Mt. Nansen Mine

Geochemical Assessment in Support of Evaluating Closure Plan Options

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1. Introduction

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).

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 stakeholders 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) of GY is implementing a process to evaluate and develop a closure plan for the Mt. Nansen site. EMR 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

EMR 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;
- Option 1B – same as option 1A with waste rock relocation into the open pit, covering the pit lake;
- Option 2A – Tailings dam upgrade with saturated soil cover, waste rock in place, open pit lake;
- Option 2B – same as option 2A with waste rock relocation into the open pit, covering the pit lake;
- Option 3 – tailings backfill into open pit (covering the pit lake) with high infiltration cover, waste rock in place, Dome Creek reclaimed;

- Option 4 – tailings and waste rock backfill into pit (covering pit lake) with low infiltration cover, Dome Creek reclaimed.

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.

2. Geochemical Characterization Tests and Study Methodology

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.

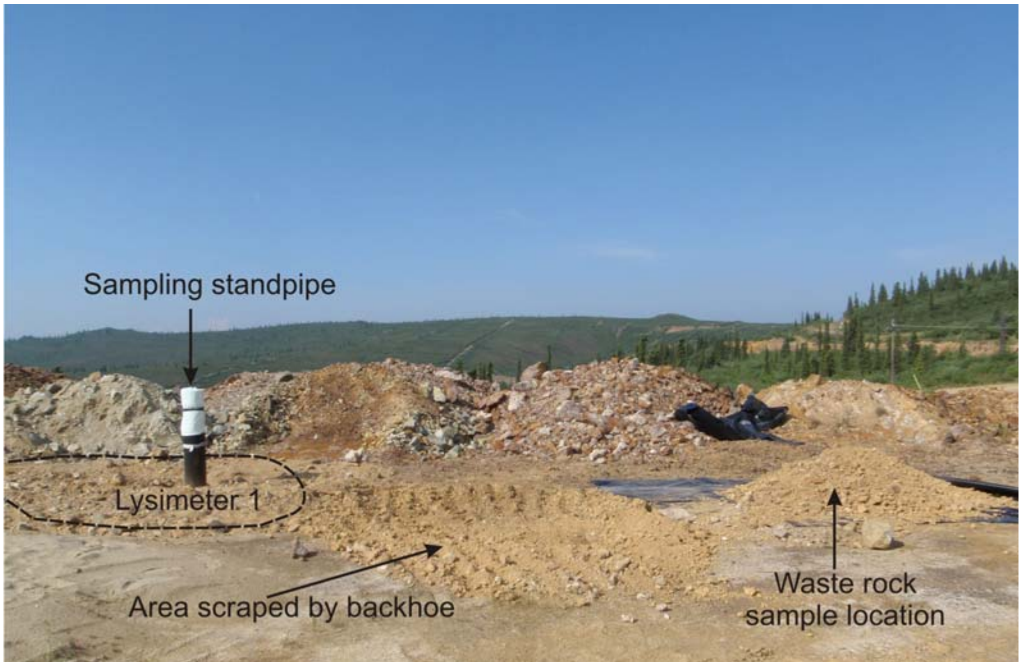


Figure 2-1: **Mt. Nansen Waste Rock Sample Collection Site**

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.

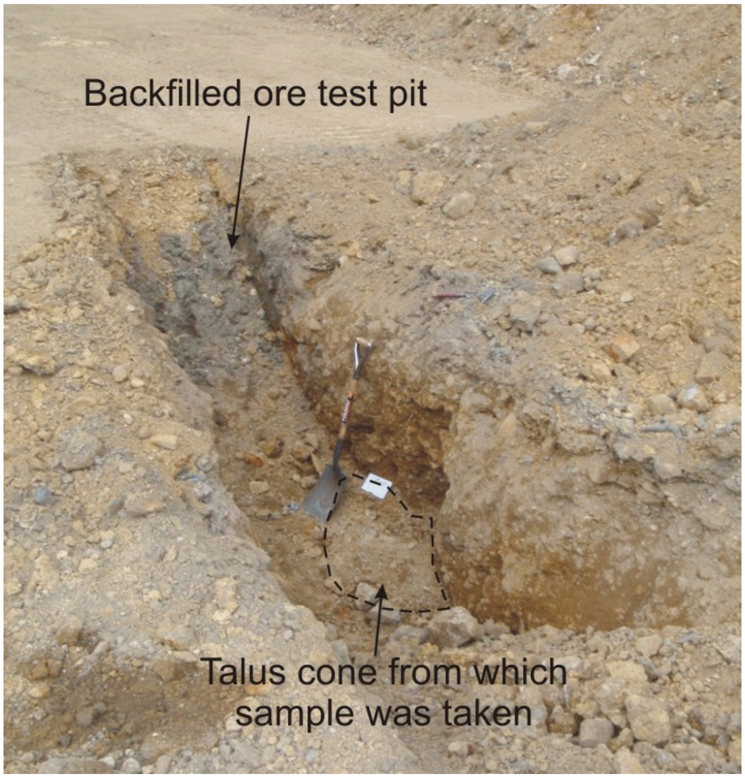


Figure 2-4: Sampling at the Backfilled Ore Test Pit

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).

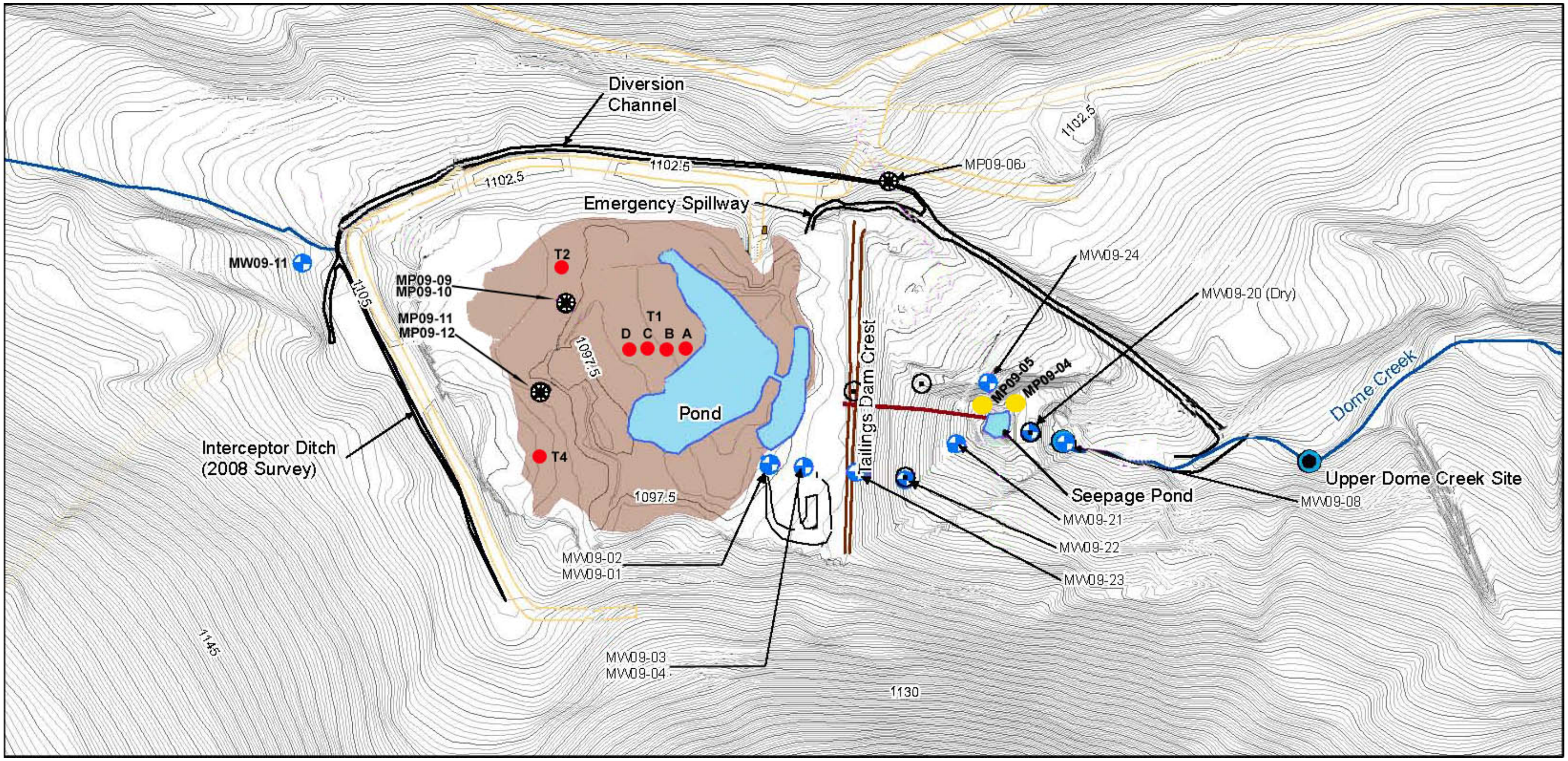


Figure 2-5: Tailings Impoundment - Location of Tailings Collection Sites, including Trenches (Red Circles), Monitoring Well Boreholes (Blue Hatch Circles) and Piezometer Boreholes (Black Hatch Circles)

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.

<u>Tailings</u>

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

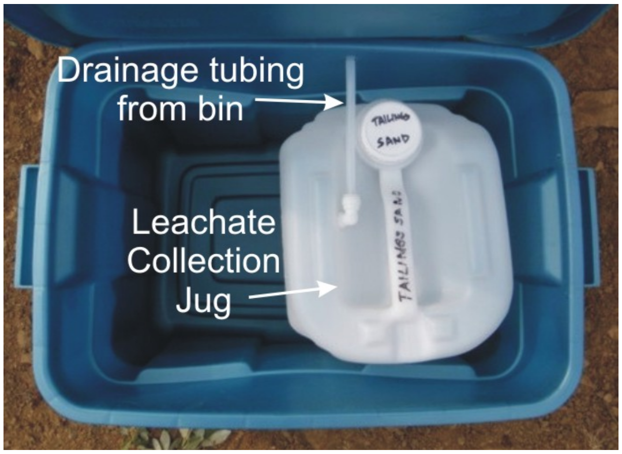


Figure 2-8: Leachate Collection System for the Tailings Field Weathering Bin

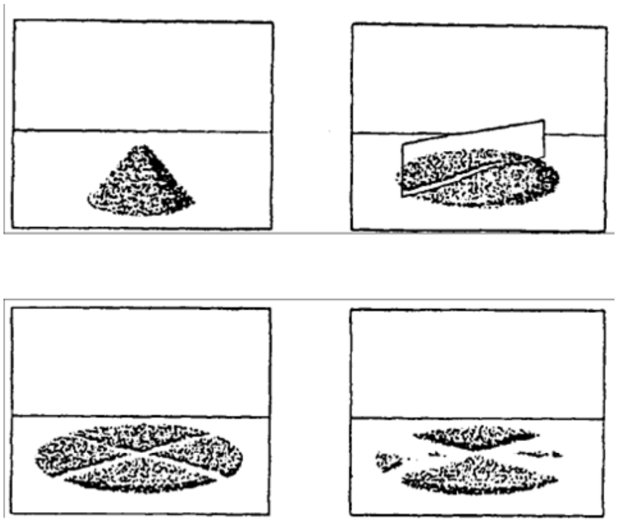


Figure 2-9: Schematic Diagram showing the "Cone-and-Quarter" Technique

<u>Waste Rock and Ore</u>

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.

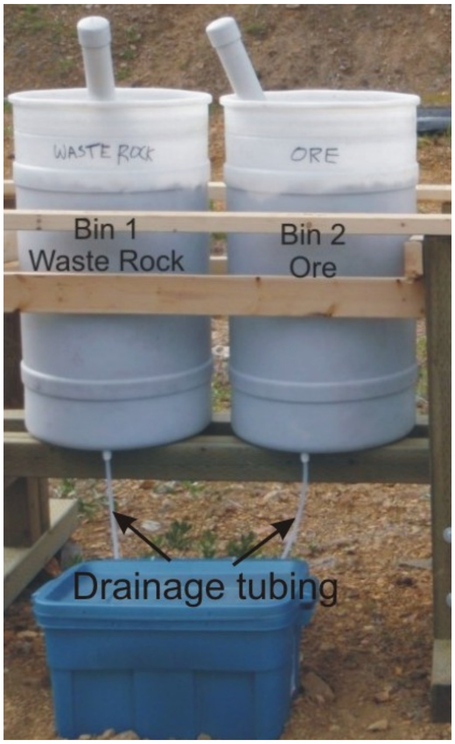


Figure 2-10: Waste Rock and Ore Field Weathering Test Set-up

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.

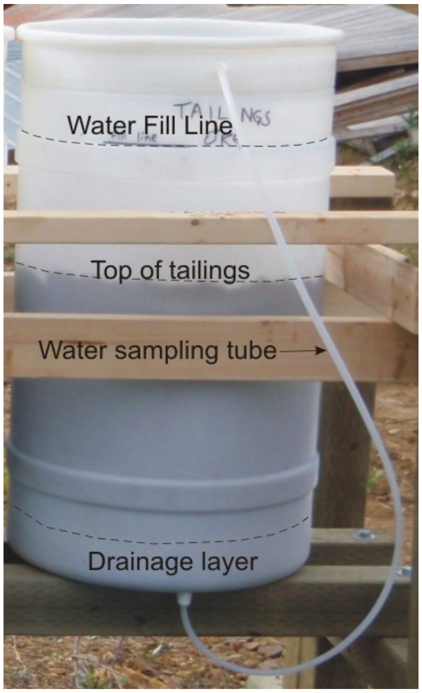


Figure 2-12: Tailings Saturated Field Column Test Set-up

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. 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.

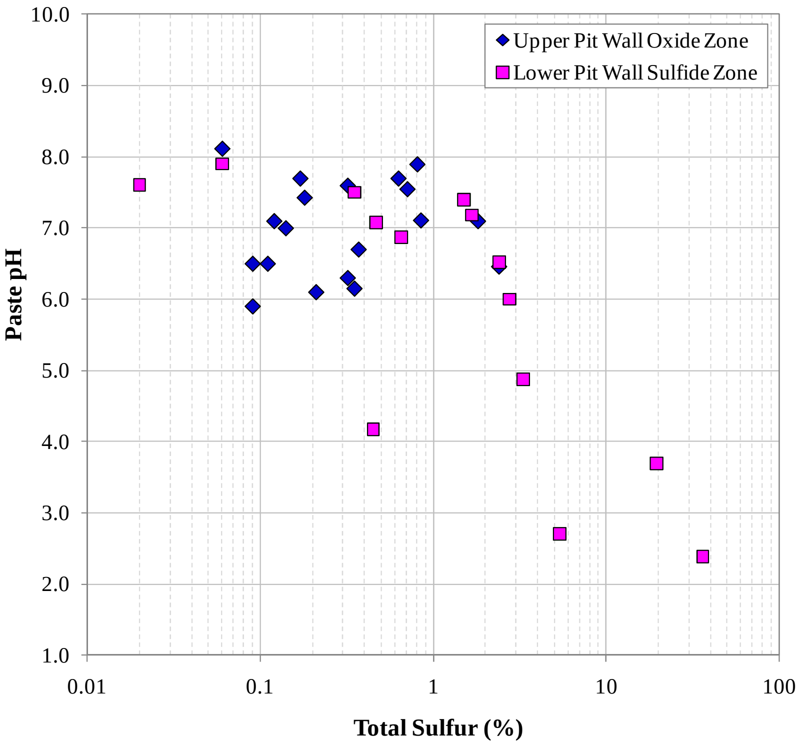


Figure 3-1: Paste pH versus Total Sulfur for Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

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.

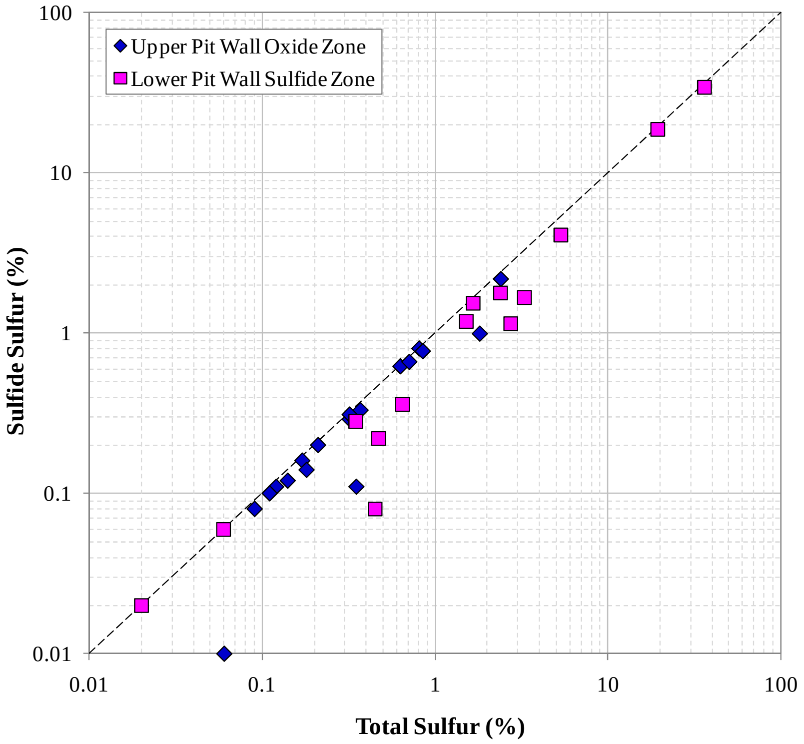


Figure 3-2: Total Sulfur versus Sulfide_Sulfur for Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

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.

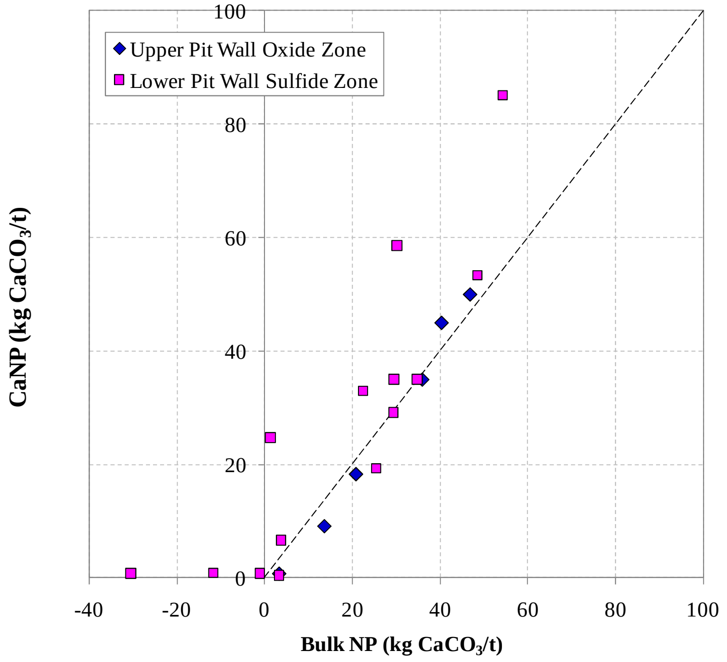


Figure 3-3: Bulk NP versus CaNP for the Upper Pit Wall (oxide zone) and Lower Pit Wall (sulfide zone) Samples

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).

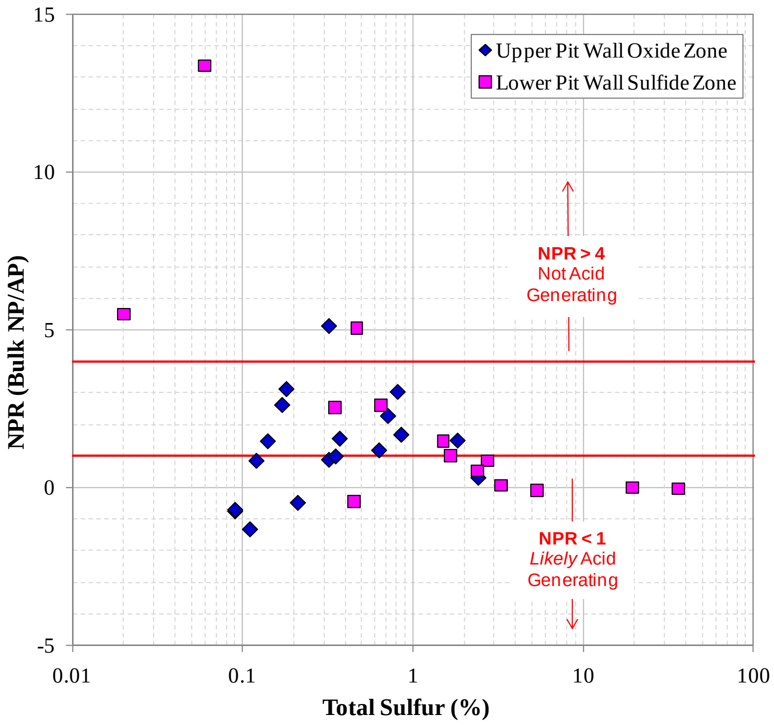


Figure 3-4: NPR versus Total Sulfur for Brown-McDade Pit Wall Samples

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	27 0	1230	287	1250	1740	804	*100*
Ammonia	mg/L	27 9	0.18	0.12	0.18	0.44	0.006	0.019
Nitrate	mg/L	27 2	0.74	0.46	0.65	1.68	0.06	13
Nitrite	mg/L	27 18	0.22	0.15	0.14	0.46	0.09	0.06
As	mg/L	27 0	0.022	0.03	0.009	0.12	0.005	0.005
Cd	mg/L	27 0	0.016	0.008	0.012	0.034	0.005	0.32a
Cu	mg/L	27 0	0.032	0.03	0.021	0.1	0.004	0.004b
Fe	mg/L	27 2	0.54	0.99	0.15	3.5	0.014	0.3c
Mn	mg/L	26 0	2.91	2.38	2.6	7.73	0.087	0.2d
Sb	mg/L	27 0	0.0036	0.002	0.0035	0.008	7E-04	*0.02e*
Zn	mg/L	27 0	1.76	0.66	1.51	2.96	0.51	0.03
Ca	mg/L	27 0	380	70	378	533	269	--
Mg	mg/L	27 0	127	28	133	176	73	--
Hardness	mg/L	21 0	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.

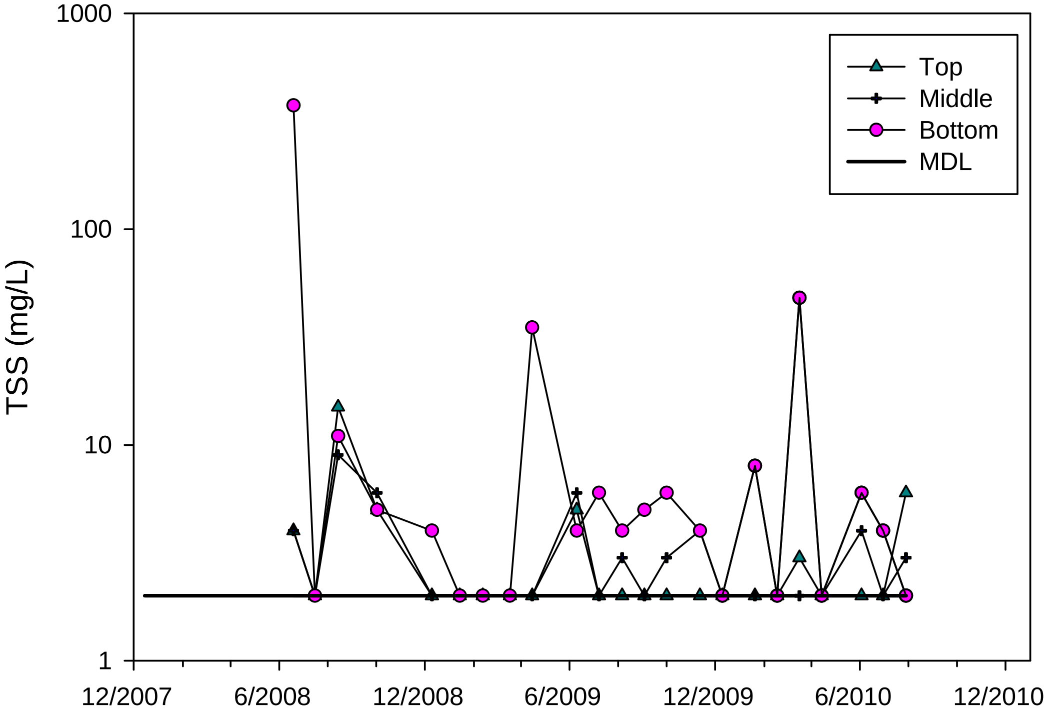


Figure 3-5: Semi-log Plot of TSS in Pit Lake Water Column

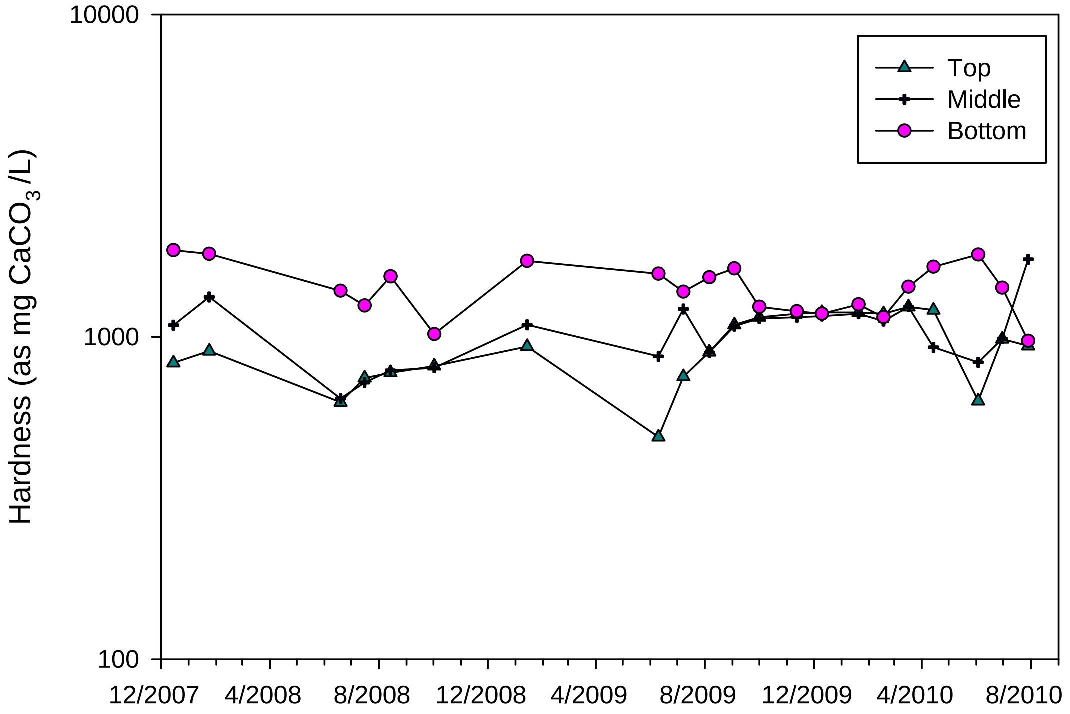
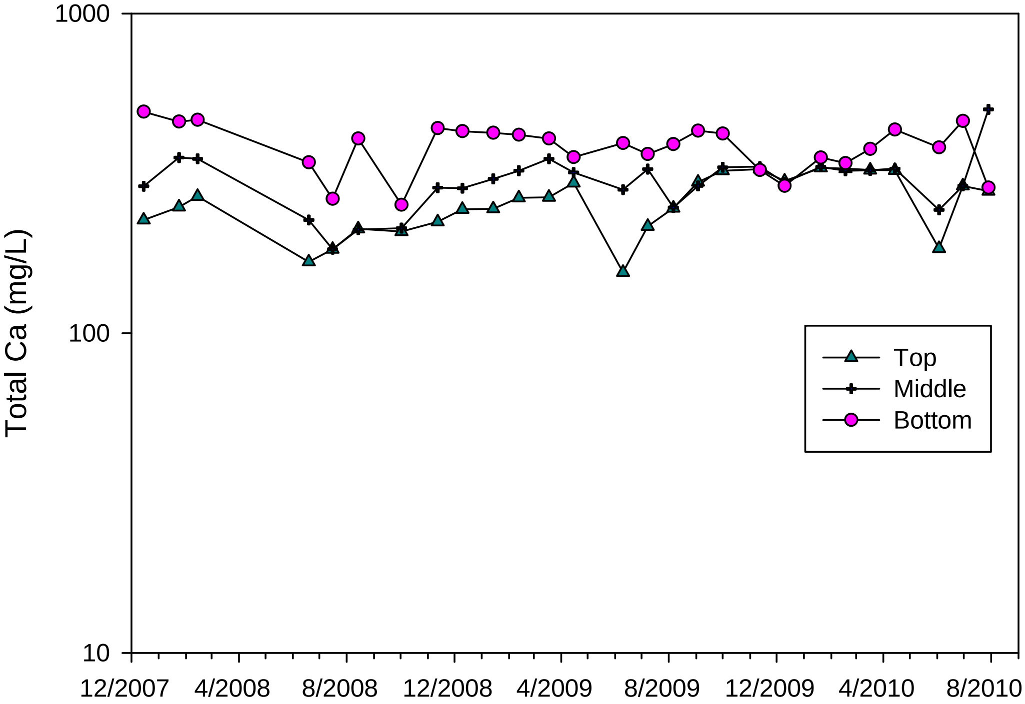


Figure 3-6: Semi-log Plot of Hardness (as mg $CaCO_3$/L) in Pit Lake Water Column

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)

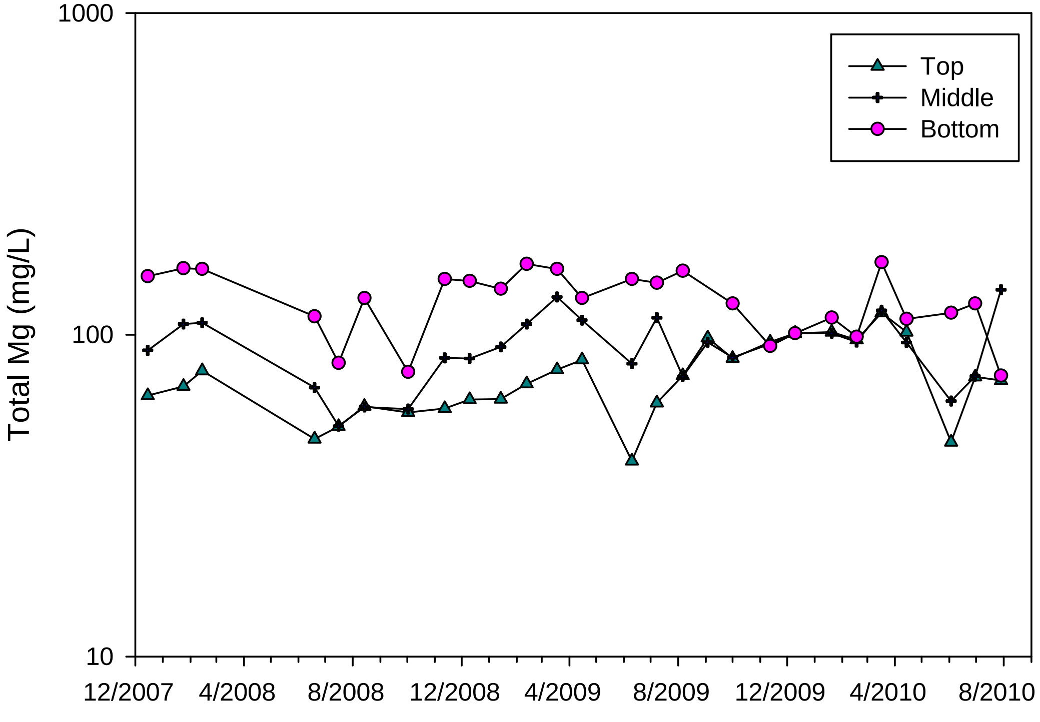


Figure 3-7: **Semi-log Plot of (a) Total Calcium and (b) Total Magnesium in Pit Lake Water Column**

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).

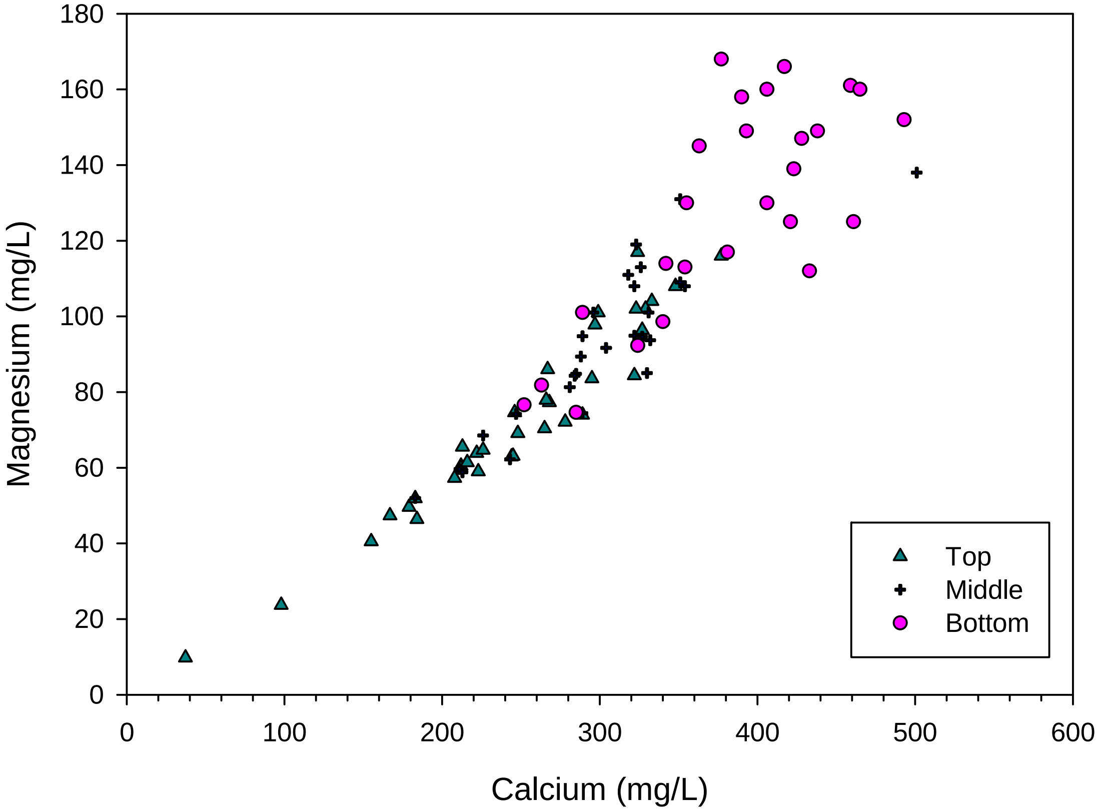


Figure 3-8: Relationship between Calcium and Magnesium Concentrations in Pit Lake Waters

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.

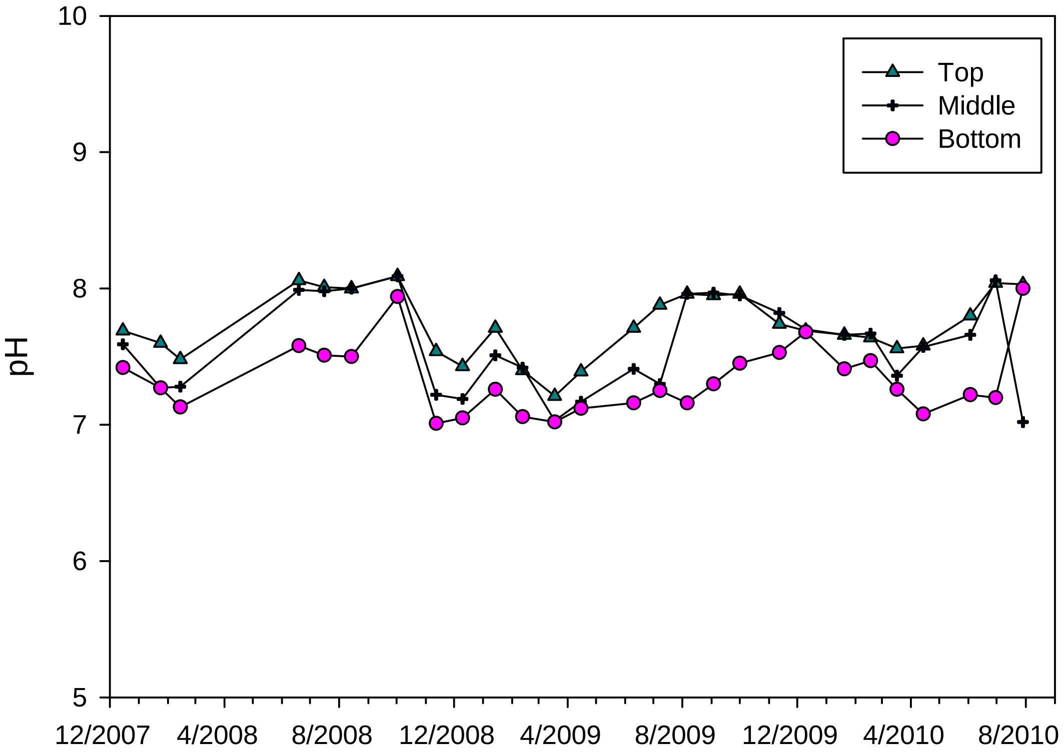


Figure 3-9: Time-series of pH in the Pit Lake Water Column

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).

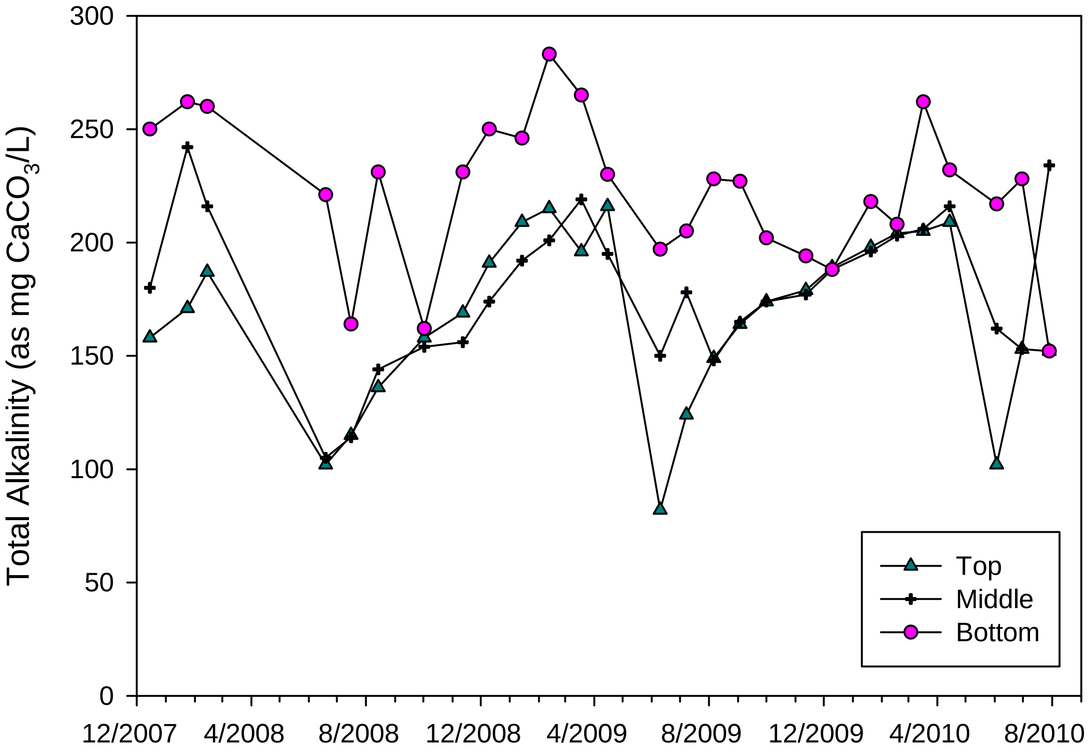


Figure 3-10: Total Alkalinity (as mg $CaCO_3$/L) in Pit Lake Water Column

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.

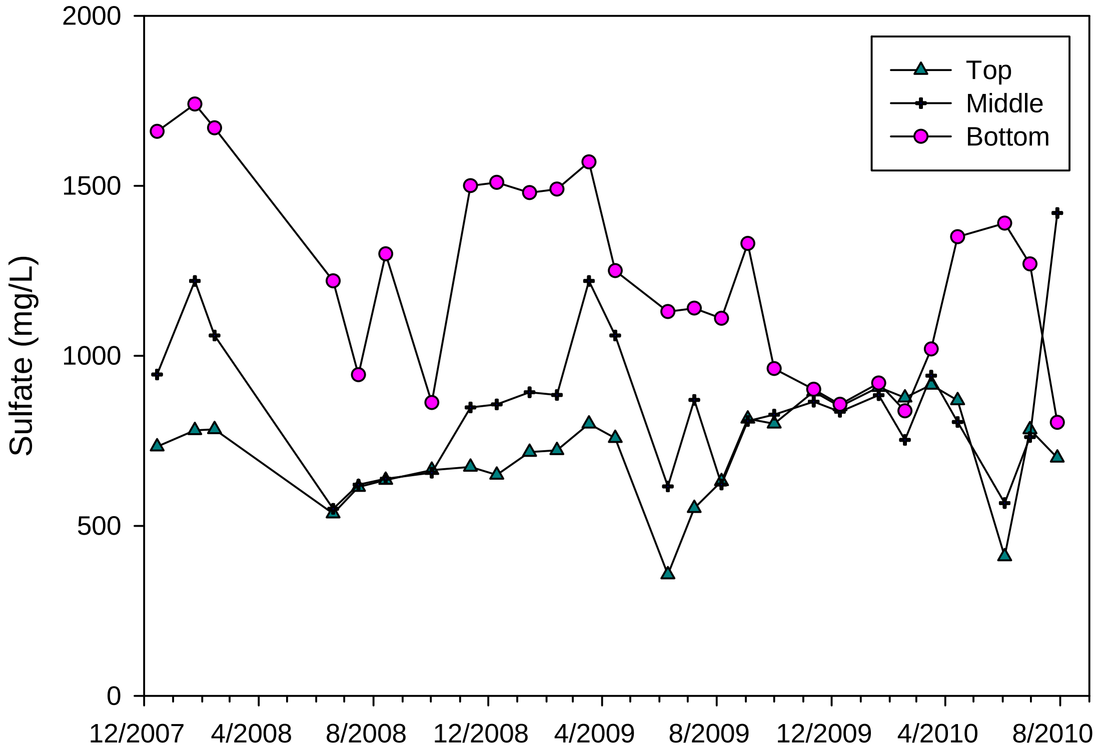


Figure 3-11: Plot of Sulfate in Pit Lake Water Column

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.

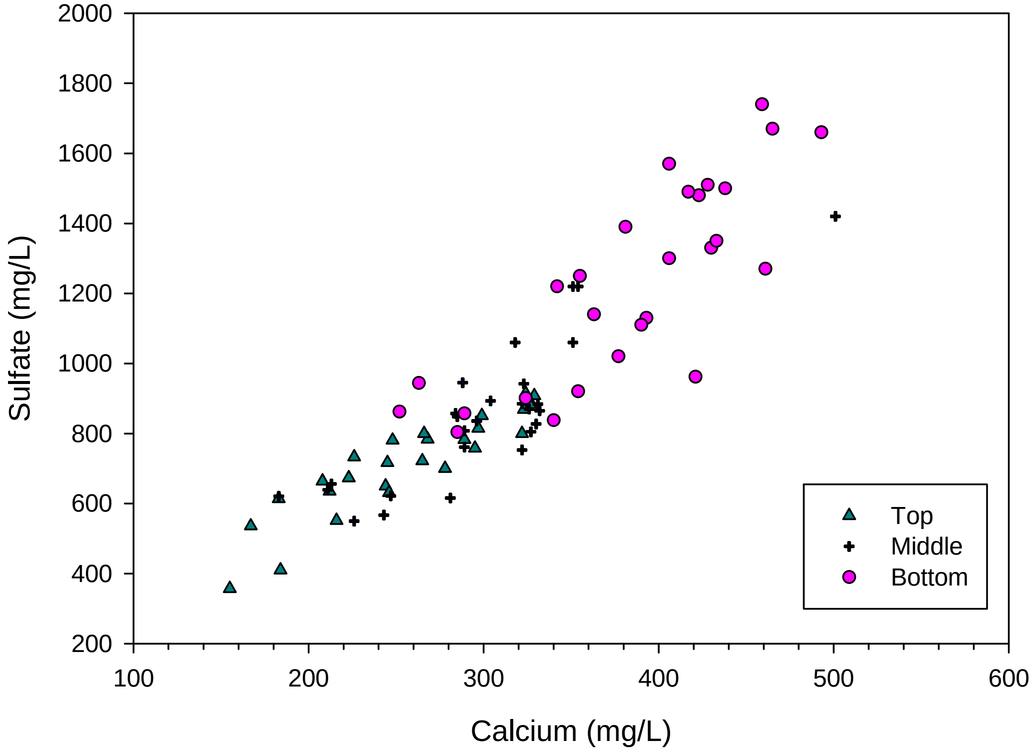


Figure 3-12: Calcium versus Sulfate in Pit Lake Water Column

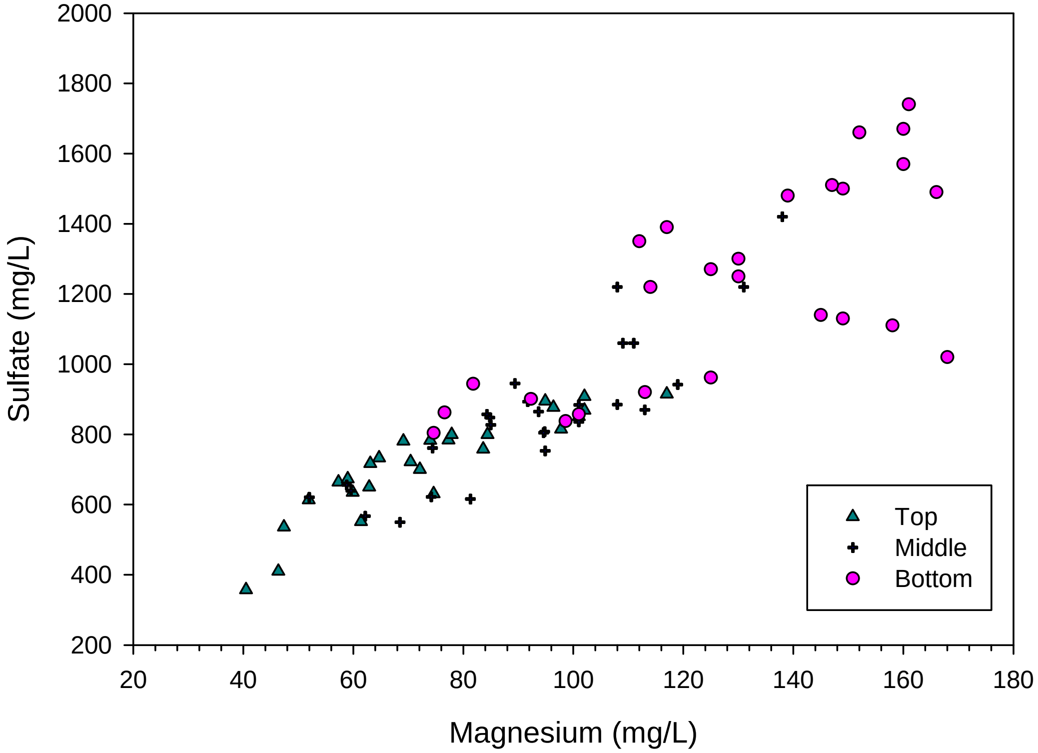


Figure 3-13: Magnesium versus Sulfate in Pit Lake Water Column

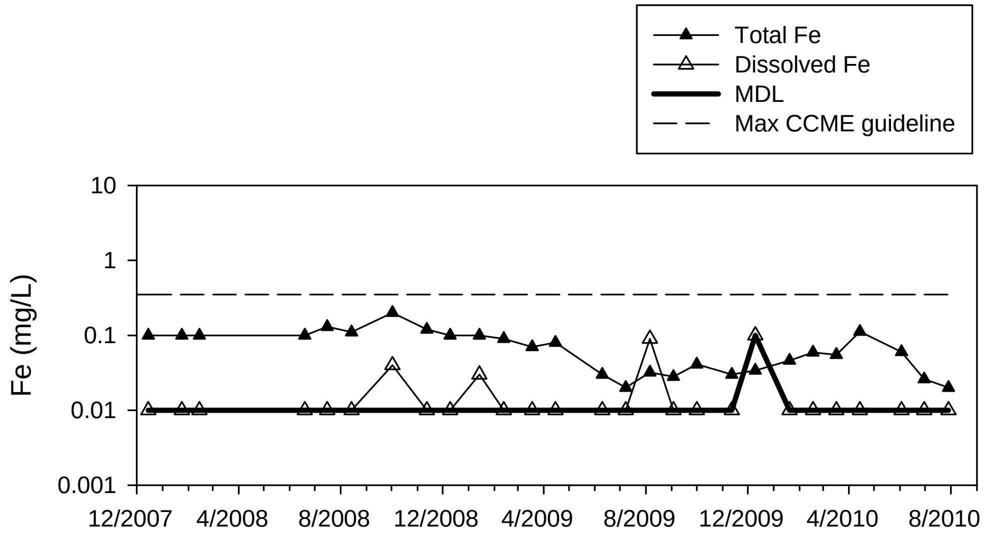
3.3.1.5 Total Iron

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.

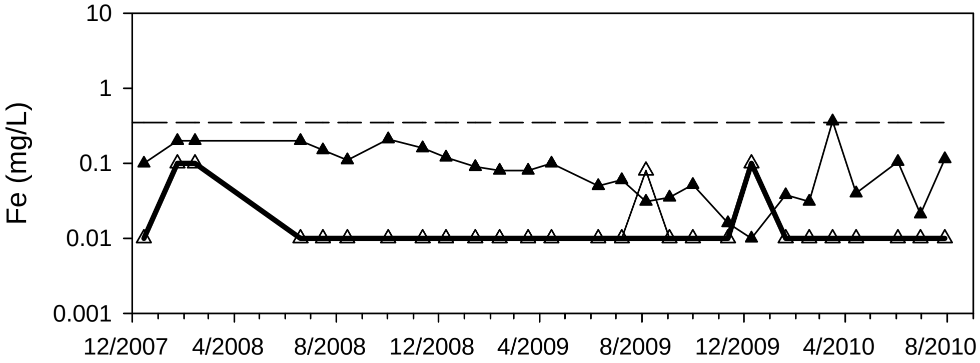
There is reason to view the dissolved Fe data with caution since the water samples were not filtered and preserved immediately in the field. The time lag between sample collection and filtration/preservation in the analytical laboratory may have resulted in the oxidation of ferrous iron to ferric iron 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.



b) Middle



c) Bottom

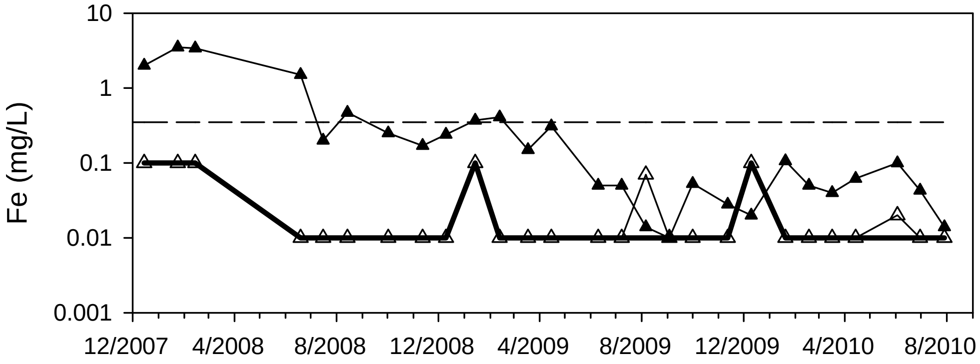


Figure 3-14: Semi-log Plot of Total and Dissolved Iron in (a) Top Zone, (b) Middle Zone and (c) Bottom Zone of the Brown-McDade Pit Lake (MDL shown is for the Dissolved Fraction)

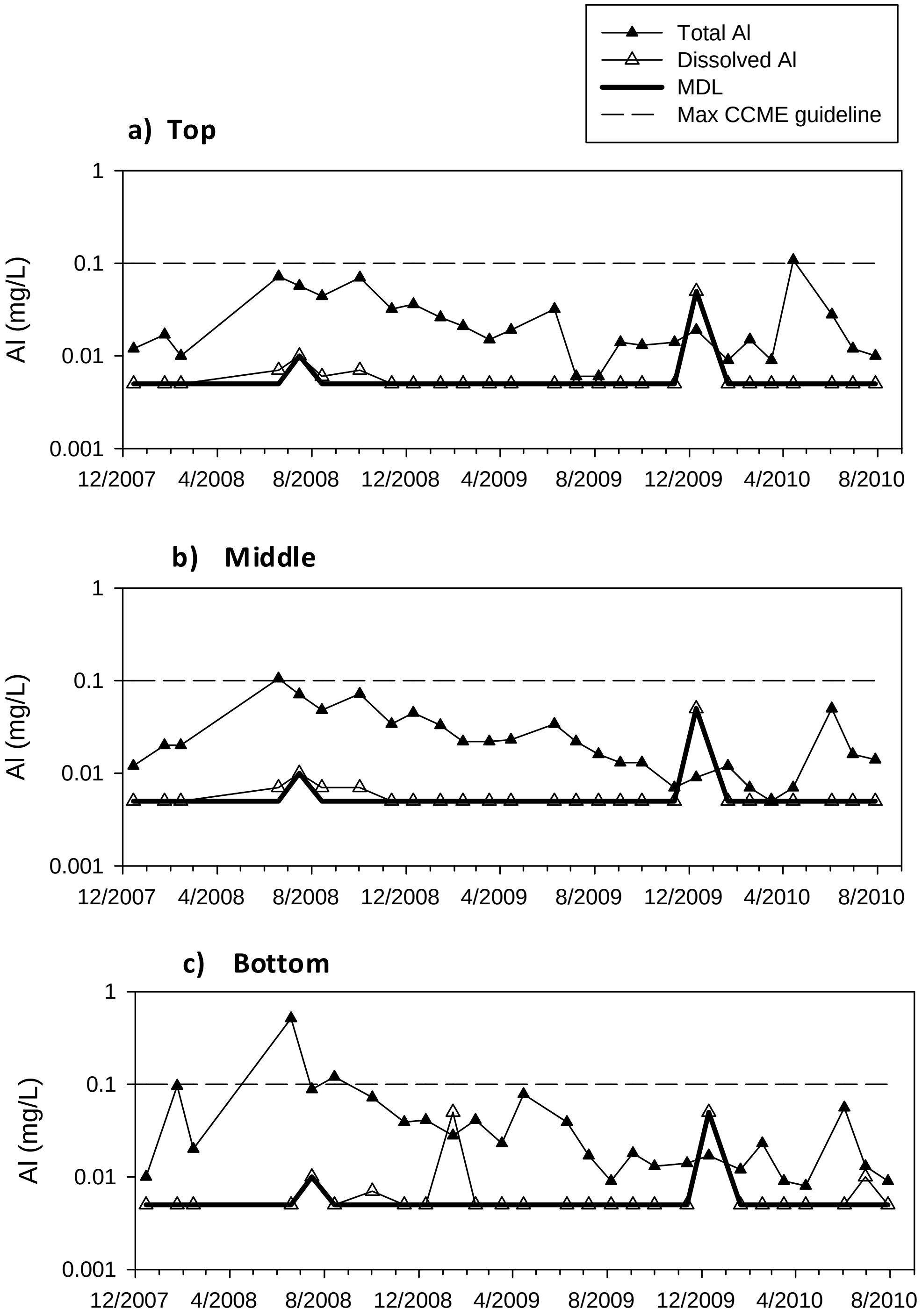


Figure 3-15: Semi-log Plot of Total and Dissolved Aluminum in (a) Top Zone, (b) Middle Zone and (c) Bottom Zone of the Pit Lake (MDL shown is for the Dissolved Fraction)

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).

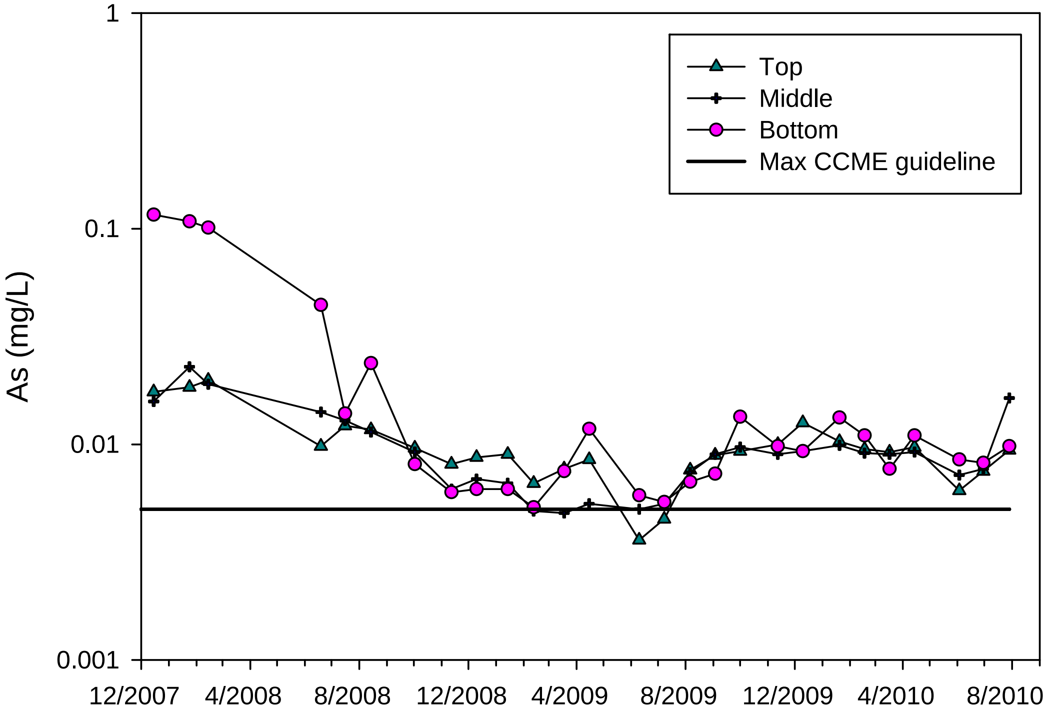


Figure 3-16: Semi-log Plot of Total Arsenic in Pit Lake Water Column

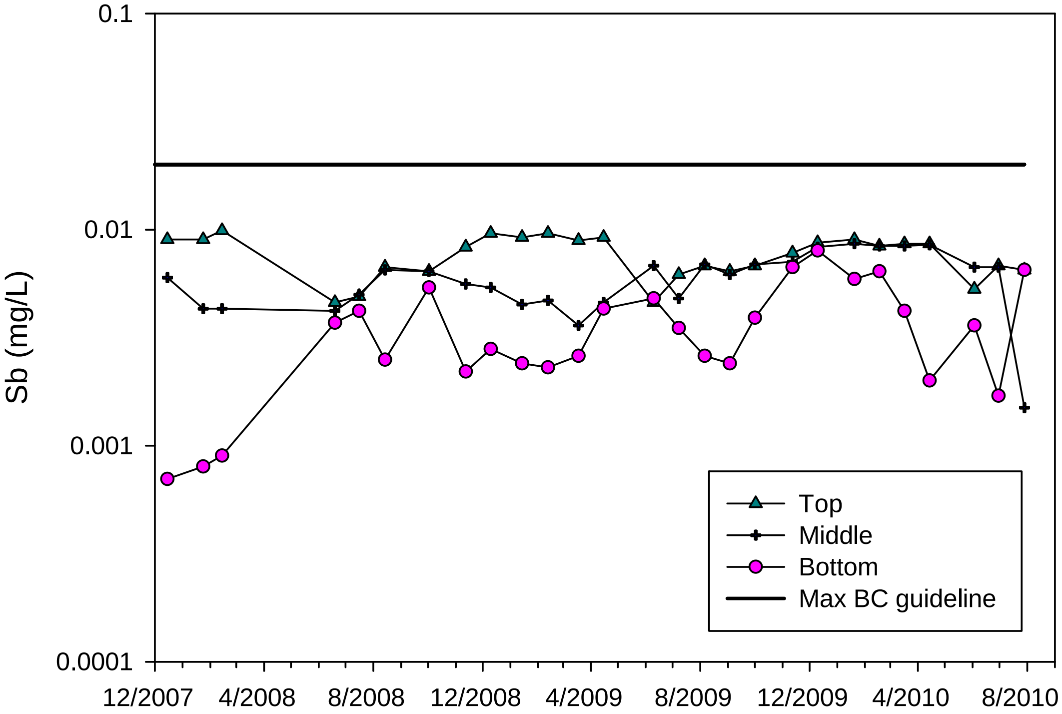
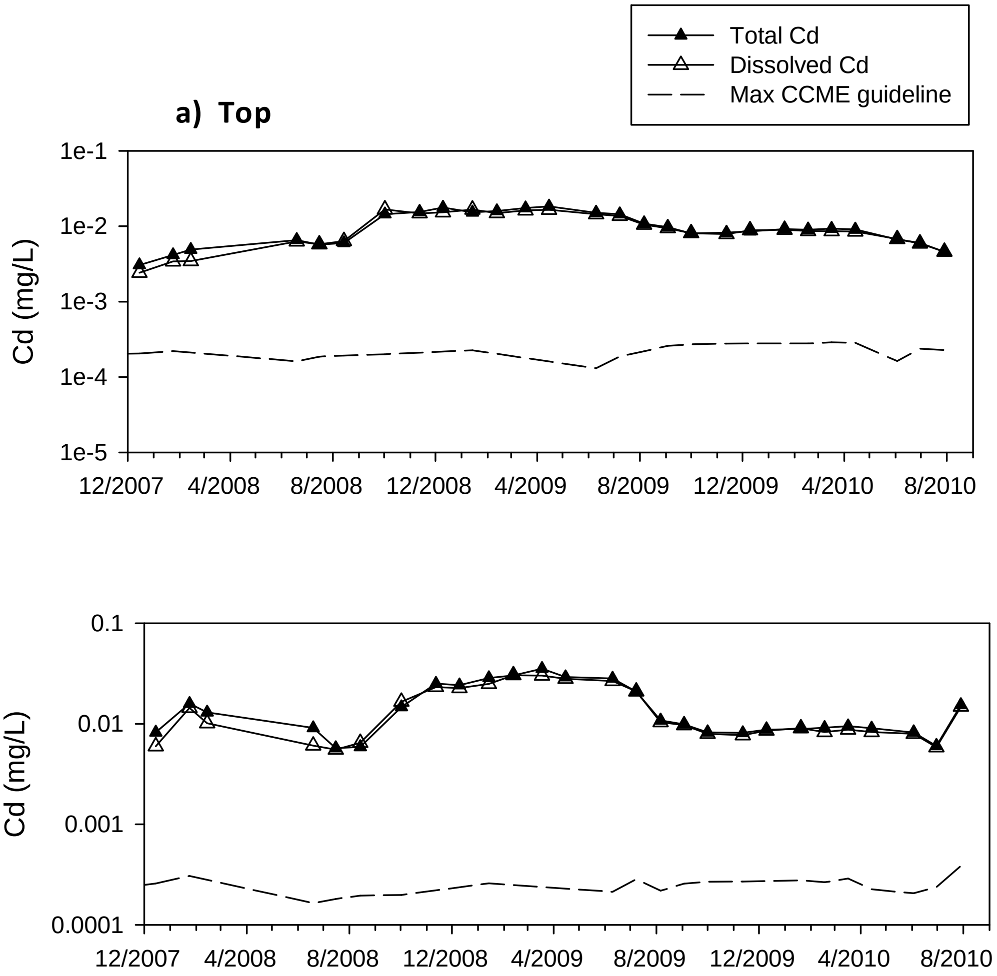


Figure 3-17: Semi-log Plot of Total Antimony in Pit Lake Water Column

3.3.1.9 Total Cadmium

Total Cd concentrations in each of the three pit lake zones were below the calculated maximum acceptable level (hardness dependent, CCME Guidelines, 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 abnormally large melting snowpack. Given the neutral to alkaline pH of the pit lake water, Cd precipitates should have been dominant; however, the dissolved Cd concentrations were relatively close to the total Cd concentrations. Generally, the trends in Cd appear to be relatively steady.

In the natural environment, Cadmium is closely associated with Zn, and a relationship between the two metals was observed in this study (Figure 3-19). The toxicity of Cd is known to increase in the presence of Zn and Cu. Following this rationale Cd may still be considered a concern despite concentrations being below the maximum acceptable level since zinc is so abundant in the pit lake water column (see below).



c) Bottom

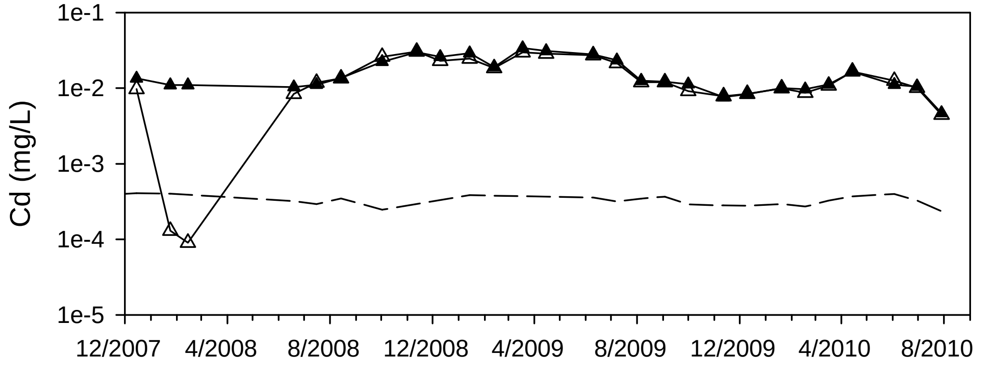


Figure 3-18: Semi-log Plot of Total and Dissolved Cadmium in (a) the Top Zone, (b) the Middle Zone and (c) the Bottom Zone of the Pit Lake

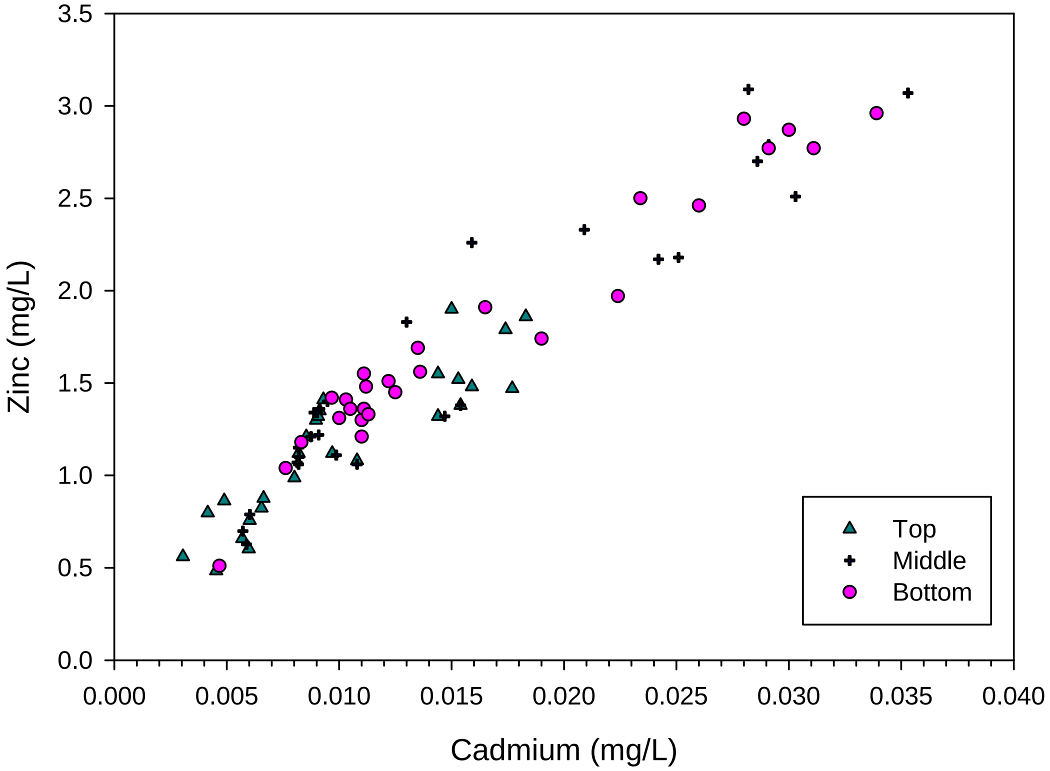


Figure 3-19: Plot of Cadmium versus Zinc in Pit Lake Water Column

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.

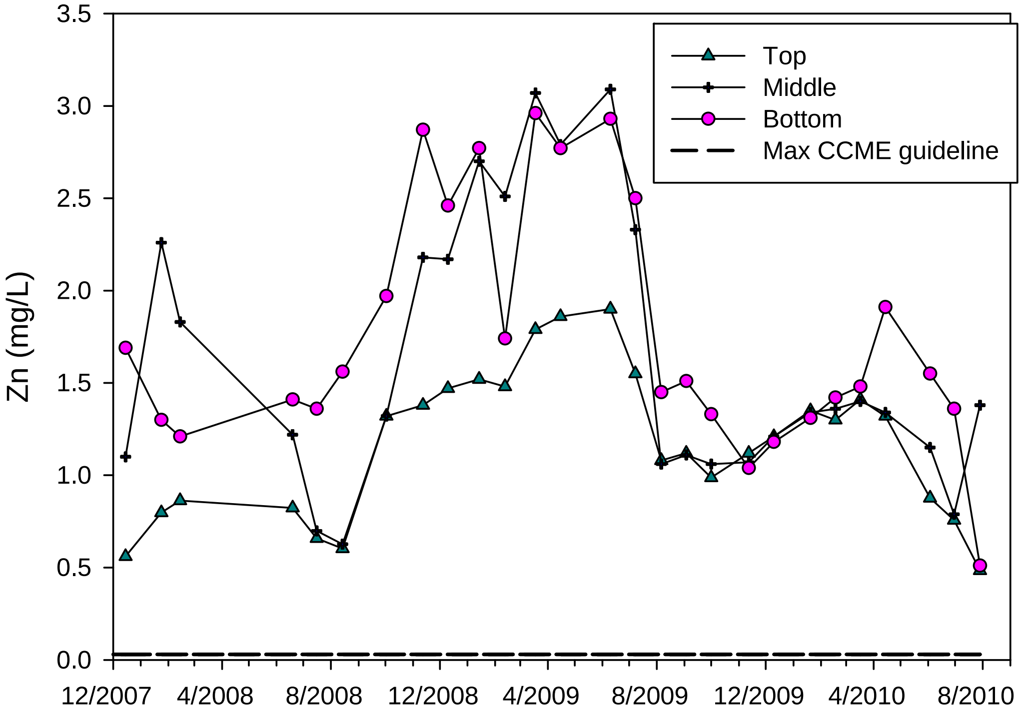


Figure 3-20: Plot of Total Zinc in Pit Lake Water Column

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.

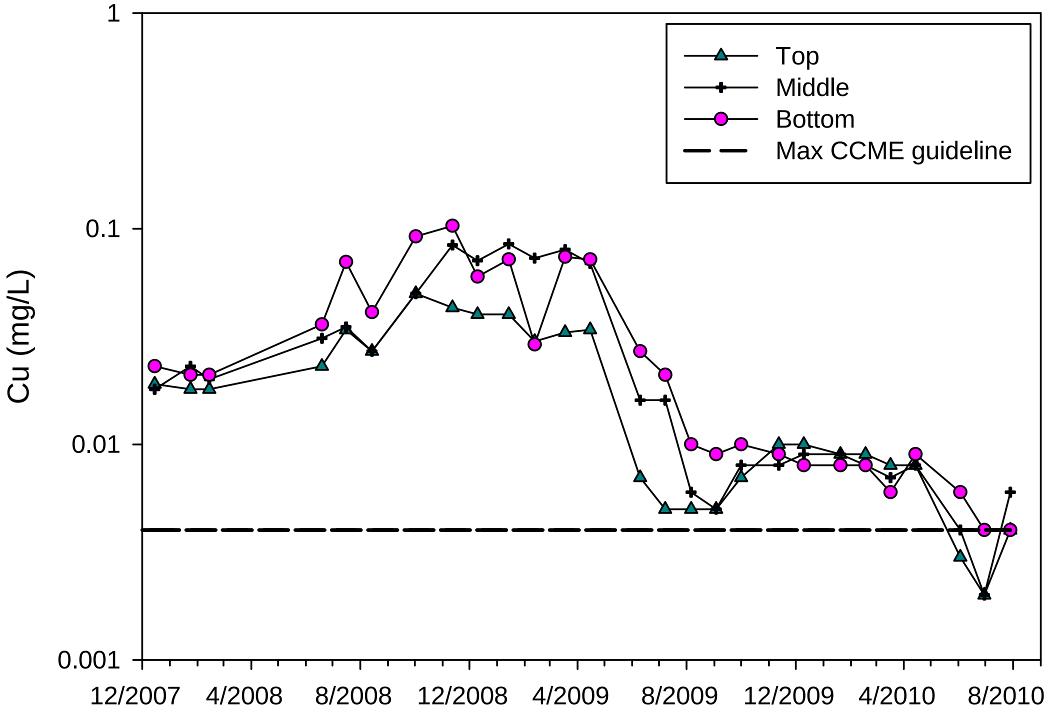


Figure 3-21: Semi-log Plot of Total Copper in Pit Lake Water Column

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.

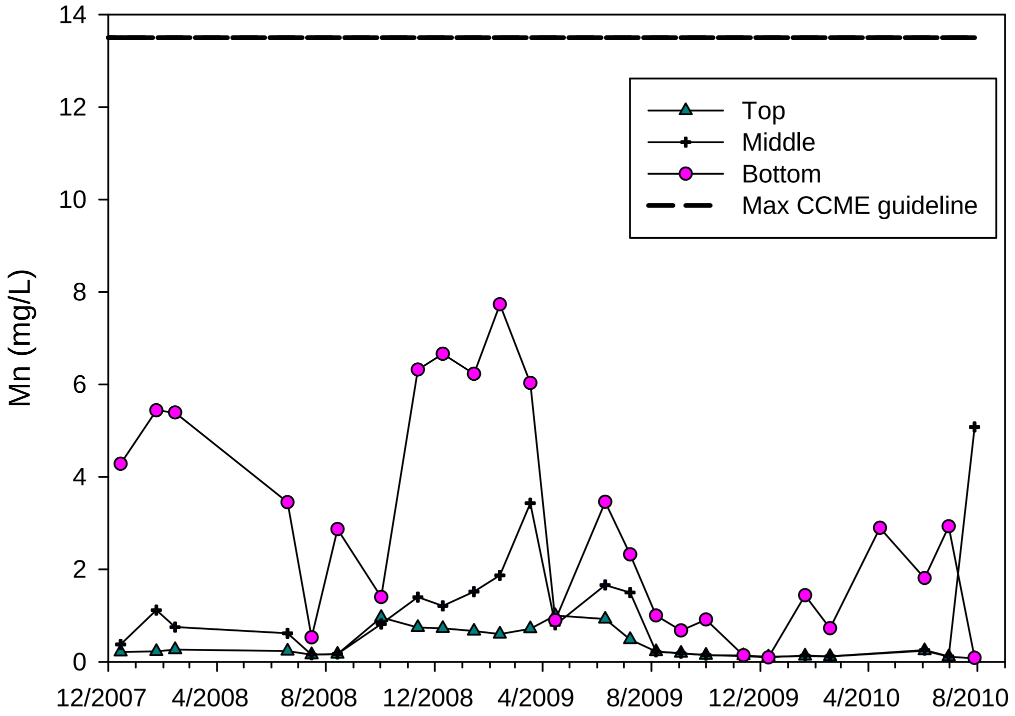


Figure 3-22: Plot of Total Manganese in Pit Lake Water Column

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.

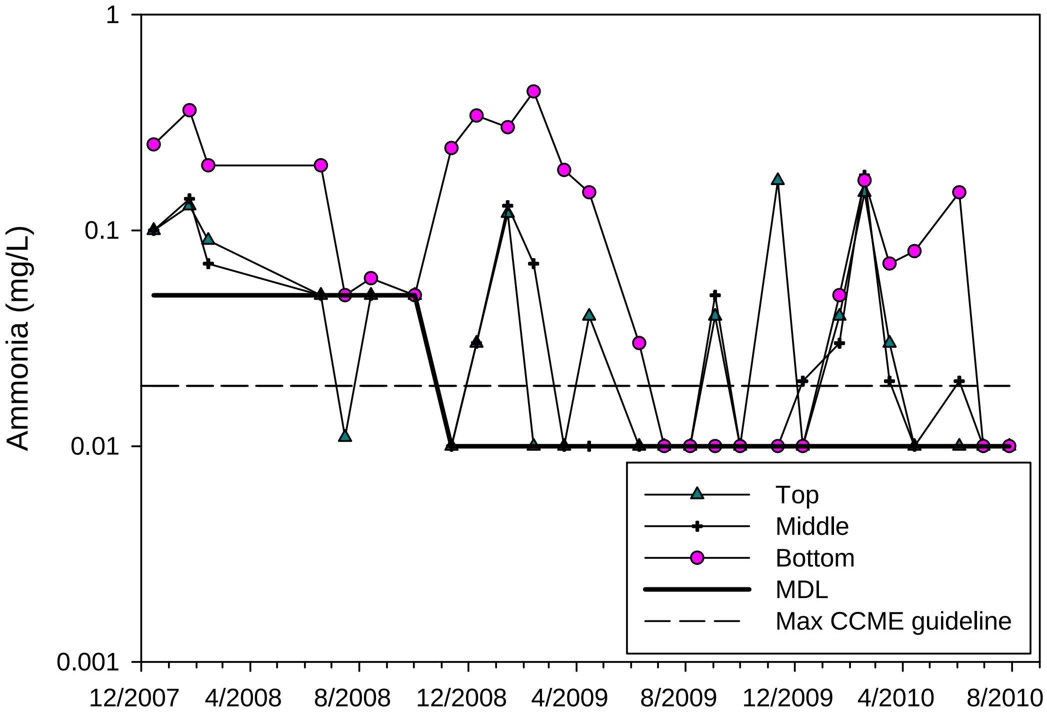


Figure 3-23: Semi-log Plot of Ammonia in Pit Lake Water Column

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.

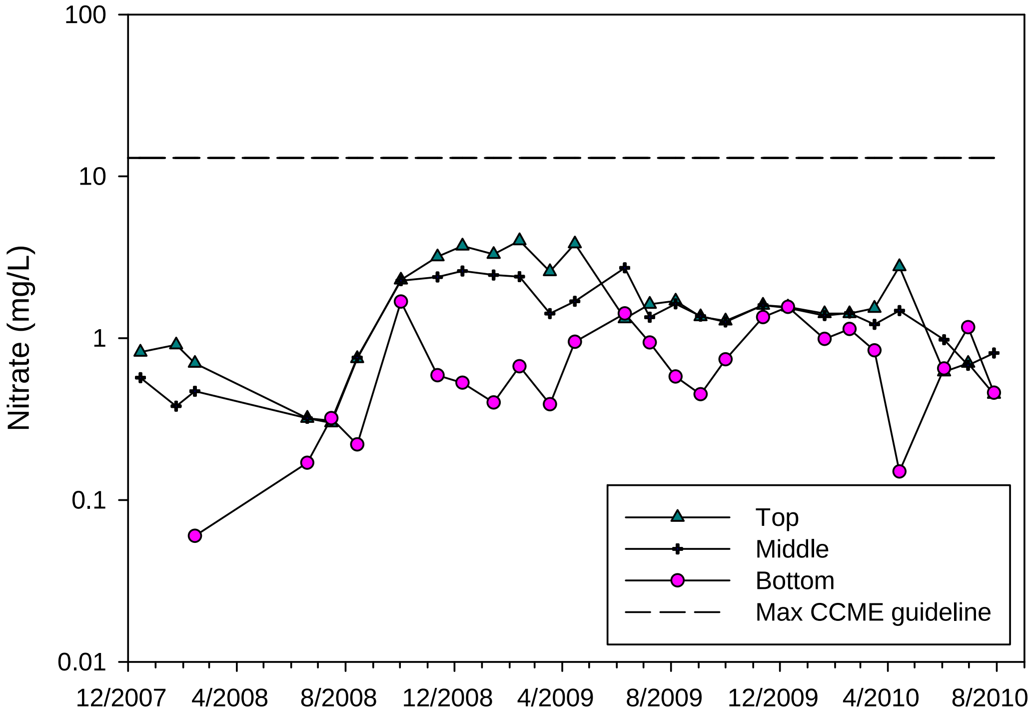


Figure 3-24: Semi-log Plot of Nitrate in Pit Lake Water Column

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.

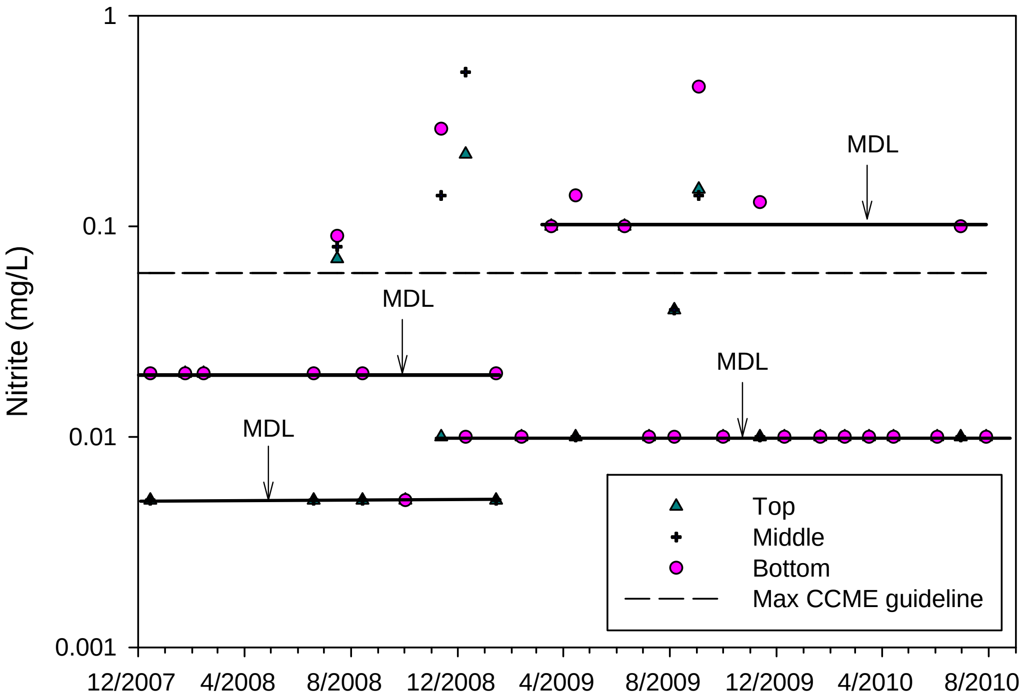


Figure 3-25: Semi-log Plot of Nitrite in Pit Lake Water Column

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. 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	kg$CaCO_3$/t	431	300	24.1	1.9	0.3	*11*	32.8
AP	kg$CaCO_3$/t	431	300	24.1	1.9	0.3		38.8
CaNP	kg$CaCO_3$/t	20.0	20.0	11.3	5.3	4.2	*8*	13.3
Bulk NP	kg$CaCO_3$/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] Max
			Min	Median	Max	Min	Median	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:

A) 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;

B) All sample sites together (*i.e.,* median values for the entire data set from all five sample sites together); and,

C) 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.

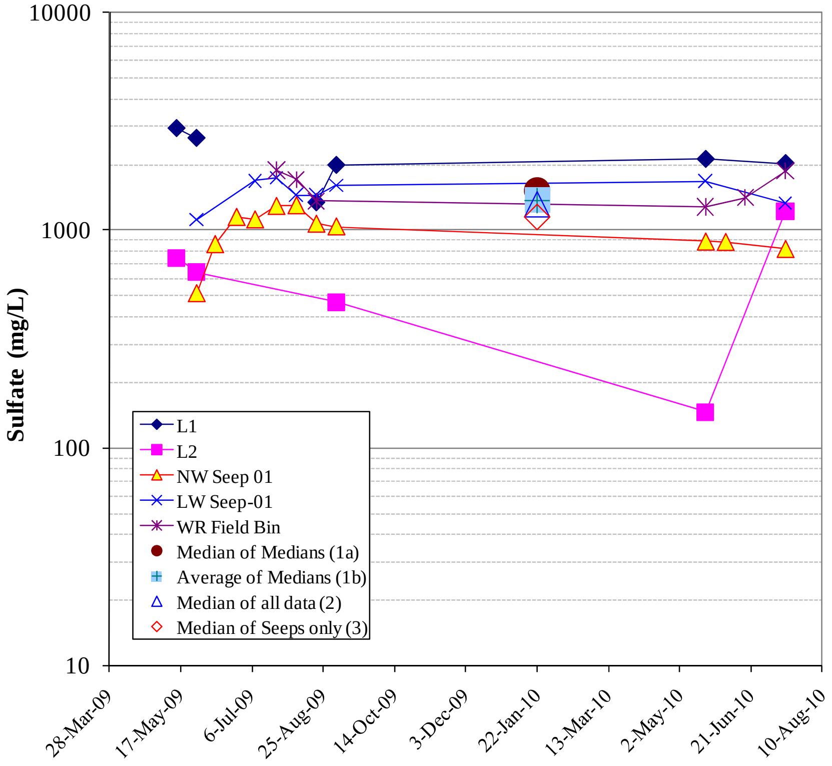


Figure 4-1: Sulfate concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

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.

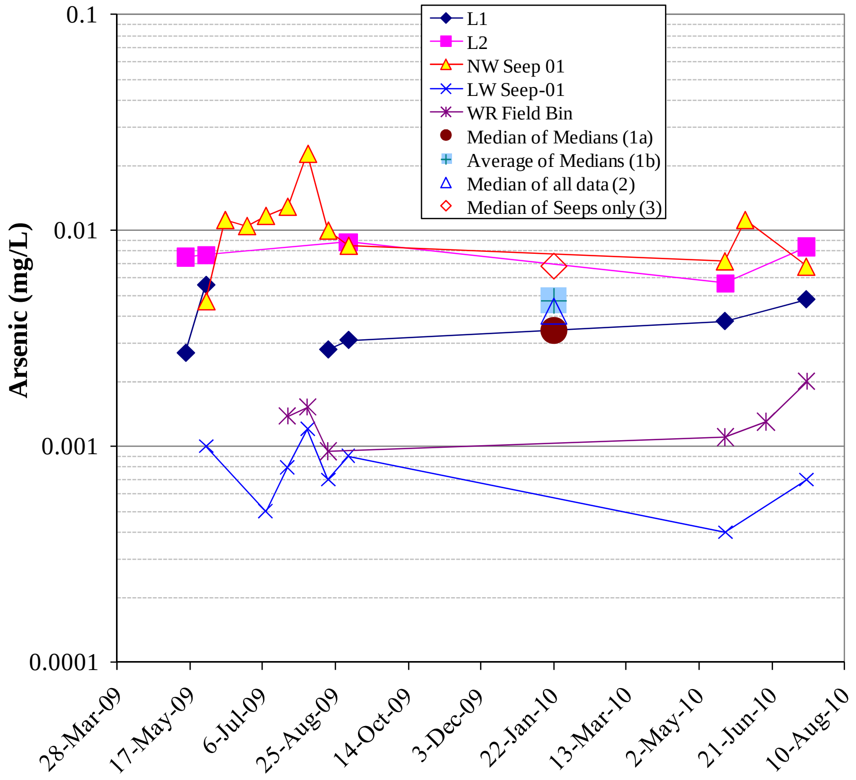


Figure 4-2: Dissolved Arsenic Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters, and Field Bin Leachate for 2009 and 2010 Field Seasons

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.

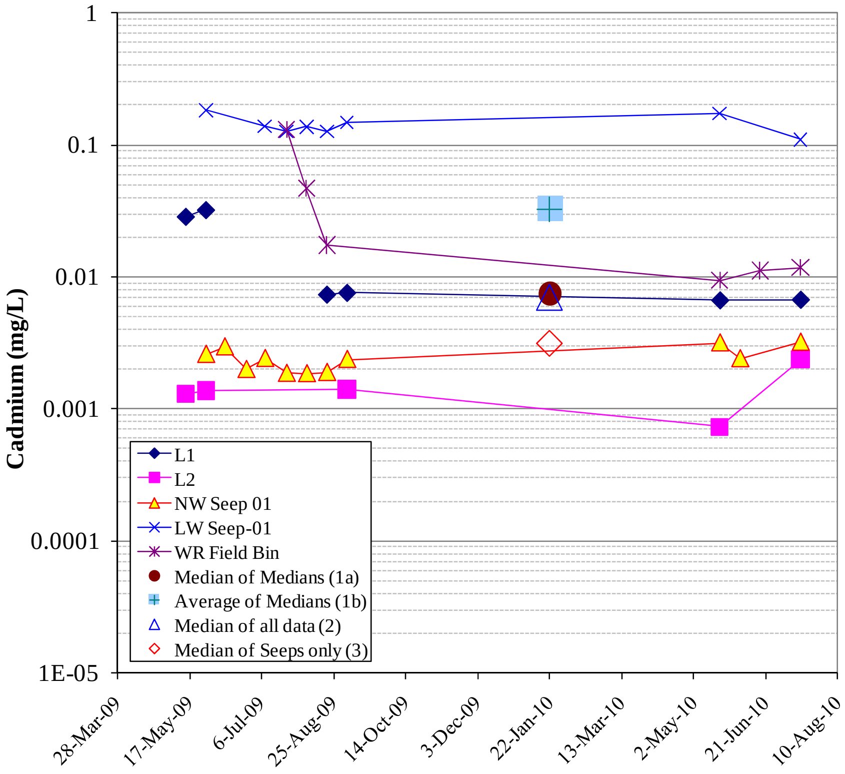


Figure 4-3: **Dissolved Cadmium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons**

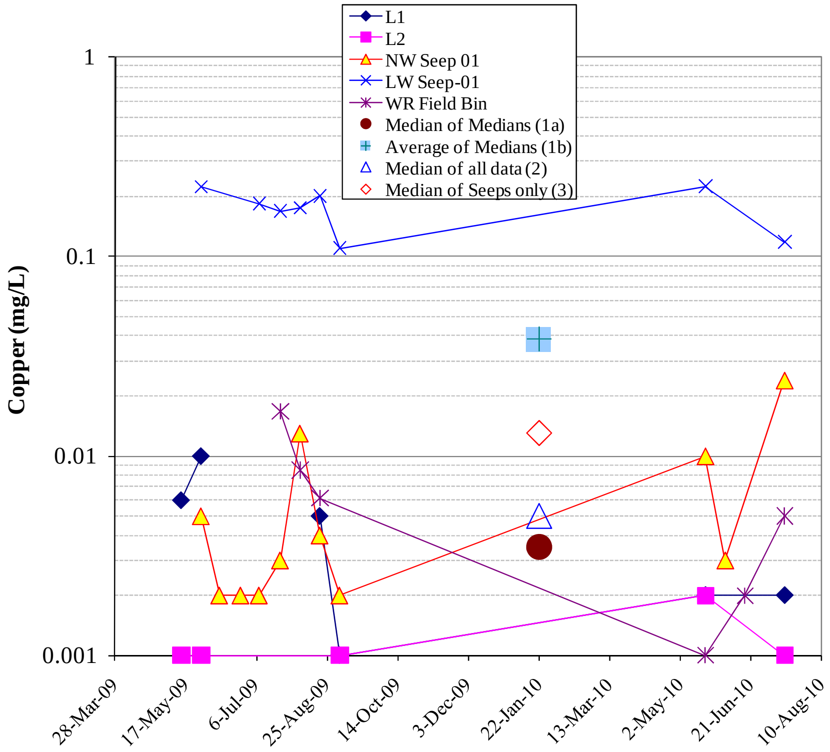


Figure 4-4: **Dissolved Copper Concentrations from Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin**

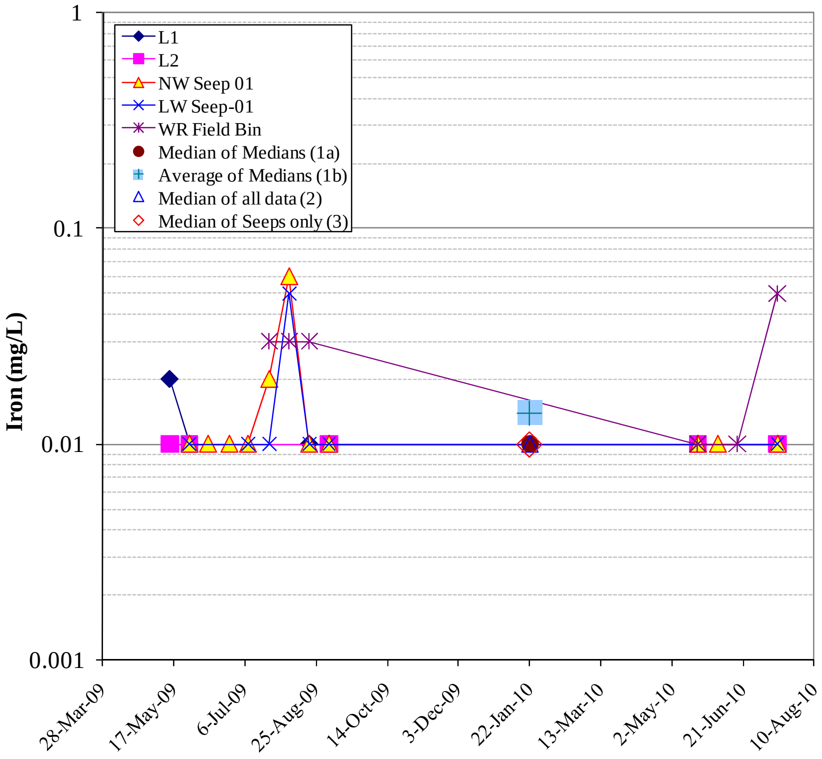


Figure 4-5: **Dissolved Iron Concentrations in Mt. Nansen Waste Rock Seeps, lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons**

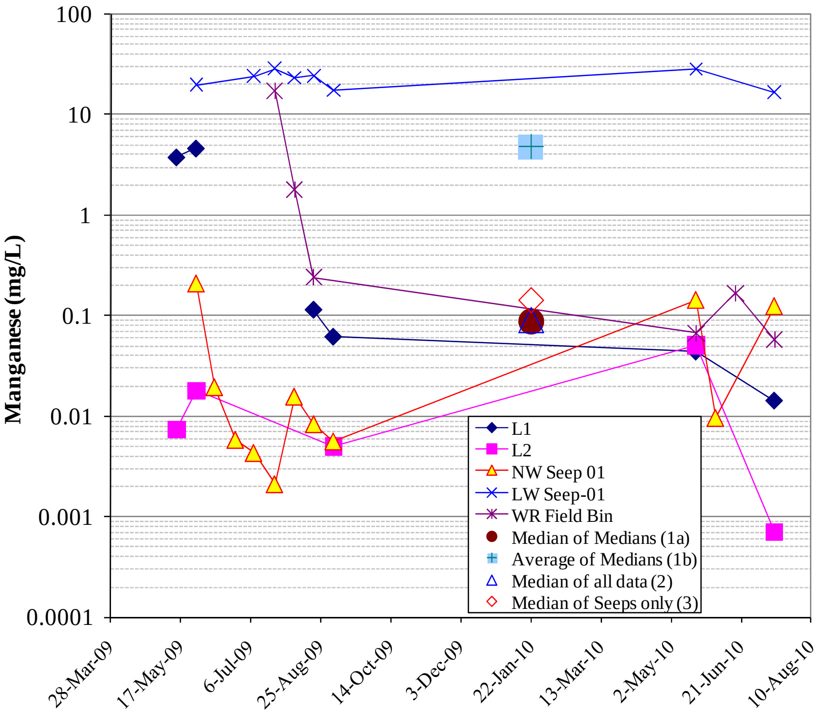


Figure 4-6: **Dissolved Manganese Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons**

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.

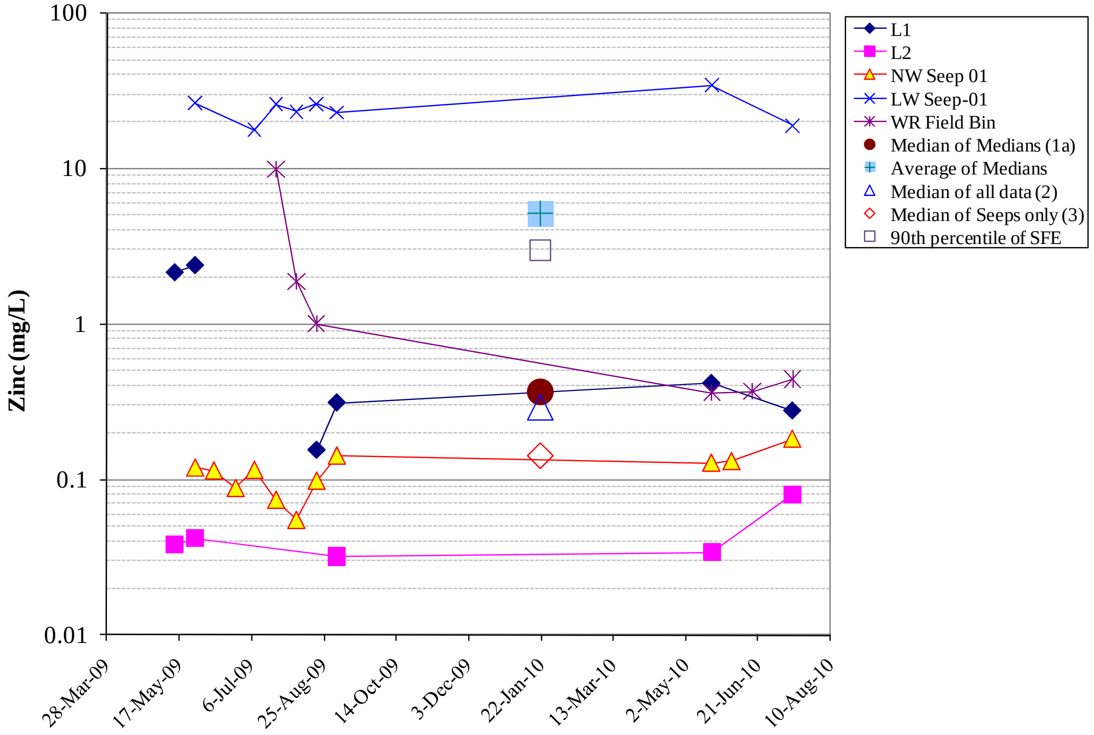


Figure 4-7: Dissolved Zinc Concentrations from Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin

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.

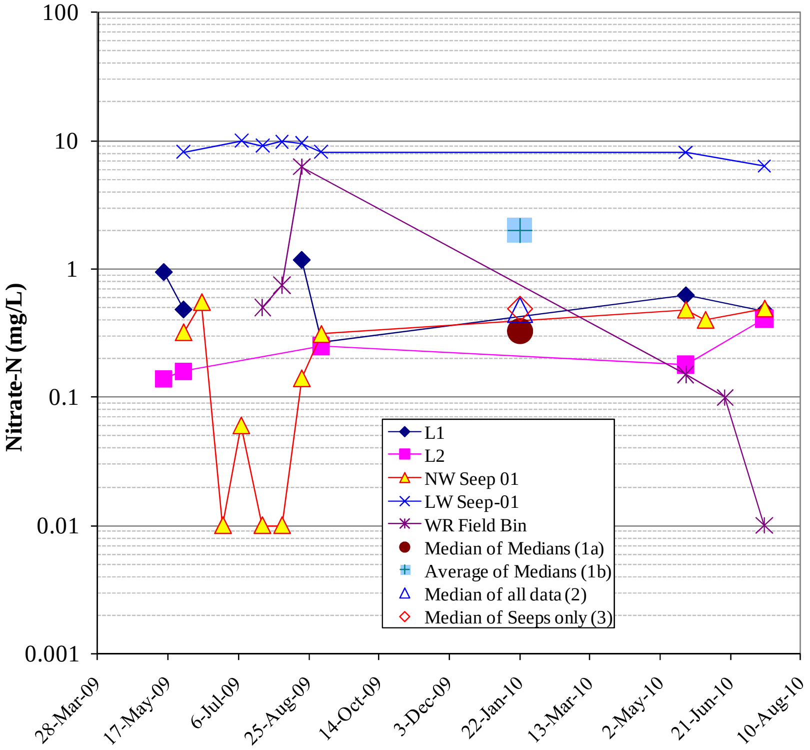


Figure 4-8: **Nitrate-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons**

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.

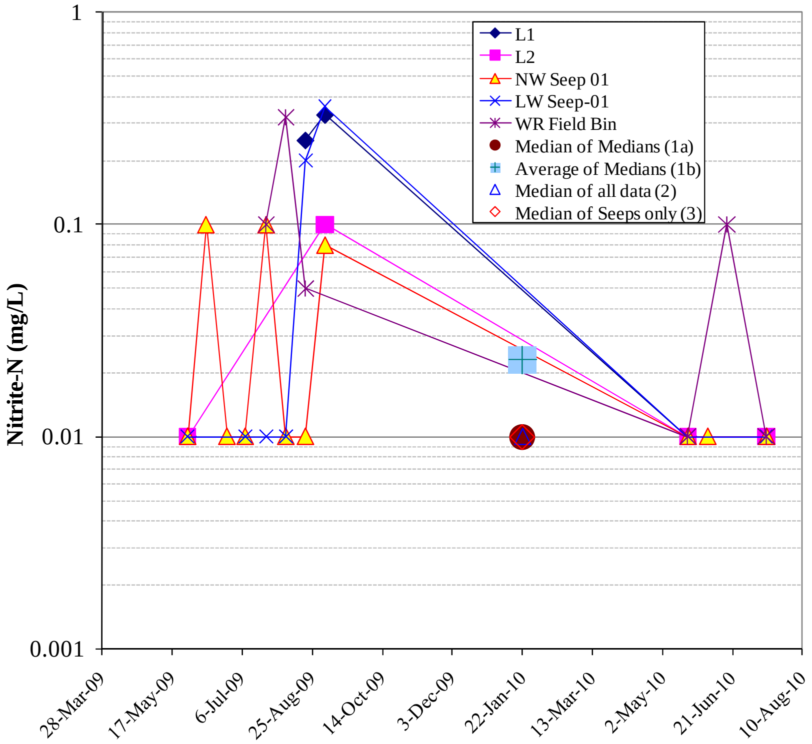


Figure 4-9: Nitrite-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

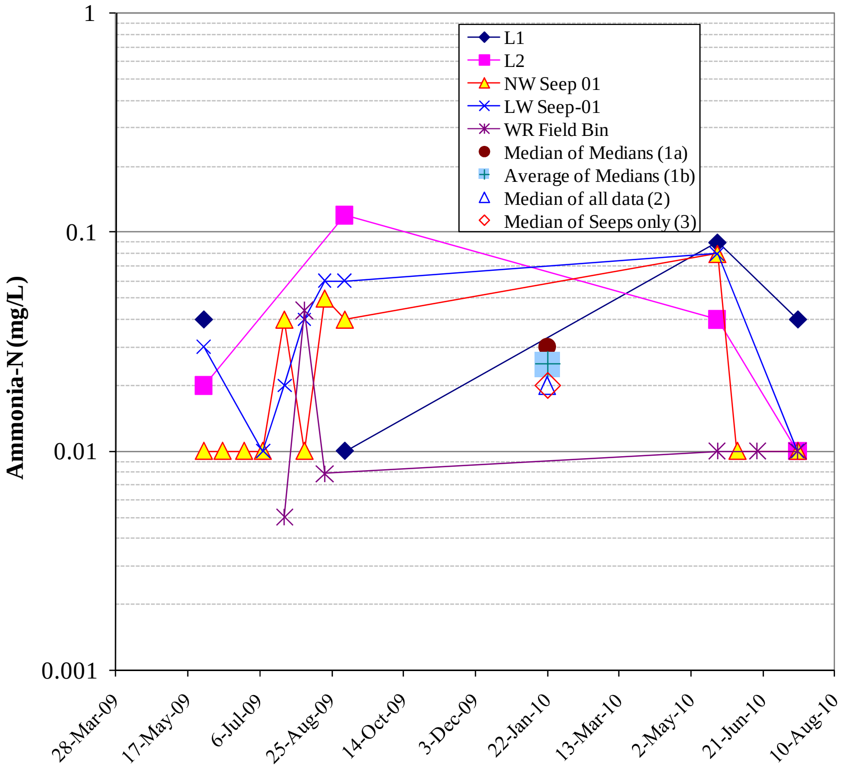


Figure 4-10: Ammonia-N Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

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.

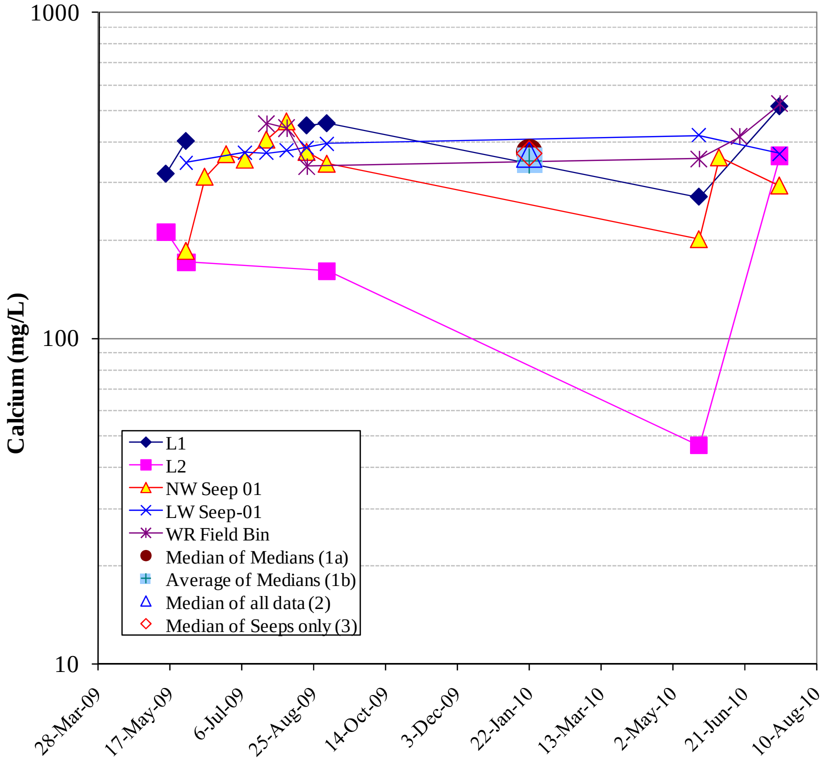


Figure 4-11: Dissolved Calcium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

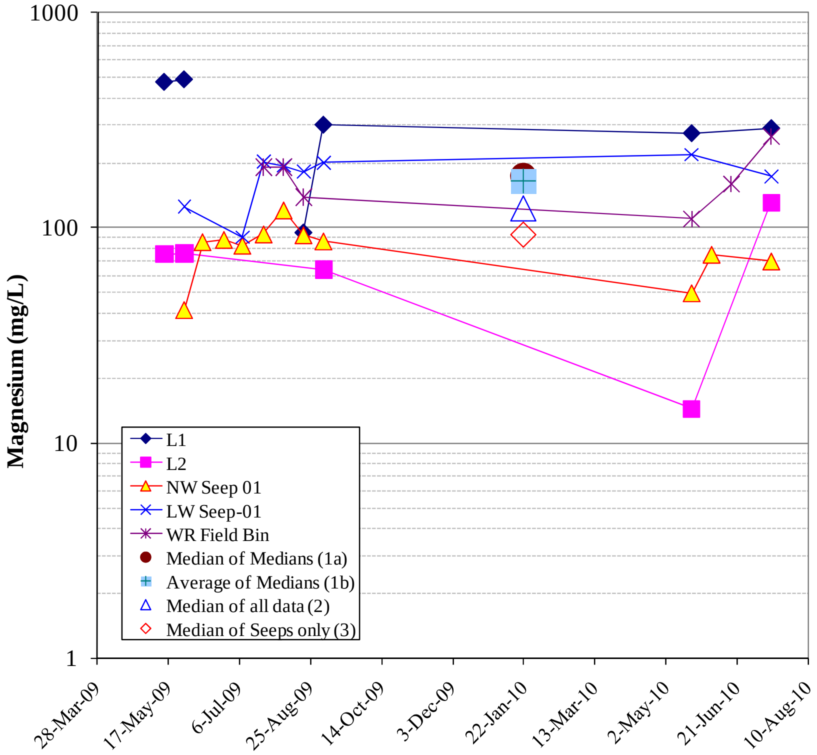


Figure 4-12: Dissolved Magnesium Concentrations in Mt. Nansen Waste Rock Seeps, Lysimeters and Field Bin Leachate for 2009 and 2010 Field Seasons

<u>“Worst Case” Source Term Development</u>

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.

<u>“Conservative Best Estimate” Saturated Source Term Development</u>

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

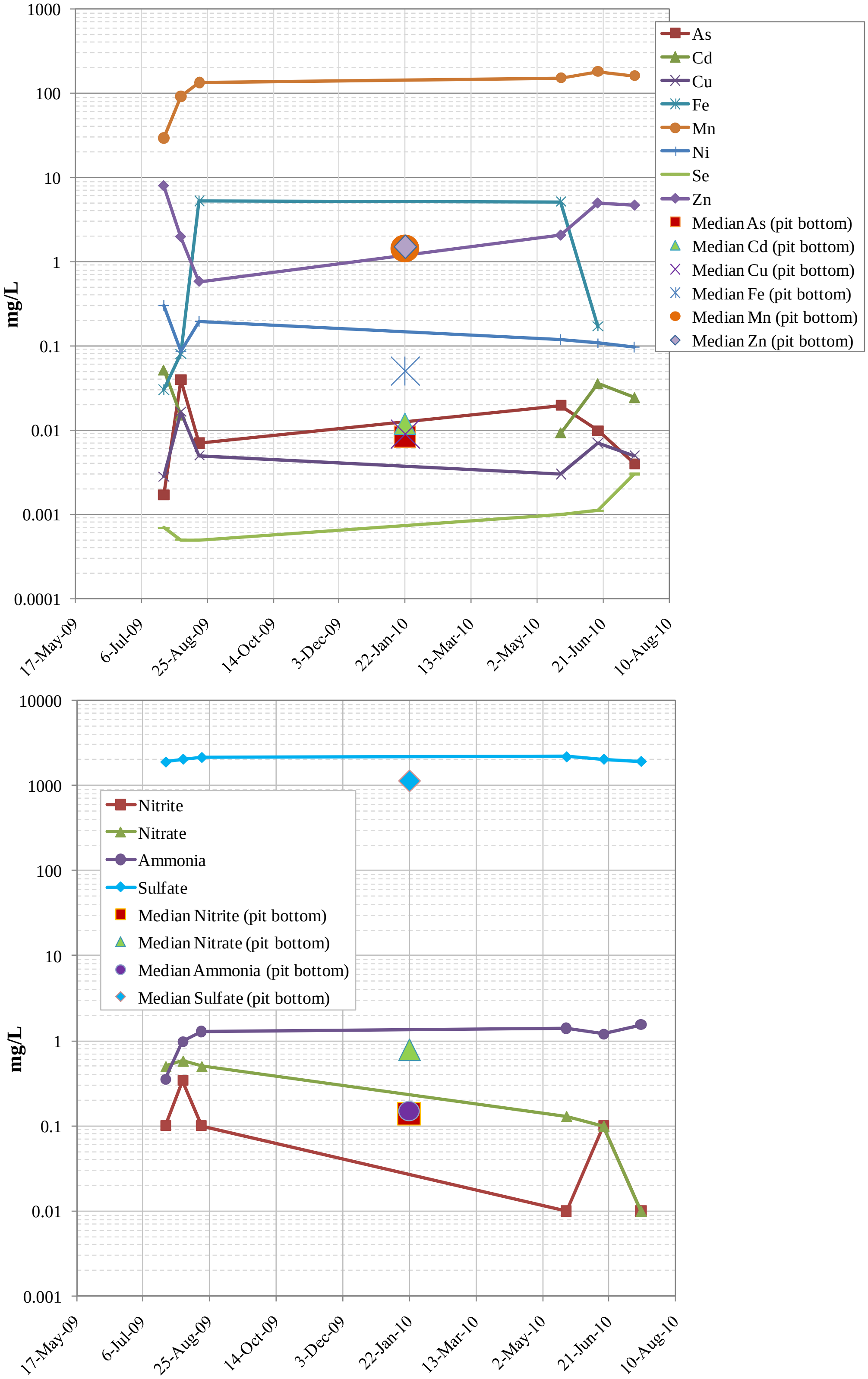


Figure 4-13: Composition of Leachate from the Saturated Waste Rock Field Column (2009 and 2010) and Median Water Quality Values from Brown-McDade Pit Bottom Waters

"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. 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). 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. 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). Summary statistics of the 2009 data set 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.

Table 5-2:
ABA Results for Tailings Humidity Cell Sub-samples Compared to ABA Statistics for Tailings Composite Samples (2009) According to Particle Sizes

Parameter	**Unit**	***Clay (2009 Statistics)***				***Silty Clay (2009 Statistics)***				***Sandy Silt (2009 Statistics)***				***Lorax Humidity Cells***		
		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		7.7	7.7	7.5	5	7.9	7.4	7	6	7.4	7.2	6.8	4	8	7.5	8.1
TIC	%	0.63	0.36	0.25	5	0.7	0.19	0.1	6	0.8	0.5	0.25	4	0.44	0.36	0.34
Total S	%	3	1.5	1.1	7	3.3	2	0.04	6	7.3	4.6	0.57	5	2.28	4.85	2.22
Sulfate S	%	1.6	1	0.8	7	1.5	0.23	0.01	6	0.82	0.54	0.44	5	1.22	0.72	0.74
Sulfide S	%	1.7	0.34	0.03	7	2.2	0.4	0.02	6	6.7	3.4	0.11	5	0.98	3.84	1.06
Insoluble S	%													0.08	0.29	0.42
Non-Sulfate S	%	1.9	0.5	0.12	7	2.6	0.44	0.03	6	6.9	3.9	0.12	5	1.06	4.13	1.48
CaNP	kgCaCO$_3$/t	53	30	21	5	58	16	4.2	6	67	41	21	4	36.7	30	28.3
Bulk NP	kgCaCO$_3$/t	54	33	31	5	58	24	13	6	58	39	21	4	42.1	31.5	34.3
SAP	kgCaCO$_3$/t	52	10	0.9	7	68	13	0.6	6	209	106	3.4	5	30.6	120	33.1
AP	kgCaCO$_3$/t	58	16	3.8	7	80	14	0.9	6	216	122	3.8	5	33.1	129	46.3
NPR (CaNP/AP)		1.6	1.3	0.7	5	4.4	1.7	0.4	6	0.5	0.3	0.1	4	1.1	0.2	0.6
NPR (Bulk NP/AP)		2.1	1.8	0.8	5	13.5	4.2	0.5	6	0.5	0.3	0.1	4	1.3	0.2	0.7

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) and Tailings Component Samples

		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		8.1	7.9	7.5	7.1	6.8	18	6	7.3	6.95	6.56	6.15	4.35
Total C	%	NA	NA	NA	NA	NA		1.21	0.81	0.37	0.46	0.37	23.3
Organic C	%	NA	NA	NA	NA	NA		0.23	0.01	0.09	0.08	0.08	23.1
TIC	%	0.8	0.7	0.4	0.06	0.05	18	0.4	0.22	0.28	0.38	0.29	0.25
Total S	%	7.3	4.9	1.8	0.37	0.04	27	3.3	1.56	1.37	2.69	3.14	1.96
Sulfate S	%	1.6	1.2	0.8	0.14	0.01	27	0.78	0.2	0.27	0.67	0.7	0.18
Sulfide S	%	6.7	3.8	0.7	0.03	0.02	27	2.31	1.17	0.94	1.85	1.56	0.77
Insoluble S	%							0.21	0.19	0.16	0.17	0.88	1.01
Non-Sulfate S	%	6.9	4.3	0.8	0.1	0.03	27	2.52	1.36	1.1	2.02	2.44	1.78
CaNP	kgCaCO$_3$/t	66.7	56.6	29.2	5	4.2	18	33.3	18.3	23.3	31.7	24.2	20.8
Bulk NP	kgCaCO$_3$/t	58.1	55.3	33.2	14.8	12.7	18	34.5	18.1	20.8	34.8	27.5	4.8
SAP	kgCaCO$_3$/t	209	120	20.9	0.9	0.6	27	72.2	36.6	29.4	57.8	48.8	24.1
AP	kgCaCO$_3$/t	216	133	25.6	3	0.9	27	78.8	42.5	34.4	63.1	76.3	55.6
NPR	(CaNP/SAP)	6.7	5.3	0.9	0.2	0.1	18	0.5	0.5	0.8	0.5	0.5	0.9
NPR	(CaNP/AP)	4.4	2.8	0.7	0.2	0.1	18	0.4	0.4	0.7	0.5	0.3	0.4

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.

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).

Table 5-4:
Solid Phase Metals Results for Tailings Humidity Cell Sub-samples Compared to Statistics for Tailings Samples (2009)[1]

Metal	**Unit**	***Clay***			***Silty Clay***			***Sandy Silt***			***Lorax Humidity Cells***			**Average Crust Values[2]**
		(2009 Statistics, n = 7)			***(2009 Statistics, n = 6)***			***(2009 Statistics, n = 5)***						
		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 th percentile	Median	10th th 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)

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).

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 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	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	10	1.0	750	500	20-22
T2	tailings sand silt composite sample	28-Jul-09	10	1.0	750	500	20-22
T3	tailings silt clay composite sample	28-Jul-09	10	1.0	750	500	20-22
T4	carbonate depleted sub-sample of T1	11-Aug-09	8	1.0	750	500	20-22
T5	carbonate depleted sub-sample of T2	11-Aug-09	8	1.0	750	500	20-22
T6	carbonate depleted sub-sample of T3	11-Aug-09	8	1.0	750	500	20-22

Notes: Sampling Frequency: Weekly
Operation Procedure: Flood Leach
Sample Preparation for Flushing: Stirred
Column description: perforated plexiglass, inner diameter 21 cm, length 20.5 cm
Method Reference: MEND

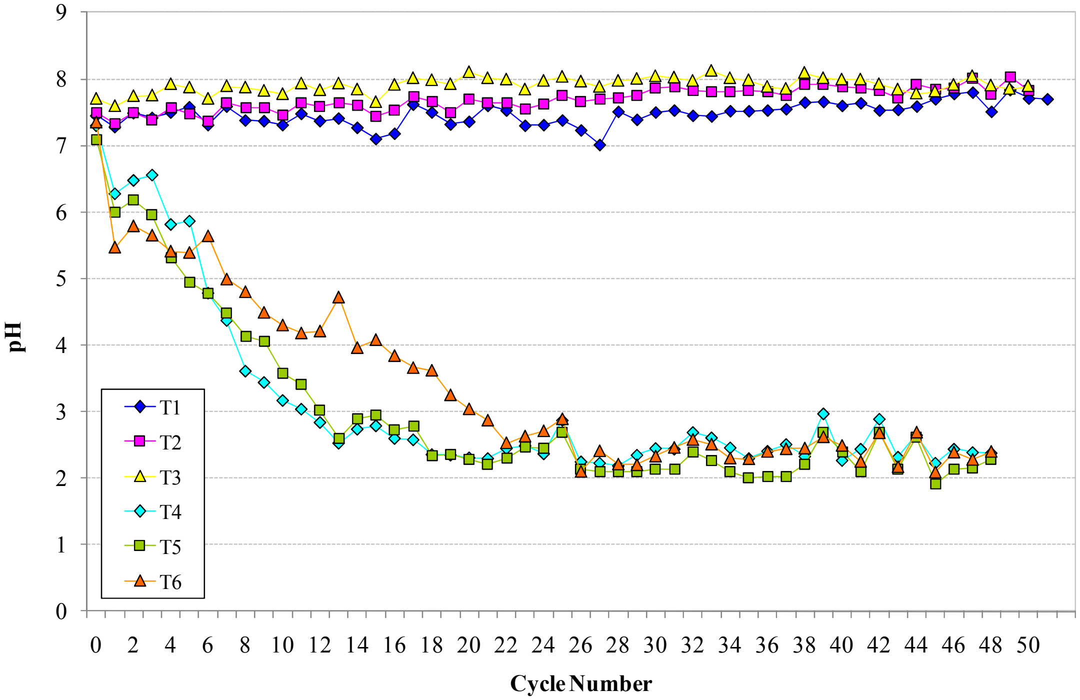
As previously discussed, split samples of humidity cells T1, T2 and T3 were each subjected to a sulfuric acid leach before commencing the laboratory experiments with the intention of removing carbonate minerals, and thereby CaNP, as well as secondary sulfate products. The removal of CaNP from tailings 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 50 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 during the first 26 weeks. 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).



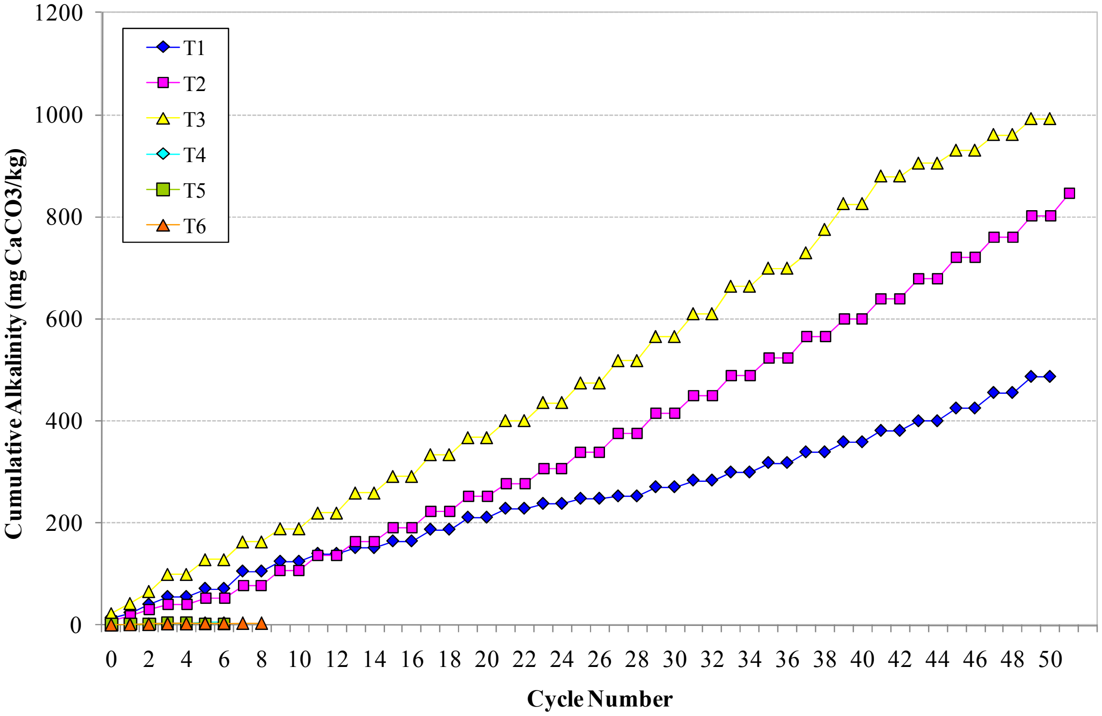


Figure 5-1: **pH and Cumulative Alkalinity Loads in Tailings Humidity Cell Leachate**

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:

- exsolution of carbon dioxide gas;
- contribution of Ca and Mg from non-carbonate minerals; or,

- 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, and SO_4, which can be used to calculate the carbonate molar ratio (CMR):

$$CMR = \frac{\left[Ca^{2+}\right]\left[Mg^{2+}\right]}{\left[SO_4^{2-}\right]}$$

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.

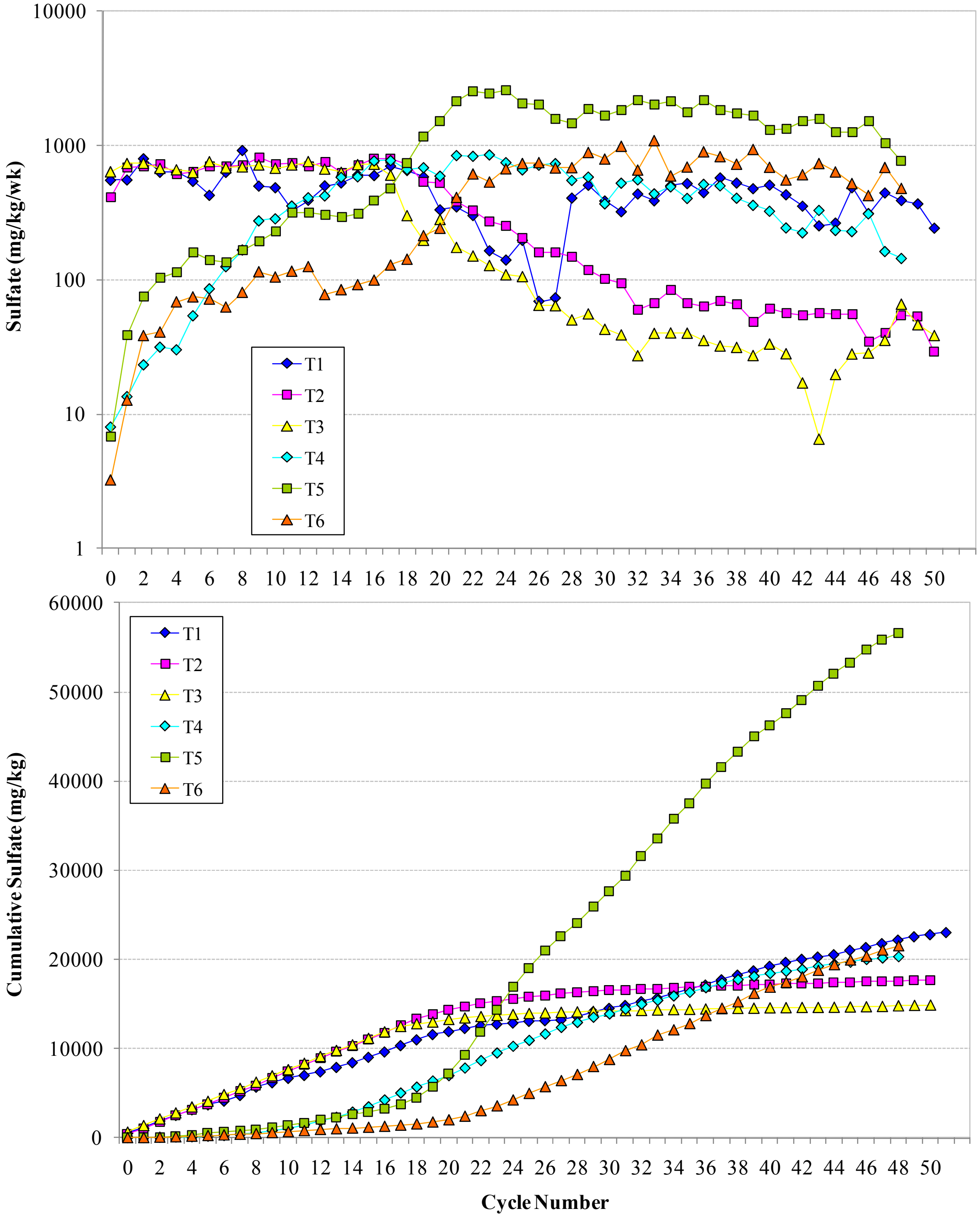


Figure 5-2: Weekly Sulfate Production and Cumulative Sulfate Loading from Tailings Humidity Cells

Concentrations of sulfate in leachate from T1, T2 and T3 are initially high (>500 mg/L), consistent with high initial sulfate-sulfur concentrations (Table 5-4) 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 near 50 mg/kg/wk for the last 20 cycles of the experiments. After cycle 28, sulfate production in leachate from T1 (clay tailings) increases again and remains between 250 and 500 mg/kg/wk for the last 20 cycles. 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).

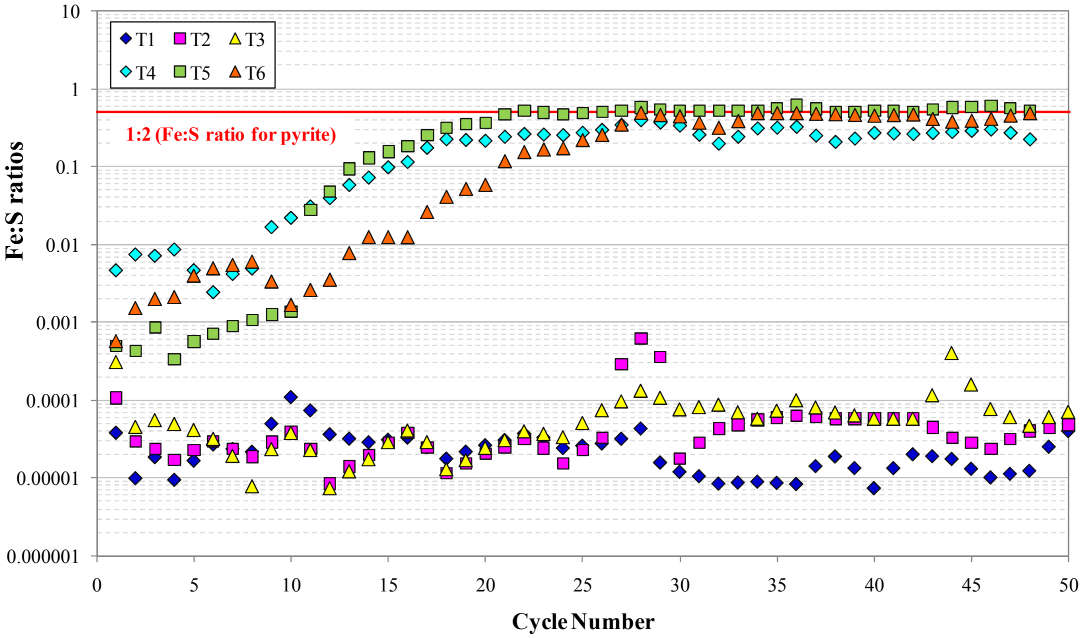


Figure 5-3: Fe:S (umol/kg) Ratios in Leachate from Tailings Humidity Cells

Table 5-9 provides the average sulfate production rates for the Mt. Nansen tailings humidity cell samples, as obtained from the final five cycles of available data (*i.e.*, cycles 45 through 49). 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	Sulfate Production[1] (mg/kg/wk)	Initial Solid-Phase Non-Sulfate-S[2] (%)	Initial Solid-Phase Sulfate-S (%)
T1	401	1.06	1.22
T2	47.7	4.13	0.72
T3	41.1	1.48	0.74
T4	254	1.06	1.22
T5	1336	4.13	0.72
T6	602	1.48	0.74

Notes: 1. Average value obtained from the last five weeks of available data
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 0.001 during the test, consistent with pH values (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 from after the first 25 cycles.

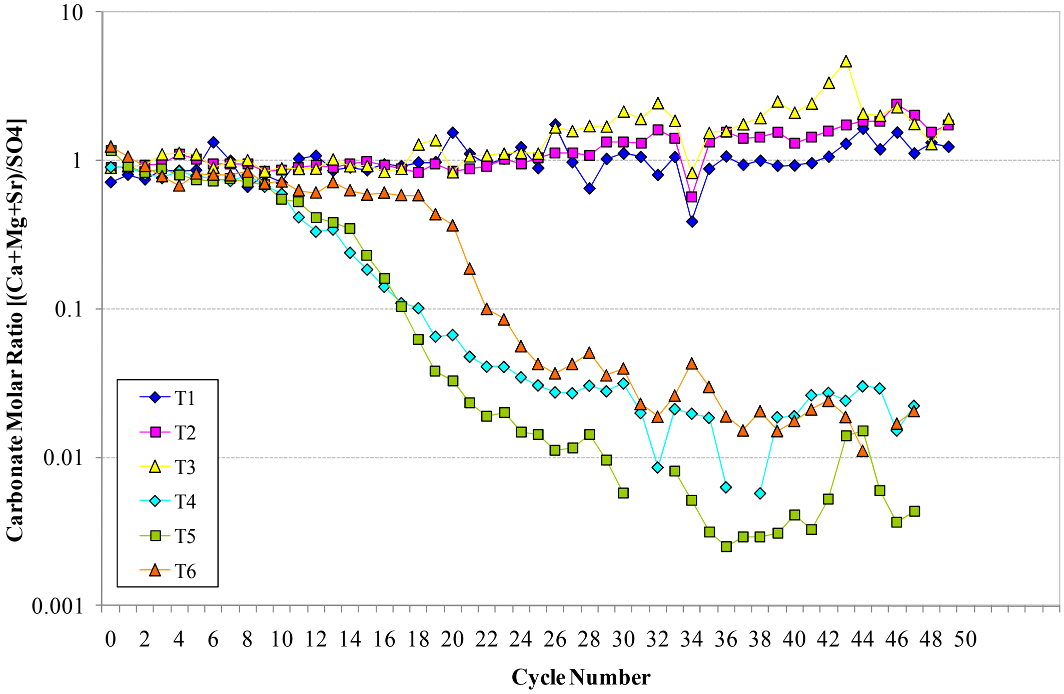


Figure 5-4: Carbonate Molar Ratios for Tailings Humidity Cell Leachate

The Release rates for silicon and aluminum for the Mt. Nansen tailings humidity cells are presented in Figure 5-5. 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 samples.

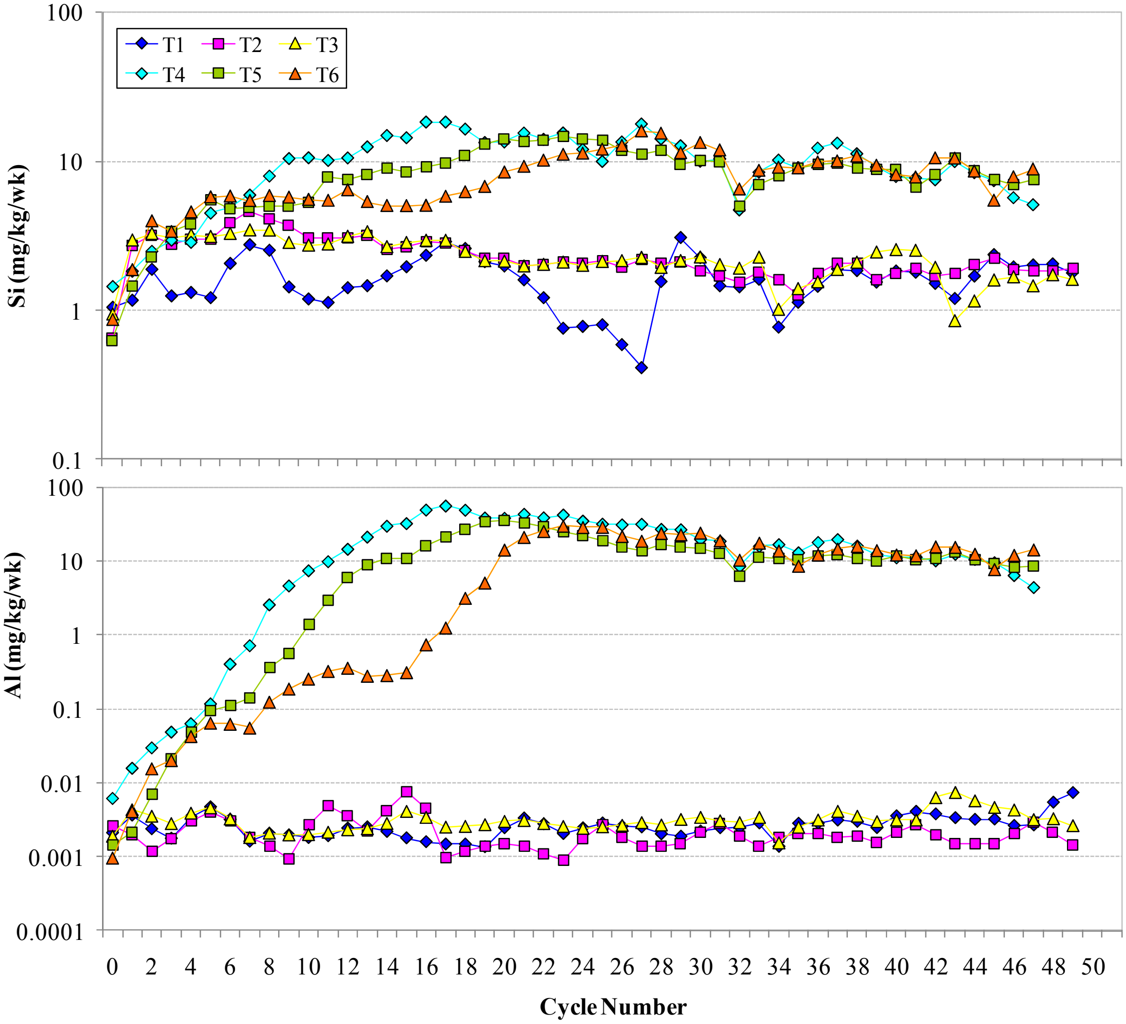


Figure 5-5: Silicon and Aluminum Production in Leachate from Tailings Humidity Cell Tests

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 between half a year and 3 years (in addition to the 49 weeks of the experiment) 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:
Estimated Time to Depletion of CaNP in Tailings Humidity Cells

Humidity Cell	Initial CaNP[1]	CaNP remaining after HC test		Average Consumption rate		Time to depletion[6]	
	kg $CaCO_3$/t	% of initial[2]	kg $CaCO_3$/kg sample[3]	mg $CaCO_3$/kg /wk[4]	kg $CaCO_3$/kg/ wk[5]	weeks	years
T1	36.67	38.0%	0.0139	527.56	0.000528	26	0.51
T2	30.00	40.0%	0.0120	92.26	0.000092	130	2.50
T3	28.33	44.0%	0.0125	75.37	0.000075	165	3.18

Notes:
1. From Table 5-2
2. From Appendix B1
3. = initial CaNP * % of initial ÷ 1,000 kg of sample
4. Calculated as the average of the final five humidity cell values
5. = mg $CaCO_3$/kg/wk ÷ 1,000,000 mg/kg
6. = (CaNP remaining after HC test) ÷ average leaching rate

5.4.1.3 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.

As discussed, humidity cell leachate concentrations represent primary metal release rates with no consideration given to the influence of field conditions that govern the actual metal concentrations in mine drainage. 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 the value of detection.

Table 5-11 and Figure 5-6 present the average metal release rates calculated from the final five test cycles of available data for the Mt. Nansen tailings humidity cells. Note that the blue print values in the table indicate that at least three of the five analyses used in the calculation of the final average leaching rate were reported to be below the detection limit.

Figures 5-7 through 5-17 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 experiment. Concentrations of As (< 100 mg/L), Zn (< 100 mg/L) and Fe (< 1000 mg/L), 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 sulfide-sulfur concentrations (4.85 mg/L and 3.84 mg/L, respectively, Table 5-4) 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 T2 and T3 (constant between 0.1 and 1 mg/L) and the other cells remaining < 0.1 mg/L, particularly, T4.

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 indicated for this sample relative to the other cell samples, enhanced by the finer particle size of cell sample T1.

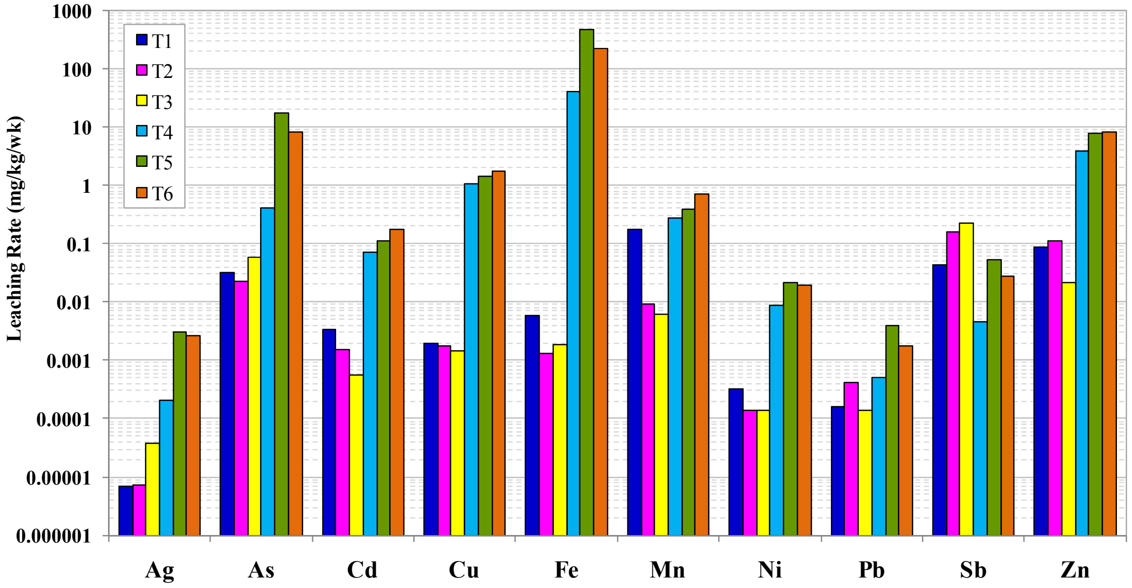


Figure 5-6: **Average Metal (Ag, As, Cd, Cu, Fe, Mn, Pb, Ni, Sb and Zn) Release Rates from Final Five Weeks of Tailings Humidity Cell Testing**

Table 5-11: Average Leaching Rates (mg/kg/wk) from Final Five Test Cycles for Tailings Humidity Cells[1]

Parameter	T1	T2	T3	T4	T5	T6	CCME Max[2]
pH	7.7	7.9	7.9	2.4	2.2	2.3	
SO_4	401	47.7	41.1	254	1336	602	*100*
Ag	**0.000007**	**0.000007**	**0.000038**	**0.0002**	**0.0030**	**0.0026**	0.0001
Al	0.0043	0.0020	0.0036	8.71	9.85	12.5	0.1
As	**0.033**	**0.022**	**0.059**	**0.419**	**17.3**	**8.25**	0.005
Ba	0.0060	0.0109	0.0157	0.0021	0.0017	0.0016	
Be	<0.00002	<0.000004	<0.000004	0.0009	0.0007	0.0009	
Bi	**<0.00001**	**<0.000002**	**<0.000002**	**<0.00002**	**0.0004**	**<0.0002**	
Ca	194	25.8	26.8	1.40	5.41	2.41	
Cd	**0.0033**	**0.0015**	**0.0006**	**0.072**	**0.11**	**0.18**	0.000017a
Co	0.0030	0.0002	0.0003	0.014	0.055	0.036	*0.11*
Cr	<0.0002	<0.00001	0.00005	0.022	0.043	0.036	0.001b
Cu	**0.0019**	**0.0018**	**0.0015**	**1.05**	**1.42**	**1.73**	0.004c
Fe	0.0059	0.0013	0.0018	41.2	481	222	0.3d
K	1.66	0.33	0.44	<0.2	<1.3	<1.6	
Li	0.0036	0.0007	0.0008	0.0040	<0.01	<0.02	
Mg	10.3	6.75	2.07	0.67	<0.3	0.63	
Mn	**0.18**	0.009	0.006	**0.27**	0.40	0.73	0.2d
Mo	0.0009	0.0016	0.0015	0.0002	<0.0001	<0.002	0.073
Na	0.16	0.058	0.15	0.061	<1.3	<1.6	
Ni	0.0003	0.0001	0.0001	0.0086	0.0220	0.0194	0.15c
P	<0.0044	<0.0009	0.0021	0.045	1.77	0.454	
Pb	**0.0002**	**0.0004**	**0.0001**	**0.0005**	**0.0039**	**0.0017**	0.007c
Sb	**0.044**	**0.157**	**0.221**	**0.0046**	**0.052**	**0.028**	*0.02e*
Se	**<0.00009**	**0.00003**	**0.00008**	**0.00008**	**<0.0009**	**<0.0001**	0.001
Si	2.03	1.94	1.62	7.32	8.26	8.25	
Sn	0.0042	0.0025	0.0001	0.013	0.035	0.042	
Sr	0.20	0.039	0.036	0.013	0.020	0.015	
Ti	<0.001	<0.0002	<0.0002	<0.002	<0.01	<0.02	
Tl	0.00012	0.00003	0.00003	0.00002	0.00007	<0.00002	0.0008
U	0.0005	0.0001	0.0002	0.0020	0.0022	0.0026	*0.3*
V	<0.0004	<0.0001	<0.0001	0.0013	0.0218	0.0127	
Zn	**0.085**	**0.11**	**0.021**	**3.96**	**7.75**	**8.08**	0.03

Notes: 1. Bold values are metals which were elevated in aqua regia digestion (Table 5-5); and 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.

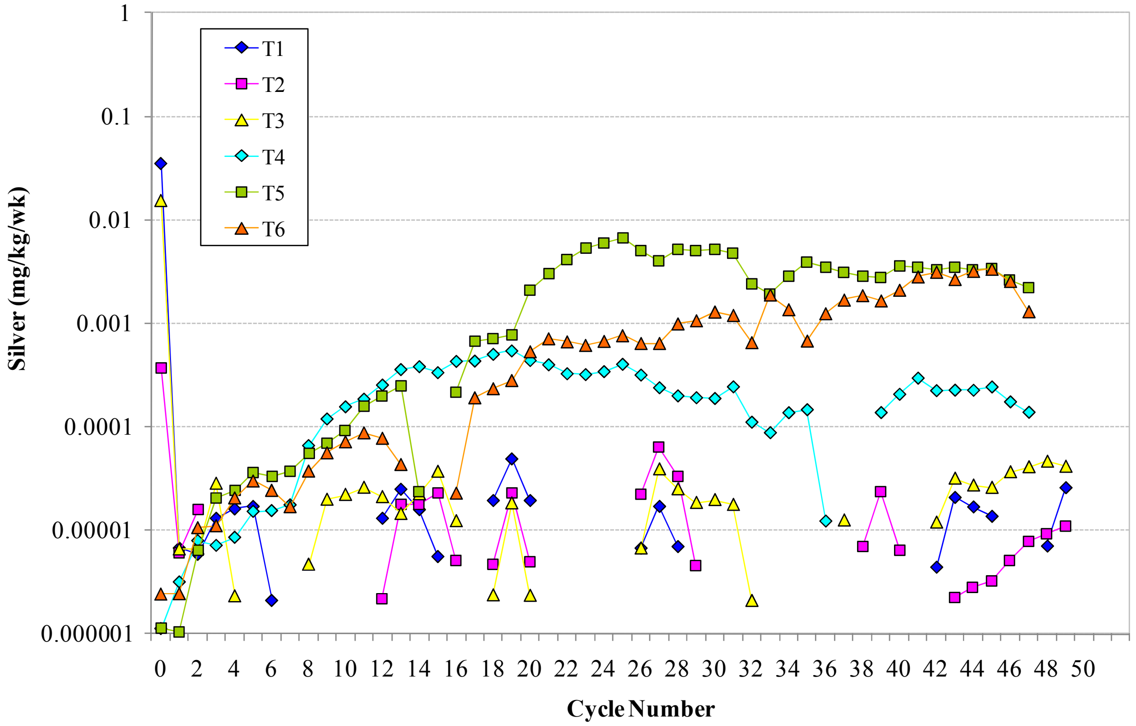


Figure 5-7: Weekly Silver Loads in Tailings Humidity Cell Leachate

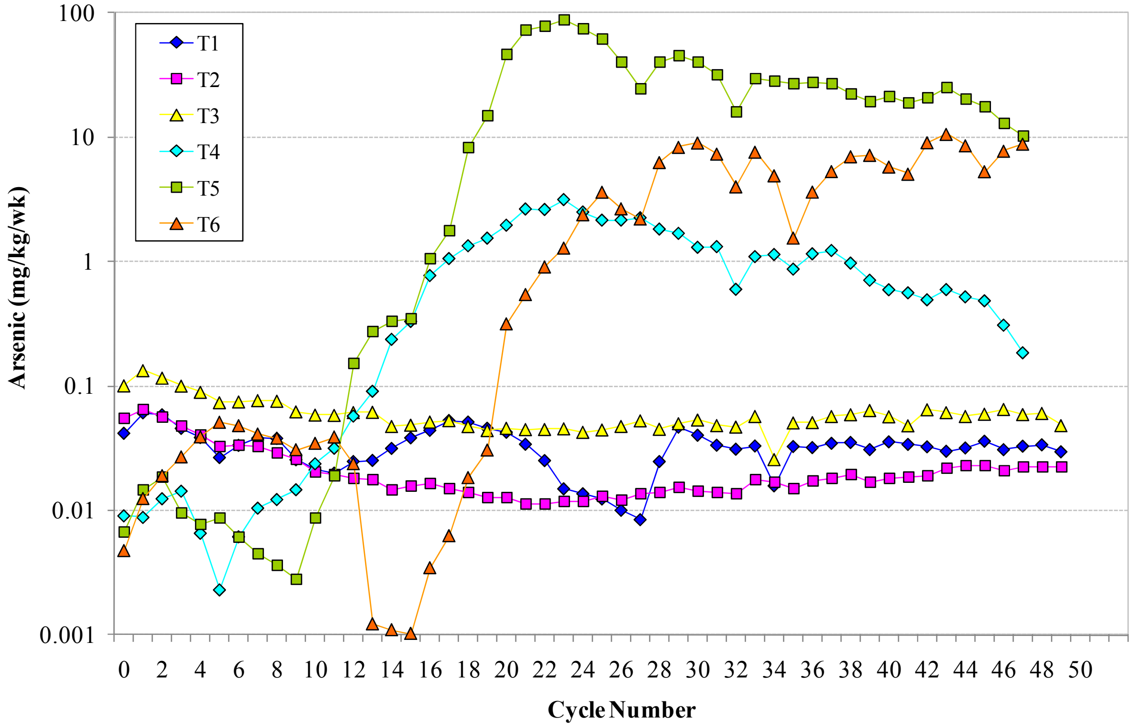


Figure 5-8: Weekly Arsenic Loads in Tailings Humidity Cell Leachate

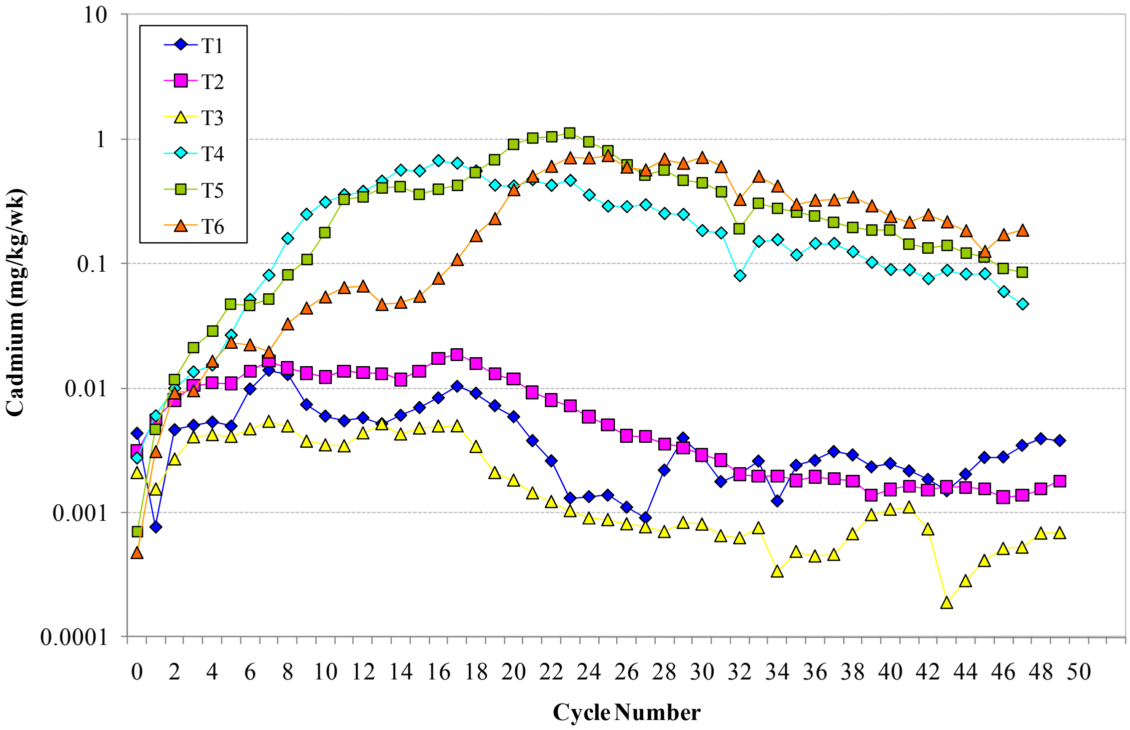


Figure 5-9: Weekly Cadmium Loads in Tailings Humidity Cell Leachate

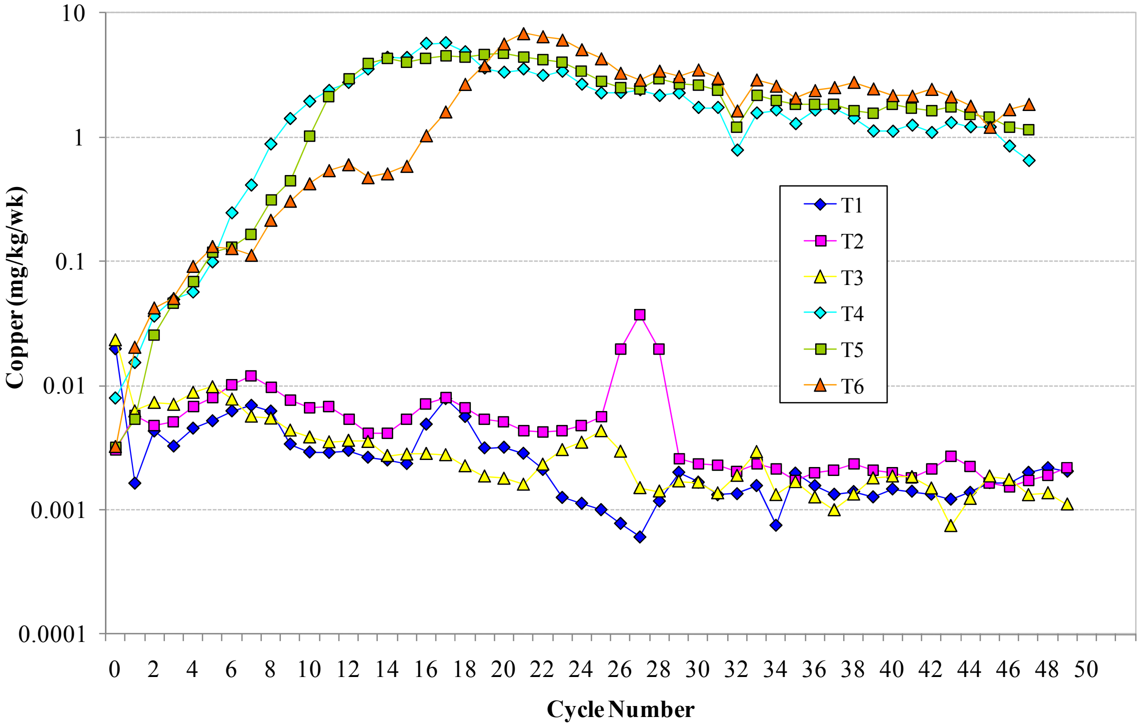


Figure 5-10: Weekly Copper Loads in Tailings Humidity Cell Leachate

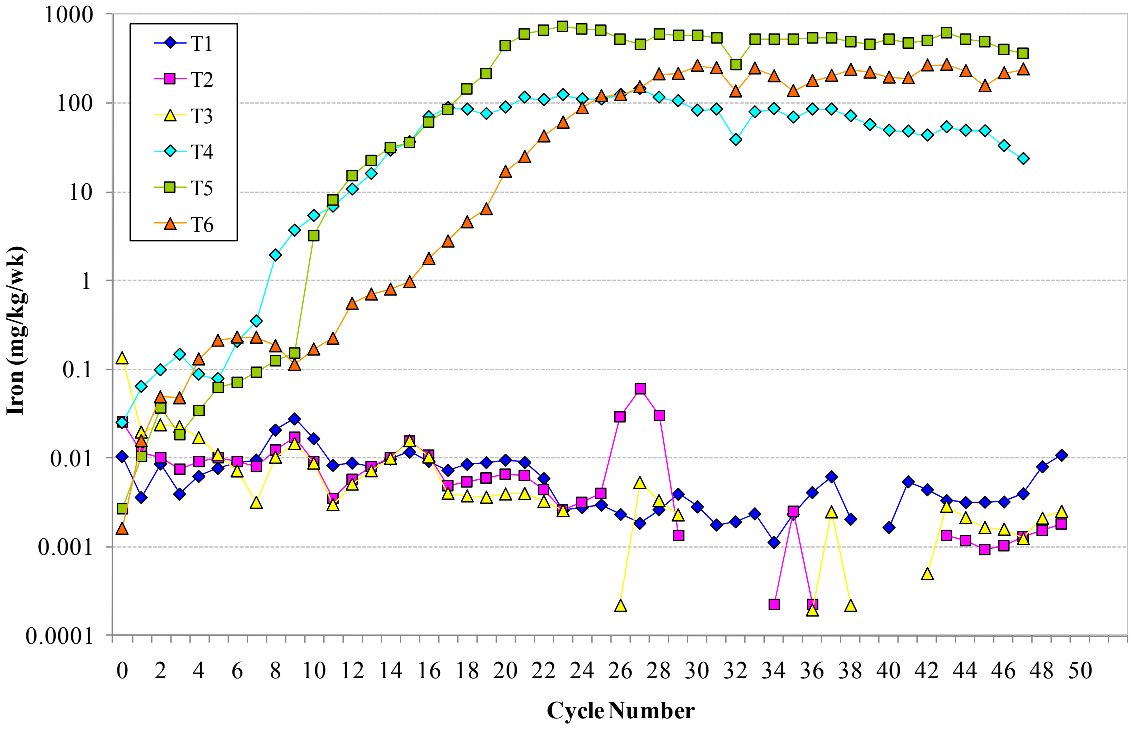


Figure 5-11: Weekly Iron Loads in Tailings Humidity Cell Leachate

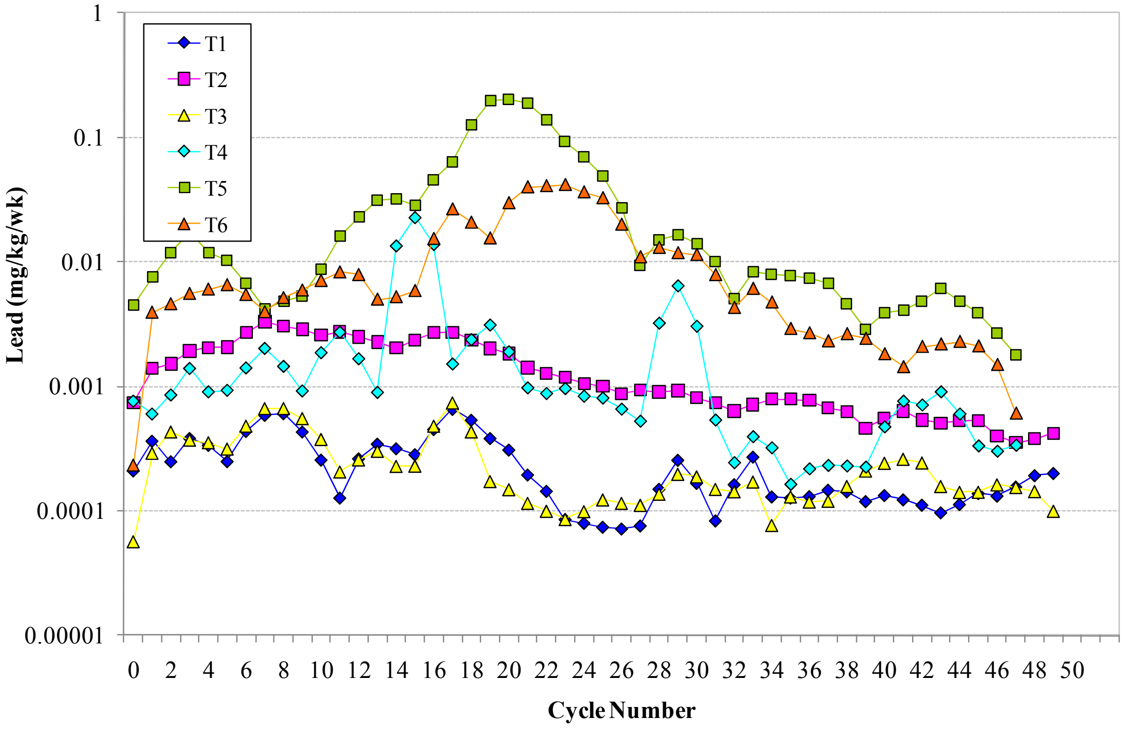


Figure 5-12: Weekly Lead Loads in Tailings Humidity Cell Leachate

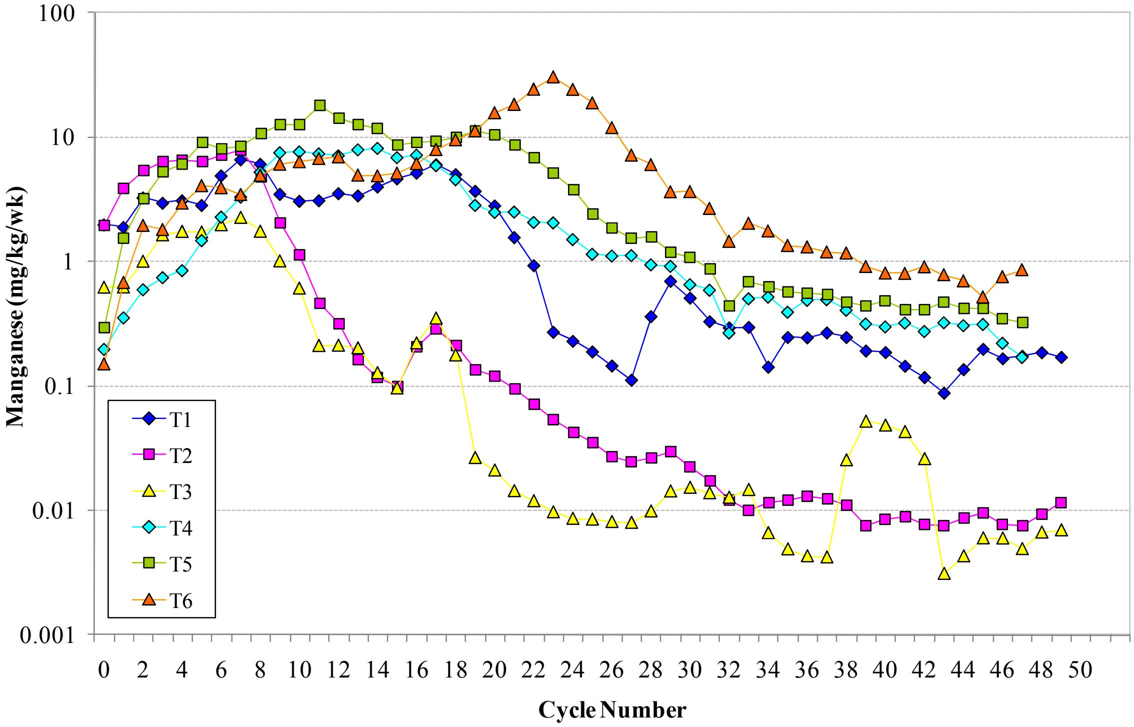


Figure 5-13: Weekly Manganese Loads in Tailings Humidity Cell Leachate

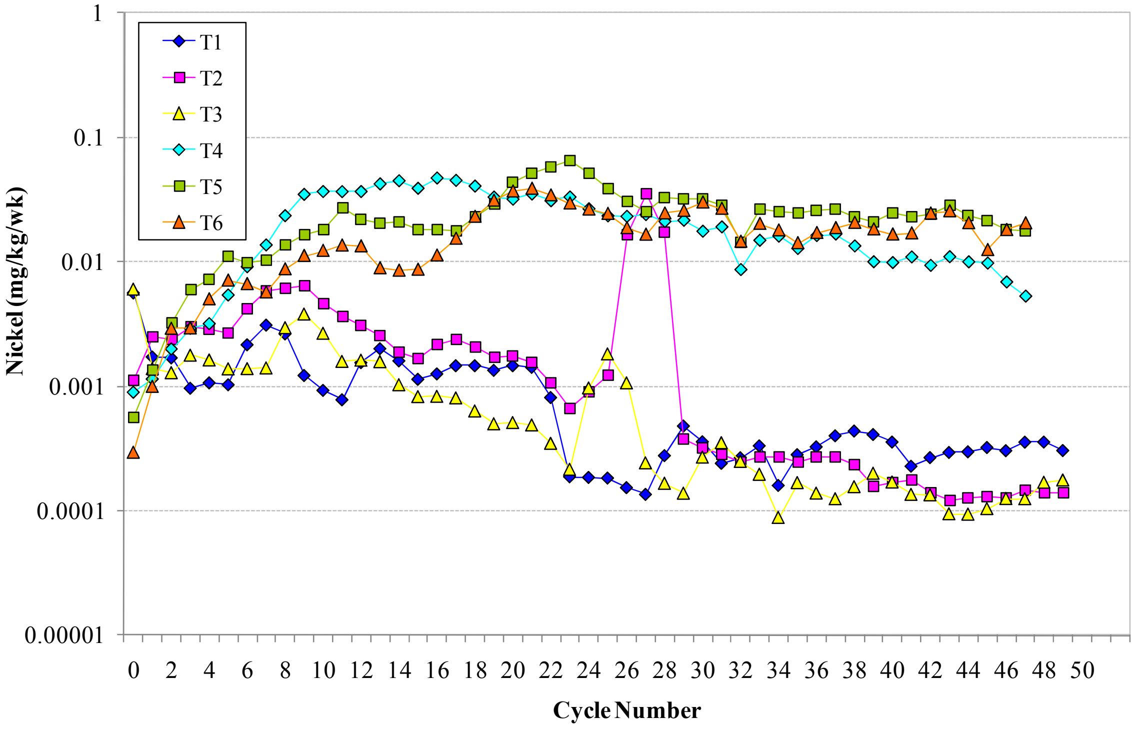


Figure 5-14: Weekly Nickel Loads in Tailings Humidity Cell Leachate

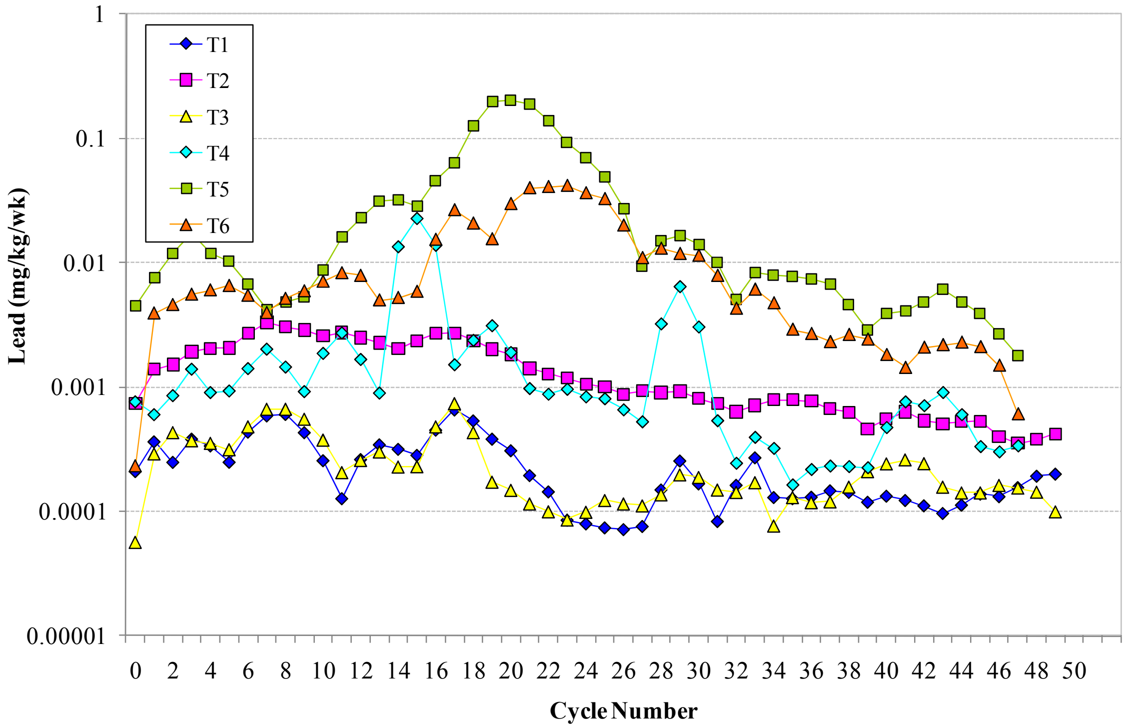


Figure 5-15: Weekly Lead Loads in Tailings Humidity Cell Leachate

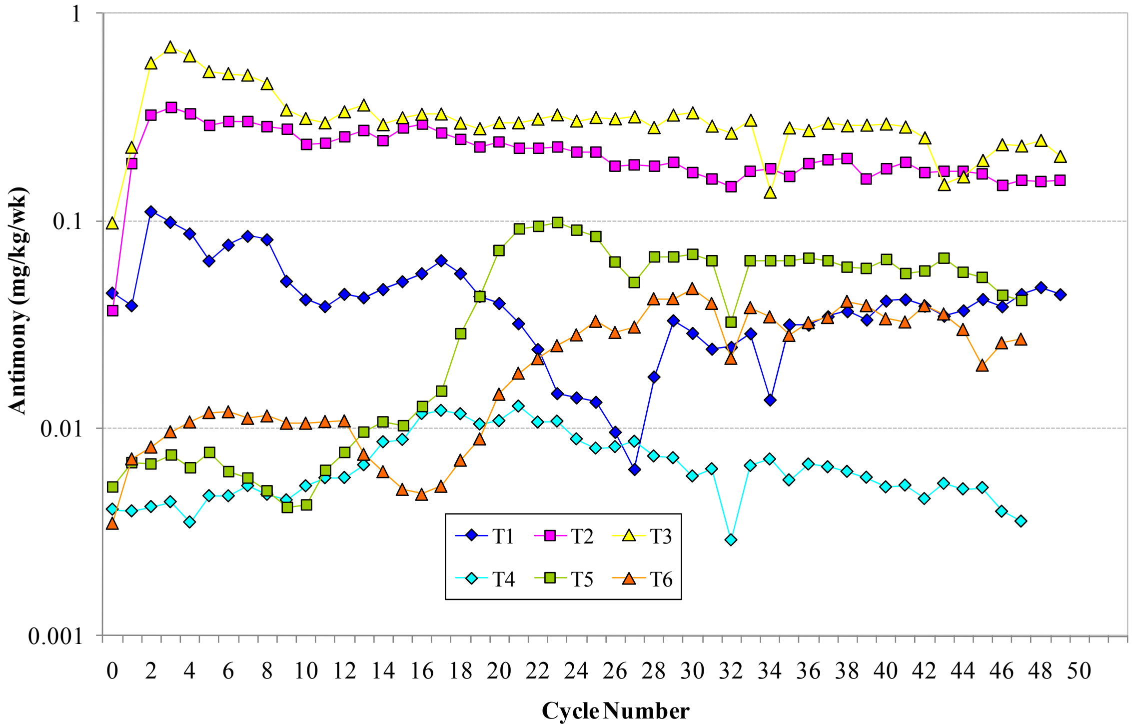


Figure 5-16: Weekly Antimony Loads in Tailings Humidity Cell Leachate

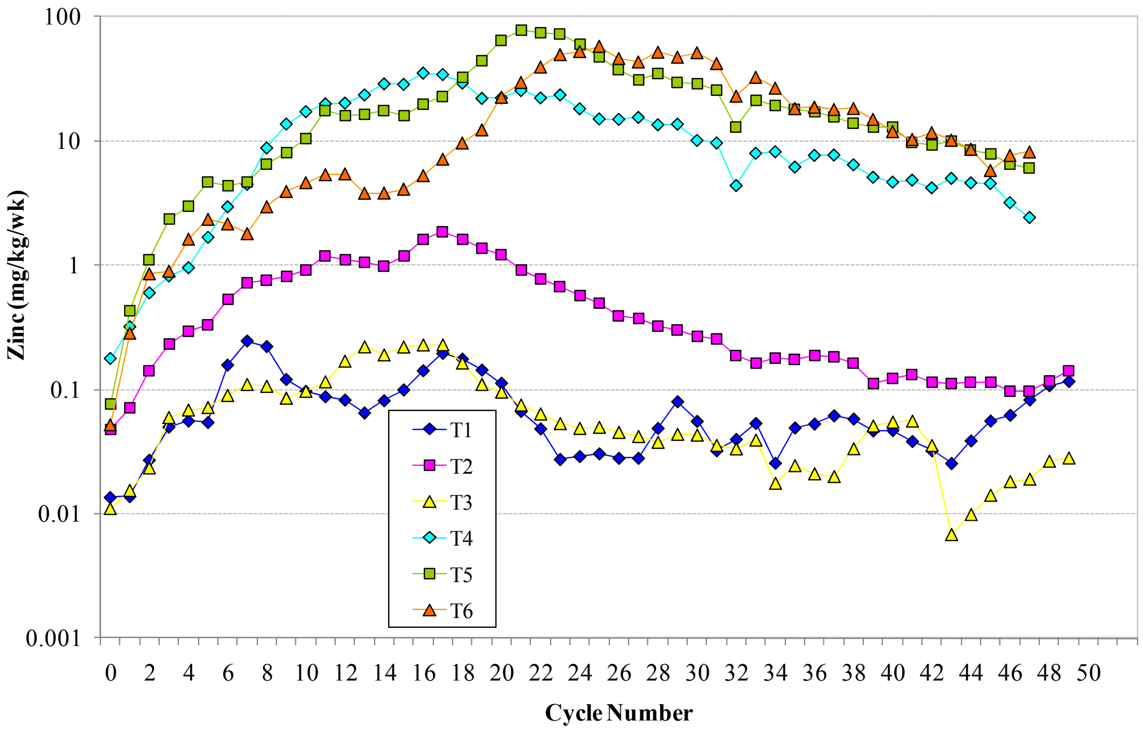


Figure 5-17: Weekly Zinc Loads in Tailings Humidity Cell Leachate

5.4.2 Field Bin Leachate

Two field kinetic tests were developed for the Mt. Nansen tailings. Table 5-12 presents the leachate results from the 2009 and 2010 tailings field bin sampling program. Also presented in Table 5-12 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 5-12 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 5-12 and Figure 5-18). 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).

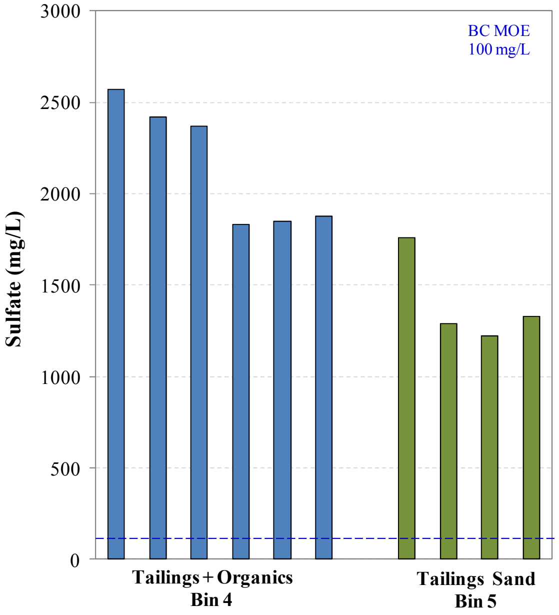


Figure 5-18: Concentrations of Sulfate in Leachate from the Tailings Field Bins

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 5-12). 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 5-19 and 5-20). 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 5-12; Figure 5-20). 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 5-12, Figures 5-19 and 5-20). 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 5-12:
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 5-12:
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.

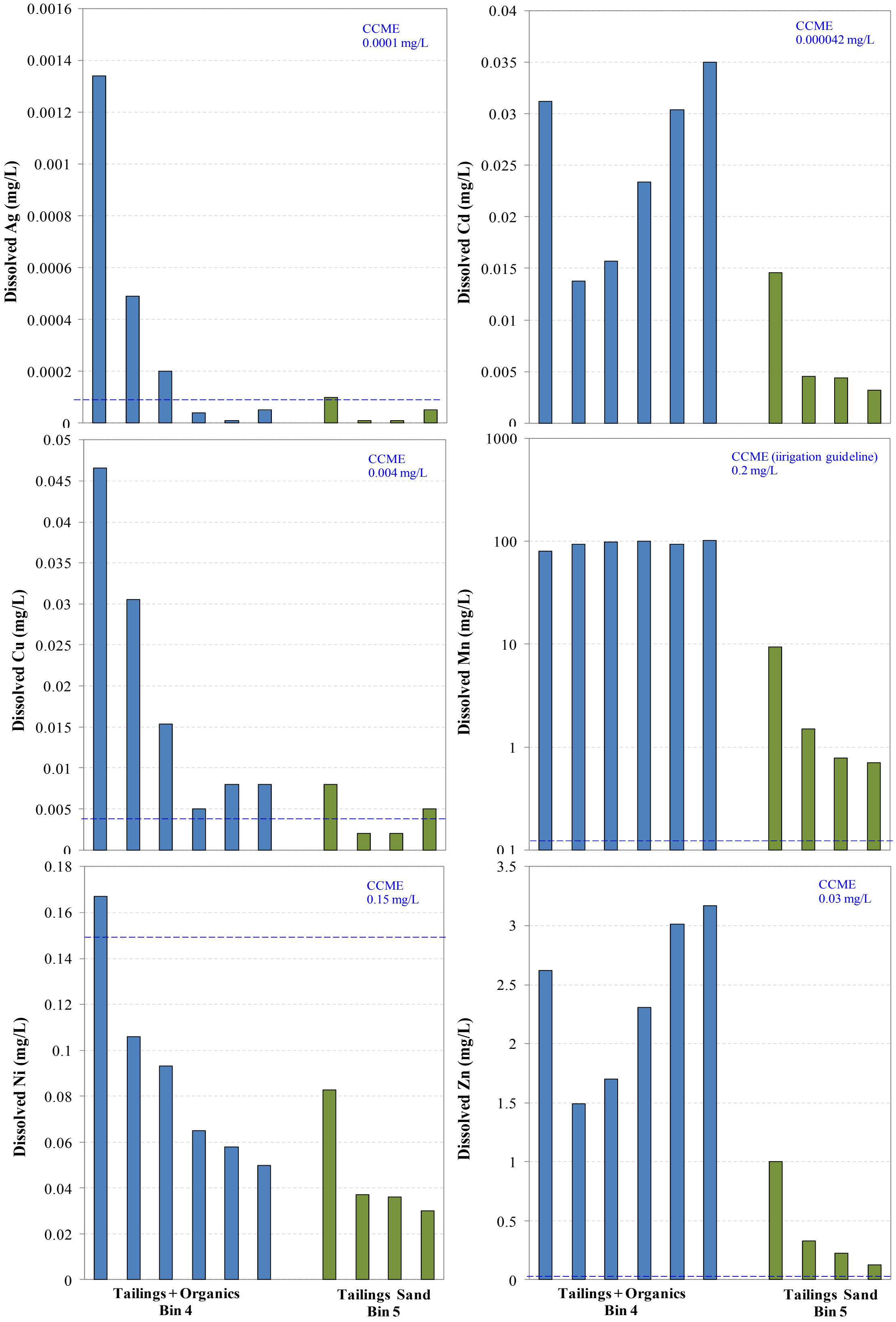


Figure 5-19: Dissolved Ag, Cd, Cu, Mn, Ni and Zn in Leachate from Tailings Field Kinetic Tests

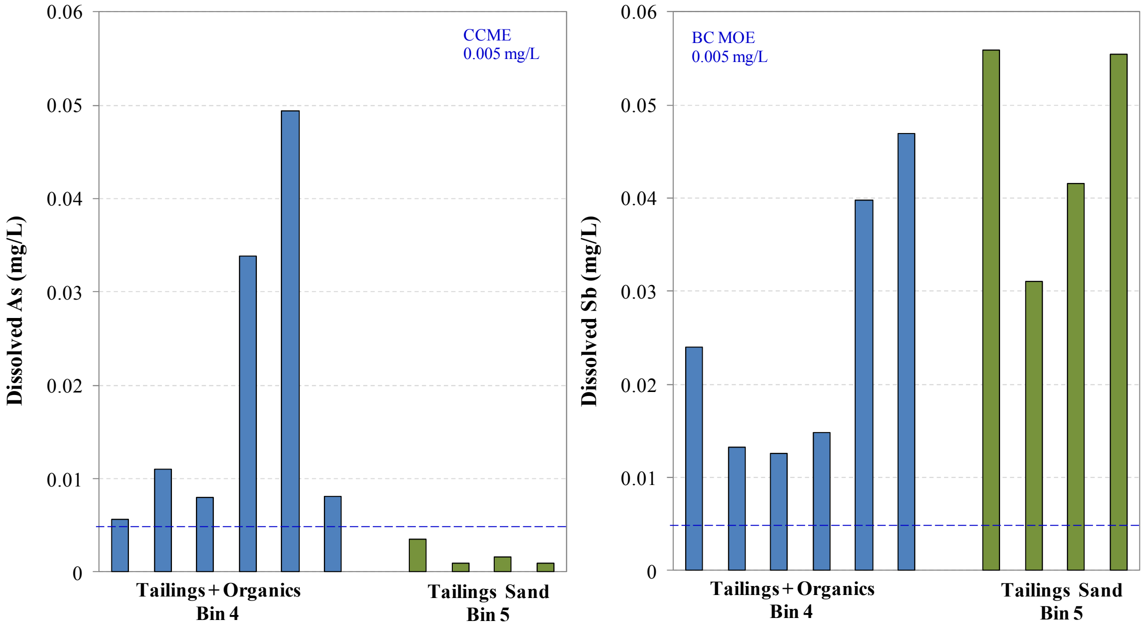


Figure 5-20: Dissolved As and Sb Concentrations in Leachate from Tailings Field Kinetic Tests

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 5-21 and 5-22) 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 5-21 and 5-22) 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 5-23). 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 5-24 and 5-25). For example, Fe and Mn (Figure 5-24) and alkalinity and ammonia (Figure 5-25) 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 5-13). 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 5-26 and 5-27, 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.

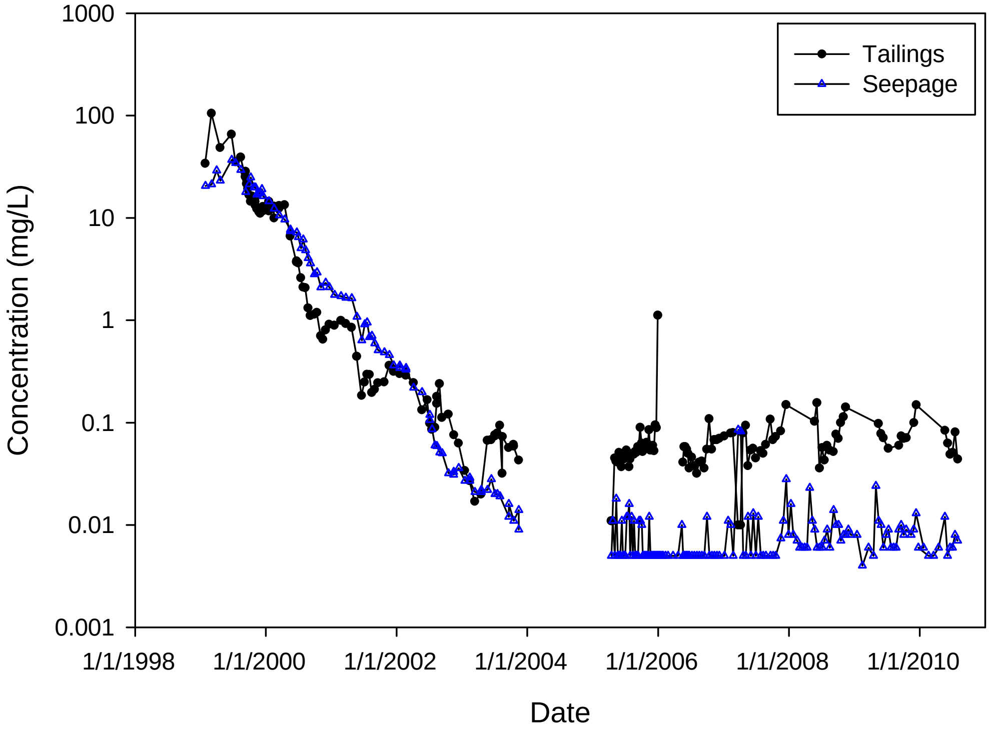


Figure 5-21: Time-series Copper Concentrations in Tailings and Seepage Ponds

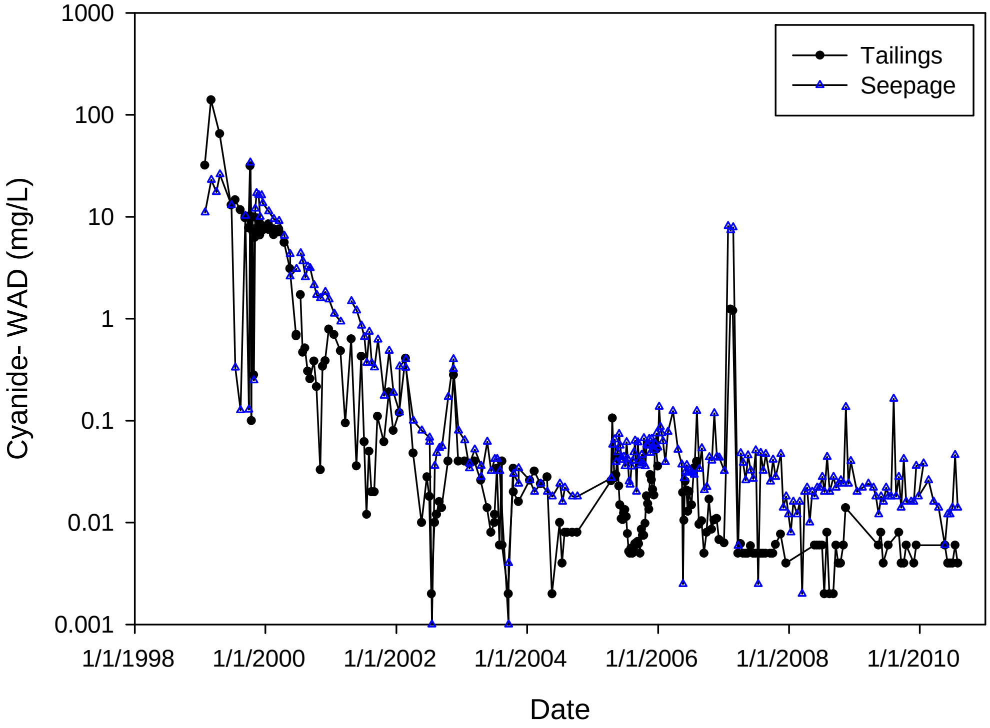


Figure 5-22: Time-series Cyanide Concentrations in Tailings and Seepage Ponds

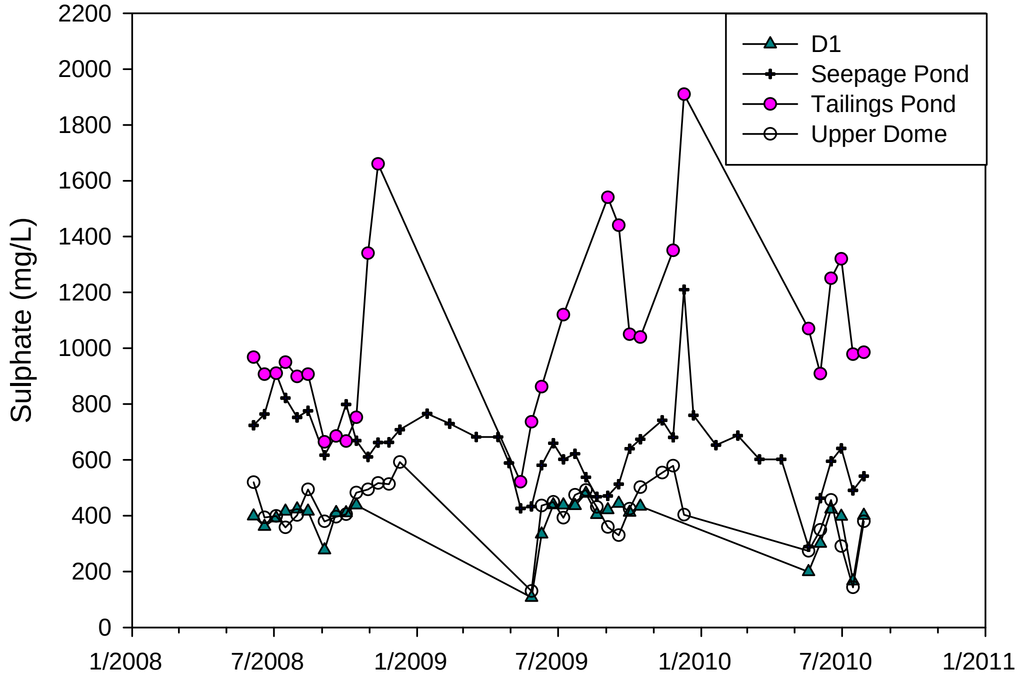


Figure 5-23: Time-series Sulfate Concentrations in the Tailings, Seepage Ponds and Dome Creek (D1)

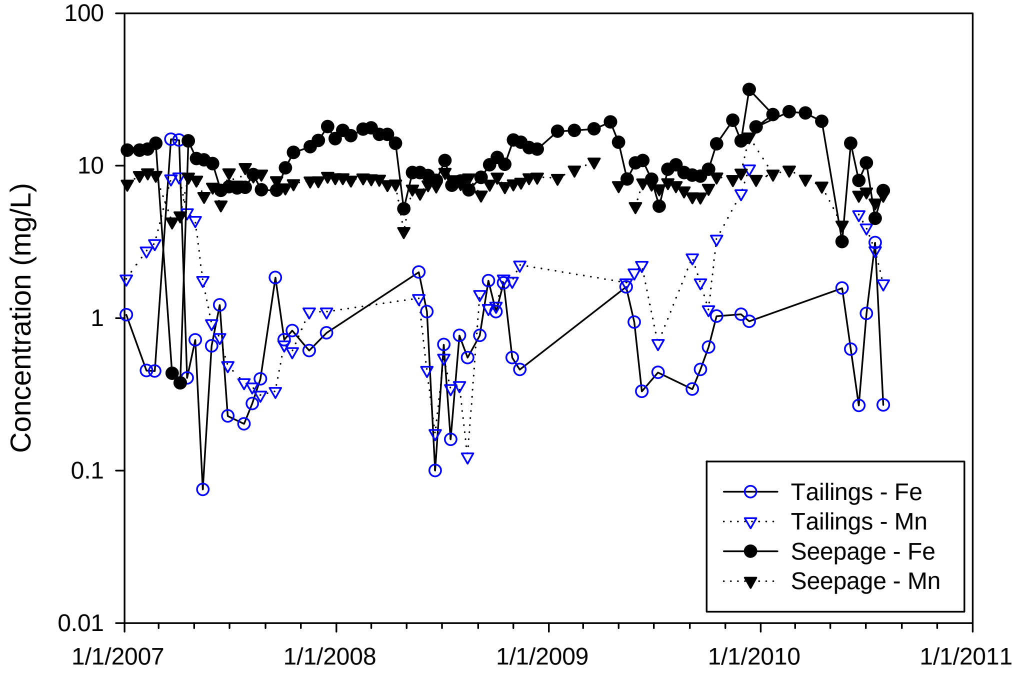


Figure 5-24: Time-series Iron and Manganese Concentrations in Tailings and Seepage Ponds

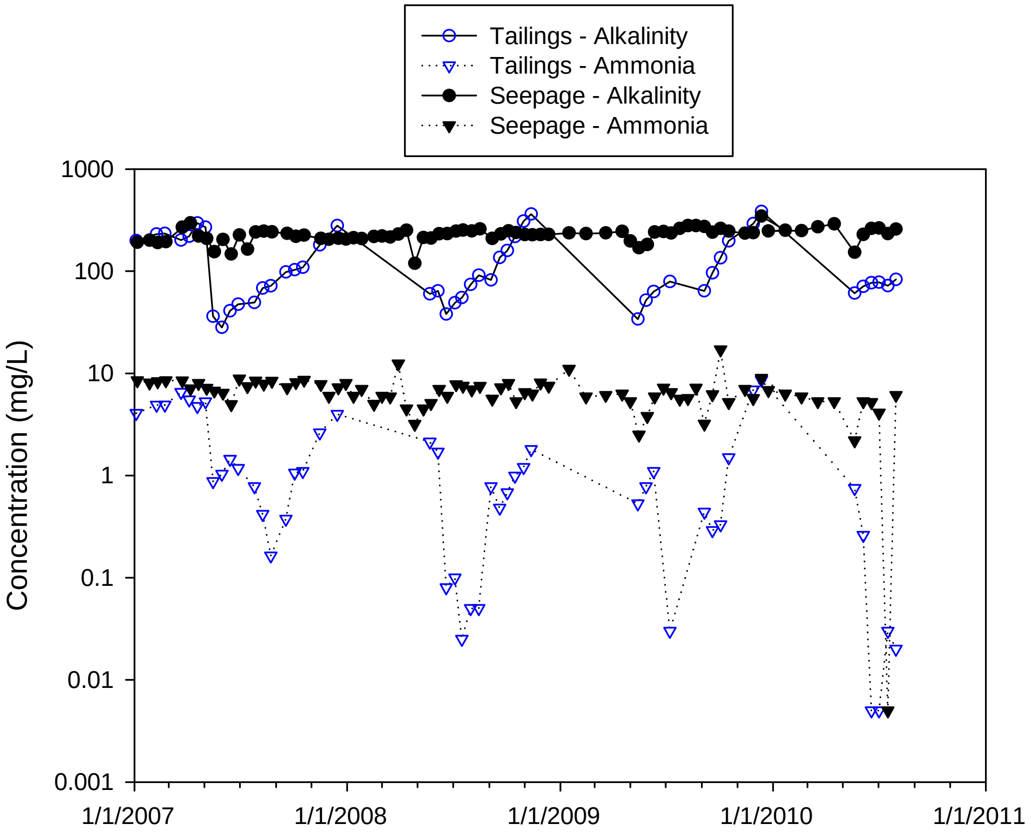


Figure 5-25: Time-series Alkalinity and Ammonia in Tailings and Seepage Ponds

**Table 5-13:
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		

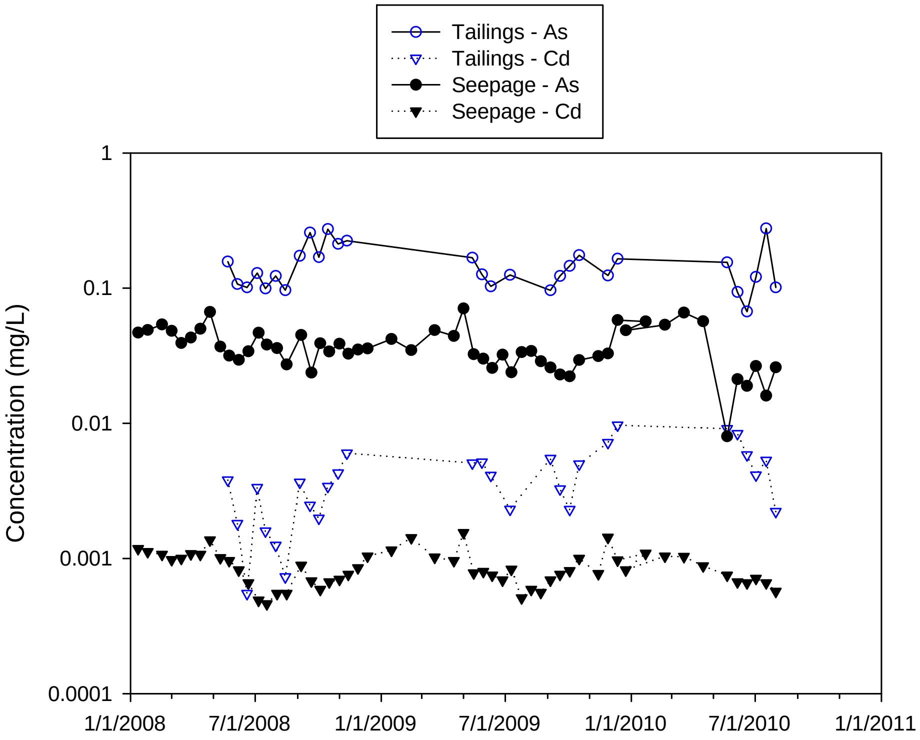


Figure 5-26: Time-series Arsenic and Cadmium Concentrations in Tailings and Seepage Ponds

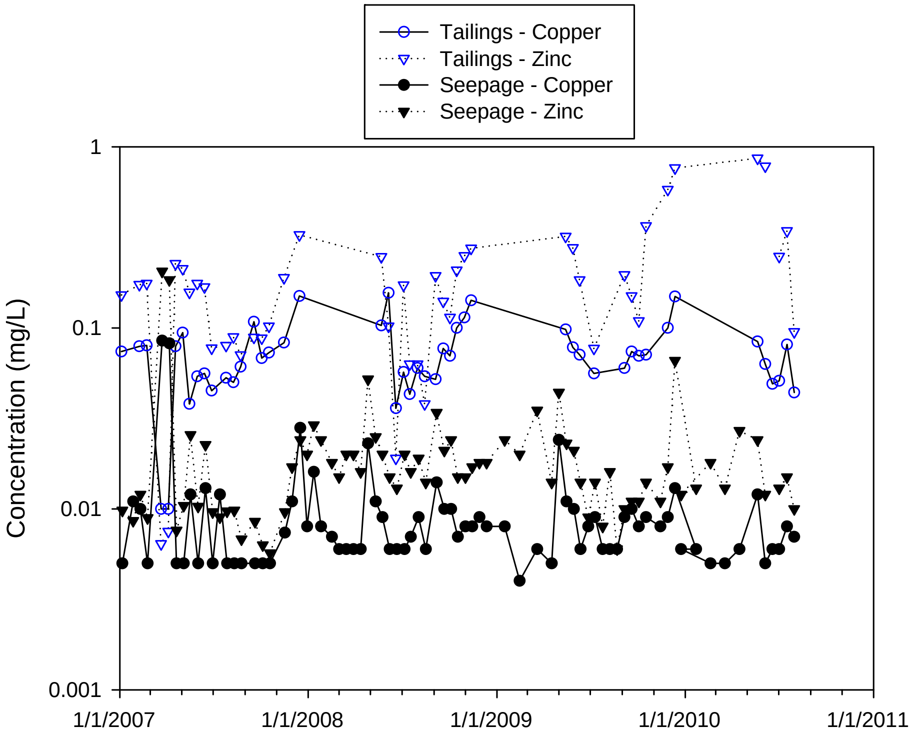


Figure 5-27: Time-series Copper and Zinc Concentrations in Tailings and Seepage Ponds

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 5-14.

Groundwater collected from all the tailings wells exceeded CCME guidelines for ammonia and arsenic (Table 5-14). 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 5-14) 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 5-13.

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 5-15).

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 5-14).

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 5-28.

Table 5-14:
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 5-15:
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

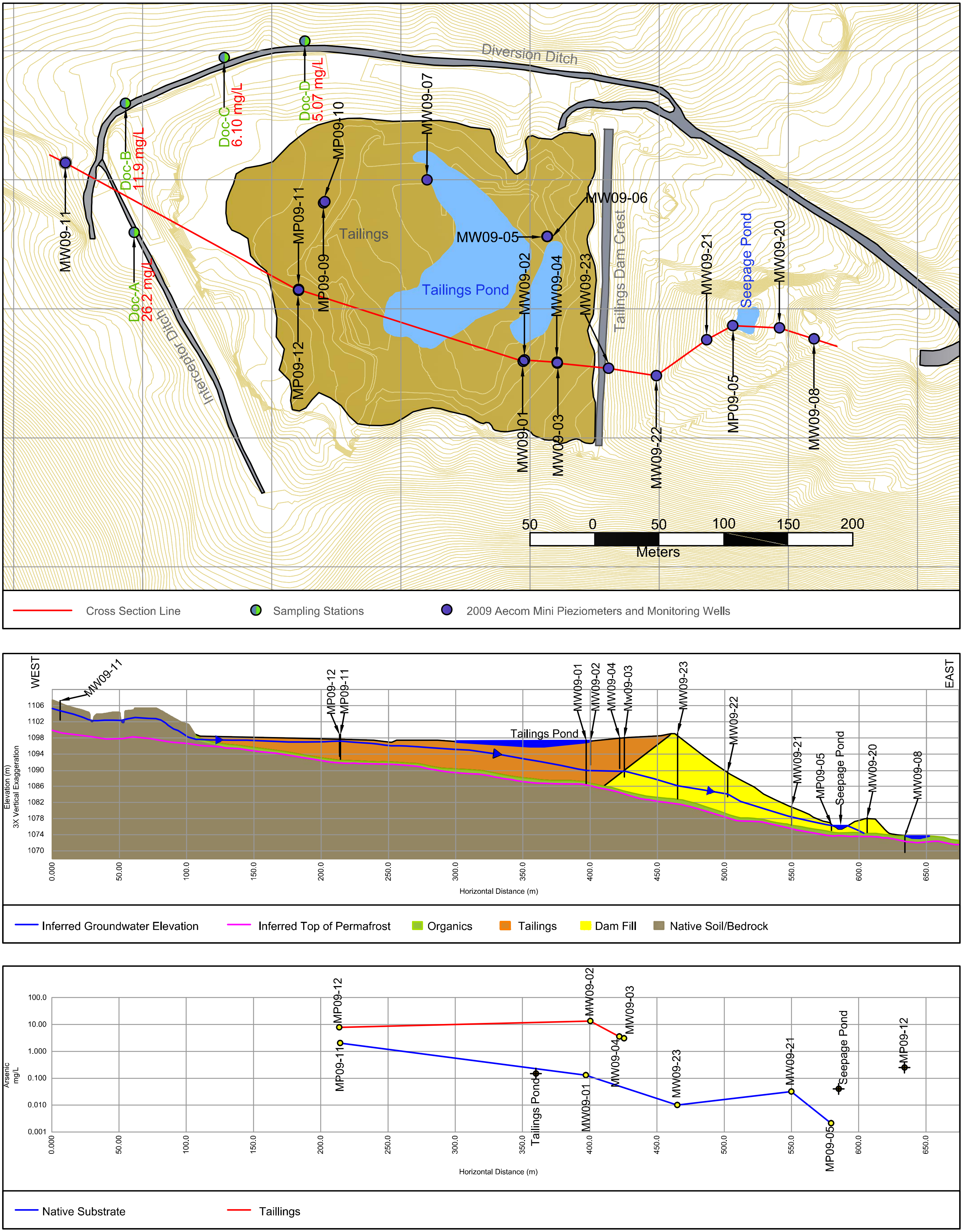


Figure 5-28 As concentrations along the groundwater flowpath from the tailings to the seepage collection pond

Project: J907-4 Drawing File: J907-4 Fig 5-28.dwg PDF File: J907-4 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 5-28). 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 5-21 and 5-22. 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 5-14), orders of magnitude lower than in MP09-10. Similar Cu concentrations were observed in the tailings and seepage ponds between 2001 and 2002 (Figure 5-21) 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 5-28). 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 5-24 and 5-25 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 5-26 and 5-27)
- 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 5-14).

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 5-28). As shown in Figure 5-28 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 5-16).

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 5-16:
ABA Data for Mt. Nansen, Venus and Arctic Tailings

		Paste pH	S (T) %	S (SO4) %	S (S2) %	AP	Sobek NP	Net NP	NPR
Mt Nansen Tailings	**# samples**	**29**	**29**	**29**	**29**	**29**	**29**	**29**	**29**
	min	6.8	0.3	0.1	0.2	6.6	7.4	-82.1	0.1
	max	9.1	4.3	0.9	3.6	113.8	42.9	14.2	3.2
	mean	8.0	2.2	0.4	1.9	58.1	19.5	-36.9	0.4
	median	7.9	2.2	0.5	1.8	55.9	21.7	-34.3	0.5
	std dev	0.58	1.02	0.24	0.90	28.03	9.61	22.75	0.55
Venus Tailings	**# samples**	**27**	**27**	**27**	**27**	**27**	**27**	**27**	**27**
	min	2.51	0.96	0.02	0.35	10.9	3.9	-207.0	0.36
	max	8.43	8.45	1.48	8.41	262.8	67.0	13.3	0.25
	mean	7.65	4.81	0.05	4.35	135.9	40.8	-101.0	0.30
	median	7.34	4.72	0.17	4.55	142.3	38.9	-103.4	0.27
	std dev	1.29	1.63	0.31	1.69	52.9	13.8	50.9	0.26
Arctic Tailings	**# samples**	**17**	**17**	**17**	**17**	**17**	**17**	**17**	**17**
	min	1.75	0.02	0.01	0.01	0.31	-38.41	-38.72	-122.91
	max	7.70	3.57	1.50	2.94	91.88	2.30	-89.58	0.03
	mean	2.50	0.88	0.52	0.57	17.81	-11.70	-29.51	-0.66
	median	2.89	1.20	0.59	0.77	24.01	-12.66	-36.67	-0.53
	std dev	1.35	0.96	0.41	0.94	29.36	9.35	-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 5-17). 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 5-17:
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 5-17).

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 5-17). 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 5-18. 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 5-18:
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 5-19. The seepage contains high dissolved metal concentrations, including arsenic, zinc, selenium, iron, lead, cobalt and copper.

**Table 5-19:
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 5-19).

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 5-20:
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 5-20, 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:

$$J_z = \frac{D^o_j}{F}\,\phi\,\frac{dc}{dz}$$

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 concentration in suboxic porewaters minus the median concentration in inflows to the tailings impoundment via Dome Creek; and,
- d^z = depth of the sand diffusion barrier (30 cm).

Based on these inputs, respective diffusive flux estimates of 0.14, 0.12 and 49 mg/m^2/dayfor As, Mn and sulfate were calculated (Table 5-21). 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 5-21). 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 5-21:
Diffusive Flux Estimates for As, Mn and Sulfate (30 cm sand diffusion layer)

Concentration in Tailings Porewater (mg/L)	Concentration in Dome Creek Inflow (mg/L)	Sand Thickness (cm)	Dj (cm^2/s)	F (no unit)	Porosity (no unit)	dc/dz (g/cm^4)	Flux (mg/m^2/day)	Tailings Area (m^2)	Daily Flux 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 assumed that metal attenuation processes currently occurring along the groundwater path from the tailings to the seepage pond will not occur in the pit. 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.

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.

6. Mill Area Characterization

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::

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Legend

⬟	Dome Ck WQ Sites
⤙	Adit
▭	Mill Area
▭	Contoured Heustis Workings
—	Dome Creek
—	Mine Road

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: **J907-4**

FIGURE No: **6-2**

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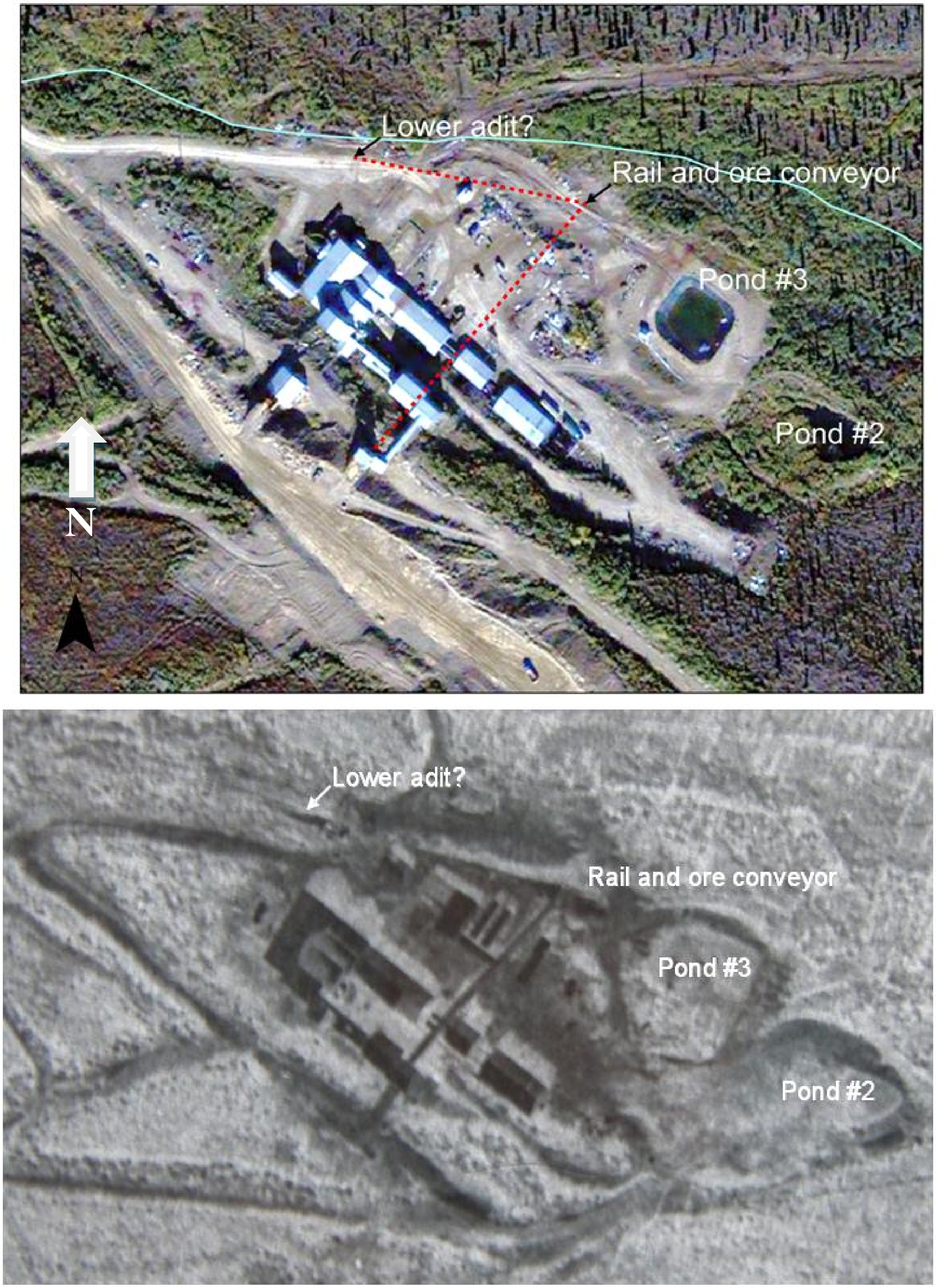


Figure 6-3: **Earlier Mining Features Superimposed on 2008 Satellite Image and Lower Image is a Negative of an Aerial Photograph taken around 1986**

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.

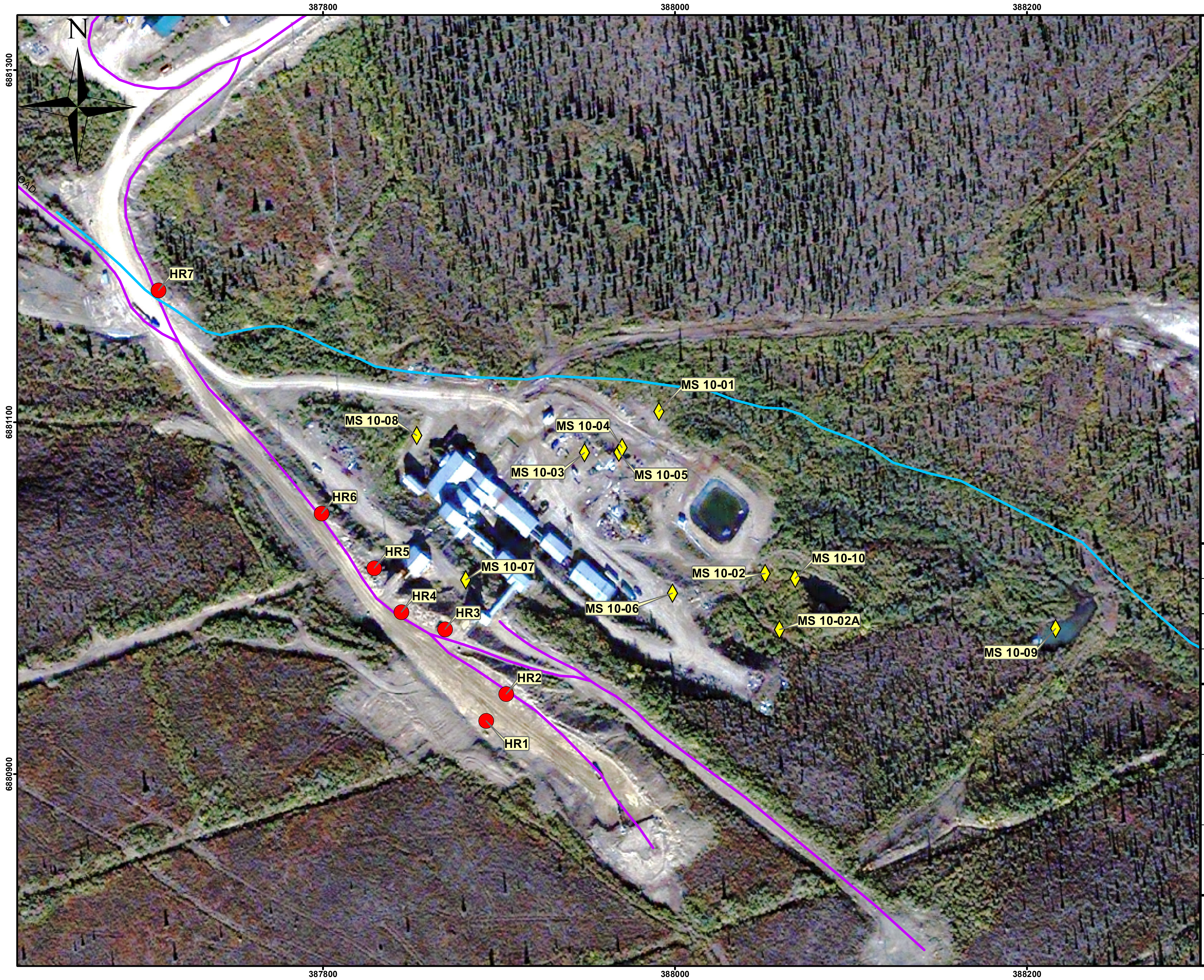
6.2.1 Rock Fill

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.



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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

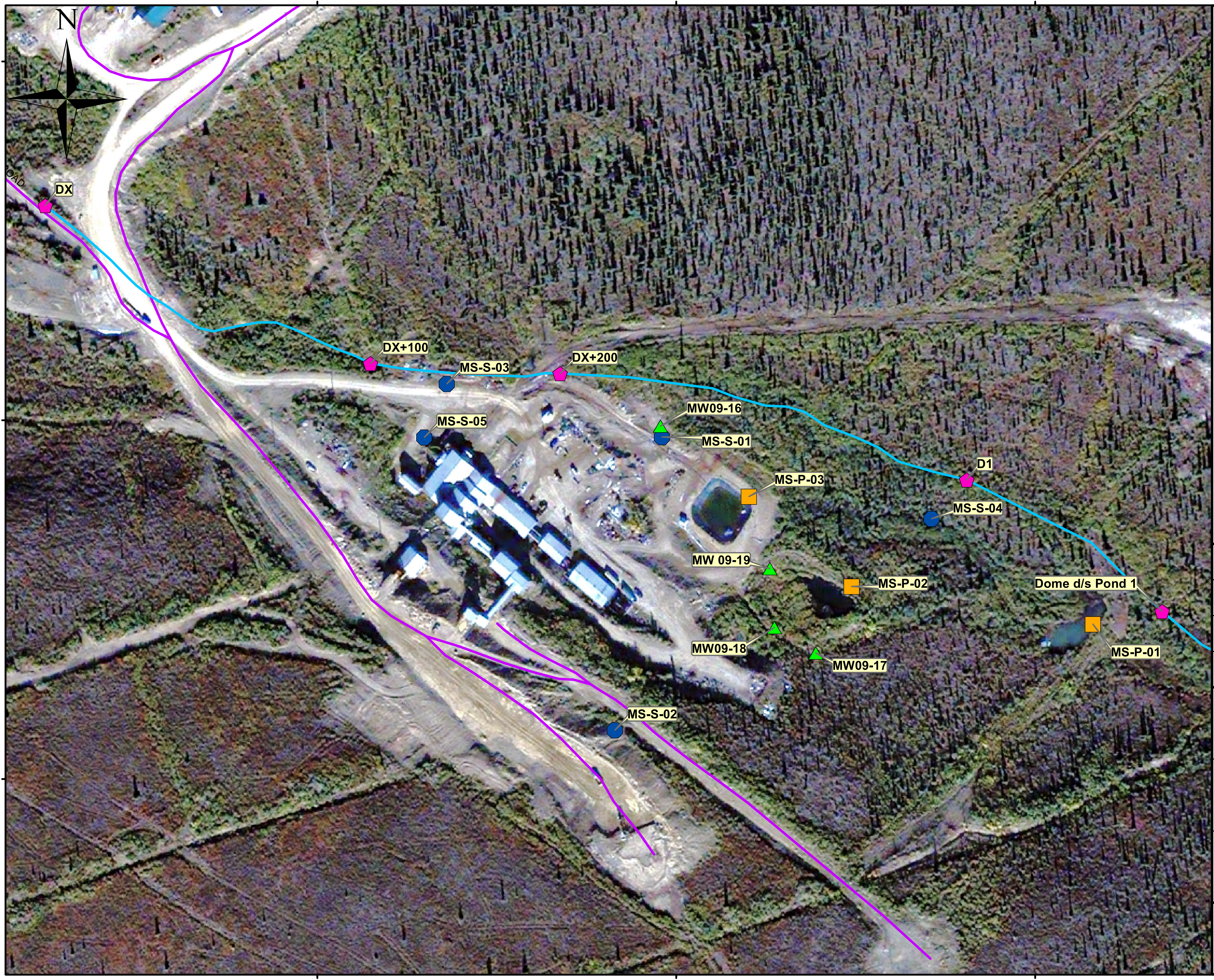
Table 6-3:
Summary of Acid Base Accounting Results for the 2010 Sampling of Pond #1 and Pond #2

	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: **J907-4**

FIGURE No: **6-5**

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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.

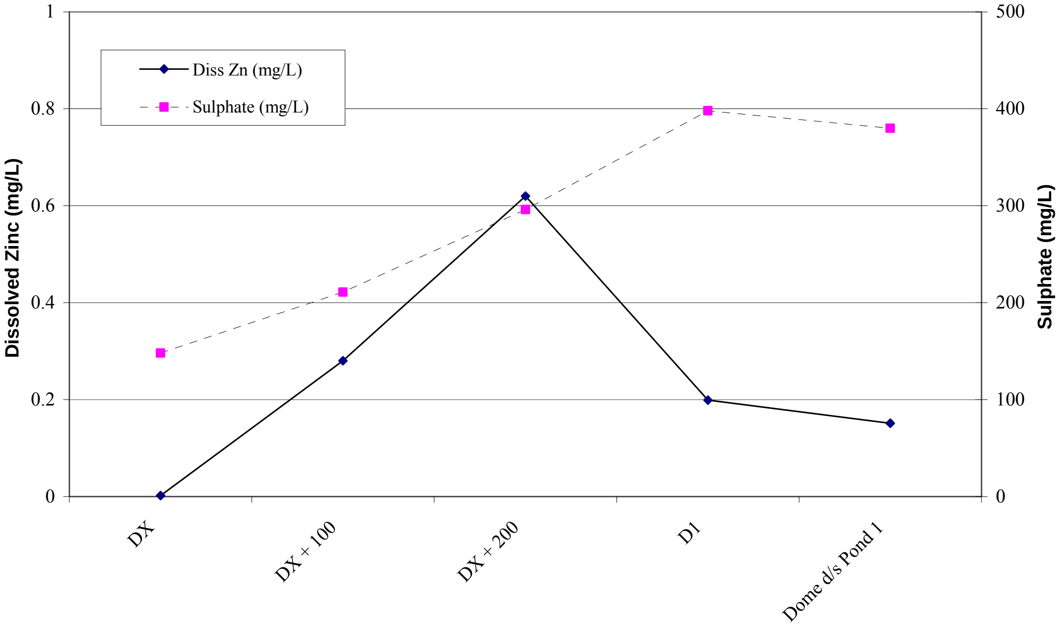

Figure 6-6: Dissolved Zinc and Sulfate in Upper Dome Creek

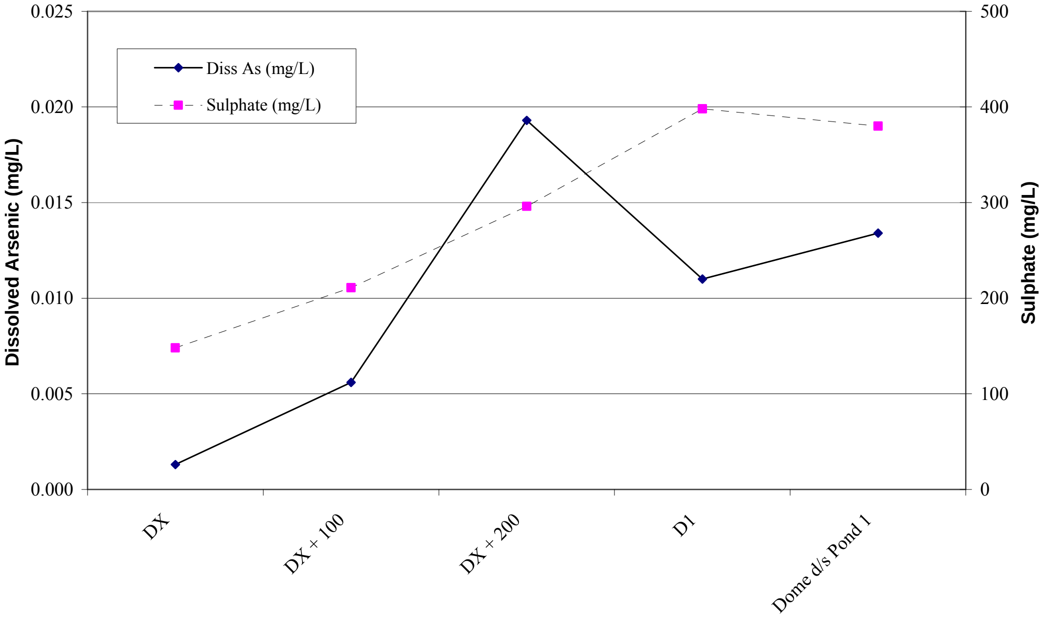

Figure 6-7: Dissolved Arsenic and Sulfate in Upper Dome Creek

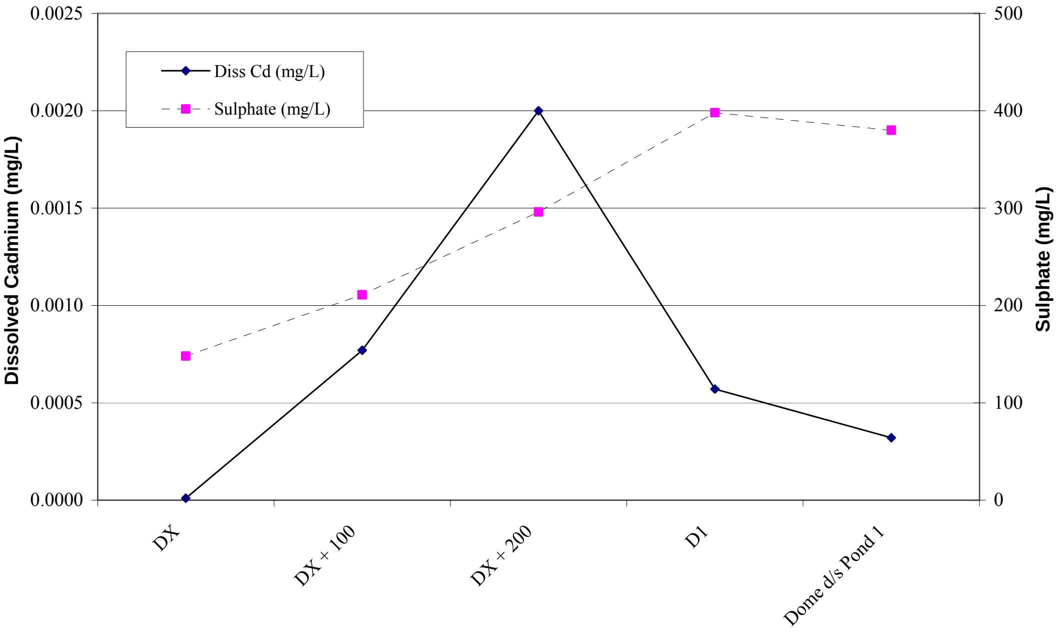

Figure 6-8: Dissolved Cadmium and Sulfate in Upper Dome Creek

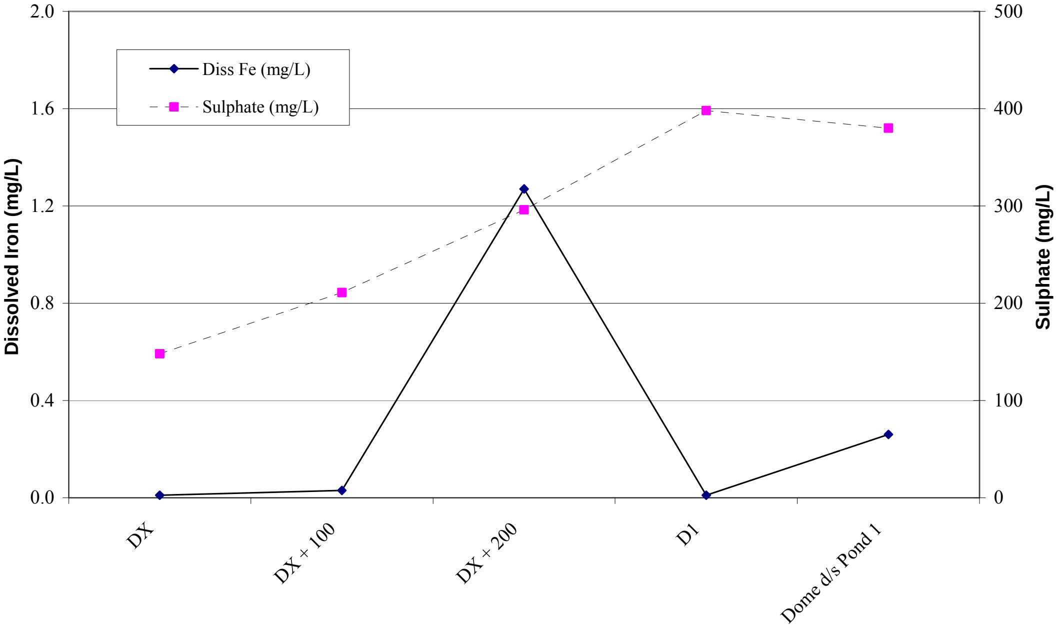

Figure 6-9: Dissolved Iron and Sulfate in Upper Dome Creek

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. 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.

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Appendices

Appendix A: Static Characterization Results

Appendix A-1 Waste Rock ABA and Elemental Abundance Results

Appendix A-2 Tailings ABA and Elemental abundance Results

Appendix A-3 Native Substrate ABA and Elemental Abundance Results

Appendix A-4 Shakeflask Extraction Results

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^{o}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**								
	(mm)	**(g)**	**(%)**	**Cumulative (%)**	**(g)**	**(%)**	**Cumulative (%)**	**(g)**	**(%)**	**Cumulative (%)**
+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**											
	(mm)	**(g)**	**(%)**	**Cumulative (%)**	**(g)**	**(%)**	**Cumulative (%)**	**(g)**	**(%)**	**Cumulative (%)**	**(g)**	**(%)**	**Cumulative (%)**
+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**		
	(mm)	**(g)**	**(%)**	**Cumulative (%)**
+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 kgCaCO$_3$/t	NP kgCaCO$_3$/t	SAP kgCaCO$_3$/t	CalcSAP (non-sulfate S) AP kgCaCO$_3$/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

	Paste	TIC	Total C	Organic C	Total S	Sulfate S	Sulfide S	Insoluble S	Non-Sulfate S	SAP	AP	CaNP	BulkNP	Net	NPR	NPR	NPR
Sample ID	**pH**	**% C**	**%**	**%**	**%**	**%**	**%**	**%**	**%**	**kgCaCO$_3$/t**	**kgCaCO$_3$/t**	**kgCaCO$_3$/t**	**kgCaCO$_3$/t**	**NP**	**(CaNP/SAP)**	**(CaNP/AP)**	**(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

	Ag	Al	As	Au	B	Ba	Bi	Ca	Cd	Co	Cr	Cu	Fe	Ga	Hg	K	La
Sample ID	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**%**	**ppm**	**ppm**	**%**	**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

	Mg	Mn	Mo	Na	Ni	P	Pb	S	Sb	Sc	Se	Sr	Te	Th	Ti	Tl	U	V	W	Zn
Sample ID	**%**	**ppm**	**ppm**	**%**	**ppm**	**%**	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**ppm**	**%**	**ppm**	**ppm**	**ppm**	**ppm**	**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	<0.000005	<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 Sample s***									***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 $CaCO_3$/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})

Appendix B:
Kinetic Characterization Results

Appendix B-1 Laboratory-based Humidity Cell Results

Appendix B-2 Field Bin Results

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^{TM} 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

Humidity Cell Leachate Chemistry for T1 (untreated Clay Composite)

										Dissolved Metals											
Date	**Cycle No.**	**Volume mL**		**pH**	**Cond.**	**Acidity (pH 8.3)**	**Alkalinity**	**Sulfate**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**
		Input	**Output**		**umhos/cm**	mgCaCO$_3$/L	mgCaCO$_3$/L	**mg/L**	mgCaCO$_3$/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	750	210	7.5	4548	22.2	67.2	2640	1970	<0.02	0.215	0.199	0.034	<0.001	<0.0005	<5	0.0206	565	<0.01	0.0158	0.094
04-Aug-09	1	500	455	7.3	2019	9.2	21.8	1224	1020	0.008	0.0862	0.134	0.0093	<0.00005	<0.00003	<0.3	0.00169	352	<0.0005	0.00395	0.0036
11-Aug-09	2	500	395	7.5	2799	12.4	41.0	2032	1580	0.006	0.282	0.149	0.0113	<0.00005	<0.00003	<0.3	0.0117	535	<0.0005	0.00439	0.0109
18-Aug-09	3	500	440	7.4	2194	9.8	34.1	1445	1290	0.004	0.225	0.104	0.0114	<0.00005	<0.00003	<0.3	0.0114	450	<0.0005	0.00267	0.0074
25-Aug-09	4	500	465	7.5	2049			1361													
01-Sep-09	5	500	430	7.6	1897	9.0	37.3	1264	1130	0.011	0.15	0.0621	0.0136	<0.00005	<0.00003	<0.3	0.0115	393	<0.0005	0.00245	0.0121
08-Sep-09	6	500	425	7.3	1518			1006													
15-Sep-09	7	500	400	7.6	2560	14.4	84.7	1587	1650	0.004	0.212	0.0953	0.0209	<0.00005	<0.00003	<0.3	0.0346	550	<0.0005	0.00738	0.0173
22-Sep-09	8	500	515	7.4	2405			1798													
29-Sep-09	9	500	490	7.4	1384	7.6	39.1	1022	850	0.004	0.105	0.0523	0.0108	<0.00005	<0.00003	<0.3	0.015	301	<0.0005	0.00869	0.0069
06-Oct-09	10	500	445	7.3	1474			1094													
13-Oct-09	11	500	465	7.5	1322	4.8	33.2	713	765	0.0041	0.0835	0.0431	0.0112	<0.00001	<0.000005	<0.05	0.0117	276	<0.0001	0.0185	0.00622
20-Oct-09	12	500	480	7.4	1218			817													
27-Oct-09	13	500	420	7.4	1772	4.9	26.7	1198	1070	0.006	0.102	0.0603	0.0098	<0.00005	<0.00003	<0.3	0.0123	392	<0.0005	0.0228	0.0063
03-Nov-09	14	500	445	7.3	1765			1189													
10-Nov-09	15	500	470	7.1	1802	7.7	28.2	1290	1160	0.0038	0.109	0.0817	0.011	<0.00001	<0.000005	0.052	0.0148	424	<0.0001	0.0268	0.00501
17-Nov-09	16	500	465	7.2	1876			1292													
24-Nov-09	17	500	490	7.6	2165	5.7	46.5	1444	1380	0.003	0.132	0.108	0.0116	<0.00005	<0.00003	<0.3	0.021	506	<0.0005	0.0272	0.016
01-Dec-09	18	500	490	7.5	1970			1338													
08-Dec-09	19	500	450	7.3	2047	8.3	52.5	1305	1330	0.003	0.0966	0.102	0.0105	<0.00005	<0.00003	<0.3	0.016	485	<0.0005	0.0241	0.007
15-Dec-09	20	500	490	7.4	1085			680													
22-Dec-09	21	500	475	7.6	1274	4.0	36.6	737	854	0.007	0.0676	0.0719	0.0097	<0.00005	<0.00003	<0.3	0.00795	310	<0.0005	0.0129	0.006
29-Dec-09	22	500	475	7.5	1075			635													
05-Jan-10	23	500	435	7.3	771	3.8	22.2	378	404	0.0047	0.034	0.0344	0.00715	<0.00001	<0.000005	<0.05	0.00301	145	<0.0001	0.00525	0.00289
12-Jan-10	24	500	430	7.3	641			326													
19-Jan-10	25	500	425	7.4	791	5.0	23.5	463	431	0.0067	0.0316	0.0292	0.00847	<0.00001	<0.000005	<0.05	0.00325	153	0.0001	0.00521	0.00236
26-Jan-10	26	500	425	7.2	325			162													
02-Feb-10	27	500	465	7.0	264	2.9	9.8	157	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
09-Feb-10	28	500	440	7.5	1466			927													
16-Feb-10	29	500	495	7.4	1509	6.0	36.5	1028	1100	0.0038	0.0671	0.0945	0.0103	<0.00001	<0.000005	<0.05	0.00801	389	<0.0001	0.00954	0.00405
23-Feb-10	30	500	475	7.5	1134			816													
02-Mar-10	31	500	445	7.5	1208	3.1	29.3	724	798	0.0055	0.0544	0.0753	0.00778	<0.00001	<0.000005	<0.05	0.00399	281	<0.0001	0.00792	0.00297
09-Mar-10	32	500	430	7.5	1508			1017													
16-Mar-10	33	500	475	7.4	1336	4.9	33.3	819	901	0.006	0.0605	0.0696	0.0078	<0.00005	<0.00003	<0.3	0.00546	320	<0.0005	0.00799	0.0033
23-Mar-10	34	500	455	7.5	1551			1110													
30-Mar-10	35	500	470	7.5	1627	4.4	39.6	1114	1020	0.006	0.0675	0.0696	0.0089	<0.00005	<0.00003	<0.3	0.00511	364	<0.0005	0.00878	0.0042
06-Apr-10	36	500	435	7.5	1729			1029													
13-Apr-10	37	500	445	7.6	1883	7.5	46.9	1297	1260	0.007	0.078	0.078	0.0115	<0.00005	<0.00003	<0.3	0.00694	454	<0.0005	0.0109	0.003
20-Apr-10	38	500	460	7.7	1791	5.6	50.6	1149	1090	0.007	0.0836	0.0732	0.0129	<0.00005	<0.00003	<0.3	0.00575	392	<0.0005	0.00898	0.004
27-Apr-10	39	500	410	7.7	1774	3.5	48.0	1169	1120	0.006	0.0817	0.0754	0.0111	<0.00005	<0.00003	<0.3	0.00568	405	<0.0005	0.00905	0.0031
04-May-10	40	500	475	7.6	1661			1073													
11-May-10	41	500	455	7.6	1546	5.6	49.1	949	950	0.009	0.0922	0.0748	0.0103	<0.00005	<0.00003	<0.3	0.00476	346	<0.0005	0.0061	0.0031
18-May-10	42	500	445	7.5	1378			797													
25-May-10	43	500	420	7.5	1289	7.7	44.9	602	813	0.008	0.0831	0.0714	0.0106	<0.00005	<0.00003	<0.3	0.00356	297	<0.0005	0.00533	0.0029
01-Jun-10	44	500	425	7.6	1214			623													
08-Jun-10	45	500	460	7.7	1594	5.9	54.3	1058	1310	0.007	0.0914	0.0785	0.0139	<0.00005	<0.00003	<0.3	0.00602	481	<0.0005	0.00843	0.0036
15-Jun-10	46	500	405	7.8	1607			771													
22-Jun-10	47	500	445	7.8	1783	5.9	68.5	1001	1170	0.006	0.1	0.074	0.0136	<0.00005	<0.00003	<0.3	0.00778	430	<0.0005	0.00667	0.0045
29-Jun-10	48	500	475	7.5	1717			823													
06-Jul-10	49	500	435	7.8	1494	4.9	72.2	848	1090	0.017	0.102	0.0682	0.0129	<0.00005	<0.00003	<0.3	0.0087	404	<0.0005	0.00502	0.0047
13-Jul-10	50	500	475	7.7	1351			511													
20-Jul-10	51	500	440	7.7	1526	8.4	80.8	840	1050	0.006	0.0989	0.0641	0.0129	<0.00005	<0.00003	<0.3	0.00874	392	<0.0005	0.00605	0.0031
27-Jul-10	52	500	485	7.8	1644			1124													
03-Aug-10	53	500	485	7.9	1290	7.8	83.8	754	867	0.006	0.112	0.0699	0.0128	<0.00005	<0.00003	<0.3	0.00876	324	<0.0005	0.00456	0.004
10-Aug-10	54	500	485	7.8	1223			813													
17-Aug-10	55	500	440	7.9	960	5.4	80.2	429	602	0.006	0.12	0.0682	0.0131	<0.00001	<0.000005	<0.05	0.00616	224	<0.0001	0.00305	0.00503
24-Aug-10	56	500	475	7.7	666			239													
31-Aug-10	57	500	481	7.8	393	7.8	43.3	236													
07-Sep-10	58	500	525	7.6	651																

Note: NA = not analyzed; negative values are less than detection

Appendix B-1
Humidity Cell Leachate Chemistry for T1 (untreated Clay Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	<0.1	0.001	<0.05	135	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	0.008	0.0008	0.011	35.3	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	0.022	0.00063	0.017	59.6	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	0.009	0.00087	0.014	40.2	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	0.018	0.00058	0.013	37.2	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	0.024	0.00147	0.025	66.4	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	0.057	0.00088	0.01	24.3	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	0.018	0.000273	0.0087	18.4	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	0.019	0.00082	0.011	21.6	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	0.025	0.000603	0.012	23.9	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	0.015	0.00134	0.014	28.5	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	0.02	0.00085	0.014	28	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	0.019	0.00041	0.01	19.2	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	0.006	0.000196	0.0047	10.3	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	0.007	0.000174	0.0044	11.5	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	0.004	0.000163	0.0017	4.44	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	0.008	0.000516	0.0095	30.6	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	0.004	0.000187	0.0074	23.3	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	0.005	0.00057	0.008	24.5	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	0.005	0.00027	0.009	27	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	0.014	0.00033	0.009	31.7	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	0.013	0.00037	0.01	27.8	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	<0.005	0.00029	0.009	27.2	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	0.012	0.00027	0.007	20.8	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	0.008	0.00023	0.006	17.4	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	0.007	0.0003	0.008	27	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	0.009	0.00035	0.008	22.6	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	0.025	0.00046	0.008	20.3	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	0.009	0.00036	0.007	17.2	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	<0.005	0.00051	0.007	14.2	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	0.003	0.00046	0.0057	10.3	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																							
07-Sep-10	58																							

Note: NA = not analyzed; negative values are less than detection

Appendix B-1
Humidity Cell Leachate Chemistry for T2 (untreated Sand-Silt Composite)

										Dissolved Metals											
Date	**Cycle No.**	**Volume mL**		**pH**	**Cond.**	**Acidity (pH 8.3)**	**Alkalinity**	**Sulfate**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**
		Input	**Output**		**umhos/cm**	**$mgCaCO_3/L$**	**$mgCaCO_3/L$**	**mg/L**	**$mgCaCO_3/L$**	**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	750	440	7.5	1470	8.0	20.4	936	882	0.0059	0.0843	0.126	0.011	<0.00001	<0.000005	<0.05	0.0071	315	<0.0001	0.00364	0.00695
04-Aug-09	1	500	400	7.3	2362	6.7	24.9	1709	1630	0.005	0.472	0.163	0.0079	<0.00005	<0.00003	<0.3	0.014	551	<0.0005	0.00849	0.0143
11-Aug-09	2	500	400	7.5	2364	10.9	27.9	1748	1700	0.003	0.808	0.14	0.0076	<0.00005	<0.00003	<0.3	0.02	580	<0.0005	0.00832	0.0118
18-Aug-09	3	500	440	7.4	2216	7.9	26.3	1650	1640	0.004	0.805	0.109	0.0075	<0.00005	<0.00003	<0.3	0.0239	590	<0.0005	0.00786	0.0117
25-Aug-09	4	500	430	7.6	2160			1441													
01-Sep-09	5	500	400	7.5	2278	12.0	30.3	1589	1690	0.01	0.718	0.0812	0.0099	<0.0001	<0.00005	<0.5	0.0272	633	<0.001	0.00789	0.0202
08-Sep-09	6	500	440	7.4	2232			1606													
15-Sep-09	7	500	465	7.6	2209	13.0	53.6	1508	1490	0.004	0.649	0.0698	0.011	<0.00005	<0.00003	<0.3	0.0353	572	<0.0005	0.0105	0.026
22-Sep-09	8	500	455	7.6	2132			1559													
29-Sep-09	9	500	460	7.6	2147	10.2	61.5	1783	1580	0.002	0.604	0.0565	0.0099	<0.00005	<0.00003	<0.3	0.0286	594	<0.0005	0.00419	0.0168
06-Oct-09	10	500	410	7.5	2299			1762													
13-Oct-09	11	500	440	7.6	2282	9.1	69.2	1676	1580	0.011	0.542	0.0439	0.009	<0.00005	<0.00003	<0.3	0.0312	591	<0.0005	0.00188	0.0154
20-Oct-09	12	500	440	7.6	2204			1601													
27-Oct-09	13	500	450	7.6	2310	8.5	58.8	1676	1560	0.005	0.61	0.0392	0.0079	<0.00005	<0.00003	<0.3	0.029	580	<0.0005	0.00187	0.0091
03-Nov-09	14	500	400	7.6	2275			1575													
10-Nov-09	15	500	465	7.4	2180	12.0	56.5	1529	1560	0.016	0.608	0.0339	0.0096	<0.00005	<0.00003	<0.3	0.0296	590	<0.0005	0.00146	0.0115
17-Nov-09	16	500	505	7.5	2262			1593													
24-Nov-09	17	500	485	7.7	2216	10.5	68.0	1649	1500	0.002	0.546	0.0309	0.0099	<0.00005	<0.00003	<0.3	0.0384	575	<0.0005	0.00103	0.0166
01-Dec-09	18	500	475	7.7	2078			1538													
08-Dec-09	19	500	465	7.5	1823	9.6	62.7	1163	1140	0.003	0.489	0.0272	0.0069	<0.00005	<0.00003	<0.3	0.0279	434	<0.0005	0.001	0.0115
15-Dec-09	20	500	490	7.7	1570			1086													
22-Dec-09	21	500	455	7.7	1159	6.3	54.9	836	771	0.003	0.495	0.0249	0.0065	<0.00005	<0.00003	<0.3	0.0203	290	<0.0005	0.00083	0.0095
29-Dec-09	22	500	440	7.7	1289			755													
05-Jan-10	23	500	440	7.6	1157	8.0	64.2	621	662	0.002	0.516	0.0269	0.0077	<0.00005	<0.00003	<0.3	0.0163	242	<0.0005	0.00088	0.0099
12-Jan-10	24	500	430	7.6	1033			590													
19-Jan-10	25	500	450	7.8	915	7.8	73.3	457	500	0.006	0.48	0.0287	0.0105	<0.00005	<0.00003	<0.3	0.0112	178	<0.0005	0.00068	0.0125
26-Jan-10	26	500	410	7.7	727			390													
02-Feb-10	27	500	455	7.7	619	5.5	80.3	352	409	0.003	0.41	0.0303	0.0118	<0.00005	<0.00003	<0.3	0.00895	143	<0.0005	0.00043	0.0829
09-Feb-10	28	500	440	7.7	693			341													
16-Feb-10	29	500	455	7.8	592	6.1	89.8	262	362	0.0033	0.424	0.0334	0.0139	<0.00001	<0.000005	<0.05	0.0073	124	<0.0001	0.000877	0.00566
23-Feb-10	30	500	420	7.9	606			243													
02-Mar-10	31	500	405	7.9	546	3.5	81.4	233	315	0.007	0.395	0.0341	0.0173	<0.00005	<0.00003	<0.3	0.00654	103	<0.0005	0.0007	0.0056
09-Mar-10	32	500	375	7.8	457			159													
16-Mar-10	33	500	455	7.8	425	4.7	89.1	149	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
23-Mar-10	34	500	455	7.8	458			185													
30-Mar-10	35	500	415	7.8	428	4.1	81.7	161	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
06-Apr-10	36	500	455	7.8	393			139													
13-Apr-10	37	500	450	7.8	431	6.0	94.3	155	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
20-Apr-10	38	500	470	7.9	443	4.4	96.5	141	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
27-Apr-10	39	500	390	7.9	391	2.6	89.7	124	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
04-May-10	40	500	425	7.9	430			143													
11-May-10	41	500	445	7.9	395	4.1	84.5	128	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
18-May-10	42	500	420	7.8	403			129													
25-May-10	43	500	450	7.7	421	6.0	88.9	127	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
01-Jun-10	44	500	465	7.9	416			120													
08-Jun-10	45	500	465	7.8	415	5.0	93.6	119	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
15-Jun-10	46	500	410	7.9	343			84													
22-Jun-10	47	500	435	8.0	364	2.9	87.3	92	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
29-Jun-10	48	500	440	7.8	368			125													
06-Jul-10	49	500	460	8.0	371	2.9	94.1	117	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
13-Jul-10	50	500	415	7.8	291			71													
20-Jul-10	51	500	495	7.9	353	5.0	87.6	87	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
27-Jul-10	52	500	460	7.7	366			116													
03-Aug-10	53	500	435	7.9	332	4.3	79.0	115	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
10-Aug-10	54	500	450	7.9	314			125													
17-Aug-10	55	500	435	7.7	134	3.4	29.1	29	61.3	0.0205	0.137	0.0341	0.0099	<0.00001	0.000034	<0.05	0.00188	15.9	<0.0001	0.000094	0.00313
24-Aug-10	56	500	435	7.6	590			183													
31-Aug-10	57	500	430	7.8	363	8.0	65.0	207													
07-Sep-10	58	500	430	7.7	341																

Appendix B-1
Humidity Cell Leachate Chemistry for T2 (untreated Sand-Silt Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	0.059	0.00169	0.0047	23.2	4.41	0.06	0.00392	0.00253	0.013	10.6	0.00037	1.49	0.000854	6.07	0.455	319	0.00048	0.0092	<0.0005	5.5E-05	<0.0002	0.109	<0.0001
04-Aug-09	1	0.029	0.00347	0.014	63	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	0.0054	<0.003	0.0002	<0.001	0.177	<0.0005
11-Aug-09	2	0.025	0.00379	0.016	61.8	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	0.0053	<0.003	0.00016	<0.001	0.355	<0.0005
18-Aug-09	3	0.017	0.00436	0.015	40.1	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	0.0048	<0.003	0.00014	<0.001	0.533	<0.0005
25-Aug-09	4																							
01-Sep-09	5	0.025	0.00518	0.014	27.2	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	0.017	0.00714	0.014	16.3	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	0.037	0.00627	0.01	22.8	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	0.008	0.00626	0.009	25.1	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	0.018	0.00506	0.007	25.9	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	0.033	0.0051	0.006	22	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	0.01	0.00563	0.005	16.2	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	0.013	0.00435	0.004	13.6	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	0.0081	0.003	0.00062	<0.001	2.94	<0.0005
15-Dec-09	20																							
22-Dec-09	21	0.014	0.00312	0.003	11.7	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	0.0077	<0.003	0.00042	<0.001	2.03	<0.0005
29-Dec-09	22																							
05-Jan-10	23	0.006	0.00268	0.003	13.9	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	0.0099	<0.003	0.00041	<0.001	1.54	<0.0005
12-Jan-10	24																							
19-Jan-10	25	0.009	0.00222	<0.003	13.5	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	0.0087	<0.003	0.00034	<0.001	1.1	<0.0005
26-Jan-10	26																							
02-Feb-10	27	0.133	0.00205	<0.003	13	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	0.0088	<0.003	0.00034	<0.001	0.819	<0.0005
09-Feb-10	28																							
16-Feb-10	29	0.003	0.00204	0.0024	13.1	0.0652	<0.01	0.00333	0.00082	0.002	1.13	0.00009	4.6	0.00001	0.2	0.131	96	5.4E-05	0.015	<0.0005	0.00031	<0.0002	0.657	<0.0001
23-Feb-10	30																							
02-Mar-10	31	<0.005	0.00182	<0.003	14.4	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	0.0091	<0.003	0.00029	<0.001	0.634	<0.0005
09-Mar-10	32																							
16-Mar-10	33	<0.005	0.00157	<0.003	11.5	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	0.0086	<0.003	0.00027	<0.001	0.358	<0.0005
23-Mar-10	34																							
30-Mar-10	35	0.006	0.0019	<0.003	12.8	0.0295	<0.05	0.004	0.0006	<0.01	0.82	<0.0002	3.08	<0.00003	0.21	0.087	54	0.00005	0.0099	<0.003	0.00038	<0.001	0.425	<0.0005
06-Apr-10	36																							
13-Apr-10	37	<0.005	0.00149	<0.003	14.1	0.0273	<0.05	0.0037	0.0006	<0.01	0.8	<0.0002	4.62	<0.00003	<0.3	0.092	<50	0.00005	0.0085	<0.003	0.00025	<0.001	0.407	<0.0005
20-Apr-10	38	<0.005	0.00152	<0.003	14.1	0.0289	<0.05	0.0039	0.0005	<0.01	0.8	<0.0002	3.94	0.00004	<0.3	0.094	<50	0.00007	0.01	<0.003	0.00024	<0.001	0.379	<0.0005
27-Apr-10	39	<0.005	0.00119	<0.003	13.3	0.0195	0.09	0.0037	0.0004	<0.01	0.8	0.0003	4.14	0.00006	<0.3	0.083	<50	0.00008	0.0069	<0.003	0.0002	<0.001	0.288	<0.0005
04-May-10	40																							
11-May-10	41	<0.005	0.00142	<0.003	12.8	0.0201	<0.05	0.0036	0.0004	<0.01	0.8	<0.0002	4.26	<0.00003	<0.3	0.084	<50	0.00006	0.0069	<0.003	0.00019	<0.001	0.296	<0.0005
18-May-10	42																							
25-May-10	43	0.003	0.00113	0.0017	15.6	0.0169	<0.01	0.00403	0.00027	<0.002	0.81	0.00008	3.89	0.000005	0.13	0.093	53	6.1E-05	0.0078	<0.0005	0.00025	<0.0002	0.251	<0.0001
01-Jun-10	44																							
08-Jun-10	45	0.002	0.00115	0.0016	16	0.0204	<0.01	0.00395	0.00028	<0.002	0.77	0.00007	4.8	0.000007	0.15	0.088	48	6.1E-05	0.0074	<0.0005	0.00024	<0.0002	0.247	<0.0001
15-Jun-10	46																							
22-Jun-10	47	0.003	0.000811	0.0016	14.2	0.0172	<0.01	0.00346	0.00034	<0.002	0.71	0.00008	4.26	0.000018	0.12	0.086	43	6.2E-05	0.0053	<0.0005	0.00022	<0.0002	0.224	<0.0001
29-Jun-10	48																							
06-Jul-10	49	0.004	0.000911	0.0017	15.9	0.0254	<0.01	0.00316	0.0003	<0.002	0.76	0.00007	4.16	0.000024	0.13	0.092	48	6.3E-05	0.0048	<0.0005	0.00021	<0.0002	0.308	<0.0001
13-Jul-10	50																							
20-Jul-10	51	0.005	0.000728	0.0013	13.7	0.0268	<0.01	0.00282	0.00014	<0.002	0.63	0.00005	3.85	0.00005	0.1	0.08	39	5.5E-05	0.0044	<0.0005	0.00018	<0.0002	0.294	<0.0001
27-Jul-10	52																							
03-Aug-10	53	0.002	0.000702	0.0013	13.4	0.021	<0.01	0.00259	0.00018	<0.002	0.62	<0.00004	3.63	0.000012	0.1	0.077	41	5.8E-05	0.0038	<0.0005	0.00016	<0.0002	0.289	<0.0001
10-Aug-10	54																							
17-Aug-10	55	0.026	0.00301	<0.0005	5.22	0.0513	<0.01	0.0009	0.00028	0.002	0.22	<0.00004	1.38	0.000025	0.21	0.028	14	1.2E-05	0.0008	<0.0005	2.8E-05	<0.0002	0.202	<0.0001
24-Aug-10	56																							
31-Aug-10	57																							
07-Sep-10	58																							

Appendix B-1

Humidity Cell Leachate Chemistry for T3 (untreated Silt-Clay Composite)

Dissolved Metals

Date	Cycle No.	Volume mL		pH	Cond.	Acidity (pH 8.3)	Alkalinity	Sulfate	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
		Input	Output		umhos/cm	mgCaCO$_3$/L	mgCaCO$_3$/L	mg/L	mgCaCO$_3$/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	750	380	7.7	2790	11.8	60.2	1685	1580	<0.01	0.257	0.266	0.031	<0.0005	<0.0003	<3	0.0055	539	<0.005	0.0186	0.062
04-Aug-09	1	500	435	7.6	2522	8.4	45.6	1698	1630	0.01	0.52	0.308	0.0107	<0.00005	<0.00003	<0.3	0.00354	571	<0.0005	0.0199	0.0144
11-Aug-09	2	500	445	7.7	2374	9.7	52.9	1667	1600	0.008	1.3	0.262	0.0088	<0.00005	<0.00003	<0.3	0.00602	568	<0.0005	0.0141	0.0165
18-Aug-09	3	500	470	7.8	2227	8.5	71.0	1445	1670	0.006	1.47	0.214	0.0099	<0.00005	<0.00003	<0.3	0.00859	607	<0.0005	0.0146	0.0151
25-Aug-09	4	500	460	7.9	2139			1441													
01-Sep-09	5	500	420	7.9	2288	10.8	68.5	1507	1740	0.011	1.25	0.176	0.0114	<0.0001	<0.00005	<0.5	0.00968	648	<0.001	0.0136	0.0234
08-Sep-09	6	500	435	7.7	2221			1751													
15-Sep-09	7	500	455	7.9	2209	10.7	76.3	1508	1550	0.004	1.11	0.169	0.0108	<0.00005	<0.00003	<0.3	0.0118	590	<0.0005	0.0122	0.0125
22-Sep-09	8	500	465	7.9	2132			1500													
29-Sep-09	9	500	395	7.8	2158	8.0	65.6	1824	1610	0.005	0.867	0.158	0.0098	<0.00005	<0.00003	<0.3	0.00943	621	<0.0005	0.00861	0.0111
06-Oct-09	10	500	400	7.8	2270			1703													
13-Oct-09	11	500	430	7.9	2262	5.6	71.3	1676	1540	0.005	0.691	0.136	0.0092	<0.00005	<0.00003	<0.3	0.00796	594	<0.0005	0.00526	0.0082
20-Oct-09	12	500	465	7.8	2173			1642													
27-Oct-09	13	500	480	7.9	2220	6.6	81.8	1398	1490	0.005	0.754	0.129	0.009	<0.00005	<0.00003	<0.3	0.0107	577	<0.0005	0.00343	0.0074
03-Nov-09	14	500	405	7.8	2222			1567													
10-Nov-09	15	500	460	7.7	2138	11.2	70.5	1574	1520	0.009	0.684	0.106	0.0104	<0.00005	<0.00003	<0.3	0.0103	590	<0.0005	0.003	0.0061
17-Nov-09	16	500	490	7.9	2151			1489													
24-Nov-09	17	500	505	8.0	1763	6.2	84.4	1197	1100	0.005	0.649	0.105	0.0094	<0.00005	<0.00003	<0.3	0.0098	431	<0.0005	0.00214	0.0055
01-Dec-09	18	500	470	8.0	1075			643													
08-Dec-09	19	500	455	7.9	1088	6.1	73.1	435	625	0.006	0.612	0.097	0.0084	<0.00005	<0.00003	<0.3	0.00459	242	<0.0005	0.00157	0.0041
15-Dec-09	20	500	465	8.1	983			609													
22-Dec-09	21	500	445	8.0	732	3.4	75.2	394	441	0.007	0.668	0.101	0.0101	<0.00005	<0.00003	<0.3	0.00322	170	<0.0005	0.00128	0.0036
29-Dec-09	22	500	435	8.0	777			348													
05-Jan-10	23	500	430	7.8	685	5.6	82.1	299	348	0.006	0.755	0.106	0.0124	<0.00005	<0.00003	<0.3	0.0024	133	<0.0005	0.00102	0.0071
12-Jan-10	24	500	405	8.0	646			271													
19-Jan-10	25	500	425	8.0	598	5.8	90.3	250	290	0.006	0.742	0.105	0.0156	<0.0001	<0.00005	<0.5	0.00206	110	<0.001	0.00075	0.0102
26-Jan-10	26	500	445	8.0	414			146													
02-Feb-10	27	500	485	7.9	354	4.1	90.0	133	220	0.006	0.655	0.109	0.0174	<0.00005	<0.00003	<0.3	0.00158	82.3	<0.0005	0.00048	0.0031
09-Feb-10	28	500	415	8.0	428			122													
16-Feb-10	29	500	460	8.0	387	3.8	102.4	122	216	0.007	0.704	0.109	0.0232	<0.00005	<0.00003	<0.3	0.00181	80	<0.0005	0.00045	0.0037
23-Feb-10	30	500	490	8.0	352			88													
02-Mar-10	31	500	440	8.0	338	3.3	101.6	89	177	0.007	0.651	0.11	0.0422	<0.00005	<0.00003	<0.3	0.00148	65	<0.0005	0.00063	0.0031
09-Mar-10	32	500	415	8.0	309			66													
16-Mar-10	33	500	490	8.1	352	2.4	109.7	82	159	0.007	0.624	0.117	0.028	<0.00005	<0.00003	<0.3	0.00154	57.8	<0.0005	0.00038	0.006
23-Mar-10	34	500	440	8.0	315			92													
30-Mar-10	35	500	420	8.0	299	2.6	84.5	96	154	0.006	0.668	0.121	0.0255	<0.00005	<0.00003	<0.3	0.00116	56	<0.0005	0.00054	0.004
06-Apr-10	36	500	395	7.9	285			90													
13-Apr-10	37	500	415	7.9	287	4.0	72.3	78	143	0.01	0.712	0.138	0.025	<0.00005	<0.00003	<0.3	0.00111	51.5	<0.0005	0.00059	0.0024
20-Apr-10	38	500	445	8.1	330	3.1	102.9	71	157	0.007	0.691	0.122	0.0359	<0.00005	<0.00003	<0.3	0.00174	56.1	<0.0005	0.00043	0.0036
27-Apr-10	39	500	500	8.0	284	2.5	101.1	55	144	0.006	0.579	0.128	0.0323	<0.00005	<0.00003	<0.3	0.00192	51.2	<0.0005	0.0003	0.0036
04-May-10	40	500	485	8.0	301			69													
11-May-10	41	500	450	8.0	325	4.1	120.2	63	160	0.007	0.63	0.107	0.0407	<0.00005	<0.00003	<0.3	0.00246	57	<0.0005	0.00034	0.0041
18-May-10	42	500	505	7.9	289			34													
25-May-10	43	500	410	7.8	160	4.3	61.1	16	78.3	0.0183	0.365	0.15	0.0172	<0.00001	<0.000005	<0.05	0.000464	28.2	0.0004	0.000312	0.00181
01-Jun-10	44	500	390	7.8	240			51													
08-Jun-10	45	500	415	7.8	283	3.6	61.2	68	143	0.0113	0.471	0.144	0.0319	<0.00001	<0.000005	<0.05	0.000994	51.1	0.0002	0.000695	0.0045
15-Jun-10	46	500	455	7.9	289			63													
22-Jun-10	47	500	415	8.0	322	2.4	74.1	86	159	0.0077	0.553	0.143	0.0358	<0.00001	<0.000005	<0.05	0.00127	55.8	<0.0001	0.000638	0.00318
29-Jun-10	48	500	470	7.9	401			141													
06-Jul-10	49	500	420	7.9	393	3.6	73.9	111	222	0.0063	0.487	0.115	0.0408	<0.00001	<0.000005	<0.05	0.00164	79.4	0.0003	0.000635	0.00264
13-Jul-10	50	500	440	7.9	380			88													
20-Jul-10	51	500	460	7.9	391	4.6	87.5	116	213	0.005	0.419	0.114	0.0418	<0.00001	<0.000005	<0.05	0.00191	75.6	<0.0001	0.000613	0.00237
27-Jul-10	52	500	475	7.8	382			122													
03-Aug-10	53	500	455	8.0	408	4.1	87.5	115	210	0.008	0.442	0.124	0.0415	<0.00001	<0.000005	<0.05	0.00206	74.2	0.0001	0.000628	0.00254
10-Aug-10	54	500	440	8.0	366			150													
17-Aug-10	55	500	435	8.0	356	3.7	76.7	119	184	0.0081	0.457	0.124	0.0346	<0.00001	<0.000005	<0.05	0.0017	64.7	<0.0001	0.000538	0.00529
24-Aug-10	56	500	430	8.0	346			95													
31-Aug-10	57	500	445	8.0	322	7.3	88.1	119													
07-Sep-10	58	500	420	7.8	334																

Appendix B-1
Humidity Cell Leachate Chemistry for T3 (untreated Silt-Clay Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	0.352	<0.0003	<0.03	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	0.045	0.00067	0.011	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	0.0075	<0.003	0.00185	<0.001	0.036	<0.0005
11-Aug-09	2	0.053	0.00097	0.012	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	0.0067	<0.003	0.00164	<0.001	0.053	<0.0005
18-Aug-09	3	0.048	0.00079	0.012	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	0.026	0.00075	0.013	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	0.007	0.00146	0.012	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	0.037	0.0014	0.01	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	0.007	0.00048	0.009	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	0.0086	<0.003	0.00162	<0.001	0.269	<0.0005
20-Oct-09	12																							
27-Oct-09	13	0.015	0.00063	0.009	12	0.422	<0.05	0.0048	0.0033	<0.01	5	<0.0002	7	0.00003	0.56	0.595	500	0.0002	0.0088	<0.003	0.0017	<0.001	0.461	<0.0005
03-Nov-09	14																							
10-Nov-09	15	0.034	0.0005	0.008	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	0.0063	<0.003	0.00179	<0.001	0.48	<0.0005
17-Nov-09	16																							
24-Nov-09	17	0.008	0.00146	0.006	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	0.0081	<0.003	0.00127	<0.001	0.455	<0.0005
01-Dec-09	18																							
08-Dec-09	19	0.008	0.00038	0.004	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	0.0047	0.004	0.00084	<0.001	0.242	<0.0005
15-Dec-09	20																							
22-Dec-09	21	0.009	0.00026	0.003	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	0.0046	<0.003	0.00058	<0.001	0.169	<0.0005
29-Dec-09	22																							
05-Jan-10	23	0.006	0.0002	0.003	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	0.0059	<0.003	0.00052	<0.001	0.124	<0.0005
12-Jan-10	24																							
19-Jan-10	25	<0.01	0.00029	<0.005	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	0.011	0.00023	<0.003	3.5	0.0164	<0.05	0.004	0.0005	<0.01	1.34	<0.0002	4.67	0.00008	0.27	0.09	48	0.00008	0.0054	<0.003	0.00041	<0.001	0.087	<0.0005
09-Feb-10	28																							
16-Feb-10	29	0.005	0.00043	<0.003	4.05	0.031	<0.05	0.0049	0.0003	<0.01	1.36	<0.0002	4.69	0.00004	0.28	0.098	38	0.00007	0.0082	<0.003	0.00045	<0.001	0.095	<0.0005
23-Feb-10	30																							
02-Mar-10	31	<0.005	0.00034	0.003	3.71	0.0313	<0.05	0.0048	0.0008	<0.01	1.23	0.0003	4.61	0.00004	0.26	0.087	33	0.00008	0.0063	<0.003	0.00043	<0.001	0.081	<0.0005
09-Mar-10	32																							
16-Mar-10	33	<0.005	0.00035	<0.003	3.6	0.0299	<0.05	0.0044	0.0004	<0.01	1.1	<0.0002	4.64	<0.00003	<0.3	0.08	<50	0.00008	0.008	<0.003	0.00032	<0.001	0.08	<0.0005
23-Mar-10	34																							
30-Mar-10	35	<0.005	0.00031	<0.003	3.51	0.0116	<0.05	0.0047	0.0004	<0.01	1.03	<0.0002	3.34	<0.00003	0.24	0.074	29	0.00006	0.0038	<0.003	0.00038	<0.001	0.058	<0.0005
06-Apr-10	36																							
13-Apr-10	37	0.006	0.00029	<0.003	3.6	0.0101	<0.05	0.0047	0.0003	<0.01	1	<0.0002	4.54	0.00003	<0.3	0.069	<50	0.00006	0.0035	<0.003	0.00029	<0.001	0.048	<0.0005
20-Apr-10	38	<0.005	0.0004	<0.003	4.2	0.0235	<0.05	0.0043	0.0003	<0.01	1.1	<0.0002	4.45	0.00004	<0.3	0.085	<50	0.00007	0.0047	<0.003	0.00034	<0.001	0.078	<0.0005
27-Apr-10	39	<0.005	0.00042	<0.003	3.9	0.104	<0.05	0.0046	0.0004	<0.01	1	<0.0002	4.92	<0.00003	<0.3	0.07	<50	0.00006	0.0046	<0.003	0.00029	<0.001	0.102	<0.0005
04-May-10	40																							
11-May-10	41	<0.005	0.00058	<0.003	4.2	0.0953	<0.05	0.0038	0.0003	<0.01	1	<0.0002	5.61	<0.00003	<0.3	0.083	<50	0.00007	0.0054	<0.003	0.00029	<0.001	0.124	<0.0005
18-May-10	42																							
25-May-10	43	0.007	0.000385	0.001	1.9	0.00754	<0.01	0.00217	0.00023	0.011	0.54	8E-05	2.09	7.7E-05	0.22	0.039	<10	0.00003	0.0024	<0.0005	0.00019	<0.0002	0.017	<0.0001
01-Jun-10	44																							
08-Jun-10	45	0.004	0.000342	0.0017	3.64	0.0144	<0.01	0.00327	0.00025	0.005	0.95	7E-05	3.86	6.2E-05	0.33	0.067	30	6.5E-05	0.0005	<0.0005	0.00032	<0.0002	0.034	<0.0001
15-Jun-10	46																							
22-Jun-10	47	0.003	0.000374	0.0017	4.75	0.0118	<0.01	0.00379	0.0003	0.007	1.07	6E-05	3.53	9.8E-05	0.29	0.083	37	7.9E-05	0.0001	<0.0005	0.00039	<0.0002	0.046	<0.0001
29-Jun-10	48																							
06-Jul-10	49	0.006	0.000238	0.0021	5.83	0.0165	<0.01	0.00303	0.00042	0.002	0.97	0.0005	3.85	9.8E-05	0.4	0.1	49	4.5E-05	0.0002	<0.0005	0.00038	<0.0002	0.067	<0.0001
13-Jul-10	50																							
20-Jul-10	51	0.004	0.000341	0.0023	5.85	0.0168	<0.01	0.00257	0.00011	0.004	1	7E-05	3.66	0.00011	0.24	0.102	45	6.2E-05	0.0002	<0.0005	0.0004	<0.0002	0.093	<0.0001
27-Jul-10	52																							
03-Aug-10	53	0.007	0.000437	0.0021	5.98	0.0179	<0.01	0.00306	0.00032	0.005	1.05	6E-05	3.79	4.5E-05	0.23	0.102	53	7.7E-05	0.0001	<0.0005	0.00041	<0.0002	0.097	<0.0001
10-Aug-10	54																							
17-Aug-10	55	0.009	0.000457	0.0019	5.46	0.0163	<0.01	0.00298	0.00034	0.003	0.84	9E-05	3.48	1.3E-05	0.27	0.087	42	0.00006	0.0001	<0.0005	0.00036	<0.0002	0.071	<0.0001
24-Aug-10	56																							
31-Aug-10	57																							
07-Sep-10	58																							

Appendix B-1
Humidity Cell Leachate Chemistry for T4 (treated Clay Composite)

Date	Cycle No.	Volume mL		pH	Cond.	Acidity (pH 4.5)	Acidity (pH 8.3)	Alkalinity	Sulfate	Hardness	Al	Sb	As	Ba	Be	Bi	B	Cd	Ca	Cr	Co	Cu
		Input	Output		umhos/cm	mgCaCO$_3$/L	mg CaCO$_3$/L	mg CaCO$_3$/L	mg/L	mg CaCO$_3$/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	500	445	7.29	55	#N/A	5.6	3.2	18	17	0.0139	0.00914	0.0204	0.0661	0.00003	<0.000005	<0.05	0.00617	5.94	<0.0001	0.00046	0.0181
18-Aug-09	1	500	450	6.27	88	#N/A	6.3	1.8	30	28.2	0.0352	0.00887	0.0196	0.0915	0.00007	<0.000005	<0.05	0.0133	10	<0.0001	0.00081	0.0345
25-Aug-09	2	500	440	6.47	131	#N/A	9.4	2.2	53	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
01-Sep-09	3	500	445	6.55	166	#N/A	12.9	2.9	71	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
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	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
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	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
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	421	10.1	0.0098	0.032	0.0114	0.00504	<0.00003	<0.3	0.54	147	0.0048	0.0334	3.07
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	333	21.3	0.0124	0.0682	0.0031	0.0087	<0.0001	<1	0.767	117	0.019	0.0412	5.11
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	338	47.3	0.0148	0.202	0.0021	0.014	<0.0001	<1	1.02	117	0.049	0.0579	7.84
17-Nov-09	14	500	480	2.74	2142				1217													
24-Nov-09	15	500	420	2.79	2277	517.7	1200.0	#N/A	1403	270	77.2	0.021	0.787	0.002	0.017	<0.0003	<3	1.32	91.8	0.122	0.0724	10.4
01-Dec-09	16	500	480	2.60	2512				1612													
08-Dec-09	17	500	435	2.58	2210	600.0	1225.0	#N/A	1791	205	129	0.028	2.43	0.002	0.0193	<0.0003	<3	1.47	65	0.246	0.101	13.2
15-Dec-09	18	500	460	2.36	2610				1454													
22-Dec-09	19	500	455	2.35	2980	987.5	1437.5	#N/A	1515	103	84.9	0.023	3.39	0.001	0.0115	<0.0003	<3	0.935	28.2	0.198	0.0689	7.91
29-Dec-09	20	500	420	2.31	2990				1419													
05-Jan-10	21	500	445	2.30	3910	987.5	1475.0	#N/A	1908	95.1	97.5	0.0287	5.94	0.0023	0.0122	<0.0001	<1	1.06	20	0.26	0.087	7.94
12-Jan-10	22	500	410	2.45	4590				2044													
19-Jan-10	23	500	460	2.49	4740	1375.0	1800.0	#N/A	1867	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
26-Jan-10	24	500	430	2.37	4120				1748													
02-Feb-10	25	500	450	2.87	3390	1175.0	1325.0	#N/A	1475	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
09-Feb-10	26	500	455	2.25	3470				1581													
16-Feb-10	27	500	480	2.23	3270	975.0	1450.0	#N/A	1540	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
23-Feb-10	28	500	445	2.19	2980				1246													
02-Mar-10	29	500	480	2.35	3340	1275.0	1475.0	#N/A	1222	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
09-Mar-10	30	500	420	2.45	3520				882													
16-Mar-10	31	500	490	2.44	3250	975.0	1475.0	#N/A	1078	22.5	38.2	0.013	2.69	0.002	0.0042	<0.0003	<3	0.359	4	0.101	0.0502	3.54
23-Mar-10	32	500	445	2.69	4310				1257													
30-Mar-10	33	500	440	2.61	3680	1275	1450	#N/A	1000	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
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	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
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	20.2	42.4	0.014	2.64	0.005	0.0028	<0.0003	<3	0.312	3	0.094	0.0547	3.68
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	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
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	15.6	26.8	0.0125	1.32	0.0037	0.0025	<0.0001	<1	0.209	3	0.068	0.0408	2.94
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	16.8	27.4	0.0119	1.31	0.0041	0.0025	<0.0001	<1	0.194	4	0.064	0.0382	2.88
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	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
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	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
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	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
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	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
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	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
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													
07-Sep-10	56	500	450	2.38	1263																	

Appendix B-1
Humidity Cell Leachate Chemistry for T4 (treated Clay Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	0.056	0.00172	0.0019	0.53	0.447	<0.01	<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	3E-06	<0.0002	0.398	<0.0001
18-Aug-09	1	0.141	0.00134	0.0033	0.77	0.791	<0.01	<0.00005	0.00254	0.003	0.82	0.00019	4.07	0.000007	0.62	0.0241	11	5.5E-05	0.00472	<0.0005	9E-06	<0.0002	0.709	<0.0001
25-Aug-09	2	0.222	0.00195	0.0049	1.34	1.36	<0.01	<0.00005	0.00453	<0.002	1.08	0.00021	5.66	0.000018	0.79	0.0364	18	7.8E-05	0.00559	<0.0005	2.6E-05	<0.0002	1.36	<0.0001
01-Sep-09	3	0.327	0.00315	0.0061	1.69	1.68	0.01	<0.00005	0.00656	<0.002	1.16	0.00027	6.65	0.000016	0.76	0.0454	22	9.5E-05	0.00745	<0.0005	2.6E-05	<0.0002	1.84	<0.0001
08-Sep-09	4																							
15-Sep-09	5	0.163	0.00197	0.01	2.93	3.12	<0.01	<0.00005	0.0114	0.003	1.64	0.00042	9.46	0.000032	0.87	0.0682	39	0.00015	0.012	<0.0005	7.6E-05	<0.0002	3.53	<0.0001
22-Sep-09	6																							
29-Sep-09	7	0.785	0.00462	0.0142	6.57	7.52	<0.01	<0.00005	0.0311	0.002	2.69	0.00043	13.5	0.00004	0.91	0.136	93	0.00025	0.0304	<0.0005	0.00061	<0.0002	10.2	<0.0001
06-Oct-09	8																							
13-Oct-09	9	7.91	0.00201	0.023	12.8	16.3	<0.05	<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	14.6	0.0059	0.019	10	15.8	<0.2	<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	35.2	0.002	0.023	11.3	17.6	<0.2	<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	86	0.0546	<0.03	10	16.3	<0.5	<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	201	0.0035	<0.03	10.3	13.6	<0.5	<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	165	0.0069	<0.03	7.9	6.24	<0.5	<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	258	0.0022	0.026	10.9	5.64	<0.2	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	267	0.0021	0.025	10.4	4.47	<0.2	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	244	0.0018	0.017	6.8	2.56	<0.2	<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	299	0.0011	<0.03	6	2.34	<0.5	<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	218	0.0135	<0.03	4.8	1.92	<0.5	<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	172	0.0011	<0.03	3	1.21	<0.5	<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	178	0.0009	0.012	2.8	1.15	<0.2	<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	163	0.00039	0.012	2.4	0.94	<0.1	<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	181	0.0005	<0.03	<3	1.07	<0.5	<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	123	0.00049	0.01	1.7	0.691	<0.05	<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	112	0.0018	0.01	2	0.761	<0.2	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	117	0.002	0.011	2	0.715	<0.2	<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	102	0.00071	0.009	1.6	0.671	<0.05	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	44.9	0.00065	0.0058	0.74	0.33	<0.01	0.00008	0.0102	0.033	0.08	0.00005	9.84	0.000267	0.46	0.02	115	5.1E-05	0.0173	<0.0005	0.0026	0.0014	4.66	<0.0001
13-Jul-10	48																							
20-Jul-10	49	61.3	0.00022	0.007	1	0.439	<0.05	<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	35.2	0.000624	0.0061	0.74	0.346	<0.01	0.00007	0.0099	0.036	<0.05	0.00005	11.5	0.000361	0.55	0.0235	120	4.4E-05	0.0183	<0.0005	0.00201	0.001	4.54	<0.0001
10-Aug-10	52																							
17-Aug-10	53	26.2	0.00319	0.0059	0.65	0.269	<0.01	<0.00005	0.0078	0.023	0.05	0.00005	9.54	0.000332	0.57	0.0192	92	5.4E-05	0.0132	<0.0005	0.00182	0.0008	3.6	<0.0001
24-Aug-10	54																							
31-Aug-10	55																							
07-Sep-10	56																							

Appendix B-1
Humidity Cell Leachate Chemistry for T5 (treated Sand-Silt Composite)

											Dissolved Metals											
Date	**Cycle No.**	**Volume mL**		**pH**	**Cond.**	**Acidity (pH 4.5)**	**Acidity (pH 8.3)**	**Alkalinity**	**Sulfate**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**
		Input	**Output**		**umhos/cm**	**mgCaCO$_3$/L**	**mgCaCO$_3$/L**	**mgCaCO$_3$/L**	**mg/L**	**mgCaCO$_3$/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	500	455	7.1	49	#N/A	4.6	2.7	15	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
18-Aug-09	1	500	420	6.0	207	#N/A	6.9	1.2	92	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
25-Aug-09	2	500	375	6.2	391	#N/A	12.9	1.9	202	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
01-Sep-09	3	500	415	6.0	518	#N/A	25.1	2.1	251	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
08-Sep-09	4	500	370	5.3	601				306													
15-Sep-09	5	500	450	4.9	677	#N/A	43.1	-0.1	357	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
22-Sep-09	6	500	420	4.8	638				336													
29-Sep-09	7	500	460	4.5	568	2.7	41.2	#N/A	292	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
06-Oct-09	8	500	455	4.1	682				369													
13-Oct-09	9	500	440	4.1	826	8.8	74.2	#N/A	440	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
20-Oct-09	10	500	400	3.6	1000				577													
27-Oct-09	11	500	520	3.4	1102	51.1	211.9	#N/A	611	338	5.74	0.012	0.0366	0.004	0.0078	<0.0001	<1	0.639	75.2	<0.002	0.0463	4.05
03-Nov-09	12	500	435	3.0	1323				729													
10-Nov-09	13	500	420	2.6	1315	219.5	459.9	#N/A	720	287	21.6	0.023	0.657	0.006	0.015	<0.0003	<3	0.956	57.2	0.02	0.0484	9.4
17-Nov-09	14	500	470	2.9	1419				624													
24-Nov-09	15	500	450	3.0	1440	194.4	525.9	#N/A	694	165	24.1	0.023	0.769	0.006	0.011	<0.0005	<5	0.795	27	0.027	0.0349	8.85
01-Dec-09	16	500	475	2.7	1647				821													
08-Dec-09	17	500	485	2.8	1189	550	875	#N/A	1000	106	44	0.031	3.64	0.006	0.009	<0.0005	<5	0.88	15	0.069	0.0463	9.43
15-Dec-09	18	500	455	2.3	3310				1618													
22-Dec-09	19	500	460	2.4	4150	1700	3425	#N/A	2522	102	75	0.094	32.5	0.013	0.006	0.0011	<5	1.49	9	0.207	0.0866	10.2
29-Dec-09	20	500	465	2.3	5290				3276													
05-Jan-10	21	500	425	2.2	7750	1875	2587.5	#N/A	4999	123	77.6	0.217	169	0.009	0.007	0.0133	<5	2.41	9	0.333	0.155	10.4
12-Jan-10	22	500	430	2.3	9930				5905													
19-Jan-10	23	500	450	2.5	9210	1975	3325	#N/A	5425	114	56	0.22	197	0.005	0.006	0.0102	<5	2.51	9	0.381	0.179	9.04
26-Jan-10	24	500	445	2.5	8040				5860													
02-Feb-10	25	500	450	2.7	8180	1875	2375	#N/A	4608	66.7	42.1	0.188	137	0.005	0.005	0.0049	<5	1.81	9	0.292	0.142	6.32
09-Feb-10	26	500	415	2.1	7200				4880													
16-Feb-10	27	500	425	2.1	6000	2800	3350	#N/A	3707	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
23-Feb-10	28	500	480	2.1	4840				3043													
02-Mar-10	29	500	410	2.1	7940	2950	3050	#N/A	4571	43	37.3	0.163	110	0.004	0.004	0.003	<5	1.14	10	0.238	0.142	6.58
09-Mar-10	30	500	450	2.1	110500				3736													
16-Mar-10	31	500	455	2.1	8020	2750	3450	#N/A	4033	20.6	27.7	0.142	69.2	0.014	0.003	0.0014	<5	0.828	8	0.169	0.123	5.22
23-Mar-10	32	500	460	2.4	10500				4699													
30-Mar-10	33	500	450	2.3	10660	2850	3450	#N/A	4505	37.5	25	0.143	66.2	0.004	0.0022	0.0011	<3	0.678	10.6	0.153	0.127	4.85
06-Apr-10	34	500	450	2.1	10880				4728													
13-Apr-10	35	500	455	2.0	10630	2800	3450	#N/A	3880	34.9	22.9	0.142	58.8	0.003	0.0021	0.0016	<3	0.568	10	0.134	0.124	4.03
20-Apr-10	36	500	455	2.0	10130				4828													
27-Apr-10	37	500	440	2.0	10960	2800	3550	#N/A	4186	35.7	28.3	0.147	61.4	0.004	0.0019	0.0015	<3	0.492	10	0.14	0.132	4.16
04-May-10	38	500	420	2.2	6970				4157													
11-May-10	39	500	425	2.7	3700	2750	3400	#N/A	3948	25	23.8	0.139	45.2	0.002	0.0022	0.0006	<3	0.44	10	0.108	0.119	3.72
18-May-10	40	500	490	2.4	6290				2687													
25-May-10	41	500	445	2.1	6780	2700	3450	#N/A	2986	23.6	23.3	0.126	42.4	0.003	0.0017	0.0011	<3	0.32	9	0.107	0.128	3.86
01-Jun-10	42	500	410	2.7	8900				3720													
08-Jun-10	43	500	425	2.1	7120	3150	3800	#N/A	3744	56.3	30.7	0.155	59.6	0.006	0.0024	0.0019	<3	0.33	17	0.141	0.162	4.13
15-Jun-10	44	500	410	2.6	7130				3078													
22-Jun-10	45	500	440	1.9	6950	2700	3450	#N/A	2864	41.3	20.7	0.121	39.7	0.003	0.0014	0.0009	<3	0.257	12	0.096	0.129	3.31
29-Jun-10	46	500	420	2.1	7170				3629													
06-Jul-10	47	500	465	2.2	5550	2550	3300	#N/A	2238	22.5	18.1	0.089	22	0.003	0.0013	<0.0003	<3	0.184	9	0.069	0.0953	2.45
13-Jul-10	48	500	455	2.3	6680				1706													
20-Jul-10	49	500	495	2.3	4650	2600	3350	#N/A	1070	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
27-Jul-10	50	500	455	2.2	6160				2556													
03-Aug-10	51	500	410	2.3	7650	2550	3350	#N/A	4225	30.9	22.2	0.11	45	0.003	0.0018	0.0011	<3	0.195	12	0.091	0.15	3.41
10-Aug-10	52	500	495	2.0	4890				2078													
17-Aug-10	53	500	435	2.1	6570	2650	3300	#N/A	2901	32.2	17	0.0878	24.2	0.0031	0.0012	0.0005	<1	0.117	10	0.059	0.106	2.66
24-Aug-10	54	500	460	2.0	6490				1986													
31-Aug-10	55	500	435	2.2	6250	2600	3250	#N/A	3834													
07-Sep-10	56	500	445	2.2	6890																	

Appendix B-1
Humidity Cell Leachate Chemistry for T5 (treated Sand-Silt Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	0.006	0.0098	<0.0005	0.83	0.649	<0.01	<0.00005	0.00123	0.003	0.21	4E-05	1.38	<0.000005	0.55	0.01	7	1.2E-05	0.0031	<0.0005	3E-06	<0.0002	0.17	<0.0001
18-Aug-09	1	0.025	0.0179	0.0014	4.24	3.64	<0.01	<0.00005	0.00321	0.003	0.55	0.0002	3.44	<0.000005	0.94	0.048	33	0.00002	0.0055	<0.0005	2E-06	<0.0002	1.02	<0.0001
25-Aug-09	2	0.097	0.0319	0.0027	8.69	8.6	<0.01	<0.00005	0.00867	0.003	0.88	0.0003	6.1	0.000017	1.16	0.087	65	3.4E-05	0.008	<0.0005	1.1E-05	<0.0002	2.96	<0.0001
01-Sep-09	3	0.044	0.0417	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	0.141	0.0231	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	0.201	0.00905	0.006	19.7	18.3	<0.05	<0.0003	0.0225	<0.01	1.29	<0.0002	10.7	0.00008	0.51	0.1	108	0.00005	0.0407	<0.003	0.00018	<0.001	10.2	<0.0005
06-Oct-09	8																							
13-Oct-09	9	0.35	0.0122	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	15.5	0.0313	<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	54.3	0.0749	<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	80.7	0.0631	<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	175	0.13	<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	465	0.432	<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	1430	0.445	<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	1600	0.206	<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	1480	0.108	<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	1070	0.0222	<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	1400	0.0401	<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	1180	0.0222	<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	1180	0.0187	<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
06-Apr-10	34																							
13-Apr-10	35	1170	0.0169	<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	1220	0.0153	<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	1080	0.0067	<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	1060	0.0092	<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	1440	0.0145	<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	1130	0.0089	<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	788	0.0039	<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	364	0.00096	<0.005	1.2	0.434	<0.1	<0.0005	0.0216	0.288	<0.5	<0.0004	10.9	0.00265	<0.5	0.024	394	0.00021	0.0408	<0.005	0.00205	0.03	5.92	<0.001
27-Jul-10	50																							
03-Aug-10	51	1240	0.0098	<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	813	0.0075	<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																							
07-Sep-10	56																							

Appendix B-1:
Humidity Cell Leachate Chemistry for T6 (treated Silt-Clay Composite)

											Dissolved Metals											
Date	**Cycle No.**	**Volume mL**			**Cond.**	**Acidity (pH 4.5)**	**Acidity (pH 8.3)**	**Alkalinity**	**Sulfate**	**Hardness**	**Al**	**Sb**	**As**	**Ba**	**Be**	**Bi**	**B**	**Cd**	**Ca**	**Cr**	**Co**	**Cu**
		Input	**Output**	**pH**	**umhos/cm**	**mgCaCO$_3$/L**	**mgCaCO$_3$/L**	**mgCaCO$_3$/L**	**mg/L**	**mgCaCO$_3$/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	500	405	7.4	33	#N/A	4.4	3.9	8	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
18-Aug-09	1	500	490	5.5	87	#N/A	5.7	0.8	26	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
25-Aug-09	2	500	410	5.8	234	#N/A	11.3	1.4	94	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
01-Sep-09	3	500	445	5.7	205	#N/A	13.5	2.4	92	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
08-Sep-09	4	500	435	5.4	335				158													
15-Sep-09	5	500	430	5.4	394	#N/A	26.1	1.9	174	148	0.151	0.0278	0.119	0.0495	0.00019	<0.00003	<0.3	0.0543	43	<0.0005	0.00956	0.307
22-Sep-09	6	500	445	5.6	340				162													
29-Sep-09	7	500	425	5.0	319	#N/A	21.0	0.5	148	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
06-Oct-09	8	500	470	4.8	335				172													
13-Oct-09	9	500	470	4.5	460	2.0	32.4	#N/A	245	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
20-Oct-09	10	500	450	4.3	460				234													
27-Oct-09	11	500	440	4.2	523	6.1	50.1	#N/A	264	173	0.742	0.0246	0.0885	0.0214	0.001	<0.0001	<1	0.146	45	<0.002	0.0188	1.23
03-Nov-09	12	500	520	4.2	476				242													
10-Nov-09	13	500	435	4.7	336	#N/A	33.0	1.0	179	133	0.645	0.0173	0.0028	0.0158	0.001	<0.0001	<1	0.108	32.8	<0.002	0.0155	1.09
17-Nov-09	14	500	455	4.0	442				186													
24-Nov-09	15	500	510	4.1	383	8.4	41.4	#N/A	181	111	0.614	0.01	0.002	0.016	0.0008	<0.0003	<3	0.107	25.8	<0.005	0.0153	1.15
01-Dec-09	16	500	460	3.8	477				217													
08-Dec-09	17	500	480	3.7	579	24.3	97.9	#N/A	269	164	2.63	0.011	0.013	0.014	0.0028	<0.0003	<3	0.225	35.3	<0.005	0.0273	3.35
15-Dec-09	18	500	470	3.6	652				304													
22-Dec-09	19	500	470	3.3	816	60.0	206.9	#N/A	455	207	10.9	0.019	0.065	0.013	0.007	<0.0005	<5	0.489	43	<0.01	0.0463	8.08
29-Dec-09	20	500	465	3.0	1253				522													
05-Jan-10	21	500	420	2.9	1927	382.2	905.9	#N/A	981	193	50.6	0.044	1.3	0.01	0.015	<0.0005	<5	1.2	37	0.044	0.0844	16.4
12-Jan-10	22	500	430	2.5	2345				1432													
19-Jan-10	23	500	440	2.6	3290	675	1075	#N/A	1219	108	68.2	0.057	2.94	0.008	0.0137	<0.0003	<3	1.61	18.4	0.093	0.112	13.9
26-Jan-10	24	500	435	2.7	2900				1545													
02-Feb-10	25	500	450	2.9	3190	800	1275	#N/A	1636	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
09-Feb-10	26	500	415	2.1	3400				1803													
16-Feb-10	27	500	460	2.4	2790	850	1375	#N/A	1483	68	41	0.067	4.82	0.003	0.005	<0.0005	<5	1.23	5	0.082	0.0602	6.3
23-Feb-10	28	500	485	2.2	2410				1415													
02-Mar-10	29	500	395	2.2	2430	1450	2375	#N/A	2254	87.2	58.2	0.107	21.2	0.004	0.006	<0.0005	<5	1.62	4	0.14	0.0961	7.87
09-Mar-10	30	500	480	2.3	4170				1656													
16-Mar-10	31	500	445	2.5	3190	1050	1775	#N/A	2225	67	43	0.09	16.6	0.014	0.005	<0.0005	<5	1.35	<5	0.114	0.0859	6.76
23-Mar-10	32	500	485	2.6	3840				1357													
30-Mar-10	33	500	430	2.5	3710	1100	1725	#N/A	2538	68.2	41.3	0.089	17.8	0.013	0.004	<0.0005	<5	1.17	3	0.107	0.0903	6.78
06-Apr-10	34	500	470	2.3	3700				1266													
13-Apr-10	35	500	485	2.3	3680	825.0	1775	#N/A	1430	43.3	17.8	0.058	3.21	0.004	0.0024	<0.0001	<1	0.616	3	0.053	0.0462	4.28
20-Apr-10	36	500	480	2.4	4160				1875													
27-Apr-10	37	500	445	2.4	4370	850.0	1725	#N/A	1862	35.8	33.2	0.077	12	0.004	0.0028	<0.0003	<3	0.731	<3	0.085	0.0756	5.69
04-May-10	38	500	485	2.5	3120				1501													
11-May-10	39	500	425	2.6	2930	1225	1700	#N/A	2205	36.1	33.1	0.092	17	0.003	0.0029	<0.0003	<3	0.685	4	0.087	0.0839	5.81
18-May-10	40	500	405	2.5	3240				1704													
25-May-10	41	500	435	2.3	3350	1450	1775	#N/A	1277	27.1	27.5	0.075	11.7	0.003	0.0022	<0.0003	<3	0.494	3	0.075	0.0763	4.96
01-Jun-10	42	500	480	2.7	3890				1266													
08-Jun-10	43	500	405	2.2	4740	1775	2225	#N/A	1818	36.8	38.4	0.088	26.3	0.006	0.003	<0.0005	<5	0.535	6	0.105	0.105	5.25
15-Jun-10	44	500	445	2.7	3360				1432													
22-Jun-10	45	500	430	2.1	2380	1100	1275	#N/A	1215	19.3	18.1	0.047	12.4	0.003	0.0012	<0.0003	<3	0.292	4	0.058	0.0596	2.81
29-Jun-10	46	500	475	2.4	2450				895													
06-Jul-10	47	500	435	2.3	3660	1675	1925	#N/A	1582	32.9	33	0.062	20.4	0.002	0.0022	<0.0003	<3	0.427	7	0.093	0.0933	4.26
13-Jul-10	48	500	470	2.4	3840				1023													
20-Jul-10	49	500	445	2.3	4390	975	1300	#N/A	1325	21.8	23.1	0.0515	15.7	0.0024	0.0017	<0.0001	<1	0.249	5	0.067	0.0774	3.12
27-Jul-10	50	500	460	2.2	3970				1449													
03-Aug-10	51	500	425	2.3	3270	1025	1325	#N/A	1196	14.8	15.1	0.0358	13.7	0.0016	0.0011	<0.0001	<1	0.161	4	0.048	0.0588	2.05
10-Aug-10	52	500	435	2.2	4580				2273													
17-Aug-10	53	500	440	2.3	3150	1050	1325	#N/A	1080	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
24-Aug-10	54	500	495	2.1	1940				346													
31-Aug-10	55	500	430	2.2	2120	1025	1300	#N/A	989													
07-Sep-10	56	500	430	2.4	2570																	

Appendix B-1: Laboratory-based humidity cell results
Humidity Cell Leachate Chemistry for T6 (treated Silt-Clay Composite), Dissolved Metals continued

Date	Cycle No.	Fe	Pb	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	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	0.004	0.000574	0.0006	0.55	0.373	<0.01	<0.00005	0.00073	0.002	0.27	<0.00004	2.12	6E-06	0.75	0.0084	4	0.00002	0.0035	<0.0005	<0.000002	0.0002	0.128	<0.0001
18-Aug-09	1	0.032	0.00802	0.0017	1.47	1.39	<0.01	<0.00005	0.00204	<0.002	0.46	0.00005	3.8	5E-06	0.75	0.0226	12	7.5E-05	0.0068	<0.0005	0.000002	<0.0002	0.579	<0.0001
25-Aug-09	2	0.119	0.0112	0.0041	5.03	4.77	<0.01	<0.00005	0.00711	0.004	0.9	0.00022	9.68	2.6E-05	1.44	0.0602	34	6.2E-05	0.009	<0.0005	0.000016	<0.0002	2.08	<0.0001
01-Sep-09	3	0.107	0.0125	0.0035	4.48	4.07	<0.01	<0.00005	0.0066	<0.002	1.07	0.00017	7.56	2.5E-05	1.1	0.0474	29	0.00013	0.008	<0.0005	0.000012	<0.0002	2.01	<0.0001
08-Sep-09	4																							
15-Sep-09	5	0.493	0.0152	0.006	9.91	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	0.539	0.00932	0.0064	8.8	8.14	<0.01	<0.00005	0.0134	0.002	1.26	0.00014	12.8	0.00004	0.59	0.0695	51	0.00011	0.0323	<0.0005	0.000032	<0.0002	4.23	<0.0001
06-Oct-09	8																							
13-Oct-09	9	0.241	0.0126	0.007	14.1	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	0.508	0.0188	<0.01	14.8	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	1.61	0.0115	<0.01	12.5	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	1.89	0.0115	<0.03	11.3	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	5.77	0.0553	<0.03	18.4	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	13.6	0.033	<0.05	24	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	58.9	0.095	<0.05	24	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	137	0.0946	<0.03	15.1	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	266	0.0725	<0.03	13.2	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	328	0.0238	<0.05	13	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	540	0.0299	<0.05	18	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	556	0.0177	<0.05	16	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	570	0.0142	<0.05	15	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																							
13-Apr-10	35	282	0.006	<0.01	9	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	456	0.0052	<0.03	9	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	518	0.0057	<0.03	6	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	438	0.0033	<0.03	5	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	666	0.0054	<0.05	5	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	362	0.0049	<0.03	<3	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	550	0.0014	<0.03	4	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	469	0.0013	<0.01	2	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	344	0.0031	<0.01	1	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	264	0.00099	0.004	1	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																							
07-Sep-10	56																							

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] max
				23-Jul-09	8-May-09	19-Aug-09	20-May-10	17-Jun-10	15-Jul-10	12-Aug-10	8-Sep-10	
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 Sand Bin		Tailings + Org		Tailings + Org		Blanks				
					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	<0.002	<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

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	ºC			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	°C	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

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

Appendix E:
Mill Area Characterization Results

Appendix E-1 Mill Area Static Characterization Results

Appendix E-2 Mill Area Drainage Quality Results

Appendix E-3 Mill Area Groundwater Chemistry Results

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 Sampled Date Matrix Detection Limit	Pond			Seep					Dome Creek				
			Sample Site	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

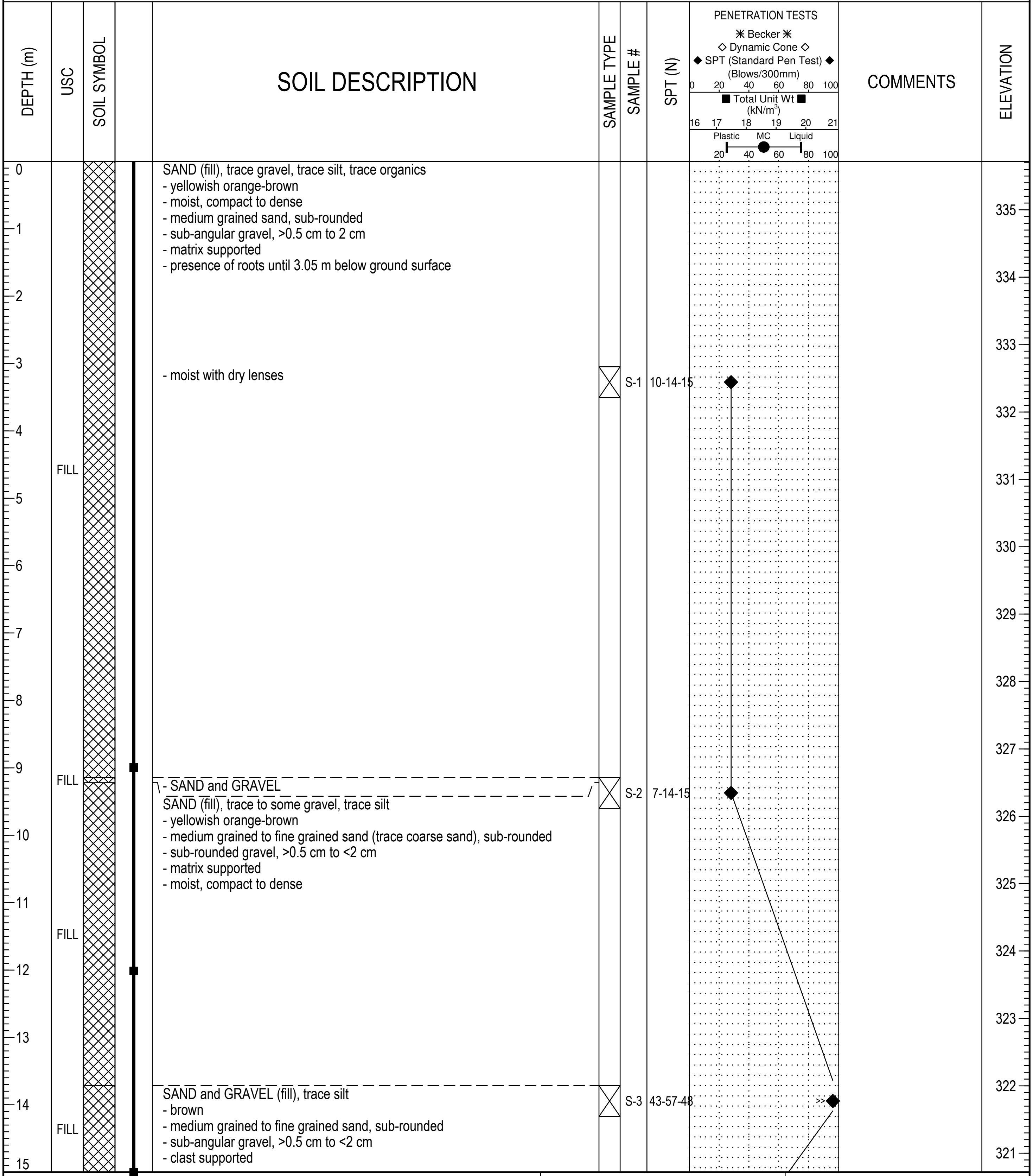
Sample ID	CCME Freshwater Aquatic Life Guidelines	MW09-16		MW09-17		MW09-18			MW09-19	
Date Sampled		19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10	19-JUL-09	19-JUL-09	02-JUL-10	19-JUL-09	02-JUL-10
Dissolved Metals										
Aluminum (Al)-Dissolved	0.10	<0.025	<0.0050	<0.025	<0.0050	<0.025	<0.025	<0.0050	<0.025	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**

Appendix F:
Mt. Nansen 2009 Borehole Logs

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
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					
		- moist with dry lenses	☒	S-1	10-14-15		
	FILL	- SAND and GRAVEL					
	FILL	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	☒	S-2	7-14-15		
	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		



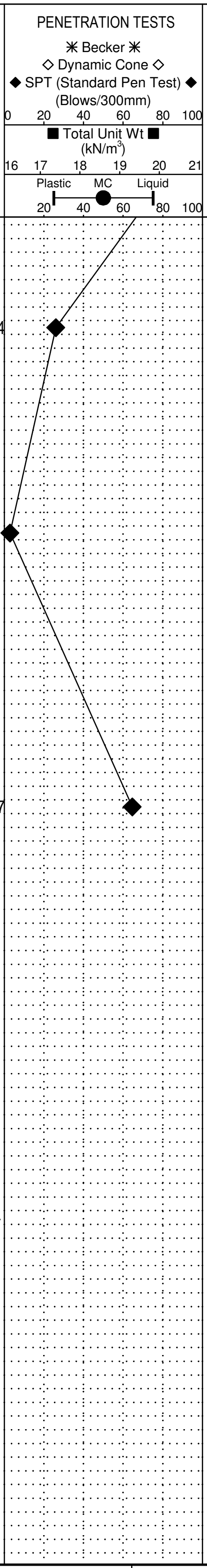
LOGGED BY: Marc Lavigne
REVIEWED BY: Alex Knop
PROJECT ENGINEER: Ken Skaftfeld
COMPLETION DEPTH: 30.18 m
COMPLETION DATE: 7/19/09

AECOM

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 - clast supported - wet, very loose	☒	S-5	2-1-2		318
18.7	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					317
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, 2.8°C	☒	S-6	4-20-47		314
22	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 - fine sand content decreases with depth - some gravel	☒	S-7	31-61-		313
27.7	GRSA	SAND and GRAVEL - light grey-brown - fine grained to medium-coarse sand, sub-rounded - sub-angular gravel, <1 cm - coarsening downward sequences	■	G-8			307



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

AECOM

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 ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
30			■	END OF DRILLING at 30.18 m in permafrost (refusal) - 10 cm of heaving at 17.53 m below ground surface 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						

Depth (m): 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45

Elevation: 305, 304, 303, 302, 301, 300, 299, 298, 297, 296, 295, 294, 293, 292, 291

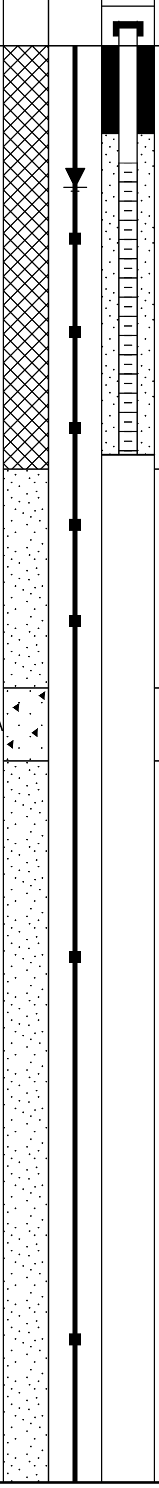
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 30.18 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/19/09
PROJECT ENGINEER: Ken Skaftfeld	Page 3 of 3

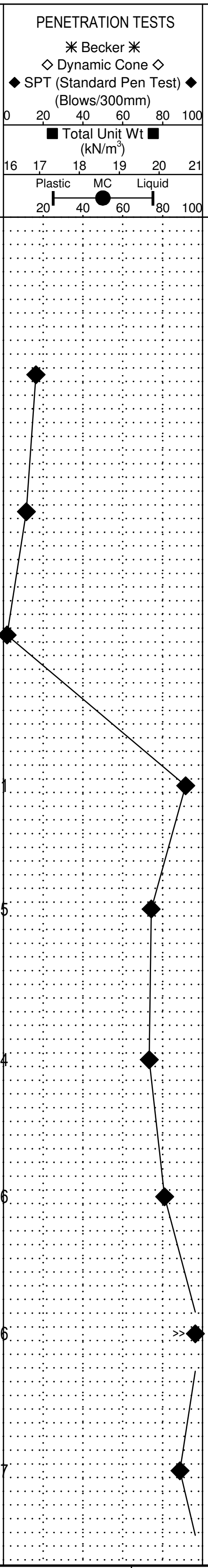
AECOM

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 DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
0		SAND (fill), trace silt					
		- medium brown					332
		- fine grained to medium grained sand, sub-rounded					
		- moist, loose					
1							
							331
			☒	S-1	5-7-10		
2							
	FILL	- some gravel below 2.13 m below ground surface					
							330
3							
			☒	S-2	5-6-6		
							329
4							
							328
		SAND, trace silt, trace organics	☒	S-3	1-1-1		
		- wood debris, <2 cm					
5		- dark grey					
		- sub-rounded					327
	SA	- permafrost at 5.64 m below ground surface, Nbn, 1.6°C					
		- gravel content increases with depth to "gravelly"					
6							
			☒	S-4	28-34-61		326
		GRAVEL, sandy, trace silt					
7	GRSA	- dark grey					
		- medium to coarse sand, sub-angular					325
		- sub-angular gravel, >0.5 cm to 2 cm					
		SAND, trace silt	☒	S-5	25-42-35		
8		- dark grey					
		- medium grained sand, sub-rounded					324
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		323
10							
		- medium grained sand below 10.36 m below ground surface					322
		- trace gravel (<2 cm) below 10.67 m below ground surface	☒	S-7	37-38-46		
11	SA						321
12							
		- fine grained to medium grained sand below 12.19 m below ground surface	☒	S-8	38-47-56		320
13							
		- some gravel below 13.41 m below ground surface					319
14			☒	S-9	37-45-47		
							318
15							

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					☒	S-10	38-49-60	>>◆		317
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						316
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						315
18											314
19											313
20											312
21											311
22											310
23											309
24											308
25											307
26											306
27											305
28											304
29											303
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: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/17/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

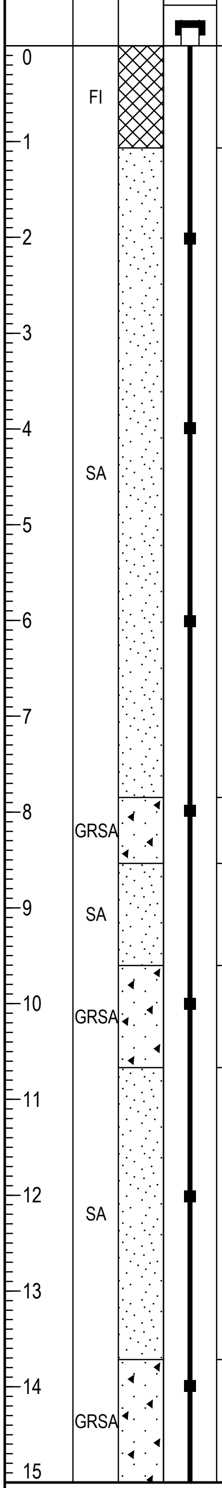
PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **GT09-03**
LOCATION: Tailings Dam, North Terrace N 2,097,213.3 E 118,722.8		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Air Rotary - 114 mm	ELEVATION (m): 1092.33

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ◪ NO RECOVERY ▮ CORE

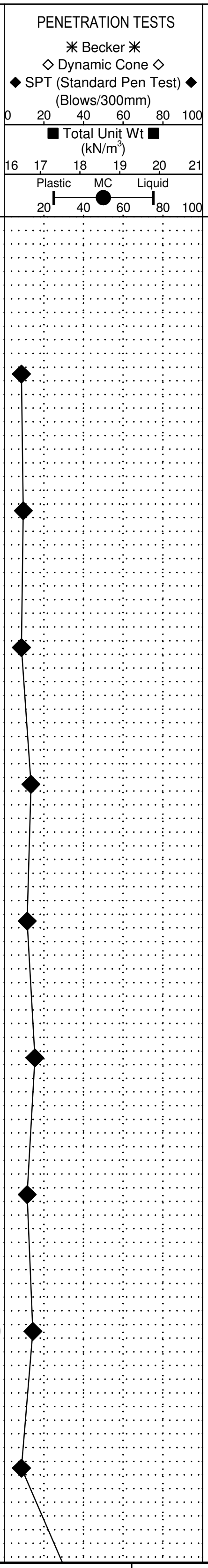
BACKFILL TYPE: ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁘ SAND

DEPTH (m)	USC	SOIL DESCRIPTION
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
	SA	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 - some gravel below 5.33 m below ground surface - trace gravel below 6.10 m below ground surface - some gravel below 7.32 m below ground surface
8	GRSA	SAND and GRAVEL, trace silt - light brown-orange - moist, compact - medium grained sand, sub-rounded - sub-angular gravel, >0.5 cm to 2 cm - iron staining on gravel
	SA	SAND, trace gravel, trace silt (Aeolian) - orange-brown - moist, compact - medium grained sand, sub-rounded
	GRSA	- sub-rounded gravel, 1 cm to 1.5 cm - matrix supported SAND and GRAVEL, trace silt
	SA	SAND, trace gravel, trace silt - some gravel below 12.19 m below ground surface
14	GRSA	SAND and GRAVEL, trace silt - coarsening downward sequence

SAMPLE TYPE	SAMPLE #	SPT (N)
☒	S-1	4-5-4
☒	S-2	4-5-5
☒	S-3	3-4-5
☒	S-4	6-7-7
☒	S-5	4-7-5
☒	S-6	3-7-9
☒	S-7	6-8-4
☒	S-8	4-5-10
☒	S-9	3-7-2



PENETRATION TESTS



COMMENTS

ELEVATION
332
331
330
329
328
327
326
325
324
323
322
321
320
319

AECOM

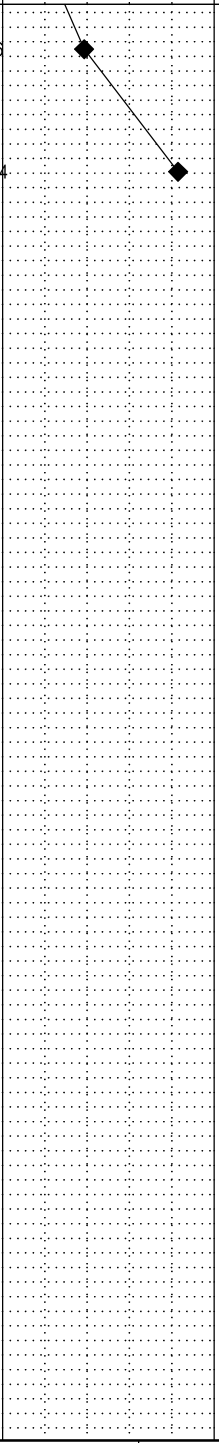
LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/19/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 2

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

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
		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		
17							316
18	SA						315
19							314
		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					
20							313
21							312
22							311
23							310
24							309
25							308
26							307
27							306
28							305
29							304
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



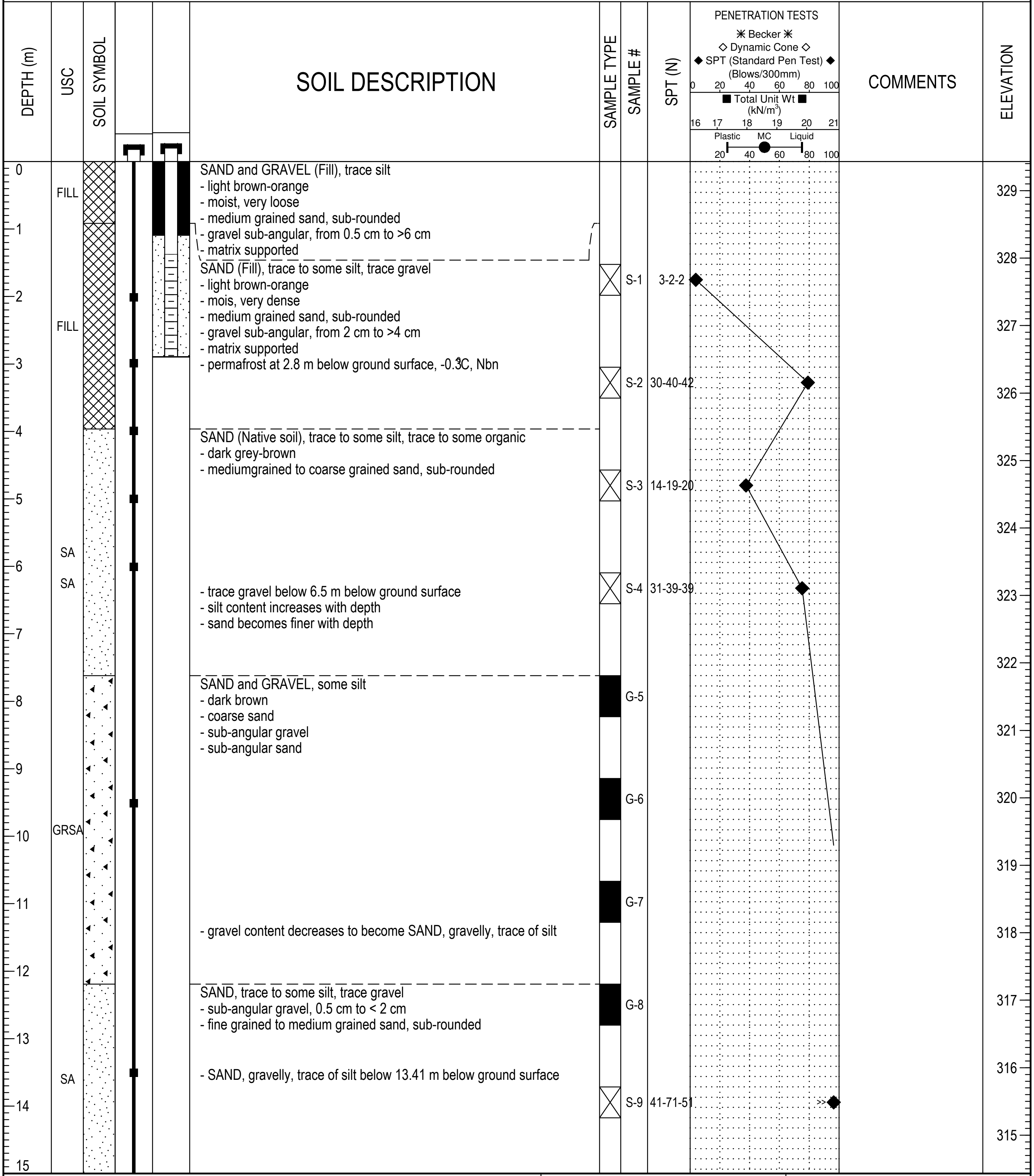
AECOM

LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 19.81 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/19/09
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



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

SAND (Fill), trace to some silt, trace gravel
- light brown-orange
- mois, very dense
- medium grained sand, sub-rounded
- gravel sub-angular, from 2 cm to >4 cm
- matrix supported
- permafrost at 2.8 m below ground surface, -0.3°C, Nbn

SAND (Native soil), trace to some silt, trace to some organic
- dark grey-brown
- mediumgrained to coarse grained sand, sub-rounded
- trace gravel below 6.5 m below ground surface
- silt content increases with depth
- sand becomes finer with depth

SAND and GRAVEL, some silt
- dark brown
- coarse sand
- sub-angular gravel
- sub-angular sand
- gravel content decreases to become SAND, gravelly, trace of silt

SAND, trace to some silt, trace gravel
- sub-angular gravel, 0.5 cm to < 2 cm
- fine grained to medium grained sand, sub-rounded
- SAND, gravelly, trace of silt below 13.41 m below ground surface

SAMPLE TYPE	SAMPLE #	SPT (N)
☒	S-1	3-2-2
☒	S-2	30-40-42
☒	S-3	14-19-20
☒	S-4	31-39-39
■	G-5	
■	G-6	
■	G-7	
■	G-8	
☒	S-9	41-71-51

AECOM

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

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

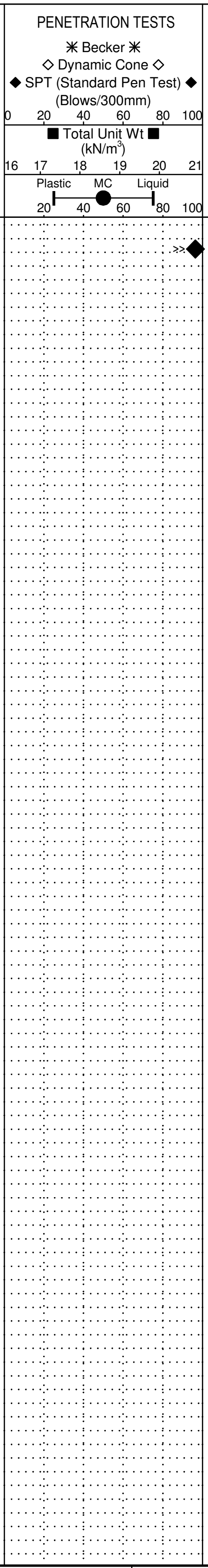
DEPTH (m)	USC	SOIL SYMBOL	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS	ELEVATION
15	SA	⁙						
				☒	S-10	67--		314
	GRSA	⁙	SAND and GRAVEL, trace of silt - dark grey-brown - medium sand, sub-rounded - gravel sub-angular, from 0.5 cm to > 4 cm - silt content increases with depth - permafrost temperature: 0.9 oC description: Nbn					
16								313
17			END OF DRILLING at16.23 m in permafrost (refusal)					312

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

DEPTH (m): 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

ELEVATION: 314 313 312 311 310 309 308 307 306 305 304 303 302 301 300

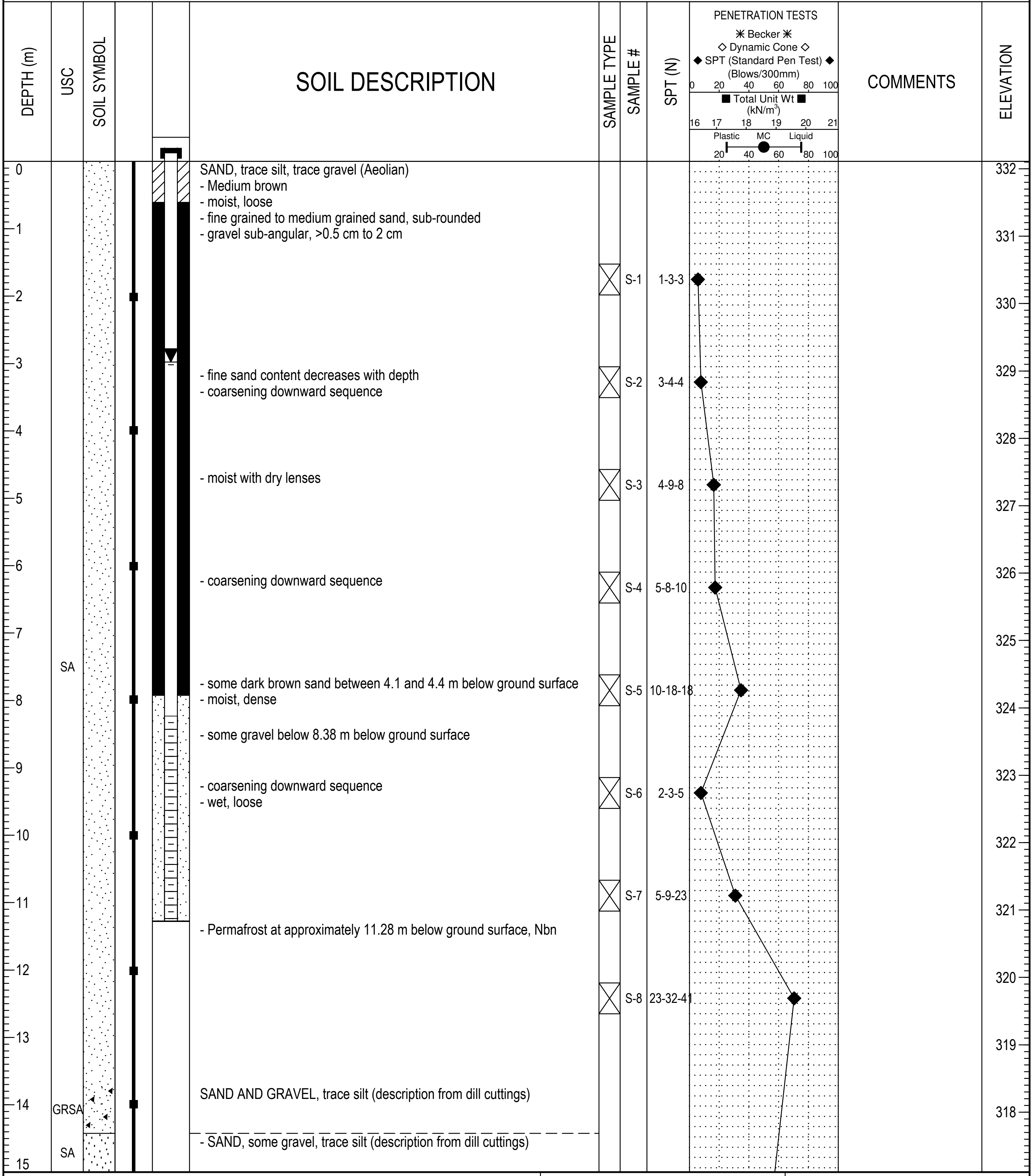


LOGGED BY: Marc Lavigne	COMPLETION DEPTH: 16.23 m
REVIEWED BY: Alex Knop	COMPLETION DATE: 7/16/09
PROJECT ENGINEER: Ken Skaftfeld	Page 2 of 2

AECOM

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



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
- fine sand content decreases with depth
- coarsening downward sequence
- moist with dry lenses
- coarsening downward sequence
- some dark brown sand between 4.1 and 4.4 m below ground surface
- moist, dense
- some gravel below 8.38 m below ground surface
- coarsening downward sequence
- wet, loose
- Permafrost at approximately 11.28 m below ground surface, Nbn

SAND AND GRAVEL, trace silt (description from dill cuttings)

- SAND, some gravel, trace silt (description from dill cuttings)

☒	S-1	1-3-3
☒	S-2	3-4-4
☒	S-3	4-9-8
☒	S-4	5-8-10
☒	S-5	10-18-18
☒	S-6	2-3-5
☒	S-7	5-9-23
☒	S-8	23-32-41

AECOM

LOGGED BY: Marc Lavigne
REVIEWED BY: Alex Knop
PROJECT ENGINEER: Ken Skaftfeld
COMPLETION DEPTH: 19.81 m
COMPLETION DATE: 7/21/09

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

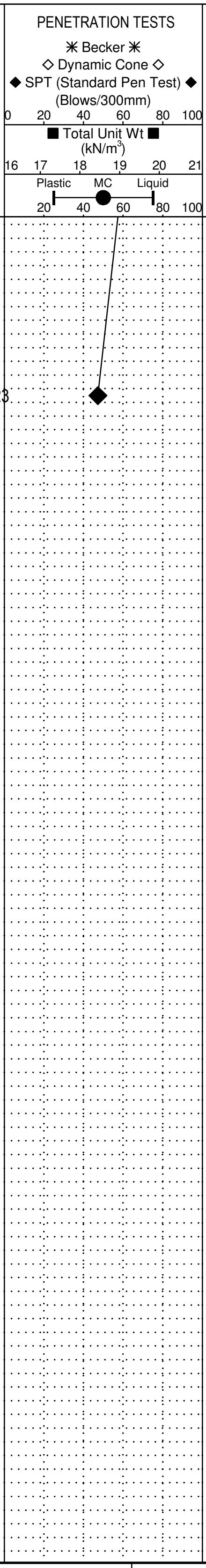
USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)
SASI	SILT, some sand, trace gravel, trace organic (description from dill cuttings) - sand content increases with depth			
SA	SAND, trace to some silt, trace gravel - dark grey - dense - fine grained to medium grained sand, sub-rounded - sub-angular gravel, < 1 cm - matrix supported - lenses of organic material, <2 cm	☒	S-9	21-26-23
GRSA	SAND and GRAVEL, trace silt - gravel content increases with depth - sub-angular gravel, < 2 cm - coarse sand, sub-rounded			

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

DEPTH (m)	ELEVATION
15	317
16	316
17	315
18	314
19	313
20	312
21	311
22	310
23	309
24	308
25	307
26	306
27	305
28	304
29	303
30	



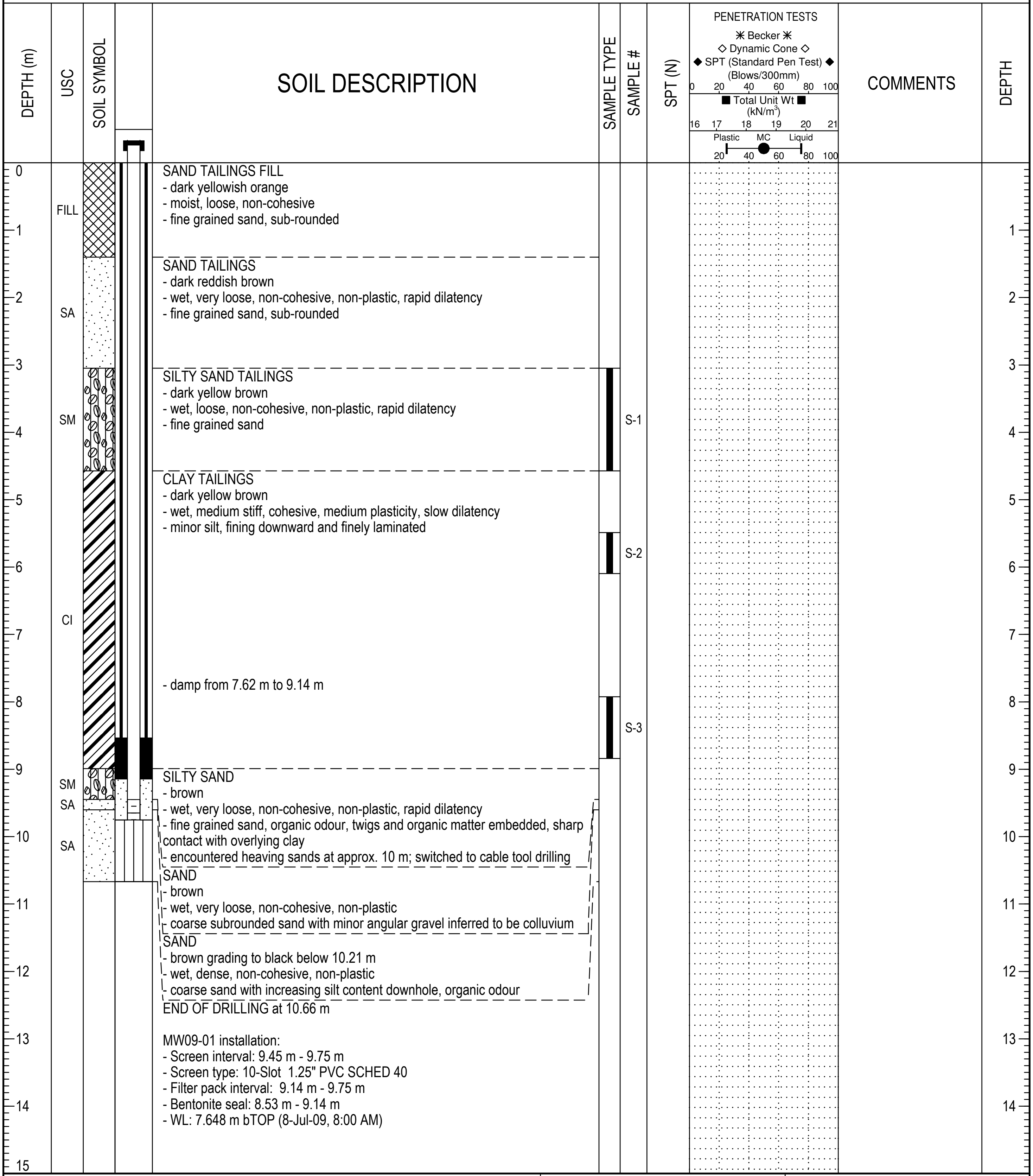
COMMENTS

LOGGED BY: Marc Lavigne
REVIEWED BY: Alex Knop
PROJECT ENGINEER: Ken Skaftfeld
COMPLETION DEPTH: 19.81 m
COMPLETION DATE: 7/21/09

AECOM

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



SOIL DESCRIPTION

SAND TAILINGS FILL
- dark yellowish orange
- moist, loose, non-cohesive
- fine grained sand, sub-rounded

SAND TAILINGS
- dark reddish brown
- wet, very loose, non-cohesive, non-plastic, rapid dilatency
- fine grained sand, sub-rounded

SILTY SAND TAILINGS
- dark yellow brown
- wet, loose, non-cohesive, non-plastic, rapid dilatency
- fine grained sand

CLAY TAILINGS
- dark yellow brown
- wet, medium stiff, cohesive, medium plasticity, slow dilatency
- minor silt, fining downward and finely laminated
- damp from 7.62 m to 9.14 m

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

SAND
- brown
- wet, very loose, non-cohesive, non-plastic
- coarse subrounded sand with minor angular gravel inferred to be colluvium

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

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)

AECOM

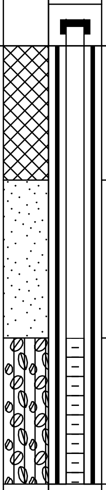
LOGGED BY: Ryan Mills
REVIEWED BY: Marc Lavigne
PROJECT ENGINEER: Ken Skaftfeld
COMPLETION DEPTH: 10.67 m
COMPLETION DATE: 7/7/09

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	DEPTH
0	FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive - fine grained sand, sub-rounded					
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		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)					5
6							6
7							7
8							8
9							9
10							10
11							11
12							12
13							13
14							14
15							

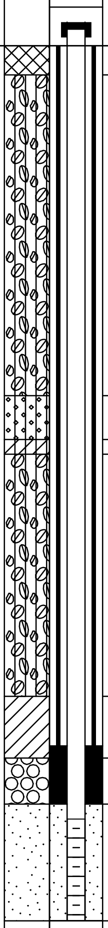
AECOM

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

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



USC	SOIL DESCRIPTION	SAMPLE #
FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded	
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	S-1 S-2
SASI	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded	
SICL	SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency	
SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded	
CL	CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, high plasticity, slow dilatency	S-3
CB	COBBLES AND SAND AND SILT - brown - wet, dense, non-cohesive, non-plastic - loose fine sand, silt and clay fraction inferred to be waste rock armouring on upstream face of dam	S-4
SA	SAND - brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium sand with minor silt inferred to be dam fill	

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)

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): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15

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

AECOM

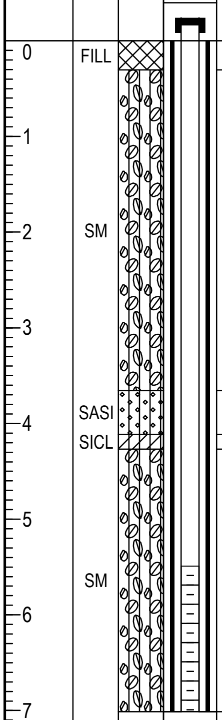
PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-04**
LOCATION: South side of tailings empoundment		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push - 114 mm	ELEVATION (m): 1103 (est.)

SAMPLE TYPE: ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▮ CORE

BACKFILL TYPE: ■ BENTONITE ⁚ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁚ SAND

DEPTH (m) | USC | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE # | SPT (N) | PENETRATION TESTS | COMMENTS | DEPTH

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



USC	SOIL DESCRIPTION	SAMPLE #
FILL	SAND TAILINGS FILL - dark yellowish orange - moist, loose, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded	
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	S-1
SASI	SANDY SILT TAILINGS - dark yellowish orange - wet, medium dense, non-cohesive, non-plastic, slow dilatency - fine grained sand, sub-rounded	
SICL	SILTY CLAY TAILINGS - dark yellow brown - wet, soft, cohesive, medium plasticity, slow dilatency	S-2
SM	SILTY SAND - dark yellow brown - wet, medium dense, non-cohesive, non-plastic, rapid dilatency - fine grained sand, sub-rounded	

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)

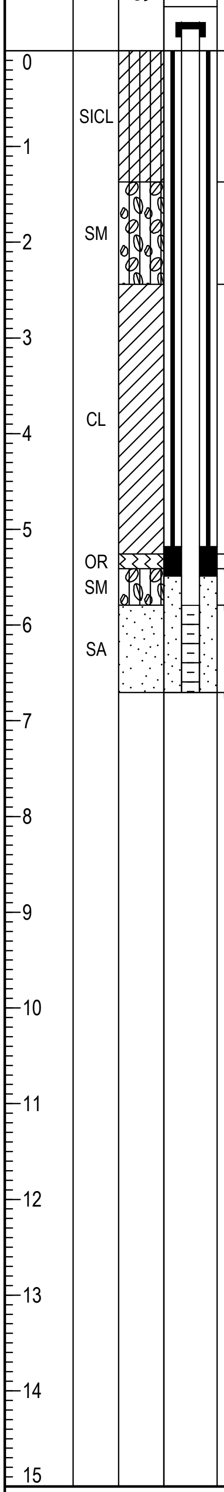
AECOM

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

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 ✳ 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	DEPTH



SILTY CLAY TAILINGS
- dark yellow orange
- wet, soft, cohesive, medium plasticity, rapid dilatency

SILTY SAND TAILINGS
- dark yellowish brown
- wet, loose, non-cohesive, non-plastic, rapid dilatency
- fine to medium grained sand, sub-rounded

CLAY TAILINGS
- dark yellow brown
- wet, very soft, cohesive, high plasticity, rapid dilatency

ORGANICS
- dark brown
- wet
- primarily moss

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

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

END OF DRILLING at 6.71 m

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)

AECOM

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

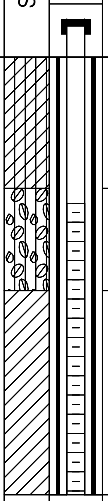
PROJECT: Mt. Nansen Mine Closure	CLIENT: Yukon Government - EMR	TESTHOLE NO: **MW09-06**
LOCATION: North side of tailings empoundment N 2,097,224.9 E 2,097,224.9		PROJECT NO.: 112359
CONTRACTOR: Geotech Drilling Ltd.	METHOD: Geoprobe 8040DT, Direct Push - 114 mm	ELEVATION (m): 1103 (est.)

SAMPLE TYPE ■ GRAB ▥ SHELBY TUBE ☒ SPLIT SPOON ☰ BULK ▨ NO RECOVERY ▌ CORE

BACKFILL TYPE ■ BENTONITE ⁘ GRAVEL ▥ SLOUGH ⁘ GROUT ▨ CUTTINGS ⁘ SAND

DEPTH (m) | USC | SOIL SYMBOL | SOIL DESCRIPTION | SAMPLE TYPE | SAMPLE # | SPT (N) | COMMENTS | DEPTH

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



USC	SOIL DESCRIPTION
SICL	SILTY CLAY TAILINGS - dark yellow orange - wet, soft, cohesive, medium plasticity, rapid dilatency
SM	SILTY SAND TAILINGS - dark yellowish brown - wet, loose, non-cohesive, non-plastic, rapid dilatency - fine to medium grained sand, sub-rounded
CL	CLAY TAILINGS - dark yellow brown - wet, very soft, cohesive, high plasticity, rapid dilatency

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)

Depth scale (m): 0 1 2 3 4 5 6 7 8 9 10 11 12 13 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

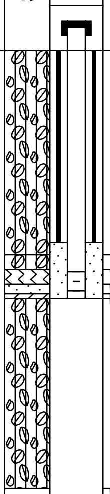
PROJECT: Mt. Nansen Mine Closure | CLIENT: Yukon Government - EMR | TESTHOLE NO: **MW09-07**

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

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/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	COMMENTS	DEPTH
0			SILTY SAND FILL - brown - dry, loose, non-cohesive, non-plastic - native fill used for drill pad construction						
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	SM		ORGANICS - dark brown to black - moist - fibrous roots and moss becoming more decomposed with depth						3
4			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

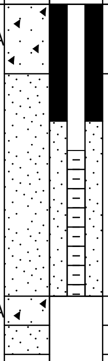
PROJECT ENGINEER: Ken Skaftfeld

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 DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS: ✳ Becker ✳; ◇ Dynamic Cone ◇; ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100; ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21; Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0	GRSA	SAND and GRAVEL, trace silt - orange-brown - moist, loose - medium grained sand, sub-rounded - gravel sub-angular to sub-angular, 0.5 cm to 5 cm - clast supported - presence of organic (roots, grass)						
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 SA	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								324
5		SAND, trace silt - dark brown and grey - very dense - medium grained sand - presence of wood debris - permafrost, Nbn						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								

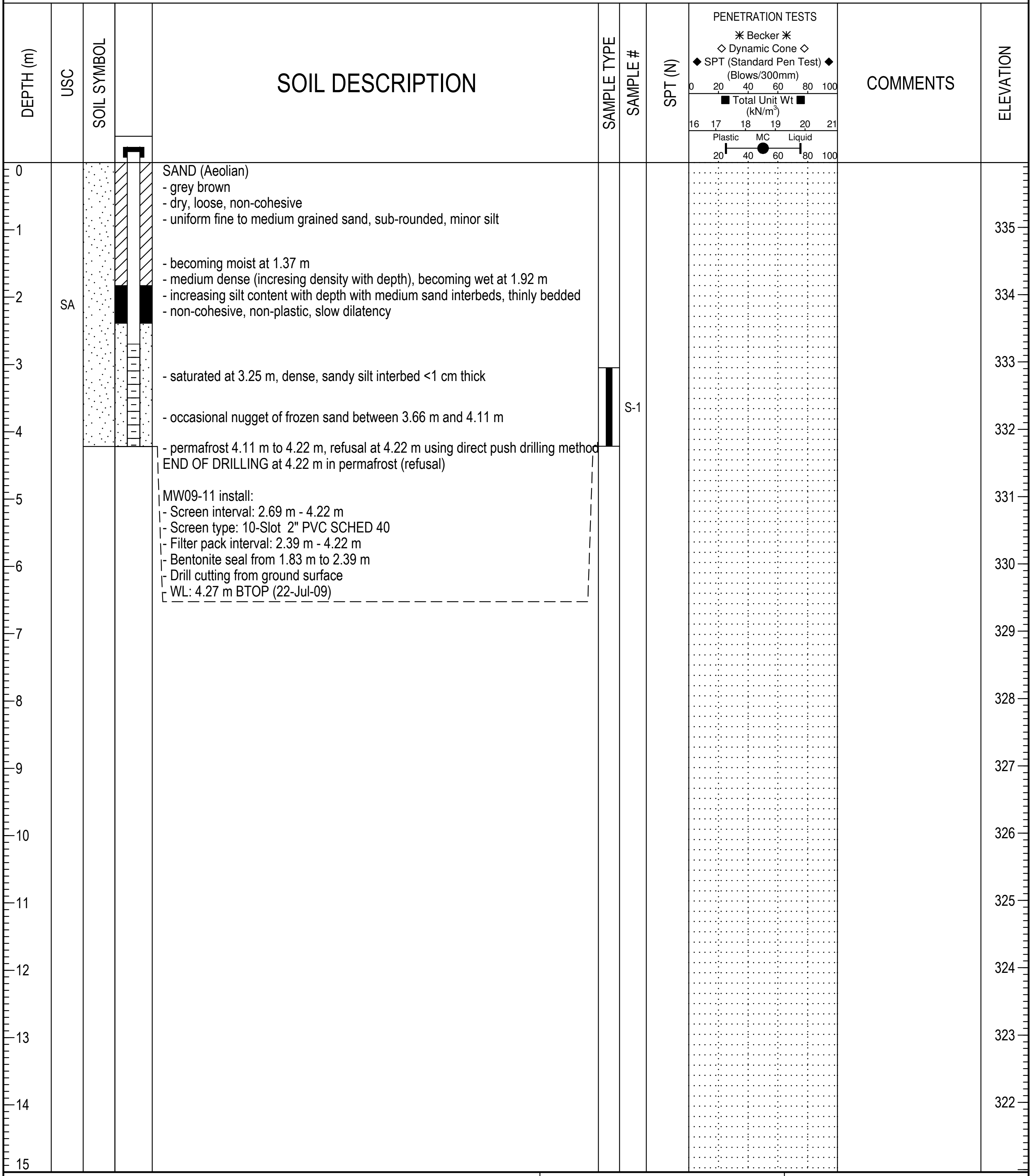


AECOM

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

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



SAND (Aeolian)
- grey brown
- dry, loose, non-cohesive
- uniform fine to medium grained sand, sub-rounded, minor silt

- 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

- saturated at 3.25 m, dense, sandy silt interbed <1 cm thick

- 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)

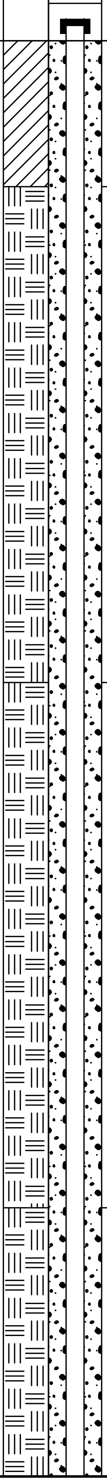
MW09-11 install:
- Screen interval: 2.69 m - 4.22 m
- Screen type: 10-Slot 2" PVC SCHED 40
- Filter pack interval: 2.39 m - 4.22 m
- Bentonite seal from 1.83 m to 2.39 m
- Drill cutting from ground surface
- WL: 4.27 m BTOP (22-Jul-09)

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

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

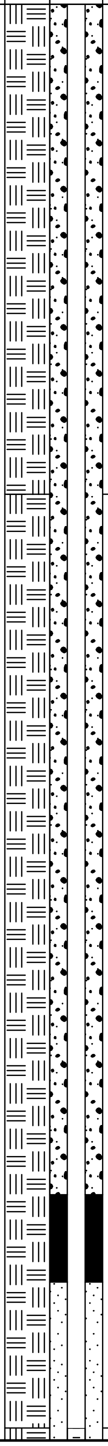


DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m³) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	COMMENTS	ELEVATION
0 1	CL	CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet	■	S-1				368
2 3 4 5 6	BE	DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet - casing to 4.57 m - borehole producing approx. 1-2 L/min during air development	■	S-2 S-3 S-4 S-5 S-6 S-7 S-8 S-9 S-10				367 366 365 364 363 362
7 8 9 10 11 12	BE	GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole - chips coarser from 8.53 m to 10.46 m	■	S-11 S-12 S-13 S-14 S-15 S-16 S-17 S-18 S-19				361 360 359 358 357
13 14 15	BE	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 S-22 S-23				356 355 354

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

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 ✳ 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			■	S-24				
			■	S-25				353
16								
			■	S-26				
								352
			■	S-27				
17								
			■	S-28				
	BE							351
18			■	S-29				
			■	S-30				350
19								
			■	S-31				
								349
			■	S-32				
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
			■	S-37				
23								
			■	S-38				345
24			■	S-39				
			■	S-40				344
25	BE							
			■	S-41				
								343
			■	S-42				
26								
			■	S-43				342
27								
			■	S-44				
			■	S-45				341
28								
			■	S-46				
								340
29			■	S-47				
			■	S-48				339
30								

AECOM

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

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	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 S-50 S-51 S-52 S-53				338 337 336
31	BE							
33		GRANODIORITE - light grey - dry, high quartz content with minor amount of highly weathered potassium feldspar	■	S-54 S-55 S-56 S-57 S-58				335 334 333
34	BE							
36		END OF DRILLING at 35.97 m MW09-13 install: - Screen interval: 29.87 m - 35.97 m - Screen type: 20-Slot 2" PVC SCHED 40 - Filter pack interval: 28.34 m - 35.97 m - Bentonite seal from 27.43 m to 28.34 m - Grouted to ground surface - WL: 33.24 m BTOP (22-Jul-09)						332 331 330
37								
38								
39								329
40								328
41								327
42								326
43								325
44								324
45								

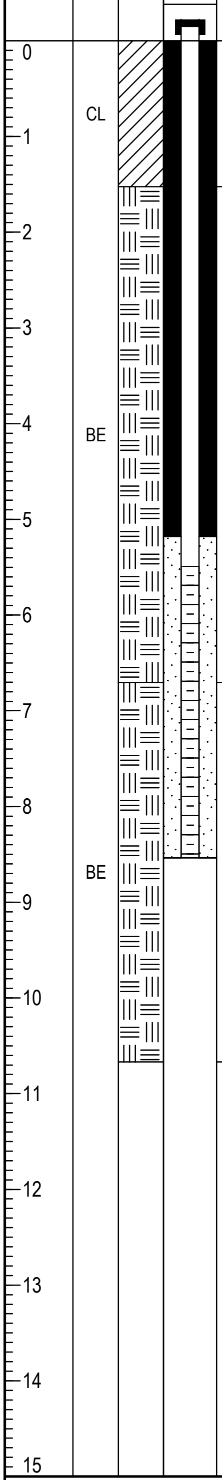
PENETRATION TESTS
✳ Becker ✳
◇ Dynamic Cone ◇
◆ SPT (Standard Pen Test) ◆
(Blows/300mm)
0 20 40 60 80 100
■ Total Unit Wt ■
(kN/m^3)
16 17 18 19 20 21
Plastic MC Liquid
20 40 60 80 100

AECOM

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

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

USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS
CL	CLAY (minor SAND and some SILT) - brown - dry, loose, cohesive, plasic, rapid dilatency when wet	■	S-1		
BE	DIORITE - yellow-orange - dry, highly weathered with iron staining, chips very coarse - inferred to be shallow fractured bedrock aquifer - becoming wet - casing to 4.57 m - borehole producing approx. 1-2 L/min during air development	■	S-2 S-3 S-4 S-5 S-6 S-7 S-8 S-9 S-10		
BE	GRANODIORITE - light grey - moist, moderately weathered, abundant iron staining, chips fine - increasing mafic content downhole - chips coarser from 8.53 m to 10.46 m	■	S-11 S-12 S-13 S-14 S-15 S-16		

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

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										
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	

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/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	COMMENTS	DEPTH
30										
31										31
32										32
33										33
34										34
35										35
36				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)						36
37										37
38										38
39										39
40										40
41										41
42										42
43										43
44										44
45										

AECOM

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

PROJECT: Mt. Nansen Mine Closure | CLIENT: Yukon Government - EMR | TESTHOLE NO: **MW09-15**

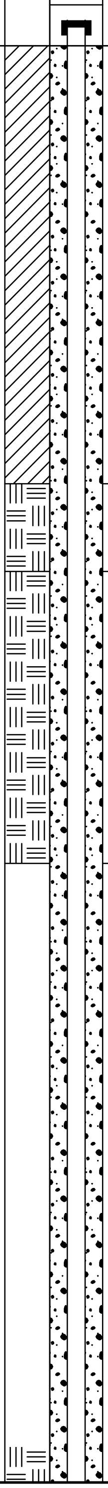
LOCATION: North of Brown-McDade pit N 2,097,550.1 E 118,541.3 | PROJECT NO.: 112359

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 DESCRIPTION	SAMPLE #	SPT (N)	COMMENTS	DEPTH
0		CLAY (minor SAND and some GRAVEL) - brown - dry, loose, cohesive, non-plastic, rapid dilatency when wet				
1			S-1			1
2	CL					2
3			S-2			3
4			S-3			4
		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			
5	BE		S-5 S-6 S-7			5
		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			S-9			6
7	BE		S-10			7
8			S-11			8
		- 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			9
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

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.)

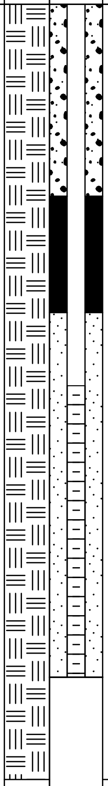
SAMPLE TYPE	■ GRAB	▥ SHELBY TUBE	☒ SPLIT SPOON	☰ BULK	◿ NO RECOVERY	▌CORE
BACKFILL TYPE	■ BENTONITE	⁘ GRAVEL	▥ SLOUGH	⁘ GROUT	▨ CUTTINGS	⁘ SAND

DEPTH (m)	USC	SOIL 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 16 17 18	BE	- 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 S-24 S-25 S-26 S-27				16 17 18
19 20 21	BE	HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor potassium feldspar, chips fine	■	S-28 S-29 S-30 S-31 S-32				19 20 21
22	BE	GRANODIORITE - grey-brown - moist, highly weathered, heavily fractured and iron stained, rapid drilling rates	■	S-33 S-34				22
23	BE	DIORITE - light grey - dry, moderately weathered, trace feldspar	■	S-35 S-36				23
24	BE	GRANODIORITE - orange-brown - moist, highly weathered with high clay mineral content inferred to be fault gouge - potentially conductive fracture zone	■	S-37 S-38				24
25 26 27 28 29 30	BE	HORNEBLENDE DIORITE - light grey - dry, moderately weathered, minor iron staining, chips fine - less than 1 m of water in borehole after sitting overnight without rods in hole	■	S-39 S-40 S-41 S-42 S-43 S-44 S-45 S-46				25 26 27 28 29

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

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

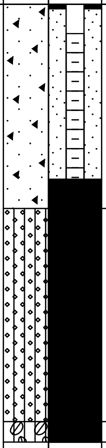


DEPTH (m)	USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	PENETRATION TESTS ✳ Becker ✳ ◇ Dynamic Cone ◇ ◆ SPT (Standard Pen Test) ◆ (Blows/300mm) 0 20 40 60 80 100 ■ Total Unit Wt ■ (kN/m^3) 16 17 18 19 20 21 Plastic MC Liquid 20 40 60 80 100	COMMENTS	DEPTH
30	BE	DIORITE - light grey - dry, soft, moderately weathered, minor iron staining	■	S-47				
			■	S-48				
31			■					31
			■	S-49				
32			■	S-50				32
			■	S-51				
33			■					33
			■	S-52				
			■	S-53				
34	BE		■					34
		- highly weathered from 34.14 m to end of hole at 38.10 m	■	S-54				
35			■	S-55				35
		- moist from 35.36 m to 35.38 m	■	S-56				
36			■					36
			■	S-57				
		- wet from 35.38 m to end of hole at 38.10 m	■	S-58				
37			■					37
			■	S-59				
38			■	S-60				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)						
39								39
40								40
41								41
42								42
43								43
44								44
45								

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

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)	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	DEPTH
0	GR	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	▮	S-1				
	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						
	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

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)

AECOM

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

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

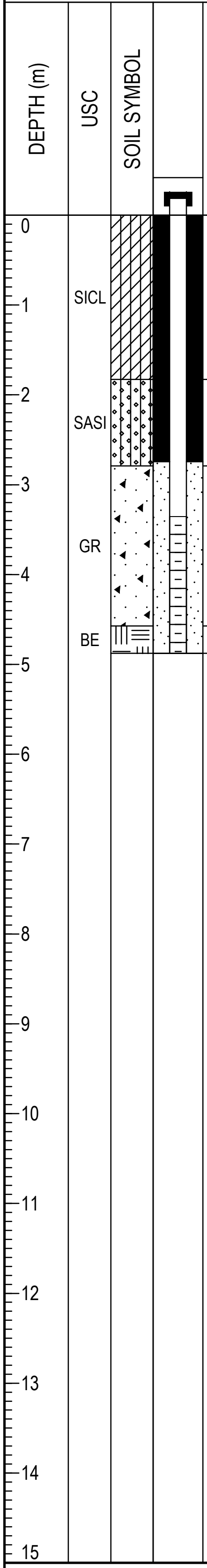
PROJECT NO.: 112359

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



SOIL DESCRIPTION

SILTY CLAY with some SAND and GRAVEL
- orange
- dry, dense, cohesive, low plasticity
- inferred to be waste rock fill used for road bed construction

- becomes moist at 1.37 m

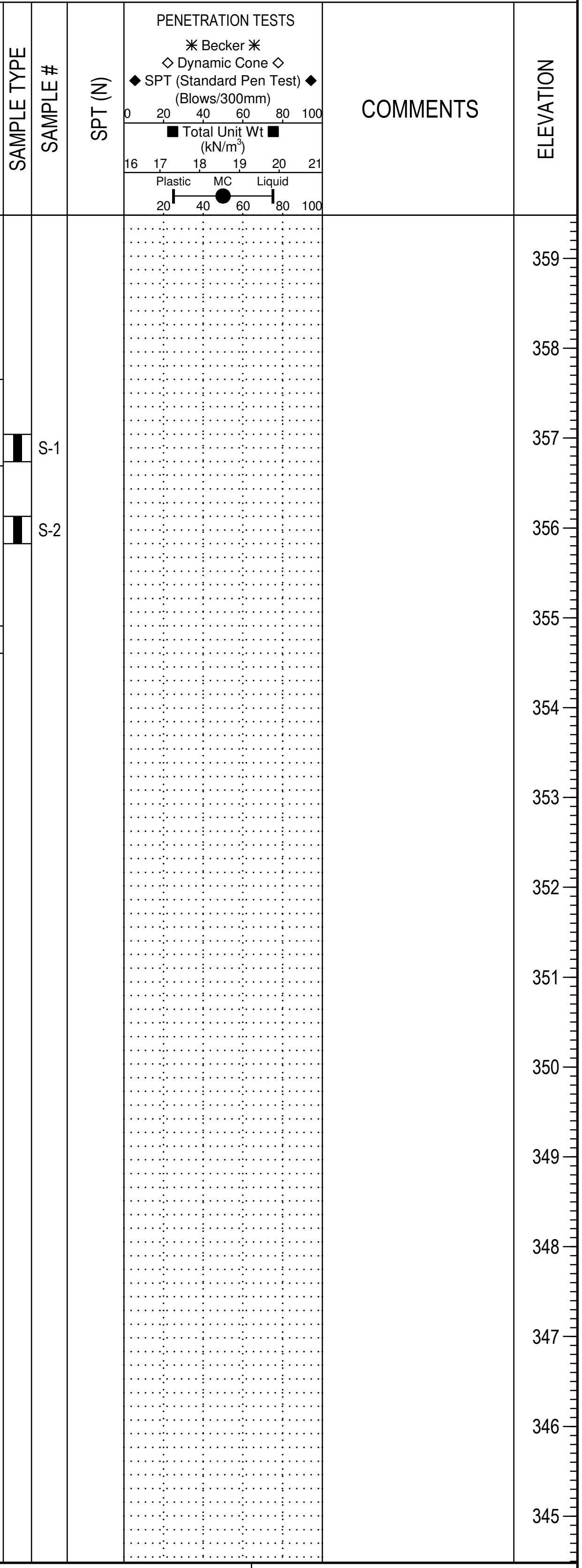
SANDY SILT
- black
- moist, medium dense, cohesive, medium plasticity
- odour likely the result of organics in soil; does not smell like hydrocarbon

GRAVEL with some CLAY, SILT and SAND filling interstices
- yellow-brown
- wet to saturated, dense, non-cohesive, non-plastic fines, highly weathered
- gravel to 10 cm along long axis
- inferred to be colluvium

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

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)



AECOM

LOGGED BY: Ryan Mills

REVIEWED BY: Marc Lavigne

PROJECT ENGINEER: Ken Skaftfeld

COMPLETION DEPTH: 4.88 m

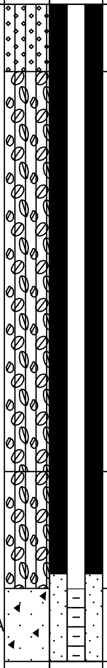
COMPLETION DATE: 7/14/09

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)	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	SASI	SANDY SILT - brown with red staining - dry, loose, non-cohesive, non-plastic - organic rich with pervasive roots, mild unknown odour	▮	S-1				
1	SM	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 - dry from 3.81 m to 4.88 m; loose						359
5	SM	SILTY SAND TAILINGS - yellow-orange - dry, medium dense, cohesive, low plasticity, rapid dilatency - minor subangular gravel	▮	S-2				355
6	GRSA	SAND and GRAVEL with minor CLAY - brown - wet, loose, non-cohesive, non-plastic - angular gravel sized clasts - inferred to be colluvium, potential bedrock contact at 6.70 m	▮	S-3				354



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)

0	
1	359
2	358
3	357
4	356
5	355
6	354
7	353
8	352
9	351
10	350
11	349
12	348
13	347
14	346
15	

AECOM

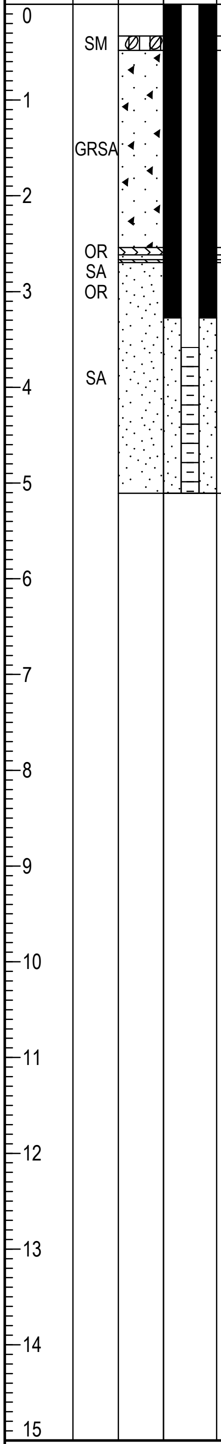
LOGGED BY: Ryan Mills	COMPLETION DEPTH: 6.86 m
REVIEWED BY: Marc Lavigne	COMPLETION DATE: 7/15/09
PROJECT ENGINEER: Ken Skaftfeld	Page 1 of 1

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



USC	SOIL DESCRIPTION	SAMPLE TYPE	SAMPLE #	SPT (N)	COMMENTS
	No recovery				
SM	SAND, silty - orange-brown - dry, loose - fine grained to medium grained sand				
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) - clast supported - presence of wood debris (waste rock?)	■	G-1 G-2 G-3		
OR	ORGANIC, some silt, trace sand - black - moist, loose - presence of roots				
SA	SAND, gravelly, trace of silt - orange-brown - moist, dense - fine grained sand, sub-rounded - volcanic ash marker	■	G-4		
OR	ORGANIC, some silt, trace sand - dark brown - moist, loose - presence of roots				
SA	SAND, some silt, trace gravel - dark grey - wet, loose - medium grained sand, sub-rounded - sub-angular gravel, 1 cm to >4 cm - matrix supported				

END OF DRILLING at 5.11 m in permafrost (refusal)

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)

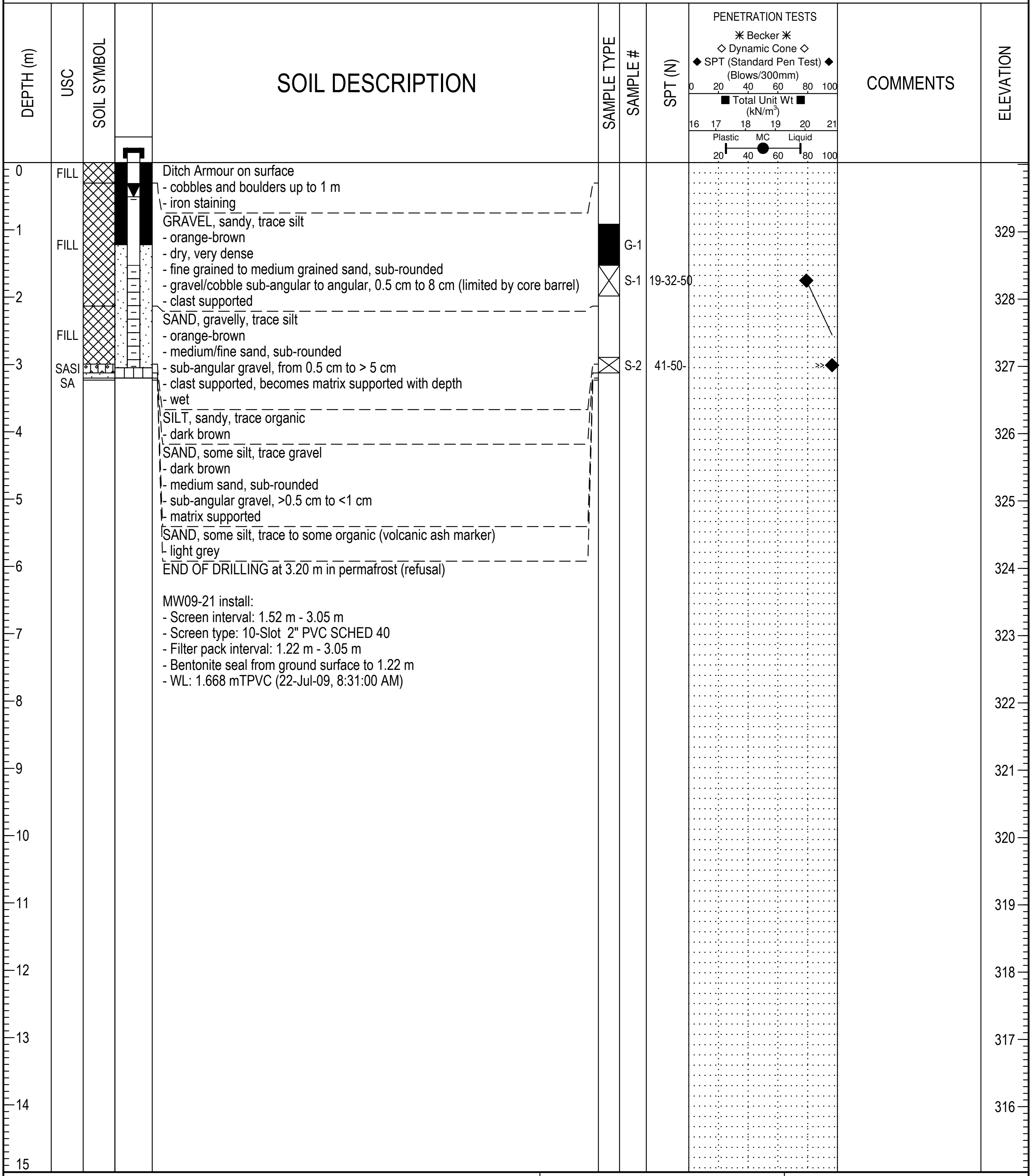
AECOM

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

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



SOIL DESCRIPTION

Ditch Armour on surface
- cobbles and boulders up to 1 m
- iron staining

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

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

SILT, sandy, trace organic
- dark brown

SAND, some silt, trace gravel
- dark brown
- medium sand, sub-rounded
- sub-angular gravel, >0.5 cm to <1 cm
- matrix supported

SAND, some silt, trace to some organic (volcanic ash marker)
- light grey

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)

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