt fences, bypass pumping of water) - rock and/or bio-engineering to stabilize/terrace surface as required; installation of drain structures as required - coarse woody debris over entire surface	- cuttings and direct seeding over 50% of surface	- removal of temporary accesses (leave trail for ongoing access) - remedial works as required	- remedial and temporary control works as required	- remedial and temporary revegetation as required
Dome Creek Watercourse Restoration Area	4.4	issues as per remnant footprint, plus necessity to provide suitable long term armouring/stabilization, as suited to watercourse	- within excavated footprint (assume 20% of total): material placement, re-contouring, surface hummocking to restore topography, improve water management and control physical stability - establish temporary accesses	- rock and/or bio-engineering to stabilize/terrace surface as required; - armouring and/or bio-engineering to create stable creek structure - coarse woody debris over entire area	- cuttings and direct seeding over 100% of surface	- phased diversion of creek waters into restored watercourse - remedial and temporary control works as required - removal of temporary accesses (leave trail for ongoing access)	- remedial and temporary control works as required	- remedial and temporary revegetation as required
Peripheral Restoration Areas	5.9	surface-disturbed, general re-grading/site preparation required	- general re-grading and surface roughening; assume 25% of area	-coarse woody debris over 25% of area	- cuttings and direct seeding over 25% of surface	- general re-grading and surface roughening; assume 25% of area including old diversion structure - removal of temporary accesses (leave trail for ongoing access)	-coarse woody debris over 25% of area	- cuttings and direct seeding over 25% of surface
Total	17.7							

TOTAL $ 1,440,575

Phase	Area	Aspect	Task	Unit	Quantity	Rate	Extension	Comment/Note
0	Footprint	Design	Field investigation and design	allowance	1	$ 50,000	$ 50,000	
0	Watercourse	Design	Field investigation and design	allowance	1	$ 50,000	$ 50,000	
0	Peripheral	Design	Field investigation and design	allowance	0	$ -	$ -	
1	Footprint	Earthworks	material hauling (select dam material)	m3	17760	$ -	$ -	cost included in closure estimate; avg 0.3m thickness
1	Footprint	Earthworks	temporary accesses	allowance	1	$ 20,000	$ 20,000	80 equipment hours
1	Footprint	Earthworks	surface preparation	ha	5.92	$ 12,500	$ 74,000	50 equip hrs/ha
1	Footprint	Physical Wc	temporary water control works	allowance	1	$ 25,000	$ 25,000	
1	Footprint	Physical Wc	rock and/or bio-engineering	allowance	1	$ 75,000	$ 75,000	
1	Footprint	Physical Wc	installation of drain structures as required	allowance	1	$ 20,000	$ 20,000	80 equipment hours
1	Footprint	Physical Wc	coarse woody debris	allowance	1	$ 20,000	$ 20,000	over entire surface
1	Footprint	Revegetatio	revegetation	ha	3.0	$ 16,000	$ 47,360	cuttings and direct seeding over 50% of surface
1	Watercourse	Earthworks	material hauling (select dam material)	m3	10560	$ -	$ -	cost included in closure estimate; avg 0.3m thickness
1	Watercourse	Earthworks	temporary accesses	allowance	1	$ 20,000	$ 20,000	80 equipment hours
1	Watercourse	Earthworks	surface preparation	ha	3.5	$ 20,000	$ 70,400	80 equip hrs/ha
1	Watercourse	Earthworks	temporary water control works	allowance	1	$ 50,000	$ 50,000	
1	Watercourse	Earthworks	channel excavation	m3	1200	$ 20	$ 24,000	rate from AECOM costs
1	Watercourse	Physical Wc	armouring and/or bio-engineering tc	allowance	1	$ 100,000	$ 100,000	800m of watercourse
1	Watercourse	Physical Wc	rock and/or bio-engineering	allowance	1	$ 50,000	$ 50,000	
1	Watercourse	Physical Wc	coarse woody debris	allowance	1	$ 15,000	$ 15,000	over entire surface
1	Watercourse	Revegetatio	revegetation	ha	3.52	$ 16,000	$ 56,320	cuttings and direct seeding over 100% of surface
1	Peripheral	Earthworks	surface preparation	ha	2.95	$ 6,250	$ 18,438	25 equip hrs/ha
1	Peripheral	Physical Wc	coarse woody debris	allowance	1	$ 5,000	$ 5,000	over 25% of surface
1	Peripheral	Revegetatio	revegetation	ha	0.7	$ 16,000	$ 11,800	over 25% of surface
2	Footprint	Earthworks	material hauling (select dam material)	m3	4440	$ -	$ -	
2	Footprint	Earthworks	temporary accesses	allowance	1	$ 10,000	$ 10,000	40 equipment hours
2	Footprint	Earthworks	surface preparation	ha	1.48	$ 12,500	$ 18,500	50 equip hrs/ha
2	Footprint	Physical Wc	temporary water control works	allowance	1	$ 25,000	$ 25,000	
2	Footprint	Physical Wc	rock and/or bio-engineering	allowance	1	$ 50,000	$ 50,000	
2	Footprint	Physical Wc	installation of drain structures as required	allowance	1	$ 10,000	$ 10,000	80 equipment hours
2	Footprint	Physical Wc	coarse woody debris	allowance	1	$ 10,000	$ 10,000	entire surface
2	Footprint	Revegetatio	revegetation	ha	0.7	$ 16,000	$ 11,840	over 50% of surface
2	Watercourse	Earthworks	material hauling (select dam material)	m3	0.3	$ -	$ -	cost included in closure estimate; avg 0.3m thickness
2	Watercourse	Earthworks	temporary accesses	allowance	1	$ 15,000	$ 15,000	60 equipment hours
2	Watercourse	Earthworks	surface preparation	ha	0.9	$ 20,000	$ 17,600	80 equip hrs/ha
2	Watercourse	Earthworks	temporary water control works	allowance	1	$ 50,000	$ 50,000	
2	Watercourse	Earthworks	channel excavation	m3	300	$ 20	$ 6,000	rate from AECOM costs
2	Watercourse	Physical Wc	armouring and/or bio-engineering tc	allowance	1	$ 30,000	$ 30,000	200m of watercourse
2	Watercourse	Physical Wc	rock and/or bio-engineering	allowance	1	$ 25,000	$ 25,000	
2	Watercourse	Physical Wc	coarse woody debris	allowance	1	$ 10,000	$ 10,000	over entire surface
2	Watercourse	Revegetatio	revegetation	ha	0.9	$ 16,000	$ 14,080	cuttings and direct seeding over 100% of surface
2	Peripheral	Earthworks	surface preparation	ha	1.5	$ 6,250	$ 9,219	25 equip hrs/ha
2	Peripheral	Physical Wc	coarse woody debris	allowance	1	$ 2,500	$ 2,500	over 25% of surface
2	Peripheral	Revegetatio	revegetation	ha	0.4	$ 16,000	$ 5,900	over 25% of surface
3	Footprint	Earthworks	temporary access removal	hours	80	$ 250	$ 20,000	
3	Footprint	Earthworks	remedial control works as required	hours	80	$ 250	$ 20,000	
3	Footprint	Physical Wc	remedial control works as required	allowance	1	$ 50,000	$ 50,000	
3	Footprint	Revegetatio	remedial revegetation as required	allowance	1	$ 25,000	$ 25,000	
3	Watercourse	Earthworks	phased diversion of creek waters int	allowance	1	25000	$ 25,000	
3	Watercourse	Earthworks	temporary access removal	hours	80	$ 250	$ 20,000	
3	Watercourse		remedial control works as required	hours	160	$ 250	$ 40,000	
3	Watercourse		remedial control works as required	allowance	1	$ 50,000	$ 50,000	
3	Watercourse		remedial revegetation as required	allowance	1	$ 50,000	$ 50,000	
3	Peripheral	Earthworks	surface preparation	ha	1.5	$ 6,250	$ 9,219	25 equip hrs/ha
3	Peripheral	Physical Wc	coarse woody debris	allowance	1	$ 2,500	$ 2,500	over 25% of surface
3	Peripheral	Revegetatio	revegetation	ha	0.4	$ 16,000	$ 5,900	over 25% of surface

Option	Description	Waste Rock Area to be Re-graded (ha)	Waste Rock Area to be Re-sloped (ha)	Re-Grade Cost/ha	Est. Re-Grade Cost	Est. Re-Slope Cost (see Table below)	*Total Site Prep Cost*	*Revegetation Cost*	Total Cost
1A	tailings dam upgrade with water cover, waste rock in place, open pit lake	7.2	4.8	$ 6,250	$ 45,100	$ 49,285	*$ 94,385*	*$ 48,000*	**$ 142,385**
1B	same as option 1A with waste rock relocation into the open pit, covering the pit lake	12	0	$ 6,250	$ 75,000	0	*$ 75,000*	*$ 48,000*	**$ 123,000**
2A	tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake	7.2	4.8	$ 6,250	$ 45,100	$ 49,285	*$ 94,385*	*$ 48,000*	**$ 142,385**
2B	same as option 2A with waste rock relocation into the open pit, covering the pit lake	12	0	$ 6,250	$ 75,000	0	*$ 75,000*	*$ 48,000*	**$ 123,000**
3	tailings backfill into open pit (covering the pit lake) with high infiltration cover, waste rock in place, Dome Creek reclaimed	7.2	4.8	$ 6,250	$ 45,100	$ 49,285	*$ 94,385*	*$ 48,000*	**$ 142,385**
4	tailings and waste rock backfill into open pit (covering the pit lake) with low infiltration cover, waste rock in place, Dome Creek reclaimed	12	0	$ 6,250	$ 75,000	0	*$ 75,000*	*$ 48,000*	**$ 123,000**

Table Waste Rock - 1

Waste Rock Pile Crest Inventory & Re-Sloping Cost Estimate

Crest	Total Crest Length (m)		Crest toeing into undisturbed areas (m) - excavator pull	Crest toeing into disturbed area (m) - dozer push	Comments
West Pile Slope Crest	650		480	170	
West Haul Road Edge	109		109	0	
Upper West Slope Crest	270		0	270	
Northwest Pile Crest	490		0	490	
East Pile Crest	201		201	0	
South Pile Crest	426		0	426	
Southwest Pile Crest	246		200	46	
Total Estimated Crest Length (m)	**2392**		**990**	**1402**	
Total Estimated Area (ha)*	**4.8**		**2.0**	**2.8**	
Resloping Rate (equip hrs/ha)			**50**	**35**	to 2:1 H:V or flatter; D8/D9; Cat 325 or equiv.
Estimated Re-sloping cost @ $250/hr	**$ 49,285**		**$ 24,750**	**$ 24,535**	

* assuming 20m horizontally projected slope length

Table Waste Rock - 2

Sectors and Approximate Areas and Volumes of the Brown McDade Waste Rock Pile

Excerpt from Altura Environmental Consulting, Brown McDade Waste Rock Pile, Mount Nansen Mine Site, Yukon, Geochemical Characterization, 2009, Table 4.1

Sector		Estimated Area (m^2)	Estimated Average Thickness (m)	Estimated Volume (m^3)
Northwest		19300	7	135100
East		9000	4	36000
South and West Sectors	62500	m^2 including:		
South		12200	4	48800
Southwest Upper		10000	5	50000
Southwest Lower		6800	6	40800
West Lower		16000	7	112000
West Mid		16900	5	84500
Ore Stockpile		600	3	1800
TOTAL		**90800**		**509000**

Option	Description	Residual Exposed Pit Walls / Floor / Fill (ha)	Residual Exposed Pit Lake	Pit Fill to be Re-graded (ha)	Pit Rim Crest Length to be Bermed (m)	Est. Fill Re-Grade Cost	Est. Fill Revegetation Cost	Est. Berming/Signage Cost	Total Est. Reveg / Safety Barrier Cost	Supplemental Backfill Option A[1]	Supplemental Backfill Option B[2]	Comments
1A	tailings dam upgrade with water cover, waste rock in place, open pit lake	3.8	0.5	0.0	1000	$ -	$ -	$ 23,500	**$ 23,500**	$ 1,729,674	$ 528,844	
1B	same as option 1A with waste rock relocation into the open pit, covering the pit lake	0.5	0.0	3.8	600	$ 23,438	$ 15,000	$ 14,100	**$ 52,538**			
2A	tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake	3.8	0.5	0.0	1000	$ -	$ -	$ 23,500	**$ 23,500**	$ 1,729,674	$ 528,844	
2B	same as option 2A with waste rock relocation into the open pit, covering the pit lake	0.5	0.0	3.8	600	$ 23,438	$ 15,000	$ 14,100	**$ 52,538**			
3	tailings backfill into open pit (covering the pit lake) with high infiltration cover, waste rock in place, Dome Creek reclaimed	1.8	0.0	2.5	1000	$ 15,750	$ 10,080	$ 23,500	**$ 49,330**			
4	tailings and waste rock backfill into open pit (covering the pit lake) with low infiltration cover, waste rock in place, Dome Creek reclaimed	0.0	0.0	4.3	100	$ 26,875	$ 17,200	$ 2,350	**$ 46,425**			

[1] Supplemental Backfill Option A: Estimated cost to cover pit lake and improve pit wall stability; and revegetate (300,000m^3 waste rock backfill, to approximately 1205 masl level of open pit). See Table Pit-3.

[2] Supplemental Backfill Option B: As for Supplemental Backfill Option A, but 155,000m^3 waste rock backfill to approximately 1200 masl level of open pit. See Table Pit-4.

Table Pit-1

Status Quo Values:

Approx. Area of Pit to top of Pit Rim (ha)	4.3
Approx. Area of Pit Lake (ha)	0.5
Approx Area of Pit Walls, misc pit fill and explosed floor (ha)	3.8
Approx. Crest Length of Pit Rim (m)	1000

Table Pit-2

Cost Rates	**Site Preparation**		**Revegetation**		**Other**		
	Unit	$/Unit	Unit	$/Unit	Unit		$/Unit
Residual Exposed Pit Wall/Floor	ha		ha				
Pit Fill	ha	$ 6,250	ha	$ 4,000			
Safety Berm and Signage, Pit rim (2m high, 8m3/m)	m	$ 16	m	$ -	m		$ 7.5

Table Pit-3

1A & 2A Supplemental Backfill Option
Cost - 300,000m3

	Priority Borrow Areas (proximity, reactivity considerations)						**Volume Make-Up Areas**		
	Northwest Pile	South Pile	Free Dump Piles West-Mid	Free Dump Piles West-Lower	Clay Ore Pile	West Lower	Other Areas	**Total Volume**	**Cost for Pit Placement**
Total Approx. Volume Insitu	135100	48800	3000	15000	1800	50000	80000		
Percentage Available for Borrow	90%	90%	90%	90%	90%	90%	90%		
Avail Volume for Borrow	121590	43920	2700	13500	1620	45000	72000	300330	
Loose m3 for equip calc. purposes	151988	54900	3375	16875	2025	56250	90000	375412.5	
Loader/Rock Truck/Dump	101988	4900	3375	16875	2025		30000	159163	$ 809,742
Excavator/Rock Truck/Dump	0	0				56250	60000	116250	$ 793,891
Dozer Push, Short	0	50000						50000	$ 34,375
Dozer Push, Long	50000	0						50000	$ 91,667
									$ 1,729,674

Table Pit-4

1A & 2A Supplemental Backfill Option
Cost - 154,000m3

	Priority Borrow Areas (proximity, reactivity considerations)						**Volume Make-Up Areas**		
	Northwest Pile	South Pile	Free Dump Piles West-Mid	Free Dump Piles West-Lower	Clay Ore Pile	West Lower	Other Areas	**Total Volume**	**Cost for Pit Placement**
Total Approx. Volume Insitu to be moved	120000	48800	1000	1000	1800	0	0		
Percentage Available for Borrow	90%	90%	90%	90%	90%	90%	90%		
Avail Volume for Borrow	108000	43920	900	900	1620	0	0	155340	
Loose m3 for equip calc. purposes	135000	54900	1125	1125	2025	0	0	194175	
Loader/Rock Truck/Dump	70000	4900	1125	1125	2025		0	79175	$ 402,803
Excavator/Rock Truck/Dump	0	0				0	0	0	$ -
Dozer Push, Short	0	50000						50000	$ 34,375
Dozer Push, Long	50000	0						50000	$ 91,667
									$ 528,844

Table Pit-5

Dozer Push Cost, South Pile	**Short Push**	**Long Push**
D9 LCM/hr for 45m (short) or 100m (long) average straight push, slot doze (Cat Handbook *0.5)	400	150
Rate D9/hr	$ 250	$ 250
$/LCM push to pit	$ 0.63	$ 1.67
Total $/LCM, with +10% for secondary push to direct material once in pit	**$ 0.69**	**$ 1.83**

Table Pit-6

Load / Haul Costs	**k Truck/Dum**	**Rock Truck/Dum**
Loader or Exc. Loading Time (min)	4	6
Truck Queue/Load/Haul/Dump time (min)	9	11
LCM volume of truck	10	10
Loader or Exc. Rate/hr	$ 300	$ 300
Truck Rate/hr	$ 175	$ 175
Loading Cost/LCM	$ 2.00	$ 3.00
Trucking Cost/LCM	$ 2.63	$ 3.21
Total $/LCM, with +10% for secondary push to direct material once in pit	**$ 5.09**	**$ 6.83**

APPENDIX B

Details of Common Element Closure Costs

B.1 Pre-Closure Cost Estimate Items

B.2 Active Closure Cost Estimate Items

B.3 Estimate of Exploration Trench Meterage

B.4 Estimate of Miscellaneous Clearing Areas

Mill Area

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		no mobilization nor demobilization costs assumed
Control of water flow through mill disturance area					*$ 10,000*	*additional investigation above and at the north corner of the mill to source the high volume seep (possibly old adit?)*
Investigation	allowance	1	10,000	10,000		
Removal of reactive rock fill from old ore transfer site					*$ -*	*no specific assessments identified*
	allowance	1	0	0		
Decomissioning of Pond #1 - Accumulation of Old Tailings					*$ 7,500*	*additional field and document investigation and sampling to determine extent of tailings*
Investigation	allowance	1	7,500	7,500		
Decomissioning of Pond #2					*$ 7,500*	*additional field and document investigation and sampling to determine presence/absence of tailings*
Investigation	allowance	1	7,500	7,500		
Decomissioning of Pond #3					*$ 3,000*	*additional field and document investigation and sampling to determine presence/absence of tailings (note some of this assessment is deferred to active closure phase once pond liner is removed)*
Investigation	allowance	1	3,000	3,000		
Watercourse restoration					*$ -*	*no specific assessments identified*
	allowance	1	0	0		
Removal of fuel storage equipment and hydrocarbon contaminated soil / concrete					*$ 10,000*	*soil investigation for local hydrocarbon contaminaton*
Investigation	allowance	1	10,000	10,000		
Removal of mill buildings and other structures					*$ 20,000*	*final assessment for hazardous products and local soil contamination*
Investigation	allowance	1	20,000	20,000		
Removal of hazardous products and refuse around mill					*$ 15,000*	*assess for hazardous products, and as required, local soil assessment*
Investigation	allowance	1	15,000	15,000		assume conducted concurrent with mill building assessment, by same contractor
Recontouring and revegetating mill disturbance area					*$ -*	*no specific assessments identified*
	allowance	1	0	0		
Subtotal				73,000		
TOTAL ESTIMATED COST				73,000		

Camp and Ancillary Buildings

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Camp Area					*$ 20,000*	*- hazardous product inventory* *- hydrocarbon contaminated soil assessment*
hazardous product inventory	allowance	1	5,000	5,000		
hydrocarbon soil contamination investigation	allowance	1	15,000	15,000		
Water Tank					*$ -*	*no specific assessments identified*
	allowance	0	0	0		
Mine Shop and Laydown					*20,000*	*- hazardous product inventory* *- hydrocarbon contaminated soil assessment*
hazardous product inventory	allowance	1	5,000	5,000		
hydrocarbon soil contamination investigation	allowance	1	15,000	15,000		
Subtotal				40,000		
TOTAL ESTIMATED COST				40,000		

Roads

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Mine Roads (all non-public roads within OIC boundary)					*$ 15,000*	*- hydrocarbon contaminated soil assessment; ground-truthing to evaluate decommissioning requirements*
investigation	allowance	1	15,000	15,000		
Haul Road					*$ 10,000*	*- hydrocarbon contaminated soil assessment*
	allowance	1	10,000	10,000		
Trails					*$ -*	*no closure activities*
Subtotal				25,000		
TOTAL ESTIMATED COST				25,000		

Exploration Trenches

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Backfill Trenches					*$ 15,000*	*- ground-truthing survey to assess state of trenches, confirm conceptual estimates, and assess viability of access for reclamation*
investigation	allowance	1	15,000	15,000		
Subtotal				15,000		
TOTAL ESTIMATED COST				15,000		

Miscellaneous Infrastructure

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Power Supply Infrastructure					*$ 5,000*	*- field assessment and inventory*
blanket allowance	allowance	1	5,000	5,000		
Pipelines					*$ 5,000*	*- field assessment and inventory*
blanket allowance	allowance	1	5,000	5,000		
Victoria Creek Pump House					*$ 5,000*	*-assess artesian well and develop decommissioning strategy*
blanket allowance	allowance	1	5,000	5,000		
Core Storage Areas					*$ -*	*- no specific assessments identified*
blanket allowance	allowance	0	0	0		
Subtotal				15,000		
TOTAL ESTIMATED COST				15,000		

Revegetation and Site Restoration of Other Disturbances

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Miscellaneous clearings					*$ 5,000*	*- field assessment and inventory*
blanket allowance	allowance	1	5,000	5,000		
Tailings Peripheral Areas					*$ -*	*- no specific assessments identified*
blanket allowance	allowance	0	0	0		
Waste Rock Pile and Open Pit Areas					*$ -*	*- costs for this element addressed in Supplemental Costs for Short-Listed Options*
blanket allowance	allowance	0	0	0		
Subtotal				5,000		
TOTAL ESTIMATED COST				5,000		

Mill Area

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		no mobilization nor demobilization costs assumed
Control of water flow through mill disturance area					*$ 19,100*	*- improve cut-off ditching to direct drainage around millsite area* *- armour and stabilize any permanent water diversion structures*
Excavation	m^3	1,500	10	15,000		1500 m ditching, 1m wide x 1m deep
Armouring	m^3	60	35	2,100		miscellaneous protection where required
Geotextile	m^2	400	5	2,000		miscellaneous protection where required
Removal of reactive rock fill from old ore transfer site					*$ 102,500*	*- remove rock fill in lower platform area that is demonstrably leachable and within or near the saturated zone (eg. old ore transfer area that has been re-worked) - estimate up to 6500m3;* *- adjustment of excavation based on material and flowpath characteristics*
Temporary sediment control	allowance	1	5,000	5,000		
Transport and place	m^3	6,500	15	97,500		assuming conventional excavator+15m3 truck operation, 2.5km haul to pit
Re-grading	hectare	0	0	0		Cost included under recontouring and revegetating mill disturbance area
Revegetation	hectare	0	0	0		Cost included under recontouring and revegetating mill disturbance area
Decomissioning of Pond #1 - Accumulation of Old Tailings					*$ 204,400*	*-removal of accumulation tailings fines in Pond #1 (roughly estimated at up to 1000m3)* *- watercourse restoration and revegetation*
Temporary sediment control	allowance	1	20,000	20,000		
Temporary access improvement	allowance	1	30,000	30,000		
Tailings removal	m^3	1,000	100	100,000		assuming slurry pumping and dewatering - this costs needs review
Re-grading	hectare	1	10,000	10,000		40 heavy equipment hours/ha @ $250/hr; minimum 5 hours (includes temporary access re-grading)
Revegetation	hectare	0.8	16,000	12,000		active revegetation over 75% of assumed 1ha area (including revegetation of temporary access)
Excavation	m^3	100	10	1,000		watercourse restoration
Armouring	m^3	40	35	1,400		watercourse restoration
Field monitoring and material control, analysis, reporting	allowance	1	30,000	30,000		

Mill Area, cont..

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Decomissioning of Pond #2					*$ 19,625*	*- dewater impounded water via pump, recontour and ditch to ensure no water impoundment, encourage revegetation*
Temporary sediment control	allowance	1	5,000	5,000		
Dewater pond	allowance	1	3,000	3,000		
Temporary access improvement	allowance	1	2,000	2,000		
Re-grading	hectare	0.5	6,250	3,125		25 heavy equipment hours/ha @ $250/hr; minimum 5 hours
Revegetation	hectare	0.25	16,000	4,000		active revegetation over 50% of disturbed area
Excavation	m^3	50	10	500		diversion ditching
Field monitoring and material control, analysis, reporting	allowance	1	2,000	2,000		
Decomissioning of Pond #3					*$ 16,000*	*- dewater impounded water via pump. Characterize any accumulated solids at pond bottom. Remove liner and dispose with non-hazardous waste.* *- assess fill below and in immediate area of pond to identify any significant amounts of old tailings*
Temporary sediment control	allowance	1	0	0		
Dewater pond	allowance	1	3,000	3,000		
Characterize and remove solids	allowance	1	3,000	3,000		
Remove and dispose of liner	allowance	1	3,000	3,000		
Test pitting below liner	allowance	1	5,000	5,000		confirm presence/absence of tailings
Re-grading	hectare	0	0	0		included under recontouring and revegetating mill disturbance area
Revegetation	hectare	0	0	0		included under recontouring and revegetating mill disturbance area
Field monitoring and material control, analysis, reporting	allowance	1	2,000	2,000		
Watercourse restoration					*$ 41,200*	*- removal of culvert and road crossing at start of reclaim line road - estimate 500m3* *- removal of other rockfill within 5 metres of Dome Creek watercourse - estimate 500m3* *- recontour and encourage natural revegetation*
Temporary sediment control	allowance	1	10,000	10,000		
Transport and place	m^3	500	15	7,500		removal of other rockfill within 5 metres of Dome Creek watercourse - estimate 500m3
Excavation	m^3	500	10	5,000		removal of other rockfill within 5 metres of Dome Creek watercourse - estimate 500m3
Armouring	m^3	300	35	10,500		miscellaneous protection where required
Geotextile	m^2	400	5	2,000		miscellaneous protection where required
Revegetation	hectare	0.20	16,000	3,200		active revegetation over 75% of assumed 0.2ha area
Field monitoring and material control, analysis, reporting	allowance	1	3,000	3,000		

Mill Area, cont..

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Removal of fuel storage equipment and hydrocarbon contaminated soil / concrete					*$ 45,000*	*- remove tanks and appurtenances; remove contaminated soils and contaminated concrete as required*
Removal of residual products	allowance	1	5,000	5,000		
Tank and equipment removal	allowance	1	5,000	5,000		
Contaminated concrete disposal	allowance	1	10,000	10,000		
Contaminated soil excavation/treatment/disposal	allowance	1	10,000	10,000		
Field monitoring and material control, analysis, reporting	allowance	1	15,000	15,000		
Removal of mill buildings and other structures					*$ 1,550,000*	*- remove any remaining hazardous products, remove contaminated soil if required, salvage/recycle material as feasible, landfill remainder in place* *- drainage control to reduce seepage through excavation*
Hazardous product removal, demolition, salvage, recycling as feasible, in-place landfilling of remainder	allowance	1	1,500,000	1,500,000		final hazardous material assessment included in Pre-Closure activities. Final re-grading covered under Re-grading section
Field monitoring and material control, analysis, reporting	allowance	1	50,000	50,000		assume 3rd party from contractor
Removal of hazardous products and refuse around mill					*$ 70,000*	*- remove any remaining hazardous products, remove contaminated soil if required* *- remove any surface-exposed non-hazardous refuse*
Hazardous product removal	allowance	1	20,000	20,000		
Surface-exposed refuse removal	allowance	1	20,000	20,000		
Sulphur dioxide tank removal	allowance	1	20,000	20,000		
Field monitoring and material control, analysis, reporting	allowance	1	10,000	10,000		
Recontouring and revegetating mill disturbance area					*$ 121,000*	*- recontour to a stable configuration; create small scale undulations (±0.5m) to encourage natural recolonization* *- de-compact all exposed roads and platforms to 0.8m depth* *- assumes no placement of cover material* *- encourage natural revegetation*
Temporary sediment control	allowance	1	10,000	10,000		
De-compaction	m^2	20,000	2	40,000		
Re-grading	hectare	4	10,000	40,000		40 heavy equipment hours/ha @ $250/hr (higher equipment requirement due to re-sloping and refuse covering)
Revegetation	hectare	1	16,000	16,000		active revegetation over 25% of assumed 4ha area
Field monitoring and material control, analysis, reporting	allowance	1	15,000	15,000		
Subtotal				2,188,825		
TOTAL ESTIMATED COST				2,188,825		

Camp and Ancillary Buildings

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Camp Area					*$ 215,000*	*- remove refuse and stored material, remove hazardous products* *- remediate hydrocarbon soil contamination as required* *- remove propane and gasoline storage tanks* *- dismantle buildings, recycle and salvage as feasible.* *- platform decompaction, regrade and encourage natural revegetation*
remove refuse and stored material in laydowns; relocate stored core	allowance	1	20,000	20,000		
remove gasoline tank and appurtenances; remediate hydrocarbon soil contamination	allowance	1	20,000	20,000		
remove propane tanks	allowance	1	5,000	5,000		
remove hazardous products	allowance	1	5,000	5,000		
dismantle buildings, recycle and salvage as feasible. In-place landfilling of non-hazardous waste	allowance	1	100,000	100,000		
decomission septic system	allowance	1	5,000	5,000		
de-compaction	m2	10,000	2	20,000		
Re-grading	hectare	2	10,000	20,000		40 heavy equipment hours/ha @ $250/hr (higher equipment requirement due to re-sloping and refuse covering)
re-vegetation	allowance	1	5,000	5,000		
Field monitoring and material control, analysis, reporting	allowance	1	15,000	15,000		
Water Tank					*$ 39,125*	*- remove tank and building, remove surface-exposed piping, re-grade*
removal of tank, building	allowance	1	30,000	30,000		
removal of surface-exposed piping	allowance	1	3,000	3,000		
re-grading, surface preparation	hectare	1	6,250	3,125		25 heavy equipment hours/ha @ $250/hr; minimum 5 hours
Field monitoring and material control, analysis, reporting	allowance	1	3,000	3,000		

Camp and Ancillary Buildings, cont…

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mine Shop and Laydown					*$ 130,200*	*-remove refuse and stored material, remove hazardous products* *- remediate hydrocarbon soil contamination as required* *- dismantle buildings, recycle and salvage as feasible.* *- regrade and encourage natural revegetation*
removal of scrap and products	allowance	1	10,000	10,000		
remove hazardous products	allowance	1	5,000	5,000		
remediate hydrocarbon soil contamination	allowance	1	25,000	25,000		
dismantle building, recycle and salvage as feasible	allowance	1	75,000	75,000		
de-compaction	m^2	2,000	2	4,000		
re-grading, surface preparation	hectare	0.8	6,250	5,000		25 heavy equipment hours/ha @ $250/hr; minimum 5 hours
revegetation	allowance	0.20	16,000	3,200		active revegetation over 25% of assumed 0.5 ha area; remainder revegetated with waste rock pile
Field monitoring and material control, analysis, reporting	allowance	1	3,000	3,000		
Subtotal				384,325		
TOTAL ESTIMATED COST				384,325		

Roads

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Mine Roads (all non-public roads within OIC boundary)					*$ 120,340*	*- site preparation: decompaction and recontouring, culvert removal, drainage control, coarse woody debris dispersal as available* *- remediate soil hydrocarbon contamination* *- encourage natural re-vegetation*
site preparation	km	11.6	6,250	72,500		assumes heavy equipment rate of $250/hr and 25 equipment-hrs/km
revegetation	hectare	1.7	16,000	27,840		active revegetation over 10% of 15m-wide road disturbance
remediate hydrocarbon soil contamination	allowance	1	5,000	5,000		
field monitoring and material control, reporting	allowance	1	15,000	15,000		
Haul Road					*$ 91,700*	*- site preparation: decompaction and recontouring, relocation of potentially reactive berm material, drainage control, coarse woody debris dispersal as available* *- remediate soil hydrocarbon contamination* *- encourage natural re-vegetation*
site preparation	km	1.2	18,750	22,500		assumes heavy equipment rate of $250/hr and 75 equipment-hrs/km
material removal	m3	1,000	15	15,000		
remediate hydrocarbon soil contamination	allowance	1	20,000	20,000		*at least one identified potential occurrence of hydrocarbon contamination*
revegetation	hectare	1	16,000	19,200		active revegetation over 25% of 40m-wide road disturbance
field monitoring and material control, reporting	allowance	1	15,000	15,000		
Trails					*$ -*	*no closure activities*
Subtotal				212,040		
TOTAL ESTIMATED COST				212,040		

Exploration Trenches

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Backfill Trenches					*$ 214,060*	*- access trenches via existing roads/trails, or create temporary trails, backfill using available sidecast material, contour to integrate with surrounding terrain, drainage control and erosion prevention, coarse woody debris dispersal as available, limited re-vegetation*
Backfill remaining deep trenches, Huestis area	km	2	18,750	37,500		75 equipment hours per km @$250/hr
Backfill all other trenches	km	9	15,000	132,000		assuming 80% of 11 lineal km can be feasibly backfilled; 60 equipment hours per km @$250/hr
Revegetation	hectare	2	16,000	34,560		active revegetation over 2% of 10m-wide trench disturbance
Field monitoring and material control, reporting	allowance	1	10,000	10,000		
Subtotal				214,060		
TOTAL ESTIMATED COST				214,060		

Miscellaneous Infrastructure

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Power Supply Infrastructure					*$ 50,000*	*- deactivate powerlines - remove remnant cable and switchgear, salvage/recycle/dispose as feasible; remove transformer and dispose/salvage - remove newer power poles and salvage as feasible - no re-vegetation allowance assumed*
blanket allowance	allowance	1	50,000	50,000		
Pipelines					*$ 50,000*	*- remove above-surface pipelines along with remnant insulation and debris, salvage/recycle/dispose as feasible - remove pump shacks and equipment; salvage/recycle/dispose as feasible - no re-vegetation allowance assumed*
blanket allowance	allowance	1	50,000	50,000		
Victoria Creek Pump House					*$ 75,000*	*- decommission and seal artesian well - remove pump house and equipment; salvage/recycle/dispose as feasible - surface preparation of clearing, minor re-vegetation allowance assumed*
blanket allowance	allowance	1	75,000	75,000		
Core Storage Areas					*$ 25,000*	*- archive representative drill holes, disposal of remaining drill core*
blanket allowance	allowance	1	25,000	25,000		
Subtotal				200,000		
TOTAL ESTIMATED COST				200,000		

Revegetation and Site Restoration of Other Disturbances

Cost Estimate						
Item	Units	Quantity	Unit Price	Extension	Subtotal	Comments
Mobilization and demobilization	allowance	0	0	0		
Miscellaneous clearings					*$ 118,400*	*- surface preparation* *- revegetation (assume of 15 percent of disturbance)*
surface preparation	hectares	16	5,000	80,000		20 heavy equipment hours/hectare
revegetation	hectares	2.4	16,000	38,400		15% active revegetation over 16 hectares of disturbance
Tailings Peripheral Areas					*$ 90,200*	*see Appendix A.1 and A.2 for supporting data (Option 1 and 2 Tailings Peripheral Area Cost)*
final surface preparation and revegetation	allowance	1	90,200	90,200		see Appendix A.1 and A.2 for supporting data (Option 1 and 2 tailings Peripheral Area Cost)
Waste Rock Pile and Open Pit Areas					*$ -*	*- costs for this element addressed in Supplemental Costs for Short-Listed Options*
final surface preparation	hectares	0	0	0		
revegetation	hectares	0.0	0	0		
Subtotal				208,600		
TOTAL ESTIMATED COST				208,600		

	Total Lineal metres of Trenches within Nansen OIC Boundary*	
	Unfilled	***Filled***
Total Estimated Lineal Metres	***13,175***	***1,700***

Segment	**Unfilled** (m)	**Filled** (m)	**Comments**
Heustis west of mill, two outer trenches from ridge to mill	0	1,700	
Heustis west of mill, middle trench from ridge to mill	800	0	
Heustis west of mill, trenches on far side of ridge	1,485	0	
Heustis northwest of mill, headwaters of Dome Ck	1,840	0	limited access to about 400m of these (southern trenches)
Flex Zone trenches	1,500	0	
Dickson Zone and area to east	3,400	0	
BMX zone, both sides of Pony Creek	3,300	0	
Brown McDade south, downhill from waste rock piles	850	0	limited access to some of these trenches

* as measured from 2008 geo-referenced site satellite image

	Total Area of Clearings within Nansen OIC Boundary*
Total Estimated *(m^2)*	***80,550***

Segment		**Comments**
Flex zone clearing	10,800	
Dickson zone clearing	25,470	
Pony Ck / Brown McDade Adit	4,360	mainly recountoured
Upper Huestis workings	11,590	mainly recountoured
above Nansen Public Road near Brown McDade pit	6,520	
Borrow areas north of tailings, laydown	17,610	
Power line/water line road to mill, sand area	2,700	
Old explosives area east of mill	1,500	

* as measured from 2008 geo-referenced site satellite image

Clearings Covered in other Common Element Costing	*Common Element*
Bunkhouse/office	Camp and Ancilliary Facilities
Victoria Ck Pumphouse	Miscellaneous Infrastructure
Mill Site, main disturbance	Mill Area

TECHNICAL MEMORANDUM

DATE October 1, 2010 **PROJECT No.** 10-1427-0018

TO Mr. Justin Stockwell
Lorax Environmental Services Ltd.

CC Bjorn Weeks

FROM Fernando Junqueira and John Hull **EMAIL** fjunqueira@golder.com; jhull@golder.com

ASSESSMENT OF CLOSURE OPTIONS AND COVER WATER BALANCE FOR THE MT. NANSEN PROJECT, YUKON

1.0 INTRODUCTION

Lorax Environmental Services Ltd. (Lorax) is currently assessing the viability of a number of closure options for the Mt. Nansen project in the Yukon. Lorax requested that Golder Associates Ltd. (Golder) provide support to assess the feasibility of a closure option that consists of relocation of tailings into an on-site abandoned open pit (activities designated as Closure Option 3 by Lorax). The purpose of the study is to identify the potential for the tailings to sustain or maintain saturation values higher than 85% in the long term, which would minimize to a large degree the generation of Acid Rock Drainage (ARD).

In addition, as a secondary task, Golder was requested to conduct cover water balance models for different closure options related to the tailings management. This information was to provide inputs for the site-wide water balance model developed by Gomm Environmental Engineering Consulting. The closure options identified by Lorax and modelled by Golder in this study were as follows:

- Option 1: Upgrade the tailings dam and install a water cover over the tailings.
- Option 2: Upgrade the tailings dam and install a 1-meter thick saturated soil cover over the tailings.
- Option 3: Relocate the tailings into an on-site abandoned open pit and install a 1-meter thick soil cover over the tailings (the same option described above for the previous phase of the work).
- Option B: Relocate waste rock material into the on-site abandoned open pit.

This Technical Memorandum presents the results obtained from the different models, summarizes main conclusions, and presents recommendations for additional works.

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2.0 BACKGROUND INFORMATION

The Mount Nansen Mine is a former gold and silver mine which is currently under government care. The Mount Nansen property is located 60 km west of Carmacks and 180 km north of Whitehorse. Evaporation is reported to exceed precipitation in the region, and therefore the local climate is classified as semi-arid.

A series of input data was required to prepare the numerical models discussed in this document. The data was provided by Lorax and included:

- Cross-sectional drawings of the different options to be evaluated (Appendix A).
- Climate data set from Environment Canada based on the Carmacks weather station for the period of 1964 to 2006. Climate data included: daily snow melt (April 15 to April 31), daily maximum and minimum air temperature, and daily precipitation. Climate parameters also included general monthly evaporation values, relative humidity and wind speed estimated for Mt. Nansen.
- Measured grain size distributions and Soil-Water Characteristic Curves (SWCC) for samples of coarse and fine tailings.
- Measured grain size distributions for two different samples of waste rock.
- Average pit lake water level in the abandoned on-site open pit.
- In-situ tailings density measurements (8 boreholes).

Long term tailings saturation and cover water balances were evaluated using numerical models by means of the program SVFlux (Soil Vision 2006). The numerical model used incorporated soil properties and atmospheric conditions with a coupled flux boundary model to compute fluxes through saturated or unsaturated soils.

3.0 MODEL LIMITATIONS

The models prepared for this study were aimed at providing general understanding of the process of tailings drainage or desaturation for Closure Option 3, as well as computing estimates of cover water balance fluxes for the different closure options modelled. These models were simplifications of what would happen in the field and did not incorporate all processes that would occur in the field. The main model simplifications and assumptions that limit the model were as follows:

- The one-dimensional (1D) models did not incorporate lateral fluxes that might occur associated with material layering.
- The models did not incorporate spatial variation of material properties associated with layering and confining pressures.
- The scope of the present work did not include the design of the cover system to be installed on top of the tailings. A 1-meter layer of coarse waste rock was assumed to be placed on top of the tailings for all scenarios. The model work completed did not include assessment of the impact on the net flux of changes in the cover system configuration (thickness, type(s) of materials, layering).

- Closure Options 1 and 2 involved modeling a water table above the surface of tailings. In the models, it was assumed that there was enough water on site to sustain the water levels. The water balances presented in this study were restricted to flux associated with climate components only, and did not include external sources of water supply.

4.0 ASSESSMENT OF FEASIBILITY OF CLOSURE OPTION 3

The Closure Option 3 involved relocation of the tailings into an on-site abandoned open pit which contains a perennial pit lake at average elevation of about 1182 m. After placement in the pit, the tailings would be covered with a 1-meter granular cover to minimize evaporation and maximize surface water infiltration. The success of this closure option would rely on the ability of the tailings to maintain a saturation of 85% or more over the long term, which would minimize the potential to a large degree the generation of Acid Rock Drainage (ARD) by greatly limiting the possible diffusion of oxygen into the tailings.

Numerical models were prepared to evaluate the potential of the in-pit tailings to desaturate to saturation levels below the target value of 85%.

4.1 Model Setup

4.1.1 Geometry and Boundary Conditions

One-dimensional (1D) models were used to provide general understanding of the desaturation process for tailings relocated to the pit. The model geometry was based on cross section drawings for Option 3 provided by Lorax (Appendix A, Drawing 3), and consisted of a one-meter soil cover underlain by 30 m of combined mixed tailings, underlain in turn by over 10 m of weathered bedrock.

Two climate data sets were compiled to represent periods of dry and mean years based on climate data from the Carmacks weather station as shown in Figure 1. Based on the data set developed, the average annual precipitation was 283 mm/year, which corresponded approximately to the precipitation in the year 2003. The year 2003 was therefore used in the models as representative of mean conditions, and used for simulating conditions over a period of 15 years (*i.e.,* 15 years with mean precipitation), based on yearly 200-day climate cycles from April 15 to October 31.

In addition, the years of 1964 to 1966 were modelled to assess the impact of prolonged drier years in the tailings desaturation process. Annual precipitation for those years was below historic average (*i.e.,* 263 mm in 1964, 198 mm in 1965 and 242 mm in 1966).

An average annual potential evaporation value of 369 mm was estimated for the Mt. Nansen site by Lorax, and used for all scenarios modelled.

An average pit lake elevation of 1182.3 m was used as lower boundary condition in the models, while the climate data compiled for dry and mean years were applied as top boundary condition.

4.1.2 Material Properties

Key material properties for the model include saturated hydraulic conductivities, grain size distributions, and the Soil-Water Characteristic Curve (SWCC, a relationship between the soil suction and water content of the soil). Values for these properties needed to be measured or estimated for both the mixed tailings and the coarse waste rock modeled.

Tailings - For the initial phase of the work, the hydraulic conductivity of the combined tailings was estimated based on grain size distribution information provided by Lorax for the fine and coarse tailings. The estimated range for combined tailings was between $1x10^{-8}$ m/s and $5x10^{-9}$ m/s, and the upper and lower limits of this range were applied as a sensitivity analysis in the modeling runs presented in this document.

At the request of Lorax, Golder performed supplementary laboratory tests on two samples of combined tailings, after the initiation of the modeling work. These supplemental tests included grain size distribution and hydraulic conductivity tests on samples of combined tailings (coarse and fine). Figure 2 shows the grain size distribution measured for the two samples, as well as the grain size curves previously provided by Lorax for the coarse and fine tailings, and the grain size curve initially estimated for the models based on that information.

Hydraulic conductivity tests were also performed on samples of combined tailings. These samples were prepared at average 35% moisture content and wet density of 1850 kg/m^3, which is slightly above maximum in-situ density reported for the tailings to a depth of about 8 m. The laboratory tests showed that, with reported field conditions, the permeability of the combined tailings will be affected significantly by the prevailing hydraulic gradient, as shown in Figure 3. For a hydraulic gradient of 1, the average conductivity value measured was about $1x10^{-8}$ m/s. This value fell within the range of conductivity values previously defined for the models.

The soil-water characteristic curve of the combined tailings was estimated using the method proposed by Fredlund et al (1997), based on the gradation of the combined tailings. Figure 4 shows the Golder-estimated SWCC for the combined tailings used in the models, as well as Lorax-measured SWCC curves for fine and coarse tailings.

Waste Rock - The hydraulic conductivity of the coarse cover layer was estimated as $1.4x10^{-4}$ m/s using Hazen's equation (Holtz et al 1981), based on waste rock grain size distribution information provided by Lorax. Figure 5 shows the grain size distribution curve provided and the soil-water characteristic curve estimated for the model based on this curve.

Bedrock - The pit foundation is reported to consist of weathered bedrock with average hydraulic conductivity value of $1x10^{-6}$ m/s. This value was applied to all models. A soil-water characteristic curve was not needed for the bedrock, as it remains saturated due to the boundary conditions used in the model.

4.2 Model Results

The evolution of the tailings saturation profiles with time for Option 3 (tailings relocated to an on-site pit) are shown in Figures 6 and 7. Figure 6 shows the evolution of the saturation profile for the case where the combined tailings have an average hydraulic conductivity of $1x10^{-8}$ m/s, while Figure 7 shows the case for a hydraulic conductivity of $5x10^{-9}$ m/s.

The evolution of cumulative fluxes through the top of the cover system, top of tailings and bottom of tailings computed for mean and dry year periods is shown in Figures 8 and 9 for tailings with average hydraulic conductivity of $1x10^{-8}$ m/s and $5x10^{-9}$ m/s, respectively.

The models showed that if the combined tailings have an average hydraulic conductivity value of $1x10^{-8}$ m/s, the tailings would desaturate progressively with time. Although the degree of saturation remained above 85% for the time period covered by the mean-year models (*i.e.,* 15 years), the model exhibits a clear trend towards tailings desaturation. This suggests that the tailings saturation would be less than 85% in the long term. The models also showed that tailings desaturation could be much faster during prolonged periods of dry years, such as have been historically observed between 1964 and 1966.

For the scenario with combined tailings presenting average hydraulic conductivity of $5x10^{-9}$ m/s, the model results suggested that the tailings would sustain saturation values above 85% in the long term in spite of slight desaturation on top of tailings.

Table 1 summarizes the computed cumulative annual fluxes through the bottom of the cover into the tailings (Influx), and through the bottom of the tailings (outflux) for mean and dry years (1964-1966) at the end of the cycles modeled. The models indicate that there would be a deficit of water for dry and mean years if the combined tailings have a hydraulic conductivity of $1x10^{-8}$ m/s. If the hydraulic conductivity of the in-pit tailings is $5x10^{-9}$ m/s or less, then the models indicate that a deficit of water would still exist for dry years, but fluxes into the tailings during mean years would likely cause the tailings to re-saturate after dry years.

Table 1: Summary of Computed Annual Cumulative Fluxes In and Out the Tailings

Tailings Saturated Hydraulic Conductivity	Mean Years (End of Year 15)			Dry Years (End of Year 3)		
	Annual Influx (m^3/m^2)	Annual Outflux (m^3/m^2)	Flux Balance (m^3/m^2)	Annual Influx (m^3/m^2)	Annual Outflux (m^3/m^2)	Flux Balance (m^3/m^2)
K= $1x10^{-8}$ m/s	0.14	0.16	-0.02	0.12	0.16	-0.04
K = $5x10^{-9}$ m/s	0.08	0.08	0.00	0.07	0.08	-0.01

The models suggest that the hydraulic conductivity of the combined tailings must be approximately $5x10^{-9}$ m/s or less for the tailings to sustain or maintain saturation above 85% in the long term. The actual in-pit tailings hydraulic conductivity will depend on several factors including:

- The ratio of coarse to fine tailings.
- The effectiveness of the mixing procedures during tailings relocation.
- The tailings consolidation properties.
- Actual in-pit tailings density.

The current in-situ wet density of tailings obtained from different boreholes is reported to vary between 990 kg/m^3 and 1785 kg/m^3, with moisture contents varying from 27% for coarse tailings to 51% for fine tailings. If similar conditions existed in the relocated (in pit) tailings, and the hydraulic gradient across the in-pit fully saturated tailings was close to 1, then the anticipated hydraulic conductivity of the tailings would be around $1x10^{-8}$ m/s, based on laboratory tests. Under these conditions, the models suggested that the tailings would not sustain the needed high saturation over the long term.

However, tailings relocated into the pit would likely consolidate to higher densities than reported for the existing tailings area. Measurements of the tailings consolidation properties and variation of hydraulic conductivity with increasing confining pressures would be required to assess whether the reduction in the permeability values would be enough to ensure tailings saturation in the long term. Relocation of the tailings to the pit would increase the average tailings thickness from about 14 m to almost 30 m, and It would be expected that the hydraulic conductivity of the tailings at depth would decrease due to consolidation and increased density, reducing overall tailings drainage capacity.

5.0 COVER WATER BALANCE MODELS

5.1 Models Setup

The second component of the present study involved the run of numerical models to estimate cover water balance fluxes associated with different closure options. The flux models covered the period between April 15 and October 31 of each year, and computed fluxes associated with: actual evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the tailings (or waste rock for Option B).

Three climate data sets were prepared using the years of 2003 (mean year, 283 mm precipitation), 1976 (dry year, 180 mm precipitation) and 2000 (wet year, 477 mm precipitation).

An average hydraulic conductivity value of $1x10^{-8}$ m/s was used for the tailings, equal to the higher permeability condition evaluated for Option 3 in Section 4.0 of this report. Properties for the other materials were the same as described in Section 3.

The lower boundary condition for all models was set as a constant hydraulic head at El. 1074 m, which is approximately the elevation of the seepage pond downstream from the tailings dam.

Table 2 summarizes the models scenarios.

Table 2: Summary of Cover Water Balance Models

Closure Option	Geometry (from upper layer to lower)	Upper BC	Lower BC	Time Span
Option 1 (In place tailings with water cover)	■ 0.2 m thick diffusion layer (El.1098 m to 1098.2 m) ■ 14 m thick tailings (El. 1084 m to 1098 m) ■ 10 m thick bedrock (El. 1074 m to 1084 m)	Constant head at el. 1099 m	Constant head at el. 1074 m	April 15 to October 31
Option 2 (In place tailings with saturated soil cover)	■ 1.0 m thick soil cover (El.1098 m to 1099 m) ■ 14 m thick tailings (El. 1084 m to 1098 m) ■ 10 m thick bedrock (El. 1074 m to 1084 m)	Head function (between el. 1099 m and el. 1098.5 m)	Constant head at el. 1074 m	April 15 to October 31

Closure Option	Geometry (from upper layer to lower)	Upper BC	Lower BC	Time Span
Option 3 (In pit tailings with soil cover)	■ 1.0 m thick soil cover (El.1210 m to 1211 m) ■ 30 m thick tailings (el. 1180 m to el. 1210 m) ■ 10 m thick bedrock (el. 1170 m to el. 1180 m)	Climate Data (Dry, Mean and Wet years)	Pit lake at el. 1182.3 m	April 15 to October 31
Option B (In pit waste rock)	■ 30 m thick waste rock (el. 1180 m to el. 1210 m) ■ 10 m thick bedrock (el. 1170 m to el. 1180 m)	Climate Data (Dry, Mean and Wet years)	Pit lake at el. 1182.3 m.	■ Dry and Wet Years: April 15 to October 31 ■ Mean year: 16 years (model year runs from April 15 to Oct 31)

5.2 Model Results

Table 3 summarizes cumulative fluxes through the top of cover, top of tailings and bottom of tailings computed for the period between April 15 and October 31 for all closure options, including Option B (In-Pit waste rock only). Negative values in Table 3 indicate an upwards flux. Table 4 summarizes cumulative values computed for climate water balance components. Details of computed values for all options are presented in Appendix B.

Table 3: Summary Cumulative Fluxes (April 15 to October 31)

Case	Dry Year (m^3/m^2)			Mean year (m^3/m^2)			Wet Year (m^3/m^2)		
Location	Top of Cover	Top of Tailings	Bottom of Tailings	Top of Cover	Top of Tailings	Bottom of Tailings	Top of Cover	Top of Tailings or Waste Rock	Bottom of Tailings
Option 1	-	0.21	0.21	-	0.21	0.21	-	0.21	0.21
Option 2	-0.22	0.21	0.21	-0.11	0.21	0.21	0.06	0.21	0.21
Option 3	0.02	0.13	0.15	0.06	0.14	0.16	0.18	0.16	0.16
Option B[1]	-	0.08	-	-	[1] 0.12	[1] 0.12	-	0.24	-

[1] Annual flux through bottom of waste rock computed for mean years after 12 years.

Table 4: Summary of Climate Water Balance

Case	Dry Year				Mean Year				Wet Year			
Location	**PPT**	**AE**	**RO**	**NI**	**PPT**	**AE**	**RO**	**NI**	**PPT**	**AE**	**RO**	**NI**
Option 1	183	367	-	208	283	367	-	208	477	367	-	208
Option 2	183	341	57	-217	283	345	51	-112	477	345	68	59
Option 3	183	165	0	20	283	229	0	57	477	293	0	178
Option B[1]	183	108	0	76	283	171	0	117	477	234	0	244

PPT = Precipitation, AE = Actual Evaporation, RO = Runoff and NI = Net Surface Infiltration.

As expected, the models showed that the tailings would remain saturated during all times for Closure Options 1 and 2, which have the water table above the tailings surface. For Option 1 (water cover), the climatic conditions will not play a role in fluxes through the tailings as long as there is enough water supply to sustain the water cover.

For Option 2, flows through the top and bottom of tailings will be similar to what was computed for Option 1 because the water table is above the surface of tailings for both options, and difference in hydraulic gradients associated with the slight variation of the water table in Option 2 is minor. The water table was assumed to drop 0.5 m within the cover during the summer, and a negative (evaporation) net flux would occur from the top of cover during dry and mean years, in response to the site high evaporation demand. During wet years net flux through the top of the cover would be positive.

Runoff values computed for Option 2 are associated with the April freshet period, when the water table is located on top of the cover. During that period, additional water would either runoff or pond on the tailings surface. Once the water table drops within the cover during the summer, rainfall water infiltrates and runoff will no longer occur. Similarly to Option 1, the models assumed that there will be enough water on site to sustain the water table above the surface of tailings during all times.

As discussed before, the models showed that for Option 3 there would be a deficit of water during dry and mean years, meaning that the tailings would desaturate progressively under the model conditions.

For Option B, the models showed that water would take over 12 years to reach the bottom of the 30-meter thick waste rock pile relocated into the pit. Once water reaches the bottom of the waste rock, there would be a steady flux as indicated In Table 3. It is however important to consider that waste rock piles are typically very heterogeneous, and therefore preferential flow paths could exist within the pile that would cause water to flow faster through the waste rock. This aspect has not been assessed in the simplified models prepared for this study.

6.0 CONCLUSIONS AND RECOMMENDATIONS

Simplified cover water balance models were prepared to assess a closure option for the Mt. Nansen site that consists of relocating tailings to an abandoned on-site open pit. The intent of the modeling was to evaluate if the tailings would be able to sustain needed saturation values above 85% in the pit during all times. In addition, cover water balance models were prepared to estimate fluxes through cover and tailings materials for additional closure options that are under consideration.

The models indicated that the ability of in-pit disposed tailings to maintain a saturation of 85% or more over the long term would be dependant on the saturated hydraulic conductivity of the combined tailings. If the relocated in-pit tailings have an average hydraulic conductivity value of $1x10^{-8}$ m/s or higher, there would be a deficit of water for dry and mean years, with a tendency for the tailings to desaturate with time unless supplementary water supply is used to offset the water deficit.

If however the relocated tailings have a hydraulic conductivity of $5x10^{-9}$ m/s or less, the models suggested that the degree of saturation of the tailings would be above the target 85% value in the long term.

The hydraulic and unsaturated properties of the tailings that would be relocated to the pit (*i.e.,* saturated hydraulic conductivity, soil-water characteristic curve and unsaturated hydraulic conductivity function) would play a major role in the final tailings saturation profile. Additional components that will impact the tailings saturation include: fluctuation of the pit lake level, climatic conditions, and configuration of the cover system installed on top of tailings.

It is recommended that a slurry consolidation test be performed on samples of combined tailings with measurements of the hydraulic conductivity at different confining pressures, incorporating the range of pressures expected to exist in the field. This would provide valuable information on the range of hydraulic conductivity values that could be attained in the field after tailings relocations, and support the discussions presented in this document about the feasibility of Closure Option 3.

Measurement of the soil-water characteristic curve for samples of combined tailings should be conducted to confirm the curve estimated from the grain size distribution.

It is also recommended that the models be adjusted to incorporate different hydraulic conductivities for different portions of the in-pit tailings, as well as to assess the impact of different cover alternatives for the tailings.

Future stages for the detailed design of Closure Option 3 would also require additional lab testing and preparation of an instrumentation and monitoring program to be followed during the first years after tailings relocation.

7.0 CLOSURE

We trust that the information presented in this memorandum meets your expectation. Should you have any question or require additional assistance, please do not hesitate to contact one of the undersigned.

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Fernando Junqueira, Ph.D., P.Eng.
Project Engineer

ORIGINAL SIGNED

John A. Hull, P.Eng.
Principal

FJ/JAH/rs/aw

Attachments: Figures 1 to 9
Appendix A: Draft Reference Drawings of Closure Options Provided by AECOM
Appendix B: Summary Fluxes for Cover Water Balance Models

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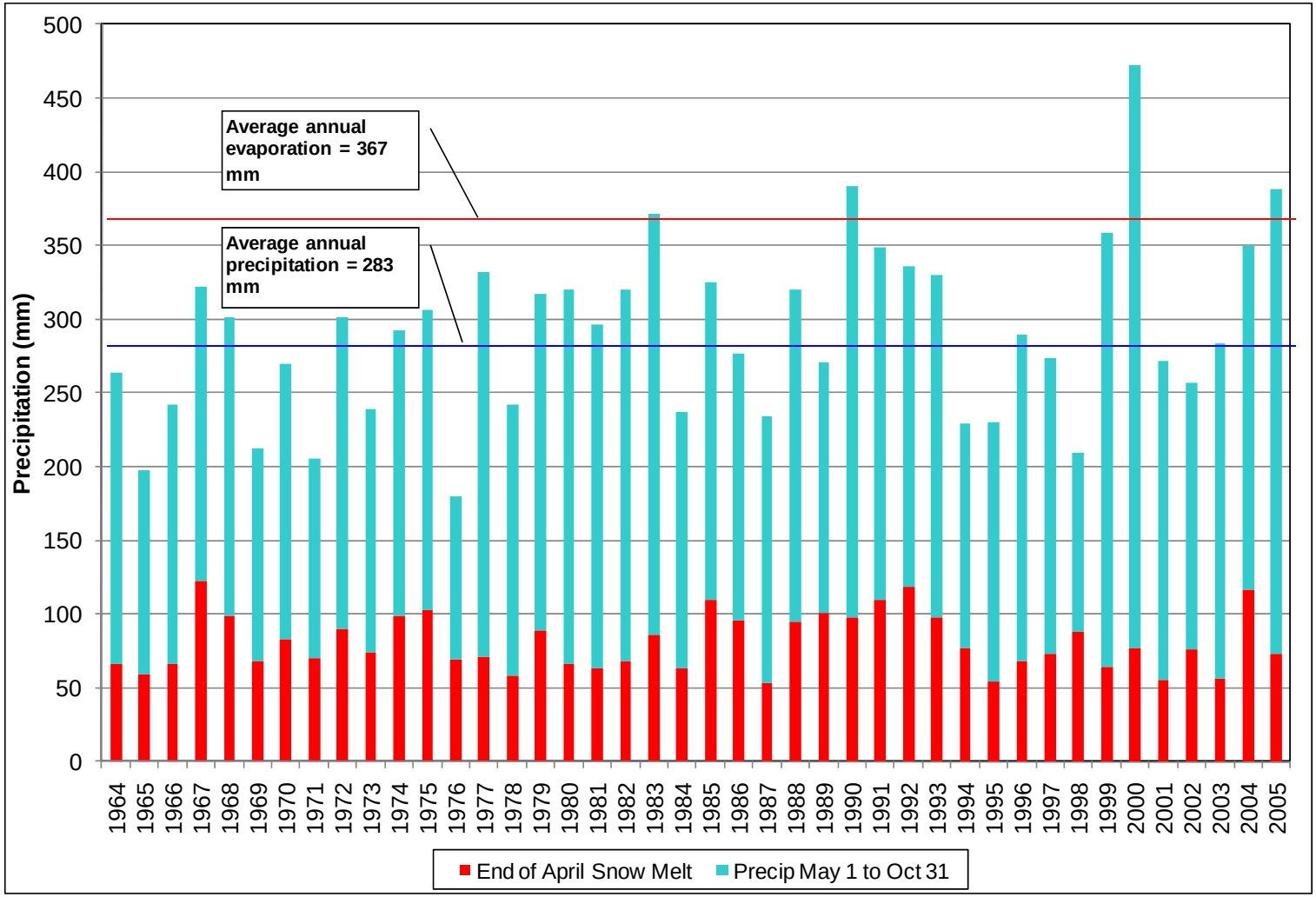
REFERENCES

Holtz R. D. and Kovacs W. D. (1981): Introduction to Geotechnical Engineering. Prentice-Hall Inc. Englewood Cliffs, New Jersey.

Fredlund M.D., Wilson G.W. and Fredlund D.G. (1997): Prediction of the Soil-Water Characteristic Curve from the Grain-Size Distribution Curve. 3rd Symposium on Unsaturated Soils. Rio de Janeiro, Brazil. April 20-22, pp. 13-23.



PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Carmacks Climate Data Adjusted for Mt. Nansen.

Golder Associates

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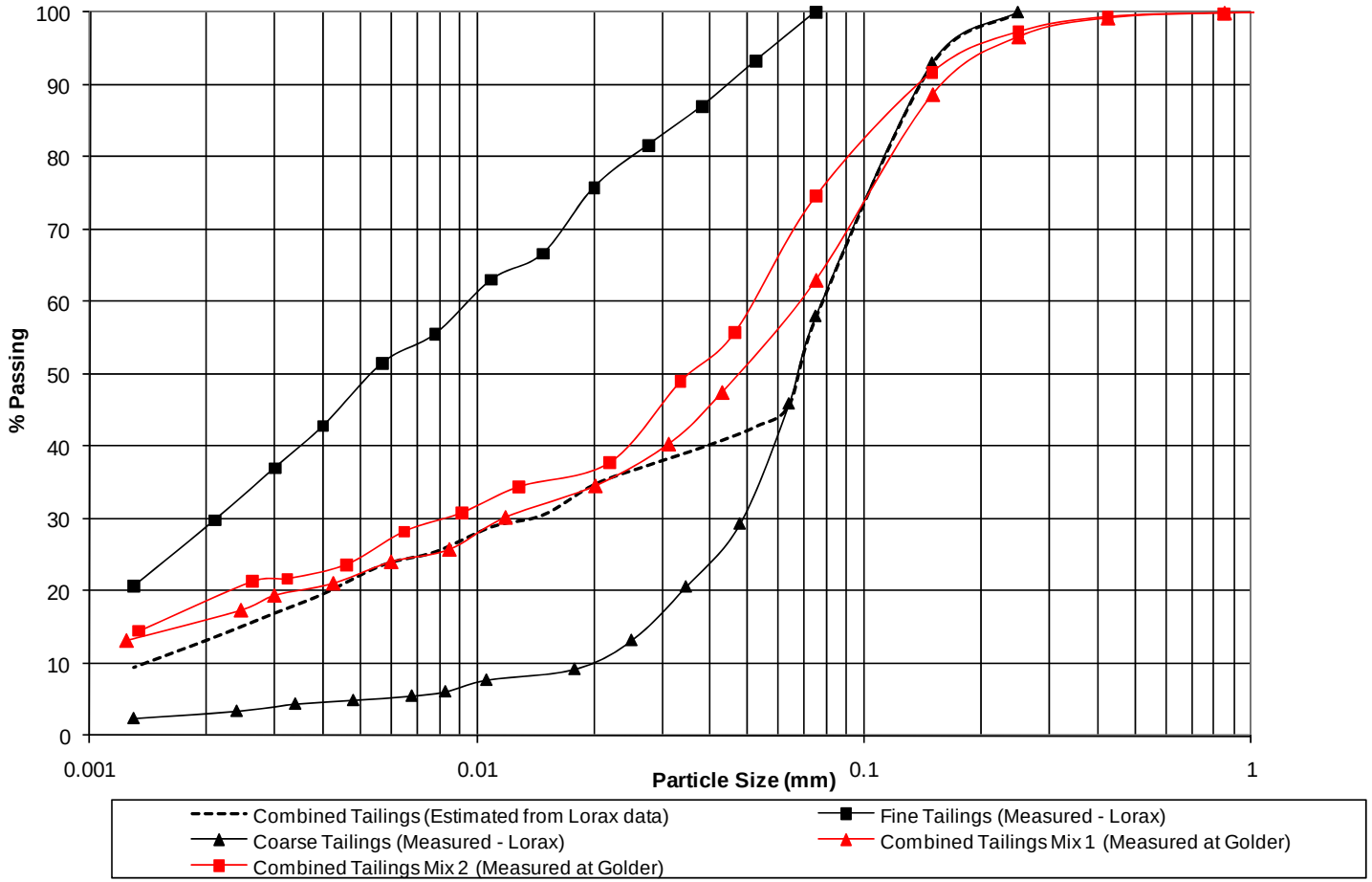
Tailings Grain Size Distribution



PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Measured and Estimated Tailings Gradation

Golder Associates

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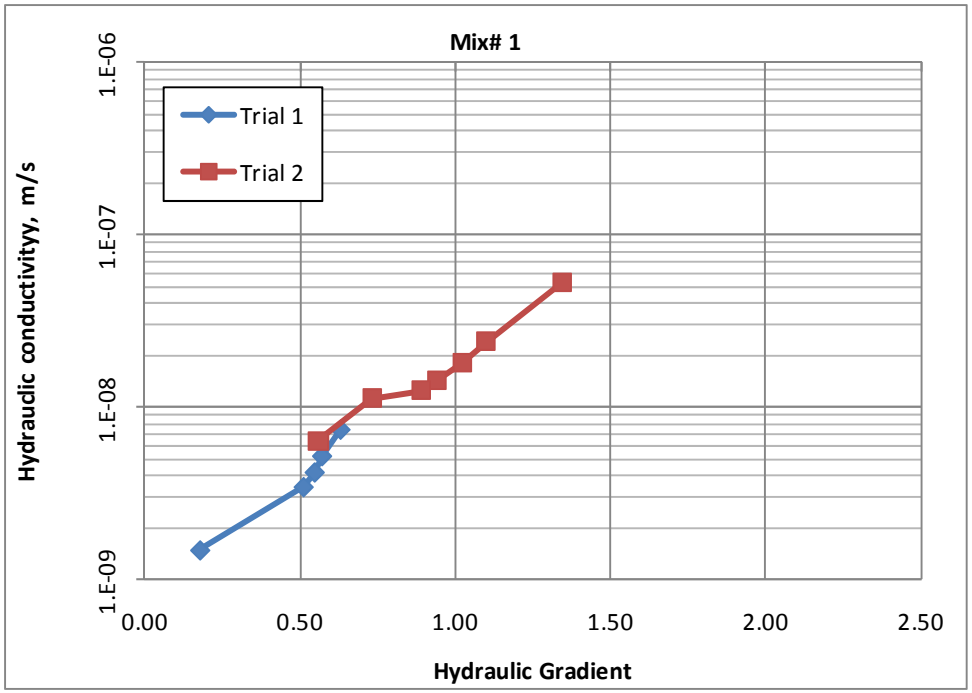

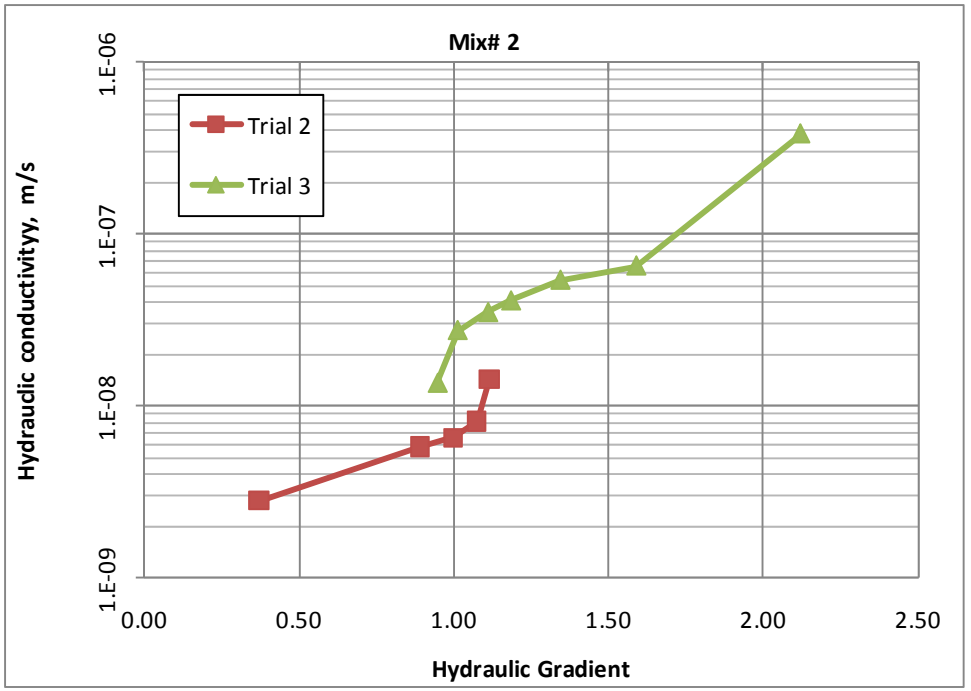

PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Measured Tailings Hydraulic Conductivity Vs. Hydraylic Gradient

Golder Associates

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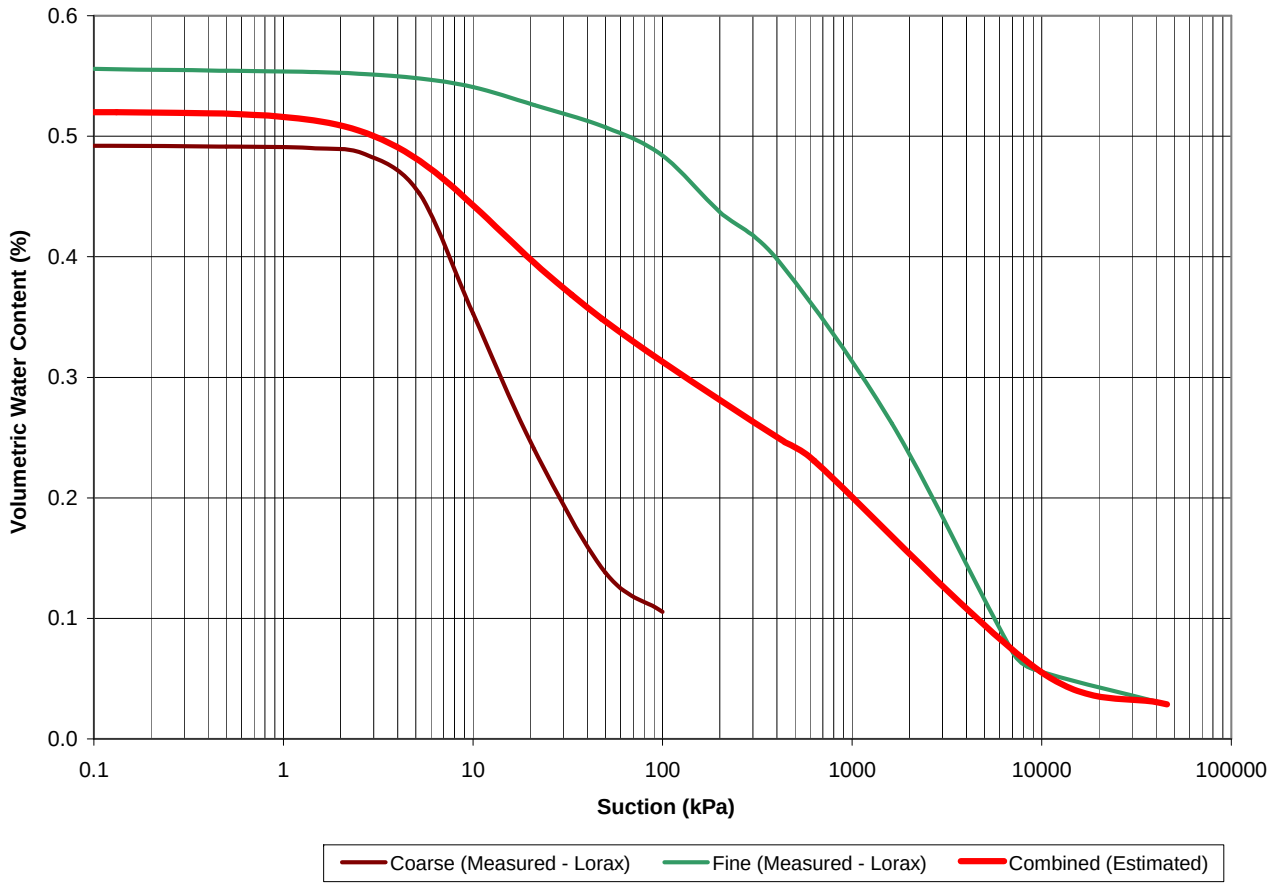
Tailings SWCC



PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Measured and Estimated Tailings SWCC

Golder Associates

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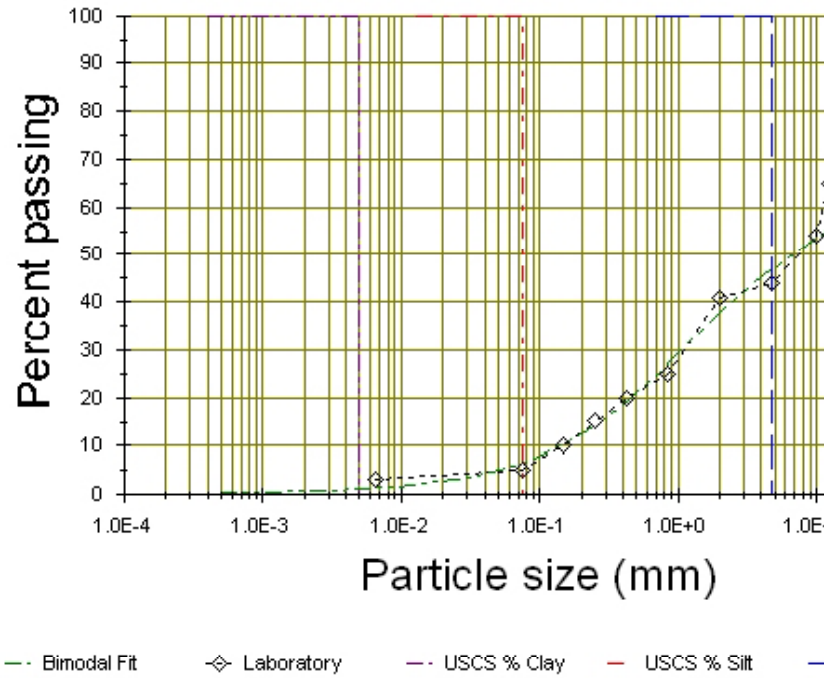

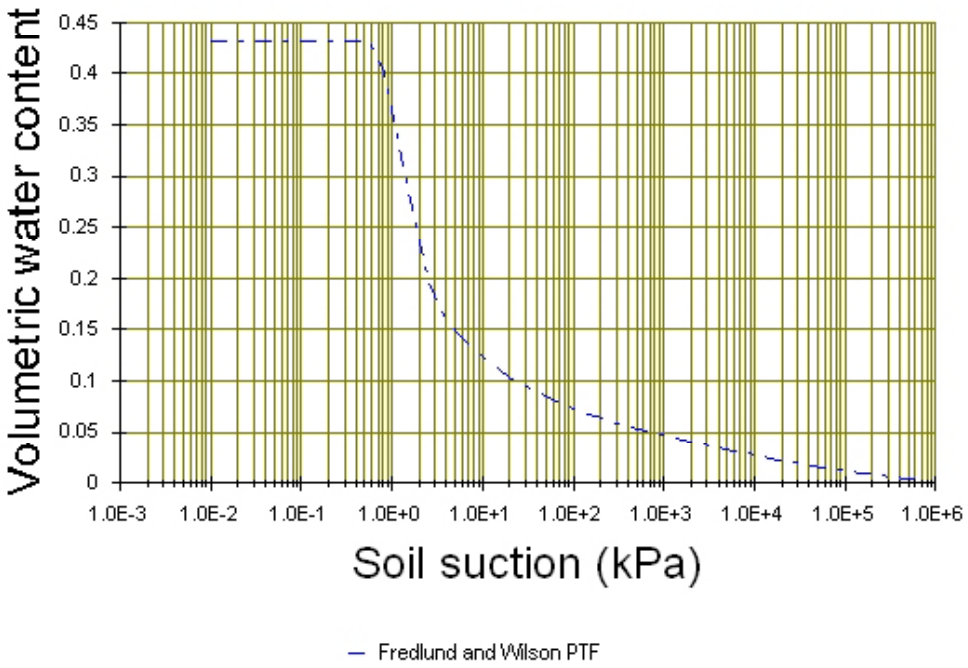

Notes:

- Grain size provided by Lorax
  - Sample: Bulk 2
  - Sample Location: Ramp to Pit
- Soil-Water Characteristic Curve estimated based on Fredlund and Wilson (1997)

PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Measured Gradation and and Estimated SWCC for Coarse Waste Rock

Golder Associates

PROJECT No.	10-1427-0018		FILE No.	--	
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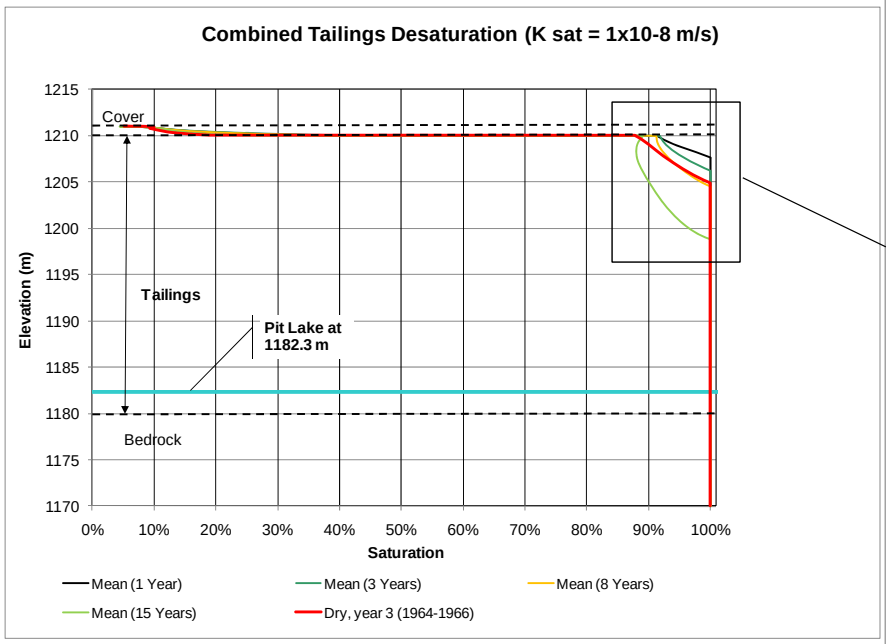

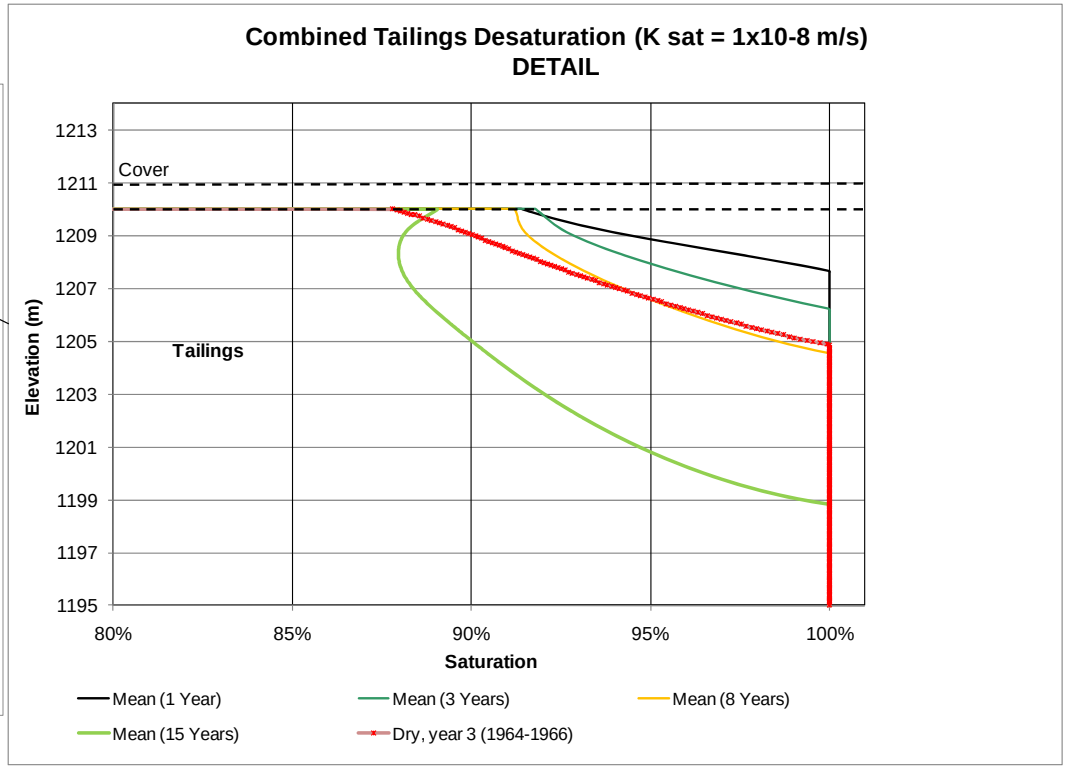

PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Evolution of Tailings Saturation Profile Modeled Tailings k = 1x10^{-8} m/s

Golder Associates

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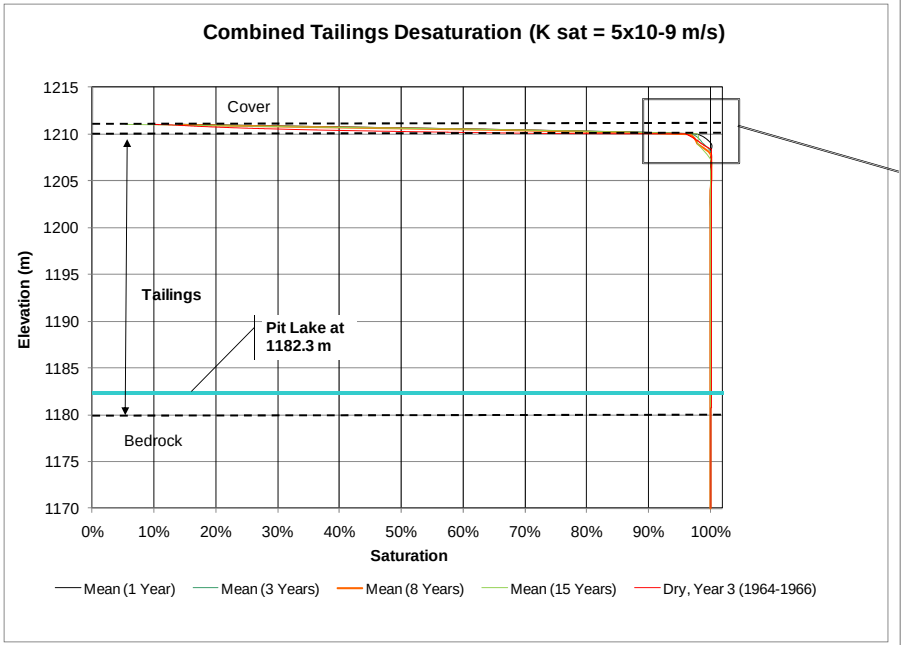
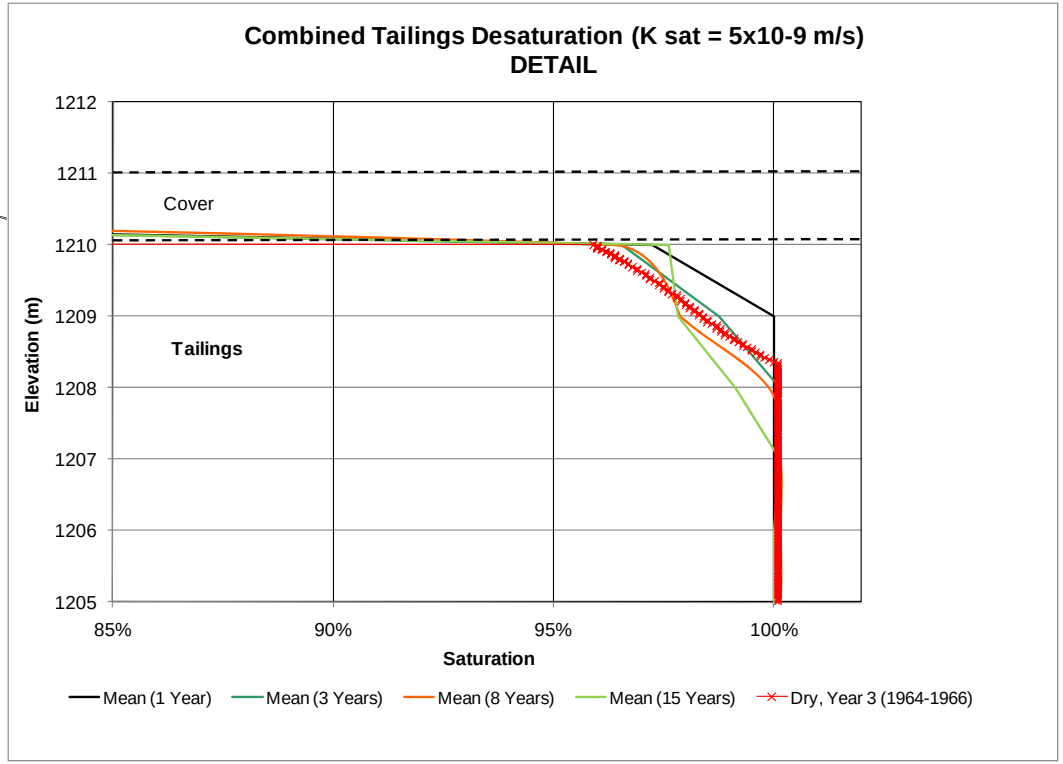
FIGURE 6





PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Evolution of Tailings Saturation Profile Modeled Tailings k = $5x10^{-9}$ m/s

Golder Associates

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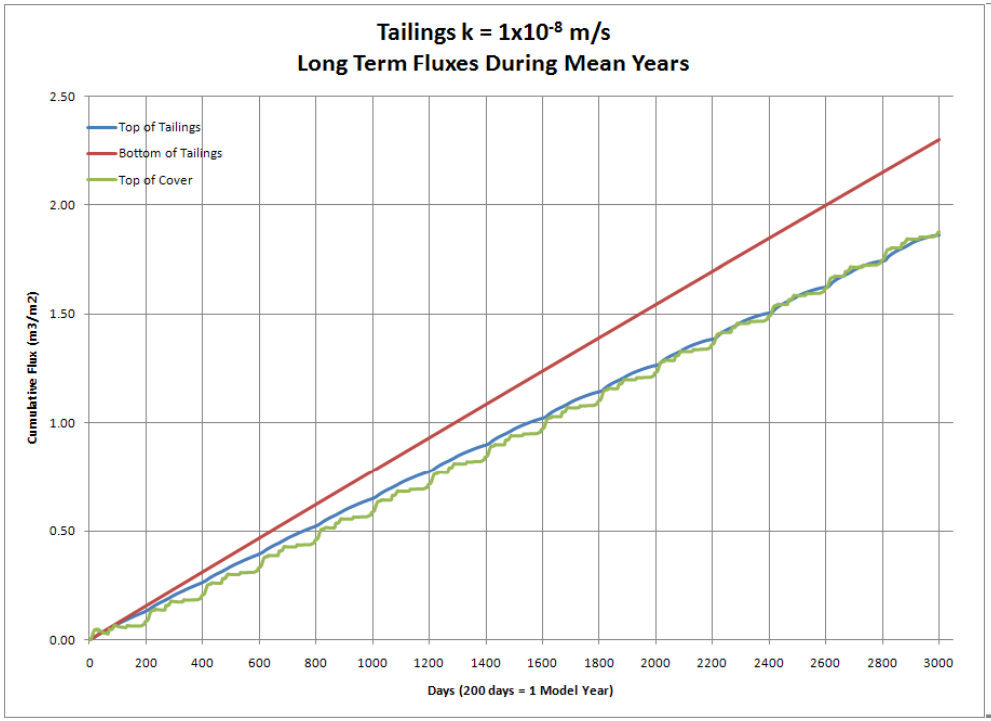

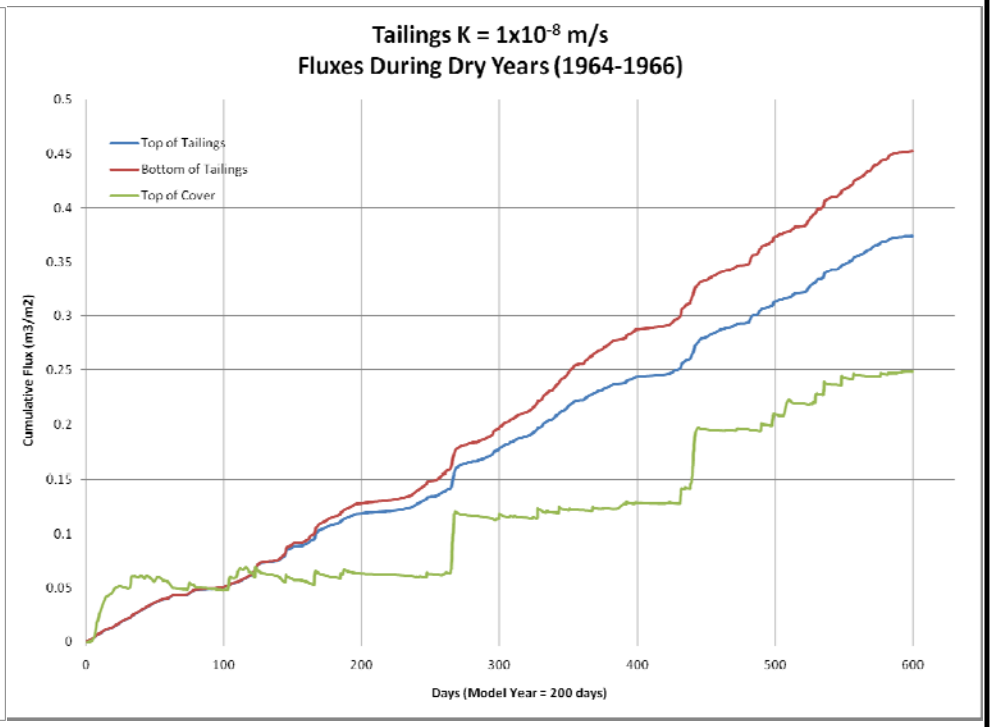

PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Cumulative Fluxes During Mean and Dry Years -Tailings k = 1x10-8 m/s

Golder Associates

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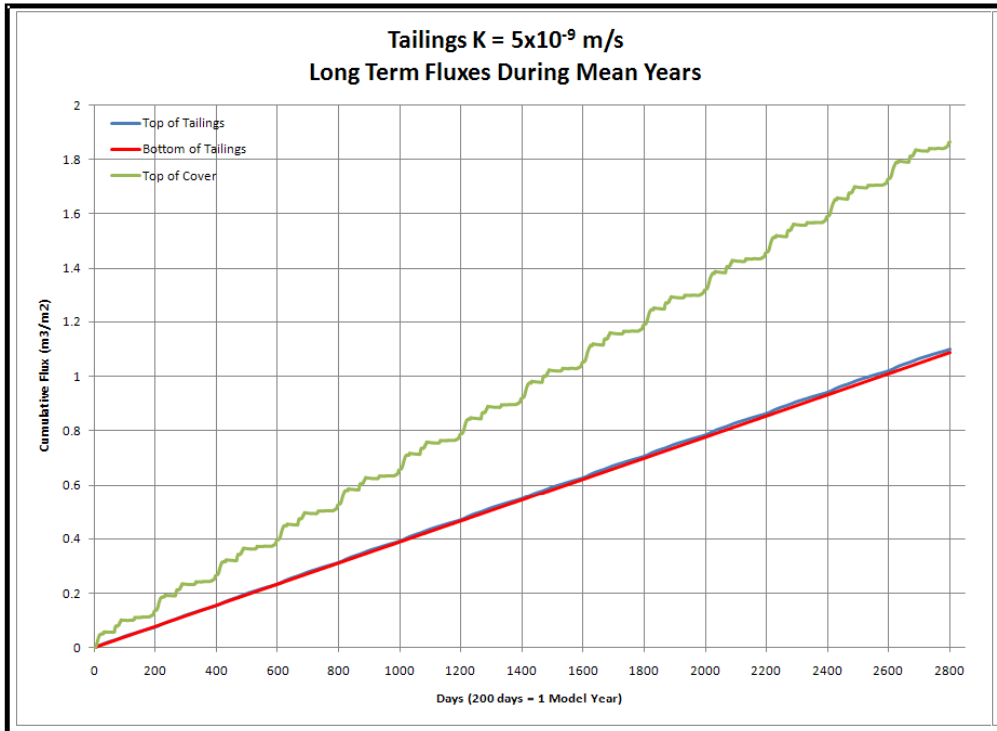

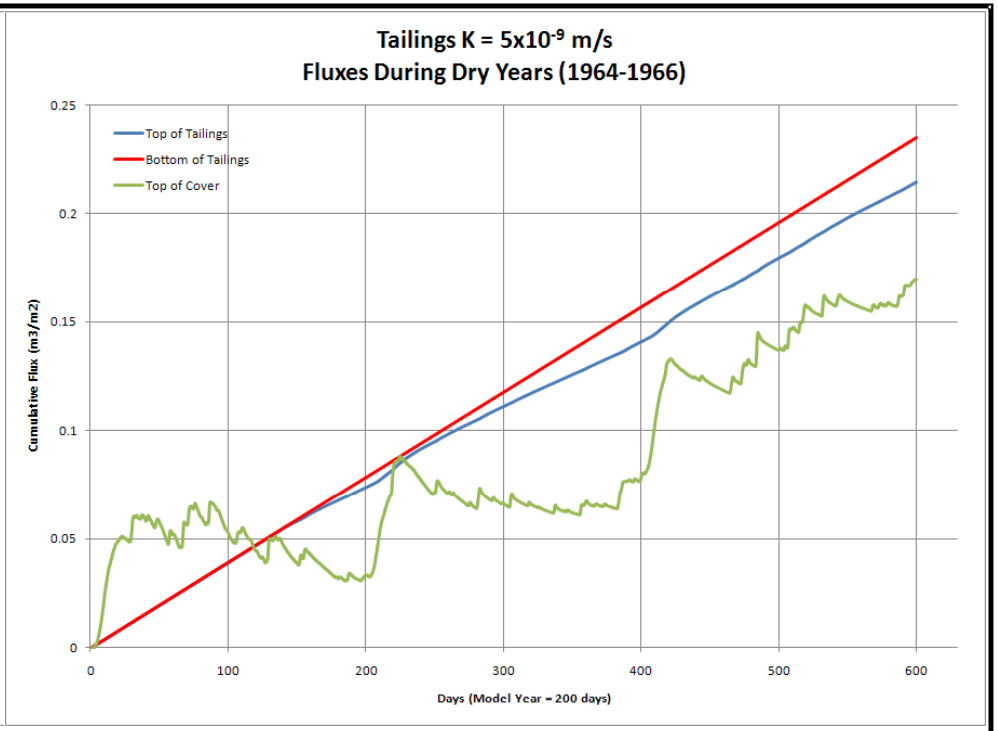

PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Cumulative Fluxes During Mean and Dry Years -Tailings k = 5x10-9 m/s

Golder Associates

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DESIGN	FJ	20-AUG-10	SCALE	NTS	REV.
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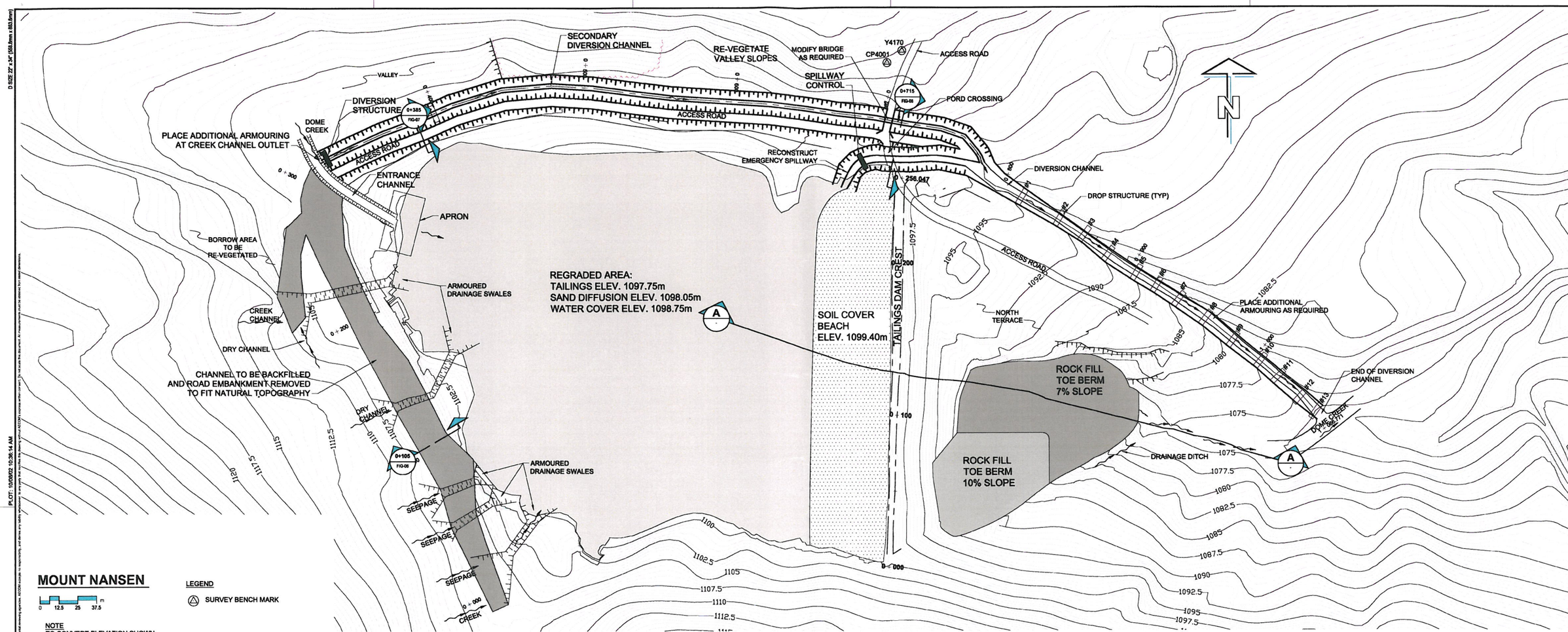
APPENDIX A
Draft Reference Drawings of Closure Options Provided by AECOM



OP 1 -

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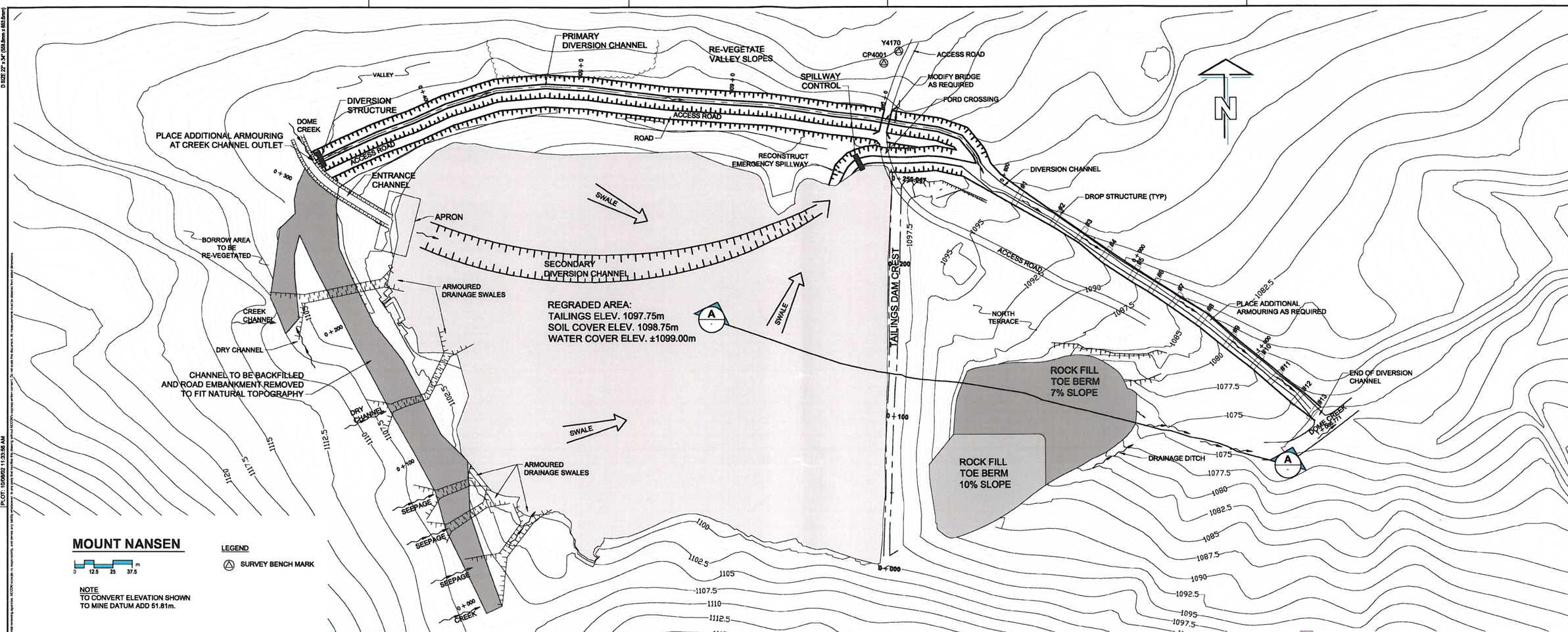
Yukon Government
Mt. Nansen Closure Alternatives Characterization

Option 1A - Water Cover
Site Plan & Profile
Drawing - 01

AECOM



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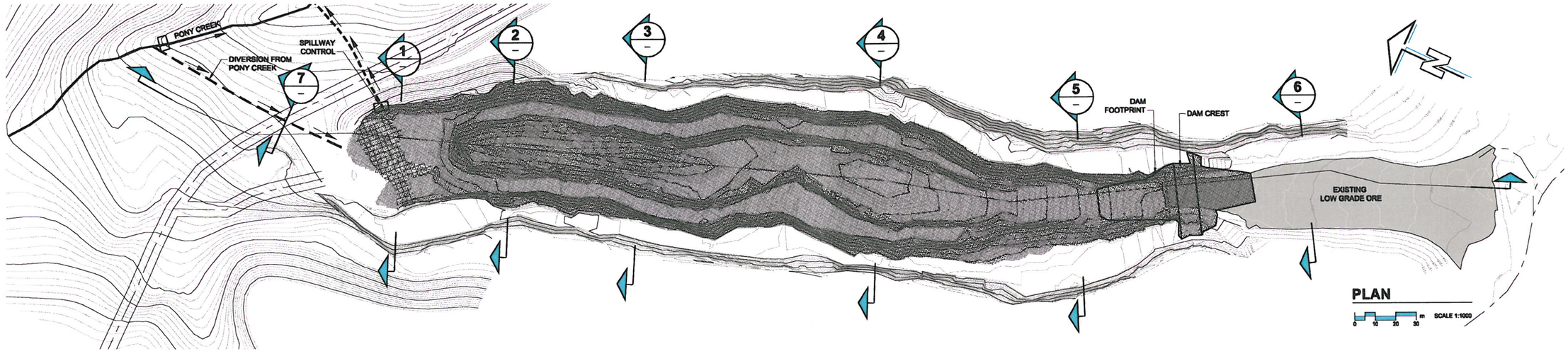
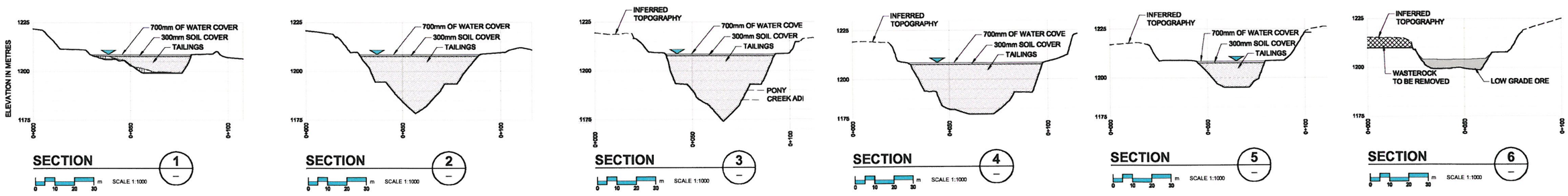
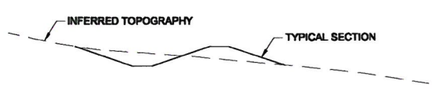
Yukon Government
Mt. Nansen Closure Alternatives Characterization

Option 2A - Soil Cover Site Plan & Profile Drawing 02

AECOM







SECTION 7
SCALE 1:150
TYPICAL DIVERSION DITCH

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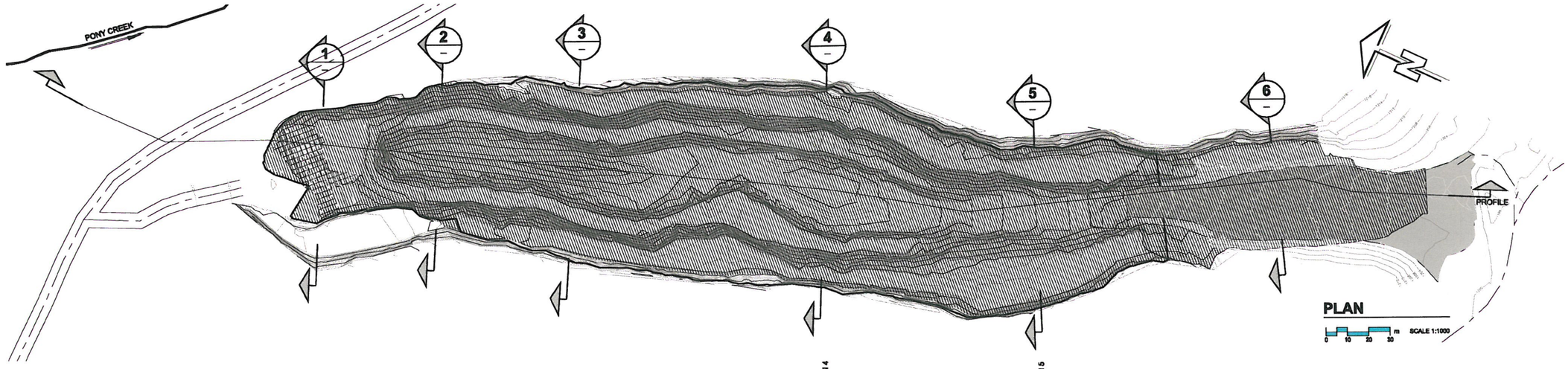
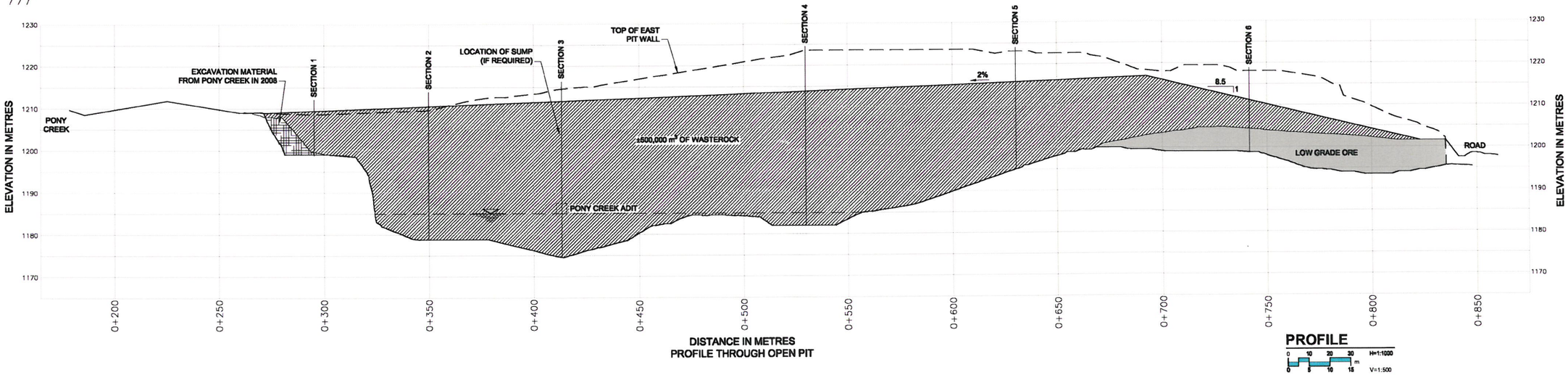
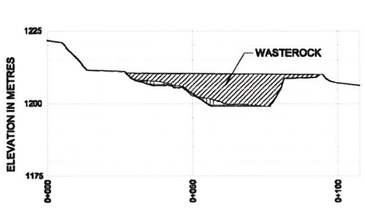
Mt. Nansen Closure Alternatives Characterization

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







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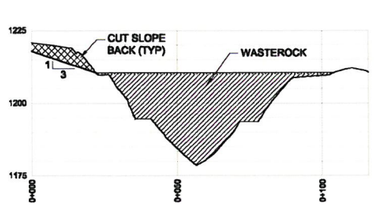

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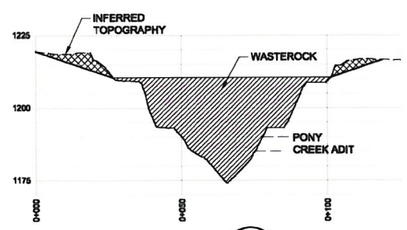

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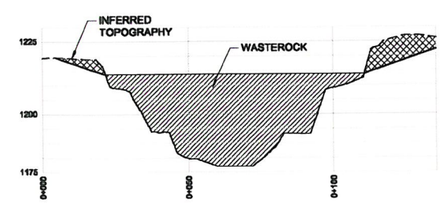

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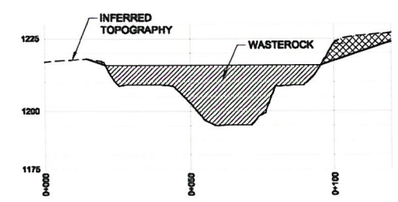

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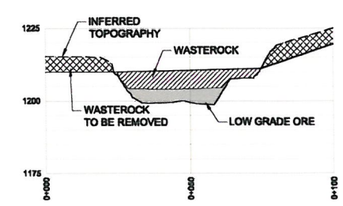

SECTION 6 SCALE 1:1000

NOTE: REFER TO DRAWING 01 AND 02 FOR DAM UPGRADING

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Mt. Nansen Closure Alternatives Characterization

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

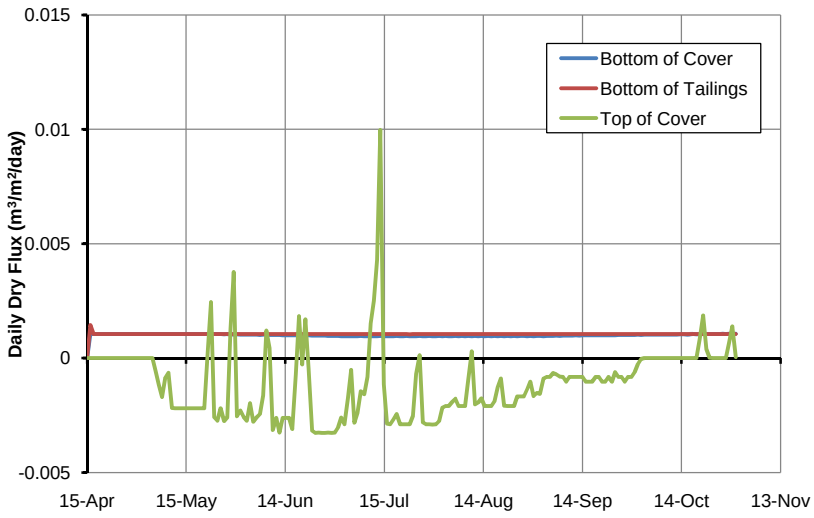
APPENDIX B
Summary Fluxes for Cover Water Balance Models

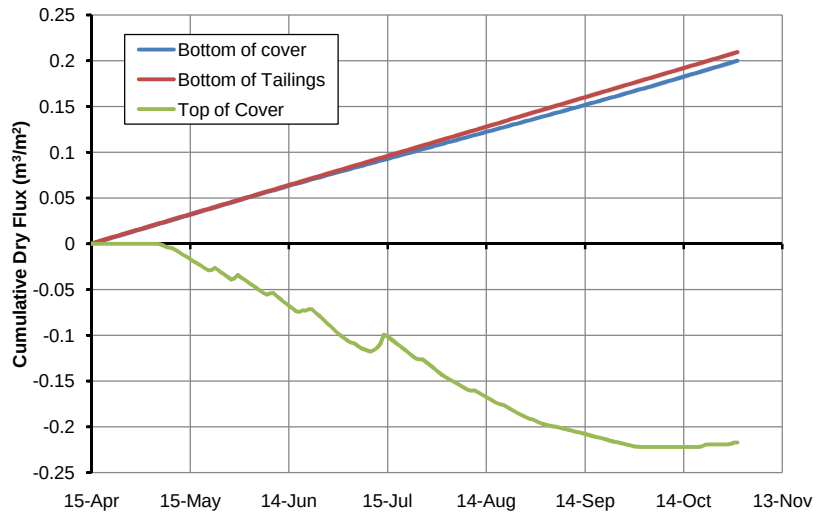
SUMMARY FLUXES THROUGH TAILINGS
OPTION 1 - WATER COVER (ALL YEARS)

		DAILY VALUES VS. TIME (m^3/m^2/day)		CUMULATIVE VALUES VS. TIME (m^3/m^2)	
Time	Date	Top of Tailings	Bottom of Tailings	Top of Tailings	Bottom of Tailings
1	15-Apr	0.00019	0.00019	0.00019	3E-05
2	16-Apr	0.00104	0.00107	0.00123	0.0011
3	17-Apr	0.00103	0.00107	0.00226	0.00217
4	18-Apr	0.00104	0.00107	0.0033	0.00324
5	19-Apr	0.00103	0.00107	0.00433	0.00431
6	20-Apr	0.00104	0.00107	0.00537	0.00538
7	21-Apr	0.00103	0.00107	0.0064	0.00645
8	22-Apr	0.00104	0.00107	0.00744	0.00752
9	23-Apr	0.00104	0.00106	0.00848	0.00858
10	24-Apr	0.00103	0.00107	0.00951	0.00965
11	25-Apr	0.00104	0.00107	0.01055	0.01072
12	26-Apr	0.00103	0.00107	0.01158	0.01179
13	27-Apr	0.00104	0.00107	0.01262	0.01286
14	28-Apr	0.00104	0.00107	0.01366	0.01393
15	29-Apr	0.00103	0.00107	0.01469	0.015
16	30-Apr	0.00104	0.00107	0.01573	0.01607
17	1-May	0.00104	0.00107	0.01677	0.01714
18	2-May	0.00104	0.00107	0.01781	0.01821
19	3-May	0.00103	0.00107	0.01884	0.01928
20	4-May	0.00104	0.00107	0.01988	0.02035
21	5-May	0.00104	0.00107	0.02092	0.02142
22	6-May	0.00103	0.00106	0.02195	0.02248
23	7-May	0.00104	0.00107	0.02299	0.02355
24	8-May	0.00104	0.00107	0.02403	0.02462
25	9-May	0.00104	0.00107	0.02507	0.02569
26	10-May	0.00103	0.00107	0.0261	0.02676
27	11-May	0.00104	0.00107	0.02714	0.02783
28	12-May	0.00104	0.00107	0.02818	0.0289
29	13-May	0.00104	0.00107	0.02922	0.02997
30	14-May	0.00103	0.00107	0.03025	0.03104
31	15-May	0.00104	0.00107	0.03129	0.03211
32	16-May	0.00104	0.00107	0.03233	0.03318
33	17-May	0.00104	0.00107	0.03337	0.03425
34	18-May	0.00103	0.00107	0.0344	0.03532
35	19-May	0.00104	0.00106	0.03544	0.03638
36	20-May	0.00104	0.00107	0.03648	0.03745
37	21-May	0.00104	0.00107	0.03752	0.03852
38	22-May	0.00103	0.00107	0.03855	0.03959
39	23-May	0.00104	0.00107	0.03959	0.04066
40	24-May	0.00104	0.00107	0.04063	0.04173
41	25-May	0.00104	0.00107	0.04167	0.0428
42	26-May	0.00104	0.00107	0.04271	0.04387
43	27-May	0.00104	0.00107	0.04375	0.04494
44	28-May	0.00103	0.00107	0.04478	0.04601
45	29-May	0.00104	0.00107	0.04582	0.04708
46	30-May	0.00104	0.00107	0.04686	0.04815
47	31-May	0.00104	0.00107	0.0479	0.04922
48	1-Jun	0.00104	0.00106	0.04894	0.05028
49	2-Jun	0.00103	0.00107	0.04997	0.05135
50	3-Jun	0.00104	0.00107	0.05101	0.05242
51	4-Jun	0.00104	0.00107	0.05205	0.05349
52	5-Jun	0.00104	0.00107	0.05309	0.05456
53	6-Jun	0.00104	0.00107	0.05413	0.05563
54	7-Jun	0.00104	0.00107	0.05517	0.0567
55	8-Jun	0.00104	0.00107	0.05621	0.05777
56	9-Jun	0.00103	0.00107	0.05724	0.05884
57	10-Jun	0.00104	0.00107	0.05828	0.05991
58	11-Jun	0.00104	0.00107	0.05932	0.06098
59	12-Jun	0.00104	0.00107	0.06036	0.06205
60	13-Jun	0.00104	0.00107	0.0614	0.06312
61	14-Jun	0.00104	0.00106	0.06244	0.06418
62	15-Jun	0.00104	0.00107	0.06348	0.06525
63	16-Jun	0.00104	0.00107	0.06452	0.06632
64	17-Jun	0.00103	0.00107	0.06555	0.06739
65	18-Jun	0.00104	0.00107	0.06659	0.06846
66	19-Jun	0.00104	0.00107	0.06763	0.06953
67	20-Jun	0.00104	0.00107	0.06867	0.0706
68	21-Jun	0.00104	0.00107	0.06971	0.07167
69	22-Jun	0.00104	0.00107	0.07075	0.07274
70	23-Jun	0.00104	0.00107	0.07179	0.07381
71	24-Jun	0.00104	0.00107	0.07283	0.07488
72	25-Jun	0.00104	0.00107	0.07387	0.07595
73	26-Jun	0.00104	0.00107	0.07491	0.07702
74	27-Jun	0.00103	0.00107	0.07594	0.07809
75	28-Jun	0.00104	0.00106	0.07698	0.07915
76	29-Jun	0.00104	0.00107	0.07802	0.08022
77	30-Jun	0.00104	0.00107	0.07906	0.08129
78	1-Jul	0.00104	0.00107	0.0801	0.08236
79	2-Jul	0.00104	0.00107	0.08114	0.08343
80	3-Jul	0.00104	0.00107	0.08218	0.0845
81	4-Jul	0.00104	0.00107	0.08322	0.08557
82	5-Jul	0.00104	0.00107	0.08426	0.08664
83	6-Jul	0.00104	0.00107	0.0853	0.08771
84	7-Jul	0.00104	0.00107	0.08634	0.08878
85	8-Jul	0.00104	0.00107	0.08738	0.08985
86	9-Jul	0.00104	0.00107	0.08842	0.09092
87	10-Jul	0.00104	0.00107	0.08946	0.09199
88	11-Jul	0.00104	0.00106	0.0905	0.09305
89	12-Jul	0.00103	0.00107	0.09153	0.09412
90	13-Jul	0.00104	0.00107	0.09257	0.09519
91	14-Jul	0.00104	0.00107	0.09361	0.09626
92	15-Jul	0.00104	0.00107	0.09465	0.09733
93	16-Jul	0.00104	0.00107	0.09569	0.0984
94	17-Jul	0.00104	0.00107	0.09673	0.09947
95	18-Jul	0.00104	0.00107	0.09777	0.10054
96	19-Jul	0.00104	0.00107	0.09881	0.10161
97	20-Jul	0.00104	0.00107	0.09985	0.10268
98	21-Jul	0.00104	0.00107	0.10089	0.10375
99	22-Jul	0.00104	0.00107	0.10193	0.10482
100	23-Jul	0.00104	0.00107	0.10297	0.10589

		DAILY VALUES VS. TIME ($m^3/m^2/day$)		CUMULATIVE VALUES VS. TIME (m^3/m^2)	
Time	Date	Top of Tailings	Bottom of Tailings	Top of Tailings	Bottom of Tailings
101	24-Jul	0.00104	0.00106	0.10401	0.10695
102	25-Jul	0.00104	0.00107	0.10505	0.10802
103	26-Jul	0.00104	0.00107	0.10609	0.10909
104	27-Jul	0.00104	0.00107	0.10713	0.11016
105	28-Jul	0.00104	0.00107	0.10817	0.11123
106	29-Jul	0.00104	0.00107	0.10921	0.1123
107	30-Jul	0.00104	0.00107	0.11025	0.11337
108	31-Jul	0.00104	0.00107	0.11129	0.11444
109	1-Aug	0.00104	0.00107	0.11233	0.11551
110	2-Aug	0.00104	0.00107	0.11337	0.11658
111	3-Aug	0.00104	0.00107	0.11441	0.11765
112	4-Aug	0.00104	0.00107	0.11545	0.11872
113	5-Aug	0.00104	0.00107	0.11649	0.11979
114	6-Aug	0.00104	0.00106	0.11753	0.12085
115	7-Aug	0.00104	0.00107	0.11857	0.12192
116	8-Aug	0.00104	0.00107	0.11961	0.12299
117	9-Aug	0.00104	0.00107	0.12065	0.12406
118	10-Aug	0.00104	0.00107	0.12169	0.12513
119	11-Aug	0.00104	0.00107	0.12273	0.1262
120	12-Aug	0.00104	0.00107	0.12377	0.12727
121	13-Aug	0.00104	0.00107	0.12481	0.12834
122	14-Aug	0.00104	0.00107	0.12585	0.12941
123	15-Aug	0.00104	0.00107	0.12689	0.13048
124	16-Aug	0.00104	0.00107	0.12793	0.13155
125	17-Aug	0.00104	0.00107	0.12897	0.13262
126	18-Aug	0.00104	0.00107	0.13001	0.13369
127	19-Aug	0.00104	0.00107	0.13105	0.13476
128	20-Aug	0.00104	0.00106	0.13209	0.13582
129	21-Aug	0.00104	0.00107	0.13313	0.13689
130	22-Aug	0.00105	0.00107	0.13418	0.13796
131	23-Aug	0.00104	0.00107	0.13522	0.13903
132	24-Aug	0.00104	0.00107	0.13626	0.1401
133	25-Aug	0.00104	0.00107	0.1373	0.14117
134	26-Aug	0.00104	0.00107	0.13834	0.14224
135	27-Aug	0.00104	0.00107	0.13938	0.14331
136	28-Aug	0.00104	0.00107	0.14042	0.14438
137	29-Aug	0.00104	0.00107	0.14146	0.14545
138	30-Aug	0.00104	0.00107	0.1425	0.14652
139	31-Aug	0.00104	0.00107	0.14354	0.14759
140	1-Sep	0.00104	0.00107	0.14458	0.14866
141	2-Sep	0.00104	0.00106	0.14562	0.14972
142	3-Sep	0.00104	0.00107	0.14666	0.15079
143	4-Sep	0.00104	0.00107	0.1477	0.15186
144	5-Sep	0.00104	0.00107	0.14874	0.15293
145	6-Sep	0.00104	0.00107	0.14978	0.154
146	7-Sep	0.00104	0.00107	0.15082	0.15507
147	8-Sep	0.00104	0.00107	0.15186	0.15614
148	9-Sep	0.00105	0.00107	0.15291	0.15721
149	10-Sep	0.00104	0.00107	0.15395	0.15828
150	11-Sep	0.00104	0.00107	0.15499	0.15935
151	12-Sep	0.00104	0.00107	0.15603	0.16042
152	13-Sep	0.00104	0.00107	0.15707	0.16149
153	14-Sep	0.00104	0.00107	0.15811	0.16256
154	15-Sep	0.00104	0.00106	0.15915	0.16362
155	16-Sep	0.00104	0.00107	0.16019	0.16469
156	17-Sep	0.00104	0.00107	0.16123	0.16576
157	18-Sep	0.00104	0.00107	0.16227	0.16683
158	19-Sep	0.00104	0.00107	0.16331	0.1679
159	20-Sep	0.00104	0.00107	0.16435	0.16897
160	21-Sep	0.00105	0.00107	0.1654	0.17004
161	22-Sep	0.00104	0.00107	0.16644	0.17111
162	23-Sep	0.00104	0.00107	0.16748	0.17218
163	24-Sep	0.00104	0.00107	0.16852	0.17325
164	25-Sep	0.00104	0.00107	0.16956	0.17432
165	26-Sep	0.00104	0.00107	0.1706	0.17539
166	27-Sep	0.00104	0.00107	0.17164	0.17646
167	28-Sep	0.00104	0.00106	0.17268	0.17752
168	29-Sep	0.00104	0.00107	0.17372	0.17859
169	30-Sep	0.00104	0.00107	0.17476	0.17966
170	1-Oct	0.00105	0.00107	0.17581	0.18073
171	2-Oct	0.00104	0.00107	0.17685	0.1818
172	3-Oct	0.00104	0.00107	0.17789	0.18287
173	4-Oct	0.00104	0.00107	0.17893	0.18394
174	5-Oct	0.00104	0.00107	0.17997	0.18501
175	6-Oct	0.00104	0.00107	0.18101	0.18608
176	7-Oct	0.00104	0.00107	0.18205	0.18715
177	8-Oct	0.00104	0.00107	0.18309	0.18822
178	9-Oct	0.00105	0.00107	0.18414	0.18929
179	10-Oct	0.00104	0.00106	0.18518	0.19035
180	11-Oct	0.00104	0.00107	0.18622	0.19142
181	12-Oct	0.00104	0.00107	0.18726	0.19249
182	13-Oct	0.00104	0.00107	0.1883	0.19356
183	14-Oct	0.00104	0.00107	0.18934	0.19463
184	15-Oct	0.00104	0.00107	0.19038	0.1957
185	16-Oct	0.00104	0.00107	0.19142	0.19677
186	17-Oct	0.00105	0.00107	0.19247	0.19784
187	18-Oct	0.00104	0.00107	0.19351	0.19891
188	19-Oct	0.00104	0.00107	0.19455	0.19998
189	20-Oct	0.00104	0.00107	0.19559	0.20105
190	21-Oct	0.00104	0.00107	0.19663	0.20212
191	22-Oct	0.00104	0.00106	0.19767	0.20318
192	23-Oct	0.00104	0.00107	0.19871	0.20425
193	24-Oct	0.00105	0.00107	0.19976	0.20532
194	25-Oct	0.00104	0.00107	0.2008	0.20639
195	26-Oct	0.00104	0.00107	0.20184	0.20746
196	27-Oct	0.00104	0.00107	0.20288	0.20853
197	28-Oct	0.00104	0.00107	0.20392	0.2096
198	29-Oct	0.00104	0.00107	0.20496	0.21067
199	30-Oct	0.00104	0.00107	0.206	0.21174
200	31-Oct	0.00105	0.00107	0.20705	0.21281

OPTION 2 - COVER AND TAILINGS FLUXES
DRY YEAR

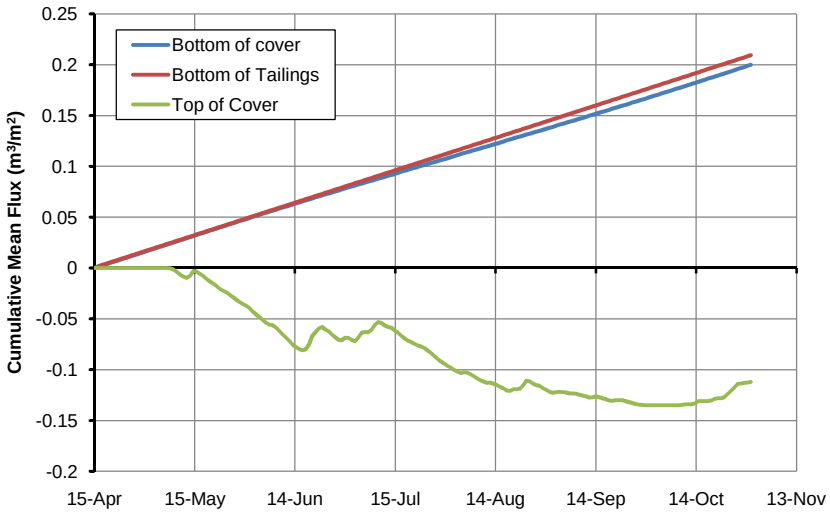


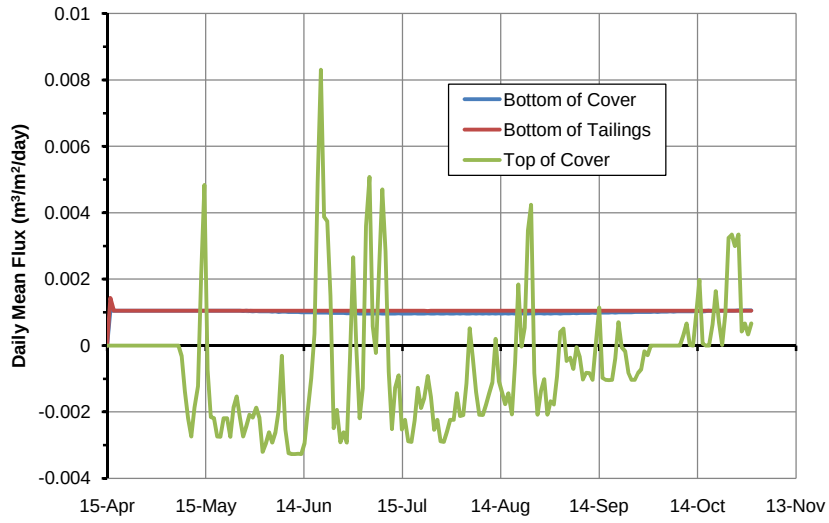


		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00105	0.00144	0	0.00105	0.00144	0
3	17-Apr	0.00105	0.00105	0	0.0021	0.00249	0
4	18-Apr	0.00105	0.00105	0	0.00315	0.00354	0
5	19-Apr	0.00105	0.00105	0	0.0042	0.00459	0
6	20-Apr	0.00105	0.00105	0	0.00525	0.00564	0
7	21-Apr	0.00105	0.00105	0	0.0063	0.00669	0
8	22-Apr	0.00105	0.00105	0	0.00735	0.00774	0
9	23-Apr	0.00105	0.00105	0	0.0084	0.00879	0
10	24-Apr	0.00105	0.00105	0	0.00945	0.00984	0
11	25-Apr	0.00105	0.00105	0	0.0105	0.01089	0
12	26-Apr	0.00105	0.00105	0	0.01155	0.01194	0
13	27-Apr	0.00105	0.00105	0	0.0126	0.01299	0
14	28-Apr	0.00105	0.00105	0	0.01365	0.01404	0
15	29-Apr	0.00105	0.00105	0	0.0147	0.01509	0
16	30-Apr	0.00105	0.00105	0	0.01575	0.01614	0
17	1-May	0.00105	0.00105	0	0.0168	0.01719	0
18	2-May	0.00105	0.00105	0	0.01785	0.01824	0
19	3-May	0.00105	0.00105	0	0.0189	0.01929	0
20	4-May	0.00105	0.00105	0	0.01995	0.02034	0
21	5-May	0.00105	0.00105	0	0.021	0.02139	0
22	6-May	0.00105	0.00105	-0.00057	0.02205	0.02244	-0.00057
23	7-May	0.00105	0.00105	-0.00117	0.0231	0.02349	-0.00174
24	8-May	0.00105	0.00105	-0.00171	0.02415	0.02454	-0.00345
25	9-May	0.00105	0.00105	-0.00086	0.0252	0.02559	-0.00431
26	10-May	0.00105	0.00105	-0.00064	0.02625	0.02664	-0.00495
27	11-May	0.00105	0.00105	-0.00218	0.0273	0.02769	-0.00713
28	12-May	0.00105	0.00105	-0.0022	0.02835	0.02874	-0.00933
29	13-May	0.00105	0.00105	-0.00219	0.0294	0.02979	-0.01152
30	14-May	0.00105	0.00105	-0.00219	0.03045	0.03084	-0.01371
31	15-May	0.00105	0.00105	-0.0022	0.0315	0.03189	-0.01591
32	16-May	0.00105	0.00105	-0.00219	0.03255	0.03294	-0.0181
33	17-May	0.00105	0.00105	-0.00219	0.0336	0.03399	-0.02029
34	18-May	0.00105	0.00105	-0.0022	0.03465	0.03504	-0.02249
35	19-May	0.00105	0.00105	-0.00219	0.0357	0.03609	-0.02468
36	20-May	0.00105	0.00105	-0.00219	0.03675	0.03714	-0.02687
37	21-May	0.00105	0.00105	-0.0022	0.0378	0.03819	-0.02907
38	22-May	0.00105	0.00105	0.00032	0.03885	0.03924	-0.02875
39	23-May	0.00105	0.00105	0.00245	0.0399	0.04029	-0.0263
40	24-May	0.00105	0.00105	-0.00258	0.04095	0.04134	-0.02888
41	25-May	0.00105	0.00105	-0.00274	0.042	0.04239	-0.03162
42	26-May	0.00105	0.00105	-0.00219	0.04305	0.04344	-0.03381
43	27-May	0.00104	0.00105	-0.00275	0.04409	0.04449	-0.03656
44	28-May	0.00105	0.00105	-0.00258	0.04514	0.04554	-0.03914
45	29-May	0.00104	0.00105	0.00129	0.04618	0.04659	-0.03785
46	30-May	0.00103	0.00105	0.00377	0.04721	0.04764	-0.03408
47	31-May	0.00104	0.00105	-0.00255	0.04825	0.04869	-0.03663
48	1-Jun	0.00103	0.00105	-0.00229	0.04928	0.04974	-0.03892
49	2-Jun	0.00103	0.00105	-0.00257	0.05031	0.05079	-0.04149
50	3-Jun	0.00103	0.00105	-0.00274	0.05134	0.05184	-0.04423
51	4-Jun	0.00103	0.00105	-0.00197	0.05237	0.05289	-0.0462
52	5-Jun	0.00102	0.00105	-0.00278	0.05339	0.05394	-0.04898
53	6-Jun	0.00103	0.00105	-0.0026	0.05442	0.05499	-0.05158
54	7-Jun	0.00101	0.00105	-0.00245	0.05543	0.05604	-0.05403
55	8-Jun	0.00102	0.00105	-0.00163	0.05645	0.05709	-0.05566
56	9-Jun	0.00102	0.00105	0.00121	0.05747	0.05814	-0.05445
57	10-Jun	0.00101	0.00105	0.00044	0.05848	0.05919	-0.05401
58	11-Jun	0.00101	0.00105	-0.00315	0.05949	0.06024	-0.05716
59	12-Jun	0.00101	0.00105	-0.00262	0.0605	0.06129	-0.05978
60	13-Jun	0.00101	0.00105	-0.00326	0.06151	0.06234	-0.06304
61	14-Jun	0.001	0.00105	-0.00261	0.06251	0.06339	-0.06565
62	15-Jun	0.001	0.00105	-0.00262	0.06351	0.06444	-0.06827
63	16-Jun	0.001	0.00105	-0.00261	0.06451	0.06549	-0.07088
64	17-Jun	0.001	0.00105	-0.00311	0.06551	0.06654	-0.07399
65	18-Jun	0.001	0.00105	-0.00072	0.06651	0.06759	-0.07471
66	19-Jun	0.00099	0.00105	0.00183	0.0675	0.06864	-0.07288
67	20-Jun	0.00099	0.00105	-0.00028	0.06849	0.06969	-0.07316
68	21-Jun	0.00099	0.00105	0.0017	0.06948	0.07074	-0.07146
69	22-Jun	0.00099	0.00105	-0.00046	0.07047	0.07179	-0.07192
70	23-Jun	0.00098	0.00105	-0.00318	0.07145	0.07284	-0.0751
71	24-Jun	0.00098	0.00105	-0.00327	0.07243	0.07389	-0.07837
72	25-Jun	0.00098	0.00105	-0.00326	0.07341	0.07494	-0.08163
73	26-Jun	0.00098	0.00105	-0.00327	0.07439	0.07599	-0.0849
74	27-Jun	0.00098	0.00105	-0.00327	0.07537	0.07704	-0.08817
75	28-Jun	0.00097	0.00105	-0.00326	0.07634	0.07809	-0.09143
76	29-Jun	0.00097	0.00105	-0.00327	0.07731	0.07914	-0.0947
77	30-Jun	0.00097	0.00105	-0.00326	0.07828	0.08019	-0.09796
78	1-Jul	0.00097	0.00105	-0.00304	0.07925	0.08124	-0.101
79	2-Jul	0.00096	0.00105	-0.0026	0.08021	0.08229	-0.1036
80	3-Jul	0.00096	0.00105	-0.0029	0.08117	0.08334	-0.1065
81	4-Jul	0.00096	0.00105	-0.00174	0.08213	0.08439	-0.10824
82	5-Jul	0.00096	0.00105	-0.00052	0.08309	0.08544	-0.10876
83	6-Jul	0.00096	0.00105	-0.00283	0.08405	0.08649	-0.11159
84	7-Jul	0.00096	0.00105	-0.00238	0.08501	0.08754	-0.11397
85	8-Jul	0.00097	0.00105	-0.00145	0.08598	0.08859	-0.11542
86	9-Jul	0.00096	0.00105	-0.00158	0.08694	0.08964	-0.117
87	10-Jul	0.00096	0.00105	-0.00083	0.0879	0.09069	-0.11783
88	11-Jul	0.00096	0.00105	0.00151	0.08886	0.09174	-0.11632
89	12-Jul	0.00096	0.00105	0.0025	0.08982	0.09279	-0.11382
90	13-Jul	0.00096	0.00105	0.00428	0.09078	0.09384	-0.10954
91	14-Jul	0.00097	0.00105	0.00998	0.09175	0.09489	-0.09956
92	15-Jul	0.00096	0.00105	-0.00115	0.09271	0.09594	-0.10071

		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
93	16-Jul	0.00096	0.00105	-0.00286	0.09367	0.09699	-0.10357
94	17-Jul	0.00096	0.00105	-0.0029	0.09463	0.09804	-0.10647
95	18-Jul	0.00096	0.00105	-0.00268	0.09559	0.09909	-0.10915
96	19-Jul	0.00097	0.00105	-0.00245	0.09656	0.10014	-0.1116
97	20-Jul	0.00096	0.00105	-0.00289	0.09752	0.10119	-0.11449
98	21-Jul	0.00096	0.00105	-0.0029	0.09848	0.10224	-0.11739
99	22-Jul	0.00097	0.00105	-0.0029	0.09945	0.10329	-0.12029
100	23-Jul	0.00096	0.00104	-0.0029	0.10041	0.10433	-0.12319
101	24-Jul	0.00096	0.00105	-0.00253	0.10137	0.10538	-0.12572
102	25-Jul	0.00096	0.00105	-0.00068	0.10233	0.10643	-0.1264
103	26-Jul	0.00097	0.00105	0.00013	0.1033	0.10748	-0.12627
104	27-Jul	0.00096	0.00105	-0.00281	0.10426	0.10853	-0.12908
105	28-Jul	0.00096	0.00105	-0.0029	0.10522	0.10958	-0.13198
106	29-Jul	0.00097	0.00105	-0.0029	0.10619	0.11063	-0.13488
107	30-Jul	0.00096	0.00105	-0.00291	0.10715	0.11168	-0.13779
108	31-Jul	0.00096	0.00105	-0.0029	0.10811	0.11273	-0.14069
109	1-Aug	0.00097	0.00105	-0.00275	0.10908	0.11378	-0.14344
110	2-Aug	0.00096	0.00105	-0.00217	0.11004	0.11483	-0.14561
111	3-Aug	0.00097	0.00105	-0.00209	0.11101	0.11588	-0.1477
112	4-Aug	0.00096	0.00105	-0.0021	0.11197	0.11693	-0.1498
113	5-Aug	0.00096	0.00105	-0.00193	0.11293	0.11798	-0.15173
114	6-Aug	0.00097	0.00105	-0.00177	0.1139	0.11903	-0.1535
115	7-Aug	0.00096	0.00105	-0.00209	0.11486	0.12008	-0.15559
116	8-Aug	0.00097	0.00105	-0.00209	0.11583	0.12113	-0.15768
117	9-Aug	0.00096	0.00105	-0.0021	0.11679	0.12218	-0.15978
118	10-Aug	0.00097	0.00105	-0.00094	0.11776	0.12323	-0.16072
119	11-Aug	0.00096	0.00105	0.00029	0.11872	0.12428	-0.16043
120	12-Aug	0.00097	0.00105	-0.00202	0.11969	0.12533	-0.16245
121	13-Aug	0.00096	0.00105	-0.00194	0.12065	0.12638	-0.16439
122	14-Aug	0.00097	0.00105	-0.00176	0.12162	0.12743	-0.16615
123	15-Aug	0.00096	0.00105	-0.00209	0.12258	0.12848	-0.16824
124	16-Aug	0.00097	0.00105	-0.0021	0.12355	0.12953	-0.17034
125	17-Aug	0.00096	0.00105	-0.00209	0.12451	0.13058	-0.17243
126	18-Aug	0.00097	0.00105	-0.00188	0.12548	0.13163	-0.17431
127	19-Aug	0.00096	0.00105	-0.00127	0.12644	0.13268	-0.17558
128	20-Aug	0.00097	0.00105	-0.00089	0.12741	0.13373	-0.17647
129	21-Aug	0.00096	0.00105	-0.00208	0.12837	0.13478	-0.17855
130	22-Aug	0.00097	0.00105	-0.00209	0.12934	0.13583	-0.18064
131	23-Aug	0.00096	0.00105	-0.0021	0.1303	0.13688	-0.18274
132	24-Aug	0.00097	0.00105	-0.00209	0.13127	0.13793	-0.18483
133	25-Aug	0.00096	0.00105	-0.00168	0.13223	0.13898	-0.18651
134	26-Aug	0.00097	0.00105	-0.00168	0.1332	0.14003	-0.18819
135	27-Aug	0.00097	0.00105	-0.00167	0.13417	0.14108	-0.18986
136	28-Aug	0.00096	0.00105	-0.00137	0.13513	0.14213	-0.19123
137	29-Aug	0.00097	0.00105	-0.00103	0.1361	0.14318	-0.19226
138	30-Aug	0.00096	0.00105	-0.00166	0.13706	0.14423	-0.19392
139	31-Aug	0.00097	0.00105	-0.00152	0.13803	0.14528	-0.19544
140	1-Sep	0.00097	0.00105	-0.00157	0.139	0.14633	-0.19701
141	2-Sep	0.00096	0.00105	-0.0009	0.13996	0.14738	-0.19791
142	3-Sep	0.00097	0.00105	-0.00083	0.14093	0.14843	-0.19874
143	4-Sep	0.00097	0.00105	-0.00083	0.1419	0.14948	-0.19957
144	5-Sep	0.00097	0.00105	-0.00066	0.14287	0.15053	-0.20023
145	6-Sep	0.00098	0.00105	-0.00071	0.14385	0.15158	-0.20094
146	7-Sep	0.00097	0.00105	-0.00081	0.14482	0.15263	-0.20175
147	8-Sep	0.00098	0.00105	-0.00083	0.1458	0.15368	-0.20258
148	9-Sep	0.00098	0.00105	-0.00103	0.14678	0.15473	-0.20361
149	10-Sep	0.00098	0.00105	-0.00083	0.14776	0.15578	-0.20444
150	11-Sep	0.00098	0.00105	-0.00082	0.14874	0.15683	-0.20526
151	12-Sep	0.00099	0.00105	-0.00083	0.14973	0.15788	-0.20609
152	13-Sep	0.00098	0.00105	-0.00083	0.15071	0.15893	-0.20692
153	14-Sep	0.00099	0.00105	-0.00082	0.1517	0.15998	-0.20774
154	15-Sep	0.00099	0.00105	-0.00104	0.15269	0.16103	-0.20878
155	16-Sep	0.00099	0.00105	-0.00103	0.15368	0.16208	-0.20981
156	17-Sep	0.00099	0.00105	-0.00103	0.15467	0.16313	-0.21084
157	18-Sep	0.001	0.00105	-0.00083	0.15567	0.16418	-0.21167
158	19-Sep	0.00099	0.00105	-0.00082	0.15666	0.16523	-0.21249
159	20-Sep	0.001	0.00105	-0.00104	0.15766	0.16628	-0.21353
160	21-Sep	0.001	0.00105	-0.00103	0.15866	0.16733	-0.21456
161	22-Sep	0.001	0.00105	-0.00083	0.15966	0.16838	-0.21539
162	23-Sep	0.001	0.00105	-0.00103	0.16066	0.16943	-0.21642
163	24-Sep	0.001	0.00105	-0.00062	0.16166	0.17048	-0.21704
164	25-Sep	0.00101	0.00105	-0.00083	0.16267	0.17153	-0.21787
165	26-Sep	0.00101	0.00105	-0.00082	0.16368	0.17258	-0.21869
166	27-Sep	0.00101	0.00105	-0.00103	0.16469	0.17363	-0.21972
167	28-Sep	0.00101	0.00105	-0.00083	0.1657	0.17468	-0.22055
168	29-Sep	0.00101	0.00105	-0.00083	0.16671	0.17573	-0.22138
169	30-Sep	0.00101	0.00105	-0.00062	0.16772	0.17678	-0.222
170	1-Oct	0.00102	0.00105	-0.00027	0.16874	0.17783	-0.22227
171	2-Oct	0.00101	0.00105	-4E-05	0.16975	0.17888	-0.22231
172	3-Oct	0.00102	0.00105	0	0.17077	0.17993	-0.22231
173	4-Oct	0.00102	0.00105	0	0.17179	0.18098	-0.22231
174	5-Oct	0.00102	0.00105	0	0.17281	0.18203	-0.22231
175	6-Oct	0.00103	0.00105	0	0.17384	0.18308	-0.22231
176	7-Oct	0.00102	0.00105	0	0.17486	0.18413	-0.22231
177	8-Oct	0.00103	0.00105	0	0.17589	0.18518	-0.22231
178	9-Oct	0.00103	0.00105	0	0.17692	0.18623	-0.22231
179	10-Oct	0.00103	0.00105	0	0.17795	0.18728	-0.22231
180	11-Oct	0.00103	0.00105	0	0.17898	0.18833	-0.22231
181	12-Oct	0.00103	0.00105	0	0.18001	0.18938	-0.22231
182	13-Oct	0.00103	0.00105	0	0.18104	0.19043	-0.22231
183	14-Oct	0.00104	0.00105	0	0.18208	0.19148	-0.22231
184	15-Oct	0.00104	0.00105	0	0.18312	0.19253	-0.22231
185	16-Oct	0.00103	0.00105	0	0.18415	0.19358	-0.22231
186	17-Oct	0.00104	0.00105	0	0.18519	0.19463	-0.22231
187	18-Oct	0.00105	0.00105	0	0.18624	0.19568	-0.22231
188	19-Oct	0.00104	0.00105	0	0.18728	0.19673	-0.22231
189	20-Oct	0.00104	0.00105	0.00082	0.18832	0.19778	-0.22149
190	21-Oct	0.00105	0.00105	0.00186	0.18937	0.19883	-0.21963
191	22-Oct	0.00105	0.00105	0.00039	0.19042	0.19988	-0.21924
192	23-Oct	0.00105	0.00105	1E-05	0.19147	0.20093	-0.21923
193	24-Oct	0.00105	0.00105	0	0.19252	0.20198	-0.21923
194	25-Oct	0.00105	0.00105	0	0.19357	0.20303	-0.21923
195	26-Oct	0.00105	0.00105	0	0.19462	0.20408	-0.21923
196	27-Oct	0.00106	0.00105	0	0.19568	0.20513	-0.21923
197	28-Oct	0.00105	0.00105	0	0.19673	0.20618	-0.21923
198	29-Oct	0.00106	0.00105	0.00067	0.19779	0.20723	-0.21856
199	30-Oct	0.00106	0.00105	0.00139	0.19885	0.20828	-0.21717
200	31-Oct	0.00106	0.00105	4E-05	0.19991	0.20933	-0.21713

OPTION 2 - COVER AND TAILINGS FLUXES
MEAN YEAR

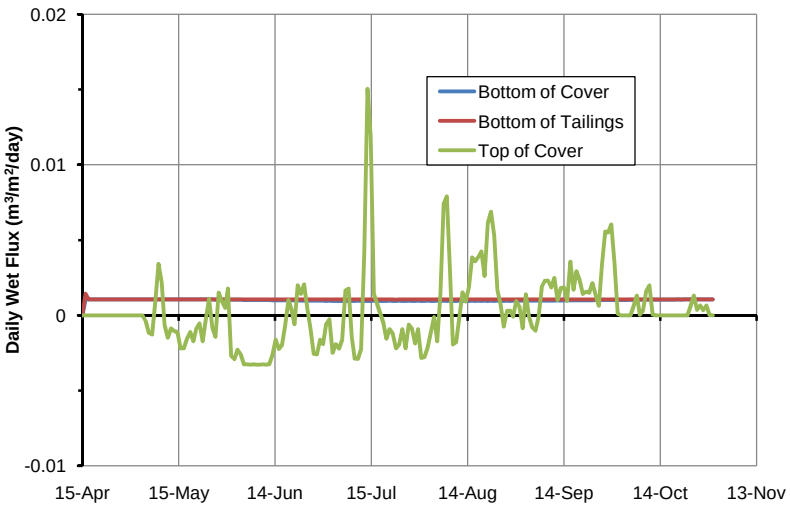


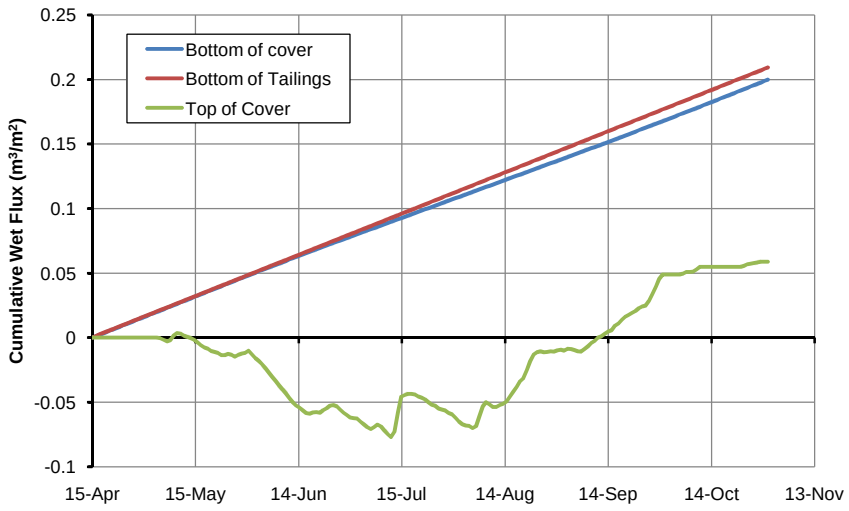


		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00105	0.00144	0	0.00105	0.00144	0
3	17-Apr	0.00105	0.00105	0	0.0021	0.00249	0
4	18-Apr	0.00105	0.00105	0	0.00315	0.00354	0
5	19-Apr	0.00105	0.00105	0	0.0042	0.00459	0
6	20-Apr	0.00105	0.00105	0	0.00525	0.00564	0
7	21-Apr	0.00105	0.00105	0	0.0063	0.00669	0
8	22-Apr	0.00105	0.00105	0	0.00735	0.00774	0
9	23-Apr	0.00105	0.00105	0	0.0084	0.00879	0
10	24-Apr	0.00105	0.00105	0	0.00945	0.00984	0
11	25-Apr	0.00105	0.00105	0	0.0105	0.01089	0
12	26-Apr	0.00105	0.00105	0	0.01155	0.01194	0
13	27-Apr	0.00105	0.00105	0	0.0126	0.01299	0
14	28-Apr	0.00105	0.00105	0	0.01365	0.01404	0
15	29-Apr	0.00105	0.00105	0	0.0147	0.01509	0
16	30-Apr	0.00105	0.00105	0	0.01575	0.01614	0
17	1-May	0.00105	0.00105	0	0.0168	0.01719	0
18	2-May	0.00105	0.00105	0	0.01785	0.01824	0
19	3-May	0.00105	0.00105	0	0.0189	0.01929	0
20	4-May	0.00105	0.00105	0	0.01995	0.02034	0
21	5-May	0.00105	0.00105	0	0.021	0.02139	0
22	6-May	0.00105	0.00105	0	0.02205	0.02244	0
23	7-May	0.00105	0.00105	0	0.0231	0.02349	0
24	8-May	0.00105	0.00105	-0.00032	0.02415	0.02454	-0.00032
25	9-May	0.00105	0.00105	-0.00138	0.0252	0.02559	-0.0017
26	10-May	0.00105	0.00105	-0.00219	0.02625	0.02664	-0.00389
27	11-May	0.00105	0.00105	-0.00274	0.0273	0.02769	-0.00663
28	12-May	0.00105	0.00105	-0.00187	0.02835	0.02874	-0.0085
29	13-May	0.00105	0.00105	-0.00122	0.0294	0.02979	-0.00972
30	14-May	0.00105	0.00105	0.00215	0.03045	0.03084	-0.00757
31	15-May	0.00105	0.00105	0.00484	0.0315	0.03189	-0.00273
32	16-May	0.00105	0.00105	-0.00072	0.03255	0.03294	-0.00345
33	17-May	0.00105	0.00105	-0.00215	0.0336	0.03399	-0.0056
34	18-May	0.00105	0.00105	-0.00219	0.03465	0.03504	-0.00779
35	19-May	0.00105	0.00105	-0.00274	0.0357	0.03609	-0.01053
36	20-May	0.00105	0.00105	-0.00275	0.03675	0.03714	-0.01328
37	21-May	0.00105	0.00105	-0.00219	0.0378	0.03819	-0.01547
38	22-May	0.00105	0.00105	-0.00219	0.03885	0.03924	-0.01766
39	23-May	0.00105	0.00105	-0.00275	0.0399	0.04029	-0.02041
40	24-May	0.00105	0.00105	-0.00187	0.04095	0.04134	-0.02228
41	25-May	0.00105	0.00105	-0.00153	0.042	0.04239	-0.02381
42	26-May	0.00105	0.00105	-0.00217	0.04305	0.04344	-0.02598
43	27-May	0.00104	0.00105	-0.00274	0.04409	0.04449	-0.02872
44	28-May	0.00105	0.00105	-0.00243	0.04514	0.04554	-0.03115
45	29-May	0.00104	0.00105	-0.00208	0.04618	0.04659	-0.03323
46	30-May	0.00103	0.00105	-0.00217	0.04721	0.04764	-0.0354
47	31-May	0.00104	0.00105	-0.00187	0.04825	0.04869	-0.03727
48	1-Jun	0.00103	0.00105	-0.00218	0.04928	0.04974	-0.03945
49	2-Jun	0.00103	0.00105	-0.0032	0.05031	0.05079	-0.04265
50	3-Jun	0.00103	0.00105	-0.00295	0.05134	0.05184	-0.0456
51	4-Jun	0.00103	0.00105	-0.00261	0.05237	0.05289	-0.04821
52	5-Jun	0.00102	0.00105	-0.00292	0.05339	0.05394	-0.05113
53	6-Jun	0.00103	0.00105	-0.00261	0.05442	0.05499	-0.05374
54	7-Jun	0.00101	0.00105	-0.00196	0.05543	0.05604	-0.0557
55	8-Jun	0.00102	0.00105	-0.00031	0.05645	0.05709	-0.05601
56	9-Jun	0.00102	0.00105	-0.00253	0.05747	0.05814	-0.05854
57	10-Jun	0.00101	0.00105	-0.00324	0.05848	0.05919	-0.06178
58	11-Jun	0.00101	0.00105	-0.00327	0.05949	0.06024	-0.06505
59	12-Jun	0.00101	0.00105	-0.00327	0.0605	0.06129	-0.06832
60	13-Jun	0.00101	0.00105	-0.00326	0.06151	0.06234	-0.07158
61	14-Jun	0.001	0.00105	-0.00327	0.06251	0.06339	-0.07485
62	15-Jun	0.001	0.00105	-0.00294	0.06351	0.06444	-0.07779
63	16-Jun	0.001	0.00105	-0.00197	0.06451	0.06549	-0.07976
64	17-Jun	0.001	0.00105	-0.00097	0.06551	0.06654	-0.08073
65	18-Jun	0.001	0.00105	0.00036	0.06651	0.06759	-0.08037
66	19-Jun	0.00099	0.00105	0.00493	0.0675	0.06864	-0.07544
67	20-Jun	0.00099	0.00105	0.00831	0.06849	0.06969	-0.06713
68	21-Jun	0.00099	0.00105	0.00387	0.06948	0.07074	-0.06326
69	22-Jun	0.00099	0.00105	0.00374	0.07047	0.07179	-0.05952
70	23-Jun	0.00098	0.00105	0.00149	0.07145	0.07284	-0.05803
71	24-Jun	0.00098	0.00105	-0.00249	0.07243	0.07389	-0.06052
72	25-Jun	0.00098	0.00105	-0.00194	0.07341	0.07494	-0.06246
73	26-Jun	0.00098	0.00105	-0.00291	0.07439	0.07599	-0.06537
74	27-Jun	0.00098	0.00105	-0.00261	0.07537	0.07704	-0.06798
75	28-Jun	0.00097	0.00105	-0.00292	0.07634	0.07809	-0.0709
76	29-Jun	0.00097	0.00105	-0.00037	0.07731	0.07914	-0.07127
77	30-Jun	0.00097	0.00105	0.00266	0.07828	0.08019	-0.06861
78	1-Jul	0.00097	0.00105	-0.00011	0.07925	0.08124	-0.06872
79	2-Jul	0.00096	0.00105	-0.00219	0.08021	0.08229	-0.07091
80	3-Jul	0.00096	0.00105	-0.00128	0.08117	0.08334	-0.07219
81	4-Jul	0.00096	0.00105	0.0036	0.08213	0.08439	-0.06859
82	5-Jul	0.00096	0.00105	0.00508	0.08309	0.08544	-0.06351
83	6-Jul	0.00096	0.00105	0.00058	0.08405	0.08649	-0.06293
84	7-Jul	0.00096	0.00105	-0.00022	0.08501	0.08754	-0.06315
85	8-Jul	0.00097	0.00105	0.00234	0.08598	0.08859	-0.06081
86	9-Jul	0.00096	0.00105	0.0047	0.08694	0.08964	-0.05611
87	10-Jul	0.00096	0.00105	0.00284	0.0879	0.09069	-0.05327
88	11-Jul	0.00096	0.00105	-0.00079	0.08886	0.09174	-0.05406
89	12-Jul	0.00096	0.00105	-0.00252	0.08982	0.09279	-0.05658
90	13-Jul	0.00096	0.00105	-0.00128	0.09078	0.09384	-0.05786
91	14-Jul	0.00097	0.00105	-0.0009	0.09175	0.09489	-0.05876

		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
92	15-Jul	0.00096	0.00105	-0.00253	0.09271	0.09594	-0.06129
93	16-Jul	0.00096	0.00105	-0.00224	0.09367	0.09699	-0.06353
94	17-Jul	0.00096	0.00105	-0.00288	0.09463	0.09804	-0.06641
95	18-Jul	0.00096	0.00105	-0.0029	0.09559	0.09909	-0.06931
96	19-Jul	0.00097	0.00105	-0.00226	0.09656	0.10014	-0.07157
97	20-Jul	0.00096	0.00105	-0.00127	0.09752	0.10119	-0.07284
98	21-Jul	0.00096	0.00105	-0.00188	0.09848	0.10224	-0.07472
99	22-Jul	0.00096	0.00105	-0.00158	0.09944	0.10329	-0.0763
100	23-Jul	0.00097	0.00104	-0.00092	0.10041	0.10433	-0.07722
101	24-Jul	0.00096	0.00105	-0.00155	0.10137	0.10538	-0.07877
102	25-Jul	0.00096	0.00105	-0.00254	0.10233	0.10643	-0.08131
103	26-Jul	0.00097	0.00105	-0.00224	0.1033	0.10748	-0.08355
104	27-Jul	0.00096	0.00105	-0.00288	0.10426	0.10853	-0.08643
105	28-Jul	0.00096	0.00105	-0.0029	0.10522	0.10958	-0.08933
106	29-Jul	0.00097	0.00105	-0.00259	0.10619	0.11063	-0.09192
107	30-Jul	0.00096	0.00105	-0.00224	0.10715	0.11168	-0.09416
108	31-Jul	0.00096	0.00105	-0.00224	0.10811	0.11273	-0.0964
109	1-Aug	0.00097	0.00105	-0.00144	0.10908	0.11378	-0.09784
110	2-Aug	0.00096	0.00105	-0.00212	0.11004	0.11483	-0.09996
111	3-Aug	0.00097	0.00105	-0.00209	0.11101	0.11588	-0.10205
112	4-Aug	0.00096	0.00105	-0.00114	0.11197	0.11693	-0.10319
113	5-Aug	0.00096	0.00105	0.00052	0.11293	0.11798	-0.10267
114	6-Aug	0.00097	0.00105	-0.00039	0.1139	0.11903	-0.10306
115	7-Aug	0.00096	0.00105	-0.0014	0.11486	0.12008	-0.10446
116	8-Aug	0.00097	0.00105	-0.00208	0.11583	0.12113	-0.10654
117	9-Aug	0.00096	0.00105	-0.00209	0.11679	0.12218	-0.10863
118	10-Aug	0.00097	0.00105	-0.00178	0.11776	0.12323	-0.11041
119	11-Aug	0.00096	0.00105	-0.00144	0.11872	0.12428	-0.11185
120	12-Aug	0.00097	0.00105	-0.00111	0.11969	0.12533	-0.11296
121	13-Aug	0.00096	0.00105	0.0002	0.12065	0.12638	-0.11276
122	14-Aug	0.00097	0.00105	-0.00106	0.12162	0.12743	-0.11382
123	15-Aug	0.00096	0.00105	-0.00141	0.12258	0.12848	-0.11523
124	16-Aug	0.00097	0.00105	-0.00176	0.12355	0.12953	-0.11699
125	17-Aug	0.00096	0.00105	-0.00144	0.12451	0.13058	-0.11843
126	18-Aug	0.00097	0.00105	-0.00207	0.12548	0.13163	-0.1205
127	19-Aug	0.00096	0.00105	-0.0005	0.12644	0.13268	-0.121
128	20-Aug	0.00097	0.00105	0.00184	0.12741	0.13373	-0.11916
129	21-Aug	0.00096	0.00105	-3E-05	0.12837	0.13478	-0.11919
130	22-Aug	0.00097	0.00105	0.00054	0.12934	0.13583	-0.11865
131	23-Aug	0.00096	0.00105	0.00347	0.1303	0.13688	-0.11518
132	24-Aug	0.00097	0.00105	0.00424	0.13127	0.13793	-0.11094
133	25-Aug	0.00096	0.00105	-0.00083	0.13223	0.13898	-0.11177
134	26-Aug	0.00097	0.00105	-0.00208	0.1332	0.14003	-0.11385
135	27-Aug	0.00097	0.00105	-0.00136	0.13417	0.14108	-0.11521
136	28-Aug	0.00096	0.00105	-0.00101	0.13513	0.14213	-0.11622
137	29-Aug	0.00097	0.00105	-0.00208	0.1361	0.14318	-0.1183
138	30-Aug	0.00096	0.00105	-0.00168	0.13706	0.14423	-0.11998
139	31-Aug	0.00097	0.00105	-0.00177	0.13803	0.14528	-0.12175
140	1-Sep	0.00097	0.00105	-0.00093	0.139	0.14633	-0.12268
141	2-Sep	0.00096	0.00105	0.00041	0.13996	0.14738	-0.12227
142	3-Sep	0.00097	0.00105	0.00051	0.14093	0.14843	-0.12176
143	4-Sep	0.00097	0.00105	-0.00046	0.1419	0.14948	-0.12222
144	5-Sep	0.00097	0.00105	-0.00037	0.14287	0.15053	-0.12259
145	6-Sep	0.00098	0.00105	-0.0007	0.14385	0.15158	-0.12329
146	7-Sep	0.00097	0.00105	-5E-05	0.14482	0.15263	-0.12334
147	8-Sep	0.00098	0.00105	-0.00035	0.1458	0.15368	-0.12369
148	9-Sep	0.00098	0.00105	-0.00102	0.14678	0.15473	-0.12471
149	10-Sep	0.00098	0.00105	-0.00082	0.14776	0.15578	-0.12553
150	11-Sep	0.00098	0.00105	-0.00083	0.14874	0.15683	-0.12636
151	12-Sep	0.00099	0.00105	-0.00103	0.14973	0.15788	-0.12739
152	13-Sep	0.00098	0.00105	0.00013	0.15071	0.15893	-0.12726
153	14-Sep	0.00099	0.00105	0.00115	0.1517	0.15998	-0.12611
154	15-Sep	0.00099	0.00105	-0.00097	0.15269	0.16103	-0.12708
155	16-Sep	0.00099	0.00105	-0.00103	0.15368	0.16208	-0.12811
156	17-Sep	0.00099	0.00105	-0.00104	0.15467	0.16313	-0.12915
157	18-Sep	0.001	0.00105	-0.00103	0.15567	0.16418	-0.13018
158	19-Sep	0.00099	0.00105	-0.00039	0.15666	0.16523	-0.13057
159	20-Sep	0.001	0.00105	0.0007	0.15766	0.16628	-0.12987
160	21-Sep	0.001	0.00105	-5E-05	0.15866	0.16733	-0.12992
161	22-Sep	0.001	0.00105	-0.00017	0.15966	0.16838	-0.13009
162	23-Sep	0.001	0.00105	-0.00081	0.16066	0.16943	-0.1309
163	24-Sep	0.001	0.00105	-0.00103	0.16166	0.17048	-0.13193
164	25-Sep	0.00101	0.00105	-0.00103	0.16267	0.17153	-0.13296
165	26-Sep	0.00101	0.00105	-0.00083	0.16368	0.17258	-0.13379
166	27-Sep	0.00101	0.00105	-0.00071	0.16469	0.17363	-0.1345
167	28-Sep	0.00101	0.00105	-0.00017	0.1657	0.17468	-0.13467
168	29-Sep	0.00101	0.00105	-0.00029	0.16671	0.17573	-0.13496
169	30-Sep	0.00101	0.00105	0	0.16772	0.17678	-0.13496
170	1-Oct	0.00102	0.00105	0	0.16874	0.17783	-0.13496
171	2-Oct	0.00101	0.00105	0	0.16975	0.17888	-0.13496
172	3-Oct	0.00102	0.00105	0	0.17077	0.17993	-0.13496
173	4-Oct	0.00102	0.00105	0	0.17179	0.18098	-0.13496
174	5-Oct	0.00102	0.00105	0	0.17281	0.18203	-0.13496
175	6-Oct	0.00103	0.00105	0	0.17384	0.18308	-0.13496
176	7-Oct	0.00102	0.00105	0	0.17486	0.18413	-0.13496
177	8-Oct	0.00103	0.00105	0	0.17589	0.18518	-0.13496
178	9-Oct	0.00103	0.00105	0	0.17692	0.18623	-0.13496
179	10-Oct	0.00103	0.00105	0.00032	0.17795	0.18728	-0.13464
180	11-Oct	0.00103	0.00105	0.00066	0.17898	0.18833	-0.13398
181	12-Oct	0.00103	0.00105	2E-05	0.18001	0.18938	-0.13396
182	13-Oct	0.00103	0.00105	0	0.18104	0.19043	-0.13396
183	14-Oct	0.00104	0.00105	0.00096	0.18208	0.19148	-0.133
184	15-Oct	0.00104	0.00105	0.00198	0.18312	0.19253	-0.13102
185	16-Oct	0.00103	0.00105	6E-05	0.18415	0.19358	-0.13096
186	17-Oct	0.00104	0.00105	0	0.18519	0.19463	-0.13096
187	18-Oct	0.00105	0.00105	0	0.18624	0.19568	-0.13096
188	19-Oct	0.00104	0.00105	0.00064	0.18728	0.19673	-0.13032
189	20-Oct	0.00104	0.00105	0.00164	0.18832	0.19778	-0.12868
190	21-Oct	0.00105	0.00105	0.0007	0.18937	0.19883	-0.12798
191	22-Oct	0.00105	0.00105	2E-05	0.19042	0.19988	-0.12796
192	23-Oct	0.00105	0.00105	0.00096	0.19147	0.20093	-0.127
193	24-Oct	0.00105	0.00105	0.00325	0.19252	0.20198	-0.12375
194	25-Oct	0.00105	0.00105	0.00334	0.19357	0.20303	-0.12041
195	26-Oct	0.00105	0.00105	0.003	0.19462	0.20408	-0.11741
196	27-Oct	0.00106	0.00105	0.00334	0.19568	0.20513	-0.11407
197	28-Oct	0.00105	0.00105	0.00042	0.19673	0.20618	-0.11365
198	29-Oct	0.00106	0.00105	0.00066	0.19779	0.20723	-0.11299
199	30-Oct	0.00106	0.00105	0.00034	0.19885	0.20828	-0.11265
200	31-Oct	0.00106	0.00105	0.00066	0.19991	0.20933	-0.11199

OPTION 2 - COVER AND TAILINGS FLUXES
WET YEAR

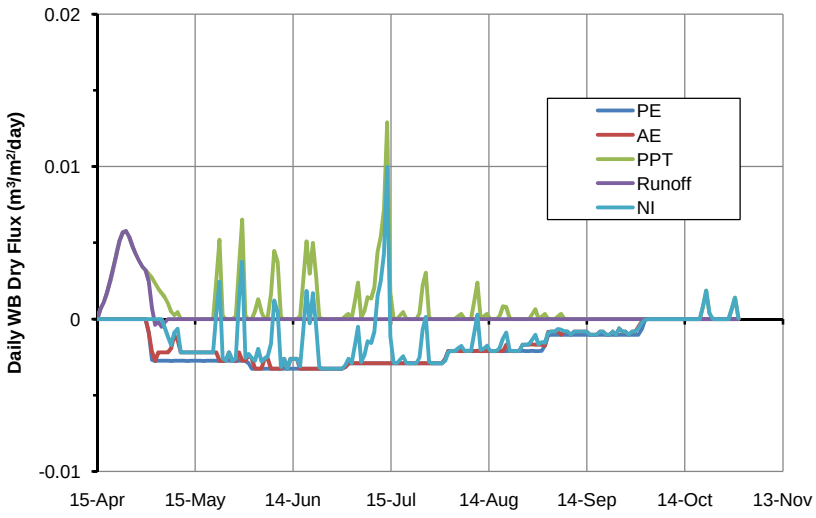


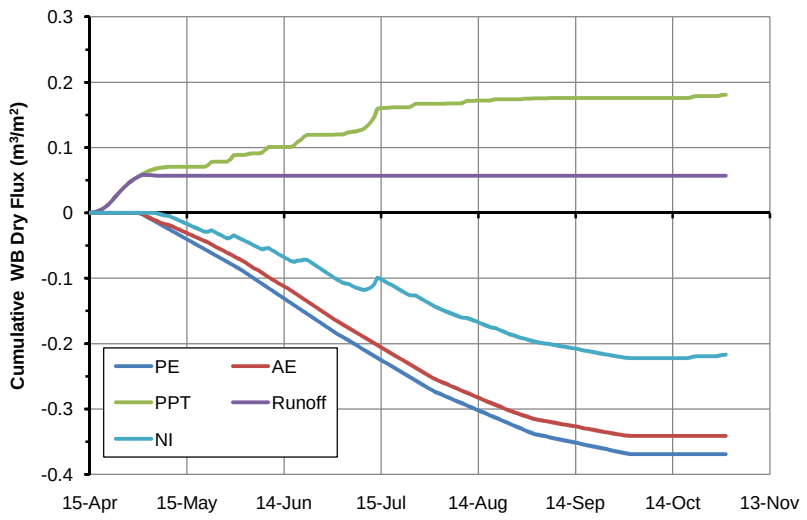


		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00105	0.00144	0	0.00105	0.00144	0
3	17-Apr	0.00105	0.00105	0	0.0021	0.00249	0
4	18-Apr	0.00105	0.00105	0	0.00315	0.00354	0
5	19-Apr	0.00105	0.00105	0	0.0042	0.00459	0
6	20-Apr	0.00105	0.00105	0	0.00525	0.00564	0
7	21-Apr	0.00105	0.00105	0	0.0063	0.00669	0
8	22-Apr	0.00105	0.00105	0	0.00735	0.00774	0
9	23-Apr	0.00105	0.00105	0	0.0084	0.00879	0
10	24-Apr	0.00105	0.00105	0	0.00945	0.00984	0
11	25-Apr	0.00105	0.00105	0	0.0105	0.01089	0
12	26-Apr	0.00105	0.00105	0	0.01155	0.01194	0
13	27-Apr	0.00105	0.00105	0	0.0126	0.01299	0
14	28-Apr	0.00105	0.00105	0	0.01365	0.01404	0
15	29-Apr	0.00105	0.00105	0	0.0147	0.01509	0
16	30-Apr	0.00105	0.00105	0	0.01575	0.01614	0
17	1-May	0.00105	0.00105	0	0.0168	0.01719	0
18	2-May	0.00105	0.00105	0	0.01785	0.01824	0
19	3-May	0.00105	0.00105	0	0.0189	0.01929	0
20	4-May	0.00105	0.00105	0	0.01995	0.02034	0
21	5-May	0.00105	0.00105	-0.00038	0.021	0.02139	-0.00038
22	6-May	0.00105	0.00105	-0.00117	0.02205	0.02244	-0.00155
23	7-May	0.00105	0.00105	-0.00128	0.0231	0.02349	-0.00283
24	8-May	0.00105	0.00105	0.00092	0.02415	0.02454	-0.00191
25	9-May	0.00105	0.00105	0.00341	0.0252	0.02559	0.0015
26	10-May	0.00105	0.00105	0.00218	0.02625	0.02664	0.00368
27	11-May	0.00105	0.00105	-0.00066	0.0273	0.02769	0.00302
28	12-May	0.00105	0.00105	-0.00149	0.02835	0.02874	0.00153
29	13-May	0.00105	0.00105	-0.00088	0.0294	0.02979	0.00065
30	14-May	0.00105	0.00105	-0.00105	0.03045	0.03084	-0.0004
31	15-May	0.00105	0.00105	-0.0011	0.0315	0.03189	-0.0015
32	16-May	0.00105	0.00105	-0.00219	0.03255	0.03294	-0.00369
33	17-May	0.00105	0.00105	-0.0022	0.0336	0.03399	-0.00589
34	18-May	0.00105	0.00105	-0.00155	0.03465	0.03504	-0.00744
35	19-May	0.00105	0.00105	-0.0011	0.0357	0.03609	-0.00854
36	20-May	0.00105	0.00105	-0.00172	0.03675	0.03714	-0.01026
37	21-May	0.00105	0.00105	-0.00088	0.0378	0.03819	-0.01114
38	22-May	0.00105	0.00105	-0.00053	0.03885	0.03924	-0.01167
39	23-May	0.00105	0.00105	-0.00172	0.0399	0.04029	-0.01339
40	24-May	0.00105	0.00105	-0.00024	0.04095	0.04134	-0.01363
41	25-May	0.00105	0.00105	0.00111	0.042	0.04239	-0.01252
42	26-May	0.00105	0.00105	-0.00079	0.04305	0.04344	-0.01331
43	27-May	0.00104	0.00105	-0.00143	0.04409	0.04449	-0.01474
44	28-May	0.00105	0.00105	0.0015	0.04514	0.04554	-0.01324
45	29-May	0.00104	0.00105	0.00096	0.04618	0.04659	-0.01228
46	30-May	0.00103	0.00105	0.00049	0.04721	0.04764	-0.01179
47	31-May	0.00104	0.00105	0.00178	0.04825	0.04869	-0.01001
48	1-Jun	0.00103	0.00105	-0.00271	0.04928	0.04974	-0.01272
49	2-Jun	0.00103	0.00105	-0.00291	0.05031	0.05079	-0.01563
50	3-Jun	0.00103	0.00105	-0.00228	0.05134	0.05184	-0.01791
51	4-Jun	0.00103	0.00105	-0.00259	0.05237	0.05289	-0.0205
52	5-Jun	0.00102	0.00105	-0.00325	0.05339	0.05394	-0.02375
53	6-Jun	0.00102	0.00105	-0.00326	0.05441	0.05499	-0.02701
54	7-Jun	0.00102	0.00105	-0.00327	0.05543	0.05604	-0.03028
55	8-Jun	0.00102	0.00105	-0.00326	0.05645	0.05709	-0.03354
56	9-Jun	0.00102	0.00105	-0.00327	0.05747	0.05814	-0.03681
57	10-Jun	0.00101	0.00105	-0.00327	0.05848	0.05919	-0.04008
58	11-Jun	0.00101	0.00105	-0.00326	0.05949	0.06024	-0.04334
59	12-Jun	0.00101	0.00105	-0.00327	0.0605	0.06129	-0.04661
60	13-Jun	0.00101	0.00105	-0.00326	0.06151	0.06234	-0.04987
61	14-Jun	0.001	0.00105	-0.00263	0.06251	0.06339	-0.0525
62	15-Jun	0.001	0.00105	-0.00163	0.06351	0.06444	-0.05413
63	16-Jun	0.001	0.00105	-0.00224	0.06451	0.06549	-0.05637
64	17-Jun	0.001	0.00105	-0.00195	0.06551	0.06654	-0.05832
65	18-Jun	0.001	0.00105	-0.00065	0.06651	0.06759	-0.05897
66	19-Jun	0.00099	0.00105	0.00102	0.0675	0.06864	-0.05795
67	20-Jun	0.00099	0.00105	0.00043	0.06849	0.06969	-0.05752
68	21-Jun	0.00099	0.00105	-0.00059	0.06948	0.07074	-0.05811
69	22-Jun	0.00099	0.00105	0.002	0.07047	0.07179	-0.05611
70	23-Jun	0.00098	0.00105	0.00141	0.07145	0.07284	-0.0547
71	24-Jun	0.00098	0.00105	0.00205	0.07243	0.07389	-0.05265
72	25-Jun	0.00098	0.00105	0.00046	0.07341	0.07494	-0.05219
73	26-Jun	0.00098	0.00105	-0.00089	0.07439	0.07599	-0.05308
74	27-Jun	0.00097	0.00105	-0.00255	0.07536	0.07704	-0.05563
75	28-Jun	0.00098	0.00105	-0.0026	0.07634	0.07809	-0.05823
76	29-Jun	0.00097	0.00105	-0.00163	0.07731	0.07914	-0.05986
77	30-Jun	0.00097	0.00105	-0.00192	0.07828	0.08019	-0.06178
78	1-Jul	0.00096	0.00105	-0.00058	0.07924	0.08124	-0.06236
79	2-Jul	0.00097	0.00105	-0.00026	0.08021	0.08229	-0.06262
80	3-Jul	0.00096	0.00105	-0.0025	0.08117	0.08334	-0.06512
81	4-Jul	0.00096	0.00105	-0.00192	0.08213	0.08439	-0.06704
82	5-Jul	0.00096	0.00105	-0.00222	0.08309	0.08544	-0.06926
83	6-Jul	0.00096	0.00105	-0.00161	0.08405	0.08649	-0.07087
84	7-Jul	0.00096	0.00105	0.00166	0.08501	0.08754	-0.06921
85	8-Jul	0.00096	0.00105	0.00178	0.08597	0.08859	-0.06743
86	9-Jul	0.00096	0.00105	-0.00146	0.08693	0.08964	-0.06889
87	10-Jul	0.00096	0.00105	-0.00287	0.08789	0.09069	-0.07176
88	11-Jul	0.00097	0.00105	-0.0029	0.08886	0.09174	-0.07466
89	12-Jul	0.00096	0.00105	-0.00226	0.08982	0.09279	-0.07692
90	13-Jul	0.00096	0.00105	0.00416	0.09078	0.09384	-0.07276
91	14-Jul	0.00096	0.00105	0.01505	0.09174	0.09489	-0.05771

		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
92	15-Jul	0.00096	0.00105	0.01192	0.0927	0.09594	-0.04579
93	16-Jul	0.00097	0.00105	0.00141	0.09367	0.09699	-0.04438
94	17-Jul	0.00096	0.00105	0.00078	0.09463	0.09804	-0.0436
95	18-Jul	0.00096	0.00105	0.00012	0.09559	0.09909	-0.04348
96	19-Jul	0.00096	0.00105	-0.00054	0.09655	0.10014	-0.04402
97	20-Jul	0.00096	0.00105	-0.00155	0.09751	0.10119	-0.04557
98	21-Jul	0.00097	0.00105	-0.00092	0.09848	0.10224	-0.04649
99	22-Jul	0.00096	0.00105	-0.00122	0.09944	0.10329	-0.04771
100	23-Jul	0.00096	0.00104	-0.0022	0.1004	0.10433	-0.04991
101	24-Jul	0.00097	0.00105	-0.00193	0.10137	0.10538	-0.05184
102	25-Jul	0.00096	0.00105	-0.00092	0.10233	0.10643	-0.05276
103	26-Jul	0.00096	0.00105	-0.0022	0.10329	0.10748	-0.05496
104	27-Jul	0.00097	0.00105	-0.00062	0.10426	0.10853	-0.05558
105	28-Jul	0.00096	0.00105	-0.00089	0.10522	0.10958	-0.05647
106	29-Jul	0.00096	0.00105	-0.00188	0.10618	0.11063	-0.05835
107	30-Jul	0.00097	0.00105	-0.00092	0.10715	0.11168	-0.05927
108	31-Jul	0.00096	0.00105	-0.00284	0.10811	0.11273	-0.06211
109	1-Aug	0.00096	0.00105	-0.00276	0.10907	0.11378	-0.06487
110	2-Aug	0.00097	0.00105	-0.00216	0.11004	0.11483	-0.06703
111	3-Aug	0.00096	0.00105	-0.00114	0.111	0.11588	-0.06817
112	4-Aug	0.00096	0.00105	-0.00011	0.11196	0.11693	-0.06828
113	5-Aug	0.00097	0.00105	-0.00172	0.11293	0.11798	-0.07
114	6-Aug	0.00096	0.00105	0.00144	0.11389	0.11903	-0.06856
115	7-Aug	0.00097	0.00105	0.0074	0.11486	0.12008	-0.06116
116	8-Aug	0.00096	0.00105	0.00791	0.11582	0.12113	-0.05325
117	9-Aug	0.00097	0.00105	0.0034	0.11679	0.12218	-0.04985
118	10-Aug	0.00096	0.00105	-0.00193	0.11775	0.12323	-0.05178
119	11-Aug	0.00096	0.00105	-0.00178	0.11871	0.12428	-0.05356
120	12-Aug	0.00097	0.00105	-0.00016	0.11968	0.12533	-0.05372
121	13-Aug	0.00096	0.00105	0.00153	0.12064	0.12638	-0.05219
122	14-Aug	0.00097	0.00105	0.00092	0.12161	0.12743	-0.05127
123	15-Aug	0.00096	0.00105	0.00186	0.12257	0.12848	-0.04941
124	16-Aug	0.00097	0.00105	0.00385	0.12354	0.12953	-0.04556
125	17-Aug	0.00096	0.00105	0.00358	0.1245	0.13058	-0.04198
126	18-Aug	0.00097	0.00105	0.00389	0.12547	0.13163	-0.03809
127	19-Aug	0.00096	0.00105	0.00424	0.12643	0.13268	-0.03385
128	20-Aug	0.00097	0.00105	0.00261	0.1274	0.13373	-0.03124
129	21-Aug	0.00096	0.00105	0.00613	0.12836	0.13478	-0.02511
130	22-Aug	0.00097	0.00105	0.00689	0.12933	0.13583	-0.01822
131	23-Aug	0.00096	0.00105	0.00531	0.13029	0.13688	-0.01291
132	24-Aug	0.00097	0.00105	0.00168	0.13126	0.13793	-0.01123
133	25-Aug	0.00097	0.00105	0.00071	0.13223	0.13898	-0.01052
134	26-Aug	0.00096	0.00105	-0.00074	0.13319	0.14003	-0.01126
135	27-Aug	0.00097	0.00105	0.0003	0.13416	0.14108	-0.01096
136	28-Aug	0.00096	0.00105	0.00032	0.13512	0.14213	-0.01064
137	29-Aug	0.00097	0.00105	-9E-05	0.13609	0.14318	-0.01073
138	30-Aug	0.00096	0.00105	0.00096	0.13705	0.14423	-0.00977
139	31-Aug	0.00097	0.00105	0.00058	0.13802	0.14528	-0.00919
140	1-Sep	0.00097	0.00105	-0.00086	0.13899	0.14633	-0.01005
141	2-Sep	0.00096	0.00105	0.00139	0.13995	0.14738	-0.00866
142	3-Sep	0.00097	0.00105	-0.00011	0.14092	0.14843	-0.00877
143	4-Sep	0.00097	0.00105	-0.00081	0.14189	0.14948	-0.00958
144	5-Sep	0.00097	0.00105	-0.00103	0.14286	0.15053	-0.01061
145	6-Sep	0.00098	0.00105	-7E-05	0.14384	0.15158	-0.01068
146	7-Sep	0.00097	0.00105	0.0019	0.14481	0.15263	-0.00878
147	8-Sep	0.00098	0.00105	0.00229	0.14579	0.15368	-0.00649
148	9-Sep	0.00098	0.00105	0.00231	0.14677	0.15473	-0.00418
149	10-Sep	0.00098	0.00105	0.00185	0.14775	0.15578	-0.00233
150	11-Sep	0.00098	0.00105	0.00249	0.14873	0.15683	0.00016
151	12-Sep	0.00099	0.00105	0.00101	0.14972	0.15788	0.00117
152	13-Sep	0.00098	0.00105	0.00181	0.1507	0.15893	0.00298
153	14-Sep	0.00099	0.00105	0.00186	0.15169	0.15998	0.00484
154	15-Sep	0.00099	0.00105	0.00096	0.15268	0.16103	0.0058
155	16-Sep	0.00099	0.00105	0.00357	0.15367	0.16208	0.00937
156	17-Sep	0.00099	0.00105	0.00169	0.15466	0.16313	0.01106
157	18-Sep	0.001	0.00105	0.00292	0.15566	0.16418	0.01398
158	19-Sep	0.00099	0.00105	0.00233	0.15665	0.16523	0.01631
159	20-Sep	0.001	0.00105	0.00142	0.15765	0.16628	0.01773
160	21-Sep	0.001	0.00105	0.00158	0.15865	0.16733	0.01931
161	22-Sep	0.001	0.00105	0.0015	0.15965	0.16838	0.02081
162	23-Sep	0.001	0.00105	0.00215	0.16065	0.16943	0.02296
163	24-Sep	0.00101	0.00105	0.00133	0.16166	0.17048	0.02429
164	25-Sep	0.001	0.00105	0.00064	0.16266	0.17153	0.02493
165	26-Sep	0.00101	0.00105	0.00342	0.16367	0.17258	0.02835
166	27-Sep	0.00101	0.00105	0.00556	0.16468	0.17363	0.03391
167	28-Sep	0.00101	0.00105	0.00551	0.16569	0.17468	0.03942
168	29-Sep	0.00101	0.00105	0.00603	0.1667	0.17573	0.04545
169	30-Sep	0.00101	0.00105	0.00344	0.16771	0.17678	0.04889
170	1-Oct	0.00102	0.00105	0.0001	0.16873	0.17783	0.04899
171	2-Oct	0.00102	0.00105	0	0.16975	0.17888	0.04899
172	3-Oct	0.00101	0.00105	0	0.17076	0.17993	0.04899
173	4-Oct	0.00102	0.00105	0	0.17178	0.18098	0.04899
174	5-Oct	0.00103	0.00105	0	0.17281	0.18203	0.04899
175	6-Oct	0.00102	0.00105	0.00064	0.17383	0.18308	0.04963
176	7-Oct	0.00102	0.00105	0.00132	0.17485	0.18413	0.05095
177	8-Oct	0.00103	0.00105	4E-05	0.17588	0.18518	0.05099
178	9-Oct	0.00103	0.00105	0.00032	0.17691	0.18623	0.05131
179	10-Oct	0.00103	0.00105	0.00162	0.17794	0.18728	0.05293
180	11-Oct	0.00103	0.00105	0.002	0.17897	0.18833	0.05493
181	12-Oct	0.00103	0.00105	6E-05	0.18	0.18938	0.05499
182	13-Oct	0.00103	0.00105	0	0.18103	0.19043	0.05499
183	14-Oct	0.00104	0.00105	0	0.18207	0.19148	0.05499
184	15-Oct	0.00104	0.00105	0	0.18311	0.19253	0.05499
185	16-Oct	0.00104	0.00105	0	0.18415	0.19358	0.05499
186	17-Oct	0.00104	0.00105	0	0.18519	0.19463	0.05499
187	18-Oct	0.00104	0.00105	0	0.18623	0.19568	0.05499
188	19-Oct	0.00104	0.00105	0	0.18727	0.19673	0.05499
189	20-Oct	0.00105	0.00105	0	0.18832	0.19778	0.05499
190	21-Oct	0.00104	0.00105	0	0.18936	0.19883	0.05499
191	22-Oct	0.00105	0.00105	0	0.19041	0.19988	0.05499
192	23-Oct	0.00105	0.00105	0	0.19146	0.20093	0.05499
193	24-Oct	0.00105	0.00105	0.00064	0.19251	0.20198	0.05563
194	25-Oct	0.00105	0.00105	0.00132	0.19356	0.20303	0.05695
195	26-Oct	0.00105	0.00105	0.00036	0.19461	0.20408	0.05731
196	27-Oct	0.00106	0.00105	0.00066	0.19567	0.20513	0.05797
197	28-Oct	0.00106	0.00105	0.00034	0.19673	0.20618	0.05831
198	29-Oct	0.00105	0.00105	0.00066	0.19778	0.20723	0.05897
199	30-Oct	0.00106	0.00105	2E-05	0.19884	0.20828	0.05899
200	31-Oct	0.00106	0.00105	0	0.1999	0.20933	0.05899

OPTION 2 CLIMATE WATER BALANCE
DRY YEAR

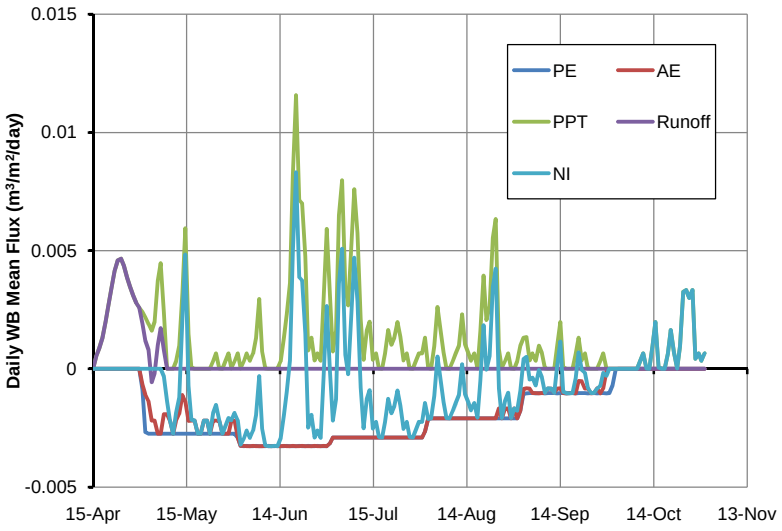


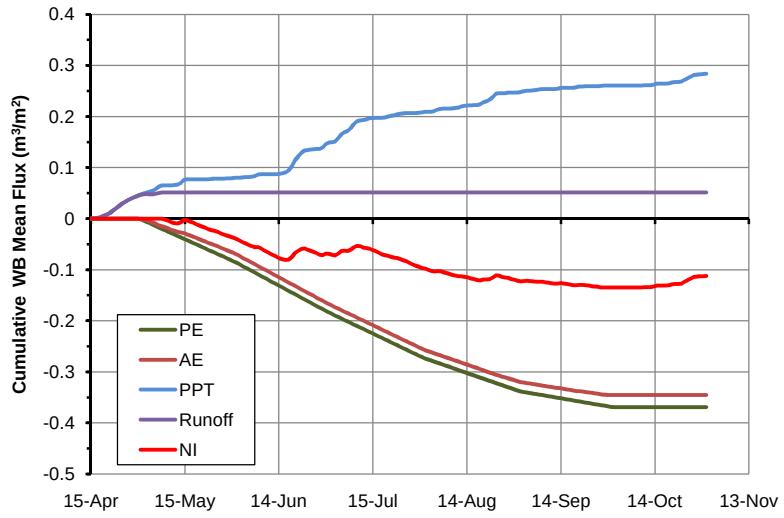


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.00068	0.00065	0	0	0	0.00068	0.00065	0
3	17-Apr	0	0	0.00107	0.00108	0	0	0	0.00175	0.00173	0
4	18-Apr	0	0	0.0017	0.0017	0	0	0	0.00345	0.00343	0
5	19-Apr	0	0	0.00247	0.00246	0	0	0	0.00592	0.00589	0
6	20-Apr	0	0	0.00335	0.00336	0	0	0	0.00927	0.00925	0
7	21-Apr	0	0	0.00426	0.00425	0	0	0	0.01353	0.0135	0
8	22-Apr	0	0	0.00514	0.00515	0	0	0	0.01867	0.01865	0
9	23-Apr	0	0	0.00567	0.00567	0	0	0	0.02434	0.02432	0
10	24-Apr	0	0	0.00577	0.00576	0	0	0	0.03011	0.03008	0
11	25-Apr	0	0	0.00539	0.00539	0	0	0	0.0355	0.03547	0
12	26-Apr	0	0	0.00477	0.00478	0	0	0	0.04027	0.04025	0
13	27-Apr	0	0	0.0043	0.0043	0	0	0	0.04457	0.04455	0
14	28-Apr	0	0	0.00384	0.00383	0	0	0	0.04841	0.04838	0
15	29-Apr	0	0	0.00344	0.00344	0	0	0	0.05185	0.05182	0
16	30-Apr	0	0	0.0032	0.00321	0	0	0	0.05505	0.05503	0
17	1-May	-0.00088	-0.00088	0.00297	0.00247	0	-0.00088	-0.00088	0.05802	0.0575	0
18	2-May	-0.00268	-0.00214	0.0027	0.00072	0	-0.00356	-0.00302	0.06072	0.05822	0
19	3-May	-0.00275	-0.00274	0.00235	-0.00039	0	-0.00631	-0.00576	0.06307	0.05783	0
20	4-May	-0.00274	-0.00219	0.00199	-0.00019	0	-0.00905	-0.00795	0.06506	0.05764	0
21	5-May	-0.00274	-0.0022	0.00169	-0.00051	0	-0.01179	-0.01015	0.06675	0.05713	0
22	6-May	-0.00274	-0.00219	0.00141	-0.00021	-0.00057	-0.01453	-0.01234	0.06816	0.05692	-0.00057
23	7-May	-0.00274	-0.00219	0.00103	0	-0.00117	-0.01727	-0.01453	0.06919	0.05692	-0.00174
24	8-May	-0.00275	-0.00192	0.00048	0	-0.00171	-0.02002	-0.01645	0.06967	0.05692	-0.00345
25	9-May	-0.00274	-0.0011	0.00024	0	-0.00086	-0.02276	-0.01755	0.06991	0.05692	-0.00431
26	10-May	-0.00274	-0.00137	0.00045	0	-0.00064	-0.0255	-0.01892	0.07036	0.05692	-0.00495
27	11-May	-0.00274	-0.00219	2E-05	0	-0.00218	-0.02824	-0.02111	0.07038	0.05692	-0.00713
28	12-May	-0.00274	-0.0022	0	0	-0.0022	-0.03098	-0.02331	0.07038	0.05692	-0.00933
29	13-May	-0.00275	-0.00219	0	0	-0.00219	-0.03373	-0.0255	0.07038	0.05692	-0.01152
30	14-May	-0.00274	-0.00219	0	0	-0.00219	-0.03647	-0.02769	0.07038	0.05692	-0.01371
31	15-May	-0.00274	-0.0022	0	0	-0.0022	-0.03921	-0.02989	0.07038	0.05692	-0.01591
32	16-May	-0.00274	-0.00219	0	0	-0.00219	-0.04195	-0.03208	0.07038	0.05692	-0.0181
33	17-May	-0.00274	-0.00219	0	0	-0.00219	-0.04469	-0.03427	0.07038	0.05692	-0.02029
34	18-May	-0.00275	-0.0022	0	0	-0.0022	-0.04744	-0.03647	0.07038	0.05692	-0.02249
35	19-May	-0.00274	-0.00219	0	0	-0.00219	-0.05018	-0.03866	0.07038	0.05692	-0.02468
36	20-May	-0.00274	-0.0022	0	0	-0.00219	-0.05292	-0.04086	0.07038	0.05692	-0.02687
37	21-May	-0.00274	-0.00219	0	0	-0.0022	-0.05566	-0.04305	0.07038	0.05692	-0.02907
38	22-May	-0.00274	-0.00219	0.00251	0	0.00032	-0.0584	-0.04524	0.07289	0.05692	-0.02875
39	23-May	-0.00275	-0.00274	0.00519	0	0.00245	-0.06115	-0.04798	0.07808	0.05692	-0.0263
40	24-May	-0.00274	-0.00275	0.00016	0	-0.00258	-0.06389	-0.05073	0.07824	0.05692	-0.02888
41	25-May	-0.00274	-0.00274	0	0	-0.00274	-0.06663	-0.05347	0.07824	0.05692	-0.03162
42	26-May	-0.00274	-0.00219	0	0	-0.00219	-0.06937	-0.05566	0.07824	0.05692	-0.03381
43	27-May	-0.00274	-0.00274	0	0	-0.00275	-0.07211	-0.0584	0.07824	0.05692	-0.03656
44	28-May	-0.00275	-0.00275	0.00016	0	-0.00258	-0.07486	-0.06115	0.0784	0.05692	-0.03914
45	29-May	-0.00274	-0.00219	0.00348	0	0.00129	-0.0776	-0.06334	0.08188	0.05692	-0.03785
46	30-May	-0.00274	-0.00274	0.00651	0	0.00377	-0.08034	-0.06608	0.08839	0.05692	-0.03408
47	31-May	-0.00274	-0.00274	0.0002	0	-0.00255	-0.08308	-0.06882	0.08859	0.05692	-0.03663
48	1-Jun	-0.00291	-0.00237	0	0	-0.00229	-0.08599	-0.07119	0.08859	0.05692	-0.03892
49	2-Jun	-0.00326	-0.0026	0	0	-0.00257	-0.08925	-0.07379	0.08859	0.05692	-0.04149
50	3-Jun	-0.00327	-0.00327	0.00052	0	-0.00274	-0.09252	-0.07706	0.08911	0.05692	-0.04423
51	4-Jun	-0.00326	-0.00326	0.0013	0	-0.00197	-0.09578	-0.08032	0.09041	0.05692	-0.0462
52	5-Jun	-0.00327	-0.00327	0.00049	0	-0.00278	-0.09905	-0.08359	0.0909	0.05692	-0.04898
53	6-Jun	-0.00327	-0.00261	1E-05	0	-0.0026	-0.10232	-0.0862	0.09091	0.05692	-0.05158
54	7-Jun	-0.00326	-0.00262	0.00016	0	-0.00245	-0.10558	-0.08882	0.09107	0.05692	-0.05403
55	8-Jun	-0.00327	-0.00326	0.00164	0	-0.00163	-0.10885	-0.09208	0.09271	0.05692	-0.05566
56	9-Jun	-0.00327	-0.00327	0.00447	0	0.00121	-0.11212	-0.09535	0.09718	0.05692	-0.05445
57	10-Jun	-0.00327	-0.00327	0.00371	0	0.00044	-0.11539	-0.09862	0.10089	0.05692	-0.05401
58	11-Jun	-0.00326	-0.00326	0.00011	0	-0.00315	-0.11865	-0.10188	0.101	0.05692	-0.05716
59	12-Jun	-0.00327	-0.00262	0	0	-0.00262	-0.12192	-0.1045	0.101	0.05692	-0.05978
60	13-Jun	-0.00327	-0.00326	0	0	-0.00326	-0.12519	-0.10776	0.101	0.05692	-0.06304
61	14-Jun	-0.00326	-0.00262	0	0	-0.00261	-0.12845	-0.11038	0.101	0.05692	-0.06565
62	15-Jun	-0.00327	-0.00261	0	0	-0.00262	-0.13172	-0.11299	0.101	0.05692	-0.06827
63	16-Jun	-0.00327	-0.00262	0	0	-0.00261	-0.13499	-0.11561	0.101	0.05692	-0.07088
64	17-Jun	-0.00326	-0.00326	0.00016	0	-0.00311	-0.13825	-0.11887	0.10116	0.05692	-0.07399
65	18-Jun	-0.00327	-0.00327	0.00255	0	-0.00072	-0.14152	-0.12214	0.10371	0.05692	-0.07471
66	19-Jun	-0.00327	-0.00327	0.0051	0	0.00183	-0.14479	-0.12541	0.10881	0.05692	-0.07288
67	20-Jun	-0.00327	-0.00326	0.00297	0	-0.00028	-0.14806	-0.12867	0.11178	0.05692	-0.07316
68	21-Jun	-0.00326	-0.00327	0.00498	0	0.0017	-0.15132	-0.13194	0.11676	0.05692	-0.07146
69	22-Jun	-0.00327	-0.00327	0.0028	0	-0.00046	-0.15459	-0.13521	0.11956	0.05692	-0.07192
70	23-Jun	-0.00327	-0.00326	9E-05	0	-0.00318	-0.15786	-0.13847	0.11965	0.05692	-0.0751
71	24-Jun	-0.00326	-0.00327	0	0	-0.00327	-0.16112	-0.14174	0.11965	0.05692	-0.07837
72	25-Jun	-0.00327	-0.00327	0	0	-0.00326	-0.16439	-0.14501	0.11965	0.05692	-0.08163
73	26-Jun	-0.00327	-0.00326	0	0	-0.00327	-0.16766	-0.14827	0.11965	0.05692	-0.0849
74	27-Jun	-0.00326	-0.00327	0	0	-0.00327	-0.17092	-0.15154	0.11965	0.05692	-0.08817
75	28-Jun	-0.00327	-0.00327	0	0	-0.00326	-0.17419	-0.15481	0.11965	0.05692	-0.09143
76	29-Jun	-0.00327	-0.00326	0	0	-0.00327	-0.17746	-0.15807	0.11965	0.05692	-0.0947
77	30-Jun	-0.00327	-0.00327	0	0	-0.00326	-0.18073	-0.16134	0.11965	0.05692	-0.09796
78	1-Jul	-0.00315	-0.00315	0.00016	0	-0.00304	-0.18388	-0.16449	0.11981	0.05692	-0.101
79	2-Jul	-0.00291	-0.00291	0.00033	0	-0.0026	-0.18679	-0.1674	0.12014	0.05692	-0.1036
80	3-Jul	-0.0029	-0.0029	1E-05	0	-0.0029	-0.18969	-0.1703	0.12015	0.05692	-0.1065
81	4-Jul	-0.0029	-0.00291	0.00115	0	-0.00174	-0.19259	-0.17321	0.1213	0.05692	-0.10824
82	5-Jul	-0.0029	-0.0029	0.00239	0	-0.00052	-0.19549	-0.17611	0.12369	0.05692	-0.10876
83	6-Jul	-0.00291	-0.0029	7E-05	0	-0.00283	-0.1984	-0.17901	0.12376	0.05692	-0.11159
84	7-Jul	-0.0029	-0.00291	0.00052	0	-0.00238	-0.2013	-0.18192	0.12428	0.05692	-0.11397
85	8-Jul	-0.0029	-0.0029	0.00145	0	-0.00145	-0.2042	-0.18482	0.12573	0.05692	-0.11542
86	9-Jul	-0.00291	-0.0029	0.00133	0	-0.00158	-0.20711	-0.18772	0.12706	0.05692	-0.117
87	10-Jul	-0.0029	-0.0029	0.00207	0	-0.00083	-0.21001	-0.19062	0.12913	0.05692	-0.11783
88	11-Jul	-0.0029	-0.00291	0.00441	0	0.00151	-0.21291	-0.19353	0.13354	0.05692	-0.11632
89	12-Jul	-0.00291	-0.0029	0.0054	0	0.0025	-0.21582	-0.19643	0.13894	0.05692	-0.11382
90	13-Jul	-0.0029	-0.0029	0.00718	0	0.00428	-0.21872	-0.19933	0.14612	0.05692	-0.10954
91	14-Jul	-0.0029	-0.00291	0.01289	0	0.00998	-0.22162	-0.20224	0.15901	0.05692	-0.09956

		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
92	15-Jul	-0.0029	-0.0029	0.00175	0	-0.00115	-0.22452	-0.20514	0.16076	0.05692	-0.10071
93	16-Jul	-0.00291	-0.0029	4E-05	0	-0.00286	-0.22743	-0.20804	0.1608	0.05692	-0.10357
94	17-Jul	-0.0029	-0.0029	0	0	-0.0029	-0.23033	-0.21094	0.1608	0.05692	-0.10647
95	18-Jul	-0.0029	-0.00291	0.00022	0	-0.00268	-0.23323	-0.21385	0.16102	0.05692	-0.10915
96	19-Jul	-0.00291	-0.0029	0.00046	0	-0.00245	-0.23614	-0.21675	0.16148	0.05692	-0.1116
97	20-Jul	-0.0029	-0.0029	1E-05	0	-0.00289	-0.23904	-0.21965	0.16149	0.05692	-0.11449
98	21-Jul	-0.0029	-0.00291	0	0	-0.0029	-0.24194	-0.22256	0.16149	0.05692	-0.11739
99	22-Jul	-0.00291	-0.0029	0	0	-0.0029	-0.24485	-0.22546	0.16149	0.05692	-0.12029
100	23-Jul	-0.0029	-0.0029	0	0	-0.0029	-0.24775	-0.22836	0.16149	0.05692	-0.12319
101	24-Jul	-0.0029	-0.0029	0.00038	0	-0.00253	-0.25065	-0.23126	0.16187	0.05692	-0.12572
102	25-Jul	-0.0029	-0.00291	0.00222	0	-0.00068	-0.25355	-0.23417	0.16409	0.05692	-0.1264
103	26-Jul	-0.00291	-0.0029	0.00303	0	0.00013	-0.25646	-0.23707	0.16712	0.05692	-0.12627
104	27-Jul	-0.0029	-0.0029	0.0001	0	-0.00281	-0.25936	-0.23997	0.16722	0.05692	-0.12908
105	28-Jul	-0.0029	-0.00291	0	0	-0.0029	-0.26226	-0.24288	0.16722	0.05692	-0.13198
106	29-Jul	-0.00291	-0.0029	0	0	-0.0029	-0.26517	-0.24578	0.16722	0.05692	-0.13488
107	30-Jul	-0.0029	-0.0029	0	0	-0.00291	-0.26807	-0.24868	0.16722	0.05692	-0.13779
108	31-Jul	-0.0029	-0.0029	0	0	-0.0029	-0.27097	-0.25158	0.16722	0.05692	-0.14069
109	1-Aug	-0.00265	-0.00265	0	0	-0.00275	-0.27362	-0.25423	0.16722	0.05692	-0.14344
110	2-Aug	-0.00211	-0.00211	0	0	-0.00217	-0.27573	-0.25634	0.16722	0.05692	-0.14561
111	3-Aug	-0.0021	-0.0021	0	0	-0.00209	-0.27783	-0.25844	0.16722	0.05692	-0.1477
112	4-Aug	-0.0021	-0.0021	0	0	-0.0021	-0.27993	-0.26054	0.16722	0.05692	-0.1498
113	5-Aug	-0.00209	-0.00209	0.00016	0	-0.00193	-0.28202	-0.26263	0.16738	0.05692	-0.15173
114	6-Aug	-0.0021	-0.0021	0.00033	0	-0.00177	-0.28412	-0.26473	0.16771	0.05692	-0.1535
115	7-Aug	-0.0021	-0.0021	1E-05	0	-0.00209	-0.28622	-0.26683	0.16772	0.05692	-0.15559
116	8-Aug	-0.00209	-0.00209	0	0	-0.00209	-0.28831	-0.26892	0.16772	0.05692	-0.15768
117	9-Aug	-0.0021	-0.0021	0	0	-0.0021	-0.29041	-0.27102	0.16772	0.05692	-0.15978
118	10-Aug	-0.0021	-0.0021	0.00115	0	-0.00094	-0.29251	-0.27312	0.16887	0.05692	-0.16072
119	11-Aug	-0.00209	-0.00209	0.00239	0	0.00029	-0.2946	-0.27521	0.17126	0.05692	-0.16043
120	12-Aug	-0.0021	-0.0021	7E-05	0	-0.00202	-0.2967	-0.27731	0.17133	0.05692	-0.16245
121	13-Aug	-0.0021	-0.0021	0.00016	0	-0.00194	-0.2988	-0.27941	0.17149	0.05692	-0.16439
122	14-Aug	-0.0021	-0.00209	0.00033	0	-0.00176	-0.3009	-0.2815	0.17182	0.05692	-0.16615
123	15-Aug	-0.00209	-0.0021	1E-05	0	-0.00209	-0.30299	-0.2836	0.17183	0.05692	-0.16824
124	16-Aug	-0.0021	-0.0021	0	0	-0.0021	-0.30509	-0.2857	0.17183	0.05692	-0.17034
125	17-Aug	-0.0021	-0.0021	0	0	-0.00209	-0.30719	-0.2878	0.17183	0.05692	-0.17243
126	18-Aug	-0.00209	-0.00209	0.00022	0	-0.00188	-0.30928	-0.28989	0.17205	0.05692	-0.17431
127	19-Aug	-0.0021	-0.0021	0.00083	0	-0.00127	-0.31138	-0.29199	0.17288	0.05692	-0.17558
128	20-Aug	-0.0021	-0.00168	0.00078	0	-0.00089	-0.31348	-0.29367	0.17366	0.05692	-0.17647
129	21-Aug	-0.00209	-0.00209	3E-05	0	-0.00208	-0.31557	-0.29576	0.17369	0.05692	-0.17855
130	22-Aug	-0.0021	-0.0021	0	0	-0.00209	-0.31767	-0.29786	0.17369	0.05692	-0.18064
131	23-Aug	-0.0021	-0.0021	0	0	-0.0021	-0.31977	-0.29996	0.17369	0.05692	-0.18274
132	24-Aug	-0.0021	-0.00209	0	0	-0.00209	-0.32187	-0.30205	0.17369	0.05692	-0.18483
133	25-Aug	-0.00209	-0.00168	0	0	-0.00168	-0.32396	-0.30373	0.17369	0.05692	-0.18651
134	26-Aug	-0.0021	-0.00168	0	0	-0.00168	-0.32606	-0.30541	0.17369	0.05692	-0.18819
135	27-Aug	-0.0021	-0.00168	0	0	-0.00167	-0.32816	-0.30709	0.17369	0.05692	-0.18986
136	28-Aug	-0.00209	-0.00167	0.00031	0	-0.00137	-0.33025	-0.30876	0.174	0.05692	-0.19123
137	29-Aug	-0.0021	-0.00168	0.00064	0	-0.00103	-0.33235	-0.31044	0.17464	0.05692	-0.19226
138	30-Aug	-0.0021	-0.00168	2E-05	0	-0.00166	-0.33445	-0.31212	0.17466	0.05692	-0.19392
139	31-Aug	-0.00209	-0.00168	0.00016	0	-0.00152	-0.33654	-0.3138	0.17482	0.05692	-0.19544
140	1-Sep	-0.00176	-0.00175	0.00033	0	-0.00157	-0.3383	-0.31555	0.17515	0.05692	-0.19701
141	2-Sep	-0.00105	-0.00085	1E-05	0	-0.0009	-0.33935	-0.3164	0.17516	0.05692	-0.19791
142	3-Sep	-0.00104	-0.00083	0	0	-0.00083	-0.34039	-0.31723	0.17516	0.05692	-0.19874
143	4-Sep	-0.00103	-0.00082	0	0	-0.00083	-0.34142	-0.31805	0.17516	0.05692	-0.19957
144	5-Sep	-0.00103	-0.00083	0.00016	0	-0.00066	-0.34245	-0.31888	0.17532	0.05692	-0.20023
145	6-Sep	-0.00104	-0.00103	0.00033	0	-0.00071	-0.34349	-0.31991	0.17565	0.05692	-0.20094
146	7-Sep	-0.00103	-0.00083	1E-05	0	-0.00081	-0.34452	-0.32074	0.17566	0.05692	-0.20175
147	8-Sep	-0.00103	-0.00083	0	0	-0.00083	-0.34555	-0.32157	0.17566	0.05692	-0.20258
148	9-Sep	-0.00104	-0.00103	0	0	-0.00103	-0.34659	-0.3226	0.17566	0.05692	-0.20361
149	10-Sep	-0.00103	-0.00082	0	0	-0.00083	-0.34762	-0.32342	0.17566	0.05692	-0.20444
150	11-Sep	-0.00103	-0.00083	0	0	-0.00082	-0.34865	-0.32425	0.17566	0.05692	-0.20526
151	12-Sep	-0.00103	-0.00083	0	0	-0.00083	-0.34968	-0.32508	0.17566	0.05692	-0.20609
152	13-Sep	-0.00104	-0.00082	0	0	-0.00083	-0.35072	-0.3259	0.17566	0.05692	-0.20692
153	14-Sep	-0.00103	-0.00083	0	0	-0.00082	-0.35175	-0.32673	0.17566	0.05692	-0.20774
154	15-Sep	-0.00103	-0.00103	0	0	-0.00104	-0.35278	-0.32776	0.17566	0.05692	-0.20878
155	16-Sep	-0.00104	-0.00104	0	0	-0.00103	-0.35382	-0.3288	0.17566	0.05692	-0.20981
156	17-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.35485	-0.32983	0.17566	0.05692	-0.21084
157	18-Sep	-0.00103	-0.00083	0	0	-0.00083	-0.35588	-0.33066	0.17566	0.05692	-0.21167
158	19-Sep	-0.00104	-0.00082	0	0	-0.00082	-0.35692	-0.33148	0.17566	0.05692	-0.21249
159	20-Sep	-0.00103	-0.00103	0	0	-0.00104	-0.35795	-0.33251	0.17566	0.05692	-0.21353
160	21-Sep	-0.00103	-0.00104	0	0	-0.00103	-0.35898	-0.33355	0.17566	0.05692	-0.21456
161	22-Sep	-0.00103	-0.00082	0	0	-0.00083	-0.36001	-0.33437	0.17566	0.05692	-0.21539
162	23-Sep	-0.00104	-0.00104	0	0	-0.00103	-0.36105	-0.33541	0.17566	0.05692	-0.21642
163	24-Sep	-0.00103	-0.00062	0	0	-0.00062	-0.36208	-0.33603	0.17566	0.05692	-0.21704
164	25-Sep	-0.00103	-0.00082	0	0	-0.00083	-0.36311	-0.33685	0.17566	0.05692	-0.21787
165	26-Sep	-0.00104	-0.00083	0	0	-0.00082	-0.36415	-0.33768	0.17566	0.05692	-0.21869
166	27-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.36518	-0.33871	0.17566	0.05692	-0.21972
167	28-Sep	-0.00103	-0.00083	0	0	-0.00083	-0.36621	-0.33954	0.17566	0.05692	-0.22055
168	29-Sep	-0.00104	-0.00083	0	0	-0.00083	-0.36725	-0.34037	0.17566	0.05692	-0.22138
169	30-Sep	-0.00103	-0.00051	0	0	-0.00062	-0.36828	-0.34088	0.17566	0.05692	-0.222
170	1-Oct	-0.0007	-0.00021	0	0	-0.00027	-0.36898	-0.34109	0.17566	0.05692	-0.22227
171	2-Oct	-2E-05	0	0	0	-4E-05	-0.369	-0.34109	0.17566	0.05692	-0.22231
172	3-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
173	4-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
174	5-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
175	6-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
176	7-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
177	8-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
178	9-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
179	10-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
180	11-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
181	12-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
182	13-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
183	14-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
184	15-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
185	16-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
186	17-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
187	18-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
188	19-Oct	0	0	0	0	0	-0.369	-0.34109	0.17566	0.05692	-0.22231
189	20-Oct	0	0	0.00083	0	0.00082	-0.369	-0.34109	0.17649	0.05692	-0.22149
190	21-Oct	0	0	0.00186	0	0.00186	-0.369	-0.34109	0.17835	0.05692	-0.21963
191	22-Oct	0	0	0.00038	0	0.00039	-0.369	-0.34109	0.17873	0.05692	-0.21924
192	23-Oct	0	0	1E-05	0	1E-05	-0.369	-0.34109	0.17874	0.05692	-0.21923
193	24-Oct	0	0	0	0	0	-0.369	-0.34109	0.17874	0.05692	-0.21923
194	25-Oct	0	0	0	0	0	-0.369	-0.34109	0.17874	0.05692	-0.21923
195	26-Oct	0	0	0	0	0	-0.369	-0.34109	0.17874	0.05692	-0.21923
196	27-Oct	0	0	0	0	0	-0.369	-0.34109	0.17874	0.05692	-0.21923
197	28-Oct	0	0	0	0	0	-0.369	-0.34109	0.17874	0.05692	-0.21923
198	29-Oct	0	0	0.00067	0	0.00067	-0.369	-0.34109	0.17941	0.05692	-0.21856
199	30-Oct	0	0	0.00139	0	0.00139	-0.369	-0.34109	0.1808	0.05692	-0.21717
200	31-Oct	0	0	4E-05	0	4E-05	-0.369	-0.34109	0.18084	0.05692	-0.21713

OPTION 2 CLIMATE WATER BALANCE
MEAN YEAR

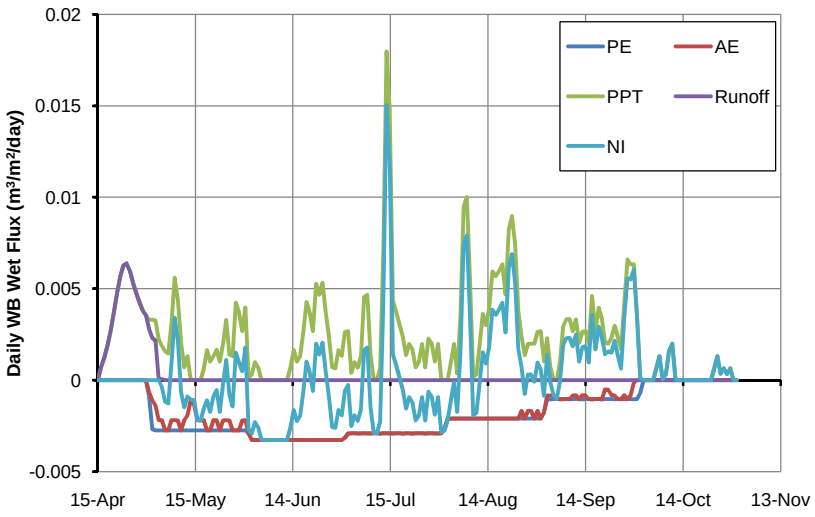


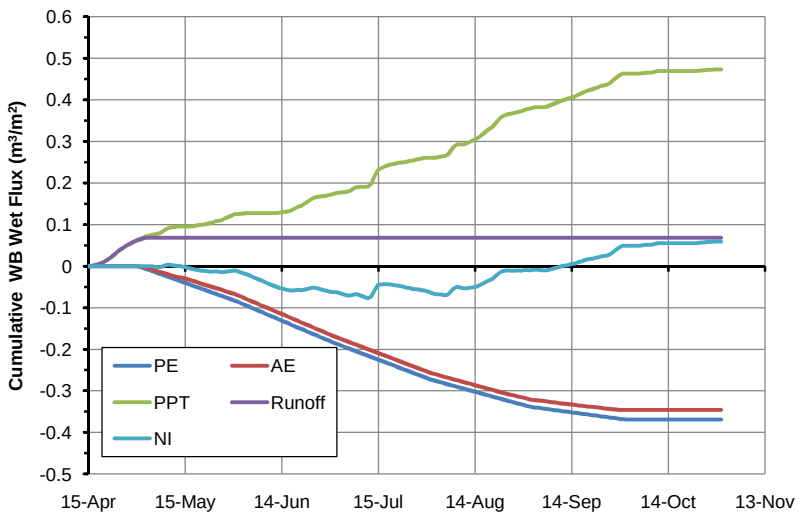


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.00055	0.00055	0	0	0	0.00055	0.00055	0
3	17-Apr	0	0	0.00087	0.00087	0	0	0	0.00142	0.00142	0
4	18-Apr	0	0	0.00132	0.00131	0	0	0	0.00274	0.00273	0
5	19-Apr	0	0	0.002	0.00201	0	0	0	0.00474	0.00474	0
6	20-Apr	0	0	0.00271	0.00271	0	0	0	0.00745	0.00745	0
7	21-Apr	0	0	0.00348	0.00347	0	0	0	0.01093	0.01092	0
8	22-Apr	0	0	0.00413	0.00414	0	0	0	0.01506	0.01506	0
9	23-Apr	0	0	0.00459	0.00459	0	0	0	0.01965	0.01965	0
10	24-Apr	0	0	0.00466	0.00466	0	0	0	0.02431	0.02431	0
11	25-Apr	0	0	0.00436	0.00436	0	0	0	0.02867	0.02867	0
12	26-Apr	0	0	0.00386	0.00386	0	0	0	0.03253	0.03253	0
13	27-Apr	0	0	0.00348	0.00348	0	0	0	0.03601	0.03601	0
14	28-Apr	0	0	0.0031	0.0031	0	0	0	0.03911	0.03911	0
15	29-Apr	0	0	0.00278	0.00278	0	0	0	0.04189	0.04189	0
16	30-Apr	0	0	0.00259	0.00259	0	0	0	0.04448	0.04448	0
17	1-May	-0.00088	-0.00066	0.0024	0.00191	0	-0.00088	-0.00066	0.04688	0.04639	0
18	2-May	-0.00268	-0.00109	0.00218	0.00119	0	-0.00356	-0.00175	0.04906	0.04758	0
19	3-May	-0.00275	-0.00138	0.0019	0.0008	0	-0.00631	-0.00313	0.05096	0.04838	0
20	4-May	-0.00274	-0.00219	0.00162	-0.00057	0	-0.00905	-0.00532	0.05258	0.04781	0
21	5-May	-0.00274	-0.00219	0.002	-0.00019	0	-0.01179	-0.00751	0.05458	0.04762	0
22	6-May	-0.00274	-0.00275	0.00374	0.001	0	-0.01453	-0.01026	0.05832	0.04862	0
23	7-May	-0.00274	-0.00274	0.00447	0.00172	0	-0.01727	-0.013	0.06279	0.05034	0
24	8-May	-0.00275	-0.00192	0.00239	0.00079	-0.00032	-0.02002	-0.01492	0.06518	0.05113	-0.00032
25	9-May	-0.00274	-0.00192	0	0	-0.00138	-0.02276	-0.01684	0.06518	0.05113	-0.0017
26	10-May	-0.00274	-0.00219	0	0	-0.00219	-0.0255	-0.01903	0.06518	0.05113	-0.00389
27	11-May	-0.00274	-0.00274	0	0	-0.00274	-0.02824	-0.02177	0.06518	0.05113	-0.00663
28	12-May	-0.00274	-0.0022	0.00032	0	-0.00187	-0.03098	-0.02397	0.0655	0.05113	-0.0085
29	13-May	-0.00275	-0.00191	0.00098	0	-0.00122	-0.03373	-0.02588	0.06648	0.05113	-0.00972
30	14-May	-0.00274	-0.0011	0.00324	0	0.00215	-0.03647	-0.02698	0.06972	0.05113	-0.00757
31	15-May	-0.00274	-0.00137	0.00594	0	0.00484	-0.03921	-0.02835	0.07566	0.05113	-0.00273
32	16-May	-0.00274	-0.0022	0.00148	0	-0.00072	-0.04195	-0.03055	0.07714	0.05113	-0.00345
33	17-May	-0.00274	-0.00219	4E-05	0	-0.00215	-0.04469	-0.03274	0.07718	0.05113	-0.0056
34	18-May	-0.00275	-0.00219	0	0	-0.00219	-0.04744	-0.03493	0.07718	0.05113	-0.00779
35	19-May	-0.00274	-0.00275	0	0	-0.00274	-0.05018	-0.03768	0.07718	0.05113	-0.01053
36	20-May	-0.00274	-0.00274	0	0	-0.00275	-0.05292	-0.04042	0.07718	0.05113	-0.01328
37	21-May	-0.00274	-0.00219	0	0	-0.00219	-0.05566	-0.04261	0.07718	0.05113	-0.01547
38	22-May	-0.00274	-0.00219	0	0	-0.00219	-0.0584	-0.0448	0.07718	0.05113	-0.01766
39	23-May	-0.00275	-0.00275	0	0	-0.00275	-0.06115	-0.04755	0.07718	0.05113	-0.02041
40	24-May	-0.00274	-0.00219	0.00032	0	-0.00187	-0.06389	-0.04974	0.0775	0.05113	-0.02228
41	25-May	-0.00274	-0.00219	0.00066	0	-0.00153	-0.06663	-0.05193	0.07816	0.05113	-0.02381
42	26-May	-0.00274	-0.0022	2E-05	0	-0.00217	-0.06937	-0.05413	0.07818	0.05113	-0.02598
43	27-May	-0.00274	-0.00274	0	0	-0.00274	-0.07211	-0.05687	0.07818	0.05113	-0.02872
44	28-May	-0.00275	-0.00274	0.00032	0	-0.00243	-0.07486	-0.05961	0.0785	0.05113	-0.03115
45	29-May	-0.00274	-0.00274	0.00066	0	-0.00208	-0.0776	-0.06235	0.07916	0.05113	-0.03323
46	30-May	-0.00274	-0.0022	2E-05	0	-0.00217	-0.08034	-0.06455	0.07918	0.05113	-0.0354
47	31-May	-0.00274	-0.00219	0.00032	0	-0.00187	-0.08308	-0.06674	0.0795	0.05113	-0.03727
48	1-Jun	-0.00291	-0.00291	0.00066	0	-0.00218	-0.08599	-0.06965	0.08016	0.05113	-0.03945
49	2-Jun	-0.00326	-0.00326	2E-05	0	-0.0032	-0.08925	-0.07291	0.08018	0.05113	-0.04265
50	3-Jun	-0.00327	-0.00326	0.00032	0	-0.00295	-0.09252	-0.07617	0.0805	0.05113	-0.0456
51	4-Jun	-0.00326	-0.00327	0.00066	0	-0.00261	-0.09578	-0.07944	0.08116	0.05113	-0.04821
52	5-Jun	-0.00327	-0.00327	0.00034	0	-0.00292	-0.09905	-0.08271	0.0815	0.05113	-0.05113
53	6-Jun	-0.00327	-0.00326	0.00066	0	-0.00261	-0.10232	-0.08597	0.08216	0.05113	-0.05374
54	7-Jun	-0.00326	-0.00327	0.0013	0	-0.00196	-0.10558	-0.08924	0.08346	0.05113	-0.0557
55	8-Jun	-0.00327	-0.00327	0.00296	0	-0.00031	-0.10885	-0.09251	0.08642	0.05113	-0.05601
56	9-Jun	-0.00327	-0.00327	0.00074	0	-0.00253	-0.11212	-0.09578	0.08716	0.05113	-0.05854
57	10-Jun	-0.00327	-0.00326	2E-05	0	-0.00324	-0.11539	-0.09904	0.08718	0.05113	-0.06178
58	11-Jun	-0.00326	-0.00327	0	0	-0.00327	-0.11865	-0.10231	0.08718	0.05113	-0.06505
59	12-Jun	-0.00327	-0.00327	0	0	-0.00327	-0.12192	-0.10558	0.08718	0.05113	-0.06832
60	13-Jun	-0.00327	-0.00326	0	0	-0.00326	-0.12519	-0.10884	0.08718	0.05113	-0.07158
61	14-Jun	-0.00326	-0.00327	0	0	-0.00327	-0.12845	-0.11211	0.08718	0.05113	-0.07485
62	15-Jun	-0.00327	-0.00327	0.00032	0	-0.00294	-0.13172	-0.11538	0.0875	0.05113	-0.07779
63	16-Jun	-0.00327	-0.00326	0.0013	0	-0.00197	-0.13499	-0.11864	0.0888	0.05113	-0.07976
64	17-Jun	-0.00326	-0.00327	0.0023	0	-0.00097	-0.13825	-0.12191	0.0911	0.05113	-0.08073
65	18-Jun	-0.00327	-0.00327	0.00362	0	0.00036	-0.14152	-0.12518	0.09472	0.05113	-0.08037
66	19-Jun	-0.00327	-0.00326	0.0082	0	0.00493	-0.14479	-0.12844	0.10292	0.05113	-0.07544
67	20-Jun	-0.00327	-0.00327	0.01158	0	0.00831	-0.14806	-0.13171	0.1145	0.05113	-0.06713
68	21-Jun	-0.00326	-0.00327	0.00714	0	0.00387	-0.15132	-0.13498	0.12164	0.05113	-0.06326
69	22-Jun	-0.00327	-0.00326	0.007	0	0.00374	-0.15459	-0.13824	0.12864	0.05113	-0.05952
70	23-Jun	-0.00327	-0.00327	0.00476	0	0.00149	-0.15786	-0.14151	0.1334	0.05113	-0.05803
71	24-Jun	-0.00326	-0.00327	0.00078	0	-0.00249	-0.16112	-0.14478	0.13418	0.05113	-0.06052
72	25-Jun	-0.00327	-0.00327	0.00132	0	-0.00194	-0.16439	-0.14805	0.1355	0.05113	-0.06246
73	26-Jun	-0.00327	-0.00326	0.00036	0	-0.00291	-0.16766	-0.15131	0.13586	0.05113	-0.06537
74	27-Jun	-0.00326	-0.00327	0.00066	0	-0.00261	-0.17092	-0.15458	0.13652	0.05113	-0.06798
75	28-Jun	-0.00327	-0.00327	0.00034	0	-0.00292	-0.17419	-0.15785	0.13686	0.05113	-0.0709
76	29-Jun	-0.00327	-0.00326	0.0029	0	-0.00037	-0.17746	-0.16111	0.13976	0.05113	-0.07127
77	30-Jun	-0.00327	-0.00327	0.00592	0	0.00266	-0.18073	-0.16438	0.14568	0.05113	-0.06861
78	1-Jul	-0.00315	-0.00315	0.0031	0	-0.00011	-0.18388	-0.16753	0.14878	0.05113	-0.06872
79	2-Jul	-0.00291	-0.00291	0.00074	0	-0.00219	-0.18679	-0.17044	0.14952	0.05113	-0.07091
80	3-Jul	-0.0029	-0.0029	0.00162	0	-0.00128	-0.18969	-0.17334	0.15114	0.05113	-0.07219
81	4-Jul	-0.0029	-0.00291	0.0065	0	0.0036	-0.19259	-0.17625	0.15764	0.05113	-0.06859
82	5-Jul	-0.0029	-0.0029	0.00798	0	0.00508	-0.19549	-0.17915	0.16562	0.05113	-0.06351
83	6-Jul	-0.00291	-0.0029	0.00348	0	0.00058	-0.1984	-0.18205	0.1691	0.05113	-0.06293
84	7-Jul	-0.0029	-0.0029	0.00268	0	-0.00022	-0.2013	-0.18495	0.17178	0.05113	-0.06315
85	8-Jul	-0.0029	-0.00291	0.00524	0	0.00234	-0.2042	-0.18786	0.17702	0.05113	-0.06081
86	9-Jul	-0.00291	-0.0029	0.0076	0	0.0047	-0.20711	-0.19076	0.18462	0.05113	-0.05611
87	10-Jul	-0.0029	-0.0029	0.00574	0	0.00284	-0.21001	-0.19366	0.19036	0.05113	-0.05327
88	11-Jul	-0.0029	-0.00291	0.00212	0	-0.00079	-0.21291	-0.19657	0.19248	0.05113	-0.05406
89	12-Jul	-0.00291	-0.0029	0.00038	0	-0.00252	-0.21582	-0.19947	0.19286	0.05113	-0.05658

		DAILY VALUES VS. TIME ($m^3/m^2/day$)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
90	13-Jul	-0.0029	-0.0029	0.00162	0	-0.00128	-0.21872	-0.20237	0.19448	0.05113	-0.05786
91	14-Jul	-0.0029	-0.0029	0.002	0	-0.0009	-0.22162	-0.20527	0.19648	0.05113	-0.05876
92	15-Jul	-0.0029	-0.00291	0.00038	0	-0.00253	-0.22452	-0.20818	0.19686	0.05113	-0.06129
93	16-Jul	-0.00291	-0.0029	0.00066	0	-0.00224	-0.22743	-0.21108	0.19752	0.05113	-0.06353
94	17-Jul	-0.0029	-0.0029	2E-05	0	-0.00288	-0.23033	-0.21398	0.19754	0.05113	-0.06641
95	18-Jul	-0.0029	-0.00291	0	0	-0.0029	-0.23323	-0.21689	0.19754	0.05113	-0.06931
96	19-Jul	-0.00291	-0.0029	0.00064	0	-0.00226	-0.23614	-0.21979	0.19818	0.05113	-0.07157
97	20-Jul	-0.0029	-0.0029	0.00164	0	-0.00127	-0.23904	-0.22269	0.19982	0.05113	-0.07284
98	21-Jul	-0.0029	-0.0029	0.00102	0	-0.00188	-0.24194	-0.22559	0.20084	0.05113	-0.07472
99	22-Jul	-0.00291	-0.00291	0.00132	0	-0.00158	-0.24485	-0.2285	0.20216	0.05113	-0.0763
100	23-Jul	-0.0029	-0.0029	0.00198	0	-0.00092	-0.24775	-0.2314	0.20414	0.05113	-0.07722
101	24-Jul	-0.0029	-0.0029	0.00136	0	-0.00155	-0.25065	-0.2343	0.2055	0.05113	-0.07877
102	25-Jul	-0.0029	-0.00291	0.00036	0	-0.00254	-0.25355	-0.23721	0.20586	0.05113	-0.08131
103	26-Jul	-0.00291	-0.0029	0.00066	0	-0.00224	-0.25646	-0.24011	0.20652	0.05113	-0.08355
104	27-Jul	-0.0029	-0.0029	2E-05	0	-0.00288	-0.25936	-0.24301	0.20654	0.05113	-0.08643
105	28-Jul	-0.0029	-0.0029	0	0	-0.0029	-0.26226	-0.24591	0.20654	0.05113	-0.08933
106	29-Jul	-0.00291	-0.00291	0.00032	0	-0.00259	-0.26517	-0.24882	0.20686	0.05113	-0.09192
107	30-Jul	-0.0029	-0.0029	0.00066	0	-0.00224	-0.26807	-0.25172	0.20752	0.05113	-0.09416
108	31-Jul	-0.0029	-0.0029	0.00066	0	-0.00224	-0.27097	-0.25462	0.20818	0.05113	-0.0964
109	1-Aug	-0.00265	-0.00265	0.00132	0	-0.00144	-0.27362	-0.25727	0.2095	0.05113	-0.09784
110	2-Aug	-0.00211	-0.00211	4E-05	0	-0.00212	-0.27573	-0.25938	0.20954	0.05113	-0.09996
111	3-Aug	-0.0021	-0.0021	0	0	-0.00209	-0.27783	-0.26148	0.20954	0.05113	-0.10205
112	4-Aug	-0.0021	-0.00209	0.00096	0	-0.00114	-0.27993	-0.26357	0.2105	0.05113	-0.10319
113	5-Aug	-0.00209	-0.0021	0.00262	0	0.00052	-0.28202	-0.26567	0.21312	0.05113	-0.10267
114	6-Aug	-0.0021	-0.0021	0.0017	0	-0.00039	-0.28412	-0.26777	0.21482	0.05113	-0.10306
115	7-Aug	-0.0021	-0.00209	0.0007	0	-0.0014	-0.28622	-0.26986	0.21552	0.05113	-0.10446
116	8-Aug	-0.00209	-0.0021	2E-05	0	-0.00208	-0.28831	-0.27196	0.21554	0.05113	-0.10654
117	9-Aug	-0.0021	-0.0021	0	0	-0.00209	-0.29041	-0.27406	0.21554	0.05113	-0.10863
118	10-Aug	-0.0021	-0.0021	0.00032	0	-0.00178	-0.29251	-0.27616	0.21586	0.05113	-0.11041
119	11-Aug	-0.00209	-0.00209	0.00066	0	-0.00144	-0.2946	-0.27825	0.21652	0.05113	-0.11185
120	12-Aug	-0.0021	-0.0021	0.00098	0	-0.00111	-0.2967	-0.28035	0.2175	0.05113	-0.11296
121	13-Aug	-0.0021	-0.0021	0.0023	0	0.0002	-0.2988	-0.28245	0.2198	0.05113	-0.11276
122	14-Aug	-0.0021	-0.00209	0.00104	0	-0.00106	-0.3009	-0.28454	0.22084	0.05113	-0.11382
123	15-Aug	-0.00209	-0.0021	0.00068	0	-0.00141	-0.30299	-0.28664	0.22152	0.05113	-0.11523
124	16-Aug	-0.0021	-0.0021	0.00034	0	-0.00176	-0.30509	-0.28874	0.22186	0.05113	-0.11699
125	17-Aug	-0.0021	-0.00209	0.00066	0	-0.00144	-0.30719	-0.29083	0.22252	0.05113	-0.11843
126	18-Aug	-0.00209	-0.0021	2E-05	0	-0.00207	-0.30928	-0.29293	0.22254	0.05113	-0.1205
127	19-Aug	-0.0021	-0.0021	0.0016	0	-0.0005	-0.31138	-0.29503	0.22414	0.05113	-0.121
128	20-Aug	-0.0021	-0.00209	0.00394	0	0.00184	-0.31348	-0.29712	0.22808	0.05113	-0.11916
129	21-Aug	-0.00209	-0.0021	0.00206	0	-3E-05	-0.31557	-0.29922	0.23014	0.05113	-0.11919
130	22-Aug	-0.0021	-0.0021	0.00264	0	0.00054	-0.31767	-0.30132	0.23278	0.05113	-0.11865
131	23-Aug	-0.0021	-0.00209	0.00556	0	0.00347	-0.31977	-0.30341	0.23834	0.05113	-0.11518
132	24-Aug	-0.0021	-0.0021	0.00634	0	0.00424	-0.32187	-0.30551	0.24468	0.05113	-0.11094
133	25-Aug	-0.00209	-0.00168	0.00084	0	-0.00083	-0.32396	-0.30719	0.24552	0.05113	-0.11177
134	26-Aug	-0.0021	-0.0021	2E-05	0	-0.00208	-0.32606	-0.30929	0.24554	0.05113	-0.11385
135	27-Aug	-0.0021	-0.00167	0.00032	0	-0.00136	-0.32816	-0.31096	0.24586	0.05113	-0.11521
136	28-Aug	-0.00209	-0.00168	0.00066	0	-0.00101	-0.33025	-0.31264	0.24652	0.05113	-0.11622
137	29-Aug	-0.0021	-0.0021	2E-05	0	-0.00208	-0.33235	-0.31474	0.24654	0.05113	-0.1183
138	30-Aug	-0.0021	-0.00168	0	0	-0.00168	-0.33445	-0.31642	0.24654	0.05113	-0.11998
139	31-Aug	-0.00209	-0.00209	0.00032	0	-0.00177	-0.33654	-0.31851	0.24686	0.05113	-0.12175
140	1-Sep	-0.00176	-0.00176	0.00098	0	-0.00093	-0.3383	-0.32027	0.24784	0.05113	-0.12268
141	2-Sep	-0.00105	-0.00085	0.00132	0	0.00041	-0.33935	-0.32112	0.24916	0.05113	-0.12227
142	3-Sep	-0.00104	-0.00082	0.00134	0	0.00051	-0.34039	-0.32194	0.2505	0.05113	-0.12176
143	4-Sep	-0.00103	-0.00083	0.00036	0	-0.00046	-0.34142	-0.32277	0.25086	0.05113	-0.12222
144	5-Sep	-0.00103	-0.00103	0.00066	0	-0.00037	-0.34245	-0.3238	0.25152	0.05113	-0.12259
145	6-Sep	-0.00104	-0.00103	0.00034	0	-0.0007	-0.34349	-0.32483	0.25186	0.05113	-0.12329
146	7-Sep	-0.00103	-0.00104	0.00098	0	-5E-05	-0.34452	-0.32587	0.25284	0.05113	-0.12334
147	8-Sep	-0.00103	-0.00103	0.00068	0	-0.00035	-0.34555	-0.3269	0.25352	0.05113	-0.12369
148	9-Sep	-0.00104	-0.00103	2E-05	0	-0.00102	-0.34659	-0.32793	0.25354	0.05113	-0.12471
149	10-Sep	-0.00103	-0.00083	0	0	-0.00082	-0.34762	-0.32876	0.25354	0.05113	-0.12553
150	11-Sep	-0.00103	-0.00083	0	0	-0.00083	-0.34865	-0.32959	0.25354	0.05113	-0.12636
151	12-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.34968	-0.33062	0.25354	0.05113	-0.12739
152	13-Sep	-0.00104	-0.00083	0.00096	0	0.00013	-0.35072	-0.33145	0.2545	0.05113	-0.12726
153	14-Sep	-0.00103	-0.00082	0.00198	0	0.00115	-0.35175	-0.33227	0.25648	0.05113	-0.12611
154	15-Sep	-0.00103	-0.00103	6E-05	0	-0.00097	-0.35278	-0.3333	0.25654	0.05113	-0.12708
155	16-Sep	-0.00104	-0.00104	0	0	-0.00103	-0.35382	-0.33434	0.25654	0.05113	-0.12811
156	17-Sep	-0.00103	-0.00103	0	0	-0.00104	-0.35485	-0.33537	0.25654	0.05113	-0.12915
157	18-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.35588	-0.3364	0.25654	0.05113	-0.13018
158	19-Sep	-0.00104	-0.00104	0.00064	0	-0.00039	-0.35692	-0.33744	0.25718	0.05113	-0.13057
159	20-Sep	-0.00103	-0.00051	0.00132	0	0.0007	-0.35795	-0.33795	0.2585	0.05113	-0.12987
160	21-Sep	-0.00103	-0.00052	0.00036	0	-5E-05	-0.35898	-0.33847	0.25886	0.05113	-0.12992
161	22-Sep	-0.00103	-0.00083	0.00066	0	-0.00017	-0.36001	-0.3393	0.25952	0.05113	-0.13009
162	23-Sep	-0.00104	-0.00082	2E-05	0	-0.00081	-0.36105	-0.34012	0.25954	0.05113	-0.1309
163	24-Sep	-0.00103	-0.00104	0	0	-0.00103	-0.36208	-0.34116	0.25954	0.05113	-0.13193
164	25-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.36311	-0.34219	0.25954	0.05113	-0.13296
165	26-Sep	-0.00104	-0.00082	0	0	-0.00083	-0.36415	-0.34301	0.25954	0.05113	-0.13379
166	27-Sep	-0.00103	-0.00104	0.00032	0	-0.00071	-0.36518	-0.34405	0.25986	0.05113	-0.1345
167	28-Sep	-0.00103	-0.00082	0.00066	0	-0.00017	-0.36621	-0.34487	0.26052	0.05113	-0.13467
168	29-Sep	-0.00104	-0.00011	2E-05	0	-0.00029	-0.36725	-0.34498	0.26054	0.05113	-0.13496
169	30-Sep	-0.00103	0	0	0	0	-0.36828	-0.34498	0.26054	0.05113	-0.13496
170	1-Oct	-0.0007	0	0	0	0	-0.36898	-0.34498	0.26054	0.05113	-0.13496
171	2-Oct	-2E-05	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
172	3-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
173	4-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
174	5-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
175	6-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
176	7-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
177	8-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
178	9-Oct	0	0	0	0	0	-0.369	-0.34498	0.26054	0.05113	-0.13496
179	10-Oct	0	0	0.00032	0	0.00032	-0.369	-0.34498	0.26086	0.05113	-0.13464
180	11-Oct	0	0	0.00066	0	0.00066	-0.369	-0.34498	0.26152	0.05113	-0.13398
181	12-Oct	0	0	2E-05	0	2E-05	-0.369	-0.34498	0.26154	0.05113	-0.13396
182	13-Oct	0	0	0	0	0	-0.369	-0.34498	0.26154	0.05113	-0.13396
183	14-Oct	0	0	0.00096	0	0.00096	-0.369	-0.34498	0.2625	0.05113	-0.133
184	15-Oct	0	0	0.00198	0	0.00198	-0.369	-0.34498	0.26448	0.05113	-0.13102
185	16-Oct	0	0	6E-05	0	6E-05	-0.369	-0.34498	0.26454	0.05113	-0.13096
186	17-Oct	0	0	0	0	0	-0.369	-0.34498	0.26454	0.05113	-0.13096
187	18-Oct	0	0	0	0	0	-0.369	-0.34498	0.26454	0.05113	-0.13096
188	19-Oct	0	0	0.00064	0	0.00064	-0.369	-0.34498	0.26518	0.05113	-0.13032
189	20-Oct	0	0	0.00164	0	0.00164	-0.369	-0.34498	0.26682	0.05113	-0.12868
190	21-Oct	0	0	0.0007	0	0.0007	-0.369	-0.34498	0.26752	0.05113	-0.12798
191	22-Oct	0	0	2E-05	0	2E-05	-0.369	-0.34498	0.26754	0.05113	-0.12796
192	23-Oct	0	0	0.00096	0	0.00096	-0.369	-0.34498	0.2685	0.05113	-0.127
193	24-Oct	0	0	0.00326	0	0.00325	-0.369	-0.34498	0.27176	0.05113	-0.12375
194	25-Oct	0	0	0.00334	0	0.00334	-0.369	-0.34498	0.2751	0.05113	-0.12041
195	26-Oct	0	0	0.003	0	0.003	-0.369	-0.34498	0.2781	0.05113	-0.11741
196	27-Oct	0	0	0.00334	0	0.00334	-0.369	-0.34498	0.28144	0.05113	-0.11407
197	28-Oct	0	0	0.00042	0	0.00042	-0.369	-0.34498	0.28186	0.05113	-0.11365
198	29-Oct	0	0	0.00066	0	0.00066	-0.369	-0.34498	0.28252	0.05113	-0.11299
199	30-Oct	0	0	0.00034	0	0.00034	-0.369	-0.34498	0.28286	0.05113	-0.11265
200	31-Oct	0	0	0.00066	0	0.00066	-0.369	-0.34498	0.28352	0.05113	-0.11199

OPTION 2 CLIMATE WATER BALANCE
WET YEAR

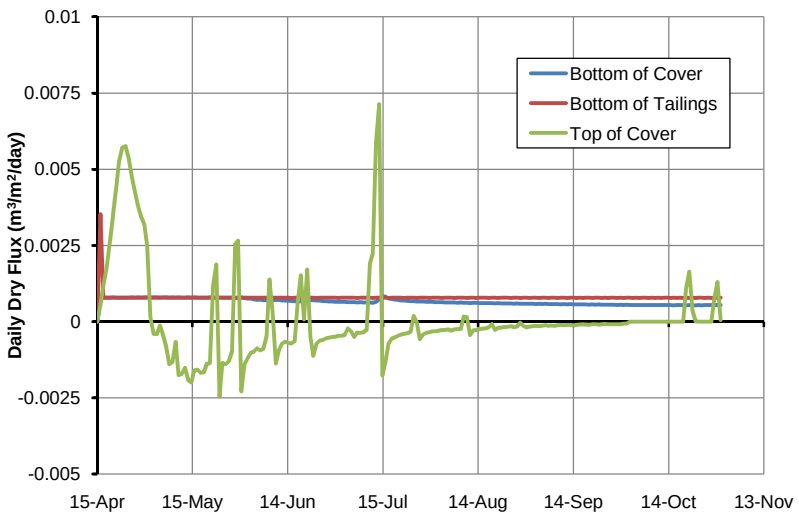


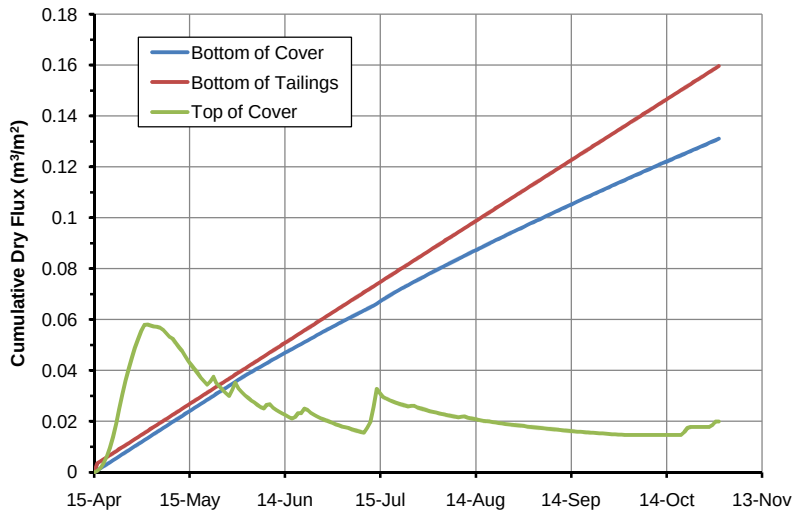


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.00074	0.00071	0	0	0	0.00074	0.00071	0
3	17-Apr	0	0	0.00123	0.00122	0	0	0	0.00197	0.00193	0
4	18-Apr	0	0	0.00188	0.00189	0	0	0	0.00385	0.00382	0
5	19-Apr	0	0	0.00271	0.0027	0	0	0	0.00656	0.00652	0
6	20-Apr	0	0	0.00372	0.00372	0	0	0	0.01028	0.01024	0
7	21-Apr	0	0	0.00477	0.00477	0	0	0	0.01505	0.01501	0
8	22-Apr	0	0	0.00567	0.00567	0	0	0	0.02072	0.02068	0
9	23-Apr	0	0	0.00629	0.00629	0	0	0	0.02701	0.02697	0
10	24-Apr	0	0	0.00639	0.00639	0	0	0	0.0334	0.03336	0
11	25-Apr	0	0	0.00598	0.00598	0	0	0	0.03938	0.03934	0
12	26-Apr	0	0	0.0053	0.0053	0	0	0	0.04468	0.04464	0
13	27-Apr	0	0	0.00477	0.00477	0	0	0	0.04945	0.04941	0
14	28-Apr	0	0	0.00426	0.00426	0	0	0	0.05371	0.05367	0
15	29-Apr	0	0	0.00381	0.00382	0	0	0	0.05752	0.05749	0
16	30-Apr	0	0	0.00356	0.00355	0	0	0	0.06108	0.06104	0
17	1-May	-0.00088	-0.00066	0.00329	0.0028	0	-0.00088	-0.00066	0.06437	0.06384	0
18	2-May	-0.00268	-0.00109	0.00331	0.00232	0	-0.00356	-0.00175	0.06768	0.06616	0
19	3-May	-0.00275	-0.00138	0.00326	0.00217	0	-0.00631	-0.00313	0.07094	0.06833	0
20	4-May	-0.00274	-0.00219	0.00224	4E-05	0	-0.00905	-0.00532	0.07318	0.06837	0
21	5-May	-0.00274	-0.00219	0.00187	6E-05	-0.00038	-0.01179	-0.00751	0.07505	0.06843	-0.00038
22	6-May	-0.00274	-0.00275	0.00157	0	-0.00117	-0.01453	-0.01026	0.07662	0.06843	-0.00155
23	7-May	-0.00274	-0.00274	0.00146	0	-0.00128	-0.01727	-0.013	0.07808	0.06843	-0.00283
24	8-May	-0.00275	-0.00219	0.00312	0	0.00092	-0.02002	-0.01519	0.0812	0.06843	-0.00191
25	9-May	-0.00274	-0.00219	0.0056	0	0.00341	-0.02276	-0.01738	0.0868	0.06843	0.0015
26	10-May	-0.00274	-0.0022	0.00438	0	0.00218	-0.0255	-0.01958	0.09118	0.06843	0.00368
27	11-May	-0.00274	-0.00274	0.00208	0	-0.00066	-0.02824	-0.02232	0.09326	0.06843	0.00302
28	12-May	-0.00274	-0.00219	0.0007	0	-0.00149	-0.03098	-0.02451	0.09396	0.06843	0.00153
29	13-May	-0.00275	-0.00192	0.00132	0	-0.00088	-0.03373	-0.02643	0.09528	0.06843	0.00065
30	14-May	-0.00274	-0.0011	4E-05	0	-0.00105	-0.03647	-0.02753	0.09532	0.06843	-0.0004
31	15-May	-0.00274	-0.00137	0	0	-0.0011	-0.03921	-0.0289	0.09532	0.06843	-0.0015
32	16-May	-0.00274	-0.00219	0	0	-0.00219	-0.04195	-0.03109	0.09532	0.06843	-0.00369
33	17-May	-0.00274	-0.0022	0	0	-0.0022	-0.04469	-0.03329	0.09532	0.06843	-0.00589
34	18-May	-0.00275	-0.00219	0.00064	0	-0.00155	-0.04744	-0.03548	0.09596	0.06843	-0.00744
35	19-May	-0.00274	-0.00274	0.00164	0	-0.0011	-0.05018	-0.03822	0.0976	0.06843	-0.00854
36	20-May	-0.00274	-0.00275	0.00102	0	-0.00172	-0.05292	-0.04097	0.09862	0.06843	-0.01026
37	21-May	-0.00274	-0.00219	0.00132	0	-0.00088	-0.05566	-0.04316	0.09994	0.06843	-0.01114
38	22-May	-0.00274	-0.00219	0.00166	0	-0.00053	-0.0584	-0.04535	0.1016	0.06843	-0.01167
39	23-May	-0.00275	-0.00274	0.00102	0	-0.00172	-0.06115	-0.04809	0.10262	0.06843	-0.01339
40	24-May	-0.00274	-0.0022	0.00196	0	-0.00024	-0.06389	-0.05029	0.10458	0.06843	-0.01363
41	25-May	-0.00274	-0.00219	0.0033	0	0.00111	-0.06663	-0.05248	0.10788	0.06843	-0.01252
42	26-May	-0.00274	-0.0022	0.0014	0	-0.00079	-0.06937	-0.05468	0.10928	0.06843	-0.01331
43	27-May	-0.00274	-0.00274	0.00132	0	-0.00143	-0.07211	-0.05742	0.1106	0.06843	-0.01474
44	28-May	-0.00275	-0.00274	0.00424	0	0.0015	-0.07486	-0.06016	0.11484	0.06843	-0.01324
45	29-May	-0.00274	-0.00274	0.0037	0	0.00096	-0.0776	-0.0629	0.11854	0.06843	-0.01228
46	30-May	-0.00274	-0.0022	0.00268	0	0.00049	-0.08034	-0.0651	0.12122	0.06843	-0.01179
47	31-May	-0.00274	-0.00219	0.00398	0	0.00178	-0.08308	-0.06729	0.1252	0.06843	-0.01001
48	1-Jun	-0.00291	-0.00291	0.00012	0	-0.00271	-0.08599	-0.0702	0.12532	0.06843	-0.01272
49	2-Jun	-0.00326	-0.00326	0.00032	0	-0.00291	-0.08925	-0.07346	0.12564	0.06843	-0.01563
50	3-Jun	-0.00327	-0.00326	0.00098	0	-0.00228	-0.09252	-0.07672	0.12662	0.06843	-0.01791
51	4-Jun	-0.00326	-0.00327	0.00068	0	-0.00259	-0.09578	-0.07999	0.1273	0.06843	-0.0205
52	5-Jun	-0.00327	-0.00327	2E-05	0	-0.00325	-0.09905	-0.08326	0.12732	0.06843	-0.02375
53	6-Jun	-0.00327	-0.00326	0	0	-0.00326	-0.10232	-0.08652	0.12732	0.06843	-0.02701
54	7-Jun	-0.00326	-0.00327	0	0	-0.00327	-0.10558	-0.08979	0.12732	0.06843	-0.03028
55	8-Jun	-0.00327	-0.00327	0	0	-0.00326	-0.10885	-0.09306	0.12732	0.06843	-0.03354
56	9-Jun	-0.00327	-0.00326	0	0	-0.00327	-0.11212	-0.09632	0.12732	0.06843	-0.03681
57	10-Jun	-0.00327	-0.00327	0	0	-0.00327	-0.11539	-0.09959	0.12732	0.06843	-0.04008
58	11-Jun	-0.00326	-0.00327	0	0	-0.00326	-0.11865	-0.10286	0.12732	0.06843	-0.04334
59	12-Jun	-0.00327	-0.00326	0	0	-0.00327	-0.12192	-0.10612	0.12732	0.06843	-0.04661
60	13-Jun	-0.00327	-0.00327	0	0	-0.00326	-0.12519	-0.10939	0.12732	0.06843	-0.04987
61	14-Jun	-0.00326	-0.00327	0.00064	0	-0.00263	-0.12845	-0.11266	0.12796	0.06843	-0.0525
62	15-Jun	-0.00327	-0.00327	0.00164	0	-0.00163	-0.13172	-0.11593	0.1296	0.06843	-0.05413
63	16-Jun	-0.00327	-0.00326	0.00102	0	-0.00224	-0.13499	-0.11919	0.13062	0.06843	-0.05637
64	17-Jun	-0.00326	-0.00327	0.00132	0	-0.00195	-0.13825	-0.12246	0.13194	0.06843	-0.05832
65	18-Jun	-0.00327	-0.00327	0.00262	0	-0.00065	-0.14152	-0.12573	0.13456	0.06843	-0.05897
66	19-Jun	-0.00327	-0.00326	0.00428	0	0.00102	-0.14479	-0.12899	0.13884	0.06843	-0.05795
67	20-Jun	-0.00327	-0.00327	0.0037	0	0.00043	-0.14806	-0.13226	0.14254	0.06843	-0.05752
68	21-Jun	-0.00326	-0.00327	0.00268	0	-0.00059	-0.15132	-0.13553	0.14522	0.06843	-0.05811
69	22-Jun	-0.00327	-0.00326	0.00526	0	0.002	-0.15459	-0.13879	0.15048	0.06843	-0.05611
70	23-Jun	-0.00327	-0.00327	0.00468	0	0.00141	-0.15786	-0.14206	0.15516	0.06843	-0.0547
71	24-Jun	-0.00326	-0.00327	0.00532	0	0.00205	-0.16112	-0.14533	0.16048	0.06843	-0.05265
72	25-Jun	-0.00327	-0.00326	0.00372	0	0.00046	-0.16439	-0.14859	0.1642	0.06843	-0.05219
73	26-Jun	-0.00327	-0.00327	0.00238	0	-0.00089	-0.16766	-0.15186	0.16658	0.06843	-0.05308
74	27-Jun	-0.00326	-0.00327	0.00072	0	-0.00255	-0.17092	-0.15513	0.1673	0.06843	-0.05563
75	28-Jun	-0.00327	-0.00326	0.00066	0	-0.0026	-0.17419	-0.15839	0.16796	0.06843	-0.05823
76	29-Jun	-0.00327	-0.00327	0.00164	0	-0.00163	-0.17746	-0.16166	0.1696	0.06843	-0.05986
77	30-Jun	-0.00327	-0.00327	0.00134	0	-0.00192	-0.18073	-0.16493	0.17094	0.06843	-0.06178
78	1-Jul	-0.00315	-0.00315	0.00262	0	-0.00058	-0.18388	-0.16808	0.17356	0.06843	-0.06236
79	2-Jul	-0.00291	-0.00291	0.00268	0	-0.00026	-0.18679	-0.17099	0.17624	0.06843	-0.06262
80	3-Jul	-0.0029	-0.0029	0.0004	0	-0.0025	-0.18969	-0.17389	0.17664	0.06843	-0.06512
81	4-Jul	-0.0029	-0.0029	0.00098	0	-0.00192	-0.19259	-0.17679	0.17762	0.06843	-0.06704
82	5-Jul	-0.0029	-0.00291	0.00068	0	-0.00222	-0.19549	-0.1797	0.1783	0.06843	-0.06926
83	6-Jul	-0.00291	-0.0029	0.0013	0	-0.00161	-0.1984	-0.1826	0.1796	0.06843	-0.07087
84	7-Jul	-0.0029	-0.0029	0.00456	0	0.00166	-0.2013	-0.1855	0.18416	0.06843	-0.06921
85	8-Jul	-0.0029	-0.00291	0.00468	0	0.00178	-0.2042	-0.18841	0.18884	0.06843	-0.06743
86	9-Jul	-0.00291	-0.0029	0.00144	0	-0.00146	-0.20711	-0.19131	0.19028	0.06843	-0.06889
87	10-Jul	-0.0029	-0.0029	4E-05	0	-0.00287	-0.21001	-0.19421	0.19032	0.06843	-0.07176
88	11-Jul	-0.0029	-0.0029	0	0	-0.0029	-0.21291	-0.19711	0.19032	0.06843	-0.07466
89	12-Jul	-0.00291	-0.00291	0.00064	0	-0.00226	-0.21582	-0.20002	0.19096	0.06843	-0.07692
90	13-Jul	-0.0029	-0.0029	0.00706	0	0.00416	-0.21872	-0.20292	0.19802	0.06843	-0.07276
91	14-Jul	-0.0029	-0.0029	0.01796	0	0.01505	-0.22162	-0.20582	0.21598	0.06843	-0.05771

		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
92	15-Jul	-0.0029	-0.00291	0.01482	0	0.01192	-0.22452	-0.20873	0.2308	0.06843	-0.04579
93	16-Jul	-0.00291	-0.0029	0.00432	0	0.00141	-0.22743	-0.21163	0.23512	0.06843	-0.04438
94	17-Jul	-0.0029	-0.0029	0.00368	0	0.00078	-0.23033	-0.21453	0.2388	0.06843	-0.0436
95	18-Jul	-0.0029	-0.0029	0.00302	0	0.00012	-0.23323	-0.21743	0.24182	0.06843	-0.04348
96	19-Jul	-0.00291	-0.00291	0.00236	0	-0.00054	-0.23614	-0.22034	0.24418	0.06843	-0.04402
97	20-Jul	-0.0029	-0.0029	0.00136	0	-0.00155	-0.23904	-0.22324	0.24554	0.06843	-0.04557
98	21-Jul	-0.0029	-0.0029	0.00198	0	-0.00092	-0.24194	-0.22614	0.24752	0.06843	-0.04649
99	22-Jul	-0.00291	-0.00291	0.00168	0	-0.00122	-0.24485	-0.22905	0.2492	0.06843	-0.04771
100	23-Jul	-0.0029	-0.0029	0.0007	0	-0.0022	-0.24775	-0.23195	0.2499	0.06843	-0.04991
101	24-Jul	-0.0029	-0.0029	0.00098	0	-0.00193	-0.25065	-0.23485	0.25088	0.06843	-0.05184
102	25-Jul	-0.0029	-0.0029	0.00198	0	-0.00092	-0.25355	-0.23775	0.25286	0.06843	-0.05276
103	26-Jul	-0.00291	-0.00291	0.0007	0	-0.0022	-0.25646	-0.24066	0.25356	0.06843	-0.05496
104	27-Jul	-0.0029	-0.0029	0.00228	0	-0.00062	-0.25936	-0.24356	0.25584	0.06843	-0.05558
105	28-Jul	-0.0029	-0.0029	0.00202	0	-0.00089	-0.26226	-0.24646	0.25786	0.06843	-0.05647
106	29-Jul	-0.00291	-0.0029	0.00102	0	-0.00188	-0.26517	-0.24936	0.25888	0.06843	-0.05835
107	30-Jul	-0.0029	-0.00291	0.00198	0	-0.00092	-0.26807	-0.25227	0.26086	0.06843	-0.05927
108	31-Jul	-0.0029	-0.0029	6E-05	0	-0.00284	-0.27097	-0.25517	0.26092	0.06843	-0.06211
109	1-Aug	-0.00265	-0.00265	0	0	-0.00276	-0.27362	-0.25782	0.26092	0.06843	-0.06487
110	2-Aug	-0.00211	-0.00211	0	0	-0.00216	-0.27573	-0.25993	0.26092	0.06843	-0.06703
111	3-Aug	-0.0021	-0.0021	0.00096	0	-0.00114	-0.27783	-0.26203	0.26188	0.06843	-0.06817
112	4-Aug	-0.0021	-0.00209	0.00198	0	-0.00011	-0.27993	-0.26412	0.26386	0.06843	-0.06828
113	5-Aug	-0.00209	-0.0021	0.00038	0	-0.00172	-0.28202	-0.26622	0.26424	0.06843	-0.07
114	6-Aug	-0.0021	-0.0021	0.00354	0	0.00144	-0.28412	-0.26832	0.26778	0.06843	-0.06856
115	7-Aug	-0.0021	-0.00209	0.00948	0	0.0074	-0.28622	-0.27041	0.27726	0.06843	-0.06116
116	8-Aug	-0.00209	-0.0021	0.01	0	0.00791	-0.28831	-0.27251	0.28726	0.06843	-0.05325
117	9-Aug	-0.0021	-0.0021	0.0055	0	0.0034	-0.29041	-0.27461	0.29276	0.06843	-0.04985
118	10-Aug	-0.0021	-0.00209	0.00016	0	-0.00193	-0.29251	-0.2767	0.29292	0.06843	-0.05178
119	11-Aug	-0.00209	-0.0021	0.00032	0	-0.00178	-0.2946	-0.2788	0.29324	0.06843	-0.05356
120	12-Aug	-0.0021	-0.0021	0.00194	0	-0.00016	-0.2967	-0.2809	0.29518	0.06843	-0.05372
121	13-Aug	-0.0021	-0.00209	0.00362	0	0.00153	-0.2988	-0.28299	0.2988	0.06843	-0.05219
122	14-Aug	-0.0021	-0.0021	0.00302	0	0.00092	-0.3009	-0.28509	0.30182	0.06843	-0.05127
123	15-Aug	-0.00209	-0.0021	0.00396	0	0.00186	-0.30299	-0.28719	0.30578	0.06843	-0.04941
124	16-Aug	-0.0021	-0.00209	0.00594	0	0.00385	-0.30509	-0.28928	0.31172	0.06843	-0.04556
125	17-Aug	-0.0021	-0.0021	0.00568	0	0.00358	-0.30719	-0.29138	0.3174	0.06843	-0.04198
126	18-Aug	-0.00209	-0.0021	0.00598	0	0.00389	-0.30928	-0.29348	0.32338	0.06843	-0.03809
127	19-Aug	-0.0021	-0.0021	0.00634	0	0.00424	-0.31138	-0.29558	0.32972	0.06843	-0.03385
128	20-Aug	-0.0021	-0.00209	0.0047	0	0.00261	-0.31348	-0.29767	0.33442	0.06843	-0.03124
129	21-Aug	-0.00209	-0.0021	0.00822	0	0.00613	-0.31557	-0.29977	0.34264	0.06843	-0.02511
130	22-Aug	-0.0021	-0.0021	0.00898	0	0.00689	-0.31767	-0.30187	0.35162	0.06843	-0.01822
131	23-Aug	-0.0021	-0.00209	0.0074	0	0.00531	-0.31977	-0.30396	0.35902	0.06843	-0.01291
132	24-Aug	-0.0021	-0.0021	0.00378	0	0.00168	-0.32187	-0.30606	0.3628	0.06843	-0.01123
133	25-Aug	-0.00209	-0.00168	0.00238	0	0.00071	-0.32396	-0.30774	0.36518	0.06843	-0.01052
134	26-Aug	-0.0021	-0.00209	0.00136	0	-0.00074	-0.32606	-0.30983	0.36654	0.06843	-0.01126
135	27-Aug	-0.0021	-0.00168	0.00198	0	0.0003	-0.32816	-0.31151	0.36852	0.06843	-0.01096
136	28-Aug	-0.00209	-0.00168	0.002	0	0.00032	-0.33025	-0.31319	0.37052	0.06843	-0.01064
137	29-Aug	-0.0021	-0.0021	0.002	0	-9E-05	-0.33235	-0.31529	0.37252	0.06843	-0.01073
138	30-Aug	-0.0021	-0.00167	0.00264	0	0.00096	-0.33445	-0.31696	0.37516	0.06843	-0.00977
139	31-Aug	-0.00209	-0.0021	0.00268	0	0.00058	-0.33654	-0.31906	0.37784	0.06843	-0.00919
140	1-Sep	-0.00176	-0.00176	0.00104	0	-0.00086	-0.3383	-0.32082	0.37888	0.06843	-0.01005
141	2-Sep	-0.00105	-0.00084	0.0023	0	0.00139	-0.33935	-0.32166	0.38118	0.06843	-0.00866
142	3-Sep	-0.00104	-0.00083	0.00072	0	-0.00011	-0.34039	-0.32249	0.3819	0.06843	-0.00877
143	4-Sep	-0.00103	-0.00083	2E-05	0	-0.00081	-0.34142	-0.32332	0.38192	0.06843	-0.00958
144	5-Sep	-0.00103	-0.00103	0	0	-0.00103	-0.34245	-0.32435	0.38192	0.06843	-0.01061
145	6-Sep	-0.00104	-0.00103	0.00096	0	-7E-05	-0.34349	-0.32538	0.38288	0.06843	-0.01068
146	7-Sep	-0.00103	-0.00104	0.00294	0	0.0019	-0.34452	-0.32642	0.38582	0.06843	-0.00878
147	8-Sep	-0.00103	-0.00103	0.00332	0	0.00229	-0.34555	-0.32745	0.38914	0.06843	-0.00649
148	9-Sep	-0.00104	-0.00103	0.00334	0	0.00231	-0.34659	-0.32848	0.39248	0.06843	-0.00418
149	10-Sep	-0.00103	-0.00083	0.00268	0	0.00185	-0.34762	-0.32931	0.39516	0.06843	-0.00233
150	11-Sep	-0.00103	-0.00082	0.00332	0	0.00249	-0.34865	-0.33013	0.39848	0.06843	0.00016
151	12-Sep	-0.00103	-0.00104	0.00204	0	0.00101	-0.34968	-0.33117	0.40052	0.06843	0.00117
152	13-Sep	-0.00104	-0.00082	0.00264	0	0.00181	-0.35072	-0.33199	0.40316	0.06843	0.00298
153	14-Sep	-0.00103	-0.00083	0.00268	0	0.00186	-0.35175	-0.33282	0.40584	0.06843	0.00484
154	15-Sep	-0.00103	-0.00103	0.002	0	0.00096	-0.35278	-0.33385	0.40784	0.06843	0.0058
155	16-Sep	-0.00104	-0.00104	0.0046	0	0.00357	-0.35382	-0.33489	0.41244	0.06843	0.00937
156	17-Sep	-0.00103	-0.00103	0.00272	0	0.00169	-0.35485	-0.33592	0.41516	0.06843	0.01106
157	18-Sep	-0.00103	-0.00103	0.00396	0	0.00292	-0.35588	-0.33695	0.41912	0.06843	0.01398
158	19-Sep	-0.00104	-0.00104	0.00336	0	0.00233	-0.35692	-0.33799	0.42248	0.06843	0.01631
159	20-Sep	-0.00103	-0.00051	0.00204	0	0.00142	-0.35795	-0.3385	0.42452	0.06843	0.01773
160	21-Sep	-0.00103	-0.00052	0.002	0	0.00158	-0.35898	-0.33902	0.42652	0.06843	0.01931
161	22-Sep	-0.00103	-0.00082	0.00232	0	0.0015	-0.36001	-0.33984	0.42884	0.06843	0.02081
162	23-Sep	-0.00104	-0.00083	0.00298	0	0.00215	-0.36105	-0.34067	0.43182	0.06843	0.02296
163	24-Sep	-0.00103	-0.00103	0.00236	0	0.00133	-0.36208	-0.3417	0.43418	0.06843	0.02429
164	25-Sep	-0.00103	-0.00104	0.00168	0	0.00064	-0.36311	-0.34274	0.43586	0.06843	0.02493
165	26-Sep	-0.00104	-0.00082	0.00424	0	0.00342	-0.36415	-0.34356	0.4401	0.06843	0.02835
166	27-Sep	-0.00103	-0.00104	0.0066	0	0.00556	-0.36518	-0.3446	0.4467	0.06843	0.03391
167	28-Sep	-0.00103	-0.00082	0.00634	0	0.00551	-0.36621	-0.34542	0.45304	0.06843	0.03942
168	29-Sep	-0.00104	-0.00011	0.00634	0	0.00603	-0.36725	-0.34553	0.45938	0.06843	0.04545
169	30-Sep	-0.00103	0	0.00344	0	0.00344	-0.36828	-0.34553	0.46282	0.06843	0.04889
170	1-Oct	-0.0007	0	1E-04	0	0.0001	-0.36898	-0.34553	0.46292	0.06843	0.04899
171	2-Oct	-2E-05	0	0	0	0	-0.369	-0.34553	0.46292	0.06843	0.04899
172	3-Oct	0	0	0	0	0	-0.369	-0.34553	0.46292	0.06843	0.04899
173	4-Oct	0	0	0	0	0	-0.369	-0.34553	0.46292	0.06843	0.04899
174	5-Oct	0	0	0	0	0	-0.369	-0.34553	0.46292	0.06843	0.04899
175	6-Oct	0	0	0.00064	0	0.00064	-0.369	-0.34553	0.46356	0.06843	0.04963
176	7-Oct	0	0	0.00132	0	0.00132	-0.369	-0.34553	0.46488	0.06843	0.05095
177	8-Oct	0	0	4E-05	0	4E-05	-0.369	-0.34553	0.46492	0.06843	0.05099
178	9-Oct	0	0	0.00032	0	0.00032	-0.369	-0.34553	0.46524	0.06843	0.05131
179	10-Oct	0	0	0.00162	0	0.00162	-0.369	-0.34553	0.46686	0.06843	0.05293
180	11-Oct	0	0	0.002	0	0.002	-0.369	-0.34553	0.46886	0.06843	0.05493
181	12-Oct	0	0	6E-05	0	6E-05	-0.369	-0.34553	0.46892	0.06843	0.05499
182	13-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
183	14-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
184	15-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
185	16-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
186	17-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
187	18-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
188	19-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
189	20-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
190	21-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
191	22-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
192	23-Oct	0	0	0	0	0	-0.369	-0.34553	0.46892	0.06843	0.05499
193	24-Oct	0	0	0.00064	0	0.00064	-0.369	-0.34553	0.46956	0.06843	0.05563
194	25-Oct	0	0	0.00132	0	0.00132	-0.369	-0.34553	0.47088	0.06843	0.05695
195	26-Oct	0	0	0.00036	0	0.00036	-0.369	-0.34553	0.47124	0.06843	0.05731
196	27-Oct	0	0	0.00066	0	0.00066	-0.369	-0.34553	0.4719	0.06843	0.05797
197	28-Oct	0	0	0.00034	0	0.00034	-0.369	-0.34553	0.47224	0.06843	0.05831
198	29-Oct	0	0	0.00066	0	0.00066	-0.369	-0.34553	0.4729	0.06843	0.05897
199	30-Oct	0	0	2E-05	0	2E-05	-0.369	-0.34553	0.47292	0.06843	0.05899
200	31-Oct	0	0	0	0	0	-0.369	-0.34553	0.47292	0.06843	0.05899

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
SUMMARY FLUXES THROUGH COVER AND TAILINGS
DRY YEAR

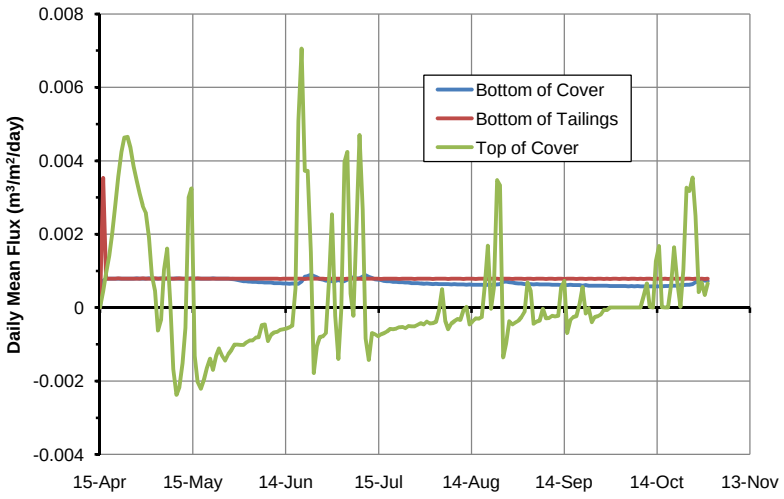


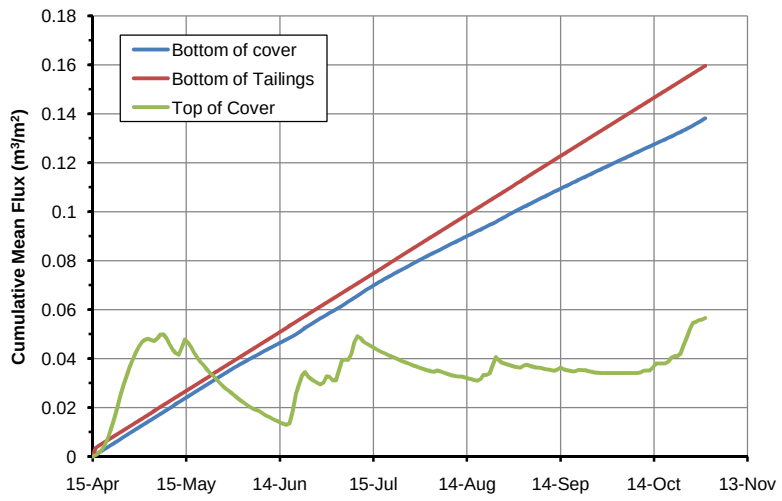


		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00074	0.00353	0.00056	0.00074	0.00353	0.00056
3	17-Apr	0.00079	0.00079	0.00117	0.00153	0.00432	0.00173
4	18-Apr	0.00079	0.00079	0.00175	0.00232	0.00511	0.00348
5	19-Apr	0.00079	0.00079	0.00258	0.00311	0.0059	0.00606
6	20-Apr	0.00079	0.0008	0.00347	0.0039	0.0067	0.00953
7	21-Apr	0.00079	0.00079	0.00437	0.00469	0.00749	0.0139
8	22-Apr	0.00079	0.00079	0.00526	0.00548	0.00828	0.01916
9	23-Apr	0.00079	0.00079	0.00571	0.00627	0.00907	0.02487
10	24-Apr	0.00079	0.00079	0.00576	0.00706	0.00986	0.03063
11	25-Apr	0.00079	0.00079	0.00536	0.00785	0.01065	0.03599
12	26-Apr	0.0008	0.00079	0.00475	0.00865	0.01144	0.04074
13	27-Apr	0.00079	0.00079	0.00429	0.00944	0.01223	0.04503
14	28-Apr	0.00079	0.0008	0.00381	0.01023	0.01303	0.04884
15	29-Apr	0.00079	0.00079	0.00344	0.01102	0.01382	0.05228
16	30-Apr	0.0008	0.00079	0.00319	0.01182	0.01461	0.05547
17	1-May	0.00079	0.0008	0.00248	0.01261	0.01541	0.05795
18	2-May	0.00079	0.00079	0.00015	0.0134	0.0162	0.0581
19	3-May	0.0008	0.00079	-0.0004	0.0142	0.01699	0.0577
20	4-May	0.00079	0.0008	-0.00041	0.01499	0.01779	0.05729
21	5-May	0.00079	0.00079	-0.00013	0.01578	0.01858	0.05716
22	6-May	0.0008	0.00079	-0.00042	0.01658	0.01937	0.05674
23	7-May	0.00079	0.0008	-0.00081	0.01737	0.02017	0.05593
24	8-May	0.00079	0.00079	-0.0014	0.01816	0.02096	0.05453
25	9-May	0.0008	0.00079	-0.00132	0.01896	0.02175	0.05321
26	10-May	0.00079	0.00079	-0.00066	0.01975	0.02254	0.05255
27	11-May	0.00079	0.0008	-0.00175	0.02054	0.02334	0.0508
28	12-May	0.00079	0.00079	-0.00171	0.02133	0.02413	0.04909
29	13-May	0.00079	0.00079	-0.00151	0.02212	0.02492	0.04758
30	14-May	0.0008	0.00079	-0.00191	0.02292	0.02571	0.04567
31	15-May	0.00079	0.00079	-0.002	0.02371	0.0265	0.04367
32	16-May	0.00079	0.0008	-0.0016	0.0245	0.0273	0.04207
33	17-May	0.00079	0.00079	-0.00158	0.02529	0.02809	0.04049
34	18-May	0.00079	0.00079	-0.00168	0.02608	0.02888	0.03881
35	19-May	0.00079	0.00079	-0.00166	0.02687	0.02967	0.03715
36	20-May	0.00079	0.00079	-0.00139	0.02766	0.03046	0.03576
37	21-May	0.0008	0.00079	-0.00136	0.02846	0.03125	0.0344
38	22-May	0.00079	0.00079	0.00122	0.02925	0.03204	0.03562
39	23-May	0.00079	0.00079	0.00188	0.03004	0.03283	0.0375
40	24-May	0.00079	0.00079	-0.00246	0.03083	0.03362	0.03504
41	25-May	0.00079	0.00079	-0.00136	0.03162	0.03441	0.03368
42	26-May	0.00079	0.00079	-0.0014	0.03241	0.0352	0.03228
43	27-May	0.00079	0.00079	-0.0013	0.0332	0.03599	0.03098
44	28-May	0.00079	0.00079	-0.00098	0.03399	0.03678	0.03
45	29-May	0.00077	0.00079	0.00254	0.03476	0.03757	0.03254
46	30-May	0.00079	0.00079	0.00265	0.03555	0.03836	0.03519
47	31-May	0.0008	0.00079	-0.00229	0.03635	0.03915	0.0329
48	1-Jun	0.00078	0.00079	-0.0014	0.03713	0.03994	0.0315
49	2-Jun	0.00075	0.00079	-0.0012	0.03788	0.04073	0.0303
50	3-Jun	0.00075	0.00079	-0.00102	0.03863	0.04152	0.02928
51	4-Jun	0.00073	0.00079	-0.00099	0.03936	0.04231	0.02829
52	5-Jun	0.00071	0.00079	-0.00087	0.04007	0.0431	0.02742
53	6-Jun	0.00072	0.00079	-0.00095	0.04079	0.04389	0.02647
54	7-Jun	0.0007	0.00079	-0.00089	0.04149	0.04468	0.02558
55	8-Jun	0.0007	0.00079	-0.00048	0.04219	0.04547	0.0251
56	9-Jun	0.00069	0.00079	0.00139	0.04288	0.04626	0.02649
57	10-Jun	0.0007	0.00079	0.00029	0.04358	0.04705	0.02678
58	11-Jun	0.00071	0.00079	-0.00138	0.04429	0.04784	0.0254
59	12-Jun	0.00071	0.00079	-0.00092	0.045	0.04863	0.02448
60	13-Jun	0.00069	0.00079	-0.00073	0.04569	0.04942	0.02375
61	14-Jun	0.00069	0.00079	-0.00065	0.04638	0.05021	0.0231
62	15-Jun	0.00068	0.00079	-0.0007	0.04706	0.051	0.0224
63	16-Jun	0.00068	0.00078	-0.00072	0.04774	0.05178	0.02168
64	17-Jun	0.00067	0.00079	-0.00064	0.04841	0.05257	0.02104
65	18-Jun	0.00066	0.00079	0.0006	0.04907	0.05336	0.02164
66	19-Jun	0.00067	0.00079	0.00152	0.04974	0.05415	0.02316
67	20-Jun	0.00068	0.00079	7E-05	0.05042	0.05494	0.02323
68	21-Jun	0.00068	0.00079	0.00171	0.0511	0.05573	0.02494
69	22-Jun	0.0007	0.00079	-0.00049	0.0518	0.05652	0.02445
70	23-Jun	0.0007	0.00079	-0.00112	0.0525	0.05731	0.02333
71	24-Jun	0.00069	0.00078	-0.00073	0.05319	0.05809	0.0226
72	25-Jun	0.00069	0.00079	-0.00062	0.05388	0.05888	0.02198
73	26-Jun	0.00067	0.00079	-0.0006	0.05455	0.05967	0.02138
74	27-Jun	0.00067	0.00079	-0.00055	0.05522	0.06046	0.02083
75	28-Jun	0.00066	0.00079	-0.00053	0.05588	0.06125	0.0203
76	29-Jun	0.00066	0.00079	-0.0005	0.05654	0.06204	0.0198
77	30-Jun	0.00065	0.00079	-0.00049	0.05719	0.06283	0.01931
78	1-Jul	0.00065	0.00078	-0.00046	0.05784	0.06361	0.01885
79	2-Jul	0.00065	0.00079	-0.00046	0.05849	0.0644	0.01839
80	3-Jul	0.00065	0.00079	-0.00044	0.05914	0.06519	0.01795
81	4-Jul	0.00064	0.00079	-0.00022	0.05978	0.06598	0.01773
82	5-Jul	0.00064	0.00079	-0.00032	0.06042	0.06677	0.01741
83	6-Jul	0.00064	0.00079	-0.0005	0.06106	0.06756	0.01691
84	7-Jul	0.00063	0.00078	-0.00036	0.06169	0.06834	0.01655
85	8-Jul	0.00064	0.00079	-0.00037	0.06233	0.06913	0.01618
86	9-Jul	0.00063	0.00079	-0.00035	0.06296	0.06992	0.01583
87	10-Jul	0.00063	0.00079	-0.00026	0.06359	0.07071	0.01557
88	11-Jul	0.00063	0.00079	0.00191	0.06422	0.0715	0.01748
89	12-Jul	0.00062	0.00078	0.00223	0.06484	0.07228	0.01971
90	13-Jul	0.00065	0.00079	0.0059	0.06549	0.07307	0.02561

		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
91	14-Jul	0.00072	0.00079	0.00714	0.06621	0.07386	0.03275
92	15-Jul	0.00084	0.00079	-0.00177	0.06705	0.07465	0.03098
93	16-Jul	0.00082	0.00079	-0.0013	0.06787	0.07544	0.02968
94	17-Jul	0.00077	0.00078	-0.00073	0.06864	0.07622	0.02895
95	18-Jul	0.00074	0.00079	-0.00056	0.06938	0.07701	0.02839
96	19-Jul	0.00072	0.00079	-0.00052	0.0701	0.0778	0.02787
97	20-Jul	0.00071	0.00079	-0.00046	0.07081	0.07859	0.02741
98	21-Jul	0.00069	0.00079	-0.00042	0.0715	0.07938	0.02699
99	22-Jul	0.00069	0.00078	-0.0004	0.07219	0.08016	0.02659
100	23-Jul	0.00068	0.00079	-0.00038	0.07287	0.08095	0.02621
101	24-Jul	0.00067	0.00079	-0.00034	0.07354	0.08174	0.02587
102	25-Jul	0.00067	0.00079	0.00019	0.07421	0.08253	0.02606
103	26-Jul	0.00066	0.00078	0	0.07487	0.08331	0.02606
104	27-Jul	0.00066	0.00079	-0.00058	0.07553	0.0841	0.02548
105	28-Jul	0.00066	0.00079	-0.00042	0.07619	0.08489	0.02506
106	29-Jul	0.00065	0.00079	-0.00037	0.07684	0.08568	0.02469
107	30-Jul	0.00065	0.00078	-0.00035	0.07749	0.08646	0.02434
108	31-Jul	0.00065	0.00079	-0.00032	0.07814	0.08725	0.02402
109	1-Aug	0.00064	0.00079	-0.00032	0.07878	0.08804	0.0237
110	2-Aug	0.00064	0.00079	-0.00029	0.07942	0.08883	0.02341
111	3-Aug	0.00064	0.00078	-0.00027	0.08006	0.08961	0.02314
112	4-Aug	0.00063	0.00079	-0.00027	0.08069	0.0904	0.02287
113	5-Aug	0.00063	0.00079	-0.00025	0.08132	0.09119	0.02262
114	6-Aug	0.00063	0.00079	-0.00029	0.08195	0.09198	0.02233
115	7-Aug	0.00063	0.00078	-0.00025	0.08258	0.09276	0.02208
116	8-Aug	0.00062	0.00079	-0.00024	0.0832	0.09355	0.02184
117	9-Aug	0.00063	0.00079	-0.00024	0.08383	0.09434	0.0216
118	10-Aug	0.00062	0.00079	0.00017	0.08445	0.09513	0.02177
119	11-Aug	0.00062	0.00078	0.00015	0.08507	0.09591	0.02192
120	12-Aug	0.00061	0.00079	-0.00044	0.08568	0.0967	0.02148
121	13-Aug	0.00062	0.00079	-0.00028	0.0863	0.09749	0.0212
122	14-Aug	0.00062	0.00078	-0.00027	0.08692	0.09827	0.02093
123	15-Aug	0.00061	0.00079	-0.00024	0.08753	0.09906	0.02069
124	16-Aug	0.00061	0.00079	-0.00023	0.08814	0.09985	0.02046
125	17-Aug	0.00061	0.00079	-0.00022	0.08875	0.10064	0.02024
126	18-Aug	0.00061	0.00078	-0.00018	0.08936	0.10142	0.02006
127	19-Aug	0.00061	0.00079	-7E-05	0.08997	0.10221	0.01999
128	20-Aug	0.0006	0.00079	-0.00027	0.09057	0.103	0.01972
129	21-Aug	0.00061	0.00078	-0.0002	0.09118	0.10378	0.01952
130	22-Aug	0.0006	0.00079	-0.00019	0.09178	0.10457	0.01933
131	23-Aug	0.0006	0.00079	-0.00018	0.09238	0.10536	0.01915
132	24-Aug	0.0006	0.00079	-0.00017	0.09298	0.10615	0.01898
133	25-Aug	0.0006	0.00078	-0.00015	0.09358	0.10693	0.01883
134	26-Aug	0.00059	0.00079	-0.00018	0.09417	0.10772	0.01865
135	27-Aug	0.0006	0.00079	-0.00016	0.09477	0.10851	0.01849
136	28-Aug	0.00059	0.00078	-3E-05	0.09536	0.10929	0.01846
137	29-Aug	0.00059	0.00079	-0.00014	0.09595	0.11008	0.01832
138	30-Aug	0.00059	0.00079	-0.00019	0.09654	0.11087	0.01813
139	31-Aug	0.00059	0.00078	-0.00016	0.09713	0.11165	0.01797
140	1-Sep	0.00059	0.00079	-0.00015	0.09772	0.11244	0.01782
141	2-Sep	0.00058	0.00079	-0.00014	0.0983	0.11323	0.01768
142	3-Sep	0.00059	0.00078	-0.00015	0.09889	0.11401	0.01753
143	4-Sep	0.00058	0.00079	-0.00014	0.09947	0.1148	0.01739
144	5-Sep	0.00059	0.00079	-0.00012	0.10006	0.11559	0.01727
145	6-Sep	0.00058	0.00078	-0.00014	0.10064	0.11637	0.01713
146	7-Sep	0.00058	0.00079	-0.00013	0.10122	0.11716	0.017
147	8-Sep	0.00058	0.00079	-0.00014	0.1018	0.11795	0.01686
148	9-Sep	0.00058	0.00078	-0.00012	0.10238	0.11873	0.01674
149	10-Sep	0.00057	0.00079	-0.00011	0.10295	0.11952	0.01663
150	11-Sep	0.00058	0.00079	-0.00012	0.10353	0.12031	0.01651
151	12-Sep	0.00057	0.00078	-0.00011	0.1041	0.12109	0.0164
152	13-Sep	0.00058	0.00079	-0.00011	0.10468	0.12188	0.01629
153	14-Sep	0.00057	0.00079	-0.00012	0.10525	0.12267	0.01617
154	15-Sep	0.00057	0.00078	-0.00011	0.10582	0.12345	0.01606
155	16-Sep	0.00057	0.00079	-0.0001	0.10639	0.12424	0.01596
156	17-Sep	0.00057	0.00078	-9E-05	0.10696	0.12502	0.01587
157	18-Sep	0.00057	0.00079	-1E-04	0.10753	0.12581	0.01577
158	19-Sep	0.00056	0.00079	-0.00011	0.10809	0.1266	0.01566
159	20-Sep	0.00057	0.00078	-9E-05	0.10866	0.12738	0.01557
160	21-Sep	0.00056	0.00079	-9E-05	0.10922	0.12817	0.01548
161	22-Sep	0.00057	0.00079	-0.0001	0.10979	0.12896	0.01538
162	23-Sep	0.00056	0.00078	-9E-05	0.11035	0.12974	0.01529
163	24-Sep	0.00056	0.00079	-7E-05	0.11091	0.13053	0.01522
164	25-Sep	0.00056	0.00078	-9E-05	0.11147	0.13131	0.01513
165	26-Sep	0.00056	0.00079	-9E-05	0.11203	0.1321	0.01504
166	27-Sep	0.00056	0.00079	-9E-05	0.11259	0.13289	0.01495
167	28-Sep	0.00055	0.00078	-9E-05	0.11314	0.13367	0.01486
168	29-Sep	0.00056	0.00079	-8E-05	0.1137	0.13446	0.01478
169	30-Sep	0.00055	0.00078	-6E-05	0.11425	0.13524	0.01472
170	1-Oct	0.00056	0.00079	-6E-05	0.11481	0.13603	0.01466
171	2-Oct	0.00055	0.00079	0	0.11536	0.13682	0.01466
172	3-Oct	0.00055	0.00078	0	0.11591	0.1376	0.01466
173	4-Oct	0.00055	0.00079	0	0.11646	0.13839	0.01466
174	5-Oct	0.00055	0.00078	0	0.11701	0.13917	0.01466
175	6-Oct	0.00055	0.00079	0	0.11756	0.13996	0.01466
176	7-Oct	0.00054	0.00079	0	0.1181	0.14075	0.01466
177	8-Oct	0.00055	0.00078	0	0.11865	0.14153	0.01466
178	9-Oct	0.00055	0.00079	0	0.1192	0.14232	0.01466
179	10-Oct	0.00054	0.00078	0	0.11974	0.1431	0.01466
180	11-Oct	0.00054	0.00079	0	0.12028	0.14389	0.01466
181	12-Oct	0.00054	0.00078	0	0.12082	0.14467	0.01466
182	13-Oct	0.00055	0.00079	0	0.12137	0.14546	0.01466
183	14-Oct	0.00054	0.00079	0	0.12191	0.14625	0.01466
184	15-Oct	0.00054	0.00078	0	0.12245	0.14703	0.01466
185	16-Oct	0.00053	0.00079	0	0.12298	0.14782	0.01466
186	17-Oct	0.00054	0.00078	0	0.12352	0.1486	0.01466
187	18-Oct	0.00054	0.00079	0	0.12406	0.14939	0.01466
188	19-Oct	0.00054	0.00078	0	0.1246	0.15017	0.01466
189	20-Oct	0.00053	0.00079	0.00109	0.12513	0.15096	0.01575
190	21-Oct	0.00054	0.00078	0.00164	0.12567	0.15174	0.01739
191	22-Oct	0.00053	0.00079	0.00037	0.1262	0.15253	0.01776
192	23-Oct	0.00053	0.00078	1E-05	0.12673	0.15331	0.01777
193	24-Oct	0.00054	0.00079	0	0.12727	0.1541	0.01777
194	25-Oct	0.00053	0.00079	0	0.1278	0.15489	0.01777
195	26-Oct	0.00054	0.00078	0	0.12834	0.15567	0.01777
196	27-Oct	0.00054	0.00079	0	0.12888	0.15646	0.01777
197	28-Oct	0.00054	0.00078	0	0.12942	0.15724	0.01777
198	29-Oct	0.00055	0.00079	0.00081	0.12997	0.15803	0.01858
199	30-Oct	0.00054	0.00078	0.0013	0.13051	0.15881	0.01988
200	31-Oct	0.00054	0.00079	5E-05	0.13105	0.1596	0.01993

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
SUMMARY FLUXES THROUGH COVER AND TAILINGS
MEAN YEAR

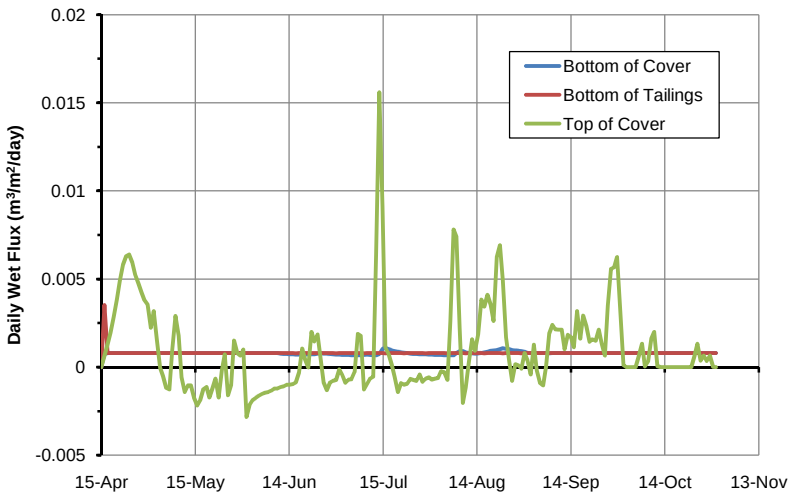


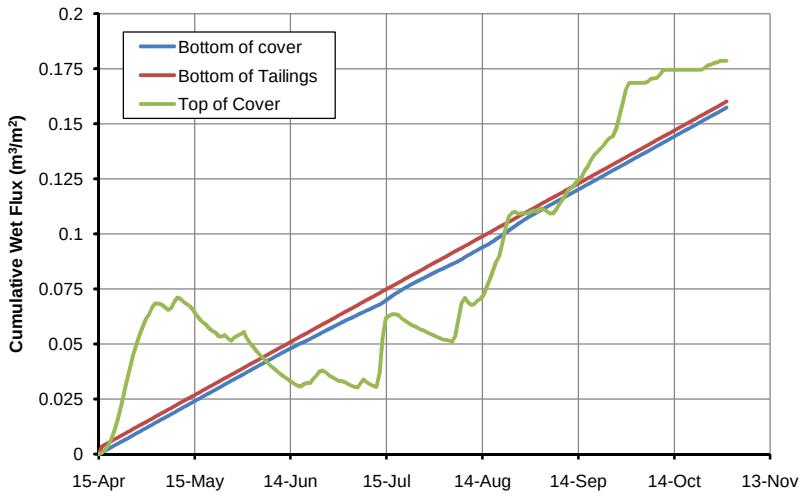


		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00074	0.00353	0.00045	0.00074	0.00353	0.00045
3	17-Apr	0.00079	0.00079	0.00094	0.00153	0.00432	0.00139
4	18-Apr	0.00079	0.00079	0.00142	0.00232	0.00511	0.00281
5	19-Apr	0.00079	0.00079	0.00201	0.00311	0.0059	0.00482
6	20-Apr	0.00079	0.00079	0.00281	0.0039	0.00669	0.00763
7	21-Apr	0.00079	0.0008	0.00356	0.00469	0.00749	0.01119
8	22-Apr	0.00079	0.00079	0.00424	0.00548	0.00828	0.01543
9	23-Apr	0.00079	0.00079	0.00463	0.00627	0.00907	0.02006
10	24-Apr	0.00079	0.00079	0.00465	0.00706	0.00986	0.02471
11	25-Apr	0.00079	0.00079	0.00436	0.00785	0.01065	0.02907
12	26-Apr	0.00079	0.00079	0.00385	0.00864	0.01144	0.03292
13	27-Apr	0.0008	0.00079	0.00345	0.00944	0.01223	0.03637
14	28-Apr	0.00079	0.00079	0.00311	0.01023	0.01302	0.03948
15	29-Apr	0.00079	0.0008	0.00277	0.01102	0.01382	0.04225
16	30-Apr	0.00079	0.00079	0.00259	0.01181	0.01461	0.04484
17	1-May	0.0008	0.00079	0.00191	0.01261	0.0154	0.04675
18	2-May	0.00079	0.00079	0.00088	0.0134	0.01619	0.04763
19	3-May	0.00079	0.0008	0.00046	0.01419	0.01699	0.04809
20	4-May	0.00079	0.00079	-0.00062	0.01498	0.01778	0.04747
21	5-May	0.0008	0.00079	-0.00032	0.01578	0.01857	0.04715
22	6-May	0.00079	0.00079	0.00103	0.01657	0.01936	0.04818
23	7-May	0.00079	0.0008	0.00161	0.01736	0.02016	0.04979
24	8-May	0.00079	0.00079	7E-05	0.01815	0.02095	0.04986
25	9-May	0.00079	0.00079	-0.00168	0.01894	0.02174	0.04818
26	10-May	0.0008	0.00079	-0.00238	0.01974	0.02253	0.0458
27	11-May	0.00079	0.0008	-0.00217	0.02053	0.02333	0.04363
28	12-May	0.00079	0.00079	-0.00151	0.02132	0.02412	0.04212
29	13-May	0.00079	0.00079	-0.00055	0.02211	0.02491	0.04157
30	14-May	0.00079	0.00079	0.00299	0.0229	0.0257	0.04456
31	15-May	0.0008	0.00079	0.00325	0.0237	0.02649	0.04781
32	16-May	0.00079	0.00079	-0.00131	0.02449	0.02728	0.0465
33	17-May	0.00079	0.0008	-0.00203	0.02528	0.02808	0.04447
34	18-May	0.00079	0.00079	-0.00221	0.02607	0.02887	0.04226
35	19-May	0.00079	0.00079	-0.00196	0.02686	0.02966	0.0403
36	20-May	0.00079	0.00079	-0.00164	0.02765	0.03045	0.03866
37	21-May	0.00079	0.00079	-0.00139	0.02844	0.03124	0.03727
38	22-May	0.0008	0.00079	-0.0017	0.02924	0.03203	0.03557
39	23-May	0.00079	0.00079	-0.00131	0.03003	0.03282	0.03426
40	24-May	0.00079	0.00079	-0.00111	0.03082	0.03361	0.03315
41	25-May	0.00079	0.00079	-0.00131	0.03161	0.0344	0.03184
42	26-May	0.00079	0.00079	-0.00144	0.0324	0.03519	0.0304
43	27-May	0.00079	0.00079	-0.00127	0.03319	0.03598	0.02913
44	28-May	0.00078	0.00079	-0.00116	0.03397	0.03677	0.02797
45	29-May	0.00077	0.00079	-0.00101	0.03474	0.03756	0.02696
46	30-May	0.00075	0.00079	-0.00101	0.03549	0.03835	0.02595
47	31-May	0.00074	0.00079	-0.00102	0.03623	0.03914	0.02493
48	1-Jun	0.00072	0.00079	-0.00102	0.03695	0.03993	0.02391
49	2-Jun	0.00072	0.00079	-0.00095	0.03767	0.04072	0.02296
50	3-Jun	0.00071	0.00079	-0.00089	0.03838	0.04151	0.02207
51	4-Jun	0.0007	0.00079	-0.00089	0.03908	0.0423	0.02118
52	5-Jun	0.0007	0.00079	-0.00082	0.03978	0.04309	0.02036
53	6-Jun	0.00069	0.00079	-0.00081	0.04047	0.04388	0.01955
54	7-Jun	0.00069	0.00079	-0.00048	0.04116	0.04467	0.01907
55	8-Jun	0.00068	0.00079	-0.00046	0.04184	0.04546	0.01861
56	9-Jun	0.00068	0.00079	-0.00091	0.04252	0.04625	0.0177
57	10-Jun	0.00068	0.00079	-0.00074	0.0432	0.04704	0.01696
58	11-Jun	0.00067	0.00079	-0.00068	0.04387	0.04783	0.01628
59	12-Jun	0.00067	0.00079	-0.00066	0.04454	0.04862	0.01562
60	13-Jun	0.00067	0.00078	-0.00061	0.04521	0.0494	0.01501
61	14-Jun	0.00066	0.00079	-0.00059	0.04587	0.05019	0.01442
62	15-Jun	0.00066	0.00079	-0.00057	0.04653	0.05098	0.01385
63	16-Jun	0.00065	0.00079	-0.00054	0.04718	0.05177	0.01331
64	17-Jun	0.00066	0.00079	-0.00049	0.04784	0.05256	0.01282
65	18-Jun	0.00065	0.00079	0.00053	0.04849	0.05335	0.01335
66	19-Jun	0.00065	0.00079	0.00509	0.04914	0.05414	0.01844
67	20-Jun	0.00071	0.00079	0.00706	0.04985	0.05493	0.0255
68	21-Jun	0.00084	0.00078	0.00373	0.05069	0.05571	0.02923
69	22-Jun	0.00086	0.00079	0.00373	0.05155	0.0565	0.03296
70	23-Jun	0.00089	0.00079	0.0015	0.05244	0.05729	0.03446
71	24-Jun	0.00086	0.00079	-0.00178	0.0533	0.05808	0.03268
72	25-Jun	0.00082	0.00079	-0.00104	0.05412	0.05887	0.03164
73	26-Jun	0.00078	0.00079	-0.0008	0.0549	0.05966	0.03084
74	27-Jun	0.00076	0.00079	-0.00078	0.05566	0.06045	0.03006
75	28-Jun	0.00074	0.00078	-0.00069	0.0564	0.06123	0.02937
76	29-Jun	0.00073	0.00079	0.00081	0.05713	0.06202	0.03018
77	30-Jun	0.00072	0.00079	0.00254	0.05785	0.06281	0.03272
78	1-Jul	0.00073	0.00079	-0.00022	0.05858	0.0636	0.0325
79	2-Jul	0.00075	0.00079	-0.0014	0.05933	0.06439	0.0311
80	3-Jul	0.00073	0.00079	-6E-05	0.06006	0.06518	0.03104
81	4-Jul	0.00072	0.00078	0.00396	0.06078	0.06596	0.035
82	5-Jul	0.00075	0.00079	0.00424	0.06153	0.06675	0.03924
83	6-Jul	0.00081	0.00079	0.00038	0.06234	0.06754	0.03962
84	7-Jul	0.00082	0.00079	-0.00022	0.06316	0.06833	0.0394
85	8-Jul	0.00079	0.00079	0.00234	0.06395	0.06912	0.04174
86	9-Jul	0.0008	0.00079	0.0047	0.06475	0.06991	0.04644
87	10-Jul	0.00085	0.00078	0.00267	0.0656	0.07069	0.04911
88	11-Jul	0.00088	0.00079	-0.00084	0.06648	0.07148	0.04827
89	12-Jul	0.00084	0.00079	-0.00143	0.06732	0.07227	0.04684
90	13-Jul	0.00081	0.00079	-0.00069	0.06813	0.07306	0.04615
91	14-Jul	0.00077	0.00079	-0.00073	0.0689	0.07385	0.04542
92	15-Jul	0.00076	0.00079	-0.00078	0.06966	0.07464	0.04464
93	16-Jul	0.00075	0.00078	-0.00073	0.07041	0.07542	0.04391

		DAILY VALUES VS. TIME (m^3/m^2/day)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
94	17-Jul	0.00073	0.00079	-0.00069	0.07114	0.07621	0.04322
95	18-Jul	0.00072	0.00079	-0.00065	0.07186	0.077	0.04257
96	19-Jul	0.00072	0.00079	-0.00058	0.07258	0.07779	0.04199
97	20-Jul	0.0007	0.00079	-0.00059	0.07328	0.07858	0.0414
98	21-Jul	0.0007	0.00079	-0.00057	0.07398	0.07937	0.04083
99	22-Jul	0.00069	0.00078	-0.00054	0.07467	0.08015	0.04029
100	23-Jul	0.00069	0.00079	-0.00053	0.07536	0.08094	0.03976
101	24-Jul	0.00068	0.00079	-0.00056	0.07604	0.08173	0.0392
102	25-Jul	0.00068	0.00079	-0.0005	0.07672	0.08252	0.0387
103	26-Jul	0.00067	0.00079	-0.00051	0.07739	0.08331	0.03819
104	27-Jul	0.00067	0.00078	-0.00051	0.07806	0.08409	0.03768
105	28-Jul	0.00067	0.00079	-0.00047	0.07873	0.08488	0.03721
106	29-Jul	0.00066	0.00079	-0.00042	0.07939	0.08567	0.03679
107	30-Jul	0.00065	0.00079	-0.00046	0.08004	0.08646	0.03633
108	31-Jul	0.00066	0.00079	-0.00038	0.0807	0.08725	0.03595
109	1-Aug	0.00065	0.00079	-0.00043	0.08135	0.08804	0.03552
110	2-Aug	0.00064	0.00078	-0.00042	0.08199	0.08882	0.0351
111	3-Aug	0.00065	0.00079	-0.00039	0.08264	0.08961	0.03471
112	4-Aug	0.00064	0.00079	-9E-05	0.08328	0.0904	0.03462
113	5-Aug	0.00064	0.00079	0.0005	0.08392	0.09119	0.03512
114	6-Aug	0.00064	0.00079	-0.00036	0.08456	0.09198	0.03476
115	7-Aug	0.00064	0.00078	-0.00059	0.0852	0.09276	0.03417
116	8-Aug	0.00063	0.00079	-0.00043	0.08583	0.09355	0.03374
117	9-Aug	0.00064	0.00079	-0.00037	0.08647	0.09434	0.03337
118	10-Aug	0.00063	0.00079	-0.00031	0.0871	0.09513	0.03306
119	11-Aug	0.00063	0.00079	-0.00034	0.08773	0.09592	0.03272
120	12-Aug	0.00063	0.00078	-7E-05	0.08836	0.0967	0.03265
121	13-Aug	0.00062	0.00079	2E-05	0.08898	0.09749	0.03267
122	14-Aug	0.00063	0.00079	-0.00046	0.08961	0.09828	0.03221
123	15-Aug	0.00062	0.00079	-0.00038	0.09023	0.09907	0.03183
124	16-Aug	0.00062	0.00078	-0.00029	0.09085	0.09985	0.03154
125	17-Aug	0.00062	0.00079	-0.0003	0.09147	0.10064	0.03124
126	18-Aug	0.00062	0.00079	-0.00026	0.09209	0.10143	0.03098
127	19-Aug	0.00061	0.00079	0.00065	0.0927	0.10222	0.03163
128	20-Aug	0.00062	0.00078	0.00169	0.09332	0.103	0.03332
129	21-Aug	0.00061	0.00079	-3E-05	0.09393	0.10379	0.03329
130	22-Aug	0.00062	0.00079	0.00054	0.09455	0.10458	0.03383
131	23-Aug	0.00063	0.00079	0.00347	0.09518	0.10537	0.0373
132	24-Aug	0.00064	0.00078	0.00333	0.09582	0.10615	0.04063
133	25-Aug	0.0007	0.00079	-0.00136	0.09652	0.10694	0.03927
134	26-Aug	0.00071	0.00079	-0.00098	0.09723	0.10773	0.03829
135	27-Aug	0.00069	0.00079	-0.00037	0.09792	0.10852	0.03792
136	28-Aug	0.00068	0.00078	-0.00046	0.0986	0.1093	0.03746
137	29-Aug	0.00067	0.00079	-0.00041	0.09927	0.11009	0.03705
138	30-Aug	0.00066	0.00079	-0.00035	0.09993	0.11088	0.0367
139	31-Aug	0.00066	0.00079	-0.00026	0.10059	0.11167	0.03644
140	1-Sep	0.00064	0.00078	-0.00011	0.10123	0.11245	0.03633
141	2-Sep	0.00064	0.00079	0.00068	0.10187	0.11324	0.03701
142	3-Sep	0.00064	0.00079	0.00045	0.10251	0.11403	0.03746
143	4-Sep	0.00063	0.00078	-0.00044	0.10314	0.11481	0.03702
144	5-Sep	0.00064	0.00079	-0.00038	0.10378	0.1156	0.03664
145	6-Sep	0.00063	0.00079	-0.00035	0.10441	0.11639	0.03629
146	7-Sep	0.00063	0.00079	-3E-05	0.10504	0.11718	0.03626
147	8-Sep	0.00063	0.00078	-0.00029	0.10567	0.11796	0.03597
148	9-Sep	0.00063	0.00079	-0.00028	0.1063	0.11875	0.03569
149	10-Sep	0.00062	0.00079	-0.00022	0.10692	0.11954	0.03547
150	11-Sep	0.00062	0.00078	-0.00024	0.10754	0.12032	0.03523
151	12-Sep	0.00062	0.00079	-0.00022	0.10816	0.12111	0.03501
152	13-Sep	0.00061	0.00079	0.00054	0.10877	0.1219	0.03555
153	14-Sep	0.00061	0.00078	0.00073	0.10938	0.12268	0.03628
154	15-Sep	0.00061	0.00079	-0.00069	0.10999	0.12347	0.03559
155	16-Sep	0.00062	0.00079	-0.00034	0.11061	0.12426	0.03525
156	17-Sep	0.00061	0.00079	-0.00026	0.11122	0.12505	0.03499
157	18-Sep	0.00061	0.00078	-0.00023	0.11183	0.12583	0.03476
158	19-Sep	0.00061	0.00079	0.00011	0.11244	0.12662	0.03487
159	20-Sep	0.0006	0.00079	0.00056	0.11304	0.12741	0.03543
160	21-Sep	0.00061	0.00078	-0.00016	0.11365	0.12819	0.03527
161	22-Sep	0.0006	0.00079	-1E-05	0.11425	0.12898	0.03526
162	23-Sep	0.0006	0.00079	-0.0004	0.11485	0.12977	0.03486
163	24-Sep	0.0006	0.00078	-0.00026	0.11545	0.13055	0.0346
164	25-Sep	0.0006	0.00079	-0.00023	0.11605	0.13134	0.03437
165	26-Sep	0.0006	0.00079	-0.00019	0.11665	0.13213	0.03418
166	27-Sep	0.0006	0.00078	-6E-05	0.11725	0.13291	0.03412
167	28-Sep	0.0006	0.00079	-7E-05	0.11785	0.1337	0.03405
168	29-Sep	0.00059	0.00078	0	0.11844	0.13448	0.03405
169	30-Sep	0.00059	0.00079	0	0.11903	0.13527	0.03405
170	1-Oct	0.00059	0.00079	0	0.11962	0.13606	0.03405
171	2-Oct	0.00059	0.00078	0	0.12021	0.13684	0.03405
172	3-Oct	0.00059	0.00079	0	0.1208	0.13763	0.03405
173	4-Oct	0.00059	0.00079	0	0.12139	0.13842	0.03405
174	5-Oct	0.00058	0.00078	0	0.12197	0.1392	0.03405
175	6-Oct	0.00059	0.00079	0	0.12256	0.13999	0.03405
176	7-Oct	0.00058	0.00079	0	0.12314	0.14078	0.03405
177	8-Oct	0.00059	0.00078	0	0.12373	0.14156	0.03405
178	9-Oct	0.00058	0.00079	0	0.12431	0.14235	0.03405
179	10-Oct	0.00058	0.00078	0.00032	0.12489	0.14313	0.03437
180	11-Oct	0.00058	0.00079	0.00066	0.12547	0.14392	0.03503
181	12-Oct	0.00058	0.00079	2E-05	0.12605	0.14471	0.03505
182	13-Oct	0.00058	0.00078	0	0.12663	0.14549	0.03505
183	14-Oct	0.00058	0.00079	0.00126	0.12721	0.14628	0.03631
184	15-Oct	0.00058	0.00079	0.00168	0.12779	0.14707	0.03799
185	16-Oct	0.00058	0.00078	1E-05	0.12837	0.14785	0.038
186	17-Oct	0.00059	0.00079	0	0.12896	0.14864	0.038
187	18-Oct	0.00059	0.00078	0	0.12955	0.14942	0.038
188	19-Oct	0.0006	0.00079	0.00064	0.13015	0.15021	0.03864
189	20-Oct	0.0006	0.00079	0.00164	0.13075	0.151	0.04028
190	21-Oct	0.0006	0.00078	0.0007	0.13135	0.15178	0.04098
191	22-Oct	0.00061	0.00079	2E-05	0.13196	0.15257	0.041
192	23-Oct	0.00061	0.00078	0.00103	0.13257	0.15335	0.04203
193	24-Oct	0.00062	0.00079	0.00326	0.13319	0.15414	0.04529
194	25-Oct	0.00062	0.00079	0.00318	0.13381	0.15493	0.04847
195	26-Oct	0.00064	0.00078	0.00354	0.13445	0.15571	0.05201
196	27-Oct	0.00069	0.00079	0.0025	0.13514	0.1565	0.05451
197	28-Oct	0.00072	0.00078	0.00042	0.13586	0.15728	0.05493
198	29-Oct	0.00075	0.00079	0.00068	0.13661	0.15807	0.05561
199	30-Oct	0.00074	0.00078	0.00034	0.13735	0.15885	0.05595
200	31-Oct	0.00073	0.00079	0.00066	0.13808	0.15964	0.05661

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
SUMMARY FLUXES THROUGH COVER AND TAILINGS
WET YEAR

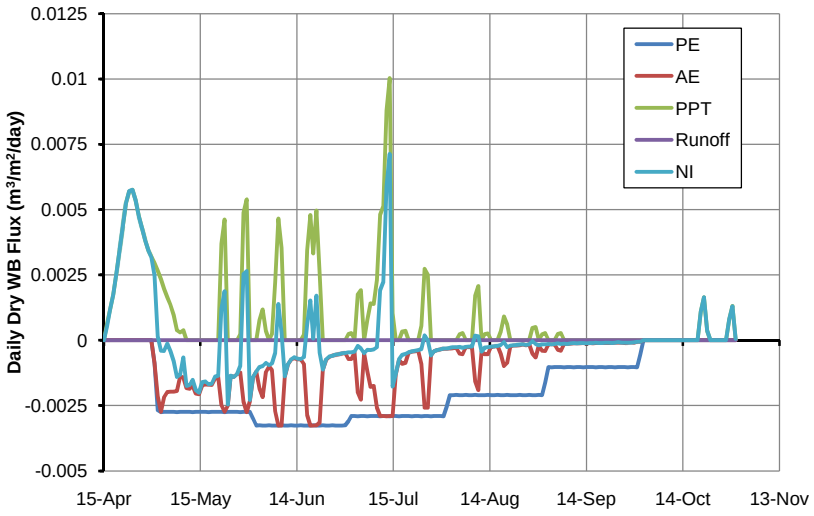


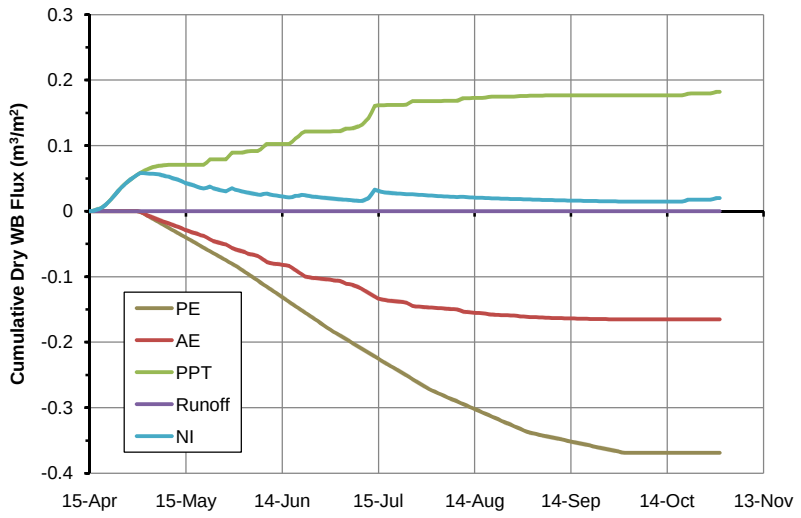


		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
1	15-Apr	0	0	0	0	0	0
2	16-Apr	0.00074	0.00353	0.00063	0.00074	0.00353	0.00063
3	17-Apr	0.00079	0.00079	0.0013	0.00153	0.00432	0.00193
4	18-Apr	0.00079	0.00079	0.00195	0.00232	0.00511	0.00388
5	19-Apr	0.00079	0.00079	0.00285	0.00311	0.0059	0.00673
6	20-Apr	0.00079	0.0008	0.00385	0.0039	0.0067	0.01058
7	21-Apr	0.00079	0.00079	0.00489	0.00469	0.00749	0.01547
8	22-Apr	0.00079	0.00079	0.00582	0.00548	0.00828	0.02129
9	23-Apr	0.00079	0.00079	0.0063	0.00627	0.00907	0.02759
10	24-Apr	0.00079	0.00079	0.00639	0.00706	0.00986	0.03398
11	25-Apr	0.00079	0.00079	0.00593	0.00785	0.01065	0.03991
12	26-Apr	0.0008	0.00079	0.00524	0.00865	0.01144	0.04515
13	27-Apr	0.00079	0.0008	0.00476	0.00944	0.01224	0.04991
14	28-Apr	0.00079	0.00079	0.00423	0.01023	0.01303	0.05414
15	29-Apr	0.0008	0.00079	0.0038	0.01103	0.01382	0.05794
16	30-Apr	0.00079	0.0008	0.00355	0.01182	0.01462	0.06149
17	1-May	0.00079	0.00079	0.00223	0.01261	0.01541	0.06372
18	2-May	0.0008	0.00079	0.00317	0.01341	0.0162	0.06689
19	3-May	0.00079	0.0008	0.00152	0.0142	0.017	0.06841
20	4-May	0.0008	0.00079	-4E-05	0.015	0.01779	0.06837
21	5-May	0.00079	0.00079	-0.0005	0.01579	0.01858	0.06787
22	6-May	0.00079	0.0008	-0.00118	0.01658	0.01938	0.06669
23	7-May	0.0008	0.00079	-0.00128	0.01738	0.02017	0.06541
24	8-May	0.00079	0.0008	0.001	0.01817	0.02097	0.06641
25	9-May	0.00079	0.00079	0.0029	0.01896	0.02176	0.06931
26	10-May	0.0008	0.00079	0.00178	0.01976	0.02255	0.07109
27	11-May	0.00079	0.0008	-0.00059	0.02055	0.02335	0.0705
28	12-May	0.0008	0.00079	-0.00141	0.02135	0.02414	0.06909
29	13-May	0.00079	0.0008	-0.00103	0.02214	0.02494	0.06806
30	14-May	0.00079	0.00079	-0.00104	0.02293	0.02573	0.06702
31	15-May	0.0008	0.00079	-0.00175	0.02373	0.02652	0.06527
32	16-May	0.00079	0.0008	-0.00218	0.02452	0.02732	0.06309
33	17-May	0.00079	0.00079	-0.00189	0.02531	0.02811	0.0612
34	18-May	0.0008	0.00079	-0.00126	0.02611	0.0289	0.05994
35	19-May	0.00079	0.00079	-0.00112	0.0269	0.02969	0.05882
36	20-May	0.00079	0.0008	-0.00173	0.02769	0.03049	0.05709
37	21-May	0.00079	0.00079	-0.00118	0.02848	0.03128	0.05591
38	22-May	0.0008	0.00079	-0.00066	0.02928	0.03207	0.05525
39	23-May	0.00079	0.00079	-0.00172	0.03007	0.03286	0.05353
40	24-May	0.00079	0.0008	-0.00017	0.03086	0.03366	0.05336
41	25-May	0.00079	0.00079	0.00073	0.03165	0.03445	0.05409
42	26-May	0.00079	0.00079	-0.00159	0.03244	0.03524	0.0525
43	27-May	0.00079	0.00079	-0.00099	0.03323	0.03603	0.05151
44	28-May	0.0008	0.00079	0.0015	0.03403	0.03682	0.05301
45	29-May	0.00079	0.00079	0.0008	0.03482	0.03761	0.05381
46	30-May	0.00079	0.0008	0.00065	0.03561	0.03841	0.05446
47	31-May	0.00079	0.00079	0.00099	0.0364	0.0392	0.05545
48	1-Jun	0.00079	0.00079	-0.00284	0.03719	0.03999	0.05261
49	2-Jun	0.00079	0.00079	-0.00212	0.03798	0.04078	0.05049
50	3-Jun	0.0008	0.00079	-0.00187	0.03878	0.04157	0.04862
51	4-Jun	0.00079	0.00079	-0.00175	0.03957	0.04236	0.04687
52	5-Jun	0.00079	0.00079	-0.00162	0.04036	0.04315	0.04525
53	6-Jun	0.00079	0.00079	-0.00152	0.04115	0.04394	0.04373
54	7-Jun	0.00079	0.0008	-0.00145	0.04194	0.04474	0.04228
55	8-Jun	0.00079	0.00079	-0.00142	0.04273	0.04553	0.04086
56	9-Jun	0.00079	0.00079	-0.00134	0.04352	0.04632	0.03952
57	10-Jun	0.00079	0.00079	-0.00121	0.04431	0.04711	0.03831
58	11-Jun	0.00079	0.00079	-0.00121	0.0451	0.0479	0.0371
59	12-Jun	0.00077	0.00079	-0.00114	0.04587	0.04869	0.03596
60	13-Jun	0.00075	0.00079	-0.00109	0.04662	0.04948	0.03487
61	14-Jun	0.00074	0.00079	-0.00099	0.04736	0.05027	0.03388
62	15-Jun	0.00073	0.00079	-0.00099	0.04809	0.05106	0.03289
63	16-Jun	0.00072	0.00079	-0.00096	0.04881	0.05185	0.03193
64	17-Jun	0.00071	0.00078	-0.00088	0.04952	0.05263	0.03105
65	18-Jun	0.00071	0.00079	-0.00031	0.05023	0.05342	0.03074
66	19-Jun	0.0007	0.00079	0.00106	0.05093	0.05421	0.0318
67	20-Jun	0.0007	0.00079	0.00043	0.05163	0.055	0.03223
68	21-Jun	0.00072	0.00079	-2E-05	0.05235	0.05579	0.03221
69	22-Jun	0.00072	0.00079	0.00199	0.05307	0.05658	0.0342
70	23-Jun	0.00073	0.00079	0.00146	0.0538	0.05737	0.03566
71	24-Jun	0.00076	0.00079	0.00185	0.05456	0.05816	0.03751
72	25-Jun	0.00078	0.00079	0.00041	0.05534	0.05895	0.03792
73	26-Jun	0.00077	0.00079	-0.00088	0.05611	0.05974	0.03704
74	27-Jun	0.00077	0.00079	-0.00131	0.05688	0.06053	0.03573
75	28-Jun	0.00074	0.00079	-0.00088	0.05762	0.06132	0.03485
76	29-Jun	0.00072	0.00079	-0.00079	0.05834	0.06211	0.03406
77	30-Jun	0.00071	0.00078	-0.00073	0.05905	0.06289	0.03333
78	1-Jul	0.0007	0.00079	-0.00012	0.05975	0.06368	0.03321
79	2-Jul	0.00069	0.00079	-0.00044	0.06044	0.06447	0.03277
80	3-Jul	0.00069	0.00079	-0.00089	0.06113	0.06526	0.03188
81	4-Jul	0.00069	0.00079	-0.0007	0.06182	0.06605	0.03118
82	5-Jul	0.00067	0.00079	-0.00069	0.06249	0.06684	0.03049
83	6-Jul	0.00068	0.00079	-0.00027	0.06317	0.06763	0.03022
84	7-Jul	0.00067	0.00079	0.00189	0.06384	0.06842	0.03211
85	8-Jul	0.00067	0.00079	0.00178	0.06451	0.06921	0.03389
86	9-Jul	0.00069	0.00078	-0.00127	0.0652	0.06999	0.03262
87	10-Jul	0.0007	0.00079	-0.00094	0.0659	0.07078	0.03168
88	11-Jul	0.00069	0.00079	-0.00066	0.06659	0.07157	0.03102
89	12-Jul	0.00067	0.00079	-0.00054	0.06726	0.07236	0.03048
90	13-Jul	0.00067	0.00079	0.00644	0.06793	0.07315	0.03692
91	14-Jul	0.00074	0.00079	0.0156	0.06867	0.07394	0.05252

		DAILY VALUES VS. TIME ($m^3/m^2/day$)			CUMULATIVE VALUES VS. TIME (m^3/m^2)		
Time	Date	Bottom of Cover	Bottom of Tailings	Top of Cover	Bottom of cover	Bottom of Tailings	Top of Cover
92	15-Jul	0.00103	0.00079	0.0091	0.0697	0.07473	0.06162
93	16-Jul	0.00109	0.00078	0.0011	0.07079	0.07551	0.06272
94	17-Jul	0.00101	0.00079	0.00074	0.0718	0.0763	0.06346
95	18-Jul	0.00095	0.00079	0.00012	0.07275	0.07709	0.06358
96	19-Jul	0.00091	0.00079	-0.00057	0.07366	0.07788	0.06301
97	20-Jul	0.00087	0.00079	-0.00141	0.07453	0.07867	0.0616
98	21-Jul	0.00083	0.00079	-0.00091	0.07536	0.07946	0.06069
99	22-Jul	0.00081	0.00078	-0.001	0.07617	0.08024	0.05969
100	23-Jul	0.00079	0.00079	-0.00094	0.07696	0.08103	0.05875
101	24-Jul	0.00077	0.00079	-0.00068	0.07773	0.08182	0.05807
102	25-Jul	0.00075	0.00079	-0.00073	0.07848	0.08261	0.05734
103	26-Jul	0.00075	0.00079	-0.00078	0.07923	0.0834	0.05656
104	27-Jul	0.00073	0.00079	-0.00042	0.07996	0.08419	0.05614
105	28-Jul	0.00072	0.00079	-0.00083	0.08068	0.08498	0.05531
106	29-Jul	0.00072	0.00078	-0.00066	0.0814	0.08576	0.05465
107	30-Jul	0.00071	0.00079	-0.00059	0.08211	0.08655	0.05406
108	31-Jul	0.00071	0.00079	-0.0007	0.08282	0.08734	0.05336
109	1-Aug	0.00069	0.00079	-0.00065	0.08351	0.08813	0.05271
110	2-Aug	0.00069	0.00079	-0.00062	0.0842	0.08892	0.05209
111	3-Aug	0.00069	0.00079	-0.00023	0.08489	0.08971	0.05186
112	4-Aug	0.00067	0.00079	-0.00029	0.08556	0.0905	0.05157
113	5-Aug	0.00068	0.00078	-0.00072	0.08624	0.09128	0.05085
114	6-Aug	0.00067	0.00079	0.0026	0.08691	0.09207	0.05345
115	7-Aug	0.00068	0.00079	0.0078	0.08759	0.09286	0.06125
116	8-Aug	0.0008	0.00079	0.0074	0.08839	0.09365	0.06865
117	9-Aug	0.00091	0.00079	0.00224	0.0893	0.09444	0.07089
118	10-Aug	0.0009	0.00079	-0.00203	0.0902	0.09523	0.06886
119	11-Aug	0.00084	0.00078	-0.00117	0.09104	0.09601	0.06769
120	12-Aug	0.00079	0.00079	0.00031	0.09183	0.0968	0.068
121	13-Aug	0.00078	0.00079	0.00158	0.09261	0.09759	0.06958
122	14-Aug	0.00076	0.00079	0.00092	0.09337	0.09838	0.0705
123	15-Aug	0.00078	0.00079	0.00187	0.09415	0.09917	0.07237
124	16-Aug	0.0008	0.00079	0.00384	0.09495	0.09996	0.07621
125	17-Aug	0.00084	0.00078	0.00344	0.09579	0.10074	0.07965
126	18-Aug	0.00088	0.00079	0.0041	0.09667	0.10153	0.08375
127	19-Aug	0.00092	0.00079	0.00355	0.09759	0.10232	0.0873
128	20-Aug	0.00094	0.00079	0.00262	0.09853	0.10311	0.08992
129	21-Aug	0.00096	0.00079	0.00622	0.09949	0.1039	0.09614
130	22-Aug	0.00102	0.00079	0.00691	0.10051	0.10469	0.10305
131	23-Aug	0.00108	0.00078	0.0049	0.10159	0.10547	0.10795
132	24-Aug	0.00104	0.00079	0.00168	0.10263	0.10626	0.10963
133	25-Aug	0.00101	0.00079	0.00033	0.10364	0.10705	0.10996
134	26-Aug	0.00097	0.00079	-0.00078	0.10461	0.10784	0.10918
135	27-Aug	0.00094	0.00079	0.00016	0.10555	0.10863	0.10934
136	28-Aug	0.00092	0.00079	9E-05	0.10647	0.10942	0.10943
137	29-Aug	0.00091	0.00078	-0.0001	0.10738	0.1102	0.10933
138	30-Aug	0.00088	0.00079	0.0008	0.10826	0.11099	0.11013
139	31-Aug	0.00079	0.00079	0.00038	0.10905	0.11178	0.11051
140	1-Sep	0.00079	0.00079	-0.00042	0.10984	0.11257	0.11009
141	2-Sep	0.00079	0.00079	0.00127	0.11063	0.11336	0.11136
142	3-Sep	0.00079	0.00079	-0.00019	0.11142	0.11415	0.11117
143	4-Sep	0.0008	0.00079	-0.00089	0.11222	0.11494	0.11028
144	5-Sep	0.00079	0.0008	-0.00103	0.11301	0.11574	0.10925
145	6-Sep	0.00079	0.00079	2E-05	0.1138	0.11653	0.10927
146	7-Sep	0.00078	0.00079	0.00191	0.11458	0.11732	0.11118
147	8-Sep	0.00079	0.00079	0.00239	0.11537	0.11811	0.11357
148	9-Sep	0.00079	0.00079	0.00215	0.11616	0.1189	0.11572
149	10-Sep	0.00079	0.00079	0.00212	0.11695	0.11969	0.11784
150	11-Sep	0.00079	0.00079	0.00213	0.11774	0.12048	0.11997
151	12-Sep	0.0008	0.00079	0.00101	0.11854	0.12127	0.12098
152	13-Sep	0.00079	0.00079	0.00184	0.11933	0.12206	0.12282
153	14-Sep	0.00079	0.00079	0.0017	0.12012	0.12285	0.12452
154	15-Sep	0.00079	0.00079	0.00112	0.12091	0.12364	0.12564
155	16-Sep	0.00079	0.00079	0.00317	0.1217	0.12443	0.12881
156	17-Sep	0.00079	0.00079	0.00161	0.12249	0.12522	0.13042
157	18-Sep	0.00079	0.00079	0.00293	0.12328	0.12601	0.13335
158	19-Sep	0.00079	0.00079	0.00232	0.12407	0.1268	0.13567
159	20-Sep	0.00079	0.00079	0.00143	0.12486	0.12759	0.1371
160	21-Sep	0.00079	0.00079	0.00158	0.12565	0.12838	0.13868
161	22-Sep	0.00079	0.00079	0.00149	0.12644	0.12917	0.14017
162	23-Sep	0.00079	0.00079	0.00213	0.12723	0.12996	0.1423
163	24-Sep	0.0008	0.0008	0.00133	0.12803	0.13076	0.14363
164	25-Sep	0.00079	0.00079	0.00065	0.12882	0.13155	0.14428
165	26-Sep	0.00079	0.00079	0.00348	0.12961	0.13234	0.14776
166	27-Sep	0.00079	0.00079	0.00557	0.1304	0.13313	0.15333
167	28-Sep	0.00079	0.00079	0.00567	0.13119	0.13392	0.159
168	29-Sep	0.00079	0.00079	0.00625	0.13198	0.13471	0.16525
169	30-Sep	0.0008	0.0008	0.0032	0.13278	0.13551	0.16845
170	1-Oct	0.00079	0.00079	0.0001	0.13357	0.1363	0.16855
171	2-Oct	0.00079	0.00079	0	0.13436	0.13709	0.16855
172	3-Oct	0.00079	0.00079	0	0.13515	0.13788	0.16855
173	4-Oct	0.0008	0.0008	0	0.13595	0.13868	0.16855
174	5-Oct	0.00079	0.00079	0	0.13674	0.13947	0.16855
175	6-Oct	0.00079	0.00079	0.00064	0.13753	0.14026	0.16919
176	7-Oct	0.00079	0.00079	0.00132	0.13832	0.14105	0.17051
177	8-Oct	0.0008	0.0008	4E-05	0.13912	0.14185	0.17055
178	9-Oct	0.00079	0.00079	0.00032	0.13991	0.14264	0.17087
179	10-Oct	0.00079	0.00079	0.00162	0.1407	0.14343	0.17249
180	11-Oct	0.00079	0.00079	0.002	0.14149	0.14422	0.17449
181	12-Oct	0.0008	0.0008	6E-05	0.14229	0.14502	0.17455
182	13-Oct	0.00079	0.00079	0	0.14308	0.14581	0.17455
183	14-Oct	0.00079	0.00079	0	0.14387	0.1466	0.17455
184	15-Oct	0.00079	0.00079	0	0.14466	0.14739	0.17455
185	16-Oct	0.0008	0.0008	0	0.14546	0.14819	0.17455
186	17-Oct	0.00079	0.00079	0	0.14625	0.14898	0.17455
187	18-Oct	0.00079	0.00079	0	0.14704	0.14977	0.17455
188	19-Oct	0.00079	0.00079	0	0.14783	0.15056	0.17455
189	20-Oct	0.0008	0.0008	0	0.14863	0.15136	0.17455
190	21-Oct	0.00079	0.00079	0	0.14942	0.15215	0.17455
191	22-Oct	0.00079	0.00079	0	0.15021	0.15294	0.17455
192	23-Oct	0.00079	0.00079	0	0.151	0.15373	0.17455
193	24-Oct	0.00079	0.00079	0.00064	0.15179	0.15452	0.17519
194	25-Oct	0.0008	0.0008	0.00132	0.15259	0.15532	0.17651
195	26-Oct	0.00079	0.00079	0.00036	0.15338	0.15611	0.17687
196	27-Oct	0.00079	0.00079	0.00066	0.15417	0.1569	0.17753
197	28-Oct	0.00079	0.00079	0.00034	0.15496	0.15769	0.17787
198	29-Oct	0.00079	0.00079	0.00066	0.15575	0.15848	0.17853
199	30-Oct	0.0008	0.0008	2E-05	0.15655	0.15928	0.17855
200	31-Oct	0.00079	0.00079	0	0.15734	0.16007	0.17855

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
CLIMATE WATER BALANCE
DRY YEAR

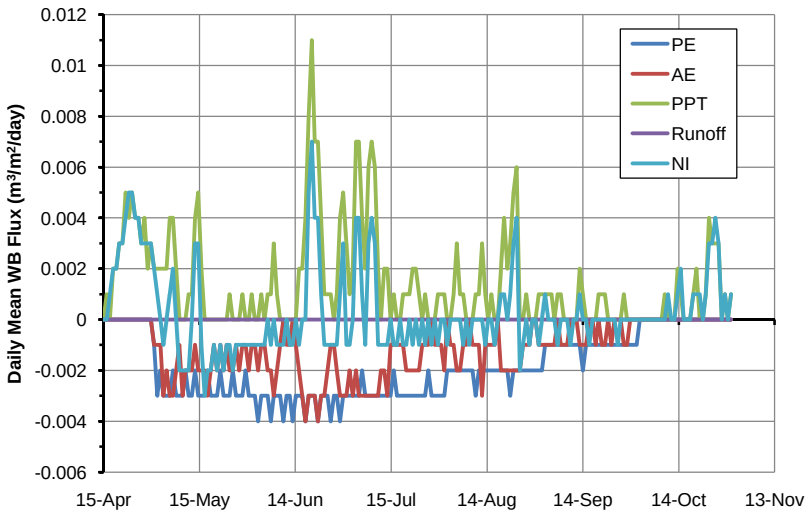


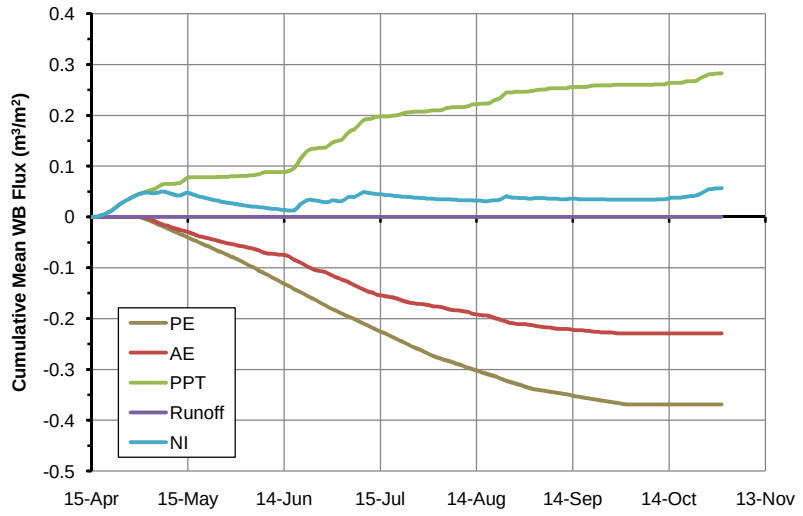


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.00067	0	0.00056	0	0	0.00067	0	0.00056
3	17-Apr	0	0	0.00117	0	0.00117	0	0	0.00184	0	0.00173
4	18-Apr	0	0	0.00175	0	0.00175	0	0	0.00359	0	0.00348
5	19-Apr	0	0	0.00257	0	0.00258	0	0	0.00616	0	0.00606
6	20-Apr	0	0	0.00347	0	0.00347	0	0	0.00963	0	0.00953
7	21-Apr	0	0	0.00437	0	0.00437	0	0	0.014	0	0.0139
8	22-Apr	0	0	0.00526	0	0.00526	0	0	0.01926	0	0.01916
9	23-Apr	0	0	0.0057	0	0.00571	0	0	0.02496	0	0.02487
10	24-Apr	0	0	0.00576	0	0.00576	0	0	0.03072	0	0.03063
11	25-Apr	0	0	0.00536	0	0.00536	0	0	0.03608	0	0.03599
12	26-Apr	0	0	0.00476	0	0.00475	0	0	0.04084	0	0.04074
13	27-Apr	0	0	0.00428	0	0.00429	0	0	0.04512	0	0.04503
14	28-Apr	0	0	0.00381	0	0.00381	0	0	0.04893	0	0.04884
15	29-Apr	0	0	0.00344	0	0.00344	0	0	0.05237	0	0.05228
16	30-Apr	0	0	0.00321	0	0.00319	0	0	0.05558	0	0.05547
17	1-May	-0.00088	-0.00088	0.00297	0	0.00248	-0.00088	-0.00088	0.05855	0	0.05795
18	2-May	-0.00268	-0.00214	0.00266	0	0.00015	-0.00356	-0.00302	0.06121	0	0.0581
19	3-May	-0.00275	-0.00274	0.00234	0	-0.0004	-0.00631	-0.00576	0.06355	0	0.0577
20	4-May	-0.00274	-0.00218	0.00196	0	-0.00041	-0.00905	-0.00794	0.06551	0	0.05729
21	5-May	-0.00274	-0.00198	0.00165	0	-0.00013	-0.01179	-0.00992	0.06716	0	0.05716
22	6-May	-0.00274	-0.00197	0.00137	0	-0.00042	-0.01453	-0.01189	0.06853	0	0.05674
23	7-May	-0.00274	-0.00197	0.00096	0	-0.00081	-0.01727	-0.01386	0.06949	0	0.05593
24	8-May	-0.00275	-0.00194	0.00039	0	-0.0014	-0.02002	-0.0158	0.06988	0	0.05453
25	9-May	-0.00274	-0.00139	0.0003	0	-0.00132	-0.02276	-0.01719	0.07018	0	0.05321
26	10-May	-0.00274	-0.00142	0.00038	0	-0.00066	-0.0255	-0.01861	0.07056	0	0.05255
27	11-May	-0.00274	-0.00183	0	0	-0.00175	-0.02824	-0.02044	0.07056	0	0.0508
28	12-May	-0.00274	-0.00186	0	0	-0.00171	-0.03098	-0.0223	0.07056	0	0.04909
29	13-May	-0.00275	-0.00173	0	0	-0.00151	-0.03373	-0.02403	0.07056	0	0.04758
30	14-May	-0.00274	-0.00204	0	0	-0.00191	-0.03647	-0.02607	0.07056	0	0.04567
31	15-May	-0.00274	-0.00206	0	0	-0.002	-0.03921	-0.02813	0.07056	0	0.04367
32	16-May	-0.00274	-0.00172	0	0	-0.0016	-0.04195	-0.02985	0.07056	0	0.04207
33	17-May	-0.00274	-0.00169	0	0	-0.00158	-0.04469	-0.03154	0.07056	0	0.04049
34	18-May	-0.00275	-0.0017	0	0	-0.00168	-0.04744	-0.03324	0.07056	0	0.03881
35	19-May	-0.00274	-0.00171	0	0	-0.00166	-0.05018	-0.03495	0.07056	0	0.03715
36	20-May	-0.00274	-0.00148	0	0	-0.00139	-0.05292	-0.03643	0.07056	0	0.03576
37	21-May	-0.00274	-0.0014	0	0	-0.00136	-0.05566	-0.03783	0.07056	0	0.0344
38	22-May	-0.00274	-0.00248	0.0037	0	0.00122	-0.0584	-0.04031	0.07426	0	0.03562
39	23-May	-0.00275	-0.00274	0.00462	0	0.00188	-0.06115	-0.04305	0.07888	0	0.0375
40	24-May	-0.00274	-0.00251	0	0	-0.00246	-0.06389	-0.04556	0.07888	0	0.03504
41	25-May	-0.00274	-0.00137	0	0	-0.00136	-0.06663	-0.04693	0.07888	0	0.03368
42	26-May	-0.00274	-0.00141	0	0	-0.0014	-0.06937	-0.04834	0.07888	0	0.03228
43	27-May	-0.00274	-0.00129	0	0	-0.0013	-0.07211	-0.04963	0.07888	0	0.03098
44	28-May	-0.00275	-0.00123	0.00024	0	-0.00098	-0.07486	-0.05086	0.07912	0	0.03
45	29-May	-0.00274	-0.00235	0.00488	0	0.00254	-0.0776	-0.05321	0.084	0	0.03254
46	30-May	-0.00274	-0.00275	0.00539	0	0.00265	-0.08034	-0.05596	0.08939	0	0.03519
47	31-May	-0.00274	-0.00233	0	0	-0.00229	-0.08308	-0.05829	0.08939	0	0.0329
48	1-Jun	-0.003	-0.00142	0	0	-0.0014	-0.08608	-0.05971	0.08939	0	0.0315
49	2-Jun	-0.00327	-0.0012	0	0	-0.0012	-0.08935	-0.06091	0.08939	0	0.0303
50	3-Jun	-0.00326	-0.00185	0.00078	0	-0.00102	-0.09261	-0.06276	0.09017	0	0.02928
51	4-Jun	-0.00327	-0.00218	0.00118	0	-0.00099	-0.09588	-0.06494	0.09135	0	0.02829
52	5-Jun	-0.00327	-0.00122	0.00036	0	-0.00087	-0.09915	-0.06616	0.09171	0	0.02742
53	6-Jun	-0.00326	-0.001	0	0	-0.00095	-0.10241	-0.06716	0.09171	0	0.02647
54	7-Jun	-0.00327	-0.00115	0.00024	0	-0.00089	-0.10568	-0.06831	0.09195	0	0.02558
55	8-Jun	-0.00327	-0.00272	0.00221	0	-0.00048	-0.10895	-0.07103	0.09416	0	0.0251
56	9-Jun	-0.00327	-0.00327	0.00466	0	0.00139	-0.11222	-0.0743	0.09882	0	0.02649
57	10-Jun	-0.00326	-0.00327	0.00353	0	0.00029	-0.11548	-0.07757	0.10235	0	0.02678
58	11-Jun	-0.00327	-0.00141	0	0	-0.00138	-0.11875	-0.07898	0.10235	0	0.0254
59	12-Jun	-0.00327	-0.00093	0	0	-0.00092	-0.12202	-0.07991	0.10235	0	0.02448
60	13-Jun	-0.00326	-0.00074	0	0	-0.00073	-0.12528	-0.08065	0.10235	0	0.02375
61	14-Jun	-0.00327	-0.00068	0	0	-0.00065	-0.12855	-0.08133	0.10235	0	0.0231
62	15-Jun	-0.00327	-0.00073	0	0	-0.0007	-0.13182	-0.08206	0.10235	0	0.0224
63	16-Jun	-0.00326	-0.00073	0	0	-0.00072	-0.13508	-0.08279	0.10235	0	0.02168
64	17-Jun	-0.00327	-0.00091	0.00023	0	-0.00064	-0.13835	-0.0837	0.10258	0	0.02104
65	18-Jun	-0.00327	-0.00286	0.00345	0	0.0006	-0.14162	-0.08656	0.10603	0	0.02164
66	19-Jun	-0.00327	-0.00327	0.00479	0	0.00152	-0.14489	-0.08983	0.11082	0	0.02316
67	20-Jun	-0.00326	-0.00327	0.00333	0	7E-05	-0.14815	-0.0931	0.11415	0	0.02323
68	21-Jun	-0.00327	-0.00326	0.00497	0	0.00171	-0.15142	-0.09636	0.11912	0	0.02494
69	22-Jun	-0.00327	-0.00315	0.00256	0	-0.00049	-0.15469	-0.09951	0.12168	0	0.02445
70	23-Jun	-0.00326	-0.00112	0	0	-0.00112	-0.15795	-0.10063	0.12168	0	0.02333
71	24-Jun	-0.00327	-0.00075	0	0	-0.00073	-0.16122	-0.10138	0.12168	0	0.0226
72	25-Jun	-0.00327	-0.00064	0	0	-0.00062	-0.16449	-0.10202	0.12168	0	0.02198
73	26-Jun	-0.00326	-0.00058	0	0	-0.0006	-0.16775	-0.1026	0.12168	0	0.02138
74	27-Jun	-0.00327	-0.00056	0	0	-0.00055	-0.17102	-0.10316	0.12168	0	0.02083
75	28-Jun	-0.00327	-0.00053	0	0	-0.00053	-0.17429	-0.10369	0.12168	0	0.0203
76	29-Jun	-0.00327	-0.00051	0	0	-0.0005	-0.17756	-0.1042	0.12168	0	0.0198
77	30-Jun	-0.00326	-0.00049	0	0	-0.00049	-0.18082	-0.10469	0.12168	0	0.01931
78	1-Jul	-0.0031	-0.00072	0.00024	0	-0.00046	-0.18392	-0.10541	0.12192	0	0.01885
79	2-Jul	-0.0029	-0.00072	0.00027	0	-0.00046	-0.18682	-0.10613	0.12219	0	0.01839
80	3-Jul	-0.0029	-0.00046	0	0	-0.00044	-0.18972	-0.10659	0.12219	0	0.01795
81	4-Jul	-0.00291	-0.00198	0.00174	0	-0.00022	-0.19263	-0.10857	0.12393	0	0.01773
82	5-Jul	-0.0029	-0.00227	0.00191	0	-0.00032	-0.19553	-0.11084	0.12584	0	0.01741
83	6-Jul	-0.0029	-0.0005	0	0	-0.0005	-0.19843	-0.11134	0.12584	0	0.01691
84	7-Jul	-0.00291	-0.00118	0.00078	0	-0.00036	-0.20134	-0.11252	0.12662	0	0.01655
85	8-Jul	-0.0029	-0.00178	0.00141	0	-0.00037	-0.20424	-0.1143	0.12803	0	0.01618
86	9-Jul	-0.0029	-0.00175	0.00139	0	-0.00035	-0.20714	-0.11605	0.12942	0	0.01583
87	10-Jul	-0.0029	-0.00258	0.00231	0	-0.00026	-0.21004	-0.11863	0.13173	0	0.01557
88	11-Jul	-0.00291	-0.0029	0.00481	0	0.00191	-0.21295	-0.12153	0.13654	0	0.01748
89	12-Jul	-0.0029	-0.0029	0.00512	0	0.00223	-0.21585	-0.12443	0.14166	0	0.01971
90	13-Jul	-0.0029	-0.00291	0.0088	0	0.0059	-0.21875	-0.12734	0.15046	0	0.02561

		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
91	14-Jul	-0.00291	-0.0029	0.01004	0	0.00714	-0.22166	-0.13024	0.1605	0	0.03275
92	15-Jul	-0.0029	-0.0029	0.00105	0	-0.00177	-0.22456	-0.13314	0.16155	0	0.03098
93	16-Jul	-0.0029	-0.00131	0	0	-0.0013	-0.22746	-0.13445	0.16155	0	0.02968
94	17-Jul	-0.00291	-0.00075	0	0	-0.00073	-0.23037	-0.1352	0.16155	0	0.02895
95	18-Jul	-0.0029	-0.0009	0.00033	0	-0.00056	-0.23327	-0.1361	0.16188	0	0.02839
96	19-Jul	-0.0029	-0.00086	0.00036	0	-0.00052	-0.23617	-0.13696	0.16224	0	0.02787
97	20-Jul	-0.0029	-0.00047	0	0	-0.00046	-0.23907	-0.13743	0.16224	0	0.02741
98	21-Jul	-0.00291	-0.00044	0	0	-0.00042	-0.24198	-0.13787	0.16224	0	0.02699
99	22-Jul	-0.0029	-0.00042	0	0	-0.0004	-0.24488	-0.13829	0.16224	0	0.02659
100	23-Jul	-0.0029	-0.0004	0	0	-0.00038	-0.24778	-0.13869	0.16224	0	0.02621
101	24-Jul	-0.00291	-0.00092	0.00056	0	-0.00034	-0.25069	-0.13961	0.1628	0	0.02587
102	25-Jul	-0.0029	-0.00258	0.00274	0	0.00019	-0.25359	-0.14219	0.16554	0	0.02606
103	26-Jul	-0.0029	-0.00258	0.00252	0	0	-0.25649	-0.14477	0.16806	0	0.02606
104	27-Jul	-0.00291	-0.00058	0	0	-0.00058	-0.2594	-0.14535	0.16806	0	0.02548
105	28-Jul	-0.0029	-0.00043	0	0	-0.00042	-0.2623	-0.14578	0.16806	0	0.02506
106	29-Jul	-0.0029	-0.00038	0	0	-0.00037	-0.2652	-0.14616	0.16806	0	0.02469
107	30-Jul	-0.0029	-0.00035	0	0	-0.00035	-0.2681	-0.14651	0.16806	0	0.02434
108	31-Jul	-0.00291	-0.00033	0	0	-0.00032	-0.27101	-0.14684	0.16806	0	0.02402
109	1-Aug	-0.00254	-0.00033	0	0	-0.00032	-0.27355	-0.14717	0.16806	0	0.0237
110	2-Aug	-0.0021	-0.00031	0	0	-0.00029	-0.27565	-0.14748	0.16806	0	0.02341
111	3-Aug	-0.0021	-0.0003	0	0	-0.00027	-0.27775	-0.14778	0.16806	0	0.02314
112	4-Aug	-0.00209	-0.00029	0	0	-0.00027	-0.27984	-0.14807	0.16806	0	0.02287
113	5-Aug	-0.0021	-0.00051	0.00023	0	-0.00025	-0.28194	-0.14858	0.16829	0	0.02262
114	6-Aug	-0.0021	-0.00054	0.00027	0	-0.00029	-0.28404	-0.14912	0.16856	0	0.02233
115	7-Aug	-0.00209	-0.00027	0	0	-0.00025	-0.28613	-0.14939	0.16856	0	0.02208
116	8-Aug	-0.0021	-0.00027	0	0	-0.00024	-0.28823	-0.14966	0.16856	0	0.02184
117	9-Aug	-0.0021	-0.00026	0	0	-0.00024	-0.29033	-0.14992	0.16856	0	0.0216
118	10-Aug	-0.00209	-0.00156	0.00169	0	0.00017	-0.29242	-0.15148	0.17025	0	0.02177
119	11-Aug	-0.0021	-0.00191	0.00207	0	0.00015	-0.29452	-0.15339	0.17232	0	0.02192
120	12-Aug	-0.0021	-0.00044	1E-05	0	-0.00044	-0.29662	-0.15383	0.17233	0	0.02148
121	13-Aug	-0.0021	-0.00053	0.00024	0	-0.00028	-0.29872	-0.15436	0.17257	0	0.0212
122	14-Aug	-0.00209	-0.00053	0.00026	0	-0.00027	-0.30081	-0.15489	0.17283	0	0.02093
123	15-Aug	-0.0021	-0.00025	0	0	-0.00024	-0.30291	-0.15514	0.17283	0	0.02069
124	16-Aug	-0.0021	-0.00024	0	0	-0.00023	-0.30501	-0.15538	0.17283	0	0.02046
125	17-Aug	-0.00209	-0.00022	0	0	-0.00022	-0.3071	-0.1556	0.17283	0	0.02024
126	18-Aug	-0.0021	-0.00052	0.00033	0	-0.00018	-0.3092	-0.15612	0.17316	0	0.02006
127	19-Aug	-0.0021	-0.00099	0.00091	0	-7E-05	-0.3113	-0.15711	0.17407	0	0.01999
128	20-Aug	-0.00209	-0.00087	0.0006	0	-0.00027	-0.31339	-0.15798	0.17467	0	0.01972
129	21-Aug	-0.0021	-0.00023	0	0	-0.0002	-0.31549	-0.15821	0.17467	0	0.01952
130	22-Aug	-0.0021	-0.0002	0	0	-0.00019	-0.31759	-0.15841	0.17467	0	0.01933
131	23-Aug	-0.0021	-0.0002	0	0	-0.00018	-0.31969	-0.15861	0.17467	0	0.01915
132	24-Aug	-0.00209	-0.00019	0	0	-0.00017	-0.32178	-0.1588	0.17467	0	0.01898
133	25-Aug	-0.0021	-0.00016	0	0	-0.00015	-0.32388	-0.15896	0.17467	0	0.01883
134	26-Aug	-0.0021	-0.00019	0	0	-0.00018	-0.32598	-0.15915	0.17467	0	0.01865
135	27-Aug	-0.00209	-0.00016	0	0	-0.00016	-0.32807	-0.15931	0.17467	0	0.01849
136	28-Aug	-0.0021	-0.00051	0.00047	0	-3E-05	-0.33017	-0.15982	0.17514	0	0.01846
137	29-Aug	-0.0021	-0.00066	0.00051	0	-0.00014	-0.33227	-0.16048	0.17565	0	0.01832
138	30-Aug	-0.00209	-0.0002	0	0	-0.00019	-0.33436	-0.16068	0.17565	0	0.01813
139	31-Aug	-0.0021	-0.0004	0.00023	0	-0.00016	-0.33646	-0.16108	0.17588	0	0.01797
140	1-Sep	-0.00161	-0.00041	0.00027	0	-0.00015	-0.33807	-0.16149	0.17615	0	0.01782
141	2-Sep	-0.00103	-0.00015	0	0	-0.00014	-0.3391	-0.16164	0.17615	0	0.01768
142	3-Sep	-0.00104	-0.00015	0	0	-0.00015	-0.34014	-0.16179	0.17615	0	0.01753
143	4-Sep	-0.00103	-0.00016	0	0	-0.00014	-0.34117	-0.16195	0.17615	0	0.01739
144	5-Sep	-0.00103	-0.00036	0.00024	0	-0.00012	-0.3422	-0.16231	0.17639	0	0.01727
145	6-Sep	-0.00103	-0.0004	0.00027	0	-0.00014	-0.34323	-0.16271	0.17666	0	0.01713
146	7-Sep	-0.00104	-0.00014	0	0	-0.00013	-0.34427	-0.16285	0.17666	0	0.017
147	8-Sep	-0.00103	-0.00014	0	0	-0.00014	-0.3453	-0.16299	0.17666	0	0.01686
148	9-Sep	-0.00103	-0.00013	0	0	-0.00012	-0.34633	-0.16312	0.17666	0	0.01674
149	10-Sep	-0.00104	-0.00012	0	0	-0.00011	-0.34737	-0.16324	0.17666	0	0.01663
150	11-Sep	-0.00103	-0.00012	0	0	-0.00012	-0.3484	-0.16336	0.17666	0	0.01651
151	12-Sep	-0.00103	-0.00012	0	0	-0.00011	-0.34943	-0.16348	0.17666	0	0.0164
152	13-Sep	-0.00104	-0.00011	0	0	-0.00011	-0.35047	-0.16359	0.17666	0	0.01629
153	14-Sep	-0.00103	-0.00013	0	0	-0.00012	-0.3515	-0.16372	0.17666	0	0.01617
154	15-Sep	-0.00103	-0.00011	0	0	-0.00011	-0.35253	-0.16383	0.17666	0	0.01606
155	16-Sep	-0.00103	-0.00012	0	0	-0.0001	-0.35356	-0.16395	0.17666	0	0.01596
156	17-Sep	-0.00104	-1E-04	0	0	-9E-05	-0.3546	-0.16405	0.17666	0	0.01587
157	18-Sep	-0.00103	-1E-04	0	0	-1E-04	-0.35563	-0.16415	0.17666	0	0.01577
158	19-Sep	-0.00103	-0.00011	0	0	-0.00011	-0.35666	-0.16426	0.17666	0	0.01566
159	20-Sep	-0.00104	-0.00011	0	0	-9E-05	-0.3577	-0.16437	0.17666	0	0.01557
160	21-Sep	-0.00103	-0.0001	0	0	-9E-05	-0.35873	-0.16447	0.17666	0	0.01548
161	22-Sep	-0.00103	-1E-04	0	0	-0.0001	-0.35976	-0.16457	0.17666	0	0.01538
162	23-Sep	-0.00104	-9E-05	0	0	-9E-05	-0.3608	-0.16466	0.17666	0	0.01529
163	24-Sep	-0.00103	-9E-05	0	0	-7E-05	-0.36183	-0.16475	0.17666	0	0.01522
164	25-Sep	-0.00103	-9E-05	0	0	-9E-05	-0.36286	-0.16484	0.17666	0	0.01513
165	26-Sep	-0.00103	-0.0001	0	0	-9E-05	-0.36389	-0.16494	0.17666	0	0.01504
166	27-Sep	-0.00104	-9E-05	0	0	-9E-05	-0.36493	-0.16503	0.17666	0	0.01495
167	28-Sep	-0.00103	-8E-05	0	0	-9E-05	-0.36596	-0.16511	0.17666	0	0.01486
168	29-Sep	-0.00103	-9E-05	0	0	-8E-05	-0.36699	-0.1652	0.17666	0	0.01478
169	30-Sep	-0.00104	-6E-05	0	0	-6E-05	-0.36803	-0.16526	0.17666	0	0.01472
170	1-Oct	-0.00055	-6E-05	0	0	-6E-05	-0.36858	-0.16532	0.17666	0	0.01466
171	2-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
172	3-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
173	4-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
174	5-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
175	6-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
176	7-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
177	8-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
178	9-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
179	10-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
180	11-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
181	12-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
182	13-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
183	14-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
184	15-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
185	16-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
186	17-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
187	18-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
188	19-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17666	0	0.01466
189	20-Oct	0	0	0.00109	0	0.00109	-0.36858	-0.16532	0.17775	0	0.01575
190	21-Oct	0	0	0.00165	0	0.00164	-0.36858	-0.16532	0.1794	0	0.01739
191	22-Oct	0	0	0.00036	0	0.00037	-0.36858	-0.16532	0.17976	0	0.01776
192	23-Oct	0	0	1E-05	0	1E-05	-0.36858	-0.16532	0.17977	0	0.01777
193	24-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17977	0	0.01777
194	25-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17977	0	0.01777
195	26-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17977	0	0.01777
196	27-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17977	0	0.01777
197	28-Oct	0	0	0	0	0	-0.36858	-0.16532	0.17977	0	0.01777
198	29-Oct	0	0	0.0008	0	0.00081	-0.36858	-0.16532	0.18057	0	0.01858
199	30-Oct	0	0	0.00131	0	0.0013	-0.36858	-0.16532	0.18188	0	0.01988
200	31-Oct	0	0	4E-05	0	5E-05	-0.36858	-0.16532	0.18192	0	0.01993

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
CLIMATE WATER BALANCE
MEAN YEAR

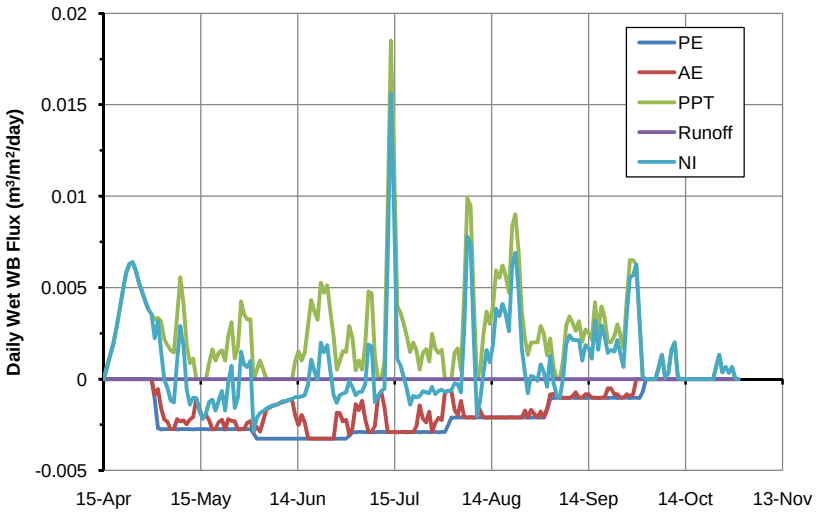


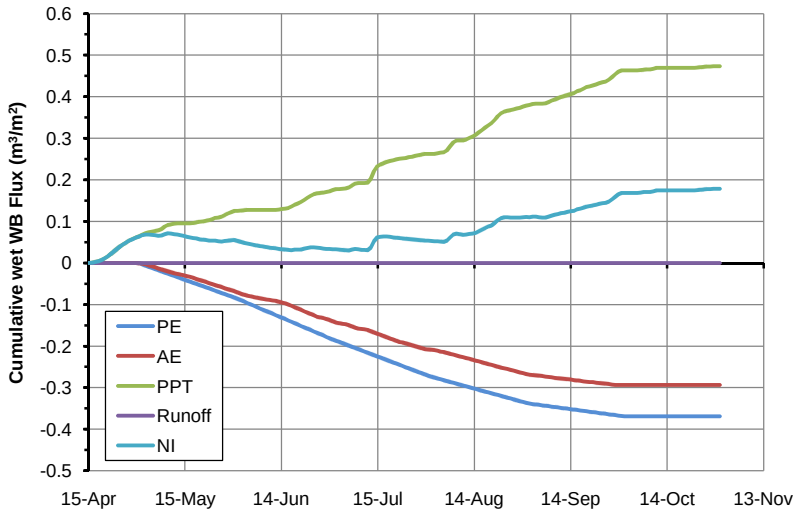


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.001	0	0	0	0	0.001	0	0
3	17-Apr	0	0	0	0	0.001	0	0	0.001	0	0.001
4	18-Apr	0	0	0.002	0	0.002	0	0	0.003	0	0.003
5	19-Apr	0	0	0.002	0	0.002	0	0	0.005	0	0.005
6	20-Apr	0	0	0.003	0	0.003	0	0	0.008	0	0.008
7	21-Apr	0	0	0.003	0	0.003	0	0	0.011	0	0.011
8	22-Apr	0	0	0.005	0	0.004	0	0	0.016	0	0.015
9	23-Apr	0	0	0.004	0	0.005	0	0	0.02	0	0.02
10	24-Apr	0	0	0.005	0	0.005	0	0	0.025	0	0.025
11	25-Apr	0	0	0.004	0	0.004	0	0	0.029	0	0.029
12	26-Apr	0	0	0.004	0	0.004	0	0	0.033	0	0.033
13	27-Apr	0	0	0.003	0	0.003	0	0	0.036	0	0.036
14	28-Apr	0	0	0.004	0	0.003	0	0	0.04	0	0.039
15	29-Apr	0	0	0.002	0	0.003	0	0	0.042	0	0.042
16	30-Apr	0	0	0.003	0	0.003	0	0	0.045	0	0.045
17	1-May	-0.001	-0.001	0.002	0	0.002	-0.001	-0.001	0.047	0	0.047
18	2-May	-0.003	-0.001	0.002	0	0.001	-0.004	-0.002	0.049	0	0.048
19	3-May	-0.002	-0.001	0.002	0	0	-0.006	-0.003	0.051	0	0.048
20	4-May	-0.003	-0.003	0.002	0	-0.001	-0.009	-0.006	0.053	0	0.047
21	5-May	-0.003	-0.002	0.002	0	0	-0.012	-0.008	0.055	0	0.047
22	6-May	-0.003	-0.003	0.004	0	0.001	-0.015	-0.011	0.059	0	0.048
23	7-May	-0.002	-0.003	0.004	0	0.002	-0.017	-0.014	0.063	0	0.05
24	8-May	-0.003	-0.002	0.002	0	0	-0.02	-0.016	0.065	0	0.05
25	9-May	-0.003	-0.001	0	0	-0.002	-0.023	-0.017	0.065	0	0.048
26	10-May	-0.003	-0.003	0	0	-0.002	-0.026	-0.02	0.065	0	0.046
27	11-May	-0.002	-0.002	0	0	-0.002	-0.028	-0.022	0.065	0	0.044
28	12-May	-0.003	-0.002	0.001	0	-0.002	-0.031	-0.024	0.066	0	0.042
29	13-May	-0.003	-0.002	0.001	0	0	-0.034	-0.026	0.067	0	0.042
30	14-May	-0.002	-0.001	0.004	0	0.003	-0.036	-0.027	0.071	0	0.045
31	15-May	-0.003	-0.002	0.005	0	0.003	-0.039	-0.029	0.076	0	0.048
32	16-May	-0.003	-0.002	0.002	0	-0.001	-0.042	-0.031	0.078	0	0.047
33	17-May	-0.003	-0.002	0	0	-0.003	-0.045	-0.033	0.078	0	0.044
34	18-May	-0.002	-0.003	0	0	-0.002	-0.047	-0.036	0.078	0	0.042
35	19-May	-0.003	-0.002	0	0	-0.002	-0.05	-0.038	0.078	0	0.04
36	20-May	-0.003	-0.001	0	0	-0.001	-0.053	-0.039	0.078	0	0.039
37	21-May	-0.003	-0.002	0	0	-0.002	-0.056	-0.041	0.078	0	0.037
38	22-May	-0.002	-0.001	0	0	-0.001	-0.058	-0.042	0.078	0	0.036
39	23-May	-0.003	-0.002	0	0	-0.002	-0.061	-0.044	0.078	0	0.034
40	24-May	-0.003	-0.001	0	0	-0.001	-0.064	-0.045	0.078	0	0.033
41	25-May	-0.003	-0.002	0.001	0	-0.001	-0.067	-0.047	0.079	0	0.032
42	26-May	-0.002	-0.002	0	0	-0.002	-0.069	-0.049	0.079	0	0.03
43	27-May	-0.003	-0.001	0	0	-0.001	-0.072	-0.05	0.079	0	0.029
44	28-May	-0.003	-0.002	0	0	-0.001	-0.075	-0.052	0.079	0	0.028
45	29-May	-0.003	-0.001	0.001	0	-0.001	-0.078	-0.053	0.08	0	0.027
46	30-May	-0.002	-0.001	0	0	-0.001	-0.08	-0.054	0.08	0	0.026
47	31-May	-0.003	-0.002	0	0	-0.001	-0.083	-0.056	0.08	0	0.025
48	1-Jun	-0.003	-0.001	0.001	0	-0.001	-0.086	-0.057	0.081	0	0.024
49	2-Jun	-0.003	-0.001	0	0	-0.001	-0.089	-0.058	0.081	0	0.023
50	3-Jun	-0.004	-0.002	0	0	-0.001	-0.093	-0.06	0.081	0	0.022
51	4-Jun	-0.003	-0.001	0.001	0	-0.001	-0.096	-0.061	0.082	0	0.021
52	5-Jun	-0.003	-0.001	0	0	-0.001	-0.099	-0.062	0.082	0	0.02
53	6-Jun	-0.003	-0.002	0.001	0	0	-0.102	-0.064	0.083	0	0.02
54	7-Jun	-0.004	-0.002	0.001	0	-0.001	-0.106	-0.066	0.084	0	0.019
55	8-Jun	-0.003	-0.003	0.003	0	0	-0.109	-0.069	0.087	0	0.019
56	9-Jun	-0.003	-0.002	0.001	0	-0.001	-0.112	-0.071	0.088	0	0.018
57	10-Jun	-0.003	-0.001	0	0	-0.001	-0.115	-0.072	0.088	0	0.017
58	11-Jun	-0.004	0	0	0	-0.001	-0.119	-0.072	0.088	0	0.016
59	12-Jun	-0.003	-0.001	0	0	0	-0.122	-0.073	0.088	0	0.016
60	13-Jun	-0.003	-0.001	0	0	-0.001	-0.125	-0.074	0.088	0	0.015
61	14-Jun	-0.004	0	0	0	-0.001	-0.129	-0.074	0.088	0	0.014
62	15-Jun	-0.003	-0.001	0	0	0	-0.132	-0.075	0.088	0	0.014
63	16-Jun	-0.003	-0.002	0.002	0	-0.001	-0.135	-0.077	0.09	0	0.013
64	17-Jun	-0.003	-0.003	0.002	0	0	-0.138	-0.08	0.092	0	0.013
65	18-Jun	-0.004	-0.004	0.004	0	0	-0.142	-0.084	0.096	0	0.013
66	19-Jun	-0.003	-0.003	0.008	0	0.005	-0.145	-0.087	0.104	0	0.018
67	20-Jun	-0.003	-0.003	0.011	0	0.007	-0.148	-0.09	0.115	0	0.025
68	21-Jun	-0.003	-0.003	0.007	0	0.004	-0.151	-0.093	0.122	0	0.029
69	22-Jun	-0.004	-0.004	0.007	0	0.004	-0.155	-0.097	0.129	0	0.033
70	23-Jun	-0.003	-0.003	0.004	0	0.001	-0.158	-0.1	0.133	0	0.034
71	24-Jun	-0.003	-0.003	0.001	0	-0.001	-0.161	-0.103	0.134	0	0.033
72	25-Jun	-0.003	-0.002	0.001	0	-0.001	-0.164	-0.105	0.135	0	0.032
73	26-Jun	-0.004	-0.001	0.001	0	-0.001	-0.168	-0.106	0.136	0	0.031
74	27-Jun	-0.003	-0.001	0	0	-0.001	-0.171	-0.107	0.136	0	0.03
75	28-Jun	-0.003	-0.002	0.001	0	-0.001	-0.174	-0.109	0.137	0	0.029
76	29-Jun	-0.004	-0.003	0.004	0	0.001	-0.178	-0.112	0.141	0	0.03
77	30-Jun	-0.003	-0.003	0.005	0	0.003	-0.181	-0.115	0.146	0	0.033
78	1-Jul	-0.003	-0.003	0.003	0	-0.001	-0.184	-0.118	0.149	0	0.032
79	2-Jul	-0.003	-0.002	0.001	0	-0.001	-0.187	-0.12	0.15	0	0.031
80	3-Jul	-0.003	-0.003	0.002	0	0	-0.19	-0.123	0.152	0	0.031
81	4-Jul	-0.003	-0.002	0.007	0	0.004	-0.193	-0.125	0.159	0	0.035
82	5-Jul	-0.003	-0.003	0.007	0	0.004	-0.196	-0.128	0.166	0	0.039
83	6-Jul	-0.002	-0.003	0.004	0	0.001	-0.198	-0.131	0.17	0	0.04
84	7-Jul	-0.003	-0.003	0.002	0	-0.001	-0.201	-0.134	0.172	0	0.039
85	8-Jul	-0.003	-0.003	0.006	0	0.003	-0.204	-0.137	0.178	0	0.042
86	9-Jul	-0.003	-0.003	0.007	0	0.004	-0.207	-0.14	0.185	0	0.046
87	10-Jul	-0.003	-0.003	0.006	0	0.003	-0.21	-0.143	0.191	0	0.049
88	11-Jul	-0.003	-0.003	0.002	0	-0.001	-0.213	-0.146	0.193	0	0.048
89	12-Jul	-0.003	-0.002	0	0	-0.001	-0.216	-0.148	0.193	0	0.047
90	13-Jul	-0.003	-0.002	0.002	0	-0.001	-0.219	-0.15	0.195	0	0.046

		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
91	14-Jul	-0.003	-0.003	0.002	0	-0.001	-0.222	-0.153	0.197	0	0.045
92	15-Jul	-0.003	-0.001	0	0	0	-0.225	-0.154	0.197	0	0.045
93	16-Jul	-0.002	-0.001	0.001	0	-0.001	-0.227	-0.155	0.198	0	0.044
94	17-Jul	-0.003	-0.001	0	0	-0.001	-0.23	-0.156	0.198	0	0.043
95	18-Jul	-0.003	-0.001	0	0	0	-0.233	-0.157	0.198	0	0.043
96	19-Jul	-0.003	-0.001	0.001	0	-0.001	-0.236	-0.158	0.199	0	0.042
97	20-Jul	-0.003	-0.002	0.001	0	-0.001	-0.239	-0.16	0.2	0	0.041
98	21-Jul	-0.003	-0.002	0.001	0	0	-0.242	-0.162	0.201	0	0.041
99	22-Jul	-0.003	-0.002	0.002	0	-0.001	-0.245	-0.164	0.203	0	0.04
100	23-Jul	-0.003	-0.002	0.002	0	0	-0.248	-0.166	0.205	0	0.04
101	24-Jul	-0.003	-0.002	0.001	0	-0.001	-0.251	-0.168	0.206	0	0.039
102	25-Jul	-0.003	-0.001	0	0	0	-0.254	-0.169	0.206	0	0.039
103	26-Jul	-0.003	-0.001	0.001	0	-0.001	-0.257	-0.17	0.207	0	0.038
104	27-Jul	-0.002	-0.001	0	0	0	-0.259	-0.171	0.207	0	0.038
105	28-Jul	-0.003	0	0	0	-0.001	-0.262	-0.171	0.207	0	0.037
106	29-Jul	-0.003	-0.001	0	0	0	-0.265	-0.172	0.207	0	0.037
107	30-Jul	-0.003	-0.001	0.001	0	-0.001	-0.268	-0.173	0.208	0	0.036
108	31-Jul	-0.003	-0.001	0.001	0	0	-0.271	-0.174	0.209	0	0.036
109	1-Aug	-0.003	-0.002	0.001	0	0	-0.274	-0.176	0.21	0	0.036
110	2-Aug	-0.002	0	0	0	-0.001	-0.276	-0.176	0.21	0	0.035
111	3-Aug	-0.002	-0.001	0	0	0	-0.278	-0.177	0.21	0	0.035
112	4-Aug	-0.002	-0.001	0.001	0	0	-0.28	-0.178	0.211	0	0.035
113	5-Aug	-0.002	-0.002	0.003	0	0	-0.282	-0.18	0.214	0	0.035
114	6-Aug	-0.002	-0.002	0.001	0	0	-0.284	-0.182	0.215	0	0.035
115	7-Aug	-0.002	-0.001	0.001	0	-0.001	-0.286	-0.183	0.216	0	0.034
116	8-Aug	-0.002	-0.001	0	0	0	-0.288	-0.184	0.216	0	0.034
117	9-Aug	-0.002	0	0	0	-0.001	-0.29	-0.184	0.216	0	0.033
118	10-Aug	-0.002	-0.001	0	0	0	-0.292	-0.185	0.216	0	0.033
119	11-Aug	-0.003	-0.001	0.001	0	0	-0.295	-0.186	0.217	0	0.033
120	12-Aug	-0.002	-0.001	0.001	0	0	-0.297	-0.187	0.218	0	0.033
121	13-Aug	-0.002	-0.003	0.003	0	0	-0.299	-0.19	0.221	0	0.033
122	14-Aug	-0.002	-0.001	0.001	0	-0.001	-0.301	-0.191	0.222	0	0.032
123	15-Aug	-0.002	-0.001	0	0	0	-0.303	-0.192	0.222	0	0.032
124	16-Aug	-0.002	-0.001	0.001	0	0	-0.305	-0.193	0.223	0	0.032
125	17-Aug	-0.002	-0.001	0	0	-0.001	-0.307	-0.194	0.223	0	0.031
126	18-Aug	-0.002	0	0	0	0	-0.309	-0.194	0.223	0	0.031
127	19-Aug	-0.002	-0.002	0.002	0	0.001	-0.311	-0.196	0.225	0	0.032
128	20-Aug	-0.002	-0.002	0.004	0	0.001	-0.313	-0.198	0.229	0	0.033
129	21-Aug	-0.002	-0.002	0.002	0	0	-0.315	-0.2	0.231	0	0.033
130	22-Aug	-0.003	-0.002	0.003	0	0.001	-0.318	-0.202	0.234	0	0.034
131	23-Aug	-0.002	-0.002	0.005	0	0.003	-0.32	-0.204	0.239	0	0.037
132	24-Aug	-0.002	-0.002	0.006	0	0.004	-0.322	-0.206	0.245	0	0.041
133	25-Aug	-0.002	-0.002	0	0	-0.002	-0.324	-0.208	0.245	0	0.039
134	26-Aug	-0.002	-0.001	0	0	-0.001	-0.326	-0.209	0.245	0	0.038
135	27-Aug	-0.002	-0.001	0.001	0	0	-0.328	-0.21	0.246	0	0.038
136	28-Aug	-0.002	-0.001	0	0	-0.001	-0.33	-0.211	0.246	0	0.037
137	29-Aug	-0.002	0	0	0	0	-0.332	-0.211	0.246	0	0.037
138	30-Aug	-0.002	0	0	0	0	-0.334	-0.211	0.246	0	0.037
139	31-Aug	-0.002	-0.001	0.001	0	-0.001	-0.336	-0.212	0.247	0	0.036
140	1-Sep	-0.002	-0.001	0.001	0	0	-0.338	-0.213	0.248	0	0.036
141	2-Sep	-0.001	-0.001	0.001	0	0.001	-0.339	-0.214	0.249	0	0.037
142	3-Sep	-0.001	-0.001	0.001	0	0	-0.34	-0.215	0.25	0	0.037
143	4-Sep	-0.001	-0.001	0.001	0	0	-0.341	-0.216	0.251	0	0.037
144	5-Sep	-0.001	-0.001	0	0	0	-0.342	-0.217	0.251	0	0.037
145	6-Sep	-0.001	0	0.001	0	-0.001	-0.343	-0.217	0.252	0	0.036
146	7-Sep	-0.001	-0.001	0.001	0	0	-0.344	-0.218	0.253	0	0.036
147	8-Sep	-0.001	-0.001	0	0	0	-0.345	-0.219	0.253	0	0.036
148	9-Sep	-0.001	-0.001	0	0	0	-0.346	-0.22	0.253	0	0.036
149	10-Sep	-0.001	0	0	0	-0.001	-0.347	-0.22	0.253	0	0.035
150	11-Sep	-0.001	0	0	0	0	-0.348	-0.22	0.253	0	0.035
151	12-Sep	-0.001	0	0	0	0	-0.349	-0.22	0.253	0	0.035
152	13-Sep	-0.001	-0.001	0.002	0	0.001	-0.35	-0.221	0.255	0	0.036
153	14-Sep	-0.002	-0.001	0.001	0	0	-0.352	-0.222	0.256	0	0.036
154	15-Sep	-0.001	-0.001	0	0	0	-0.353	-0.223	0.256	0	0.036
155	16-Sep	-0.001	0	0	0	-0.001	-0.354	-0.223	0.256	0	0.035
156	17-Sep	-0.001	0	0	0	0	-0.355	-0.223	0.256	0	0.035
157	18-Sep	-0.001	-0.001	0	0	0	-0.356	-0.224	0.256	0	0.035
158	19-Sep	-0.001	0	0.001	0	0	-0.357	-0.224	0.257	0	0.035
159	20-Sep	-0.001	-0.001	0.001	0	0	-0.358	-0.225	0.258	0	0.035
160	21-Sep	-0.001	-0.001	0.001	0	0	-0.359	-0.226	0.259	0	0.035
161	22-Sep	-0.001	0	0	0	0	-0.36	-0.226	0.259	0	0.035
162	23-Sep	-0.001	-0.001	0	0	0	-0.361	-0.227	0.259	0	0.035
163	24-Sep	-0.001	0	0	0	0	-0.362	-0.227	0.259	0	0.035
164	25-Sep	-0.001	0	0	0	-0.001	-0.363	-0.227	0.259	0	0.034
165	26-Sep	-0.001	0	0	0	0	-0.364	-0.227	0.259	0	0.034
166	27-Sep	-0.001	-0.001	0.001	0	0	-0.365	-0.228	0.26	0	0.034
167	28-Sep	-0.001	-0.001	0	0	0	-0.366	-0.229	0.26	0	0.034
168	29-Sep	-0.001	0	0	0	0	-0.367	-0.229	0.26	0	0.034
169	30-Sep	-0.001	0	0	0	0	-0.368	-0.229	0.26	0	0.034
170	1-Oct	-0.001	0	0	0	0	-0.369	-0.229	0.26	0	0.034
171	2-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
172	3-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
173	4-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
174	5-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
175	6-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
176	7-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
177	8-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
178	9-Oct	0	0	0	0	0	-0.369	-0.229	0.26	0	0.034
179	10-Oct	0	0	0.001	0	0	-0.369	-0.229	0.261	0	0.034
180	11-Oct	0	0	0	0	0.001	-0.369	-0.229	0.261	0	0.035
181	12-Oct	0	0	0	0	0	-0.369	-0.229	0.261	0	0.035
182	13-Oct	0	0	0	0	0	-0.369	-0.229	0.261	0	0.035
183	14-Oct	0	0	0.002	0	0.001	-0.369	-0.229	0.263	0	0.036
184	15-Oct	0	0	0.001	0	0.002	-0.369	-0.229	0.264	0	0.038
185	16-Oct	0	0	0	0	0	-0.369	-0.229	0.264	0	0.038
186	17-Oct	0	0	0	0	0	-0.369	-0.229	0.264	0	0.038
187	18-Oct	0	0	0	0	0	-0.369	-0.229	0.264	0	0.038
188	19-Oct	0	0	0.001	0	0.001	-0.369	-0.229	0.265	0	0.039
189	20-Oct	0	0	0.002	0	0.001	-0.369	-0.229	0.267	0	0.04
190	21-Oct	0	0	0	0	0.001	-0.369	-0.229	0.267	0	0.041
191	22-Oct	0	0	0	0	0	-0.369	-0.229	0.267	0	0.041
192	23-Oct	0	0	0.001	0	0.001	-0.369	-0.229	0.268	0	0.042
193	24-Oct	0	0	0.004	0	0.003	-0.369	-0.229	0.272	0	0.045
194	25-Oct	0	0	0.003	0	0.003	-0.369	-0.229	0.275	0	0.048
195	26-Oct	0	0	0.003	0	0.004	-0.369	-0.229	0.278	0	0.052
196	27-Oct	0	0	0.003	0	0.003	-0.369	-0.229	0.281	0	0.055
197	28-Oct	0	0	0	0	0	-0.369	-0.229	0.281	0	0.055
198	29-Oct	0	0	0.001	0	0.001	-0.369	-0.229	0.282	0	0.056
199	30-Oct	0	0	0	0	0	-0.369	-0.229	0.282	0	0.056
200	31-Oct	0	0	0.001	0	0.001	-0.369	-0.229	0.283	0	0.057

OPTION 3 - IN PIT TAILINGS PLUS 1 M COVER
CLIMATE WATER BALANCE
WET YEAR

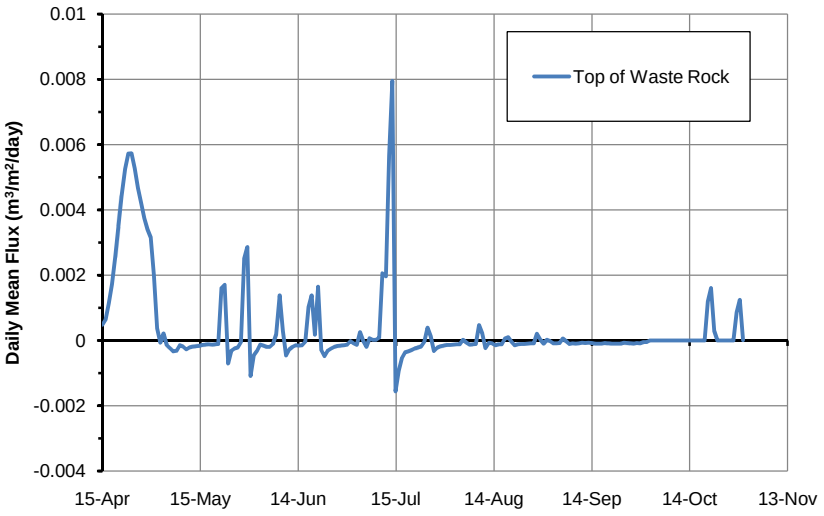


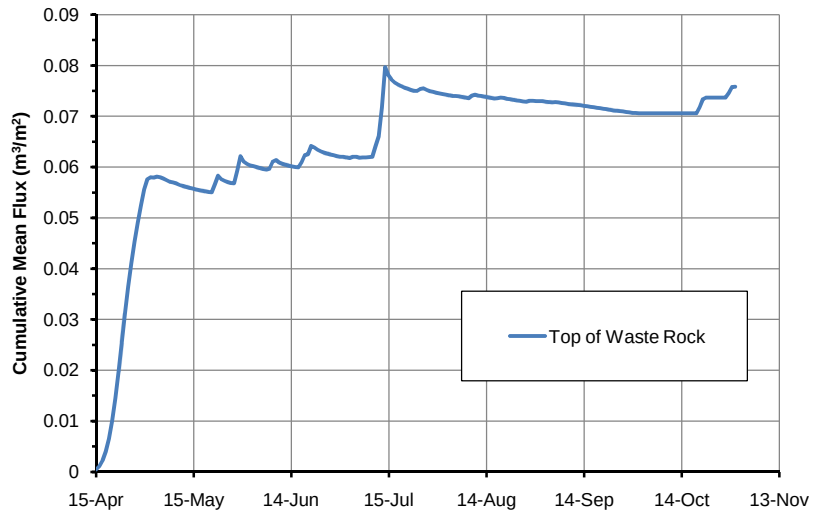


		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
1	15-Apr	0	0	0	0	0	0	0	0	0	0
2	16-Apr	0	0	0.00075	0	0.00063	0	0	0.00075	0	0.00063
3	17-Apr	0	0	0.0013	0	0.0013	0	0	0.00205	0	0.00193
4	18-Apr	0	0	0.00195	0	0.00195	0	0	0.004	0	0.00388
5	19-Apr	0	0	0.00285	0	0.00285	0	0	0.00685	0	0.00673
6	20-Apr	0	0	0.00384	0	0.00385	0	0	0.01069	0	0.01058
7	21-Apr	0	0	0.00489	0	0.00489	0	0	0.01558	0	0.01547
8	22-Apr	0	0	0.00582	0	0.00582	0	0	0.0214	0	0.02129
9	23-Apr	0	0	0.0063	0	0.0063	0	0	0.0277	0	0.02759
10	24-Apr	0	0	0.00638	0	0.00639	0	0	0.03408	0	0.03398
11	25-Apr	0	0	0.00593	0	0.00593	0	0	0.04001	0	0.03991
12	26-Apr	0	0	0.00525	0	0.00524	0	0	0.04526	0	0.04515
13	27-Apr	0	0	0.00475	0	0.00476	0	0	0.05001	0	0.04991
14	28-Apr	0	0	0.00423	0	0.00423	0	0	0.05424	0	0.05414
15	29-Apr	0	0	0.00381	0	0.0038	0	0	0.05805	0	0.05794
16	30-Apr	0	0	0.00355	0	0.00355	0	0	0.0616	0	0.06149
17	1-May	-0.0011	-0.00088	0.00327	0	0.00223	-0.0011	-0.00088	0.06487	0	0.06372
18	2-May	-0.00268	-0.00055	0.00334	0	0.00317	-0.00378	-0.00143	0.06821	0	0.06689
19	3-May	-0.00275	-0.0016	0.00312	0	0.00152	-0.00653	-0.00303	0.07133	0	0.06841
20	4-May	-0.00274	-0.00221	0.00217	0	-4E-05	-0.00927	-0.00524	0.0735	0	0.06837
21	5-May	-0.00274	-0.00234	0.00184	0	-0.0005	-0.01201	-0.00758	0.07534	0	0.06787
22	6-May	-0.00274	-0.00274	0.00156	0	-0.00118	-0.01475	-0.01032	0.0769	0	0.06669
23	7-May	-0.00274	-0.00274	0.00145	0	-0.00128	-0.01749	-0.01306	0.07835	0	0.06541
24	8-May	-0.00275	-0.0022	0.00345	0	0.001	-0.02024	-0.01526	0.0818	0	0.06641
25	9-May	-0.00274	-0.00231	0.00555	0	0.0029	-0.02298	-0.01757	0.08735	0	0.06931
26	10-May	-0.00274	-0.00226	0.00413	0	0.00178	-0.02572	-0.01983	0.09148	0	0.07109
27	11-May	-0.00274	-0.00247	0.00186	0	-0.00059	-0.02846	-0.0223	0.09334	0	0.0705
28	12-May	-0.00274	-0.00222	0.00086	0	-0.00141	-0.0312	-0.02452	0.0942	0	0.06909
29	13-May	-0.00275	-0.00209	0.00111	0	-0.00103	-0.03395	-0.02661	0.09531	0	0.06806
30	14-May	-0.00274	-0.00109	0	0	-0.00104	-0.03669	-0.0277	0.09531	0	0.06702
31	15-May	-0.00274	-0.00165	0	0	-0.00175	-0.03943	-0.02935	0.09531	0	0.06527
32	16-May	-0.00274	-0.00214	0	0	-0.00218	-0.04217	-0.03149	0.09531	0	0.06309
33	17-May	-0.00274	-0.00197	0	0	-0.00189	-0.04491	-0.03346	0.09531	0	0.0612
34	18-May	-0.00275	-0.00225	0.00086	0	-0.00126	-0.04766	-0.03571	0.09617	0	0.05994
35	19-May	-0.00274	-0.00275	0.00162	0	-0.00112	-0.0504	-0.03846	0.09779	0	0.05882
36	20-May	-0.00274	-0.00274	0.001	0	-0.00173	-0.05314	-0.0412	0.09879	0	0.05709
37	21-May	-0.00274	-0.00235	0.00145	0	-0.00118	-0.05588	-0.04355	0.10024	0	0.05591
38	22-May	-0.00274	-0.00223	0.00156	0	-0.00066	-0.05862	-0.04578	0.1018	0	0.05525
39	23-May	-0.00275	-0.00274	0.001	0	-0.00172	-0.06137	-0.04852	0.1028	0	0.05353
40	24-May	-0.00274	-0.0022	0.00236	0	-0.00017	-0.06411	-0.05072	0.10516	0	0.05336
41	25-May	-0.00274	-0.00229	0.0031	0	0.00073	-0.06685	-0.05301	0.10826	0	0.05409
42	26-May	-0.00274	-0.00232	0.00113	0	-0.00159	-0.06959	-0.05533	0.10939	0	0.0525
43	27-May	-0.00274	-0.00275	0.00176	0	-0.00099	-0.07233	-0.05808	0.11115	0	0.05151
44	28-May	-0.00275	-0.00274	0.00424	0	0.0015	-0.07508	-0.06082	0.11539	0	0.05301
45	29-May	-0.00274	-0.00274	0.00354	0	0.0008	-0.07782	-0.06356	0.11893	0	0.05381
46	30-May	-0.00274	-0.00238	0.00327	0	0.00065	-0.08056	-0.06594	0.1222	0	0.05446
47	31-May	-0.00274	-0.0023	0.00326	0	0.00099	-0.0833	-0.06824	0.12546	0	0.05545
48	1-Jun	-0.00298	-0.00288	0	0	-0.00284	-0.08628	-0.07112	0.12546	0	0.05261
49	2-Jun	-0.00326	-0.00262	0.00048	0	-0.00212	-0.08954	-0.07374	0.12594	0	0.05049
50	3-Jun	-0.00327	-0.00287	0.001	0	-0.00187	-0.09281	-0.07661	0.12694	0	0.04862
51	4-Jun	-0.00327	-0.00228	0.00052	0	-0.00175	-0.09608	-0.07889	0.12746	0	0.04687
52	5-Jun	-0.00326	-0.00166	0	0	-0.00162	-0.09934	-0.08055	0.12746	0	0.04525
53	6-Jun	-0.00327	-0.00156	0	0	-0.00152	-0.10261	-0.08211	0.12746	0	0.04373
54	7-Jun	-0.00327	-0.00148	0	0	-0.00145	-0.10588	-0.08359	0.12746	0	0.04228
55	8-Jun	-0.00326	-0.0014	0	0	-0.00142	-0.10914	-0.08499	0.12746	0	0.04086
56	9-Jun	-0.00327	-0.00134	0	0	-0.00134	-0.11241	-0.08633	0.12746	0	0.03952
57	10-Jun	-0.00327	-0.00126	0	0	-0.00121	-0.11568	-0.08759	0.12746	0	0.03831
58	11-Jun	-0.00327	-0.00121	0	0	-0.00121	-0.11895	-0.0888	0.12746	0	0.0371
59	12-Jun	-0.00326	-0.00115	0	0	-0.00114	-0.12221	-0.08995	0.12746	0	0.03596
60	13-Jun	-0.00327	-0.00111	0	0	-0.00109	-0.12548	-0.09106	0.12746	0	0.03487
61	14-Jun	-0.00327	-0.00199	0.00097	0	-0.00099	-0.12875	-0.09305	0.12843	0	0.03388
62	15-Jun	-0.00326	-0.00251	0.00152	0	-0.00099	-0.13201	-0.09556	0.12995	0	0.03289
63	16-Jun	-0.00327	-0.00196	0.001	0	-0.00096	-0.13528	-0.09752	0.13095	0	0.03193
64	17-Jun	-0.00327	-0.00239	0.00147	0	-0.00088	-0.13855	-0.09991	0.13242	0	0.03105
65	18-Jun	-0.00326	-0.00322	0.00291	0	-0.00031	-0.14181	-0.10313	0.13533	0	0.03074
66	19-Jun	-0.00327	-0.00327	0.00432	0	0.00106	-0.14508	-0.1064	0.13965	0	0.0318
67	20-Jun	-0.00327	-0.00327	0.0037	0	0.00043	-0.14835	-0.10967	0.14335	0	0.03223
68	21-Jun	-0.00327	-0.00326	0.00324	0	-2E-05	-0.15162	-0.11293	0.14659	0	0.03221
69	22-Jun	-0.00326	-0.00327	0.00526	0	0.00199	-0.15488	-0.1162	0.15185	0	0.0342
70	23-Jun	-0.00327	-0.00327	0.00472	0	0.00146	-0.15815	-0.11947	0.15657	0	0.03566
71	24-Jun	-0.00327	-0.00326	0.00512	0	0.00185	-0.16142	-0.12273	0.16169	0	0.03751
72	25-Jun	-0.00326	-0.00327	0.00368	0	0.00041	-0.16468	-0.126	0.16537	0	0.03792
73	26-Jun	-0.00327	-0.00327	0.00234	0	-0.00088	-0.16795	-0.12927	0.16771	0	0.03704
74	27-Jun	-0.00327	-0.00184	0.00051	0	-0.00131	-0.17122	-0.13111	0.16822	0	0.03573
75	28-Jun	-0.00326	-0.00187	0.00097	0	-0.00088	-0.17448	-0.13298	0.16919	0	0.03485
76	29-Jun	-0.00327	-0.00232	0.00152	0	-0.00079	-0.17775	-0.1353	0.17071	0	0.03406
77	30-Jun	-0.00327	-0.00223	0.00148	0	-0.00073	-0.18102	-0.13753	0.17219	0	0.03333
78	1-Jul	-0.0031	-0.00303	0.0029	0	-0.00012	-0.18412	-0.14056	0.17509	0	0.03321
79	2-Jul	-0.0029	-0.00269	0.00224	0	-0.00044	-0.18702	-0.14325	0.17733	0	0.03277
80	3-Jul	-0.00291	-0.00138	0.00048	0	-0.00089	-0.18993	-0.14463	0.17781	0	0.03188
81	4-Jul	-0.0029	-0.00171	0.001	0	-0.0007	-0.19283	-0.14634	0.17881	0	0.03118
82	5-Jul	-0.0029	-0.00119	0.00051	0	-0.00069	-0.19573	-0.14753	0.17932	0	0.03049
83	6-Jul	-0.00291	-0.00221	0.00192	0	-0.00027	-0.19864	-0.14974	0.18124	0	0.03022
84	7-Jul	-0.0029	-0.0029	0.00478	0	0.00189	-0.20154	-0.15264	0.18602	0	0.03211
85	8-Jul	-0.0029	-0.0029	0.00468	0	0.00178	-0.20444	-0.15554	0.1907	0	0.03389
86	9-Jul	-0.00291	-0.00256	0.00125	0	-0.00127	-0.20735	-0.1581	0.19195	0	0.03262
87	10-Jul	-0.0029	-0.00094	0	0	-0.00094	-0.21025	-0.15904	0.19195	0	0.03168
88	11-Jul	-0.0029	-0.0007	0	0	-0.00066	-0.21315	-0.15974	0.19195	0	0.03102
89	12-Jul	-0.0029	-0.00155	0.00097	0	-0.00054	-0.21605	-0.16129	0.19292	0	0.03048
90	13-Jul	-0.00291	-0.00289	0.00933	0	0.00644	-0.21896	-0.16418	0.20225	0	0.03692
91	14-Jul	-0.0029	-0.0029	0.0185	0	0.0156	-0.22186	-0.16708	0.22075	0	0.05252

		DAILY VALUES VS. TIME (m^3/m^2/day)					CUMULATIVE VALUES VS. TIME (m^3/m^2)				
Time	Date	PE	AE	PPT	Runoff	NI	PE	AE	PPT	Runoff	NI
92	15-Jul	-0.0029	-0.0029	0.012	0	0.0091	-0.22476	-0.16998	0.23275	0	0.06162
93	16-Jul	-0.00291	-0.00291	0.004	0	0.0011	-0.22767	-0.17289	0.23675	0	0.06272
94	17-Jul	-0.0029	-0.0029	0.00364	0	0.00074	-0.23057	-0.17579	0.24039	0	0.06346
95	18-Jul	-0.0029	-0.0029	0.00302	0	0.00012	-0.23347	-0.17869	0.24341	0	0.06358
96	19-Jul	-0.00291	-0.00291	0.00232	0	-0.00057	-0.23638	-0.1816	0.24573	0	0.06301
97	20-Jul	-0.0029	-0.0029	0.00148	0	-0.00141	-0.23928	-0.1845	0.24721	0	0.0616
98	21-Jul	-0.0029	-0.0029	0.00198	0	-0.00091	-0.24218	-0.1874	0.24919	0	0.06069
99	22-Jul	-0.0029	-0.00258	0.00156	0	-0.001	-0.24508	-0.18998	0.25075	0	0.05969
100	23-Jul	-0.00291	-0.00145	0.00052	0	-0.00094	-0.24799	-0.19143	0.25127	0	0.05875
101	24-Jul	-0.0029	-0.00217	0.00145	0	-0.00068	-0.25089	-0.1936	0.25272	0	0.05807
102	25-Jul	-0.0029	-0.00237	0.00164	0	-0.00073	-0.25379	-0.19597	0.25436	0	0.05734
103	26-Jul	-0.00291	-0.00179	0.00095	0	-0.00078	-0.2567	-0.19776	0.25531	0	0.05656
104	27-Jul	-0.0029	-0.00289	0.00246	0	-0.00042	-0.2596	-0.20065	0.25777	0	0.05614
105	28-Jul	-0.0029	-0.00238	0.00166	0	-0.00083	-0.2625	-0.20303	0.25943	0	0.05531
106	29-Jul	-0.00291	-0.00213	0.00143	0	-0.00066	-0.26541	-0.20516	0.26086	0	0.05465
107	30-Jul	-0.0029	-0.00225	0.0016	0	-0.00059	-0.26831	-0.20741	0.26246	0	0.05406
108	31-Jul	-0.0029	-0.00072	0	0	-0.0007	-0.27121	-0.20813	0.26246	0	0.05336
109	1-Aug	-0.00252	-0.00066	0	0	-0.00065	-0.27373	-0.20879	0.26246	0	0.05271
110	2-Aug	-0.0021	-0.00063	0	0	-0.00062	-0.27583	-0.20942	0.26246	0	0.05209
111	3-Aug	-0.0021	-0.00169	0.00142	0	-0.00023	-0.27793	-0.21111	0.26388	0	0.05186
112	4-Aug	-0.0021	-0.00199	0.00168	0	-0.00029	-0.28003	-0.2131	0.26556	0	0.05157
113	5-Aug	-0.00209	-0.0012	0.00048	0	-0.00072	-0.28212	-0.2143	0.26604	0	0.05085
114	6-Aug	-0.0021	-0.00208	0.00467	0	0.0026	-0.28422	-0.21638	0.27071	0	0.05345
115	7-Aug	-0.0021	-0.0021	0.00989	0	0.0078	-0.28632	-0.21848	0.2806	0	0.06125
116	8-Aug	-0.00209	-0.00209	0.0095	0	0.0074	-0.28841	-0.22057	0.2901	0	0.06865
117	9-Aug	-0.0021	-0.0021	0.00432	0	0.00224	-0.29051	-0.22267	0.29442	0	0.07089
118	10-Aug	-0.0021	-0.00208	0	0	-0.00203	-0.29261	-0.22475	0.29442	0	0.06886
119	11-Aug	-0.00209	-0.00169	0.00049	0	-0.00117	-0.2947	-0.22644	0.29491	0	0.06769
120	12-Aug	-0.0021	-0.00209	0.00239	0	0.00031	-0.2968	-0.22853	0.2973	0	0.068
121	13-Aug	-0.0021	-0.0021	0.00368	0	0.00158	-0.2989	-0.23063	0.30098	0	0.06958
122	14-Aug	-0.0021	-0.00209	0.00302	0	0.00092	-0.301	-0.23272	0.304	0	0.0705
123	15-Aug	-0.00209	-0.0021	0.00396	0	0.00187	-0.30309	-0.23482	0.30796	0	0.07237
124	16-Aug	-0.0021	-0.0021	0.00594	0	0.00384	-0.30519	-0.23692	0.3139	0	0.07621
125	17-Aug	-0.0021	-0.00209	0.00554	0	0.00344	-0.30729	-0.23901	0.31944	0	0.07965
126	18-Aug	-0.00209	-0.0021	0.0062	0	0.0041	-0.30938	-0.24111	0.32564	0	0.08375
127	19-Aug	-0.0021	-0.0021	0.00564	0	0.00355	-0.31148	-0.24321	0.33128	0	0.0873
128	20-Aug	-0.0021	-0.00209	0.00472	0	0.00262	-0.31358	-0.2453	0.336	0	0.08992
129	21-Aug	-0.00209	-0.0021	0.00832	0	0.00622	-0.31567	-0.2474	0.34432	0	0.09614
130	22-Aug	-0.0021	-0.0021	0.009	0	0.00691	-0.31777	-0.2495	0.35332	0	0.10305
131	23-Aug	-0.0021	-0.00209	0.007	0	0.0049	-0.31987	-0.25159	0.36032	0	0.10795
132	24-Aug	-0.0021	-0.0021	0.00378	0	0.00168	-0.32197	-0.25369	0.3641	0	0.10963
133	25-Aug	-0.00209	-0.00172	0.00221	0	0.00033	-0.32406	-0.25541	0.36631	0	0.10996
134	26-Aug	-0.0021	-0.0021	0.00132	0	-0.00078	-0.32616	-0.25751	0.36763	0	0.10918
135	27-Aug	-0.0021	-0.00169	0.00198	0	0.00016	-0.32826	-0.2592	0.36961	0	0.10934
136	28-Aug	-0.00209	-0.00192	0.002	0	9E-05	-0.33035	-0.26112	0.37161	0	0.10943
137	29-Aug	-0.0021	-0.00209	0.002	0	-0.0001	-0.33245	-0.26321	0.37361	0	0.10933
138	30-Aug	-0.0021	-0.00177	0.00289	0	0.0008	-0.33455	-0.26498	0.3765	0	0.11013
139	31-Aug	-0.00209	-0.0021	0.00247	0	0.00038	-0.33664	-0.26708	0.37897	0	0.11051
140	1-Sep	-0.00167	-0.00166	0.0013	0	-0.00042	-0.33831	-0.26874	0.38027	0	0.11009
141	2-Sep	-0.00105	-0.00085	0.00221	0	0.00127	-0.33936	-0.26959	0.38248	0	0.11136
142	3-Sep	-0.00104	-0.00082	0.00067	0	-0.00019	-0.3404	-0.27041	0.38315	0	0.11117
143	4-Sep	-0.00103	-0.00086	2E-05	0	-0.00089	-0.34143	-0.27127	0.38317	0	0.11028
144	5-Sep	-0.00103	-0.00104	0	0	-0.00103	-0.34246	-0.27231	0.38317	0	0.10925
145	6-Sep	-0.00103	-0.00103	0.00105	0	2E-05	-0.34349	-0.27334	0.38422	0	0.10927
146	7-Sep	-0.00104	-0.00103	0.00294	0	0.00191	-0.34453	-0.27437	0.38716	0	0.11118
147	8-Sep	-0.00103	-0.00104	0.00342	0	0.00239	-0.34556	-0.27541	0.39058	0	0.11357
148	9-Sep	-0.00103	-0.00093	0.00308	0	0.00215	-0.34659	-0.27634	0.39366	0	0.11572
149	10-Sep	-0.00104	-0.00072	0.00264	0	0.00212	-0.34763	-0.27706	0.3963	0	0.11784
150	11-Sep	-0.00103	-0.00103	0.00316	0	0.00213	-0.34866	-0.27809	0.39946	0	0.11997
151	12-Sep	-0.00103	-0.00103	0.00204	0	0.00101	-0.34969	-0.27912	0.4015	0	0.12098
152	13-Sep	-0.00104	-0.00083	0.00271	0	0.00184	-0.35073	-0.27995	0.40421	0	0.12282
153	14-Sep	-0.00103	-0.00083	0.00252	0	0.0017	-0.35176	-0.28078	0.40673	0	0.12452
154	15-Sep	-0.00103	-0.00103	0.00215	0	0.00112	-0.35279	-0.28181	0.40888	0	0.12564
155	16-Sep	-0.00103	-0.00103	0.0042	0	0.00317	-0.35382	-0.28284	0.41308	0	0.12881
156	17-Sep	-0.00104	-0.00104	0.00264	0	0.00161	-0.35486	-0.28388	0.41572	0	0.13042
157	18-Sep	-0.00103	-0.00103	0.00396	0	0.00293	-0.35589	-0.28491	0.41968	0	0.13335
158	19-Sep	-0.00103	-0.00103	0.00336	0	0.00232	-0.35692	-0.28594	0.42304	0	0.13567
159	20-Sep	-0.00104	-0.00052	0.00204	0	0.00143	-0.35796	-0.28646	0.42508	0	0.1371
160	21-Sep	-0.00103	-0.00051	0.002	0	0.00158	-0.35899	-0.28697	0.42708	0	0.13868
161	22-Sep	-0.00103	-0.00083	0.00234	0	0.00149	-0.36002	-0.2878	0.42942	0	0.14017
162	23-Sep	-0.00104	-0.00083	0.00298	0	0.00213	-0.36106	-0.28863	0.4324	0	0.1423
163	24-Sep	-0.00103	-0.00103	0.00236	0	0.00133	-0.36209	-0.28966	0.43476	0	0.14363
164	25-Sep	-0.00103	-0.00103	0.00168	0	0.00065	-0.36312	-0.29069	0.43644	0	0.14428
165	26-Sep	-0.00103	-0.00083	0.00434	0	0.00348	-0.36415	-0.29152	0.44078	0	0.14776
166	27-Sep	-0.00104	-0.00093	0.0065	0	0.00557	-0.36519	-0.29245	0.44728	0	0.15333
167	28-Sep	-0.00103	-0.00083	0.0065	0	0.00567	-0.36622	-0.29328	0.45378	0	0.159
168	29-Sep	-0.00103	0	0.00624	0	0.00625	-0.36725	-0.29328	0.46002	0	0.16525
169	30-Sep	-0.00104	0	0.0032	0	0.0032	-0.36829	-0.29328	0.46322	0	0.16845
170	1-Oct	-0.0007	0	1E-04	0	0.0001	-0.36899	-0.29328	0.46332	0	0.16855
171	2-Oct	-2E-05	0	0	0	0	-0.36901	-0.29328	0.46332	0	0.16855
172	3-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46332	0	0.16855
173	4-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46332	0	0.16855
174	5-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46332	0	0.16855
175	6-Oct	0	0	0.00064	0	0.00064	-0.36901	-0.29328	0.46396	0	0.16919
176	7-Oct	0	0	0.00132	0	0.00132	-0.36901	-0.29328	0.46528	0	0.17051
177	8-Oct	0	0	4E-05	0	4E-05	-0.36901	-0.29328	0.46532	0	0.17055
178	9-Oct	0	0	0.00032	0	0.00032	-0.36901	-0.29328	0.46564	0	0.17087
179	10-Oct	0	0	0.00162	0	0.00162	-0.36901	-0.29328	0.46726	0	0.17249
180	11-Oct	0	0	0.002	0	0.002	-0.36901	-0.29328	0.46926	0	0.17449
181	12-Oct	0	0	6E-05	0	6E-05	-0.36901	-0.29328	0.46932	0	0.17455
182	13-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
183	14-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
184	15-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
185	16-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
186	17-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
187	18-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
188	19-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
189	20-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
190	21-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
191	22-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
192	23-Oct	0	0	0	0	0	-0.36901	-0.29328	0.46932	0	0.17455
193	24-Oct	0	0	0.00064	0	0.00064	-0.36901	-0.29328	0.46996	0	0.17519
194	25-Oct	0	0	0.00132	0	0.00132	-0.36901	-0.29328	0.47128	0	0.17651
195	26-Oct	0	0	0.00036	0	0.00036	-0.36901	-0.29328	0.47164	0	0.17687
196	27-Oct	0	0	0.00066	0	0.00066	-0.36901	-0.29328	0.4723	0	0.17753
197	28-Oct	0	0	0.00034	0	0.00034	-0.36901	-0.29328	0.47264	0	0.17787
198	29-Oct	0	0	0.00066	0	0.00066	-0.36901	-0.29328	0.4733	0	0.17853
199	30-Oct	0	0	2E-05	0	2E-05	-0.36901	-0.29328	0.47332	0	0.17855
200	31-Oct	0	0	0	0	0	-0.36901	-0.29328	0.47332	0	0.17855

OPTION B - IN PIT WASTE ROCK
SUMMARY FLUXES THROUGH WASTE ROCK
DRY YEAR

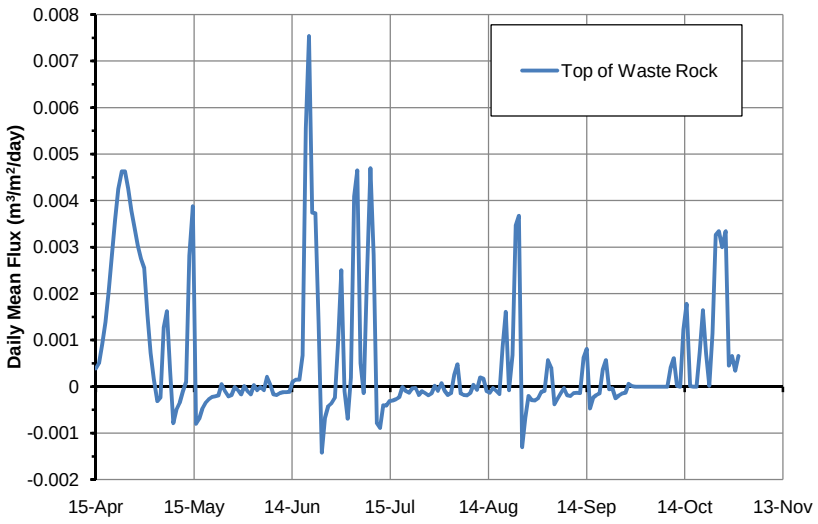


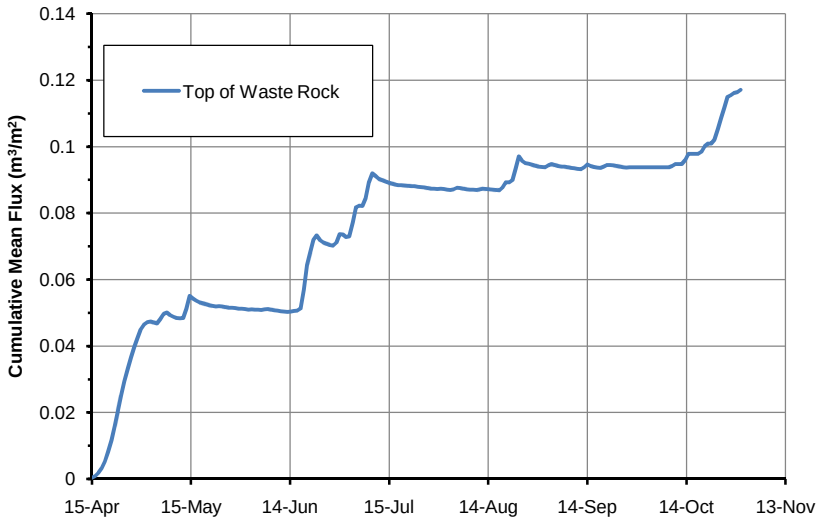


		DAILY VALUES VS. TIME (m^3/m^2/day)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
1	15-Apr	0.00048	0.00048
2	16-Apr	0.00064	0.00112
3	17-Apr	0.00114	0.00226
4	18-Apr	0.00173	0.00399
5	19-Apr	0.00255	0.00654
6	20-Apr	0.00349	0.01003
7	21-Apr	0.00443	0.01446
8	22-Apr	0.00525	0.01971
9	23-Apr	0.00572	0.02543
10	24-Apr	0.00573	0.03116
11	25-Apr	0.00527	0.03643
12	26-Apr	0.00468	0.04111
13	27-Apr	0.00421	0.04532
14	28-Apr	0.00374	0.04906
15	29-Apr	0.0034	0.05246
16	30-Apr	0.00316	0.05562
17	1-May	0.00199	0.05761
18	2-May	0.00037	0.05798
19	3-May	-7E-05	0.05791
20	4-May	0.00022	0.05813
21	5-May	-0.00014	0.05799
22	6-May	-0.00023	0.05776
23	7-May	-0.00033	0.05743
24	8-May	-0.00031	0.05712
25	9-May	-0.00015	0.05697
26	10-May	-0.00019	0.05678
27	11-May	-0.00027	0.05651
28	12-May	-0.00021	0.0563
29	13-May	-0.00019	0.05611
30	14-May	-0.00018	0.05593
31	15-May	-0.00017	0.05576
32	16-May	-0.00014	0.05562
33	17-May	-0.00013	0.05549
34	18-May	-0.00012	0.05537
35	19-May	-0.00013	0.05524
36	20-May	-0.00012	0.05512
37	21-May	-0.00011	0.05501
38	22-May	0.00161	0.05662
39	23-May	0.00171	0.05833
40	24-May	-0.0007	0.05763
41	25-May	-0.00031	0.05732
42	26-May	-0.00024	0.05708
43	27-May	-0.00021	0.05687
44	28-May	-5E-05	0.05682
45	29-May	0.0025	0.05932
46	30-May	0.00286	0.06218
47	31-May	-0.00109	0.06109
48	1-Jun	-0.00046	0.06063
49	2-Jun	-0.00032	0.06031
50	3-Jun	-0.00013	0.06018
51	4-Jun	-0.00016	0.06002
52	5-Jun	-0.0002	0.05982
53	6-Jun	-0.0002	0.05962
54	7-Jun	-0.00011	0.05951
55	8-Jun	0.00019	0.0597
56	9-Jun	0.00138	0.06108
57	10-Jun	0.00029	0.06137
58	11-Jun	-0.00046	0.06091
59	12-Jun	-0.00027	0.06064
60	13-Jun	-0.0002	0.06044
61	14-Jun	-0.00015	0.06029
62	15-Jun	-0.00016	0.06013
63	16-Jun	-0.00015	0.05998
64	17-Jun	-4E-05	0.05994
65	18-Jun	0.00101	0.06095
66	19-Jun	0.00138	0.06233
67	20-Jun	0.00018	0.06251
68	21-Jun	0.00165	0.06416
69	22-Jun	-0.00029	0.06387
70	23-Jun	-0.00048	0.06339
71	24-Jun	-0.00031	0.06308
72	25-Jun	-0.00024	0.06284
73	26-Jun	-0.0002	0.06264
74	27-Jun	-0.00017	0.06247
75	28-Jun	-0.00016	0.06231
76	29-Jun	-0.00015	0.06216
77	30-Jun	-0.00013	0.06203
78	1-Jul	-2E-05	0.06201
79	2-Jul	-9E-05	0.06192
80	3-Jul	-0.00014	0.06178
81	4-Jul	0.00026	0.06204
82	5-Jul	-1E-05	0.06203
83	6-Jul	-0.0002	0.06183
84	7-Jul	7E-05	0.0619
85	8-Jul	2E-05	0.06192
86	9-Jul	2E-05	0.06194
87	10-Jul	9E-05	0.06203
88	11-Jul	0.00206	0.06409
89	12-Jul	0.00196	0.06605
90	13-Jul	0.00567	0.07172

		DAILY VALUES VS. TIME (m^3/m^2/day)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
91	14-Jul	0.00795	0.07967
92	15-Jul	-0.00156	0.07811
93	16-Jul	-0.00093	0.07718
94	17-Jul	-0.00054	0.07664
95	18-Jul	-0.00036	0.07628
96	19-Jul	-0.00033	0.07595
97	20-Jul	-0.00029	0.07566
98	21-Jul	-0.00024	0.07542
99	22-Jul	-0.00021	0.07521
100	23-Jul	-0.00019	0.07502
101	24-Jul	-4E-05	0.07498
102	25-Jul	0.00039	0.07537
103	26-Jul	0.00013	0.0755
104	27-Jul	-0.00032	0.07518
105	28-Jul	-0.00021	0.07497
106	29-Jul	-0.00018	0.07479
107	30-Jul	-0.00016	0.07463
108	31-Jul	-0.00014	0.07449
109	1-Aug	-0.00014	0.07435
110	2-Aug	-0.00013	0.07422
111	3-Aug	-0.00012	0.0741
112	4-Aug	-0.00012	0.07398
113	5-Aug	2E-05	0.074
114	6-Aug	-6E-05	0.07394
115	7-Aug	-0.00013	0.07381
116	8-Aug	-0.00012	0.07369
117	9-Aug	-0.00011	0.07358
118	10-Aug	0.00047	0.07405
119	11-Aug	0.00022	0.07427
120	12-Aug	-0.00023	0.07404
121	13-Aug	-7E-05	0.07397
122	14-Aug	-9E-05	0.07388
123	15-Aug	-0.00015	0.07373
124	16-Aug	-0.00012	0.07361
125	17-Aug	-0.00012	0.07349
126	18-Aug	6E-05	0.07355
127	19-Aug	1E-04	0.07365
128	20-Aug	-4E-05	0.07361
129	21-Aug	-0.00015	0.07346
130	22-Aug	-0.00012	0.07334
131	23-Aug	-0.00011	0.07323
132	24-Aug	-0.00011	0.07312
133	25-Aug	-0.0001	0.07302
134	26-Aug	-9E-05	0.07293
135	27-Aug	-9E-05	0.07284
136	28-Aug	0.00021	0.07305
137	29-Aug	2E-05	0.07307
138	30-Aug	-0.0001	0.07297
139	31-Aug	2E-05	0.07299
140	1-Sep	-2E-05	0.07297
141	2-Sep	-9E-05	0.07288
142	3-Sep	-9E-05	0.07279
143	4-Sep	-8E-05	0.07271
144	5-Sep	6E-05	0.07277
145	6-Sep	-2E-05	0.07275
146	7-Sep	-0.00011	0.07264
147	8-Sep	-9E-05	0.07255
148	9-Sep	-0.0001	0.07245
149	10-Sep	-9E-05	0.07236
150	11-Sep	-7E-05	0.07229
151	12-Sep	-8E-05	0.07221
152	13-Sep	-7E-05	0.07214
153	14-Sep	-8E-05	0.07206
154	15-Sep	-0.0001	0.07196
155	16-Sep	-0.0001	0.07186
156	17-Sep	-1E-04	0.07176
157	18-Sep	-8E-05	0.07168
158	19-Sep	-9E-05	0.07159
159	20-Sep	-0.0001	0.07149
160	21-Sep	-0.0001	0.07139
161	22-Sep	-1E-04	0.07129
162	23-Sep	-0.0001	0.07119
163	24-Sep	-7E-05	0.07112
164	25-Sep	-8E-05	0.07104
165	26-Sep	-9E-05	0.07095
166	27-Sep	-0.0001	0.07085
167	28-Sep	-8E-05	0.07077
168	29-Sep	-9E-05	0.07068
169	30-Sep	-5E-05	0.07063
170	1-Oct	-5E-05	0.07058
171	2-Oct	0	0.07058
172	3-Oct	0	0.07058
173	4-Oct	0	0.07058
174	5-Oct	0	0.07058
175	6-Oct	0	0.07058
176	7-Oct	0	0.07058
177	8-Oct	0	0.07058
178	9-Oct	0	0.07058
179	10-Oct	0	0.07058
180	11-Oct	0	0.07058
181	12-Oct	0	0.07058
182	13-Oct	0	0.07058
183	14-Oct	0	0.07058
184	15-Oct	0	0.07058
185	16-Oct	0	0.07058
186	17-Oct	0	0.07058
187	18-Oct	0	0.07058
188	19-Oct	0	0.07058
189	20-Oct	0.0012	0.07178
190	21-Oct	0.00161	0.07339
191	22-Oct	0.00029	0.07368
192	23-Oct	0	0.07368
193	24-Oct	0	0.07368
194	25-Oct	0	0.07368
195	26-Oct	0	0.07368
196	27-Oct	0	0.07368
197	28-Oct	0	0.07368
198	29-Oct	0.00086	0.07454
199	30-Oct	0.00125	0.07579
200	31-Oct	1E-05	0.0758

OPTION B - IN PIT WASTE ROCK
SUMMARY FLUXES THROUGH WASTE ROCK
MEAN YEAR

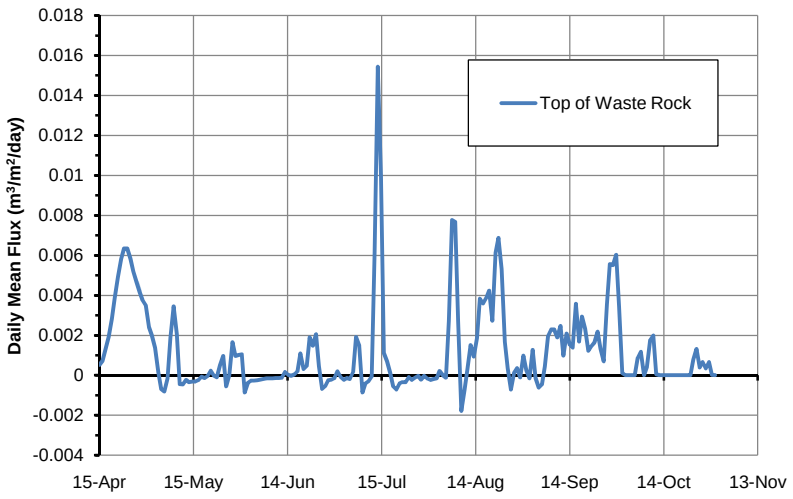


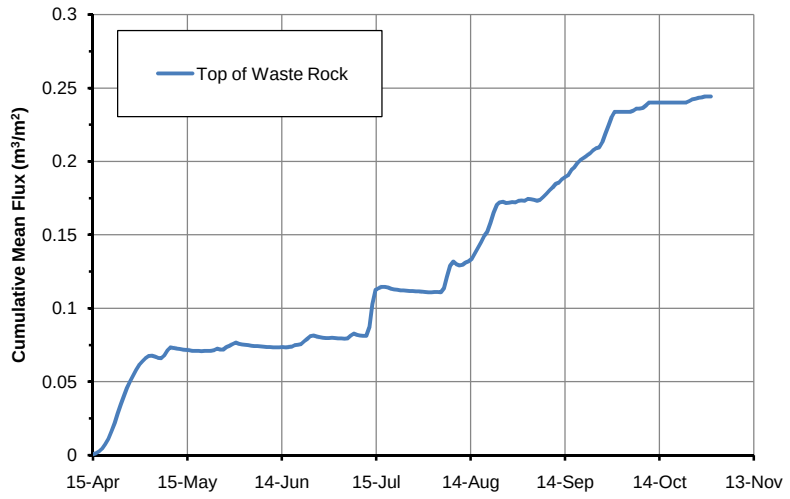


		DAILY VALUES VS. TIME (m^3/m^2/day)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
1	15-Apr	0.00039	0.00039
2	16-Apr	0.00051	0.0009
3	17-Apr	0.00092	0.00182
4	18-Apr	0.00139	0.00321
5	19-Apr	0.00205	0.00526
6	20-Apr	0.00282	0.00808
7	21-Apr	0.00358	0.01166
8	22-Apr	0.00425	0.01591
9	23-Apr	0.00463	0.02054
10	24-Apr	0.00463	0.02517
11	25-Apr	0.00426	0.02943
12	26-Apr	0.00378	0.03321
13	27-Apr	0.00341	0.03662
14	28-Apr	0.00303	0.03965
15	29-Apr	0.00275	0.0424
16	30-Apr	0.00255	0.04495
17	1-May	0.00155	0.0465
18	2-May	0.00072	0.04722
19	3-May	0.00016	0.04738
20	4-May	-0.00031	0.04707
21	5-May	-0.00023	0.04684
22	6-May	0.00127	0.04811
23	7-May	0.00162	0.04973
24	8-May	0.00034	0.05007
25	9-May	-0.00079	0.04928
26	10-May	-0.00049	0.04879
27	11-May	-0.00035	0.04844
28	12-May	-1E-04	0.04834
29	13-May	1E-04	0.04844
30	14-May	0.00282	0.05126
31	15-May	0.00388	0.05514
32	16-May	-0.0008	0.05434
33	17-May	-0.00069	0.05365
34	18-May	-0.00047	0.05318
35	19-May	-0.00035	0.05283
36	20-May	-0.00027	0.05256
37	21-May	-0.00022	0.05234
38	22-May	-0.00021	0.05213
39	23-May	-0.00019	0.05194
40	24-May	5E-05	0.05199
41	25-May	-9E-05	0.0519
42	26-May	-0.00021	0.05169
43	27-May	-0.00018	0.05151
44	28-May	-1E-05	0.0515
45	29-May	-8E-05	0.05142
46	30-May	-0.00017	0.05125
47	31-May	1E-05	0.05126
48	1-Jun	-0.0001	0.05116
49	2-Jun	-0.00017	0.05099
50	3-Jun	3E-05	0.05102
51	4-Jun	-8E-05	0.05094
52	5-Jun	-1E-05	0.05093
53	6-Jun	-8E-05	0.05085
54	7-Jun	0.00021	0.05106
55	8-Jun	5E-05	0.05111
56	9-Jun	-0.00017	0.05094
57	10-Jun	-0.00018	0.05076
58	11-Jun	-0.00014	0.05062
59	12-Jun	-0.00012	0.0505
60	13-Jun	-0.00012	0.05038
61	14-Jun	-0.00011	0.05027
62	15-Jun	0.00011	0.05038
63	16-Jun	0.00015	0.05053
64	17-Jun	0.00015	0.05068
65	18-Jun	0.00067	0.05135
66	19-Jun	0.00555	0.0569
67	20-Jun	0.00754	0.06444
68	21-Jun	0.00374	0.06818
69	22-Jun	0.00373	0.07191
70	23-Jun	0.00137	0.07328
71	24-Jun	-0.00142	0.07186
72	25-Jun	-0.00067	0.07119
73	26-Jun	-0.00042	0.07077
74	27-Jun	-0.00036	0.07041
75	28-Jun	-0.00024	0.07017
76	29-Jun	0.00097	0.07114
77	30-Jun	0.0025	0.07364
78	1-Jul	-0.0001	0.07354
79	2-Jul	-0.00069	0.07285
80	3-Jul	0.00019	0.07304
81	4-Jul	0.00409	0.07713
82	5-Jul	0.00465	0.08178
83	6-Jul	0.0005	0.08228
84	7-Jul	-0.00014	0.08214
85	8-Jul	0.00234	0.08448
86	9-Jul	0.0047	0.08918
87	10-Jul	0.00284	0.09202
88	11-Jul	-0.00079	0.09123
89	12-Jul	-0.00089	0.09034
90	13-Jul	-0.0004	0.08994
91	14-Jul	-0.00041	0.08953

		DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
92	15-Jul	-0.00031	0.08922
93	16-Jul	-0.0003	0.08892
94	17-Jul	-0.00027	0.08865
95	18-Jul	-0.00023	0.08842
96	19-Jul	-1E-05	0.08841
97	20-Jul	-0.0001	0.08831
98	21-Jul	-0.00013	0.08818
99	22-Jul	-4E-05	0.08814
100	23-Jul	-3E-05	0.08811
101	24-Jul	-0.00018	0.08793
102	25-Jul	-1E-04	0.08783
103	26-Jul	-0.00014	0.08769
104	27-Jul	-0.00019	0.0875
105	28-Jul	-0.00015	0.08735
106	29-Jul	2E-05	0.08737
107	30-Jul	-9E-05	0.08728
108	31-Jul	7E-05	0.08735
109	1-Aug	-9E-05	0.08726
110	2-Aug	-0.00018	0.08708
111	3-Aug	-0.00014	0.08694
112	4-Aug	0.00026	0.0872
113	5-Aug	0.00048	0.08768
114	6-Aug	-0.00015	0.08753
115	7-Aug	-0.00018	0.08735
116	8-Aug	-0.00019	0.08716
117	9-Aug	-0.00014	0.08702
118	10-Aug	4E-05	0.08706
119	11-Aug	-7E-05	0.08699
120	12-Aug	0.0002	0.08719
121	13-Aug	0.00017	0.08736
122	14-Aug	-1E-04	0.08726
123	15-Aug	-0.00013	0.08713
124	16-Aug	-3E-05	0.0871
125	17-Aug	-9E-05	0.08701
126	18-Aug	-0.00016	0.08685
127	19-Aug	0.00085	0.0877
128	20-Aug	0.00161	0.08931
129	21-Aug	-8E-05	0.08923
130	22-Aug	0.00068	0.08991
131	23-Aug	0.00346	0.09337
132	24-Aug	0.00367	0.09704
133	25-Aug	-0.0013	0.09574
134	26-Aug	-0.00067	0.09507
135	27-Aug	-0.0002	0.09487
136	28-Aug	-0.00029	0.09458
137	29-Aug	-0.0003	0.09428
138	30-Aug	-0.00025	0.09403
139	31-Aug	-0.00011	0.09392
140	1-Sep	-9E-05	0.09383
141	2-Sep	0.00057	0.0944
142	3-Sep	0.00041	0.09481
143	4-Sep	-0.00038	0.09443
144	5-Sep	-0.00026	0.09417
145	6-Sep	-0.00014	0.09403
146	7-Sep	-3E-05	0.094
147	8-Sep	-0.00019	0.09381
148	9-Sep	-0.0002	0.09361
149	10-Sep	-0.00014	0.09347
150	11-Sep	-0.00013	0.09334
151	12-Sep	-0.00014	0.0932
152	13-Sep	0.00062	0.09382
153	14-Sep	0.00081	0.09463
154	15-Sep	-0.00047	0.09416
155	16-Sep	-0.00024	0.09392
156	17-Sep	-0.00018	0.09374
157	18-Sep	-0.00015	0.09359
158	19-Sep	0.00036	0.09395
159	20-Sep	0.00057	0.09452
160	21-Sep	-6E-05	0.09446
161	22-Sep	-4E-05	0.09442
162	23-Sep	-0.00025	0.09417
163	24-Sep	-0.00019	0.09398
164	25-Sep	-0.00015	0.09383
165	26-Sep	-0.00013	0.0937
166	27-Sep	6E-05	0.09376
167	28-Sep	1E-05	0.09377
168	29-Sep	0	0.09377
169	30-Sep	0	0.09377
170	1-Oct	0	0.09377
171	2-Oct	0	0.09377
172	3-Oct	0	0.09377
173	4-Oct	0	0.09377
174	5-Oct	0	0.09377
175	6-Oct	0	0.09377
176	7-Oct	0	0.09377
177	8-Oct	0	0.09377
178	9-Oct	0	0.09377
179	10-Oct	0.0004	0.09417
180	11-Oct	0.00061	0.09478
181	12-Oct	2E-05	0.0948
182	13-Oct	0	0.0948
183	14-Oct	0.00123	0.09603
184	15-Oct	0.00178	0.09781
185	16-Oct	1E-05	0.09782
186	17-Oct	0	0.09782
187	18-Oct	0	0.09782
188	19-Oct	0.00074	0.09856
189	20-Oct	0.00164	0.1002
190	21-Oct	0.0007	0.1009
191	22-Oct	2E-05	0.10092
192	23-Oct	0.00115	0.10207
193	24-Oct	0.00326	0.10533
194	25-Oct	0.00334	0.10867
195	26-Oct	0.003	0.11167
196	27-Oct	0.00334	0.11501
197	28-Oct	0.00045	0.11546
198	29-Oct	0.00066	0.11612
199	30-Oct	0.00034	0.11646
200	31-Oct	0.00066	0.11712

OPTION B - IN PIT WASTE ROCK
SUMMARY FLUXES THROUGH WASTE ROCK
WET YEAR

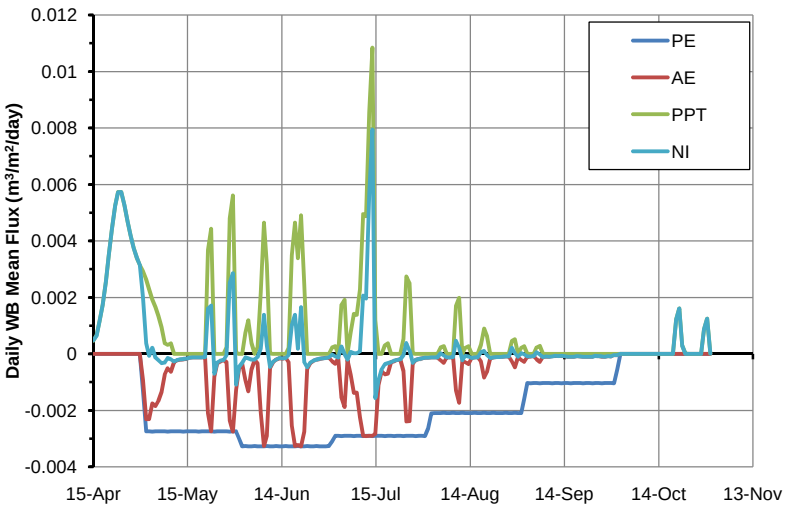


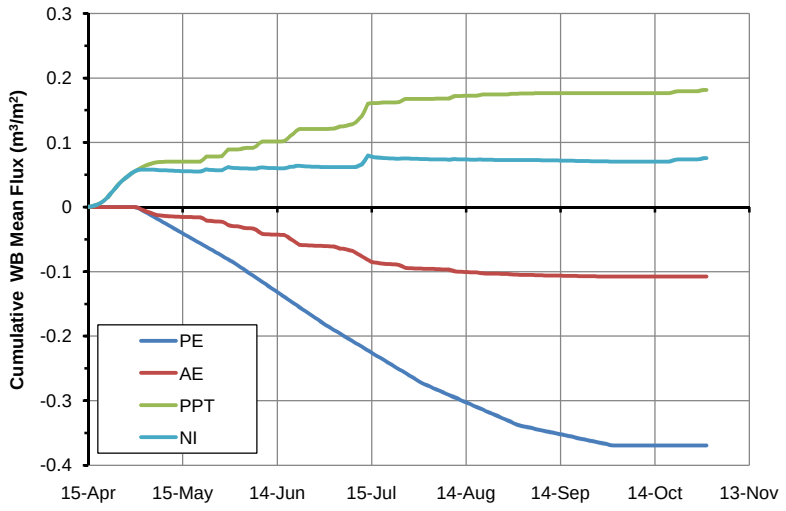


		DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
1	15-Apr	0.00052	0.00052
2	16-Apr	0.00072	0.00124
3	17-Apr	0.00128	0.00252
4	18-Apr	0.00192	0.00444
5	19-Apr	0.00282	0.00726
6	20-Apr	0.00388	0.01114
7	21-Apr	0.00492	0.01606
8	22-Apr	0.00582	0.02188
9	23-Apr	0.00635	0.02823
10	24-Apr	0.00635	0.03458
11	25-Apr	0.00584	0.04042
12	26-Apr	0.0052	0.04562
13	27-Apr	0.00467	0.05029
14	28-Apr	0.00416	0.05445
15	29-Apr	0.00376	0.05821
16	30-Apr	0.0035	0.06171
17	1-May	0.00241	0.06412
18	2-May	0.002	0.06612
19	3-May	0.00137	0.06749
20	4-May	0.00017	0.06766
21	5-May	-0.00068	0.06698
22	6-May	-0.00081	0.06617
23	7-May	-0.00016	0.06601
24	8-May	0.0019	0.06791
25	9-May	0.00345	0.07136
26	10-May	0.00206	0.07342
27	11-May	-0.00044	0.07298
28	12-May	-0.00046	0.07252
29	13-May	-0.00023	0.07229
30	14-May	-0.00034	0.07195
31	15-May	-0.00031	0.07164
32	16-May	-0.00031	0.07133
33	17-May	-0.00025	0.07108
34	18-May	-7E-05	0.07101
35	19-May	-0.00013	0.07088
36	20-May	-4E-05	0.07084
37	21-May	0.00023	0.07107
38	22-May	-2E-05	0.07105
39	23-May	-0.0001	0.07095
40	24-May	0.0005	0.07145
41	25-May	0.00097	0.07242
42	26-May	-0.00056	0.07186
43	27-May	3E-05	0.07189
44	28-May	0.00166	0.07355
45	29-May	0.00097	0.07452
46	30-May	0.00101	0.07553
47	31-May	0.00104	0.07657
48	1-Jun	-0.00085	0.07572
49	2-Jun	-0.00038	0.07534
50	3-Jun	-0.00026	0.07508
51	4-Jun	-0.00027	0.07481
52	5-Jun	-0.00025	0.07456
53	6-Jun	-0.00021	0.07435
54	7-Jun	-0.00018	0.07417
55	8-Jun	-0.00016	0.07401
56	9-Jun	-0.00015	0.07386
57	10-Jun	-0.00015	0.07371
58	11-Jun	-0.00013	0.07358
59	12-Jun	-0.00013	0.07345
60	13-Jun	-0.00012	0.07333
61	14-Jun	0.00016	0.07349
62	15-Jun	3E-05	0.07352
63	16-Jun	-3E-05	0.07349
64	17-Jun	4E-05	0.07353
65	18-Jun	0.0002	0.07373
66	19-Jun	0.0011	0.07483
67	20-Jun	0.00031	0.07514
68	21-Jun	0.00047	0.07561
69	22-Jun	0.0019	0.07751
70	23-Jun	0.00148	0.07899
71	24-Jun	0.00205	0.08104
72	25-Jun	0.00045	0.08149
73	26-Jun	-0.00068	0.08081
74	27-Jun	-0.00054	0.08027
75	28-Jun	-0.00025	0.08002
76	29-Jun	-0.00022	0.0798
77	30-Jun	-0.00014	0.07966
78	1-Jul	0.0002	0.07986
79	2-Jul	-9E-05	0.07977
80	3-Jul	-0.00023	0.07954
81	4-Jul	-0.00013	0.07941
82	5-Jul	-0.00018	0.07923
83	6-Jul	0.00017	0.0794
84	7-Jul	0.00192	0.08132
85	8-Jul	0.00148	0.0828
86	9-Jul	-0.00085	0.08195
87	10-Jul	-0.00041	0.08154
88	11-Jul	-0.00029	0.08125
89	12-Jul	-6E-05	0.08119
90	13-Jul	0.00613	0.08732
91	14-Jul	0.01544	0.10276
92	15-Jul	0.00991	0.11267

		DAILY VALUES VS. TIME (m^3/m^2/day)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
Time	Date	Top of Waste Rock	Top of Waste Rock
93	16-Jul	0.00111	0.11378
94	17-Jul	0.0007	0.11448
95	18-Jul	0.0001	0.11458
96	19-Jul	-0.00055	0.11403
97	20-Jul	-0.00071	0.11332
98	21-Jul	-0.00041	0.11291
99	22-Jul	-0.00035	0.11256
100	23-Jul	-0.00034	0.11222
101	24-Jul	-9E-05	0.11213
102	25-Jul	-0.00023	0.1119
103	26-Jul	-0.00012	0.11178
104	27-Jul	-2E-05	0.11176
105	28-Jul	-0.00021	0.11155
106	29-Jul	-2E-05	0.11153
107	30-Jul	-0.00017	0.11136
108	31-Jul	-0.00023	0.11113
109	1-Aug	-0.00018	0.11095
110	2-Aug	-0.00016	0.11079
111	3-Aug	0.00021	0.111
112	4-Aug	1E-05	0.11101
113	5-Aug	-0.00012	0.11089
114	6-Aug	0.00271	0.1136
115	7-Aug	0.00777	0.12137
116	8-Aug	0.00767	0.12904
117	9-Aug	0.00271	0.13175
118	10-Aug	-0.00178	0.12997
119	11-Aug	-0.00075	0.12922
120	12-Aug	0.0003	0.12952
121	13-Aug	0.00152	0.13104
122	14-Aug	0.00093	0.13197
123	15-Aug	0.00186	0.13383
124	16-Aug	0.00384	0.13767
125	17-Aug	0.00359	0.14126
126	18-Aug	0.00388	0.14514
127	19-Aug	0.00424	0.14938
128	20-Aug	0.00273	0.15211
129	21-Aug	0.00612	0.15823
130	22-Aug	0.00688	0.16511
131	23-Aug	0.00531	0.17042
132	24-Aug	0.00168	0.1721
133	25-Aug	0.00035	0.17245
134	26-Aug	-0.00072	0.17173
135	27-Aug	0.00014	0.17187
136	28-Aug	0.00036	0.17223
137	29-Aug	-1E-04	0.17213
138	30-Aug	0.00099	0.17312
139	31-Aug	0.00027	0.17339
140	1-Sep	-0.00015	0.17324
141	2-Sep	0.00127	0.17451
142	3-Sep	-0.00014	0.17437
143	4-Sep	-0.00062	0.17375
144	5-Sep	-0.00045	0.1733
145	6-Sep	0.00044	0.17374
146	7-Sep	0.00196	0.1757
147	8-Sep	0.00229	0.17799
148	9-Sep	0.0023	0.18029
149	10-Sep	0.0019	0.18219
150	11-Sep	0.00247	0.18466
151	12-Sep	0.00098	0.18564
152	13-Sep	0.00209	0.18773
153	14-Sep	0.00153	0.18926
154	15-Sep	0.00138	0.19064
155	16-Sep	0.00357	0.19421
156	17-Sep	0.00169	0.1959
157	18-Sep	0.00293	0.19883
158	19-Sep	0.00232	0.20115
159	20-Sep	0.00122	0.20237
160	21-Sep	0.00145	0.20382
161	22-Sep	0.00164	0.20546
162	23-Sep	0.00219	0.20765
163	24-Sep	0.00132	0.20897
164	25-Sep	0.0007	0.20967
165	26-Sep	0.00355	0.21322
166	27-Sep	0.00557	0.21879
167	28-Sep	0.00551	0.2243
168	29-Sep	0.00603	0.23033
169	30-Sep	0.00344	0.23377
170	1-Oct	1E-04	0.23387
171	2-Oct	0	0.23387
172	3-Oct	0	0.23387
173	4-Oct	0	0.23387
174	5-Oct	0	0.23387
175	6-Oct	0.00085	0.23472
176	7-Oct	0.00118	0.2359
177	8-Oct	1E-05	0.23591
178	9-Oct	0.00043	0.23634
179	10-Oct	0.00176	0.2381
180	11-Oct	0.002	0.2401
181	12-Oct	6E-05	0.24016
182	13-Oct	0	0.24016
183	14-Oct	0	0.24016
184	15-Oct	0	0.24016
185	16-Oct	0	0.24016
186	17-Oct	0	0.24016
187	18-Oct	0	0.24016
188	19-Oct	0	0.24016
189	20-Oct	0	0.24016
190	21-Oct	0	0.24016
191	22-Oct	0	0.24016
192	23-Oct	0	0.24016
193	24-Oct	0.00079	0.24095
194	25-Oct	0.00132	0.24227
195	26-Oct	0.00039	0.24266
196	27-Oct	0.00066	0.24332
197	28-Oct	0.00034	0.24366
198	29-Oct	0.00066	0.24432
199	30-Oct	2E-05	0.24434
200	31-Oct	0	0.24434

OPTION B - IN PIT WASTE ROCK NO COVER
CLIMATE WATER BALANCE
DRY YEAR

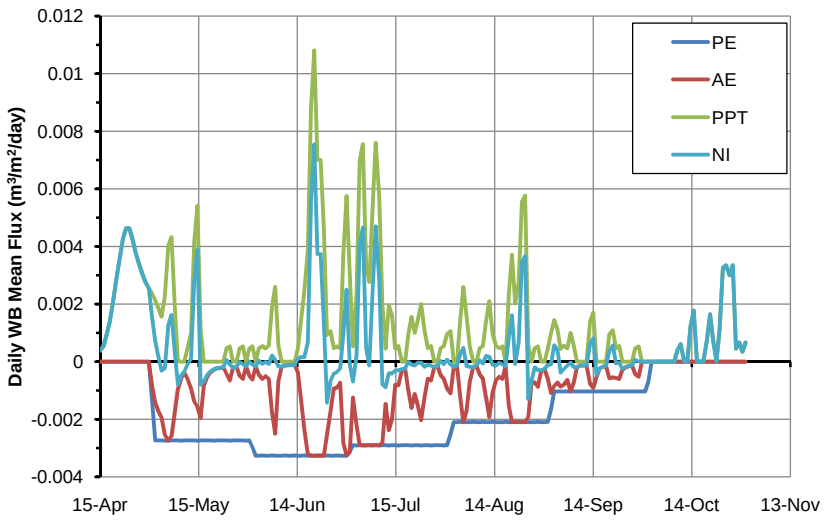


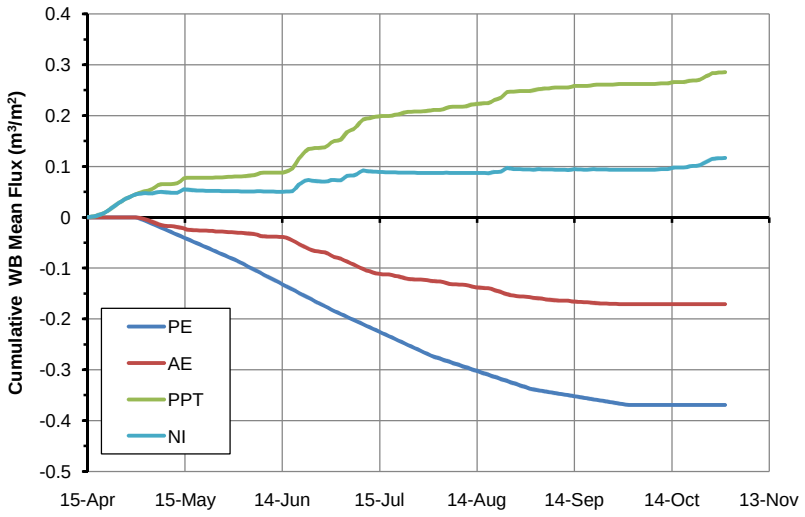


		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m^3/m^2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
1	15-Apr	0	0	0.00047	0.00048	0	0	0.00047	0.00048
2	16-Apr	0	0	0.00067	0.00064	0	0	0.00114	0.00112
3	17-Apr	0	0	0.00115	0.00114	0	0	0.00229	0.00226
4	18-Apr	0	0	0.00173	0.00173	0	0	0.00402	0.00399
5	19-Apr	0	0	0.00255	0.00255	0	0	0.00657	0.00654
6	20-Apr	0	0	0.00349	0.00349	0	0	0.01006	0.01003
7	21-Apr	0	0	0.00443	0.00443	0	0	0.01449	0.01446
8	22-Apr	0	0	0.00525	0.00525	0	0	0.01974	0.01971
9	23-Apr	0	0	0.00573	0.00572	0	0	0.02547	0.02543
10	24-Apr	0	0	0.00573	0.00573	0	0	0.0312	0.03116
11	25-Apr	0	0	0.00526	0.00527	0	0	0.03646	0.03643
12	26-Apr	0	0	0.00468	0.00468	0	0	0.04114	0.04111
13	27-Apr	0	0	0.00421	0.00421	0	0	0.04535	0.04532
14	28-Apr	0	0	0.00375	0.00374	0	0	0.0491	0.04906
15	29-Apr	0	0	0.00339	0.0034	0	0	0.05249	0.05246
16	30-Apr	0	0	0.00316	0.00316	0	0	0.05565	0.05562
17	1-May	-0.00133	-0.00093	0.00293	0.00199	-0.00133	-0.00093	0.05858	0.05761
18	2-May	-0.00274	-0.00231	0.00263	0.00037	-0.00407	-0.00324	0.06121	0.05798
19	3-May	-0.00274	-0.00231	0.00229	-7E-05	-0.00681	-0.00555	0.0635	0.05791
20	4-May	-0.00275	-0.00176	0.00193	0.00022	-0.00956	-0.00731	0.06543	0.05813
21	5-May	-0.00274	-0.00185	0.00165	-0.00014	-0.0123	-0.00916	0.06708	0.05799
22	6-May	-0.00274	-0.00166	0.00135	-0.00023	-0.01504	-0.01082	0.06843	0.05776
23	7-May	-0.00274	-0.00135	0.00094	-0.00033	-0.01778	-0.01217	0.06937	0.05743
24	8-May	-0.00274	-0.00074	0.00037	-0.00031	-0.02052	-0.01291	0.06974	0.05712
25	9-May	-0.00275	-0.00051	0.00032	-0.00015	-0.02327	-0.01342	0.07006	0.05697
26	10-May	-0.00274	-0.00063	0.00037	-0.00019	-0.02601	-0.01405	0.07043	0.05678
27	11-May	-0.00274	-0.0003	0	-0.00027	-0.02875	-0.01435	0.07043	0.05651
28	12-May	-0.00274	-0.00023	0	-0.00021	-0.03149	-0.01458	0.07043	0.0563
29	13-May	-0.00274	-0.0002	0	-0.00019	-0.03423	-0.01478	0.07043	0.05611
30	14-May	-0.00275	-0.00019	0	-0.00018	-0.03698	-0.01497	0.07043	0.05593
31	15-May	-0.00274	-0.00018	0	-0.00017	-0.03972	-0.01515	0.07043	0.05576
32	16-May	-0.00274	-0.00014	0	-0.00014	-0.04246	-0.01529	0.07043	0.05562
33	17-May	-0.00274	-0.00013	0	-0.00013	-0.0452	-0.01542	0.07043	0.05549
34	18-May	-0.00274	-0.00013	0	-0.00012	-0.04794	-0.01555	0.07043	0.05537
35	19-May	-0.00275	-0.00012	0	-0.00013	-0.05069	-0.01567	0.07043	0.05524
36	20-May	-0.00274	-0.00012	0	-0.00012	-0.05343	-0.01579	0.07043	0.05512
37	21-May	-0.00274	-0.00011	0	-0.00011	-0.05617	-0.0159	0.07043	0.05501
38	22-May	-0.00274	-0.00211	0.00368	0.00161	-0.05891	-0.01801	0.07411	0.05662
39	23-May	-0.00274	-0.00274	0.00443	0.00171	-0.06165	-0.02075	0.07854	0.05833
40	24-May	-0.00275	-0.0008	0	-0.0007	-0.0644	-0.02155	0.07854	0.05763
41	25-May	-0.00274	-0.00033	0	-0.00031	-0.06714	-0.02188	0.07854	0.05732
42	26-May	-0.00274	-0.00027	0	-0.00024	-0.06988	-0.02215	0.07854	0.05708
43	27-May	-0.00274	-0.00021	0	-0.00021	-0.07262	-0.02236	0.07854	0.05687
44	28-May	-0.00274	-0.00029	0.00023	-5E-05	-0.07536	-0.02265	0.07877	0.05682
45	29-May	-0.00275	-0.00235	0.00481	0.0025	-0.07811	-0.025	0.08358	0.05932
46	30-May	-0.00274	-0.00275	0.00561	0.00286	-0.08085	-0.02775	0.08919	0.06218
47	31-May	-0.00274	-0.00127	3E-05	-0.00109	-0.08359	-0.02902	0.08922	0.06109
48	1-Jun	-0.00298	-0.00052	0	-0.00046	-0.08657	-0.02954	0.08922	0.06063
49	2-Jun	-0.00327	-0.00035	0	-0.00032	-0.08984	-0.02989	0.08922	0.06031
50	3-Jun	-0.00326	-0.00093	0.00075	-0.00013	-0.0931	-0.03082	0.08997	0.06018
51	4-Jun	-0.00327	-0.00133	0.00119	-0.00016	-0.09637	-0.03215	0.09116	0.06002
52	5-Jun	-0.00327	-0.00056	0.00038	-0.0002	-0.09964	-0.03271	0.09154	0.05982
53	6-Jun	-0.00326	-0.00022	0	-0.0002	-0.1029	-0.03293	0.09154	0.05962
54	7-Jun	-0.00327	-0.00034	0.00023	-0.00011	-0.10617	-0.03327	0.09177	0.05951
55	8-Jun	-0.00327	-0.00209	0.00218	0.00019	-0.10944	-0.03536	0.09395	0.0597
56	9-Jun	-0.00327	-0.00326	0.00465	0.00138	-0.11271	-0.03862	0.0986	0.06108
57	10-Jun	-0.00326	-0.00289	0.00317	0.00029	-0.11597	-0.04151	0.10177	0.06137
58	11-Jun	-0.00327	-0.00051	1E-05	-0.00046	-0.11924	-0.04202	0.10178	0.06091
59	12-Jun	-0.00327	-0.00029	0	-0.00027	-0.12251	-0.04231	0.10178	0.06064
60	13-Jun	-0.00326	-0.0002	0	-0.0002	-0.12577	-0.04251	0.10178	0.06044
61	14-Jun	-0.00327	-0.00016	0	-0.00015	-0.12904	-0.04267	0.10178	0.06029
62	15-Jun	-0.00327	-0.00017	0	-0.00016	-0.13231	-0.04284	0.10178	0.06013
63	16-Jun	-0.00326	-0.00014	0	-0.00015	-0.13557	-0.04298	0.10178	0.05998
64	17-Jun	-0.00327	-0.00029	0.00022	-4E-05	-0.13884	-0.04327	0.102	0.05994
65	18-Jun	-0.00327	-0.00254	0.00349	0.00101	-0.14211	-0.04581	0.10549	0.06095
66	19-Jun	-0.00327	-0.00326	0.00465	0.00138	-0.14538	-0.04907	0.11014	0.06233
67	20-Jun	-0.00326	-0.00323	0.00339	0.00018	-0.14864	-0.0523	0.11353	0.06251
68	21-Jun	-0.00327	-0.00327	0.00491	0.00165	-0.15191	-0.05557	0.11844	0.06416
69	22-Jun	-0.00327	-0.00275	0.00245	-0.00029	-0.15518	-0.05832	0.12089	0.06387
70	23-Jun	-0.00326	-0.00054	0	-0.00048	-0.15844	-0.05886	0.12089	0.06339
71	24-Jun	-0.00327	-0.00033	0	-0.00031	-0.16171	-0.05919	0.12089	0.06308
72	25-Jun	-0.00327	-0.00025	0	-0.00024	-0.16498	-0.05944	0.12089	0.06284
73	26-Jun	-0.00326	-0.0002	0	-0.0002	-0.16824	-0.05964	0.12089	0.06264
74	27-Jun	-0.00327	-0.00018	0	-0.00017	-0.17151	-0.05982	0.12089	0.06247
75	28-Jun	-0.00327	-0.00016	0	-0.00016	-0.17478	-0.05998	0.12089	0.06231
76	29-Jun	-0.00327	-0.00014	0	-0.00015	-0.17805	-0.06012	0.12089	0.06216
77	30-Jun	-0.00326	-0.00014	0	-0.00013	-0.18131	-0.06026	0.12089	0.06203
78	1-Jul	-0.00311	-0.00026	0.00023	-2E-05	-0.18442	-0.06052	0.12112	0.06201
79	2-Jul	-0.0029	-0.00035	0.00027	-9E-05	-0.18732	-0.06087	0.12139	0.06192
80	3-Jul	-0.0029	-0.00014	0	-0.00014	-0.19022	-0.06101	0.12139	0.06178
81	4-Jul	-0.00291	-0.00153	0.00173	0.00026	-0.19313	-0.06254	0.12312	0.06204
82	5-Jul	-0.0029	-0.00188	0.00191	-1E-05	-0.19603	-0.06442	0.12503	0.06203
83	6-Jul	-0.0029	-0.00021	1E-05	-0.0002	-0.19893	-0.06463	0.12504	0.06183
84	7-Jul	-0.0029	-0.00074	0.00076	7E-05	-0.20183	-0.06537	0.1258	0.0619
85	8-Jul	-0.00291	-0.00138	0.00142	2E-05	-0.20474	-0.06675	0.12722	0.06192
86	9-Jul	-0.0029	-0.00137	0.00138	2E-05	-0.20764	-0.06812	0.1286	0.06194
87	10-Jul	-0.0029	-0.00224	0.00228	9E-05	-0.21054	-0.07036	0.13088	0.06203
88	11-Jul	-0.00291	-0.0029	0.00495	0.00206	-0.21345	-0.07326	0.13583	0.06409
89	12-Jul	-0.0029	-0.00291	0.00487	0.00196	-0.21635	-0.07617	0.1407	0.06605
90	13-Jul	-0.0029	-0.0029	0.00857	0.00567	-0.21925	-0.07907	0.14927	0.07172
91	14-Jul	-0.00291	-0.0029	0.01085	0.00795	-0.22216	-0.08197	0.16012	0.07967

		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m^3/m^2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
92	15-Jul	-0.0029	-0.00283	0.0012	-0.00156	-0.22506	-0.0848	0.16132	0.07811
93	16-Jul	-0.0029	-0.0011	0	-0.00093	-0.22796	-0.0859	0.16132	0.07718
94	17-Jul	-0.0029	-0.00061	0	-0.00054	-0.23086	-0.08651	0.16132	0.07664
95	18-Jul	-0.00291	-0.00072	0.00031	-0.00036	-0.23377	-0.08723	0.16163	0.07628
96	19-Jul	-0.0029	-0.0007	0.00037	-0.00033	-0.23667	-0.08793	0.162	0.07595
97	20-Jul	-0.0029	-0.0003	0	-0.00029	-0.23957	-0.08823	0.162	0.07566
98	21-Jul	-0.00291	-0.00026	0	-0.00024	-0.24248	-0.08849	0.162	0.07542
99	22-Jul	-0.0029	-0.00022	0	-0.00021	-0.24538	-0.08871	0.162	0.07521
100	23-Jul	-0.0029	-0.00019	0	-0.00019	-0.24828	-0.0889	0.162	0.07502
101	24-Jul	-0.00291	-0.00061	0.00053	-4E-05	-0.25119	-0.08951	0.16253	0.07498
102	25-Jul	-0.0029	-0.00239	0.00274	0.00039	-0.25409	-0.0919	0.16527	0.07537
103	26-Jul	-0.0029	-0.00238	0.00251	0.00013	-0.25699	-0.09428	0.16778	0.0755
104	27-Jul	-0.0029	-0.00034	1E-05	-0.00032	-0.25989	-0.09462	0.16779	0.07518
105	28-Jul	-0.00291	-0.00022	0	-0.00021	-0.2628	-0.09484	0.16779	0.07497
106	29-Jul	-0.0029	-0.00018	0	-0.00018	-0.2657	-0.09502	0.16779	0.07479
107	30-Jul	-0.0029	-0.00016	0	-0.00016	-0.2686	-0.09518	0.16779	0.07463
108	31-Jul	-0.00291	-0.00014	0	-0.00014	-0.27151	-0.09532	0.16779	0.07449
109	1-Aug	-0.00264	-0.00014	0	-0.00014	-0.27415	-0.09546	0.16779	0.07435
110	2-Aug	-0.00211	-0.00012	0	-0.00013	-0.27626	-0.09558	0.16779	0.07422
111	3-Aug	-0.0021	-0.00012	0	-0.00012	-0.27836	-0.0957	0.16779	0.0741
112	4-Aug	-0.0021	-0.00012	0	-0.00012	-0.28046	-0.09582	0.16779	0.07398
113	5-Aug	-0.0021	-0.00023	0.00023	2E-05	-0.28256	-0.09605	0.16802	0.074
114	6-Aug	-0.00209	-0.00032	0.00027	-6E-05	-0.28465	-0.09637	0.16829	0.07394
115	7-Aug	-0.0021	-0.00013	0	-0.00013	-0.28675	-0.0965	0.16829	0.07381
116	8-Aug	-0.0021	-0.00012	0	-0.00012	-0.28885	-0.09662	0.16829	0.07369
117	9-Aug	-0.00209	-0.00011	0	-0.00011	-0.29094	-0.09673	0.16829	0.07358
118	10-Aug	-0.0021	-0.00129	0.00169	0.00047	-0.29304	-0.09802	0.16998	0.07405
119	11-Aug	-0.0021	-0.00173	0.00198	0.00022	-0.29514	-0.09975	0.17196	0.07427
120	12-Aug	-0.00209	-0.00024	0	-0.00023	-0.29723	-0.09999	0.17196	0.07404
121	13-Aug	-0.0021	-0.0003	0.00022	-7E-05	-0.29933	-0.10029	0.17218	0.07397
122	14-Aug	-0.0021	-0.00036	0.00027	-9E-05	-0.30143	-0.10065	0.17245	0.07388
123	15-Aug	-0.0021	-0.00015	0	-0.00015	-0.30353	-0.1008	0.17245	0.07373
124	16-Aug	-0.00209	-0.00012	0	-0.00012	-0.30562	-0.10092	0.17245	0.07361
125	17-Aug	-0.0021	-0.00011	0	-0.00012	-0.30772	-0.10103	0.17245	0.07349
126	18-Aug	-0.0021	-0.00027	0.00032	6E-05	-0.30982	-0.1013	0.17277	0.07355
127	19-Aug	-0.00209	-0.00084	0.0009	1E-04	-0.31191	-0.10214	0.17367	0.07365
128	20-Aug	-0.0021	-0.00063	0.00062	-4E-05	-0.31401	-0.10277	0.17429	0.07361
129	21-Aug	-0.0021	-0.00016	0	-0.00015	-0.31611	-0.10293	0.17429	0.07346
130	22-Aug	-0.00209	-0.00012	0	-0.00012	-0.3182	-0.10305	0.17429	0.07334
131	23-Aug	-0.0021	-0.00011	0	-0.00011	-0.3203	-0.10316	0.17429	0.07323
132	24-Aug	-0.0021	-0.0001	0	-0.00011	-0.3224	-0.10326	0.17429	0.07312
133	25-Aug	-0.0021	-1E-04	0	-0.0001	-0.3245	-0.10336	0.17429	0.07302
134	26-Aug	-0.00209	-9E-05	0	-9E-05	-0.32659	-0.10345	0.17429	0.07293
135	27-Aug	-0.0021	-9E-05	0	-9E-05	-0.32869	-0.10354	0.17429	0.07284
136	28-Aug	-0.0021	-0.00027	0.00046	0.00021	-0.33079	-0.10381	0.17475	0.07305
137	29-Aug	-0.00209	-0.00048	0.00052	2E-05	-0.33288	-0.10429	0.17527	0.07307
138	30-Aug	-0.0021	-0.00011	0	-0.0001	-0.33498	-0.1044	0.17527	0.07297
139	31-Aug	-0.0021	-0.00021	0.00022	2E-05	-0.33708	-0.10461	0.17549	0.07299
140	1-Sep	-0.00161	-0.00028	0.00027	-2E-05	-0.33869	-0.10489	0.17576	0.07297
141	2-Sep	-0.00103	-0.0001	0	-9E-05	-0.33972	-0.10499	0.17576	0.07288
142	3-Sep	-0.00104	-9E-05	0	-9E-05	-0.34076	-0.10508	0.17576	0.07279
143	4-Sep	-0.00103	-8E-05	0	-8E-05	-0.34179	-0.10516	0.17576	0.07271
144	5-Sep	-0.00103	-0.00019	0.00023	6E-05	-0.34282	-0.10535	0.17599	0.07277
145	6-Sep	-0.00104	-0.00028	0.00028	-2E-05	-0.34386	-0.10563	0.17627	0.07275
146	7-Sep	-0.00103	-0.0001	0	-0.00011	-0.34489	-0.10573	0.17627	0.07264
147	8-Sep	-0.00103	-1E-04	0	-9E-05	-0.34592	-0.10583	0.17627	0.07255
148	9-Sep	-0.00103	-0.0001	0	-0.0001	-0.34695	-0.10593	0.17627	0.07245
149	10-Sep	-0.00104	-8E-05	0	-9E-05	-0.34799	-0.10601	0.17627	0.07236
150	11-Sep	-0.00103	-8E-05	0	-7E-05	-0.34902	-0.10609	0.17627	0.07229
151	12-Sep	-0.00103	-7E-05	0	-8E-05	-0.35005	-0.10616	0.17627	0.07221
152	13-Sep	-0.00104	-8E-05	0	-7E-05	-0.35109	-0.10624	0.17627	0.07214
153	14-Sep	-0.00103	-8E-05	0	-8E-05	-0.35212	-0.10632	0.17627	0.07206
154	15-Sep	-0.00103	-0.0001	0	-0.0001	-0.35315	-0.10642	0.17627	0.07196
155	16-Sep	-0.00104	-0.0001	0	-0.0001	-0.35419	-0.10652	0.17627	0.07186
156	17-Sep	-0.00103	-0.0001	0	-1E-04	-0.35522	-0.10662	0.17627	0.07176
157	18-Sep	-0.00103	-8E-05	0	-8E-05	-0.35625	-0.1067	0.17627	0.07168
158	19-Sep	-0.00103	-9E-05	0	-9E-05	-0.35728	-0.10679	0.17627	0.07159
159	20-Sep	-0.00104	-0.0001	0	-0.0001	-0.35832	-0.10689	0.17627	0.07149
160	21-Sep	-0.00103	-0.0001	0	-0.0001	-0.35935	-0.10699	0.17627	0.07139
161	22-Sep	-0.00103	-0.0001	0	-1E-04	-0.36038	-0.10709	0.17627	0.07129
162	23-Sep	-0.00104	-1E-04	0	-0.0001	-0.36142	-0.10719	0.17627	0.07119
163	24-Sep	-0.00103	-6E-05	0	-7E-05	-0.36245	-0.10725	0.17627	0.07112
164	25-Sep	-0.00103	-8E-05	0	-8E-05	-0.36348	-0.10733	0.17627	0.07104
165	26-Sep	-0.00104	-0.0001	0	-9E-05	-0.36452	-0.10743	0.17627	0.07095
166	27-Sep	-0.00103	-0.0001	0	-0.0001	-0.36555	-0.10753	0.17627	0.07085
167	28-Sep	-0.00103	-8E-05	0	-8E-05	-0.36658	-0.10761	0.17627	0.07077
168	29-Sep	-0.00103	-9E-05	0	-9E-05	-0.36761	-0.1077	0.17627	0.07068
169	30-Sep	-0.00104	-5E-05	0	-5E-05	-0.36865	-0.10775	0.17627	0.07063
170	1-Oct	-0.00056	-5E-05	0	-5E-05	-0.36921	-0.1078	0.17627	0.07058
171	2-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
172	3-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
173	4-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
174	5-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
175	6-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
176	7-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
177	8-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
178	9-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
179	10-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
180	11-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
181	12-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
182	13-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
183	14-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
184	15-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
185	16-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
186	17-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
187	18-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
188	19-Oct	0	0	0	0	-0.36921	-0.1078	0.17627	0.07058
189	20-Oct	0	0	0.00121	0.0012	-0.36921	-0.1078	0.17748	0.07178
190	21-Oct	0	0	0.00161	0.00161	-0.36921	-0.1078	0.17909	0.07339
191	22-Oct	0	0	0.00029	0.00029	-0.36921	-0.1078	0.17938	0.07368
192	23-Oct	0	0	1E-05	0	-0.36921	-0.1078	0.17939	0.07368
193	24-Oct	0	0	0	0	-0.36921	-0.1078	0.17939	0.07368
194	25-Oct	0	0	0	0	-0.36921	-0.1078	0.17939	0.07368
195	26-Oct	0	0	0	0	-0.36921	-0.1078	0.17939	0.07368
196	27-Oct	0	0	0	0	-0.36921	-0.1078	0.17939	0.07368
197	28-Oct	0	0	0	0	-0.36921	-0.1078	0.17939	0.07368
198	29-Oct	0	0	0.00085	0.00086	-0.36921	-0.1078	0.18024	0.07454
199	30-Oct	0	0	0.00125	0.00125	-0.36921	-0.1078	0.18149	0.07579
200	31-Oct	0	0	1E-05	1E-05	-0.36921	-0.1078	0.1815	0.0758

OPTION B - IN PIT WASTE ROCK NO COVER
CLIMATE WATER BALANCE
MEAN YEAR

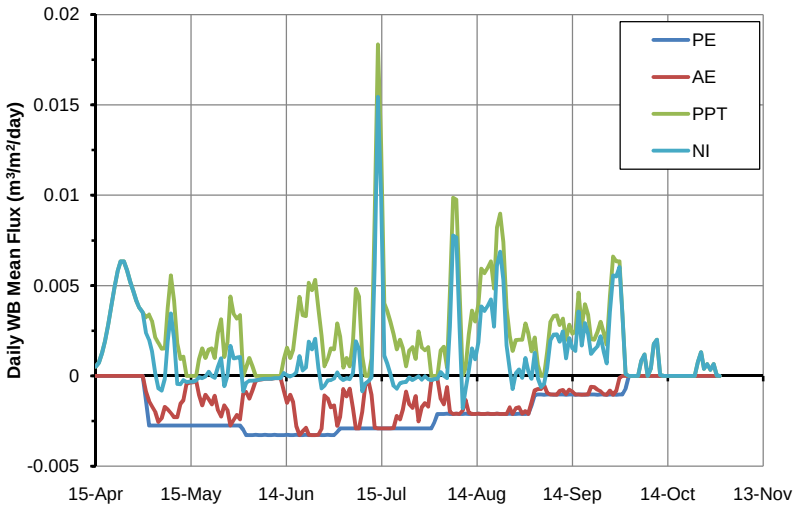


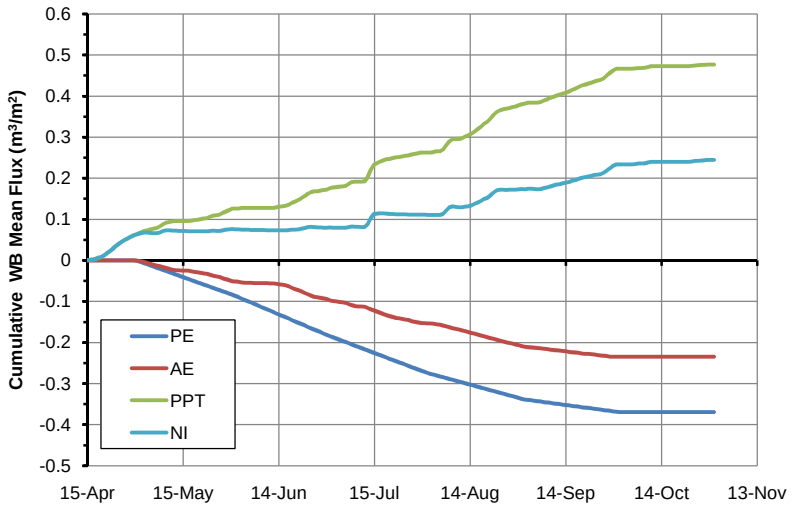


		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m3/m2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
1	15-Apr	0	0	0.00038	0.00039	0	0	0.00038	0.00039
2	16-Apr	0	0	0.00054	0.00051	0	0	0.00092	0.0009
3	17-Apr	0	0	0.00093	0.00092	0	0	0.00185	0.00182
4	18-Apr	0	0	0.00139	0.00139	0	0	0.00324	0.00321
5	19-Apr	0	0	0.00205	0.00205	0	0	0.00529	0.00526
6	20-Apr	0	0	0.00282	0.00282	0	0	0.00811	0.00808
7	21-Apr	0	0	0.00358	0.00358	0	0	0.01169	0.01166
8	22-Apr	0	0	0.00425	0.00425	0	0	0.01594	0.01591
9	23-Apr	0	0	0.00463	0.00463	0	0	0.02057	0.02054
10	24-Apr	0	0	0.00463	0.00463	0	0	0.0252	0.02517
11	25-Apr	0	0	0.00426	0.00426	0	0	0.02946	0.02943
12	26-Apr	0	0	0.00379	0.00378	0	0	0.03325	0.03321
13	27-Apr	0	0	0.0034	0.00341	0	0	0.03665	0.03662
14	28-Apr	0	0	0.00304	0.00303	0	0	0.03969	0.03965
15	29-Apr	0	0	0.00274	0.00275	0	0	0.04243	0.0424
16	30-Apr	0	0	0.00255	0.00255	0	0	0.04498	0.04495
17	1-May	-0.00132	-0.00082	0.00237	0.00155	-0.00132	-0.00082	0.04735	0.0465
18	2-May	-0.00274	-0.00142	0.00213	0.00072	-0.00406	-0.00224	0.04948	0.04722
19	3-May	-0.00274	-0.00172	0.00185	0.00016	-0.0068	-0.00396	0.05133	0.04738
20	4-May	-0.00274	-0.00195	0.00157	-0.00031	-0.00954	-0.00591	0.0529	0.04707
21	5-May	-0.00275	-0.00254	0.00226	-0.00023	-0.01229	-0.00845	0.05516	0.04684
22	6-May	-0.00274	-0.00275	0.00402	0.00127	-0.01503	-0.0112	0.05918	0.04811
23	7-May	-0.00274	-0.00258	0.00432	0.00162	-0.01777	-0.01378	0.0635	0.04973
24	8-May	-0.00274	-0.00177	0.00196	0.00034	-0.02051	-0.01555	0.06546	0.05007
25	9-May	-0.00274	-0.00096	1E-05	-0.00079	-0.02325	-0.01651	0.06547	0.04928
26	10-May	-0.00275	-0.00059	0	-0.00049	-0.026	-0.0171	0.06547	0.04879
27	11-May	-0.00274	-0.00037	0	-0.00035	-0.02874	-0.01747	0.06547	0.04844
28	12-May	-0.00274	-0.0006	0.00046	-1E-04	-0.03148	-0.01807	0.06593	0.04834
29	13-May	-0.00274	-0.00094	0.001	1E-04	-0.03422	-0.01901	0.06693	0.04844
30	14-May	-0.00274	-0.00138	0.00418	0.00282	-0.03696	-0.02039	0.07111	0.05126
31	15-May	-0.00275	-0.00157	0.00541	0.00388	-0.03971	-0.02196	0.07652	0.05514
32	16-May	-0.00274	-0.00196	0.00111	-0.0008	-0.04245	-0.02392	0.07763	0.05434
33	17-May	-0.00274	-0.00082	0	-0.00069	-0.04519	-0.02474	0.07763	0.05365
34	18-May	-0.00274	-0.00055	0	-0.00047	-0.04793	-0.02529	0.07763	0.05318
35	19-May	-0.00274	-0.00038	0	-0.00035	-0.05067	-0.02567	0.07763	0.05283
36	20-May	-0.00275	-0.00028	0	-0.00027	-0.05342	-0.02595	0.07763	0.05256
37	21-May	-0.00274	-0.00024	0	-0.00022	-0.05616	-0.02619	0.07763	0.05234
38	22-May	-0.00274	-0.00022	0	-0.00021	-0.0589	-0.02641	0.07763	0.05213
39	23-May	-0.00274	-0.00019	0	-0.00019	-0.06164	-0.0266	0.07763	0.05194
40	24-May	-0.00274	-0.00044	0.00046	5E-05	-0.06438	-0.02704	0.07809	0.05199
41	25-May	-0.00275	-0.00066	0.00053	-9E-05	-0.06713	-0.0277	0.07862	0.0519
42	26-May	-0.00274	-0.00022	0	-0.00021	-0.06987	-0.02792	0.07862	0.05169
43	27-May	-0.00274	-0.00017	0	-0.00018	-0.07261	-0.02809	0.07862	0.05151
44	28-May	-0.00274	-0.0005	0.00047	-1E-05	-0.07535	-0.02859	0.07909	0.0515
45	29-May	-0.00274	-0.0006	0.00053	-8E-05	-0.07809	-0.02919	0.07962	0.05142
46	30-May	-0.00275	-0.00017	0	-0.00017	-0.08084	-0.02936	0.07962	0.05125
47	31-May	-0.00274	-0.00048	0.00044	1E-05	-0.08358	-0.02984	0.08006	0.05126
48	1-Jun	-0.00298	-0.00062	0.00053	-0.0001	-0.08656	-0.03046	0.08059	0.05116
49	2-Jun	-0.00327	-0.00017	0	-0.00017	-0.08983	-0.03063	0.08059	0.05099
50	3-Jun	-0.00327	-0.00046	0.00047	3E-05	-0.0931	-0.03109	0.08106	0.05102
51	4-Jun	-0.00326	-0.0006	0.00054	-8E-05	-0.09636	-0.03169	0.0816	0.05094
52	5-Jun	-0.00327	-0.0005	0.00045	-1E-05	-0.09963	-0.03219	0.08205	0.05093
53	6-Jun	-0.00327	-0.0006	0.00055	-8E-05	-0.1029	-0.03279	0.0826	0.05085
54	7-Jun	-0.00326	-0.00176	0.0019	0.00021	-0.10616	-0.03455	0.0845	0.05106
55	8-Jun	-0.00327	-0.0025	0.0026	5E-05	-0.10943	-0.03705	0.0871	0.05111
56	9-Jun	-0.00327	-0.00068	0.00055	-0.00017	-0.1127	-0.03773	0.08765	0.05094
57	10-Jun	-0.00327	-0.00018	0	-0.00018	-0.11597	-0.03791	0.08765	0.05076
58	11-Jun	-0.00326	-0.00014	0	-0.00014	-0.11923	-0.03805	0.08765	0.05062
59	12-Jun	-0.00327	-0.00012	0	-0.00012	-0.1225	-0.03817	0.08765	0.0505
60	13-Jun	-0.00327	-0.00012	0	-0.00012	-0.12577	-0.03829	0.08765	0.05038
61	14-Jun	-0.00326	-0.00011	0	-0.00011	-0.12903	-0.0384	0.08765	0.05027
62	15-Jun	-0.00327	-0.00038	0.00047	0.00011	-0.1323	-0.03878	0.08812	0.05038
63	16-Jun	-0.00327	-0.00135	0.00146	0.00015	-0.13557	-0.04013	0.08958	0.05053
64	17-Jun	-0.00326	-0.00235	0.00246	0.00015	-0.13883	-0.04248	0.09204	0.05068
65	18-Jun	-0.00327	-0.00322	0.00387	0.00067	-0.1421	-0.0457	0.09591	0.05135
66	19-Jun	-0.00327	-0.00326	0.00882	0.00555	-0.14537	-0.04896	0.10473	0.0569
67	20-Jun	-0.00327	-0.00327	0.01081	0.00754	-0.14864	-0.05223	0.11554	0.06444
68	21-Jun	-0.00326	-0.00327	0.007	0.00374	-0.1519	-0.0555	0.12254	0.06818
69	22-Jun	-0.00327	-0.00326	0.007	0.00373	-0.15517	-0.05876	0.12954	0.07191
70	23-Jun	-0.00327	-0.00327	0.00463	0.00137	-0.15844	-0.06203	0.13417	0.07328
71	24-Jun	-0.00326	-0.00252	0.00092	-0.00142	-0.1617	-0.06455	0.13509	0.07186
72	25-Jun	-0.00327	-0.00172	0.00106	-0.00067	-0.16497	-0.06627	0.13615	0.07119
73	26-Jun	-0.00327	-0.00094	0.00046	-0.00042	-0.16824	-0.06721	0.13661	0.07077
74	27-Jun	-0.00326	-0.0009	0.00053	-0.00036	-0.1715	-0.06811	0.13714	0.07041
75	28-Jun	-0.00327	-0.00074	0.00046	-0.00024	-0.17477	-0.06885	0.1376	0.07017
76	29-Jun	-0.00327	-0.00283	0.00375	0.00097	-0.17804	-0.07168	0.14135	0.07114
77	30-Jun	-0.00327	-0.00326	0.00576	0.0025	-0.18131	-0.07494	0.14711	0.07364
78	1-Jul	-0.00314	-0.00312	0.00305	-0.0001	-0.18445	-0.07806	0.15016	0.07354
79	2-Jul	-0.0029	-0.00125	0.00053	-0.00069	-0.18735	-0.07931	0.15069	0.07285
80	3-Jul	-0.00291	-0.00219	0.00233	0.00019	-0.19026	-0.0815	0.15302	0.07304
81	4-Jul	-0.0029	-0.0029	0.00699	0.00409	-0.19316	-0.0844	0.16001	0.07713
82	5-Jul	-0.0029	-0.00291	0.00755	0.00465	-0.19606	-0.08731	0.16756	0.08178
83	6-Jul	-0.00291	-0.0029	0.0034	0.0005	-0.19897	-0.09021	0.17096	0.08228
84	7-Jul	-0.0029	-0.0029	0.00277	-0.00014	-0.20187	-0.09311	0.17373	0.08214
85	8-Jul	-0.0029	-0.00291	0.00524	0.00234	-0.20477	-0.09602	0.17897	0.08448
86	9-Jul	-0.0029	-0.0029	0.0076	0.0047	-0.20767	-0.09892	0.18657	0.08918
87	10-Jul	-0.00291	-0.0029	0.00574	0.00284	-0.21058	-0.10182	0.19231	0.09202
88	11-Jul	-0.0029	-0.00282	0.00197	-0.00079	-0.21348	-0.10464	0.19428	0.09123
89	12-Jul	-0.0029	-0.00147	0.00045	-0.00089	-0.21638	-0.10611	0.19473	0.09034
90	13-Jul	-0.00291	-0.00238	0.00195	-0.0004	-0.21929	-0.10849	0.19668	0.08994
91	14-Jul	-0.0029	-0.00199	0.0016	-0.00041	-0.22219	-0.11048	0.19828	0.08953

		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m3/m2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
92	15-Jul	-0.0029	-0.00081	0.00045	-0.00031	-0.22509	-0.11129	0.19873	0.08922
93	16-Jul	-0.00291	-0.00082	0.00054	-0.0003	-0.228	-0.11211	0.19927	0.08892
94	17-Jul	-0.0029	-0.00029	0	-0.00027	-0.2309	-0.1124	0.19927	0.08865
95	18-Jul	-0.0029	-0.00024	0	-0.00023	-0.2338	-0.11264	0.19927	0.08842
96	19-Jul	-0.0029	-0.001	0.00094	-1E-05	-0.2367	-0.11364	0.20021	0.08841
97	20-Jul	-0.00291	-0.00161	0.00155	-0.0001	-0.23961	-0.11525	0.20176	0.08831
98	21-Jul	-0.0029	-0.00112	0.001	-0.00013	-0.24251	-0.11637	0.20276	0.08818
99	22-Jul	-0.0029	-0.00154	0.00146	-4E-05	-0.24541	-0.11791	0.20422	0.08814
100	23-Jul	-0.00291	-0.00203	0.002	-3E-05	-0.24832	-0.11994	0.20622	0.08811
101	24-Jul	-0.0029	-0.00121	0.00106	-0.00018	-0.25122	-0.12115	0.20728	0.08793
102	25-Jul	-0.0029	-0.00059	0.00047	-1E-04	-0.25412	-0.12174	0.20775	0.08783
103	26-Jul	-0.00291	-0.00066	0.00054	-0.00014	-0.25703	-0.1224	0.20829	0.08769
104	27-Jul	-0.0029	-0.00019	0	-0.00019	-0.25993	-0.12259	0.20829	0.0875
105	28-Jul	-0.0029	-0.00015	0	-0.00015	-0.26283	-0.12274	0.20829	0.08735
106	29-Jul	-0.0029	-0.00047	0.00046	2E-05	-0.26573	-0.12321	0.20875	0.08737
107	30-Jul	-0.00291	-0.0006	0.00054	-9E-05	-0.26864	-0.12381	0.20929	0.08728
108	31-Jul	-0.0029	-0.00093	0.00095	7E-05	-0.27154	-0.12474	0.21024	0.08735
109	1-Aug	-0.00252	-0.0011	0.00105	-9E-05	-0.27406	-0.12584	0.21129	0.08726
110	2-Aug	-0.0021	-0.00019	0	-0.00018	-0.27616	-0.12603	0.21129	0.08708
111	3-Aug	-0.0021	-0.00014	0	-0.00014	-0.27826	-0.12617	0.21129	0.08694
112	4-Aug	-0.00209	-0.00121	0.00142	0.00026	-0.28035	-0.12738	0.21271	0.0872
113	5-Aug	-0.0021	-0.0021	0.00259	0.00048	-0.28245	-0.12948	0.2153	0.08768
114	6-Aug	-0.0021	-0.0017	0.00157	-0.00015	-0.28455	-0.13118	0.21687	0.08753
115	7-Aug	-0.0021	-0.0007	0.00053	-0.00018	-0.28665	-0.13188	0.2174	0.08735
116	8-Aug	-0.00209	-0.00018	0	-0.00019	-0.28874	-0.13206	0.2174	0.08716
117	9-Aug	-0.0021	-0.00015	0	-0.00014	-0.29084	-0.13221	0.2174	0.08702
118	10-Aug	-0.0021	-0.00045	0.00046	4E-05	-0.29294	-0.13266	0.21786	0.08706
119	11-Aug	-0.00209	-0.00059	0.00054	-7E-05	-0.29503	-0.13325	0.2184	0.08699
120	12-Aug	-0.0021	-0.00126	0.00141	0.0002	-0.29713	-0.13451	0.21981	0.08719
121	13-Aug	-0.0021	-0.00192	0.0021	0.00017	-0.29923	-0.13643	0.22191	0.08736
122	14-Aug	-0.00209	-0.00109	0.001	-1E-04	-0.30132	-0.13752	0.22291	0.08726
123	15-Aug	-0.0021	-0.00065	0.00054	-0.00013	-0.30342	-0.13817	0.22345	0.08713
124	16-Aug	-0.0021	-0.00052	0.00047	-3E-05	-0.30552	-0.13869	0.22392	0.0871
125	17-Aug	-0.0021	-0.0006	0.00053	-9E-05	-0.30762	-0.13929	0.22445	0.08701
126	18-Aug	-0.00209	-0.00016	0	-0.00016	-0.30971	-0.13945	0.22445	0.08685
127	19-Aug	-0.0021	-0.00153	0.00233	0.00085	-0.31181	-0.14098	0.22678	0.0877
128	20-Aug	-0.0021	-0.0021	0.00371	0.00161	-0.31391	-0.14308	0.23049	0.08931
129	21-Aug	-0.00209	-0.0021	0.00202	-8E-05	-0.316	-0.14518	0.23251	0.08923
130	22-Aug	-0.0021	-0.00209	0.00277	0.00068	-0.3181	-0.14727	0.23528	0.08991
131	23-Aug	-0.0021	-0.0021	0.00556	0.00346	-0.3202	-0.14937	0.24084	0.09337
132	24-Aug	-0.00209	-0.0021	0.00577	0.00367	-0.32229	-0.15147	0.24661	0.09704
133	25-Aug	-0.0021	-0.00191	0.00057	-0.0013	-0.32439	-0.15338	0.24718	0.09574
134	26-Aug	-0.0021	-0.00076	0	-0.00067	-0.32649	-0.15414	0.24718	0.09507
135	27-Aug	-0.0021	-0.00072	0.00047	-0.0002	-0.32859	-0.15486	0.24765	0.09487
136	28-Aug	-0.00209	-0.00088	0.00053	-0.00029	-0.33068	-0.15574	0.24818	0.09458
137	29-Aug	-0.0021	-0.00032	0	-0.0003	-0.33278	-0.15606	0.24818	0.09428
138	30-Aug	-0.0021	-0.00027	0	-0.00025	-0.33488	-0.15633	0.24818	0.09403
139	31-Aug	-0.00209	-0.0006	0.00046	-0.00011	-0.33697	-0.15693	0.24864	0.09392
140	1-Sep	-0.00166	-0.00109	0.001	-9E-05	-0.33863	-0.15802	0.24964	0.09383
141	2-Sep	-0.00103	-0.00085	0.00144	0.00057	-0.33966	-0.15887	0.25108	0.0944
142	3-Sep	-0.00104	-0.00072	0.00112	0.00041	-0.3407	-0.15959	0.2522	0.09481
143	4-Sep	-0.00103	-0.00087	0.00044	-0.00038	-0.34173	-0.16046	0.25264	0.09443
144	5-Sep	-0.00103	-0.0008	0.00055	-0.00026	-0.34276	-0.16126	0.25319	0.09417
145	6-Sep	-0.00104	-0.00064	0.00046	-0.00014	-0.3438	-0.1619	0.25365	0.09403
146	7-Sep	-0.00103	-0.00103	0.001	-3E-05	-0.34483	-0.16293	0.25465	0.094
147	8-Sep	-0.00103	-0.00072	0.00055	-0.00019	-0.34586	-0.16365	0.2552	0.09381
148	9-Sep	-0.00104	-0.0002	0	-0.0002	-0.3469	-0.16385	0.2552	0.09361
149	10-Sep	-0.00103	-0.00014	0	-0.00014	-0.34793	-0.16399	0.2552	0.09347
150	11-Sep	-0.00103	-0.00013	0	-0.00013	-0.34896	-0.16412	0.2552	0.09334
151	12-Sep	-0.00103	-0.00013	0	-0.00014	-0.34999	-0.16425	0.2552	0.0932
152	13-Sep	-0.00104	-0.00077	0.00138	0.00062	-0.35103	-0.16502	0.25658	0.09382
153	14-Sep	-0.00103	-0.00091	0.0017	0.00081	-0.35206	-0.16593	0.25828	0.09463
154	15-Sep	-0.00103	-0.00053	0	-0.00047	-0.35309	-0.16646	0.25828	0.09416
155	16-Sep	-0.00104	-0.00024	0	-0.00024	-0.35413	-0.1667	0.25828	0.09392
156	17-Sep	-0.00103	-0.00018	0	-0.00018	-0.35516	-0.16688	0.25828	0.09374
157	18-Sep	-0.00103	-0.00016	0	-0.00015	-0.35619	-0.16704	0.25828	0.09359
158	19-Sep	-0.00104	-0.00058	0.00094	0.00036	-0.35723	-0.16762	0.25922	0.09395
159	20-Sep	-0.00103	-0.00055	0.00109	0.00057	-0.35826	-0.16817	0.26031	0.09452
160	21-Sep	-0.00103	-0.00057	0.00046	-6E-05	-0.35929	-0.16874	0.26077	0.09446
161	22-Sep	-0.00103	-0.0006	0.00054	-4E-05	-0.36032	-0.16934	0.26131	0.09442
162	23-Sep	-0.00104	-0.00028	0	-0.00025	-0.36136	-0.16962	0.26131	0.09417
163	24-Sep	-0.00103	-0.00019	0	-0.00019	-0.36239	-0.16981	0.26131	0.09398
164	25-Sep	-0.00103	-0.00016	0	-0.00015	-0.36342	-0.16997	0.26131	0.09383
165	26-Sep	-0.00104	-0.00012	0	-0.00013	-0.36446	-0.17009	0.26131	0.0937
166	27-Sep	-0.00103	-0.00044	0.00046	6E-05	-0.36549	-0.17053	0.26177	0.09376
167	28-Sep	-0.00103	-0.00052	0.00053	1E-05	-0.36652	-0.17105	0.2623	0.09377
168	29-Sep	-0.00104	0	0	0	-0.36756	-0.17105	0.2623	0.09377
169	30-Sep	-0.00103	0	0	0	-0.36859	-0.17105	0.2623	0.09377
170	1-Oct	-0.0007	0	0	0	-0.36929	-0.17105	0.2623	0.09377
171	2-Oct	-2E-05	0	0	0	-0.36931	-0.17105	0.2623	0.09377
172	3-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
173	4-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
174	5-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
175	6-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
176	7-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
177	8-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
178	9-Oct	0	0	0	0	-0.36931	-0.17105	0.2623	0.09377
179	10-Oct	0	0	0.0004	0.0004	-0.36931	-0.17105	0.2627	0.09417
180	11-Oct	0	0	0.00061	0.00061	-0.36931	-0.17105	0.26331	0.09478
181	12-Oct	0	0	2E-05	2E-05	-0.36931	-0.17105	0.26333	0.0948
182	13-Oct	0	0	0	0	-0.36931	-0.17105	0.26333	0.0948
183	14-Oct	0	0	0.00123	0.00123	-0.36931	-0.17105	0.26456	0.09603
184	15-Oct	0	0	0.00177	0.00178	-0.36931	-0.17105	0.26633	0.09781
185	16-Oct	0	0	2E-05	1E-05	-0.36931	-0.17105	0.26635	0.09782
186	17-Oct	0	0	0	0	-0.36931	-0.17105	0.26635	0.09782
187	18-Oct	0	0	0	0	-0.36931	-0.17105	0.26635	0.09782
188	19-Oct	0	0	0.00073	0.00074	-0.36931	-0.17105	0.26708	0.09856
189	20-Oct	0	0	0.00164	0.00164	-0.36931	-0.17105	0.26872	0.1002
190	21-Oct	0	0	0.0007	0.0007	-0.36931	-0.17105	0.26942	0.1009
191	22-Oct	0	0	2E-05	2E-05	-0.36931	-0.17105	0.26944	0.10092
192	23-Oct	0	0	0.00116	0.00115	-0.36931	-0.17105	0.2706	0.10207
193	24-Oct	0	0	0.00326	0.00326	-0.36931	-0.17105	0.27386	0.10533
194	25-Oct	0	0	0.00334	0.00334	-0.36931	-0.17105	0.2772	0.10867
195	26-Oct	0	0	0.003	0.003	-0.36931	-0.17105	0.2802	0.11167
196	27-Oct	0	0	0.00334	0.00334	-0.36931	-0.17105	0.28354	0.11501
197	28-Oct	0	0	0.00044	0.00045	-0.36931	-0.17105	0.28398	0.11546
198	29-Oct	0	0	0.00066	0.00066	-0.36931	-0.17105	0.28464	0.11612
199	30-Oct	0	0	0.00034	0.00034	-0.36931	-0.17105	0.28498	0.11646
200	31-Oct	0	0	0.00066	0.00066	-0.36931	-0.17105	0.28564	0.11712

OPTION B - IN PIT WASTE ROCK NO COVER
CLIMATE WATER BALANCE
WET YEAR

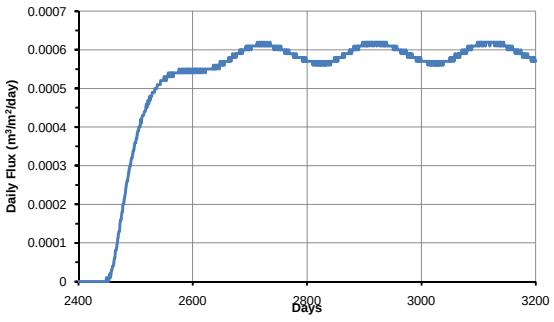


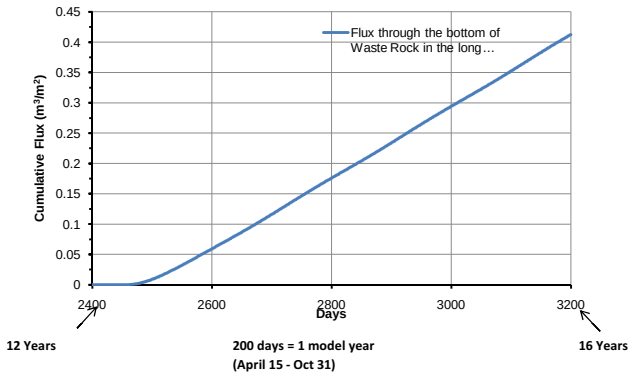


		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m^3/m^2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
1	15-Apr	0	0	0.00052	0.00052	0	0	0.00052	0.00052
2	16-Apr	0	0	0.00075	0.00072	0	0	0.00127	0.00124
3	17-Apr	0	0	0.00128	0.00128	0	0	0.00255	0.00252
4	18-Apr	0	0	0.00192	0.00192	0	0	0.00447	0.00444
5	19-Apr	0	0	0.00283	0.00282	0	0	0.0073	0.00726
6	20-Apr	0	0	0.00388	0.00388	0	0	0.01118	0.01114
7	21-Apr	0	0	0.00491	0.00492	0	0	0.01609	0.01606
8	22-Apr	0	0	0.00583	0.00582	0	0	0.02192	0.02188
9	23-Apr	0	0	0.00635	0.00635	0	0	0.02827	0.02823
10	24-Apr	0	0	0.00635	0.00635	0	0	0.03462	0.03458
11	25-Apr	0	0	0.00584	0.00584	0	0	0.04046	0.04042
12	26-Apr	0	0	0.0052	0.0052	0	0	0.04566	0.04562
13	27-Apr	0	0	0.00467	0.00467	0	0	0.05033	0.05029
14	28-Apr	0	0	0.00416	0.00416	0	0	0.05449	0.05445
15	29-Apr	0	0	0.00376	0.00376	0	0	0.05825	0.05821
16	30-Apr	0	0	0.0035	0.0035	0	0	0.06175	0.06171
17	1-May	-0.00134	-0.00084	0.00325	0.00241	-0.00134	-0.00084	0.065	0.06412
18	2-May	-0.00274	-0.0014	0.0034	0.002	-0.00408	-0.00224	0.0684	0.06612
19	3-May	-0.00274	-0.00168	0.00305	0.00137	-0.00682	-0.00392	0.07145	0.06749
20	4-May	-0.00274	-0.00199	0.00215	0.00017	-0.00956	-0.00591	0.0736	0.06766
21	5-May	-0.00275	-0.00255	0.00182	-0.00068	-0.01231	-0.00846	0.07542	0.06698
22	6-May	-0.00274	-0.00235	0.0015	-0.00081	-0.01505	-0.01081	0.07692	0.06617
23	7-May	-0.00274	-0.00171	0.00153	-0.00016	-0.01779	-0.01252	0.07845	0.06601
24	8-May	-0.00274	-0.00185	0.00376	0.0019	-0.02053	-0.01437	0.08221	0.06791
25	9-May	-0.00274	-0.00205	0.00556	0.00345	-0.02327	-0.01642	0.08777	0.07136
26	10-May	-0.00275	-0.00228	0.00416	0.00206	-0.02602	-0.0187	0.09193	0.07342
27	11-May	-0.00274	-0.00228	0.00183	-0.00044	-0.02876	-0.02098	0.09376	0.07298
28	12-May	-0.00274	-0.00154	0.00094	-0.00046	-0.0315	-0.02252	0.0947	0.07252
29	13-May	-0.00274	-0.00135	0.00106	-0.00023	-0.03424	-0.02387	0.09576	0.07229
30	14-May	-0.00274	-0.00043	0	-0.00034	-0.03698	-0.0243	0.09576	0.07195
31	15-May	-0.00275	-0.00037	0	-0.00031	-0.03973	-0.02467	0.09576	0.07164
32	16-May	-0.00274	-0.00035	0	-0.00031	-0.04247	-0.02502	0.09576	0.07133
33	17-May	-0.00274	-0.00027	0	-0.00025	-0.04521	-0.02529	0.09576	0.07108
34	18-May	-0.00274	-0.00106	0.00094	-7E-05	-0.04795	-0.02635	0.0967	0.07101
35	19-May	-0.00274	-0.00163	0.00153	-0.00013	-0.05069	-0.02798	0.09823	0.07088
36	20-May	-0.00275	-0.00104	0.001	-4E-05	-0.05344	-0.02902	0.09923	0.07084
37	21-May	-0.00274	-0.00129	0.00146	0.00023	-0.05618	-0.03031	0.10069	0.07107
38	22-May	-0.00274	-0.00158	0.00153	-2E-05	-0.05892	-0.03189	0.10222	0.07105
39	23-May	-0.00274	-0.0011	0.001	-0.0001	-0.06166	-0.03299	0.10322	0.07095
40	24-May	-0.00274	-0.0019	0.0024	0.0005	-0.0644	-0.03489	0.10562	0.07145
41	25-May	-0.00275	-0.00225	0.00313	0.00097	-0.06715	-0.03714	0.10875	0.07242
42	26-May	-0.00274	-0.00163	0.00105	-0.00056	-0.06989	-0.03877	0.1098	0.07186
43	27-May	-0.00274	-0.0019	0.00188	3E-05	-0.07263	-0.04067	0.11168	0.07189
44	28-May	-0.00274	-0.00274	0.00439	0.00166	-0.07537	-0.04341	0.11607	0.07355
45	29-May	-0.00274	-0.00244	0.00343	0.00097	-0.07811	-0.04585	0.1195	0.07452
46	30-May	-0.00275	-0.00215	0.00317	0.00101	-0.08086	-0.048	0.12267	0.07553
47	31-May	-0.00274	-0.0024	0.00336	0.00104	-0.0836	-0.0504	0.12603	0.07657
48	1-Jun	-0.00298	-0.00099	0	-0.00085	-0.08658	-0.05139	0.12603	0.07572
49	2-Jun	-0.00327	-0.00089	0.00046	-0.00038	-0.08985	-0.05228	0.12649	0.07534
50	3-Jun	-0.00327	-0.00126	0.00099	-0.00026	-0.09312	-0.05354	0.12748	0.07508
51	4-Jun	-0.00327	-0.0008	0.00054	-0.00027	-0.09639	-0.05434	0.12802	0.07481
52	5-Jun	-0.00326	-0.00026	0	-0.00025	-0.09965	-0.0546	0.12802	0.07456
53	6-Jun	-0.00327	-0.00021	0	-0.00021	-0.10292	-0.05481	0.12802	0.07435
54	7-Jun	-0.00327	-0.00019	0	-0.00018	-0.10619	-0.055	0.12802	0.07417
55	8-Jun	-0.00326	-0.00016	0	-0.00016	-0.10945	-0.05516	0.12802	0.07401
56	9-Jun	-0.00327	-0.00015	0	-0.00015	-0.11272	-0.05531	0.12802	0.07386
57	10-Jun	-0.00327	-0.00015	0	-0.00015	-0.11599	-0.05546	0.12802	0.07371
58	11-Jun	-0.00326	-0.00013	0	-0.00013	-0.11925	-0.05559	0.12802	0.07358
59	12-Jun	-0.00327	-0.00013	0	-0.00013	-0.12252	-0.05572	0.12802	0.07345
60	13-Jun	-0.00327	-0.00012	0	-0.00012	-0.12579	-0.05584	0.12802	0.07333
61	14-Jun	-0.00327	-0.00083	0.00094	0.00016	-0.12906	-0.05667	0.12896	0.07349
62	15-Jun	-0.00326	-0.00148	0.00156	3E-05	-0.13232	-0.05815	0.13052	0.07352
63	16-Jun	-0.00327	-0.00104	0.001	-3E-05	-0.13559	-0.05919	0.13152	0.07349
64	17-Jun	-0.00327	-0.00145	0.00146	4E-05	-0.13886	-0.06064	0.13298	0.07353
65	18-Jun	-0.00326	-0.00277	0.00292	0.0002	-0.14212	-0.06341	0.1359	0.07373
66	19-Jun	-0.00327	-0.00327	0.00437	0.0011	-0.14539	-0.06668	0.14027	0.07483
67	20-Jun	-0.00327	-0.00306	0.00337	0.00031	-0.14866	-0.06974	0.14364	0.07514
68	21-Jun	-0.00326	-0.00287	0.00331	0.00047	-0.15192	-0.07261	0.14695	0.07561
69	22-Jun	-0.00327	-0.00326	0.00516	0.0019	-0.15519	-0.07587	0.15211	0.07751
70	23-Jun	-0.00327	-0.00327	0.00475	0.00148	-0.15846	-0.07914	0.15686	0.07899
71	24-Jun	-0.00327	-0.00327	0.00532	0.00205	-0.16173	-0.08241	0.16218	0.08104
72	25-Jun	-0.00326	-0.00326	0.00372	0.00045	-0.16499	-0.08567	0.1659	0.08149
73	26-Jun	-0.00327	-0.00292	0.00221	-0.00068	-0.16826	-0.08859	0.16811	0.08081
74	27-Jun	-0.00327	-0.00108	0.00054	-0.00054	-0.17153	-0.08967	0.16865	0.08027
75	28-Jun	-0.00326	-0.00124	0.00092	-0.00025	-0.17479	-0.09091	0.16957	0.08002
76	29-Jun	-0.00327	-0.00173	0.00153	-0.00022	-0.17806	-0.09264	0.1711	0.0798
77	30-Jun	-0.00327	-0.00163	0.00147	-0.00014	-0.18133	-0.09427	0.17257	0.07966
78	1-Jul	-0.0031	-0.00276	0.0029	0.0002	-0.18443	-0.09703	0.17547	0.07986
79	2-Jul	-0.0029	-0.00224	0.00218	-9E-05	-0.18733	-0.09927	0.17765	0.07977
80	3-Jul	-0.00291	-0.00072	0.00047	-0.00023	-0.19024	-0.09999	0.17812	0.07954
81	4-Jul	-0.0029	-0.00113	0.001	-0.00013	-0.19314	-0.10112	0.17912	0.07941
82	5-Jul	-0.0029	-0.0007	0.00054	-0.00018	-0.19604	-0.10182	0.17966	0.07923
83	6-Jul	-0.00291	-0.00178	0.00189	0.00017	-0.19895	-0.1036	0.18155	0.0794
84	7-Jul	-0.0029	-0.0029	0.00482	0.00192	-0.20185	-0.1065	0.18637	0.08132
85	8-Jul	-0.0029	-0.00291	0.00438	0.00148	-0.20475	-0.10941	0.19075	0.0828
86	9-Jul	-0.00291	-0.00198	0.00111	-0.00085	-0.20766	-0.11139	0.19186	0.08195
87	10-Jul	-0.0029	-0.00046	0	-0.00041	-0.21056	-0.11185	0.19186	0.08154
88	11-Jul	-0.0029	-0.00031	0	-0.00029	-0.21346	-0.11216	0.19186	0.08125
89	12-Jul	-0.0029	-0.00104	0.00095	-6E-05	-0.21636	-0.1132	0.19281	0.08119
90	13-Jul	-0.00291	-0.00286	0.00898	0.00613	-0.21927	-0.11606	0.20179	0.08732
91	14-Jul	-0.0029	-0.00291	0.01834	0.01544	-0.22217	-0.11897	0.22013	0.10276

		DAILY VALUES VS. TIME (m^3/m^2/day)				CUMULATIVE VALUES VS. TIME (m^3/m^2)			
Time	Date	PE	AE	PPT	NI	PE	AE	PPT	NI
92	15-Jul	-0.0029	-0.0029	0.01282	0.00991	-0.22507	-0.12187	0.23295	0.11267
93	16-Jul	-0.00291	-0.0029	0.00401	0.00111	-0.22798	-0.12477	0.23696	0.11378
94	17-Jul	-0.0029	-0.0029	0.0036	0.0007	-0.23088	-0.12767	0.24056	0.11448
95	18-Jul	-0.0029	-0.00291	0.003	0.0001	-0.23378	-0.13058	0.24356	0.11458
96	19-Jul	-0.00291	-0.00288	0.00231	-0.00055	-0.23669	-0.13346	0.24587	0.11403
97	20-Jul	-0.0029	-0.00222	0.00147	-0.00071	-0.23959	-0.13568	0.24734	0.11332
98	21-Jul	-0.0029	-0.00241	0.002	-0.00041	-0.24249	-0.13809	0.24934	0.11291
99	22-Jul	-0.0029	-0.00186	0.00153	-0.00035	-0.24539	-0.13995	0.25087	0.11256
100	23-Jul	-0.00291	-0.00086	0.00054	-0.00034	-0.2483	-0.14081	0.25141	0.11222
101	24-Jul	-0.0029	-0.00158	0.00142	-9E-05	-0.2512	-0.14239	0.25283	0.11213
102	25-Jul	-0.0029	-0.00176	0.00159	-0.00023	-0.2541	-0.14415	0.25442	0.1119
103	26-Jul	-0.00291	-0.00111	0.00094	-0.00012	-0.25701	-0.14526	0.25536	0.11178
104	27-Jul	-0.0029	-0.00252	0.00246	-2E-05	-0.25991	-0.14778	0.25782	0.11176
105	28-Jul	-0.0029	-0.00174	0.00158	-0.00021	-0.26281	-0.14952	0.2594	0.11155
106	29-Jul	-0.00291	-0.00151	0.00141	-2E-05	-0.26572	-0.15103	0.26081	0.11153
107	30-Jul	-0.0029	-0.00169	0.00159	-0.00017	-0.26862	-0.15272	0.2624	0.11136
108	31-Jul	-0.0029	-0.00025	0	-0.00023	-0.27152	-0.15297	0.2624	0.11113
109	1-Aug	-0.00259	-0.00018	0	-0.00018	-0.27411	-0.15315	0.2624	0.11095
110	2-Aug	-0.0021	-0.00016	0	-0.00016	-0.27621	-0.15331	0.2624	0.11079
111	3-Aug	-0.0021	-0.00125	0.0014	0.00021	-0.27831	-0.15456	0.2638	0.111
112	4-Aug	-0.0021	-0.00158	0.00161	1E-05	-0.28041	-0.15614	0.26541	0.11101
113	5-Aug	-0.00209	-0.00061	0.00046	-0.00012	-0.2825	-0.15675	0.26587	0.11089
114	6-Aug	-0.0021	-0.00199	0.00468	0.00271	-0.2846	-0.15874	0.27055	0.1136
115	7-Aug	-0.0021	-0.0021	0.00987	0.00777	-0.2867	-0.16084	0.28042	0.12137
116	8-Aug	-0.00209	-0.00209	0.00976	0.00767	-0.28879	-0.16293	0.29018	0.12904
117	9-Aug	-0.0021	-0.0021	0.00481	0.00271	-0.29089	-0.16503	0.29499	0.13175
118	10-Aug	-0.0021	-0.00191	3E-05	-0.00178	-0.29299	-0.16694	0.29502	0.12997
119	11-Aug	-0.00209	-0.00132	0.00045	-0.00075	-0.29508	-0.16826	0.29547	0.12922
120	12-Aug	-0.0021	-0.00203	0.00231	0.0003	-0.29718	-0.17029	0.29778	0.12952
121	13-Aug	-0.0021	-0.0021	0.00362	0.00152	-0.29928	-0.17239	0.3014	0.13104
122	14-Aug	-0.0021	-0.0021	0.00302	0.00093	-0.30138	-0.17449	0.30442	0.13197
123	15-Aug	-0.00209	-0.00209	0.00396	0.00186	-0.30347	-0.17658	0.30838	0.13383
124	16-Aug	-0.0021	-0.0021	0.00594	0.00384	-0.30557	-0.17868	0.31432	0.13767
125	17-Aug	-0.0021	-0.0021	0.00568	0.00359	-0.30767	-0.18078	0.32	0.14126
126	18-Aug	-0.00209	-0.00209	0.00598	0.00388	-0.30976	-0.18287	0.32598	0.14514
127	19-Aug	-0.0021	-0.0021	0.00634	0.00424	-0.31186	-0.18497	0.33232	0.14938
128	20-Aug	-0.0021	-0.0021	0.00483	0.00273	-0.31396	-0.18707	0.33715	0.15211
129	21-Aug	-0.00209	-0.00209	0.00822	0.00612	-0.31605	-0.18916	0.34537	0.15823
130	22-Aug	-0.0021	-0.0021	0.00898	0.00688	-0.31815	-0.19126	0.35435	0.16511
131	23-Aug	-0.0021	-0.0021	0.0074	0.00531	-0.32025	-0.19336	0.36175	0.17042
132	24-Aug	-0.0021	-0.0021	0.00378	0.00168	-0.32235	-0.19546	0.36553	0.1721
133	25-Aug	-0.00209	-0.00174	0.00222	0.00035	-0.32444	-0.1972	0.36775	0.17245
134	26-Aug	-0.0021	-0.0021	0.00138	-0.00072	-0.32654	-0.1993	0.36913	0.17173
135	27-Aug	-0.0021	-0.00179	0.00199	0.00014	-0.32864	-0.20109	0.37112	0.17187
136	28-Aug	-0.00209	-0.00174	0.002	0.00036	-0.33073	-0.20283	0.37312	0.17223
137	29-Aug	-0.0021	-0.00209	0.002	-1E-04	-0.33283	-0.20492	0.37512	0.17213
138	30-Aug	-0.0021	-0.00194	0.00291	0.00099	-0.33493	-0.20686	0.37803	0.17312
139	31-Aug	-0.00209	-0.0021	0.00235	0.00027	-0.33702	-0.20896	0.38038	0.17339
140	1-Sep	-0.00162	-0.00147	0.00136	-0.00015	-0.33864	-0.21043	0.38174	0.17324
141	2-Sep	-0.00104	-0.00079	0.00213	0.00127	-0.33968	-0.21122	0.38387	0.17451
142	3-Sep	-0.00103	-0.00072	0.00057	-0.00014	-0.34071	-0.21194	0.38444	0.17437
143	4-Sep	-0.00103	-0.00073	0	-0.00062	-0.34174	-0.21267	0.38444	0.17375
144	5-Sep	-0.00104	-0.00049	0	-0.00045	-0.34278	-0.21316	0.38444	0.1733
145	6-Sep	-0.00103	-0.00093	0.00135	0.00044	-0.34381	-0.21409	0.38579	0.17374
146	7-Sep	-0.00103	-0.00103	0.00299	0.00196	-0.34484	-0.21512	0.38878	0.1757
147	8-Sep	-0.00104	-0.00103	0.00332	0.00229	-0.34588	-0.21615	0.3921	0.17799
148	9-Sep	-0.00103	-0.00104	0.00334	0.0023	-0.34691	-0.21719	0.39544	0.18029
149	10-Sep	-0.00103	-0.00083	0.00282	0.0019	-0.34794	-0.21802	0.39826	0.18219
150	11-Sep	-0.00103	-0.00078	0.00318	0.00247	-0.34897	-0.2188	0.40144	0.18466
151	12-Sep	-0.00104	-0.00101	0.00201	0.00098	-0.35001	-0.21981	0.40345	0.18564
152	13-Sep	-0.00103	-0.00076	0.00284	0.00209	-0.35104	-0.22057	0.40629	0.18773
153	14-Sep	-0.00103	-0.00086	0.00234	0.00153	-0.35207	-0.22143	0.40863	0.18926
154	15-Sep	-0.00104	-0.00103	0.00242	0.00138	-0.35311	-0.22246	0.41105	0.19064
155	16-Sep	-0.00103	-0.00103	0.0046	0.00357	-0.35414	-0.22349	0.41565	0.19421
156	17-Sep	-0.00103	-0.00104	0.00272	0.00169	-0.35517	-0.22453	0.41837	0.1959
157	18-Sep	-0.00104	-0.00103	0.00396	0.00293	-0.35621	-0.22556	0.42233	0.19883
158	19-Sep	-0.00103	-0.00103	0.00336	0.00232	-0.35724	-0.22659	0.42569	0.20115
159	20-Sep	-0.00103	-0.0006	0.00204	0.00122	-0.35827	-0.22719	0.42773	0.20237
160	21-Sep	-0.00103	-0.00062	0.002	0.00145	-0.3593	-0.22781	0.42973	0.20382
161	22-Sep	-0.00104	-0.00076	0.00242	0.00164	-0.36034	-0.22857	0.43215	0.20546
162	23-Sep	-0.00103	-0.00085	0.003	0.00219	-0.36137	-0.22942	0.43515	0.20765
163	24-Sep	-0.00103	-0.00103	0.00236	0.00132	-0.3624	-0.23045	0.43751	0.20897
164	25-Sep	-0.00104	-0.00104	0.00172	0.0007	-0.36344	-0.23149	0.43923	0.20967
165	26-Sep	-0.00103	-0.00082	0.00443	0.00355	-0.36447	-0.23231	0.44366	0.21322
166	27-Sep	-0.00103	-0.00104	0.0066	0.00557	-0.3655	-0.23335	0.45026	0.21879
167	28-Sep	-0.00104	-0.00082	0.00634	0.00551	-0.36654	-0.23417	0.4566	0.2243
168	29-Sep	-0.00103	-0.00011	0.00634	0.00603	-0.36757	-0.23428	0.46294	0.23033
169	30-Sep	-0.00103	0	0.00344	0.00344	-0.3686	-0.23428	0.46638	0.23377
170	1-Oct	-0.0007	0	1E-04	1E-04	-0.3693	-0.23428	0.46648	0.23387
171	2-Oct	-2E-05	0	0	0	-0.36932	-0.23428	0.46648	0.23387
172	3-Oct	0	0	0	0	-0.36932	-0.23428	0.46648	0.23387
173	4-Oct	0	0	0	0	-0.36932	-0.23428	0.46648	0.23387
174	5-Oct	0	0	0	0	-0.36932	-0.23428	0.46648	0.23387
175	6-Oct	0	0	0.00084	0.00085	-0.36932	-0.23428	0.46732	0.23472
176	7-Oct	0	0	0.00119	0.00118	-0.36932	-0.23428	0.46851	0.2359
177	8-Oct	0	0	1E-05	1E-05	-0.36932	-0.23428	0.46852	0.23591
178	9-Oct	0	0	0.00042	0.00043	-0.36932	-0.23428	0.46894	0.23634
179	10-Oct	0	0	0.00176	0.00176	-0.36932	-0.23428	0.4707	0.2381
180	11-Oct	0	0	0.002	0.002	-0.36932	-0.23428	0.4727	0.2401
181	12-Oct	0	0	6E-05	6E-05	-0.36932	-0.23428	0.47276	0.24016
182	13-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
183	14-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
184	15-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
185	16-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
186	17-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
187	18-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
188	19-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
189	20-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
190	21-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
191	22-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
192	23-Oct	0	0	0	0	-0.36932	-0.23428	0.47276	0.24016
193	24-Oct	0	0	0.00079	0.00079	-0.36932	-0.23428	0.47355	0.24095
194	25-Oct	0	0	0.00132	0.00132	-0.36932	-0.23428	0.47487	0.24227
195	26-Oct	0	0	0.00039	0.00039	-0.36932	-0.23428	0.47526	0.24266
196	27-Oct	0	0	0.00066	0.00066	-0.36932	-0.23428	0.47592	0.24332
197	28-Oct	0	0	0.00034	0.00034	-0.36932	-0.23428	0.47626	0.24366
198	29-Oct	0	0	0.00066	0.00066	-0.36932	-0.23428	0.47692	0.24432
199	30-Oct	0	0	2E-05	2E-05	-0.36932	-0.23428	0.47694	0.24434
200	31-Oct	0	0	0	0	-0.36932	-0.23428	0.47694	0.24434

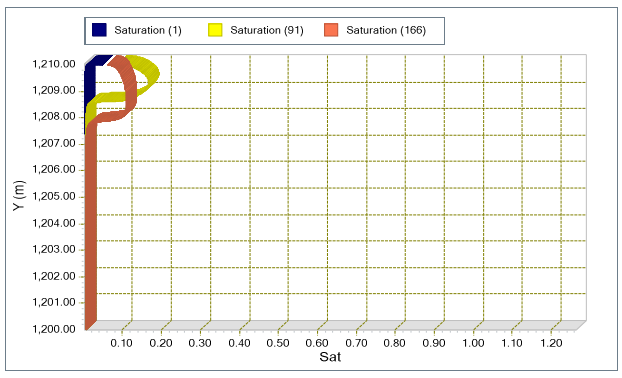
Flux through the bottom of Waste Rock in the long term for mean years
Note: Day 2400 means 12 Years - every 200 days mean one more year





Day	DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
2400	0	0
2401	0	0
2402	0	0
2403	0	0
2404	0	0
2405	0	0
2406	0	0
2407	0	0
2408	0	0
2409	0	0
2410	0	0
2411	0	0
2412	0	0
2413	0	0
2414	0	0
2415	0	0
2416	0	0
2417	0	0
2418	0	0
2419	0	0
2420	0	0
2421	0	0
2422	0	0
2423	0	0
2424	0	0
2425	0	0
2426	0	0
2427	0	0
2428	0	0
2429	0	0
2430	0	0
2431	0	0
2432	0	0
2433	0	0
2434	0	0
2435	0	0
2436	0	0
2437	0	0
2438	0	0
2439	0	0
2440	0	0
2441	0	0
2442	0	0
2443	0	0
2444	0	0
2445	0	0
2446	0	0
2447	0	0
2448	0	0
2449	0.00001	0.00001
2450	0	0.00001
2451	0	0.00001
2452	0.00001	0.00002
2453	0	0.00002
2454	0.00001	0.00003
2455	0.00002	0.00005
2456	0.00001	0.00006
2457	0.00002	0.00008
2458	0.00003	0.00011
2459	0.00003	0.00014
2460	0.00004	0.00018
2461	0.00004	0.00022
2462	0.00005	0.00027
2463	0.00006	0.00033
2464	0.00006	0.00039
2465	0.00008	0.00047
2466	0.00008	0.00055
2467	0.00009	0.00064
2468	1E-04	0.00074
2469	0.00011	0.00085
2470	0.00012	0.00097
2471	0.00013	0.0011
2472	0.00013	0.00123
2473	0.00015	0.00138
2474	0.00016	0.00154
2475	0.00016	0.0017
2476	0.00018	0.00188
2477	0.00018	0.00206
2478	0.0002	0.00226
2479	0.0002	0.00246
2480	0.00021	0.00267
2481	0.00022	0.00289
2482	0.00023	0.00312
2483	0.00024	0.00336
2484	0.00025	0.00361
2485	0.00026	0.00387
2486	0.00026	0.00413
2487	0.00027	0.0044
2488	0.00028	0.00468
2489	0.00029	0.00497
2490	0.0003	0.00527
2491	0.0003	0.00557
2492	0.00031	0.00588
2493	0.00032	0.0062
2494	0.00032	0.00652
2495	0.00033	0.00685
2496	0.00034	0.00719
2497	0.00034	0.00753
2498	0.00035	0.00788
2499	0.00036	0.00824
2500	0.00036	0.0086
2501	0.00037	0.00897
2502	0.00037	0.00934
2503	0.00038	0.00972
2504	0.00039	0.01011
2505	0.00039	0.0105
2506	0.0004	0.0109
2507	0.0004	0.0113
2508	0.0004	0.0117
2509	0.00042	0.01212
2510	0.00041	0.01253
2511	0.00042	0.01295
2512	0.00043	0.01338
2513	0.00043	0.01381
2514	0.00043	0.01424
2515	0.00044	0.01468
2516	0.00044	0.01512
2517	0.00044	0.01556
2518	0.00045	0.01601
2519	0.00046	0.01647
2520	0.00045	0.01692
2521	0.00046	0.01738
2522	0.00047	0.01785
2523	0.00046	0.01831
2524	0.00047	0.01878
2525	0.00048	0.01926
2526	0.00047	0.01973
2527	0.00048	0.02021
2528	0.00048	0.02069
2529	0.00049	0.02118
2530	0.00049	0.02167
2531	0.00049	0.02216
2532	0.00049	0.02265
2533	0.00049	0.02314
2534	0.0005	0.02364
2535	0.0005	0.02414
2536	0.0005	0.02464
2537	0.0005	0.02514
2538	0.00051	0.02565
2539	0.00051	0.02616
2540	0.00051	0.02667

General Pattern of Water Flowing down the permeable waste rock during first year



Day	DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
2541	0.00051	0.02718
2542	0.00051	0.02769
2543	0.00051	0.0282
2544	0.00052	0.02872
2545	0.00052	0.02924
2546	0.00052	0.02976
2547	0.00052	0.03028
2548	0.00052	0.0308
2549	0.00052	0.03132
2550	0.00053	0.03185
2551	0.00052	0.03237
2552	0.00053	0.0329
2553	0.00053	0.03343
2554	0.00052	0.03395
2555	0.00053	0.03448
2556	0.00053	0.03501
2557	0.00054	0.03555
2558	0.00053	0.03608
2559	0.00053	0.03661
2560	0.00054	0.03715
2561	0.00053	0.03768
2562	0.00054	0.03822
2563	0.00053	0.03875
2564	0.00054	0.03929
2565	0.00054	0.03983
2566	0.00053	0.04036
2567	0.00054	0.0409
2568	0.00054	0.04144
2569	0.00054	0.04198
2570	0.00054	0.04252
2571	0.00054	0.04306
2572	0.00054	0.0436
2573	0.00054	0.04414
2574	0.00054	0.04468
2575	0.00054	0.04522
2576	0.00055	0.04577
2577	0.00054	0.04631
2578	0.00054	0.04685
2579	0.00054	0.04739
2580	0.00055	0.04794
2581	0.00054	0.04848
2582	0.00054	0.04902
2583	0.00055	0.04957
2584	0.00054	0.05011
2585	0.00055	0.05066
2586	0.00054	0.0512
2587	0.00054	0.05174
2588	0.00055	0.05229
2589	0.00054	0.05283
2590	0.00055	0.05338
2591	0.00054	0.05392
2592	0.00055	0.05447
2593	0.00054	0.05501
2594	0.00055	0.05556
2595	0.00055	0.05611
2596	0.00054	0.05665
2597	0.00055	0.0572
2598	0.00054	0.05774
2599	0.00055	0.05829
2600	0.00054	0.05883
2601	0.00055	0.05938
2602	0.00055	0.05993
2603	0.00054	0.06047
2604	0.00055	0.06102
2605	0.00054	0.06156
2606	0.00055	0.06211
2607	0.00055	0.06266
2608	0.00054	0.0632
2609	0.00055	0.06375
2610	0.00055	0.0643
2611	0.00054	0.06484
2612	0.00055	0.06539
2613	0.00055	0.06594
2614	0.00054	0.06648
2615	0.00055	0.06703
2616	0.00055	0.06758
2617	0.00054	0.06812
2618	0.00055	0.06867
2619	0.00055	0.06922
2620	0.00055	0.06977
2621	0.00055	0.07032
2622	0.00054	0.07086
2623	0.00055	0.07141
2624	0.00055	0.07196
2625	0.00055	0.07251
2626	0.00055	0.07306
2627	0.00055	0.07361
2628	0.00055	0.07416
2629	0.00055	0.07471
2630	0.00055	0.07526
2631	0.00055	0.07581
2632	0.00055	0.07636
2633	0.00055	0.07691
2634	0.00055	0.07746
2635	0.00055	0.07801
2636	0.00056	0.07857
2637	0.00055	0.07912
2638	0.00055	0.07967
2639	0.00056	0.08023
2640	0.00055	0.08078
2641	0.00056	0.08134
2642	0.00055	0.08189
2643	0.00056	0.08245
2644	0.00056	0.08301
2645	0.00056	0.08357
2646	0.00056	0.08413
2647	0.00055	0.08468
2648	0.00057	0.08525
2649	0.00056	0.08581
2650	0.00056	0.08637
2651	0.00056	0.08693
2652	0.00057	0.0875
2653	0.00056	0.08806
2654	0.00057	0.08863
2655	0.00056	0.08919
2656	0.00057	0.08976
2657	0.00057	0.09033
2658	0.00057	0.0909
2659	0.00057	0.09147
2660	0.00057	0.09204
2661	0.00057	0.09261
2662	0.00057	0.09318
2663	0.00058	0.09376
2664	0.00057	0.09433
2665	0.00058	0.09491
2666	0.00058	0.09549
2667	0.00057	0.09606
2668	0.00058	0.09664
2669	0.00058	0.09722
2670	0.00059	0.09781
2671	0.00058	0.09839
2672	0.00058	0.09897
2673	0.00058	0.09955
2674	0.00059	0.10014
2675	0.00059	0.10073
2676	0.00058	0.10131
2677	0.00059	0.1019
2678	0.00059	0.10249
2679	0.00059	0.10308
2680	0.00059	0.10367
2681	0.00059	0.10426
2682	0.0006	0.10486
2683	0.00059	0.10545
2684	0.0006	0.10605
2685	0.00059	0.10664
2686	0.0006	0.10724
2687	0.00059	0.10783
2688	0.0006	0.10843
2689	0.0006	0.10903
2690	0.0006	0.10963
2691	0.0006	0.11023
2692	0.0006	0.11083
2693	0.00061	0.11144
2694	0.0006	0.11204
2695	0.0006	0.11264
2696	0.00061	0.11325
2697	0.0006	0.11385
2698	0.00061	0.11446
2699	0.0006	0.11506
2700	0.00061	0.11567
2701	0.00061	0.11628
2702	0.0006	0.11688
2703	0.00061	0.11749
2704	0.00061	0.1181
2705	0.00061	0.11871
2706	0.00061	0.11932

Day	DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
2707	0.00061	0.11993
2708	0.00061	0.12054
2709	0.00061	0.12115
2710	0.00061	0.12176
2711	0.00061	0.12237
2712	0.00061	0.12298
2713	0.00062	0.1236
2714	0.00061	0.12421
2715	0.00061	0.12482
2716	0.00061	0.12543
2717	0.00062	0.12605
2718	0.00061	0.12666
2719	0.00061	0.12727
2720	0.00062	0.12789
2721	0.00061	0.1285
2722	0.00061	0.12911
2723	0.00062	0.12973
2724	0.00061	0.13034
2725	0.00061	0.13095
2726	0.00062	0.13157
2727	0.00061	0.13218
2728	0.00061	0.13279
2729	0.00061	0.1334
2730	0.00062	0.13402
2731	0.00061	0.13463
2732	0.00061	0.13524
2733	0.00061	0.13585
2734	0.00061	0.13646
2735	0.00062	0.13708
2736	0.00061	0.13769
2737	0.00061	0.1383
2738	0.00061	0.13891
2739	0.00061	0.13952
2740	0.00061	0.14013
2741	0.00061	0.14074
2742	0.0006	0.14134
2743	0.00061	0.14195
2744	0.00061	0.14256
2745	0.00061	0.14317
2746	0.0006	0.14377
2747	0.00061	0.14438
2748	0.00061	0.14499
2749	0.0006	0.14559
2750	0.0006	0.14619
2751	0.00061	0.1468
2752	0.0006	0.1474
2753	0.0006	0.148
2754	0.00061	0.14861
2755	0.0006	0.14921
2756	0.0006	0.14981
2757	0.0006	0.15041
2758	0.0006	0.15101
2759	0.0006	0.15161
2760	0.0006	0.15221
2761	0.00059	0.1528
2762	0.0006	0.1534
2763	0.0006	0.154
2764	0.00059	0.15459
2765	0.0006	0.15519
2766	0.00059	0.15578
2767	0.00059	0.15637
2768	0.0006	0.15697
2769	0.00059	0.15756
2770	0.00059	0.15815
2771	0.00059	0.15874
2772	0.00059	0.15933
2773	0.00059	0.15992
2774	0.00059	0.16051
2775	0.00059	0.1611
2776	0.00058	0.16168
2777	0.00059	0.16227
2778	0.00059	0.16286
2779	0.00058	0.16344
2780	0.00058	0.16402
2781	0.00059	0.16461
2782	0.00058	0.16519
2783	0.00058	0.16577
2784	0.00058	0.16635
2785	0.00058	0.16693
2786	0.00058	0.16751
2787	0.00058	0.16809
2788	0.00058	0.16867
2789	0.00058	0.16925
2790	0.00058	0.16983
2791	0.00058	0.17041
2792	0.00057	0.17098
2793	0.00058	0.17156
2794	0.00057	0.17213
2795	0.00058	0.17271
2796	0.00057	0.17328
2797	0.00057	0.17385
2798	0.00058	0.17443
2799	0.00057	0.175
2800	0.00057	0.17557
2801	0.00057	0.17614
2802	0.00057	0.17671
2803	0.00057	0.17728
2804	0.00057	0.17785
2805	0.00057	0.17842
2806	0.00057	0.17899
2807	0.00057	0.17956
2808	0.00057	0.18013
2809	0.00057	0.1807
2810	0.00056	0.18126
2811	0.00057	0.18183
2812	0.00057	0.1824
2813	0.00056	0.18296
2814	0.00057	0.18353
2815	0.00057	0.1841
2816	0.00056	0.18466
2817	0.00057	0.18523
2818	0.00056	0.18579
2819	0.00057	0.18636
2820	0.00056	0.18692
2821	0.00057	0.18749
2822	0.00056	0.18805
2823	0.00056	0.18861
2824	0.00057	0.18918
2825	0.00056	0.18974
2826	0.00057	0.19031
2827	0.00056	0.19087
2828	0.00057	0.19144
2829	0.00056	0.192
2830	0.00056	0.19256
2831	0.00057	0.19313
2832	0.00056	0.19369
2833	0.00057	0.19426
2834	0.00056	0.19482
2835	0.00057	0.19539
2836	0.00057	0.19596
2837	0.00056	0.19652
2838	0.00057	0.19709
2839	0.00057	0.19766
2840	0.00057	0.19823
2841	0.00056	0.19879
2842	0.00057	0.19936
2843	0.00057	0.19993
2844	0.00057	0.2005
2845	0.00057	0.20107
2846	0.00057	0.20164
2847	0.00057	0.20221
2848	0.00058	0.20279
2849	0.00057	0.20336
2850	0.00057	0.20393
2851	0.00058	0.20451
2852	0.00057	0.20508
2853	0.00058	0.20566
2854	0.00057	0.20623
2855	0.00058	0.20681
2856	0.00058	0.20739
2857	0.00058	0.20797
2858	0.00058	0.20855
2859	0.00058	0.20913
2860	0.00058	0.20971
2861	0.00058	0.21029
2862	0.00059	0.21088
2863	0.00058	0.21146
2864	0.00059	0.21205
2865	0.00058	0.21263
2866	0.00059	0.21322
2867	0.00059	0.21381
2868	0.00059	0.2144
2869	0.00059	0.21499
2870	0.00059	0.21558
2871	0.00059	0.21617
2872	0.00059	0.21676

Day	DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
2873	0.00059	0.21735
2874	0.0006	0.21795
2875	0.00059	0.21854
2876	0.0006	0.21914
2877	0.0006	0.21974
2878	0.00059	0.22033
2879	0.0006	0.22093
2880	0.0006	0.22153
2881	0.0006	0.22213
2882	0.00061	0.22274
2883	0.0006	0.22334
2884	0.0006	0.22394
2885	0.0006	0.22454
2886	0.00061	0.22515
2887	0.0006	0.22575
2888	0.00061	0.22636
2889	0.00061	0.22697
2890	0.0006	0.22757
2891	0.00061	0.22818
2892	0.00061	0.22879
2893	0.00061	0.2294
2894	0.00061	0.23001
2895	0.00061	0.23062
2896	0.00061	0.23123
2897	0.00062	0.23185
2898	0.00061	0.23246
2899	0.00061	0.23307
2900	0.00061	0.23368
2901	0.00062	0.2343
2902	0.00061	0.23491
2903	0.00062	0.23553
2904	0.00061	0.23614
2905	0.00062	0.23676
2906	0.00061	0.23737
2907	0.00062	0.23799
2908	0.00062	0.23861
2909	0.00061	0.23922
2910	0.00062	0.23984
2911	0.00062	0.24046
2912	0.00062	0.24108
2913	0.00061	0.24169
2914	0.00062	0.24231
2915	0.00062	0.24293
2916	0.00062	0.24355
2917	0.00061	0.24416
2918	0.00062	0.24478
2919	0.00062	0.2454
2920	0.00062	0.24602
2921	0.00062	0.24664
2922	0.00061	0.24725
2923	0.00062	0.24787
2924	0.00062	0.24849
2925	0.00062	0.24911
2926	0.00062	0.24973
2927	0.00061	0.25034
2928	0.00062	0.25096
2929	0.00062	0.25158
2930	0.00061	0.25219
2931	0.00062	0.25281
2932	0.00062	0.25343
2933	0.00061	0.25404
2934	0.00062	0.25466
2935	0.00061	0.25527
2936	0.00062	0.25589
2937	0.00061	0.2565
2938	0.00061	0.25711
2939	0.00062	0.25773
2940	0.00061	0.25834
2941	0.00061	0.25895
2942	0.00061	0.25956
2943	0.00061	0.26017
2944	0.00061	0.26078
2945	0.00061	0.26139
2946	0.00061	0.262
2947	0.00061	0.26261
2948	0.00061	0.26322
2949	0.00061	0.26383
2950	0.00061	0.26444
2951	0.0006	0.26504
2952	0.00061	0.26565
2953	0.0006	0.26625
2954	0.00061	0.26686
2955	0.0006	0.26746
2956	0.0006	0.26806
2957	0.00061	0.26867
2958	0.0006	0.26927
2959	0.0006	0.26987
2960	0.0006	0.27047
2961	0.0006	0.27107
2962	0.0006	0.27167
2963	0.0006	0.27227
2964	0.00059	0.27286
2965	0.0006	0.27346
2966	0.0006	0.27406
2967	0.00059	0.27465
2968	0.00059	0.27524
2969	0.0006	0.27584
2970	0.00059	0.27643
2971	0.00059	0.27702
2972	0.00059	0.27761
2973	0.0006	0.27821
2974	0.00059	0.2788
2975	0.00059	0.27939
2976	0.00058	0.27997
2977	0.00059	0.28056
2978	0.00059	0.28115
2979	0.00059	0.28174
2980	0.00058	0.28232
2981	0.00059	0.28291
2982	0.00058	0.28349
2983	0.00058	0.28407
2984	0.00059	0.28466
2985	0.00058	0.28524
2986	0.00058	0.28582
2987	0.00058	0.2864
2988	0.00058	0.28698
2989	0.00058	0.28756
2990	0.00058	0.28814
2991	0.00057	0.28871
2992	0.00058	0.28929
2993	0.00058	0.28987
2994	0.00057	0.29044
2995	0.00058	0.29102
2996	0.00057	0.29159
2997	0.00058	0.29217
2998	0.00057	0.29274
2999	0.00058	0.29332
3000	0.00057	0.29389
3001	0.00057	0.29446
3002	0.00057	0.29503
3003	0.00057	0.2956
3004	0.00057	0.29617
3005	0.00057	0.29674
3006	0.00057	0.29731
3007	0.00057	0.29788
3008	0.00057	0.29845
3009	0.00057	0.29902
3010	0.00057	0.29959
3011	0.00056	0.30015
3012	0.00057	0.30072
3013	0.00057	0.30129
3014	0.00057	0.30186
3015	0.00056	0.30242
3016	0.00057	0.30299
3017	0.00056	0.30355
3018	0.00057	0.30412
3019	0.00056	0.30468
3020	0.00057	0.30525
3021	0.00056	0.30581
3022	0.00057	0.30638
3023	0.00056	0.30694
3024	0.00057	0.30751
3025	0.00056	0.30807
3026	0.00057	0.30864
3027	0.00056	0.3092
3028	0.00057	0.30977
3029	0.00056	0.31033
3030	0.00057	0.3109
3031	0.00056	0.31146
3032	0.00057	0.31203
3033	0.00056	0.31259
3034	0.00057	0.31316
3035	0.00056	0.31372
3036	0.00057	0.31429
3037	0.00057	0.31486
3038	0.00056	0.31542

Day	DAILY VALUES VS. TIME ($m^3/m^2/day$)	CUMULATIVE VALUES VS. TIME (m^3/m^2)
3039	0.00057	0.31599
3040	0.00057	0.31656
3041	0.00057	0.31713
3042	0.00057	0.3177
3043	0.00057	0.31827
3044	0.00057	0.31884
3045	0.00057	0.31941
3046	0.00057	0.31998
3047	0.00057	0.32055
3048	0.00057	0.32112
3049	0.00057	0.32169
3050	0.00058	0.32227
3051	0.00057	0.32284
3052	0.00058	0.32342
3053	0.00057	0.32399
3054	0.00058	0.32457
3055	0.00058	0.32515
3056	0.00058	0.32573
3057	0.00057	0.3263
3058	0.00058	0.32688
3059	0.00059	0.32747
3060	0.00058	0.32805
3061	0.00058	0.32863
3062	0.00058	0.32921
3063	0.00059	0.3298
3064	0.00058	0.33038
3065	0.00059	0.33097
3066	0.00059	0.33156
3067	0.00058	0.33214
3068	0.00059	0.33273
3069	0.00059	0.33332
3070	0.00059	0.33391
3071	0.0006	0.33451
3072	0.00059	0.3351
3073	0.00059	0.33569
3074	0.0006	0.33629
3075	0.00059	0.33688
3076	0.0006	0.33748
3077	0.0006	0.33808
3078	0.0006	0.33868
3079	0.00059	0.33927
3080	0.0006	0.33987
3081	0.00061	0.34048
3082	0.0006	0.34108
3083	0.0006	0.34168
3084	0.0006	0.34228
3085	0.00061	0.34289
3086	0.0006	0.34349
3087	0.00061	0.3441
3088	0.0006	0.3447
3089	0.00061	0.34531
3090	0.00061	0.34592
3091	0.00061	0.34653
3092	0.00061	0.34714
3093	0.00061	0.34775
3094	0.00061	0.34836
3095	0.00061	0.34897
3096	0.00061	0.34958
3097	0.00061	0.35019
3098	0.00062	0.35081
3099	0.00061	0.35142
3100	0.00061	0.35203
3101	0.00062	0.35265
3102	0.00061	0.35326
3103	0.00062	0.35388
3104	0.00062	0.3545
3105	0.00061	0.35511
3106	0.00062	0.35573
3107	0.00062	0.35635
3108	0.00061	0.35696
3109	0.00062	0.35758
3110	0.00062	0.3582
3111	0.00062	0.35882
3112	0.00061	0.35943
3113	0.00062	0.36005
3114	0.00062	0.36067
3115	0.00062	0.36129
3116	0.00062	0.36191
3117	0.00062	0.36253
3118	0.00062	0.36315
3119	0.00062	0.36377
3120	0.00061	0.36438
3121	0.00062	0.365
3122	0.00062	0.36562
3123	0.00062	0.36624
3124	0.00062	0.36686
3125	0.00062	0.36748
3126	0.00062	0.3681
3127	0.00062	0.36872
3128	0.00061	0.36933
3129	0.00062	0.36995
3130	0.00062	0.37057
3131	0.00062	0.37119
3132	0.00061	0.3718
3133	0.00062	0.37242
3134	0.00062	0.37304
3135	0.00061	0.37365
3136	0.00062	0.37427
3137	0.00061	0.37488
3138	0.00062	0.3755
3139	0.00061	0.37611
3140	0.00062	0.37673
3141	0.00061	0.37734
3142	0.00061	0.37795
3143	0.00061	0.37856
3144	0.00062	0.37918
3145	0.00061	0.37979
3146	0.00061	0.3804
3147	0.00061	0.38101
3148	0.00061	0.38162
3149	0.00061	0.38223
3150	0.0006	0.38283
3151	0.00061	0.38344
3152	0.00061	0.38405
3153	0.0006	0.38465
3154	0.00061	0.38526
3155	0.0006	0.38586
3156	0.00061	0.38647
3157	0.0006	0.38707
3158	0.0006	0.38767
3159	0.00061	0.38828
3160	0.0006	0.38888
3161	0.0006	0.38948
3162	0.0006	0.39008
3163	0.0006	0.39068
3164	0.00059	0.39127
3165	0.0006	0.39187
3166	0.0006	0.39247
3167	0.00059	0.39306
3168	0.0006	0.39366
3169	0.00059	0.39425
3170	0.0006	0.39485
3171	0.00059	0.39544
3172	0.00059	0.39603
3173	0.00059	0.39662
3174	0.0006	0.39722
3175	0.00059	0.39781
3176	0.00059	0.3984
3177	0.00058	0.39898
3178	0.00059	0.39957
3179	0.00059	0.40016
3180	0.00059	0.40075
3181	0.00058	0.40133
3182	0.00059	0.40192
3183	0.00058	0.4025
3184	0.00058	0.40308
3185	0.00058	0.40366
3186	0.00059	0.40425
3187	0.00058	0.40483
3188	0.00058	0.40541
3189	0.00058	0.40599
3190	0.00058	0.40657
3191	0.00058	0.40715
3192	0.00057	0.40772
3193	0.00058	0.4083
3194	0.00058	0.40888
3195	0.00057	0.40945
3196	0.00058	0.41003
3197	0.00057	0.4106
3198	0.00058	0.41118
3199	0.00057	0.41175
3200	0.00057	0.41232

TECHNICAL MEMORANDUM

DATE October 1, 2010 **PROJECT No.** 10-1427-0018

TO Mr. Justin Stockwell
Lorax Environmental Services Ltd.

CC Bjorn Weeks

FROM Fernando Junqueira and John Hull **EMAIL** fjunqueira@golder.com; jhull@golder.com

CONCEPTUAL ASSESSMENT OF LOW INFILTRATION COVER OPTIONS FOR THE MT. NANSEN PROJECT, YUKON

1.0 INTRODUCTION

Lorax Environmental Services Ltd. (Lorax) is currently assessing the viability of a closure option (referenced as Closure Option 4) for the Mt. Nansen project in the Yukon. The closure Option 4 involves relocation of tailings to an abandoned on-site open pit partially filled with waste rock, and installation of a low infiltration dry cover on top of the tailings, which are potentially acid generating. The purpose of the cover is to minimize water percolation into the tailings and to limit transport of possible acid mine drainage. Lorax has defined three scenarios for closure Option 4 as follows:

1) Place waste rock over the tailings, and then place an engineered cover on top of waste rock;

2) Place an engineered cover on top of the tailings, then place waste rock on top of the cover; and

3) A combination of 1 and 2 above.

Lorax requested that Golder Associates Ltd. (Golder) identify potential types of engineered low-infiltration covers and conduct a conceptual assessment of cover performance for cover options within the three scenarios listed above. In addition, it was requested that Golder conduct preliminary infiltration modeling for one of the identified cover options, and provide a range of infiltration that could be expected for the assessed options.

This Technical Memorandum outlines potential cover options identified that would suit the site conditions, includes typical range of infiltration rates expected for the different cover types, presents results of preliminary conceptual model for a chosen option, provides comments on aspects that can impact the long term performance of cover systems, and provides indication of future activities that should be completed for the detail design of the cover for closure Option 4 at Mt. Nansen.

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2.0 COVER OBJECTIVE AND GUIDELINES

The objective of the cover system is to reduce the infiltration of precipitation and snow melt water into the tailings material, thereby reducing the potential for future impacts to the environment in the long term associated with the potential generation and leaching of acid mine drainage.

General criteria, guidelines and assumptions used for the conceptual cover assessment included:

- The site receives total precipitation averaging 283 mm per year, of which about 30% comes as snowfall between October and March. Evaporation occurs between May and September with an annual potential evaporation rate of approximately 369 mm over open water. Potential evaporation exceeds precipitation in the region and the climate is therefore classified as semi-arid.
- Materials available for cover construction include the following:
  - Waste rock with variable gradation (typically gravel with silt and sand);
  - Borrow material from the Victoria Creek pit that consists of relatively well-graded silty sand with gravel; and
  - A borrow material that is a poorly graded sand (this sand is reported to have been used to construct the tailings dam).
- Tailings that will be relocated to the on-site abandoned pit can potentially be included as a cover system component for specific cover configurations, either at natural conditions or amended with limestone.
- It has been assumed that it will be possible to sustain at least a poor quality cover of vegetation on top of the cover. Based on the local climate data, the growing season has been assumed to last between May and October, with peak growth occurring during the summer.

Note that the climate conditions considered in this evaluation are the same conditions as were detailed in the Golder Memorandum to Lorax dated August 27, 2010, which addressed the wet cover options.

3.0 CONCEPTUAL COVER OPTIONS

For the Mt. Nansen site, potential evaporation is reported to exceed precipitation by some 155 mm between May and September for a mean year as seen in Figure 1. This suggests that a store-and-release type of cover system could be used to minimize infiltration during this period. However, evaporation is practically nonexistent in April, when about 30% of average annual precipitation (snowfall) is expected to melt and flow during the freshet period. During this critical period with little or no evaporation, and with vegetation still in the early growing stages, freshet water will likely infiltrate into the cover. The cover system must be designed with sufficient storage capacity to retain water that infiltrates during this period, storing it for evaporation in the following months. Placement of waste rock on top of tailings will have a positive impact in the cover performance as it might create a capillary break effect that will minimize percolation of water through the bottom of the cover during the freshet period, promote storage and allow time for the evapo-transpiration process to remove water from the cover during the summer.

Installation of a low-permeability layer of geosynthetic at the bottom of the cover would also minimize water percolation to a large extent.

3.1 Potential Cover System Types

Based on the assumptions and criteria described above, five types of cover systems are conceptually envisaged that could suit the site conditions and meet the main objective of reducing overall infiltration rates to the tailings:

1) A single-layer, vegetated, store-and-release soil cover – This scenario would involve the placement of a growth media to establish vegetation over a layer of well-graded material (potentially from the Victoria Creek borrow pit). In this scenario, the well-graded material is placed directly over the tailings. A properly functioning cover with this type of design would store part of the infiltrating water in the well-graded material. This "stored" infiltration would be removed from storage during the summer by evaporation.

2) Vegetated, store-release-divert soil cover – This scenario is equivalent to scenario (1), but with a 1 m layer of waste rock under the Victoria Creek material, directly over the tailings. The design concept is that the waste rock layer could create a capillary break effect, which would limit the infiltration of water from the overlying Victoria Creek material to the waste rock. The upper portion of the cover would act as a store-and-release cover, while the infiltration that exceeds the storage capacity would be diverted laterally over the capillary break without being in contact with the tailings. This laterally diverted water could then be collected and discharged elsewhere. Proper functioning of the capillary break is dependant on the grain-size gradations of the waste rock and the Victoria Creek material being compatible in such a way as to meet design requirements.

3) Multi-layer vegetated, store-release-divert soil cover – This scenario would be similar to scenario (2), but would include a layer of fine tailings placed between the bottom layer of coarse waste rock and the storage layer of Victoria Creek material. The greater variation in the unsaturated hydraulic conductivity and soil-water characteristic curves between the coarse waste rock and fine tailings could improve the efficiency of the capillary break. Similar to scenario (2), part of the infiltration will be stored in the upper layer, while another portion would be diverted over the capillary break barrier for discharge elsewhere. For this option, it would be important to evaluate the potential impacts of using tailings in the cover, to ensure that discharge water quality is not impacted. Treatment of the portion of the tailings to be used in the cover with a limestone admixture would be one option to be evaluated in detailed design.

4) Synthetic barrier cover system – This option would involve the placement of a layer of well-graded Victoria Creek material over a drainage layer of sandy material placed on top of a low permeability (10^{-10} m/s) synthetic media (HDPE, GCL or Bitumen liner), which in turn would be underlain by a transition layer of sand and coarse waste rock. Water percolating the upper layer will reach the geomembrane and be drained away from the cover system through the sand drainage layer.

5) Multi-layer capillary break cover system – This scenario would involve the placement of waste rock over a layer of well-graded Victoria Creek material, underlain by a second layer of coarse waste rock material to create a capillary break effect. The top layer of waste rock will reduce the effect of freeze-thaw cycles in the storage layer of well-graded material. Part of the infiltration will be stored in the mid layer, while another portion would runoff over the capillary break barrier and be diverted for future evaporation. This option would require careful evaluation and design to ensure its applicability, as the presence of waste rock at the surface, while protective against freeze-thaw damage, would tend to limit evaporation from the storage layer and promote infiltration.

A conventional barrier cover which uses a layer of low-permeability compacted clayey material to prevent infiltration has not been considered. Local borrow sources for suitable clay have not been identified in the area of the site. Further, practical experience has shown that this type of cover tends to degrade and lose performance with time due to development of cracks associated with freeze/thawing and wet/drying cycles. Conventional covers with stiff compacted layers are also less resistant to deformations, and at this site deformations are to be expected due to differential long term consolidation of the tailings relocated to the pit.

Table 1 summarizes the alternative types of cover system designs that have been identified conceptually for installation on top of the tailings as part of Closure Option 4. The base geometries presented were defined to allow for sufficient water storage capacity and/or promote runoff of water during the freshet period, specifically, and year round, in general. Typical values of infiltration rates are mentioned as reference values based on common engineering practice and design target infiltration values. Accomplishment of these infiltration rates will largely depend on the cover geometry and material specifications that are defined during detailed design.

Table 1: Cover types assessed - Option summary for Mt. Nansen

Cover Option	Base Geometry (Top to Base)	Typical range of Infiltration rate (% of annual precipitation)	Remarks
1 – Single vegetated store-release	■ 0.3 m top soil [1] ■ 1.0 m well graded Victoria Creek material	10%-20%	Vegetation must be sustained on top. Cover performance is affected by vegetation condition.
2 - Vegetated, store-release-divert soil cover	■ 0.3 m top soil[1] ■ 1.0 m well graded Victoria Creek material [2] ■ 1.0 m coarse waste rock.	2-15%	Gradation and permeability of Victoria creek material and coarse waste rock must meet design requirements to generate the capillary break effect.
3 - Multi-layer vegetated, store-release-divert soil cover	■ 0.3 m top soil[1] ■ 1.0 m well graded Victoria Creek material ■ 0.5 m fine tailings ■ Geotextile filter ■ 1.0 m coarse waste rock	3%-10%	Fine tailings used to enhance the capillary break effect and minimize downward fluxes. Tailings layer might need to be amended with limestone to minimize acid generation potential.
4 - Synthetic barrier cover system	■ 0.5 m Victoria Creek material ■ 0.3 m drainage sand ■ Geosynthetic liner ■ 0.5 m transition sand ■ 1.0 m waste rock	1%-3%	Base layer of waste rock placed to provide a more stable base for the synthetic liner in an attempt to reduce overall deformation in the liner. Vegetation is not necessary, but can be added for aesthetic purposes without negative impact on cover performance and would help to minimize surface erosion.
5 - Multi-layer capillary break cover	■ 1.0 m Waste Rock ■ 1.0 m well graded Victoria Creek material ■ 1.0 m waste rock.	5%-20%	Top layer of waste rock placed to reduce the impact of freeze/thaw cycles in the long term. Evaporation might be limited by top layer of coarse waste rock.

1 If organic soils are not available, the Victoria Creek material might be tested as a growth media to establish vegetation

2 A layer of Geotextile might be needed to prevent migration of fines from the Victoria Creek material into the coarser waste rock.

3.2 Estimated Costs

A generic cost estimate is provided as reference to allow for preliminary cost comparison for base geometries of the different types of cover systems identified in Table 1. Material costs were based on mining projects developed in the Northwest Territories and should be taken as +/-35% accuracy. Average material costs used to make the cost estimates are summarized in Table 2, while Table 3 presents average unit costs for the different cover options.

The costs presented in Tables 2 and 3 are for reference only. Changes in the cover geometry during the detail design stage will affect actual cover costs.

Table 2: Summary of general material costs for mining projects in the NWT (+/- 35% up to summer 2010)

Material	Mt. Nansen equivalent	Average Unit Cost (+/- 35%)	Remarks
General cover fill	Victoria Creek borrow material	\$20 / m^3	
General drainage sand	Poorly graded sand (tailings dam)	\$28 / m^3	
Sub grade - general fill	Waste Rock	\$2.5 / m^3	Average cost for re-use of on-site material
Tailings	Relocated Tailings	\$4 / m^3	Estimated cost associated with haulage and spreading. Not including any tailings treatment.
Organic Soil	-	\$30 / m^3	
Synthetic liner	-	\$23 / m^2	Including installation
Geotextile filter	-	\$3 / m^2	Including installation

Table 3: Estimated general costs for proposed cover options

Cover Option	Base Geometry (Top to Base)	Cost per material (\$/m^2)	Total Cost (\$/m^2)
1 – Single vegetated store-release	■ 0.3 m top soil [1] ■ 1.0 m well graded Victoria Creek material	■ \$10 ■ \$20	\$30
2 - Vegetated, store-release-divert soil cover	■ 0.3 m top soil[1] ■ 1.0 m well graded Victoria Creek material [2] ■ 1.0 m coarse waste rock.	■ \$10 ■ \$20 ■ \$2.5	\$32.5
3 - Multi-layer vegetated, store-release-divert soil cover	■ 0.3 m top soil[1] ■ 1.0 m well graded Victoria Creek material ■ 0.5 m fine tailings ■ Geotextile filter layer ■ 1.0 m coarse waste rock	■ \$10 ■ \$20 ■ \$2 ■ \$3 ■ \$2.5	\$37.5
4 - Synthetic barrier cover system	■ 0.5 m Victoria Creek material ■ 0.3 m drainage sand ■ Geosynthetic liner ■ 0.5 m transition sand ■ 1.0 m waste rock	■ \$10 ■ \$9.5 ■ \$23 ■ \$10 ■ \$2.5	\$ 55

Cover Option	Base Geometry (Top to Base)	Cost per material ($/m^2)	Total Cost ($/m^2)
5 - Multi-layer capillary break cover	■ 1.0 m Waste Rock ■ 1.0 m well graded Victoria Creek material ■ 1.0 m waste rock.	■ $2.5 ■ $20 ■ $2.5	$ 25

4.0 BASE CASE MODEL

All the options listed in Table 1 have the potential to minimize water infiltration to the tailings and can be further investigated. The cover option 2 (Store-release-divert soil cover) was selected based on readily available materials at the site. This conceptual cover design is used as a base case for preliminary infiltration modeling as a means to understand the general infiltration pattern through this type of cover under the climatic conditions prevailing at Mt. Nansen, and to assess the predicted infiltration rates for this site compared to typical values reported for this type of cover.

The main objective of the conceptual modeling exercise is not to provide an accurate estimate of actual net infiltration through the cover, but to provide a measure of the applicability of this type of cover to the site's climatic conditions and readily available materials for cover construction.

4.1 Model Preparation

The modeled geometry consisted of 1.0 meter of Victoria Creek material underlain by 1.0 meter of coarse waste rock placed over 4.5 m of tailings.

Material properties were defined as follows:

Victoria Creek material: The hydraulic conductivity and soil-water characteristic curve of the Victoria Creek material were estimated based on a grain size distribution curve provided by Lorax and presented in Appendix I. The hydraulic conductivity was initially estimated based on Hazen's equation (Holtz 1981) as 2.3×10^{-5} m/s, using a Hazen's coefficient equal 10. Subsequently, this value was adjusted to 3×10^{-5} m/s based on measured values for materials with similar grain size distribution obtained from Golder's soil data base.

The soil-water characteristic curve was estimated using the method proposed by Fredlund et al (1997) as shown in Figure 2. The hydraulic conductivity function was estimated based on the SWCC using the method proposed by Fredlund and Xing (1994), and is shown in Figure 3.

Coarse Waste Rock: the properties estimated for coarse waste rock used to evaluate wet cover options for Mt. Nansen (Golder 2010) were used in the present study. The hydraulic conductivity was estimated as 1.4×10^{-4} m/s. The soil-water characteristic curve estimated based on waste rock grain size curves provided by Lorax (Appendix I) is shown in Figure 2, and the estimated hydraulic conductivity function is shown in Figure 3.

Tailings: The material properties defined for the tailings during evaluation of wet cover options (Golder 2010) were used in the present study. The average measured hydraulic conductivity of 1×10^{-8} m/s was used in the models. The SWCC and hydraulic conductivity functions were estimated using the same methods used for the waste rock and Victoria Creek.

A climate data set compiled for the year of 2003 on a daily basis was used as the upper boundary condition in the models. This data set consisted of maximum and minimum air temperature, precipitation, potential evaporation, and relative humidity. A constant head of 1182.3 m representing the average pit lake water level was applied as lower boundary condition.

For this conceptual model, vegetation was not considered on top of the cover and removal of water from the cover depended on the evaporation process and the ability of the capillary break layer to prevent bottom water percolation during periods of high infiltration periods (e.g., April freshet). This was used as a more conservative approach compatible with the purposes of this conceptual study, and the uncertainty regarding the amount and quality of the vegetation that could be maintained over the cover.

The models covered the period between April 15 and October 31 and extended for a period of 10 years. It was assumed that no flow occurs during the winter. Accumulated snow fall between November 1 and April 14 was considered in the models as additional water supply during the freshet period in April.

4.2 Model Results

The conceptual model showed that fluxes through the bottom of the capillary break layer would be very low (less than 1% of total precipitation) during the 10 year model period as shown in Figure 4. Fluxes through the top of the storage layer presented high fluctuation associated with periods of infiltration and evaporation. Infiltration occurred during the freshet season and sporadic periods of rainfall events during the year. Increased evaporation rates in the summer removed water from the cover and reduced water percolation through the bottom of the capillary break layer.

Table 4 summarizes computed cumulative fluxes through the top of the cover, bottom of the capillary break layer, and through the tailings at a depth of 4.5 m.

Table 4: Summary of computed cumulative fluxes through the Cover System and Tailings

Year	Cumulative Fluxes (m^3/m^2)		
	Top of Cover	Bottom of Cover	Tailings (4 m depth)
1	-0.0034	0.0005	0.0002
5	-0.0004	0.0016	0.0014
10	0.0033	0.0027	0.0026

Figure 5 shows computed daily flux rates through the top of the storage layer and at the bottom of the capillary break layer. The model showed that daily fluxes through the base of the cover also responded to seasonal precipitation; net percolation rates were much smaller than fluxes computed through the top of the cover system.

Figure 6 shows the evolution of the saturation profile within the cover system during a modelled year. It shows that the degree of saturation of the storage layer increased markedly during the first 30 days of high infiltration during spring freshet. Subsequently, evaporation exceeded precipitation during summer and water was progressively removed from the storage layer. The degree of saturation in the storage layer in the end of October was low, allowing storage capacity for the next freshet period in the subsequent year.

It can also be seen in Figure 6 that the degree of saturation in the capillary break layer remained low during all times, indicating that the capillary break effect was sustained and water percolation was minimized. Similarly, the degree of saturation of the tailings under the cover remained stable.

The very low percolation rates computed in this conceptual model are compatible with percolation rates reported for the Alternate Cover Assessment Program (ACAP) which was conducted by the United States Environmental Protection Agency (ACAP 2007). Different test areas involving store-and-release and capillary break covers were constructed in six arid and semi-arid climates in the southern and western regions of the United States. It has been reported that infiltration through the alternative covers is typically less than one percent of annual precipitation. However, the long term performance (more than 10 years) of the different covers is yet to be assessed.

We note that maintenance of the capillary break effect is very sensitive to the hydraulic properties of the cover materials, and additional studies would be required to confirm that these very low infiltration rates could in fact be achieved with the materials under consideration at site.

Additional laboratory testing will be required to confirm the suitability of combining the Victoria Creek material and waste rock to generate a capillary break effect. Maintenance of performance in the long term will depend on whether the materials properties will change with time subjected to freeze and thaw cycles. Additional studies are required to assess potential variations in the depth of the active layer, and to evaluate the need to increase the thickness of waste rock placed on top of the tailings.

As discussed above, the models developed for this conceptual study are based on general assumptions. The models have not been calibrated and did not include sensitivity analysis. It is therefore, recommended that, until the models are refined, a conservative approach be used to develop a site-wide water balance model. It is recommended that the upper bound of infiltration values in Table 1 be used in this pre-feasibility stage (e.g. 15% infiltration for cover option 2).

5.0 COMMENTS ON LONG TERM COVER INTEGRITY

5.1 General comments

Soil cover systems function at the interface between the atmosphere, biosphere and the geosphere. Fluctuations in temperature, soil moisture, and heat and mass transfer rates are the most extreme at this position within the soil–atmosphere profile. Engineered soil cover systems are designed to control these variables, but some aspects must be considered that will affect the performance of different types of cover systems in the long term.

Type of material:

Clays and silts are known as problematic soils for road construction, and the same can be said for the construction of cover systems as both are located within the active zone (i.e. the upper 0 - 3 m of the soil profile with seasonal variation in temperature and water content). Clay materials degrade rapidly in the active zone. Silt-rich soils are somewhat less susceptible to volume change, but are most susceptible to frost heave and erosion. Sand and gravel soils offer high strength and typically present low volume change compared to clay. However, granular materials have higher permeability with poor moisture retaining capacity and offer limited benefit with respect to barrier or store/release covers (Wilson et al 2003). Well-graded materials have proven to

perform best for the construction of the base and sub-layers in pavement structures, and in general this rule is applied for the design of cover systems.

Type of cover

As mentioned before, barrier type covers that incorporate compacted layers of clay materials typically fail associated with the development of soil structures and cracking in the active zone. This type of cover is very susceptible to foundation deformation and variations in soil properties in portions located within the active zone. The design low permeability characteristic of this type of cover tends to degrade rapidly with consequent loss in cover performance (Benson 2007).

Failure of store-and-release cover systems occurs less frequently than for barrier-type (compacted) covers (Wilson et al 2003). In general, the primary mechanisms that affect the performance of store-release covers are lack of storage capacity and lack of vegetation. Wetting and drying may cause the soil structure to consolidate and/or become aggregated, leading to significant reduction in porosity that can cause reduction in storage capacity of up to 50 per cent.

Store-and-release covers have also been reported to reduce performance due to degradation of vegetation in the long term (Durham et al, 2000). The role of vegetation to continuously extract infiltration waters is of paramount importance, and vegetation condition must always be monitored when single-layer store-and-release cover systems are used.

One of the most important mechanisms that affects the performance of capillary-break cover systems is related to weathering of coarse material at the base of the cover. Weathering causes progressive increases in the amount of fines in the coarse layer. This process causes the hydraulic conductivity function of the coarse material to change with time and approach the hydraulic conductivity function of the fine material, greatly reducing the efficiency of the capillary break.

5.2 Context of Mt. Nansen

Specific maintenance needs for the cover system to be installed at Mt. Nansen will be defined upon detail design of the cover. However, preliminary models showed that a store-release-and-divert cover type composed of a storage layer underlain by a capillary break layer would be a viable option that could limit water percolation to the tailings.

If this type of cover is properly designed, and the cover construction follows a Quality Control / Quality Assurance (QC/QA) Plan prepared for the site, long term maintenance of the cover would be limited. The key maintenance activity would be related to sustaining at least a basic vegetation canopy on top of the cover, while preventing the growth of trees (tree roots can lead to the development of preferential flow paths through the cover).

Monitoring of the depth of the active zone will indicate whether, and to what extent, the active zone advances into the capillary break layer. The Monitoring Plan should be prepared during the detail design stage of the cover system.

The detail design of the cover should include additional seepage models, as well as thermal models to assess the extent of freeze and thaw cycles. The final monitoring plan shall be prepared under the light of the final cover geometry.

6.0 FUTURE WORKS

The conceptual study presented in this memorandum was mainly intended to provide general understanding of potential cover system types that could be installed on top of tailings at the Mt. Nansen site. Different cover alternatives were identified based on available construction materials and local climatic conditions. Preliminary infiltration models developed for a store-release-and-divert cover type showed that infiltration can be reduced to a great extent, but this tendency, as well as the final definition of the best type of cover system and cover geometry for the site should be further evaluated during the detail design stage. Activities that should be developed in the detail design phase include:

- Measurement of key geotechnical and hydraulic properties on multiple samples of potential cover construction materials to characterize both their properties and their variability;
- Run detailed numerical models for a range of scenarios to assess model sensitivity to design parameters and to refine cover geometry;
- Run of thermal models to assess the extent of the active zone within the cover system in the long term. Results from the thermal model will be used to refine the final cover geometry.
- Definition of specifications for the different construction materials;
- Preparation of a QC/QA Plan for cover construction; and
- Preparation of a staged monitoring plan to assess cover performance in the long term.

Consideration should also be give to pilot tests to evaluate alternative cover performance in-situ prior to design and construction of the final cover.

7.0 CLOSURE

We trust that the information presented in this document meets your expectation. Should you have any question or comment, please do not hesitate to contact one of the undersigned.

Yours very truly,

GOLDER ASSOCIATES LTD.

ORIGINAL SIGNED

Fernando Junqueira, Ph.D., P.Eng. (BC)
Project Engineer

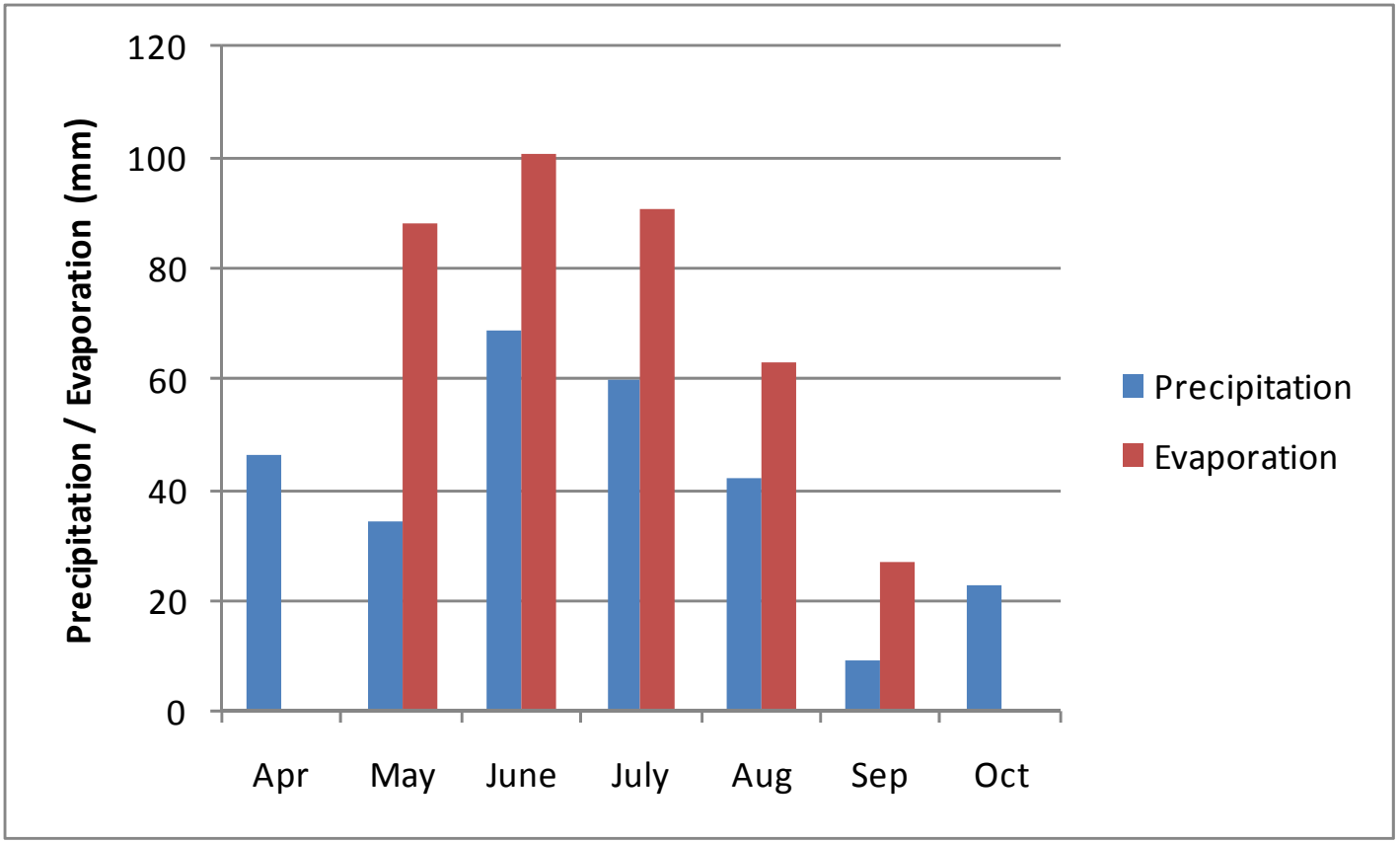
ORIGINAL SIGNED

John A. Hull, P.Eng. (BC, NWT, NU, YK)
Principal

FJ/JAH/rs/aw

Attachments: Figures
Appendix I: Grain Size Distribution of Samples of Waste Rock and Victoria Creek Materials

\\bur1-s-filesrv2\final\2010\1427\10-1427-0018\tm 1001_10 conceptual assessment of dry covers-final\tm 1001_10 conceptual assessment of dry covers-final.docx



PROJECT

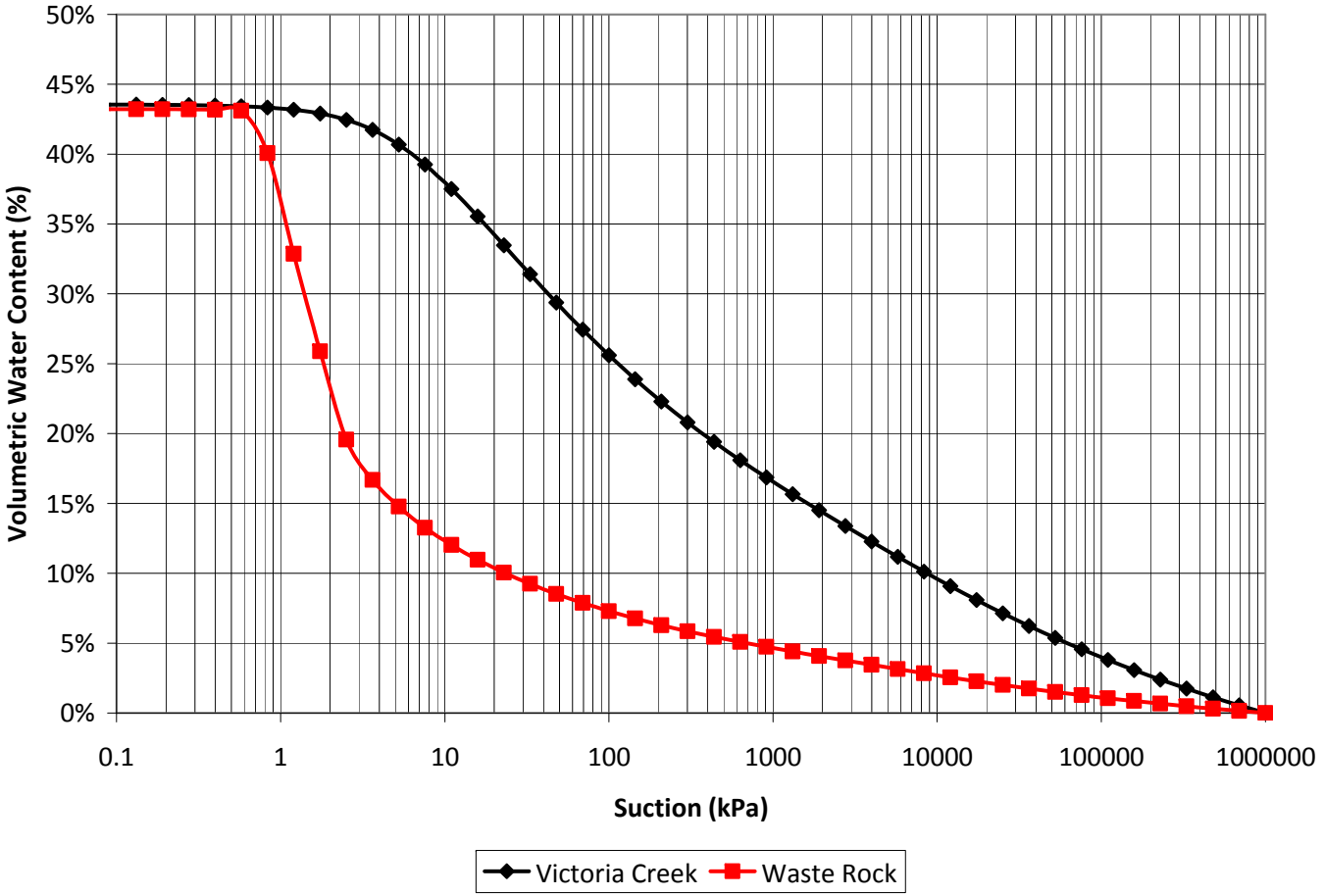
MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Average Monthly Precipitation (for mean years) vs. Monthly Evaporation

Golder Associates

PROJECT No. 10-1427-0018			FILE No. --	
DESIGN	FJ	20-AUG-10	SCALE NTS	REV.
CADD		--	**FIGURE 1**	
CHECK	--	--		
REVIEW				



PROJECT

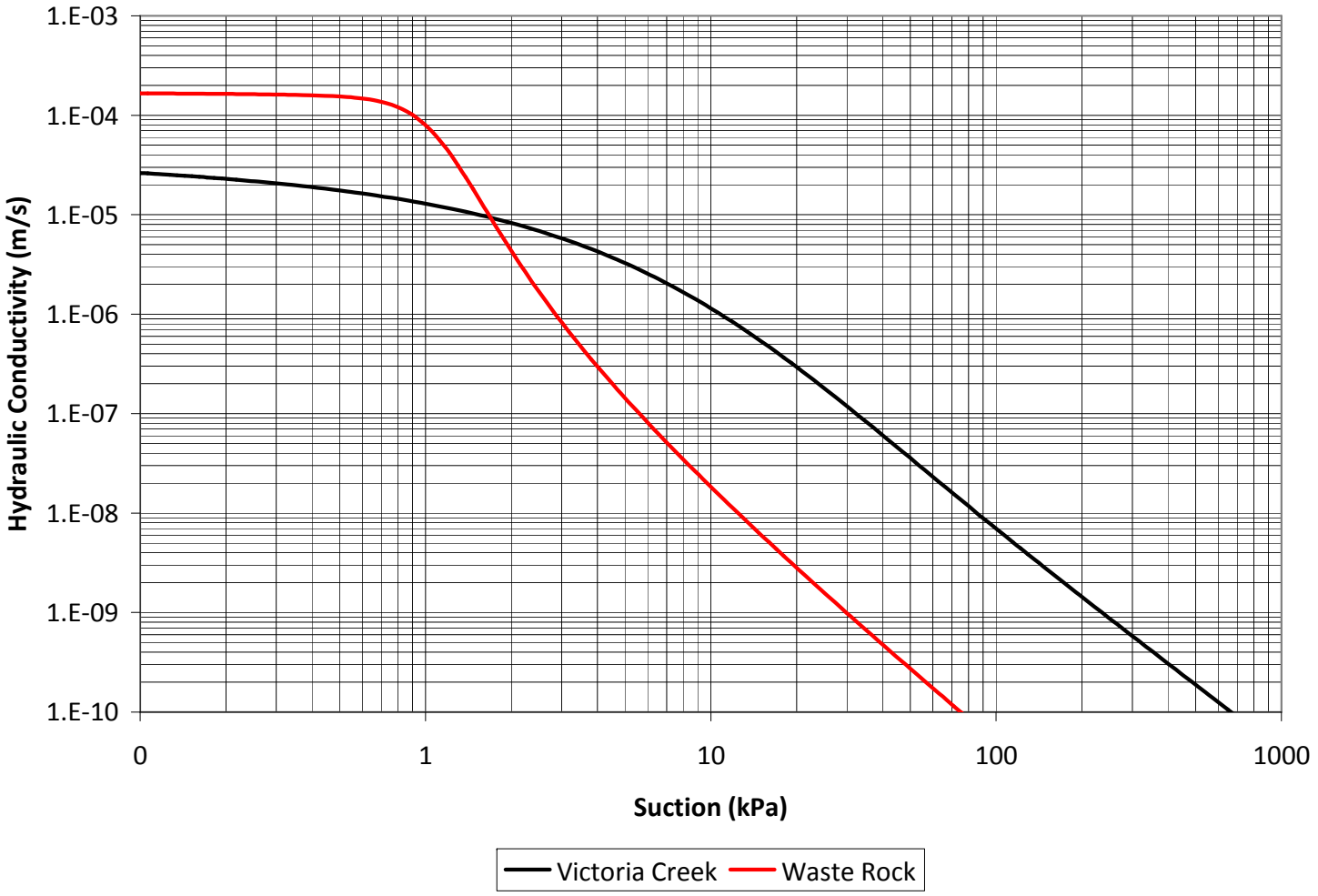
MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Estimated SWCC for the Victoria Creek and Coarse Waste Rock Materials (Fredlund et al, 1997)

Golder Associates

PROJECT No.	10-1427-0018		FILE No.	--	
DESIGN	FJ	20-AUG-10	SCALE	NTS	REV.
CADD		--	**FIGURE 2**		
CHECK	--	--			
REVIEW					



PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

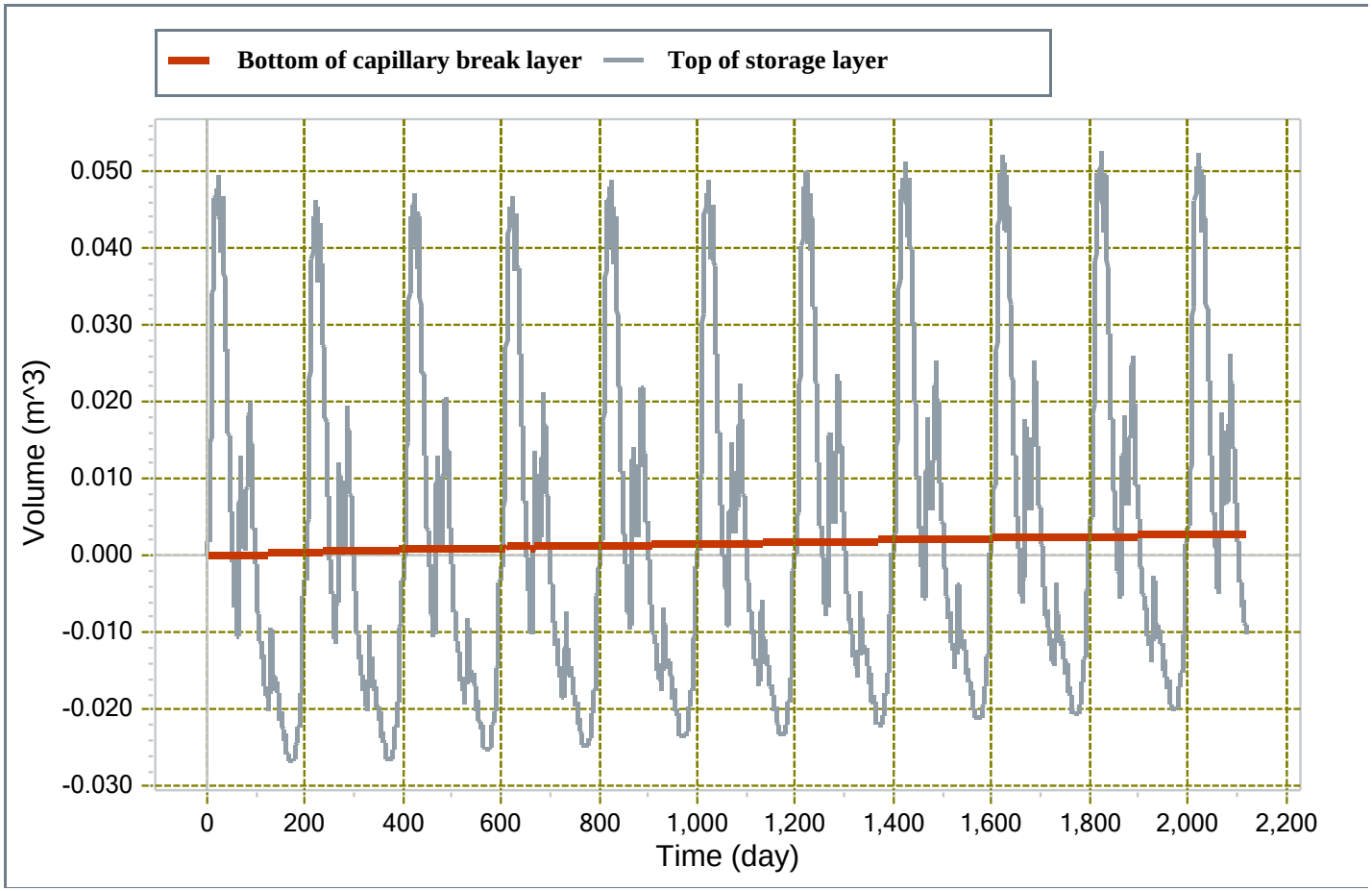
TITLE

Estimated Hydraulic Conductivity Function for the Victoria Creek and Coarse Waste Rock Materials (Fredlund and Xing, 1994)

Golder Associates

PROJECT No.	10-1427-0018		FILE No.	--
DESIGN	FJ	20-AUG-10	SCALE NTS	REV.
CADD		--		
CHECK	--	--		
REVIEW				

FIGURE 3



PROJECT

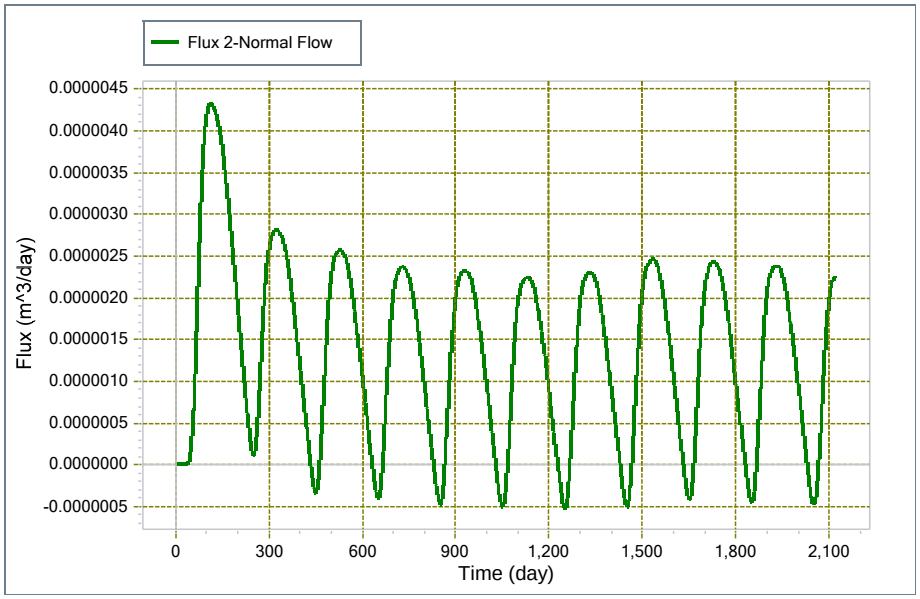
MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

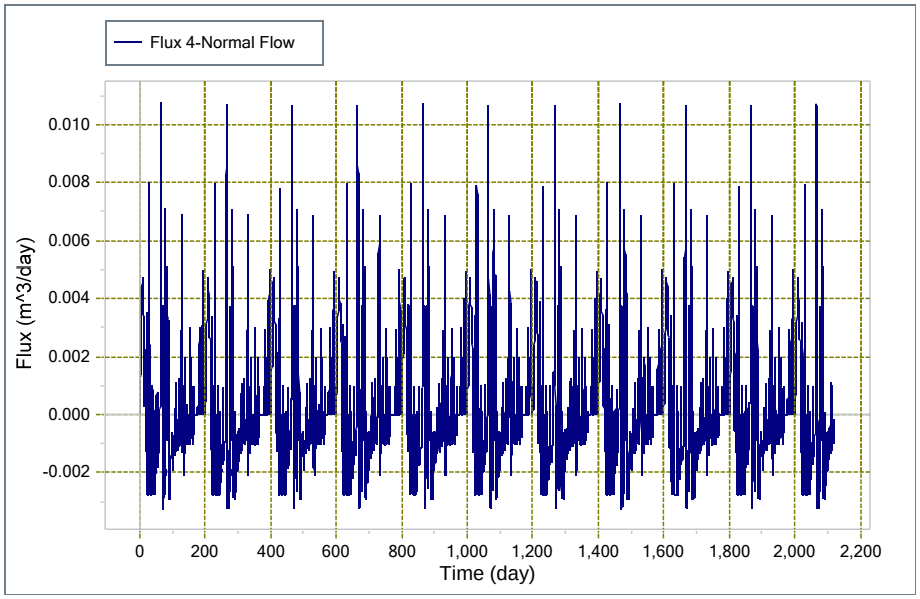
Evolution of Fluxes Through the Top of the Storage Layer and Bottom of the Capillary Break Layer

Golder Associates

PROJECT No.	10-1427-0018		FILE No.	--	
DESIGN	FJ	20-AUG-10	SCALE	NTS	REV.
CADD		--	**FIGURE 4**		
CHECK	--	--			
REVIEW					



Daily flux rates through the bottom of capillary break layer.



Daily flux rates through the surface of storage layer.

PROJECT

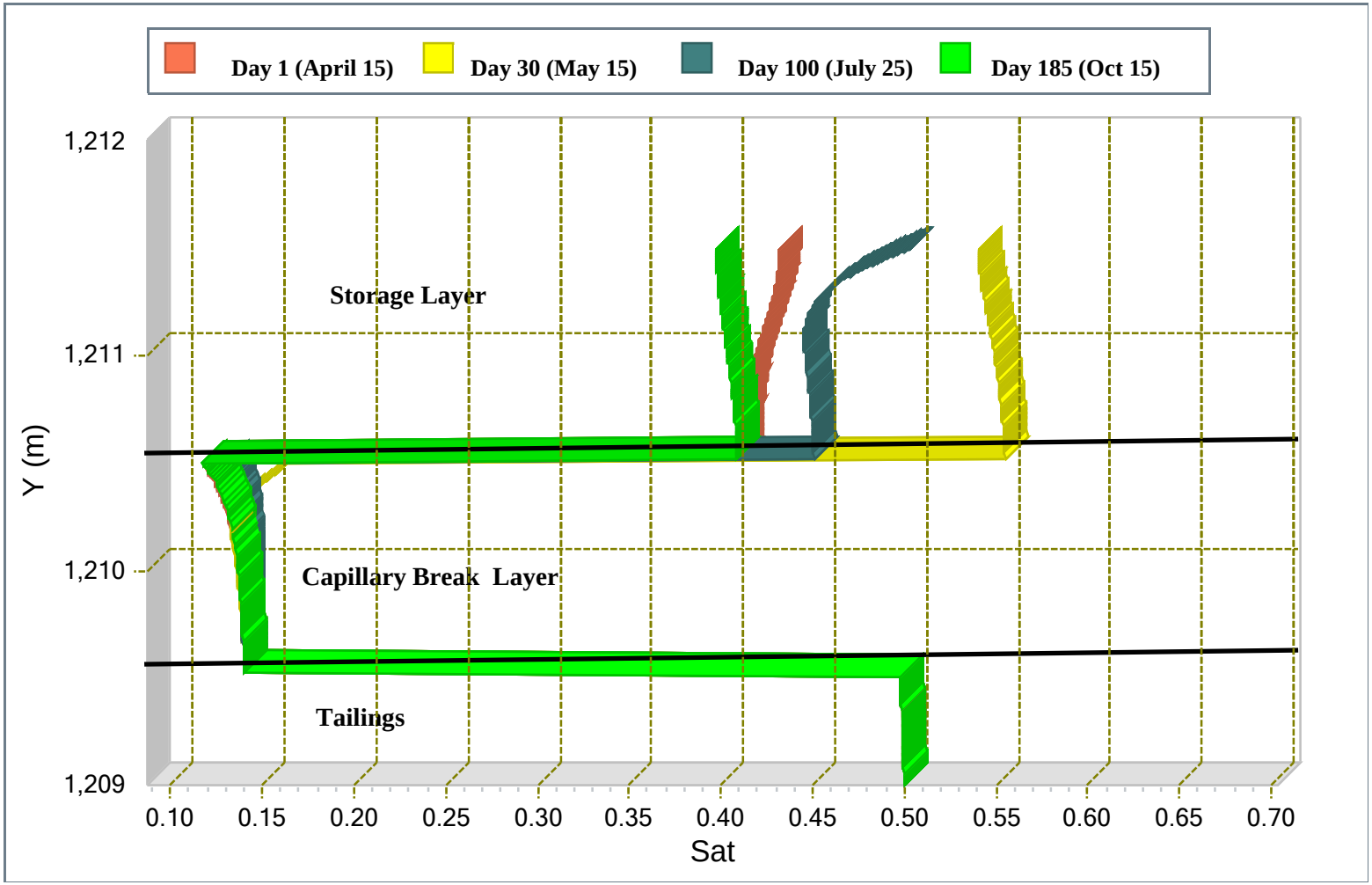
MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Variation of Daily Fluxes Through the Top of the Storage Layer and Bottom of the Capllary Break Layer.

Golder Associates

PROJECT No. 10-1427-0018			FILE No. --	
DESIGN	FJ	20-AUG-10	SCALE NTS	REV.
CADD		--	**FIGURE 5**	
CHECK	--	--		
REVIEW				



PROJECT

MT. NANSEN CLOSURE OPTIONS STUDY

TITLE

Evolution of Saturation within the Cover system for a Single Year.

Golder Associates

PROJECT No. 10-1427-0018			FILE No. --	
DESIGN	FJ	20-AUG-10	SCALE NTS	REV.
CADD		--	**FIGURE 6**	
CHECK	--	--		
REVIEW				

REFERENCES

Benson, C. H., Sawangsunya, A., Trzbiatowski, B. and Albrigth, W. (2007): Postconstruction Changes in the Hydraulic Properties of Water Balance Cover Soils. Journal of Geotechnical and Environmental Engineering. April 2007. pp 349-359

Durham, A, Wilson, G W and Currey, N, (2000). Field performance of two low infiltration cover systems at a semi-arid environment. 5th International Conference on Acid Rock Drainage (ICARD), pp 1319-1326. Denver, United States (2000).

Fredlund, M. D., Wilson, G. W., and Fredlund, D. G. (1997): Prediction of the Soil-Water Characteristic Curve from the Grain-Size Distribution Curve. 3rd Symposium on Unsaturated Soils. Rio de Janeiro, Brazil. April 20-22, pp. 13-23.

Fredlund, D.G., Xing, A., and Huang, S. (1994): Predicting the Permeability Function of Unsaturated Soils Using Soil-Water Characteristic Curve. Canadian Geotechnical Journal. Vol 31. No 3. pp 533-546.

Golder Associates Ltd (2010): Technical Memorandum on Assessment of Closure Options and Cover Water Balance for the Mt. Nansen Project, Yukon. August 27, 2010.

Holtz, R. D., and Kovacs, W. D. (1981): Introduction to Geotechnical Engineering. Prentice-Hall Inc. Englewood Cliffs, New Jersey.

G. W., Wilson, D. G. Williams, and Rykaart, E. M. (2003): The Integrity of Cover Systems – An Update. 6th International Conference on Acid Rock Drainage (ICARD). pp. 445-451. Caims, Australia (2003).

APPENDIX I
Grain Size Distribution of Samples of Waste Rock and Victoria Creek Materials

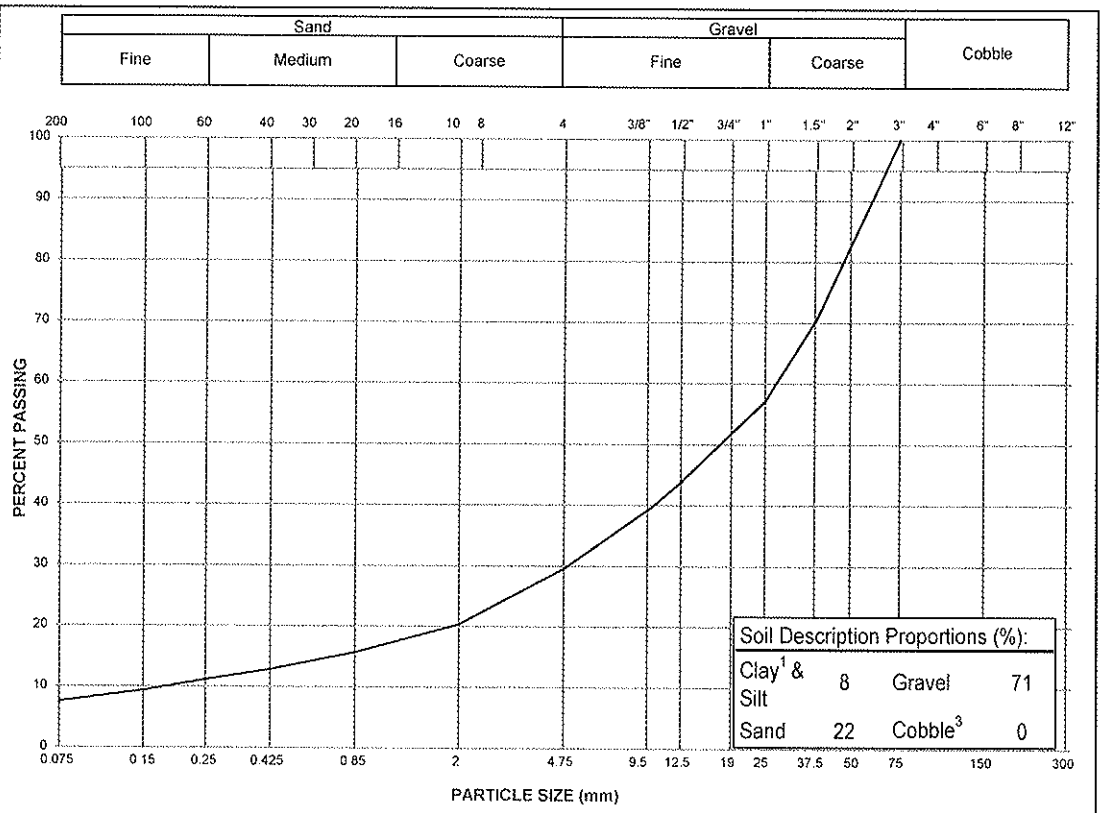
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422 & C136

Project:	Mt. Nansen	Client:	AECOM
Project No.:	W14101299	Client Rep.:	Marc-Andre Lavigne
Site:	Mt. Nansen		
Material Type:		Date Tested:	By:
Sample No.:	Bulk 1	Soil Description[2]:	GRAVEL - sandy, trace silt
Sample Loc.:	NW Pile		
Sample Depth:		USC Classification:	SM
Sampling Method:			
Date sampled:	20-Jul-2009 By: NSP	Moisture Content:	4.1

Cu:	147.6
Cc:	4.8

Particle Size (mm)	Percent Passing
300	
200	
150	
100	
75	100
50	0
38	71
25	57
19	
12.5	44
10	40
4.75	30
2	20
0.85	16
0.425	13
0.25	11
0.15	9
0.075	8



Notes:

[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____

Data presented hereon is for the sole use of the stipulated client. EBA is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of EBA. The testing services reported herein have been performed by an EBA technician to recognized industry standards, unless otherwise noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, EBA will provide it upon written request.

EBA Engineering Consultants Ltd. eba

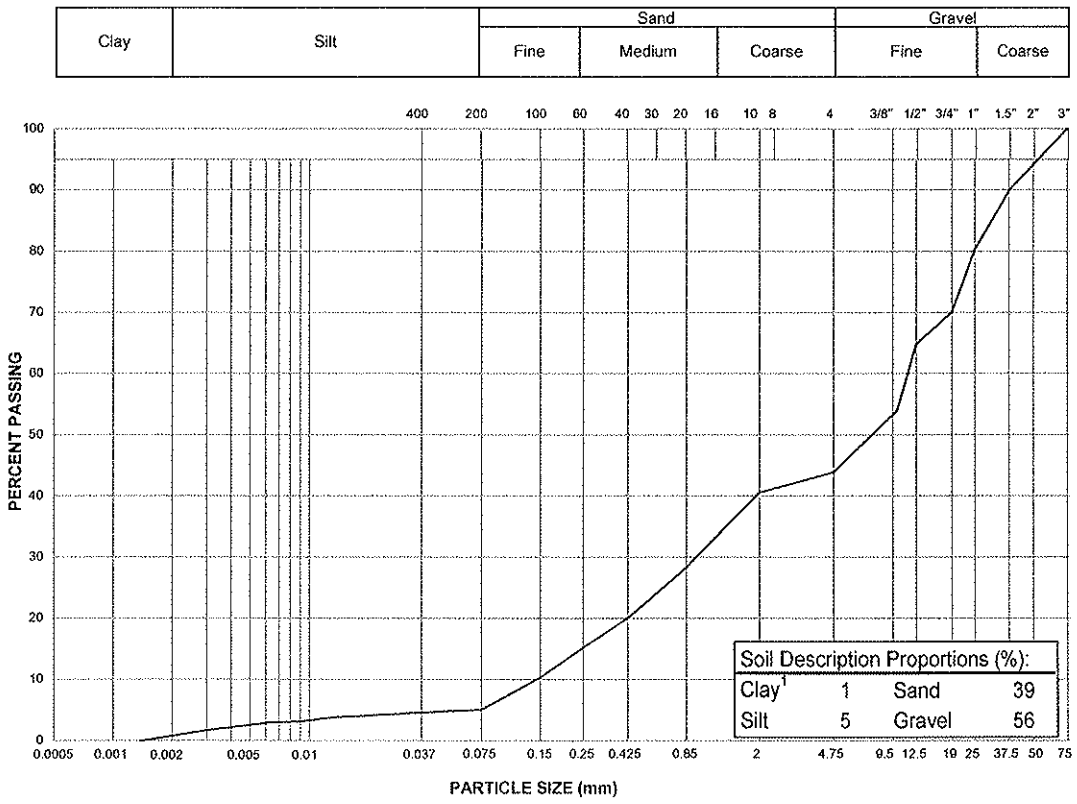
PARTICLE SIZE ANALYSIS TEST REPORT

ASTM D422 & C136

Project:	Mt. Nansen	Client:	AECOM
Project No.:	W14101299	Client Rep.:	Marc-Andre Lavigne
Site:	Mt. Nansen		
Material Type:		Date Tested:	By:
Sample No.:	Bulk 2	Soil Description[2]:	GRAVEL and SAND - trace silt, trace clay
Sample Loc.:	Ramp to Pit		
Sample Depth:		USC Classification:	SM
Sampling Method:			
Date sampled:	28-Jul-2009 By: NSP	Moisture Content:	3.4

Cu:	78.4
Cc:	0.6

Particle Size (mm)	Percent Passing
75	100
50	
38	90
25	80
19	70
12.5	65
10	54
4.75	44
2	41
0.85	28
0.425	20
0.25	15
0.15	10
0.075	5
0.0348	4.6
0.0222	4.2
0.0129	3.8
0.0092	3.2
0.0065	3.0
0.0032	1.8
0.0014	0.0



Notes:

[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____

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EBA Engineering Consultants Ltd. eba

GRAIN SIZE DISTRIBUTION

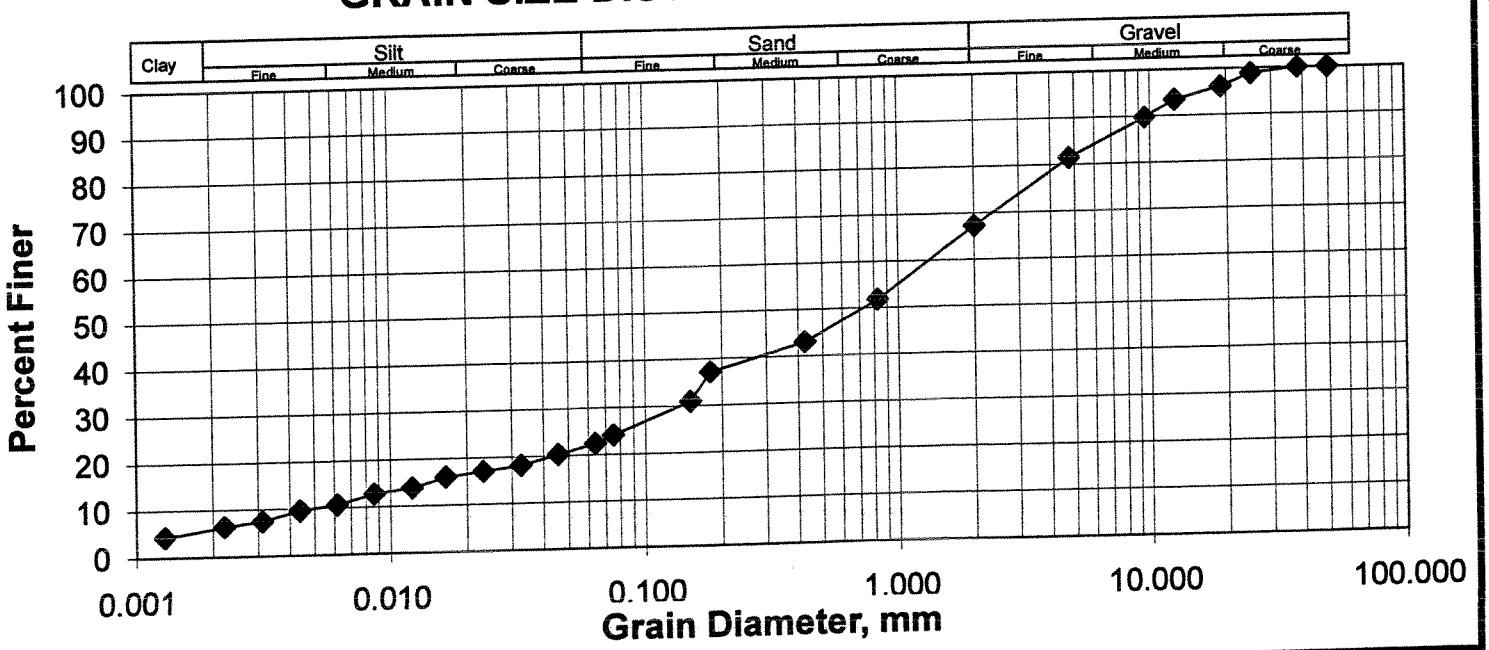
AECOM
MATERIALS LABORATORY
AECOM
99 Commerce Dr., Winnipeg, MB R3P 0Y7 Canada
tel (204) 477-5381 fax (204) 284-2040

Job No.: 60159089
Client: Government of Yukon
Project : MT Nansen Mine
Date Tested: 8-Jul-10
Tested By:

Sample No.
Hole No. Victoria Creek Borrow Pit
Depth:
Date Sampled:
Sampled By:

GRAVEL SIZES		SAND SIZES		FINES	
Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing	Grain Size (mm.)	Total Percent Passing
50.0	100.0	2.00	67.2	0.0750	24.1
38.0	100.0	0.83	51.8	0.0638	22.4
25.0	98.8	0.43	43.0	0.0456	20.2
19.0	96.1	0.18	37.1	0.0325	18.1
12.5	93.5	0.15	30.9	0.0231	17.0
9.5	89.8	0.075	24.1	0.0164	16.0
4.75	81.4			0.0121	13.8
2.00	67.2			0.0086	12.8
				0.0061	10.6
				0.0044	9.6
				0.0031	7.4
				0.0022	6.4
				0.0013	4.2

GRAIN SIZE DISTRIBUTION CURVE



Gravel	**32.8%**	**Silt**	**16.1%**
Sand	**45.3%**	**Clay**	**5.9%**

** Note: Soil Classification based on Grain Size from Canadian Foundation Engineering Manual, 3rd edition (1992).

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204 284 2040 fax

Memorandum

To	Justin Stockwell	Page	1
CC			
Subject	Mount Nansen: Dam Classifications		
From	Kendall Thiessen		
Date	April 27, 2011	Project Number	60159089 (402.1)

Introduction

This memorandum discusses the dam classification assessment of the closure options for the Mt. Nansen tailings facility. The classifications have implications for spillway design, minimum factors of safety for earthquake analysis, dam safety reviews, maintenance and operations. This memorandum is an update to the "Dam Classification" memorandum written by AECOM, December 2009.

The objective of this task is to establish the appropriate classification of the proposed dam structures that would be upgraded or constructed for:

- Option 1 - Tailings Dam Upgrade with Water Cover
- Option 2 - Tailings Dam Upgrade with Saturated Soil Cover
- Option 3 - Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place

The classifications are a function of the potential risk to people, property and the environment. The criteria and classifications are defined in the Canadian Dam Association (CDA) *Dam Safety Guidelines 2007*. Table 1 shows the consequence criteria for the various dam classifications (CDA 2007). EBA (2002) considered the existing facility to be a *high* to *very-high* consequence facility.

The following discussion is based on the conceptual designs for the closure options (Lorax 2010). The applicable dam classification should be reconsidered during the detailed design phase, and during subsequent dam safety reviews.

Dam class	Population at risk [note 1]	Incremental losses		
		Loss of life [note 2]	Environmental and cultural values	Infrastructure and economics
Low	None	0	Minimal short-term loss No long-term loss	Low economic losses; area contains limited infrastructure or services
Significant	Temporary only	Unspecified	No significant loss or deterioration of fish or wildlife habitat Loss of marginal habitat only Restoration or compensation in kind highly possible	Losses to recreational facilities, seasonal workplaces, and infrequently used transportation routes
High	Permanent	10 or fewer	Significant loss or deterioration of *important* fish or wildlife habitat Restoration or compensation in kind highly possible	High economic losses affecting infrastructure, public transportation, and commercial facilities
Very high	Permanent	100 or fewer	Significant loss or deterioration of *critical* fish or wildlife habitat Restoration or compensation in kind possible but impractical	Very high economic losses affecting important infrastructure or services (e.g., highway, industrial facility, storage facilities for dangerous substances)
Extreme	Permanent	More than 100	Major loss of *critical* fish or wildlife habitat Restoration or compensation in kind impossible	Extreme losses affecting critical infrastructure or services (e.g., hospital, major industrial complex, major storage facilities for dangerous substances)

Note 1. Definitions for population at risk:

None—There is no identifiable population at risk, so there is no possibility of loss of life other than through unforeseeable misadventure.

Temporary—People are only temporarily in the dam-breach inundation zone (e.g., seasonal cottage use, passing through on transportation routes, participating in recreational activities).

Permanent—The population at risk is ordinarily located in the dam-breach inundation zone (e.g., as permanent residents); three consequence classes (high, very high, extreme) are proposed to allow for more detailed estimates of potential loss of life (to assist in decision-making if the appropriate analysis is carried out).

Note 2. Implications for loss of life:

Unspecified—The appropriate level of safety required at a dam where people are temporarily at risk depends on the number of people, the exposure time, the nature of their activity, and other conditions. A higher class could be appropriate, depending on the requirements. However, the design flood requirement, for example, might not be higher if the temporary population is not likely to be present during the flood season.

Table 1. Dam classification. (CDA 2007)

Discussion

In order to determine the appropriate classification, assumptions were made with respect to incremental losses resultant from a hypothetical catastrophic failure of the dam for the respective closure scenarios. Tailings run-out and hydraulic analyses were not performed as part of the current work, but they would be beneficial for characterizing the magnitude of the impact of a dam failure.

Option 1 - Tailings Dam Upgrade with Water Cover

The tailings are considered to be liquefiable in their current state (EBA 2002) and would "flow" some distance after an earthquake induced catastrophic failure of the dam. In addition, a failure of the dam or spillway would release up to 72,000 m^3 of tailings pond water. Such a failure of the dam or spillway would result in *significant loss or deterioration of important fish or wildlife habitat.* It is considered that *Restoration or compensation in kind is highly possible.* The risk to human life would

be people temporarily in the vicinity of the dam as the Dome Creek Valley is not permanently inhabited downstream of the dam.
Stability modeling of the existing dam has identified the post-earthquake scenario as the critical case (with liquefied tailings and thawed foundation material). The input parameters and design criteria for this analysis case are not a function of the dam classification, and therefore the major stabilization measures independent of the dam classification

Option 2 - Tailings Dam Upgrade with Saturated Soil Cover

The consequences of failure of the dam under the Option 2 closure would be similar to those described above for Option 1. The release of approximately 11,000 m^3 of tailings pond water would result in less impact than the release of the larger volume of water in Option 1. In our opinion, this difference would not change the dam classification as the tailings would be equally mobile.

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

A "dam" would be required to contain the saturated tailings and water cover in the wet cover pit backfill scenario. Under typical operating conditions there would be minimal free water on the surface of the tailings, though there may be some accumulation of surface water following an extreme precipitation event, or spring thaw. The tailings would be placed loosely, and saturation would be maintained, and therefore the tailings would be liquefiable and would flow some distance, possibly escaping the confines of the pit, and moving into the Dome Creek Valley if a failure of the dam occurred. The tailings would be situated approximately 500 m from Dome Creek, and this would provide a buffer in the event of a rapid release of water and/or tailings that may result from a catastrophic failure of the tailings dam.

The dam required for Option 3 could be designed and constructed to be very robust with a high factor of safety, due to the good foundation conditions, the small width, relatively low height, and the abundance of material that could be used to buttress the dam. Further considerations of the very low probability of failure, along with a more detailed assessment of the consequences of failure may provide a rational justification for classifying the tailings dam in this scenario as "low" which would then exempt it from the regular dam safety reviews.

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

The tailings will be stored in a dry state, and would not be liquefiable after an initial period of consolidation. The plug structures of the Option 4 dry disposal scenario would fall outside of the definition of a dam as they are not required to retain the contaminated solids, because the dry tailings would not be mobile.

Conclusion

Table 2 provides preliminary classifications for the design scenarios. These classifications must be reviewed again in the final design stage, with input from environmental, cultural, and hydraulics experts. The run-out of liquefied tailings following a catastrophic dam failure has not been considered. It should be noted that the probability of failure is not a consideration in the dam classification exercise. In depth analysis would help define the potential impacts and may lead to re-classification of the dam structure at future date.

Table 2. Dam classifications for Mt. Nansen Closure Options

	Description	Classification
Option 1	Tailings Dam Upgrade with Water Cover	High
Option 2	Tailings Dam Upgrade with Saturated Soil Cover	High
Option 3	Tailings Backfill into Pit with High Infiltration Cover, Waste Rock in Place	Significant
Option 4	Tailings and Waste Rock Backfill into Pit with Low Infiltration Cover	NA

REFERENCES

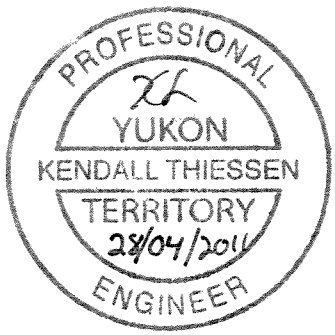
EBA, 2002
Dam Safety Assessment. May 2002.

Canadian Dam Association, 2007
Dam Safety Guidelines

Lorax, 2010
Mt. Nansen Options for Closure. November 2010.

Canadian Dam Association, 2009,
Technical Bulletin: Application of 2007 Dam Safety Guidelines to Mining Dams (DRAFT)

Prepared by:



Kendall Thiessen, P.Eng.
Geotechnical Engineer
/dh

Reviewed by:

Tom Wingrove, P.Eng.
Executive Vice-President
Deputy Operations Director,
North America, Environment

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Memorandum

To	Patricia Randell, Justin Stockwell	Page	1
CC	Tom Wingrove		
Subject	Additional Concepts for Long-Term Stabilization of Mt. Nansen Tailings Dam		
From	Kendall Thiessen		
Date	July 3, 2011	Project Number	60159089 (402.12)

Introduction

This memorandum is a revision and update to the Memorandum dated December 9, 2010, by the same author. This document is a supplement to the discussions in the AECOM November 2010 report: *Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives,* and it addresses some of the comments provided by the reviewers of that report. The following discussion applies to the proposed upgrades to the existing Mt. Nansen tailings dam included in:

- Option 1: Tailings Dam Upgrade with Water Cover
- Option 2: Tailings Dam Upgrade with Saturated Soil Cover.

This memorandum provides additional comments regarding the anticipated long-term effectiveness of anchoring the toe-berm with permafrost, and discusses alternative measures to permanently improve the stability of the Mt. Nansen tailings dam. This assessment is conceptual in nature due to the limited available information.

Background

Numerical stability analysis (AECOM 2010 and EBA 2002) found that the tailings dam does not currently meet the minimum factor of safety established by the Canadian Dam Association Guidelines (2007) for pseudo-static earthquake analysis (minimum FS of 1) and post-earthquake loading scenarios (minimum FS of 1.2-1.3). The inadequate stability in the post-earthquake loading scenario is largely due to a zone of thawed foundation material situated beneath the dam which would be liquefiable in the event of an earthquake. EBA (2002) reported the results from CPT probe holes at 17 locations, and used the results to determine the liquefaction potential of the dam and foundation soils. They concluded that liquefaction was likely to occur under the maximum design earthquake at the following locations (EBA 2002):

- within the foundation soils underneath the central and south portions of the dam crest
- within the foundation soils beneath the toe-berm
- several other localized areas, including small pockets within the dam fill itself.

The assessment completed by EBA is not extensive enough to determine whether the zones of liquefiable soils are continuous or if they are confined to specific soil strata. The liquefaction study only investigated soil conditions above the permafrost.

In the AECOM report (2010), Option 1 and Option 2 called for constructing a toe-berm and keying the toe-berm into permafrost to improve the calculated stability. The addition of a toe-berm alone does not help the stability for this scenario as the liquefied soils are assigned a residual "cohesive" shear strength, without a frictional component. EBA (2002) used a residual strength of 14.4 kPa for the thawed foundation soil based on a method proposed by Idriss (1998). Similar residual strength values for the liquefied sand are estimated using empirical relationships developed by Olson and Stark (2002) which correlate SPT blowcounts with a residual shear strength.

The stability of the dam under these analysis scenarios can be improved by either eliminating the liquefaction potential of the foundation soils by densifying the soil, or the stability can be improved by providing additional resistance by way of a shear key, rockfill caissons, structural reinforcing or cementation etc..

Permafrost Enhancement with Thermosyphons

The engineering purpose of the thermosyphons is to maintain and enhance permafrost beneath the proposed toe-berm. The toe-berm would interact structurally with the permanently frozen foundation material by way of a "shear key". The shear key could either be constructed of a compacted granular material installed to key into the frozen foundation material or alternatively, the same effect could be achieved by locally building the permafrost upwards into the granular toe-berm (Figure 1). The permafrost enhancement would be aided by thermosyphonse as described in AECOM 2010.

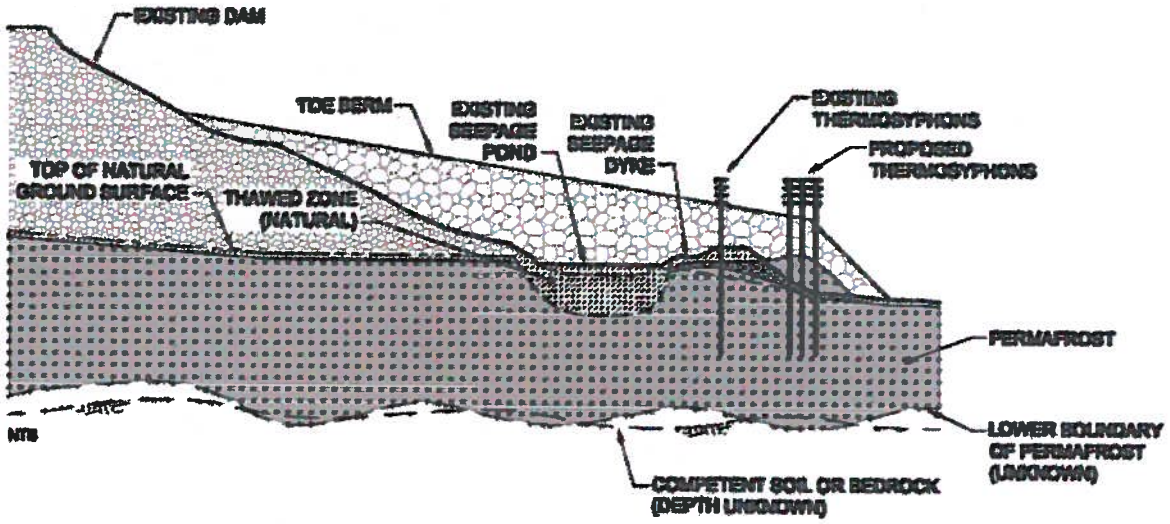


Figure 1. Proposed toe-berm with permafrost aggraded as a shear key.

The analysis performed by Naviq Consulting Ltd (2010) demonstrated that thermosyphons should be able to form and maintain permafrost under current or moderately warmer climate conditions. Thermosyphons have been effectively used at this site to aggrade permafrost into the existing seepage collection pond dike (AECOM 2010). The concepts for addressing the impacts of seepage are discussed.

The expected lifespan of a thermosyphon has not been established as many of the first thermosyphons, installed in the 1960's, are still in operation today. Some regular maintenance and periodic replacement of the thermosyphons should be anticipated. It would be reasonable to assume a 50 year lifespan for the thermosyphons before they would require replacement or extensive maintenance.

There is some uncertainty regarding the long term feasibility of thermosyphons as a way of maintaining frozen ground considering potential future climatic scenarios. The analysis by Naviq (2010) demonstrated that if current warming trends continue unabated, thermosyphons would no longer be able to maintain the frozen ground at some point in the future. The effectiveness of thermosyphons is negatively affected by warmer temperatures by both reducing the thermosyphon efficiency and increasing seasonal thawing. The analysis showed that with the estimated warming trends (0.08°C/year based on the past 50 years), the thermosyphons would only be able to maintain permafrost in a 1 m radius around the evaporator in 100 years (Ie. mean annual temperature 8°C above the present). If future climate change was limited to moderate warming, say 3°C above the present mean annual temperature, thermosyphons may possibly be a permanent solution. The long term performance would be improved with the inclusion of an insulating layer (Naviq 2010).

If thermosyphons are used to enhance the permafrost, but climate warming trends continued, then it would be expected that at some time in the future there would be significant or total thawing of the permafrost in the area of the toe, despite the contributions of thermosyphons (Figure 2). At such a time, some additional ground improvement measures would be required to maintain the long term stability of the dam. Monitoring of ground temperatures after the installation of the thermosyphons would be required to determine if and when additional stabilization measures are implemented.

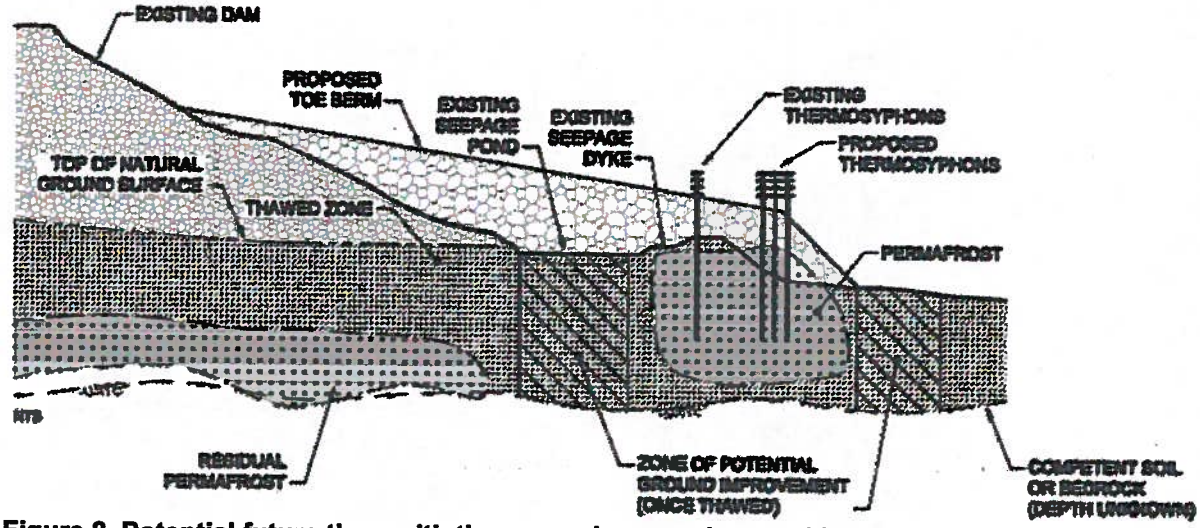


Figure 2. Potential future thaw with thermosyphons and ground improvement.

This memo will not comment on the expected nature, likelihood, magnitudes, or timing of future climate changes as there is considerable uncertainty and variability in predictions from climate experts.

Seepage Management

The concept for addressing seepage through the toe-berm is to channelize the flows, and insulate the zone of permafrost enhanced by thermosyphons. The details for seepage flow management have not been developed, as the options are at a conceptual stage. However, the following discussion will provide a more in-depth description of the concept to support the decision making process, and demonstrate confidence that seepage can be controlled in a manner that will not compromise the performance of the thermosyphons or excessively degrade the natural permafrost.

The groundwater seepage will naturally flow towards, and then follow the lowest point along the valley bottom, generally following the flow paths with the least resistance. The seepage through the dam would be managed by utilizing these concepts. A drainage channel of coarse rock would be established across the toe of the existing dam, which would be shaped to funnel seepage towards the bottom of the valley, near the center of the toe-berm. A typical section is shown in Figure 3. The coarse rock drainage channel would extend the full length of the toe-berm exiting at the toe. Insulation would be provided either at the top of the toe-berm or at some intermediate level, as shown in Figure 3, unless it was found the thickness of the toe-berm was adequate for insulation.

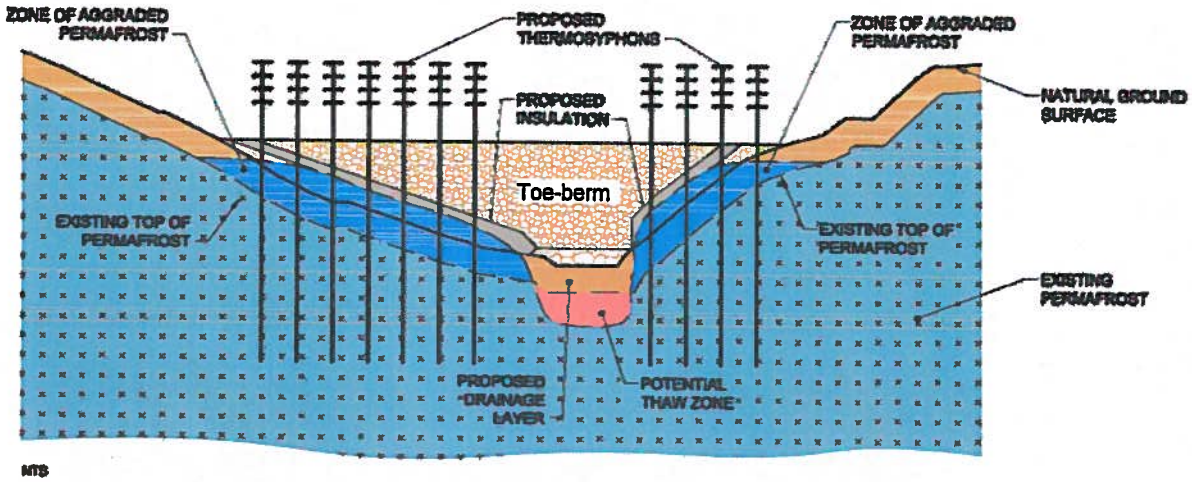


Figure 3. Section (South-North) through proposed toe-berm showning drainage layer, insulation and thermosyphon arrangement.

The area of ground improvement shown in the AECOM 2010 drawings highlighted an area across the full width of the toe-berm. The details of exactly where the thermosyphons and insulation would be installed have not been established at this stage of the design. The zone of ground improvement does not need to extend across the full width of the toe-berm, as long as adequate resistance can be developed elsewhere beneath the berm. The thermosyphons could be installed along the north and south sides of the toe-berm leaving the soil surrounding the drainage channel near the center of the toe-berm to thaw and/or freeze naturally.

The stability analysis should be revisited during preliminary and detailed design to optimize the design. A 3-dimensional stability and stress-deformation analysis would be beneficial, but may not be necessary to develop a final design. The total resisting force required to achieve the required design factor of safety would be similar whether that resistance is developed across the full width of the toe-berm, or in zones on both sides of a drainage channel.

There are several observations of the site conditions that support an assessment that the seepage through the dam would not render stabilization by way of freeze back into the toe-berm ineffective:

- Dome Creek has been conveying water along the bottom of the valley for several millennia. Permafrost has been encountered in every test hole drilled along the bottom of the valley, even at points near or along the creek alignment (or alignment prior to construction of the tailings dam). Under current and proposed operating conditions the seepage rates through the dam and along the foundation material will be several orders of magnitude less than the flow rates in Dome Creek.

- Test holes drilled in the vicinity of the toe near the dam centerline, encountered permafrost near the interface of the dam fill and the natural ground surface, in the organic layer (testhole 12861-08 EBA 2009 or MW 09-21, AECOM 2010), demonstrating that there has been negligible degradation at these locations over time. The groundwater flows at these test hole locations would be only slightly lower than the current flow rates further downslope in the area of the proposed toe-berm, (not considering seepage reduction through the dam due to

proposed upgrades). This is evidence that thawing in the foundation material has not been greatly affected by the flow rates seen through the dam. In summary, if there has been no significant thawing of permafrost upslope of the proposed toe-berm due to seepage flows, then it would be expected that the seepage flows through the toe-berm would not have a significant negative impact on the permafrost, considering the decrease in seepage rates expected after the dam upgrades.

- Thermosyphons have been effective at enhancing permafrost through the seepage collection pond dike. The pond water has acted as a heat source adjacent to the dike, but this source of heat has been overcome by the thermosyphons, as the permafrost has agraded into the dike (AECOM 2010). The water in the seepage collection pond would act as a similar boundary condition as flowing groundwater, as it has a large thermal mass, and would probably have enough convection to maintain a relatively constant boundary condition against the dike interface. In addition, the proposed thermosyphon array would have a much greater cooling capacity, per unit volume of soil, then the current installations.

Ground Improvement Alternatives Not Requiring Permafrost

There are several technologies that provide reinforcing, or reduce the liquefaction potential of the thawed soil to increase the calculated stability of the Mt. Nansen Tailings dam under post-earthquake conditions without depending on permafrost. The following list of potential ground improvement technologies was developed with input from several reputable contractors with extensive experience in ground improvement:

Densification:
- Dynamic compaction*
- Vibro-compaction*
- Vibro-replacement
- Blast- compaction

Cementation:
- Jet grouting
- Compaction grouting*
- Chemical grouting
- Deep mixing

Replacement:
- Excavation and replacement*
- Rockfill caissons*

*Methods that may be most appropriate to conditions at Mt. Nansen.
The densification methods generally increase the strength and reduce the liquefaction potential of unfrozen soil by increasing the density (ie. compacting) the soil. The cementation methods fill the voids with a cement grout that displaces water and bonds the soil particles together while compacting the surrounding soil. These densification and cementation methods cannot be applied to frozen material. The replacement methods involve the removal of a volume of the loose, frozen soil with unfrozen, compacted granular material. These ground improvement methods are only effective if

they can be implemented over the full depth of the liquefiable soil. The densification and cementation methods can only be applied if the permafrost is destroyed by natural or artificial processes. The replacement methods have the significant advantage of not requiring ground thawing, thus eliminating the expense and uncertainty associated with thawing the ground.

Vibro-compaction and dynamic compaction are thought to be technically feasible methods of densifying the in situ soil once it has thawed. Additional material would be added at the surface (and possibly at depth for vibro-compaction) to maintain the ground elevation as the soil is compacted. Dynamic compaction would only be effective in the upper 10 m. Vibro-compaction could be implemented to a depth of 30 m if the soil conditions permit.

Compaction grouting would be technically feasible for improving thawed soils but its costs are significantly more than vibro-compaction per cubic metre. Because compaction grouting can be targeted at specific stratum, it may become a more appealing option if the zones of liquefiable soil are not extensive and can be delineated. Compaction grouting may also be a suitable improvement method if improvements are required below a layer that could not be easily penetrated by vibro-compaction equipment. Chemical or jet grouting can also be used to increase density and provide reinforcing and may be better solutions under certain ground conditions.

To implement one of the densification or cementation techniques of ground improvement in the near future, the permafrost at the base of the dam would need to be thawed by an engineered process (Figure 4). Once this zone is thawed, one of the densification or cementation methods could be implemented improve the characteristics of the soil as discussed in the following sections. Future freeze-thaw cycles should not have a significant impact on the engineering properties of the improved soil. Ground thawing is discussed later in this document.

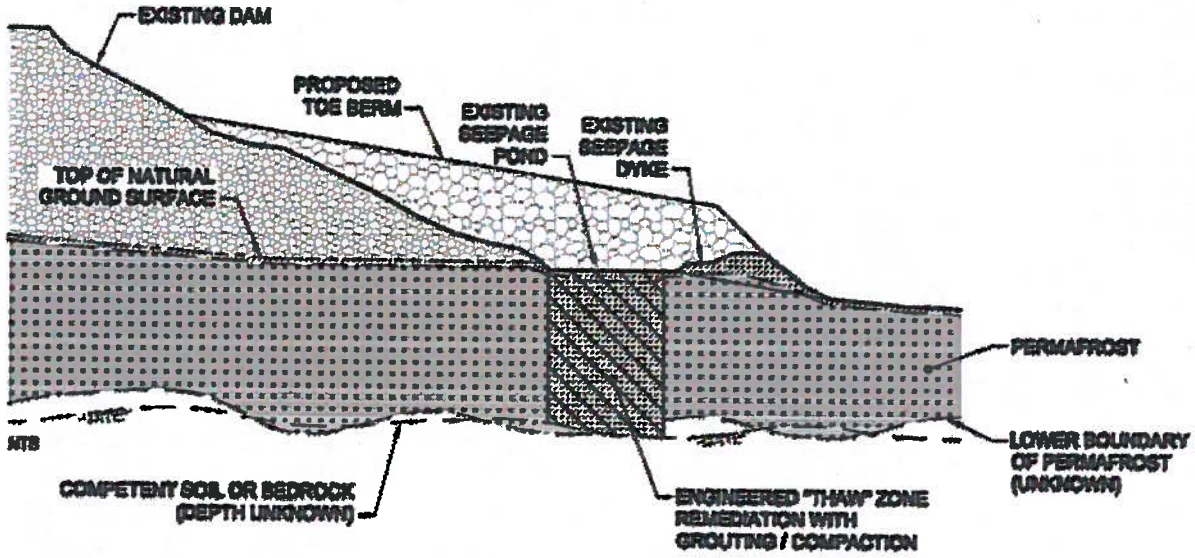


Figure 4 Engineered thawing for the purpose of ground improvement,

Alternatively, if the depth that required improvement was relatively shallow, it would be most economical to excavate the frozen, and potentially liquefiable soil, and replace it with compacted fill (possibly sourced from the waste rock). The frozen soil could be excavated using drill-and-blast methods if it is safe and practical. The stability of the dam during construction is imperative, and the impact of any temporary construction activities must be considered.

Rockfill caissons may be a suitable method of providing sufficient shear strength to maintain the stability of the dam if the sands are liquefied due to an earthquake. The caissons could be installed in the frozen sand, and would maintain their integrity if the surrounding loose sands thawed at some future time. The caissons would be advanced to a competent soil or bedrock strata. They would be backfilled with crushed rockfill (inert waste rock may be suitable), and compacted with a vibrolance. Rockfill is considered to be more suitable than concrete caissons because of its flexibility and the local availability of material. Rockfill caissons would also provide a vertical drainage path for excess porewater pressures.

There is inadequate subsurface information to develop these concepts further at this time, but we have confidence that there is an engineering solution to maintaining the stability of the Mt. Nansen Tailings Dam with or without permafrost. The key pieces of information needed to further assess the ground improvement alternatives are:

- Thickness, extent and characteristics of the permafrost zone.
- Depth to bedrock or other competent, non-liquefiable bearing layer.
- Characteristics and properties of materials in the permafrost zone. Frozen samples could collected and then transported in a frozen state to a materials testing facility, where they would be thawed and tested under confinement to determine thawed properties. The

applicability of some of the improvement measures are limited by grain sizes, and the occurrence of dense layers.

- Depth of thawing beneath seepage collection pond. The "warm" pond water may have accelerated thawing beneath the pond.

The depth of the overburden has not been confirmed in the vicinity of the proposed toe-berm, but reports have identified the depth of bedrock ranging from 1m, on the valley slopes, to over 20 m in the valley bottom (Higgs and Associates 1994). A test hole drilled by Klohn Leonoff Ltd approximately 400m North-East of the proposed toe-berm, in the Dome Creek Valley refused at 28 m, but bedrock was not confirmed (Klohn Leonoff 1988). Two test holes drilled by AECOM in 2009 in the north terrace area were advanced up to 19 m through overburden before refusal in permafrost. The test holes drilled through the dam (by AECOM 2009) were advanced through a maximum of 14 m of overburden before refusal. Downstream of the seepage collection dam, in the vicinity of the proposed toe-berm, an air-rotary drill refused at 5 m (though the type of bit used is not noted) (AECOM 2010). Based on this information it could be expected that the depth to bedrock or a competent bearing layer may be as little as 5 m, but may be greater than 30 m.

The interpretation of the CPT results by EBA (2002) do indicate a general trend of reduced liquefaction potential with depth, suggesting that it may not be necessary to extend ground improvement measures all the way to bedrock, though this cannot be confirmed with the current information.

To implement densification or cementation methods of ground improvements in the near future, the permafrost would need to be thawed. Thawing of frozen ground has been implemented on numerous projects, but typically the thawing is limited to relatively shallow depths where surface heating through artificial or passive solar means is effective. Steam injection wells have been used successfully to thaw an area 3000 m^2 to a depth of 12.2 m over a 3 ½ month period (Andersland and Ladanyi 2004). By extension, it would be reasonable to expect that a similar technique may be suitable to thaw to the depths required for this project. A circulation system may also be suitable, similar to a vertical loop used for geothermal applications. A number of contractors experienced in the far north, and experts in the field of permafrost engineering were consulted, but none had experience with costing or implementing this type of thawing program.

Developing a detailed methodology and estimating the costs of thawing the soil would require a level of design which is beyond the scope of this memo. Some considerations that need to be addressed included:

- Dimensions of area to be thawed (ie. volume)
- Thermal properties including temperature, unfrozen water content function, and heat capacity
- Source of heat, cost of fuel, and efficiency of heat source and distribution system
- Potential sources of heat loss (flowing groundwater for example)
- Heat distribution including installation of steam injection wells, or circulation heat loops
- Collection of excess pore water
- Seasonal, environmental and location limitations

Estimated Costs

Estimated costs for select methods of ground improvement are plotted against the required depth of improvement in Figure 5. It is important to note that the costs for dynamic compaction and vibro-compaction do not include an allowance for thawing of the in situ soil. The excavation and replacement option would not require ground thawing.

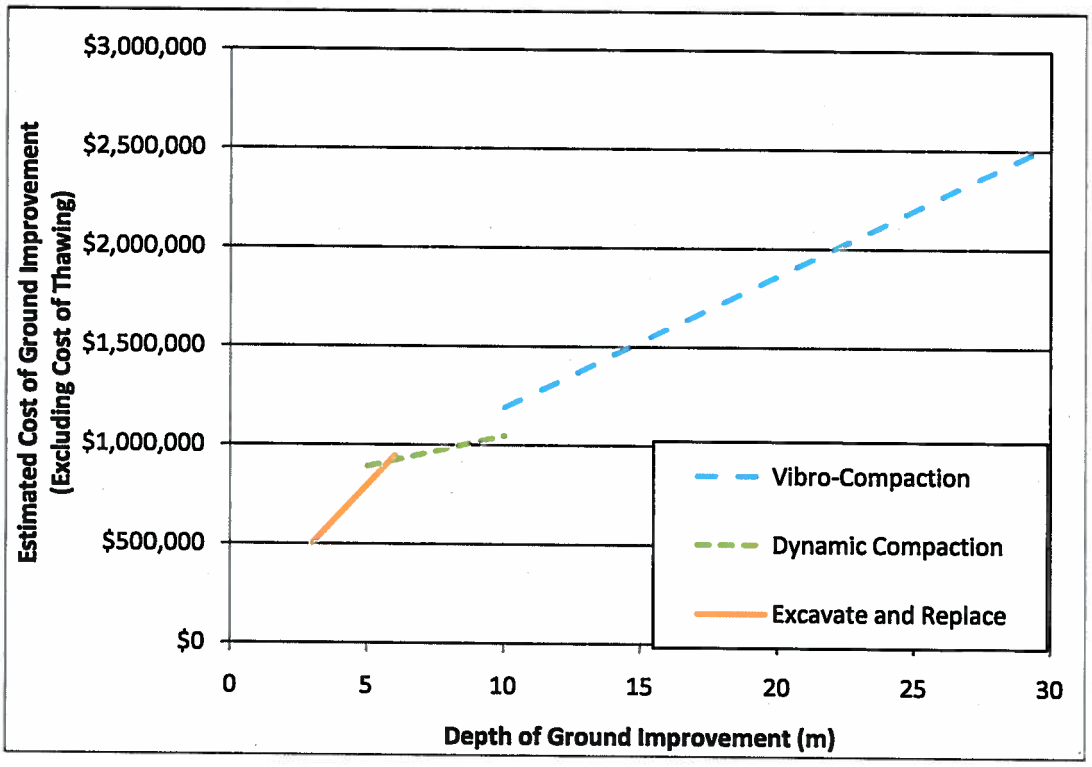


Figure 5. Estimated costs of various ground improvement methods vs. required improvement depth. These costs do not include thawing of the in situ soil.

The cementation methods also require ground thawing, and are approximately an order of magnitude more expensive than vibro-compaction per cubic metre of improved ground. If grouting can be targeted at specific zones, it may be a cost effective solution.

The cost of installing rockfill caissons to a depth of 12 m through frozen sand has been estimated at $12,500,000. It should be noted that this estimate assumes consistent frozen ground conditions. Challenging subsurface conditions could increase this cost. Although this cost is significantly more than the costs of the other ground improvement measures, it does not require any ground thawing (cost which has not been included in the costs plotted in Figure 5). The $12,500,000 for installing rockfill caissons should be carried as a provisional cost for ground improvement as this measure can be implemented without ground thawing.

Table 01 summarizes these methods, and indicates our confidence in the feasibility of these methods. It should be noted that as the depth of required improvement increases, that the level of

confidence decreases. With greater improvement depth comes greater uncertainty in ground conditions, fewer applicable methods and more technical challenges. Excavation and replacement, or rockfill columns could be implemented at the present time, under a wide range of ground conditions, without requiring ground thawing. This is reflected in our higher level of confidence shown in Table 01.

Table 01. Summary of potential ground improvements

Depth Range	Technique	Thawing Required	Level of Confidence
5-10	Dynamic Compaction	Yes	Medium to Low
10	Vibro-Compaction	Yes	Medium to Low
5-30	Cementation (Compaction/Chemical/Jet)	Yes	Medium
0-6 m	Excavate and Replace	No	High
6-30	Rockfill Caissons	No	Medium to High

Discussion and Conclusion

Permafrost must be a consideration in any long-term stabilization works for the Mt. Nansen Tailings Dam. Based on our assessment, the alternatives are to:

Proposed Alternative

- Alternative 1: Enhance the permafrost and utilize it as an element of the stabilization measures. If and when climate changes begin to overwhelm the permafrost and thermosyphons, ground improvement measures on unfrozen soil should be implemented

Provisional Alternatives

- Alternative 2: Eliminate reliance on permafrost by implementing long term stabilization measures through the permafrost. Appropriate techniques may include excavation and replacement, rockfill caissons or other structural reinforcing measure.

- Alternative 3: Eliminate reliance on permafrost by using an engineered process to remove or destroy the permafrost and then permanently improve the characteristics of the in-situ soil at that location. Appropriate techniques may include dynamic compaction, vibro-compaction or cementation.

Thermosyphons are considered to be a feasible means of enhancing the permafrost to provide a non-liquefiable anchor for the shear key under current climatic conditions based on the performance of the existing thermosyphons and the analysis by Naviq (2010). The thermosyphons should be able to continue performing adequately under moderately warmer environmental conditions. However, there is considerable uncertainty linked to our inability to predict climate changes accurately, and the resulting degradation of permafrost. If current warming trends continue (0.08°C/year based on Naviq (2010)), the effectiveness of thermosyphons will decrease with time, and permafrost cannot be maintained beyond the next 50-150 years (Naviq 2010). The scope of the work by Naviq was limited to a high level assessment of feasibility, and a more comprehensive assessment of potential climate conditions, existing ground conditions and design concepts would be required in future design stages.

If it is desirable to eliminate the uncertainty regarding the long term effectiveness of maintaining permafrost with thermosyphyons, then other methods of ground improvement should be considered to reduce the liquefaction potential of the foundation material. The ground improvement measures could be implemented in the near term if the permafrost is deliberately eliminated by some engineered process or at some future date.

If Closure Option 1 or Option 2 are attractive to the stakeholders based on other merits, then it would be reasonable to address the information gaps and uncertainties as an intermediate investigation phase prior to detailed design. It is our opinion that the uncertainties regarding the long term behaviour of the permafrost, and characteristics of the foundation soils under thawed conditions warrant further investigation before advancing to detailed design if either Closure Option 1 or Closure Option 2 are selected.

The following investigations would address the information gaps and provide more certainty:

- A geotechnical/geophysical site investigation is neededto identify the depth to competent ground (that is not liquefiable). This layer may be bedrock, or may be a shallower stratum of dense granular material. There are no in situ testing techniques that can be performed in frozen soil that can predict the compactness condition of that soil once thawed. Therefore, the site investigation would require that undisturbed frozen samples be collected and transported in a frozen state to a geotechnical laboratory for testing. In addition to a limited number of test holes strategically located, we would recommend a geophysical survey to provide more continuous subsurface information extrapolating with more confidence between test holes.

- An assessment of thawing technologies and preliminary design and costing of a ground thawing system would be beneficial. The costs and appropriate technologies and techniques are a function of the depth that requires thawing.

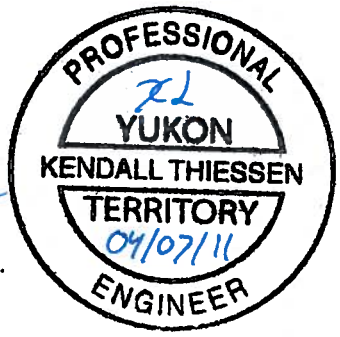
- A desktop study of climate prediction models for the Mt. Nansen area would help to understand the potential limitations of ground freezing. A linear interpretation of the mean annual temperature changes that have occurred in past 50 years cannot be reasonably extrapolated into the distant future. A study of potential climate change scenarios may be helpful in identifying the useful lifespan of thermosyphons, and could improve the estimated rate of thaw for permafrost.

As stated previously, it is our opinion that a shear key that is anchored with permanently frozen ground is still a feasible and economical means of ensuring the stability of the dam at the present time.

Please contact the undersigned with comments or questions.

AECOM Canada Ltd.

Prepared by:



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REFERENCES

AECOM 2010
Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives, November 2010.

Andersland, O. B., and Ladanyi, B. 2004
Frozen Ground Engineering. American Society of Civil Engineers and John Wiley & Sons Inc.

EBA 2002
Dam Safety Assessment: Mount Nansen Tailings Facility near Carmacks, YT. May 2002.

Higgs, T.W. and Associates, 1994,
Initial Environmental Evaluation, Mt. Nansen Development (prepared for B.Y.G. Natural Resources Inc.).

Klohn Leonoff 1988,
Mt. Nansen Gold Project: Tailings Dam Preliminary Design Report.

Olsen S. M., and Stark, T. D.,2002.
Liquefied strength ratio from liquefaction flow failure case histories. Canadian Geotechnical Journal. 39: 629-647.

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To: Justin Stockwell, Lorax Environmental Services Ltd.

From: Diane Lister

Date: May 13, 2011

RE: **Mount Nansen Mine Site - Provisional Cost Estimates for Water Quality Mitigation FINAL DRAFT**

1.0 Introduction

This memorandum provides a background summary of provisional water quality mitigation and associated costs considered during evaluation of closure options for the Mt. Nansen Mine site, an abandoned gold and silver mine located approximately 60 km west of Carmacks, Yukon.

1.1 Purpose

During the stakeholder reviews of the draft "Mount Nansen Options for Closure" report issued by Lorax Environmental Services in November 2010, certain comments pertaining to costs for mitigation of potential water quality issues during and after closure were raised (see Table 1). Altura Environmental Consulting was requested to compile a memorandum clearly presenting the various water quality mitigation measures and associated costs in order to address reviewer comments and to facilitate the consideration of these issues during Closure Option evaluation.

1.2 Approach

The Options for Closure report (Lorax 2010) describes in detail the relevant background information and design concept of the various closure alternatives for Mount Nansen, along with their associated capital costs. These cost estimates are being augmented with consulting, engineering, design, and site supervision allowances as well as life cycle costs in the report "Summary of Estimated Closure Costs" (AECOM, 2011).

Each closure option incorporates water quality mitigation measures and associated costs based on expected conditions both during active closure, and following closure. Such measures were derived using available information from investigations and ongoing site data collection. Nonetheless, it is recognized that other water quality issues may arise as a result of either unforeseen circumstances or failure of the option as designed. The occurrence and mitigation costs of these issues, herein termed 'Provisional' water quality considerations, are presented in this memorandum.

Table 1. Stakeholder Reviewer Comments Pertaining to Water Quality Mitigation

Tracking #	Comment	Response[1]
11	Pg3, fourth bullet	Noted, however a passive wetland would likely preclude the need for a water treatment plant (as stated in the following paragraph).
33	Only in pit options include costs for water treatment. The bulk of the cost is capital cost for establishing treatment facilities. All options require some re-grading and relocation of tailings. Also, all options require cleanup in the mill area where current seepage concentrations are high and in some cases exceed effluent limits. As a result, there appears to be a high likelihood that water treatment facilities (capital costs) will be required for all options, though operating costs may be slightly different.	Considering the re-location of tailings, there is potentially a need for water treatment, and short term treatment should be considered. It has been assumed that the mill area does not currently require treatment. Reclamation activities are expected to improve water quality emanating from the mill.
27	There is no cost estimate for this contingency pumping from the covered pit discussed for Option 4 although it may significantly increase long term maintenance cost.	Clarification on interim water treatment activities during and after closure implementation for each of the options will be provided. It was assumed water treatment would be required in the short term during primary consolidation. Updated costs will be provided, as required.

[1] Response as provided by Lorax Environmental, April, 2011

Tables 2 through 4 summarize water quality considerations included as 'Base Case' costs in AECOM (2011) and for Provisional considerations identified during the course of several discussions amongst Yukon Government Assessment and Abandoned Mines, Lorax Environmental Services Limited (Lorax), AECOM, Gomm Environmental Engineering Consulting, and Altura Environmental Consulting. Similar Provisional issues were identified for more than one option. For simplicity, the following three groupings of options are considered in this evaluation:

1. Options 1A/2A: Tailings Dam Upgrade with either Water or Saturated Soil Cover, Pit Lake, Waste Rock Piles Remain in Place
2. Options 1B/2B: Tailings Dam Upgrade with either Water or Saturated Soil Cover, Pit Backfilled with Waste Rock
3. Options 3/4: Tailings Wet or Dry Backfill into Pit with Cover, with or Without Waste Rock Backfill

Two time periods were considered in this evaluation: i) issues of likely short-term duration during Active Closure phase, associated with construction activities, and ii) issues of longer term duration occurring during the Post-Closure phase.

Estimated costs for these Provisional mitigation measures were primarily provided by Lorax Environmental Services and AECOM. The following sections provide explanatory background, and costs are summarized in Tables 8 and 9.

By necessity these estimated costs are based on mitigation of assumed scenarios which are believed to represent a reasonably conservative approach to a credible 'worst case' water quality issue. As noted above, these issues are assumed to arise as a result of either unforeseen circumstances or failure of the option as designed. The proposed mitigation and associated costs presented in this memorandum are intended solely for the purpose of facilitating an estimate of residual risk for each of the Mount Nansen closure options. Provisional treatment concepts are conceptual by definition. A conceptual level of design specific to each mitigation measure has been applied, and further levels of engineering design are considered beyond the scope of this costing task. Conceptual cost estimates have been extrapolated from existing cost bases and studies.

Table 2. Summary of Base Case and Provisional Water Quality Mitigation, Options 1A / 2A

		ACTIVE CLOSURE (Short Term)			**POST-CLOSURE (Long Term)**		
		Base Case	**Provisional Considerations**		***Base Case***	**Provisional Considerations**	
Item #	**Area**	***Water Quality Management Measure Assumed for Costing***	**Potential Short Term Water Quality Issue**	**Provisional Allowance**	***Water Quality Management Measure Assumed for Conceptual Closure***	**Credible Worst Case Long Term Water Quality Issue**	**Provisional Allowance**
	Mill	*Provision for temporary sediment control during active closure phase.*	Metal concentrations in storm water and other construction discharges do not meet water quality objectives. (eg. water from high volume seep above mill, water infiltrating through lower mill platform).	Temporary collection of elevated-metal water. Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product.	*Long term water quality objectives are met through closure measures*	None - reasonable expectation that remedial and closure measures will result in meeting of water quality objectives over the long term	None
	Tailings	*Tailings area, toe berm construction, tailings surface grading and cover construction, spillway and diversion construction works are assumed to incorporate basic sediment control measures such as ditching, silt fencing, and check dams to reduce suspended sediment load.*	Metal concentrations in storm water and other construction discharges do not meet water quality objectives. (eg. surface water and tailings porewater released during construction activities)	Temporary collection of elevated-sediment / elevated-metal water. Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product.	*Long term water quality objectives are met through closure measures*	Seepage / shallow groundwater downstream of toe of dam does not meet long term water quality objectives	Construct and operate passive biological treatment system in Dome Creek valley downstream of dam
	Pit	*No specific provisions for treatment of pit lake water during active closure.*	None expected	None	*Long term water quality objectives are met through closure measures*	Water quality in pit lake does not meet long term objectives	Alternative 1: Semi-passive biological treatment of Brown-McDade pit lake to reduce metal levels (bi-annual fertilization treatment to reduce metal levels) Alternative 2: Partial backfill of pit with waste rock to 1190 masl (above maximum historical elevation of pit lake)

Table 3. Summary of Base Case and Provisional Water Quality Mitigation, Options 1B / 2B

		ACTIVE CLOSURE (Short Term)			**POST-CLOSURE (Long Term)**		
		Base Case	**Provisional Considerations**		***Base Case***	**Provisional Considerations**	
Item #	**Area**	***Water Quality Management Measure Assumed for Conceptual Closure***	**Potential Short Term Water Quality Issue**	**Provisional Allowance**	***Water Quality Management Measure Assumed for Conceptual Closure***	**Credible Worst Case Long Term Water Quality Issue**	**Provisional Allowance**
	Mill	*Provision for temporary sediment control during active closure phase.*	Metal concentrations in storm water and other construction discharges do not meet water quality objectives. (eg. water from high volume seep above mill, water infiltrating through lower mill platform).	Temporary collection of elevated-metal water.Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product.	*Long term water quality objectives are met through closure measures*	None - reasonable expectation that remedial and closure measures will result in meeting of water quality objectives over the long term	None
	Tailings	*Tailings area, toe berm construction, tailings surface grading and cover construction, spillway and diversion construction works are assumed to incorporate basic sediment control measures such as ditching, silt fencing, and check dams to reduce suspended sediment load.*	Metal concentrations in storm water and other construction discharges do not meet water quality objectives. (eg. surface water and tailings porewater released during construction activities)	Temporary collection of elevated-sediment / elevated-metal water. Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product.	*Long term water quality objectives are met through closure measures*	Seepage / shallow groundwater downstream of toe of dam does not meet long term water quality objectives	Construct and operate passive biological treatment system in Dome Creek valley downstream of dam
	Pit	*No specific provisions for treatment of pit lake water during active closure (eg. pit lake is not assumed to be dewatered prior to waste rock backfill).*	Potential displacement of elevated-metal water into bedrock during pit backfilling	Alternative 1: Dewatering of pit lake water prior to backfilling. Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product. Alternative 2: Semi-passive biological treatment of Brown-McDade pit lake to reduce metal levels (bi-annual fertilization treatment conducted in year prior to backfilling) Alternative 3: Staged backfill of waste rock (assumed over 3 years) in order to minimize effects on local groundwater gradient.	*Long term water quality objectives are met through closure measures*	None - reasonable expectation that backfill with waste rock will not further degrade pit lake water quality	None

Table 4. Summary of Base Case and Provisional Water Quality Mitigation, Options 3 / 4

		ACTIVE CLOSURE (Short Term)			POST-CLOSURE (Long Term)		
		Base Case	Provisional Considerations		*Base Case*	Provisional Considerations	
Item #	**Area**	***Water Quality Management Measure Assumed for Conceptual Closure***	**Potential Short Term Water Quality Issue**	**Provisional Allowance**	***Water Quality Management Measure Assumed for Conceptual Closure***	**Credible Worst Case Long Term Water Quality Issue**	**Provisional Allowance**
	Mill	*Provision for temporary sediment control during active closure phase.*	Metal concentrations in storm water and other construction discharges do not meet water quality objectives. (eg. water from high volume seep above mill, water infiltrating through lower mill platform).	Temporary collection of elevated-metal water. Treatment as recommended in AECOM (2009) Water Treatment Study. Effluent discharge and management of sludge by-product.	*Long term water quality objectives are met through closure measures*	None - reasonable expectation that remedial and closure measures will result in meeting of water quality objectives over the long term	None
	Tailings	*Provision for temporary collection of tailings pond water and pore water. Treatment via Actiflo/Actidyn Mobile Unit and discharge. Management of sludge by-product.*	None; the base case mitigation (water treatment plant) is expected to address short term water quality issues	None	*Long term water quality objectives are met through closure measures*	None - reasonable expectation that remedial and closure measures will result in meeting of water quality objectives over the long term	None
	Pit	*Dewatering and treatment of one volume of pit water (approximately 10 day campaign) specified in AECOM (2009).*	None; the base case mitigation (water treatment plant) is expected to address short term water quality issues	None	*Long term water quality objectives are met through closure measures*	Pore water within or downgradient of pit does not meet long term water quality objectives	Long term collection and treatment of porewater, including up to 5 collection wells

1.3 Water Treatment – General Assumptions

1.3.1 Active Treatment

Active water treatment (treatment that requires ongoing mechanical, electrical, and/or chemical input) has been identified as a mitigation measure in several options and scenarios, both in the Base Case and for Provisional Considerations.

Design of the active treatment system to remove metals is based the specifications outlined in "Mount Nansen Mine Water Treatment Study" (AECOM, 2009) provided in Appendix 1. The report recommends that an Actiflo/Actidyn Mobile Unit would be suitable for treatment requirements at the Mt. Nansen Mine. This unit provides flexibility, mobility, and minimal construction. One unit could theoretically be relocated to treat water at different locations as the project advanced, avoiding the need for extensive piping or additional plants. The conceptual treatment plant would be suitable for treating pit lake and tailings porewater, and given its similar chemistry, water from the mill area. The plant may also be used for long term treatment if necessary, although lifecycle costing must then considered (AECOM 2009).

Estimated costs for installation and operation of an Actiflo/Actidyn Mobile Unit are given in Table 5. The incremental costs for treating different volumes of water across the various options and scenarios are expected to result in relatively marginal cost differences.

It has been assumed that the sludge produced by a long term water treatment process could be disposed of on top of the tailings in a containment cell, and estimated costs are included in Table 5. In the event that long term treatment is required, the environmental impact of placing the sludge on the tailings is considered to be minor. The sludge produced during construction (i.e., pit lake water or tailings pond water) would be disposed of with the tailings, and a containment cell would not be necessary.

Table 5. Estimated Costs for Installation and Operation of Actiflo/Actidyn Mobile Water Treatment Unit[1]

			Life Cycle Costs[2] (Net Present Value [3])	
Item	**Capital**	**Annual O&M**	O&M	Replacement (Frequency)
Treatment Plant	$2,200,000	$33,000	$825,000	$1,679,000 (20yrs)
Sludge Management	$50,000	$5,000	$125,000	$42,000 (20 yrs)

1. Estimated costs as provided by AECOM, May 2011. See Appendix 1 for background details.
2. Life Cycle costs to be applied to long term treatment scenarios only
3. Calculated using a discount rate of 4%.

1.3.2 Passive and Semi-Passive Treatment

Tailings Area Passive Biological Treatment System

As described in Appendix 1, frequent monitoring over a period of greater than 6 years has regularly demonstrated that arsenic attenuation processes in the tailings area have been stable and effective. In the event that seepage / shallow groundwater downstream of toe of dam does not meet long term water quality

objectives at some point following closure, provisional measures incorporate installation of a Passive Biological Treatment System. This system will route tailings dam seepage through organic-rich, naturally occurring substrates, fostering conditions favourable to sulphate reduction and the precipitation of metal sulphides including arsenic sulphides and co-precipitation of arsenic with iron sulphides in situ.

Further details of the system are described in Appendix 2. Estimated costs are given in Table 6. It should be noted that in the case of the seepage area below the tailings dam, replacement of the organic substrate is not considered necessary in order for the system to function in the long-term. Labile organic carbon has been demonstrated to naturally occur within groundwater along Dome Creek and is assumed to remain present in the long-term.

Table 6. Estimated Costs for Installation and Operation of Tailings Area Passive Biological Treatment System, Options 1 and 2 [1]

Item	Capital	Annual O&M	Life Cycle Costs (Net Present Value [4])	
			O&M	Replacement (Frequency)
Passive Biological Treatment System	$292,531[2]	$7,000[3]	$175,000	$- (-)

1. Based on estimated costs as provided by Lorax Environmental Services, April 2011 (see Appendix 2).
2. Includes 15% allowance for Engineering and Construction Management
3. Includes $2000 Maintenance, $5000 Operating Costs
4. Calculated using an annual discount rate of 4%, 150-year time period.

Semi-Passive Biological Treatment of Brown-McDade Pit Lake

A semi-passive fertilization program is proposed as one potential provisional measure for treating pit lake water quality. Pit lake fertilization has been applied at numerous mine pit lakes (e.g., Faro) as a cost effective means of managing neutral mine drainage of poor quality.

Further details of the system are described in Appendix 3. Estimated costs are given in Table 7. Life cycle costs are applicable to longer term treatment scenarios and include periodic re-application of the fertilization treatment. It is important to note that frequency of fertilization is based on field observations and evolving lake chemistry. In Table 7 a five year cycle has been assumed solely for cost approximation purposes.

Table 7. Estimated Costs for Semi-Passive Biological Treatment of Brown-McDade Pit Lake [1]

Item	Capital	Annual O&M	Life Cycle Costs (Net Present Value[4])	
			O&M	Replacement (Frequency)
Semi-Passive Biological Treatment of Pit Lake	$64,850[2]	$-[3]	$-	$1,100,000[5] (5 years, assumed)

1. Based on estimated costs as provided by Lorax Environmental Services, April 2011 (see Appendix 3).
2. Estimated cost for two fertilization treatments in a given year – includes labour, materials, supervision, and monitoring
3. No specific O&M required
4. Calculated using an annual discount rate of 4%, 150-year time period.
5. Re-treatment every 5 years is assumed solely for this calculation, however frequency of fertilization should be adjusted based on field observations and evolving lake chemistry.

2.0 Provisional Considerations for the Mill Area

2.1 Active Closure Phase

While a significant allowance has been made for sediment control and water management in the existing cost estimate, certain water seepages in the mill area have been identified as containing elevated metal levels, one possibly associated with an historic adit opening. It is possible that sediment control and other water management measures will be insufficient over the short term to control metal concentrations, and that additional treatment will be required prior to discharge. Provisional costing assumes this water would be collected and treated via the Actiflo/Actidyn mobile water treatment unit described in section 1.3.1 prior to discharge.

2.2 Post-Closure Phase

It is expected that long term water quality objectives will be met through closure measures, and is believed reasonable that the potential contaminant sources identified during site investigations can be adequately remediated, as outlined in Lorax (2011). Hence, no long term water quality provisions for the mill area are anticipated.

3.0 Provisional Considerations for Tailings and Open Pit Area

3.1 Options 1A / 2A

3.1.1 Active Closure Phase

In the tailings area, toe berm construction, tailings surface grading and cover construction, spillway and diversion construction works are assumed to incorporate basic sediment control measures such as ditching, silt fencing, and check dams to reduce suspended sediment load.

As a provisional consideration, tailings pond water may require additional treatment prior to discharge, depending on the water quality and pond volume at the start of construction. Pond volume and water quality vary seasonally and as a function of facility operations. It may also be necessary to treat porewater released during construction activities and other surface water that has been contaminated by interacting with the tailings during the construction period. Because of the many unknowns, it is not possible to reasonably determine the optimal process or equipment for treating this water. Based on the current understanding of the pond water quality, it is reasonable to assume that the Actiflo/Actidyn mobile water treatment plant recommended by AECOM (2009) and discussed in section 1.3.1 would be suitable for treating contaminated water in the tailings storage area during construction activities. Treatment of pond water is not expected to be necessary after the completion of construction if the cover system functions as designed.

There are no specific allowances for treatment of pit lake water during active closure for Options 1A and 2A. Works such as scaling and stabilizing of pit walls, berming and signage are not expected to modify pit water quality, and hence no provisional considerations during active closure are identified for the open pit.

3.1.2 Post-Closure Phase

In the event that seepage / shallow groundwater downstream of the tailings dam does not meet long term water quality objectives at some point following closure, provisional costs assume installation and long term operation of the passive biological treatment system described in section 1.3.2.

Should it be determined that the quality of the pit lake water is unacceptable over the long term, two mitigation alternatives are proposed:

Alternative 1: Semi-passive fertilization as described in section 1.3.2; or

Alternative 2: Partial backfill the pit with waste rock. Backfilling the lake would significantly decrease the volume of water in the pit (porewater versus lake volume), and the hazard of open water would be eliminated. This would essentially be a hybrid of the A and B alternatives for Option 1 and Option 2. The pit would be backfilled to an elevation above the water table (approximate elevation 1190 m), requiring approximately 44,000 m^3 of fill. Inert waste rock, or locally available granular soils would be a suitable backfill. The pit lake water could either be treated and discharged into Pony or Dome Creek or the lake water could displaced into the bedrock if it was considered to acceptable from and environmental perspective. Backfilling the lake would significantly decrease the volume of water in the pit (porewater versus lake volume), and the hazard of open water would be eliminated. A unit cost of $\$5.00/m^3$ is assumed, and \$50,000 for mobilization/demobilization costs.

3.2 Options 1B / 2B

3.2.1 Active Closure Phase

Provisional considerations for the tailings area are identical to those given for Options 1A / 2B. Therefore, provisional cost estimates allow for installation and operation of the Actiflo/Actidyn mobile water treatment plant discussed in section 1.3.1 for treating contaminated water in the tailings storage area during construction activities.

Base case costing assumes that pit backfill with waste rock proceeds without dewatering of the pit lake. Nonetheless, concerns may arise from directly backfilling the pit lake with waste rock. These issues may include various constructability concerns, or the potential of displacing potentially elevated metal water into the bedrock during the backfilling process. Three mitigation alternatives are considered, as described below:

Alternative 1: The design, operation and costing of the Actiflo/Actidyn mobile water treatment plant described in section 1.3.1. The sludge produced by treating the water in this scenario would be disposed in the in the tailings storage area. It should be noted that a single water treatment plant could feasibly treat both the tailings pond water and the pit water, and therefore only one capital expenditure is assumed for an active treatment system under Options 1B / 2B. There would be some additional maintenance and operations costs associated with using the same treatment plant for treating both the pit lake water and the tailings pond water, but these costs are considered to be relatively minor compared to the overall system costs, and these costs have not been considered specifically.

Alternative 2: Semi-passive fertilization as described in section 1.3.2; or

Alternative 3: A gradual, staged backfill of waste rock into the pit lake (assumed over 3 years). This measure would likely minimize effects on local groundwater gradient, and not require pit dewatering. The primary incremental cost associated with staged backfill over the single-campaign backfill in the base case is assumed to be mobilization and demobilization costs for two additional seasons, estimated at $50,000 each for Year 2 and Year 3.

3.2.2 Post-Closure Phase

Similar to Options 1A / 1B, in the event that seepage / shallow groundwater downstream of the tailings dam does not meet long term water quality objectives at some point following closure, provisional costs assume installation and long term operation of the passive biological treatment system described in section 1.3.2.

Within the pit, investigations indicate that the residual ore in the footwall zone is a prime contributor of metals (Zn, Cd) to pit lake water quality. Based on sampling results, the residual footwall tends to contain soluble metal levels that are an order of magnitude or greater than that of the majority of waste rock stored in the Brown McDade rock pile. It is therefore considered a reasonable expectation that backfill with waste rock will not further degrade pit lake water quality over the long term, and no provisional allowances for long term water quality mitigation have been made.

3.3 Options 3/4

3.3.1 Active Closure Phase

Options 3 and 4, involving relocation of tailings from Dome Creek valley to the open pit, assume there may be a short term requirement to treat porewater released during tailings consolidation following pit backfill. These costs have been included in the capital cost estimates presented in the AECOM Costing Memo (2011) and in the Mt. Nansen Options for Closure report by Lorax (2011). The AECOM Water Treatment Study (2009) indicates that pit dewatering and treatment prior to tailings backfill would require an approximately 10-day campaign and thus would comprise a very small proportion of the treatment plant's operating and capital budget.

Allowances for general sediment control measures in Dome Creek valley are also provided during the restoration phase of the tailings impoundment footprint.

Beyond these water quality mitigation measures already considered in the base case, another potential source of contaminated water that may require short term active treatment includes the tailings pond water during construction (unless the tailings are dredged in which case treatment may be required at the end of construction). This would be similar to the pond water treatment required for Options 1 and 2. Nonetheless, since the base case cost estimate for Options 3 / 4 already allow for installation and operation of a treatment plant, incremental costs for collecting and treating this additional water would likely be marginal.

3.4 Post-Closure Phase

Site investigations and modelling using conservative inputs indicate that long term porewater quality of backfilled material within the open pit will be acceptable. Nonetheless, in the unlikely event that objectives are not being met, groundwater that has passed through the tailings and is reporting to the base of the pit or the surrounding bedrock may require long-term treatment. A provision for this treatment is considered in the following paragraphs.

Groundwater extraction wells would be required to capture any tailings-affected groundwater. In order to provide adequate groundwater capture, it is assumed that 1 to 5 wells would be required. The number and positioning of wells is highly dependent on the final design of each option, the infiltration rate, treatment interval, and storage capacity in the tailings/waste rock/bedrock.

The Actiflo/Actidyn mobile water treatment plant discussed in section 1.3.1 was scoped to treat the contaminated porewater following deposition, as well as the pit water prior to pit backfilling. It has been assumed that the same treatment plant could be used to treat seepage from pit backfill on an ongoing basis. It is proposed that due to low expected rates of infiltration the treatment plant would only need to be operated intermittently. The coarse layers of tailings (Option 3) and waste rock (Option 4) at the bottom of the pit would serve as storage between dewatering and treatment campaigns. Additional wells situated outside of the pit, and in the downstream flow path may also serve to monitor and/or capture water that may have migrated from the pit into the surrounding bedrock. The details of storage capacities, pumping rates and treatment intervals are beyond the scope of the current analysis. It should be noted that closure options have been designed in such a way that treatment is not expected to be necessary; therefore a requirement for future treatment suggests that these design assumptions were no longer valid.

Following removal of tailings and restoration of the tailings footprint area it has been assumed that water in the restored Dome Creek valley will not require treatment over the long-term. Therefore, no provisional allowances for additional mitigation have been considered.

4.0 Summary

Estimates of provisional costs for water quality mitigation are summarized in Tables 8 and 9. As noted in section 1.2, these costs are intended solely for the purpose of facilitating an estimate of residual risk for each of the Mount Nansen closure options.

It should be noted that if active treatment is required for multiple aspects of a single option, then the only one capital investment for a treatment plant is assumed to be required. This is reflected in the costs shown in Tables 8 and 9.

For the long term costs summarized in Table 9, it should be kept in mind that capital and annual O&M are estimated based on 2011 costs and current conditions.

Table 8. Summary of Estimated Short-Term Provisional Treatment Costs by Option [1]

	Item	Capital	Annual O&M
Option 1A/2A	Treatment for Metals (Mill and/or Tailings Area)	$2,200,000	$33,000
	Sludge Management	$50,000	$5,000
Option 1B/2B	Treatment for Metals (Mill, Tailings Area and/or Pit)	$2,200,000	$33,000
	Sludge Management	$50,000	$5,000
	Pit Lake Alternative 2: Semi-passive biological treatment	$64,850	$-
	Pit Lake Alternative 3: Staged backfill	$100,000	$-
Option 3/4	Treatment for Metals (Mill, Tailings Area and/or Pit)	$ - (allowance in Base Case)	$ - (allowance in Base Case)
	Sludge Management	$ - (allowance in Base Case)	$ - (allowance in Base Case)

1. Based on explanatory tables and text presented in sections 2 and 3.

Table 9. Summary of Estimated Long-Term Provisional Treatment Costs by Option [1]

	Item	Capital	Annual O&M	Life Cycle Costs (Net Present Value [3])	
				O&M	Replacement (Frequency)
Option 1A/2A	Passive Biological Treatment System, Tailings Area	$292,531	$7,000	$175,000	$- (-)
	Alternative 1: Semi-passive biological treatment of pit lake	$64,850	$-	$-	$1,100,000 (5 years, assumed)
	Alternative 2: Partial backfill of pit with waste rock	$270,000	$-	$-	$-
Option 1B/2B	Passive Biological Treatment System, Tailings Area	$292,531	$7,000	$175,000	$- (-)
Option 3/4	Long term collection and treatment of porewater	$2,200,000[2]	$33,000	$825,000	$1,679,000 (20yrs)
	Sludge Management	$50,000	$5,000	$125,000	$42,000 (20 yrs)

1. Based on explanatory tables and text presented in sections 2 and 3.
2. The capital cost for an identical treatment system is incurred during the active closure phase for this option; hence this additional expenditure of $2.2M may not be required if the initial treatment system were still installed on site and functional.
3. Calculated using an annual discount rate of 4%, 150-year time period.

5.0 Closure

This document was prepared by Altura Environmental Consulting (Altura) for Lorax Environmental Services Ltd. on behalf of Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources of the Government of Yukon. The document, which specifically includes all text, tables and appendices, is largely based on costing and explanatory descriptive information provided by the client and by AECOM Canada Ltd.. Altura has organized this information so as to clarify the presentation, and where necessary, has performed net present value calculations to allow a consistent presentation of costs.

The work described in this report was conducted in a manner consistent with that level of care and skill normally exercised by other members of the engineering and science professions currently practicing under similar conditions, subject to the time limits and financial and physical constraints applicable to the services.

Altura Environmental Consulting sincerely appreciates the opportunity to participate in and contribute to the decommissioning phase of the Mount Nansen site. Please direct any questions regarding the contents of this report to the undersigned at 867-335-2006.

Prepared by:

ALTURA ENVIRONMENTAL CONSULTING

Diane Lister, M.A.Sc., P.Eng.

6.0 References

AECOM, 2009. *Government of Yukon-Energy, Mines and Resources, Mount Nansen Mine Water Treatment Study*. March 2009, 28 pp.

AECOM, 2011. *Summary of Estimated Closure Costs, Mt. Nansen Mine Site*. May 2011.

Lorax Environmental Services Ltd., 2011. *Mt. Nansen Options for Closure.* Draft report prepared for Government of Yukon Assessment and Abandoned Mines Branch, Energy, Mines and Resources, May, 2011.

APPENDIX 1

Mount Nansen Mine

Water Treatment Study

AECOM Canada Limited, March 2009

AECOM

Government of Yukon-Energy, Mines and Resources

Mount Nansen Mine
Water Treatment Study

Prepared by:

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Project No.: 2940 045 00 (4.6.1)

Date: March, 2009

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This Statement of Qualifications and Limitations is attached to and forms part of the Report.

March 9, 2009 Project No. 2940 045 00 (4.6.1)

Mr. Frank Patch
Project Manager
Energy, Mines and Resources
Government of Yukon
P.O. Box 2703 (K-419)
Whitehorse, Yukon Y1A 2C6

Dear Mr. Patch:

Re: Mount Nansen Mine Water Treatment Study

AECOM Canada Ltd. is pleased to submit our water treatment study report to the Government of Yukon.

Should you have any queries, please do not hesitate to contact Barry Williamson, P.Eng. directly at 204-284-0580.

Sincerely,

AECOM Canada Ltd.

S. R. (Ray) Bilevicius, M.A.Sc., P.Eng.
Manager
Global Water Department
BW/dh

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Appendix A Water Quality Results
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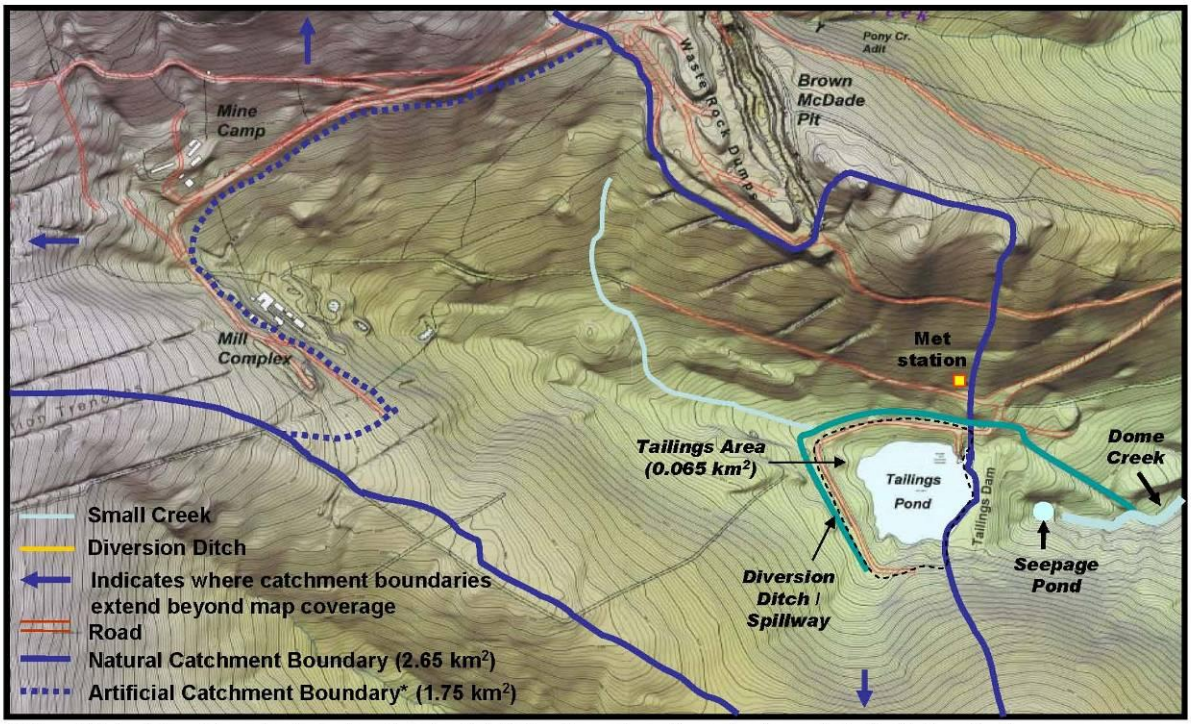
1. Introduction

1.1 Background

Mount Nansen Mine is a former gold and silver mine that is currently under the care of the Government of Yukon. The Mount Nansen property is located 60 km west of Carmacks and 180 km north of Whitehorse, Yukon and is within the traditional territory of the Little Salmon Carmacks First Nation. The general layout of the mine site is shown below in Figure 1.



* The artificial catchment boundary is due to a diversion ditch that captures all runoff up-valley from entering the Tailings Pond.

Figure 1 – Mount Nansen Mine General Layout (GLL, 2005)

In 1999, the mine owner, BYG Natural Resources (BYG), was unable to meet the requirements of the water licence and as a result, the mine was closed down. Immediately after shutdown, BYG appointed a receiver. On July 28, 1999, the receiver abandoned the property, leaving a significant environmental liability. Since this time, the government has taken responsibility for care and maintenance of the property.

During operations, tailings pond water had to be pumped up to the mill site on a seasonal basis for treatment prior to discharge to Dome Creek. After the site was abandoned in 1999, the Department of Indian Affairs and Northern Development (DIAND) converted some of the mill process tanks into an improved water treatment system and continued to treat tailings pond water on a seasonal basis with a modified INCO SO_2

process. In 2005, treatment prior to discharge ceased when it was determined that cyanide and metal concentrations were below discharge criteria for the mine' s operational water licence.

The Government of Yukon and the Government of Canada along with Little Salmon Carmacks First Nation are actively involved in the planning for the final closure of this mine. The overall goal is to bring Mount Nansen to closure as soon as possible. AECOM recently submitted the *2008 Geotechnical Inspections* report, which identifies three potential closure options for Mount Nansen:

1) Upgrade the existing Tailings Management Area (TMA) structures in accordance with the 2007 CDA Guideline and include a permanent long term closure plan for the tailings (soil cover)

2) Dispose of tailings in the Brown-McDade pit and breach the existing dams to restore Dome Creek valley

3) Excavate and redistribute a sufficient volume of tailings to allow the tailings dam to be breached and the Dome Creek valley restored

If the Second option were selected, tailings from the TMA would be relocated to the Brown-McDade Pit and a cover of clean soil or waste rock would be used to cap the tailings. To accomplish this, water from the pit, water accumulating in the tailings pond, and the tailings' porewater would need to be removed and treated before the tailings could be relocated. Depending on the change in water quality during tailing relocation, the water in the seepage pond downstream of the TMA may also require treatment before being discharged to the environment.

As with option two, if the third option were selected, porewater contained within the tailings would likely have to be collected and treated prior to breaching the dams.

1.2 Scope

The purpose of this study is to summarize the existing water quality information from the pit lake, tailings pond and seepage pond, and to identify suitable water treatment systems. These systems will be evaluated based on capital and operational cost, constructability and performance. The study will also provide expected sludge volumes to be produced by the recommended treatment system, and recommendations for sludge management.

2. Review of Background Information

A considerable amount of information was provided to AECOM for use in preparing this report. Where applicable, the following reports are referenced throughout this document, as is anecdotal information provided by the Government of Yukon:

- AECOM – 2008 Geotechnical Inspections report (Draft), November 2008
- Government of Yukon – Options for Closure of Mt. Nansen Mine, Technical Review Version, July 2008
- Lorax Environmental – Tailings Porewater Assessment, April 2008
- Gartner Lee Limited – 2005 Water Balance for the Mount Nansen Mine Tailings Pond, Yukon, February 2006
- Lorax Environmental – Mount Nansen Bioremediation Assessment (Draft), February 2006
- Gartner Lee Limited – Mt. Nansen Mine Site, Brown-McDade Pit Desktop Hydrogeological Study, May 2007

The reader is encouraged to read these documents for more thorough discussions on previous engineering and environmental assessments and investigations.

3. Water Treatment Objectives

3.1 Treated Water Quality Objectives

To determine the most appropriate treatment objectives, three sets of standards were evaluated:

- BYG's water use licence
- Department of the Environment's Metal Mining Effluent Regulations (MMER)
- Canadian Council of Ministers of the Environment (CCME) Canadian Environmental Quality Guidelines

Table 1 outlines the licence and MMER limits as well as the related CCME guidelines.

Table 1 – Discharge Regulations and Guidelines

Parameter	Licence Limits[a]	MMER Limits[a]	CCME Guidelines[a]
pH	6.0 – 8.5 (pH units)	6.0 – 9.5 (pH units)	6.0 – 9.0 (pH units)
Total Suspended Solids (TSS)	50	15	
Toxicity (LC_{50})	100%	100%	
Arsenic (total)		0.50	0.005
Arsenic (dissolved)	0.15		
Antimony (total)	0.15		
Barium (total)	1.0		
Cadmium (total)	0.02		0.017 µg/L
Chromium (total)	0.04		
Chromium (trivalent)			0.0089
Chromium (hexavalent)			0.001
Copper (total)	0.2	0.30	0.004[b]
Cyanide (total)	0.3	1.0	
Cyanide (WAD)	0.1		
Cyanide (free)			0.005
Iron (total)	1.0		0.3
Lead	0.1	0.20	0.007[c]
Manganese	0.5		
Mercury	5.0 µg/L		
Mercury (Inorganic)			0.026 µg/L
Methylmercury			0.004 µg/L
Nickel (total)	0.3	0.50	0.15[d]
Silver	0.1		0.0001
Zinc (total)	0.3	0.50	0.03

[a] *all units mg/L unless otherwise noted*

[b] *CCME copper guideline = 4 µg/L at water hardness > 180 mg/L (very hard) as $CaCO_3$*

[c] *CCME lead guideline = 7 µg/L at water hardness > 180 mg/L (very hard) as $CaCO_3$*

[d] *CCME nickel guideline = 150 µg/L at water hardness > 180 mg/L (very hard) as $CaCO_3$*

The water quality objectives outlined in this section were developed for treatment process selection only. Discharge water quality objectives for the site should be discussed with the appropriate regulators and stakeholders as a continuing part of the closure planning process.

In general, the licence limits are more stringent than the MMER limits, except in the case of total suspended solids (TSS). The water use licence also provides water quality limits for several deleterious substances not covered by the MMER. The CCME guidelines are more stringent than both the licence and MMER, and are even more stringent than the Guidelines for Canadian Drinking Water Quality for each of the substances of concern.

Currently, water discharged from site is required to meet the water quality standards outlined in the licence. It is expected that once the tailings have been relocated, further water treatment will not be required. As discussions continue regarding closure however, it may be decided that the MMER limits should be met in case ongoing treatment is deemed necessary. The CCME guidelines will not be included in the treatment objectives, as reference samples taken from surrounding areas, including Dome Creek and Victoria Creek, indicate that some parameters are naturally above the CCME guidelines. This is most likely due to mineralization, and not from effects of mining activities. In addition, the CCME guidelines are so stringent that achieving such low concentrations at Mount Nansen is most likely not feasible. Therefore, only the licence limits and MMER limits have been used to develop water quality objectives, as shown below in Table 2. Where the licence and the MMER were in disagreement, the more conservative values were selected. Existing water quality is discussed in greater detail in Section 4.

Table 2 – Treatment Objectives

Parameter	Effluent Concentration Objectives[a]	Existing Water Quality (*all units mg/L unless otherwise noted)*			
		Brown-McDade Pit	Tailings Pond	Tailings Porewater	Seepage Pond
pH	6.0-8.5 (pH units)	7.27-8.75	1.6-11.6	7.16-8.8	6.51-11.6
Total Suspended Solids (TSS)	15	1-375	1-236		1-490
Toxicity (LC_{50})	100%				
Arsenic (total)	0.50	0.0081-0.24	0.01-1.86	0.0407-22.9	0.01-0.5
Arsenic (dissolved)	0.15	0.00216-0.0199	0.0025-0.141		0.00137-0.0549
Antimony (total)	0.15	0.0007-0.1	0.01-2.18	0.00045-0.589	0.0008-0.5
Barium (total)	1.0	0.005-0.04	0.005-0.258	0.0032-0.435	0.031-0.262
Cadmium (total)	0.02	0.00305-0.029	0.00025-0.028	0.000073-0.0012	0.0003-0.025
Chromium (total)	0.04	0.00025-0.005	0.00025-0.013	0.00138	0.0005-0.062
Copper (total)	0.2	0.005-0.095	0.005-105	0.00114-7.57	0.005-36.8
Cyanide (total)	0.3		0.0025-0.248	0.00136-22	0.0189-0.532
Cyanide (WAD)	0.1		0.001-140		0.001-34
Iron (total)	1.0	0.015-8.45	0.0025-38.3	0.04-36.6	0.375-18
Lead	0.1	0.0006-0.116	0.0025-1.44	0.00091-0.0142	0.00005-0.125
Manganese	0.5	0.0408-9.58	0.123-26.6	0.0345-15.9	0.116-16.9
Mercury	5.0 µg/L				
Nickel (total)	0.3	0.0016-0.025	0.0005-0.869	0.0041-0.0883	0.00024-0.222
Silver	0.1	0.0002-0.01	0.00011-0.238	0.000015-0.0184	0.00002-0.122
Zinc (total)	0.3	0.16-2.26	0.0002-5.01	0.0086-0.206	0.0005-0.888

3.2 Expected Water Treatment Volumes and Flow Rates

The volume of water in the pit lake is estimated to be approximately 8000-10 000 m^3 (Yukon Energy Mines and Resources, 2008). The maximum volume of water expected within the TMA has been estimated at 156 000 m^3 with approximately 140 000 m^3 existing as porewater within the tailings (Gartner Lee, 2006). Since the volume of water in the TMA is an order of magnitude greater than in the pit, this is the volume for which an estimated treatment plant flow rate will be developed.

To determine the approximate flow rates that the treatment system will be required to meet to treat the tailings water, it is necessary to estimate approximately how long it would take to move the tailings. This approach assumes the treatment of the tailings water will be preformed concurrently with the earth moving operations.

Assuming the relocation of 300 000 m^3 of materials would be required (Yukon Energy and Mines, 2008), if four trucks with 10 m^3 capacities worked 10 hours a day, and each truck was capable of completing approximately 2 loads per hour, it should take about 375 days to move the tailings from the TMA to the Brown-McDade Pit. Therefore, the minimum daily flow rate that the treatment plant would be required to treat is:

$$\frac{156\ 000\ m^3}{375\ days} = 427\ m^3/day$$

Since the water removal must occur ahead of the earth moving operations, the tailings dewatering technology selected for the closure plan should be capable of providing a water removal rate greater than 427 m^3/day. Consequently, a higher flow rate through the treatment system should also be used. For this reason, the treatment systems being investigated will be sized to treat a flow rate of at least 1000 m^3/day, more than double the 427 m^3/day minimum required flow rate. This should allow any treatment system selected to meet the flow rates that will be produced during the dewatering, ensuring earth moving operations will not be held up by the water treatment process.

The Government of Yukon has indicated that it would like to dewater the pit during the summer a year before moving the tailings so that a useful water balance for the pit can be developed. Given a treatment plant with a 1000 m^3/day capacity, the pit dewatering should only take about 8-10 days. This should allow ample time for a water balance investigation to be undertaken during one summer.

4. Raw Water Quality

4.1 Brown-McDade Pit

Water quality data at varying depths has been recorded on a monthly basis since Dec. 5, 2005. Concentrations of constituents that exceed the licence and MMER limits in the pit lake are presented in section 1 of appendix A.

The data provided by the Government of Yukon indicates that water quality varies slightly with depth, with manganese and zinc regularly surpassing the water quality limits. Both lead and cadmium have also surpassed the limits on occasion, but for the most part are satisfactorily low. The pH typically falls within the acceptable range for discharge, slightly exceeding the licence limit in the summer of 2007. The pH remained within the MMER limits during the entire recording period.

4.2 Tailings Pond and Seepage Pond

Water quality sampling from the surface water in the tailings pond (pond water) is performed biweekly on a year-round basis, as is sampling from the water in the seepage pond (seepage water). Unfortunately, very little data is available with respect to the tailings porewater quality. In September 2007, eleven porewater samples were collected from five locations in the TMA for comparison to the pond and seepage water (Lorax, 2008). Water quality results for the pond water, porewater and seepage water are presented in section 2 of appendix A.

In general, the concentrations of the deleterious substances in the pond water, porewater, and the seepage water follow each other closely. Concentrations and trends followed by the deleterious substances found in these bodies of water are discussed in greater detail in sections 4.2.1-4.2.5, below.

4.2.1 pH

Typically, pH levels in the porewater, pond and seepage waters are neutral to slightly basic. According to the data provided, pH levels frequently exceeded the licence limit prior to 2001, but apart from one anomalous spike, appear to have stabilized. The pH in the porewater was somewhat elevated in two samples, slightly exceeding the licence limit; however the majority of readings show the porewater to be fairly consistent with the pH of the pond and seepage water.

4.2.2 TSS

The licence limit for TSS is relatively high in comparison to the TSS concentrations regulated by the MMER (Licence TSS: 50 mg/L, MMER TSS: 15 mg/L). There is a gap in sampling records for TSS from Jan. 2004 to May 2008. Prior to this gap, TSS concentrations of the pond water were generally well within the licence limits, and only exceeded MMER limits on a few occasions. Since sampling resumed in May 2008, however, TSS concentrations have varied widely, regularly exceeding MMER limits, and surpassing the licence limit on one occasion as well.

The TSS concentrations in the seepage water appear more erratic than the pond water' s, however they still seem to follow the same rough trends. In general, the TSS concentrations were above MMER limits but only exceeded the licence limits on a few occasions.

Because the sampling technique used to extract the porewater involved a filtration step, TSS values were not taken on the porewater samples. The concentration of TSS in the porewater will most likely be dependant on the dewatering method selected for the tailings during the development of the final closure scenario.

4.2.3 Cyanide

Concentration data for the weak acid dissociable (WAD) cyanide goes back to January 1999. Early testing indicated extremely elevated WAD cyanide concentrations (up to 140 mg/L), however these levels dropped significantly over the next few years, and by April 2002, had levelled out below the licence discharge limit, spiking on only a few occasions. This indicates that significant natural attenuation of the cyanide has taken place, and that the source of WAD cyanide is finite and being depleted (Lorax, 2008).

The results for the total cyanide in the system only go back to 2005, but support the theory that the cyanide is being depleted. The total cyanide concentration since readings began show only one instance where levels exceeded the licence limit of 0.3 mg/L, and all concentrations are well below the MMER limit of 1.00 mg/L.

In general, this appears to be the case in the porewater as well, with the exception of an anomalous reading of 22 mg/L in one of the samples. This is an important reading, as it may represent isolated porewater from operations; a theory that is supported by the anomalous pH, sodium and thiocyanate concentrations also recorded at this location. This means that elevated levels of deleterious substances, including cyanide, may be encountered within the tailings. However, these pockets appear to be rare and isolated, as all other samples taken contained less than 0.1 mg/L cyanide (Lorax, 2008).

4.2.4 Arsenic

The test results show very low levels of total arsenic in the pond and seepage waters; however the concentrations appear to be increasing steadily in the pond. The porewater results show arsenic concentrations many times higher than either the pond or seepage waters. The majority or porewater readings taken were in excess of the pond and seepage values, and as high as 22.9 mg/L. These high concentrations are believed to reflect the remobilization of arsenic-bearing iron oxyhydroxides (Lorax, 2008). The increase in the dissolved arsenic in the pond water in recent years may also be partly due to the remobilization of arsenic in the tailings.

4.2.5 Other Metals

For the majority of the metals being investigated, the porewater, pond and seepage waters all follow very similar concentrations and trends. Apart from some higher readings prior to December 2002 and a large one-time spike recorded in December 2005, cadmium, nickel and silver concentrations are well within the licence limits, with barium staying well below the licence limit since sampling began. The metals of highest concern are iron and manganese, which consistently surpass the effluent limits set out in the water use licence.

Antimony, copper, lead and zinc concentrations are much closer to the licence limit, occasionally surpassing it. In the porewater, one sample contained an uncharacteristically high concentration of copper (7.57 mg/L). This was the same sample that exhibited the high levels of cyanide, discussed above in section 4.2.3. Again, this indicates that pockets of higher metals concentrations may exist throughout the tailings; however, they appear to be rare.

5. Evaluation of Treatment Options

5.1 Pre-Treatment Options

For a treatment system to operate at maximum efficiency, it is sometimes necessary to pre-treat the raw water before primary treatment. Pre-treatment technologies are selected based on the levels and types of deleterious substances in the raw water, as well as the specific requirements of the selected primary treatment system. For Mount Nansen, pre-treatment may be recommended to improve the removal efficiency of cyanide and arsenic, as discussed in sections 5.1.1 and 5.1.2, below.

5.1.1 Pre-treatment for Cyanide

Several treatment options are available for treating cyanide. These options rely on chemical, physical or biological processes to reduce cyanide levels. Cyanide can be destroyed and converted to harmless substances with the addition of oxidants including chlorine gas, sodium or calcium hypochlorite, ozone, hydrogen peroxide or sulphur dioxide and air, i.e. SO_2-INCO process. The by-products of these reactions include cyanate, carbon dioxide, bicarbonate, nitrogen, nitrate, ammonia and sulphate. Cyanide can also be precipitated with the addition of iron which leads to the formation of insoluble metal cyanides. The precipitate accumulates as sludge that would then require disposal, as discussed below in section 5.3 - Sludge Management Options.

Currently, based on the water sampling data, it is assumed that cyanide removal at the pit lake is unnecessary. At the TMA, it appears from the data that significant natural attenuation of the cyanide in the water has already occurred. It is expected, however that the concentrations of cyanide may increase as the treatment of the porewater begins if many pockets containing cyanide are encountered within the tailings.

If it is decided that pre-treatment for cyanide is necessary, to avoid adverse affects such as unwanted chemical interactions, any pre-treatment options for cyanide should be chosen based on the primary treatment process selected.

5.1.2 Pre-treatment for Arsenic

Arsenic is the primary metal of concern in the TMA as it is present in relatively high concentrations in the tailings solids (Lorax, 2006). Arsenic does not currently appear to be an issue in the surface waters, as the recorded concentrations have been below the licence limits for discharge. As treatment of the porewater begins, however, this concentration is expected to rise significantly.

Arsenic is a metalloid that is found naturally in water, most commonly present as arsenite, As(III), and arsenate, As(V). While metals scans typically target the total or dissolved arsenic, the speciation of arsenic as either As(III) or As(V) is significant because of the differences in removal efficiencies. The preoxidation of As(III) to As(V) is commonly used to facilitate the removal of arsenic, as it is typically more efficient to remove As(V). Therefore, if it is determined that As(III) is predominant, a pre-oxidation step should be considered for the treatment system to ensure efficient arsenic removal.

5.2 Primary Treatment Options

In general, the concentrations of metals in the surface waters are low enough to allow discharge directly to the environment, especially in recent years. As water levels decrease, as tailings are disturbed, and as porewater is drawn out of the tailings for treatment, it is expected that higher concentrations will be seen, requiring treatment.

Besides the ability to treat the pit and tailings porewater to meet the current water licence limits and possible future effluent criteria, additional plant requirements must be considered when selecting a suitable treatment option. For Mount Nansen, the most important factor to consider will be the flexibility. There are several bodies of water to be treated, each with their own unique water quality characteristics. Further to that, each body of water shows varying concentrations of deleterious substances at different depths. For this reason, selecting a flexible treatment system is essential.

5.2.1 Conventional Clarification

Conventional clarification typically involves the removal of particulate matter, chemical floc and precipitates from suspension through gravity settling. Chemicals are added to raw water to adjust pH and assist precipitation, causing precipitates to settle. The treated water rises vertically where it overflows the weir of a discharge channel at the tank' s surface. The settled solids are then removed mechanically. These systems have a large footprint and slow reaction time compared to other treatment options, but they are capable of handling large quantities of water, and they are relatively simple to operate and maintain. However, because of the large space requirement and slow reaction time, conventional clarification is not recommended for Mount Nansen mine and will not be discussed further.

5.2.2 High Rate Clarification

High rate clarification refers to clarification systems that can be loaded at higher rates than is typical for conventional clarifiers. The two types of high-rate clarification systems being considered for Mount Nansen include solids contact/slurry recirculation and ballasted flocculation.

5.2.2.1 Solids Contact/Slurry Recirculation

Solids contact/slurry recirculation units typically combine mixing, flocculation and sedimentation in a single compartmented tank. A typical solids contact clarifier injects coagulant and softening chemicals in the influent and mixes the water under a center cone-shaped skirt, where a high floc concentration is maintained. Flow then passes through a sludge blanket at the bottom of tank to promote the growth of larger clusters. Then, as in conventional clarification, the treated water continues to rise vertically where it is collected in discharge troughs or channels at the surface.

These systems have a smaller footprint than conventional clarifiers, however they are usually limited in their operational flexibility because they must maintain a sludge blanket. They are most commonly used in systems with uniform water characteristics and consistent flow rates.

The solids contact system being considered for use at Mount Nansen is the Contrafast CF-350 (Figure 2). This system is a high rate clarification/thickening system with a 1900 m^3/day (350 gpm) nominal design rate. The Contrafast unit is capable of producing sludge with more than 20% solids by weight, making additional sludge thickening unnecessary.

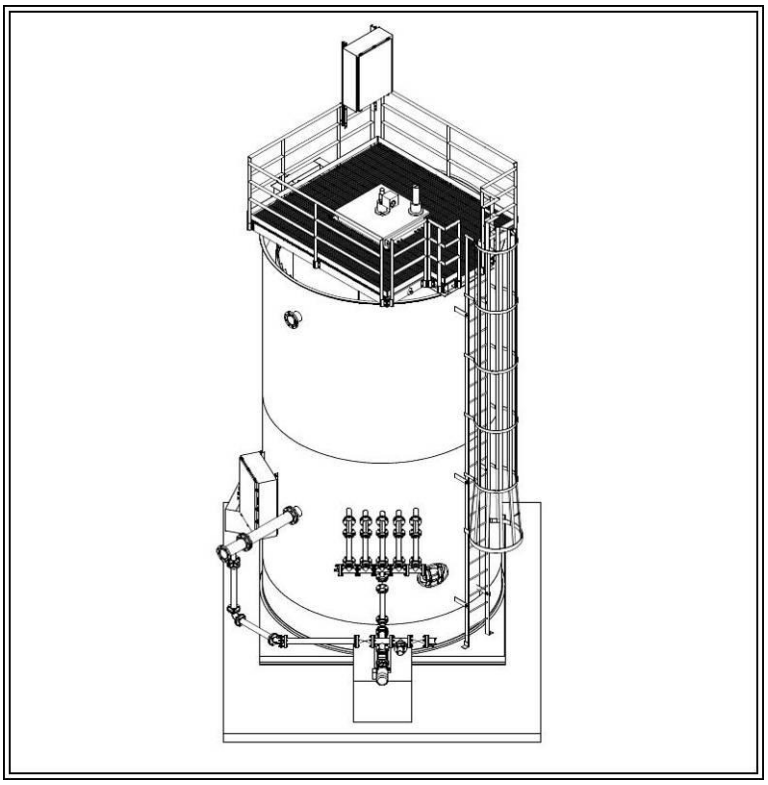


Figure 2 – CF-350 Contrafast Unit (courtesy of Siemens Water Technologies Corp.)

As shown in the flow diagram in Figure 3 on the following page, raw water combined with recycled sludge and treatment chemicals enter the center draft tube (1). There they are mixed and recirculated within the reactor (2) by the variable speed impeller. The impeller aids in accelerating solids formation and densifying the sludge. A high-velocity upflow port prevents settling in the reactor and transfers the water to the settling chamber. The water passes under a baffle and continues upward through the settling tubes (3) and into the effluent collection launder (4). The dense sludge settles to the basin floor where it is continually scraped and further thickened, until it is removed from the unit (5).

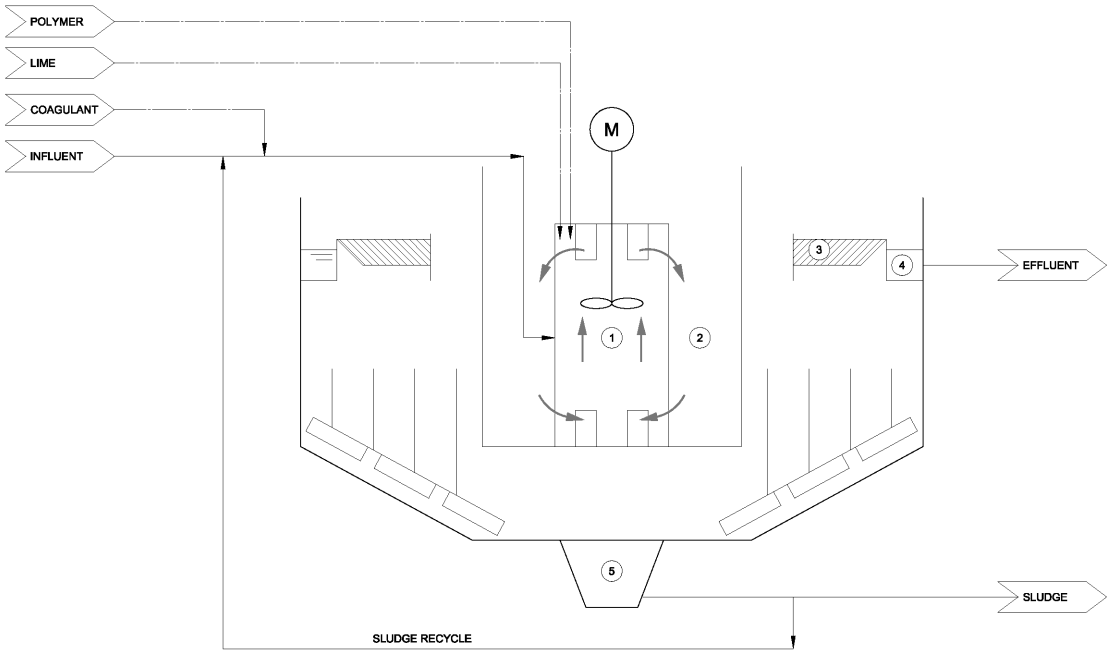


Figure 3 – Contrafast Process Diagram

5.2.2.2 Ballasted Flocculation

In this process, microsand is added after chemical coagulation but before flocculation to act as a basis for floc formation. The microsand improves both the settling velocity and the speed at which floc formation takes place. These systems require a substantially smaller footprint than conventional solid contact clarifiers and can react quickly to varying flow rates and water quality. With the small space requirement and operational flexibility, this technology could be well suited to the conditions at Mount Nansen.

A trailer mounted Actiflo ballasted flocculation system, shown in Figure 4, is currently being considered to treat the water at Mount Nansen. The trailer is divided into two sections: one for the Actiflo unit and the chemical dosing systems and one for the laboratory area. Actiflo systems are currently being used at a number of mine sites in both Canada and the United States to treat mining wastewater.

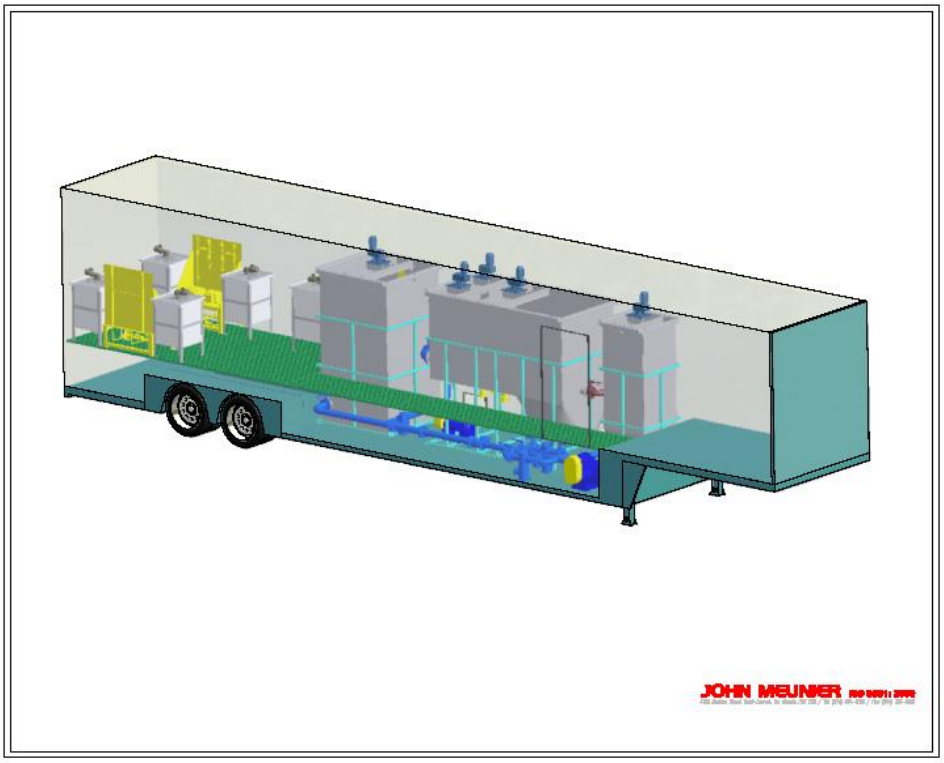


Figure 4 – Mobile Actiflo Metals Removal Unit (courtesy of Veolia Water)

The mobile unit includes a reaction tank for enhanced metals precipitation, and an Actidyn sludge thickener. This design has the flexibility to allow for mobility of the plant while providing the same treatment capability of a permanent Actiflo plant. The design treatment rate for this system is 1025 m^3/d at 80 m/h. The unit can treat up to 115 m/h; however, this must be validated for the individual application. The benefits to employing this system at Mount Nansen include flexible treatment, a small footprint, minimal site preparation, and a quick set-up and start-up time.

As shown in the Actiflo process diagram in Figure 5, lime softening is initially performed in the reaction tank (1). From there, the water enters a coagulation chamber (2) equipped with a mixer, where coagulant may be added. From the coagulation chamber, the coagulated water overflows to the injection chamber where the microsand and polymer are injected to form the ballasted floc. The overflow from the flocculation chamber then flows upward through the lamella gravity settlers (4). Scrapers force the sludge collected at the bottom of the clarifier chamber into the center cone, from which it is continuously withdrawn and directed to the Actidyn thickener (5) where sludge is conditioned and thickened. From the thickener, the sludge is pumped to the hydrocyclone where sludge and microsand are separated by centrifugal forces. The microsand is then recycled to the injection tank and the sludge is returned to the Actidyn thickener. Part of the sludge is also recycled back into the reaction chamber to enhance the crystallization kinetics and maximize the density of the settled sludge. The thickened sludge is then discharged outside of the system for handling.

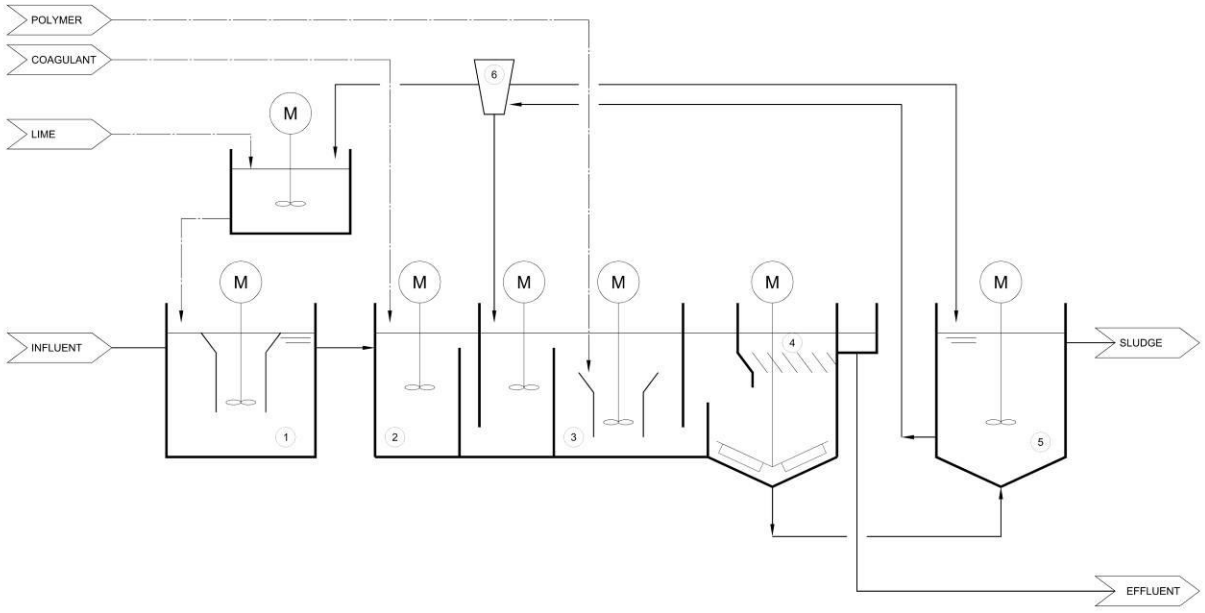


Figure 5 – Actiflo Process Diagram

The Actidyn sludge thickener included in the mobile plant typically achieves solids concentrations of 4-6% solids. This solids content is too low for transportation and disposal in a landfill. However, it would be suitable for pumping to another location, such as back to the TMA or to the pit for disposal with the tailings. Sludge management options are discussed in detail in section 5.3.

5.2.3 Membrane Filtration

In comparison with conventional treatment, membrane technology has been shown to provide superior discharge quality of mine effluent while offering lower capital and operating costs. Membrane technology cannot, however, completely replace conventional treatment as it is not a standalone technology. Pre-treatment would still be required, however the footprint, capital costs and chemical consumption can be substantially reduced.

Membranes are categorized by pore size ranging from microfiltration (MF) to ultrafiltration (UF), nanofiltration (NF), and reverse osmosis (RO). Typically, membrane filter units have a higher capital cost than other treatment options, but they require little supervision and minimal operator training. Membrane systems can also treat varying water quality, however membrane fouling has been found to be a significant issue with heavy metals removal. With appropriate pre-treatment, this risk can be mitigated to a degree.

Discussions with a supplier familiar with membrane treatment for mining applications indicated that a mobile UF/RO or MF/RO system with oxidation and coagulation for pre-treatment of Mn and As could be used at Mount Nansen. However, the reject stream would be equal to about 25% of the total flow. Because of this poor estimated process efficiency, this option will not be discussed further.

5.3 Sludge Management Options

With the exception of the Contrafast system that can produce sludge with more than 20% solids, the treatment options presented above are capable of producing sludge with about 2-10% solids depending on the influent water quality. A sludge disposal scenario will need to be developed to manage the sludge. This may be accomplished through disposal with the tailings in the pit or through transportation to a landfill. For transportation and disposal in a landfill, further dewatering of the sludge will be required. If it is decided that sludge may be disposed of with the tailings, additional thickening may not be required, and maintaining a lower percent solids would facilitate pumping the sludge to the final location. Because the final closure scenario, including the sludge management, has yet to be developed, the sludge dewater information discussed in section 5.3.1 below is being provided for information only, and will not be included in the final costs and recommendations for the water treatment facility at this time.

5.3.1 Sludge Dewatering Options

5.3.1.1 Centrifuge

In a typical centrifuge, sludge is fed into a rotating drum that separates it into a sludge cake and a dilute called ‘ centrate’ . The centrate contains fine low-density solids and is typically returned to the wastewater system. These systems can produce dense sludge cakes (10-30% solids) which makes this technology suitable for applications where sludge must be trucked away or landfilled. Additional advantages include fast startup and shutdown capabilities and a relatively small footprint. The disadvantages of this type of system are that skilled operators and maintenance personnel are typically required. The high suspended solids content in the centrate also mean that the centrate must be returned to the wastewater system for retreatment, marginally reducing the overall treatment system efficiency.

5.3.1.2 Belt-filter Press

Belt filter presses are continuous-feed dewatering devices that may apply chemical conditioning, gravity drainage and mechanically applied pressure to dewater sludge. In most systems, the first step is to drain free water from the sludge by gravity, sometimes with a slight vacuum to assist drainage and reduce odours. Next, a low-pressure section squeezes the sludge between two opposing porous cloth belts. In some systems, the low-pressure section is followed by a high-pressure section that squeezes the sludge between a series of rollers. These rollers produce shearing forces that release additional quantities of water from the sludge. Finally, the sludge cake is removed from belts by scraper blades.

These systems can achieve 15-30% solids in the sludge cake. Typically, they have low energy requirements and low mechanical complexity, therefore they tend to be relatively easy to maintain. Unfortunately, they tend to be very sensitive to incoming sludge feed characteristics. Wide variations in sludge characteristics can reduce dewatering efficiencies.

5.3.1.3 Recessed-plate Filter Press

In a plate filter press, dewatering is achieved by forcing the water from the sludge between recessed plates under high pressure. A typical recessed-plate filter consists of a series of vertical rectangular recessed plates on a frame with a fixed and movable head. A filter cloth is hung or fitted over each plate, and the plates are pressed together with sufficient force to seal them and withstand the pressure applied during the filtration process. Sludge is then pumped into the space between the plates and pressure is applied and maintained for 1-3 hours, forcing the water through the filter cloth and plate outlet ports. The filtrate is typically returned to the influent of the treatment plant. The plates are then separated and sludge is removed. Of the dewatering options being investigated for Mount Nansen, recessed-plate filter presses may achieve the highest cake solids concentration (20-50%) with low suspended solids in the filtrate. The primary disadvantage of this system is that a lot of operator attention is required, especially during feed, discharge and wash intervals.

5.3.1.4 Drying Beds & Freeze Thaw Ponds

In a typical sludge drying bed, sludge is dewatered through two main mechanisms: evaporation, and drainage through sand and an under-drainage system. Subjecting the sludge to freeze-thaw cycles can further reduce sludge volumes, though this would require a time commitment of at least one annual cycle.

These system typically have a low capital cost, low energy consumption and can provide a high solids content of dried product. The disadvantages are that a large space is required, and solids removal can be expensive and labour intensive.

5.3.1.5 Geotextile Tubes (Sludge Tubes)

Geotextile tubes, commonly known as sludge tubes, are used extensively for sludge dewatering on water treatment projects. This technology is often the most inexpensive and economical route to consider for treating a specific sludge stream. The benefits of using sludge tubes include:

- Minimal equipment required
- Simple to operate with no complicated procedures or parts
- Typically, the most economical approach to sludge dewatering

The sludge tubes should be left in left in place to dewater over a period of time to achieve the best volume reduction. It may also be necessary to use a polymer to achieve optimal sludge thickening. The correct use of polymer can reduce total thickening time and provide savings on a sludge tube system, but must be carefully monitored during the tube filling operation. Once the sludge is sufficiently thickened, the tube material can be trucked off-site for disposal or used as fill.

6. Estimated Costs (Class C Estimate)

The estimated capital, operation and maintenance costs for the two options being considered are compared below in Table 3.

Table 3 – Estimated Cost Comparison

COST ITEM	CONTRAFAST High Rate Clarifier/Thickener	ACTIFLO/ACTIDYN MOBILE UNIT Ballasted Flocculation Clarifier & Thickener
Capital Costs		
Packaged Treatment Plant	$560,300	$860,000
Chemical Feed Equipment	$15,000	Included
Foundations and Equipment Pads	$100,000	Not Required
Mechanical/Electrical Installation	$130,000	$75,000
Subtotal	$805,000	$935,000
Contingency (40%)	$322,000	$374,000
Engineering (15%)	$169,050	$196,350
Total Capital Costs	$1,296,050	$1,505,350
Operation and Maintenance Costs		
Labour @ $50/hr including benefits	$18,200	$18,200
Consumables	$14,500	$14,500
Total Annual Costs	$32,700	$32,700
Life Cycle Costing		
Capital	$1,296,050	$1,505,350
Operation and Maintenance	$87,907	$87,907
Total	$1,383,957	$1,593,257

To develop these costs, the following assumptions were made:

- Annual costs are averaged out over three years treatment, six months per year
- Discount rate of 4.4% applied
- Operator required about two hours a day, seven days a week during treatment season
- Existing raw water pumps can be reused to supply treatment plant

These costs do not include pre-treatment, additional sludge thickening, start-up or commissioning costs.

7. Recommendations and Conclusions

7.1 Treatment Process Recommendation

Though the Contrafast clarifier has a lower cost and is capable of producing a denser sludge without secondary thickening, the flexibility, mobility, and minimal construction required for the Actiflo system makes Actiflo better suited to meet the treatment needs at Mount Nansen.

High rate clarification systems like Contrafast perform best with relatively consistent influent water quality, whereas the Actiflo system is able of adapting quickly to varying water qualities. Because it is expected that the water quality of the pit, tailings pond, porewater and seepage pond waters will all have different water quality characteristics, the Actiflo system would be the more suitable technology. In addition, because the Actiflo unit being considered is mobile, it can be parked directly adjacent to the body of water being treated. A fixed plant would require extensive piping across the mine site to be able to treat water from all three locations; the pit, the TMA and the seepage pond.

The Contrafast system would also require the construction of a concrete pad and supports prior to placement, and installation would be relatively complicated, requiring a crane rental and qualified construction contractor to be brought to site to complete the work. The Actiflo trailer simply needs to be parked on a flat surface capable of supporting 27,215 kg (60,000 lbs).

Another benefit of the Actiflo system is that, because it is mobile, once the final closure project is complete, the system can easily be relocated to another site and reused with minimal decommissioning at Mount Nansen, and minimum set up at the next site. Or, if deemed necessary, the system can remain in place to continue treatment.

The main disadvantage of the Actiflo system is that, even with the Actidyn thickener in operation, sludge density would most likely not exceed 4-6% solids. The Actiflo system would be expected to produce roughly 27 m^3 of sludge per day before thickening (1-2% solids). Depending on the final closure scenario selected, dewatering of the tailings in the TMA will most likely be occurring at the same time as the water treatment operations, therefore, simply returning the sludge to the TMA to be dewatered and placed with the tailings may be an acceptable and inexpensive sludge management solution. An alternate solution would be to dewater the tailings using geotextile tubes as discussed previously in section 5.3.1.5. Geotextile tubes are a very simple and economical way to dewater sludge. The thickened sludge could then be trucked off-site for disposal or used as fill.

The Actiflo system will require an adequate supply of Ferric chloride (34%), Lime, Hydrex polymer and microsand to operate. These items are not included with the mobile unit, and will need to be brought in to site before treatment operations can begin.

7.2 Recommendations for Ongoing Testing

Ongoing water sampling of the pond and seepage water is recommended, as well as additional sampling of the porewater at different locations and depths to gain a clearer picture of the conditions that will be faced when treatment begins. One particular item of interest is the frequency of which pockets of cyanide might be encountered within the tailings. This could have an effect on whether or not pre-treatment for cyanide will be required.

The speciation of arsenic should also be determined. Currently, it is not known if As(III) or As(V) is predominant in the tailings pond, seepage pond or porewater. As discussed previously in section 4.2.4, if it is determined that As(III) is predominant, a pre-oxidation step should be considered for the treatment system to ensure efficient arsenic removal. Because this has not been confirmed, the pre-oxidation step is not being considered in the treatment recommendations or costs at this time.

7.3 Estimated Construction Schedule

The current estimated construction schedule is summarized below in Table 4. This schedule assumes a February 2009 project initiation, at which time detailed design will commence.

Table 4 – Estimated Construction Schedule

Task	Date
Project Initiation – Detailed Design Begins	March 2009
Tender	May 2009
Construction and Commissioning	December 2009

Appendix A
Water Quality Results

Section 1 – Brown-McDade Pit Lake

Section 2 – Tailings Pond and Seepage Pond

APPENDIX 2

Contingency Passive Biological Treatment System Options 1 and 2

Lorax Environmental Services Ltd., April 2011

APPENDIX 2 - Contingency Passive Biological Treatment System – Options 1 and 2[1]

The Closure Options 1A/1B and Options 2A/2B includes a contingency plan for mitigating the potential for poor quality groundwater, originating in the upstream tailings material, and discharging into Dome Creek. Geochemical characterization work on the Mt. Nansen tailings porewaters and groundwater in the vicinity of the existing tailings impoundment has indicated that arsenic (As) is the primary parameter of environmental concern with respect to closure planning. Dam seepage and groundwater data has shown that As concentrations are currently being strongly attenuated along the groundwater flow path from the tailings impoundment to the seepage collection pond down-gradient of the dam. Frequent monitoring over a period of approximately 10 years has regularly demonstrated that As attenuation processes have been stable and effective. Further, As concentrations in seepage have remained adequately low- to meet applicable guidelines. Evaluation and assessment of attenuation mechanisms has concluded that the most likely geochemical processes controlling As concentrations in groundwater downstream of the tailings impoundment are:

- precipitation of arsenic-sulfides; and/or
- adsorption onto precipitating sulphides and/or iron oxides.

The formation of secondary sulphides or soluble iron in neutral waters requires reducing conditions. These conditions are dependent upon a steady supply of readily available organic carbon for microbial growth and the generation of electrons. Sufficient sulphate is also required to provide a continuous supply of reactive sulphide from sulphate reduction. Mt. Nansen appears to have an adequate supply of organic carbon, both in natural runoff and from the decomposition of naturally occurring organic-rich layers in the valley substrates. Sulphate is similarly available from gypsum solubility from within the tailings mass. Given the above, the conceptual contingency plan for closure Options 1A/1B and 2A/2B is to provide significant quantities of organic-rich substrate, immediately down-gradient of the proposed tailings dam toe berm, and to route tailings dam seepage water through this material. The contingency system will operate as a passive biological treatment system, fostering conditions favourable to sulphate reduction and the precipitation of metal sulphides including arsenic sulphides and coprecipitation of As with iron sulphides in situ.

Closure costing of the contingency program is based on the excavation of approximately 9,000 m^3 of sediments immediately below the toe berm and subsequent replacement with organic-rich, naturally occurring substrates. A high permeability rock drain will be constructed to direct toe seepage water to the base of the excavation to ensure that seepage waters are forced into contact with and through the mass of overlying organics (Figure 1). Low permeability baffles will be constructed perpendicular to the valley axis to increase the retention time of seepage water flowing through the organics. Seepage water would then be allowed to discharge into Dome Creek at the point of confluence with the upstream diversion channel (Figure 2).

[1] As provided to Altura by Lorax Environmental Services, April 2011

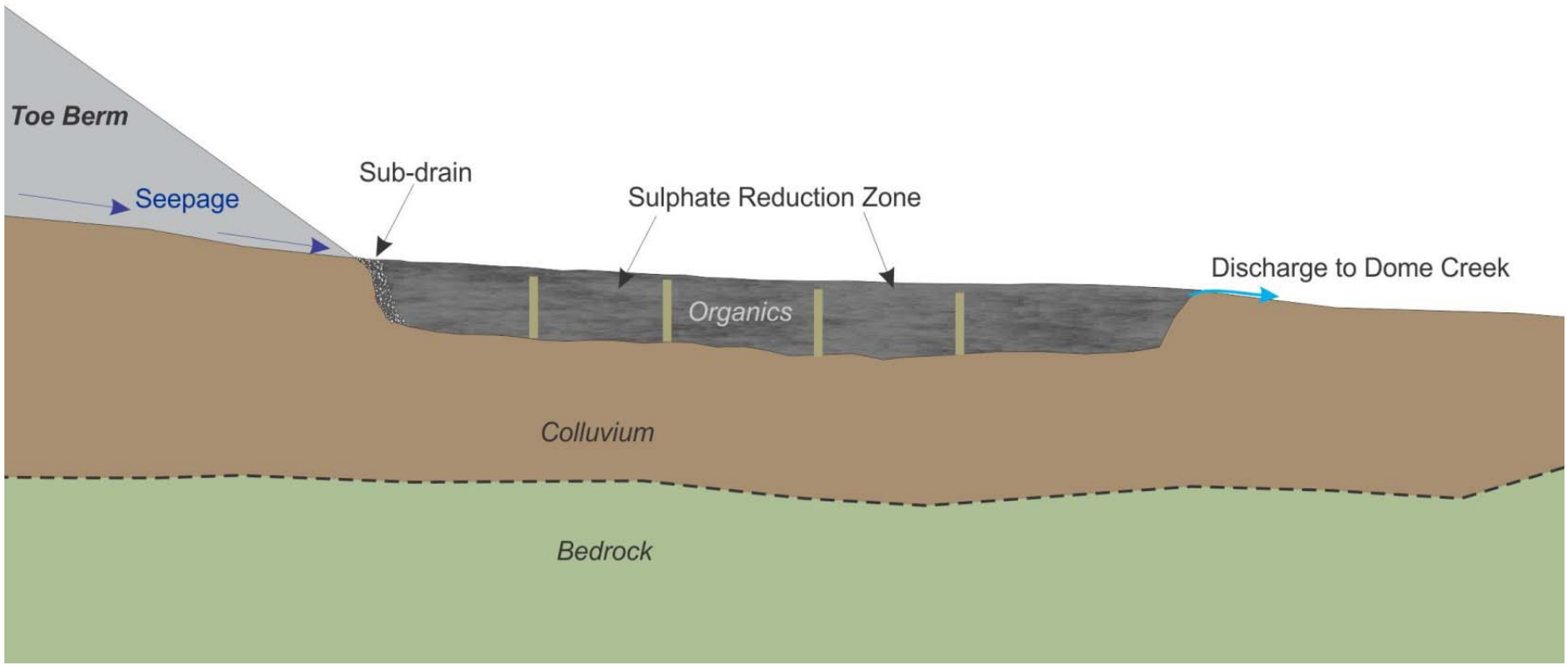
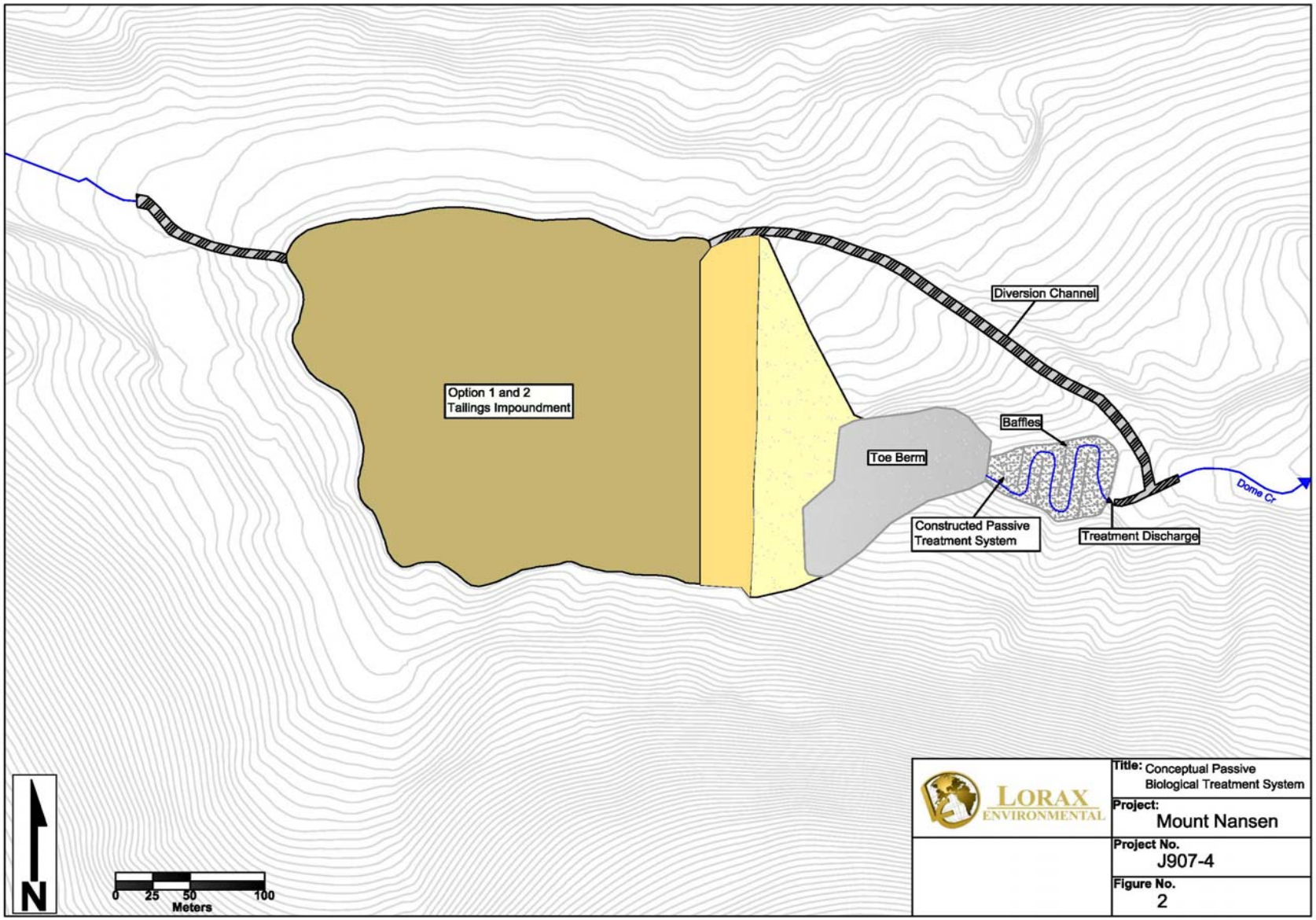


Figure 1: Schematic of Conceptual Passive Biological Treatment System for Mt. Nansen Closure Options 1 and 2


Option 1 and 2
Tailings Impoundment
Diversion Channel
Toe Berm
Baffles
Constructed Passive
Treatment System
Treatment Discharge
Dome Cr.
N
0 25 50 100
Meters
LORAX
ENVIRONMENTAL
Title: Conceptual Passive
Biological Treatment System
Project:
Mount Nansen
Project No.
J907-4
Figure No.
2

Estimates of the cost for constructing and implementing the contingency strategy of a passive biological treatment system are summarized in Table 1 below. The total estimated cost is approximately $312,500.

Table 1:
Summary of Estimated Costs for Passive Biological Treatment System Contingency for Closure Options 1 and 2

Option 1A/1B 2A/2B

Work Item Description	Units	Quantity	Unit Cost	Total Cost
Passive Biological Treatment Contingency				
Excavation of existing materials	m^3	9,175	$ 10	$ 91,750
Source, haul and place organics	m^3	9,175	$ 15	$ 137,625
Construct flow baffles	L.S.	3	$ 5,000	$ 15,000
Construct discharge to Dome Creek	L.S.	1	$ 10,000	$ 10,000
Engineering, Construction Management	15% of capital cost			$ 38,156
Maintenance	annual	10	$ 2,000	$ 20,000
Sub Total				**$ 312,531**

APPENDIX 3

Contingency for Semi-Passive Biological Treatment of Brown-McDade Pit Lake

Lorax Environmental Services Ltd., April 2011

APPENDIX 3 - Contingency for Semi-Passive Biological Treatment of Brown-McDade Pit Lake[1]

The Brown-McDade pit is flooded and contains neutral mine drainage water that is elevated in zinc and cadmium. Short-term and long-term management of the pit lake may be required for the following:

- Short-term treatment of pit lake water column so that the pit lake can be dewatered prior to backfilling with waste rock (Options 1B and 2B) and/or tailings (Options 3 and 4); and

- Long-term, insitu treatment of pit lake water (Options 1A and 2A) for the protection of aquatic resources and/or wildlife. It is assumed that water treatment in the long-term will not require dewatering or managed discharge of pit lake volumes.

A semi-passive fertilization program is proposed as one potential contingency for treating pit lake water quality. Pit lake fertilization has been applied at numerous mine pit lakes (e.g., Faro) as a cost effective means of managing neutral mine drainage of poor quality. Alternative mitigations also include treatment with a conventional treatment facility (short-term or long-term) or partial backfill of the pit with waste rock (long-term).

Fertilization Program: Fertilization of the pit lake will be conducted twice per year to optimize biotic uptake of nutrients and capitalize on the short growing season. It has been assumed that fertilization and monitoring will be conducted by a local, Yukon-based contractor. This approach will decrease field costs considerably; fertilization does not necessarily require the field expertise afforded by an outside firm. It is important to note that the frequency of fertilization can be adjusted based on field observations and evolving lake chemistry.

Whole lake manipulations will be delivered using liquid fertilizer and amendments, as performed elsewhere (e.g., Faro). The liquid nutrient mix is typically fed by hose from a reservoir on a boat into the prop wash. Due to the relatively small size of the Brown-McDade pit lake, fertilizer may be affectively applied from onshore. Dose volumes will be adjusted for the thickness of the mixed layer, as required.

Monitoring Program: Pit lake water quality and sediment sampling should be conducted three times per year to confirm the effectiveness of the program. Metal removal

[1] As provided to Altura by Lorax Environmental Services, April 2011

associated with adsorption to algae and subsequent particle settling will occur on the order of several weeks. Lake sampling will occur from a boat at three depths, per the current monitoring program. Profiling of the water column will occur using a CTD and dissolved oxygen meter. Sediment traps in the lake will also be sampled.

A technical memorandum will be generated which will concisely summarize the results of each field program. This memorandum and regular reports generated from the other fertilization events, as necessary, will be integrated to recommend robust management strategies for the pit lake should long-term treatment be required.

Treatment Reporting: A technical memorandum will be generated which will concisely summarize the results of each field program. This memorandum and an annual report will describe fertilization events and their effectiveness.

Cost Estimate: Estimates of the cost for implementing a semi-passive pit lake treatment program through fertilization are summarized in Table 1 below. The total estimated cost is approximately $65,000.

Table 1:
Summary of Estimated Annual Costs for Semi-Passive, Biological Treatment of Brown-McDade Pit Lake

Field Work				
Senior Specialist	day	3	$ 1,480	$ 4,440
Senior Tech	day	10	$ 750	$ 7,500
Assistant	day	10	$ 500	$ 5,000
			Subtotal	*$ 16,940*
Analytical				
Metals	each	12	$ 250	$ 3,000
Nutrients	each	12	$ 100	$ 1,200
Sediments	each	12	$ 250	$ 3,000
			Subtotal	*$ 7,200*
Disbursements				
Amendments	each	1	$ 10,000	$ 10,000
Field Equipment	each	1	$ 10,000	$ 10,000
Shipping	each	1	$ 750	$ 750
Per Diem	each	20	$ 250	$ 5,000
			Subtotal	*$ 25,750*
Reporting				
Senior Scientist	day	2	$ 1,480	$ 2,960
Junior Scientist	day	10	$ 1,200	$ 12,000
			Subtotal	*$ 14,960*
			Total	**$ 64,850**

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Memorandum

To	Eric Blais, Manager AECOM Water Resources	Page	1
CC	Jim Friesen, P.Eng		
Subject	Mt. Nansen Closure – Wave Induced Sediment Transport Analysis		
From	Tyson Ehnes E.I.T.		
Date	July 30, 2010	Project Number	60159089

This memorandum discusses the analysis for the potential movement of the proposed sand cover due to wave action on the surface of the tailings pond. A potential closure solution for the Mt. Nansen tailings pond is to install a 0.3 m cover layer of Aeolian sand over the current tailings deposit which would in turn be covered by a 0.7 m deep layer of water. A particle size analysis of the sand revealed that the median diameter (D50) is approximately 0.13 mm.

In order to maintain anoxic conditions in the tailings deposit and mitigate oxidation the sand layer must not be susceptible to erosion from wave action in the water cover. The onset of erosion due to wind induced waves and currents is predicted by comparing the shear stress imposed by the waves to the critical shear stress of the sand. A maximum velocity criterion of 20 cm/s as suggested by Hjulstrom's Diagram (1956) was also used as the critical velocity for the movement of the sand.

A design wind and fetch length were required to determine the properties of the design wave. Due to a lack of wind data at Mt. Nansen, wind data was obtained from Environment Canada for Whitehorse, YK. A design wind of 14 m/s (50.4 km/h) was selected based on the maximum hourly wind during non frozen conditions and a low exceedance over the period of record (1971 – 2000). The fetch distance was taken as the maximum distance in any direction across the tailings deposit once the sand and water cover were applied. This distance was measured in GIS maps to be 400 m.

According the US Amry Coastal Engineering Research Center (1984) the amplitude and period of fetch limited waves can be calculated for deep water waves (d/L > 0.5) by:

$$H = 0.0016\sqrt{\frac{FU_a^2}{g}}$$

$$T = 0.2714^3\sqrt{\frac{FU_a}{g^2}}$$

and for shallow water waves (d/L < 0.5) by:

$$H = 0.283\frac{U_a^2}{g}\tanh\left[0.53\left(\frac{gd}{U_a^2}\right)^{\frac{3}{4}}\right]\tanh\left\{\frac{0.00565\left(\frac{gF}{U_a^2}\right)^{\frac{1}{2}}}{\tanh\left[0.53\left(\frac{gd}{U_a^2}\right)^{\frac{3}{4}}\right]}\right\}$$

$$T = 7.54\frac{U_a}{g}\tanh\left[0.833\left(\frac{gd}{U_a^2}\right)^{\frac{3}{8}}\right]\tanh\left\{\frac{0.0379\left(\frac{gF}{U_a^2}\right)^{\frac{1}{2}}}{\tanh\left[0.833\left(\frac{gd}{U_a^2}\right)^{\frac{3}{8}}\right]}\right\}$$

In the above equations Ts = significant wave period (equal to the average period of the highest one-third of the waves), Hs = significant wave height (equal to the average height of the highest one-third of the waves), U_a = wind speed, d is the depth of water cover in the pond, and F = fetch distance. The wavelength L used to determine whether the waves are shallow or deep was calculated using the following equation (Eckart 1952):

$$L = \frac{gT^2}{2\pi}\sqrt{\tanh\left(\frac{4\pi^2 d}{T^2 g}\right)}$$

The wave orbital velocity above the sand bed is then calculated based on small amplitude wave theory (Eagleson and Dean 1996) by:

$$U_b = \frac{\pi H}{T\sinh\left(\frac{2\pi d}{L}\right)}$$

The shear stress in the sand bed due to the waves by then be estimated by the following equation (Sleath 1984; Dyer 1986; Jonsson 1966; Leuttich 1990; and Soulsby 1997):

$$\tau_w = \frac{1}{2}\rho f_w U_b^2$$

where f_w = wave friction factor and ρ = density of water (1000 kg/m^3). The wave friction factor is dependent on whether the flow above the sand bed is laminar or smooth turbulent, which in turn is dependent on the wave Reynolds number given by:

$$R_w = \frac{U_b^2 T}{2\pi v}$$

where v is the kinematic viscosity of water (1.3 x 10^{-6} m^2/s at 10°C). The wave friction factor is then calculated by the equation:

$$f_w = BR_w^{-N}$$

where B = 2 and N = 0.5 if the flow is laminar (R_w <= 5 x 10^5) and B = 0.0521 and N = 0.187 if the flow is smooth turbulent (R_w > 5 x 10^5) (Whitehouse et al. 1999).

Shear stress is induced not only by wave action but by wind generated currents as well. The wind induced shear stress at the surface of the water may be calculated by the quadratic drag law (Webster 1990) as:

$$\tau_o = C_D \rho_a U_a^2$$

where ρ_a = the density of air (1.24 kg/m^3 at 10°C) and C_D = drag coefficient and is calculated using Garratt's formula (Garratt 1977):

$$0.75 + 0.067 U_a$$

The works of Reid (1957) and Baines and Knapp (1965) show that the bed shear stress due to currents is about 10% of the surface shear stress τ_o. Thus the bed shear stress due to currents may be calculated as:

$$\tau_r = 0.1 C_D \rho_a U_a^2$$

Therefore the total shear stress experienced by the sand bed due to wind induced waves and currents is the sum of the two shear components τ_w and τ_r.

The critical shear stress of sand particles in a flat pond can be determined using the Shields Diagram shown in **Figure 1**.

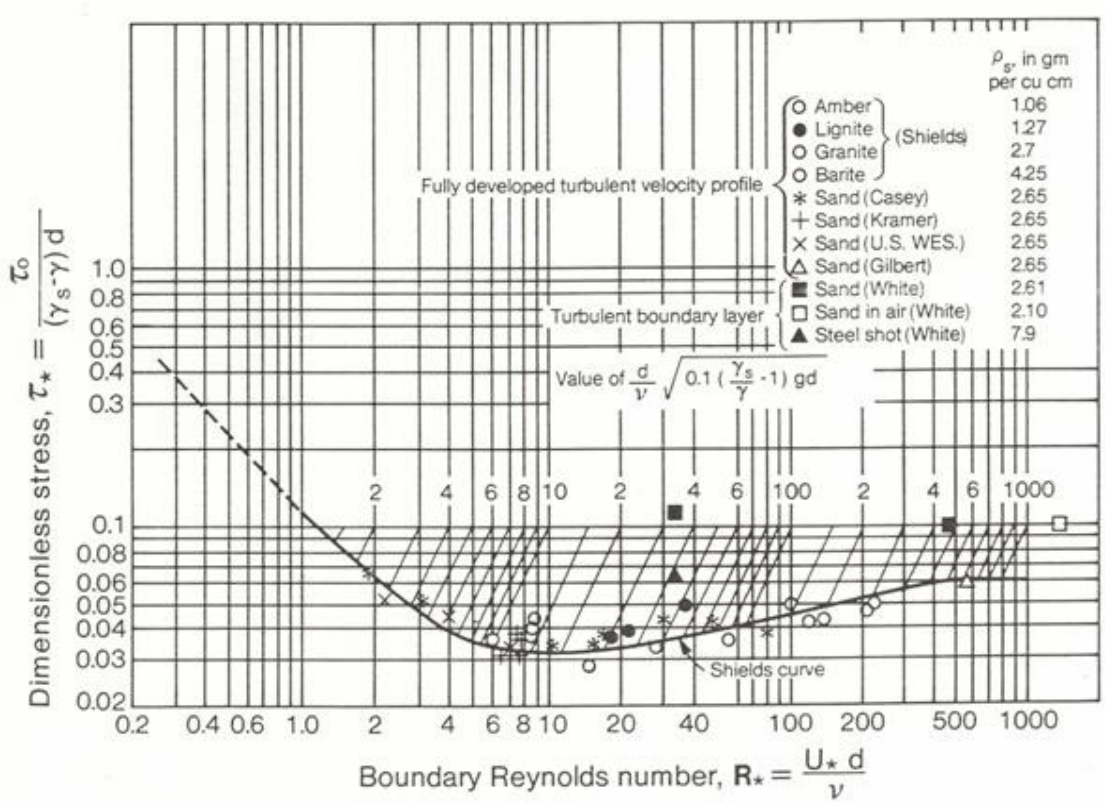

Figure 1: Shields Diagram for critical dimensionless shear stress (1936)

Using the previously presented theory a critical shear stress of 0.073 Pa was calculated for the Aeolian sand. The wave orbital velocity and total shear stress at the sand bed were calculated to be 5.7 cm/s and 0.2 Pa respectively. Based on this analysis the Aeolian sand meets the velocity criterion for particle movement but not the shear stress criterion for erosion.

If a sand with a D_{50} of 0.4 mm were used instead of the 0.13 mm Aeolian sand the critical shear stress would be increased to 0.21 Pa. Therefore a sand with a median diameter of 0.4 mm would meet both the velocity and shear stress requirements. **Table 1** compares the velocity and shear stress produced by the design wave with the critical velocity and critical shear of various sized sand particles.

Table 1: Critical velocity and critical shear of sand particles based on median diameter

	Wave Induced	Sand Median Diameter (mm)				
		0.13	0.25	0.4	0.7	1
U_b (cm/s)	5.7	20	20	20	20	20
T_c (Pa)	0.2	0.073	0.13	0.21	0.41	0.61

The use of Aeolian sand is not ideal due to its relatively low critical shear stress. Sediment movement by itself does not necessarily negate the benefits of the diffusion layer. Initial movement would result in ripples forming at the top of the sand layer which will change the flow characteristics and shear stress at the surface of diffusion layer and act to limit further movement of sediment. Observing the sediment movement and performing any minor maintenance would maintain the performance of the diffusion layer.

A more proactive approach is to recognize the limitation in the performance of the Aeolian sand and consider it in the final design of the tailings area. The analysis presented assumes a uniform bottom the full dimensions of the tailings pond. The effective fetch length can be reduced in the final design by incorporating conveyance channels, submerged berms and vegetation in the tailings pond. This will serve to produce a more natural appearance and reduce the probability of critical amounts of movement. A reduction in the effective reach length from 400m to 180m would reduce the shear stress below the critical shear for Aelolian sand and reduce or eliminate any concern about sediment movement..

Environment

Government of Yukon

Summary of Estimated Closure Costs Mt. Nansen Mine Site

final draft

Prepared by:

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Project Number:

60159089 (402)

Date:

May 2011

Statement of Qualifications and Limitations

The attached Report (the "Report") has been prepared by AECOM Canada Ltd. ("Consultant") for the benefit of the client ("Client") in accordance with the agreement between Consultant and Client, including the scope of work detailed therein (the "Agreement").

The information, data, recommendations and conclusions contained in the Report (collectively, the "Information"):

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- represents Consultant's professional judgement in light of the Limitations and industry standards for the preparation of similar reports
- may be based on information provided to Consultant which has not been independently verified
- has not been updated since the date of issuance of the Report and its accuracy is limited to the time period and circumstances in which it was collected, processed, made or issued
- must be read as a whole and sections thereof should not be read out of such context
- was prepared for the specific purposes described in the Report and the Agreement
- in the case of subsurface, environmental or geotechnical conditions, may be based on limited testing and on the assumption that such conditions are uniform and not variable either geographically or over time

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May 13, 2011

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Dear Ms. Randell:

Project No: 60159089 (402)
Regarding: Summary of Estimated Closure Costs
Mt. Nansen Mine Site

Further to our letter proposal dated April 8, 2011, AECOM Canada Ltd. (AECOM) is pleased to provide you with a summary of estimated costs per closure option proposed at the Mt. Nansen Mine Site. The summary is inclusive of all costs previously provided in reports authored by AECOM, Lorax Environmental and Altura Environmental Consulting. Additional costs have been provided for various contingencies and long term operations, care and maintenance following the conclusion of construction activities at the site.

We trust that this meets your current needs and expectation. If you require further clarification or information on any matter, please contact the undersigned at (204) 928-7408.

Sincerely,
AECOM Canada Ltd.

Tom Wingrove, P.Eng.
Deputy Operations Director
North America Environment

AH:dh
Encl.
cc:

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Revision Log

Revision #	Revised By	Date	Issue / Revision Description
1	K.Thiessen	May 13, 2011	Final Draft

AECOM Signatures

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1. Introduction

1.1 Purpose

This report provides a detailed summary of the various costing information that has been provided to, and requested by, the Yukon Government thus far in support of the evaluation of closure options for the Mt. Nansen Mine site, an abandoned gold and silver mine located approximately 60 km west of Carmacks, Yukon. As such, all cost estimates completed to date, including those for additional investigation (Pre-Closure Estimates), construction phase of the each proposed closure option, and long term operation, care and maintenance of the site following closure have been tabulated based on estimated unit prices or allowances (i.e. lump sums) per activity. The costs have largely been synthesized from summary Tables 5.4-10, 5.4-11, 5.5-5, 5.5-6, 5.6-5, and 5.7-4 provided in "*Mount Nansen Options for Closure"*, Lorax Environmental Services Ltd. (Lorax), November 2010. Appendices C-1 and C-2, authored by AECOM Canada Ltd. (AECOM) and Altura Environmental Consulting (Altura), respectively, provided the source costs for the aforementioned summary tables.

The primary objective of this document is to provide all information necessary to allow for a meaningful side-by-side comparison of the estimated costs associated with each closure option. As such, all costing information, estimated by Lorax, Altura, and AECOM has been brought forth herein. In addition, costs associated with ongoing operation, care and maintenance at the site have been provided as present values and added to the pre-closure and active closure estimates such that a total estimated capital expenditure is provided for each option. All assumptions made in the development of the costs have been provided for clarity. Also provided in this document is a preliminary schedule of expenditures for the construction phase of the project.

The costs presented in this document have been referenced according to stakeholder comments provided in the most current update of the tracking table, which has been provided in this document as Table 1-1. The table has been edited to include responses to only those items pertaining to cost. Where applicable, references have been made to sections of this report in which the responses can be found.

1.2 Basis for Costing

All documentation provided to the Yukon Government has indicated that the level of detail, performance and costing has been conducted to the pre-feasibility level, and thus, the closure costs provided herein have been defined as Class 'D' estimates (or ASTM E2516-06 Class 5). The Treasury Board Secretariat of Public Works and Government Services Canada (PWGSC) provides the following commentary on Class 'D' cost estimates, also known as 'indicative estimates:

"(A Class 'D' cost estimate is) *to be in unit cost analysis format (such as cost per m² or other measurement unit) based upon a comprehensive list of project requirements (i.e. scope) and assumptions; the Class D estimate is evolved throughout the phases of the Project Identification Stage, finally being incorporated into the cash flows in the Analysis Phase; for more complex projects such as laboratories, elemental cost analysis and the input of specific disciplines may be required; the Class D Indicative estimates developed during the National Project Management System (NPMS) Feasibility Phase shall be revisited with cost planners in the Analysis Phase before finalizing."*

Furthermore, an indicative estimate is defined as:

> *"an estimate that is not sufficiently accurate to warrant Treasury Board approval as a cost objective and provides a rough cost projection used for budget planning purposes in the early stages of concept development of a project. It is usually based: on an operational statement of requirement (SOR), a market assessment of products and technological availability that would meet the requirement and other considerations such as implementation, life cycle costs and operational savings."*

By definition, the cost estimates provided in this document satisfy the criteria for Class 'D' cost estimates, but it must be reinforced that they are based on the best knowledge we have to date and will be re-examined in at specific milestones, such as the 60%, 90% design stages, and prior to tendering of bids. The above definitions can be found on the PWGSC website (http://www.tpsgc-pwgsc.gc.ca/biens-property/sngp-npms/conn-know/couts-cost/definition-eng.html).

Table 1-1: Comment Tracking Table

Agency	Area	Tracking #	Comment	Response	Where Addressed	Second Round of Comments	Response
IPRP	Dam upgrade/Spillway	12	Minor Items to be Resolved #2: The spillway design concept appears to be based upon a very conservative approach. (Mt. Nansen is in a very similar meteorological setting as Faro however the design flows are proportionally 50% greater than at Faro). This is unlikely to materially affect the evaluation of closure options. However, the hydraulic assessment might be revisited in detailed design should in-place stabilization be the preferred closure strategy.	**Faro is a much bigger watershed and probably used a snowmelt event as the design event. A rainfall event is the critical event at Nansen due to a contributing area of only 3.3 km^2. Rainfall on a small watershed has the potential to produce a higher peak flow rate than a snowmelt event for the same watershed. In addition larger watersheds have a smaller difference between flow rates reported as mean daily and instantaneous peaks.** **If required, this is a relatively minor cost addition with spillway excavation and armouring, totaling ~$70,000.**	-		
INAC	Clarification	7	The report indicates that Class D estimates range from -25% to +75% for Common Closure elements but -25% to +40% for the closure options; are these considered Class D estimates with these ranges; which range is used?	**Regardless of the stated range of accuracy, both are considered Class D estimates, as they are considered conceptual in design.**			
INAC	Tailings Area Reclamation	24	Options 3 and 4 indicate tailings and contaminated soil will be moved to the pit. What thickness of contaminated soil is expected and what is the remaining soil stratigraphy, as this will affect costs? There are no closure measures for the tailings storage facility outlined in these options which could significantly change the cost of these options. (pg5-89)	**Soil under the tailings was characterized in 5 locations up to 1m depth below the tails-native soil interface. It was assumed that a soil thickness of 15 cm was relocated to the pit (Appendix B - Section 5.3).** **Quantity of soil excavation is included in this report.**	Item 3C, Table 3-9 and Table 3-11		
INAC	Cost	25	Options 1B and 2B cost for backfilling pit with waste rock is only $5, this value seems low compared to other material unit costs. The cost should be around $9-$10 which would make the estimate approximately $2M short; what assumptions were made for the $5/$m^3$?	**Discussed with local contractor. Pelly construction suggested a rate of $2-3/$m^3$. This is a short haul, and would require no special handling. Previous estimate (2009) at $10 was criticized for being too high. We believe that $5/$m^3$ is appropriate.**	Assumptions 7 and 8, Table 3-3 and Table 3-7, respectively		
INAC	Cost	26	O&M is estimated for Option 4 but has not been calculated for the other three options. O&M estimates should include specific horizons.	**Was included in AECOM's Geotechnical Report (Section 4.1.1)**	Section 4		
INAC	Cost	27	C&M cost estimates are not included in the costing for the options.	**See above.**	Section 4		
INAC	Cost	28	Timeframe of costs.	**A schedule of projected expenditures over the construction period has been provided in this report.**	Section 5		
INAC	Cost	30	Cost estimates cannot be indicative of total cost of project; additional information and costing will be required for closure plan. Example: 5.2.2.3 Where will the mill material be landfilled?	**Noted. This element will be considered once a Closure Option has been selected and detailed design can be pursued. Material will be land-filled in place. INAC should provide specific feedback on specific costs that have not been included.**			

Table 1-1: Comment Tracking Table (continued)

Agency	Area	Tracking #	Comment	Response	Where Addressed	Second Round of Comments	Response
INAC	Cost	31	Report indicates engineering, design or detailed planning is not included in closure cost; however given the complexity of the specific option, these costs could vary greatly. A fixed percentage of total costs or some method should be added to the closure cost option to provide a more meaningful value.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Table 3-1, Table 3-3, Table 3-5, Table 3-7, Table 3-9, and Table 3-11		
INAC	Cost	32	5.4.2.3 Indicates that numerous ongoing O&M costs are required; however, these are not covered in the estimate.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Section 4	Provided response is unclear and does appear to address the issue.	**O&M costs will be provided per option in the supplemental closure costing memo**
INAC	Cost	33	5.4.6 Indicates that design engineering, routine inspections and operations and maintenance are expected to be similar for all options this is believed to not be the case. Example: Waste rock in place would likely require more inspections than if the waste rock was moved to the pit.	**Although not assessed in detail, these varied costs were included in Table 12 (Section 4.1.1) in AECOM's geotechnical report. We agree that actual O & M costs will vary by option.**	Section 4		
INAC	Cost	36	All associated costs with each option need to be included in the cost estimates, such as: life cycle, C&M, capital costs, interim treatment/reclamation.	**See above for notes on O & M costs and engineering allowances.**	Section 4		
INAC	Cost	37	Detailed engineering/allowance and construction services need to be included. I.e. Based on fixed percentages of reclamation cost of each option.	**Agreed. We would suggest that all design phases plus construction supervision be estimated at 15% of capital. Actual costs may vary by option.**	Table 3-1, Table 3-3, Table 3-5, Table 3-7, Table 3-9, and Table 3-11	It is assumed that the allowance for engineering services will be backed out of the contingency allowance, i.e. the contingency will be reduced proportionally.	**The allowance for engineering has been added as a separate estimate. This estimate may be revised or removed, as deemed appropriate by the parties.**
LSCFN	Dam Stability	6	Information should be provided to demonstrate performance at Mt. Nansen and effects need to be considered in the options characterization before proceeding with the evaluation process because the changes may affect cost and risks. It may also affect the flow paths for contaminants and related effects on attenuation mechanisms that have been assumed for geochemical analyses. In my view, the approach taken here does not demonstrate the same level of conservativeness in geotechnical design as that for the tailings relocation options.	**The geotechnical considerations are different between in-pit and in-place options. The geotechnical considerations are more significant for the in-place option, but have been approached with industry standard safety factors for performance.** **Ongoing monitoring and inspection is required for compliance with CDA Guidelines (Options 1, 2 and 3).**	Section 4		

Table 1-1: Comment Tracking Table (continued)

Agency	Area	Tracking #	Comment	Response	Where Addressed	Second Round of Comments	Response
LSCFN	Long-term Thermosyphon Operation and Maintenance	13	AECOM's geotechnical assessment (Section 2.2.11) does not identify the need for long-term maintenance and operation of thermosyphons or other methods for maintaining frozen conditions at the shear key. It is not clear whether the cost estimates for Options 1 and 2 include such costs. This should be confirmed before the evaluation process begins.	**Annual operating costs for thermosyphons are considered nominal. The life-expectancy of thermosyphons is unknown, and we have not allowed for future replacement costs. If temperature increases do not exceed the performance capabilities of the thermosyphons, then future replacement should be expected.**	Section 4		
LSCFN	Water Quality Issues - Mill Area	28	The Lorax Report and attachments provides some characterization of conditions in the mill area. Currently, sources in this area are the dominant contaminant loading to Dome Creek. The "Common Element and Supplemental Cost Estimate" prepared by Altura assumes that these sources will be addressed and no treatment will be required. However, the same report provides the description of closure activities for the mill area and does not include measures that are likely to address the water quality issues. Given the current information available, there appears to be significant likelihood that greater efforts will be required to address closure issues in this area. Costs for this are probably common to all options but are likely to be higher than current estimates.	**Cost estimates for mill closure presented in the Options for Closure Report include the removal of up to 6500 m^3 of mineralized fill, and this action is expected to mitigate some of the Mill Area metal loading to Dome Creek. However it is acknowledged that due to insufficient information, no specific closure measures were included to address the high-volume seep discovered in 2010 just west of the mill. This seep with estimated flow of 75 l/min and concentration of 0.7 mg/L dissolved zinc is likely another primary contributor to Dome Creek zinc loading in this sector. Further investigation is needed to first characterize the path and origin of this flow (which is possibly associated with an historic adit opening) prior to determining what, if any closure measures may be required. For the purposes of a preliminary estimate, a cost equivalent to plugging of the Pony Creek adit ($250,000) has been assumed and added to the mill closure costs.**	Table 2-2		
LSCFN	Cost Consistency for Options	32	A consistency check should be completed for costing for the various options. Some examples that warrant consideration include: Option 3 includes costs for tailings cover maintenance and repair, while Options 1 and 2 do not. The tailings covers are also susceptible to damage with the in-valley options. Potential for damage may be greater in the valley due to continuous water flows. Also, the total cover area is larger for valley options, thus increasing potential maintenance costs.	**For Option 3, maintenance of cover is required because of short-medium term settlement and/or consolidation of tailings. Tailings in valley are already consolidated.**			

Table 1-1: Comment Tracking Table (continued)

Agency	Area	Tracking #	Comment	Response	Where Addressed	Second Round of Comments	Response
LSCFN	Cost Consistency for Options	33	Only in-pit options include costs for water treatment. The bulk of the cost is capital cost for establishing treatment facilities. All options require some re-grading and relocation of tailings. Also, all options require cleanup in the mill area where current seepage concentrations are high and in some cases exceed effluent limits. As a result, there appears to be a high likelihood that water treatment facilities (capital costs) will be required for all options, though operating costs may be slightly different.	**Considering the re-location of tailings, there is potentially a need for water treatment, and short term treatment should be considered. It has been assumed that the mill area does not currently require treatment. Reclamation activities are expected to improve water quality emanating from the mill.**	Section 4.2	Lorax indicates that water treatment costs will not be part of any options that do not include tailings relocation to the pit. As a result, the options characterization assumes that all other options can be undertaken without any adverse effects on water quality for any water that may require discharge. I believe that this would be challenging and would anticipate that water treatment would be required for other options too.	Provisional treatment and associated costs will be provided for all options in a separate memo to be issued by Altura.
GY	Dam Stability	13	We need to have a cost for alternative approaches that will be used for ground freezing for this as it is a residual risk.	**No alternative feasible methods of ground freezing have been identified.**			
GY	Option 1	14	Is there a mitigation for the uncertainty related to the long-term integrity of the sand diffusion layer and, if so, does it have a cost?	**See AECOM memo on wave action and re-suspension of material (AECOM, July 2010). Inlet and outlet areas of the TMA will require erosion protection (as shown on drawings) Inlet and outlet of TMA will be protected with armouring to reduce potential for erosion. Potential for adhesion and transport of sand from diffusion layer, by ice, will need to be monitored, and may require periodic maintenance. An alternative design is provided by Option 2.**	Section 4		
GY	Option 4	26	It is unclear where topsoil required for Option 4 will be found nearby the site. It may form an additional cost.	**Sources of growth and borrow material will be reviewed and provided; ensure cost of excavation, transport and placement in included in the costing.**			
GY	Water Treatment	27	There is no cost estimate for this contingency pumping from the covered pit discussed for Option 4 although it may significantly increase long term maintenance cost.	**Clarification on interim water treatment activities during and after closure implementation for each of the options will be provided. It was assumed water treatment would be required in the short term during primary consolidation. Updated costs will be provided, as required.**	Section 4.2		

2. Common Element Cost Estimates

2.1 Approach

The draft document produced by Altura Environmental Consulting (Altura) and entitled, “Common Element and Supplemental Cost Estimates for Conceptual Closure Planning”, November 2010, there are several common construction elements to be undertaken at the site as part of closure activities, regardless of which remedial alternative is brought forth as preferred. The common closure elements identified by the Government of Yukon have been limited to features located within the Mt. Nansen Order in Council (OIC) Boundary, including the following:

- Mill area;
- Camp and ancillary buildings (i.e. camp, mine shop, water storage tank building above camp);
- Roads;
- Exploration trenches;
- Miscellaneous infrastructure (i.e. power supply infrastructure, pipelines, Victoria Cree pump house, core storage areas); and
- Other areas requiring revegetation and site restoration (i.e. exploration clearings, adit disturbance areas, borrow areas)

Detailed summaries of the pre-closure and active closure phase costs are presented in Table 2-1 and Table 2-2, respectively. In brief, the following broad assumptions have been made:

- While it is recognized that some buildings or infrastructure may be re-purposed in support of ongoing care and maintenance of the site or to provide services to other interested parties (i.e. Little Salmon Carmacks First Nation), the costing assumes that all facilities and working will be fully decommissioned, removed or demolished. In addition to buildings, power lines, pipelines, non-public roads, tanks and other associated equipment will be removed from service. Roads have been distinguished from trails on the basis of information provided by the Government of Yukon. Trails have been identified as needing no specific closure measures.
- Additional investigation will be required in some areas of the site in support of detailed engineering design. The cost for this investigative work is summarized in the “Pre-Closure Phase Costs (Table 2-1). The investigations will be limited in scope and the presented costs are not intended to include any engineering, design, or detailed planning.

Further assumptions are provided in Section 2.2. A summary of all common element costs is provided in Table 2-3.

Table 2-1: Pre-Closure Cost Estimate for Common Elements

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Mill Area	Control of water flow through mill disturbance area	Complete additional investigation above and at the north corner of the mill to source the high volume seep	Allowance	1	$ 10,000.00	$ 10,000.00
	Removal of reactive rock fill from old ore transfer site	No specific assessments identified	-	-	$ -	$ -
	Decommissioning of Pond #1 (Accumulation of Old Tailings)	Additional investigation to determine extent of tailings (literature review and field work).	Allowance	1	$ 7,500.00	$ 7,500.00
	Decommissioning of Pond #2	Additional investigation to confirm presence/absence of tailings (literature review and field work).	Allowance	1	$ 7,500.00	$ 7,500.00
	Decommissioning of Pond #3	Additional investigation to confirm presence/absence of tailings (literature review and field work). Note some of this assessment is deferred to active closure phase once pond liner is removed.	Allowance	1	$ 3,000.00	$ 3,000.00
	Watercourse Restoration	No specific assessments identified	-	-	$ -	$ -
	Removal of fuel storage equipment and hydrocarbon contaminated soil/concrete	Soil investigation for local hydrocarbon contamination	Allowance	1	$ 10,000.00	$ 10,000.00
	Removal of mill buildings and other structures	Final assessment for hazardous products and local soil contamination	Allowance	1	$ 20,000.00	$ 20,000.00
	Removal of hazardous products and refuse around mill	Assess for hazardous products, and as required, local soil assessment	Allowance	1	$ 20,000.00	$ 20,000.00
	Recontouring and revegetating mill disturbance area	No specific assessments identified	Allowance	1	$ -	$ -
					Sub-Total Mill Area	**$ 78,000.00**
Camp and Site Ancillary Buildings	Camp area	Hazardous product inventory	Allowance	1	$ 5,000.00	$ 5,000.00
		Assessment/delineation of hydrocarbon contaminated soil	Allowance	1	$ 15,000.00	$ 15,000.00
	Water tank	No specific assessments identified	-	-	$ -	$ -
	Mine shop and laydown	Hazardous product inventory	Allowance	1	$ 5,000.00	$ 5,000.00
		Assessment/delineation of hydrocarbon contaminated soil	Allowance	1	$ 15,000.00	$ 15,000.00
					Sub-Total Camp Area	**$ 40,000.00**

Table 2-1: Pre-Closure Cost Estimate for Common Elements (continued)

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Roads	Mine roads (all non-public roads within OIC boundary)	(1) Assessment of presence/absence of hydrocarbon contaminated soil (2) Ground-truthing to evaluate decommissioning requirements	Allowance	1	$ 15,000.00	$ 15,000.00
	Haul road	Assessment of presence/absence of hydrocarbon contaminated soil	Allowance	1	$ 10,000.00	$ 10,000.00
	Trails	No closure activities	-	-	$	$ -
					Sub-Total Roads	**$ 25,000.00**
Backfill Trenches		Ground-truthing to assess state of trenches, confirm conceptual estimates, and assess viability of access for reclamation	Allowance	1	$ 15,000.00	$ 15,000.00
					Sub-Total Backfill Trenches	**$ 15,000.00**
Miscellaneous Infrastructure	Power supply infrastructure	Field assessment and inventory	Allowance	1	$ 5,000.00	$ 5,000.00
	Pipelines	Field assessment and inventory	Allowance	1	$ 5,000.00	$ 5,000.00
	Victoria creek pump house	Assess artesian well and develop decommissioning strategy	Allowance	1	$ 5,000.00	$ 5,000.00
	Core storage areas	No specific assessments identified	-	-	$ -	$ -
					Sub-Total Miscellaneous Infrastructure	**$ 15,000.00**
Revegetation and Restoration of Other Areas	Miscellaneous clearings	Field assessment and inventory	Allowance	1	$ 5,000.00	$ 5,000.00
	Tailings peripheral areas	No specific assessments identified	-	-	$ -	$ -
	Waste rock pile and open pit areas	Costs for this element addressed elsewhere	-	-	$ -	$ -
					Sub-Total Revegetation/Restoration	**$ 5,000.00**
					Total Pre-Closure Assessment Costs	**$ 178,000.00**

Table 2-2: Active Closure Cost Estimate for Common Elements

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Mill Area	Control of water flow through mill disturbance area[1]	Excavation	m^3	1,500	$ 10.00	$ 15,000.00
		Armouring	m^3	60	$ 35.00	$ 2,100.00
		Geotextile	m^2	400	$ 5.00	$ 2,000.00
		Plug suspected adit	Allowance	1	$ 250,000.00	$ 250,000.00
	Removal of reactive rock fill from old ore transfer site[2]	Temporary sediment control	Allowance	1	$ 5,000.00	$ 5,000.00
		Transport and place potentially acid-generating, leachable material located near saturated zone (lower platform)	m^3	6,500	$ 15.00	$ 97,500.00
	Decommissioning of Pond #1 (Accumulation of Old Tailings)[3]	Temporary sediment control	Allowance	1	$ 20,000.00	$ 20,000.00
		Temporary access improvement	Allowance	1	$ 30,000.00	$ 30,000.00
		Tailings removal	m^3	1,000	$ 100.00	$ 100,000.00
		Re-grading	Hectare	1	$ 10,000.00	$ 10,000.00
		Revegetation	Hectare	0.75	$ 16,000.00	$ 12,000.00
		Excavation	m^3	100	$ 10.00	$ 1,000.00
		Armouring	m^3	40	$ 35.00	$ 1,400.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 30,000.00	$ 30,000.00
	Decommissioning of Pond #2[3,4]	Temporary sediment control	Allowance	1	$ 5,000.00	$ 5,000.00
		Dewater pond (assumes pond water meets licensing requirements)	Allowance	1	$ 3,000.00	$ 3,000.00
		Temporary access improvement	Allowance	1	$ 2,000.00	$ 2,000.00
		Re-grading	Hectare	0.5	$ 6,250.00	$ 3,125.00
		Revegetation	Hectare	0.25	$ 16,000.00	$ 4,000.00
		Excavation (assumes no tailings are presence in Pond #2)	m^3	50	$ 10.00	$ 500.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 2,000.00	$ 2,000.00
	Decommissioning of Pond #3[3,4]	Dewater pond (assumes pond water meets licensing requirements)	Allowance	1	$ 3,000.00	$ 3,000.00
		Characterize and remove solids	Allowance	1	$ 3,000.00	$ 3,000.00
		Remove and dispose of liner	Allowance	1	$ 3,000.00	$ 3,000.00
		Test pitting below liner	Allowance	1	$ 5,000.00	$ 5,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 2,000.00	$ 2,000.00

Table 2-2: Active Closure Cost Estimate for Common Elements (continued)

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Mill Area	Watercourse Restoration	Temporary sediment control	Allowance	1	$ 10,000.00	$ 10,000.00
		Transport and place	m^3	500	$ 15.00	$ 7,500.00
		Excavation	m^3	500	$ 10.00	$ 5,000.00
		Armouring	m^3	300	$ 35.00	$ 10,500.00
		Geotextile	m^2	400	$ 5.00	$ 2,000.00
		Revegetation	Hectare	0.2	$ 16,000.00	$ 3,200.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 3,000.00	$ 3,000.00
	Removal of fuel storage equipment and hydrocarbon contaminated soil/concrete	Removal of residual products	Allowance	1	$ 5,000.00	$ 5,000.00
		Tank and equipment removal (two (2) 45,500 L diesel tanks)	Allowance	1	$ 5,000.00	$ 5,000.00
		Contaminated concrete disposal	Allowance	1	$ 10,000.00	$ 10,000.00
		Contaminated soil excavation/treatment/disposal	Allowance	1	$ 10,000.00	$ 10,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 15,000.00	$ 15,000.00
	Removal of mill buildings and other structures[5,6]	Hazardous product removal, demolition, salvage, recycling as feasible, in-place landfilling of remainder	Allowance	1	$ 1,500,000.00	$ 1,500,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 50,000.00	$ 50,000.00
	Removal of hazardous products and refuse around mill[5]	Hazardous product removal (assumes minor quantities)	Allowance	1	$ 20,000.00	$ 20,000.00
		Surface-exposed refuse removal	Allowance	1	$ 20,000.00	$ 20,000.00
		Sulphur dioxide tank removal (i.e. rail tanker)	Allowance	1	$ 20,000.00	$ 20,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 10,000.00	$ 10,000.00
	Recontouring and revegetating mill disturbance area	Temporary sediment control	Allowance	1	$ 10,000.00	$ 10,000.00
		De-compaction/scarification of roads	m^2	20,000	$ 2.00	$ 40,000.00
		Re-grading	Hectare	4	$ 10,000.00	$ 40,000.00
		Revegetation	Hectare	1	$ 16,000.00	$ 16,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 15,000.00	$ 15,000.00
					Sub-Total Mill Area	$ **2,438,825.00**

Table 2-2: Active Closure Cost Estimate for Common Elements (continued)

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Camp and Site Ancillary Buildings	Camp area[5 7]	Remove refuse and stored material in laydowns; relocated stored core	Allowance	1	$ 20,000.00	$ 20,000.00
		Remove gasoline tank (4,550 L) and appurtenances; remediated hydrocarbon contaminated soil	Allowance	1	$ 20,000.00	$ 20,000.00
		Remove propane tanks (4 x 1000 lb)	Allowance	1	$ 5,000.00	$ 5,000.00
		Remove hazardous products	Allowance	1	$ 5,000.00	$ 5,000.00
		Dismantle buildings, recycle and salvage as feasibile. In-place landfilling of non-hazardous waste	Allowance	1	$ 100,000.00	$ 100,000.00
		Decommission of septic system	Allowance	1	$ 5,000.00	$ 5,000.00
		De-compaction/scarification of ground surface	m^2	10,000	$ 2.00	$ 20,000.00
		Re-grading	Hectare	2	$ 10,000.00	$ 20,000.00
		Revegetation	Allowance	1	$ 5,000.00	$ 5,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 15,000.00	$ 15,000.00
	Water tank	Removal of tank (161,500 L), building	Allowance	1	$ 30,000.00	$ 30,000.00
		Removal of surface-exposed piping	Allowance	1	$ 3,000.00	$ 3,000.00
		Re-grading, surface preparation	Hectare	0.5	$ 6,250.00	$ 3,125.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 3,000.00	$ 3,000.00
	Mine shop and laydown[8]	Removal of scrap and products	Allowance	1	$ 10,000.00	$ 10,000.00
		Remove hazardous products	Allowance	1	$ 5,000.00	$ 5,000.00
		Remediate hydrocarbon contaminated soil	Allowance	1	$ 25,000.00	$ 25,000.00
		Dismantle buildings, recycle and salvage as feasibile	Allowance	1	$ 75,000.00	$ 75,000.00
		De-compaction/scarification of ground surface	m^2	2,000	$ 2.00	$ 4,000.00
		Re-grading, surface preparation	Hectare	0.8	$ 6,250.00	$ 5,000.00
		Revegetation	Hectare	0.2	$ 16,000.00	$ 3,200.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 3,000.00	$ 3,000.00
					Sub-Total Camp Area	**$ 384,325.00**

Table 2-2: Active Closure Cost Estimate for Common Elements (continued)

Common Element	Component	Proposed Work	Units	Quantity	Unit Price	Estimated Cost
Roads	Mine roads (all non-public roads within OIC boundary)[9]	Site preparation	km	11.6	$ 6,250.00	$ 72,500.00
		Revegetation	Hectare	1.74	$ 16,000.00	$ 27,840.00
		Remediate hydrocarbon contaminated soil	Allowance	1	$ 5,000.00	$ 5,000.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 15,000.00	$ 15,000.00
	Haul road[10]	Site preparation	km	1.2	$ 18,750.00	$ 22,500.00
		Material removal	m^3	1,000	$ 15.00	$ 15,000.00
		Remediate hydrocarbon contaminated soil	Allowance	1	$ 20,000.00	$ 20,000.00
		Revegetation	Hectare	1.2	$ 16,000.00	$ 19,200.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 15,000.00	$ 15,000.00
	Trails	No closure activities	-	-	$ -	$ -
					Sub-Total Roads	**$ 212,040.00**
Backfill Trenches[11]		Backfill remaining deep trenches, Huestis area	km	2	$ 18,750.00	$ 37,500.00
		Backfill all other trenches	km	8.80	$ 15,000.00	$ 132,000.00
		Revegetation	Hectare	2.16	$ 16,000.00	$ 34,560.00
		Field monitoring and material control, analysis, reporting	Allowance	1	$ 10,000.00	$ 10,000.00
					Sub-Total Backfill Trenches	**$ 214,060.00**
Miscellaneous Infrastructure	Power supply infrastructure[12]	(1) De-activate power lines (2) Remove remnant cable and switchgear, salvage/recycle/dispose as feasible; remove transformer and dispose/salvage (3) Remove newer power poles and salvage as feasibile (4) No allowance for revegetation assumed	Allowance	1	$ 50,000.00	$ 50,000.00
	Pipelines[13]	(1) Remove above-surface pipelines along with remnant insulation and debris, salvage/recycle/dispose as feasible (2) Remove pump shacks and equipment; salvage/recycle/dispose as feasibile (3) No revegetation allowance assumed	Allowance	1	$ 50,000.00	$ 50,000.00
	Victoria creek pump house[14]	(1) Decommission and seal artesian well (2) Remove pump house and equipment; salvage/recycle/dispose as feasible (3) Surface preparation of clearing, minor revegetation allowance assumed	Allowance	1	$ 75,000.00	$ 75,000.00
	Core storage areas[15]	Archive representative drill holes, disposal of remaining drill core	Allowance	1	$ 25,000.00	$ 25,000.00
					Sub-Total Miscellaneous Infrastructure	**$ 200,000.00**
Revegetation and Restoration of Other Areas	Miscellaneous clearings[16]	Surface preparation	Hectare	16	$ 5,000.00	$ 80,000.00
		Revegetation	Hectare	2.4	$ 16,000.00	$ 38,400.00
	Tailings peripheral areas	Final surface preparation and revegetation	Allowance	1	$ 90,200.00	$ 90,200.00
					Sub-Total Revegetation/Restoration	**$ 208,600.00**
					Total Active Closure Costs	**$ 3,657,850.00**

2.2 Assumptions/Notes

1. Although further investigation is required to characterize the path and origin of the flow of contaminated water to Dome Creek (i.e. zinc loading), a preliminary estimate of $250,000 has been provided in the common cost estimate in the event that the flow is related to the presence of a historical adit in the area. This accounts for construction of a concrete plug to seal the adit, with the same costs assumed for plugging the Pony Creek adit.
2. Conservative estimate of 6,500 m^3 of potentially acid-generating/leachable material from the lower mill platform only.
3. Assumes that water in the ponds meets licensing requirements and no treatment will be necessary.(The Altura estimate assumed basic sediment control measures during decommissioning, and conceptually assumed that any required removal of suspended solids during pond dewatering would also be covered.)
4. Assumes tailings are only present in Pond #1.
5. Assumes no asbestos or PCBs are present and only minor quantities of lead-based paint.
6. Assumes sufficient cover material is available for in-place landfilling of mill demolition refuse.
7. Area is 2 hectares, which exists as a series of four (4) platforms connected by roads.
8. Metal-clad building (250 m^2), minor laydowns of supplies and small equipment, 1,500 m^2 metal and miscellaneous scrap yard to southeast, equipment parking platform to the north, potential for hydrocarbon soil contamination due to maintenance activities and fuel tanks during mining.
9. Assumes all mine roads are to be decommissioned, and that all material is geochemically stable, with only a minor amount of hydrocarbon contamination.
10. Assumes that 1,000 m^3 of berm material is potentially leachable and that all other haul road material will have minimal potential effect on water quality. Assumes a minor amount of hydrocarbon contaminated soil is present.
11. Assumes that of the 15 lineal kilometres within the OIC boundary, (i) 2 lineal km of deep trenches were backfilled during care and maintenance; (ii) 2 km of deep trenches require backfilling; and (iii) 80% of the remaining 11 lineal km can feasibly be backfilled.
12. Assumes 5 km of active lines, 4 km of historical lines, no hazardous products are present and that there is limited vehicular access.
13. Assumes 5 km of main pipeline routes, plus 4 km of miscellaneous pipeline sections in other areas, with the majority aboveground. Also assumes no hazardous products are present and that there is limited vehicular access.
14. Assumes one (1) well and that the clearing requiring revegetation is 1,000 m^2 in area.
15. Assumes that the sites are accessible to vehicles and heavy equipment.
16. Requires additional field reconnaissance. Borrow areas have not been finalized.

2.3 Summary of Common Element Costs

The following is a summary of the costs included in Table 2-1 and Table 2-2. Deviations from the costs presented in the Altura report are noted below the table.

Table 2-3: Summary of Common Element Costs

Component	Cost Estimate Pre-Closure Phase	Cost Estimate Active Closure Phase
Mill Area	$ 78,000.00	$ 2,440,000.00[1]
Camp and Site Ancillary Buildings	$ 40,000.00	$ 390,000.00[2]
Roads	$ 25,000.00	$ 210,000.00[3]
Backfill Trenches	$ 15,000.00	$ 210,000.00[4]
Miscellaneous Infrastructure	$ 15,000.00	$ 210,000.00[5]
Revegetation and Restoration of Other Areas	$ 5,000.00	$ 210,000.00[6]
Subtotal	**$ 178,000.00**	**$ 3,670,000.00**
Total Cost	**$3,850,000**[7]	

2.3.1 Table 2-3 Notes

1. Cost has been rounded from that shown in Table 2-2 ($2,438,825.00).Cost for watercourse has been updated from the estimate of $2,190,000 included in Altura Environmental's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010.
2. Cost has been rounded from that shown in Table 2-2 ($384,325.00).
3. Cost has been rounded from that shown in Table 2-2 ($212,040.00).
4. Cost has been rounded from that shown in Table 2-2 ($214,060.00).
5. Cost has been rounded from that shown in Table 2-2 ($200,000.00).
6. Cost has been rounded from that shown in Table 2-2 ($208,600.00).
7. Number rounded up. With the exception of the addition of $250,000 to address contaminated flows potentially related to a historical adit, total costs are consistent with those listed in the Altura report.

The total costs provided in Table 2-3 are included in each of the detailed cost estimates for Options 1A, 1B, 2A, 2B, 3, and 4.

3. Capital Closure Cost Estimates

3.1 Class 'D' Capital Cost Estimates by Option

The following sections present detailed capital cost estimates associated with Options 1A, 1B, 2A, 2B, 3, and 4. The estimates have been updated from those included in the Lorax Environmental report entitled, "*Mount Nansen Options for Closure*". The changes are based on feedback from all stakeholders. Amongst the most significant additions/changes to the tables are the inclusions of:

- A 15% contingency, allowing for engineering design, ongoing consultation and resident and non-resident contract administration during construction. This contingency is in addition to the 30% allowance made for design changes during construction and items that have not been identified at the current level of design.
- Annual and lower-frequency care and maintenance costs associated with each option. These costs have been projected into perpetuity costs and converted to present values.
- Common element costs, as per Table 2-3.
- An allowance for plugging the Pony Creek adit has been added to all options (was not previously included in Options 1A and 2A).
- An allowance for the excavation and relocation of metals contaminated soil underlying the tailings has been added to Options 3 and 4.

Comprehensive lists of assumptions are provided following each detailed cost table.

Table 3-1: Summary of Estimated Capital Costs - Option 1A

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/ Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Demobilization	Lump Sum	1	$ 50,000.00	$ 50,000.00
					Sub-Total Mobilization/Demobilization	**$ 250,000.00**[1,2]
2A	Construction of Toe Berm	Crush, transport and place rock fill	m^3	40,000	$ 35.00	$ 1,400,000.00[1]
2B		Geosynthetic filter placement	m^2	5,400	$ 20.00	$ 108,000.00[1]
					Sub-Total Construction of Toe Berm	**$ 1,508,000.00**
3A	Ground Improvement	Thermosyphons	Lump Sum	1	$ 600,000.00	$ 600,000.00[1,3]
3B		Drainage, insulation, site preparation, etc.	Lump Sum	1	$ 900,000.00	$ 900,000.00[1,4]
					Sub-Total Ground Improvement	**$ 1,500,000.00**
4A	Tailings Management Area (TMA)	Regrading	m^2	71,000	$ 5.00	$ 355,000.00[1]
4B		Sand diffusion barrier cover	m^3	18,000	$ 15.00	$ 270,000.00[1]
4C		Soil cover beach	m^3	20,000	$ 15.00	$ 300,000.00[1]
4D		Beach armouring	m^3	3,300	$ 50.00	$ 165,000.00[1]
4E		Replace coarse tails with fine tails	m^3	68,000	$ 12.00	$ 816,000.00[1,5]
4F		Final site preparation, revegetation	Lump Sum	1	$ 34,000.00	$ 34,000.00[6]
					Sub-Total TMA	**$ 1,940,000.00**
5A	Spillway	Excavation	m^3	2,000	$ 10.00	$ 20,000.00[1]
5B		Concrete overflow	Lump Sum	1	$ 150,000.00	$ 150,000.00[1]
5C		Geotextile placement	m^2	3,000	$ 10.00	$ 30,000.00[1]
5D		Armouring	m^3	1,000	$ 50.00	$ 50,000.00[1]
5E		South-side berm – fill	m^3	500	$ 10.00	$ 5,000.00[1]
5F		South-side berm - erosion protection	Lump Sum	1	$ 15,000.00	$ 15,000.00[1]
					Sub-Total Spillway	**$ 270,000.00**
6A	Dome Creek Diversion into TMA	Excavation	m^3	750	$ 10.00	$ 7,500.00[1]
6B		Geotextile placement	m^2	675	$ 10.00	$ 6,750.00[1]
6C		Armouring	m^3	340	$ 50.00	$ 17,000.00[1]
6D		Water level controls	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
6E		Dome Creek channel and apron	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
					Sub-Total Dome Creek Diversion	**$ 131,250.00**
7	Dam Raise		Lump Sum	1	$ 25,000.00	**$ 25,000.00**[1]
8A	Diversion/Interceptor Ditch Upstream of Spillway	Fill in interceptor ditch	m^3	3,400	$ 10.00	$ 34,000.00[1]
8B		Fill in interceptor diversion channel	m^3	5,400	$ 10.00	$ 54,000.00[1]
					Sub-Total Diversion/Interceptor Ditch	**$ 88,000.00**
9A	Reslope, Regrade and Revegetate Waste Rock Storage Area	Regrade waste rock	Hectare	7.216	$ 6,250.00	$ 45,100.00
9B		Reslope waste rock	hr/Hectare	41	$ 1,200.00	$ 49,285.00
9C		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 142,000.00**[7]
10	Road Construction – Base		m^3	900	$ 50.00	**$ 45,000.00**[1]
11	Plug Pony Creek Adit		Lump Sum	1	$ 250,000.00	**$ 250,000.00**[1]
12	Diversion Channel Downstream of Spillway		Lump Sum	1	$ 500,000.00	**$ 500,000.00**[1]
13	Monitoring Instrumentation		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
14	Scale/Flatten Pit Walls		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
15	Pit Safety (Signage and Berm)		Lump Sum	1	$ 24,000.00	**$ 24,000.00**[8]
16	Common Elements - Active Closure					**$ 3,657,850.00**[9]
17	Sub-Total All Items (Construction Costs)					**$ 10,731,100.00**
18	Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)					**$ 1,609,665.00**[10]
19	Recommended Contingency (30% of Estimated Construction Costs)``					**$ 3,219,330.00**[11]
20	Pre-Closure Common Elements Cost (Investigation)					**$ 178,000.00**[12]
21	Operation, Care and Maintenance (Life Cycle Costs)					**$ 7,823,250.00**[13]
22					**Total Estimated Cost - Option 1A**	**$ 23,561,345.00**[14]

3.1.1 Option 1A Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Cost for thermosyphons is based on two (2) rows 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 site.
4. Assumes that seepage water from the TMA would not require treatment or containment.
5. 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.
6. Cost derived from Appendix A.1 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. See below.

Table 3-2: Summary of Revegetation Costs – Option 1A

Work Sub-Item	Description	Units	Quantity	Unit Price	Estimated Cost
Final Site Preparation	Beach soil cover	hr	12.5	$ 250.00	$ 3,125.00
	Dam crest and upstream	hr	10		$ 2,500.00
	Downstream dam face	hr	32		$ 8,000.00
	Rock fill toe berm	hr	15		$ 3,750.00
Sub-Total Final Site Preparation					**$ 17,375.00**
Final Site Revegetation	Beach soil cover	Hectare	0.375	$ 16,000.00	$ 6,000.00
	Dam crest and upstream	Hectare	0.1		$ 1,600.00
	Downstream dam face	Hectare	0.4		$ 6,400.00
	Rock fill toe berm	Hectare	0.15		$ 2,400.00
Sub-Total Final Site Revegetation					**$ 16,400.00**
Total Estimated Cost - Final Site Preparation/Revegetation					**$ 33,775.00**

7. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.4-10).
8. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.4-10).
9. Refer to Table 2-2 for further detail.
10. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
11. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
12. Refer to Table 2-1 for further detail.
13. Refer to Section 4.1 and Table 4-1 for further detail.
14. Sum of Items 17 to 21.

Table 3-3: Summary of Estimated Capital Costs - Option 1B

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Demobilization	Lump Sum	1	$ 50,000.00	$ 50,000.00
					Sub-Total Mobilization/Demobilization	**$ 250,000.00**[1,2]
2A	Construction of Toe Berm	Crush, transport and place rock fill	m^3	40,000	$ 35.00	$ 1,400,000.00[1]
2B		Geosynthetic filter placement	m^2	5,400	$ 20.00	$ 108,000.00[1]
					Sub-Total Construction of Toe Berm	**$ 1,508,000.00**
3A	Ground Improvement	Thermosyphons	Lump Sum	1	$ 600,000.00	$ 600,000.00[1,3]
3B		Drainage, insulation, site preparation, etc.	Lump Sum	1	$ 900,000.00	$ 900,000.00[1,4]
					Sub-Total Ground Improvement	**$ 1,500,000.00**
4A	Tailings Management Area (TMA)	Regrading	m^2	71,000	$ 5.00	$ 355,000.00[1]
4B		Sand diffusion barrier cover	m^3	18,000	$ 15.00	$ 270,000.00[1]
4C		Soil cover beach	m^3	20,000	$ 15.00	$ 300,000.00[1]
4D		Beach armouring	m^3	3,300	$ 50.00	$ 165,000.00[1]
4E		Replace coarse tails with fine tails	m^3	68,000	$ 12.00	$ 816,000.00[1,5]
4F		Final site preparation, revegetation	Lump Sum	1	$ 34,000.00	$ 34,000.00[6]
					Sub-Total TMA	**$ 1,940,000.00**
5A	Spillway	Excavation	m^3	2,000	$ 10.00	$ 20,000.00[1]
5B		Concrete overflow	Lump Sum	1	$ 150,000.00	$ 150,000.00[1]
5C		Geotextile placement	m^2	3,000	$ 10.00	$ 30,000.00[1]
5D		Armouring	m^3	1,000	$ 50.00	$ 50,000.00[1]
5E		South-side berm – fill	m^3	500	$ 10.00	$ 5,000.00[1]
5F		South-side berm - erosion protection	Lump Sum	1	$ 15,000.00	$ 15,000.00[1]
					Sub-Total Spillway	**$ 270,000.00**
6A	Dome Creek Diversion into TMA	Excavation	m^3	750	$ 10.00	$ 7,500.00[1]
6B		Geotextile placement	m^2	675	$ 10.00	$ 6,750.00[1]
6C		Armouring	m^3	340	$ 50.00	$ 17,000.00[1]
6D		Water level controls	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
6E		Dome Creek channel and apron	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
					Sub-Total Dome Creek Diversion	**$ 131,250.00**
7	Dam Raise		Lump Sum	1	$ 25,000.00	**$ 25,000.00**[1]
8A	Diversion/Interceptor Ditch Upstream of Spillway	Fill in interceptor ditch	m^3	3,400	$ 10.00	$ 34,000.00[1]
8B		Fill in interceptor diversion channel	m^3	5,400	$ 10.00	$ 54,000.00[1]
					Sub-Total Diversion/Interceptor Ditch	**$ 88,000.00**
9A	Backfill Pit with Waste Rock	Load, haul, backfill pit with waste rock	m^3	510,000	$ 5.00	$ 2,550,000.00[1,7]
9B		Regrade and revegetate pit fill, safety measures	Lump Sum	1	$ 53,000.00	$ 53,000.00[8]
9C		Plug Pony Creek adit	Lump Sum	1	$ 250,000.00	$ 250,000.00[1]
					Sub-Total Pit Backfilling	**$ 2,853,000.00**[9]
10A	Reslope, Regrade and Revegetate Waste Rock Storage Area	Regrade waste rock	Hectare	12	$ 6,250.00	$ 75,000.00
10B		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 123,000.00**[10]
11	Road Construction – Base		m^3	900	$ 50.00	**$ 45,000.00**[1]
12	Diversion Channel Downstream of Spillway		Lump Sum	1	$ 500,000.00	**$ 500,000.00**[1]
13	Monitoring Instrumentation		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
14	Scale/Flatten Pit Walls		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
15	Common Elements - Active Closure					$ 3,657,850.00
16	Sub-Total All Items (Construction Costs)					**$ 13,291,100.00**[11]
17	Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)					**$ 1,993,665.00**[12]
18	Recommended Contingency (30% of Estimated Construction Costs)					**$ 3,987,330.00**[13]
19	Pre-Closure Common Elements Cost (Investigation)					**$ 178,000.00**[14]
20	Operation, Care and Maintenance (Life Cycle Costs)					**$ 7,500,000.00**[15]
21					**Total Estimated Cost - Option 1B**	**$ 26,950,095.00**[16]

3.1.2 Option 1B Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Cost for thermosyphons is based on two (2) rows 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 site.
4. Assumes that seepage water from the TMA would not require treatment or containment.
5. 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.
6. Cost derived from Appendix A.1 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. See below.

Table 3-4: Summary of Revegetation Costs – Option 1B

Work Sub-Item	Description	Units	Quantity	Unit Price	Estimated Cost
Final Site Preparation	Beach soil cover	hr	12.5	$ 250.00	$ 3,125.00
	Dam crest and upstream	hr	10		$ 2,500.00
	Downstream dam face	hr	32		$ 8,000.00
	Rock fill toe berm	hr	15		$ 3,750.00
Sub-Total Final Site Preparation					**$ 17,375.00**
Final Site Revegetation	Beach soil cover	Hectare	0.375	$ 16,000.00	$ 6,000.00
	Dam crest and upstream	Hectare	0.1		$ 1,600.00
	Downstream dam face	Hectare	0.4		$ 6,400.00
	Rock fill toe berm	Hectare	0.15		$ 2,400.00
Sub-Total Final Site Revegetation					**$ 16,400.00**
Total Estimated Cost - Final Site Preparation/Revegetation					**$ 33,775.00**

7. Cost verified by local contractor, Pelly Construction.
8. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.4-11).
9. Costs do not allow for extensive sorting of waste rock.
10. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.4-11).
11. Refer to Table 2-2 for further detail.
12. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
13. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
14. Refer to Table 2-1 for further detail.
15. Refer to Section 4.1 and Table 4-1 for further detail.
16. Sum of Items 16 to 20.

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Table 3-5: Summary of Estimated Capital Costs - Option 2A

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Demobilization	Lump Sum	1	$ 50,000.00	$ 50,000.00
					Sub-Total Mobilization/Demobilization	**$ 250,000.00**[1,2]
2A	Construction of Toe Berm	Crush, transport and place rock fill	m^3	40,000	$ 35.00	$ 1,400,000.00[1]
2B		Geosynthetic filter placement	m^2	5,400	$ 20.00	$ 108,000.00[1]
					Sub-Total Construction of Toe Berm	**$ 1,508,000.00**
3A	Ground Improvement	Thermosyphons	Lump Sum	1	$ 600,000.00	$ 600,000.00[1,3]
3B		Drainage, insulation, site preparation, etc.	Lump Sum	1	$ 900,000.00	$ 900,000.00[1,4]
					Sub-Total Ground Improvement	**$ 1,500,000.00**
4A	Tailings Management Area (TMA)	Regrading	m^2	71,000	$ 5.00	$ 355,000.00[1]
4B		1.0 m soil cover	m^3	60,000	$ 15.00	$ 900,000.00[1]
4C		Vegetate cover	m^2	60,000	$ 3.00	$ 180,000.00[1]
4D		Drainage swales - geotextile	m^2	5,000	$ 10.00	$ 50,000.00[1]
4E		Drainage swales - armouring	m^3	1,500	$ 50.00	$ 75,000.00[1]
4F		Soil cover - beach	m^3	20,000	$ 15.00	$ 300,000.00[1]
4G		Beach armouring	m^3	3,300	$ 50.00	$ 165,000.00[1]
4H		Replace coarse tails with fine tails	m^3	68,000	$ 12.00	$ 816,000.00[1,5]
4I		Final site preparation, revegetation	Lump Sum	1	$ 124,000.00	$ 124,000.00[6]
					Sub-Total TMA	**$ 2,965,000.00**
5A	Spillway	Excavation	m^3	2,000	$ 10.00	$ 20,000.00[1]
5B		Concrete overflow	Lump Sum	1	$ 150,000.00	$ 150,000.00[1]
5C		Geotextile placement	m^2	3,000	$ 10.00	$ 30,000.00[1]
5D		Armouring	m^3	1,000	$ 50.00	$ 50,000.00[1]
5E		South-side berm - fill	m^3	500	$ 10.00	$ 5,000.00[1]
5F		South-side berm - erosion protection	Lump Sum	1	$ 15,000.00	$ 15,000.00[1]
					Sub-Total Spillway	**$ 270,000.00**
6A	Dome Creek Diversion into TMA	Excavation	m^3	750	$ 10.00	$ 7,500.00[1]
6B		Geotextile placement	m^2	675	$ 10.00	$ 6,750.00[1,7]
6C		Armouring	m^3	340	$ 50.00	$ 17,000.00[1]
6D		Water level controls	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
6E		Dome Creek channel and apron	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
					Sub-Total Dome Creek Diversion	**$ 131,250.00**
7	Dam Raise		Lump Sum	1	$ 25,000.00	**$ 25,000.00**[1]
8A	Diversion/Interceptor Ditch Upstream of Spillway	Fill in interceptor ditch	m^3	3,400	$ 10.00	$ 34,000.00[1]
8B		Fill in interceptor diversion channel	m^3	5,400	$ 10.00	$ 54,000.00[1]
					Sub-Total Diversion/Interceptor Ditch	**$ 88,000.00**
9A	Reslope, Regrade and Revegetate Waste Rock Storage Area	Regrade waste rock	Hectare	7.216	$ 6,250.00	$ 45,100.00
9B		Reslope waste rock	hr/Hectare	41	$ 1,200.00	$ 49,285.00
9C		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 142,000.00**[8]
10	Road Construction – Base		m^3	900	$ 50.00	**$ 45,000.00**[1]
11	Plug Pony Creek Adit		Lump Sum	1	$ 250,000.00	**$ 250,000.00**[1]
12	Diversion Channel Downstream of Spillway		Lump Sum	1	$ 500,000.00	**$ 500,000.00**[1]
13	Monitoring Instrumentation		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
14	Scale/Flatten Pit Walls		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
15	Pit Safety (Signage and Berm)		Lump Sum	1	$ 24,000.00	**$ 24,000.00**[9]
16	Common Elements - Active Closure					$ **3,657,850.00**[10]
17	Sub-Total All Items (Construction Costs)					**$ 11,756,100.00**
18	Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)					**$ 1,763,415.00**[11]
19	Recommended Contingency (30% of Estimated Construction Costs)					**$ 3,526,830.00**[12]
20	Pre-Closure Common Elements Cost (Investigation)					**$ 178,000.00**[13]
21	Operation, Care and Maintenance (Life Cycle Costs)					**$ 7,823,250.00**[14]
22					**Total Estimated Cost - Option 2A**	**$ 25,047,595.00**[15]

3.1.3 Option 2A Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Cost for thermosyphons is based on two (2) rows 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 site.
4. Assumes that seepage water from the TMA would not require treatment or containment.
5. 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.
6. Cost derived from Appendix A.1 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. See below.

Table 3-6: Summary of Revegetation Costs – Option 2A

Work Sub-Item	Description	Units	Quantity	Unit Price	Estimated Cost
Final Site Preparation	Soil cover, main tailings mass	hr	162.5	$ 250.00	$ 40,625.00
	Soil cover, beach area	hr	12.5		$ 3,125.00
	Dam crest and upstream face	hr	10		$ 2,500.00
	Downstream dam face	hr	32		$ 8,000.00
	Rock fill toe berm	hr	15		$ 3,750.00
Sub-Total Final Site Preparation					**$ 58,000.00**
Final Site Revegetation	Soil cover, main tailings mass	Hectare	3.25	$ 16,000.00	$ 52,000.00
	Soil cover, beach area	Hectare	0.25		$ 4,000.00
	Dam crest and upstream face	Hectare	0.1		$ 1,600.00
	Downstream dam face	Hectare	0.4		$ 6,400.00
	Rock fill toe berm	Hectare	0.15		$ 2,400.00
Sub-Total Final Site Revegetation					**$ 66,400.00**
Total Estimated Cost - Final Site Preparation/Revegetation					**$ 124,400.00**

7. Cost in AECOM report was $5/m^2.
8. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.5-5).
9. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.5-5).
10. Refer to Table 2-2 for further detail.
11. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
12. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
13. Refer to Table 2-1 for further detail.
14. Refer to Section 4.1 and Table 4-1 for further detail.
15. Sum of Items 17 to 21.

Table 3-7: Summary of Estimated Capital Costs - Option 2B

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Demobilization	Lump Sum	1	$ 50,000.00	$ 50,000.00
					Sub-Total Mobilization/Demobilization	**$ 250,000.00**[1,2]
2A	Construction of Toe Berm	Crush, transport and place rock fill	m^3	40,000	$ 35.00	$ 1,400,000.00[1]
2B		Geosynthetic filter placement	m^2	5,400	$ 20.00	$ 108,000.00[1]
					Sub-Total Construction of Toe Berm	**$ 1,508,000.00**
3A	Ground Improvement	Thermosyphons	Lump Sum	1	$ 600,000.00	$ 600,000.00[1,3]
3B		Drainage, insulation, site preparation, etc.	Lump Sum	1	$ 900,000.00	$ 900,000.00[1,4]
					Sub-Total Ground Improvement	**$ 1,500,000.00**
4A	Tailings Management Area (TMA)	Regrading	m^2	71,000	$ 5.00	$ 355,000.00[1]
4B		1.0 m soil cover	m^3	60,000	$ 15.00	$ 900,000.00[1]
4C		Vegetate cover	m^2	60,000	$ 3.00	$ 180,000.00[1]
4D		Drainage swales – Geotextile	m^2	5,000	$ 10.00	$ 50,000.00[1]
4E		Drainage swales - armouring	m^3	1,500	$ 50.00	$ 75,000.00[1]
4F		Soil cover - beach	m^3	20,000	$ 15.00	$ 300,000.00[1]
4G		Beach armouring	m^3	3,300	$ 50.00	$ 165,000.00[1]
4H		Replace coarse tails with fine tails	m^3	68,000	$ 12.00	$ 816,000.00[1,5]
4I		Final site preparation, revegetation	Lump Sum	1	$ 124,000.00	$ 124,000.00[6]
					Sub-Total TMA	**$ 2,965,000.00**
5A	Spillway	Excavation	m^3	2,000	$ 10.00	$ 20,000.00[1]
5B		Concrete overflow	Lump Sum	1	$ 150,000.00	$ 150,000.00[1]
5C		Geotextile placement	m^2	3,000	$ 10.00	$ 30,000.00[1]
5D		Armouring	m^3	1,000	$ 50.00	$ 50,000.00[1]
5E		South-side berm - fill	m^3	500	$ 10.00	$ 5,000.00[1]
5F		South-side berm - erosion protection	Lump Sum	1	$ 15,000.00	$ 15,000.00[1]
					Sub-Total Spillway	**$ 270,000.00**
6A	Dome Creek Diversion into TMA	Excavation	m^3	750	$ 10.00	$ 7,500.00[1]
6B		Geotextile placement	m^2	675	$ 10.00	$ 6,750.00[1,7]
6C		Armouring	m^3	340	$ 50.00	$ 17,000.00[1]
6D		Water level controls	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
6E		Dome Creek channel and apron	Lump Sum	1	$ 50,000.00	$ 50,000.00[1]
					Sub-Total Dome Creek Diversion	**$ 131,250.00**
7	Dam Raise		Lump Sum	1	$ 25,000.00	**$ 25,000.00**[1]
8A	Diversion/Interceptor Ditch Upstream of Spillway	Fill in interceptor ditch	m^3	3,400	$ 10.00	$ 34,000.00[1]
8B		Fill in interceptor diversion channel	m^3	5,400	$ 10.00	$ 54,000.00[1]
					Sub-Total Diversion/Interceptor Ditch	**$ 88,000.00**
9A	Backfill Pit with Waste Rock	Load, haul, backfill pit with waste rock	m^3	510,000	$ 5.00	$ 2,550,000.00[1,8]
9B		Regrade and revegetate pit fill, safety measures	Lump Sum	1	$ 53,000.00	$ 53,000.00[9]
9C		Plug Pony Creek adit	Lump Sum	1	$ 250,000.00	$ 250,000.00[1]
					Sub-Total Pit Backfilling	**$ 2,853,000.00**[10]
10A	Reslope, Regrade and Revegetate Waste Rock Storage Area	Regrade waste rock	Hectare	12	$ 6,250.00	$ 75,000.00
10B		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 123,000.00**[11]
11	**Road Construction – Base**		m^3	900	$ 50.00	**$ 45,000.00**[1]
12	**Diversion Channel Downstream of Spillway**		Lump Sum	1	$ 500,000.00	**$ 500,000.00**[1]
13	**Monitoring Instrumentation**		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
14	**Scale/Flatten Pit Walls**		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
16	**Common Elements - Active Closure**					**$ 3,657,850.00**[12]
17	**Sub-Total All Items (Construction Costs)**					**$ 14,316,100.00**
18	**Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)**					**$ 2,147,415.00**[13]
19	**Recommended Contingency (30% of Estimated Construction Costs)**					**$ 4,294,830.00**[14]
20	**Pre-Closure Common Elements Cost (Investigation)**					**$ 178,000.00**[15]
21	**Operation, Care and Maintenance (Life Cycle Costs)**					**$ 7,500,000.00**[16]
22					**Total Estimated Cost - Option 2B**	**$ 28,436,345.00**[17]

3.1.4 Option 2B Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Cost for thermosyphons is based on two (2) rows 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 site.
4. Assumes that seepage water from the TMA would not require treatment or containment.
5. 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.
6. Cost derived from Appendix A.1 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. See below.

Table 3-8: Summary of Revegetation Costs – Option 2B

Work Sub-Item	Description	Units	Quantity	Unit Price	Estimated Cost
Final Site Preparation	Soil cover, main tailings mass	hr	162.5	$ 250.00	$ 40,625.00
	Soil cover, beach area	hr	12.5		$ 3,125.00
	Dam crest and upstream face	hr	10		$ 2,500.00
	Downstream dam face	hr	32		$ 8,000.00
	Rock fill toe berm	hr	15		$ 3,750.00
Sub-Total Final Site Preparation					**$ 58,000.00**
Final Site Revegetation	Soil cover, main tailings mass	Hectare	3.25	$ 16,000.00	$ 52,000.00
	Soil cover, beach area	Hectare	0.25		$ 4,000.00
	Dam crest and upstream face	Hectare	0.1		$ 1,600.00
	Downstream dam face	Hectare	0.4		$ 6,400.00
	Rock fill toe berm	Hectare	0.15		$ 2,400.00
Sub-Total Final Site Revegetation					**$ 66,400.00**
Total Estimated Cost - Final Site Preparation/Revegetation					**$ 124,400.00**

7. Cost in AECOM report was $5/m^2.
8. Cost verified by local contractor, Pelly Construction.
9. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.5-6).
10. Costs do not allow for extensive sorting of waste rock.
11. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.5-6).
12. Refer to Table 2-2 for further detail.
13. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
14. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
15. Refer to Table 2-1 for further detail.
16. Refer to Section 4.1 and Table 4-1 for further detail.
17. Sum of Items 17 to 21.

Table 3-9: Summary of Estimated Capital Costs - Option 3

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Partial Demobilization	Lump Sum	1	$ 225,000.00	$ 225,000.00
1C		Final Demobilization	Lump Sum	1	$ 75,000.00	$ 75,000.00
					Sub-Total Mobilization/Demobilization	**$ 500,000.00**[1,2]
2A	Transport and Place Tailings	Set up dredges, pumps, and lines	Lump Sum	1	$ 2,000,000.00	$ 2,000,000.00[1]
2B		Dredge tailings	m^3	300,000	$ 9.00	$ 2,700,000.00[1,3]
					Sub-Total Construction of Toe Berm	**$ 4,700,000.00**
3A	Restore Tailings Management Area (TMA)	Relocate dam fill to borrow sources	m^3	80,000	$ 5.00	$ 400,000.00[1]
3B		Relocate dam fill to pit	m^3	80,000	$ 12.00	$ 960,000.00[1]
3C		Excavate metals contaminated soil underlying tailings and relocate to pit	m^3	11,000	$ 12.00	$ 132,000.00[4]
3D		Restoration of Dome Creek valley	Lump Sum	1	$ 1,670,000.00	$ 1,670,000.00[5]
					Sub-Total TMA Restoration	**$ 3,162,000.00**
4A	Construct In-Pit Tailings Dam	Fill material	m^3	10,000	$ 35.00	$ 350,000.00[1]
4B		Tailings dam liner	m^2	1,000	$ 150.00	$ 150,000.00[1]
4C		Foundation preparation	Lump Sum	1	$ 500,000.00	$ 500,000.00[1]
4D		Monitoring instrumentation	Lump Sum	1	$ 200,000.00	$ 200,000.00[1]
					Sub-Total Dam Construction	**$ 1,200,000.00**
5	1 m High Infiltration Cover Over Tailings		m^3	21,000	$ 15.00	**$ 315,000.00**
6A	Spillway	Excavation	m^3	500	$ 20.00	$ 10,000.00[1]
6B		Geotextile placement	m^2	500	$ 10.00	$ 5,000.00[1]
6C		Armouring	m^3	250	$ 50.00	$ 12,500.00[1]
					Sub-Total Spillway	**$ 27,500.00**
7A	Regrade and Repair Cover		m^3	21,000	$ 5.00	**$ 105,000.00**[1,6]
8A	Reslope, Regrade and Revegetate Waste Rock Storage Area	Regrade waste rock	Hectare	7.216	$ 6,250.00	$ 45,100.00
8B		Reslope waste rock	hr/Hectare	41	$ 1,200.00	$ 49,285.00
8C		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 142,000.00**[7]
9	Plug Pony Creek Adit		Lump Sum	1	$ 250,000.00	**$ 250,000.00**[1,8]
10	Scale/Flatten Pit Walls		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
11	Revegetate Pit Fill, Pit Safety (Signage and Berm)		Lump Sum	1	$ 49,000.00	**$ 49,000.00**[9]
12	Monitoring Instrumentation		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
13	Water Treatment – Total		Lump Sum	1	$ 2,000,000.00	**$ 2,000,000.00**[10]
14	Common Elements - Active Closure					**$ 3,657,850.00**[11]
15	Sub-Total All Items (Construction Costs)					**$ 16,508,350.00**
16	Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)					**$ 2,476,252.50**[12]
17	Recommended Contingency (30% of Estimated Construction Costs)					**$ 4,952,505.00**[13]
18	Pre-Closure Common Elements Cost (Investigation)					**$ 178,000.00**[14]
19	Operation, Care and Maintenance (Life Cycle Costs)					**$ 4,525,000.00**[15]
20					**Total Estimated Cost - Option 3**	**$ 28,640,107.50**[16]

3.1.5 Option 3 Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Assumes that dredging is the preferred transportation method, and that tailings can be adequately blended in-pipe. Two (2) dredges will be used simultaneously. No allowance has been included for accelerating consolidation. It is assumed that an adequate water supply will be available for dredging operations.
4. Assumes areal extent of contaminated soil is 7.3 ha (consistent with area of tailings). Based on current site information, the average thickness of metals impacted soil is on the order of 15 cm. Cost provided is consistent with the cost to move the dam fill into the pit.
5. Cost derived from Appendix A.3, A.4, and A.5 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Cost for this item is consistent with the number provided in the November 2010 Lorax report (Table 5.6-5).

Table 3-10: Summary of Dome Creek Restoration Costs – Option 3

Work Item	Estimated Cost - Tailings Mass and Dam (7.4 ha)	Estimated Cost - Dome Creek Watercourse (4.4 ha)
Design	$ 50,000.00	$ 50,000.00
Phase 1 Activities (After excavation of tailings mass and majority of dam, upstream diversion structures and a small portion of the dam structure left in place to retain and control drainage)	$ 280,000.00	$ 390,000.00
Phase 2 Activities (Following season after completion of Phase 1, and subsequent excavation of remaining dam structures)	$ 140,000.00	$ 170,000.00
Phase 3 Activities (Season after completion of Phase 2)	$ 120,000.00	$ 190,000.00
Sub-Total	**$ 590,000.00**	**$ 800,000.00**
Field Monitoring, Quality Control, Reporting	$ 280,000.00	
Total Dome Creek	**$ 1,670,000.00**	

6. Regrading of cover surface is assumed to be a one (1)-time maintenance item to address uneven settlement.
7. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.6-5).
8. Estimated cost for plugging Pony Creek adit was based on the designs and recent construction costs for plugging similar mine adits in the Yukon. Costs are for a massive concrete plug with grouting around the circumference of the adit.
9. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.6-5).
10. Costs for water treatment are an update of Mount Nansen Mine Water Treatment Study (AECOM 2009) and includes both capital and operating costs for the duration of the construction activities.
11. Refer to Table 2-2 for further detail.

12. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
13. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
14. Refer to Table 2-1 for further detail.
15. Refer to Section 4.1 and Table 4-1 for further detail.
16. Sum of Items 16 to 20.

Table 3-11: Summary of Estimated Capital Costs - Option 4

Item	Work Item	Description	Units	Quantity	Unit Price	Estimated Cost
1A	Mobilization/Demobilization	Mobilization	Lump Sum	1	$ 200,000.00	$ 200,000.00
1B		Partial Demobilization	Lump Sum	1	$ 225,000.00	$ 150,000.00
1C		Final Demobilization	Lump Sum	1	$ 75,000.00	$ 50,000.00
					Sub-Total Mobilization/Demobilization	**$ 400,000.00**[1,2]
2	**Transport and Place Tailings**		m^3	300,000	$ 15.00	$ **4,500,000.00**[1]
3A	Restore Tailings Management Area (TMA)	Relocate dam fill to borrow sources	m^3	80,000	$ 5.00	$ 400,000.00[1]
3B		Relocate dam fill to pit	m^3	80,000	$ 12.00	$ 960,000.00[1]
3C		Excavate metals contaminated soil underlying tailings and relocate to pit	m^3	11,000	$ 12.00	$ 132,000.00[3]
3D		Restoration of Dome Creek valley	Lump Sum	1	$ 1,670,000.00	$ 1,670,000.00[4]
					Sub-Total TMA Restoration	**$ 3,162,000.00**
4	**Waste Rock Placement (Bottom and Top)**		m^3	344,000	$ 5.00	**$ 1,720,000.00**[1]
5	**Low Infiltration Synthetic Cover**		m^3	43,000	$ 55.00	**$ 2,365,000.00**[1]
6	**Regrade and Repair Cover**		m^3	43,000	$ 5.00	**$ 215,000.00**[1,5]
7A	**Reslope, Regrade and Revegetate Waste Rock Storage Area**	Regrade waste rock	Hectare	12	$ 6,250.00	$ 75,000.00
7B		Revegetation	Lump Sum	1.0	$ 48,000.00	$ 48,000.00
					Subtotal Waste Rock Storage Area	**$ 123,000.00**[6]
8	**Plug Pony Creek Adit**		Lump Sum	1	$ 250,000.00	**$ 250,000.00**[7]
9	**Revegetate Pit Fill, Pit Safety (Signage and Berm)**		Lump Sum	1	$ 46,000.00	**$ 46,000.00**[8]
10	**Monitoring Instrumentation**		Lump Sum	1	$ 200,000.00	**$ 200,000.00**[1]
11	**Water Treatment – Total**		Lump Sum	1	$ 2,000,000.00	**$ 2,000,000.00**[9]
12	**Common Elements - Active Closure**					**$ 3,657,850.00**[10]
13	**Sub-Total All Items (Construction Costs)**					**$ 18,638,850.00**
14	**Recommended Contingency - Consulting, Engineering , Design, and Site Supervision (15% of Estimated Construction Costs)**					**$ 2,795,827.50**[11]
15	**Recommended Contingency (30% of Estimated Construction Costs)**					**$ 5,591,655.00**[12]
16	**Pre-Closure Common Elements Cost (Investigation)**					**$ 178,000.00**[13]
17	**Operation, Care and Maintenance (Life Cycle Costs)**					**$ 3,750,000.00**[14]
18					**Total Estimated Cost - Option 4**	**$ 30,954,332.50**[15]

3.1.6 Option 4 Cost Assumptions/Notes

1. Costs derived from AECOM's report entitled, "*Geotechnical Assessment and Cost of the Mt. Nansen Mine Closure Alternatives*", November 2010 (Appendix C-1 "*Mount Nansen Options for Closure"*, Lorax Environmental, November 2010).
2. Mobilization/demobilization costs assume that the majority of the required equipment is available locally.
3. Assumes areal extent of contaminated soil is 7.3 ha (consistent with area of tailings). Based on current site information, the average thickness of metals impacted soil is on the order of 15 cm. Cost provided is consistent with the cost to move the dam fill into the pit.
4. Cost derived from Appendix A.3, A.4, and A.5 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Cost for this item is consistent with the number provided in the November 2010 Lorax report (Table 5.7-4).

Table 3-12: Summary of Dome Creek Restoration Costs – Option 4

Work Item	Estimated Cost - Tailings Mass and Dam (7.4 ha)	Estimated Cost - Dome Creek Watercourse (4.4 ha)
Design	$ 50,000.00	$ 50,000.00
Phase 1 Activities (After excavation of tailings mass and majority of dam, upstream diversion structures and a small portion of the dam structure left in place to retain and control drainage)	$ 280,000.00	$ 390,000.00
Phase 2 Activities (Following season after completion of Phase 1, and subsequent excavation of remaining dam structures)	$ 140,000.00	$ 170,000.00
Phase 3 Activities (Season after completion of Phase 2)	$ 120,000.00	$ 190,000.00
Sub-Total	**$ 590,000.00**	**$ 800,000.00**
Field Monitoring, Quality Control, Reporting	$ 280,000.00	
Total Dome Creek	**$ 1,670,000.00**	

5. Regrading of cover surface is assumed to be a one (1)-time maintenance item to address uneven settlement.
6. Cost derived from Appendix A.6 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.7-4).
7. Estimated cost for plugging Pony Creek adit was based on the designs and recent construction costs for plugging similar mine adits in the Yukon. Costs are for a massive concrete plug with grouting around the circumference of the adit.
8. Cost derived from Appendix A.7 in Altura's report entitled, "*Common Element and Supplemental Cost Estimates for Conceptual Closure Planning*", November 2010. Total cost for this item has been rounded, consistent with the number provided in the November 2010 Lorax report (Table 5.7-4).
9. Costs for water treatment are an update of Mount Nansen Mine Water Treatment Study (AECOM 2009) and includes both capital and operating costs for the duration of the construction activities.
10. Refer to Table 2-2 for further detail.
11. 15% contingency included to allow for detailed engineering design, consultation, tendering, and resident and off-site contract administration on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).

12. 30% contingency included to allow for design changes and items that have not been identified at the current level of design. Applies to on **construction costs only** (i.e. contingency does not apply to pre-closure investigation or operation, care, and maintenance).
13. Refer to Table 2-1 for further detail.
14. Refer to Section 4.1 and Table 4-1 for further detail.
15. Sum of Items 14 to 18.

4. Life Cycle Costs

4.1 Operation, Care and Maintenance Cost Estimates

Each of the detailed cost estimates provided in Section 3 includes an approximation of potential expenditures associated with operation, care and maintenance. A more detailed presentation is provided in Table 4-1.

Table 4-1: Summary of Predicted Operation, Care and Maintenance Costs by Option

Option	Work Item	Frequency	Assessment Period	Projected Unit Price	Estimated Initial Investment (Net Present Value)
1A	Thermosyphons	50 years	Perpetuity	$ 600,000.00	$ 98,250.00
	Site Monitoring	Annual		$ 100,000.00	$ 2,500,000.00
	Miscellaneous	Annual		$ 200,000.00	$ 5,000,000.00
	Dam Safety Assessments	7 years		$ 70,000.00	$ 225,000.00
Sub-Total Option 1A					**$ 7,823,250.00**
1B	Site Monitoring	Annual	Perpetuity	$ 100,000.00	$ 2,500,000.00
	Miscellaneous	Annual		$ 200,000.00	$ 5,000,000.00
Sub-Total Option 1B					**$ 7,500,000.00**
2A	Thermosyphons	50 years	Perpetuity	$ 600,000.00	$ 98,250.00
	Site Monitoring	Annual		$ 100,000.00	$ 2,500,000.00
	Miscellaneous	Annual		$ 200,000.00	$ 5,000,000.00
	Dam Safety Assessments	7 years		$ 70,000.00	$ 225,000.00
Sub-Total Option 2A					**$ 7,823,250.00**
2B	Site Monitoring	Annual	Perpetuity	$ 100,000.00	$ 2,500,000.00
	Miscellaneous	Annual		$ 200,000.00	$ 5,000,000.00
Sub-Total Option 2B					**$ 7,500,000.00**
3	Site Monitoring	Annual	Perpetuity	$ 75,000.00	$ 1,875,000.00
	Miscellaneous	Annual		$ 100,000.00	$ 2,500,000.00
	Dam Safety Assessments	10 years		$ 70,000.00	$ 150,000.00
Sub-Total Option 3					**$ 4,525,000.00**
4	Site Monitoring	Annual	Perpetuity	$ 50,000.00	$ 1,250,000.00
	Miscellaneous	Annual		$ 100,000.00	$ 2,500,000.00
Sub-Total Option 4					**$ 3,750,000.00**

As indicated in Table 4-1, the estimated operation, care and maintenance costs have been converted to present values. Such estimates represent the total amount of money that would have to be invested today in order to cover the lifetime costs of operation, care and maintenance of the site. Present values are widely used in economics to provide a meaningful, “apples to apples” comparison of cash flows at different times. At this stage of conceptual design, it is assumed that operation, care and maintenance costs should be projected into perpetuity.

4.1.1 Annual Costs

Annual costs, such as those associated with site monitoring (i.e. collection of samples, laboratory analysis, visual inspections) and miscellaneous expenditures associated with maintaining site structures such as tailings covers, tailings dams, etc. are converted to present values through the relation:

$$P = \sum_{n=1}^{n=\infty} \frac{A}{(1+i)^n}; \text{ or } P = \frac{A}{i} * \left(1 - \frac{1}{(1+i)^n}\right)$$

Where:

P	=	Present value
A	=	Annual payment
n	=	Number of time periods
i	=	Interest rate per time period (4%)

Using the above equation, factoring in the specified annual operation, maintenance and care costs (in current year dollars) and a discounted interest rate (i.e. the rate of interest earned on the initial capital expenditure, reduced to account for annual inflation rates) of 4%, the present values of these annual costs, projected into perpetuity can be calculated. Note that the present value of yearly costs projected into perpetuity is simply the equivalent of the annual cost divided by the discount rate.

4.1.2 Periodic Costs

In addition to the abovementioned annual monitoring and maintenance costs, Options 1A, 2A, and 3 also include ongoing periodic expenditures. An allowance has been made in Options 1A and 2A for complete replacement of the thermosyphons associated with the tailings dam. Information available at this time indicates that a reasonable lifespan for the thermosyphons is on the order of fifty (50) years. In addition, periodic dam safety inspections will also be required under Options 1A, 2A, and 3, in accordance with the Canadian Dam Association *Dam Safety Guidelines*, 2007. Dam safety reviews should be conducted at 7 and 10 year intervals for *High* and *Significant* consequence dams respectively. It is unknown at this time whether or not the pit tailings dam included in Option 3 would meet the definitions of the regulation; therefore, it is considered reasonable that such an inspection would be completed every ten (10) years, as opposed to on a seven (7) year frequency as in the case of Options 1A and 2A.

All options include allowances for annual site monitoring (i.e. collection of samples, laboratory analysis, visual inspections) and miscellaneous expenditures associated with maintaining site structures such as tailings covers, tailings dams, etc. Options 1A and 2A include estimates for replacement of the thermosyphons associated with the refurbished tailings dam. The cost of completing periodic dam safety inspections under each of Options 1A, 2A, and 3 have also been provided.

Present values for the periodic expenditures are calculated through the equation:

$$P = \sum_{n}^{\infty} \frac{F}{(1 + i)^n}$$

Where:

P	=	Present value
F	=	Future sum of money
n	=	Number of time periods
i	=	Discounted interest rate per time period (4%)

The above relation indicates that the longer the period of time under study, the lower the initial capital investment required to "earn" the money required for this expenditure due to the term over which interest is allowed to compound. This is evident through comparison of the present values for the dam safety inspections and thermosyphon replacement. Although future costs thermosyphon replacement is expected to cost more than eight (8) times more than the cost of dam safety inspections, the initial investment required to cover perpetual costs is actually lower due to the decreased frequency of expenditure.

4.2 Provisional Cost Estimates

The cost estimates provided in Table 3-1, Table 3-3, Table 3-5, Table 3-7, Table 3-9, and Table 3-11 represent the design solutions proposed under each closure option, in reflection of the current level of knowledge of the site conditions. It is recognized; however, that the Government of Yukon has requested the estimation of costs for the 'worst case scenario', incurred as a result of either unforeseen circumstances or failure of the option as designed. These costs are referred to as provisional costs, and should be differentiated from contingent costs in that the latter have been accounted for on the basis of the limited amount of site data presently available at the pre-feasibility stage of this project. The intent of this report is to provide the Government of Yukon with clarity in terms of the development of those cost estimates that have already been provided for known activities required under each closure option.

The provisional cost estimates have been developed for such items as:

- Temporary collection and treatment of metals contaminated water in the vicinity of the Mill (All Options);
- Temporary collection and treatment of tailings pond water and porewater (Options 1A/B and 2A/B)
- Long term semi-passive biological treatment in Dome Creek valley downstream of tailings dam (Options 1A/B and 2A/B);
- Mitigation of elevated metal concentrations in pit water either via semi-passive biological treatment, or by partially backfilling the pit above the maximum historical elevation of the pit lake (Options 1A/2A);
- Long term collection and treatment of porewater within or downgradient of the pit (Options 3/4); and
- Ground improvements at the toe of the tailings dam (Options 1A/B and 2A/B);

Estimates of provisional costs for water quality mitigation are summarized in Table 4-2 and Table 4-3. As noted in Section 1.2, these costs are intended solely for the purpose of facilitating an estimate of residual risk for each of the Mt. Nansen closure options.

It should be noted that if active treatment is required for multiple aspects of a single option, only one (1) capital investment for a treatment plant is assumed. This is reflected in the costs shown in Table 4-2 and Table 4-3. For the long term costs summarized in Table 4-3, it should be kept in mind that the capital and annual operation and

maintenance (O&M) are estimated based on 2011 costs and conditions; however, issues described in the context of provisional costs may arise at some unknown timeframe following active closure.

Estimates of provisional costs for water quality mitigation summarized in Table 4-2 and 4-3 are based on considerations identified during the course of several discussions amongst Yukon Government Assessment and Abandoned Mines, Lorax, AECOM, Gomm Environmental Engineering Consulting (Gomm), and Altura. The reader is referred to the Altura (2011) memorandum, "*Mount Nansen Mine Site – Provisional Cost Estimates for Water Quality Mitigation*" for further detail.

Table 4-2: Summary of Short Term Provisional Treatment Costs by Option[1]

Closure Option	Item	Capital	Annual O&M
Option 1A/2A	Treatment of Metals (Mill and/or Tailings Area)	$ 2,200,000.00	$ 33,000.00
	Sludge Management	$ 50,000.00	$ 5,000.00
Option 1B/2B	Treatment of Metals (Mill, Tailings Area, and/or Pit)	$ 2,200,000.00	$ 33,000.00
	Sludge Management	$ 50,000.00	$ 5,000.00
	Pit Lake Alternative 2: Semi-Passive Biological Treatment	$ 64,850.00	$ -
	Pit Lake Alternative 3: Staged Backfill	$ 100,000.00	$ -
Option 3/4	Treatment of Metals (Mill, Tailings Area, and/or Pit)	$ - (Allowance in Base Case)	$ - (Allowance in Base Case)
	Sludge Management	$ - (Allowance in Base Case)	$ - (Allowance in Base Case)

Notes:

1. Costs are based on tables and text presented by Altura (2011).

Table 4-3: Summary of Long Term Provisional Treatment Costs by Option[1]

Closure Option	Item	Capital	Annual O&M	Life Cycle Costs (Net Present Value[3])	
				O&M	Replacement (Frequency)
Option 1A/2A	Passive Biological Treatment System, Tailings Area	$ 292,531.00	$ 7,000.00	$ 175,000.00	$ -
	Alternative 1: Semi-Passive Biological Treatment of Pit Lake	$ 64,850.00	$ -	$ -	$ 1,100,000.00 (5 years, assumed)
	Alternative 2: Partial Backfill of Pit with Waste Rock	$ 270,000.00	$ -	$ -	$ -
Option 1B/2B	Passive Biological Treatment System, Tailings area	$ 292,531.00	$ 7,000.00	$ 175,000	$ -
Option 3/4	Long Term Collection and Treatment of Porewater	$ 2,200,000.00[2]	$ 33,000.00	$ 825,000	$ 1,679,000.00 (20 years)
	Sludge Management	$ 50,000.00	$ 5,000.00	125,000	$ 42,000.00 (20 years)

Notes:

1. Costs are based on tables and text presented by Altura (2011).
2. The capital cost for an identical treatment system is incurred during the active closure phase for this option; therefore, an additional expenditure of $2.2M may not be required if the initially constructed treatment system remains on-site and is functional for future use.
3. Calculated using an annual discount rate of 4% over a period of 150 years.

At the request of the Government of Yukon, AECOM has considered additional concepts for stabilizing the Mt. Nansen tailings dam that are not dependent on maintaining permafrost conditions. These measures could be implemented if: (i) it was found that the permafrost could not be maintained, or; (ii) it was determined that a long term stabilization solution, independent of climate change, was desired at present time. A more detailed discussion of the ground improvement alternatives was presented in the AECOM memorandum "*Additional Concepts for the Long-Term Stabilization of Mt. Nansen Tailings Dam*", 2011. As discussed in the memorandum, there are several options for ground improvement. The most economical and appropriate technology is a function of several significant unknowns, the most important being the depth to which improvements are required and the characteristics of in-situ soils. Based on the current level of knowledge of the site, it is not reasonable or meaningful to develop cost estimates for all potential conditions and improvement techniques; however, the cost of installing rockfill caissons to a depth of 12 m has been evaluated as a provisional item for ground improvement. The benefit of rockfill caissons is that they can be constructed while the ground is still frozen, offering flexibility in the timing of implementation. As a result, the uncertainties regarding actively thawing the ground and the associated cost do not require consideration. With input from experienced contractors, AECOM preliminarily estimates the cost of constructing rockfill caissons to a depth of 12 m in consistent, frozen ground conditions to be on the order of $12,500,000. It should be noted that this is a rough estimate that could vary significantly based on ground conditions.

5. Schedule of Capital Expenditures (Active Phase)

Based on the expected duration of construction activities, the schedule of expenditures has been estimated per option. The graphs below show the construction work taking place over the most compressed timeframe possible, one (1) year in most cases and only represent construction phase activities. It is assumed that pre-closure common element costs will be executed in the year prior to initiation of closure activities. Contingent costs are not included.

The cost projections indicate an onset of construction activities on April 1, 2012; however, the schedule can be adjusted in the future when more accurate timelines become available. The timelines shown in this document are reflective of the information provided by Merit Consultants International Inc. in their report dated March 18, 2011.

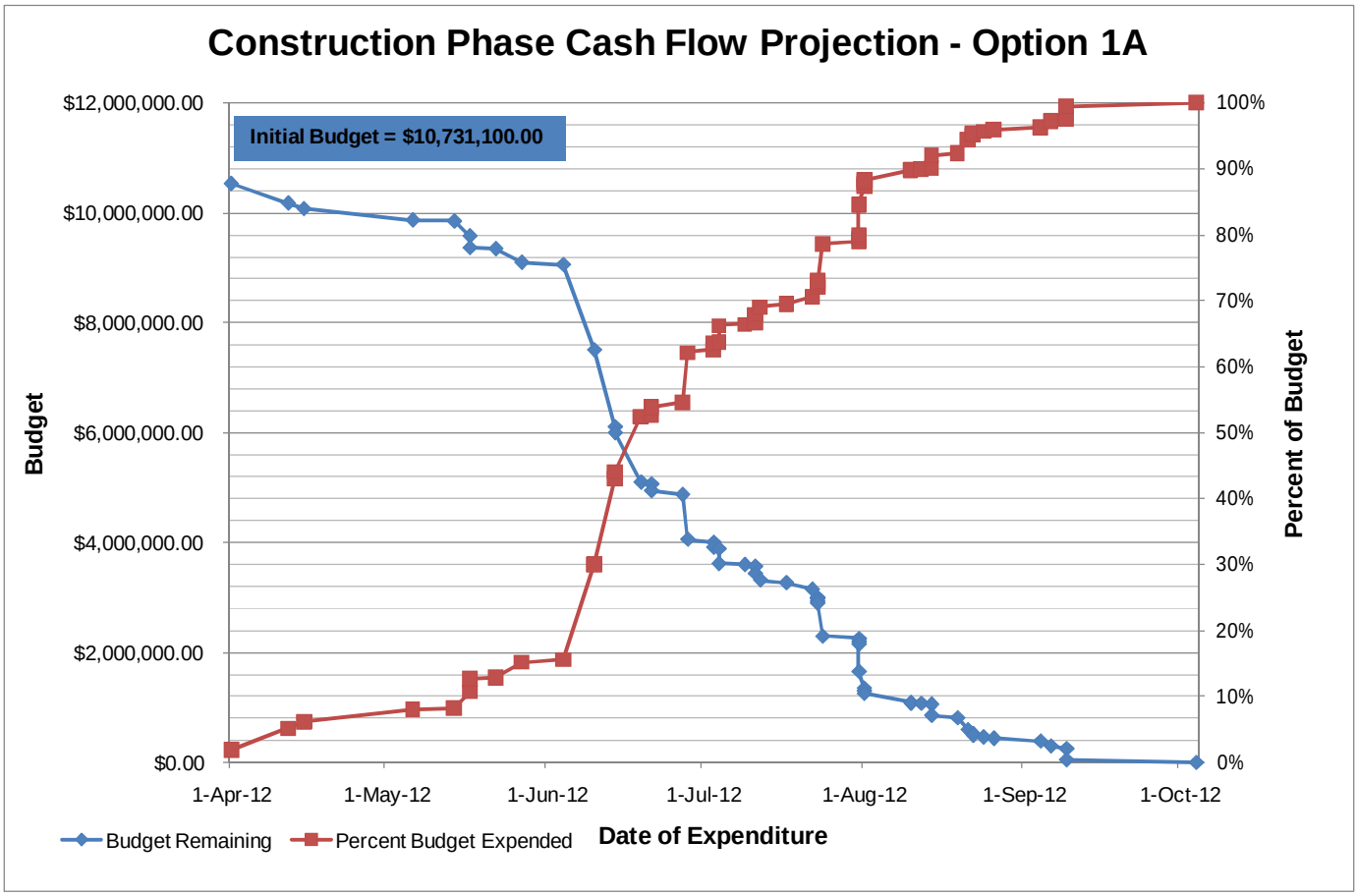

Figure 5-1: Active (Construction) Phase Cash Flow Projection – Option 1A

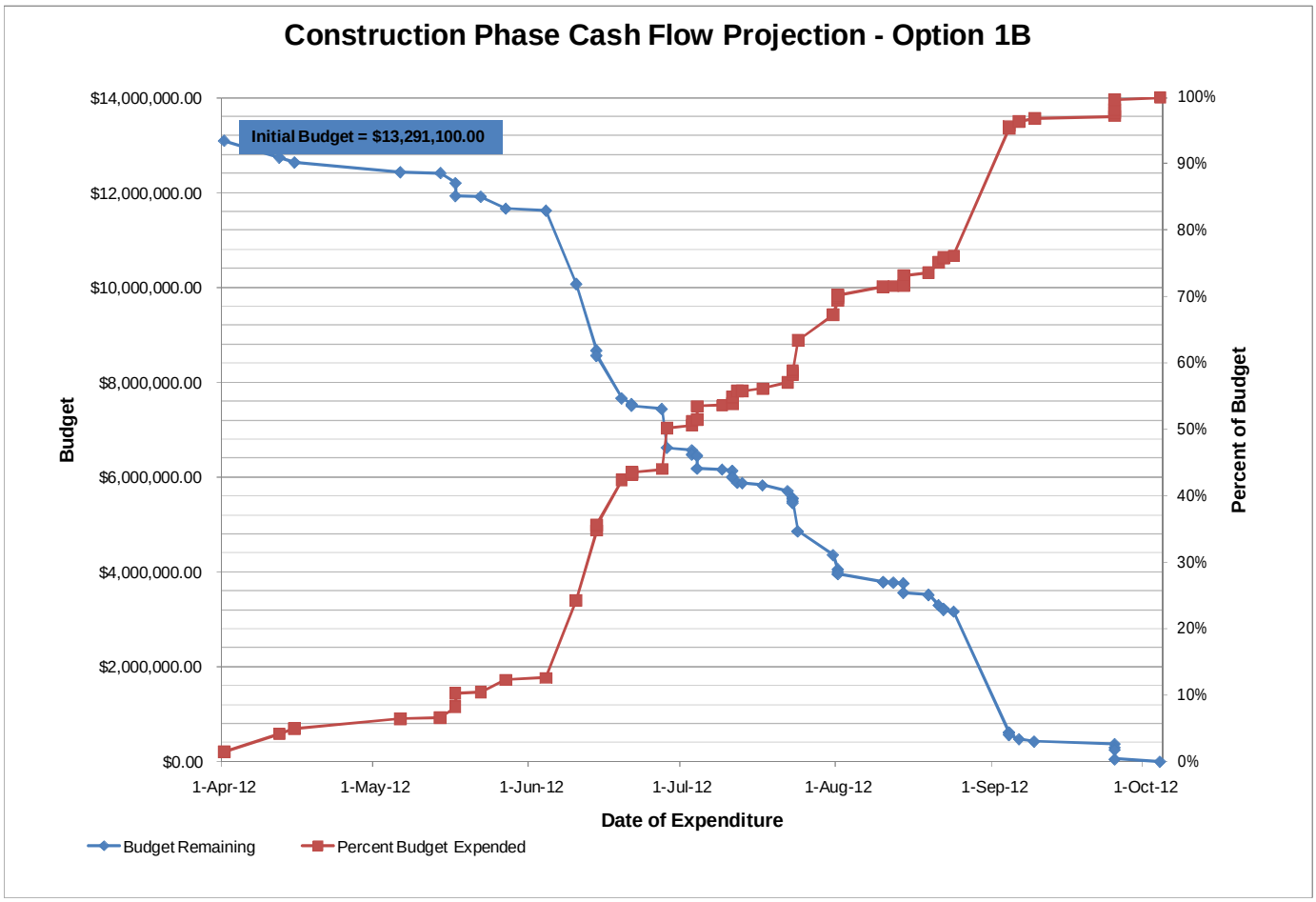

Figure 5-2: Active (Construction) Phase Cash Flow Projection – Option 1B

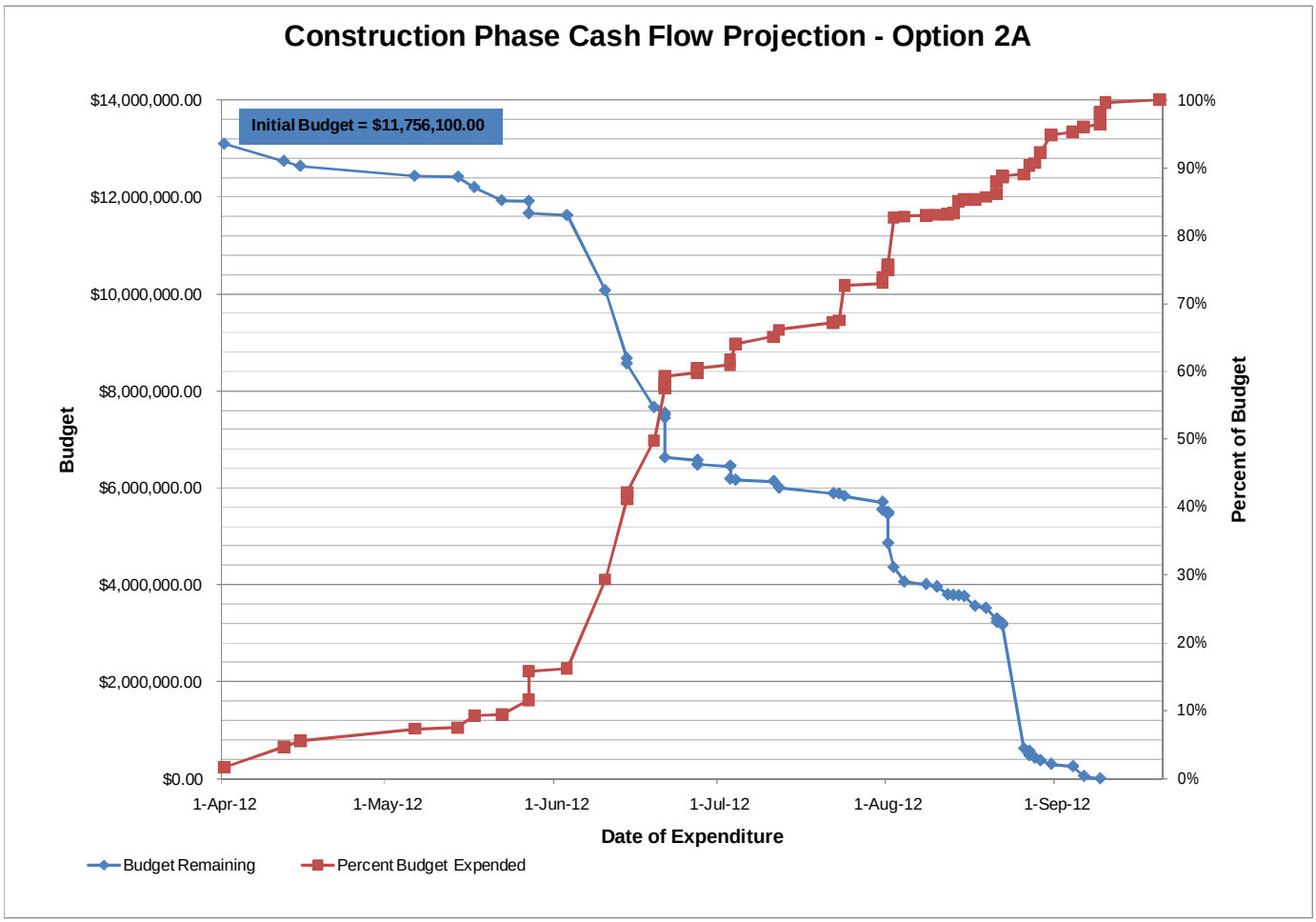

Figure 5-3: Active (Construction) Phase Cash Flow Projection – Option 2A

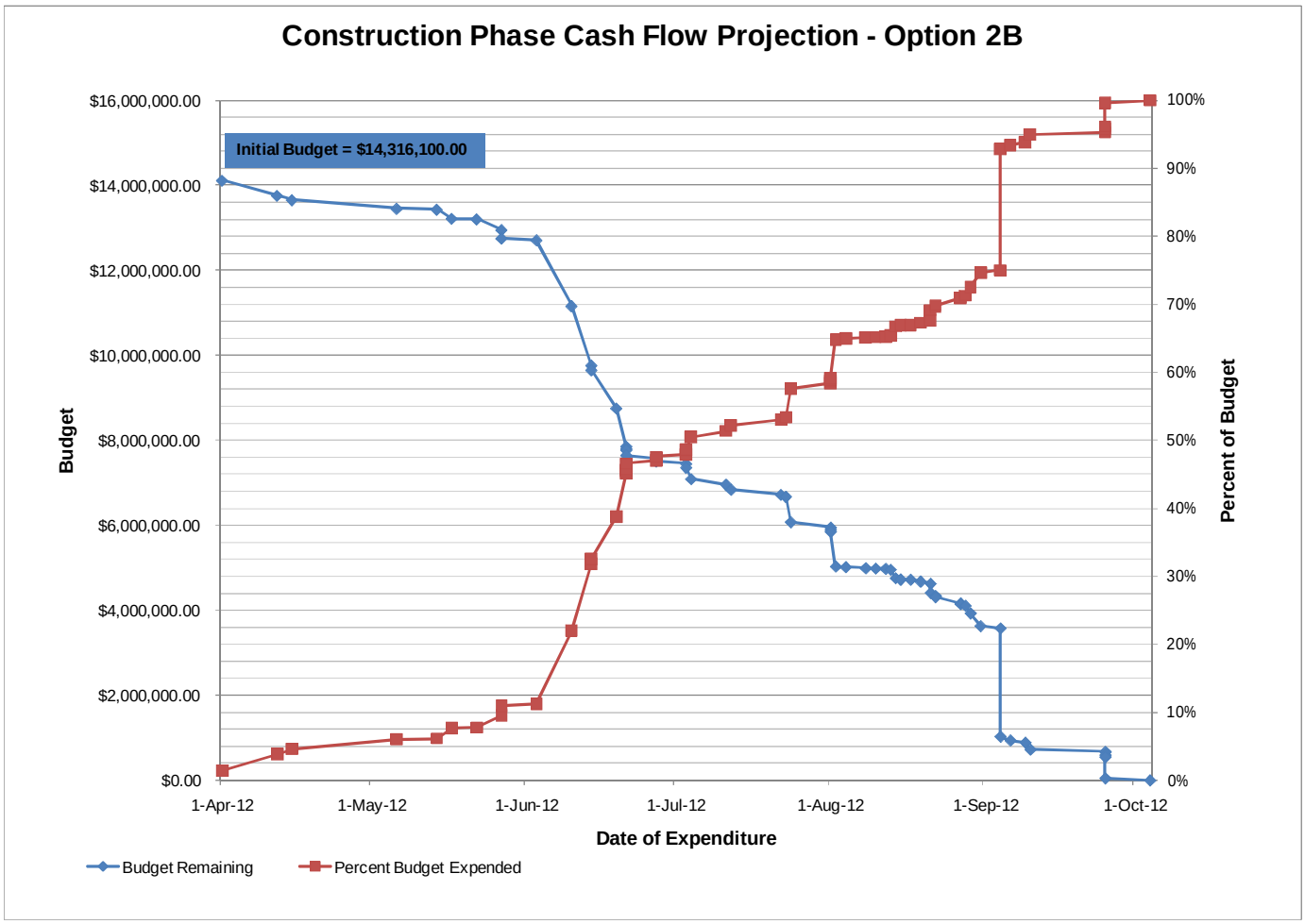

Figure 5-4: Active (Construction) Phase Cash Flow Projection – Option 2B

As shown in Figure 5-1, Figure 5-2, Figure 5-3, and Figure 5-4, current estimates indicate that total expenditure of each Option budget could occur over a one (1) year period, notwithstanding implementation of any provisional items.

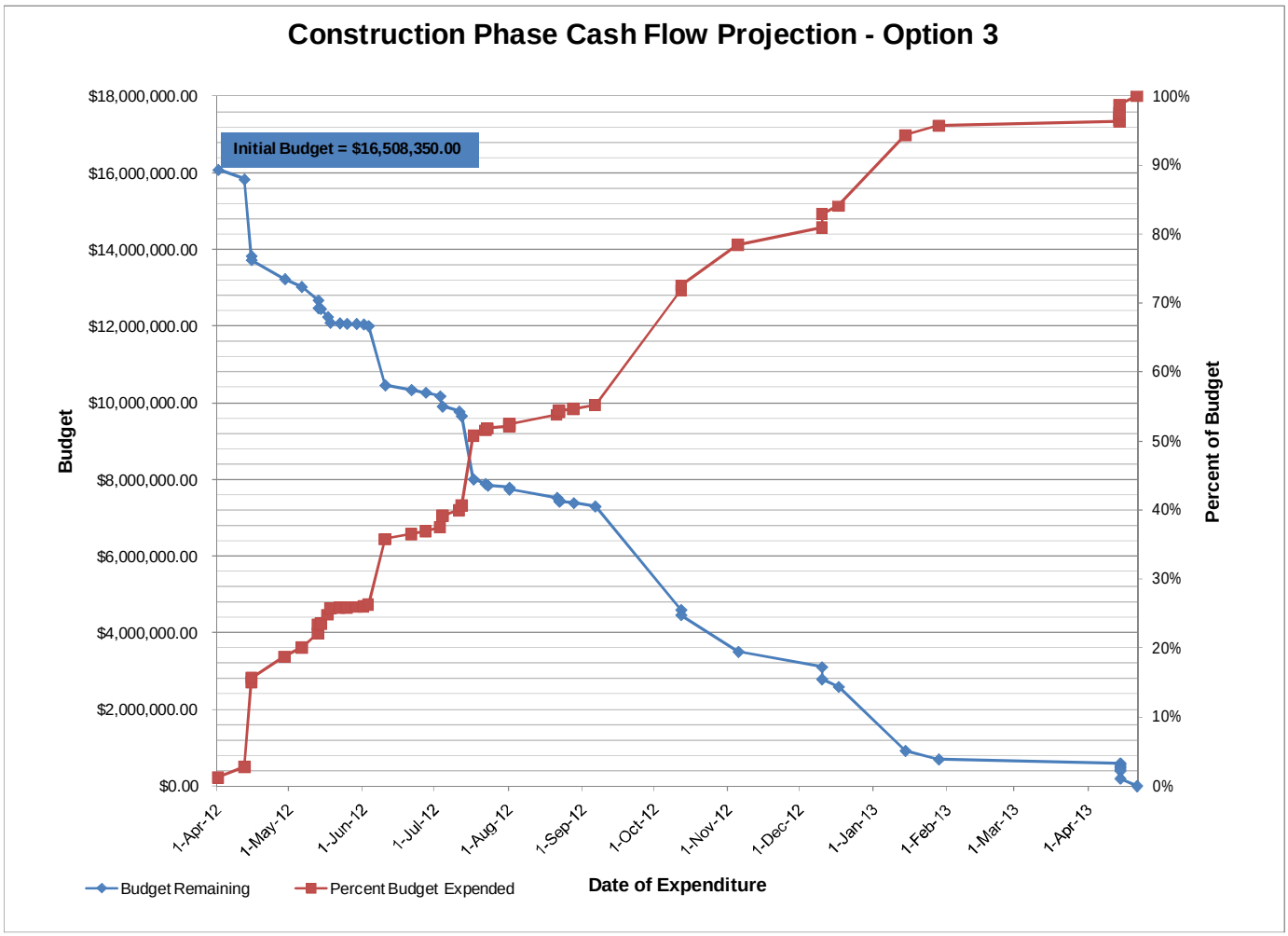

Figure 5-5: Active (Construction) Phase Cash Flow Projection – Option 3

Figure 5-5 projects construction-related expenditures over two (2) fiscal years. The costs of short term treatment of porewater releases in the pit following placement of waste materials or long term provisional water treatment at Dome Creek or Brown-McDade Pit Lake have not been accounted for.

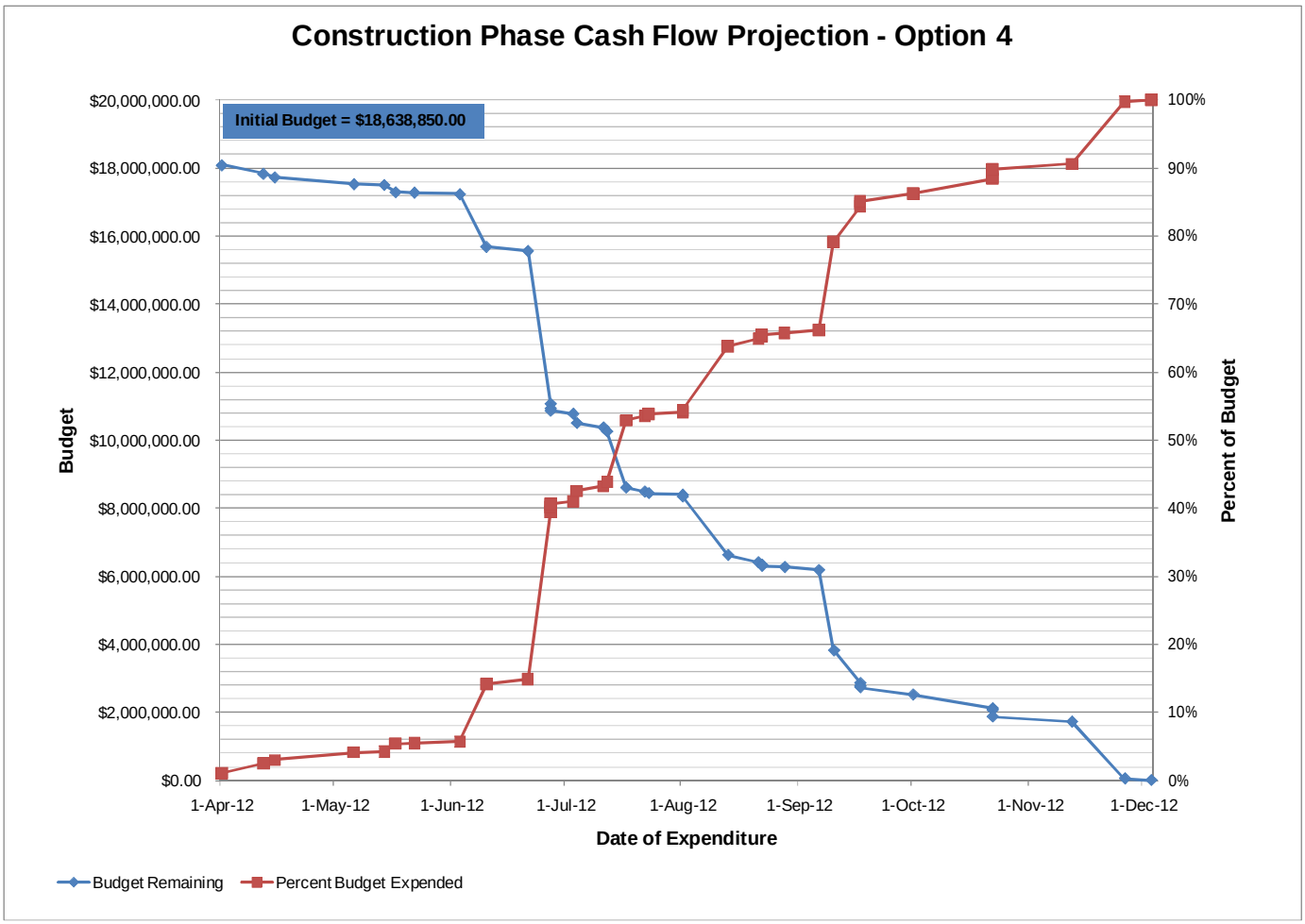

Figure 5-6: Active (Construction) Phase Cash Flow Projection – Option 4

Figure 5-6 projects construction-related expenditures over two (2) fiscal years. The costs of short term treatment of porewater releases in the pit following placement of waste materials or long term provisional water treatment at Dome Creek or Brown-McDade Pit Lake have not been accounted for.

6. Summary of Costs

The following table provides a summary of the Class ‘D’ estimates of all known project costs. It has been developed based on the information provided in Section3. The intent of the summary is to provide a side-by-side comparison of the options. Notwithstanding provisional costing associated with water treatment, the costs estimates indicate that Option 1A is the most economical option.

Table 6-1: Overall Cost Summary - All Options

Work Item/Area	Description	Estimated Cost Option 1A - Tailings Dam Upgrade with Water Cover, Waste Rock Remains in Place	Estimated Cost Option 1B - Tailings Dam Upgrade with Water Cover, Waste Rock in Pit	Estimated Cost Option 2A - Tailings Dam Upgrade with Water Cover, Waste Rock Remains in Place	Estimated Cost Option 2B - Tailings Dam Upgrade with Saturated Soil Cover, Waste Rock Moved to Pit	Estimated Cost Option 3 - Wet Tailings Pumped into Pit and Covered, Waste Rock Left in Place	Estimated Cost Option 4 - Dry Tailings and Waste Rock Placed in Pit and Covered
Mobilization/Demobilization	Mobilization	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00
	Partial Demobilization	$ -	$ -	$ -	$ -	$ 225,000.00	$ 150,000.00
	Final Demobilization	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 50,000.00	$ 75,000.00	$ 50,000.00
Tailings Management Area (TMA)	Construction of Toe Berm	$ 1,508,000.00	$ 1,508,000.00	$ 1,508,000.00	$ 1,508,000.00	$ -	$ -
	Dam Raise	$ 25,000.00	$ 25,000.00	$ 25,000.00	$ 25,000.00	$ -	$ -
	Ground Improvement	$ 1,500,000.00	$ 1,500,000.00	$ 1,500,000.00	$ 1,500,000.00	$ -	$ -
	Dome Creek Diversion into TMA	$ 131,250.00	$ 131,250.00	$ 131,250.00	$ 131,250.00	$ -	$ -
	Restore Tailings Management Area (TMA)	$ 1,940,000.00	$ 1,940,000.00	$ 2,965,000.00	$ 2,965,000.00	$ 3,162,000.00	$ 3,162,000.00
Water Management	Spillway	$ 270,000.00	$ 270,000.00	$ 270,000.00	$ 270,000.00	$ 27,500.00	$ -
	Diversion/Interceptor Ditch Upstream of Spillway	$ 88,000.00	$ 88,000.00	$ 88,000.00	$ 88,000.00	$ -	$ -
	Diversion Channel Downstream of Spillway	$ 500,000.00	$ 500,000.00	$ 500,000.00	$ 500,000.00	$ -	$ -
Waste Rock Area	Reslope, Regrade and Revegetate Waste Rock Storage Area	$ 142,000.00	$ 123,000.00	$ 142,000.00	$ 123,000.00	$ 142,000.00	$ 123,000.00
Open Pit	Plug Pony Creek Adit	$ 250,000.00	$ 250,000.00	$ 250,000.00	$ 250,000.00	$ 250,000.00	$ 250,000.00
	Scale/Flatten Pit Walls	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ -
	Backfill Pit With Waste Rock	$ -	$ 2,603,000.00	$ -	$ 2,603,000.00	$ -	$ 1,720,000.00
	Transport and Place Tailings	$ -	$ -	$ -	$ -	$ 4,700,000.00	$ 4,500,000.00
	Construct In-Pit Tailings Dam	$ -	$ -	$ -	$ -	$ 1,200,000.00	$ -
	Construct Tailings Cover	$ -	$ -	$ -	$ -	$ 315,000.00	$ 2,365,000.00
	Regrade and Repair Cover (i.e. Cover Maintenance)	$ -	$ -	$ -	$ -	$ 105,000.00	$ 215,000.00
	Pit Safety (Signage and Berm)	$ 24,000.00	$ -	$ 24,000.00	$ -	$ 49,000.00	$ 46,000.00
Miscellaneous	Road Construction - Base	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ 45,000.00	$ -	$ -
	Monitoring Instrumentation	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00	$ 200,000.00
	Common Elements - Active Closure	$ 3,657,850.00	$ 3,657,850.00	$ 3,657,850.00	$ 3,657,850.00	$ 3,657,850.00	$ 3,657,850.00
	Water Treatment	$ -	$ -	$ -	$ -	$ 2,000,000.00	$ 2,000,000.00
Contingencies	**Engineering (15% of Estimated Construction Costs)**	**$ 1,609,665.00**	**$ 1,993,665.00**	**$ 1,763,415.00**	**$ 2,147,415.00**	**$ 2,476,252.50**	**$ 2,795,827.50**
	Construction (30% of Estimated Construction Costs)	**$ 3,219,330.00**	**$ 3,987,330.00**	**$ 3,526,830.00**	**$ 4,294,830.00**	**$ 4,952,505.00**	**$ 5,591,655.00**
Pre-Closure Common Elements Cost (Investigation)		**$ 178,000.00**	**$ 178,000.00**	**$ 178,000.00**	**$ 178,000.00**	**$ 178,000.00**	**$ 178,000.00**
Operation, Care and Maintenance (Life Cycle Costs)		**$ 7,823,250.00**	**$ 7,500,000.00**	**$ 7,823,250.00**	**$ 7,500,000.00**	**$ 4,525,000.00**	**$ 3,750,000.00**
Total Estimated Cost		**$ 23,561,345.00**	**$ 26,950,095.00**	**$ 25,047,595.00**	**$ 28,436,345.00**	**$ 28,640,107.50**	**$ 30,954,332.50**

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204 284 2040 fax

Memorandum

To	Patricia Randell, Justin Stockwell	Page	1
CC	Tom Wingrove		
Subject	Tailings Relocation		
From	Kendall Thiessen		
Date	July 4, 2011	Project Number	60159089 (402.12)

The following memorandum discusses the methods of relocating tailings, as a supplement to the "Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives" document prepared for the Government of Yukon(AECOM 2010). The following discussion applies to the Closure Options where the tailings are to be re-located, specifically:

- Option 3: Tailings Backfilled into Pit with High Infiltration Cover, Waste Rock in Place
- Option 4: Tailings and Waste Rock Backfilled into Pit with Low Infiltration Cover

A more detailed description of the Options is included in AECOM (2010). A key performance criteria for Option 3, is that the tailings placed above the water table must meet a specified maximum hydraulic conductivity to support tension saturation. To accomplish this, it has been determined that the coarse and fine tailings must be blended to achieve the required volume of material that meets the specified performance criteria. For Option 3 AECOM (2010) suggested that blending and transporting of the tailings may be done by dredging the tailings with multiple dredges, and mixing of the slurried tailings would occur in-pipe en-route to the pit for placement. The AECOM (2010) geotechnical assessment notes that there may be other methods of blending and transporting the tailings, and gives an example that would involve blending tailings through a series of hoppers and conveyors. The required blending of tailings could probably not be achieved by transporting and placing (partially) frozen tailings by truck. For Option 4, AECOM noted that because the tailings did not require blending, that it may be preferable to transport the tailings by truck during winter, when heavy equipment can move on the frozen crust of the tailings. Slurrying the tailings for Option 4 is not advised, as it would add water to the tailings which are to be stored in a relatively dry condition.

The concept and pricing for excavating, blending, transporting, and placing the tailings for Option 3 and Option 4 were done in consultation with an experienced environmental services contractor who has extensive experience handling tailings, including dredging tailings and transporting tailings in winter via load and haul with trucks.

The volumes of water required for the dredging operation were discussed with the contractor, and it was determined that Dome Creek would be able to supply sufficient water if the water was recycled, and if additional water was collected and stored prior to and during dredging operations. The pit lake

is also an existing source of surface water. The existing tailings pond, with some re-grading and active management may be a suitable short-term reservoir. There are various dredging technologies available and likely a suction type dredge would be used. The contractor may determine that a land based dredging setup would be most suitable, in which case boats or barges would not be required on the tailings pond. A water cover would still be required over the tailings as a water source for the dredging and slurrying.

The costs for relocating the tailings through dredging (Option 3) and load and haul (Option 4) methods were both developed through discussions with an experienced contractor, and therefore can be reasonably compared to each other. The total relocation costs for the two methods are similar.

The water treatment costs for Options 3 and 4 have been assumed to be the same. The greatest cost associated with water treatment is the capital expenditure on the treatment equipment (estimated at approximately $2 million). Comparatively, the operating costs are relatively minor, and differences in short term operating costs are not significant. If the tailings are to be relocated in a slurry, as proposed for Option 3, then the excess water will be recycled, and would not require treatment until the completion of the relocation, when the water would then be treated and released. For both Option 3 and Option 4, there would be a period of water treatment after the placement of the tailings to treat the porewater released during consolidation.

Establishing a performance based specification that establishes a criteria for the final in-situ condition of the tailings may lead to cost savings by allowing the contractor to determine the most effective method of tailings blending, transport and placement. The purpose of the discussions with a contractor was to determine the feasibility of blending the tailings, and the best method of blending, transporting and placing the tailings. At the conceptual design stage, the costs of only one relocation method for each option were investigated.

Please contact the undersigned with comments or questions.

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REFERENCES

AECOM 2010
Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives, November 2010.

Appendix D: Climate and Hydrology Characterization (AECOM)

Yukon

Water

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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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**.

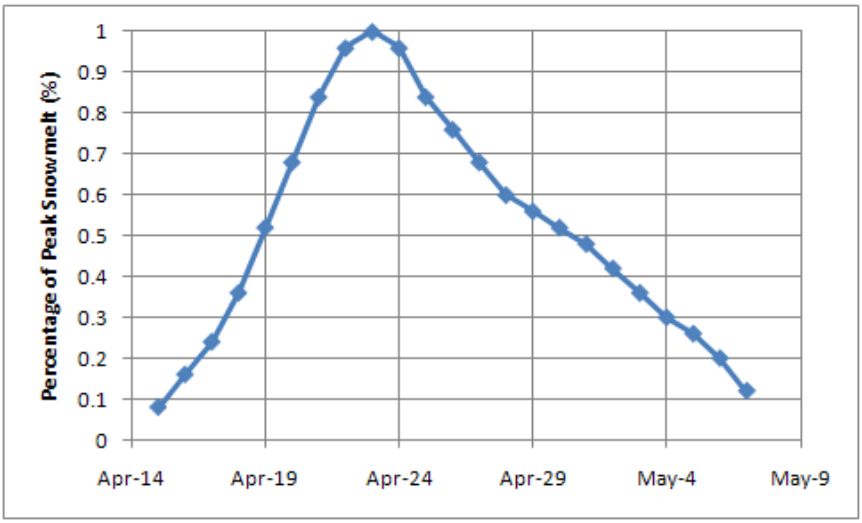

Figure 1: Snowmelt Distribution

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

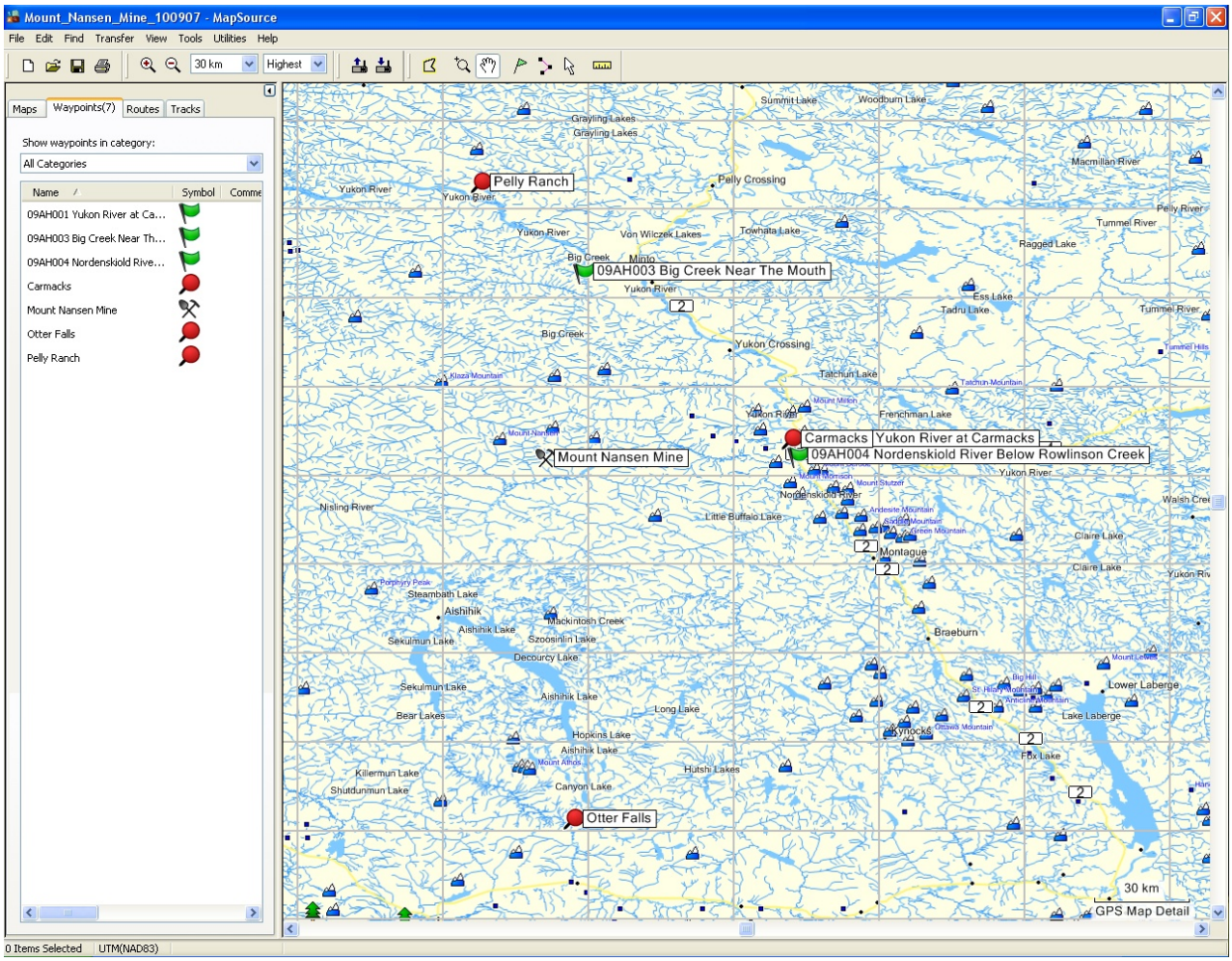

Figure 2: Map Showing Location of Stream Flow Gauge and Precipitation Gauges in Comparison to Mount Nansen Mine

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.

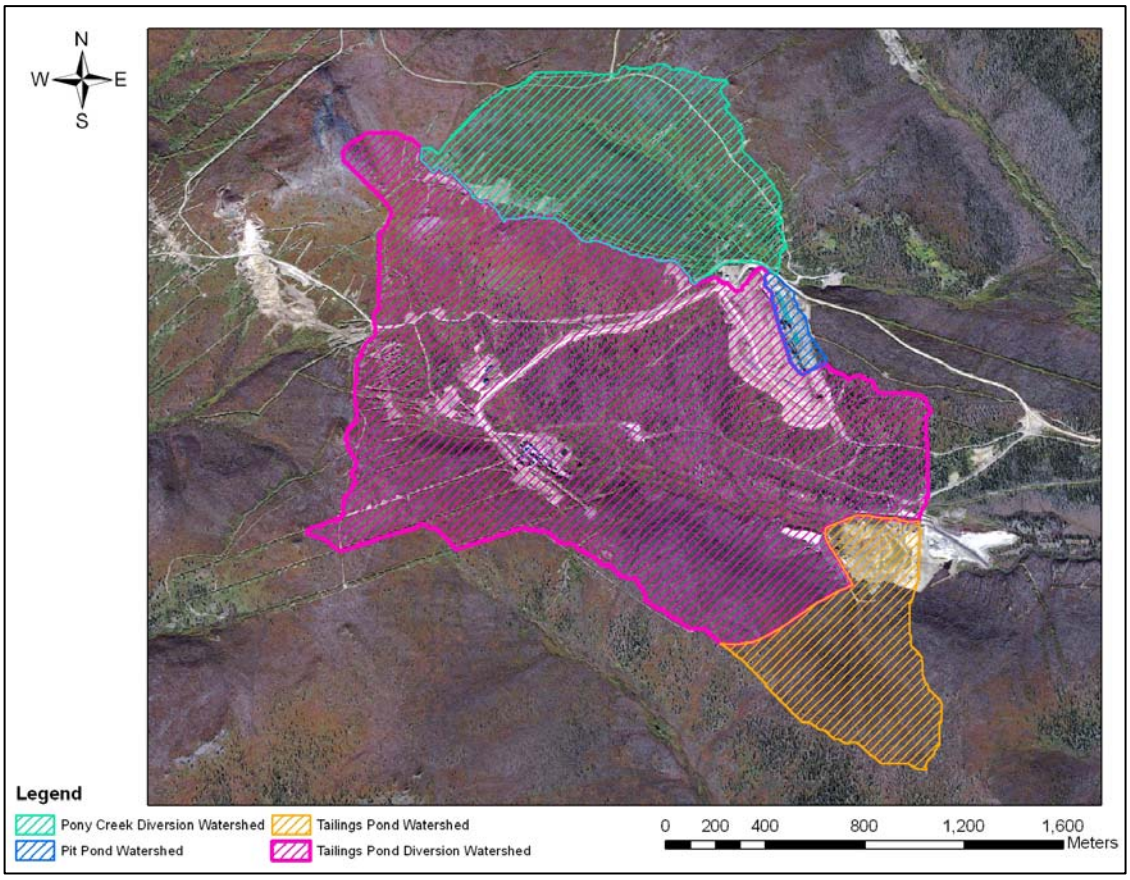

Figure 3: Mount Nansen Water Balance Catchment Areas

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 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	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 = 3.18 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	

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead - AECOM		
Subject	Mt. Nansen Winter Gauging Trip		
From	Kai Woloshyn – AECOM		
Date	April 30, 2010	Project Number	60154930

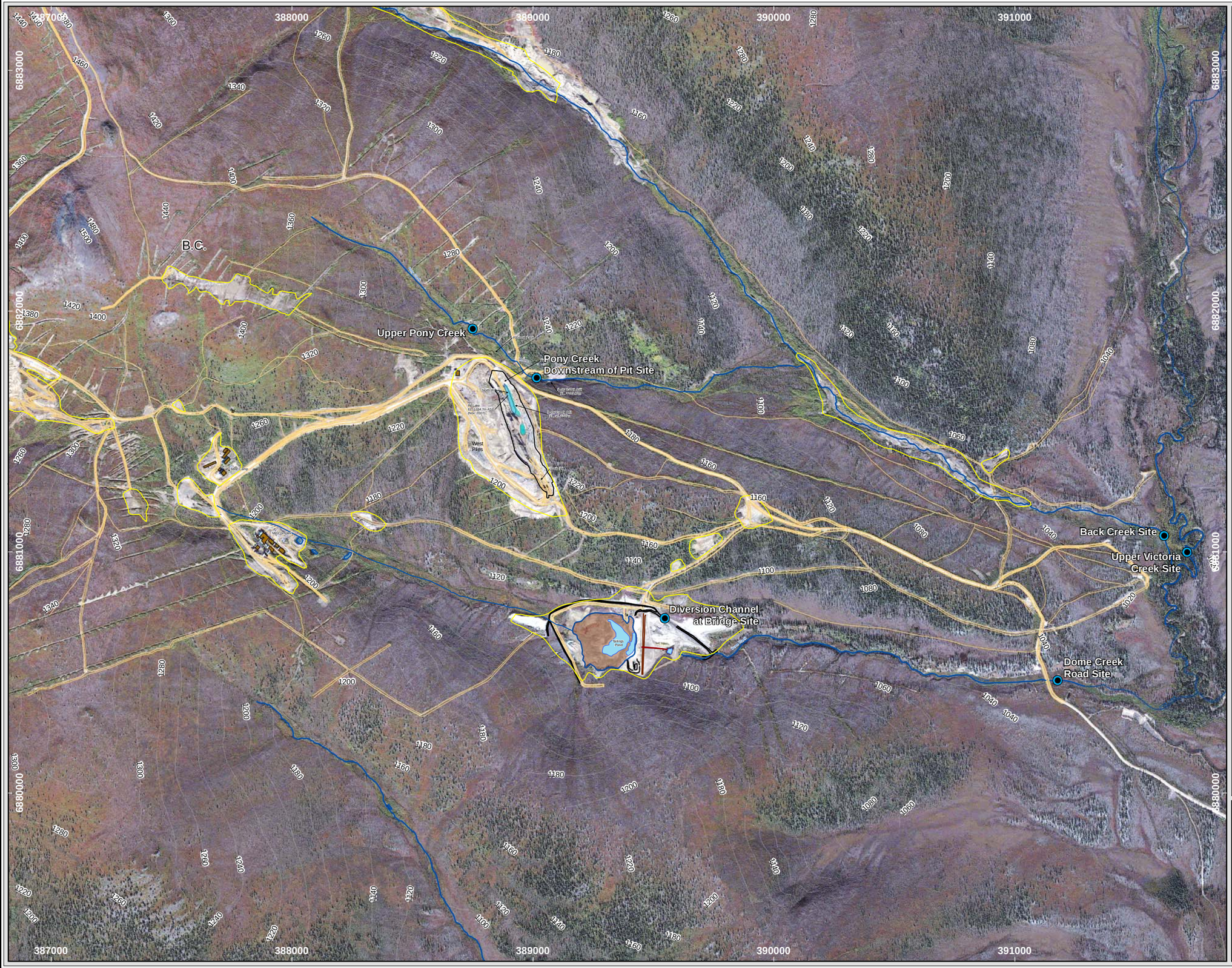
On April 26, 2010, Kai Woloshyn and Emilie Herdes of AECOM travelled to the Mt. Nansen Mine site to carry out winter flow gauging at the Upper Victoria Creek station and complete a maintenance inspection of the hydrometric stations installed by AEOM in 2009. This field memo outlines the work completed and the data collected (Table 1) during the site visit. Figure 1 shows the locations of the six hydrometric stations at the Mt. Nansen Mine. A photolog showing site conditions is also attached.

All of the hydrometric stations were gauged on April 26th with the exception of Back Creek site due to it being frozen to substrate. Visual inspections of the Victoria Creek, diversion channel, and Pony Creek downstream of pit hydrometric stations were completed and no major maintenance is required. The remaining hydrometric stations could not be completely inspected due to them being frozen in ice and will be inspected during the next site visit. Additionally, the meteorological station and barometric data logger were downloaded during the site visit.

Table 1. Field Data Collected - April 26, 2010

Station	Easting	Northing	Elevation	Time	Flow
Back Creek	391635	6880911	1030 m	-	Frozen
Upper Victoria Creek	391672	6880879	1027 m	11:00	262.6 L/s
Diversion Channel at Bridge	389488	6880775	1096 m	13:15	22.7 L/s
Upper Pony Creek	388712	6881940	1226 m	14:15	2.7 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	14:25	5.1 L/s
Dome Creek at Road	391159	6880484	1024 m	14:45	48.4 L/s
Meteorological Station	387756	6881388	1242 m	13:00	N/A

If you have any questions regarding this site visit please contact Kai Woloshyn at 867.633.6474 extension 5744.



Legend

- Gauging Site
- Mining Disturbance
- Pond/Tailings Pond
- Tailings
- Mine Infrastructure
- Road/Trail
- Contour (Index 20m)

Imagery flown September, 2008.
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. All other data, AECOM, 2009.

N
W E
S

0 250 500
Metres

1:15,000

UTM Zone 8N, NAD 83

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Yukon
Government

Mt. Nansen Mine Project
Location: West of Carmacks, Yukon Territory

Hydrometric Gauging Locations

April 2010

AECOM

Figure 1

File Location: W:\GIS\GIS_Proj\Y2010\60146995_MtNansen\MXD\112359_Fig1_MtNanGaugingStations_11x17_rh_30Apr2010.mxd Date Revised: April 30, 2010 Prepared by: RH Project: 112359

Photograph 1. Back Creek station looking upstream.

Photograph 2. Back Creek station looking downstream.

Photograph 3. Upper Victoria Creek station looking upstream.

Photograph 4. Upper Victoria Creek station looking downstream.

Photograph 5. Lower Diversion Channel station looking upstream.

Photograph 6. Lower Diversion Channel station looking downstream.

Photograph 7. Upper Pony Creek station looking upstream.

Photograph 8. Upper Pony Creek station looking downstream.

Photographs 9 & 10. Lower Pony Creek station looking upstream (left) and downstream (right).

Photograph 11. Culvert upstream of Lower Pony Creek station.

Photograph 12. Dome Creek at Road station looking upstream.

Photograph 13. Dome Creek at Road station looking downstream.

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead – AECOM		
Subject	Mt. Nansen Spring Flow Gauging Trip		
From	Emilie Herdes – AECOM		
Date	May 17, 2010	Project Number	60154930

On May 12, 2010, Stephanie Whitehead and Emilie Herdes of AECOM travelled to the Mt. Nansen Mine site to carry out spring flow gauging at the six hydrometric stations installed by AEOM in 2009 and to complete station maintenance. This field memo outlines the work completed and the data collected (Table 1) during the site visit. A photolog showing site conditions is also attached.

All of the hydrometric stations were gauged on May 12th with the exception of Back Creek site due to it being still covered in over one meter of ice. Station maintenance was completed at the Diversion Channel, Upper Pony Creek, Pony Creek Downstream of Pit, and Dome Creek at Road hydrometric stations. The Dome Creek at Road station was replaced entirely at a new location directly across from the previous station's location, as the logger from the 2009 station installation had become completely silted into place. All maintenance that could not be completed was noted and will be completed during the next site visit. Additionally, the Upper Victoria Creek hydrometric station and the meteorological station were downloaded. As requested by the water quality modelling team, a location for a new hydrometric station on upper Dome Creek (above the diversion channel) was established. Only a tentative location could be established as most of the creek was still covered in ice.

Table 1. Field Data Collected – May 12, 2010

Station	Easting	Northing	Elevation	Time	Flow
Back Creek	391635	6880911	1030 m	-	Mostly frozen
Diversion Channel at Bridge	389488	6880775	1096 m	13:45	14.5 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	14:40	4.3 L/s
Upper Victoria Creek	391672	6880879	1027 m	15:25	351.8 L/s
Upper Pony Creek	388712	6881940	1226 m	16:00	5.6 L/s
Dome Creek at Road	391159	6880484	1024 m	17:15	47.1 L/s
Meteorological Station	387756	6881388	1242 m	16:45	N/A

If you have any questions regarding this site visit please contact Stephanie Whitehead at 867.633.6474 extension 5736.

Photograph 1. Back Creek station looking upstream.

Photograph 2. Back Creek station looking downstream.

Photograph 3. Upper Victoria Creek station looking upstream.

Photograph 4. Upper Victoria Creek station looking downstream.

Photograph 5. Lower Diversion Channel station looking upstream.

Photograph 6. Lower Diversion Channel station looking downstream.

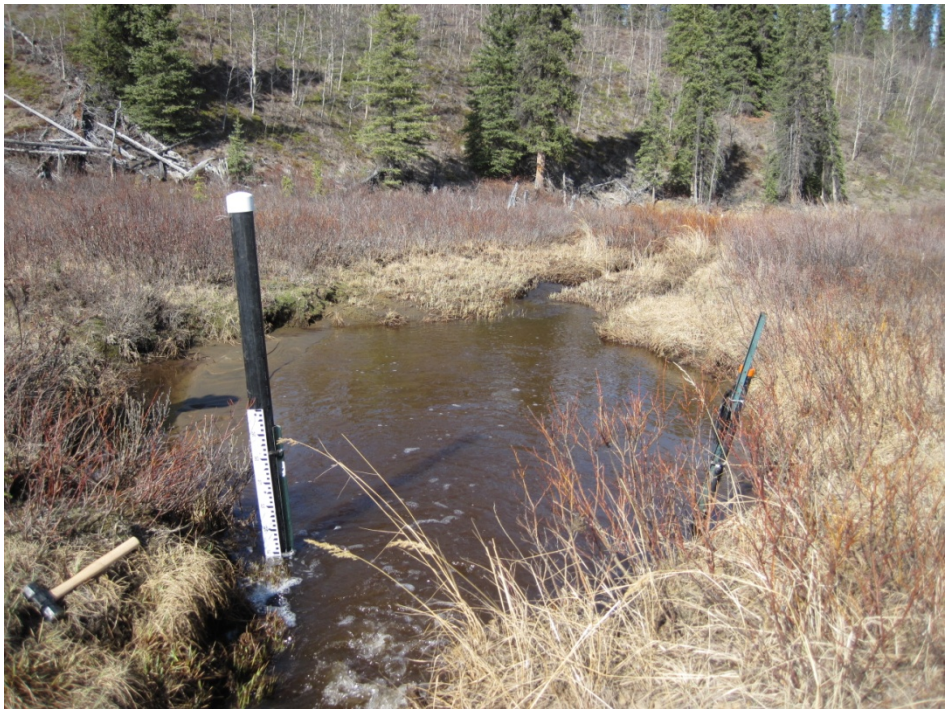
Photograph 7. Upper Pony Creek station looking upstream.

Photograph 8. Upper Pony Creek station looking downstream.

Photograph 9. Lower Pony Creek station looking upstream.

Photograph 10. Lower Pony Creek station looking downstream.

Photograph 11. Dome Creek at Road station looking upstream.



Photograph 12. Dome Creek at Road station looking downstream.

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead, AECOM		
Subject	Mt. Nansen Flow Gauging and Hydrometric Station Installation Trip		
From	Emilie Herdes, AECOM		
Date	June 1, 2010	Project Number	60154930

On May 31, 2010, Emilie Herdes and Eric Cleveland of AECOM travelled to the Mt. Nansen Mine site to carry out flow gauging at the six hydrometric stations installed by AEOM in 2009 and to establish a seventh hydrometric station on upper Dome Creek. This field memo outlines the work completed and the data collected (Table 1) during the site visit. A photolog showing site conditions is also attached.

All of the hydrometric sites were gauged and surveyed on May 31st, including the new site on upper Dome Creek. Station maintenance was completed at the Back Creek hydrometric station which was still covered in ice on previous site visits. Additionally, all six existing hydrometric stations were downloaded. As requested by the water quality modelling team, a new hydrometric station was established on upper Dome Creek above the diversion channel.

Table 1. Field Data Collected – May 12, 2010

Station	Easting	Northing	Elevation	Time	Flow
Diversion Channel at Bridge	389488	6880775	1096 m	14:00	9.0 L/s
Upper Dome Creek	388919	6880769	1120 m	14:30	13.8 L/s
Upper Pony Creek	388712	6881940	1226 m	15:00	1.2 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	15:30	0.9 L/s
Back Creek	391635	6880911	1030 m	16:00	7.5 L/s
Upper Victoria Creek	391672	6880879	1027 m	17:00	217.4 L/s
Dome Creek at Road	391159	6880484	1024 m	17:30	12.6 L/s

If you have any questions regarding this site visit please contact Stephanie Whitehead at 867.633.6474 extension 5736.

Photograph 1 ↑
Upper Dome Creek station looking upstream

Photograph 2 ↑
Upper Dome Creek station looking downstream

Diversion Channel at Bridge station looking upstream

Photograph 4 ↑
Diversion Channel at Bridge station looking downstream

Photograph 5 ↑
Upper Pony Creek station looking upstream

Photograph 6 ↑
Upper Pony Creek station looking downstream

Photograph 7 ↑
Pony Creek downstream of Pit station looking upstream

Photograph 8 ↑
Pony Creek downstream of Pit station looking downstream

Photograph 9 ↑
Back Creek station looking upstream

Photograph 10 ↑
Back Creek station looking downstream

Photograph 11 ↑
Upper Victoria Creek station looking upstream

Photograph 12 ↑
Upper Victoria Creek station looking downstream

Photograph 13 ↑
Dome Creek at Road station looking upstream

Photograph 14 ↑
Dome Creek at Road station looking downstream

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead, AECOM		
Subject	Mt. Nansen End June Flow Gauging Trip		
From	Emilie Herdes, AECOM		
Date	July 5, 2010	Project Number	60154930

On June 30, 2010, Stephanie Whitehead and Emilie Herdes of AECOM travelled to the Mt. Nansen Mine site to carry out flow gauging at the seven hydrometric stations installed by AEOM in 2009 and 2010. This field memo outlines the work completed and the data collected (Table 1) during the site visit. A photolog showing site conditions is also attached.

All of the hydrometric sites were gauged and the seven dataloggers were downloaded on June 30th. Heavy rains occurred the evening before and during the site visit allowing for medium flows to be gauged, one of the goals of the 2010 hydrology program.

Table 1. Field Data Collected – June 30, 2010

Station	Easting	Northing	Elevation	Time	Flow
Upper Dome Creek	388919	6880769	1120 m	11:50	19.7 L/s
Diversion Channel at Bridge	389488	6880775	1096 m	12:35	25.7 L/s
Upper Pony Creek	388712	6881940	1226 m	13:30	6.7 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	13:40	5.7 L/s
Back Creek	391635	6880911	1030 m	14:30	109.5 L/s
Upper Victoria Creek	391672	6880879	1027 m	14:45	1,478.3 L/s
Dome Creek at Road	391159	6880484	1024 m	16:00	59.1 L/s

If you have any questions regarding this site visit please contact Stephanie Whitehead at 867.633.6474 extension 5736.

Photograph 1 ↑
Upper Dome Creek station looking upstream

Photograph 2 ↑
Upper Dome Creek station looking downstream

Photograph 3 ↑
Diversion Channel at Bridge station looking upstream

Photograph 4 ↑
Diversion Channel at Bridge station looking downstream

Photograph 5 ↑
Upper Pony Creek station looking upstream

Photograph 6 ↑
Upper Pony Creek station looking downstream

Photograph 7 ↑
Pony Creek downstream of Pit station looking upstream

Photograph 8 ↑
Back Creek station looking upstream

Photograph 9 ↑
Upper Victoria Creek station looking upstream

Photograph 10 ↑
Upper Victoria Creek station looking downstream

Photograph 11 ↑
Dome Creek at Road station looking upstream

Photograph 12 ↑
Dome Creek at Road station looking downstream

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead, AECOM		
Subject	Mt. Nansen End July Flow Gauging Trip		
From	Emilie Herdes, AECOM		
Date	July 30, 2010	Project Number	60154930

On July 28, 2010, Stephanie Whitehead and Emilie Herdes of AECOM travelled to the Mt. Nansen Mine site to carry out flow gauging at the seven hydrometric stations installed by AEOM in 2009 and 2010. This field memo outlines the work completed and the data collected (Table 1) during the site visit. A photolog showing site conditions is also attached.

All of the hydrometric sites were gauged, the seven water level loggers were downloaded and the barologger was downloaded on July 28th.

Table 1. Field Data Collected – July 28, 2010

Station	Easting	Northing	Elevation	Time	Flow
Upper Dome Creek	388919	6880769	1120 m	13:10	10.9 L/s
Diversion Channel at Bridge	389488	6880775	1096 m	13:30	20.1 L/s
Upper Pony Creek	388712	6881940	1226 m	14:00	7.9 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	14:30	4.8 L/s
Back Creek	391635	6880911	1030 m	15:00	74.5 L/s
Upper Victoria Creek	391672	6880879	1027 m	15:30	661.5 L/s
Dome Creek at Road	391159	6880484	1024 m	16:10	21.7 L/s

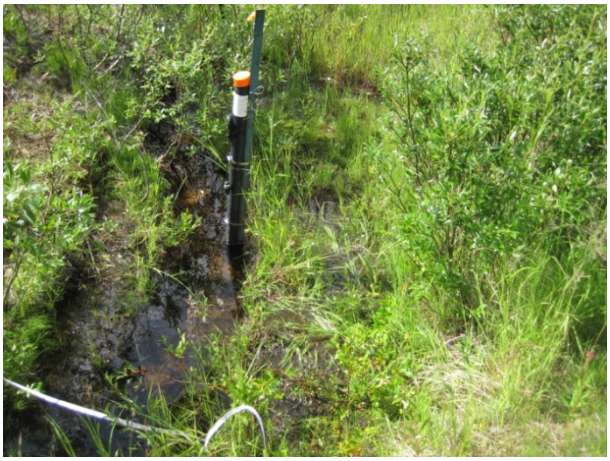
If you have any questions regarding this site visit please contact Stephanie Whitehead at 867.633.6474 extension 5736.

Photograph 1 ↑
Upper Dome Creek station looking upstream

Photograph 2 ↑
Upper Dome Creek station looking downstream

Photograph 3 ↑
Diversion Channel at Bridge station looking upstream

Photograph 4 ↑
Diversion Channel at Bridge station looking downstream



Photograph 5 ↑
Upper Pony Creek station looking upstream

Photograph 6 ↑
Upper Pony Creek station looking downstream

Photograph 7 ↑
Pony Creek downstream of Pit station looking upstream

Photograph 8 ↑
Back Creek station looking upstream

Photograph 9 ↑
Upper Victoria Creek station looking upstream

Photograph 10 ↑
Upper Victoria Creek station looking downstream

Photograph 11 ↑
Dome Creek at Road station looking upstream

Photograph 12 ↑
Dome Creek at Road station looking downstream

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Memorandum

To	Frank Patch, Yukon Government, Assessment and Abandoned Mines	Page	1
CC	Stephanie Whitehead, AECOM		
Subject	Mt. Nansen September Flow Gauging Trip		
From	Emilie Herdes, AECOM		
Date	September 9, 2010	Project Number	60154930

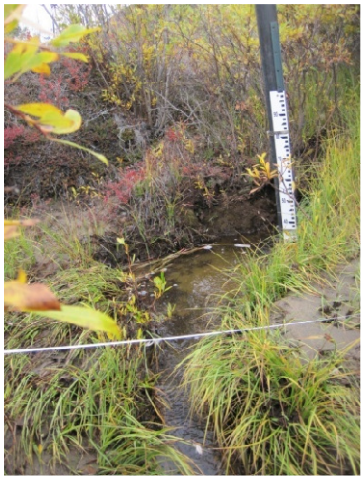
On September 8, 2010, Emilie Herdes and Leia Fougere of AECOM travelled to the Mt. Nansen Mine site to carry out flow gauging and cross-section surveys at the seven hydrometric stations installed by AECOM in 2009 and 2010. This field memo outlines the work completed and the data collected (Table 1) during the site visit. A photolog showing site conditions is also attached.

All of the hydrometric sites were gauged and five of the seven water level loggers and the barologger were downloaded. Two of the level loggers (at Back Creek and Dome Creek at Road) could not be downloaded due to a malfunction of the communication cable. It will be requested that the loggers be downloaded by EDI Environmental Dynamics during their next site visit on September 22nd. A survey of each creek flow gauging cross-section and hydrometric station was also conducted on September 8th to determine how the channels have changed over the season and whether the stations have moved.

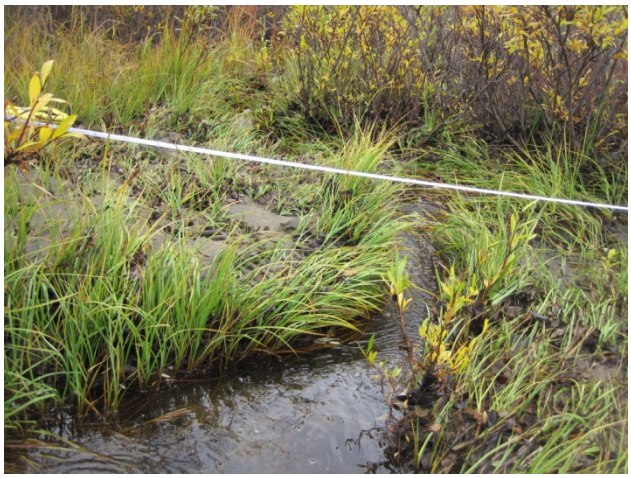
Table 1. Field Data Collected – September 8, 2010

Station	Easting	Northing	Elevation	Time	Flow
Upper Dome Creek	388919	6880769	1120 m	12:05	9.3 L/s
Diversion Channel at Bridge	389488	6880775	1096 m	12:55	27.7 L/s
Upper Pony Creek	388712	6881940	1226 m	14:30	4.7 L/s
Pony Creek d/s of Pit	388977	6881747	1196 m	13:50	6.8 L/s
Back Creek	391635	6880911	1030 m	15:20	95.4 L/s
Upper Victoria Creek	391672	6880879	1027 m	16:00	672.2 L/s
Dome Creek at Road	391159	6880484	1024 m	16:45	56.9 L/s

If you have any questions regarding this site visit please contact Stephanie Whitehead at 867.633.6474 extension 5736.



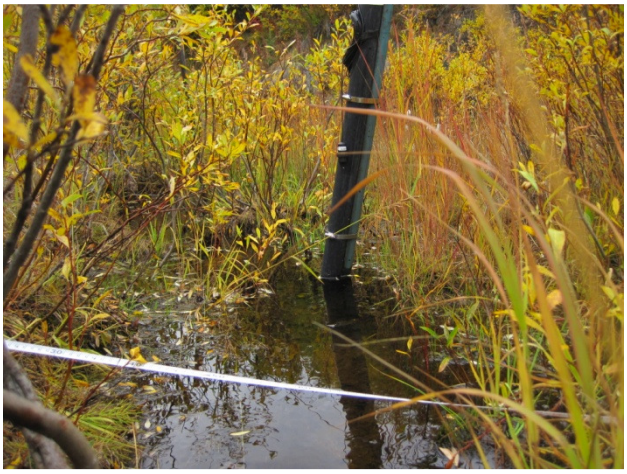
Photograph 1 ↑
Upper Dome Creek station looking upstream



Photograph 2 ↑
Upper Dome Creek station looking downstream

Photograph 3 ↑
Diversion Channel at Bridge station looking upstream

Photograph 4 ↑
Diversion Channel at Bridge station looking downstream



Photograph 5 ↑
Upper Pony Creek station looking upstream

Photograph 6 ↑
Upper Pony Creek station looking downstream

Photograph 7 ↑
Pony Creek downstream of Pit station looking upstream

Photograph 8 ↑
Back Creek station looking upstream

Photograph 9 ↑
Upper Victoria Creek station looking upstream

Photograph 10 ↑
Upper Victoria Creek station looking downstream

Photograph 11 ↑
Dome Creek at Road station looking upstream

Photograph 12 ↑
Dome Creek at Road station looking downstream

Appendix E: Hydrogeology Characterization (AECOM)

Environment

Yukon Government,
Assessment and Abandoned Mines Branch

Hydrogeological Characterization of the Mt. Nansen Mine Site - Draft

Prepared by:

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Date:

October 2010

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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.

9. References

AECOM, 2009:
Memo – Tailings Seepage Collection Pond Water Balance. November 16, 2009.

AECOM, 2010:
DRAFT Geotechnical Assessment and Costing of the Mount Nansen Mine Closure Alternatives. November 2010.

Freeze and Cherry, 1979:
Groundwater. Prentice-Hall, Englewood Cliffs, New Jersey.

Gartner Lee Limited (GLL), 2004:
Draft Water Balance for the Mt. Nansen Mine Pit. Report for Yukon Government, Abandoned Mines. June 2004.

Gartner Lee Limited (GLL), February 2006:
2005 Water Balance for the Mount Nansen Mine Tailings Pond. Report for Yukon Government, Abandoned Mines. GLL 50-382.

Gartner Lee Limited (GLL), May 2007:
Mount Nansen Mine – Brown McDade Pit Desktop Hydrogeological Study. Report for Yukon Government, Abandoned Mines. GLL 70-103.

Gartner Lee Limited (GLL), March 2008:
Hydrogeological Site Characterization at Brown-McDade Pit, Mt. Nansen. Report for Yukon Government, Abandoned Mines. GLL 70-803.

Golder Associates, August 2010:
Assessment of Closure Options and Cover Water Balance for the Mt. Nansen Project, Yukon. Draft Technical Memorandum for Lorax Environmental Services Ltd. August 27, 2010.

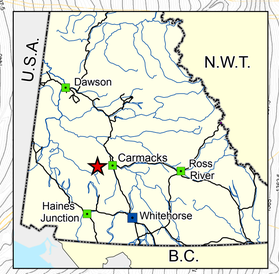
Jackson, L.E., Jr., 1997:
Surficial geology, Victoria Creek, Yukon Territory; Geological Survey of Canada, Map 1876A, Scale 1:100000.

Stroshein, R., 1999:
A summary report on the geology of the Brown-McDade gold-silver deposit, Mount Nansen mine area, Yukon. *In:* Yukon Exploration and Geology 1998, C.F. Roots and D.S. Emond (eds.), Exploration and Geological Services Division, Yukon, Indian and Northern Affairs Canada, p. 231-236.

Stroshein, R., 2009:
Memo – Geological Considerations at the Brown-McDade Open Pit. August 21, 2009.

Yukon Environment, 2010:
Yukon Snow Survey Bulletin & Water Supply Forecast April 1, 2010

Figures



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-DSB dated March 18, 2003. Inferred fault by B.Y.G. Natural Resources, Inc. Waste rock outlines and sample sites, Altura, 2009. 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

File Location: E:\GIS\GIS_proj\Y2010\60159089_MtNansen\By2_Report_Figs\60159089_By02_Fig1_GW_Flow_10Sept20.mxd Date Revised: September 20, 2010 Prepared by: MM Project: 60159089

388700 388800 388900 389000 389100

6882000 6881900 6881800 6881700 6881600 6881500 6881400 6881300 6881200

MP09-01 HBGT GDT HBGT Pony Creek Footwall Fault DDH 98-215 Hanging Wall Fault DDH 98-214 HBGDT Structural zone of weakness High porosity / permeability MP09-02 Pony Creek Footwall Fault LMSc GLL07-01 LMSc MP09-03 GDT MW09-15 LMSb Footwall Fault Pony Creek Adit EL. +/- 1183.43m Weir Location GLL07-02 Bulkhead Location MW09-13 MW09-14 LMSc LMSb Hanging Wall Fault GDT Footwall Fault Pony Creek Adit EL. +/- 1185m HBGDT LMSb LMSa Hanging Wall Fault Pit LMSa GLL07-03 Footwall Fault HBDT Hanging Wall Fault Footwall Fault HBGDT HBGDT LMSa LMSa Qfp Hanging Wall Fault Gneiss

Legend

- Monitoring Well (Gartner Lee, 2007)
- Mini Piezometer (AECOM, 2007)
- Monitoring Well (AECOM. 2009)
- Adit Path
- Road/Trail
- Exploration Borehole (BYG,1998)
- Dip Direction
- Fault Split Direction
- Geologic Contact
- Inferred Fault
- Pit Limits
- Pit Contour (Index 2.5m)

Contour (Interm. 0.5m)

- Contour (Interm. 0.5m)
- Exploration Trench Spoils

Contours (Except Pit)

- Contour (Index 5m)
- Contour (Interm. 1m)

Geology

- Mineralized zone
- Qfp - Quartz feldspar porphyry
- Igneous intrusives
- HBGDT - Hornblende Granodiorite
- HBDT - Hornblende Diorite
- GDT - Granodiorite
- Layered Metamorphic Sequence
- LMSa - Layered Metamorphic Sequence (gneiss/schist)
- LMSb - Layered Metamorphic Sequence (quartzite / calc. quartzite)
- LMSc - Layered Metamorphic Sequence (weathered quartzite / gneiss / schist)

N W E S

0 12.5 25 50

Meters

1:1,000

UTM Zone 8N, NAD 83

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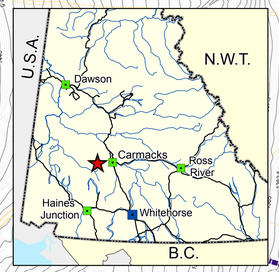
Project: Mt. Nansen Site Investigation

Brown-McDade Pit Geology

September 2010

AECOM

Figure 2



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

- Inferred Deep Groundwater Flow Direction
- Inferred Deep Groundwater Contour (metres)
- Inferred Deep Groundwater Flow Divide

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, 2009. All other data, AECOM, 2009.

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Project: Mt. Nansen Site Investigation

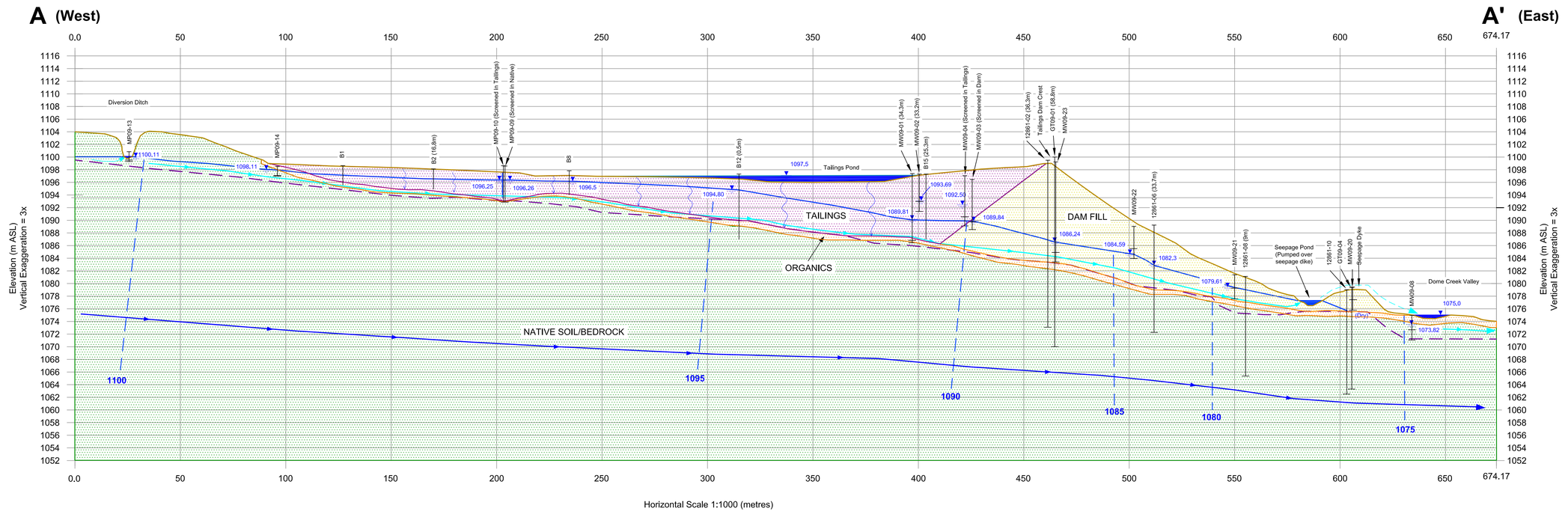
Conceptual Groundwater Flow

September 2010

AECOM

Figure 3

File Location: E:\GIS\GIS_proj\Y2009\112359_MtNansen\By16_GW_Flow\60119144_By16_Fig2_GW_Flow_09Dec15.mxd Date Revised: December 15, 2009 Prepared by: MM Project: 60159089



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.

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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

Date Plotted: September 20, 2010 File Location: E:\GIS\GIS_proj\YG\60159089_MtNansen\By2_Report_Flp\60159089_By02_Flp4_Nansen_Profiles_AA_BB_10Sept20.dwg

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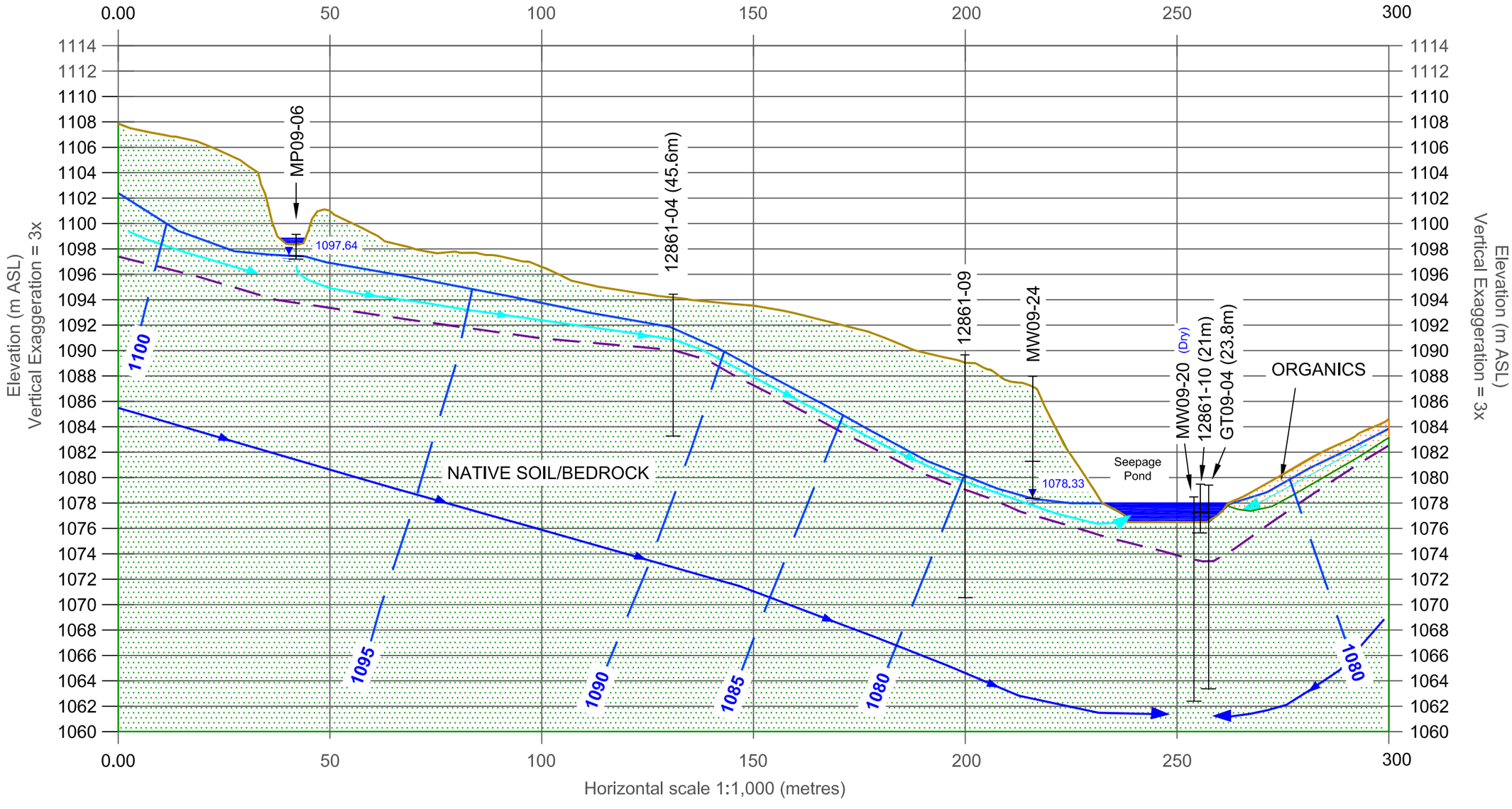
B (North) — B' (South)



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ALL MEASUREMENTS MUST BE OBTAINED FROM STATED DIMENSIONS.

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Legend

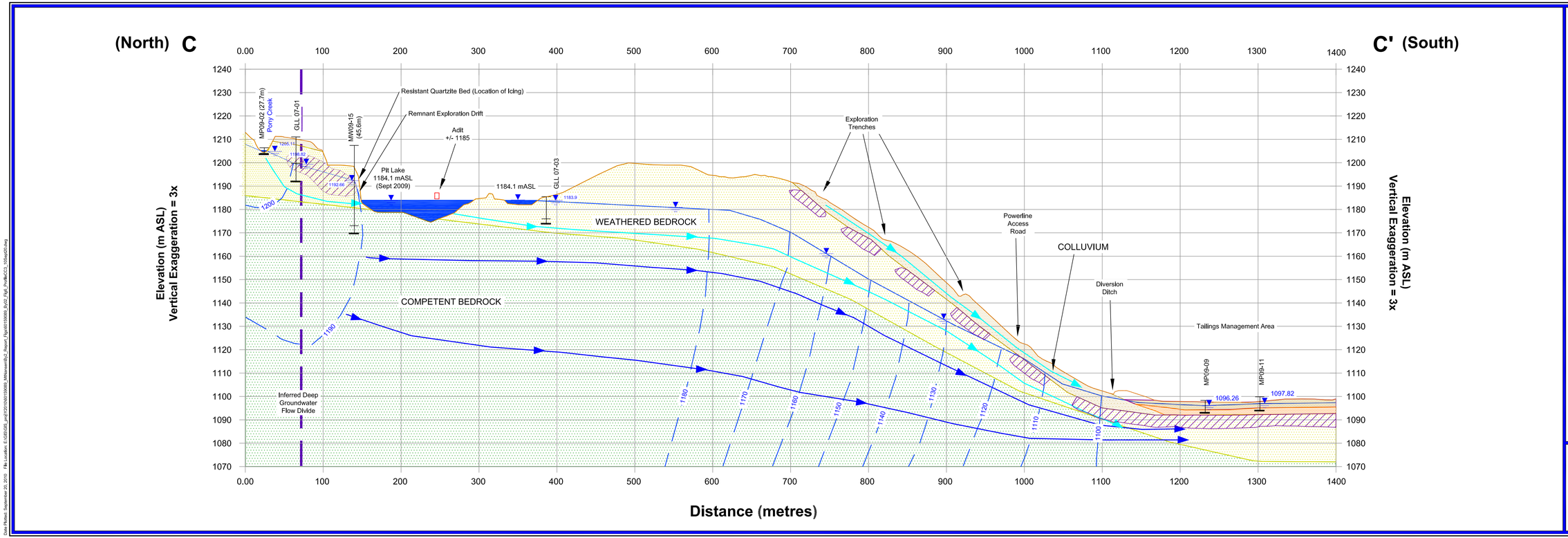
- Monitoring Well
- Top of Screen
- Bottom of Screen
- Inferred Groundwater Elevation (Deep Aquifer)
- 1079.81 Inferred Groundwater Level
- Ground Surface
- Inferred Top of Permafrost (0° isotherm)
- Organics
- Native Soil / Bedrock
- Inferred Groundwater Equipotential Line
- Inferred Shallow Groundwater Flow Direction
- Inferred Deep Groundwater Flow Direction

AECOM

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



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
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Reviewed by: RM Prepared by: MM
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')

AECOM

Figure 6

Date Plotted: September 20, 2010 File Location: E:\GIS\GIS_proj\1\2010\60159089_MtNansen\By2_Report_Figs\60159089_By02_Fig6_ProfileCC3_10Sept20.dwg

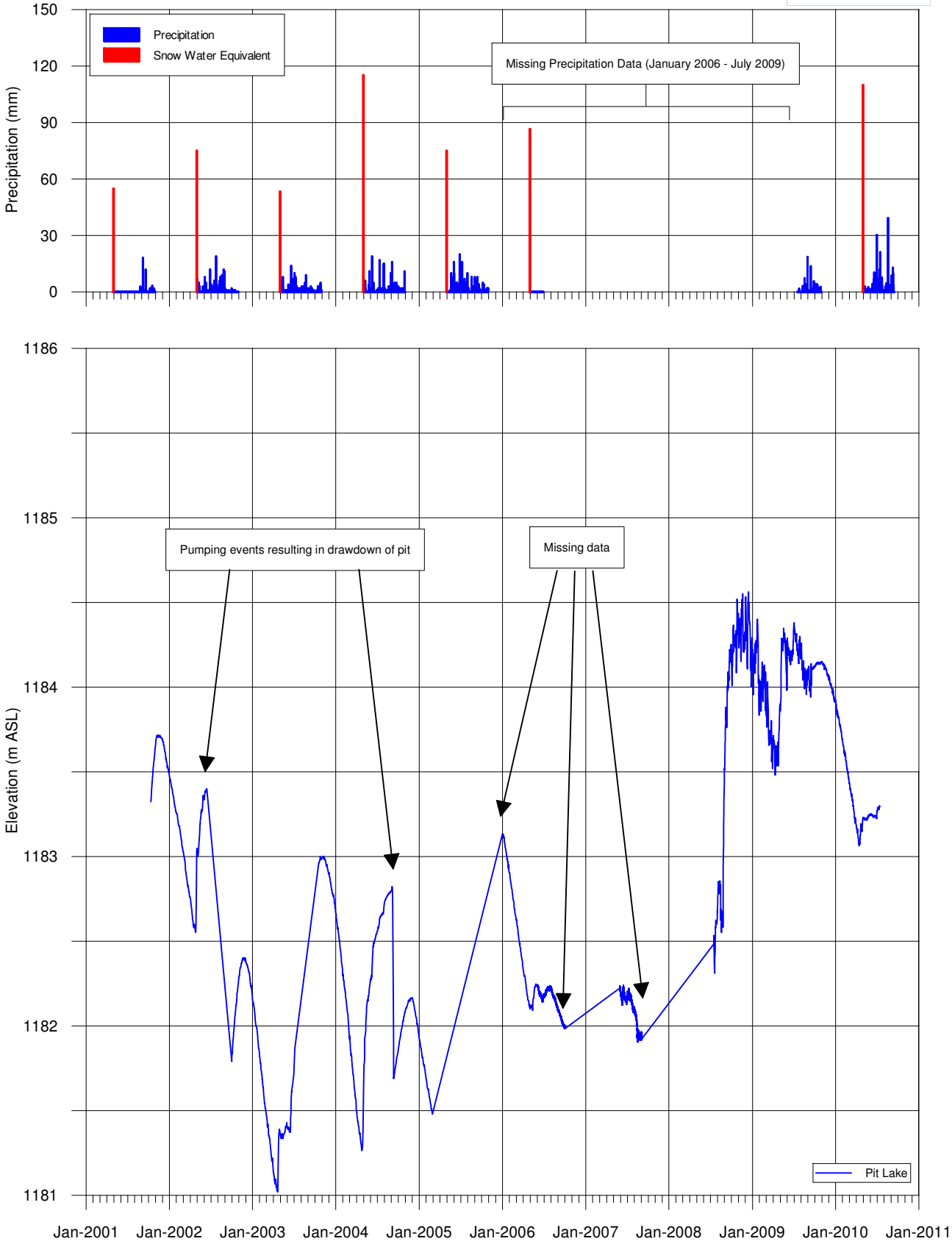


Figure 7. Brown-McDade Pit Lake Elevation (2001 - 2010)

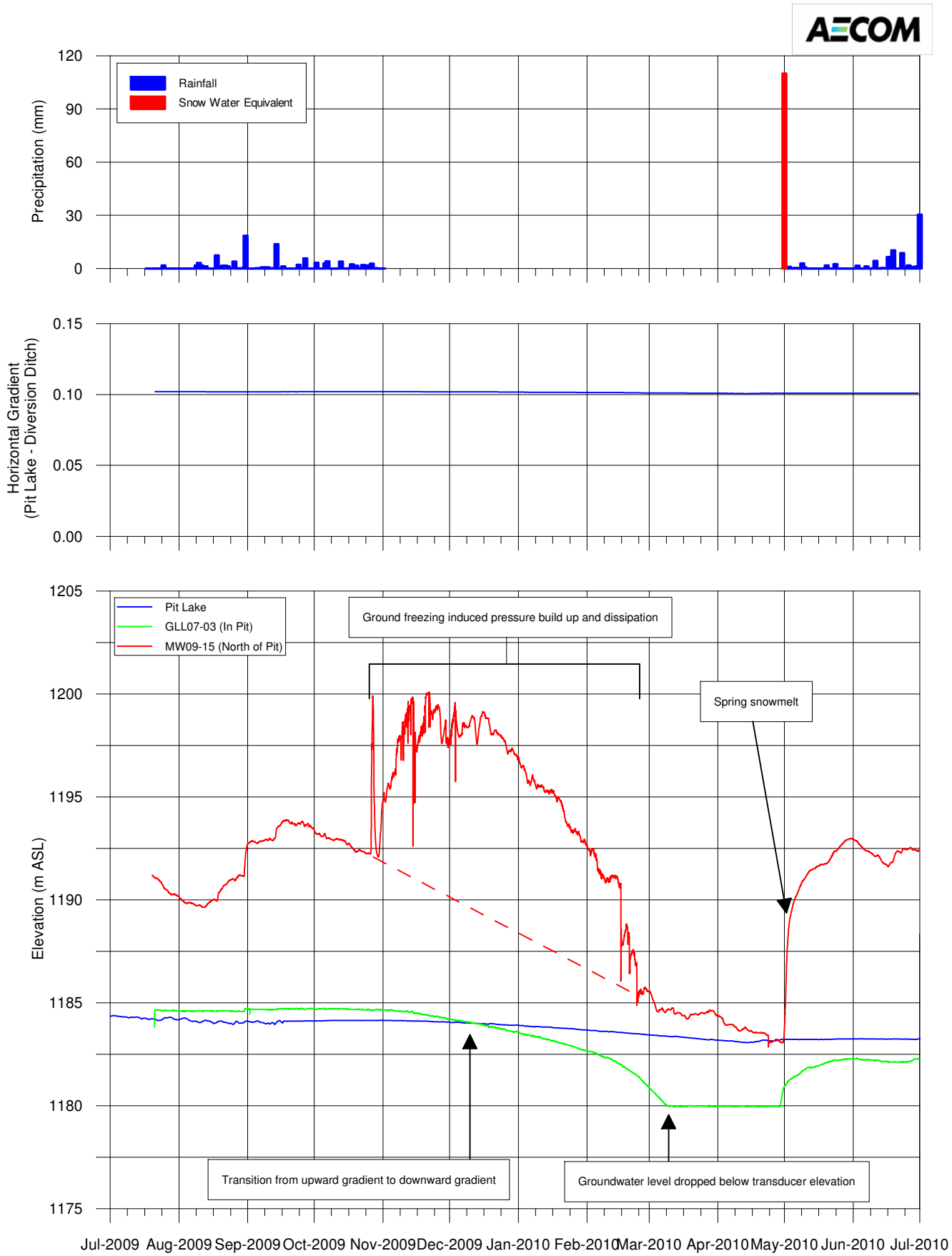


Figure 8. Brown-McDade Pit Lake and Groundwater Elevations (2009 - 2010)

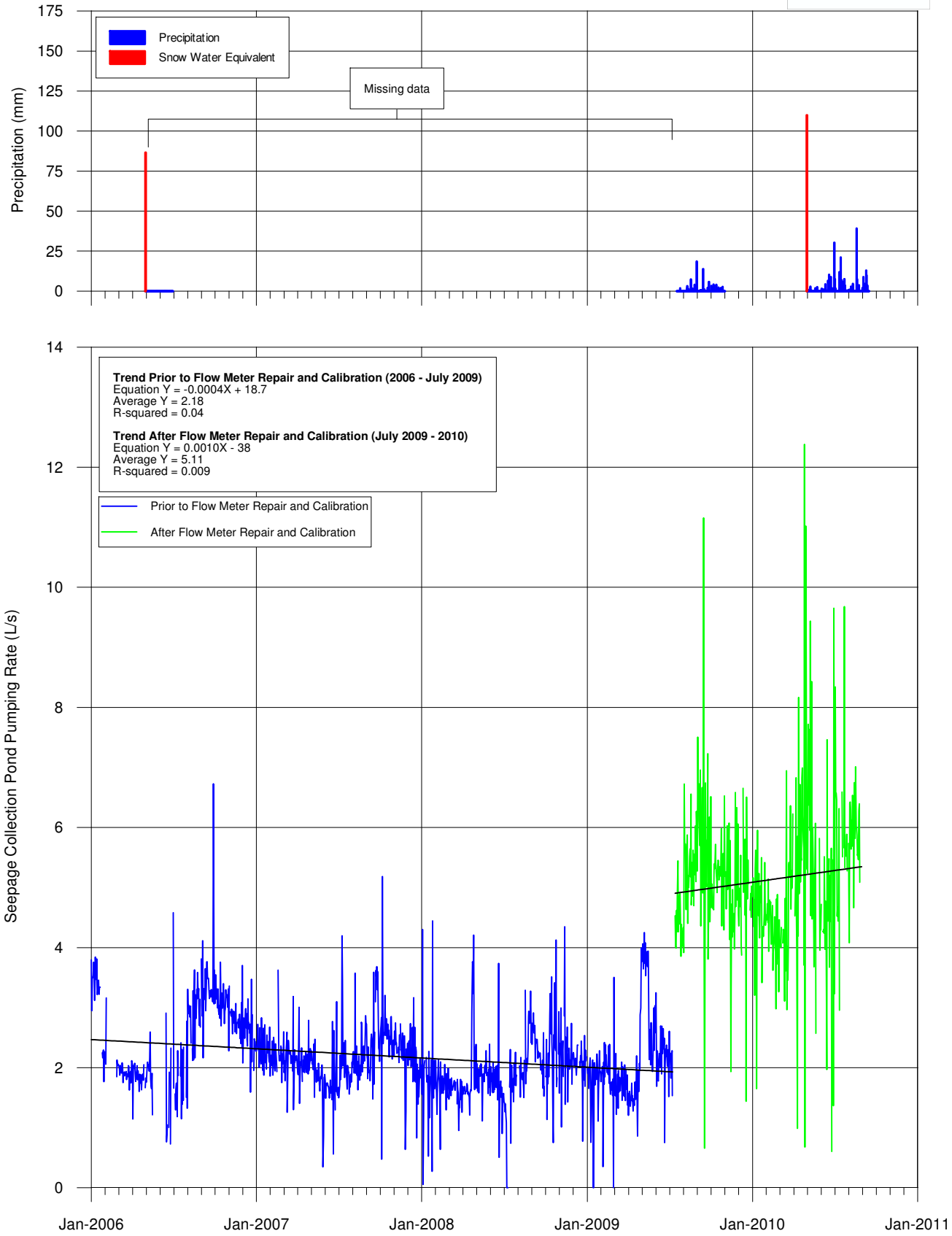


Figure 9. Precipitation and Seepage Collection Pond Pumping Rates (2006 - 2010)

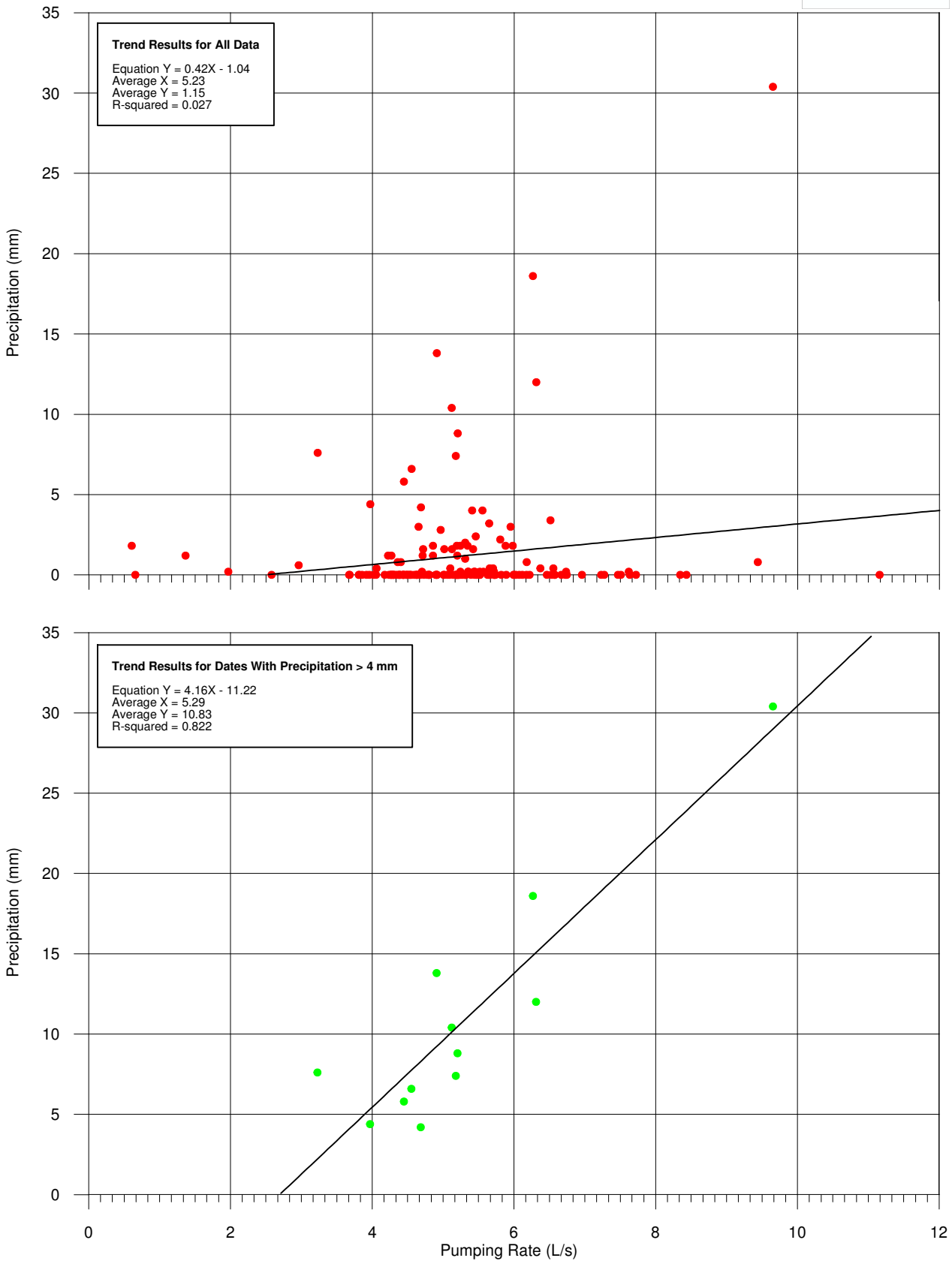


Figure 10. Correlation of Precipitation and Seepage Collection Pond Pumping Rates (2006 - 2010)

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.*

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 *fFet 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)

AECOM

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	***162***	<10	<10	11	***898***	<10
Arsenic (As)	20	20	***1980***	***65.7***	***103***	***285***	***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	***8260***	<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*

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***	***0.0834***
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.

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

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
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											1095
5	FILL										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											1088
12	FILL										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
15	FILL										

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 / 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				1070
30											

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: Marc Lavigne	COMPLETION DEPTH: 30.18 m
	REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
	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: **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 / 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

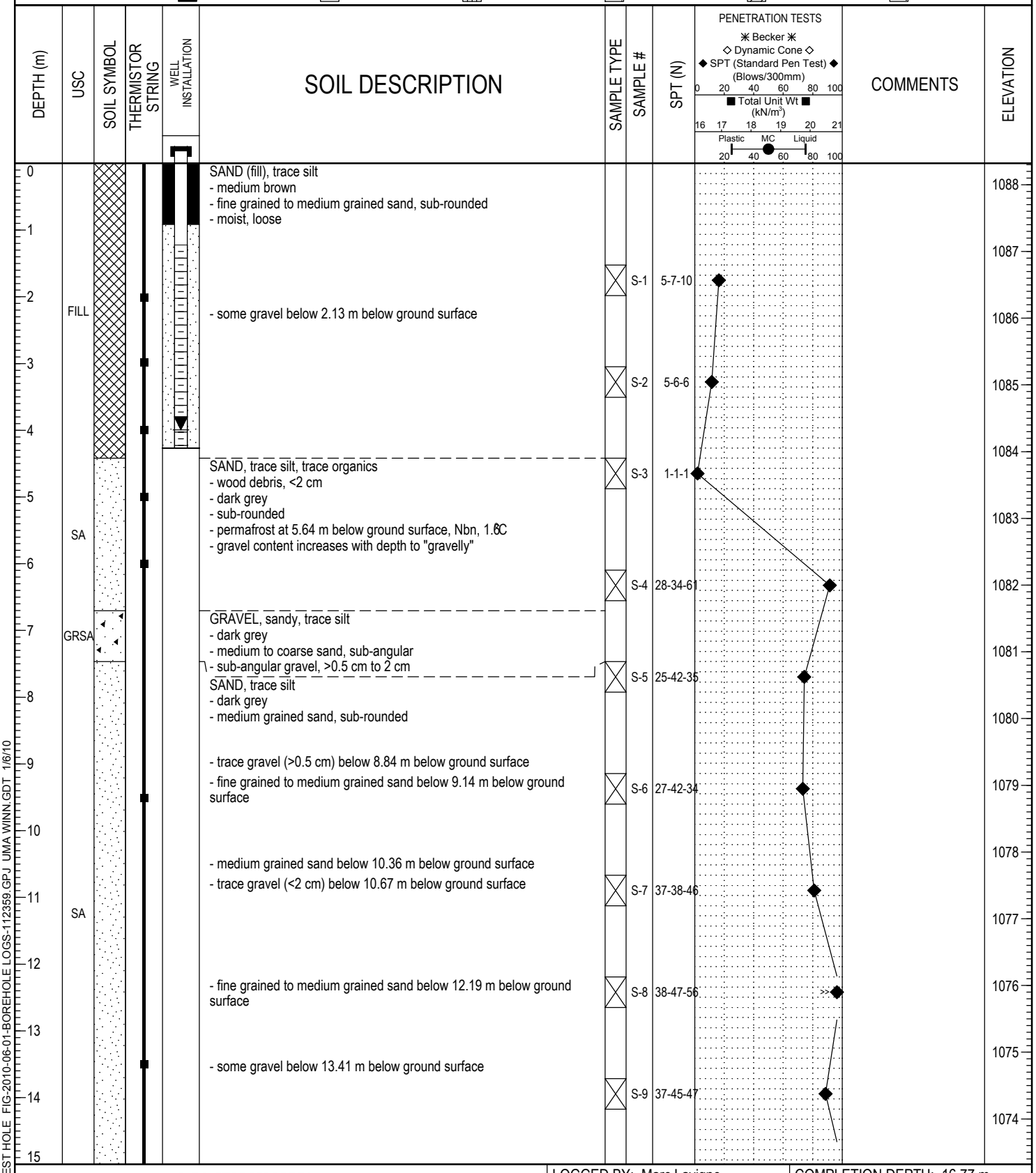
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 19/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

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 / MW09-22**
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



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 / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
15	SA				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			1073
16	GRSA				END OF DRILLING at 16.77 m in permafrost (refusal) 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) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.77 m below ground surface						1072
17											1071
18											1070
19											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

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						
				- medium grained sand, sub-angular						
1				- sub-angular gravel, 0.5 cm to <1.5 cm						1089
				- clast supported						
				- staining on gravel						
				SAND (Aeolian), trace silt, trace gravel		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						
						S-2	4-5-5			1087
4										
	SA									1086
						S-3	3-4-5			
5										
										1085
				- some gravel below 5.33 m below ground surface						
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
						S-5	4-7-5			
8	GRSA			SAND and GRAVEL, trace silt						
				- light brown-orange						1082
				- moist, compact						
				- medium grained sand, sub-rounded						
9	SA			- sub-angular gravel, >0.5 cm to 2 cm						
				- iron staining on gravel						1081
				SAND, trace gravel, trace silt (Aeolian)		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		S-7	6-8-4			
				SAND, trace gravel, trace silt						1079
12	SA									1078
				- some gravel below 12.19 m below ground surface		S-8	4-5-10			
13										1077
				SAND and GRAVEL, trace silt		S-9	3-7-2			
14	GRSA			- coarsening downward sequence						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 / Total Unit Wt / 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 - permarfrost 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										

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

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 2 of 2

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 / Plastic MC Liquid	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, -0.3°C, 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										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					- gravel content decreases to become SAND, gravelly, trace of silt		G-7				1068
12											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 / Plastic MC Liquid	COMMENTS	ELEVATION
15	SA				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	GRSA				END OF DRILLING at16.23 m in permafrost (refusal) 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) Thermistor install: - 1" PVC pipe SCHED 40 - Tip at 16.10 m below ground surface						1062
17											1061
18											1060
19											1059
20											1058
21											1057
22											1056
23											1055
24											1054
25											1053
26											1052
27											1051
28											1050
29											1049
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: 16.23 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

DEPTH (m)	USC	SOIL SYMBOL	THERMISTOR STRING	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: Becker / Dynamic Cone / SPT (Blows/300mm); Total Unit Wt (kN/m³); Plastic MC Liquid	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											1082
7					- coarsening downward sequence		S-4	5-8-10			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						1079
10					- coarsening downward sequence - wet, loose		S-6	2-3-5			1078
11							S-7	5-9-23			1077
12					- Permafrost at approximately 11.28 m below ground surface, Nbn						1076
13							S-8	23-32-41			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

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 1 of 2

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)	PENETRATION TESTS	COMMENTS	ELEVATION
15					SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth						1072
16	SASI				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/m^3)
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/m^3)
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 - 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				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	CI								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				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									

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

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		S-1				1093
4	SM									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 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, 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						1088
9	SA			- loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill		S-4				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										1082
15										

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

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: 9.14 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: **MW09-04**
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

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, 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 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)						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/m^3) 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: 7.01 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 9/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

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 / 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										1091
6	OR SM			ORGANICS - dark brown - wet - primarily moss						1090
7	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
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						1088
9				END OF DRILLING at 6.71 m						1087
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)						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/m^3) 16 17 18 19 20 21

Plastic MC Liquid 20 40 60 80 100

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/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: 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 / Total Unit Wt / 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									
2										1094
	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						
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

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			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										

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: 3.66 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 / Total Unit Wt / Plastic MC Liquid	COMMENTS	ELEVATION
0				SAND (Aeolian) - grey brown - dry, loose, non-cohesive - uniform fine to medium grained sand, sub-rounded, minor silt						1107
1										
2	SA			- 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						1106
3				- saturated at 3.25 m, dense, sandy silt interbed <1 cm thick						1105
4				- occasional nugget of frozen sand between 3.66 m and 4.11 m - 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)		S-1				1104
5				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)						1103
6										1102
7										1101
8										1100
9										1099
10										1098
11										1097
12										1096
13										1095
14										1094
15										1093

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: 4.22 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 / Total Unit Wt / Plastic MC Liquid	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 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										

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 / Total Unit Wt / Plastic MC Liquid	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
						S-34				
21						S-35				1187
						S-36				
22						S-37				1186
						S-38				
23						S-39				1185
						S-40				
24						S-41				1184
	BE									
25						S-42				1183
						S-43				
26						S-44				1182
						S-45				
27						S-46				1181
						S-47				
28						S-48				1180
29										1179
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: Ryan Mills	COMPLETION DEPTH: 35.97 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 12/7/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 3

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										1168
41										1167
42										1166
43										1165
44										1164
45										

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)

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 / Total Unit Wt / Plastic MC Liquid	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

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

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

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

DEPTH (m)	USC	SOIL SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	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
						S-3			
						S-4			
5	BE			DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer		S-5			1202
						S-6			
				- wet 4.88 m to 6.01 m		S-7			
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
						S-9			
7	BE								1200
						S-10			
8						S-11			1199
				- 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		S-12			1198
9				- slightly weathered from 9.14 m to 14.63 m - dry, light grey		S-13			
10						S-14			1197
						S-15			
11				- quartz vein 10.97 m to 11.58 m		S-16			1196
						S-17			
12						S-18			1195
13						S-19			1194
						S-20			
14						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				
16						S-23				1191
						S-24				
17	BE					S-25				1190
						S-26				
18						S-27				1189
				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor potassium feldspar, chips fine		S-28				
19						S-29				1188
	BE					S-30				
20						S-31				1187
						S-32				
21				GRANODIORITE - grey-brown - moist, highly weathered, heavily fractured and iron stained, rapid drilling rates		S-33				1186
22	BE					S-34				
				DIORITE - light grey - dry, moderately weathered, trace feldspar		S-35				1185
23	BE					S-36				
				GRANODIORITE - orange-brown - moist, highly weathered with high clay mineral content inferred to be fault gouge - potentially conductive fracture zone		S-37				1184
24	BE					S-38				
				HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor iron staining, chips fine		S-39				1183
25						S-40				
26						S-41				1182
						S-42				
27	BE					S-43				1181
28						S-44				
						S-45				1180
29				- less than 1 m of water in borehole after sitting overnight without rods in hole		S-46				1179
30										1178
										1177

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
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
						S-53				
34	BE			- highly weathered from 34.14 m to end of hole at 38.10 m		S-54				1173
						S-55				
35				- moist from 35.36 m to 35.38 m		S-56				1172
36						S-57				
				- wet from 35.38 m to end of hole at 38.10 m		S-58				1171
37						S-59				
38				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)		S-60				1170
39										1169
										1168
40										1167
41										1166
42										1165
43										1164
44										1163
45										1162

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

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 3 of 3

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 / Total Unit Wt / Plastic MC Liquid	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						
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/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 / Total Unit Wt / Plastic MC Liquid	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				GRAVEL with some CLAY, SILT and SAND filling interstices - yellow-brown - wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered						1175
4	GR			- gravel to 10 cm along long axis - inferred to be colluvium		S-2				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										

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: 4.88 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				
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										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 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)		S-3				1172
8										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/m^3) 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 SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	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)						1175
2						G-1				
	OR			- clast supported		G-2				
	SA			- presence of wood debris (waste rock?)		G-3				1174
3	OR			ORGANIC, some silt, trace sand - black - moist, loose - presence of roots						
										1173
4	SA			SAND, gravelly, trace of silt - orange-brown - moist, dense - fine grained sand, sub-rounded - volcanic ash marker		G-4				
5										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

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 SYMBOL	WELL INSTALLATION	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS / Total Unit Wt / Plastic MC Liquid	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 - sub-angular gravel, from 0.5 cm to > 5 cm - clast supported, becomes matrix supported with depth - wet						1078
3	SASI SA					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						1075
7				END OF DRILLING at 3.20 m in permafrost (refusal) 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

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

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	SAMPLE N VALUE	SAMPLE % WATER	SAMPLE % REC	SAMPLE % 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 - moderate competency and yellowish grey at 12.19 m									
12.8		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 - tan coloured between 17.07 and 18.23 m									
18.3		Borehole terminated at 18.29 m									

Printed: 8 Feb 08
File Location: 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
1		Light grey coarse GRAVEL, with some sand				GS					UTM 389071.055 W 6881702.619 N
1.5						GS					
2		Sandy silt to silt brown ORGANIC HORIZON				GS					Elevation (TOC) 1186.67 mASL
2.7						GS					
3		Moderately competant, tan coloured BEDROCK				GS					
4						GS					
4.6						GS					
5		Weathered, light tan coloured BEDROCK				GS					
6.1						GS					
7		Borehole terminated at 6.1 m									

Printed: 8 Feb 08
File Location: I:\2007\70803\gINT 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	INTERVAL	TYPE	N VALUE	% WATER	% REC	% RQD	COMMENTS
		Weathered BEDROCK									UTM 388960.200 W 6881476.290 N
1		- highly weathered				GS					
		- light brwon grading to light orange				GS					
2						GS					Elevation (TOC) 1187.90 mASL
		- dark to medium yellowish-orange				GS					
3						GS					
4						GS					
4.6						GS					
5		Compentent BEDROCK				GS					
		- yellowish orange				GS					
6		-dark yellowish orange				GS					
7		- light yellowish orange				GS					
		- light grey				GS					
8						GS					
9						GS					
		- becoming highly competent				GS					
10						GS					
10.4						GS					
11		Borehole terminated at 10.36 m									

Gartner Lee Limited

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

	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						
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

	Sample ID	L796959-1	L796959-2	L796959-3	L796959-4	L796959-5
	Description					
	Sampled Date	14-JUL-09	19-JUL-09	19-JUL-09	19-JUL-09	19-JUL-09
	Sampled Time					
	Client ID	MW09-15	MW09-16	MW09-17	MW09-18	MW09-18R
Grouping	**Analyte**					
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

		Sample ID	L796959-1	L796959-2	L796959-3	L796959-4	L796959-5
		Description					
		Sampled Date	14-JUL-09	19-JUL-09	19-JUL-09	19-JUL-09	19-JUL-09
		Sampled Time					
		Client ID	MW09-15	MW09-16	MW09-17	MW09-18	MW09-18R
Grouping	**Analyte**						
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		

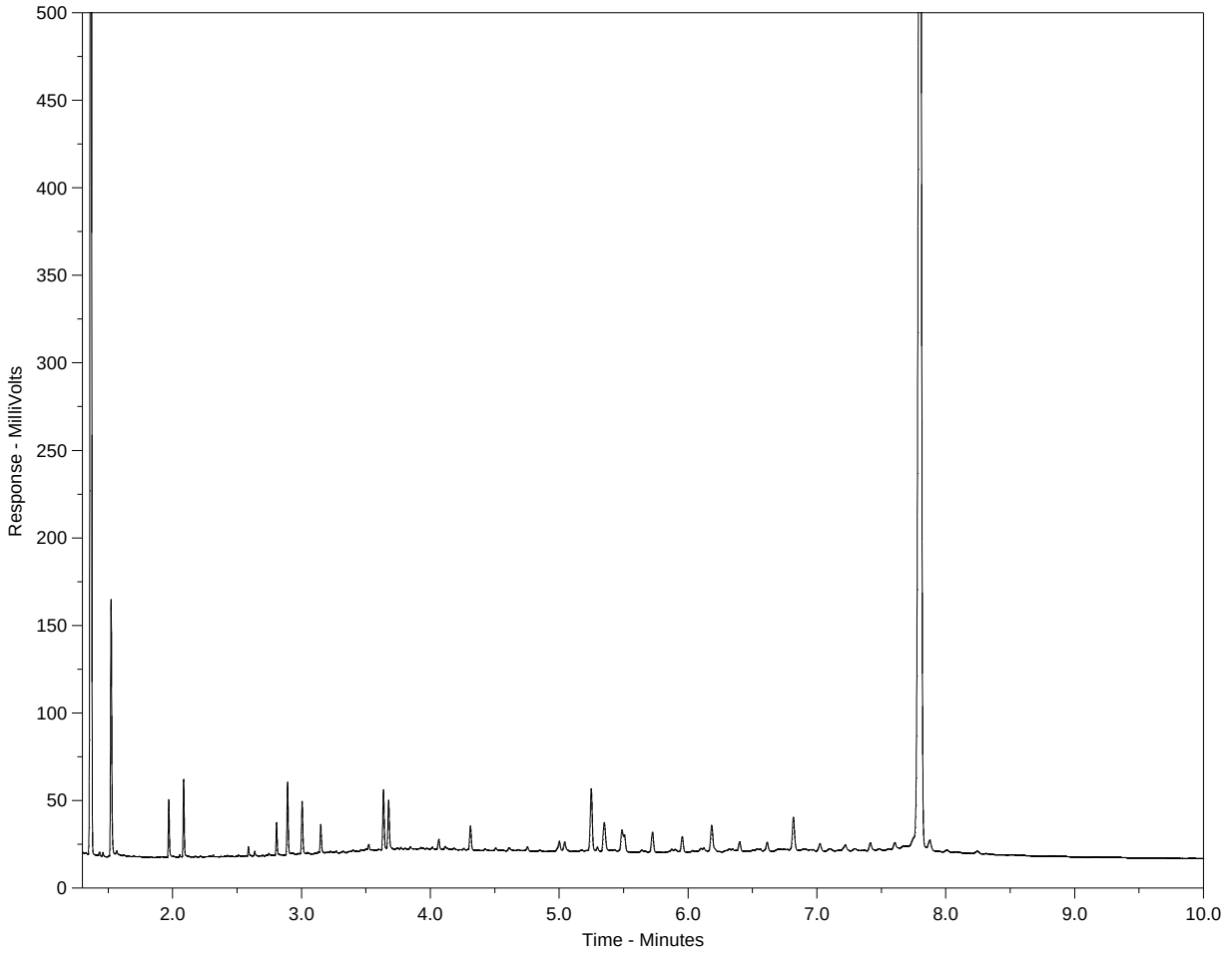
GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in enviromental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate 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

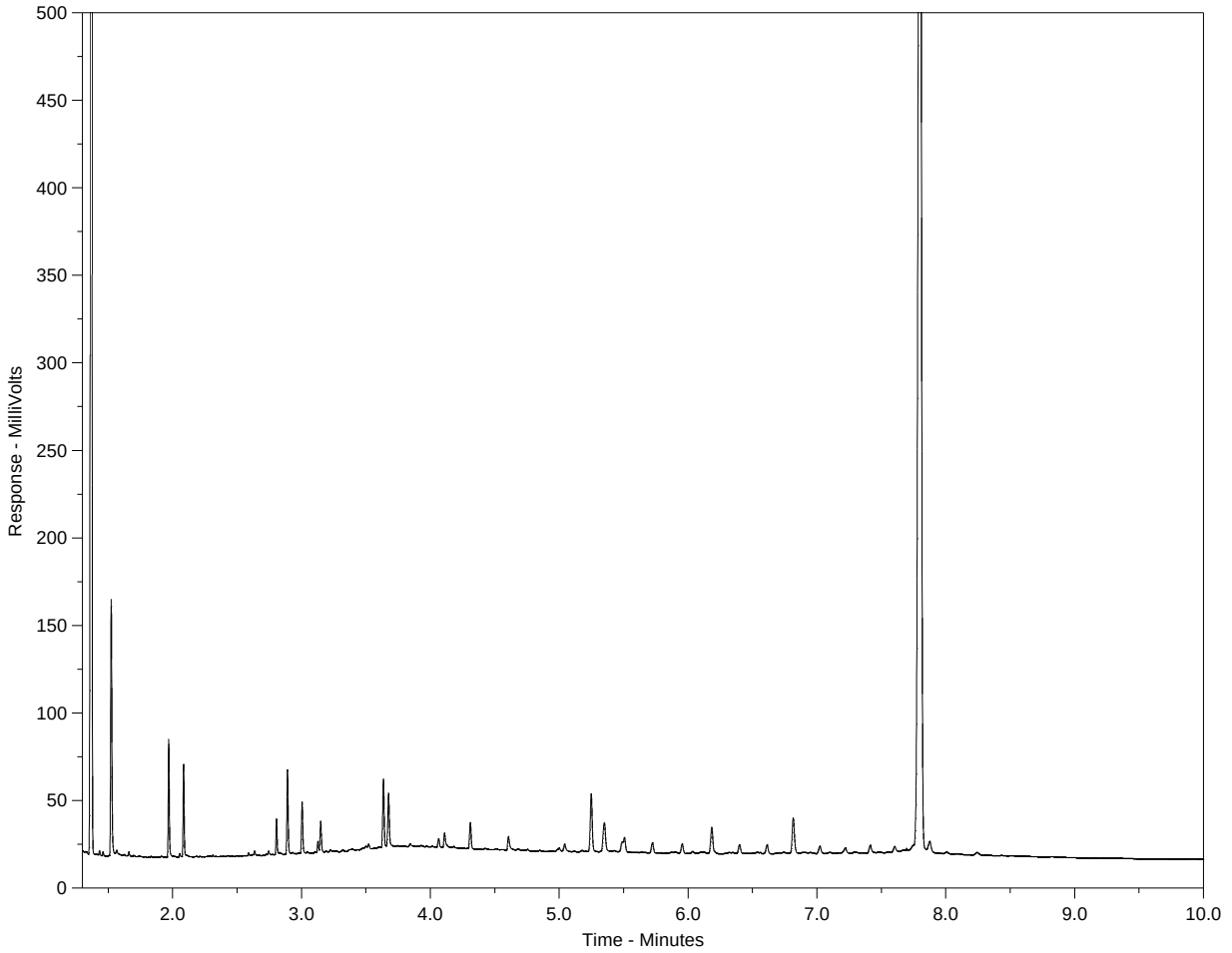
Gasoline
Motor Oils / Lube Oils / Grease
Diesel / Jet Fuels

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



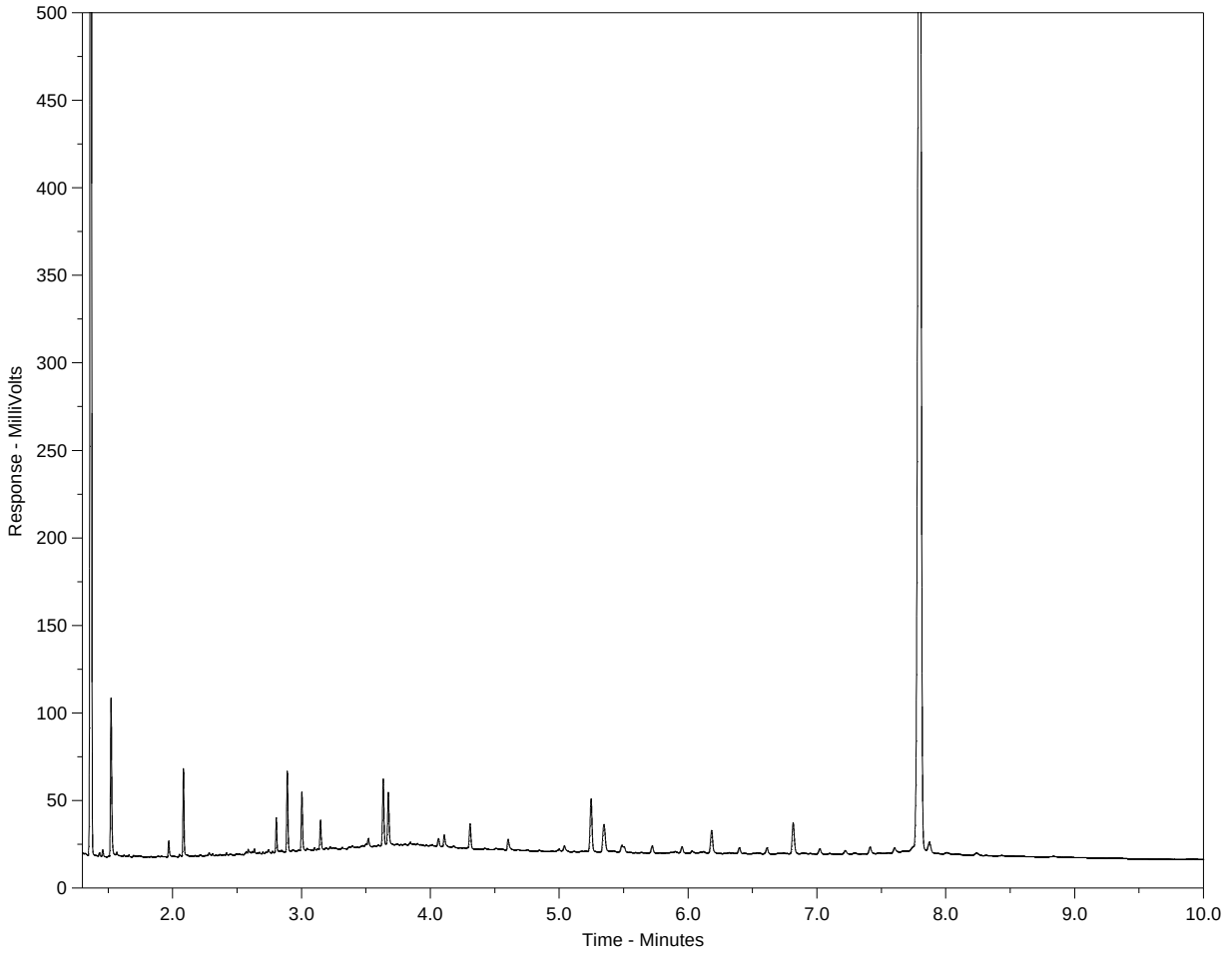
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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: L796959-4
Client Sample ID: MW09-18



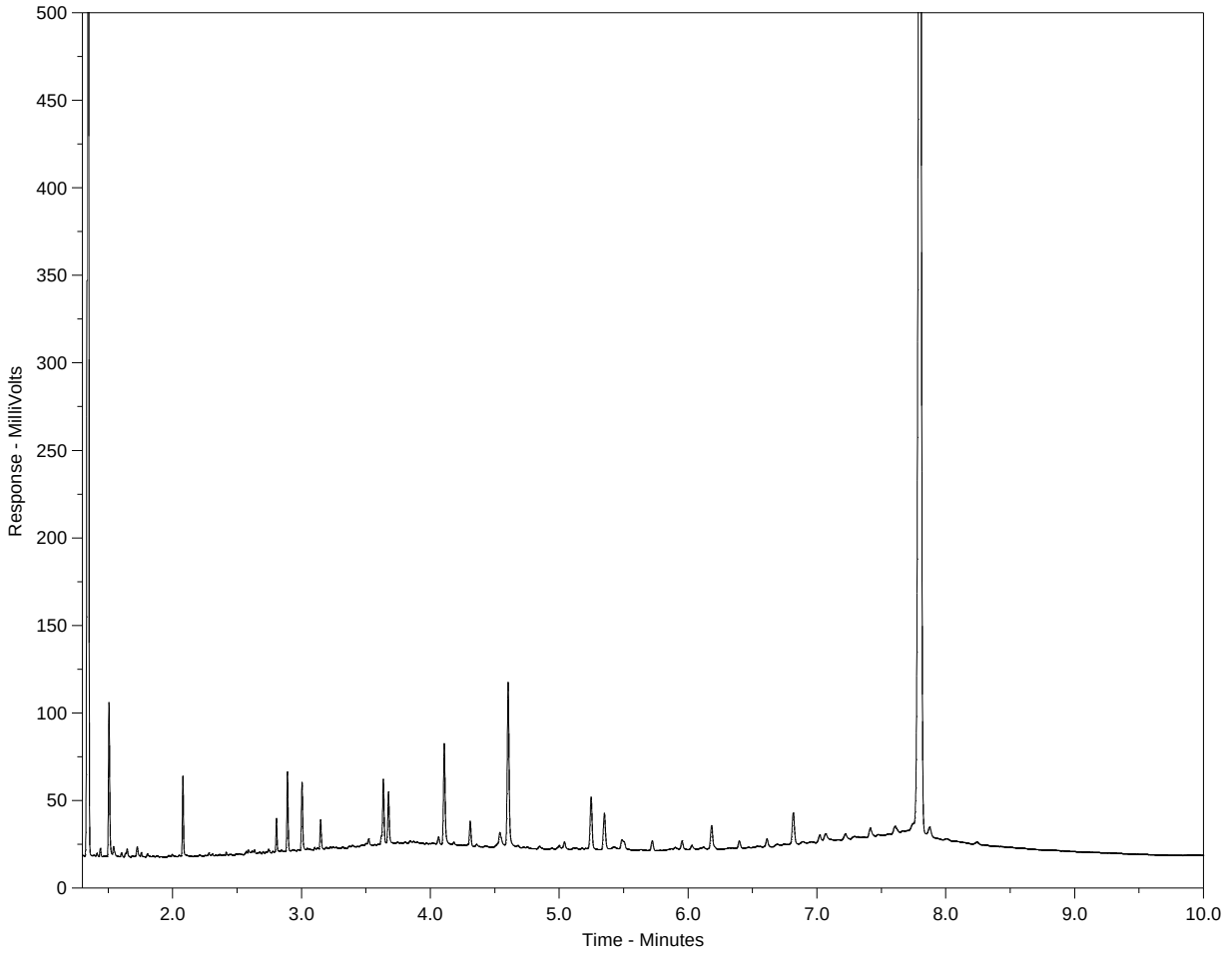
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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: L796959-5
Client Sample ID: MW09-18R



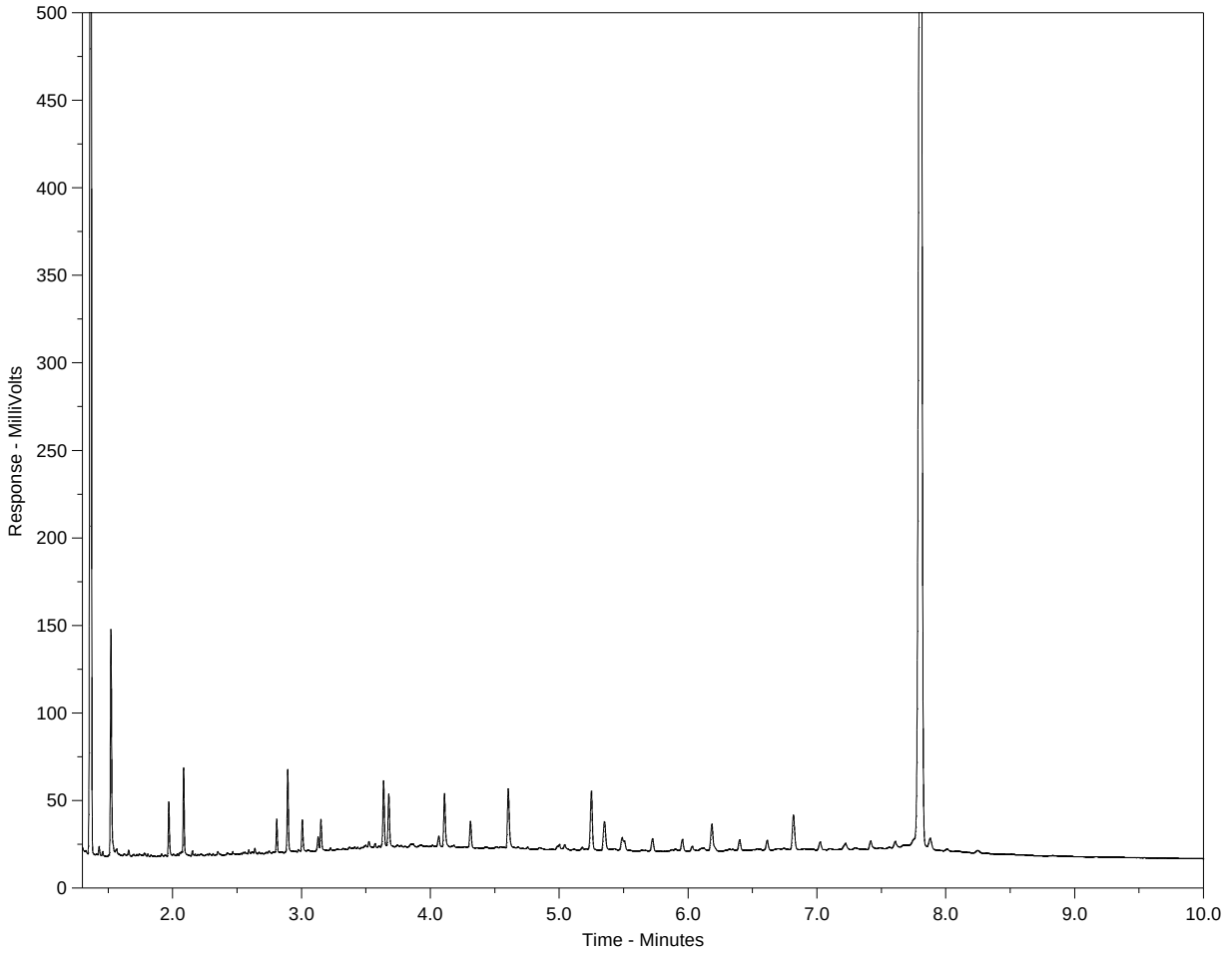
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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: L796959-6
Client Sample ID: MW09-19



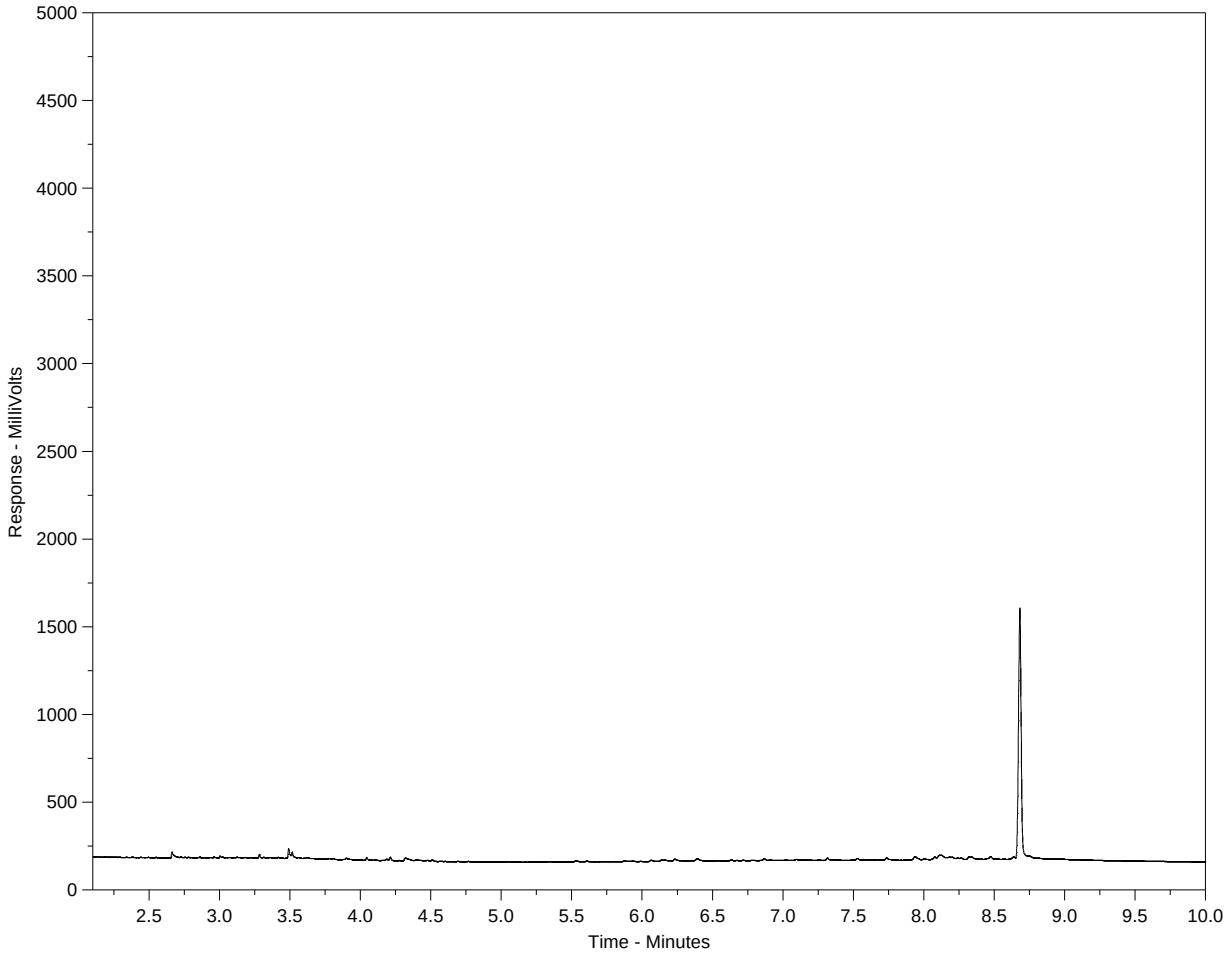
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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)



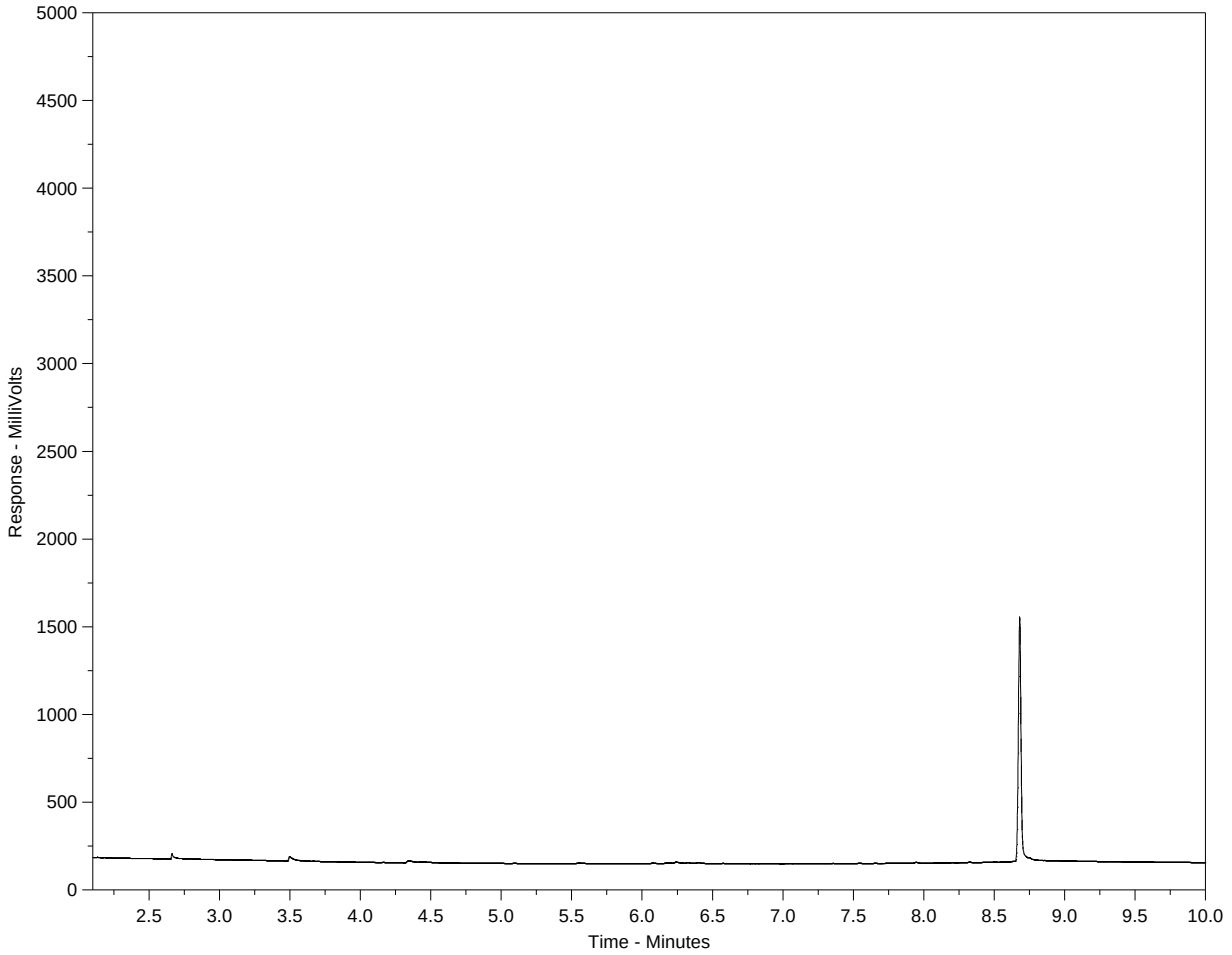
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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: L796959-9
Client ID: MW09-17(11FT-12FT)



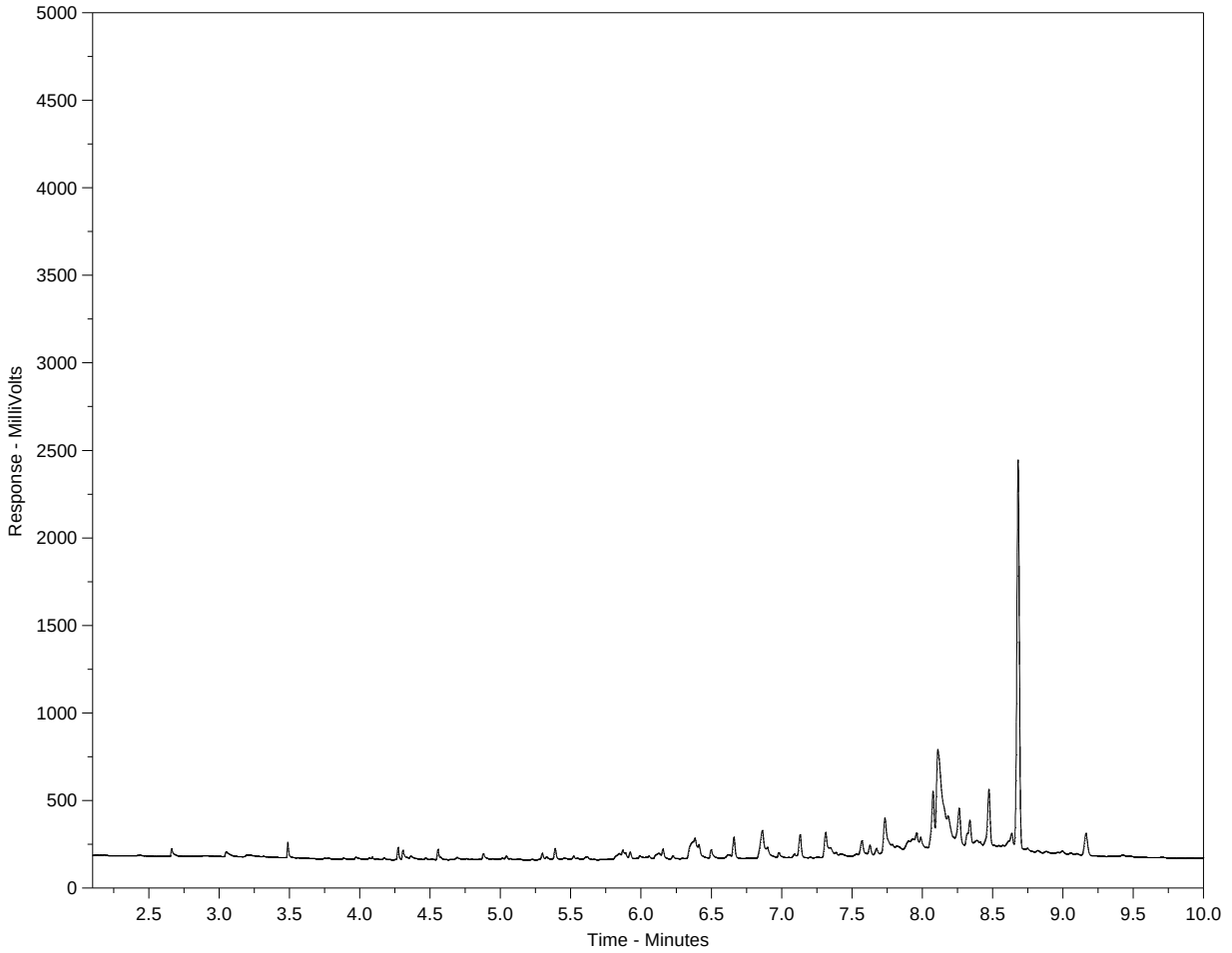
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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)



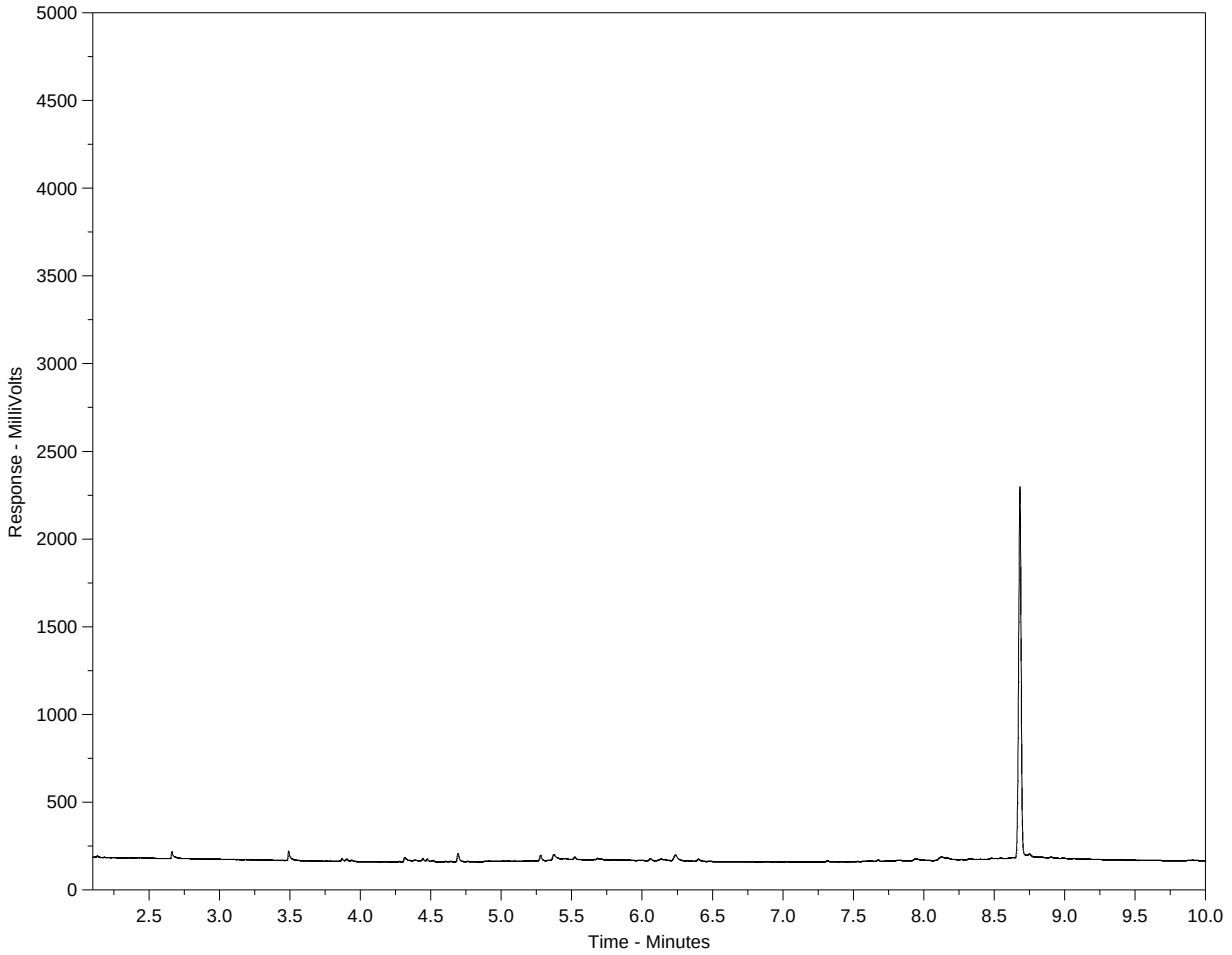
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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: L796959-11
Client ID: MW09-18(21FT-22FT)



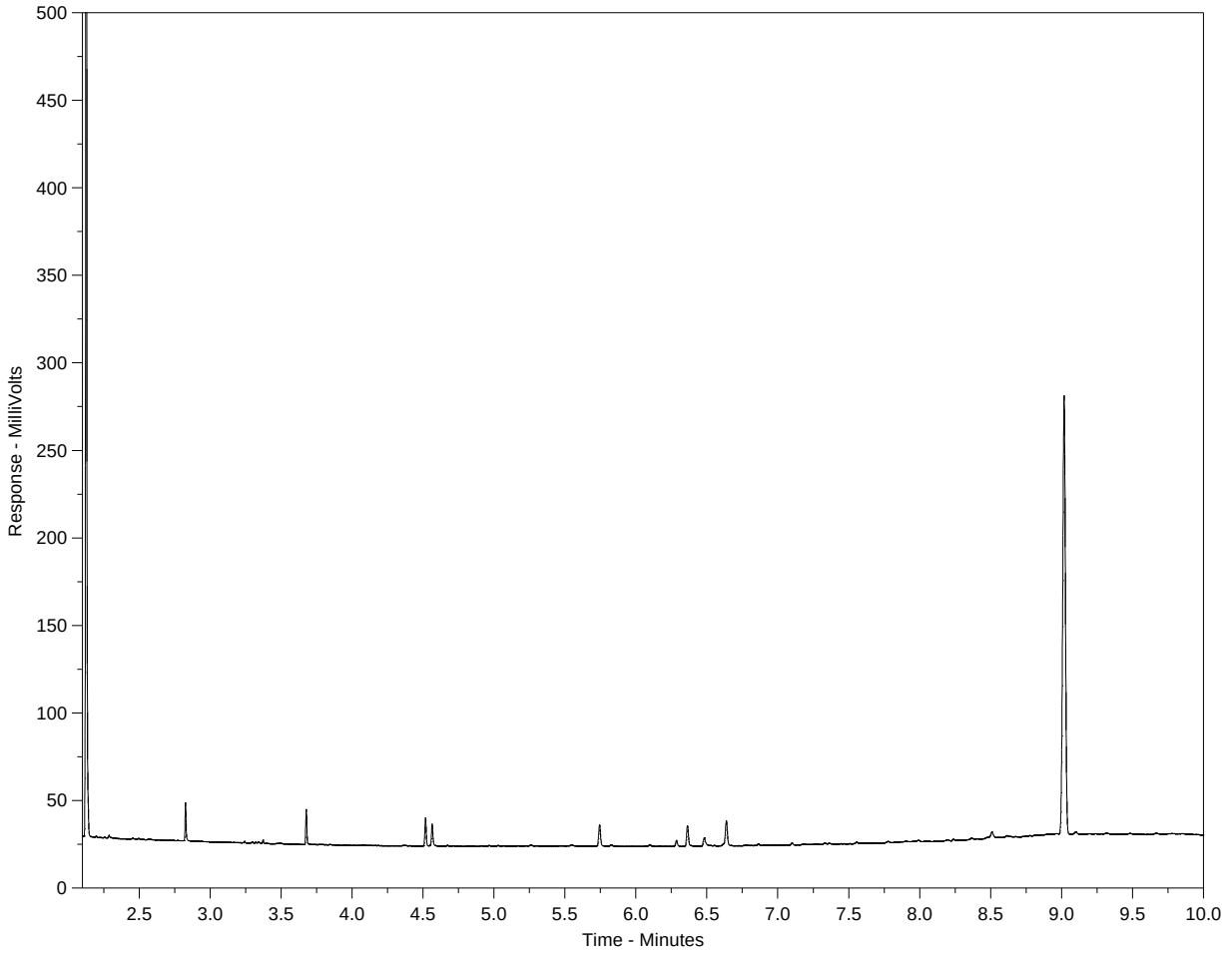
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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 346°F	330°C 626°F	467°C 873°F		522°C 972°F

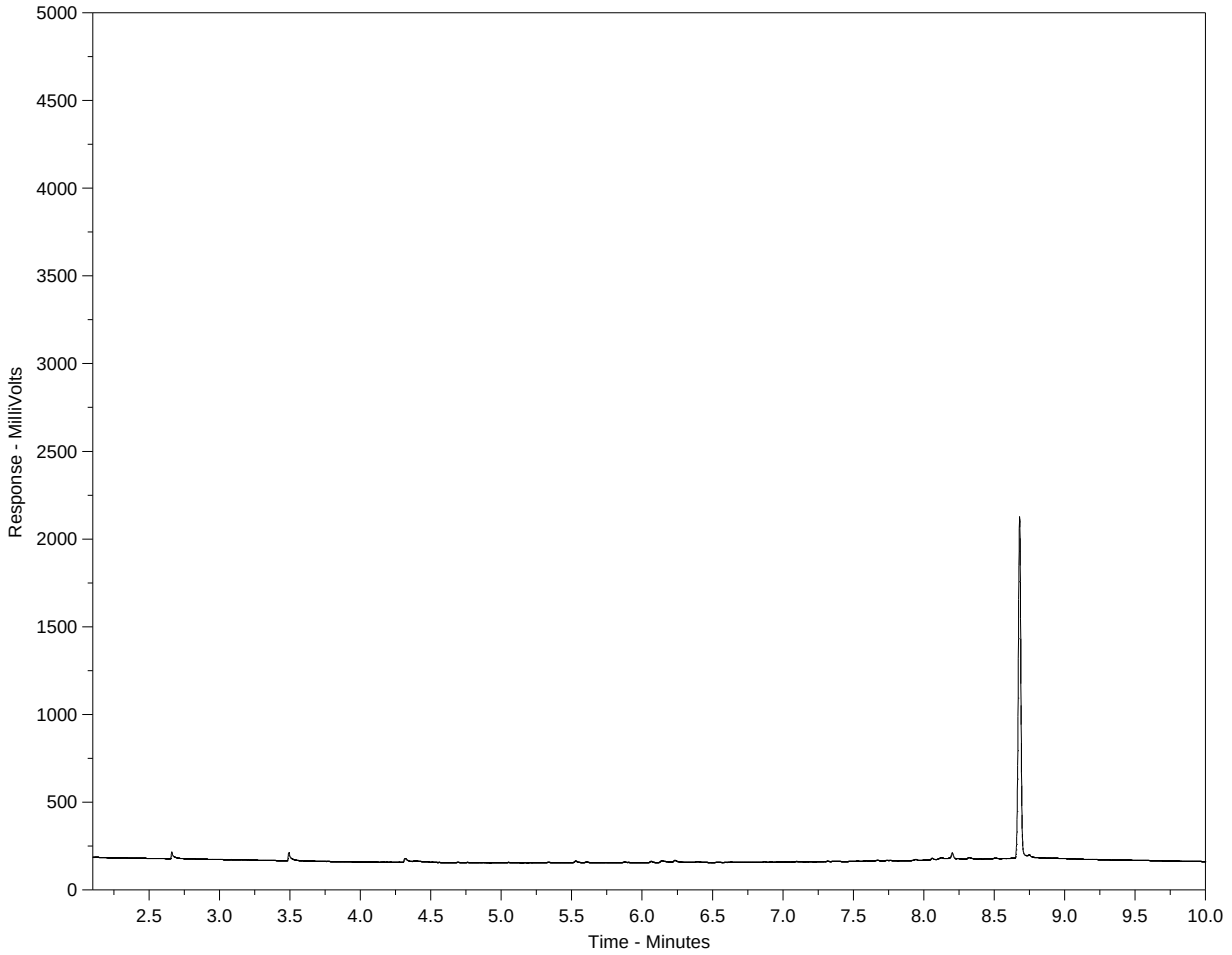
Gasoline
Motor Oils / Lube Oils / Grease
Diesel / Jet Fuels

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: WG979617-6#L796959-12
Client ID: MW09-19(7FT10



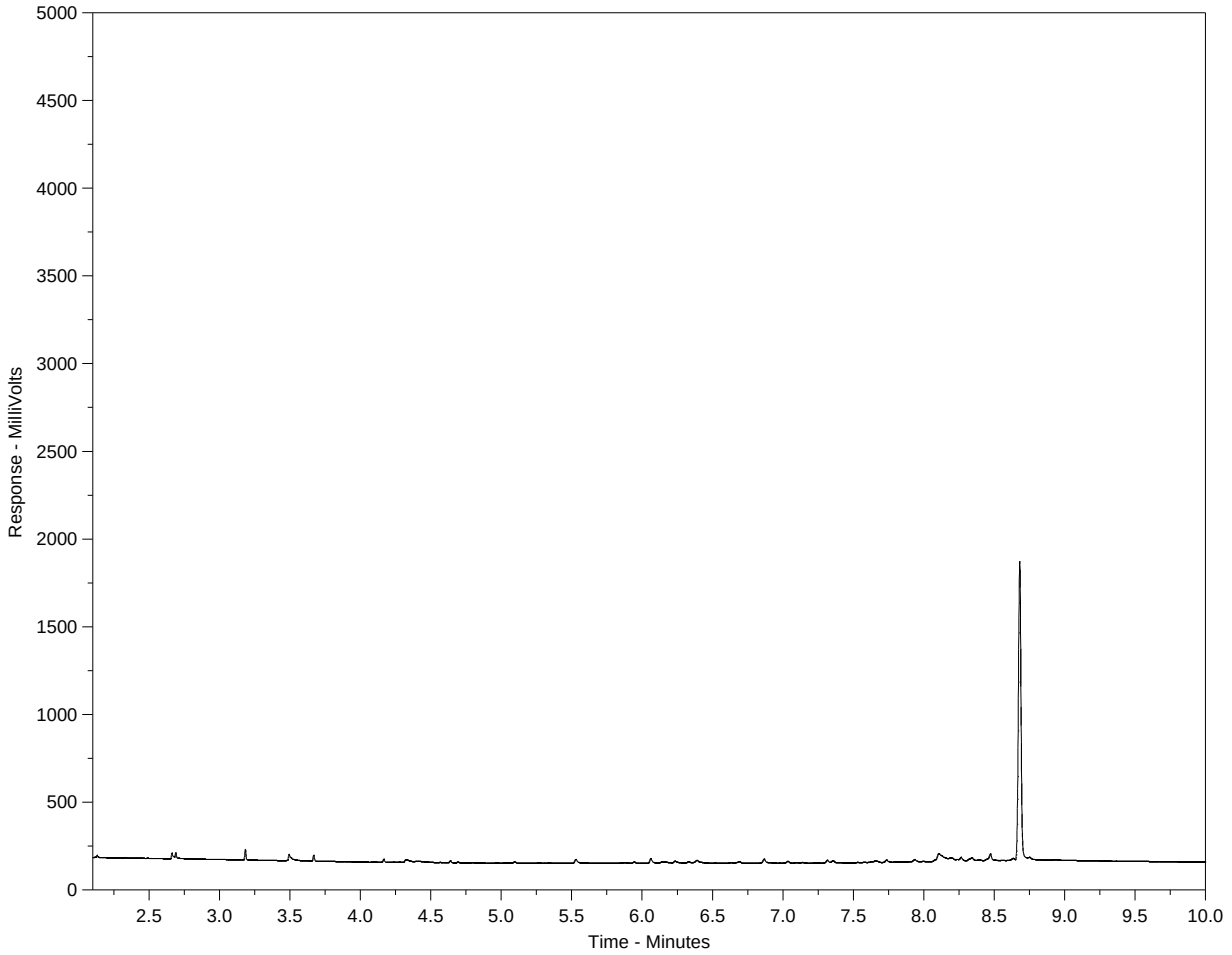
nC10	nC19	nC32	Surrogate	nC40
174°C 346°F	330°C 626°F	467°C 873°F		522°C 972°F
← Gasoline →	← Motor Oils / Lube Oils / Grease →			
← Diesel / Jet Fuels →				

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 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.

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 SUITE 275, BURNABY, B.C. V5H4W3	EMAIL 1: ryan.mills@aecom.com
	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 SCAN (F)	TOTAL/WAD/SAD CYANIDE (P)	Anion Scan	Ammonia, NO_3, NO_2 (P)	pH conductivity Alkalinity Acidity TDS Hardness	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

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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 WAYBURNE 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: 604-631-6213 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 DETECTIONS 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:
[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)
12	

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-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	L796873-1	L796873-2	L796873-3	L796873-4	L796873-5
	Description					
	Sampled Date	08-JUL-09	22-JUL-09	21-JUL-09	22-JUL-09	21-JUL-09
	Sampled Time					
	Client ID	MW09-08	MW09-11	MW09-21	MW09-22	MW09-23
Grouping	**Analyte**					
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

	Sample ID	L796873-1	L796873-2	L796873-3	L796873-4	L796873-5
	Description					
	Sampled Date	08-JUL-09	22-JUL-09	21-JUL-09	22-JUL-09	21-JUL-09
	Sampled Time					
	Client ID	MW09-08	MW09-11	MW09-21	MW09-22	MW09-23
Grouping	**Analyte**					
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

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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	Dissolved Metals (F/P)	Nutrients (P)	Cyanide (P)	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)	
Ann Thurston	July 24/09 13:00	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	5	

REFER TO BACK PAGE FOR REGIONAL LOCATIONS AND SAMPLING INFORMATION

WHITE - REPORT COPY, PINK - FILE COPY, YELLOW - CLIENT COPY

GENF14.00

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

	Sample ID	L814853-1	L814853-2	L814853-3	L814853-4	L814853-5
	Description					
	Sampled Date	01-SEP-09	01-SEP-09	02-SEP-09	01-SEP-09	01-SEP-09
	Sampled Time					
	Client ID	GLL07-03	MW09-08	MW09-11	MW09-15	MW09-16
Grouping	**Analyte**					
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

	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						
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

	Sample ID	L814853-1	L814853-2	L814853-3	L814853-4	L814853-5
	Description					
	Sampled Date	01-SEP-09	01-SEP-09	02-SEP-09	01-SEP-09	01-SEP-09
	Sampled Time					
	Client ID	GLL07-03	MW09-08	MW09-11	MW09-15	MW09-16
Grouping	**Analyte**					
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

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	

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.

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-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
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # _____

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:		
Invoice To: ☑ Same as Report	Indicate Bottles: Filtered / Preserved (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): L814853	ALS Contact: NatashaMM	Sampler (Initials): MAL/JF

Analysis Request

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
					F/P					P	P	P	P				
	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:	Marc-André	Date & Time: 02/09/09	02/09/09	Received By:		Date & Time:	9/9/3 1pm	Sample Condition (lab use only)
Relinquished By:		Date & Time:		Received By:		Date & Time:		Temperature: 5 / Samples Received in Good Condition? Y/N (if no provided details)

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 — — — — 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)	**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	02-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			5
	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			5
	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:
	02/09/09		9/9/5
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	

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 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

	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						
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

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	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

	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						
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

	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						
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).	

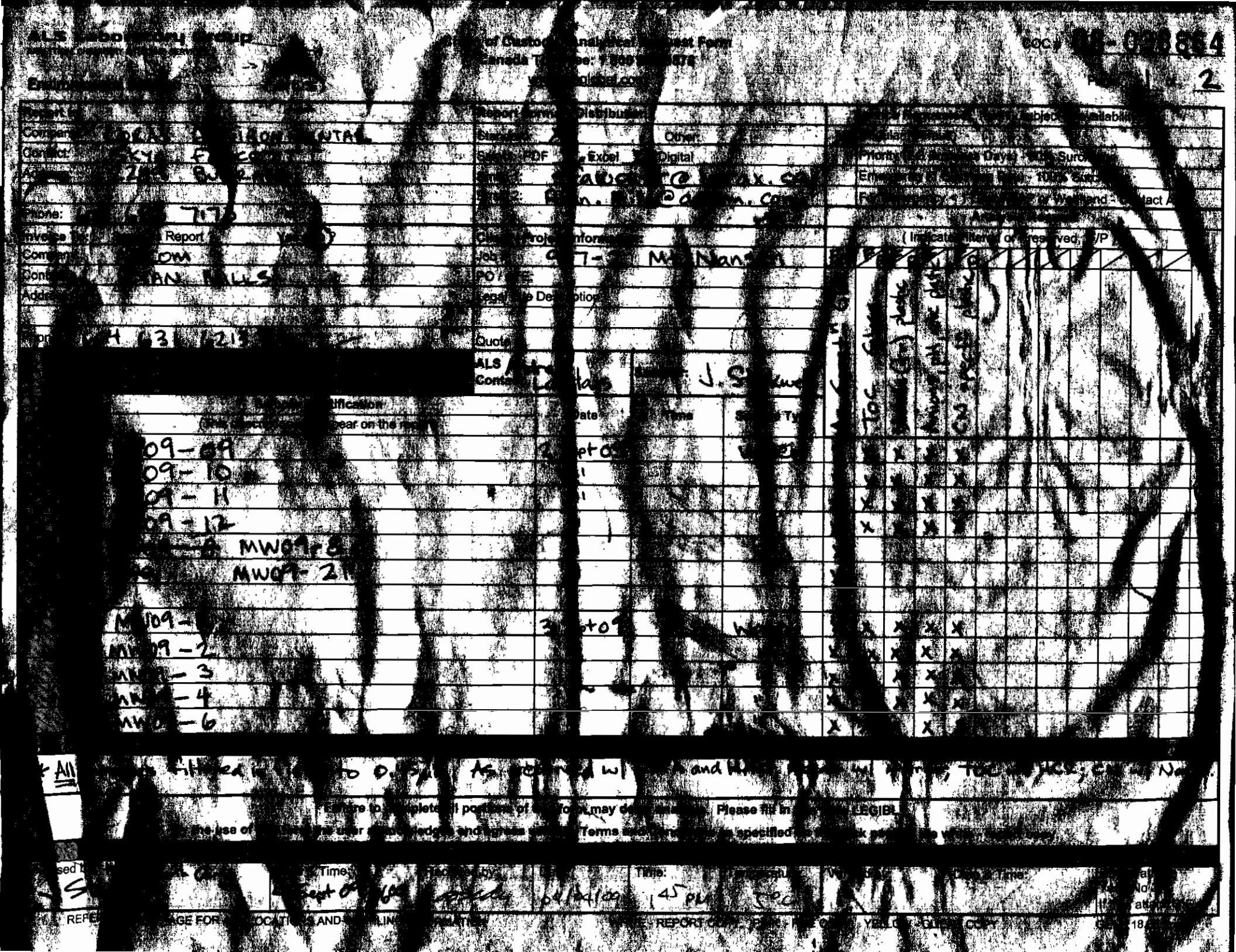
** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.
The last two letters of the above ALS Test Code column indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

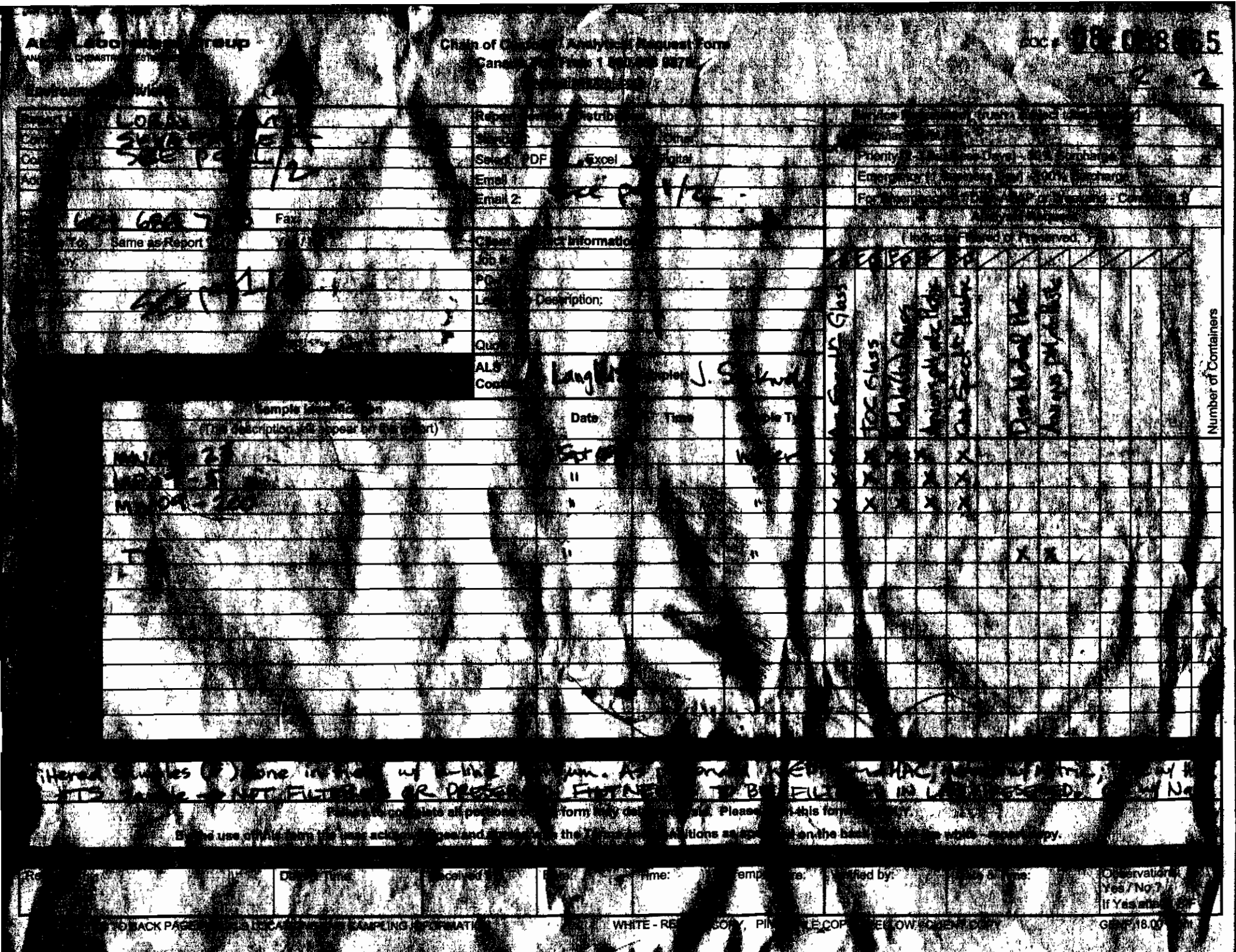
Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
VA	ALS LABORATORY GROUP - VANCOUVER, BC, CANADA		

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.





Appendix C

Groundwater Quality Analytical Results

2009 Groundwater Quality Analytical Results

	Groundwater Monitoring Wells																																		G
Sample ID	GLL07-03	MW09-01	MW09-1	MW09-02	MW09-2	MW09-03	MW09-3	MW09-04		MW09-4	MW09-06		MW09-6	MW09-08	MW09-08	MW09-11	MW09-11	MW09-15	MW09-15	MW09-16	MW09-16	MW09-17	MW09-17	MW09-18		MW09-18	MW09-19	MW09-21		MW09-21	MW09-22	MW09-22	MW09-22	MW09-23	MW09-23
Date Sampled	1-Sep-09	12-Jul-09	3-Sep-09	12-Jul-09	3-Sep-09	11-Jul-09	3-Sep-09	11-Jul-09	11-Jul-09	3-Sep-09	13-Jul-09	13-Jul-09	3-Sep-09	8-Jul-09	1-Sep-09	22-Jul-09	2-Sep-09	14-Jul-09	1-Sep-09	19-Jul-09	1-Sep-09	19-Jul-09	1-Sep-09	19-Jul-09	19-Jul-09	1-Sep-09	1-Sep-09	21-Jul-09	21-Jul-09	1-Sep-09	22-Jul-09	1-Sep-09	21-Jul-09	1-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	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	00:00	00:00	00:00	00:00	00:00
ALS Sample ID	L814853-1	L791918-12	L815006-5	L791918-13	L815006-6	L791918-5	L815006-7	L791918-6	L791918-10	L815006-8	L791918-3	L791918-4	L815006-9	L796873-1	L814853-2	L796873-2	L814853-3	L796959-1	L814853-4	L796959-2	L814853-5	L796959-3	L814853-6	L796959-4	L796959-5	L814853-7	L814853-9	L796873-3	L796873-7	L814853-10	L796873-4	L814853-11	L796873-5	L814853-12
Matrix	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water	Water
Physical Tests																																			
Conductivity	1740	-	-	-	-	-	-	-	-	-	-	-	-	187	222	433	659	1010	937	1930	1770	2570	2570	2660	2660	2670	2470	1630	1640	1790	630	543	1930	1890
Hardness (as $CaCO_3$)	1110	923	943	1390	1440	1470	1510	1410	1420	1480	1480	1490	1550	72.2	99.5	209	352	581	579	1210	1180	1760	1840	1830	1860	1920	1750	711	710	838	248	244	1020	1030
pH	5.66	-	-	-	-	-	-	-	-	-	-	-	-	7.5	6.92	7.96	7.78	7.08	7.28	7.38	7.23	7.74	7.42	7.71	7.71	7.47	7.16	7.1	7.17	6.67	7.12	6.92	7.5	7.3
Total Dissolved Solids	1670	-	-	-	-	-	-	-	-	-	-	-	-	189	233	262	445	757	682	1650	1540	2380	2430	2490	2440	2560	2370	1230	1280	1420	389	378	1630	1610
Anions and Nutrients																																			
Acidity (as $CaCO_3$)	81.4	-	-	-	-	-	-	-	-	-	-	-	-	13.9	26.6	5.3	10.9	23.3	26.3	35.4	31.2	28.5	39.9	30.3	29.7	31.9	45.7	38.8	31.9	143	21.1	27.2	21	24.4
Alkalinity, Total (as $CaCO_3$)	15.5	-	-	-	-	-	-	-	-	-	-	-	-	91.1	88.3	227	325	288	276	298	294	435	434	427	425	426	389	266	269	231	176	122	269	247
Ammonia as N	0.103	13.9	13.5	15.5	14	14.4	10.7	13.6	13.7	14.7	0.47	0.743	1.96	3.27	3.77	1.85	2.48	0.331	0.1	0.079	<0.020	0.229	<0.020	0.041	0.066	0.021	2.24	6.3	12.1	17.9	6.65	4.37	9.49	8.73
Bromide (Br)	<0.25	<0.50	<5.0	<0.50	<2.5	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.50	<1.0	<0.50	<0.25	<0.050	0.05	<0.050	<0.50	<2.5	<0.50	<2.5	<1.0	<2.5	<2.5	<1.0	<1.0	<2.5	<2.5	<1.0	<0.25	<0.50	<2.5	<0.50
Chloride (Cl)	<2.5	5.3	<50	<5.0	<25	<5.0	<10	<5.0	<5.0	<10	<5.0	<5.0	<10	<5.0	<2.5	3.23	4.9	<0.50	<5.0	<25	<5.0	<25	<10	<25	<25	<10	<10	<25	<25	<10	<2.5	<5.0	<25	<5.0
Fluoride (F)	0.15	<0.20	0.076	0.43	0.729	0.57	0.56	0.4	0.53	0.68	<0.20	<0.20	<0.40	<0.20	<0.10	0.723	0.697	0.07	<0.20	0.152	<0.20	0.144	<0.40	0.143	0.122	<0.40	<0.40	0.057	0.059	<0.40	0.075	<0.20	0.058	<0.20
Nitrate (as N)	0.779	<0.050	<0.50	<0.050	<0.25	7.07	7.15	<0.050	<0.050	<0.10	0.401	0.197	<0.10	<0.050	<0.025	0.283	0.495	<0.0050	<0.050	<0.25	0.201	<0.25	0.3	<0.25	<0.25	<0.10	<0.10	1.44	1.37	<0.10	4.79	<0.050	<0.25	<0.050
Nitrite (as N)	0.0544	<0.010	<0.10	<0.010	<0.050	0.694	1.14	0.058	0.085	<0.020	0.335	0.375	<0.020	<0.010	<0.0050	0.0059	0.0277	0.0027	<0.010	<0.050	<0.010	<0.050	<0.020	<0.050	<0.050	<0.020	<0.020	0.058	<0.050	<0.020	0.0996	<0.010	<0.050	<0.010
Sulfate (SO4)	529	646	531	1730	1690	1700	1570	1680	1650	1610	1400	1430	1450	16	14.9	11	50.2	289	271	934	832	1360	1400	1490	1470	1490	1340	617	617	818	126	156	879	916
Cyanides																																			
Cyanide, Weak Acid Diss	-	0.0261	0.0209	0.326	0.0281	0.0305	0.0107	0.207	0.295	0.0239	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0331	0.0209	0.0169	<0.0050	<0.0050	0.107	0.019
Cyanide, Total	-	0.0401	0.0525	0.547	0.361	0.254	0.298	0.654	0.812	0.0425	0.0083	0.0062	<0.0050	0.0542	0.0104	<0.0050	<0.0050	-	-	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0146	0.0504	0.0465	0.0293	0.0165	0.0102	0.419	0.0324
Cyanate (CNO)	-	<1.8	5.1	3	4.7	<1.8	1.74	<1.8	<1.8	5.9	<0.50	<0.50	<0.50	<1.6	<0.50	<1.6	<0.50	-	-	<1.8	<0.50	<0.50	<0.50	<0.50	<0.50	<0.50	5.75	5	6.9	20.7	<1.6	1.14	3.5	2.34
Thiocyanate (SCN)	0.82	35	27.1	5.56	3.11	1	1.1	3.05	2.99	1.21	0.69	0.68	0.71	-	5.8	-	1.03	-	0.93	-	1.16	-	1.35	-	-	1.23	1.25	-	-	1.98	-	1.2	-	3.72
Organic / Inorganic Carbon																																			
Total Organic Carbon	1.27	41.4	66.8	7.48	6.23	10.2	8.8	7.67	7.22	5.16	6.05	5.87	6.05	-	23.3	-	26.2	-	4.62	-	3.67	-	5.01	-	-	2.89	80.8	-	-	42.5	-	13.7	-	18.8
Dissolved Metals																																			
Aluminum (Al)-Dissolved	1.39	0.0696	0.0812	<0.0050	<0.010	0.0116	<0.010	<0.0050	<0.0050	<0.010	<0.010	<0.010	<0.010	0.118	0.098	<0.0050	<0.0050	<0.025	<0.010	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.050	<0.025	0.158	0.15	0.152	0.0332	0.0982	0.033	0.037
Antimony (Sb)-Dissolved	<0.0050	0.0124	0.00404	0.0235	0.0068	0.33	0.439	0.434	0.486	0.484	0.72	0.838	0.591	<0.00050	<0.00050	<0.00050	<0.00050	0.0178	0.0023	0.175	0.102	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.0025	<0.0025
Arsenic (As)-Dissolved	<0.0050	0.0923	0.215	10.5	15.3	3.08	3.29	2.99	3.42	4.06	0.274	0.353	0.868	0.178	0.284	0.0182	0.0239	0.122	0.187	0.0506	0.0391	0.0119	0.0128	0.0382	0.0423	0.0526	0.0834	0.0329	0.0341	0.0443	0.014	0.0368	0.01	0.0137
Barium (Ba)-Dissolved	<0.020	0.117	0.163	0.0165	0.0138	0.0652	0.0523	0.0105	0.011	0.00834	0.00531	0.00598	0.00564	0.102	0.126	0.169	0.311	<0.020	<0.020	0.034	<0.020	<0.020	<0.020	<0.020	<0.020	<0.020	0.077	0.3	0.294	0.426	0.157	0.115	0.089	0.064
Beryllium (Be)-Dissolved	<0.010	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0050	<0.0050
Bismuth (Bi)-Dissolved	<0.20	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20	<0.20
Boron (B)-Dissolved	<0.10	0.055	0.051	<0.050	<0.10	0.231	0.28	0.151	0.152	0.23	0.24	0.28	0.36	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	0.27	0.19	0.27	0.16	<0.10	<0.10	<0.10	0.4	<0.10	<0.10	<0.10	<0.10	<0.10	0.14	0.14
Cadmium (Cd)-Dissolved	0.436	<0.000085	<0.000085	0.000278	0.00019	0.000194	0.00018	0.000549	0.000364	<0.00017	0.00835	0.00894	0.00827	<0.000017	<0.000017	0.000082	0.000038	0.00754	0.000758	0.0558	0.0419	<0.000085	<0.000085	<0.000085	<0.000085	<0.00017	<0.000085	0.000196	0.000188	0.000162	0.000109	0.000077	0.000184	0.000126
Calcium (Ca)-Dissolved	336	274	293	487	488	477	493	484	484	489	528	527	548	21.8	30.9	39.3	65.5	157	158	276	273	327	350	352	355	375	373	247	247	293	91.6	89.9	327	332
Chromium (Cr)-Dissolved	<0.010	0.0036	<0.0070	<0.0025	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0050	<0.0050	<0.0050	<0.0050	0.0017	<0.0020	<0.0010	<0.0010	<0.0050	<0.0020	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0020	<0.0050	<0.0050
Cobalt (Co)-Dissolved	0.0144	0.011	0.011	0.02	0.0122	0.0123	0.0091	0.00819	0.00875	0.0051	0.0056	0.0057	0.0038	0.00145	0.00147	0.00169	0.00096	<0.0015	0.00076	0.002	<0.0015	<0.0015	<0.0015	<0.0015	<0.0015	<0.0030	<0.0015	0.0268	0.0272	0.026	0.0134	0.0123	0.0189	0.0171
Copper (Cu)-Dissolved	0.55	0.00164	<0.00050	<0.00050	<0.0010	0.0006	0.0018	0.0006	0.00286	<0.0010	0.0052	0.0055	0.0045	<0.0010	<0.0010	<0.0010	<0.0010	<0.0050	<0.0020	0.01	0.0105	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	0.0036	0.0015	<0.0050	<0.0050
Iron (Fe)-Dissolved	11.6	57.1	66.4	4.85	9.46	0.118	0.126	<0.030	<0.030	<0.030	<0.030	<0.030	<0.030	31.9	40.7	0.596	1.52	0.192	1.58	0.389	0.331	<0.030	<0.030	<0.030	<0.030	<0.030	30.4	19	18.7	66.4	3.46	14.6	3.86	7.93
Lead (Pb)-Dissolved	0.0114	0.00255	0.00044	<0.00025	<0.00050	0.00041	<0.00050	<0.00025	<0.00025	<0.00050	<0.00050	<0.00050	0.00087	<0.00050	<0.00050	<0.00050	<0.00050	0.0171	0.0059	0.0364	0.0284	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.0025	<0.0025
Lithium (Li)-Dissolved	<0.050	<0.025	<0.025	<0.025	<0.050	<0.025	<0.050	<0.025	<0.025	<0.050	<0.050	<0.050	<0.050	<0.0050	<0.0050	<0.0050	<0.0050	<0.025	<0.010	<0.025	<0.025	<0.025	<0.025	<0.025	<0.025	<0.050	<0.025	<0.025	<0.025	<0.025	<0.0050	<0.0050	<0.025	<0.025
Magnesium (Mg)-Dissolved	66.4	57.9	51.7	43.3	53.2	68.9	69	50.2	50.6	62.7	38.6	41.4	44	4.3	5.45	26.9	45.8	45.7	44.5	126	120	230	235	231	236	240	200	22.9	22.5	26.1	4.57	4.84	50.1	47.8
Manganese (Mn)-Dissolved	10.5	6.16	6.05	21.8	23.7	0.555	0.761	4.94	3.31	3.32	12.6	17.1	14	2.09	2.32	0.987	1.42	0.905	0.681	0.389	0.208	0.0164	0.0096	0.349	0.409	0.427	1.97	7.52	7.66	6.73	3.88	3.2	6.69	6.06
Mercury (Hg)-Dissolved	<0.000020	-	-	-	-	-	-	-	-	-	-	-	-	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Molybdenum (Mo)-Dissolved	<0.010	0.00292	0.00121	0.0135	0.00974	0.0229	0.0128	0.0122	0.0116	0.0105	0.0075	0.00899	0.00899	<0.0010	<0.0010	0.01	0.0079	<0.0050	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	0.0017	<0.0010	<0.0050	<0.0050
Nickel (Ni)-Dissolved	0.014	0.0038	0.0033	0.0029	<0.0050	<0.0025	<0.0050	<0.0025	<0.0025	<0.0050	0.006	0.0077	0.0059	<0.0010	<0.0010	0.0033	0.0027	<0.0050	<0.0020	0.0071	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	0.0096	0.0092	<0.0050	<0.0050
Phosphorus (P)-Dissolved	<0.30	<0.30	<0.30	<0.60	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	0.41	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30	<0.30
Potassium (K)-Dissolved	2.1	8.4	9	43.9	51.8	28.5	31	40.6	44	44	10.7	11.2	11.4	<2.0	<2.0	3.2	4.2	<2.0	<2.0	6.5	6.4	7.2	7.5	6.9	7.1	7.1	4.9	8.2	8.1	9.4	5.7	4.4	15.5	14.4
Selenium (Se)-Dissolved	<0.010	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.0010	<0.0010	0.001	<0.0010	<0.0050	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	<0.0050	<0.0050	<0.0050	<0.0010	<0.0010	<0.0050	<0.0050
Silicon (Si)-Dissolved	4.92	5.79	6.65	5.19	5.36	4.62	5.29	10.2	10.1	9.61	7.58	7.42	7.43	8.28	8.72	5.5	6.03	5.85	6.32	5.29	5.28	4.74	4.75	4.8	4.87	4.85	7.6	5.69	5.61	5.69	4.69	5.51	5.35	5.69
Silver (Ag)-Dissolved	<0.00020	<0.000050	<0.000050	<0.000050	0.00014	<0.000050	0.00012	<0.000050	0.000071	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020	<0.000020	<0.000020	<0.000020	<0.00010	<0.000040	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00020	<0.00010	<0.00010	<0.00010	<0.00010	<0.000020	<0.000020	<0.00010	<0.00010
Sodium (Na)-Dissolved	8	76.2	81.9	183	123	149	72.7	101	109	55.9	24.6	26.9	28.4	4.1	3.8	15.3	20.1	7.7	6.9	18.9	9	10.8	11	10	10.2	10.5	14	102	99.4	73.1	25.6	15.4	59.5	56.9
Strontium (Sr)-Dissolved	0.354	0.968	1.03	0.9	1.08	1.08	1.18	1.03	1.06	1.14	0.847	0.892	1.02	0.106	0.14	0.376	0.637	1.48	1.32	0.67	0.596	0.972	0.99	0.981	1	1.01	1.01	0.927	0.906	1	0.341	0.286	0.736	0.698
Thallium (Tl)-Dissolved	<0.0020	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	<0.0010	<0.00050	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.0025	<0.0010	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.0025	<0.0025
Tin (Sn)-Dissolved	<0.0050	<0.00050	<0.00050	<0.00050	<0.0010	<0.00050	<0.0010	<0.00050	<0.00050	<0.0010	<0.0010	<0.0010	<0.0010	<0.00050	<0.00050	<0.00050	<0.00050	<0.0025	<0.0010	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0025	<0.0050	<0.0025	<0.0025	<0.0025	<0.0025	<0.00050	<0.00050	<0.0025	<0.0025
Titanium (Ti)-Dissolved	0.014	0.01	<0.010	0.026	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010	0.011	0.011	0.013	0.013	0.014	0.014	0.015	0.014	0.014	0.015	0.019	0.018	0.019	<0.010	0.011	0.015	0.016
Uranium (U)-Dissolved	<0.0020	0.00209	0.0012	0.000658	0.00048	0.00514	0.00513	0.000486	0.000501	0.00015	0.00489	0.00501	0.00309	<0.00020	<0.00020	0.00273	0.00346	0.086	0.0128	0.0037	0.0029	0.007	0.007	0.0068	0.007	0.0075	<0.0010	0.0016	0.0016	0.001	0.00067	0.00071	0.0023	0.0015
Vanadium (V)-Dissolved	<0.010	0.0083	0.0125	<0.0050	<0.010	<0.0050	<0.010	<0.0050	<0.0050	<0.010	<0.010	<0.010	<0.010	0.0059	0.0048	0.0015	0.0018	<0.0050	<0.0020	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.010	<0.0050	0.0052	0.0051	0.0064	0.0019	0.0044	<0.0050	<0.0050
Zinc (Zn)-Dissolved	23.2	0.0307	0.0094	0.197	0.462	<0.0050	<0.010	<0.0050	<0.0050	<0.010	0.123	0.129	0.121	<0.0050	0.0117	<0.0050	<0.0050	0.437	0.233	4.44	3.66	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0099	0.0104	0.0076	<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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.25	-	<0.25	-	<0.25	<0.25	-	-	-	-	-	-	-	-	-	-
HEPH	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.25	-	<0.25	-	<0.25	<0.25	-	-	-	-	-	-	-	-	-	-
Polycyclic Aromatic Hydrocarbons																																			
Acenaphthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Acenaphthylene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Acridine	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Benz(a)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Benzo(a)pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Dibenz(a,h)anthracene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Fluoranthene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Fluorene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<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	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Phenanthrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Pyrene	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
Quinoline	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	<0.000050	-	<0.000050	-	<0.000050	<0.000050	-	-	-	-	-	-	-	-	-	-
d10-Acenaphthene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	93	-	97	-	98	96	-	-	-	-	-	-	-	-	-	-
d9-Acridine (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	90	-	92	-	92	89	-	-	-	-	-	-	-	-	-	-
d12-Chrysene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	89	-	91	-	92	90	-	-	-	-	-	-	-	-	-	-
d8-Naphthalene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	87	-	93	-	93	83	-	-	-	-	-	-	-	-	-	-
d10-Phenanthrene (SS)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	94	-	97	-	97	97	-	-	-	-	-	-	-	-	-	-

All values are in mg/L unless otherwise stated

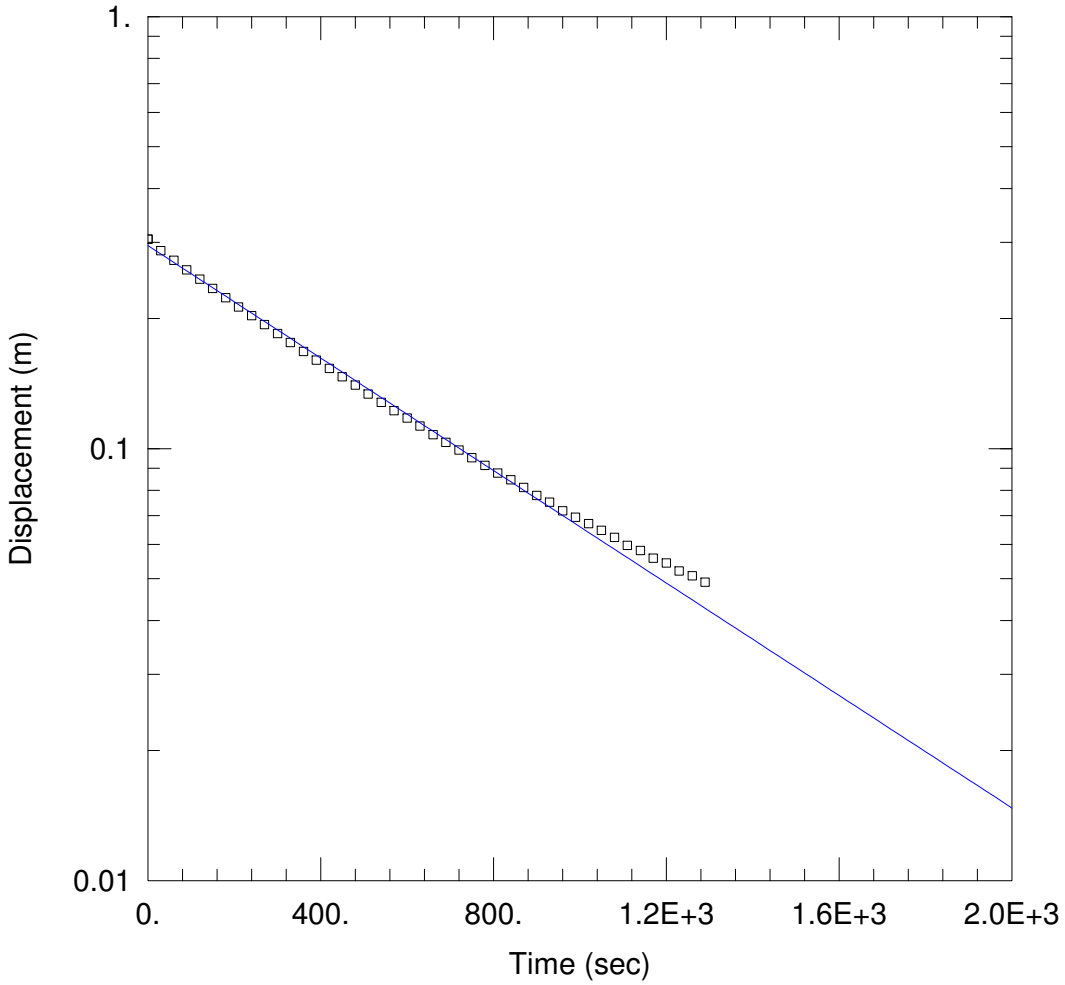
2009 Groundwater Quality Analytical Results

	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	0.000697	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.

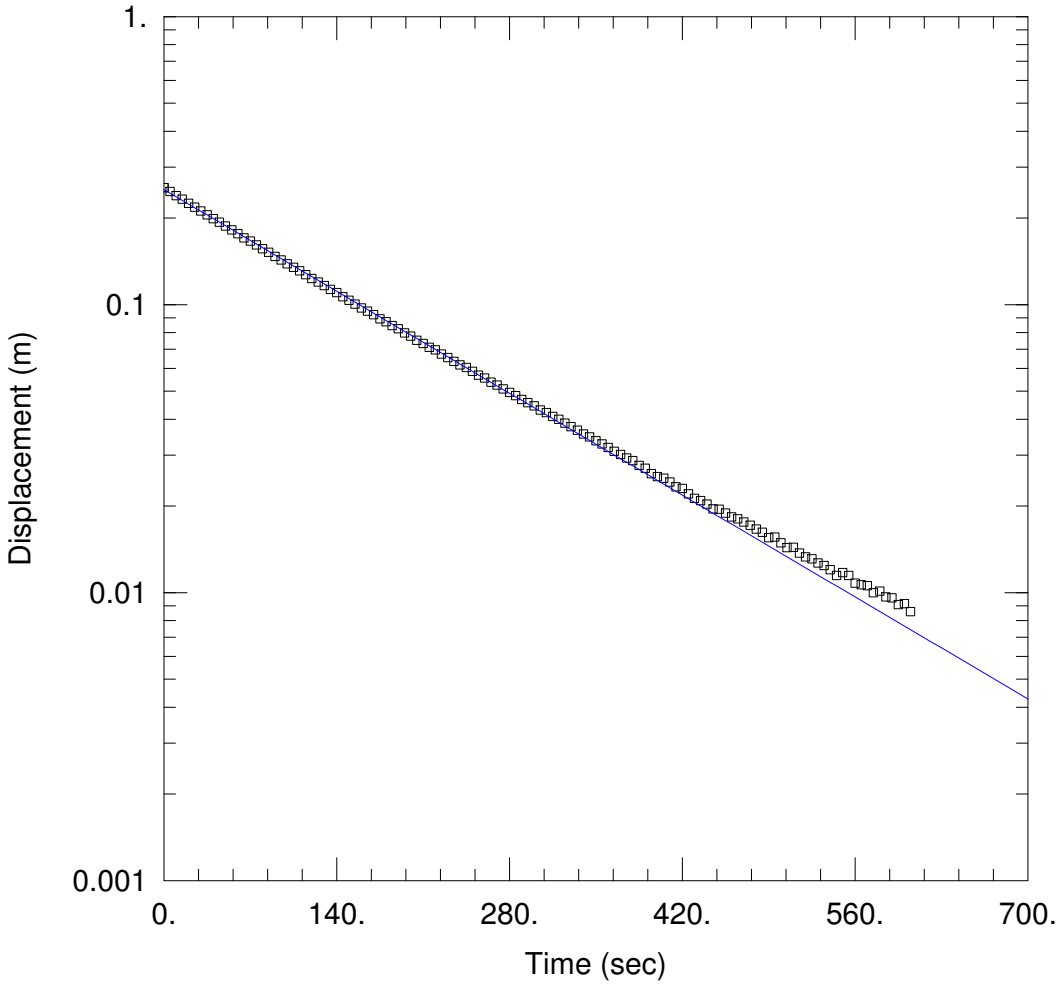
WELL DATA (MW09-02)

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.

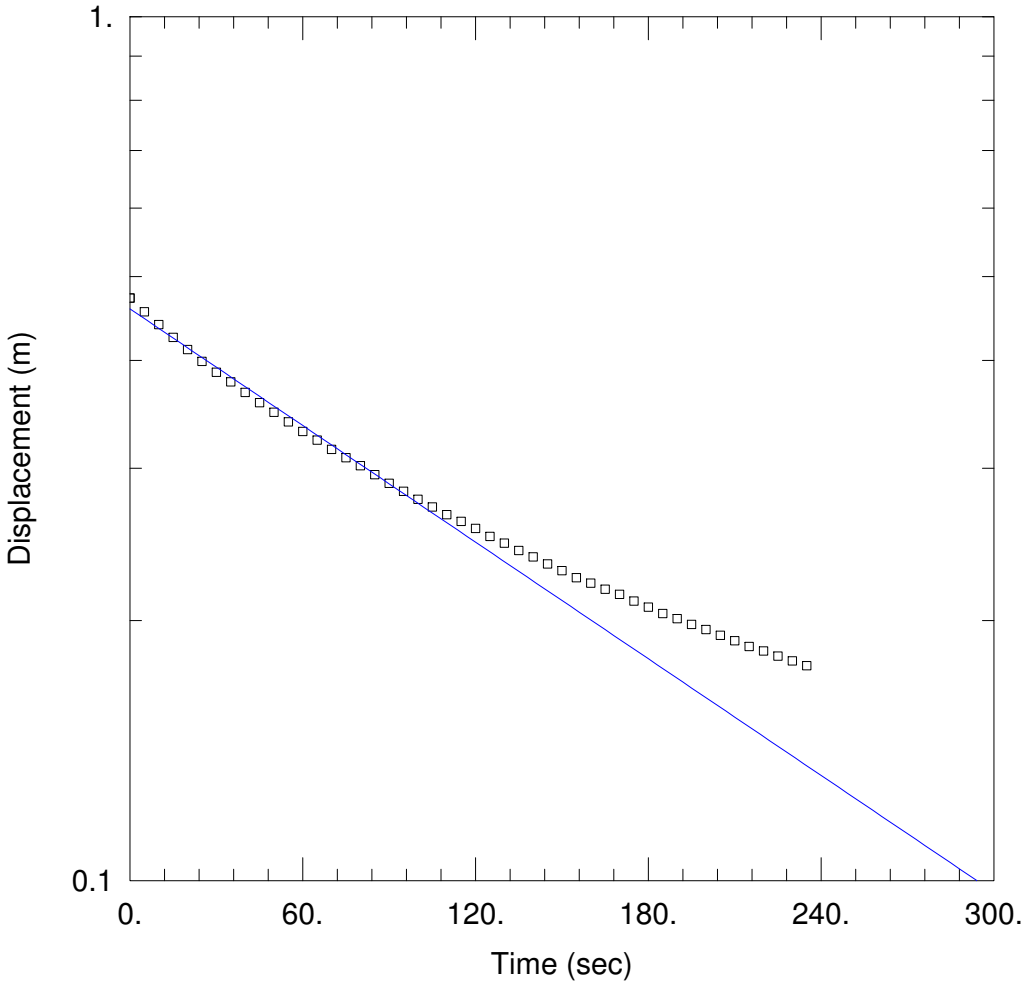
WELL DATA (MW09-03)

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.

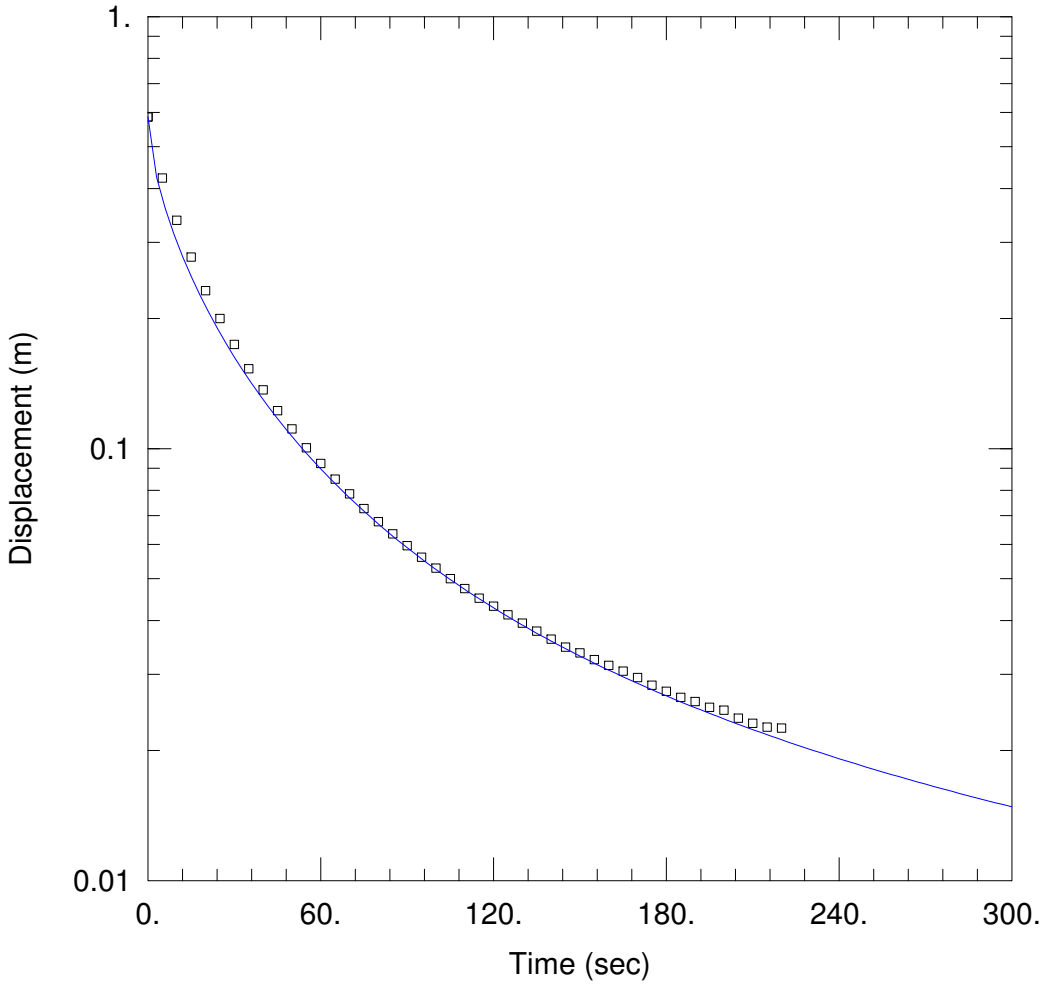
WELL DATA (MW09-06)

Initial Displacement: 0.4723 m Static Water Column Height: 2.91 m
Total Well Penetration Depth: 3.048 m Screen Length: 3.048 m
Casing Radius: 0.0254 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.

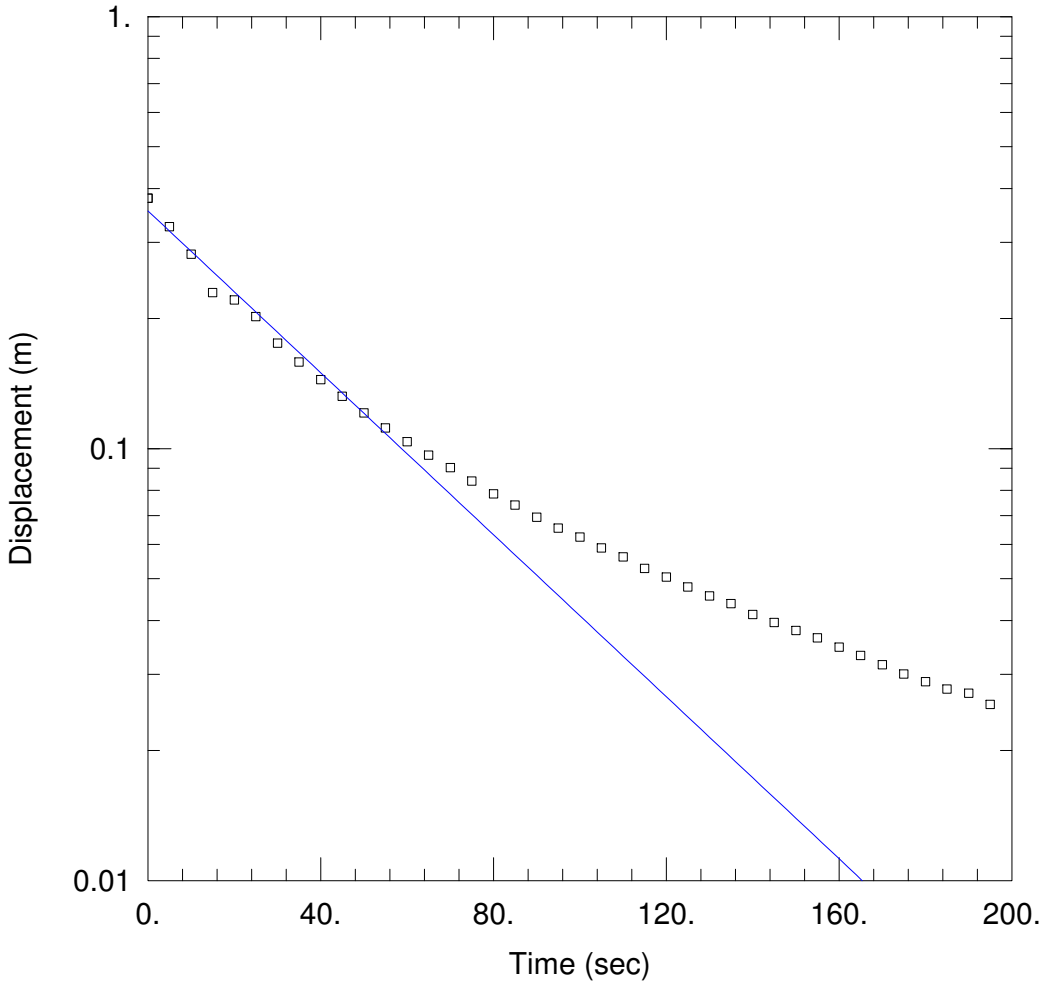
WELL DATA (MW09-15)

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

Appendix E

Open Pit Geological Considerations Memo

MEMORANDUM

August 21, 2009

To: Dian e Lister

From: Rob ert 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

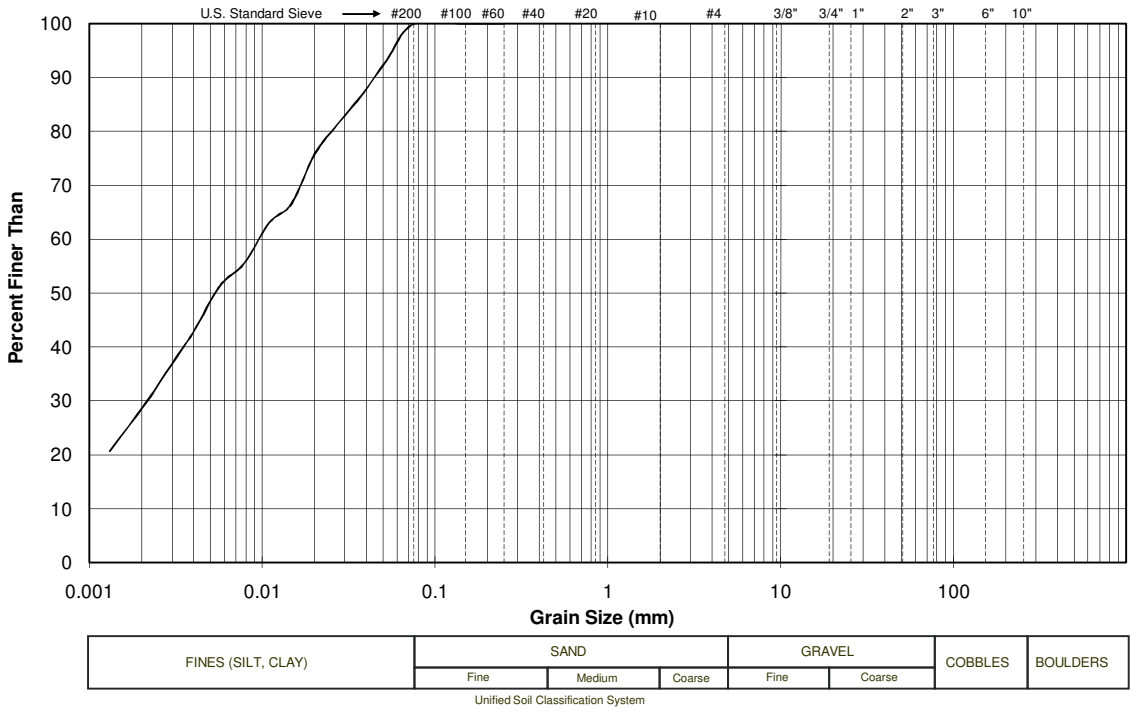
MDH ENGINEERED SOLUTIONS

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

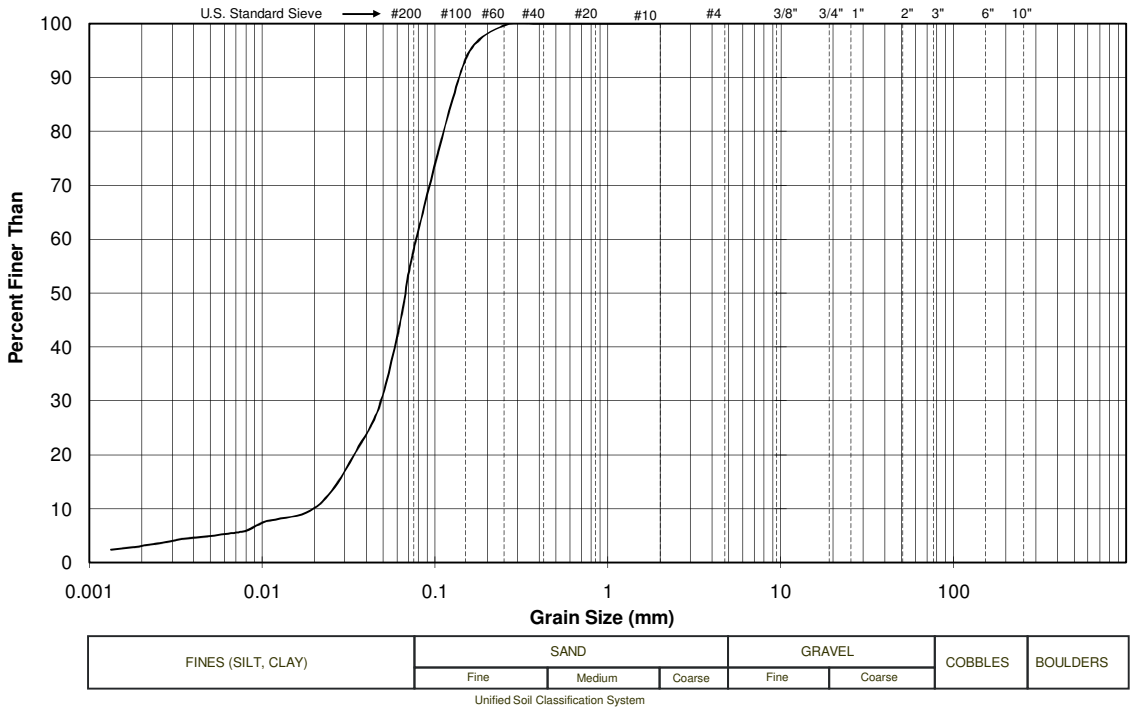
MDH ENGINEERED SOLUTIONS

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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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	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

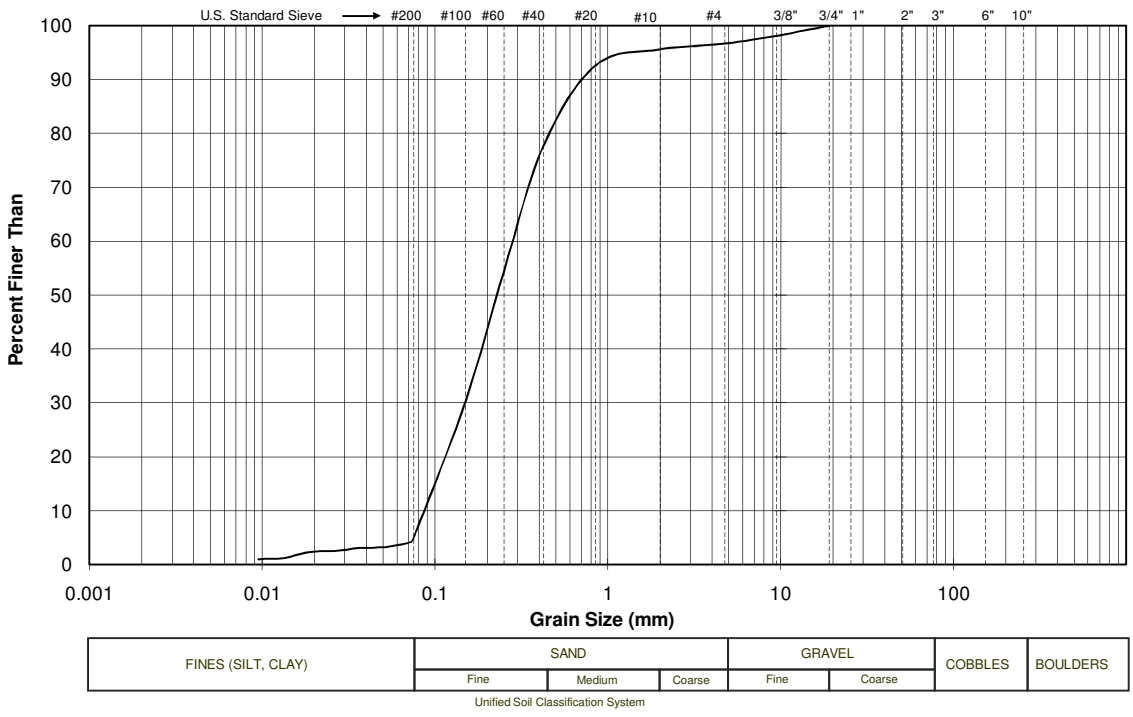
MDH ENGINEERED SOLUTIONS

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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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

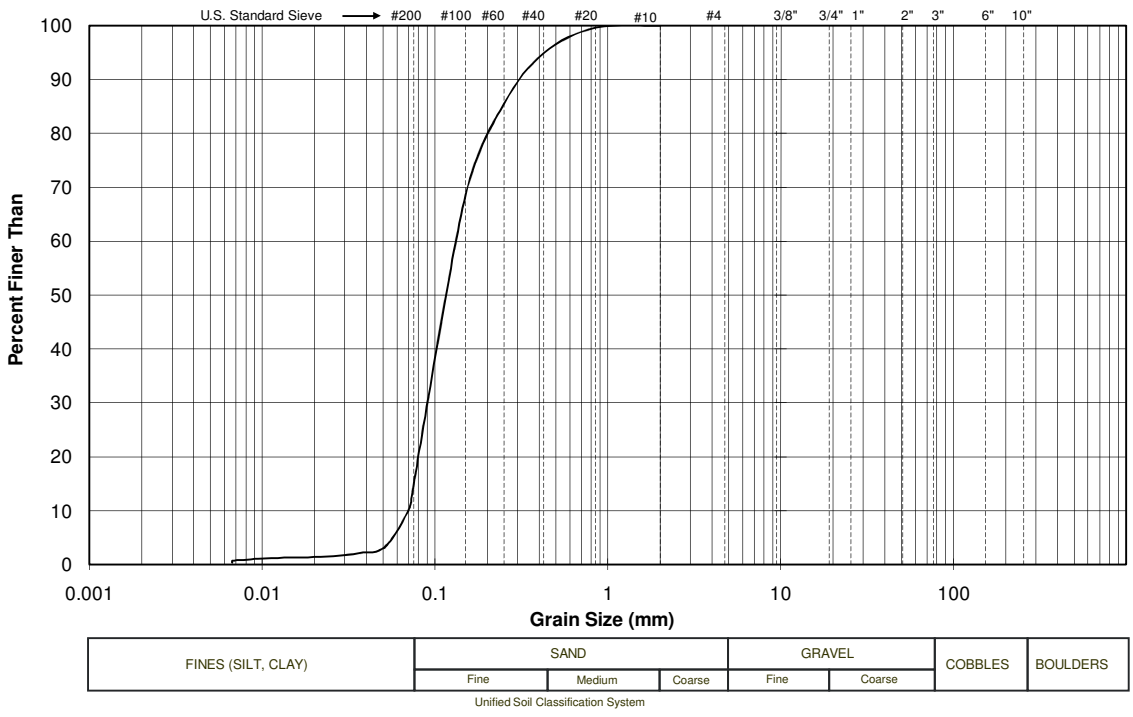
MDH ENGINEERED SOLUTIONS

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:



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.

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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Engineering interpretation will be provided by MDH Engineered Solutions Corp upon request.

Soil-Water Characteristic Curve Test Report

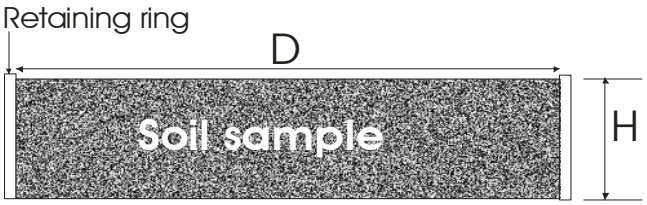
(reference standards: ASTM D6836-02)

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

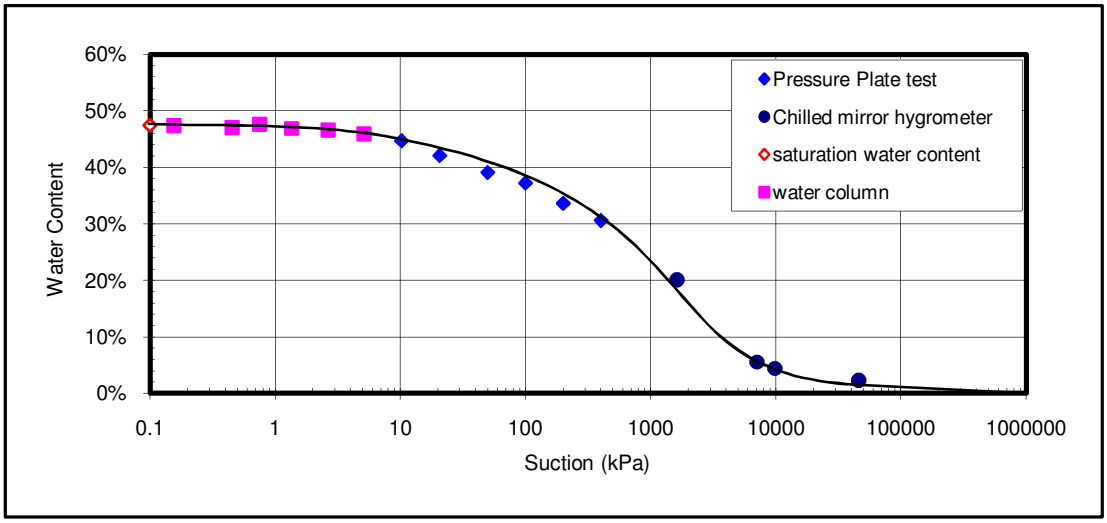
water elevation from (cm) top	water elevation from (cm) base	average suction, kPa	Gravimetric water content, %
3	0.0	0.2	47.4%
6	3.0	0.5	47.1%
9	6.0	0.8	47.7%
15	12.0	1.4	46.9%
28	25.0	2.7	46.6%
53	50.0	5.2	45.9%

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

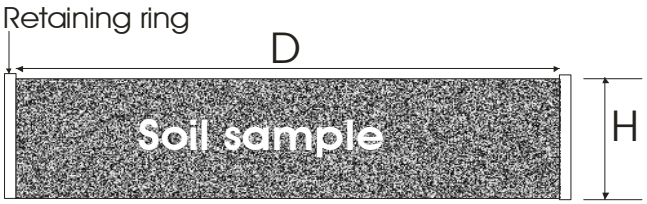
(reference standards: ASTM D6836-02)

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

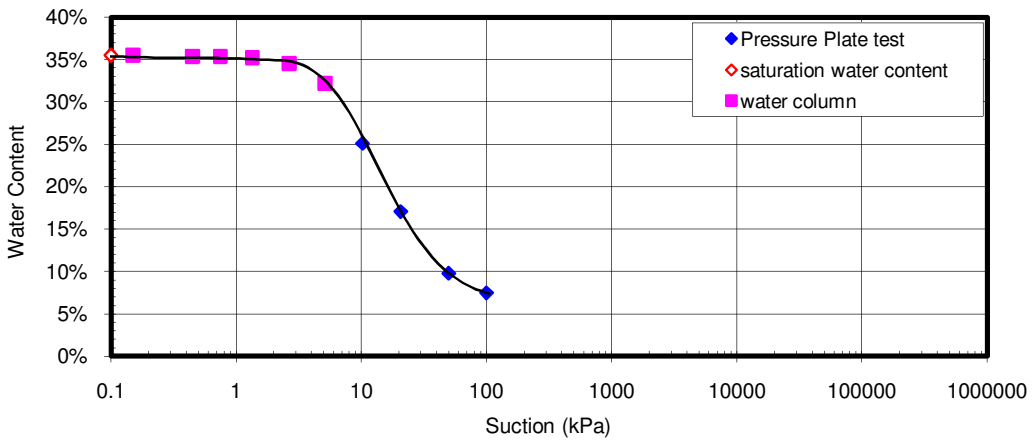
water elevation from (cm) top	water elevation from (cm) base	average suction, kPa	Gravimetric water content, %
3	0.0	0.2	35.5%
6	3.0	0.5	35.4%
9	6.0	0.8	35.3%
15	12.0	1.4	35.2%
28	25.0	2.7	34.5%
53	50.0	5.2	32.2%

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%

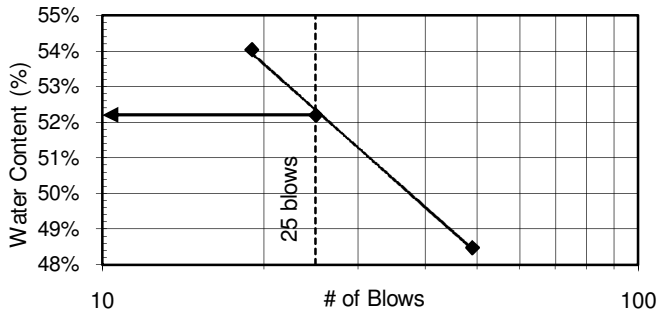
Liquid Limit (method A)

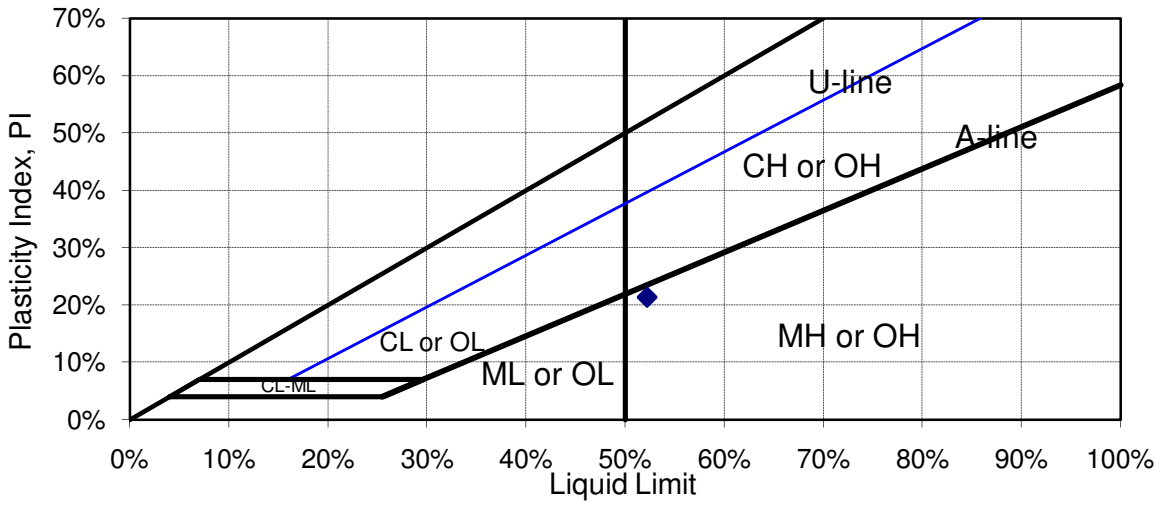
# of Blows	19	25	49
Tare #	15A	65A	9A
Tare Wt, g	14.57	14.33	14.28
Wet + tare, g	19.16	18.50	18.17
Dry + tare, g	17.55	17.07	16.90
Water content	54.0%	52.2%	48.5%

SUMMARY

Plastic Limit:	30.9%
Liquid Limit:	52.2%
Plasticity Index:	21.4%
Classification:	MH

Natural Water Content: 51.0%





Comments: -

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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

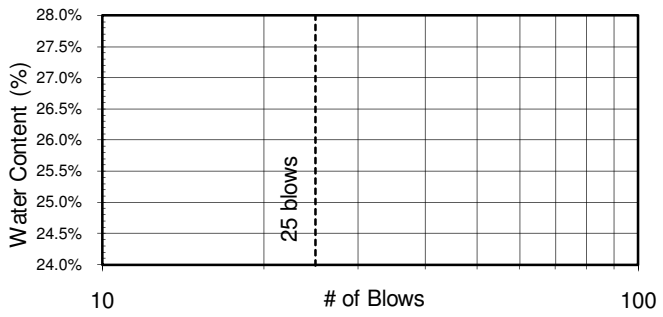
Plastic Limit: -

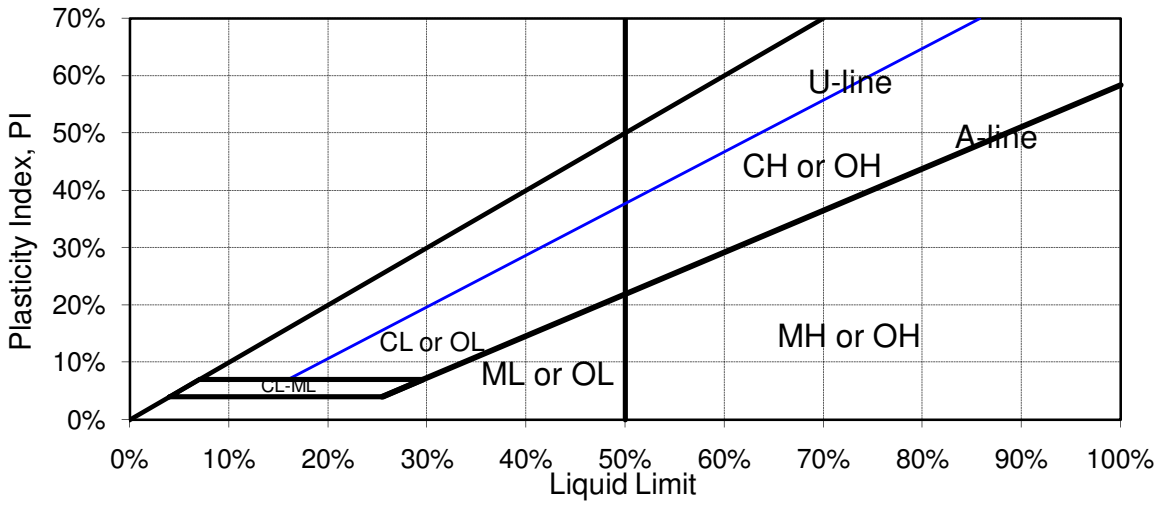
Liquid Limit: -

Plasticity Index: -

Classification: **Non Plastic**

Natural Water Content: n/a





Comments: **Material cannot be rolled. Non-plastic**

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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	Ks = 1 x 10^{-5} m/s
	90	m3/yr	Ks = 1.2 x 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

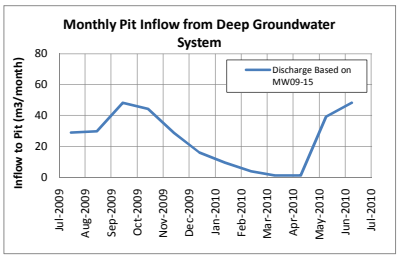
Seepage Face	Jul-09	Aug-09	Sep-09	Oct-09	Nov-09	Dec-09	Jan-10	Feb-10	Mar-10	Apr-10	May-10	Jun-10
Difference between MW09-15 and pit lake level (m)	6.70	6.80	8.80	8.30	6.80	5.00	3.80	2.50	1.20	1.30	7.80	8.80
Height of seepage face est. as 25% of difference between MW09-15 and pit lake elevation (m)	1.68	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

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

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

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).

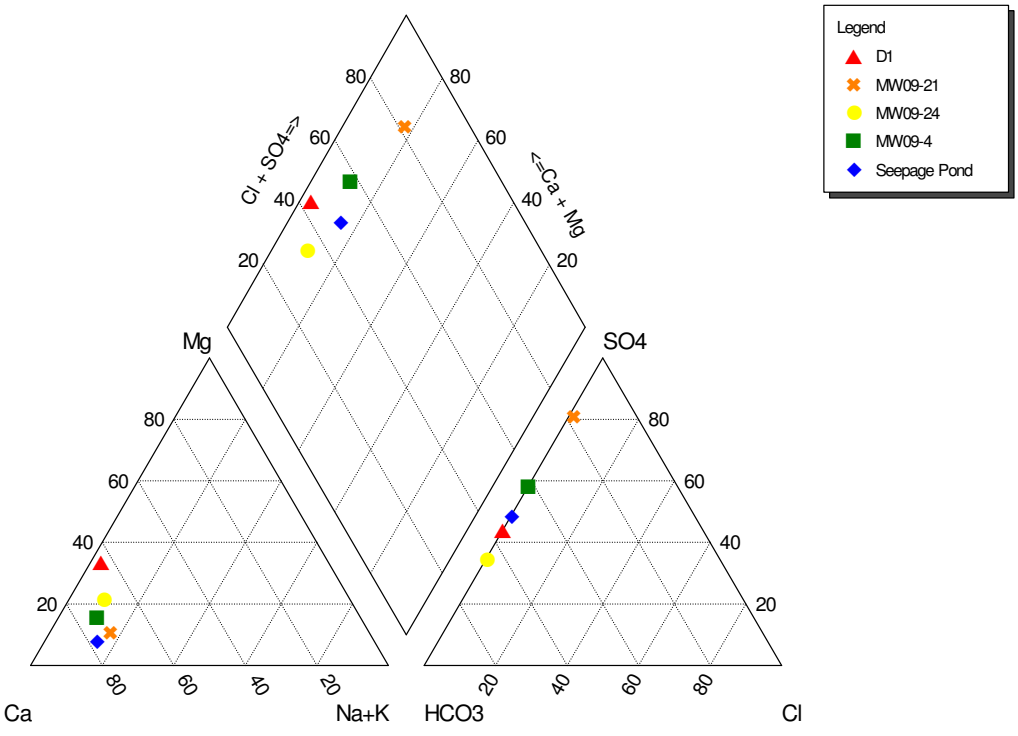


Figure 1. Piper Plot of Potential Sources Reporting to Seepage Collection Pond

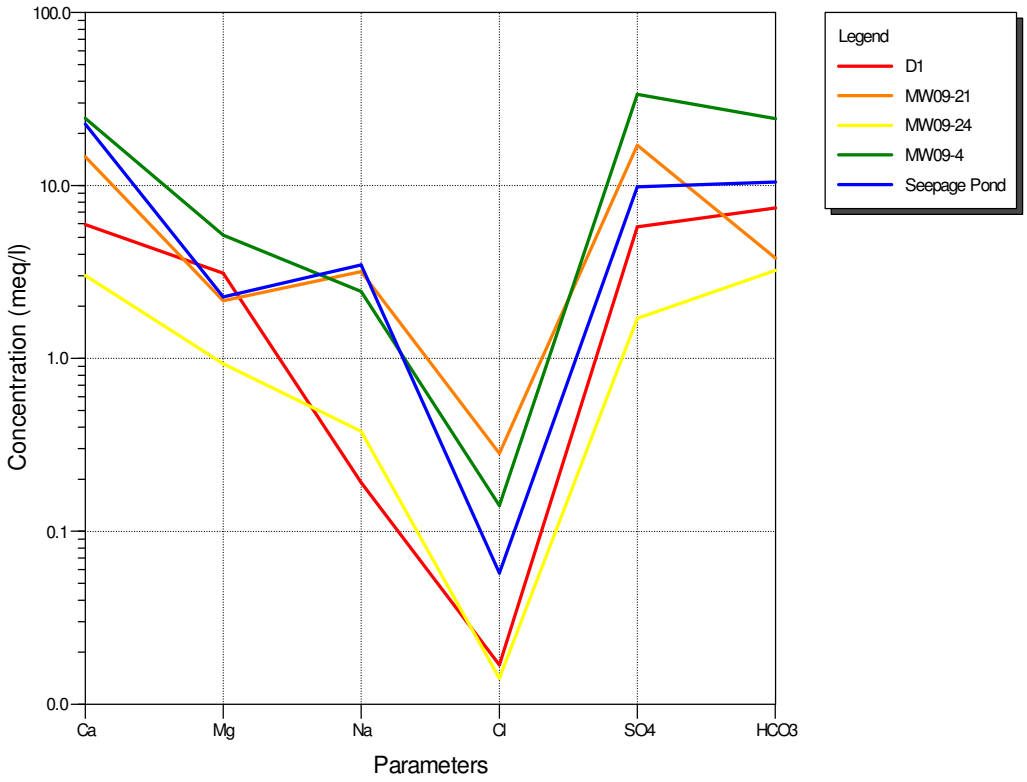


Figure 2. Schoeller Diagram Illustrating Potential Sources Reporting to Seepage Collection Pond

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.

Appendix F: Water Balance and Water Quality Modeling (Gomm Environmental Engineering Consulting)

Yukon

Mount Nansen Closure Alternatives Water Balance/Water Quality Model

Description of Model Configuration and Water Quality Predictions (Updated Final Draft)

Prepared for:
Assessment and Abandoned Mines Branch
Department of Energy, Mines and Resources
Government of Yukon

Prepared by:
Gomm Environmental Engineering Consulting
122 Alusru Way
Whitehorse, Yukon

May 2011

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1 Introduction

The overall objective of the modeling work was to develop an integrated water balance/water quality model to support the ongoing assessment of closure alternatives for the Mount Nansen Mine Site. The model was developed in Goldsim, a Monte Carlo simulator commonly used for water balance and water quality modeling at mine sites. This work built upon previous modeling efforts completed in 2009/2010 and incorporated additional information developed in 2010 and 2011 to further develop and characterize closure options for the site. The model was then used to assess the long-term performance of the closure options being evaluated with respect to predicted water quality in the downstream receiving environment in Victoria Creek. The six closure options evaluated as part of this work were:

- Option 1A – Tailings Dam Upgrade with Water Cover and Waste Rock in Place;
- Option 1B – Tailings Dam Upgrade with Water Cover and Waste Rock Backfill into Pit;
- Option 2A – Tailings Dam Upgrade with Saturated Soil Cover and Waste Rock in Place;
- Option 2B – Tailings Dam Upgrade with Saturated Soil Cover and Waste Rock Backfill into Pit;
- Option 3 – Tailings Backfill into Pit with High Infiltration Cover and Waste Rock in Place; and
- Option 4 – Tailings and Waste Rock Backfill into Pit with Low-Infiltration Cover.

The model incorporated various water balance and geochemical inputs developed by others including:

- Characterization of site hydrology and climatic conditions (AECOM 2010a);
- Definition of physical and geotechnical characteristics of each closure option (AECOM 2010b);
- Source term chemistry (Lorax 2010a);
- Hydrogeological characterization of the tailings and pit (AECOM 2010c);
- One-dimensional water balance modeling of tailings cover options (Golder 2010a);
- One-dimensional water balance modeling of waste rock backfill (Golder 2010a); and
- Low-Infiltration cover assessment and modeling (Golder 2010b)

For each closure option, the water quality model was run using monthly time steps. This time interval of the model output was selected as it is consistent with the quality of the input data and allows for the assessment of seasonal variations in water quality. For each option, two sets of source terms were developed and incorporated in to the model: Best Estimate and Upper Estimate. In addition, three different climatic conditions were evaluated for each source term scenario: dry, average and wet precipitation condition. Specific details for the model configuration, assumptions and results are discussed in the following sections.

2 Site Climate, Hydrology and Water Quality Model Assumptions

2.1 Climate

2.1.1 Precipitation

A historical climate record for precipitation was generated for the site for the period 1964 to 2006 based on climate data collected at the Environment Canada station at Carmacks (AECOM 2010a). The following provides an overview of this analysis. Specific details are provided in *Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation* (AECOM 2010a).

For summer precipitation, or rainfall, a relationship was developed using monthly precipitation data from the Carmacks climate station and the climate station at Mount Nansen for the overlapping period between 2000 and 2006. Using this relationship, the historical daily rainfall data from the Carmack's station were used to generate a proxy historical daily precipitation record for Mount Nansen. Based on this synthetic record, dry, wet and average precipitation conditions were selected. The year 1976 was selected as the dry year, 2000 was selected as the wet year, and 2003 was selected s a typical or average year. Monthly precipitation for each precipitation condition is presented in Table 2-1.

Table 2-1 Monthly Precipitation for Dry, Average and Wet Year Condition (mm)

Month	Dry Year	Average Year	Wet Year
April	57.0	46.1	63.3
May	31.4	34.1	61.9
June	31.1	68.0	47.0
July	46.9	61.0	88.0
August	7.9	38.0	117.0
September	0.5	13.0	85.0
October	5.2	23.0	10.0
Total	180.0	283.2	472.2

For snowfall and the calculation of end of March snow water equivalents (SWE), a regression formula was developed using accumulated snow at Carmacks from November 1 through March, in conjunction with the end of March SWE measured at Mount Nansen as part of the annual snow survey program. An additional correlation was then developed to account for any additional snowfall during the month of April based on April precipitation at site and Carmacks for the period of 2000 to 2006. For snowmelt it is assumed that 82% of the annual snow accumulation melts between April 15th and April 30th and 18% between from May 1st and May 7th.

2.1.2 Evaporation

There are no direct evaporation data available for the Mount Nansen site. Lake evaporation rates estimated for the Pelly Ranch Environment Canada Meteorological gauging station were used to estimate evaporation at Mount Nansen (AECOM 2010a). Mean annual lake evaporation for the site was estimated to be 369 mm occurring from May to September, with the majority occurring in June and July. Monthly mean lake evaporation rates are provided in Table 2-2.

Table 2-2 Monthly Evaporation (mm)

Month	Evaporation (mm)
May	85
June	98
July	90
August	65
September	31
Total	369

2.2 Hydrology

Using the annual precipitation for dry, average and wet year conditions, monthly flows were calculated for each precipitation condition at various locations in the mine site catchment including Dome Creek (AECOM 2010a). For the months with measurable rainfall and snowmelt (April through October) the total volume of surface flow for each month was calculated according to the following:

Monthly volume of surface flow = monthly precipitation x runoff coefficient x catchment area

A runoff coefficient of 0.6 was used for the summer months and a spring runoff coefficient of 0.8 was used for the months of April and May. Runoff coefficient estimates provided in AECOM (2010a) were not derived from site or local measurements, but were based on professional judgment.

Attempts to measure flow in winter showed that Dome Creek and Pony Creek were frozen to the substrate. As a result, zero flow was assumed for Dome Creek during the winter months (November through March).

In contrast to Dome Creek, Victoria Creek experiences some flow during the winter period, as revealed by on-site monitoring. For the Victoria Creek catchment, a different approach was adopted to calculate monthly stream flows based on the monthly distribution of annual flow as measured at the Water Survey Gauging Station on the Nordenskiold River (Table 2-3).

Table 2-3 Monthly Steam Flow Distribution for Victoria Creek

Month	Monthly Flow Distribution (%)
January	1.2
February	0.6
March	0.7
April	5
May	25.9
June	18.7
July	12.8
August	11.3
September	11.2
October	7.2
November	3.4
December	2

2.3 Water Quality

2.3.1 Summary of Existing Conditions

The Mount Nansen site is shown in relation to the receiving environment and the water quality monitoring stations in Figure 2-1. The Upper Dome Creek monitoring site is situated downstream of the tailings facility, just downstream of where tailings seepage water enters Dome Creek. Upstream of the tailings facility on Dome Creek, there are two water quality monitoring locations, DX and D1. The mill complex is situated in between these two stations. Flow at the Upper Dome Creek monitoring site is a combination of flow through the diversion channel and flow from the continuous discharge from the seepage pond. The receiving environment site for Victoria Creek is represented by the sampling location Vic @ Road. This location is downstream of inputs from both Dome Creek and Back Creek, and includes all potential mine site related inputs to the receiving environment. In contrast to Dome Creek, Victoria Creek is known to support fish and fish habitat.

A large amount of baseline water quality data were collected over the past ten years at the Mount Nansen site. Surface water quality sampling began in 1999 by the Department of Indian and Northern Affairs (DIAND). The Government of Yukon took over the sampling program in 2003, and in 2005 contracted this work to Environmental Dynamics (EDI), who continue to oversee site monitoring. In 2009, AECOM prepared a comprehensive compilation of the available site water quality data up to October 2009 (AECOM 2010d). Review of the compiled water quality data indicated a marked improvement in parameter detection limits after December 2007. Since 2007, water quality samples have been consistently analyzed at one laboratory at suitable detection limits to allow comparison to CCME Guidelines for the Protection of Aquatic Life. In consideration of this change in 2007, water quality data for modeling purposes was limited to data collected between December 2007 and July 2010.

In general, the water quality data for Victoria Creek upstream of the Dome Creek confluence (Victoria Upstream and Victoria Reference) show comparable water quality compositions (Figure 2-2). In contrast, inspection of the water quality data for Victoria Creek downstream of the Dome Creek confluence (Vic @ Road) shows a clear mine-related influence. For example, sulfate concentrations in Victoria Creek downstream of Dome Creek (mean = 28.5 mg/L) exhibit a pronounced increase in comparison to levels upstream of Back Creek (Victoria Reference mean = 12.3 mg/L) and downstream of Back Creek (Upper Victoria mean = 13.4 mg/L) (Figure 2-2). Despite the mine-related loadings from Dome Creek, sulfate concentrations in Victoria Creek remain below the working sulfate guideline (British Columbia Approved Water Quality Guideline of 100 mg/L) for all stations and time periods.

Inter-station comparisons on Victoria Creek were also conducted for the main trace elements of concern (arsenic, zinc and cadmium) (Figure 2-2). Dissolved metals, as opposed to total concentrations, were selected for the spatial comparison in order to isolate mine-related influences, and to specifically rule out the interfering effects of suspended solids contributed by both natural and anthropogenic sources (e.g., placer mining activity). In general, metal concentrations upstream of the Dome Creek confluence (Victoria Upstream and Victoria Reference) are low and show good between-station consistency. Downstream of Dome Creek, the concentrations of dissolved arsenic show well defined increases, reflecting the contribution of mine-related inputs. Dissolved arsenic concentrations in Victoria Creek increase by almost an order of magnitude from upstream values of ~0.0004 mg/L to mean levels downstream of Dome Creek of 0.003 mg/L (Figure 2-2). At all sites, dissolved arsenic values remain below the water quality guideline of 0.005 mg/L.

The downstream trends for dissolved zinc and dissolved cadmium are less pronounced than those observed for sulfate and dissolved arsenic. Mean values for dissolved zinc below the Dome Creek confluence (0.0041 mg/L) show only a minor increase in concentration in comparison to levels observed upstream (mean = 0.0027 mg/L). Similarly, inputs from Dome Creek have only a minor influence on

dissolved cadmium concentration in Victoria Creek. Dissolved cadmium concentrations upstream of Dome Creek (mean = 0.000023 mg/L) are only marginally lower than those values reported downstream of the Dome Creek confluence (mean = 0.000027 mg/L).

Collectively, the water quality data for Victoria Creek demonstrate that inputs from Dome Creek have a marked effect on water quality with respect to sulfate and arsenic. Minor mine-related signatures from Dome Creek with respect to zinc and cadmium are also observed; however, the effect on these parameters is far less pronounced. In consideration to the conditions currently observed in Victoria Creek, the existing levels of sulfate, arsenic, zinc and cadmium are not anticipated to have adverse effects on aquatic communities. This conclusion relates to the absolute concentrations currently observed, principles of metal bioavailability (i.e., toxicity dependent on free ion activity), as well as to the hardness-dependent toxicity characteristics of sulfate, cadmium and zinc.

2.3.2 Background Water Quality Assumptions

2.3.2.1 Use of Median Value

The primary objective of this document is to provide the technical information necessary from which to evaluate the merits of each closure alternative by stakeholders, including local communities, as well as federal, Yukon and First Nation governments. In order to best illustrate the differences between the closure options with regards to water quality, background conditions were assigned median values for "total" metals in the model. The rationale for the use of total metals, and the use of annual median values as opposed to monthly values, is as follows:

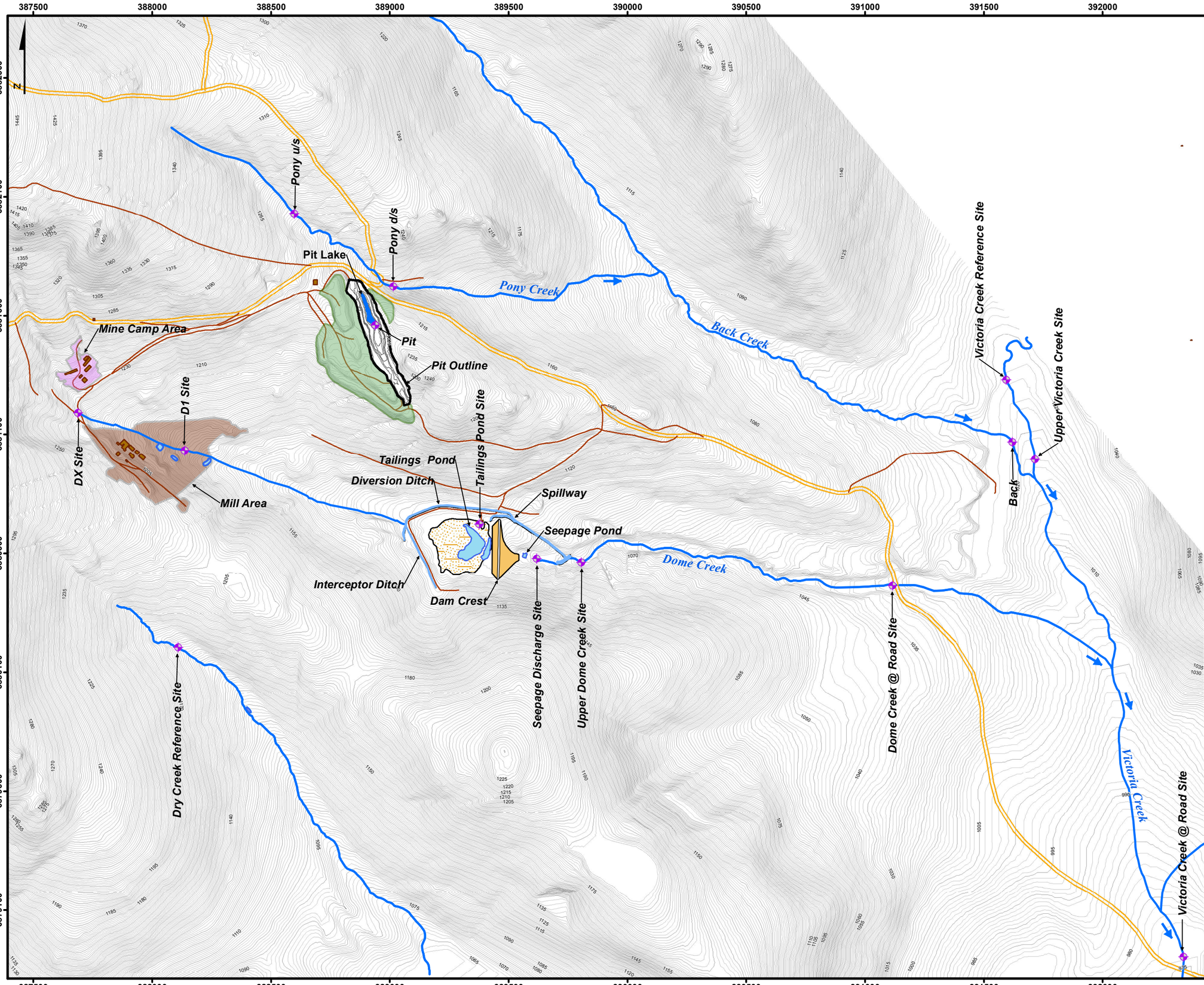
1. Inclusion of the full range in seasonal total metal levels will generate very high values for some metals at the downstream sites. This will act to overwhelm the mine-related signature and prevent adequate differentiation of the various closure options;
2. Metal levels in Victoria Creek and Back Creek are governed predominantly by particulate fractions, with maximum metal levels occurring commensurately with elevated TSS. However, there are no consistent seasonal trends in the data, which imply TSS events are governed by variables other than freshet flows, such as storm events and placer mining activities. Accordingly, it is difficult to assign defensible monthly total metal values;
3. From the perspective of metal bioavailability, it is now widely accepted that the toxicity of metals in natural waters is greatly dependent on their chemical form, and that the total metal concentration is generally a poor predictor of its biological impact. Specifically, it is recognized that for most trace elements, biologically availability and hence toxicity is governed by the concentration of the free metal-ion (or free ion activity). Accordingly, given that the median "total" background values include a high proportion of particulate species, the model will overestimate the biologically-available fraction. This adds an element of conservatism into the model;
4. Background concentrations for the winter months were assigned median values based largely on samples collected during the ice-free months. Given that samples collected during the ice-free months contain a significant proportion of particulate metals, it is likely that the median values overestimate the values observed during the winter months. This adds a further element of conservatism into the model;
5. Worst-case parameter concentrations are predicted for the low flow months, and therefore these months will be the focus of the options comparison. TSS concentrations, and hence particulate metal levels, are predicted to be low during the winter months, and hence the considerations with regards to the use of total metals has less relevance during these critical periods; and
6. The use of dissolved metal values was also avoided, given the questionable reliability of the data with regards to the lack of field filtration and the long holding times between sample collection and filtration at the laboratory.

2.3.2.2 Removal of Mill Area Influence

Assessment of all existing water quality at site (AECOM, 2010d) indicated that the mill site area is a source of contaminants to Dome Creek upstream of the tailings area. Review of the baseline data at D1 and DX indicates that the mill area has an influence on the water quality at D1 for arsenic, cadmium, manganese, zinc, sulfate, calcium, magnesium and hardness (Table 2-4). Given that reclamation of the mill area is common closure element to all six options being evaluated, the background concentrations (median) for arsenic, cadmium, zinc, sulfate, calcium, and magnesium in Dome Creek were assigned those values for Station DX. Selection of the DX water quality as input into the mass loading model allows for more effective differentiation of the performance of the various closure options.

Table 2-4 Summary of Water Quality at D1 and DX in Dome Creek (Median of 2007 to 2010 dataset)

	Median Concentration (mg/L) (2007 to 2010)	
	DX	**D1**
Sulfate	156	412
Total Arsenic	0.005	0.015
Total Cadmium	0.00004	0.00179
Total Manganese	0.064	0.252
Total Zinc	0.009	0.397
Total Calcium	65.9	170.5
Total Magnesium	16.7	54.7
Hardness	233	652



CLIENT::

Yukon Government

Legend

- Surface Water Quality Stations
- Mine Road
- Public Road
- Mill Area
- Mine Camp Area
- Tailings Dam
- Ponds
- Tailings
- Mine Infrastructure
- Pit Outline
- Waste Rock Area

Topography (Except Pit)

- Index (5m)
- Interm. (1m)

Meters
0 250 500 1,000

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE: 1:15,000

DATE: NOV 2nd, 2010

PROJECTION: NAD_1983_UTM_Zone_8N

PROJECT MANAGER: J.S.

PROJECT:

Mount Nansen Water Balance and Water Quality Predictions

TITLE: **Mount Nansen Mine Site Current Conditions and Surface Water Quality Monitoring Stations**

PROJECT No:	FIGURE No:
J907-4	**2-1**

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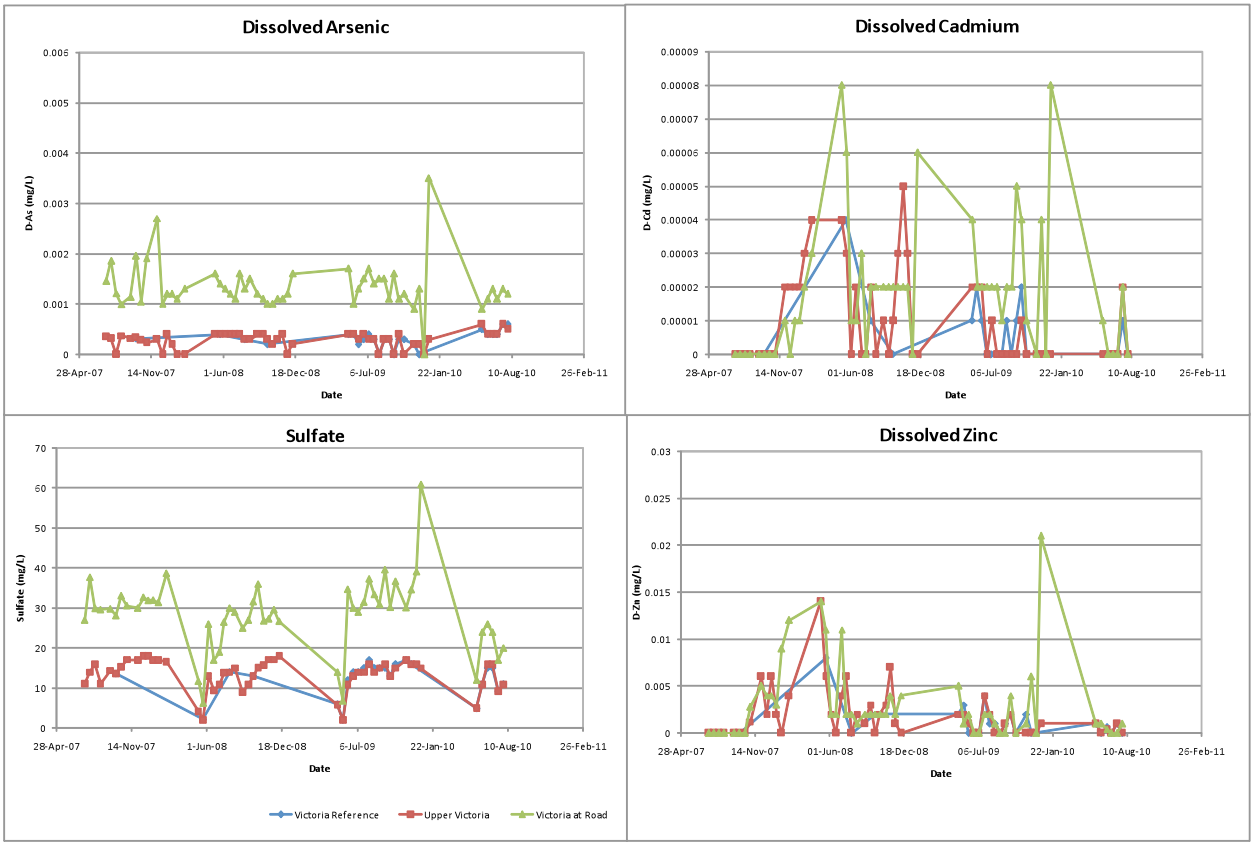


Figure 2-2 Time Series Profiles of Dissolved Arsenic, Cadmium, Zinc and Sulfate for Victoria Creek Upstream of the Back Creek Confluence (Victoria Reference), Upstream of the Dome Creek Confluence (Upper Victoria) and Downstream of Dome Creek (Victoria at Road)(existing conditions)

3 Pit and Tailings Area Water Balance Assumptions

The following sections summarize the groundwater flow regime for the Tailings Management Area and the Brown-McDade Pit presented in detail in *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM (2010c). The key water balance assumptions carried forward into the model are discussed, specifically, the assumed long-term discharge rates to the downstream receiving environment.

3.1 Brown-McDade Pit

As part of the earlier modeling work carried out by AECOM in 2009/2010 (AECOM 2010e) a pit water balance model was developed to simulate historical pit water levels. The pit lake was modeled as a reservoir or lake and the surface runoff coefficients were adjusted such that the predicted pit water levels matched the historical pit water levels. Results of this water balance indicated that relatively little groundwater makes up the water balance inflows into the pit, and that the pit water balance is dominated by surface water inflows. Since the development of the pit lake water balance model in 2009, additional field data has become available which resulted in a revision in the thinking around the pit water balance, and specifically the interactions between the pit and shallow and deep groundwater systems (AECOM 2010c).

As discussed in *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM (2010c), the pit lake is inferred to be a surface expression of the regional groundwater table and the water levels in the pit being hydraulically connected to the regional water table elevation. In the winter, the regional water table drops below the elevation of the water in the pit, resulting in a downward movement of water from the pit to the underlying groundwater system. During the open water season and periods of snowmelt and precipitation, the regional ground water table rises and there is an upward movement of water from the underlying groundwater system into the pit. Compared to the surrounding regional groundwater system, the pit water levels show relatively minimal changes in response to snowmelt and precipitation events. Given that the seasonal variations in the pit water level elevations mimic those observed in the underlying groundwater system, it appears that the water level in the pit is primarily controlled by the regional groundwater system rather than surface runoff.

In addition to the vertical fluctuations of water due to seasonal variations in the groundwater table, there is a horizontal component of groundwater flow in and out of the pit (AECOM 2010c). Based on the revised conceptual hydrogeological model, horizontal inflows into the pit consist of contributions from both the shallow and deep groundwater system while outflows from the pit to the receiving environment are solely associated with the deep groundwater system. The following summarizes the various components of groundwater inflows and outflow from the pit, although only the deep groundwater discharge from the pit to Dome Creek was used in the model.

- The shallow groundwater discharges to the north end of the pit, conveying water from Pony Creek within the active zone in the shallow fractured bedrock unit. This active zone flow is active during two periods of the year: during snowmelt and spring freshet in May and June and in late fall/early winter prior to active layer freeze back (October through December). For the remainder of the year, this shallow groundwater pathway is assumed to be either frozen (January to April) or unsaturated (July to September). Estimated shallow groundwater inflows into the pit ranged from 90 m^3/year to 750 m^3/year.

- The deep groundwater system is inferred to discharge to the north end of the pit from the regional bedrock aquifer. Estimated monthly groundwater inflows from the deep groundwater system range from 0.9 m^3/month to 48.2 m^3/month, for an estimated total of 298 m^3/year.

- Groundwater is thought to discharge from the south end of the pit towards Dome Creek via the deep groundwater system. The rate of groundwater discharge from the pit to Dome Creek was estimated using Darcy's Law for a range of hydraulic conductivity values and porosity and the long-term average gradient (2001 to 2010). Groundwater discharge from the pit was estimated to be on order of 4,249 m^3/year (0.13 L/s), but could be as low as 157 m^3/year (0.005 L/s) if permeability is lower. The discharge from the pit to Dome Creek was conservatively set to 0.13 L/s in the model.

3.2 Tailings Management Area

The tailings area is underlain by a shallow aquifer overlying permafrost. The shallow aquifer receives groundwater contributions primarily from the upstream valley bottom aquifer and the south-facing slopes of the Dome Creek catchment (AECOM 2010c). Onset precipitation and runoff infiltrates through the tailings and ultimately reports to the shallow unfrozen aquifer. The water level of the tailings pond rises each spring in response to runoff and snow melt from the tailings catchment. Below the permafrost, is a deeper groundwater system that is inferred to report to the deeper parts of the Dome Creek valley.

The tailings are in tension saturation. Tailings porewater and water in the tailings pond slowly infiltrates through the tailings and enters the underlying shallow aquifer. It then flows downgradient through the remnant organics and tailings dam fill and reports to the seepage collection pond. Groundwater flow into the seepage pond is primarily comprised of two components: 1) seepage through the dam, and 2) groundwater flow from the terrace north of the seepage collection pond. Based on measured groundwater gradients, a portion of the groundwater flowing within the terrace is likely recharge from the overlying diversion channel. 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. Review of the historical seepage data indicates that pumping rates fluctuate seasonally in response to changes in tailings and seepage pond levels as a result of precipitation and snowmelt.

A critical input to the model is the estimated long-term seepage from the tailings area for Option 1 and 2. The following summarizes the assessment of long-term seepage rates from the tailings area that was carried out by AECOM (AECOM 2010c).

- Two-dimensional groundwater flow through the tailings dam was conducted as part of the geotechnical investigation (AECOM, 2010b) to estimate the amount of groundwater seepage through the tailings dam in its current condition. A unit width seepage rate of 1.1 X 10^{-5} m^2/s was estimated for the cross-section through the centreline of the tailings dam or an overall steady-state seepage rate of 2.8 L/s.

- Historical seepage collection pond pumping data, specifically low flow or winter season data, was reviewed to confirm the results of two-dimensional seepage modeling through the dam (AECOM, 2010c). Estimates of seepage reporting to the seepage collection pond were made based on time-series analysis, correlation analysis with precipitation and catchment recharge analysis and compared to the results of two-dimensional seepage modeling (AECOM 2010c).

- Recent pumping records from the seepage collection pond that indicate minimum winter pumping rates were on the order of 3.5 L/s with an average pumping rate was 5.11 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 modeling (2.8 L/s) indicate groundwater reporting to the seepage collection pond is between 2.8 L/s and 3.5 L/s. For modeling purposes for the tailings-in-place options the long-term seepage from the tailing facility to the receiving environment is conservatively set at the maximum of the estimated seepage rates: 3.5 L/s.

- For the existing dam configuration, mass loading calculations using groundwater chemistry data indicated that approximately 66% of the groundwater reporting to the seepage pond originated 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 (AECOM 2010c).

4 Description of Model for Closure Alternatives

AECOM (2010b) and Lorax (2010b) provide detailed descriptions of each of the closure options evaluated. Table 4-1 summarizes the key components of each option with respect to general design, water management and water quality.

4.1 Overview of Model Configuration

Simplified schematics of the water balance/water quality model for each closure option are shown in Figures 4-1 to 4-6. For each option, the model integrates the mine-related loadings and flows in the receiving environment. The mine site related sources that may contribute contaminant loadings to the receiving environment for each option are summarized below, and discussed in further detail in the following sections.

- Option 1A and 2A – Tailings Dam Upgrade with Water Cover or Saturated Soil Cover and Waste Rock in Place
    1. Year-round seepage from tailings storage area;
    2. Seasonal, shallow seepage from portions of waste rock on surface;
    3. Year-round deep groundwater seepage from the low-grade ore;
    4. Year-round deep groundwater seepage from portions of waste rock on surface; and
    5. Year-round deep groundwater seepage from the pit.

- Options 1B and 2B – Tailings Dam Upgrade with Water Cover or Saturated Soil Cover and Waste Rock Backfill into Pit
    1. Year-round seepage from tailings storage area;
    2. Year-round deep groundwater seepage from the low-grade ore; and
    3. Year-round deep groundwater seepage from the backfilled pit.

- Option 3 – Tailings Backfill into Pit with High Infiltration Cover and Waste Rock in Place
    1. Year-round deep groundwater seepage from low-grade ore;
    2. Year-round deep groundwater seepage from waste rock on surface; and
    3. Year-round deep groundwater seepage from the backfilled pit.

- Option 4 – Tailings and Waste Rock Backfill into Pit with Low-Infiltration Cover
    1. Year-round deep groundwater seepage from low-grade ore;
    2. Year-round deep groundwater seepage from the backfilled pit.

For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The model was run on a monthly time step for a calendar year (12 months).

On a monthly basis (time-step), the contaminant loading from each source for each option was calculated as follows:

Load = source concentration X source flow or seepage rate.

The total load to the receiving environment at the Victoria Creek model point was then calculated for each parameter as the sum of the loads from all the contributing sources. For example for Option 1A, the total load to the receiving environment was calculated as follows:

Total Load = Load from Waste Rock (both shallow and deep seepage) + load from Tailings + Load from Pit + Load from Low-grade Ore + Load from Residual Upstream Catchment.

The residual upstream catchment area is the component of the Victoria Creek catchment area contributing flow to the Victoria Creek model point that is not mine-impacted.

Similarly, the total flow at the Victoria Creek model point was calculated as the sum of all the contributing inflows. For Option 1A, at each time step the total flow at Victoria Creek was calculated as:

Total Flow = Inflow from Waste Rock + Inflow from Tailings + Inflow from Pit + Inflow from Low-grade Ore + Inflow from Residual Upstream Catchment.

The contaminant concentration in the receiving environment at the Victoria Creek model point was then calculated as follows for each time step:

Concentration = Total Load / Total Flow

The suite of parameters included in the model are sulfate, arsenic, cadmium, copper, iron, manganese zinc, ammonia-N, nitrate-N, nitrite-N, total cyanide, WAD-cyanide, cyanate, calcium and magnesium. For modeling purposes, it is assumed that all constituents behave conservatively and all metals are modeled as total metals. In addition, hardness was calculated based on modeled calcium and magnesium concentrations.

Details regarding the specific assumptions for the modeled inflows and source chemistry for each closure option are discussed in the following sections.

Table 4-1 Summary of Closure Options Key Components

Option 1 (a and b)	Option 2 (a and b)	Option 3	Option 4
Tailings			
• Stabilized in place with dam upgrade • Water cover – 0.7 m water and 0.3 m soil diffusion layer • Tailings Elevation – 1097.75 mASL • Diffusion Layer Elevation – 1098.05 mASL • Water Cover Elevation and Spillway Invert– 1098.75 mASL • Includes a soil cover beach to keep water from crest of dam	• Stabilized in place with dam upgrade • Saturated soil cover • Tailings Elevation – 1097.75 mASL • Soil Cover Elevation – 1098.75 mASL • Spillway invert – 1099.0 mASL • Includes a soil cover beach to keep water from crest of dam	• Relocate tailings to pit with high infiltration cover to maximize tailings saturation • Tailings dam is breached and valley reclaimed	• Relocation of tailings and waste rock to the pit with low infiltration cover to maintain tailings in a dry condition • Tailings dam is breached and valley reclaimed
Dome Creek Diversion			
• Dome Creek Diversion removed and Dome Creek routed through Tailings Impoundment	• Dome Creek Diversion removed and Dome Creek routed through Tailings Impoundment	• Dome Creek Diversion removed and creek returned to original channel through tailings area	• Dome Creek Diversion removed and creek returned to original channel through tailings area
Waste Rock			
Option 1A • All waste rock is left in place Option 1B • All waste rock relocated to pit	Option 2A • All waste rock is left in place Option 2B • All waste rock relocated to pit	• All waste rock is left in place with the exception of 23,200 m^3 for tailings cover	• 44,000 m^3 of waste rock is relocated to bottom of pit and 300,000 m^3 on top of tailings • Remaining is left in place as is
Pit			
Option 1A • Pit remains as is with anticipated long-term water elevation stabilizing at 1182.3 mASL Option 1B • All waste rock relocated to pit	Option 2A • Pit remains as is with anticipated long-term water elevation stabilizing at 1182.3 mASL Option 2B • All waste rock relocated to pit	• Tailings relocated to pit and kept in a saturated state • Tailings covered with 1.0 m waste rock • All runoff from surrounding pit catchment is routed to covered tailings area to maximize infiltration	• Relocation of tailings to pit and storage in a dry condition • 44,000 m^3 of waste rock is relocated to bottom of pit and 300,000 m^3 on top of tailings • Waste rock then covered with a multi-layer vegetated, store-release soil cover • Runoff from onset precipitation routed away from pit area to either the Dome Creek or Pony Creek Catchments to minimize infiltration into tailings.

4.2 Option 1A – Tailings Dam Upgrade with Water Cover/Waste Rock in Place

4.2.1 Tailings Area Water Balance Model Assumptions

For Option 1A, the tailings area was modeled as a reservoir or pond with inflows from onset precipitation and runoff from the surrounding area, including Dome Creek. Outflows from the system include discharge via the spillway, evaporation from the pond surface area, and infiltration from the tailings pond through the tailings and the tailings dam. The soil beach area was assumed to be relatively impermeable and any onset precipitation on the soil beach area reports to the tailings pond. The physical characteristics of the pond used in the model are summarized in Table 4-2.

Table 4-2 Model Inputs for Option 1A Tailings Area

Model Inputs	Value
Tailings Elevation (mASL)	1097.75
Diffusion Layer Elevation (mASL)	1098.05
Spillway Invert Elevation (mASL)	1098.75
Maximum Depth of Water Cover (m)	0.70
Pond Surface Area (m^2)	60,000
Soil Beach Surface Area (m^2)	12,600
Soil Beach Elevation (mASL)	1099.4
Soil Beach Area Runoff Coefficient	1.0
Proportion of Dome Creek Routed to Pond (%)	100

4.2.1.1 Infiltration/Seepage through Tailings and Dam

Two separate analyses were carried out to evaluate the potential infiltration from the tailings area. Golder carried out an assessment of the cover water balance using a 1-dimensional numerical model to estimate the cover water balance fluxes (Golder 2010a). As a separate analysis, AECOM also carried out a two-dimensional analysis of seepage rates in the tailings, dam and soil foundations (AECOM 2010b).

The one-dimensional modeling carried out by Golder encompassed the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the tailings. Details of this work are provided in Lorax (2010b), Appendix C2. Table 4-3 summarizes the cumulative flux values computed for the cover water balance for Option 1.

Table 4-3 Summary of Option 1 One-Dimensional Cumulative Fluxes (April 15 to October 31)

	Dry Year (m^3/m^2)	Mean Year (m^3/m^2)	Wet Year (m^3/m^2)
Top of Cover	-	-	-
Top of Tailings	0.21	0.21	0.21
Bottom of Tailings	0.21	0.21	0.21

The results of one-dimensional modeling indicate that the tailings would remain saturated at all times for Option 1A/B. Furthermore, the fluxes through the tailings are independent of climatic conditions as long as there is sufficient water from the surrounding catchment to maintain the water cover. Based on a tailings surface area of 60,000 m^2, the one-dimensional flux over the period of April 15 to October 31 (200 days) is 12,600 m^3 or 0.7 L/s.

The 2-D analysis carried out by AECOM focused on providing an understanding of how the design of the two tailings-in-place options (Option 1A/B and Option 2A/B) will affect the pore water pressure conditions and seepage rates in the tailings, dam and foundation soils. The analysis for Option 1 looked at two scenarios. The first scenario had a wedge of coarse tailings against the dam and the second replaced the coarse tailings with fine tailings. The modeled seepage rates per metre width are:

- With "wedge" of coarse tailings against dam face – 6.5 x 10^{-6} m^2/s; and
- With coarse tailings replaced with fine tailings – 4.5 x 10^{-6} m^2/s.

The design carried forward for the assessment includes the replacement of the coarse tailings with fine tailings. The resultant seepage rate for this option, based on a dam length of 256 m is 1.18 L/s. As expected, this two-dimensional seepage rate is larger than that predicted using the one-dimensional model, and better represents the potential seepage out of the tailings pond area. Therefore, for the model a seepage rate of 1.18 L/s was adopted to characterize the seepage from the tailings pond through the tailings, dam and foundation soils.

4.2.1.2 Discharge from Tailings Area

An assessment of the seepage collection pond pumping rates was carried out by AECOM (AECOM 2010c) to determine the most appropriate long-term seepage rate to be used in the model for Options 1 and 2. Four methods were used to estimate long-term seepage from the tailings area:

- Times series analysis of historical data (2006 to 2010) specifically targeting periods of low flow;
- Correlation analysis with precipitation events;
- 2-D numerical modeling; and
- Catchment-based calculations.

The results of each of these analyses are presented in Table 4-4.

Table 4-4 Summary of Tailings Area Seepage Rates

Method	Estimated Seepage Rate (L/s)
Time Series	3.5
Precipitation Correlation	2.9
2-D Numerical Modeling	2.8
Catchment Based	2.86

Based on the results of these analyses, the long-term seepage rate for Options 1 and 2 was conservatively set to 3.5 L/s (based on time series of historical data).

4.2.2 Pit Water Balance Model Assumptions

For Option 1A, the pit is left as is and the critical input to the model is the flux of water out of the pit to the receiving environment, specifically Dome Creek. As outlined in the *Hydrogeological Characterization of the Mt. Nansen Mine Site* (AECOM 2010c), the pit lake is a surface expression of the regional groundwater system. In this system, groundwater discharges from the south end of the pit lake to the deep regional groundwater system and ultimately Dome Creek. The rate of groundwater discharge from

the pit to Dome Creek was estimated using Darcy's Law for a range of hydraulic conductivities (K) and is summarized in Table 4-5 along with the corresponding travel times.

Table 4-5 Summary of Pit Discharge Rates to Dome Creek

Hydraulic Conductivity	Estimated Discharge Rate (L/s)	Travel Times (years) 1% Porosity	Travel Times (years) 10% Porosity
Low (K=1.00 x 10^{-7})	0.005	26	262
Intermediate (K=1.50 x 10^{-6})	0.0749	1.75	17.47
High (K=2.70 x 10^{-6})	0.1347	0.97	9.71

Based on the results of this analysis, the discharge from the pit to Dome Creek was conservatively set to 0.13 L/s in the model.

4.2.3 Waste Rock Water Balance Model Assumptions

For Option 1A, all waste rock is left on surface as is. Table 4-6 provides a summary of the waste rock catchment groupings and Table 4-7 provides a summary of the waste rock catchment areas used for the water balance component of the model.

Table 4-6 Summary of Waste Rock Catchment Groupings

ID	Waste Rock Sub-Catchment	Area (m^2)	Waste Rock Catchment Label	Seepage Classification	Receiving Environment
A	None	26,425	WR-DC1	Seepage - shallow groundwater	Dome Creek
B	NW Pile	12,750	WR-DC2	Seepage – deep groundwater	Dome Creek
	Mid-Sector	21,325	WR-DC2	Seepage – deep groundwater	Dome Creek
	S-SW Pile	38,225	WR-DC2	Seepage – deep groundwater	Dome Creek
	Total	72,300			
B	Ore Backfill	4,200	ORE-DC	Seepage – deep groundwater	Dome Creek
C	NW Pile	7,025	WR-PC1	Seepage – shallow groundwater	Pony Creek
	East Pile	5,800	WR-PC1	Seepage – shallow groundwater	Pony Creek
	Total	12,825			

Table 4-7 Summary of Waste Rock Water Balance Areas

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	26,425	Seepage - shallow groundwater	Dome Creek
WR-DC2	72,300	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	12,825	Seepage – shallow groundwater	Pony Creek

For the waste rock water balance, a key assumption is that there is no net surface water runoff. Snowmelt and onset precipitation either evaporates or infiltrates into the waste rock dumps. Monthly infiltration (mm) for each precipitation condition were based on the results of the water balance work carried out by Golder for Options 1B and 2B (Golder 2010a). Monthly infiltration rates (mm) were

calculated from the daily net infiltration results for each of the average, dry and wet year condition and are summarized in

Table 4-8.

Table 4-8 Summary of Monthly Waste Rock Infiltration (mm)

Month	Monthly Waste Rock Infiltration (mm)		
	Dry Year	Average Year	Wet Year
April	55.62	44.95	61.71
May	5.47	6.31	14.86
June	0.94	22.38	3.09
July	12.46	13.71	31.47
August	0	6.57	62.26
September	0	0	60.38
October	5.17	23.35	10.57
Total	79.66	117.27	244.34

For seepage reporting as shallow groundwater to either Dome Creek or Pony Creek, the waste rock dump seepage outflow is attenuated as it flows through the dumps. For these dumps the shallow groundwater seepage outflow for each month was distributed according to the following:

- 80% of current month's net infiltration plus 20% of previous month's net infiltration.

For waste rock seepage reporting as deep groundwater to Dome Creek, the total annual infiltration was distributed evenly throughout the entire year. Since the groundwater flow system acts to dampen variations in infiltration resulting from variable precipitation conditions, it was assumed that the average year infiltration (117.27 mm) applied to all modeled precipitation conditions.

4.2.4 Water Balance Considerations for Option 1A

A critical assumption for the tailings area as part of Option 1A/B, is the ability of the contributing catchment to provide sufficient water supply to maintain a water cover of 0.7 m, particularly during the open water, non-frozen period. An assessment of the available water supply to the tailings area was carried out by AECOM (AECOM 2010a) for dry, average and wet precipitation conditions. A summary of the monthly inflows to the tailings area for each precipitation condition is provided in Table 4-9. For the Dome Creek and tailings area catchments, the inflow volumes were based on a runoff coefficient of 0.6 in the summer months and a spring runoff coefficient of 0.8 for the months of April and May. A runoff coefficient of 1.0 was assumed for the soil beach area. Monthly outflows from the tailings area included evaporation from the pond area surface and seepage through the tailings and dam. Monthly outflow volumes are presented in Table 4-9 along with the calculated deficit/surplus for each open water season month.

Based on this assessment, the inflows to the tailings area are sufficient to maintain the 0.7 m water cover over the open water season for average and wet precipitation conditions. Although for the dry precipitation condition there is a deficit in September of 3,950 m^3, this only corresponds to a minimal drop in water cover depth of 0.07 m (based on a pond area of 60,000 m^2). In the following month (October) there is sufficient surplus to bring the water cover depth back to 0.7 m.

These proposed runoff coefficients of 0.8 (spring months) and 0.6 (remaining months) are not backed up quantitatively using site data or findings from other studies and therefore may not be adequately

representative of runoff conditions at the site for all locations and conditions. Carey and Woo (2001) found runoff coefficients as high as 0.8 in the nearby Wolf Creek basin, however, they also found that hillslopes in the watershed had runoff coefficients during snowmelt that varied considerably. No runoff was observed on the south-facing slopes, but 155 mm, 50 mm and 19 mm of water were discharged from the north, east and west-slopes, giving runoff ratios of 0.8, 0.6 and 0.25 respectively. Factors such as aspect, snow redistribution, presence/absence of ice lenses, soil type/development and infiltration potential were identified as key determinants of runoff generation at different times of year. Therefore a sensitivity analysis was completed for the dry precipitation conditions assuming a lower runoff coefficient of 0.4 for all the open water season months.

The results of this assessment are presented Table 4-10. Again, there is a deficit in September of 4,250.8 m^3 which corresponds to a drop in water cover depth of 0.071 m. The following month (October) provides an estimated surplus of 3,654.1 m^3 which will result in an overall increase in the water cover depth by 0.06 m to a total water depth of 0.6 m.

Table 4-9 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 1A/B

Dry Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	123,915	17,857	719	3,422	145,912	0	3,059	3,059	142,854
May	68,269	9,838	396	1,885	80,389	5,100	3,161	8,261	72,128
June	50,615	7,294	391	1,864	60,165	5,880	3,059	8,939	51,226
July	76,445	11,016	591	2,815	90,867	5,400	3,161	8,561	82,306
August	12,939	1,865	100	476	15,380	3,900	3,161	7,061	8,319
September	815	117	6	30	969	1,860	3,059	4,919	-3,950
October	8,441	1,217	65	311	10,034	0	3,161	3,161	6,873
Total					403,714				359,757
Average Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	100,210	14,441	581	2,767	117,999	0	3,059	3,059	114,940
May	74,136	10,684	430	2,047	87,297	5,100	3,161	8,261	79,036
June	110,813	15,969	857	4,080	131,719	5,880	3,059	8,939	122,780
July	99,406	14325	769	3,660	118,159	5,400	3,161	8,561	109,599
August	61,925	8,924	479	2,280	73608	3,900	3,161	7,061	66,547
September	21,185	3,053	164	780	25182	1,860	3,059	4,919	20,263
October	37,481	5,401	290	1,380	44552	0	3,161	3,161	41,391
Total					598515				554,557
Wet Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	137,451	19,808	797	3,796	161,852	0	3,059	3,059	158,793
May	134,475	19,379	780	3,713	158,347	5,100	3,161	8,261	150,086
June	76,591	11,038	592	2,820	91,041	5,880	3,059	8,939	82,102
July	143,405	20,666	1,109	5,280	170,460	5,400	3,161	8,561	161,899
August	190,663	27,476	1,474	7,020	226,634	3,900	3,161	7,061	219,573
September	138,516	19,961	1,071	5,100	164,648	1,860	3,059	4,919	159,730
October	16,296	2,348	126	600	19,370	0	3,161	3,161	16,210
Total					992,352				948,394

Table 4-10 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 1A/B – Runoff Coefficient = 0.4

Dry Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	61,957	8,929	719	3,422	75,026	0	3,059	3,059	71,968
May	34,135	4,919	396	1,885	41,335	5,100	3,161	8,261	33,074
June	33,744	4,863	391	1,864	40,861	5,880	3,059	8,939	31,923
July	50,963	7,344	591	2,815	61,713	5,400	3,161	8,561	53,152
August	8,626	1,243	100	476	10,446	3,900	3,161	7,061	3,385
September	543	78	6	30	658	1,860	3,059	4,919	-4,261
October	5,628	811	65	311	6,815	0	3,161	3,161	3,654
Total					236,853				192,896

4.2.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-11 for Option 1A.

Table 4-11 Summary Source Term Chemistry for Option 1A (all values in mg/L)

Parameter	Best Estimate				Upper Estimate			
	Tailings	Pit Lake	Waste Rock Pile	Ore	Tailings	Pit Lake	Waste Rock Pile	Ore
Arsenic	0.04	0.02	0.0068	0.026	0.3	0.08	0.0227	0.041
Cadmium	0.00089	0.02	0.033	0.09	0.0015	0.03	0.184	0.201
Copper	0.0087	0.03	0.039	0.015	0.015	0.09	0.225	0.036
Iron	12.8	0.5	0.01	0.03	40	2.97	0.06	0.05
Manganese	7.75	2.91	4.8	49	10	6.9	28.6	97.4
Zinc	0.02	1.76	5.14	10.4	0.1	2.92	34.2	31.2
Sulfate	663	1230	1530	2265	1380	1690	2940	2680
Ammonia	6.4	0.18	0.03	0.03	12	0.4	0.12	0.093
Nitrate	3.1	1.71	2	0.33	10	3.85	9.96	0.85
Nitrite	0.25	0.06	0.023	0.08	0.6	0.3	0.36	0.1
Cyanide – T	0.7	n/a	n/a	n/a	0.5	n/a	n/a	n/a
WAD – CN	0.025	n/a	n/a	n/a	0.15	n/a	n/a	n/a
Cyanate	1.6	n/a	n/a	n/a	18	n/a	n/a	n/a
Calcium	241	385	368	431	24	470	346	431
Magnesium	32.5	124	92.7	297	4.6	163	90.5	297

The following provides a summary of the rationale for the source term chemistry for each modeled component. Full descriptions of the source terms estimate are provided in Lorax (2010a).

Waste Rock (Subaerial, Unsaturated)

- The evaluation of the waste rock source terms for Option 1A (subaerial unsaturated waste rock) utilized data acquired from seeps, lysimeters and unsaturated field bin.
- Of these data sources, water quality for the natural seeps were used to generate source term estimates. This relates to the fact that the seeps, which have been active for up to 10 years, are implicitly representative of on-site weathering conditions.
- A statistical evaluation was performed on the seepage dataset and the most appropriate mean or median value was selected as the conservative best estimate source term.
- Upper Estimate values for all parameters were derived from the maximum drainage quality values.

Low-Grade Ore (Unsaturated)

- Conservative Best Estimate source term values were determined using the higher of the median or mean concentrations from the unsaturated ore field bin drainage.
- Upper Estimate values for all parameters, except arsenic, were derived from the maximum drainage quality data obtained from the unsaturated ore field bin.
- Concentrations of arsenic measured in shake flask extraction (SFE) leachate were applied in order to provide a more conservative Upper Estimate estimate.

Pit Lake

- Pit lake water quality collected by EDI from the pit bottom, middle, and bottom were statistically analyzed.
- The median values for each layer were calculated and the most conservative value was selected as the conservative Best Estimate source term.
- The Upper Estimate source terms were determined by averaging all data that is greater than or equal to the value for the 90th percentile.

Tailings in Place

- The conservative Best Estimate tailings source terms were derived by averaging the concentration of each parameter in the seepage collection pond for data collected since November 2007. Poor detection limits present a limitation on data collected prior to November 2007,
- Upper Estimate source terms were developed using two approaches with the following assumptions: 1) infrequent yet consistent spikes observed in seepage pond data since January 1999 represent mechanisms that may dominate in the long-term; and 2) groundwater quality from well MW09-08 is a proxy for groundwater that bypasses the seepage collection pond and may report to Dome Creek in the future. There are numerous exceptions to these approaches which are outlined in detail in Lorax (2010a).
- The use of a sand diffusion layer is included as part of the design of the tailings cover system in Option 1A/B to serve two purposes:
  - Maintain the physical stability of the tailings; and
  - Reduce diffusion of constituents from the tailings pore water into the water cover.
- This upward diffusion of constituents from the tailings into the water cover is of relevance for arsenic, manganese and sulfate (Lorax 2010a). To account for the potential loading to the water cover, and ultimately Dome Creek, the diffusive flux terms presented in Table 4-12 were incorporated into the model for arsenic, manganese and sulfate (based on a water cover area of 60,000 m^2).

Table 4-12 Summary of Diffusive Flux Rate

Parameter	Diffusive Flux Rate (g/day)
Arsenic	8.6
Manganese	7.4
Sulfate	2,967

4.3 Option 1B – Tailings Dam Upgrade with Water Cover/Waste Rock Backfill into Pit

4.3.1 Tailings Area Water Balance Model Assumptions

The tailings area model assumptions for Option 1B are the same as those described in Section 4.2.1 for Option 1A.

4.3.2 Pit / Backfilled Waste Rock Water Balance Model Assumptions

Golder conducted a one-dimensional water balance model to describe the relocation and long-term storage of waste rock in the pit (Golder 2010a). The one-dimensional model covered the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed

fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the waste. Details of this work are provided in Lorax (2010b), Appendix C2. For Options 1B and 2B, the model results indicate that it would take over 12 years for water to reach the bottom of the 30 m of waste rock placed in the pit. Once water reaches the bottom of the waste rock, the flux would reach steady state conditions. The steady state cumulative annual fluxes are presented in Table 4-13 along with the steady state flux rate based on a waste rock surface area in the pit of 36,000 m^2.

Table 4-13 Summary of Option 1B and 2B 1-D Cumulative Fluxes (April 15 to October 31)

	Dry Year	Average Year	Wet Year
Cumulative Annual Flux (m^3/m^2)	0.08	0.12	0.24
Flux Rate (L/s)	0.09	0.137	0.27

Given the time to reach steady state conditions in the waste rock placed in the pit, in conjunction with the overall dampening effect on the flow imposed by the 30 m of waste rock, an average annual flux rate of 0.137 L/s was selected for all precipitation conditions in the model. Although the average annual flux rate through the waste rock and the estimated groundwater discharge rate to Dome Creek (0.1347 L/s) are similar, the higher value of 0.137 L/s was adopted as the long-term pit discharge rate to Dome Creek for Options 1b and 2b.

4.3.3 Waste Rock Water Balance Assumptions

In Option 1B, the low-grade ore remains in place and the water balance assumptions for the low-grade ore in Option 1B are the same as those described in Section 4.2.3 for Option 1A.

4.3.4 Water Balance Considerations for Option 1B

The water balance consideration for Option 1B are the same as those described in Section 4.2.4 for Option 1A.

4.3.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-14 for Option 1B. With the exception of the backfilled waste rock, the rationale for the source term chemistry for each modeled component are the same as those presented in Section 4.2.5 for Option 1A. Full descriptions of the source terms derivations are provided in Lorax (2010a).

Backfilled Waste Rock

- Option 1B dictates that a portion of the waste rock will be saturated (below the water table) and a portion of the waste rock will be unsaturated (above the water table). Therefore, the chemistry of the drainage from the pit is dictated by a combination of geochemical processes occurring within both unsaturated and saturated waste rock.
- Source terms for these backfill options were derived by selecting the most conservative values from the unsaturated/subaerially exposed waste rock source terms and the saturated waste rock source terms.
- Saturated waste rock source terms were derived using drainage data from the saturated field bin.
  - A statistical evaluation was performed on the datasets and the most appropriate mean or median value was selected as the conservative best estimate source term.
  - Arsenic, whose mobility should be greatly increased under suboxic conditions, was approached differently. The conservative Best Estimate value for arsenic release under saturated conditions was derived from the highest value from the pit bottom water quality samples (0.12 mg/L). The sample

from which the value was derived contained depressed nitrate, elevated ammonia and manganese, and slightly elevated iron compared to other samples, suggesting the presence of suboxic conditions in Brown-McDade pit bottom waters.

- Upper Estimate values for all parameters except nitrate, nitrite and copper were derived from the maximum drainage quality data obtained from the saturated waste rock field bin. Concentrations of nitrate, nitrite, and copper measured in pit bottom waters were applied in order to provide more conservative Upper Estimate estimates.
- The Upper Estimate value for dissolved arsenic under saturated conditions was derived from taking the Upper Estimate drainage value from the saturated tailings field bin and scaling it based on the median solid phase concentration of arsenic in Mount Nansen tailings (3,027 mg/L) and the median solid phase concentration in Mount Nansen waste rock (239 mg/L) to derive a value of 1.2 mg/L. This is based on the assumption that arsenic in both waste rock and tailings is primarily associated with iron-oxides and will be released under suboxic conditions.

Table 4-14 Summary Source Term Chemistry for Option 1B (all values in mg/L)

	Best Estimate				Upper Estimate			
Parameter	**Tailings**	**Pit – Waste Rock**	**Waste Rock Pile**	**Ore**	**Tailings**	**Pit – Waste Rock**	**Waste Rock Pile**	**Ore**
Arsenic	0.04	0.12	n/a	0.026	0.3	1.2	n/a	0.041
Cadmium	0.00089	0.027	n/a	0.09	0.0015	0.184	n/a	0.201
Copper	0.0087	0.04	n/a	0.015	0.015	0.225	n/a	0.036
Iron	12.8	2.15	n/a	0.03	40	5.28	n/a	0.05
Manganese	7.75	143	n/a	49	10	181	n/a	97.4
Zinc	0.02	5.14	n/a	10.4	0.1	34.2	n/a	31.2
Sulfate	663	2040	n/a	2265	1380	2940	n/a	2680
Ammonia	6.4	1.25	n/a	0.03	12	1.54	n/a	0.093
Nitrate	3.1	0.32	n/a	0.33	10	1.371	n/a	0.85
Nitrite	0.25	0.1	n/a	0.08	0.6	0.396	n/a	0.1
Cyanide – T	0.67	0	n/a	0	0.5	0	n/a	0
WAD – CN	0.025	0	n/a	0	0.15	0	n/a	0
Cyanate	1.6	0	n/a	0	18	0	n/a	0
Calcium	241	368	n/a	431	24	346	n/a	431
Magnesium	32.5	93	n/a	297	4.6	91	n/a	297

4.4 Option 2A – Tailings Dam Upgrade with Saturated Soil Cover/Waste Rock in Place

4.4.1 Tailings Area Water Balance Model Assumptions

For Option 2A, the tailings area was modeled as a very shallow reservoir or pond with inflows from onset precipitation and runoff from the surrounding area, including Dome Creek. Outflows from the system include discharge via the spillway, evaporation from the pond surface area, and infiltration from the tailings pond through the tailings and the tailings dam. In addition, the soil beach area was assumed to be relatively impermeable and any onset precipitation on the soil beach area reports to the tailings pond. The physical characteristics of the pond used in the model are summarized in Table 4-15.

Table 4-15 Model Inputs for Option 2A Tailings Area

Model Inputs	Value
Tailings Elevation (mASL)	1097.75
Soil Cover Elevation (mASL)	1098.75
Spillway Invert Elevation (mASL)	1099
Maximum Depth of Water Cover (m)	0.25
Pond Surface Area (m^2)	60,000
Soil Beach Surface Area (m^2)	12,600
Soil Beach Elevation (mASL)	1099.4
Soil Beach Area Runoff Coefficient	1.0
Proportion of Dome Creek Routed to Pond (%)	100

4.4.1.1 Infiltration/Seepage through Tailings and Dam

As outlined in Section 4.2.1.1, two separate analyses were carried out to evaluate the potential infiltration from the tailings area. Golder carried out an assessment of the cover water balance using a one-dimensional numerical model to estimate the cover water balance fluxes (Golder 2010a). AECOM carried out a two-dimensional analysis of seepage rates in the tailings, dam and soil foundations (AECOM 2010c).

The 1-D modeling carried out by Golder covered the open water season between April 15 and October 31 for mean, dry and wet precipitation conditions. The computed fluxes included evaporation, runoff, surface infiltration, and infiltration through the top and bottom of the tailings. Details of this work are provided in Appendix A. Table 4-16 summarizes the cumulative flux values computed for the cover water balance for Option 2.

Table 4-16 Summary of Option 2 1-D Cumulative Fluxes (April 15 to October 31)

	Dry Year (m^3/m^2)	Mean Year (m^3/m^2)	Wet Year (m^3/m^2)
Top of Cover	-	-	-
Top of Tailings	0.21	0.21	0.21
Bottom of Tailings	0.21	0.21	0.21

The results of one-dimensional modeling indicate that the tailings would remain saturated for all flow conditions for Option 2. Furthermore, the fluxes through the tailings are independent of climatic conditions as long as there is sufficient water from the surrounding catchment to maintain the water level within the soil cover. Based on a tailings surface area of 60,000 m^2, the one-dimensional flux over the period April 15 to October 31 (200 days) is 12,600 m^3 or 0.7 L/s.

The two-dimensional analysis carried out by AECOM focused on providing an understanding of how the design of the two tailings-in-place options (Option 1 and Option 2) will affect the pore water pressure conditions and seepage rates in the tailings, dam and foundation soils. The modeled 2-D seepage rate per metre width for the saturated soil cover is 6.7×10^{-6} m^2/s.

The resultant seepage rate for this option, based on a dam length of 256 m is 1.7 L/s. As expected, the two-dimensional seepage rate is larger than that predicted using the 1-D modeling, and better represents the potential seepage out of the tailings pond area. Therefore, for the model a seepage rate of 1.7 L/s

was adopted to characterize the seepage from the tailings pond through the tailings, dam and foundation soils.

4.4.1.2 Discharge from Tailings Area

The long-term seepage rate from the tailings area to Dome Creek for Option 2A is the same as that for Option 1A presented in Section 4.2.1.2: 3.5 L/s.

4.4.2 Pit Water Balance Model Assumptions

The pit model assumptions for Option 2A are the same as those for Option 1A presented in Sections 4.2.2.

4.4.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 2A are the same as those for Option 1A presented in Sections 4.2.3.

4.4.4 Water Balance Considerations for Option 2A

Similar to Option 2A/B, a critical assumption for Option 1A/B is the ability of the contributing catchment area to provide sufficient water supply to maintain the water elevation within the 1 m soil cover, particularly during the open water, non-frozen period. As discussed in Section 4.4.1.1, this option was modeled as a shallow pond with a maximum water cover depth of 0.25 m. The results of the assessment of available water supply to the tailings area for Option 2A/2B are presented in Table 4-17.

Similar to Option 1A/B, the inflows from the tailings area catchment are sufficient to maintain the 0.25 m water cover through open water season for average and wet precipitation conditions. For the dry precipitation conditions there is a predicted deficit in September of 5,205 m^3. However, this corresponds to a minimal drop in water cover depth of 0.09 m to a depth of 0.16 cm above the soil cover. In the following month (October) there is sufficient surplus to bring the water cover depth back to 0.25 m.

Similar to Option 1A/B, the sensitivity of the tailings area water balance to the assumed runoff coefficients was assessed for the dry precipitation condition assuming a runoff coefficient of 0.4 for all open water season months. The results of this assessment are presented in Table 4-18. Again, there is a deficit in September of 5515 m^3, corresponding to a drop in water cover depth of 0.09 m. The following month there is only an estimated surplus of 2,358m^3 which increases the water cover depth by 0.04 m, resulting in a final depth of 0.20 m. In either case the water cover is maintained.

Table 4-17 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 2A/B

Dry Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Tailings Catchment**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	123,915	17,857	719	3,422	145,912	0	4,313	4,313	141,599
May	68,269	9,838	396	1,885	80,389	5,100	4,457	9,557	70,832
June	50,615	7,294	391	1,864	60,165	5,880	4,313	10,193	49,971
July	76,445	11,016	591	2,815	90,867	5,400	4,457	9,857	81,010
August	12,939	1,865	100	476	15,380	3,900	4,457	8,357	7,023
September	815	117	6	30	969	1,860	4,313	6,173	-5,205
October	8,441	1,217	65	311	10,034	0	4,457	4,457	5,577
Total					403,714				350,808
Average Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Surplus/ Deficit**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	100,210	14,441	581	2,767	117,999	0	4,313	4,313	113,686
May	74,136	10,684	430	2,047	87,297	5,100	4,457	9,557	77,740
June	110,813	15,969	857	4,080	131,719	5,880	4,313	10,193	121,526
July	99,406	14,325	769	3,660	118,159	5,400	4,457	9,857	108,303
August	61,925	8,924	479	2,280	73,608	3,900	4,457	8,357	65,251
September	21,185	3,053	164	780	25,182	1,860	4,313	6,173	19,008
October	37,481	5,401	290	1,380	44,552	0	4,457	4,457	40,095
Total					598,515				545,608
Wet Precipitation Conditions									
Month	**Inflows (m^3)**					**Outflows (m^3)**			
	Dome Creek	**Surplus/ Deficit**	**Soil Beach**	**Pond Area**	**Total**	**Evap.**	**Seepage**	**Total**	**Surplus/ Deficit**
April	137,451	19,808	797	3,796	161,852	0	4,313	4,313	157,539
May	134,475	19,379	780	3,713	158,347	5,100	4,457	9,557	148,790
June	76,591	11,038	592	2,820	91,041	5,880	4,313	10,193	80,848
July	143,405	20,666	1,109	5,280	170,460	5,400	4,457	9,857	160,603
August	190,663	27,476	1,474	7,020	226,634	3,900	4,457	8,357	218,277
September	138,516	19,961	1,071	5,100	164,648	1,860	4,313	6,173	158,475
October	16,296	2,348	126	600	19,370	0	4,457	4,457	14,914
Total					992,352				939,445

Table 4-18 Summary of Monthly Inflows and Outflows to Tailings Pond – Option 2A/B – Runoff Coefficient = 0.4

Dry Precipitation Conditions									
Month	Inflows (m^3)					Outflows (m^3)			
	Dome Creek	Tailings Catchment	Soil Beach	Pond Area	Total	Evap.	Seepage	Total	Surplus/ Deficit
April	61,957	8,929	719	3,422	75,026	0	4,313	4,313	70,713
May	34,135	4,919	396	1,885	41,335	5,100	4,457	9,557	31,778
June	33,744	4,863	391	1,864	40,861	5,880	4,313	10,193	30,668
July	50,963	7,344	591	2,815	61,713	5,400	4,457	9,857	51,856
August	8,626	1,243	100	476	10,446	3,900	4,457	8,357	2,089
September	543	78	6	30	658	1,860	4,313	6,173	-5,515
October	5,628	811	65	311	6,815	0	4,457	4,457	2,358
Total					236,853				183,947

4.4.5 Geochemical/Source Term Assumptions

The source term estimates for Option 2A are the same as those for Option 1A presented in Section 4.2.5 with the exception that there is no diffusion of arsenic, manganese and sulfate through the cover. Full descriptions of the source term derivations are provided in Lorax (2010a).

4.5 Option 2B – Tailings Dam Upgrade wit Saturated Soil Cover/Waste Rock Backfill into Pit

4.5.1 Tailings Area Water Balance Model Assumptions

The tailings area model assumptions for Option 2B are the same as those described in Section 4.4.1 for Option 2A.

4.5.2 Pit / Backfilled Waste Rock Water Balance Model Assumptions

The pit and backfill waste rock model assumptions for Option 2B are the same as those for Option 1B presented in Sections 4.3.2.

4.5.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 2B for the low-grade ore are the same as those for Option 1B presented in Sections 4.3.3.

4.5.4 Water Balance Considerations for Option 2B

The water balance considerations for Option 2B are the same as those described for in Section 4.4.4 for Option 2A.

4.5.5 Geochemical/Source Term Assumptions

The source term estimates for Option 2B are the same as those for Option 1B presented in Sections 4.3.5 with the exception that there is no diffusion of arsenic, manganese and sulfate through the cover. Full descriptions of the source term derivations are provided in Lorax (2010a).

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

4.6.1 Tailings Area Water Balance Model Assumptions

In Option 3, all the tailings are relocated to the pit, the tailings dam is breached and the valley is reclaimed. For modeling purposes, it was assumed that the flow from Dome Creek catchment upstream of the dam and associated breach is returned to natural conditions. For each precipitation condition modeled, the contributing flow from this area is defined by the catchment area at the Upper Dome Creek model point and monthly flows were determined using the methods outlined in Section 2.

4.6.2 Pit/Backfilled Tailings Water Balance Model Assumptions

Golder constructed a one-dimensional water balance model to describe the long-term storage of tailings in the pit in support of Option 3 (Golder 2010a). Once relocated to the pit, the tailings will be covered by waste rock to minimize evaporation and maximize infiltration. Critical to the success of this option is the ability to keep the tailings saturated in the long-term (85% saturation or greater) to limit the ingress of oxygen and development of acid generating conditions. The modeling carried out by Golder for this option evaluated the potential for the tailings to de-saturate to levels below the target saturation level of

85%. The computed fluxes included evaporation, surface infiltration, and infiltration through the top and bottom of the waste. The model was conducted in one-dimension, and did not consider surface inflows from other areas in the pit catchment. In this manner, the only source of water considered was direct precipitation to the tailings footprint (details of this work are provided in Lorax (2010b), Appendix C2).

A critical physical property of the tailings in the pit is the hydraulic conductivity of the combined tailings (fine and coarse tailings). The estimated range of hydraulic conductivity of the combined tailings is between 1 x 10^{-8} m/s and 5 x 10^{-9} m/s. This range was used in the modeling carried out by Golder to assess the sensitivity of the system to the potential for tailings de-saturation. As part of the work completed by Golder, laboratory test work was performed on samples of combined tailings to support the assumptions of hydraulic conductivity. The results of this test work yielded an average conductivity value of 1 x 10 $^{-8}$ m/s for the combined tailings. This value is identical to the upper limit of the estimated range provided above.

A key component of the work completed by Golder was to assess the potential for the de-saturation of tailings relocated to the pit. For this work, two climate data sets were modeled including dry and mean year conditions. The results indicate that with an average combined hydraulic conductivity of 1 x 10^{-8} m/s, the tailings de-saturate over time for both precipitation conditions. Although the degree of saturation remains above the 85% threshold for the time period modeled for mean year conditions (15 years), there is a clear trend towards tailings de-saturation in the long-term. This de-saturation would be faster during periods of prolonged drought or dry conditions. For mean and dry conditions, the modeling indicates that there is a deficit of water at a hydraulic conductivity of 1 x 10^{-8} m/s. Model results for a combined tailings average hydraulic conductivity of 5 x 10-^{9} m/s, indicate that the tailings will maintain saturation levels above the target of 85% in the long-term. However, the feasibility of attaining this degree of tailings saturation in the pit is highly uncertain. As discussed in AECOM (2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity.

A second component of the 1-D modeling involved estimating the water balance fluxes for mean, dry and wet precipitation conditions for incorporation into the site water balance and water quality model. An average hydraulic conductivity of 1 x 10^{-8} m/s was used for the in-pit tailings. Table 4-19 summarizes the cumulative fluxes through the top of the cover, top of the tailings and bottom of the tailings for each precipitation condition.

Table 4-19 Summary of Option 3 1-D Cumulative Fluxes (April 15 to October 31)

	Cumulative Flux (m^3/m^2)			
	Top of Cover	**Top of Tailings**	**Bottom of Tailings**	**Deficit**
Dry Year	0.02	0.13	0.15	0.02
Average Year	0.06	0.14	0.16	0.02
Wet Year	0.18	0.16	0.16	0

The model results indicate that for Option 3, taking into consideration only direct onset precipitation, there would be a deficit of water during dry and mean precipitation conditions. For these cases, unless additional water can be routed to the tailings area to make up the deficit, the tailings would be predicted to de-saturate progressively over time under the conditions modeled.

Table 4-20 summarizes the steady state flux rate out of the bottom of the tailings and annual deficit for each precipitation conditions based on the proposed tailings surface area of 21,000 m^2.

Table 4-20 Summary of Option 3 Steady State Flux and Annual Deficit

	Steady State Flux (L/s)	Deficit (m^3)
Dry Year	0.099	420
Average Year	0.104	420
Wet Year	0.104	0

To ensure that the target saturation level of 85% is achieved during all precipitation conditions, the one-dimensional model predicts that an additional 420 m^3 of water would be required on an annual basis, above that provided by direct onset precipitation and snow melt. The ability of the proposed design for Option 3 to provide this quantity of water is discussed in Section 4.6.4.

Based on the steady state fluxes summarized in

Table 4-20, a flux rate though the bottom of the tails of 0.104 L/s was adopted for all precipitation conditions. For the long-term discharge rate from the pit to Dome Creek, an estimated groundwater discharge rate of 0.1347 L/s was assumed.

4.6.3 Waste Rock Water Balance Model Assumptions

The waste rock model assumptions for Option 3 for waste rock remaining on the surface are the same as those for Option 1A presented in Section 4.2.3 except for the relocation of the East Pile to the pit for use as cover material for the tailings. Table 4-21 and

Table 4-22 summarize the remaining waste rock storage areas on surface for Option 3 that are incorporated into the model.

Table 4-21 Summary of Waste Rock Storage Areas for Option 3

ID	Waste Rock Sub-Catchment	Area (m^2)	Waste Rock Catchment Label	Seepage Classification	Receiving Environment
A	None	26,425	WR-DC1	Seepage - shallow groundwater	Dome Creek
B	NW Pile	12,750	WR-DC2	Seepage – deep groundwater	Dome Creek
	Mid-Sector	21,325	WR-DC2	Seepage – deep groundwater	Dome Creek
	S-SW Pile	38,225	WR-DC2	Seepage – deep groundwater	Dome Creek
	Total	72,300			
B	Ore Backfill	4,200	ORE-DC	Seepage – deep groundwater	Dome Creek
C	NW Pile	7,025	WR-PC1	Seepage – shallow groundwater	Pony Creek
	East Pile	0	WR-PC1	Seepage – shallow groundwater	Pony Creek
	Total	12,825			

Table 4-22 Summary of Waste Rock Water Balance Areas for Option 3

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	26,425	Seepage - shallow groundwater	Dome Creek
WR-DC2	72,300	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	7,025	Seepage – shallow groundwater	Pony Creek

4.6.4 Water Balance Considerations for Option 3

As discussed in section 4.6.2 for average and dry precipitation conditions, a minimum of an additional 420 m^3 would be required to ensure tailings saturation levels are maintained at 85% or higher. The surface area of the tailings placed in the pit is 21,000 m^2, while the entire pit catchment for Option 3 is 33,930 m^2, resulting in a residual pit catchment area of 12,930 m^2.Table 4-23 summarizes the monthly and total supplemental water volume that could be provided by snowmelt and precipitation from the residual pit catchment assuming a runoff coefficient for the residual drainage area of 0.4. For both the dry and average precipitation conditions there is sufficient runoff from the surrounding catchment to provide the supplemental water required to offset the identified deficit of 420 m^3.

Table 4-23 Assessment of Residual Drainage Water Supply for Option 3

Month	Dry Year			Average Year		
	Precipitation (mm)	Precipitation (m^3)	Runoff (m3)	Precipitation (mm)	Precipitation (m^3)	Runoff (m3)
April	57.0	737.4	295.0	46.1	596.3	238.5
May	31.4	406.3	162.5	34.1	441.2	176.5
June	31.1	401.6	160.6	68.0	879.2	351.7
July	46.9	606.5	242.6	61.0	788.7	315.5
August	7.9	102.7	41.1	38.0	491.3	196.5
September	0.5	6.5	2.6	13.0	168.1	67.2
October	5.2	67.0	26.8	23.0	297.4	119.0
Total	180.0	2327.9	931.2	283.2	3662.3	1464.9

4.6.5 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-24 for Option 3. The source term estimates for waste rock and low-grade ore in Option 3 are the same as those for Option 1A presented in Sections 4.2.5. For the saturated backfilled tailings, the following summarizes the rationale behind the source term derivation. Full descriptions of the source term estimates are provided in Lorax (2010a).

Tailings Backfill (Saturated)

- Loading reduction factors of 50% for arsenic were applied to the model to account for attenuation along groundwater flowpaths between the pit and receiving water courses. Some degree of arsenic attenuation in the subsurface environment can be expected through adsorption/co-precipitation mechanisms. Specific removal mechanisms for dissolved arsenic include sorption to Fe oxides (Bowel, 1994), sorption to clay minerals (Violante and Pigna, 2002), and arsenic precipitation as secondary sulphide minerals (Martin and Pedersen, 2002). The presence of silt-clay facies in the underlying deposits in the area certainly suggests that the sorption of arsenic to clay minerals may play a dominant role. Further, the ore-body surrounding the open pit is defined as an iron-oxide deposit. The oxidized, iron-rich nature of the bedrock is also expected to provide some attenuation of arsenic, as described by Bowell (1994). The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented.

- Either mild (Best Estimate) or strongly (Upper Estimate) suboxic conditions will persist in tailings porewater. Groundwater monitoring data for wells screened in tailings materials were used to derive source term estimates.

Table 4-24 Summary Source Term Chemistry for Option 3 (all values in mg/L)

Parameter	Best Estimate			Upper Estimate		
	Pit – Tailings	Waste Rock Pile	Ore	Pit – Tailings	Waste Rock Pile	Ore
Arsenic	9.3	0.0068	0.026	15	0.0227	0.041
Cadmium	0.001	0.033	0.09	0.001	0.184	0.201
Copper	0.002	0.039	0.015	0.002	0.225	0.036
Iron	3.2	0.01	0.03	15	0.06	0.05
Manganese	5	4.8	49	24	28.6	97.4
Zinc	0.045	5.14	10.4	0.45	34.2	31.2
Sulfate	1700	1530	2265	2000	2940	2680
Ammonia	15	0.03	0.03	15	0.12	0.093
Nitrate	0.1	2	0.33	0.1	9.96	0.85
Nitrite	0.085	0.023	0.08	0.085	0.36	0.1
Cyanide – T	0.04	*n/a*	*n/a*	0.9	*n/a*	*n/a*
WAD – CN	0.03	*n/a*	*n/a*	0.2	*n/a*	*n/a*
Cyanate	6	*n/a*	*n/a*	6	*n/a*	*n/a*
Calcium	*136*	368	431	470	346	431
Magnesium	*50*	92.7	297	45	90.5	297

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

4.7.1 Tailings Area Water Balance Model Assumptions

Similar to Option 3, Option 4 includes tailings relocation to the pit, breaching of the tailings dam and reclamation of the Dome Creek valley. For modeling purposes, it was assumed that flow from the Dome Creek catchment upstream of the dam and associated breach is returned to natural conditions. For each precipitation condition modeled, the contributing flow from this area is defined by the catchment area at the Upper Dome Creek model point and monthly flows were determined using the methods outlined in Section 2.

4.7.2 Pit/Backfilled Tailings and Waste Rock Water Balance Model Assumptions

Option 4 consists of relocating the tailings to the pit following partial backfill with waste rock, and subsequently overlain by waste rock and a synthetic barrier cover system to minimize infiltration. The use of a synthetic cover system is more suitable to the climatic conditions at the site and is not reliant on a viable vegetative cover. Golder was commissioned to identify potential designs of low-infiltration covers and conduct a conceptual assessment of the cover performance for the various cover options (Golder 2010b). In addition, Golder carried out preliminary infiltration modeling of one of the cover options, specifically a store-release-divert soil cover. Details of the dry cover assessment and modeling are presented in Lorax (2010b), Appendix C3. Results of the dry cover assessment indicate that the typical range of infiltration rates for synthetic barrier cover systems is 1% to 3%. To account for possible reduction in long-term cover performance, a long-term infiltration rate of 5% of average annual precipitation was selected for modeling purposes.

In addition to the actual footprint of the relocated tailings (24,800 m^2), the pit catchment also includes an additional covered area of 9,600 m^2. For modeling purposes, it was assumed that the water infiltrating from this additional area eventually infiltrates through the tailings. The annual volume infiltrating through the tailings and the long-term infiltration rate adopted in the model are presented in Table 4-25. In summary, a long-term infiltration rate through the tailings of 0.015 L/s was selected for modeling Option 4.

Table 4-25 Summary of Infiltration through Tailings for Option 4

Contributing Area	Area (m^2)	Precipitation (mm)	Annual Infiltration Volume (m^3)	Infiltration Rate (L/s)
Tailings	24,800	283.2	351.2	-
Surrounding Catchment	9,600	283.2	135.9	-
Total			487.1	0.015

In addition to the vertical flow through the tailings of 0.015 L/s, there is a component of horizontal flow through the waste rock under laying the tailings. Given that the long-term groundwater discharge rate from the pit to Dome Creek is assumed to be 0.13 L/s, the horizontal flow rate through the waste rock was assumed to be the difference between the total pit discharge rate and the vertical infiltration rate through the tailings or 0.119 L/s.

4.7.3 Waste Rock Model Assumptions

The waste rock model assumptions for Option 4 for waste rock remaining on the surface are the same as those for Option 1A presented in Section 4.2.3 except for the relocation of approximately 344,000 m^3 of waste rock to the pit and placement of the low infiltration cover over the low-grade ore. Table 4-26 summarizes the remaining waste rock storage areas on surface for Option 4 that are incorporated into the model.

Table 4-26 Summary of Waste Rock Water Balance Areas for Option 4

Waste Rock Catchment	Area (m^2)	Seepage Classification	Receiving Environment
WR-DC1	0	Seepage - shallow groundwater	Dome Creek
WR-DC2	23,495	Seepage – deep groundwater	Dome Creek
ORE-DC	4,200	Seepage – deep groundwater	Dome Creek
WR-PC1	0	Seepage – shallow groundwater	Pony Creek

As part of the cover for the tailings in the pit, the low-grade ore pile is also incorporated into the store-release-divert cover. In addition to the footprint of the low-grade ore pile of 4,200 m^2, an additional surface area of 4,200 m^2 is also incorporated into the cover with subsequent infiltrating waters routing through the low-grade ore.

4.7.4 Geochemical/Source Term Assumptions

The source term estimates for both the Best Estimate and the Upper Estimate are presented in Table 4-27 for Option 4.

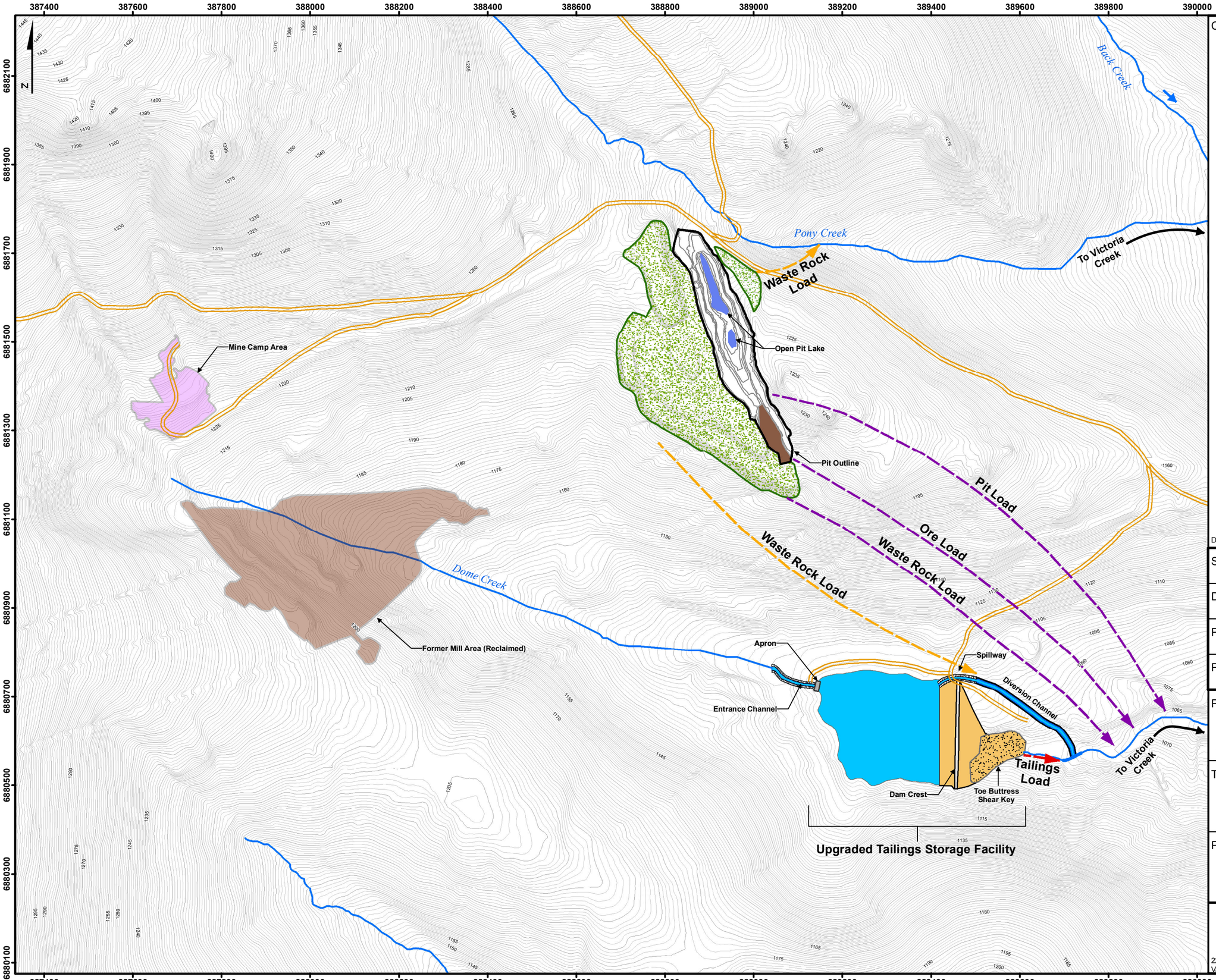
Table 4-27 Summary Source Term Chemistry for Option 4 (all values in mg/L)

Parameter	Best Estimate				Upper Estimate			
	Pit – Waste Rock	Pit – Tailings	Waste Rock Pile	Ore	Pit – Waste Rock	Pit – Waste Rock	Waste Rock Pile	Ore
Arsenic	0.12	28.4	0.0068	0.026	1.2	28.4	0.0227	0.041
Cadmium	0.027	0.184	0.033	0.09	0.184	0.184	0.184	0.201
Copper	0.04	1.4	0.039	0.015	0.225	1.4	0.225	0.036
Iron	2.15	574	0.01	0.03	5.28	574	0.06	0.05
Manganese	143	28.6	4.8	49	181	28.6	28.6	97.4
Zinc	5.14	26.2	5.14	10.4	34.2	26.2	34.2	31.2
Sulfate	2040	2500	1530	2265	2940	2500	2940	2680
Ammonia	1.25	6.5	0.03	0.03	1.54	6.5	0.12	0.093
Nitrate	0.32	3	2	0.33	1.371	3	9.96	0.85
Nitrite	0.1	0.3	0.023	0.08	0.396	0.3	0.36	0.1
Cyanide – T	n/a	0.07	n/a	n/a	n/a	0.07	n/a	n/a
WAD – CN	n/a	0.03	n/a	n/a	n/a	0.03	n/a	n/a
Cyanate	n/a	2	n/a	n/a	n/a	2	n/a	n/a
Calcium	368	250	368	431	346	250	346	431
Magnesium	93	60	92.7	297	91	60	90.5	297

The source term estimates for waste rock (subaerial) and low-grade ore in Option 4 are the same as those for Option 1A presented in Sections 4.2.5. The source term estimates for the backfilled waste rock are the same as those presented in Section 4.3.5 for Option 1B. For the backfilled tailings, which are assumed to be in an un-saturated state, the following summarizes the rationale behind the source term derivation. Full descriptions of the source terms estimate are provided in Lorax (2010a).

Tailings Backfill (Un-saturated)

- Tailings will produce acidic drainage.
- Arctic Gold and Silver tailings were used as a geochemical analogue. Values for this mine were compared to humidity cell drainage data from the three cells that went acid.
- Similar to Option 3, loading reduction factors of 50% for arsenic were applied to the model to account for attenuation along groundwater flowpaths between the pit and receiving water courses.
- Upper Estimate source terms were not developed for Option 4 due to a lack of suitable data.



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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Water Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

Data courtesy of AECOM

Figure for illustrative purposes only

SCALE:	1:8,000
DATE:	OCT 22nd, 2010
PROJECTION:	NAD_1983_UTM_Zone_8N
PROJECT MANAGER:	J.S.

PROJECT:
Mount Nansen Water Balance and Water Quality Predictions

TITLE:
Closure Option 1A Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	**4.1**

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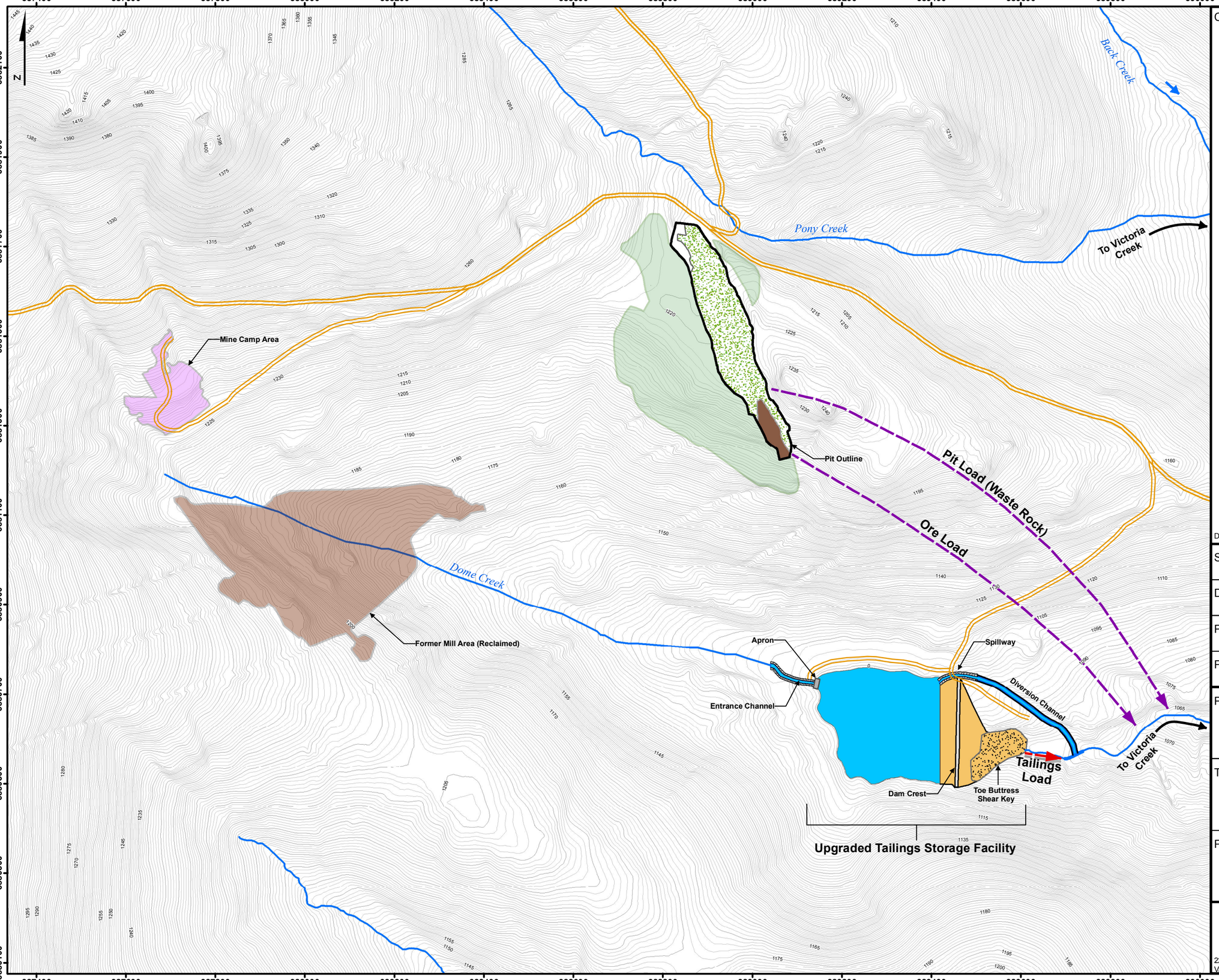

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Legend

- Mine Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit_Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Water Cover)
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

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Closure Option 1B Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	**4.2**

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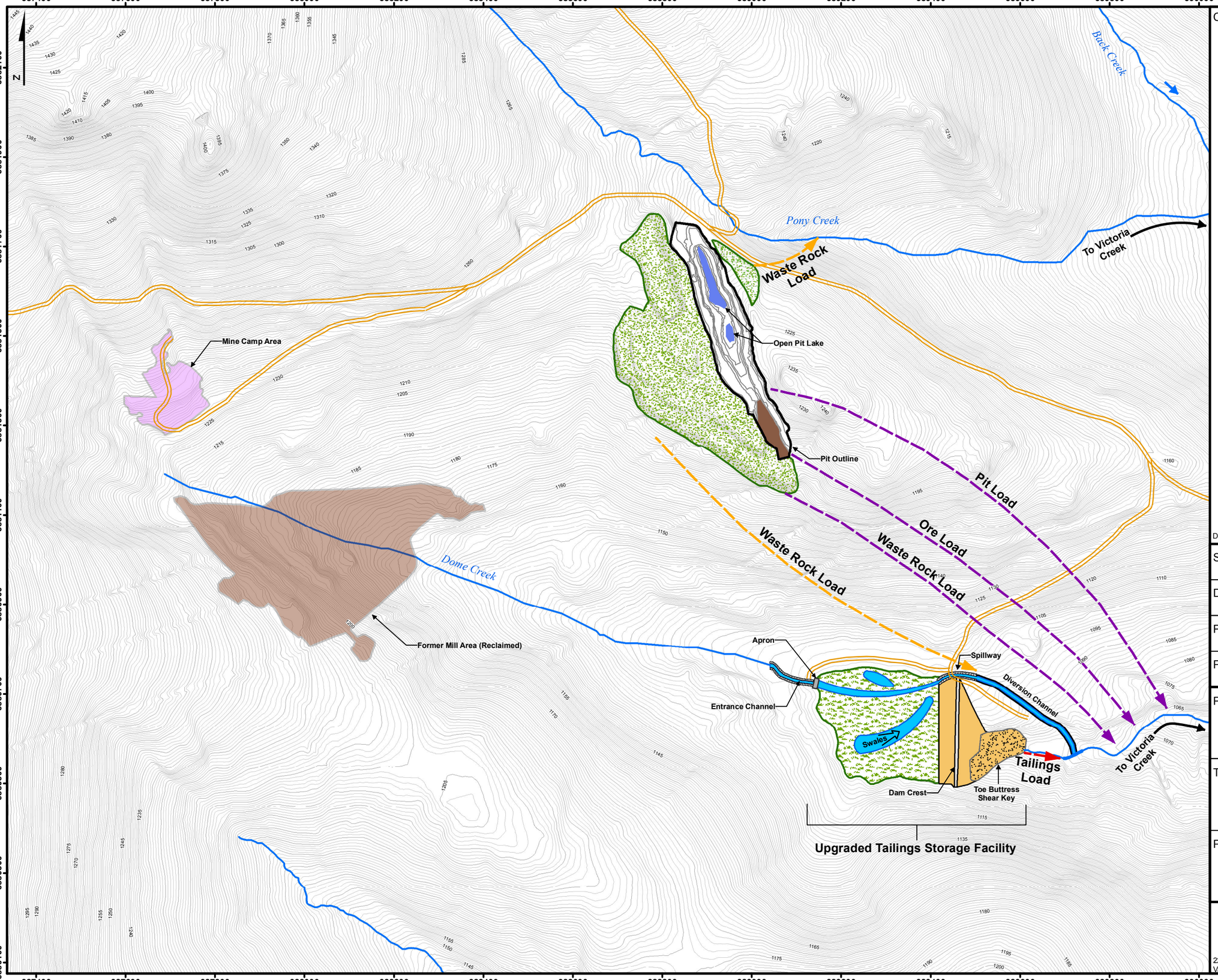

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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Dam Area
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Shallow Groundwater Seepage
- Tailings Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

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Closure Option 2A Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	**4.3**

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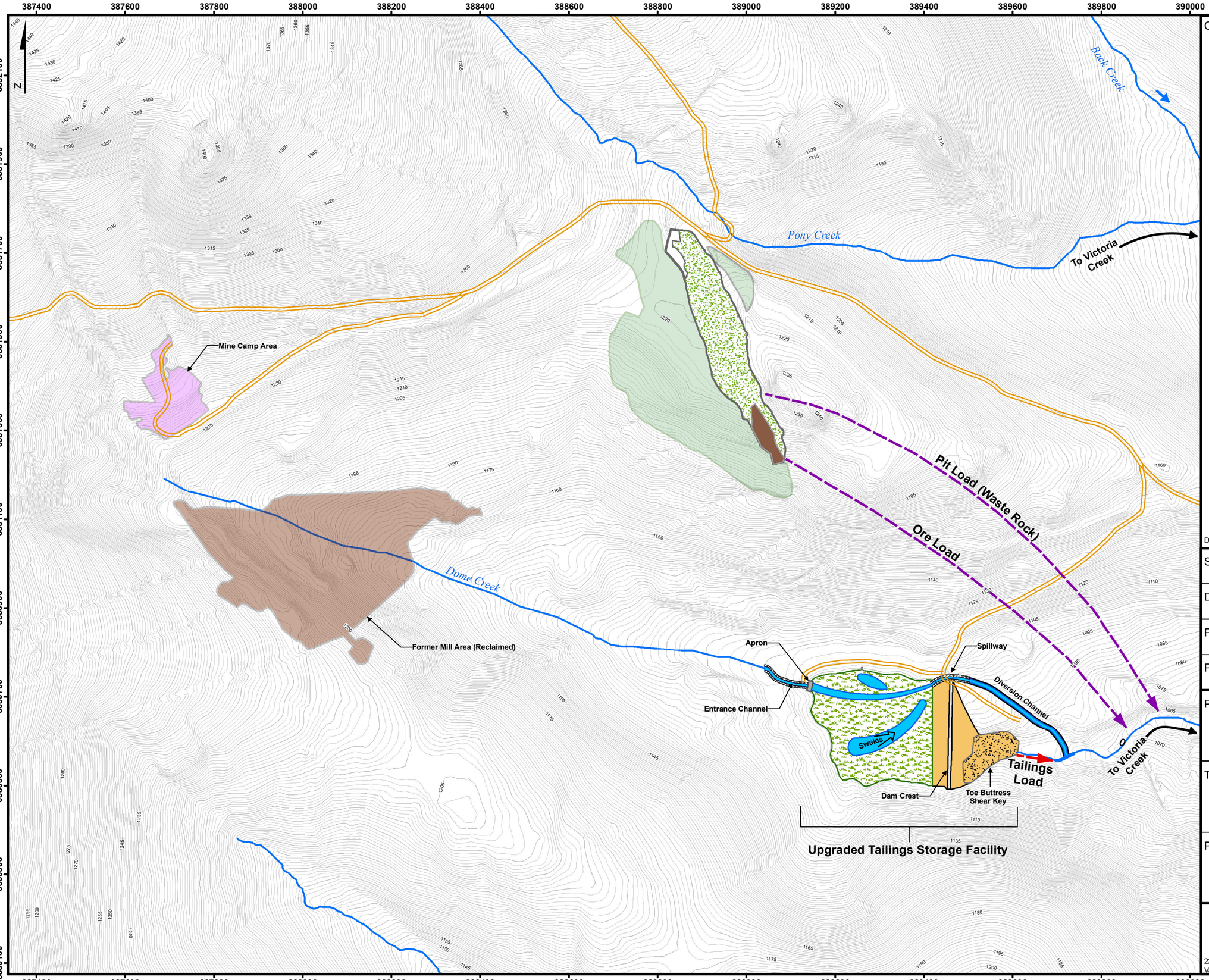

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Legend

- Roads
- Watercourse
- Dam Area
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Pit Backfill (Waste Rock)
- Upgraded Tailings Impoundment (Saturated Soil Cover)
- Deep Groundwater Seepage
- Tailings Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
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Mount Nansen Water Balance and Water Quality Predictions

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Closure Option 2B Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	4.4

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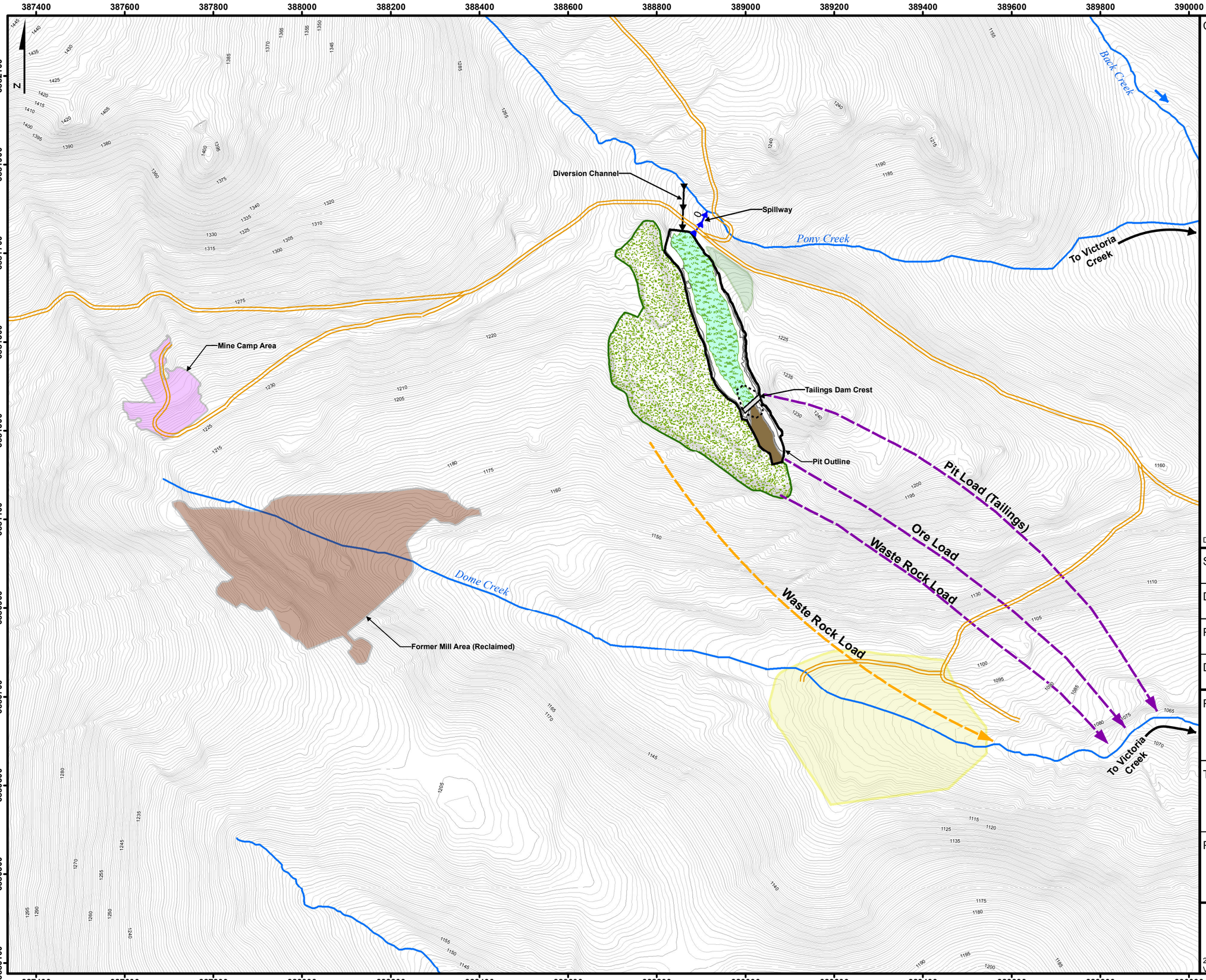

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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Tailings Dam Footprint
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings with High Infiltration Cover)
- Shallow Groundwater Seepage
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters
0 150 300 600

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TITLE:

Closure Option 3 Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	4.5

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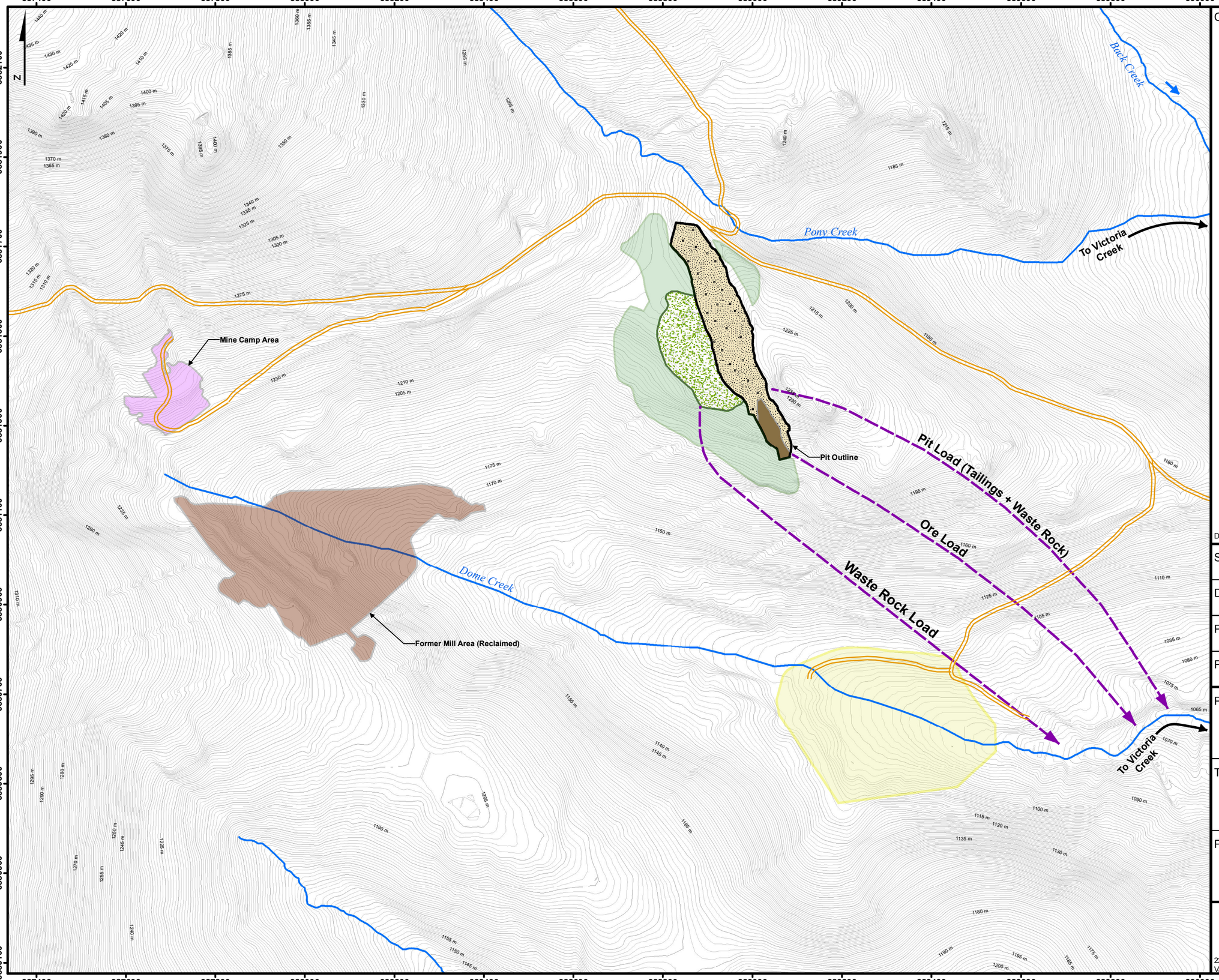

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Legend

- Roads
- Watercourse
- Former Mill Area (Reclaimed)
- Mine Camp Area
- Former Waste Rock Dump Area (Reclaimed)
- Former Tailings Impoundment Footprint (Valley Restoration)
- Pit Outline
- Reclaimed Ore Area
- Reclaimed Waste Rock Dump
- Reclaimed Backfilled Pit (Tailings + Waste Rock with Low Infiltration Cover)
- Deep Groundwater Seepage

Topography

- Index (5m)
- Interm (1m)

Meters: 0 150 300 600

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Closure Option 4 Water Model Schematic

PROJECT No:	FIGURE No:
J907-4	4.6

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5 Water Quality Predictions

A water balance and water quality model was used to support the assessment of each of the proposed closure alternatives. The results of the model, specifically predicted water quality in the receiving environment at Victoria Creek, were used to assess the overall performance of the proposed alternatives.

For each option, a total of six different model scenarios were run, including combinations of two different source term chemistry estimates (Best Estimate and Upper Estimate) and three precipitation conditions (dry, average and wet year). The Best Estimate and Upper Estimate predictions reflect the range in source concentrations used in the model (Lorax 2010). For each scenario, the model was run on a monthly time step for a calendar year (12 months). The model output included concentrations for a suite of major ions and trace elements in Victoria Creek downstream of all surface water and groundwater inputs. However, in order to illustrate the predicted performance of the various options, emphasis was placed on arsenic, sulfate, cadmium and zinc, since these constituents are the primary parameters of concern. Full results are available in Appendix A.

In addition to the six model scenarios, the following sensitivity runs were carried out to assess the implications on water quality of key uncertainties identified for various aspects of the closure options.

- Options 1 and 2 – Loss of attenuation of arsenic in tailings seepage along the flow path to the receiving environment;
- Options 3 and 4 – Loss of attenuation of arsenic along the groundwater flow path between the pit and the receiving environment; and
- Option 4 – Increased infiltration rate of 15% of annual precipitation through the low-infiltration cover.

5.1 Water Quality and Water Balance Model Results - Option 1A

5.1.1 Performance

Water quality predictions for each of the six model runs were used to assess the performance of Option 1A through comparison to existing water quality in the downstream receiving environment in Victoria Creek and to CCME Guidelines for the Protection of Aquatic Life. For cadmium, the recently updated draft chronic guideline was used (Environment Canada, 2008). The draft updated cadmium guideline for long-term exposure is:

$$CWQG = e^{(0.7409[\ln(\text{hardness})] - 4.796)}$$

where the CWQG is in µg/L and hardness is measured as $CaCO_3$ equivalents in mg/L.

A summary of the Best Estimate water quality predictions (average year) for sulfate, arsenic, cadmium and zinc in Victoria Creek for Option 1A is presented in Table 5-1. Presented for comparison are the existing minimum, median and maximum winter concentrations in Victoria Creek and the applicable CCME guidelines.

Existing metal levels in Victoria Creek are governed predominantly by particulate fractions, and show elevated levels in conjunction with TSS. However, there are no consistent seasonal trends in the data, which implies TSS events are governed by variables other than freshet flows, including storm events and upstream placer mining activities. Accordingly, maximum winter concentrations were used for the comparison as they most accurately reflect the range of current water quality conditions during the more sensitive winter low flow period when higher parameters concentrations are predicted to occur. It should

be noted that the winter dataset is limited to samples collected from November to January and likely does not capture the full range of current variability observed during the winter low-flow period. Time series of the predicted concentrations are also presented graphically in Figures 5-1 through 5-4 for each of the source chemistry and precipitation conditions. Source loading distributions of arsenic, cadmium and zinc are presented in Figure 5-9 for the Best Estimate/Average Flow Scenario.

Option 1 and Option 2 (tailings in place with dam upgrade) are designed to maintain saturated tailings conditions as a means to prevent the development of acidic conditions, thereby sustaining circum-neutral pH drainages from the tailings storage facility. This pH neutrality is expected to persist over the long-term. Further, the attenuation mechanisms currently observed in the existing tailings storage facility can also be expected to persist in the long-term (Lorax 2010a). Option 1A maintains waste rock and the Brown McDade Pit in their current configurations. Dumps will be re-graded; however their footprint will remain the same. Therefore, Option 1A (and Option 2A) is analogous to the existing status quo condition. In this regard, comparison of the predicted results for Option 1A to existing water quality for Victoria Creek can be used to assess the overall conservatism that has been built into the model, particularly given that the mill site area contaminant load has been removed in the model predictions. The performance of the other options may also be measured against Option 1A, since it most closely represents modeled status quo conditions.

Key highlights (for Best Estimate/Average Flow Scenario) of the water quality predictions for Option 1A are:

- For all modeled parameters, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the assumptions for seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year despite varying flows in Victoria Creek.

- Sulfate
  - In general, the predicted concentrations for sulfate (median = 36 mg/L) are similar to existing sulfate concentrations (median = 29.6 mg/L) in Victoria Creek, except for winter low flow periods. During this period, the predicted maximum concentration of 106 mg/L is significantly higher than the maximum observed winter sulfate concentration (60.9 mg/L).
  - The primary source of the higher predicted sulfate concentrations in the winter low flow period is the invariant discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s. In reality, it would be anticipated that the seepage discharge would decrease over the winter period. In this manner, the winter predictions likely represent over estimates.

- Arsenic
  - Predicted concentrations of arsenic (median = 0.0020 mg/L) are comparable to existing arsenic concentrations in Victoria Creek (median = 0.0016 mg/L) and are well below the CCME guideline of 0.005 mg/L.
  - Maximum concentrations of arsenic are predicted to occur during winter low flow (peaking at 0.0055 mg/L). This value marginally exceeds the CCME guideline, although is within the range of the existing maximum winter concentrations (maximum = 0.0075 mg/L).
  - The predicted loading associated with tailings seepage is the dominant source of arsenic to the receiving environment (95% of a total predicted annual loading of 4.6 kg).

- Cadmium

- Predicted cadmium concentrations are higher than the existing values currently observed in Victoria Creek.
- The predicted median cadmium concentration (0.00012 mg/L) is approximately 4 times higher than the existing median concentration in Victoria Creek data (0.00003 mg/L) but well below the CCME guideline.
- Maximum concentrations of cadmium are predicted to occur in winter (January to March) at concentrations above the draft CCME guideline.
- The predicted maximum cadmium concentration of 0.00055 mg/L is approximately twice the existing maximum winter concentration 0.0003 mg/L.
- The predicted loading from seepage from the waste rock dumps is the dominant source of cadmium to the receiving environment (72% of a total predicted annual loading of 0.7 kg).

- Zinc
  - The predicted median zinc concentration (0.018 mg/L) is approximately twice the existing median concentration (0.009 mg/L) but below the CCME guideline of 0.03 mg/L.
  - Maximum concentrations of zinc are predicted to occur in winter (December to April) at concentrations above the CCME guideline.
  - The predicted maximum zinc concentration (0.062 mg/L) is 3 times the existing winter maximum concentration (0.02 mg/L).
  - The predicted loading from seepage from the waste rock dumps is the dominant source of zinc to the receiving environment (88% of a total predicted annual loading of 82.1 kg).

For both cadmium and zinc, the over estimation of concentrations in Victoria Creek is primarily due to the overly conservative assumptions for seepage from the waste rock dumps to the receiving environment. Observations on site and elsewhere (e.g., Faro) suggest that south facing slopes will not produce much seepage due to evaporation. Despite numerous attempts to collect seepage, seeps have not been found from south facing dumps southwest of the pit. As a result, seepage rates from these areas are likely overestimated. Further, seepage from portions of the dumps is assumed to infiltrate into the bedrock aquifer and discharge to Victoria Creek via Dome Creek at a constant rate throughout the year. This assumption likely overestimates loadings in the winter and underestimates loadings during the active flow period. A further aspect contributing to model conservatism is that the model does not take into account any attenuation of species along the flow path to the receiving environment. Some degree of cadmium and zinc attenuation in the subsurface environment can be expected through adsorption/precipitation processes. Attenuation of cadmium and zinc appears to be currently occurring in the vicinity of the mill area in upper Dome Creek and below the tailings impoundment in lower Dome Creek. The persistence and long-term performance of these mechanisms is uncertain.

Table 5-1 Summary of Predicted Concentrations (mg/L) in Victoria Creek for Option 1A – Best Estimate Source Terms and Average Precipitation Conditions (all values in mg/L)

		Existing Water Quality[c]			Predicted Water Quality	
	CCME Guideline	Minimum	Median	Winter Maximum[c]	Median	Maximum
Arsenic	0.005	0.001	0.0016	0.0075	0.0020	0.0055
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00012	0.00051
Zinc	0.03	0.0005	0.009	0.02	0.018	0.062
Sulfate		6.2	29.6	60.9	36	106

Notes:

a. Draft CCME Guideline for Cadmium (Environment Canada 2008) at Hardness = 150 mg/L as $CaCO_3$.
b. Existing water quality data for Victoria Creek at Road (2007 to 2010).
c. Maximum winter concentration from the existing water quality data set for Victoria Creek (November to February, 2007 to 2010).

Overall, the Best Estimate Average Precipitation model results for Option 1A are comparable to existing water quality conditions in Victoria Creek and can be used to best represent current conditions at the site. The predicted higher winter concentrations are due to the disproportionate winter loadings from the tailings area and deep groundwater pathways which are assumed to remain constant throughout the year. The limited data set for the winter period does not likely encompass the entire range of observed water quality conditions. This presents a limitation of the comparison between predicted concentrations and existing winter values.

5.1.2 Uncertainty

As with all predictive models, there are uncertainties related to the various inputs and assumptions that form the basis of the model. Some of these uncertainties are general in nature and apply to all of the options such as monthly flow rates, annual precipitation, evaporation and background or upstream water quality. Others are unique to the specific closure options such as source term chemistry and source discharge or flow rates. Where there is more understanding and/or historical data to support the model assumptions, there is less uncertainty associated with the predicted results. The following provides a summary of the key uncertainties associated with the modeling results for Option 1A.

- For the tailings area, Option 1A has less overall uncertainty associated with the water quality predictions in comparison to the other options primarily due to the long-term flow and water quality records for the seepage collection pond. Specifically, the performance of the existing tailings facility with regards to seepage rates and water quality is predicted to provide a defensible proxy for the performance of Option 1 over the long-term. This provides a reasonable amount of confidence in the predictions. Accordingly, predictions that exceed observed water quality conditions in Victoria Creek are considered a metric of the model's conservatism.

- A significant amount of conservatism has been incorporated into the model to account for various uncertainties. One key component of this conservatism is the assumption of constant seepage rate from both the tailings area and the deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism is reflected in the higher predicted winter concentrations which generally exceed historical winter maximum concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months. In addition, the use of the assumed constant seepage rate of 3.5 L/s is also

conservative as it is based on the current dam condition is and therefore does not include the estimated reduction in seepage through the dam as a result of the dam upgrade (~1.6 L/s reduction).

- Precipitation conditions were evaluated for three precipitation conditions (average year, dry year and wet year) to account for the uncertainty associated with climate variability. Overall, the impact of varying precipitation, and subsequently flow in the receiving environment, is reflected in the predicted water quality for each precipitation condition presented in Figures 5-5 through 5-8. As expected, during dryer years, there is less dilution capacity in the receiving environment and therefore higher predicted concentrations. Conversely, during wet precipitation years, the additional flow in the receiving environment results in lower predicted concentrations.

- As outlined in AECOM (2010b), the groundwater discharge rate from the pit to Dome Creek was estimated for three different hydraulic conductivities which range over approximately 4 orders of magnitude. This uncertainty in the range of hydraulic conductivities and associated pit discharge rates has the potential to significantly impact the pit loading to the receiving environment. In the absence of the appropriate level of hydrogeological information required to refine the range of estimated hydraulic conductivities, the pit discharge rate in the model was conservatively set to the maximum estimated value of 0.13 L/s.

- A comparison of Best Estimate and Upper Estimate results provide an overall indication of the implication of the uncertainty associated with source term chemistry (Lorax 2010). This is best illustrated in the winter low flow months (January to March) where the predicted Upper Estimate concentrations are significantly higher in relation to maximum winter baseline concentrations (Figures 5-1 to 5-4). Although applying the Upper Estimate source chemistry provides an additional layer of conservatism into the model, the associated predicted downstream water quality is not consistent with the observed current range in water quality conditions. Therefore, the Upper Estimate model output is not considered to be representative of the anticipated performance of Option 1A.

- One of the key considerations for the Tailings in Place Options (Options 1 and 2) is whether the attenuation process reducing arsenic concentrations will continue in the long-term. An Upper estimate arsenic source term has been provided for seepage from the tailings mass, as represented by closure Option 1 and 2. The Upper estimate is based on elevated arsenic concentrations measured in a shallow monitoring well downgradient of the seepage collection pond. The upper estimate value (0.30 mg/L arsenic) is also supported by observed total and dissolved arsenic concentrations within the tailings pond. Maximum total and dissolved arsenic concentrations measured in the pond since October 2007 (since method detection limits improved) are 0.27 and 0.17 mg/L, respectively. The Upper Estimate for arsenic is considered a reasonable proxy for tailings seepage that does not undergo attenuation. This is supported by the tailings pond water quality, which is assumed to be representative of average seepage from the tailings mass in its current configuration. Predicted Upper Estimate arsenic concentrations in Victoria Creek range from 0.002 mg/L to 0.033 mg/L with a median concentration of 0.005 mg/L and are higher than the Best Estimate results and existing concentrations in Victoria Creek. As outlined above, although the Upper Estimate source term provides for an assessment of the impact of the loss of attenuation along the tailing seepage pathway, these predicted concentrations are not considered to be representative of the anticipate performance of Options 1 and 2.

- With respect to the tailings area water balance for Option 1A, one of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain a water cover

of 0.7 m, particularly during the open water, non-frozen period. A two-part assessment of the available water supply was carried out for this option as part of the water balance modeling. The first assessment was carried out assuming a runoff coefficient of 0.8 for spring runoff (April and May) and a runoff coefficient of 0.6 for the remaining open water season months as per AECOM (2010c). It is unclear if these proposed coefficients adequately represent runoff conditions at the site for all locations and conditions.

- Some clarification of the topic above is provided in Carey and Woo (2001), who found runoff coefficients as high as 0.8 in the nearby Wolf Creek basin; however, they also found that hillslopes in the watershed had runoff coefficients during snowmelt that varied considerably. No runoff was observed on the south-facing slopes, but 155 mm, 50 mm and 19 mm of water was discharged from the north, east and west-slopes, giving runoff ratios of 0.8, 0.6 and 0.25 respectively. Factors such as aspect, snow redistribution, presence/absence of ice lenses, soil type/development and infiltration potential were identified as key determinants of runoff generation at different times of year. In order to account for these findings, a sensitivity analysis was completed for Option 1A assuming a lower runoff coefficient of 0.4 for all the open water season months. Results of this assessment indicate that inflows to the tailings area are generally sufficient to maintain a 0.7 m water cover during the open water season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the water cover to maintain the tailings in a saturated state.

In summary, taking into consideration the uncertainties outlined above, the Best Estimate Average Precipitation results are considered to be representative of current conditions and best represent the anticipated performance of Option 1A. A considerable degree of confidence is associated with the water quality predictions. Where appropriate, conservative assumptions were incorporated into the model to offset uncertainty associated with specific model assumptions. These results, while specific to Option 1A, are representative of current site conditions and can be used as a bench mark from which to assess the performance of the other closure options.

5.2 Water Quality and Water Balance Model Results - Option 1B

The predicted water quality for each of the model runs was used to assess the performance of the other closure options. Specifically, the results of the model were compared to the Best Estimate Average Precipitation results for Option 1A, which provides a proxy for current site conditions. For each option, the predicted minimum, mean and maximum concentrations for each source term chemistry and precipitation condition are presented in Figures 5-5 through 5-8 along with the results for Option 1A. Time series profiles of the predicted concentrations for sulfate, arsenic, cadmium and zinc are presented in Figures 5-1 through 5-4. Where appropriate, CCME guidelines are provided for reference. Source loading distributions of arsenic, cadmium and zinc are presented in Figure 5-9 for the Best Estimate/Average Flow Scenario.

5.2.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 1B are:

- Similar to Option 1A, for all modeled parameters, peak predicted concentrations occur during the winter low flow period due to continuous loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year during.

- Sulfate
  - In general, the predicted concentrations of sulfate for Option 1B (median = 35 mg/L; maximum = 98 mg/L) are comparable lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L).
  - Similar to Option 1A, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 1B (median = 0.002 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) indicating no overall change in performance from current conditions.
  - The predicted loading from tailings seepage is the dominant source of arsenic to the receiving environment (89% of a total predicted annual loading of 4.9 kg) with the backfilled waste rock contributing a higher loading compared to waste rock storage on surface in Option 1A.

- Cadmium
  - The predicted cadmium concentrations for Option 1B (median = 0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below CCME guidelines.
  - Comparison of the predicted cadmium concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance.
  - The improvement in water quality relates to a decrease in loading from waste rock. Although still the dominant source of cadmium to the receiving environment, the waste rock contributes significantly less loading primarily due to the overall reduction of the waste rock footprint as a result of backfilling (62% of a total predicted annual loading of 0.3 kg).

- Zinc
  - The predicted zinc concentrations for Option 1B (median= 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint (92% of a total predicted annual loading of 30 kg).

Overall, the Best Estimate Average Precipitation model results for Option 1B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B indicates an overall improvement compared to current conditions and those predicted for Option 1A. The predicted reductions in cadmium and zinc concentrations in the receiving environment are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling.

5.2.2 Uncertainty

The key uncertainties associated with the modeling results for Option 1B are the same as those outlined in Section 5.1.2 for Option 1A.

5.3 Water Quality and Water Balance Model Results - Option 2A

5.3.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 2A are:

- Similar to Option 1A, for all modeled parameters peak concentrations occur during the winter low flow period due to ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year during.

- Sulfate
  - The predicted concentrations of sulfate (median = 36 mg/L, maximum = 106 mg/L) are the same as those for Option 1A.
  - Similar to Option 1, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 2A (median = 0.0019 mg/L, maximum = 0.0055 mg/L) are similar to those for Option 1A indicating no overall change in performance with respect to current conditions.
  - The predicted loading from tailings seepage, similar to Option 1A, is the dominant source of arsenic to the receiving environment.

- Cadmium
  - The predicted cadmium concentrations for Option 2A (median = 0.00012mg/L, maximum = 0.00051 mg/L) are the same as those predicted for Option 1A indicating no overall change in performance with respect to current conditions.
  - The predicted loading from seepage from the waste rock dumps, similar to Option 1A, is the dominant source of cadmium to the receiving environment.

- Zinc
  - The predicted zinc concentrations for Option 2A (median = 0.018 mg/L, maximum = 0.062 mg/L) are similar to those predicted for Option 1A, indicating no overall change in performance with respect to current conditions.
  - The predicted loading from seepage from the waste rock dumps, similar to Option 1A, is the dominant source of zinc to the receiving environment.

Overall, the Best Estimate Average Precipitation model results for Option 2A are comparable to Option 1A and current conditions.

5.3.2 Uncertainty

The key uncertainties associated with the modeling results for Option 2A are similar to those outlined in Section 5.1.2 for Option 1A. As outlined above for Option 1A, one of the key considerations is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain the tailings in a saturated state, and specifically, if the proposed runoff coefficients are representative of runoff conditions at the site for all locations and conditions. Results of a sensitivity analysis indicate that inflows to the tailings area are generally sufficient to maintain the assumed 0.25 m water cover during the open water

season. During dry conditions, a minimal drop in water cover would occur, although not significant enough to impact the ability of the saturated soil cover to maintain the tailings in a saturated state.

5.4 Water Quality and Water Balance Model Results - Option 2B

5.4.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 2B are:

- Similar to Option 1A, concentrations for all modeled parameters are predicted to peak during the winter low flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by the seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year.

- Sulfate
  - In general, the predicted concentrations of sulfate (median = 35 mg/L, maximum = 98 mg/L) for Option 2B are similar to Option 1B and than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L).
  - Similar to Option 1B, the primary source of predicted sulfate concentrations in the winter low flow period is the year round discharge of tailings seepage to the receiving environment at constant rate of 3.5 L/s.

- Arsenic
  - Predicted concentrations of arsenic for Option 2B (median = 0.0019 mg/L, maximum = 0.0059 mg/L) are comparable to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) indicating no change in performance from current conditions.
  - The predicted loading from tailings seepage, similar to Option 1B, is the dominant source of arsenic to the receiving environment.

- Cadmium
  - The predicted cadmium concentrations for Option 2B (median = 0.00006 mg/L, maximum = 0.00028 mg/L) are lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below CCME guidelines.
  - Comparison of the predicted cadmium concentrations for Option 2B in Victoria Creek to those for Option 1A indicate an improvement in performance from current conditions.
  - Similar to Option 1B, the backfilled waste rock, although still the dominant source of cadmium to the receiving environment, contributes significantly less loading primarily due to the overall reduction of the waste rock footprint.

- Zinc
  - The predicted zinc concentrations for Option 2B (median = 0.010 mg/L, maximum = 0.035 mg/L) are lower than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 1B in Victoria Creek to those for Option 1A indicate an improvement in performance from current conditions.
  - Similar to cadmium, the water quality improvements associated with zinc can be attributed to a decrease in the loading from waste rock primarily due to the overall reduction of the waste rock footprint.

Similar to Option 1B, the Best Estimate Average Precipitation model results for Option 2B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 2B (and 1B) indicates an overall improvement compared to current conditions and those predicted for Option 1A. The predicted reductions in cadmium and zinc concentrations in the receiving environment can be attributed to the reduction in loading from waste rock associated with the reduction in waste rock footprint after backfilling.

5.4.2 Uncertainty

The key uncertainties associated with the modeling results for Option 2B are similar to those outlined in Section 5.3.2 for Option 2A.

5.5 Water Quality and Water Balance Model Results - Option 3

5.5.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 3 are:

- Similar to Option 1A, peak concentrations for all parameters occur during the winter low flow period due to the ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock) which are assumed to remain constant throughout the year during.

- Sulfate
  - In general, predicted concentrations of sulfate (median = 30 mg/L, maximum = 44 mg/L) are lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L). The lower sulfate concentrations predicted for Option 3 reflect the removal of seepage from the tailings area which represents the primary source of sulfate to Victoria Creek.

- Arsenic
  - Predicted concentrations of arsenic for Option 3 (median = 0.0034 mg/L, maximum = 0.022 mg/L) are higher than those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) and current conditions.
  - The predicted loading from saturated tailings stored in the pit is the dominant source of arsenic to the receiving environment (99% of a total predicted annual loading of 20 kg).
  - The predicted annual loading from the saturated tailings in the pit is approximately 4 times higher that from the tailings in Option 1A and current conditions.

- Cadmium
  - The predicted cadmium concentrations for Option 3 (median = 0.00009 mg/L, maximum = 0.00038 mg/L) are marginally lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.
  - Comparison of the predicted cadmium concentrations for Option 3 in Victoria Creek to those for Option 1A indicates a marginal improvement in performance from current conditions.
  - The predicted loading from waste rock is the dominant source of cadmium to the receiving environment (99% of a total predicted annual loading of 0.5 kg).
  - The predicted total annual loading for cadmium is lower than that for Option 1A and current conditions due to a reduction in source loading from the saturated tailings, as well as the removal of the pit lake as a source of cadmium.

- Zinc
  - The predicted zinc concentrations for Option 3 (median = 0.017 mg/L, maximum = 0.059 mg/L) are similar than those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 3 in Victoria Creek to those for Option 1A indicates no improvement in performance from current conditions.
  - Similar to cadmium, the predicted loading from waste rock is the dominant source of zinc to the receiving environment (99% of a total predicted annual loading of 69 kg).
  - The predicted total annual loading for zinc is lower than that for Option 1A and current conditions due to a reduction in source loading from the saturated tailings as well as the removal of the pit lake as a source of zinc.

Overall, the Best Estimate Average Precipitation model results for Option 3 show comparable values for cadmium and zinc and in comparison to Option 1A and current conditions. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentration in Victoria Creek compared to current conditions and those predicted for Option 1A. This largely relates to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 3 are higher than those predicted for Option 1A and current conditions. The increase in arsenic largely reflects the higher residual arsenic source loading from the backfilled tailings, which incorporates a 50% reduction of arsenic loading along the groundwater flow path due to attenuation.

5.5.2 Uncertainty

With the exception of those uncertainties outlined in Section 5.1.2 for Option 1A for the tailings area, the uncertainties associated with the modeling results for Option 3 are similar to those outlined for Option 1A, specifically:

- A significant amount of conservatism has been incorporated into the model to account for various uncertainties. One key component of this conservatism is the assumption of constant seepage rate from both the tailings area and the deep groundwater pathways conveying contaminants from the pit and surrounding waste rock areas. This conservatism is reflected in the higher predicted winter concentrations which generally exceed historical winter maximum concentrations. In reality, the tailings seepage and deep groundwater flows will exhibit some seasonal variability with a reduction in flows during the winter months.
- Precipitation conditions were evaluated for three precipitation conditions (average year, dry year and wet year) to account for the uncertainty associated with climate variability. Overall, the impact of varying precipitation, and subsequently flow in the receiving environment, is reflected in the predicted water quality for each precipitation condition presented in Figures 5-5 through 5-8. As expected, during dryer years, there is less dilution capacity in the receiving environment and therefore higher predicted concentrations. Conversely, during wet precipitation years, the additional flow in the receiving environment results in lower predicted concentrations.
- As outlined in AECOM (2010b), the groundwater discharge rate from the pit to Dome Creek was estimated for three different hydraulic conductivities which range over approximately 4 orders of magnitude. This uncertainty in the range of hydraulic conductivities and associated pit discharge rates has the potential to significantly impact the pit loading to the receiving environment. In the absence of the appropriate level of hydrogeological information required to refine the range of estimated hydraulic

conductivities, the pit discharge rate in the model was conservatively set to the maximum estimated value of 0.13 L/s.

In addition, the following uncertainties are associated with the water balance and water quality predictions for Option 3:

- A critical uncertainty associated with Option 3 is related to the feasibility of attaining a desired level (85%) of tailings saturation in the pit. As discussed in the 2010 geotechnical analysis (AECOM 2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity. The water balance and water quality model for Option 3 assumed that the tailings are well mixed with a uniform hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings.

- As discussed in Section 4.6.4, the results of one-dimensional modeling indicate that a minimum annual addition of 420 m^3 of water is required to ensure tailings saturation levels are maintained at 85% or higher (i.e., water that must come from outside the tailings footprint). The water quality modeling for this option assumed that the surrounding catchment of the pit area can provide the water to offset this deficit. To ensure sufficient water is available, a water balance assessment was carried out for dry and average conditions. Assuming the surface area of the tailings placed in the pit is 21,000 m^2 and the entire pit catchment for Option 3 is 33,930 m^2, the residual pit catchment area is 12,930 m^2. Based on this assessment, this residual catchment area can provide an additional 2,328 m^3/year of potential inflow during a dry year and 3,663 m^3/year during an average year. Assuming a runoff coefficient of 0.4, these water volumes translate to 931 m^3 and 1,465 m^3 during dry and average conditions, respectively. Such volumes are sufficient to offset the assumed deficit, and therefore maintain tailings saturation.

- A relevant uncertainty is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The loading model for tailings placement in the open pit (Options 3 and 4) incorporates a reduction in arsenic loading of 50% due to attenuation along the groundwater flow path between the pit and Dome Creek and/or Victoria Creek. In this context, attenuation refers to adsorption and/or precipitation processes that result in the removal of dissolved arsenic from solution. As discussed in Section 4.6.3 some degree of arsenic attenuation in the subsurface environment can be expected through adsorption/co-precipitation mechanisms. The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented. Therefore the assumption of 50% reduction of arsenic loading in the model is considered to impart considerable conservatism into the model predictions.

- A sensitivity analysis was run to assess the impacts of zero attenuation of arsenic from the tailings along the groundwater flow paths from the pit. Loss of the anticipated attenuation of arsenic results in higher predicted concentrations in Victoria Creek (median = 0.005 mg/L and maximum = 0.043 mg/L), well above for Option 1A and current conditions.

5.6 Water Quality and Water Balance Model Results - Option 4

5.6.1 Performance

Key highlights (for Best Estimate/Average Flow Scenario) of the assessment for Option 4 are:

- Similar to Option 1A, peak concentrations for all modeled parameters are predicted to occur during the winter low flow period due to ongoing discharge of mine-related loadings during periods of minimal flow and available dilution. This disproportionate load is emphasized by discharges from the deep groundwater system (pit and waste rock), which are assumed to remain constant throughout the year.

- Sulfate
  - In general, the predicted concentrations of sulfate (median = 30 mg/L, maximum = 40 mg/L) are lower than those for Option 1A (median = 36 mg/L, maximum = 106 mg/L). The lower sulfate concentrations predicted for Option 4 largely relate to a decrease in the water flux associated with in-pit tailings placement..

- Arsenic
  - Predicted concentrations of arsenic for Option 4 (median = 0.0023 mg/L, maximum = 0.009 mg/L) are similar to those for Option 1A (median = 0.002 mg/L, maximum = 0.0055 mg/L) and current conditions, except for marginally higher predicted winter low flow concentrations.
  - The predicted loading from tailings stored in the pit is the dominant source of arsenic to the receiving environment (94% of a total predicted annual loading of 7 kg).
  - The predicted annual loading from the tailings in the pit is approximately 1.5 times higher that from the tailings in Option 1A and current conditions.

- Cadmium
  - The predicted cadmium concentrations for Option 4 (median = 0.00006 mg/L, maximum = 0.00035 mg/L) are slightly lower than those predicted for Option 1A (median = 0.00012 mg/L, maximum = 0.00051 mg/L) and well below the CCME guideline.
  - Comparison of the predicted cadmium concentrations for Option 4 in Victoria Creek to those for Option 1A indicates a minor improvement in performance from current conditions.
  - The predicted loading from waste rock is the dominant source of cadmium to the receiving environment (69% of a total predicted annual loading of 0.3 kg).
  - The predicted total annual loading for cadmium is lower than that for Option 1A and current conditions due to a reduction in source loading from waste rock as a result of the partial backfill of waste rock to the pit and the inclusion of the ore stockpile in the low-infiltration cover area.

- Zinc
  - The predicted zinc concentrations for Option 4 (median = 0.012 mg/L, maximum = 0.058 mg/L) are similar to those predicted for Option 1A (median = 0.018 mg/L, maximum = 0.062 mg/L) and generally below the CCME guideline, except during winter low flow conditions.
  - Comparison of the predicted zinc concentrations for Option 4 in Victoria Creek to those for Option 1A indicates no improvement in performance from current conditions.
  - Similar to cadmium, the predicted loading from waste rock is the dominant source of zinc to the receiving environment (73% of a total predicted annual loading of 48 kg).
  - Although the predicted annual loading from the backfilled tailings in Option 4 is lower than that for Option 1A and current conditions, the annual loading from tailings is approximately 5 times higher than that for Option 1A. The overall reduction in zinc loading is, similar to cadmium, due to a reduction in source loading from waste rock as a result of the partial backfill of waste rock to the pit inclusion of the ore stockpile in the low-infiltration cover area.

Overall, the Best Estimate Average Precipitation model results for Option 4 are comparable to Option 1A and current conditions with respect to zinc and show a marginal improvement with respect to cadmium. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentrations compared to current conditions owing to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 4 are similar those predicted for Option 1A and current conditions, except for marginally higher concentrations during the winter low flow conditions. The results for Option 4 also demonstrate that despite the assumption that acidic conditions develop within in-pit tailings, such conditions do not have a marked effect on increasing contaminant loadings when compared to Option 3. This can be related to the low water flux through the tailings cover which offsets the higher source term concentrations in the loading calculations.

5.6.2 Uncertainty

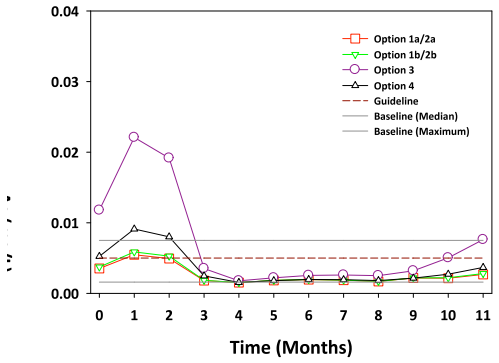
With the exception of those uncertainties outlined in Section 5.5.2 for Option 3 for the high-infiltration tailings cover, the uncertainties associated with the modeling results for Option 4 are similar to those outlined for Option 3. In addition, the following uncertainties are associated with the water balance and water quality predictions for Option 4:

- As discussed in Section 4.7.2, the typical range of infiltration rates for the synthetic barrier cover system is 1% to 3% of annual precipitation. For the loading model, an infiltration rate of 5% of average annual precipitation was conservatively assumed to account for cover degradation and the anticipated decrease in performance in the long-term. This type of cover was selected as it is the most appropriate for the site's climatic conditions and is not reliant on a viable vegetative cover. The implications of using a cover design with a higher infiltration rate of 15% was assessed as part of the sensitivity analysis, specifically on predicted arsenic concentrations in Victoria Creek. Increasing the cover infiltration rate to 15% of annual precipitation results in higher predicted concentrations in Victoria Creek (median = 0.004 mg/L and maximum = 0.023 mg/L), above those predicted for Option 1A and current conditions.

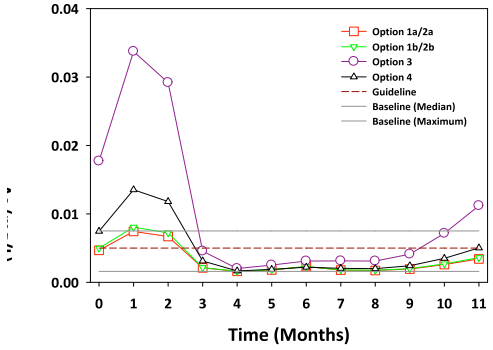
- The uncertainty with regards to potential for the attenuation of arsenic along the groundwater flow path also has direct relevance to Option 4. This topic is discussed in detail in Section 5.5.2. A sensitivity analysis was run to assess the impacts of zero attenuation of arsenic from the tailings along the groundwater flow paths from the pit. Loss of the anticipated attenuation of arsenic results in slightly higher predicted concentrations in Victoria Creek (median = 0.003 mg/L and maximum = 0.016 mg/L), marginally above for Option 1A and current conditions.

Average Flow

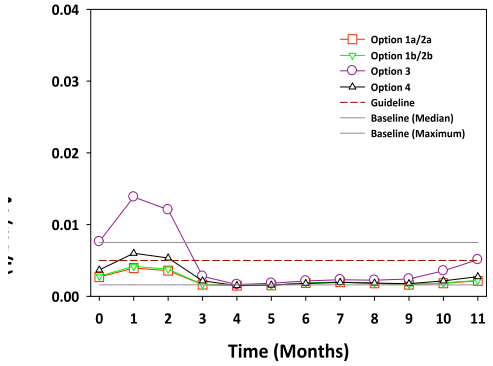
Best Estimate Scenario



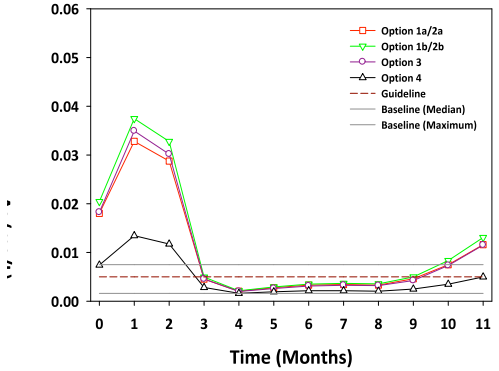
Low Flow

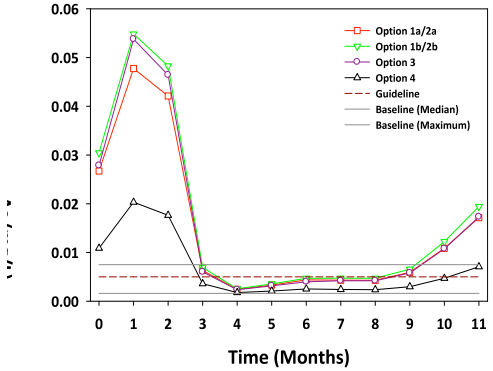


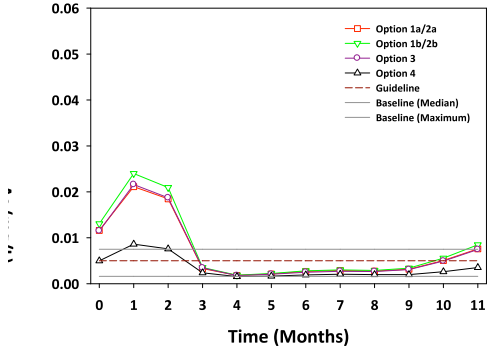
High Flow



Upper Estimate Scenario







Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

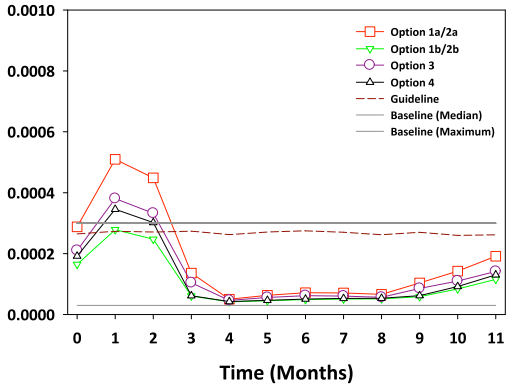
Figure 5-1 Time Series Plots of Predicted Arsenic Concentrations in Victoria Creek

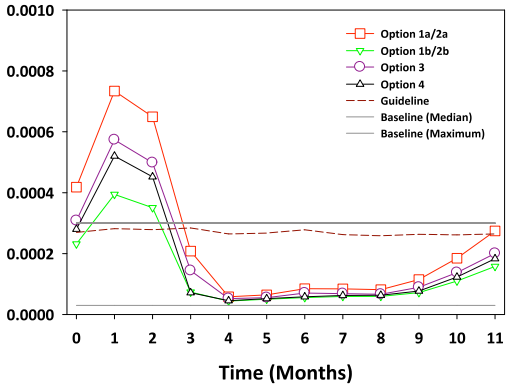
Average Flow

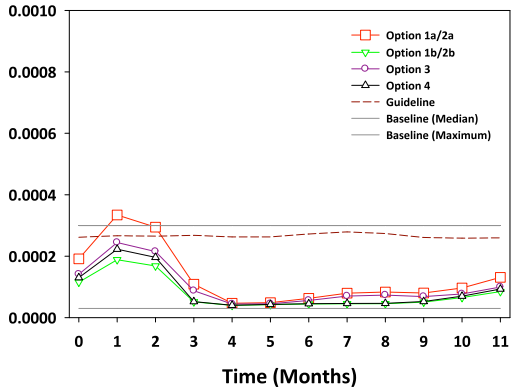
Low Flow

High Flow

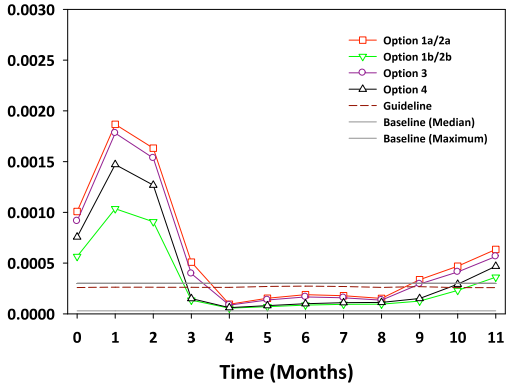
Best Estimate Scenario

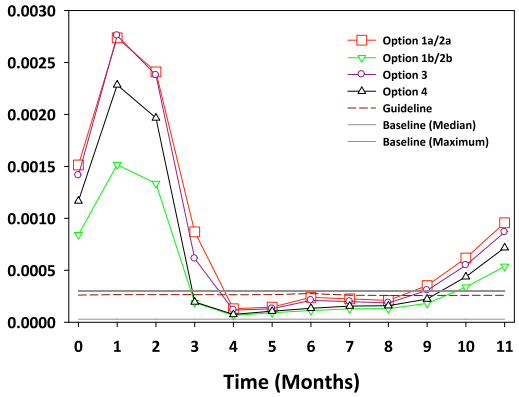


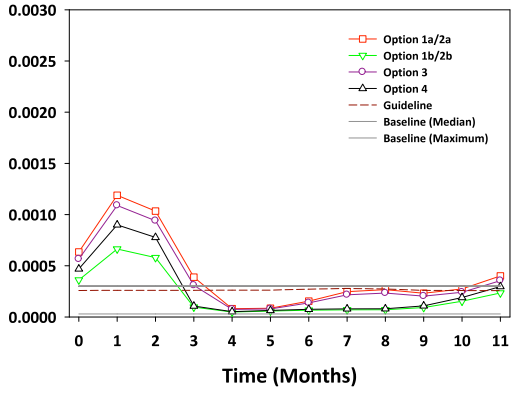




Upper Estimate Scenario





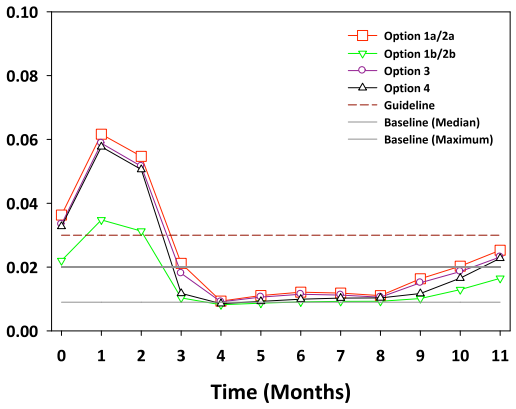


Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

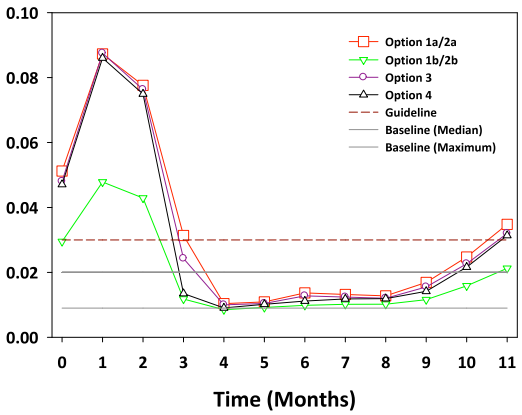
Figure 5-2 Time Series Plots of Predicted Cadmium Concentrations in Victoria Creek

Average Flow

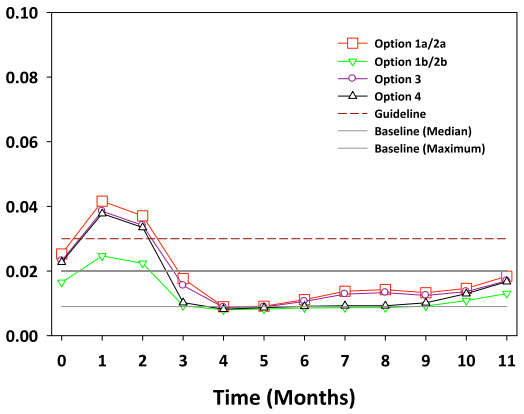
Best Estimate Scenario



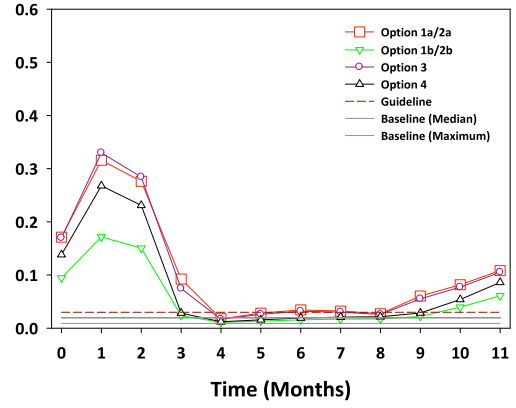
Low Flow

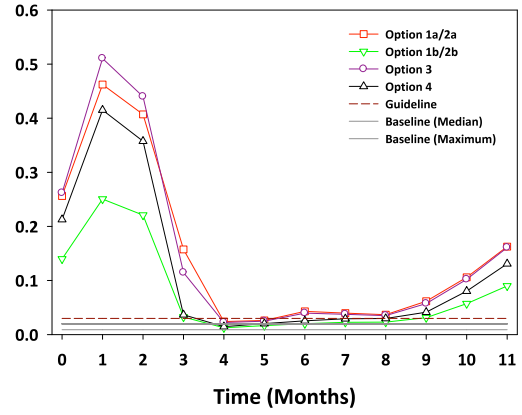


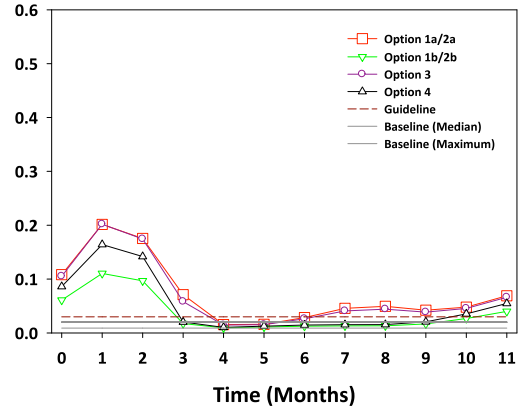
High Flow



Upper Estimate Scenario





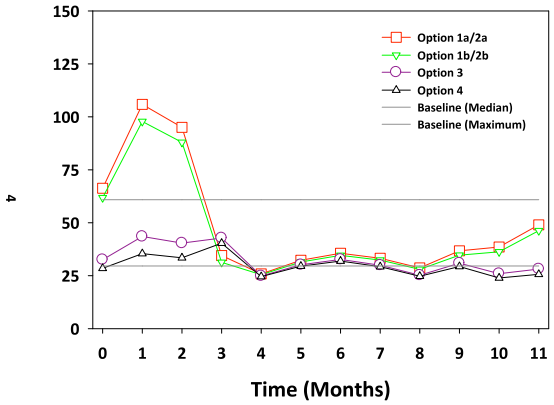


Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

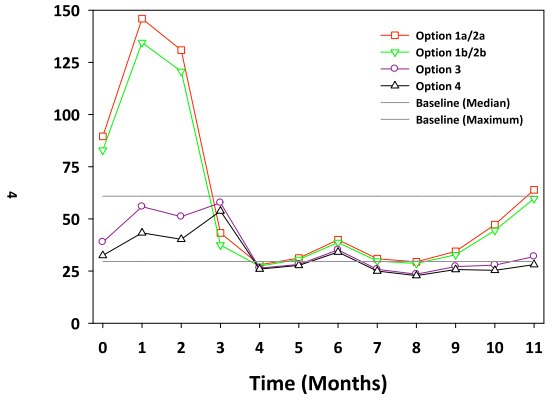
Figure 5-3 Time Series Plots of Predicted Zinc Concentrations in Victoria Creek

Average Flow

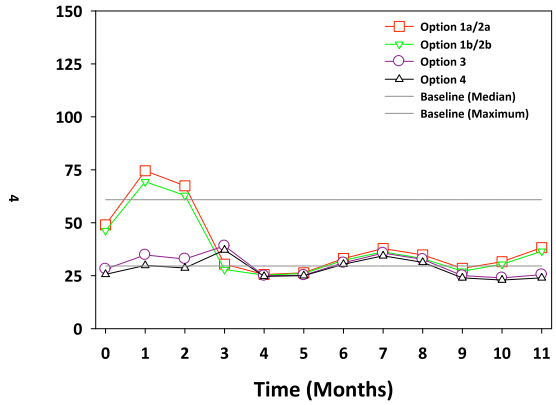
Best Estimate Scenario



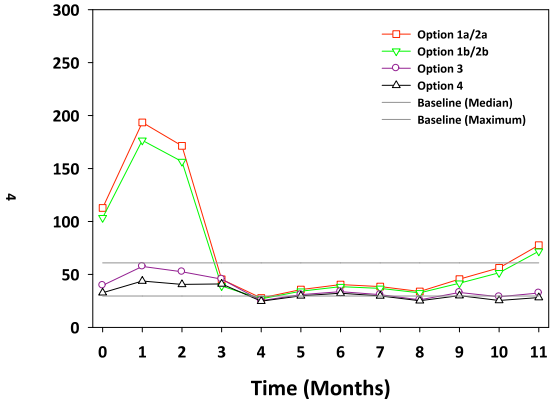
Low Flow

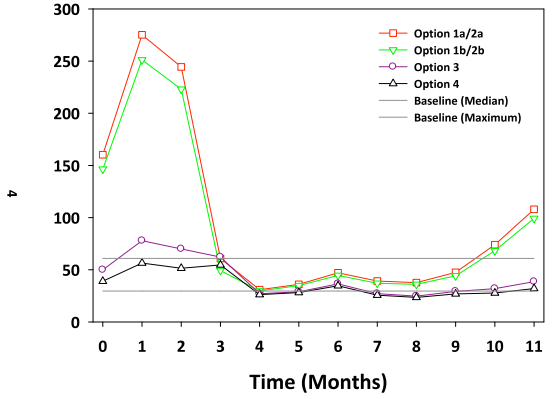


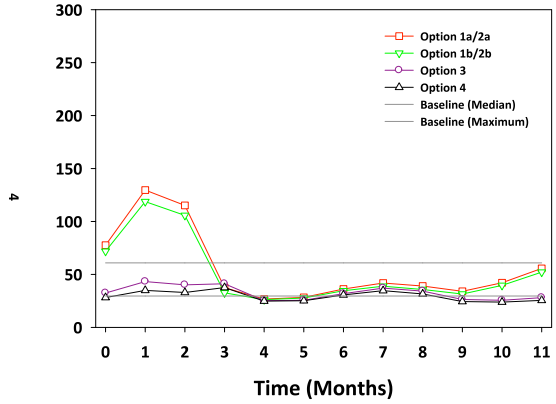
High Flow



Upper Estimate Scenario







Notes: 1. Baseline (Maximum) is equivelant to the Winter Maximum measured at Victoria Creek
2. Axes for Best Estimate Scenario and Upper Estimate Scenario are different

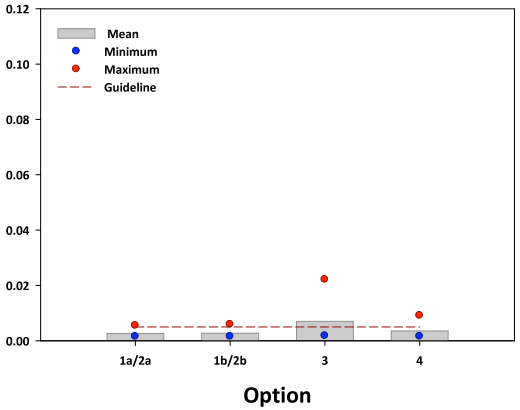
Figure 5-4 Time Series Plots of Predicted Sulphate Concentrations in Victoria Creek

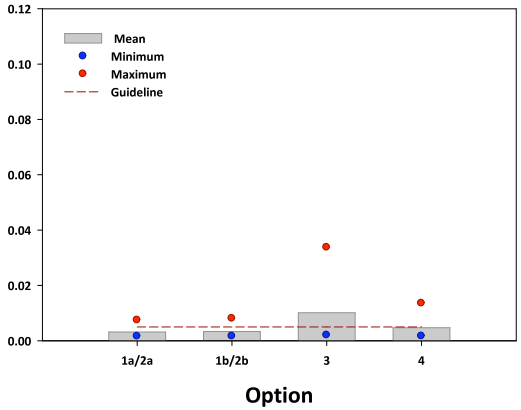
Average Flow

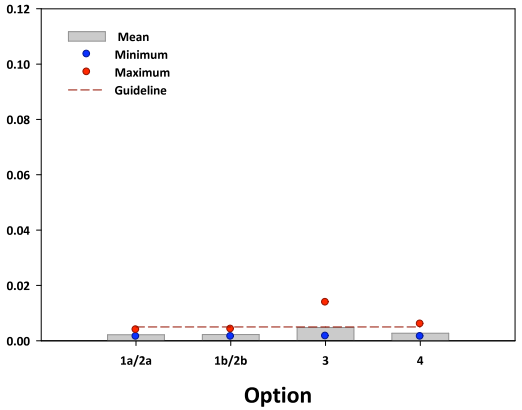
Low Flow

High Flow

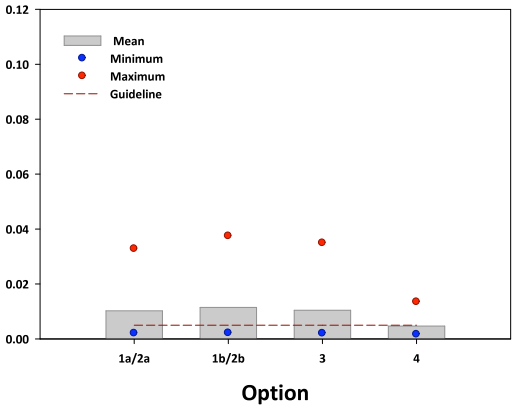
Best Estimate Scenario

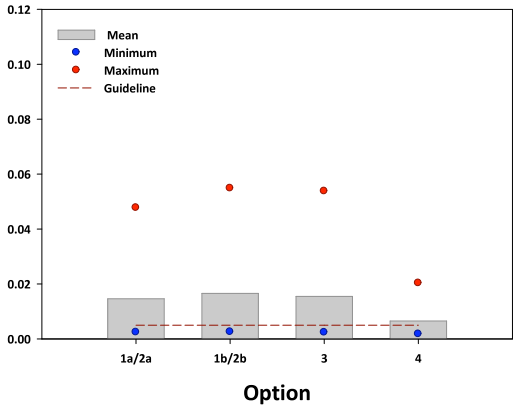






Worst Case Scenario





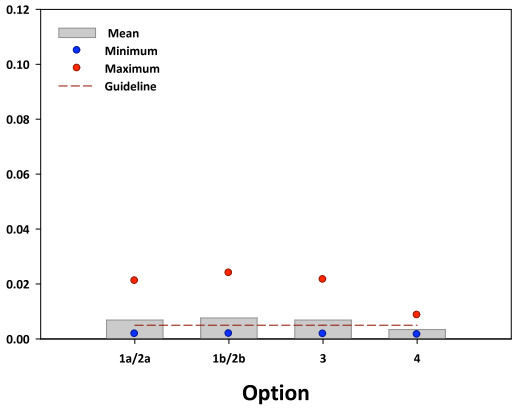
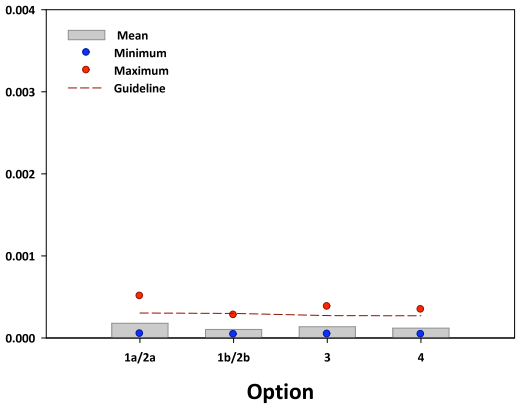


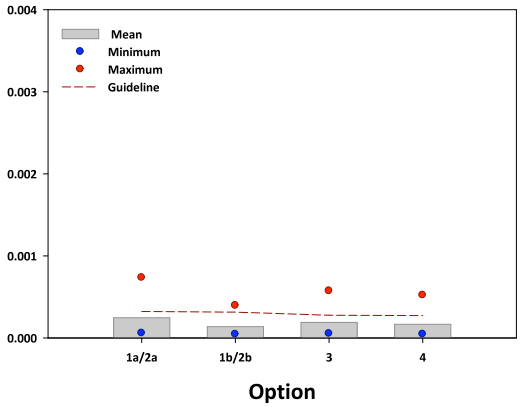
Figure 5-5 Box Plots of Predicted Mean, Minimum and Maximum Arsenic Concentrations in Victoria Creek

Average Flow

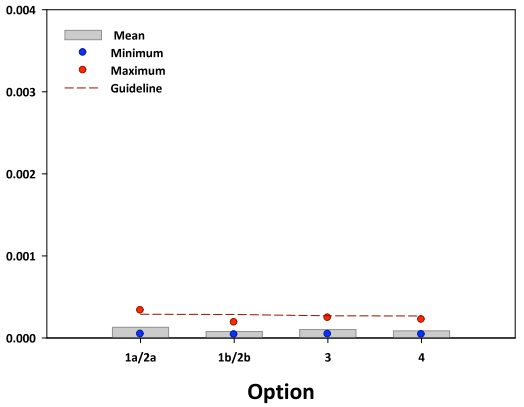
Best Estimate Scenario



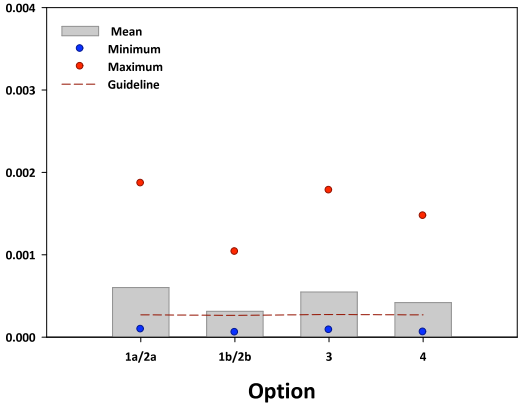
Low Flow

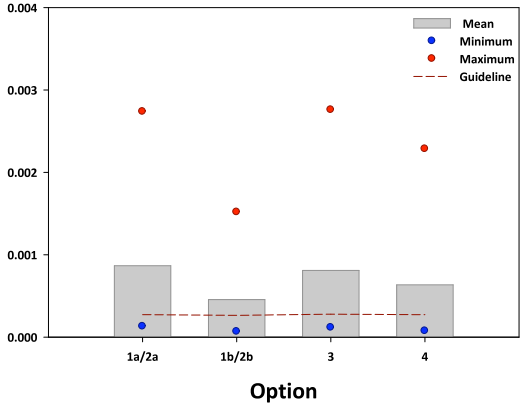


High Flow



Worst Case Scenario





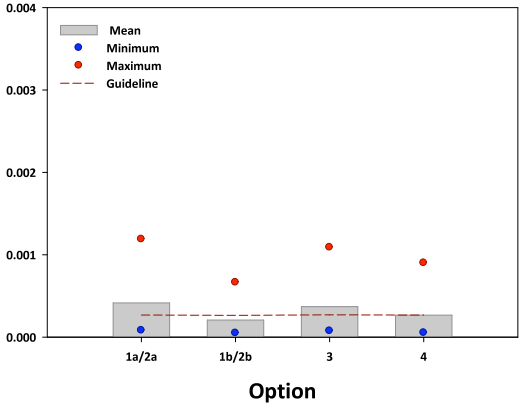
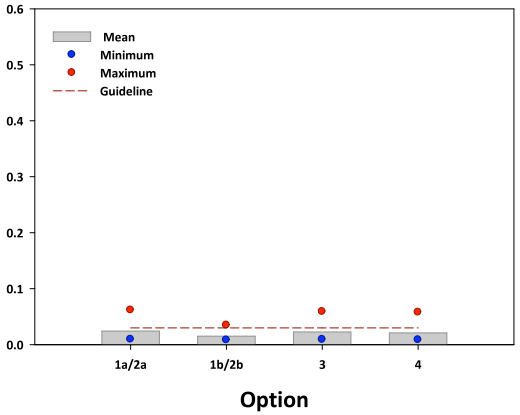


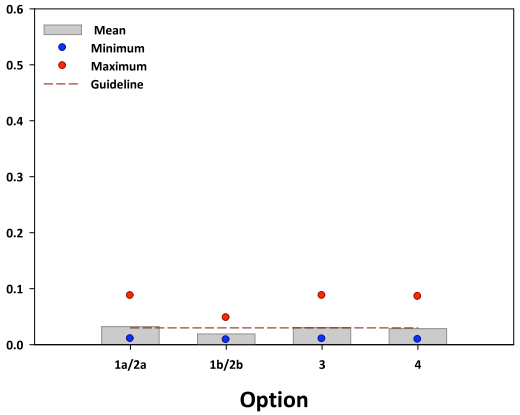
Figure 5-6 Box Plots of Predicted Mean, Minimum and Maximum Cadmium Concentrations in Victoria Creek

Average Flow

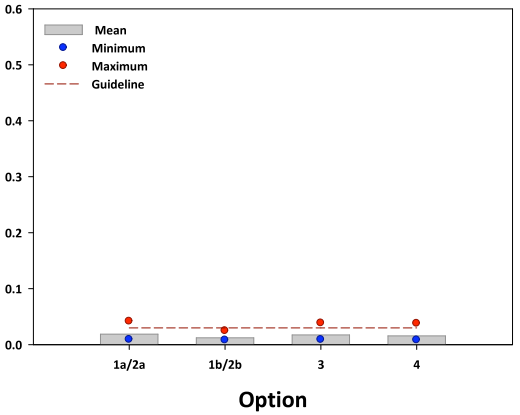
Best Estimate Scenario



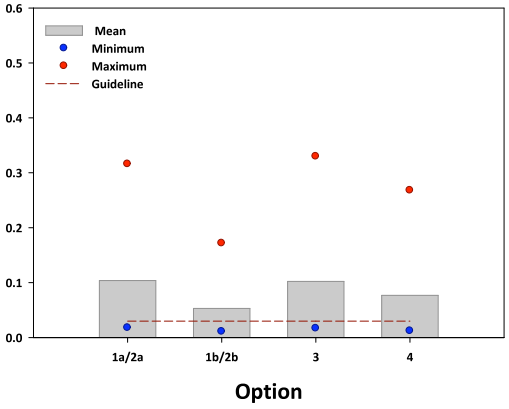
Low Flow

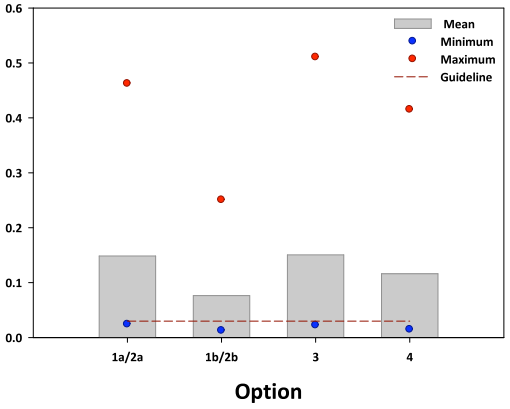


High Flow



Worst Case Scenario





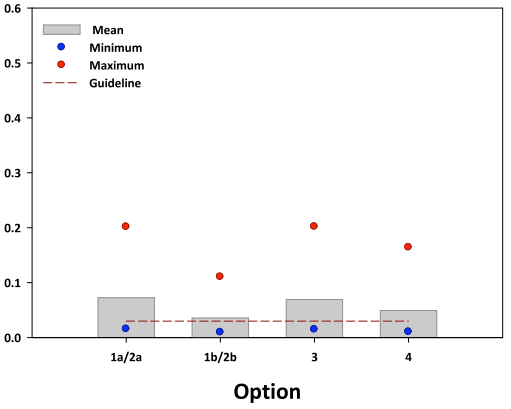
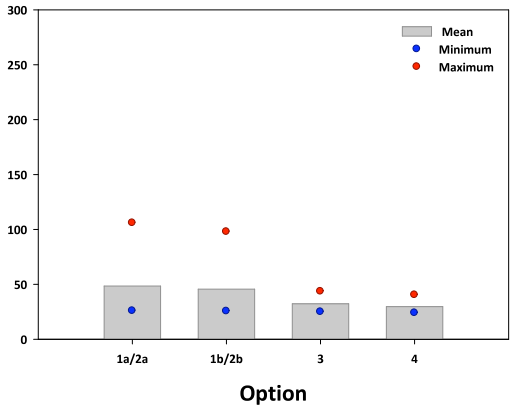


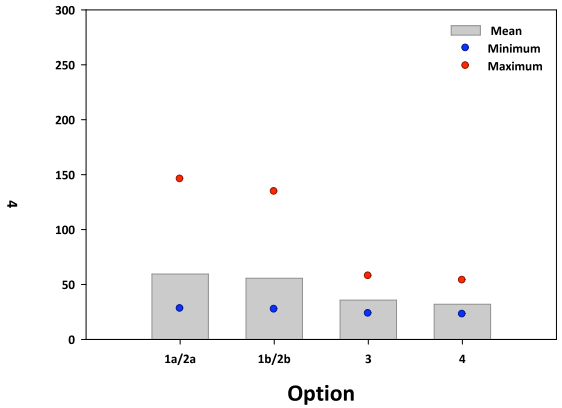
Figure 5-7 Box Plots of Predicted Mean, Minimum and Maximum Zinc Concentrations in Victoria Creek

Average Flow

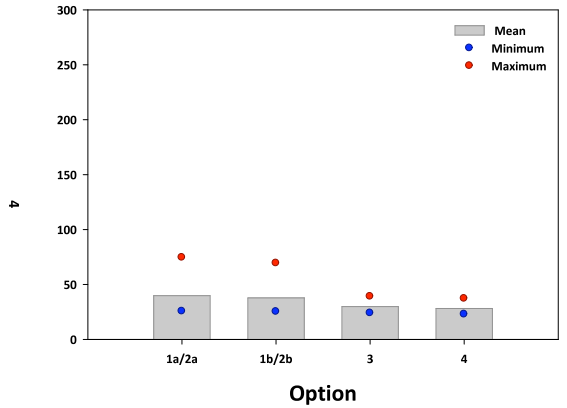
Best Estimate Scenario



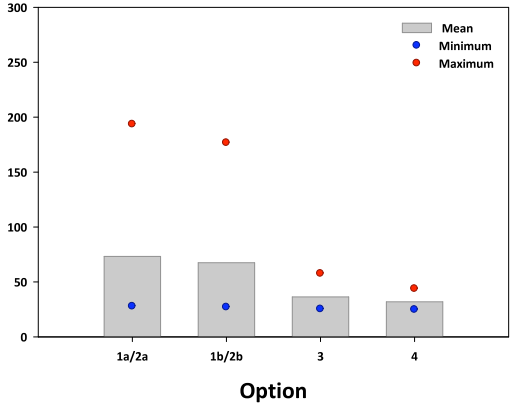
Low Flow

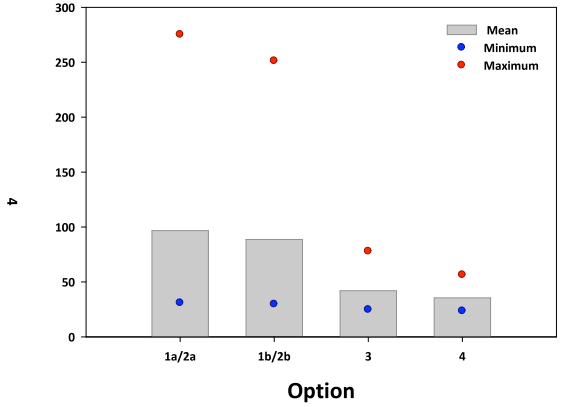


High Flow



Worst Case Scenario





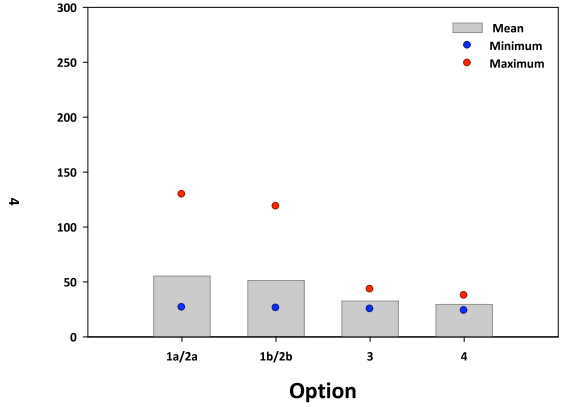


Figure 5-5 Box Plots of Predicted Mean, Minimum and Maximum Sulphate Concentrations in Victoria Creek

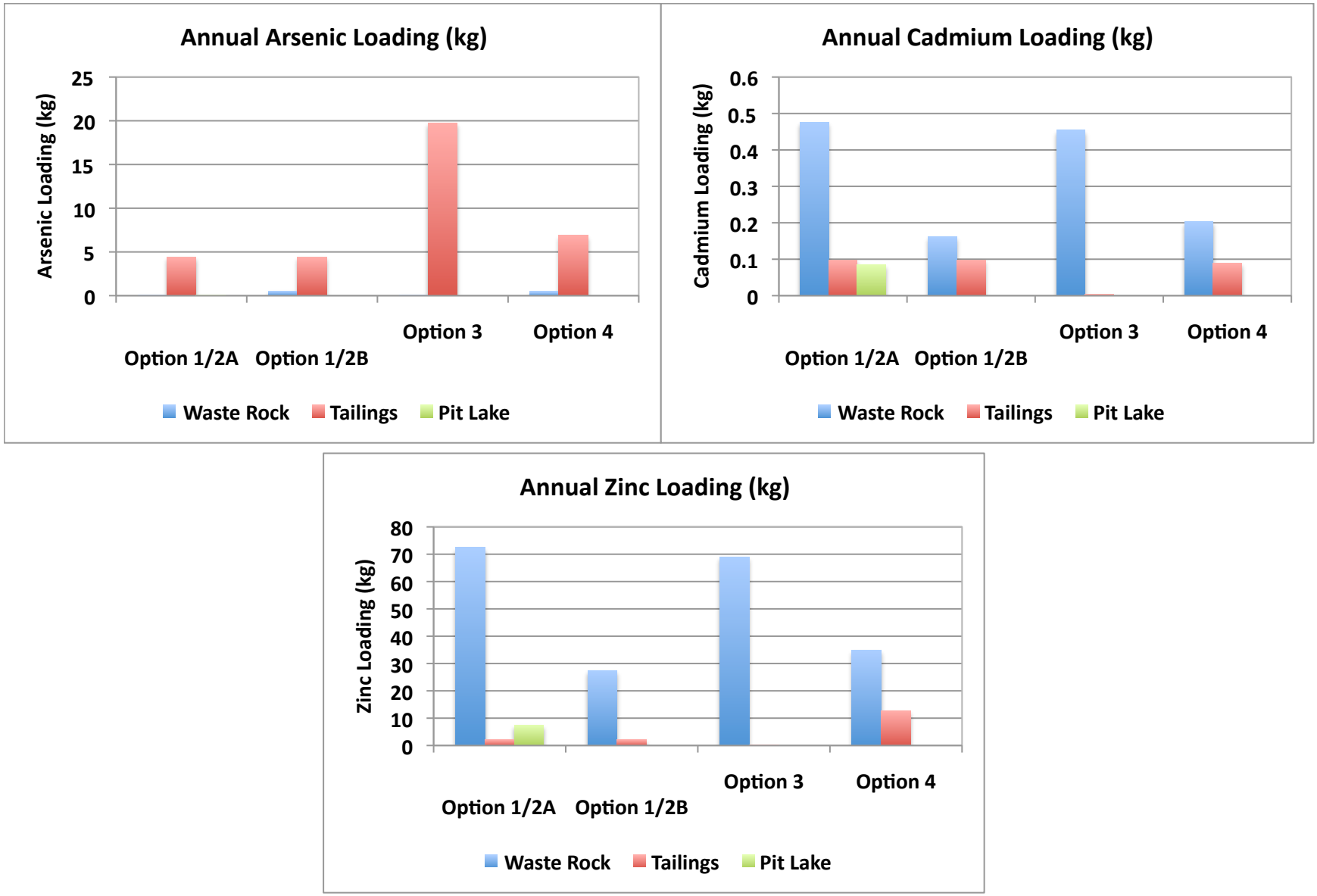


Figure 5 9 Distribution of Average Flow Scenario Arsenic, Cadmium and Zinc Annual Loading (kg)

6 Summary

The predicted water quality for each of the model runs was used to assess the performance of the closure options. Water quality predictions for each of the six model runs were used to assess the performance of Option 1A through comparison to existing water quality in the downstream receiving environment in Victoria Creek and to CCME Guidelines for the Protection of Aquatic Life. These results, while specific to Option 1A, were considered to be representative of current site conditions and were then used as a bench mark from which to assess the performance of the other closure options.

The following summarizes the key findings of the assessment of the six closure options, including sensitivity runs, from the perspective of performance related to predicted water quality in the receiving environment at Victoria Creek.

- For all options, peak concentrations are predicted to occur during the winter low flow period due to ongoing loadings from the site during periods of minimal flow and available dilution. This disproportionate load is emphasized by the assumptions for seepage rate from the tailings and discharge rate from the deep groundwater system, which are assumed to remain constant throughout the year despite varying flows in Victoria Creek.
- Overall, the Best Estimate Average Precipitation model results for Option 1A are comparable to existing water quality conditions in Victoria Creek and can be used to best represent current conditions at the site.
- For the tailings area, Options 1and 2 have less overall uncertainty associated with the water quality predictions in comparison to the other options primarily due to the long-term flow and water quality records for the seepage collection pond. Specifically, the performance of the existing tailings facility with regards to seepage rates and water quality is predicted to provide a defensible proxy for the performance of these options over the long-term.
- Overall, the Best Estimate Average Precipitation model results for Option 2A are comparable to Option 1A and current conditions.
- The Best Estimate Average Precipitation model results for Options 1B and 2B are comparable to Option 1A and current conditions for sulfate and arsenic. For cadmium and zinc, the predicted water quality for Option 1B and 2B indicates an overall improvement compared to current conditions. The predicted reductions in cadmium and zinc concentrations in the receiving environment are due to the reduction in loading from waste rock due to the reduction in the waste rock footprint after backfilling.
- One of the key considerations for the Tailings In Place Options (Options 1A, 1B, 2A and 2B) is whether there is sufficient water supply in the catchment upstream of the tailings area to maintain the tailings in a saturated state, and specifically, if the proposed runoff coefficients are representative of runoff conditions at the site for all locations and conditions. Results of the water balance analysis for both the 0.7 m water cover and the 1 m saturated soil cover indicate that inflows to the tailings area are generally sufficient to maintain the tailings in a saturated state, even during dry conditions.
- One of the key considerations for the Tailings in Place Options (Options 1 and 2) is whether the attenuation process reducing arsenic concentrations will continue in the long-term. An Upper estimate arsenic source term has been provided for seepage from the tailings mass, as represented by closure Option 1 and 2. The Upper Estimate for arsenic is considered a reasonable proxy for tailings seepage

that does not undergo attenuation. Although, the Upper Estimate source term provides for an assessment of the impact of the loss of attenuation along the tailing seepage pathway, these predicted concentrations are not considered to be representative of the anticipate performance of Options 1 and 2.

- The Best Estimate Average Precipitation model results for Option 3 showed a marginal improvement for cadmium and comparable values for zinc in comparison to Option 1A and current conditions. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentration in Victoria Creek compared to current conditions and those predicted for Option 1A. This largely relates to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 3 are significantly higher than those predicted for Option 1A and current conditions. The increase in arsenic largely reflects the higher residual arsenic source loading from the backfilled tailings, which incorporates a 50% reduction of arsenic loading along the groundwater flow path due to attenuation.

- A critical uncertainty associated with Option 3 is related to the feasibility of attaining a desired level (85%) of tailings saturation in the pit. As discussed in the 2010 geotechnical analysis (AECOM 2010b), there is a high level of uncertainty with regards to the feasibility of blending the tailings sufficiently to achieve a desired bulk hydraulic conductivity. The water balance and water quality model for Option 3 assumed that the tailings are well mixed with a uniform hydraulic conductivity. In reality, some degree of incomplete mixing will occur, resulting in spatial heterogeneity in the water holding properties of the tailings.

- Another relevant uncertainty related to Options 3 and 4 is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The loading model for tailings placement in the open pit (Options 3 and 4) incorporates a reduction in arsenic loading of 50% due to attenuation along the groundwater flow path between the pit and Dome Creek and/or Victoria Creek. Another relevant uncertainty related to Option 3 is the potential for the attenuation of contaminants along groundwater flow paths from the pit. The magnitude of the ascribed loading reductions (~50%) is based on experience at other mine operations (unpublished data) which have monitored arsenic removal in groundwater downgradient of tailings facilities. At these sites in northwestern Ontario and British Columbia arsenic loading reductions of greater than 90% have been documented. Therefore the assumption of 50% reduction of arsenic loading in the model is considered to impart considerable conservatism into the model predictions. An increase in the level of attenuation would result in further improvement of the performance of these options with respect to arsenic concentrations in the receiving environment. Conversely, a reduction in the level of assumed attenuation would result in significantly higher predicted concentrations in the downstream receiving environment.

- The Best Estimate Average Precipitation model results for Option 4 are comparable to Option 1A and current conditions with respect to cadmium and zinc. For sulfate, the removal of the tailings from the Dome Creek valley results in a reduction in concentrations compared to current conditions owing to a decrease in the water flux associated with in-pit tailings placement. For arsenic, the predicted concentrations for Option 4 are similar those predicted for Option 1A and current conditions, except for marginally higher concentrations during the winter low flow conditions. The results for Option 4 also demonstrate that despite the assumption that acidic conditions develop within in-pit tailings, such conditions do not have a marked effect on increasing contaminant loadings when compared to Option 3. This can be related to the low water flux through the tailings cover which offsets the higher source term concentrations in the loading calculations.

- For the loading model for Option 4, an infiltration rate of 5% of average annual precipitation was conservatively assumed for the low-infiltration cover (synthetic barrier cover system) to account for cover degradation and the anticipated decrease in performance in the long-term. Results of the dry cover assessment indicate that the typical range of infiltration rates for synthetic barrier cover systems is 1% to 3%. To account for possible reduction in long-term cover performance, a conservative long-term infiltration rate of 5% of average annual precipitation was selected for modeling purposes.

7 References

AECOM (2010a). Development of a Mount Nansen Precipitation, Temperature, and Evaporation Data Record and Pit and Tailings Pond Inflow Volume Estimation. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010b). Geotechnical Assessment and Costing of the Mt. Nansen Mine Closure Alternatives (Draft for Discussion). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010c). Hydrogeological Characterization of the Mt. Nansen Mine Site (Draft for Discussion). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

AECOM (2010d). Mt. Nansen Surface Water Quality Baseline Characterization. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, February 2010.

AECOM (2010e). Mt Nansen Water Quality Model for the Alternatives Assessment. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, February 2010.

Bowell R. J. (1994). Sorption of arsenic by iron oxides and oxyhydroxides in soils. Appl. Geochem. 9, 279-286.

Carey, S.K. and M.K. Woo (2001). Spatial variability of hillslope water balance, Wolf Creek basin, subarctic Yukon. Hydrol. Process. 15, 3113–3132.

Environment Canada (2008). Canadian Water Quality Guideline: Cadmium. Scientific Supporting Document (draft September 2008). Ecosystem Health: Science-based Solutions. National Guidelines and Standards Office, Environment Canada, Ottawa.

Golder (2010a). Assessment of Closure Options and Cover Water Balance for the Mt. Nansen Project, Yukon. Technical Memorandum prepared for Lorax Environmental Services Ltd., October 2010.

Golder (2010b). Conceptual Assessment of Low Infiltration Cover Options for the Mt. Nansen Project, Yukon. Technical Memorandum prepared for Lorax Environmental Services Ltd., October 2010.

Lorax (2010a). Mount Nansen Mine Geochemical Assessment in Support of Evaluation of Closure Plant Options (DRAFT). Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, October 2010.

Lorax (2010b). Mount Nansen Options for Closure. Prepared for Assessment and Abandoned Mines Branch, Department of Energy, Mines and Resources, Government of Yukon, November 2010.

Manning, B. A. and Goldberg, S. (1997). Adsorption and Stability of Arsenic (III) at the Clay Mineral - Water Interface. Environ. Sci. Technol. 31, 2005-2011.

Martin A. J. and Pedersen T. F. (2002). Seasonal and interannual mobility of arsenic in a lake impacted by metal-mining. Env. Sci. Tech. 36, 1516-1523.

Violante A. and Pigna M. (2002). Competitive Sorption of Arsenate and Phosphate on Different Clay Minerals and Soils. Soil Sci. Soc. Am. J. 66 (1788-1796).

Appendix A

Predicted Water Quality Results – Victoria Creek

Table A1 Option 1A Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0035	0.00029	0.0027	0.93	0.600	0.036	66.3	0.36	0.24	0.019	0.039	0.0033	0.182	41.5	10.5	146.6
Feb	0.0055	0.00051	0.0032	1.54	1.003	0.062	105.9	0.67	0.40	0.031	0.073	0.0044	0.254	53.9	12.2	184.9
March	0.0049	0.00045	0.0031	1.37	0.892	0.055	95.0	0.59	0.36	0.027	0.063	0.0041	0.234	50.5	11.7	174.4
April	0.0018	0.00014	0.0023	0.37	0.234	0.021	34.5	0.07	0.10	0.008	0.007	0.0022	0.115	31.2	9.1	115.5
May	0.0015	0.00005	0.0021	0.26	0.159	0.009	25.9	0.02	0.07	0.005	0.001	0.0020	0.103	28.7	8.7	107.5
June	0.0018	0.00006	0.0021	0.28	0.170	0.011	32.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.6	9.1	113.7
July	0.0020	0.00007	0.0021	0.30	0.182	0.012	35.6	0.04	0.08	0.006	0.004	0.0021	0.108	31.5	9.3	116.9
August	0.0019	0.00007	0.0021	0.31	0.189	0.012	33.3	0.05	0.08	0.006	0.004	0.0021	0.109	30.9	9.1	114.6
September	0.0017	0.00007	0.0022	0.32	0.193	0.011	28.7	0.05	0.08	0.007	0.004	0.0021	0.109	29.6	8.8	110.3
October	0.0022	0.00010	0.0022	0.35	0.220	0.016	36.7	0.07	0.09	0.007	0.006	0.0022	0.114	31.9	9.3	117.9
November	0.0021	0.00014	0.0024	0.49	0.313	0.020	38.5	0.14	0.13	0.010	0.014	0.0025	0.130	32.7	9.2	119.7
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0047	0.00042	0.0030	1.29	0.837	0.051	89.5	0.54	0.34	0.026	0.059	0.0039	0.224	48.8	11.5	169.1
Feb	0.0074	0.00073	0.0037	2.16	1.411	0.087	146.0	0.99	0.56	0.043	0.107	0.0055	0.328	66.5	14.0	223.6
March	0.0067	0.00065	0.0035	1.93	1.257	0.078	130.9	0.87	0.50	0.038	0.094	0.0051	0.300	61.7	13.3	209.0
April	0.0021	0.00021	0.0024	0.43	0.285	0.031	43.3	0.11	0.12	0.009	0.011	0.0024	0.123	33.7	9.6	123.6
May	0.0016	0.00006	0.0021	0.28	0.168	0.010	28.0	0.03	0.07	0.006	0.002	0.0021	0.105	29.3	8.8	109.5
June	0.0018	0.00006	0.0022	0.31	0.188	0.011	31.2	0.04	0.08	0.006	0.004	0.0021	0.109	30.3	9.0	112.7
July	0.0023	0.00008	0.0021	0.34	0.204	0.014	40.0	0.06	0.09	0.007	0.006	0.0022	0.112	32.9	9.5	121.3
August	0.0018	0.00008	0.0022	0.36	0.222	0.013	30.9	0.07	0.09	0.007	0.007	0.0022	0.114	30.3	8.9	112.4
September	0.0017	0.00008	0.0022	0.36	0.224	0.013	29.4	0.07	0.10	0.007	0.007	0.0022	0.115	29.9	8.8	111.0
October	0.0019	0.00011	0.0023	0.43	0.269	0.017	34.4	0.10	0.11	0.009	0.011	0.0023	0.122	31.4	9.1	115.8
November	0.0026	0.00018	0.0025	0.63	0.404	0.025	47.3	0.21	0.17	0.013	0.022	0.0027	0.147	35.5	9.6	128.2
December	0.0034	0.00027	0.0027	0.89	0.575	0.035	63.9	0.34	0.23	0.018	0.036	0.0032	0.178	40.7	10.4	144.3

Wet Precipitaiton

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.0	9.7	129.9
Feb	0.0039	0.00033	0.0028	1.06	0.684	0.042	74.6	0.43	0.28	0.021	0.046	0.0035	0.197	44.1	10.8	154.6
March	0.0036	0.00029	0.0027	0.95	0.612	0.037	67.4	0.37	0.25	0.019	0.040	0.0033	0.184	41.8	10.5	147.7
April	0.0016	0.00011	0.0022	0.32	0.200	0.018	30.4	0.05	0.09	0.007	0.004	0.0021	0.109	30.0	8.9	111.6
May	0.0015	0.00005	0.0021	0.25	0.152	0.009	25.6	0.02	0.07	0.005	0.001	0.0020	0.102	28.6	8.7	107.2
June	0.0015	0.00005	0.0021	0.27	0.160	0.009	26.4	0.02	0.07	0.006	0.002	0.0021	0.103	28.9	8.7	108.0
July	0.0019	0.00006	0.0021	0.28	0.166	0.011	33.1	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.5
August	0.0020	0.00008	0.0021	0.28	0.168	0.014	37.8	0.03	0.07	0.006	0.002	0.0021	0.105	32.1	9.4	118.9
September	0.0018	0.00008	0.0021	0.28	0.171	0.014	34.8	0.03	0.07	0.006	0.002	0.0021	0.105	31.2	9.2	115.9
October	0.0016	0.00008	0.0022	0.31	0.192	0.013	28.5	0.04	0.08	0.006	0.004	0.0021	0.108	29.5	8.8	109.9
November	0.0018	0.00010	0.0023	0.39	0.245	0.015	31.6	0.09	0.10	0.008	0.009	0.0023	0.118	30.6	8.9	113.1
December	0.0022	0.00013	0.0023	0.50	0.314	0.018	38.2	0.14	0.13	0.010	0.014	0.0025	0.131	32.7	9.2	119.5

Table A2 Option 1B Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00016	0.0026	0.94	0.885	0.022	61.8	0.36	0.23	0.019	0.037	0.0033	0.183	40.0	10.0	141.4
Feb	0.0059	0.00028	0.0030	1.56	1.546	0.035	97.8	0.68	0.38	0.031	0.070	0.0044	0.256	51.3	11.5	175.3
March	0.0053	0.00025	0.0029	1.39	1.364	0.031	87.9	0.59	0.34	0.028	0.061	0.0041	0.236	48.2	11.1	166.0
April	0.0018	0.00006	0.0022	0.37	0.280	0.010	31.3	0.07	0.09	0.008	0.007	0.0022	0.115	30.4	8.9	112.6
May	0.0015	0.00004	0.0021	0.26	0.169	0.008	25.5	0.02	0.07	0.005	0.001	0.0020	0.103	28.6	8.7	107.1
June	0.0018	0.00005	0.0021	0.28	0.187	0.009	31.5	0.03	0.07	0.006	0.002	0.0021	0.105	30.4	9.0	113.0
July	0.0020	0.00005	0.0021	0.30	0.206	0.009	34.6	0.04	0.08	0.006	0.003	0.0021	0.108	31.3	9.2	115.9
August	0.0019	0.00005	0.0021	0.31	0.219	0.009	32.4	0.05	0.08	0.006	0.004	0.0021	0.109	30.6	9.0	113.7
September	0.0017	0.00005	0.0022	0.32	0.225	0.009	28.0	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.5
October	0.0022	0.00006	0.0022	0.35	0.264	0.010	34.7	0.07	0.09	0.007	0.006	0.0022	0.114	31.4	9.1	115.9
November	0.0022	0.00008	0.0023	0.50	0.415	0.013	36.3	0.14	0.13	0.010	0.014	0.0025	0.130	32.0	9.0	117.2
December	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00023	0.0028	1.30	1.273	0.030	83.0	0.55	0.32	0.026	0.056	0.0039	0.226	46.7	10.9	161.3
Feb	0.0080	0.00039	0.0034	2.19	2.220	0.048	134.5	1.00	0.54	0.044	0.104	0.0055	0.331	62.8	12.9	209.9
March	0.0072	0.00035	0.0032	1.96	1.965	0.043	120.7	0.88	0.48	0.039	0.091	0.0051	0.303	58.5	12.4	196.8
April	0.0021	0.00007	0.0022	0.44	0.352	0.012	37.5	0.11	0.11	0.009	0.011	0.0024	0.124	32.3	9.2	118.5
May	0.0016	0.00004	0.0021	0.28	0.183	0.008	27.4	0.03	0.07	0.006	0.002	0.0021	0.105	29.1	8.8	108.9
June	0.0018	0.00005	0.0021	0.31	0.217	0.009	30.6	0.04	0.08	0.006	0.004	0.0021	0.109	30.1	8.9	112.0
July	0.0023	0.00006	0.0021	0.34	0.243	0.010	38.7	0.06	0.08	0.007	0.005	0.0022	0.112	32.5	9.4	120.0
August	0.0018	0.00006	0.0022	0.36	0.271	0.010	29.8	0.07	0.09	0.007	0.006	0.0022	0.114	30.0	8.8	111.2
September	0.0018	0.00006	0.0022	0.36	0.275	0.010	28.6	0.07	0.09	0.007	0.007	0.0022	0.115	29.6	8.7	110.0
October	0.0020	0.00007	0.0023	0.43	0.346	0.012	32.8	0.10	0.11	0.009	0.010	0.0023	0.123	30.9	8.9	114.0
November	0.0027	0.00011	0.0024	0.64	0.566	0.016	44.5	0.21	0.16	0.013	0.021	0.0027	0.147	34.6	9.4	125.0
December	0.0036	0.00016	0.0026	0.90	0.846	0.021	59.7	0.34	0.22	0.018	0.035	0.0032	0.178	39.4	10.0	139.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7
Feb	0.0042	0.00019	0.0027	1.07	1.023	0.025	69.3	0.43	0.26	0.021	0.044	0.0035	0.198	42.4	10.3	148.4
March	0.0038	0.00017	0.0026	0.96	0.904	0.022	62.9	0.37	0.24	0.019	0.038	0.0033	0.185	40.4	10.1	142.4
April	0.0017	0.00005	0.0022	0.32	0.225	0.009	27.9	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.4
May	0.0015	0.00004	0.0021	0.25	0.158	0.008	25.2	0.02	0.07	0.005	0.001	0.0020	0.102	28.5	8.7	106.9
June	0.0015	0.00004	0.0021	0.27	0.171	0.008	26.1	0.02	0.07	0.006	0.001	0.0021	0.103	28.8	8.7	107.7
July	0.0019	0.00004	0.0021	0.28	0.180	0.009	32.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.6	9.1	113.8
August	0.0020	0.00005	0.0021	0.28	0.182	0.009	36.3	0.03	0.07	0.006	0.002	0.0021	0.105	31.7	9.3	117.5
September	0.0018	0.00005	0.0021	0.28	0.185	0.009	33.1	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.4
October	0.0016	0.00005	0.0022	0.31	0.220	0.009	27.1	0.04	0.08	0.006	0.004	0.0021	0.109	29.1	8.7	108.6
November	0.0019	0.00007	0.0022	0.39	0.308	0.011	30.4	0.09	0.10	0.008	0.008	0.0023	0.118	30.2	8.8	111.7
December	0.0022	0.00008	0.0023	0.50	0.420	0.013	36.6	0.14	0.13	0.010	0.014	0.0025	0.131	32.1	9.1	117.5

Table A3 Option 2A Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0035	0.00029	0.0027	0.93	0.600	0.036	66.3	0.36	0.24	0.019	0.039	0.0033	0.182	41.5	10.5	146.6
Feb	0.0055	0.00051	0.0032	1.54	1.003	0.062	105.9	0.67	0.40	0.031	0.073	0.0044	0.254	53.9	12.2	184.9
March	0.0049	0.00045	0.0031	1.37	0.892	0.055	95.0	0.59	0.36	0.027	0.063	0.0041	0.234	50.5	11.7	174.4
April	0.0018	0.00014	0.0023	0.37	0.234	0.021	34.5	0.07	0.10	0.008	0.007	0.0022	0.115	31.2	9.1	115.5
May	0.0015	0.00005	0.0021	0.26	0.159	0.009	25.9	0.02	0.07	0.005	0.001	0.0020	0.103	28.7	8.7	107.5
June	0.0017	0.00006	0.0021	0.28	0.170	0.011	32.0	0.03	0.07	0.006	0.002	0.0021	0.105	30.5	9.1	113.4
July	0.0018	0.00007	0.0021	0.30	0.182	0.012	35.3	0.04	0.08	0.006	0.004	0.0021	0.108	31.5	9.2	116.6
August	0.0018	0.00007	0.0021	0.31	0.189	0.012	33.0	0.05	0.08	0.006	0.004	0.0021	0.109	30.8	9.1	114.4
September	0.0016	0.00007	0.0022	0.32	0.193	0.011	28.5	0.05	0.08	0.007	0.004	0.0021	0.109	29.6	8.8	110.1
October	0.0019	0.00010	0.0022	0.35	0.219	0.016	36.3	0.07	0.09	0.007	0.006	0.0022	0.114	31.8	9.2	117.4
November	0.0021	0.00014	0.0024	0.49	0.313	0.020	38.5	0.14	0.13	0.010	0.014	0.0025	0.130	32.7	9.2	119.7
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0047	0.00042	0.0030	1.29	0.837	0.051	89.5	0.54	0.34	0.026	0.059	0.0039	0.224	48.8	11.5	169.1
Feb	0.0074	0.00073	0.0037	2.16	1.411	0.087	146.0	0.99	0.56	0.043	0.107	0.0055	0.328	66.5	14.0	223.6
March	0.0067	0.00065	0.0035	1.93	1.257	0.078	130.9	0.87	0.50	0.038	0.094	0.0051	0.300	61.7	13.3	209.0
April	0.0021	0.00021	0.0024	0.43	0.285	0.031	43.3	0.11	0.12	0.009	0.011	0.0024	0.123	33.7	9.6	123.6
May	0.0016	0.00006	0.0021	0.28	0.168	0.010	28.0	0.03	0.07	0.006	0.002	0.0021	0.105	29.3	8.8	109.6
June	0.0017	0.00006	0.0022	0.31	0.188	0.011	30.9	0.04	0.08	0.006	0.004	0.0021	0.108	30.2	9.0	112.4
July	0.0020	0.00008	0.0021	0.33	0.204	0.014	39.1	0.06	0.09	0.007	0.006	0.0022	0.112	32.6	9.4	120.3
August	0.0018	0.00008	0.0022	0.36	0.223	0.013	30.7	0.07	0.09	0.007	0.007	0.0022	0.114	30.3	8.9	112.2
September	0.0017	0.00008	0.0022	0.36	0.224	0.013	29.4	0.07	0.10	0.007	0.007	0.0022	0.115	29.9	8.8	111.0
October	0.0019	0.00011	0.0023	0.43	0.269	0.017	34.4	0.10	0.11	0.009	0.011	0.0023	0.122	31.4	9.1	115.8
November	0.0026	0.00018	0.0025	0.63	0.404	0.025	47.3	0.21	0.17	0.013	0.022	0.0027	0.147	35.5	9.6	128.2
December	0.0034	0.00027	0.0027	0.89	0.575	0.035	63.9	0.34	0.23	0.018	0.036	0.0032	0.178	40.7	10.4	144.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.0	9.7	129.9
Feb	0.0039	0.00033	0.0028	1.06	0.684	0.042	74.6	0.43	0.28	0.021	0.046	0.0035	0.197	44.1	10.8	154.6
March	0.0036	0.00029	0.0027	0.95	0.612	0.037	67.4	0.37	0.25	0.019	0.040	0.0033	0.184	41.8	10.5	147.7
April	0.0016	0.00011	0.0022	0.32	0.200	0.018	30.4	0.05	0.09	0.007	0.004	0.0021	0.109	30.0	8.9	111.6
May	0.0015	0.00005	0.0021	0.25	0.152	0.009	25.6	0.02	0.07	0.005	0.001	0.0020	0.102	28.6	8.7	107.2
June	0.0015	0.00005	0.0021	0.27	0.160	0.009	26.3	0.02	0.07	0.006	0.002	0.0021	0.103	28.8	8.7	108.0
July	0.0017	0.00006	0.0021	0.28	0.166	0.011	32.7	0.03	0.07	0.006	0.002	0.0021	0.105	30.7	9.1	114.1
August	0.0018	0.00008	0.0021	0.28	0.168	0.014	37.7	0.03	0.07	0.006	0.002	0.0021	0.105	32.1	9.4	118.8
September	0.0018	0.00008	0.0021	0.28	0.171	0.014	34.9	0.03	0.07	0.006	0.002	0.0021	0.105	31.2	9.2	116.0
October	0.0016	0.00008	0.0022	0.31	0.193	0.013	28.4	0.04	0.08	0.006	0.004	0.0021	0.109	29.5	8.8	109.9
November	0.0018	0.00010	0.0023	0.39	0.245	0.015	31.6	0.09	0.10	0.008	0.009	0.0023	0.118	30.6	8.9	113.1
December	0.0022	0.00013	0.0023	0.50	0.314	0.018	38.2	0.14	0.13	0.010	0.014	0.0025	0.131	32.7	9.2	119.5

Table A4 Option 2B Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00016	0.0026	0.94	0.885	0.022	61.8	0.36	0.23	0.019	0.037	0.0033	0.183	40.0	10.0	141.4
Feb	0.0059	0.00028	0.0030	1.56	1.546	0.035	97.8	0.68	0.38	0.031	0.070	0.0044	0.256	51.3	11.5	175.3
March	0.0053	0.00025	0.0029	1.39	1.364	0.031	87.9	0.59	0.34	0.028	0.061	0.0041	0.236	48.2	11.1	166.0
April	0.0018	0.00006	0.0022	0.37	0.280	0.010	31.3	0.07	0.09	0.008	0.007	0.0022	0.115	30.4	8.9	112.6
May	0.0015	0.00004	0.0021	0.26	0.169	0.008	25.5	0.02	0.07	0.005	0.001	0.0020	0.103	28.6	8.7	107.2
June	0.0017	0.00005	0.0021	0.28	0.187	0.009	31.3	0.03	0.07	0.006	0.002	0.0021	0.105	30.3	9.0	112.7
July	0.0018	0.00005	0.0021	0.30	0.206	0.009	34.4	0.04	0.08	0.006	0.003	0.0021	0.108	31.2	9.2	115.7
August	0.0018	0.00005	0.0021	0.31	0.219	0.009	32.2	0.05	0.08	0.006	0.004	0.0021	0.109	30.6	9.0	113.6
September	0.0017	0.00005	0.0022	0.32	0.225	0.009	28.0	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.5
October	0.0019	0.00006	0.0022	0.35	0.263	0.010	34.4	0.07	0.09	0.007	0.006	0.0022	0.114	31.3	9.1	115.6
November	0.0022	0.00008	0.0023	0.50	0.415	0.013	36.3	0.14	0.13	0.010	0.014	0.0025	0.130	32.0	9.0	117.2
December	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00023	0.0028	1.30	1.273	0.030	83.0	0.55	0.32	0.026	0.056	0.0039	0.226	46.7	10.9	161.3
Feb	0.0080	0.00039	0.0034	2.19	2.220	0.048	134.5	1.00	0.54	0.044	0.104	0.0055	0.331	62.8	12.9	209.9
March	0.0072	0.00035	0.0032	1.96	1.965	0.043	120.7	0.88	0.48	0.039	0.091	0.0051	0.303	58.5	12.4	196.8
April	0.0021	0.00007	0.0022	0.44	0.352	0.012	37.5	0.11	0.11	0.009	0.011	0.0024	0.124	32.3	9.2	118.5
May	0.0016	0.00004	0.0021	0.28	0.183	0.008	27.4	0.03	0.07	0.006	0.002	0.0021	0.105	29.2	8.8	109.0
June	0.0017	0.00005	0.0021	0.31	0.217	0.009	30.4	0.04	0.08	0.006	0.004	0.0021	0.108	30.1	8.9	111.8
July	0.0020	0.00006	0.0021	0.34	0.243	0.010	38.0	0.06	0.08	0.007	0.005	0.0022	0.112	32.3	9.3	119.1
August	0.0018	0.00006	0.0022	0.36	0.271	0.010	29.8	0.07	0.09	0.007	0.006	0.0022	0.114	30.0	8.8	111.1
September	0.0018	0.00006	0.0022	0.36	0.275	0.010	28.6	0.07	0.09	0.007	0.007	0.0022	0.115	29.6	8.7	110.0
October	0.0020	0.00007	0.0023	0.43	0.346	0.012	32.8	0.10	0.11	0.009	0.010	0.0023	0.123	30.9	8.9	114.0
November	0.0027	0.00011	0.0024	0.64	0.566	0.016	44.5	0.21	0.16	0.013	0.021	0.0027	0.147	34.6	9.4	125.0
December	0.0036	0.00016	0.0026	0.90	0.846	0.021	59.7	0.34	0.22	0.018	0.035	0.0032	0.178	39.4	10.0	139.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0028	0.00012	0.0024	0.67	0.599	0.016	46.3	0.23	0.17	0.013	0.023	0.0028	0.151	35.2	9.4	126.7
Feb	0.0042	0.00019	0.0027	1.07	1.023	0.025	69.3	0.43	0.26	0.021	0.044	0.0035	0.198	42.4	10.3	148.4
March	0.0038	0.00017	0.0026	0.96	0.904	0.022	62.9	0.37	0.24	0.019	0.038	0.0033	0.185	40.4	10.1	142.4
April	0.0017	0.00005	0.0022	0.32	0.225	0.009	27.9	0.05	0.08	0.007	0.004	0.0021	0.109	29.4	8.8	109.4
May	0.0015	0.00004	0.0021	0.25	0.158	0.008	25.3	0.02	0.07	0.005	0.001	0.0020	0.102	28.5	8.7	107.0
June	0.0015	0.00004	0.0021	0.27	0.171	0.008	26.1	0.02	0.07	0.006	0.001	0.0021	0.103	28.8	8.7	107.7
July	0.0017	0.00004	0.0021	0.28	0.180	0.009	32.0	0.03	0.07	0.006	0.002	0.0021	0.105	30.5	9.1	113.4
August	0.0018	0.00005	0.0021	0.28	0.181	0.009	36.2	0.03	0.07	0.006	0.002	0.0021	0.105	31.7	9.3	117.5
September	0.0018	0.00005	0.0021	0.28	0.185	0.009	33.2	0.03	0.07	0.006	0.002	0.0021	0.105	30.8	9.1	114.6
October	0.0016	0.00005	0.0022	0.31	0.220	0.009	27.2	0.04	0.08	0.006	0.004	0.0021	0.109	29.1	8.7	108.7
November	0.0019	0.00007	0.0022	0.39	0.308	0.011	30.4	0.09	0.10	0.008	0.008	0.0023	0.118	30.2	8.8	111.7
December	0.0022	0.00008	0.0023	0.50	0.420	0.013	36.6	0.14	0.13	0.010	0.014	0.0025	0.131	32.1	9.1	117.5

Table A5 Option 3 Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0118	0.00021	0.0023	0.25	0.188	0.033	32.6	0.04	0.07	0.005	0.000	0.0021	0.113	29.3	9.0	110.2
Feb	0.0221	0.00038	0.0025	0.25	0.232	0.059	43.5	0.07	0.08	0.006	0.000	0.0021	0.125	31.1	9.6	117.0
March	0.0192	0.00033	0.0024	0.25	0.219	0.052	40.4	0.07	0.08	0.005	0.000	0.0021	0.122	30.6	9.4	115.1
April	0.0035	0.00010	0.0021	0.23	0.145	0.018	42.8	0.01	0.06	0.005	0.000	0.0020	0.102	33.2	9.7	123.0
May	0.0018	0.00005	0.0021	0.24	0.144	0.009	24.9	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0022	0.00006	0.0021	0.24	0.143	0.011	30.1	0.01	0.06	0.005	0.000	0.0020	0.101	29.8	9.0	111.4
July	0.0025	0.00006	0.0021	0.24	0.143	0.011	32.7	0.01	0.06	0.005	0.000	0.0020	0.101	30.5	9.1	113.7
August	0.0026	0.00006	0.0021	0.24	0.144	0.011	29.9	0.01	0.06	0.005	0.000	0.0020	0.101	29.7	9.0	111.0
September	0.0025	0.00006	0.0021	0.24	0.147	0.011	25.2	0.01	0.06	0.005	0.000	0.0020	0.101	28.3	8.7	106.5
October	0.0032	0.00009	0.0021	0.24	0.149	0.015	30.9	0.01	0.06	0.005	0.000	0.0020	0.102	29.8	9.0	111.7
November	0.0050	0.00011	0.0022	0.24	0.161	0.019	25.9	0.02	0.07	0.005	0.000	0.0020	0.104	28.2	8.7	106.2
December	0.0076	0.00014	0.0022	0.24	0.170	0.023	28.1	0.03	0.07	0.005	0.000	0.0020	0.108	28.5	8.8	107.5

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0177	0.00031	0.0024	0.25	0.213	0.048	38.9	0.06	0.08	0.005	0.000	0.0021	0.120	30.3	9.3	114.1
Feb	0.0337	0.00057	0.0027	0.26	0.281	0.088	55.9	0.11	0.09	0.006	0.000	0.0022	0.140	33.2	10.2	124.7
March	0.0292	0.00050	0.0026	0.25	0.262	0.076	51.0	0.10	0.09	0.006	0.000	0.0021	0.134	32.4	9.9	121.7
April	0.0046	0.00014	0.0020	0.23	0.145	0.024	57.7	0.01	0.06	0.005	0.000	0.0020	0.103	37.3	10.6	136.9
May	0.0020	0.00005	0.0021	0.24	0.144	0.010	26.4	0.01	0.06	0.005	0.000	0.0020	0.101	28.7	8.8	107.8
June	0.0025	0.00006	0.0021	0.24	0.145	0.010	28.2	0.01	0.06	0.005	0.000	0.0020	0.101	29.2	8.9	109.4
July	0.0031	0.00007	0.0021	0.24	0.144	0.013	35.1	0.01	0.06	0.005	0.000	0.0020	0.102	31.1	9.3	115.9
August	0.0031	0.00007	0.0021	0.24	0.150	0.012	25.8	0.01	0.06	0.005	0.000	0.0020	0.102	28.4	8.7	106.9
September	0.0031	0.00007	0.0022	0.24	0.151	0.012	23.5	0.01	0.06	0.005	0.000	0.0020	0.102	27.8	8.6	104.6
October	0.0041	0.00009	0.0022	0.24	0.154	0.016	27.2	0.02	0.07	0.005	0.000	0.0020	0.103	28.7	8.8	107.7
November	0.0071	0.00014	0.0022	0.24	0.169	0.023	27.8	0.03	0.07	0.005	0.000	0.0020	0.107	28.5	8.8	107.3
December	0.0112	0.00020	0.0023	0.24	0.185	0.032	31.9	0.04	0.07	0.005	0.000	0.0021	0.112	29.2	9.0	109.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0076	0.00014	0.0022	0.24	0.170	0.023	28.1	0.03	0.07	0.005	0.000	0.0020	0.108	28.5	8.8	107.5
Feb	0.0138	0.00024	0.0023	0.25	0.197	0.039	34.8	0.05	0.07	0.005	0.000	0.0021	0.115	29.6	9.1	111.6
March	0.0121	0.00021	0.0023	0.25	0.189	0.034	32.9	0.04	0.07	0.005	0.000	0.0021	0.113	29.3	9.0	110.4
April	0.0028	0.00009	0.0021	0.23	0.143	0.015	39.0	0.01	0.06	0.005	0.000	0.0020	0.101	32.2	9.5	119.6
May	0.0016	0.00004	0.0021	0.24	0.143	0.009	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
June	0.0018	0.00005	0.0021	0.24	0.143	0.009	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.8
July	0.0021	0.00006	0.0021	0.24	0.142	0.011	31.1	0.01	0.06	0.005	0.000	0.0020	0.101	30.1	9.0	112.3
August	0.0023	0.00007	0.0021	0.24	0.142	0.013	35.7	0.01	0.06	0.005	0.000	0.0020	0.101	31.3	9.3	116.6
September	0.0022	0.00007	0.0021	0.24	0.144	0.013	32.7	0.01	0.06	0.005	0.000	0.0020	0.101	30.5	9.1	113.7
October	0.0024	0.00007	0.0021	0.24	0.149	0.012	25.0	0.01	0.06	0.005	0.000	0.0020	0.101	28.3	8.7	106.3
November	0.0036	0.00008	0.0022	0.24	0.153	0.014	24.0	0.01	0.07	0.005	0.000	0.0020	0.103	27.8	8.6	104.9
December	0.0051	0.00010	0.0022	0.24	0.159	0.017	25.5	0.02	0.07	0.005	0.000	0.0020	0.105	28.1	8.7	105.8

Table A6 Option 4 Predicted Water Quality in Victoria Creek (mg/L) - Best Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0052	0.00019	0.0026	0.39	0.445	0.033	28.5	0.01	0.07	0.005	0.000	0.0020	0.100	28.7	8.8	107.8
Feb	0.0091	0.00035	0.0031	0.54	0.744	0.058	35.4	0.02	0.07	0.006	0.000	0.0020	0.100	29.9	9.1	112.2
March	0.0080	0.00030	0.0030	0.50	0.659	0.051	33.4	0.01	0.07	0.006	0.000	0.0020	0.100	29.6	9.0	110.9
April	0.0025	0.00006	0.0021	0.26	0.180	0.012	40.3	0.01	0.06	0.005	0.000	0.0020	0.100	32.7	9.6	121.2
May	0.0015	0.00004	0.0021	0.24	0.152	0.009	24.6	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
June	0.0018	0.00005	0.0021	0.25	0.157	0.009	29.5	0.01	0.06	0.005	0.000	0.0020	0.100	29.7	9.0	110.9
July	0.0020	0.00005	0.0021	0.25	0.164	0.010	31.9	0.01	0.06	0.005	0.000	0.0020	0.100	30.3	9.1	113.2
August	0.0019	0.00005	0.0021	0.25	0.170	0.010	29.3	0.01	0.06	0.005	0.000	0.0020	0.100	29.6	8.9	110.6
September	0.0018	0.00005	0.0022	0.25	0.174	0.010	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
October	0.0022	0.00006	0.0022	0.26	0.187	0.012	29.3	0.01	0.06	0.005	0.000	0.0020	0.100	29.5	8.9	110.5
November	0.0027	0.00009	0.0023	0.29	0.250	0.017	23.9	0.01	0.06	0.005	0.000	0.0020	0.100	27.8	8.6	104.9
December	0.0037	0.00013	0.0024	0.33	0.325	0.023	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.2	8.7	106.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0075	0.00028	0.0029	0.48	0.617	0.047	32.5	0.01	0.07	0.005	0.000	0.0020	0.100	29.4	9.0	110.3
Feb	0.0135	0.00052	0.0037	0.71	1.085	0.086	43.3	0.02	0.08	0.006	0.000	0.0020	0.100	31.3	9.5	117.2
March	0.0118	0.00045	0.0034	0.65	0.952	0.075	40.2	0.02	0.07	0.006	0.000	0.0020	0.100	30.8	9.3	115.3
April	0.0031	0.00007	0.0020	0.26	0.191	0.013	53.7	0.01	0.05	0.005	0.000	0.0020	0.100	36.5	10.4	134.0
May	0.0017	0.00005	0.0021	0.25	0.157	0.009	25.9	0.01	0.06	0.005	0.000	0.0020	0.100	28.6	8.7	107.5
June	0.0019	0.00005	0.0021	0.25	0.169	0.010	27.7	0.01	0.06	0.005	0.000	0.0020	0.100	29.1	8.8	109.1
July	0.0022	0.00006	0.0021	0.26	0.177	0.011	34.1	0.01	0.06	0.005	0.000	0.0020	0.100	30.9	9.2	115.2
August	0.0020	0.00006	0.0022	0.26	0.192	0.012	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.3
September	0.0020	0.00006	0.0022	0.27	0.194	0.012	22.8	0.01	0.06	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
October	0.0024	0.00008	0.0022	0.28	0.220	0.014	25.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.8
November	0.0035	0.00012	0.0024	0.32	0.311	0.022	25.4	0.01	0.07	0.005	0.000	0.0020	0.100	28.1	8.6	105.8
December	0.0050	0.00018	0.0026	0.38	0.428	0.031	28.1	0.01	0.07	0.005	0.000	0.0020	0.100	28.6	8.8	107.5

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0037	0.00013	0.0024	0.33	0.324	0.023	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.2	8.7	106.0
Feb	0.0060	0.00022	0.0027	0.42	0.505	0.038	29.9	0.01	0.07	0.005	0.000	0.0020	0.100	28.9	8.9	108.6
March	0.0053	0.00020	0.0026	0.40	0.453	0.033	28.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.7	8.8	107.9
April	0.0022	0.00005	0.0021	0.25	0.163	0.010	37.1	0.01	0.06	0.005	0.000	0.0020	0.100	31.8	9.4	118.2
May	0.0015	0.00004	0.0021	0.24	0.148	0.008	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0016	0.00004	0.0021	0.24	0.153	0.009	25.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
July	0.0018	0.00005	0.0021	0.24	0.154	0.009	30.4	0.01	0.06	0.005	0.000	0.0020	0.100	29.9	9.0	111.8
August	0.0019	0.00005	0.0021	0.24	0.153	0.009	34.4	0.01	0.06	0.005	0.000	0.0020	0.100	31.1	9.3	115.7
September	0.0018	0.00005	0.0021	0.25	0.156	0.009	31.3	0.01	0.06	0.005	0.000	0.0020	0.100	30.2	9.1	112.7
October	0.0018	0.00005	0.0022	0.25	0.172	0.010	24.0	0.01	0.06	0.005	0.000	0.0020	0.100	28.1	8.6	105.5
November	0.0022	0.00007	0.0022	0.27	0.207	0.013	22.9	0.01	0.06	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
December	0.0027	0.00009	0.0023	0.29	0.252	0.017	24.0	0.01	0.06	0.005	0.000	0.0020	0.100	27.9	8.6	104.9

Table A7 Summary of Predicted Concentrations (mg/L) in Victoria Creek - Best Case Source Terms

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Dry Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0016	0.0022	0.0032	0.0074	2	0.0016	0.0022	0.0033	0.0080	2	0.0016	0.0020	0.0031	0.0074	2	0.0016	0.0021	0.0033	0.0080	2	0.0020	0.0043	0.0101	0.0337	5	0.0017	0.0028	0.0047	0.0135	4
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00006	0.00015	0.00025	0.00073	3	0.00004	0.00007	0.00014	0.00039	0	0.00006	0.00015	0.00025	0.00073	3	0.00004	0.00007	0.00014	0.00039	0	0.00005	0.00011	0.00019	0.00057	3	0.00005	0.00007	0.00017	0.00052	3
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0023	0.0026	0.0037	6	0.0021	0.0022	0.0025	0.0034	6	0.0021	0.0023	0.0026	0.0037	6	0.0021	0.0022	0.0025	0.0034	7	0.0020	0.0022	0.0022	0.0027	9	0.0020	0.0022	0.0025	0.0037	11
Iron	0.3	0.044	0.25	0.3	0.28	0.43	0.78	2.16	11	0.28	0.43	0.79	2.19	11	0.28	0.43	0.78	2.16	11	0.28	0.43	0.79	2.19	11	0.23	0.24	0.24	0.26	0	0.25	0.27	0.36	0.71	5
Manganese		0.0025	0.0396	0.0401	0.17	0.28	0.50	1.41		0.18	0.35	0.73	2.22		0.17	0.28	0.50	1.41		0.18	0.35	0.73	2.22		0.14	0.15	0.18	0.28		0.16	0.21	0.59	1.08	
Zinc	0.03	0.0005	0.009	0.02	0.010	0.021	0.032	0.087	5	0.008	0.012	0.019	0.048	2	0.010	0.021	0.032	0.087	5	0.008	0.012	0.019	0.048	2	0.010	0.019	0.030	0.068	4	0.009	0.014	0.029	0.086	4
Sulphate		6.23	29.6	60.9	27.99	41.62	59.57	145.97		27.37	38.08	55.64	134.52		28.01	41.18	59.45	145.97		27.44	37.71	55.56	134.52		23.50	30.06	35.79	57.70		22.80	27.90	32.04	53.75	
Ammonia-N	0.832	0.005	0.005	0.01	0.03	0.11	0.29	0.99	2	0.03	0.11	0.29	1.00	2	0.03	0.11	0.29	0.99	2	0.03	0.11	0.29	1.00	2	0.01	0.02	0.04	0.11	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.072	0.116	0.204	0.561	0	0.071	0.110	0.196	0.535	0	0.072	0.116	0.205	0.561	0	0.071	0.110	0.196	0.535	0	0.057	0.065	0.069	0.091	0	0.052	0.064	0.065	0.076	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.009	0.016	0.043	0	0.006	0.009	0.016	0.044	0	0.006	0.009	0.016	0.043	0	0.006	0.009	0.016	0.044	0	0.005	0.005	0.005	0.006	0	0.005	0.005	0.005	0.006	0
Cyanide-T				0	0.002	0.011	0.030	0.107		0.002	0.010	0.029	0.104		0.002	0.011	0.030	0.107		0.002	0.010	0.029	0.104		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.003	0.005		0.002	0.002	0.003	0.006		0.002	0.002	0.003	0.005		0.002	0.002	0.003	0.006		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.105	0.123	0.165	0.328		0.105	0.123	0.166	0.331		0.105	0.123	0.165	0.328		0.105	0.123	0.165	0.331		0.101	0.103	0.111	0.140		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	29.3	33.3	39.3	66.5		29.1	32.4	38.1	62.8		29.3	33.2	39.2	66.5		29.2	32.3	38.0	62.8		27.8	29.2	30.4	37.3		27.7	28.9	29.8	36.5	
Magnesium		2	8.75	16	8.8	9.5	10.2	14.0		8.7	9.3	9.9	12.9		8.8	9.5	10.2	14.0		8.7	9.3	9.9	12.9		8.6	8.9	9.2	10.6		8.5	8.8	9.0	10.4	
Hardness		26.7	103	182	109.5	122.5	140.0	223.6		108.9	119.3	135.6	209.9		109.6	121.9	139.9	223.6		109.0	118.8	135.5	209.9		104.6	109.6	113.9	138.9		104.2	108.3	111.6	134.0	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Average Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0015	0.0020	0.0026	0.0055	2	0.0015	0.0021	0.0027	0.0059	2	0.0015	0.0019	0.0026	0.0055	1	0.0015	0.0019	0.0027	0.0059	2	0.0018	0.0034	0.0070	0.0221	5	0.0015	0.0023	0.0035	0.0091	3
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00005	0.00012	0.00018	0.00051	3	0.00004	0.00006	0.00010	0.00028	0	0.00005	0.00012	0.00018	0.00051	2	0.00004	0.00006	0.00010	0.00028	0	0.00005	0.00009	0.00014	0.00038	2	0.00004	0.00006	0.00012	0.00035	2
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0022	0.0024	0.0032	6	0.0021	0.0022	0.0023	0.0030	8	0.0021	0.0022	0.0024	0.0032	9	0.0021	0.0022	0.0023	0.0030	8	0.0021	0.0021	0.0022	0.0025	11	0.0021	0.0022	0.0024	0.0031	11
Iron	0.3	0.044	0.25	0.3	0.26	0.36	0.60	1.54	11	0.26	0.36	0.60	1.56	10	0.26	0.36	0.60	1.54	9	0.26	0.36	0.60	1.56	10	0.23	0.24	0.24	0.25	0	0.24	0.26	0.32	0.54	4
Manganese		0.0025	0.0396	0.0401	0.16	0.23	0.38	1.00		0.17	0.27	0.53	1.55		0.16	0.23	0.38	1.00		0.17	0.27	0.53	1.55		0.14	0.15	0.17	0.23		0.15	0.18	0.30	0.74	
Zinc	0.03	0.0005	0.009	0.02	0.009	0.018	0.024	0.062	5	0.008	0.010	0.015	0.035	2	0.009	0.018	0.024	0.062	3	0.008	0.010	0.015	0.035	2	0.009	0.017	0.023	0.059	3	0.009	0.012	0.021	0.058	3
Sulphate		6.23	29.6	60.9	25.86	36.17	48.47	105.87		25.48	34.65	45.67	97.82		25.87	35.81	48.36	105.87		25.52	34.41	45.60	97.82		24.86	30.53	32.26	43.51		23.94	29.29	29.71	40.35	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.07	0.19	0.67	2	0.02	0.07	0.19	0.68	0	0.02	0.07	0.19	0.67	0	0.02	0.07	0.19	0.68	0	0.01	0.01	0.03	0.07	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.069	0.096	0.156	0.400	0	0.069	0.091	0.150	0.382	0	0.069	0.096	0.156	0.400	0	0.069	0.091	0.150	0.382	0	0.060	0.063	0.067	0.081	0	0.057	0.063	0.064	0.072	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.007	0.012	0.031	0	0.005	0.005	0.005	0.006	0	0.005	0.005	0.005	0.006	0
Cyanide-T				0	0.001	0.007	0.020	0.073		0.001	0.007	0.019	0.070		0.001	0.007	0.020	0.073		0.001	0.007	0.019	0.070		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.003	0.004		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.103	0.114	0.143	0.254		0.103	0.115	0.143	0.256		0.103	0.114	0.143	0.254		0.103	0.115	0.143	0.256		0.100	0.102	0.107	0.125		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.7	31.7	35.8	53.9		28.6	31.3	34.9	51.3		28.7	31.6	35.7	53.9		28.6	31.3	34.9	51.3		28.2	29.7	29.8	33.2		27.8	29.5	29.4	32.7	
Magnesium		2	8.75	16	8.7	9.2	9.7	12.2		8.7	9.1	9.5	11.5		8.7	9.2	9.7	12.2		8.7	9.1	9.5	11.5		8.7	9.0	9.1	9.7		8.6	8.9	8.9	9.6	
Hardness		26.7	103	182	107.5	117.4	129.3	184.9		107.1	115.9	126.2	175.3		107.5	117.0	129.2	184.9		107.2	115.7	126.1	175.3		106.2	111.2	111.6	123.0		104.9	110.6	110.0	121.2	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Best Estimate Source Terms and Wet Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0015	0.0018	0.0022	0.0039	0	0.0015	0.0019	0.0022	0.0042	0	0.0015	0.0018	0.0021	0.0039	0	0.0015	0.0018	0.0022	0.0042	0	0.0016	0.0026	0.0048	0.0138	4	0.0015	0.0020	0.0027	0.0060	2
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00005	0.00009	0.00013	0.00033	0	0.00004	0.00005	0.00008	0.00019	0	0.00005	0.00009	0.00013	0.00033	0	0.00004	0.00005	0.00008	0.00019	0	0.00004	0.00008	0.00010	0.00024	0	0.00004	0.00005	0.00009	0.00022	0
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0021	0.0022	0.0023	0.0028	9	0.0021	0.0022	0.0022	0.0027	9	0.0021	0.0022	0.0023	0.0028	9	0.0021	0.0022	0.0022	0.0027	9	0.0021	0.0021	0.0022	0.0023	12	0.0021	0.0021	0.0022	0.0027	12
Iron	0.3	0.044	0.25	0.3	0.25	0.31	0.46	1.06	7	0.25	0.31	0.46	1.07	7	0.25	0.31	0.46	1.06	7	0.25	0.31	0.46	1.07	7	0.23	0.24	0.24	0.25	0	0.24	0.25	0.29	0.42	3
Manganese		0.0025	0.0396	0.0401	0.15	0.20	0.29	0.68		0.16	0.22	0.38	1.02		0.15	0.20	0.29	0.68		0.16	0.22	0.38	1.02		0.14	0.15	0.16	0.20		0.15	0.17	0.24	0.50	
Zinc	0.03	0.0005	0.009	0.02	0.009	0.014	0.019	0.042	2	0.008	0.009	0.012	0.025	0	0.009	0.014	0.019	0.042	2	0.008	0.009	0.012	0.025	0	0.009	0.013	0.017	0.039	2	0.008	0.010	0.016	0.038	2
Sulphate		6.23	29.6	60.9	25.55	33.97	39.79	74.55		25.24	32.70	37.80	69.35		25.59	33.81	39.74	74.55		25.30	32.60	37.78	69.35		23.97	29.61	29.91	39.05		22.95	27.16	28.17	37.14	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.02	0.05	0.12	0.43	0	0.01	0.01	0.02	0.05	0	0.01	0.01	0.01	0.01	0
Nitrate-N	2.9	0.005	0.1	0.24	0.066	0.084	0.121	0.275	0	0.066	0.081	0.117	0.263	0	0.066	0.084	0.121	0.275	0	0.066	0.081	0.117	0.263	0	0.060	0.064	0.065	0.074	0	0.058	0.063	0.063	0.068	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.005	0.007	0.009	0.021	0	0.005	0.006	0.009	0.021	0	0.005	0.007	0.009	0.021	0	0.005	0.006	0.009	0.021	0	0.005	0.005	0.005	0.005	0	0.005	0.005	0.005	0.005	0
Cyanide-T				0	0.001	0.004	0.012	0.046		0.001	0.004	0.012	0.044		0.001	0.004	0.012	0.046		0.001	0.004	0.012	0.044		0.000	0.000	0.000	0.000		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.004		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.004		0.002	0.002	0.002	0.002		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.102	0.109	0.126	0.197		0.102	0.109	0.127	0.198		0.102	0.109	0.126	0.197		0.102	0.109	0.127	0.198		0.100	0.101	0.104	0.115		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.6	31.0	33.0	44.1		28.5	30.7	32.4	42.4		28.6	31.0	33.0	44.1		28.5	30.7	32.4	42.4		27.8	28.9	29.4	32.2		27.7	28.5	29.1	31.8	
Magnesium		2	8.75	16	8.7	9.2	9.3	10.8		8.7	9.1	9.2	10.3		8.7	9.2	9.3	10.8		8.7	9.1	9.2	10.3		8.6	8.9	8.9	9.5		8.5	8.7	8.8	9.4	
Hardness		26.7	103	182	107.2	115.2	120.9	154.6		106.9	114.1	118.8	148.4		107.2	115.1	120.9	154.6		107.0	114.0	118.7	148.4		104.9	108.9	110.2	119.6		104.2	107.3	109.0	118.2	

Notes:

a. At Hardness = 150 mg/L as $CaCO_3$ - hardness dependent

b. 0.002 mg/L at hardness of 0 - 120 mg/L as $CaCO_3$, 0.003 mg/L at hardness of 120 - 180 mg/L as $CaCO_3$, and 0.004 mg/L at hardness of > 180 mg/L as $CaCO_3$

c. Existing water quality data set for Victoria Creek at Road (2007 to 2010)

d. Maximum of available winter water quality data (2007 to 2010) collected in November, December, January and February.

Table A8 Option 1A Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0180	0.00101	0.0040	2.43	0.844	0.171	112.8	0.67	0.66	0.040	0.028	0.0101	1.085	29.6	9.0	111.0
Feb	0.0328	0.00187	0.0056	4.37	1.464	0.316	193.5	1.25	1.19	0.071	0.052	0.0173	1.955	31.5	9.5	117.8
March	0.0288	0.00163	0.0052	3.84	1.294	0.276	171.4	1.09	1.04	0.062	0.045	0.0154	1.717	31.0	9.3	115.9
April	0.0045	0.00051	0.0028	0.65	0.317	0.092	45.4	0.13	0.19	0.012	0.005	0.0035	0.283	29.0	8.8	108.8
May	0.0020	0.00009	0.0022	0.32	0.171	0.018	27.7	0.03	0.09	0.006	0.001	0.0023	0.136	28.3	8.7	106.2
June	0.0028	0.00015	0.0023	0.38	0.193	0.028	35.7	0.05	0.10	0.007	0.002	0.0025	0.164	29.8	9.0	111.4
July	0.0033	0.00019	0.0023	0.44	0.212	0.034	40.4	0.07	0.12	0.008	0.003	0.0028	0.191	30.4	9.1	113.6
August	0.0034	0.00018	0.0023	0.47	0.220	0.032	38.5	0.08	0.13	0.009	0.003	0.0029	0.205	29.6	9.0	110.8
September	0.0033	0.00015	0.0023	0.48	0.221	0.027	33.9	0.08	0.13	0.009	0.003	0.0029	0.210	28.3	8.7	106.3
October	0.0046	0.00034	0.0026	0.60	0.278	0.060	45.6	0.12	0.17	0.011	0.005	0.0034	0.265	29.9	9.0	111.9
November	0.0075	0.00047	0.0029	1.05	0.412	0.082	56.2	0.25	0.29	0.018	0.010	0.0050	0.462	28.3	8.7	106.6
December	0.0116	0.00063	0.0033	1.59	0.575	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.706	28.8	8.8	108.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0267	0.00151	0.0049	3.57	1.209	0.256	160.2	1.01	0.97	0.058	0.042	0.0144	1.596	30.7	9.3	115.0
Feb	0.0478	0.00274	0.0073	6.33	2.092	0.462	275.2	1.85	1.72	0.102	0.076	0.0246	2.836	33.5	9.9	124.6
March	0.0421	0.00241	0.0066	5.60	1.855	0.407	244.4	1.62	1.52	0.090	0.067	0.0219	2.504	32.8	9.8	122.0
April	0.0063	0.00087	0.0033	0.86	0.427	0.158	60.8	0.20	0.26	0.016	0.008	0.0043	0.381	30.3	9.1	113.2
May	0.0024	0.00013	0.0022	0.36	0.187	0.024	30.9	0.04	0.10	0.007	0.002	0.0025	0.155	28.6	8.7	107.5
June	0.0033	0.00015	0.0023	0.46	0.214	0.026	36.1	0.08	0.12	0.009	0.003	0.0028	0.201	29.1	8.8	109.1
July	0.0044	0.00024	0.0024	0.55	0.248	0.043	47.1	0.10	0.15	0.010	0.004	0.0032	0.241	31.2	9.3	116.2
August	0.0043	0.00023	0.0025	0.62	0.268	0.040	39.2	0.12	0.17	0.011	0.005	0.0034	0.272	28.3	8.7	106.2
September	0.0043	0.00021	0.0025	0.63	0.268	0.037	37.7	0.13	0.17	0.011	0.005	0.0034	0.275	27.8	8.6	104.7
October	0.0059	0.00035	0.0027	0.84	0.343	0.062	47.6	0.19	0.23	0.015	0.008	0.0042	0.370	28.2	8.7	106.0
November	0.0109	0.00062	0.0032	1.49	0.547	0.106	74.0	0.39	0.41	0.025	0.016	0.0066	0.662	28.7	8.8	107.8
December	0.0172	0.00096	0.0039	2.32	0.807	0.163	108.0	0.63	0.63	0.038	0.026	0.0097	1.033	29.5	9.0	110.6

Wet Precipitaiton

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0116	0.00063	0.0033	1.59	0.574	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.705	28.8	8.8	108.0
Feb	0.0211	0.00119	0.0043	2.84	0.974	0.201	129.7	0.79	0.77	0.046	0.033	0.0116	1.267	30.0	9.1	112.4
March	0.0185	0.00103	0.0040	2.49	0.863	0.176	115.2	0.69	0.68	0.041	0.028	0.0103	1.111	29.7	9.0	111.2
April	0.0033	0.00039	0.0026	0.49	0.258	0.071	37.5	0.08	0.14	0.009	0.003	0.0029	0.211	28.6	8.8	107.5
May	0.0018	0.00008	0.0022	0.29	0.160	0.015	26.7	0.02	0.08	0.006	0.001	0.0022	0.121	28.3	8.7	106.4
June	0.0021	0.00009	0.0022	0.33	0.171	0.016	28.3	0.03	0.09	0.006	0.001	0.0023	0.139	28.4	8.7	106.6
July	0.0027	0.00015	0.0022	0.36	0.188	0.029	36.2	0.04	0.10	0.007	0.002	0.0025	0.155	30.1	9.1	112.5
August	0.0029	0.00025	0.0023	0.37	0.202	0.046	41.8	0.05	0.10	0.007	0.002	0.0025	0.160	31.3	9.3	116.6
September	0.0028	0.00027	0.0024	0.37	0.208	0.049	39.1	0.05	0.11	0.008	0.002	0.0025	0.162	30.4	9.1	113.6
October	0.0031	0.00023	0.0024	0.47	0.230	0.042	34.1	0.08	0.13	0.009	0.003	0.0028	0.203	28.2	8.7	106.2
November	0.0050	0.00027	0.0026	0.73	0.302	0.048	42.1	0.15	0.20	0.013	0.006	0.0038	0.319	27.9	8.6	105.1
December	0.0076	0.00040	0.0028	1.06	0.406	0.069	55.7	0.26	0.29	0.018	0.010	0.0050	0.469	28.2	8.7	106.2

Table A9 Option 1B Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0204	0.00057	0.0033	2.45	1.103	0.094	103.5	0.67	0.62	0.039	0.028	0.0102	1.089	28.0	8.5	104.9
Feb	0.0375	0.00104	0.0044	4.42	1.959	0.172	176.6	1.27	1.11	0.069	0.052	0.0175	1.970	28.5	8.5	106.4
March	0.0328	0.00091	0.0041	3.88	1.724	0.151	156.6	1.10	0.97	0.061	0.046	0.0155	1.729	28.4	8.5	106.0
April	0.0049	0.00014	0.0023	0.65	0.320	0.024	39.0	0.13	0.17	0.011	0.005	0.0035	0.284	28.2	8.6	105.9
May	0.0021	0.00006	0.0022	0.32	0.176	0.011	27.0	0.03	0.08	0.006	0.001	0.0023	0.136	28.1	8.6	105.8
June	0.0029	0.00007	0.0021	0.38	0.201	0.013	34.2	0.05	0.10	0.007	0.002	0.0025	0.164	29.6	8.9	110.6
July	0.0035	0.00009	0.0022	0.44	0.226	0.016	38.4	0.07	0.11	0.008	0.003	0.0028	0.191	30.2	9.1	112.6
August	0.0037	0.00009	0.0022	0.47	0.242	0.017	36.8	0.08	0.12	0.009	0.003	0.0029	0.205	29.4	8.9	109.9
September	0.0036	0.00010	0.0022	0.48	0.249	0.017	32.7	0.08	0.12	0.009	0.003	0.0029	0.210	28.1	8.6	105.5
October	0.0050	0.00013	0.0023	0.61	0.300	0.022	41.7	0.12	0.15	0.011	0.005	0.0034	0.265	29.4	8.9	109.9
November	0.0083	0.00023	0.0026	1.05	0.495	0.039	51.5	0.25	0.27	0.017	0.010	0.0050	0.463	27.6	8.5	103.9
December	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.9	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0304	0.00084	0.0040	3.60	1.605	0.140	146.4	1.02	0.90	0.056	0.042	0.0145	1.606	28.3	8.5	105.8
Feb	0.0548	0.00152	0.0055	6.42	2.831	0.251	251.2	1.87	1.61	0.100	0.077	0.0249	2.870	29.1	8.6	107.9
March	0.0483	0.00134	0.0051	5.66	2.502	0.221	223.1	1.64	1.42	0.088	0.068	0.0221	2.530	28.9	8.6	107.3
April	0.0069	0.00019	0.0024	0.87	0.415	0.032	49.4	0.20	0.22	0.015	0.008	0.0043	0.383	28.9	8.8	108.1
May	0.0026	0.00007	0.0022	0.36	0.195	0.013	29.7	0.05	0.09	0.007	0.002	0.0025	0.156	28.5	8.7	106.8
June	0.0035	0.00009	0.0022	0.46	0.239	0.017	34.9	0.08	0.12	0.008	0.003	0.0028	0.202	28.9	8.8	108.3
July	0.0047	0.00011	0.0022	0.55	0.275	0.020	44.6	0.10	0.14	0.010	0.004	0.0032	0.242	30.8	9.2	114.8
August	0.0047	0.00013	0.0023	0.62	0.309	0.023	37.0	0.12	0.16	0.011	0.005	0.0034	0.272	27.9	8.6	104.9
September	0.0047	0.00013	0.0023	0.63	0.313	0.023	36.0	0.13	0.16	0.011	0.005	0.0034	0.275	27.5	8.5	103.6
October	0.0066	0.00018	0.0025	0.84	0.405	0.031	44.2	0.19	0.21	0.014	0.008	0.0042	0.370	27.7	8.5	104.0
November	0.0122	0.00034	0.0028	1.50	0.690	0.057	68.2	0.39	0.38	0.024	0.016	0.0067	0.664	27.7	8.5	104.2
December	0.0194	0.00054	0.0033	2.33	1.053	0.090	99.2	0.64	0.59	0.037	0.026	0.0097	1.037	28.0	8.5	104.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.8	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3
Feb	0.0240	0.00066	0.0036	2.86	1.282	0.111	118.8	0.80	0.72	0.045	0.033	0.0117	1.273	28.1	8.5	105.2
March	0.0209	0.00058	0.0034	2.51	1.129	0.097	105.7	0.69	0.63	0.040	0.028	0.0104	1.115	28.0	8.5	105.0
April	0.0035	0.00010	0.0022	0.49	0.250	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.211	28.0	8.6	105.4
May	0.0019	0.00005	0.0021	0.29	0.162	0.010	26.1	0.02	0.07	0.006	0.001	0.0022	0.121	28.2	8.6	106.1
June	0.0022	0.00006	0.0022	0.33	0.180	0.011	27.7	0.03	0.08	0.006	0.001	0.0023	0.139	28.3	8.7	106.3
July	0.0028	0.00007	0.0021	0.36	0.192	0.013	34.6	0.04	0.09	0.007	0.002	0.0025	0.155	29.9	9.0	111.7
August	0.0030	0.00007	0.0021	0.37	0.195	0.013	38.8	0.05	0.09	0.007	0.002	0.0025	0.161	31.0	9.2	115.3
September	0.0029	0.00007	0.0021	0.38	0.199	0.013	35.8	0.05	0.09	0.007	0.002	0.0025	0.163	30.0	9.0	112.1
October	0.0034	0.00009	0.0022	0.47	0.243	0.017	31.5	0.08	0.12	0.009	0.003	0.0029	0.203	27.9	8.6	104.8
November	0.0056	0.00015	0.0024	0.73	0.356	0.027	39.7	0.16	0.19	0.012	0.006	0.0038	0.319	27.5	8.5	103.7
December	0.0085	0.00023	0.0026	1.06	0.502	0.040	52.1	0.26	0.27	0.018	0.010	0.0051	0.470	27.6	8.5	103.9

Table A10 Option 2A Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0180	0.00101	0.0040	2.43	0.844	0.171	112.8	0.67	0.66	0.040	0.028	0.0101	1.085	29.6	9.0	111.0
Feb	0.0328	0.00187	0.0056	4.37	1.464	0.316	193.5	1.25	1.19	0.071	0.052	0.0173	1.955	31.5	9.5	117.8
March	0.0288	0.00163	0.0052	3.84	1.294	0.276	171.4	1.09	1.04	0.062	0.045	0.0154	1.717	31.0	9.3	115.9
April	0.0045	0.00051	0.0028	0.65	0.317	0.092	45.4	0.13	0.19	0.012	0.005	0.0035	0.283	29.0	8.8	108.8
May	0.0020	0.00009	0.0022	0.32	0.171	0.018	27.7	0.03	0.09	0.006	0.001	0.0023	0.136	28.3	8.7	106.2
June	0.0026	0.00015	0.0023	0.38	0.193	0.028	35.4	0.05	0.10	0.007	0.002	0.0025	0.163	29.7	9.0	111.1
July	0.0032	0.00019	0.0023	0.44	0.212	0.034	40.1	0.07	0.12	0.008	0.003	0.0028	0.191	30.4	9.1	113.3
August	0.0033	0.00018	0.0023	0.47	0.220	0.032	38.3	0.08	0.13	0.009	0.003	0.0029	0.205	29.6	8.9	110.6
September	0.0033	0.00015	0.0023	0.48	0.221	0.027	33.8	0.08	0.13	0.009	0.003	0.0029	0.210	28.2	8.7	106.1
October	0.0043	0.00034	0.0026	0.60	0.278	0.060	45.1	0.12	0.17	0.011	0.005	0.0034	0.265	29.8	9.0	111.4
November	0.0075	0.00047	0.0029	1.05	0.412	0.082	56.2	0.25	0.29	0.018	0.010	0.0050	0.462	28.3	8.7	106.6
December	0.0027	0.00019	0.0025	0.66	0.424	0.025	49.0	0.22	0.17	0.013	0.024	0.0028	0.150	36.1	9.7	129.9

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0267	0.00151	0.0049	3.57	1.209	0.256	160.2	1.01	0.97	0.058	0.042	0.0144	1.596	30.7	9.3	115.0
Feb	0.0478	0.00274	0.0073	6.33	2.092	0.462	275.2	1.85	1.72	0.102	0.076	0.0246	2.836	33.5	9.9	124.6
March	0.0421	0.00241	0.0066	5.60	1.855	0.407	244.4	1.62	1.52	0.090	0.067	0.0219	2.504	32.8	9.8	122.0
April	0.0063	0.00087	0.0033	0.86	0.427	0.158	60.8	0.20	0.26	0.016	0.008	0.0043	0.381	30.3	9.1	113.2
May	0.0024	0.00013	0.0023	0.36	0.187	0.024	30.9	0.04	0.10	0.007	0.002	0.0025	0.156	28.7	8.7	107.5
June	0.0032	0.00015	0.0023	0.46	0.214	0.026	35.8	0.08	0.12	0.009	0.003	0.0028	0.201	29.0	8.8	108.8
July	0.0041	0.00024	0.0024	0.55	0.247	0.043	46.3	0.10	0.15	0.010	0.004	0.0032	0.241	30.9	9.2	115.1
August	0.0043	0.00023	0.0025	0.62	0.268	0.040	39.0	0.12	0.17	0.011	0.005	0.0034	0.272	28.2	8.6	106.0
September	0.0043	0.00021	0.0025	0.63	0.268	0.037	37.7	0.13	0.17	0.011	0.005	0.0034	0.275	27.8	8.6	104.7
October	0.0059	0.00035	0.0027	0.84	0.343	0.062	47.6	0.19	0.23	0.015	0.008	0.0042	0.370	28.2	8.7	106.0
November	0.0109	0.00062	0.0032	1.49	0.547	0.106	74.0	0.39	0.41	0.025	0.016	0.0066	0.662	28.7	8.8	107.8
December	0.0172	0.00096	0.0039	2.32	0.807	0.163	108.0	0.63	0.63	0.038	0.026	0.0097	1.033	29.5	9.0	110.6

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0116	0.00063	0.0033	1.59	0.574	0.108	77.6	0.41	0.43	0.026	0.017	0.0070	0.705	28.8	8.8	108.0
Feb	0.0211	0.00119	0.0043	2.84	0.974	0.201	129.7	0.79	0.77	0.046	0.033	0.0116	1.267	30.0	9.1	112.4
March	0.0185	0.00103	0.0040	2.49	0.863	0.176	115.2	0.69	0.68	0.041	0.028	0.0103	1.111	29.7	9.0	111.2
April	0.0033	0.00039	0.0026	0.49	0.258	0.071	37.5	0.08	0.14	0.009	0.003	0.0029	0.211	28.6	8.8	107.5
May	0.0018	0.00008	0.0022	0.29	0.160	0.015	26.8	0.02	0.08	0.006	0.001	0.0022	0.121	28.3	8.7	106.5
June	0.0021	0.00009	0.0022	0.33	0.171	0.016	28.3	0.03	0.09	0.006	0.001	0.0023	0.139	28.4	8.7	106.5
July	0.0025	0.00015	0.0022	0.36	0.187	0.029	35.8	0.04	0.10	0.007	0.002	0.0025	0.155	30.0	9.0	112.1
August	0.0027	0.00025	0.0023	0.37	0.202	0.046	41.7	0.05	0.10	0.007	0.002	0.0025	0.160	31.3	9.3	116.5
September	0.0027	0.00027	0.0024	0.38	0.208	0.049	39.1	0.05	0.11	0.008	0.002	0.0025	0.162	30.5	9.1	113.7
October	0.0031	0.00023	0.0024	0.47	0.230	0.042	34.0	0.08	0.13	0.009	0.003	0.0028	0.203	28.2	8.7	106.1
November	0.0050	0.00027	0.0026	0.73	0.302	0.048	42.1	0.15	0.20	0.013	0.006	0.0038	0.319	27.9	8.6	105.1
December	0.0076	0.00040	0.0028	1.06	0.406	0.069	55.7	0.26	0.29	0.018	0.010	0.0050	0.469	28.2	8.7	106.2

Table A11 Option 2B Predicted Water Quality in Victoria Creek (mg/L) - Worst Case Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0204	0.00057	0.0033	2.45	1.103	0.094	103.5	0.67	0.62	0.039	0.028	0.0102	1.089	28.0	8.5	104.9
Feb	0.0375	0.00104	0.0044	4.42	1.959	0.172	176.6	1.27	1.11	0.069	0.052	0.0175	1.970	28.5	8.5	106.4
March	0.0328	0.00091	0.0041	3.88	1.724	0.151	156.6	1.10	0.97	0.061	0.046	0.0155	1.729	28.4	8.5	106.0
April	0.0049	0.00014	0.0023	0.65	0.320	0.024	39.0	0.13	0.17	0.011	0.005	0.0035	0.284	28.2	8.6	105.9
May	0.0021	0.00006	0.0022	0.32	0.176	0.011	27.0	0.03	0.08	0.006	0.001	0.0023	0.136	28.2	8.6	105.9
June	0.0028	0.00007	0.0021	0.38	0.201	0.013	33.9	0.05	0.10	0.007	0.002	0.0025	0.164	29.5	8.9	110.3
July	0.0034	0.00009	0.0022	0.44	0.226	0.016	38.2	0.07	0.11	0.008	0.003	0.0028	0.191	30.1	9.0	112.4
August	0.0036	0.00009	0.0022	0.47	0.242	0.017	36.7	0.08	0.12	0.009	0.003	0.0029	0.205	29.3	8.9	109.7
September	0.0035	0.00010	0.0022	0.48	0.249	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.210	28.0	8.6	105.4
October	0.0047	0.00013	0.0023	0.61	0.300	0.022	41.4	0.12	0.15	0.011	0.005	0.0034	0.265	29.3	8.9	109.6
November	0.0083	0.00023	0.0026	1.05	0.495	0.039	51.5	0.25	0.27	0.017	0.010	0.0050	0.463	27.6	8.5	103.9
December	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.9	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0304	0.00084	0.0040	3.60	1.605	0.140	146.4	1.02	0.90	0.056	0.042	0.0145	1.606	28.3	8.5	105.8
Feb	0.0548	0.00152	0.0055	6.42	2.831	0.251	251.2	1.87	1.61	0.100	0.077	0.0249	2.870	29.1	8.6	107.9
March	0.0483	0.00134	0.0051	5.66	2.502	0.221	223.1	1.64	1.42	0.088	0.068	0.0221	2.530	28.9	8.6	107.3
April	0.0069	0.00019	0.0024	0.87	0.415	0.032	49.4	0.20	0.22	0.015	0.008	0.0043	0.383	28.9	8.8	108.1
May	0.0025	0.00007	0.0022	0.36	0.195	0.013	29.8	0.05	0.09	0.007	0.002	0.0025	0.156	28.5	8.7	107.0
June	0.0034	0.00009	0.0022	0.46	0.239	0.017	34.7	0.08	0.12	0.008	0.003	0.0028	0.202	28.8	8.8	108.1
July	0.0044	0.00011	0.0022	0.55	0.274	0.020	43.9	0.10	0.14	0.010	0.004	0.0032	0.241	30.6	9.1	113.9
August	0.0047	0.00013	0.0023	0.62	0.309	0.023	37.0	0.12	0.16	0.011	0.005	0.0034	0.272	27.9	8.6	104.8
September	0.0047	0.00013	0.0023	0.63	0.313	0.023	36.0	0.13	0.16	0.011	0.005	0.0034	0.275	27.5	8.5	103.6
October	0.0066	0.00018	0.0025	0.84	0.405	0.031	44.2	0.19	0.21	0.014	0.008	0.0042	0.370	27.7	8.5	104.0
November	0.0122	0.00034	0.0028	1.50	0.690	0.057	68.2	0.39	0.38	0.024	0.016	0.0067	0.664	27.7	8.5	104.2
December	0.0194	0.00054	0.0033	2.33	1.053	0.090	99.2	0.64	0.59	0.037	0.026	0.0097	1.037	28.0	8.5	104.8

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0131	0.00036	0.0029	1.60	0.733	0.061	71.8	0.42	0.40	0.026	0.017	0.0070	0.707	27.8	8.5	104.3
Feb	0.0240	0.00066	0.0036	2.86	1.282	0.111	118.8	0.80	0.72	0.045	0.033	0.0117	1.273	28.1	8.5	105.2
March	0.0209	0.00058	0.0034	2.51	1.129	0.097	105.7	0.69	0.63	0.040	0.028	0.0104	1.115	28.0	8.5	105.0
April	0.0035	0.00010	0.0022	0.49	0.250	0.017	32.6	0.08	0.12	0.009	0.003	0.0029	0.211	28.0	8.6	105.4
May	0.0018	0.00005	0.0021	0.29	0.162	0.010	26.2	0.02	0.07	0.006	0.001	0.0022	0.121	28.3	8.6	106.2
June	0.0022	0.00006	0.0022	0.33	0.180	0.011	27.7	0.03	0.08	0.006	0.001	0.0023	0.139	28.3	8.7	106.2
July	0.0026	0.00007	0.0021	0.36	0.192	0.013	34.3	0.04	0.09	0.007	0.002	0.0025	0.155	29.8	9.0	111.4
August	0.0029	0.00007	0.0021	0.37	0.195	0.013	38.7	0.05	0.09	0.007	0.002	0.0025	0.161	31.0	9.2	115.2
September	0.0028	0.00007	0.0021	0.38	0.199	0.013	35.9	0.05	0.09	0.007	0.002	0.0025	0.163	30.1	9.0	112.3
October	0.0034	0.00009	0.0022	0.47	0.243	0.017	31.5	0.08	0.12	0.009	0.003	0.0029	0.203	27.9	8.6	104.9
November	0.0056	0.00015	0.0024	0.73	0.356	0.027	39.7	0.16	0.19	0.012	0.006	0.0038	0.319	27.5	8.5	103.7
December	0.0085	0.00023	0.0026	1.06	0.502	0.040	52.1	0.26	0.27	0.018	0.010	0.0051	0.470	27.6	8.5	103.9

Table A12 Option 3 Predicted Water Quality in Victoria Creek (mg/L) - Upper Estimate Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0182	0.00091	0.0031	0.27	0.349	0.170	39.7	0.04	0.11	0.007	0.002	0.0024	0.113	29.9	9.0	111.7
Feb	0.0349	0.00178	0.0041	0.30	0.553	0.330	57.6	0.08	0.15	0.009	0.004	0.0029	0.125	32.4	9.5	120.1
March	0.0302	0.00153	0.0038	0.29	0.495	0.284	52.5	0.07	0.14	0.008	0.003	0.0027	0.122	31.7	9.4	117.7
April	0.0045	0.00040	0.0024	0.24	0.199	0.074	45.6	0.01	0.08	0.006	0.000	0.0021	0.102	33.3	9.7	123.1
May	0.0020	0.00009	0.0022	0.24	0.152	0.017	25.3	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.5
June	0.0026	0.00014	0.0022	0.24	0.158	0.026	30.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.8	9.0	111.5
July	0.0031	0.00017	0.0022	0.24	0.164	0.032	33.7	0.01	0.07	0.005	0.000	0.0020	0.101	30.5	9.1	113.8
August	0.0033	0.00016	0.0022	0.24	0.165	0.030	30.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.7	9.0	111.2
September	0.0032	0.00014	0.0022	0.24	0.164	0.026	26.0	0.01	0.07	0.005	0.000	0.0020	0.101	28.4	8.7	106.7
October	0.0042	0.00029	0.0024	0.24	0.190	0.055	32.9	0.01	0.07	0.006	0.000	0.0021	0.102	29.9	9.0	111.9
November	0.0073	0.00041	0.0026	0.25	0.226	0.077	28.9	0.02	0.08	0.006	0.001	0.0022	0.104	28.4	8.7	106.7
December	0.0115	0.00057	0.0027	0.26	0.267	0.105	32.4	0.03	0.09	0.006	0.001	0.0023	0.108	28.9	8.8	108.4

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0278	0.00141	0.0037	0.29	0.466	0.262	50.0	0.06	0.13	0.008	0.003	0.0027	0.120	31.4	9.3	116.5
Feb	0.0538	0.00276	0.0053	0.34	0.782	0.510	77.9	0.11	0.20	0.011	0.006	0.0033	0.140	35.2	10.1	129.5
March	0.0464	0.00238	0.0048	0.33	0.693	0.440	70.0	0.10	0.18	0.010	0.005	0.0032	0.134	34.1	9.9	125.8
April	0.0060	0.00061	0.0026	0.23	0.230	0.115	62.2	0.01	0.08	0.006	0.000	0.0021	0.103	37.4	10.6	137.1
May	0.0024	0.00012	0.0022	0.24	0.157	0.022	27.1	0.01	0.07	0.005	0.000	0.0020	0.101	28.8	8.8	107.9
June	0.0031	0.00013	0.0022	0.24	0.161	0.025	28.9	0.01	0.07	0.005	0.000	0.0020	0.101	29.3	8.9	109.5
July	0.0040	0.00021	0.0022	0.24	0.173	0.040	36.5	0.01	0.07	0.005	0.000	0.0021	0.102	31.2	9.3	116.1
August	0.0042	0.00020	0.0023	0.24	0.178	0.037	27.1	0.01	0.07	0.005	0.000	0.0021	0.102	28.5	8.7	107.1
September	0.0042	0.00019	0.0023	0.24	0.178	0.035	24.7	0.01	0.07	0.005	0.000	0.0021	0.102	27.9	8.6	104.9
October	0.0058	0.00031	0.0024	0.25	0.202	0.057	29.3	0.02	0.08	0.006	0.001	0.0021	0.103	28.8	8.8	108.1
November	0.0108	0.00055	0.0027	0.26	0.262	0.102	32.0	0.03	0.09	0.006	0.001	0.0022	0.107	28.8	8.8	108.1
December	0.0173	0.00087	0.0031	0.27	0.338	0.161	38.6	0.04	0.11	0.007	0.002	0.0024	0.112	29.8	9.0	111.3

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0115	0.00057	0.0027	0.26	0.267	0.105	32.4	0.03	0.09	0.006	0.001	0.0023	0.108	28.9	8.8	108.4
Feb	0.0216	0.00109	0.0033	0.28	0.390	0.202	43.3	0.05	0.12	0.007	0.002	0.0025	0.115	30.4	9.1	113.4
March	0.0187	0.00094	0.0032	0.27	0.355	0.174	40.2	0.04	0.11	0.007	0.002	0.0024	0.113	30.0	9.0	112.0
April	0.0034	0.00031	0.0023	0.24	0.183	0.058	41.2	0.01	0.07	0.006	0.000	0.0020	0.101	32.3	9.5	119.7
May	0.0018	0.00007	0.0021	0.24	0.149	0.015	25.3	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
June	0.0021	0.00008	0.0022	0.24	0.150	0.015	25.5	0.01	0.06	0.005	0.000	0.0020	0.100	28.5	8.7	106.8
July	0.0025	0.00014	0.0022	0.24	0.157	0.026	31.9	0.01	0.07	0.005	0.000	0.0020	0.101	30.1	9.0	112.4
August	0.0027	0.00022	0.0022	0.24	0.168	0.041	37.1	0.01	0.07	0.005	0.000	0.0020	0.101	31.4	9.3	116.7
September	0.0026	0.00023	0.0023	0.24	0.172	0.044	34.2	0.01	0.07	0.005	0.000	0.0020	0.101	30.5	9.1	113.8
October	0.0031	0.00020	0.0023	0.24	0.175	0.039	26.4	0.01	0.07	0.005	0.000	0.0020	0.101	28.3	8.7	106.4
November	0.0049	0.00024	0.0024	0.25	0.190	0.045	25.6	0.01	0.07	0.005	0.000	0.0021	0.103	28.0	8.6	105.2
December	0.0074	0.00035	0.0025	0.25	0.218	0.066	28.0	0.02	0.08	0.006	0.001	0.0022	0.105	28.3	8.7	106.3

Table A13 Option 4 Predicted Water Quality in Victoria Creek (mg/L) - Upper Source Terms

Average Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0074	0.00076	0.0033	0.40	0.571	0.138	32.7	0.01	0.08	0.006	0.000	0.0020	0.100	28.6	8.8	107.8
Feb	0.0135	0.00147	0.0044	0.55	0.994	0.268	43.8	0.02	0.10	0.008	0.000	0.0020	0.100	29.9	9.2	112.3
March	0.0117	0.00127	0.0041	0.51	0.874	0.231	40.6	0.02	0.09	0.007	0.000	0.0020	0.100	29.5	9.1	111.0
April	0.0028	0.00015	0.0022	0.26	0.200	0.028	41.0	0.01	0.06	0.005	0.000	0.0020	0.100	32.7	9.6	121.2
May	0.0016	0.00006	0.0021	0.24	0.156	0.012	24.7	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
June	0.0019	0.00008	0.0021	0.25	0.165	0.016	29.8	0.01	0.06	0.005	0.000	0.0020	0.100	29.7	9.0	110.9
July	0.0022	0.00010	0.0021	0.25	0.175	0.019	32.3	0.01	0.06	0.005	0.000	0.0020	0.100	30.3	9.1	113.2
August	0.0022	0.00011	0.0022	0.25	0.182	0.021	29.7	0.01	0.06	0.005	0.000	0.0020	0.100	29.6	8.9	110.6
September	0.0020	0.00011	0.0022	0.26	0.187	0.021	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.2
October	0.0025	0.00015	0.0023	0.26	0.207	0.028	30.0	0.01	0.06	0.005	0.000	0.0020	0.100	29.5	8.9	110.5
November	0.0035	0.00029	0.0025	0.30	0.294	0.054	25.4	0.01	0.07	0.005	0.000	0.0020	0.100	27.8	8.6	104.9
December	0.0050	0.00047	0.0028	0.33	0.400	0.086	28.2	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	106.0

Dry Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0109	0.00117	0.0039	0.49	0.814	0.213	39.1	0.02	0.09	0.007	0.000	0.0020	0.100	29.3	9.0	110.4
Feb	0.0203	0.00228	0.0057	0.73	1.477	0.415	56.4	0.02	0.12	0.009	0.000	0.0020	0.100	31.3	9.6	117.4
March	0.0176	0.00197	0.0052	0.66	1.288	0.358	51.5	0.02	0.11	0.009	0.000	0.0020	0.100	30.7	9.4	115.4
April	0.0036	0.00020	0.0021	0.26	0.219	0.037	54.7	0.01	0.06	0.005	0.000	0.0020	0.100	36.5	10.4	134.0
May	0.0018	0.00008	0.0022	0.25	0.164	0.015	26.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.6	8.7	107.5
June	0.0021	0.00011	0.0022	0.25	0.181	0.020	28.1	0.01	0.06	0.005	0.000	0.0020	0.100	29.1	8.8	109.1
July	0.0025	0.00013	0.0022	0.26	0.194	0.025	34.7	0.01	0.06	0.005	0.000	0.0020	0.100	30.9	9.2	115.2
August	0.0024	0.00016	0.0023	0.26	0.212	0.029	25.7	0.01	0.07	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
September	0.0024	0.00016	0.0023	0.27	0.215	0.030	23.5	0.01	0.07	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
October	0.0030	0.00022	0.0024	0.28	0.252	0.041	26.8	0.01	0.07	0.005	0.000	0.0020	0.100	28.4	8.7	106.9
November	0.0047	0.00044	0.0028	0.33	0.381	0.080	27.7	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	105.8
December	0.0071	0.00072	0.0032	0.39	0.547	0.131	32.0	0.01	0.08	0.006	0.000	0.0020	0.100	28.6	8.8	107.6

Wet Precipitation

Month	Arsenic	Cadmium	Copper	Iron	Manganese	Zinc	Sulfate	Ammonia-N	Nitrate-N	Nitrite-N	T-Cyanide	WAD-Cyanide	Cyanate	Calcium	Magnesium	Hardness
Jan	0.0050	0.00047	0.0028	0.33	0.400	0.086	28.2	0.01	0.07	0.006	0.000	0.0020	0.100	28.1	8.7	106.0
Feb	0.0086	0.00090	0.0035	0.43	0.655	0.164	34.9	0.01	0.08	0.007	0.000	0.0020	0.100	28.9	8.9	108.7
March	0.0076	0.00078	0.0033	0.40	0.583	0.142	33.0	0.01	0.08	0.006	0.000	0.0020	0.100	28.7	8.8	107.9
April	0.0024	0.00011	0.0021	0.25	0.176	0.020	37.5	0.01	0.06	0.005	0.000	0.0020	0.100	31.8	9.4	118.2
May	0.0015	0.00005	0.0021	0.24	0.150	0.010	24.8	0.01	0.06	0.005	0.000	0.0020	0.100	28.3	8.7	106.4
June	0.0017	0.00006	0.0021	0.24	0.157	0.013	25.2	0.01	0.06	0.005	0.000	0.0020	0.100	28.4	8.7	106.6
July	0.0019	0.00008	0.0021	0.24	0.161	0.015	30.6	0.01	0.06	0.005	0.000	0.0020	0.100	29.9	9.0	111.8
August	0.0021	0.00008	0.0021	0.24	0.161	0.015	34.6	0.01	0.06	0.005	0.000	0.0020	0.100	31.1	9.3	115.7
September	0.0020	0.00008	0.0021	0.25	0.163	0.016	31.6	0.01	0.06	0.005	0.000	0.0020	0.100	30.2	9.1	112.7
October	0.0020	0.00011	0.0022	0.25	0.184	0.021	24.4	0.01	0.06	0.005	0.000	0.0020	0.100	28.0	8.6	105.5
November	0.0026	0.00019	0.0024	0.27	0.234	0.035	23.8	0.01	0.07	0.005	0.000	0.0020	0.100	27.7	8.5	104.2
December	0.0035	0.00030	0.0025	0.30	0.297	0.055	25.5	0.01	0.07	0.006	0.000	0.0020	0.100	27.8	8.6	104.9

Table A14 Summary of Predicted Concentrations (mg/L) in Victoria Creek - Upper Estimate Source Terms

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Dry Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0024	0.0061	0.0146	0.0478	7	0.0026	0.0066	0.0166	0.0548	7	0.0024	0.0059	0.0146	0.0478	7	0.0025	0.0066	0.0165	0.0548	7	0.0024	0.0059	0.0155	0.0538	7	0.0018	0.0033	0.0065	0.0203	4
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00013	0.00049	0.00087	0.00274	7	0.00007	0.00018	0.00046	0.00152	5	0.00013	0.00035	0.00087	0.00274	7	0.00007	0.00018	0.00046	0.00152	5	0.00012	0.00043	0.00081	0.00276	7	0.00008	0.00021	0.00064	0.00228	5
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0030	0.0036	0.0073	12	0.0022	0.0024	0.0031	0.0055	12	0.0023	0.0027	0.0036	0.0073	12	0.0022	0.0024	0.0031	0.0055	12	0.0022	0.0025	0.0030	0.0053	11	0.0021	0.0024	0.0030	0.0057	11
Iron	0.3	0.044	0.25	0.3	0.36	0.85	1.97	6.33	12	0.36	0.84	1.99	6.42	12	0.36	0.84	1.97	6.33	12	0.36	0.84	1.99	6.42	12	0.23	0.25	0.26	0.34	2	0.25	0.27	0.37	0.73	5
Manganese		0.0025	0.0396	0.0401	0.19	0.38	0.71	2.09		0.20	0.41	0.90	2.83		0.19	0.34	0.71	2.09		0.20	0.41	0.90	2.83		0.16	0.22	0.32	0.78		0.16	0.24	0.50	1.48	
Zinc	0.03	0.0005	0.009	0.02	0.024	0.084	0.149	0.462	10	0.013	0.031	0.076	0.251	7	0.024	0.062	0.149	0.462	10	0.013	0.031	0.079	0.251	7	0.022	0.080	0.151	0.510	10	0.015	0.039	0.116	0.415	7
Sulphate		6.23	29.6	60.9	30.91	54.17	96.76	275.21		29.71	44.64	88.66	251.23		30.92	47.56	96.65	275.21		29.78	44.18	88.59	251.23		24.70	34.22	42.01	77.86		23.51	30.09	35.54	56.44	
Ammonia-N	0.832	0.005	0.005	0.01	0.04	0.19	0.53	1.85	3	0.05	0.19	0.54	1.87	3	0.04	0.19	0.53	1.85	3	0.05	0.19	0.54	1.87	3	0.01	0.02	0.04	0.11	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.098	0.246	0.537	1.722	0	0.093	0.214	0.500	1.610	0	0.098	0.230	0.537	1.722	0	0.093	0.214	0.500	1.610	0	0.066	0.079	0.101	0.202	0	0.055	0.067	0.076	0.119	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.007	0.015	0.033	0.102	2	0.007	0.014	0.032	0.100	2	0.007	0.015	0.033	0.102	2	0.007	0.014	0.032	0.100	2	0.005	0.006	0.007	0.011	0	0.005	0.005	0.006	0.009	0
Cyanide-T				0	0.002	0.008	0.022	0.076		0.002	0.008	0.022	0.077		0.002	0.008	0.022	0.076		0.002	0.008	0.022	0.077		0.000	0.000	0.002	0.006		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.004	0.008	0.025		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.155	0.375	0.877	2.836		0.156	0.370	0.884	2.870		0.156	0.370	0.877	2.836		0.156	0.370	0.884	2.870		0.101	0.103	0.111	0.140		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	27.8	29.3	29.9	33.5		27.5	28.5	28.5	30.8		27.8	29.0	29.9	33.5		27.5	28.5	28.5	30.6		27.9	29.5	30.9	37.4		27.7	28.9	29.8	36.5	
Magnesium		2	8.75	16	8.6	8.9	9.1	9.9		8.5	8.6	8.6	9.2		8.6	8.8	9.0	9.9		8.5	8.6	8.6	9.1		8.6	8.9	9.2	10.6		8.5	8.8	9.1	10.4	
Hardness		26.7	103	182	104.7	109.8	111.9	124.6		103.6	106.8	106.7	114.8		104.7	108.8	111.8	124.6		103.6	107.0	106.6	113.9		104.9	110.4	115.2	137.1		104.2	108.3	111.7	134.0	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Average Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0020	0.0046	0.0102	0.0328	5	0.0021	0.0049	0.0115	0.0375	5	0.0020	0.0043	0.0102	0.0328	5	0.0021	0.0047	0.0114	0.0375	5	0.0020	0.0044	0.0104	0.0349	5	0.0016	0.0027	0.0047	0.0135	3
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00009	0.00040	0.00060	0.00187	7	0.00006	0.00013	0.00031	0.00104	4	0.00009	0.00034	0.00060	0.00187	7	0.00006	0.00013	0.00031	0.00104	4	0.00009	0.00034	0.00055	0.00178	7	0.00006	0.00015	0.00042	0.00147	5
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0027	0.0031	0.0056	12	0.0021	0.0023	0.0027	0.0044	12	0.0022	0.0026	0.0031	0.0056	12	0.0021	0.0023	0.0027	0.0044	12	0.0022	0.0024	0.0027	0.0041	11	0.0021	0.0022	0.0027	0.0044	11
Iron	0.3	0.044	0.25	0.3	0.32	0.63	1.39	4.37	12	0.32	0.61	1.39	4.42	12	0.32	0.60	1.39	4.37	12	0.32	0.61	1.39	4.42	12	0.24	0.24	0.25	0.30	1	0.24	0.26	0.32	0.55	4
Manganese		0.0025	0.0396	0.0401	0.17	0.30	0.52	1.46		0.18	0.30	0.64	1.96		0.17	0.28	0.52	1.46		0.18	0.30	0.64	1.96		0.15	0.19	0.26	0.55		0.16	0.20	0.37	0.99	
Zinc	0.03	0.0005	0.009	0.02	0.018	0.071	0.104	0.316	9	0.011	0.022	0.053	0.172	5	0.018	0.060	0.104	0.316	9	0.011	0.022	0.053	0.172	5	0.017	0.065	0.102	0.330	9	0.012	0.028	0.077	0.268	5
Sulphate		6.23	29.6	60.9	27.72	45.49	73.22	193.48		26.98	39.04	67.49	176.63		27.73	45.12	73.11	193.48		27.03	39.04	67.42	176.63		25.25	32.68	38.37	57.59		24.71	29.88	31.94	43.79	
Ammonia-N	0.832	0.005	0.005	0.01	0.03	0.12	0.35	1.25	2	0.03	0.12	0.36	1.27	2	0.03	0.12	0.35	1.25	2	0.03	0.12	0.36	1.27	2	0.01	0.01	0.03	0.08	0	0.01	0.01	0.01	0.02	0
Nitrate-N	2.9	0.005	0.1	0.24	0.085	0.179	0.377	1.188	0	0.082	0.153	0.351	1.108	0	0.085	0.168	0.377	1.188	0	0.082	0.153	0.351	1.108	0	0.065	0.075	0.088	0.152	0	0.059	0.064	0.071	0.099	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.012	0.023	0.071	2	0.006	0.011	0.023	0.069	2	0.006	0.011	0.023	0.071	2	0.006	0.011	0.023	0.069	2	0.005	0.006	0.006	0.009	0	0.005	0.005	0.006	0.008	0
Cyanide-T				0	0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.001	0.005	0.014	0.052		0.000	0.000	0.001	0.004		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.003	0.006	0.017		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.136	0.274	0.615	1.955	0.1	0.136	0.265	0.618	1.970		0.136	0.265	0.615	1.955		0.136	0.265	0.618	1.970		0.100	0.102	0.107	0.125		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	28.3	29.6	29.5	31.5		27.6	28.4	28.6	30.2		28.2	29.6	29.5	31.5		27.6	28.4	28.6	30.1		28.3	29.9	30.1	33.3		27.8	29.5	29.4	32.7	
Magnesium		2	8.75	16	8.7	9.0	9.0	9.5		8.5	8.6	8.7	9.1		8.7	9.0	9.0	9.5		8.5	8.6	8.7	9.0		8.7	9.0	9.0	9.7		8.6	8.9	8.9	9.6	
Hardness		26.7	103	182	106.2	110.9	110.7	117.8		103.9	106.0	107.1	112.6		106.1	111.0	110.6	117.8		103.9	106.0	107.1	112.4		106.5	111.6	112.4	123.1		104.9	110.6	110.1	121.2	

Summary of Predicted Concentrations (mg/L) in Victoria Creek for the Upper Estimate Source Terms and Wet Precipitation Scenario

		Existing Water Quality[c]			Option 1a					Option 1b					Option 2a					Option 2b					Option 3					Option 4				
	CCME Guideline	Minimum	Median	Maximum[d]	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances	Minimum	Median	Mean	Maximum	Exceedances
Arsenic	0.005	0.001	0.0016	0.0075	0.0018	0.0032	0.0069	0.0211	5	0.0019	0.0034	0.0076	0.0240	5	0.0018	0.0031	0.0068	0.0211	5	0.0018	0.0033	0.0078	0.0240	5	0.0018	0.0033	0.0069	0.0216	4	0.0015	0.0022	0.0034	0.0086	2
Cadmium	0.00034[a]	0.000005	0.00003	0.0003	0.00008	0.00027	0.00042	0.00119	6	0.00005	0.00009	0.00021	0.00066	3	0.00008	0.00027	0.00042	0.00119	6	0.00005	0.00009	0.00021	0.00066	3	0.00007	0.00024	0.00037	0.00109	5	0.00005	0.00011	0.00027	0.00090	4
Copper	0.002 - 0.004[b]	0.0005	0.002	0.003	0.0022	0.0025	0.0028	0.0043	12	0.0021	0.0022	0.0025	0.0036	12	0.0022	0.0024	0.0028	0.0043	12	0.0021	0.0022	0.0025	0.0036	12	0.0021	0.0023	0.0025	0.0033	12	0.0021	0.0022	0.0025	0.0035	12
Iron	0.3	0.044	0.25	0.3	0.29	0.48	0.95	2.84	11	0.29	0.47	0.95	2.86	11	0.29	0.47	0.95	2.84	11	0.29	0.47	0.95	2.86	11	0.24	0.24	0.25	0.28	0	0.24	0.25	0.29	0.43	3
Manganese		0.0025	0.0396	0.0401	0.16	0.24	0.38	0.97		0.16	0.24	0.45	1.28		0.16	0.23	0.38	0.97		0.16	0.24	0.45	1.28		0.15	0.18	0.21	0.39		0.15	0.18	0.28	0.66	
Zinc	0.03	0.0005	0.009	0.02	0.015	0.049	0.073	0.201	9	0.010	0.017	0.036	0.111	4	0.015	0.048	0.073	0.201	9	0.010	0.017	0.036	0.111	4	0.015	0.045	0.069	0.202	9	0.010	0.020	0.049	0.164	5
Sulphate		6.23	29.6	60.9	26.74	40.46	55.33	129.66		26.14	35.76	51.27	118.77		26.77	39.12	55.28	129.66		26.20	35.86	51.25	118.77		25.26	32.13	32.58	43.25		23.84	29.42	29.51	37.54	
Ammonia-N	0.832	0.005	0.005	0.01	0.02	0.08	0.22	0.79	0	0.02	0.08	0.22	0.80	0	0.02	0.08	0.22	0.79	0	0.02	0.08	0.22	0.80	0	0.01	0.01	0.02	0.06	0	0.01	0.01	0.01	0.01	0
Nitrate-N	2.9	0.005	0.1	0.24	0.076	0.137	0.259	0.771	0	0.074	0.120	0.241	0.718	0	0.076	0.130	0.259	0.771	0	0.074	0.120	0.241	0.718	0	0.064	0.072	0.079	0.117	0	0.059	0.064	0.067	0.085	0
Nitrite-N	0.06	0.0025	0.005	0.05	0.006	0.009	0.016	0.046	0	0.006	0.009	0.016	0.045	0	0.006	0.009	0.016	0.046	0	0.006	0.009	0.016	0.045	0	0.005	0.005	0.006	0.007	0	0.005	0.005	0.005	0.007	0
Cyanide-T				0	0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.001	0.003	0.009	0.033		0.000	0.000	0.001	0.002		0.000	0.000	0.000	0.000	
CN_WAD		0.002	0.002	0.002	0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.003	0.005	0.012		0.002	0.002	0.002	0.003		0.002	0.002	0.002	0.002	
Cyanate		0.2	0.1	0.1	0.121	0.207	0.419	1.267		0.121	0.203	0.420	1.273		0.121	0.203	0.419	1.267		0.121	0.203	0.420	1.273		0.100	0.101	0.104	0.115		0.100	0.100	0.100	0.100	
Calcium		7.4	27.3	47.3	27.9	28.7	29.2	31.3		27.5	28.1	28.5	31.0		27.9	28.8	29.2	31.3		27.5	28.1	28.5	31.0		28.0	29.5	29.6	32.3		27.7	28.5	29.1	31.8	
Magnesium		2	8.75	16	8.6	8.8	8.9	9.3		8.5	8.6	8.7	9.2		8.6	8.8	8.9	9.3		8.5	8.6	8.7	9.2		8.6	8.9	8.9	9.5		8.5	8.8	8.9	9.4	
Hardness		26.7	103	182	105.1	107.8	109.4	116.6		103.7	105.4	107.0	115.3		105.1	108.0	109.3	116.5		103.7	105.4	107.0	115.2		105.2	110.2	110.6	119.7		104.2	107.3	109.1	118.2	

Notes:

a. At Hardness = 150 mg/L as $CaCO_3$ - hardness dependent

b. 0.002 mg/L at hardness of 0 - 120 mg/L as $CaCO_3$, 0.003 mg/L at hardness of 120 - 180 mg/L as $CaCO_3$, and 0.004 mg/L at hardness of > 180 mg/L as $CaCO_3$

c. Existing water quality data set for Victoria Creek at Road (2007 to 2010)

d. Maximum of available winter water quality data (2007 to 2010) collected in November, December, January and February.