TP-8-11-0

1. PURPOSE

This technical procedure describes the methodology to be used for the investigation and sampling of surficial soils. Contained within are detailed investigation and sampling instructions.

2. APPLICABILITY

This technical procedure is applicable to any person involved in the investigation and manual sampling of surficial soils.

3. DEFINITIONS

3.1 Chain-of Custody Forms

Standardised forms are used as a means of keeping close track of soil samples taken from the field and transported to laboratories for analysis. Whenever the samples are transported from the field, the custody is relinquished from the delivery person to the receiver by signatures on the forms. These forms substantially decrease the risk of losing samples because they provide a clear record of the chain of transport and handling of the samples.

3.2 Surficial Soil

Refers to the unconsolidated material on the ground surface that serves as a natural medium for the growth of plants, and that has been subjected to or influenced by parent material, climate, macro and microorganisms, and topography over time producing a material that differs physically, chemically, biologically and morphologically from the material from which it was derived.

4. REFERENCES AND SUGGESTED READING

Agriculture Canada Expert Committee on Soil Survey. 1987. The Canadian System of Soil Classification. 2nd ed. Agric. Can. Publ. 1646. 164pp.

5. DISCUSSION

5.1 General Safety

Refer to Golder Associates Ltd. Safety Manual.

5.2 Methods

Soils will be investigated based on a visual examination of excavated pits, with information gathered being recorded on Soil Inspection Sheets (see attached example). Certain soils are sampled from the various horizons identified during the soil investigation. Samples are taken using a shovel, trowel, or auger. Each sample is individually bagged and labeled to location and analysis to be performed. Each sample is also indicated on the appropriate soil inspection sheet as a cross reference.

5.3 Site Location

Samples are taken from the various soil horizons exposed in the excavated pits used for soil characterisation. Sites will be pinpointed on air photos and maps in the field, and marked using the global positioning system.

5.4 Sample Handling

Soil samples are placed in ziploc type plastic bags. The bagged soil samples are stored in cardboard boxes to protect the plastic bags from ripping during transport to the lab.

5.5 Cleaning Sampling Equipment

The shovel, trowel, or auger used to take each sample is wiped clean of any soil residue after each sample is taken to minimise contamination of other samples.

5.6 Field Records and Logbook

For proper interpretation of field survey results, thorough documentation of all field investigation and sample collection activities is required. All logbooks should be perfect-bound and waterproof, forms should be preprinted on waterproof paper, and only indelible ink and pencil (if form or paper is wet) should be used.

Characteristics of the soils being investigated are recorded on Soil Inspection Sheets (see attached example). Soil samples are also recorded on these sheets. Basic information from each site investigated or sampled, such as site number and GPS location, will be recorded in a logbook.

All pertinent information on field activities and sampling must be recorded in an appropriate (i.e. waterproof) bound logbook. The field crew leader is responsible for ensuring that sufficent detail is recorded in the logbook. The logbook must be complete enough to enabel someone unfamiliar with the project to completely reconstruct field activity without relying on the memory of the field crew. All entries must be made in indelible ink, with each page numbered, signed and dated by the author, and a line drawn through the remainder of any partly used page. All corrections are made by a single-line cross-out of the error, entering the correct information, dating and initialing the change. Upon return to the office, all field notes must be photocopied and placed in the appropriate project files.

Entries in the field logbook must include:

- Purpose of proposed sampling effort
- Date and time (24 hour clock) of sampling
- Names of field crew leader an tema members
- Description of each sampling site, including information on any photographs that may be taken.
- Location of each sampling site, name and number, applicable navigational coordinates, waterbody name/segment numbers.
- Details of sampling method and effort, particularly deviations from Specific Work Instructions.
- Clear identification of site names and sample numbers.
- Field observations.
- Field measurements taken (recorded on Soil Inspection Sheets)

Sample shipping information.

The field logbook should also be used to document any additional information on sample collection activities or any unusula activities observed or problems encountered that would be useful to the project manager when evaluating the quality of the soil and terrain data.

To document field activities, sample identification labels, Chain-of-Custody forms, field logbooks, field record sheets (Appendix A) should be used. This will serve as an overall "Chain-of-Custody" documenting all field samples and field events beginning with sample collection through, preservation and shipment to the laboratory.

6. EQUIPMENT

6.1 Sampling and Investigation Equipment

Soils will be investigated and sampled with a shovel, trowel and auger.

6.2 Field Location Equipment and Logs

The following pieces of equipment are required to properly investigate and sample soils.

- perfect bound, water-proof field logbook
- soil inspection sheets (sample attached)
- maps and aerial photographs of the site
- indelible ink pens and felt tip markers, and pencils
- munsell colour chart
- 12 metre tape measure
- bottle of clean water
- bottle of 10% hydrochloric acid
- clean rags
- clinometre

- compass
- shovel
- trowel
- soil auger
- penetrometer
- plastic ziploc type storage bags
- pH meter
- metre wheel

SWI-150

SOIL INSPECTION SHEET

Diavik Diamond Mines Inc. Project

Project # 962-2309 (Task 5551) **SITE** ____________________

Inspectors:____________________ **GPS #**____________________

Inspection Date:__________(day), __________(month), __________(year)

Inspection Time:____________________(24 hour clock)

Slope:__________ **Apect:**_______ **Topography:**____________________

Drainage:____________________ **Surface Stoniness:**____________________

Slope Position:________________ **Parent Material:**____________________

HORIZON	DEPTH (cm)	BDY	COLOUR	TEXTURE	STRUCTURE	STONES (%)	CONS	EFF	SAMPLE #
	-								
	-								
	-								
	-								
	-								

NOTES

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Photographs: Numbers______________________________ **Roll**________

SPECIFIC WORK INSTRUCTIONS

SPECIFIC WORK INSTRUCTIONS **SWI No.**: SWI-15.0

Project: Diavik Dimond Mines Inc. Baseline Summer Survey (SOIL INVESTIGATION AND SAMPLING)

Date: JULY 11 1996

Author:

To:

cc: Kym Holley **File No.**:

Subject: SUMMER 1996 SOIL INVESTIGATION AND SAMPLING **Job/Task No.**: 962-2309/5551

Scope of Work/Specific Instructions:

Soil Investigation: Soil investigation sites will be located using maps and aerial photographs of the local study area. The location and number of sites may be relocated or increased/decreased to ensure all soil types are represented. Each site will be pinpointed using a global positioning system, with the location being recorded. A photographic record will be kept of the existing terrain at each site. Terrain characteristics will also be recorded. At each site a soil pit will be excavated using a track shovel, trowel and auger. Soil profile characteristics (including drainage and parent material) will be investigated based on a visual examination of the excavated pits. Information will be recorded on Soil Inspection Sheets (see attached). Certain soils will be sampled from the various horizons identified during the soil investigation. Samples will be taken using the shovel or trowel. Each sample will be individually bagged and labeled with site location for analysis.

All health and safety procedures for Golder and Kennecott must be strictly adhered to during the work period.

Crew is to telephone the Golder office in Calgary a minimum of once every three days. If problems in the field arise, phone the project manager at once.

Technician: n/a

Discipline Leader: Tim Bossenberry

Technical Supervisor: David Kerr

Project Manager: Gordon Macdonald

Work Product(s) Due By: 03 September 1996

Allocated Man-hours: Task 5551

Subcontractor (as applicable): n/a

Special Handling Requirements: Forms to use: Soil Inspection Sheets (see attached), Chain of Custody Forms, Analytical Request Forms.

Applicable Specs. and Procedures: Golder T.P. 8.10-0

Project Manager Approval/Date: **QA Manager/Date**:

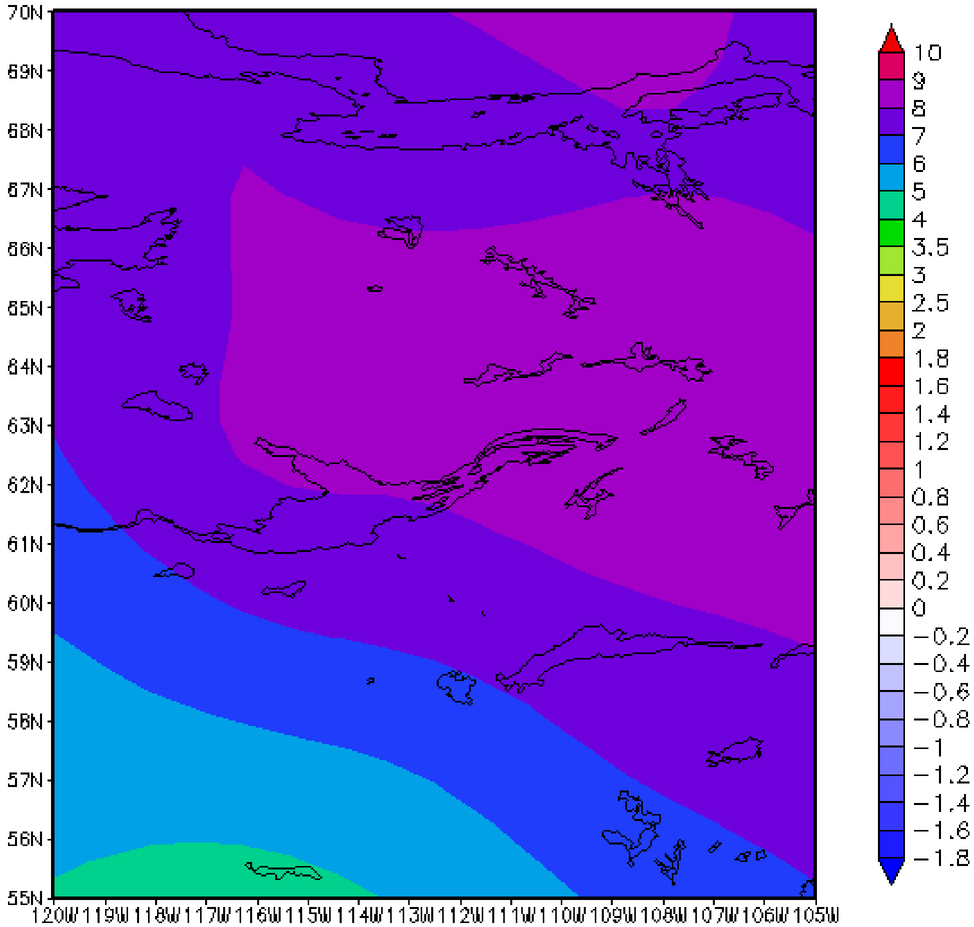
Appendix X-8

Climate Change Adaption Project

Climate Change Adaptation Project

Rio Tinto

Climate Change Impacts in the Diavik Region of Northern Canada



Future climate mean minimum temperature change predictions for Diavik for December 2060-2069

4 July 2008

Not for general distribution.
Produced by Environmental Modelling and Prediction P/L Australia exclusively for the internal use of Rio Tinto

Executive Summary

Caveat: Climate modelling is still an emerging science with practical constraints imposed by limitations on supercomputing and data processing of terabytes of data. Although the analyses that follow are based upon the best currently available science, there are inherent limitations on the skill of the techniques used. Due care should be exercised when interpreting these results.

Future climate analyses, spanning the period out to 2060, were conducted for Rio Tinto's Diavik Diamond Mine Incorporated (DDMI) operations in the Northwest Territories Province of northern Canada. The mine site at Diavik (latitude 64º 30'N, longitude 110º 20' W), is located approximately 300 km northeast of Yellowknife and is connected to this location by a 350km long ice road that is constructed annually, 75% of which is built over frozen lakes. The analyses and data provided can be used to assess what the future climate impacts are likely to be upon this ice road, as well as at the mine site itself.

The data for the analyses was from a suite of climate models especially configured and run to meet Rio Tinto's global climate change requirements which was completed in May 2007. The northern Canadian region has high resolution data (notionally a grid box size 20km x 20km, although the narrowing of the longitudes at these locations improves the effective resolution closer to 15km) available across the entire region and for the offshore waters from a suite of 12 individual century-long Coupled Ocean – Atmosphere Climate Model runs from the Oklahoma University. The numerical scheme used in the climate models means that meteorological features are able to be resolved down to an effective resolution of close to 12km.

The future climate models used a mix of mathematical and physical climate model schemes as used in the leading climate modeling centres of the world, including the Hadley Centre in the United Kingdom, and the National Center for Atmospheric Research in the USA, combined with refined versions developed by Prof. Lance Leslie at the Oklahoma University. These models have been used and verified extensively in other climate studies focused upon future climate severe weather in widely separated parts of the world for the insurance and mining industries, and have very high long term atmospheric energy stability, a critical feature of climate models.

The climate models were run in two sets of six model members, one set of which simulated the historical climate of the world, and the other set simulated the future climate using an up-to-date adjustment, valid as at early 2007 to the IPCC's A2 scenario, making the prediction most closely resembling the A1B greenhouse gas/aerosol forcing scenario (referred to as the future greenhouse gas climate, or simply "future climate" throughout this report). This approach is undertaken to identify the best performing climate model and to allow the mean of all six model members to be calculated, thereby providing future climate predictions that possess a higher level of confidence than can be achieved from a single climate model run. An analysis of all of the ensemble model runs demonstrated that the ensemble mean of the six member future Coupled Global Climate Model runs is most likely to be the best predictor of the future climate for the northern Canadian region. The analyses that are provided in the detailed report contain a mix of results from the average of the six ensemble model members and the more detailed results from the model closest to the ensemble mean.

The preliminary investigations of the future climate impacts on the northern Canadian region, under what is currently considered to be the most likely IPCC future greenhouse gas / aerosol emission scenario for the period from the present out to the year 2060, are summarized in the following paragraphs.

Temperature

The ensemble mean climate model predictions of minimum, mean and maximum temperatures were validated against those observed at Environment Canada's weather stations at Lupin A and Ekati and the limited Rio Tinto Canada data from the Diavik mine site for the period through to 2007. There are warm model biases evident for the period from January through to June, greatest in April for Diavik, Ekati and Lupin A data but not for the longer period Fort Reliance data. These biases are not thought to affect the predicted trends and bias corrections were applied to the future climate predictions to account for these differences. There are also warming trends through the model validation period (1970 to 2007) that fit the overall trends observed in the various observational data, although some months in the observational dataset were subject to multi-decadal oscillations that have the effect of producing transient cooling trends when viewed in isolation and over a limited period of record. Attachments 4a and b North that show the spatial distributions of minimum and maximum temperature across the northern Canadian region should be consulted for further information.

Using the bias corrected linear trends, the predicted annual temperature rises for Diavik, from 1970 to 2060, were as follows:

- Maxima: from -8.3°C to -2.8°C, a rise of 5.5°C over the 90 year period. This equates to an annual maximum temperature increase of 0.061°C.
- Mean temperature: from -11.0°C to -6.0°C, a rise of 5.0°C over the 90-year period. This equates to an annual mean temperature increase of approximately 0.056°C.
- Minima: from -14.7°C to -9.3°C, a rise of 5.4°C over the 90-year period. This equates to an annual minimum temperature increase of approximately 0.060°C.

The predicted temperature changes can be applied to the historical daily air temperature data to determine likely changes to the Freezing Index at any given time through the future climate period. The predicted changes in surface temperature can also be applied in the same way to historical surface temperature data to determine expected changes in the Surface Freezing Index into the future. Although it is outside the scope of this project to determine the Freezing Index, the future climate model predictions clearly show a marked reduction in the number of below-freezing days are to be expected in the future climate, with this reduction accelerating through the future climate period.

Other changes identified were:

- The greatest predicted warming is through the winter to spring period, meaning the length of the snow season, and hence the duration when the ice road is likely to be viable, are likely to be greatly shortened in the future climate period.
- The greatest predicted warming was forecast for January minima with the forecast bias-corrected change from -33.6°C in 1970 up to -25.4°C by the year 2060, a very large rise of 8.2°C over the 90-year period.
- The predicted warming through the summer months, typified by those for the month of July, were much smaller with rises of around 2°C predicted for the

minimum, mean and maximum temperatures out to the year 2060. However, the hottest of the climate models indicated one-off much warmer years could be expected with the potential for temperature jumps in the future of up to 5°C for individual summer months. This should also apply to the maximum temperatures at Diavik.

- July is predicted to remain the hottest month.
- By the year 2060, the average monthly temperatures are very likely to be hotter than the hottest months recorded in the historic record for most months of the year.
- Maximum temperatures were predicted to rise fastest through the winter and spring months.
- The predicted warming was forecast to continue well beyond the end of the analysis period.

Precipitation

It must be noted that the climate modelling technique produces rainfall predictions across a 20km x 20km grid, or an area of 400km^2, whereas the observations from Diavik are from point locations with the diameter of the precipitation gauges used being typically around 10cm. The precipitation received is inherently highly variable in space and time and snow is a particularly difficult phenomenon to accurately measure. It is almost impossible to separate wind driven snow from freshly fallen snow. There are also strong topographic influences that affect the distributions and intensities of the precipitation producing weather systems. Hence the uncertainty in future climate predictions for precipitation must be considered to be higher than those for temperature. The climate models are less likely to predict extremely heavy or light precipitation events that would completely match the observed extreme spot snow and rainfalls. There are also strong multi-decadal signals evident in the precipitation record with trends over the full length of the observational record being markedly different to those over the shorter validation period. It was also discovered that the way in which the historically measured snowfall was converted into equivalent liquid precipitation changed from month to month and year to year at Ekati, producing spurious trends and biases for many of the months in which snowfall dominates the precipitation record. Therefore there are inherent uncertainties in the observational records to consider.

The predicted trends in precipitation were more complex than for temperature. For most months of the year the climate models predicted increases in precipitation, although the magnitudes of these increases varied markedly from month to month. The predicted annual increase in precipitation went from an average of near 310mm in 1970 to near 360mm by 2060, which equates to a rise of around 16% over 90 years.

In the winter months the quantity of precipitation received at Diavik is relatively small due to the very cold conditions. The climate model predictions for the mean monthly December precipitation ranges from around 18mm in 1970 up to 25.5mm by the year 2060, an increase of 7.5mm, which equates to a very large, in percentage terms, rise of near 42% for the month. A large increase in precipitation, in percentage terms, was predicted for the mid winter month of January with an increase of 24% forecast. The actual quantity of snow involved is small, being only 4mm in liquid precipitation terms, or roughly4cm of snow. The intensity of the heavier snowfalls are also expected to increase for many of the coolest months of the year with most of the months, but not all, expected to also experience an increase in the frequency of these heavier precipitation events.

Looking at the summer precipitation, the ensemble mean model prediction for Diavik varies from month to month. In June the predictions are for no appreciable change through the future climate period although the wettest months are forecast to increase from around 65mm up to 83mm. For July the climate models predict a slight decline in rainfall, from an average of near 38mm in 1970 to near 35mm by 2060, or a decline of approximately 8%. The climate model predictions indicate a decreasing frequency of extreme heavy rainfall events, although the two heaviest July rainfall predictions lie in the future climate period, indicating new extremes of heavy rainfall are possible in the future climate period, even if the heaviest falls become less frequent than they currently are. In August the climate models return to predicting increases in precipitation, a trend that continues through the remainder of the year.

There is a marked multi-decadal oscillation in the future climate predictions, indicating these changes will not be steady increases but rather a general increasing trend interrupted by large excursions from the mean. There is a marked leveling off of the precipitation increases indicated through the future climate period beyond around model year 2025. The predictions indicate there will be fewer dry years in the future and a trend towards gradually increasing extremely wet years, by Diavik standards, although this region will still only have relatively modest precipitation through the future climate period in comparison to warmer regions of the world. The wettest years tend to occur as lone events, as are the predicted driest years.

Extreme Precipitation Events

The climate model predictions for Diavik vary from month to month. In general the predictions favour increases in both the intensity and frequency of heavy precipitation events through the future climate period. December was predicted to have a particularly large increase in extreme precipitation, jumping from 45mm for the year through the validation period to 65mm in the future climate. Although heavy by local standards, the climate models do not predict falls through the future climate period as great as for other parts of Canada.

The predictions at the lowest end of the precipitation spectrum (the dry years) are for either no change through the future climate period or for a gradual increase in the quantities of precipitation to be expected in the driest months and years.

Snowfall and Accumulation

A set of four attachments have been prepared that show the decadal monthly average snow cover, snow cover anomaly, snow depth and snow depth anomaly charts for the northern Canadian region (Attachments 3b, c, d and e North) and these should be consulted for details on the changes in the amount and depth of snowfall through the Diavik to Yellowknife region. There are also monthly decadal surface temperate average and anomaly charts that map the changes in the temperature of the ground across this region through the future climate period (Attachments 4, 4a North), which help to quantify the changes in the ground surface that affect snow and ice accumulations.

The anomaly charts for the month of January, representative of the mid winter months, show an interesting transition in the predicted snow cover. The initial predictions show an increase in snow cover over most of the region with the greatest increases centred over and southeast of the Great Slave Lake, reaching a peak of around 7.5% in the 2020-2029 decade. This anomaly pattern then generally changes to one where decreasing snow cover dominates from the decades from 2040 onwards and particularly the 2060-2069 decade. For the onset period of the snow season, the November predictions for Diavik it is likely the snow cover would vary significantly along the access road to Diavik from year to year in the expected future climate. Although this would be positive in some years, the model tends to slightly favour the years of reduced snow cover overall.

The month of April is one where the snow cover is still relatively high in the Diavik region but is rapidly declining in the Great Slave Lake region. The climate model predictions show a very interesting and unusual sequence of anomaly charts. For the first three decades – from 2010 out to 2039, the climate models predict a general increasing trend for snow cover with a strong increase predicted for the 2030-2039 decade over the north and east of the Great Slave Lake, including an area where the snow cover is predicted to increase by over 25%. The increases in cover over the Diavik region during this period are slight, given that this region has a high snow cover to begin with. However, the climate models then predict a sudden and strong reversal in this trend, particularly in the region just north of the Great Slave Lake where snow cover is predicted to decline by over 15% in the 2040-2049 decade increasing to over 22.5% by the 2060-2069 decade. The changes in snow cover at Diavik itself are not shown to be great being within +/- 2.5% for all the decades apart from the 2050-2059 decade when a 7.5% decline in coverage is predicted.

Overall the predictions show a shortening of the length of the season which has snow accumulations on the ground with a general reduction of the depth of the snow, particularly during the months of onset and cessation of the snowfall.

Wind Speeds and Directions

Attachments 5 and 5a North provides analyses of the expected average monthly wind speeds and directions and the corresponding anomalies across northern Canada out to 2060 relative to the 1970-1999 reference period. The future changes in winds are quite variable from season to season and decade to decade. Strong multi-decadal oscillations are evident in the wind anomaly predictions for each month, indicating the changes will not be simple progressions of a trend, but rather complex changes to the weather patterns throughout the future climate period.

For the mid winter month of January the climate model predictions are for initial reversals of the wind anomalies, starting with a southeasterly wind anomaly in the 2000-2009 decade but turning to a northwesterly anomaly for the following one. Then the trend is for a progressive clockwise swing in the wind anomalies. Initially in the 2010-2019 decade the wind anomalies are predicted to be from the northwest. By the 2020-2029 decade the model predicts a swing back to the north to northeast, continuing around to the northeast by the 2030-2039 decade. Then there is an abrupt reversal of the wind anomalies predicted for the 2040-2049 decade with wind anomalies forecast to change to a south southwesterly. Speeds throughout this period of time are generally within the 0.5 to 1.0m/s range for most of the region. This then settles in as the dominant wind anomaly through the remainder of the future climate analysis period, strengthening through the 2060-2069 decade.

During April the predictions are for a general increase in the easterly wind anomalies, which would serve to increase the wind speeds to the north of Diavik and decrease them to the south of the Great Slave Lake.

In July there is a predominant trend towards a strengthening of the westerly wind anomalies across much of the region to the north of the Great Slake Lake with the strength of the anomalies increasing northwards and reaching close to 1m/s in regions near the Coronation Gulf. There is a more erratic increase in the westerlies to the south of the Great Slave Lake.

During October the climate model predictions highlight a move into a future climate regime with growing variability of the weather patterns, with these variations having signatures that last a decade or more at a time.

With increased energy predicted in the summer time wind regimes and marked multi-decadal oscillations predicted in the weather systems throughout the future climate period, it is likely there will be an intensification of some of the associated weather systems. Although a detailed investigation of individual weather systems is required to quantify this, it is likely that some of these systems will have the potential to increase the severe wind storm risk for the Diavik region.

Relative Humidity

Attachment 6 North provides an analysis of the expected changes in the relative humidity over the northern Canadian region, including the Diavik to Yellowknife area. During the cold winter months there are only small changes in relative humidity predicted. The relative humidity anomalies begin to increase as temperatures rise in April. For this month a band of decreased relative humidity, mostly in the 1-2% range but with a small area of over 2%, develops with an orientation from the west northwest towards the east southeast, centred just north of the Great Slave Lake and hence across the region between Yellowknife and Diavik. Bands of increasing relative humidity, mostly only around 1%, simultaneously form over the eastern parts of the Coronation Gulf and to the southwest of the Great Slave Lake. Diavik itself tends to remain in a region of little change in relative humidity.

In the mid summer month of July the predicted changes in relative humidity become relatively large with a reasonably significant amount of variability from decade to decade. During this time of the year a region of decreasing relative humidity can be seen to become established in a west to east oriented band roughly centred over or along the northern shore-line of the Great Slave Lake. For most of the future climate decades this decrease peaks around 3% although through the 2060-2069 a decrease of over 8% is predicted, including the Yellowknife region. There tends to be a countering increase in relative humidity across the northern parts of the region, particularly near Coronation Gulf where the humidity is predicted to rise by 4-5% for several of the future climate decades, and further north. Diavik itself tends to experience little change or slight increases in humidity through to the end of the 2050-2059 decade. After this the relative humidity starts to decline.

In October the changes in relative humidity become insignificant once more.

Evaporation

Attachments 7 and 7a North provides analyses of the expected changes in the environmental evaporation for the northern Canadian region, including the Diavik to Yellowknife region. This is a measure of the actual quantity of water evaporated from the environment and not potential evaporation, which only applies to open water surfaces. The evaporation anomalies are derived based upon changes relative to the current decade (2000-2009). For the mid winter months, typified by January, the change in the evaporation rates remain low due to the continuing very cold temperatures at this time of the year. The evaporation anomaly rates remain low until the warmer months of the year, particularly north of the Great Slave Lake.

The trends in evaporation become far more significant as temperatures rise from May through to August. The trends are bimodal in nature with decreases in evaporation rates predicted across the northern parts of this region with a corresponding increase in evaporation rates to the south. There is a marked increase in evaporation rate through the central region in a band that lies across the Great Slave Lake through the 2020-2029 decade with a corresponding decrease in evaporation through the Coronation Gulf and further northwards. The 2030-2039 decade marks a transition period with the evaporation rates then accelerating over the Great Slave Lake and areas southwards, particularly to the southeast near Lake Athabasca where evaporation rates climb to over 0.4mm/day. Diavik remains in a region of slightly reduced evaporation through this period of time although at Yellowknife the evaporation rates are predicted to start to increase. Through the 2050-2059 and 2060-2069 decades the strengths of the evaporation rate anomalies tends to increase with greatest increases over and southeast of the Great Slave Lake, again peaking to the southeast over and beyond Lake Athabasca. There are opposing decreases in evaporation across the north of this region. Diavik is predicted to remain in a region where slight decreases in evaporation rate dominate, although the Yellowknife region is predicted to experience increases of around 0.25mm/day by the 2060-2069 decade.

The evaporation anomaly rates again become small from October onwards as temperatures fall.

Solar Radiation

Attachments 8 and 8a North provides analyses of the expected changes in solar radiation across northern Canada out to 2060 relative to the 1970-1999 reference period. Given there is little incident solar radiation during the winter months the anomalies are small through out the region for these months, although what trend there is indicates a reduction in incoming solar radiation due to increased cloud cover. For the mid spring month of April, both Diavik and Yellowknife tend to lie close to the no change line through the future climate period and fluctuate between increases and decreases in solar radiation through the future climate period in the order of 6 Watts/m^2.

During the mid summer month of July very strong decreases in solar radiation, in excess of 30 Watts/m^2, are predicted for the northern part of the northern Canadian domain for the period beyond 2050, as well as slightly lower reductions in solar radiation over the regions south of Lake Athabasca. However, in the area from Diavik down to Yellowknife tends to be in an area where the solar radiation anomalies oscillate from increases to decreases with the size of the anomalies remaining generally below 6 Watts/m^2.

Overall the larger solar radiation anomalies are predicted to occur during the warmer months of the year and reach a peak during the months of June and July. Although the solar radiation anomaly patterns show considerable variability from decade to decade, there is a marked move towards decreases in solar radiation across this region as a whole, although Diavik and Yellowknife are expected to remain away from the largest changes.

Climate Change Impacts in the Diavik Region of Northern Canada

1. The Current Climate

This report covers the key location of Diavik and its' access road to Yellowknife, both of which form a part of Rio Tinto's DDMI operations. The mine site at Diavik (64º 30'N, 110º 20'W) is located in the Northwest Territories of northern Canada, approximately 300km to the northeast of Yellowknife. A 350km long ice road connects the two locations that is constructed annually, with 75% built over frozen lakes. The future response of the frozen lakes to a changing climate is therefore a key concern. Although the authors of this report do not have a sufficient understanding of the response rates of these ice lakes to changing weather conditions, it is hoped that the data and analyses provided here will enable those with this knowledge to be able to determine how the ice lakes will fare in the future.

The Google Earth image in Figure 1 shows the relative positions of Diavik and Yellowknife and the general topography of the region. The climate data used to validate the climate models' performance near Diavik is from a combination of the data measured near the Diavik mine site and from the Environment Canada weather stations at Ekati and Lupin A. Obviously is it preferable to have historical climate data from the same location as the climate model data but the length of the climate data for Diavik is too short for proper climate analysis. This is the reason why historical data from relatively climate stations is also included.

Diavik's inland location protects it from the more extreme stormy weather conditions that affect coastal parts of Canada, although the intense polar low pressure systems bring recurring blizzards during the cooler months of the year. Its' northern latitude and high elevation (Ekati is at an elevation of 470m and it is assumed Diavik has a similar elevation) means it has very cold winters with minima having dropped as low as -47.0^{o}C, although the average winter temperature during the coldest month of January is -33.4^{o}C (both figures for Ekati). The high elevation and northern latitude of the Diavik to

Yellowknife region also allows its snow pack to last well through the spring months. The mean monthly temperatures climb through the 0°C during the month of May (average temperature -3.7°C) then drop below zero again early in the month of October (average temperature -9.1°C). The summers are cool to mild with temperatures rising to an average minimum of 10.2°C during its warmest month, July, with a mean monthly temperature near 14.2°C and an average maximum a mild 18.2°C. Infrequent relatively warm days can occur in this location with the all time record maximum temperature reaching 28.0°C. Being very cold through winter, little precipitation falls through the winter months, almost all of it falling as snow. The precipitation rapidly increases during the warmer months, August being the wettest month of the year with an average of 64mm. The precipitation is almost entirely rain at this time of the year.

The prevailing wind regime across the Diavik to Yellowknife region tends to be westerly winds through much of the year. However they do become quite changeable through certain months and particularly during the April to June period. At this time of the year the centres of the polar lows that dominate the regions weather tend to track eastwards between Diavik and Yellowknife. The complete set of long term average wind speed and direction charts are to be found in the report entitled “Wind average charts Canada – 2”.

The weather tends to be dominated by the passage of sometimes intense polar low pressure systems separated by transient highs. As a result of this there can be very abrupt changes in the weather from mild and sunny conditions to heavy rain or snow within a short space of time. The passage of warm and cold fronts brings the heaviest rain and snow falls. There are few thunderstorms at this high latitude and any that do occur are likely to be experienced in summer.

Diavik’s temperature and precipitation climate will be discussed in more detail in the following sections.

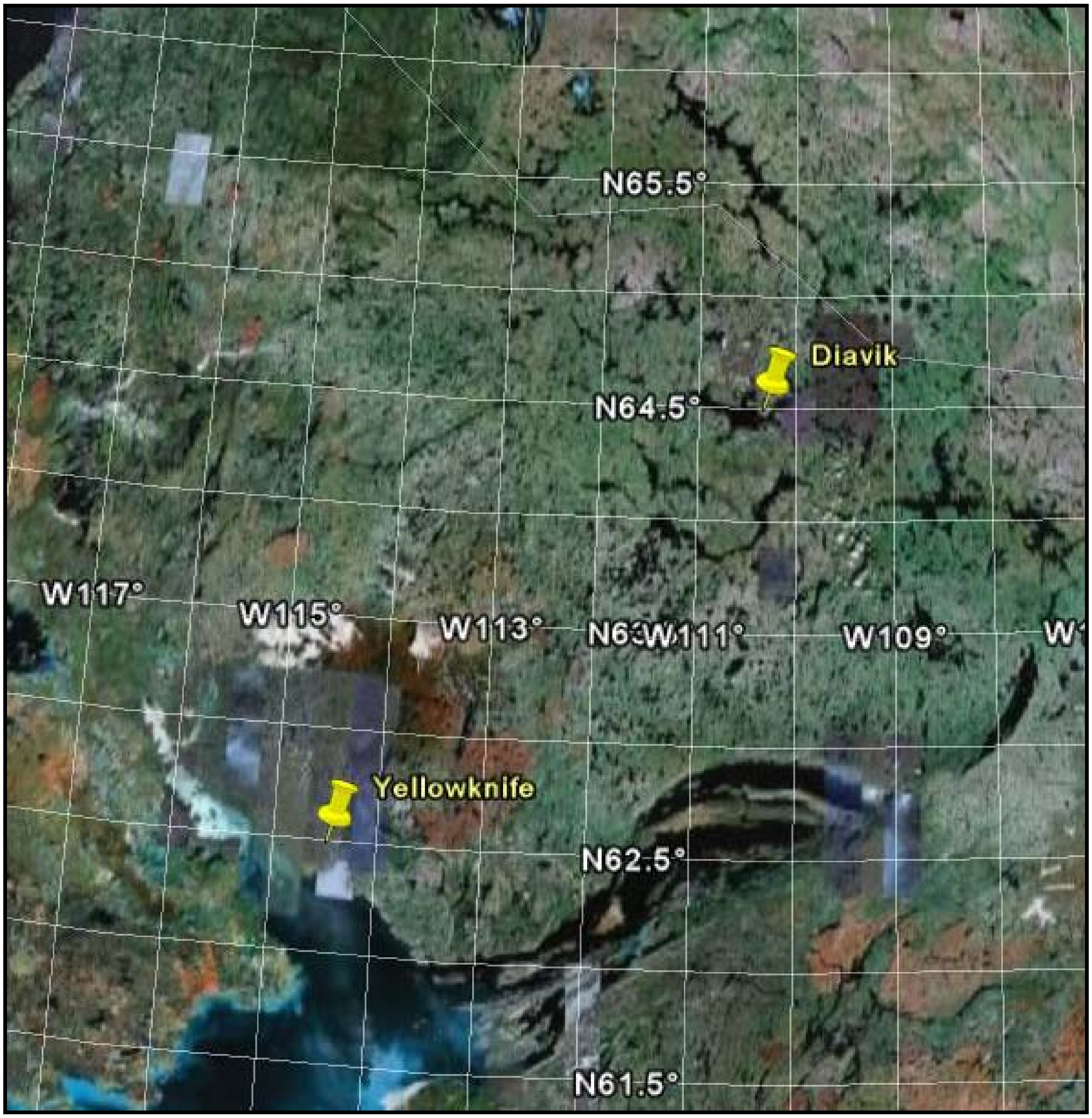


Figure 1: Location map showing Rio Tinto DDMI's Diavik operations and Yellowknife with the location of the climate model data extraction location shown as the Diavik yellow marker. Map courtesy of Google Earth.

1.1 Precipitation

The available climate data is from the Diavik mine site supplemented by the Ekati and Lupin A data from Environment Canada's records. Some long term data is also used for Fort Reliance, although this is a little further away from Diavik than is desirable. The

Environment Canada climate records are relatively complete, although there are small numbers of missing months or months when the data is estimated. The historical records can be considered comparatively good quality datasets, although there appear to be problems with the Ekati total precipitation data for months when snow falls. Diavik's precipitation is summarized in Figures 2a and b and in Table 1, although the data is actually from nearby stations. The total precipitation refers to the sum of melted snow together with any rainfall that occurred during the same month. It should be noted at this point that it is very difficult to accurately measure snowfall as the catch efficiency of snow gauges decreases rapidly with increasing exposure to wind, and it is also virtually impossible to separate out wind-driven snow that fell elsewhere and then was blown across the snow gauge from freshly fallen snow. The broader climate records shows the Diavik region has moderate to fresh average wind speeds throughout the year but with bouts of very strong winds. Hence it is to be assumed there is a large degree of uncertainty in the underlying accuracy of the snowfall records at all of the locations used in this study caused by the difficulty in measuring snowfall, not by the quality of the underlying observations program. The measurement of liquid rainfall should be considered more accurate, although the efficiency of rain gauges also declines significantly with increasing wind speed.

Diavik, being an elevated inland location with a northerly latitude, has an Arctic-type of precipitation climate with relatively low quantities of snow falling during the very cold winter months but relatively good falls of rain being received through the few warmer months of the year. There are no long term Climate Normals available for Diavik, Ekati or Lupin A from Environment Canada and so, as a general guide to the long term climate of the region, data from the nearest station with long term data, Fort Reliance (62^o 34'N, 109^o 10'W), is shown in Table 1, and graphically in Figure 2a. As Table 1 shows, from November through to March the precipitation falls almost entirely as snow. Then there is a rapid transition in the snow/rain mix from April, when snow still dominates, to May when most of the precipitation falls in liquid form. The period from June to August inclusive is almost all rain with the reverse transition occurring during the months of October and November. The greatest amount of snow is shown to fall in the month of November (29.9cm) with the greatest amount of rainfall (50mm) falling in August, which also has the greatest total precipitation. The driest month is March with around 9.6mm of total precipitation, followed closely by February with 9.9mm. The annual total precipitation is a modest 272mm, concentrated in the warmer months of the year from June to October.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rainfall (mm)	0	0	0	2.5	13.9	29.3	33.2	50	29.9	13.1	0.4	0	172.3
Snowfall (cm)	17.8	16.6	15.2	15.9	5	1.1	0	0	2.6	20.3	29.9	22.4	146.8
Precipitation (mm)	11	9.9	9.6	14.5	19.2	30.5	33.2	50	32.2	28.5	19.7	13.7	272
Ave Snow Depth	32	38	41	36	9	0	0	0	0	2	14	25	16
Median Snow Depth	31	38	41	37	7	0	0	0	0	1	15	25	16
Snow Depth End Mth	36	40	42	25	0	0	0	0	0	6	19	29	N / A

Table 1: Average monthly rainfall (mm), snowfall (cm), total precipitation (mm, average snow depth, median snow depth and snow depth at end of month (cm) for Fort Reliance from 1971 to 2000. Data courtesy of Environment Canada.

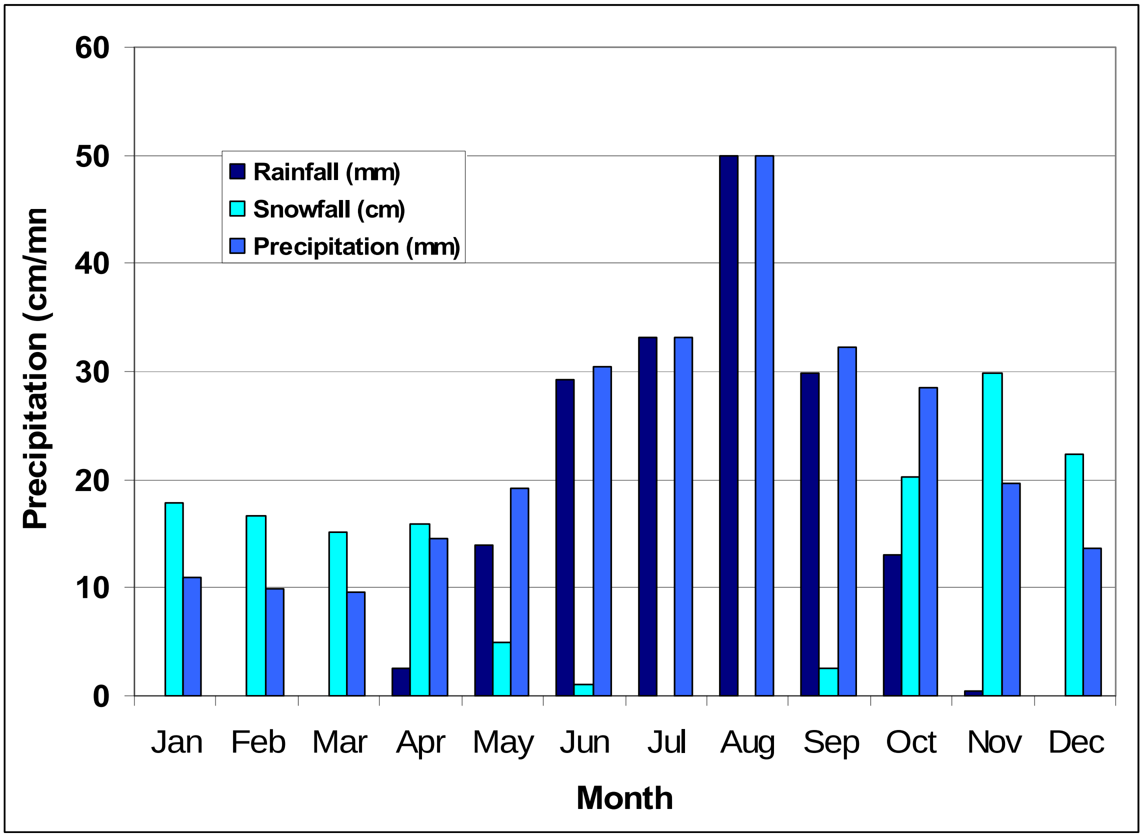


Figure 2a: Average monthly rainfall, snowfall and total precipitation graph for Fort Reliance. Data courtesy of Environment Canada.

Although the mix of snow and rainfall for the Fort Reliance area is generally indicative of that to be expected at Diavik, there are localised differences from one place to another across this region. This can be seen by comparing the longer term data in Figure 2a with the shorter length of total precipitation data from Ekati in Figure 2b. August is still the wettest month although Ekati has a larger average rainfall. The driest month shifts to April followed by January at Ekati, rather than March, although the late winter to early spring period is still the driest time of the year. The shorter period of records for Ekati means the individual months are likely to have been biased by anomalously wet and dry months within the available period of record and hence they should not be considered true long term averages. The conversion of snowfall into liquid precipitation is also an issue here. None-the-less, they do provide a useful guide of the likely climate at Diavik.

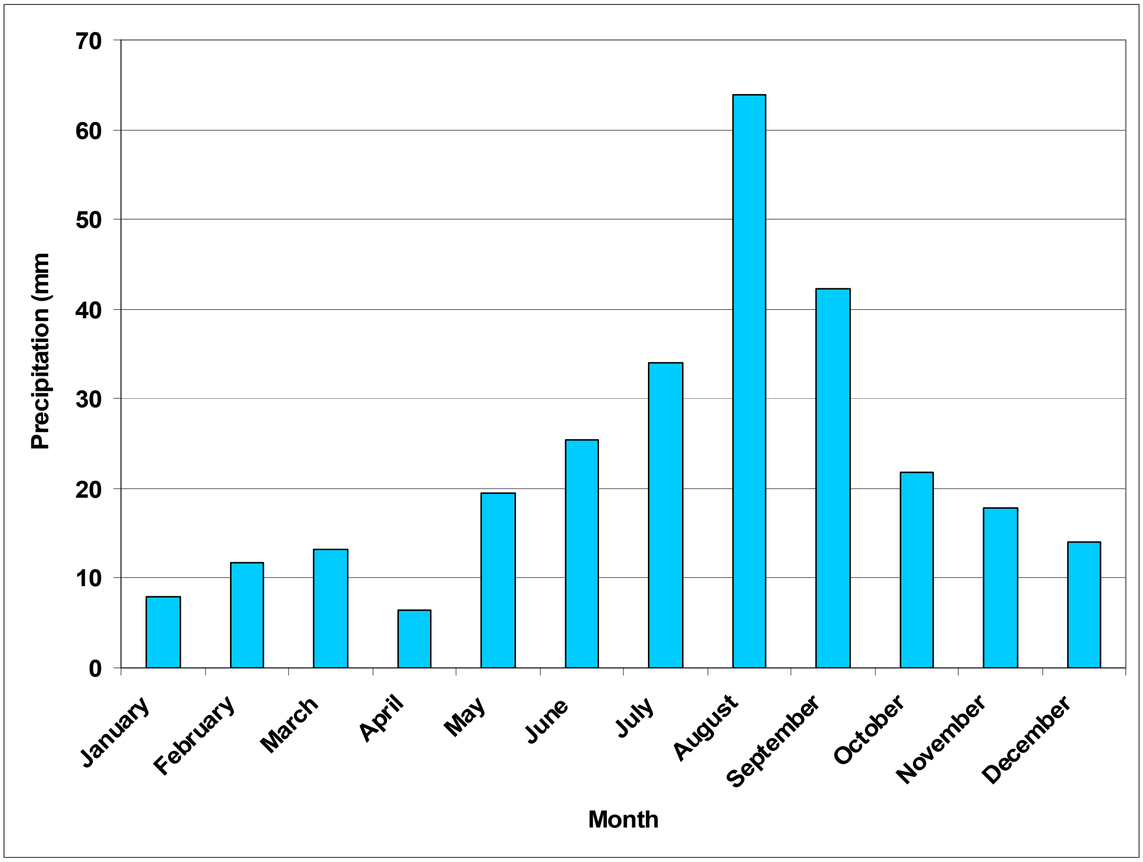


Figure 2b: Average monthly total precipitation graph for Ekati. Data courtesy of Environment Canada.

There is, unfortunately, insufficient length of observations from Diavik or Ekati to prepare a long term trend analysis. Some indications of the trends in the climate variables can be gained from viewing the time series data plotted in the model validation section that follows, although it must be noted that the trends in the observational data must be treated with extreme caution as they are prone to be heavily affected by naturally occurring multi-decadal climate variability.

The original rainfall records show the annual totals are significantly affected by one-off heavy rainfall or snowfall events in only one or two months of the year, highlighting the fact that the rainfall regime in this part of Canada are quite variable from month to month and year to year. It can be concluded that the magnitude of any long term changes in precipitation at Diavik are smaller than the magnitude of the naturally occurring multi-decadal oscillations.

1.2. Temperature

The temperature regime for the Diavik region is characterized by relatively mild summers and very cold winter days and nights, as can be seen in Table 2 and Figure 3 where the historical minimum, mean and maximum temperature records for Fort Reliance, in lieu of the limited data available for Diavik, for the period from 1971 to 2000 are shown on a monthly basis. The diurnal range ranges from around 12.1°C in the spring months of March and April to a small 5.6 °C in the mid-fall month of October. January is the coldest month for both maximum and minimum temperatures with a rapid rise in temperatures during the March to May period. July is the warmest month, again for both maximum and minimum temperatures, with the decline in temperatures during the October to December period being more rapid than the rate of the transition out of the winter period.

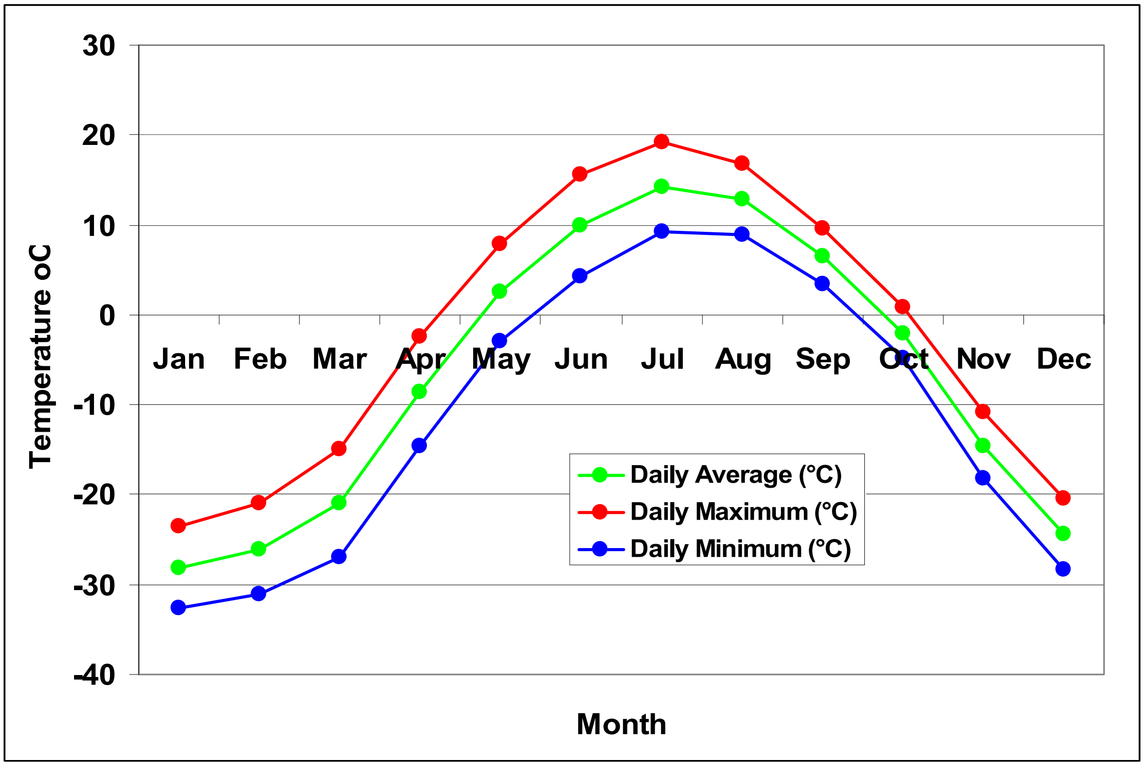


Figure 3: Average monthly maximum, mean and minimum temperature graph for Fort Reliance, in lieu of Diavik. Data courtesy of Environment Canada.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Daily Ave (°C)	-28.1	-26.1	-21	-8.6	2.5	9.9	14.3	12.9	6.5	-2	-14.6	-24.4	-6.6
Std Devn	4	5.3	3.4	3.6	3.4	1.6	1.5	1.8	1.8	2.1	3.3	4.1	5.2
Daily Max (°C)	-23.5	-21	-14.9	-2.5	7.9	15.6	19.2	16.8	9.6	0.8	-10.9	-20.4	-2
Daily Min (°C)	-32.7	-31.1	-27	-14.6	-2.9	4.2	9.3	8.9	3.4	-4.8	-18.2	-28.4	-11.2

Table 2: Monthly maximum, mean and minimum temperature (^{o}C), together with the standard deviation for the mean daily temperature for Fort Reliance, in lieu of data for Diavik, from 1971 to 2000. Data courtesy of Environment Canada.

In Diavik Attachment 2 in Figures DT1a, b and c the time series of minimum, mean and maximum temperatures are shown for the very limited period of record from 1997 through to 2008. From the data it can be seen that there is typically a variation in the monthly temperatures of around +/-1.5^{o}C from the mean monthly values from one year to the next, although there are one-off large variations of up to 10^{o}C for individual months, notably February. It is not possible to determine whether these larger excursions from the mean are true or errors in the dataset. The winter time temperatures, both maximum and minimum, can be seen to experience the greatest inter-annual variations with February being the most variable month of all. The summer months, in contrast to this, have a relatively stable temperature regime from year to year. The trends will be discussed in the model comparison section that follows.

2. Future Climate Simulations of the Diavik Region of Northern Canada

The analysis that follows utilizes the results from a suite of 12 ensemble Coupled Atmosphere-Ocean Climate model runs. The modeling procedure used is described in simple terms earlier in this report. Six of the ensemble model members were run with the observed historical greenhouse gas forcing through to 2000, after which time the greenhouse gas and aerosol concentrations were held at a constant level. This represents the historical climate. The other six model members were subject to a modified IPCC A2 scenario, similar to the A1B scenario, greenhouse gas / aerosol forcing from 2000 onwards. The ensemble means were then calculated for each suite of model runs and these are considered most likely to provide the most reliable information on future climate trends. The model member closest to the ensemble mean was then selected as being the model with both the greatest likelihood of representing the future climate and as the model that is likely to provide the most accurate detailed information on variability associated with climate change. The fields from either of the ensemble mean or of the model closest to the ensemble mean, form the basis of most of the analyses that follow, with all ensemble members used for some of the analyses.

2.1 Future Temperature Changes

In the following section the modelled changes in mean monthly air temperatures for the Diavik region will be discussed. Firstly the model validation will be discussed, followed by the future climate predictions. The model validation data is available for each month of the year. However, in order to reduce the size of the report, the comparisons between the historical observations of air temperature and the climate model predictions are discussed primarily for the middle month for each of the four seasons, namely January, April, July and October, as well as annually, although interesting aspects of the other months are also covered..

2.1.1 Model Validation

In Figures DT2a, b and c, the mean of the six climate model member predictions, the predictions from the warmest climate model member and the predictions from the coldest climate model member for the period from 1970 through to 2007 are shown for the coldest month of the year, January, against the available observations from Diavik, Ekati and Lupin A for the minimum, mean and maximum temperatures. Linear trend lines are included for the ensemble mean of the models for maximum, mean and minimum temperatures and also for the coldest of the model members. It must be remembered that the climate model predictions are for the air temperature at 2m above the ground for the 20km square grid point centred upon Diavik, whereas the comparison observations are from the temperatures measured inside a temperature screen at a point location. Hence the two datasets are not exactly the same, but are as close as the current state of the science will allow.

From the comparisons it can be seen that the ensemble mean modelled maximum, minimum and mean temperatures have a warm bias of approximately 2-3^{o}C against the observed Diavik minimum temperature data, based upon observations from Lupin A, Ekati and Diavik, which grows to around 4^{o}C for the maximum temperatures. This bias is much smaller if the long term Fort Reliance data is used (se Table 2). The coldest of the model members is, in general able to reproduce the observed temperature records best. It is likely this is also the model that is best able to predict snowfall and hence is the most skillful at these latitudes at this time of the year. The observed, ensemble mean model and coldest ensemble model member trends are very close to each other, with the linear trend lines showing very similar rates of warming through the 1970 to 2007 model validation period. This warming is predicted to affect both minimum and maximum temperatures. The observed mean temperatures show greater year to year variability, which is to be expected as the ensemble mean is an average of six models, which reduces the amount of inter-annual variability. The variability in the coldest of the model members is quite similar o that of the observations showing the individual climate model members are able to replicate the prevailing weather conditions at this location quite well.

The observed maximum temperatures, shown in Figure DT2c, tend have mean values close to those of the coldest ensemble model. The variability of maximum temperatures is greater than the climate model mean but similar to the coldest model member's variability. The hottest observed maxima remain within the envelope described by the hottest of the climate model members throughout the validation period and generally lie in the region between the ensemble mean and the coldest model member. The observed extreme low monthly maximum temperatures are very close to the coldest of the climate model member's predictions. This means that the coldest model member replicates the observed mean maxima well, with the observed extremes of temperature lying within the bounds of the range of predictions from the ensemble of model predictions. Overall the mean model bias is around 4^{o}C and this should be considered when the future climate model predictions are being considered.

The observed minimum temperatures, shown in Figure DT2b, tend have mean values mid way between those of the ensemble mean model and the coldest of the model members. The variability of observed minimum temperatures is greater than the climate model mean but is similar to that of the coldest model member. The warmest observed minima remain within the envelope described by the warmest of the climate model members throughout the validation period and, for the most part, lie below the predicted values of the ensemble mean of the models. The coldest minimum temperatures tend to be very similar to the coldest minima predicted by the coldest of the ensemble of model members. It can be concluded that the climate model predictions are quite well calibrated for minimum temperatures at Diavik for this time of the year, although the ensemble mean model has a warm bias of approximately 2^{o}C at this time of the year.

The comparisons for Diavik for February similar skill with the climate model again having a similar warm bias. It is noted the observed mean temperatures for February for Diavik and Ekati are too short to be able to identify any trend. However the longer period of record from Lupin A does show a rising trend similar o that of the climate models. Once again the observed temperatures generally sit within the envelope of predictions provided by the climate model members.

In Figures DT5a, b and c the mid-spring month of April temperature comparisons are shown for Diavik. For this month the observed temperatures from Diavik, Ekati and Lupin A continue to be cooler than the ensemble mean of the climate models with the warm bias growing to around 6^{o}C. This bias is greater than preferred but it should be noted that in complex terrain such as that around Diavik, naturally occurring variations over short distances can be of this magnitude. It should be noted that the longer term record for Fort Reliance matches the ensemble mean model values almost exactly with a monthly mean value of -8.6^{o}C. The same applies to both the maximum and minimum data with Fort Reliance matching the ensemble model mean data very well.

These local biases can be exacerbated by differential accumulations of snow and ice that can dramatically affect the temperatures over small distances. As the climate model is providing an average over an area while the observations are for point locations, differences are inevitable. Bias corrections need to be applied to the future climate model temperature predictions at Diavik to account for this warm bias, although it should also be noted that no bias correction at all is required if the Fort Reliance data is considered representative. As was the case for the preceding months, the longer period of record from Lupin A shows a warming trend comparable to that of the ensemble mean of the climate models. The observed minimum and maximum temperatures tend to show similar warm model biases with the coldest of the model members being most similar to the coldest of the climate model members. At this time of the year the observed coldest minima and maxima are lower than the lowest modelled minima and maxima and so this needs to be borne in mind when the future climate model predictions are interpreted.

In Figures DT8a, b and c the same comparisons are made for Diavik for the mid summer month of July, which is the warmest month of the year for this location. It can be seen that the climate model has a reduced warm bias for this month of the year with the warm bias for the mean temperature being around 2^{o}C. The trend for Lupin A’s observational record shows a rise of similar magnitude to the climate models mean. The observed minima and maxima for Diavik also show a similar bias of around 2^{o}C. The coldest of the observed minimum temperatures is only marginally below the coldest predictions from the coldest model member for this month with the coldest maxima being similar to the model predicted coldest maxima. The warmest of the observed temperatures are all below the highest predicted temperatures from the warmest model member.

In Figures DT11a, b and c the comparisons for the mid-fall month of October are shown for the climate models and the available observations for the Diavik region. For this month the observed minimum, mean and maximum temperature matches the climate model extremely well, with the observations being almost identical to the modelled values in both magnitude and trend. No bias correction is required at this time of the year. The minimum and maximum temperatures again sit well inside the envelope of predictions of the climate model. Hence there can be a high level of confidence in the ability of the climate model to represent the temperature regime for the Diavik region at this rapidly changing time of the year.

It should be noted that the ensemble mean model predictions require very little in the way of bias corrections for the months from August through to December inclusive. Hence the warm bias of the ensemble mean models is a seasonal feature of the climate model that applies to the period from mid winter through to mid summer, peaking in mid spring.

The annual comparisons between the climate models and the Diavik observations are shown in Figure DT14. The maximum, minimum and mean temperatures, at an annual level, are between 2 and 2.5^{o}C cooler than the ensemble mean climate model, which is considered good for an Arctic location in complex terrain such as Diavik. The modelled trend over the 38 years of this comparison for the annual data shows a 2.5^{o}C increase for the mean temperature, which is comparable to the observed warming trend at Lupin A of 2^{o}C over the period since 1982. The trend lines show that this increase is a fairly constant feature throughout the 38 years of the validation period, although there are multi-decadal oscillations present, more obvious in individual model runs. From all of the comparisons it can be concluded that the ensemble mean model temperature data recreates the observed Diavik temperature record to an acceptable degree with the application of bias corrections thought to be a suitable way of adjusting for the differences between model and observations as the trends and observed variability are similar between the datasets.

2.1.2 Future Climate Model Predictions

Next the future climate temperature predictions are analyzed for the grid box centred upon Diavik. The model predictions for Diavik for all twelve months are shown in Diavik Attachment D2 as Figures DT15 a, b and c (mean, minimum and maximum temperatures respectively) through to DT26 a, b and c with the annual predictions shown in DT27a (ensemble mean of the climate models) and DT27b (the model closest to the ensemble mean). The predictions from the hottest and the coldest of the six climate model predictions are also shown for maximum and minimum temperatures. These serve to provide an estimate of the range of possibilities for the more extreme hot or cold periods. The ensemble mean of the six models will, in general, provide the best estimate of the long term trends in the minimum, mean and maximum temperatures. The future climate temperature prediction discussions that follow are based upon the ensemble mean of the climate models. Comments on inter-annual and decadal scale oscillations, and likely changes in the frequency of more extreme events, will generally be based upon the results of the model closest to the ensemble mean. For brevity, only the months in the middle of the four seasons and the annual trends will be discussed in any detail.

The predicted temperature changes can be applied to the historical daily air temperature data to determine likely changes to the Freezing Index at any given time through the future climate period. The predicted changes in surface temperature can also be applied in the same way to historical surface temperature data to determine expected changes in the Surface Freezing Index into the future. Although it is outside the scope of this project to determine the Freezing Index, the future climate model predictions clearly show a marked reduction in the number of below-freezing days are to be expected in the future climate, with this reduction accelerating through the future climate period.

January

In Figures DT15a, b and c the ensemble mean model predictions of minimum, mean and maximum temperatures for Diavik are shown from 1970 through to 2060 for the mid-winter month of January, together with linear trend lines for the ensemble mean of the model predictions. The climate models show an ongoing, almost linear increasing trend in the minimum, mean and maximum temperatures through to at least 2060, although there is a definite multi-decadal signal in the rate at which the temperatures rise. This can be seen as a series of steps in the graphs of temperature with the temperatures remaining relatively constant for a decade or more followed by a sudden rise, then another period of relatively constant temperature before the next rapid rise occurs. The warming trends are quite significant for both minima and maxima, with the rate of rise of minimum temperatures predicted to be slightly greater than for maximum temperatures. Both are predicted to warm relatively rapidly.

Using the linear trend lines as the reference, the predicted temperature changes, from 1970 to 2060, are as follows:

- Maxima: from -23.4^{o}C to -15.8^{o}C, a rise of 7.6^{o}C over the 90-year period. This equates to an annual maximum temperature increase of 0.084^{o}C.
- Mean temperatures: from -27.3^{o}C to -19.6^{o}C, a rise of 7.7^{o}C over the 90-year period. This equates to an annual mean temperature increase of 0.086^{o}C.
- Minima: from -31.6^{o}C to -23.4^{o}C, a rise of 8.2^{o}C over the 90-year period. This equates to an annual minimum temperature increase of 0.091^{o}C.

Applying bias corrections to these datasets based upon the observations shown in Figures DT2a, b and c, adjusts the predicted temperature changes for the month of January for the period from 1970 to 2060 to the following values (bias correction not required for Fort Reliance data):

- Maxima: from -27.4^{o}C to -19.8^{o}C, a rise of 7.6^{o}C over the 90-year period.
- Mean temperatures: from -30.3^{o}C to -22.6^{o}C, a rise of 7.7^{o}C over the 90-year period.
- Minima: from -33.6^{o}C to -25.4^{o}C, a rise of 8.2^{o}C over the 90-year period.

Looking at the variability of the year to year temperature variations at Diavik it can be seen that there are likely to be decades in the future when the temperature rise plateaus for a period of time, followed by an accelerated rise. Also there are predictions of one-off years when there are spikes in the temperatures predicted – either hot or cool spikes, One key thing to note concerns the transition into a consistently warmer climate beyond the 1990-1999 decade. In the period from 1970 through to around 2000 there are occasional years when there are relatively cold years – when the January minima drop to around -32°C, well below the long term average. However, beyond 2015 these colder years become less frequent or severe, with the coldest of the years predicted to drop only as far as -27°C. The minimum temperatures predicted for the period from 2050-2060 are all shown to be higher than the warmest minimum temperature during the 1970s and 1980s.

April

For the spring month of April, the predicted changes in maximum, mean and minimum temperatures for Diavik are shown in Figures DT18a, b and c. The future climate predictions are based upon the mean of the ensemble of models. However, it must be noted that the ensemble mean model has a warm bias of approximately 4-5°C at this time of the year, based upon the Diavik, Ekati and Lupin A data but not the Fort Reliance data, and this bias correction can be applied to better match the available Diavik observations. The coldest of the model members appears to replicate Diavik's temperature regime more closely during this month. Again there are multi-decadal oscillations in the temperature predictions for both maximum and minimum evident. However, over the full 90 years of the climate model predictions the linear trend line provides a good estimate of the predicted long term trend in the temperatures.

Using the linear trend lines for the analysis, the predicted temperature changes, from 1970 to 2060, are as follows:

- Maxima: from -4.5°C to -0.9°C, a rise of 3.6°C over the 90-year period. This equates to an annual maximum temperature increase of 0.040°C.
- Mean temperatures: from -9.7°C to -5.0°C, a rise of 4.7°C over the 90-year period. This equates to an annual mean temperature increase of 0.052°C.

- Minima: from -14.8°C to -9.2°C, a rise of 5.6°C over the 90-year period. This equates to an annual minimum temperature increase of 0.062°C.

Applying bias corrections to these datasets based upon the observations, which are at their greatest at this time of the year and are shown in Figures DT5a, b and c, adjusts the predicted temperature changes for the month of January for the period from 1970 to 2060 to the following values (bias correction not required for Fort Reliance data):

- Maxima: from -11.5°C to -7.9°C, a rise of 3.6°C over the 90-year period.
- Mean temperatures: from -15.7°C to -11.0°C, a rise of 4.7°C over the 90-year period.
- Minima: from -19.3°C to -13.7°C, a rise of 5.6°C over the 90-year period.

These predictions show the April period to have a slightly slower rate of warming but still one that is considered rapid in a global context. The minima are expected to rise at a faster rate than for the maxima, although this rate is a slightly slower rate than for the mid winter months. The climate model predictions for both the minimum and maximum temperatures show a relatively large amount of variability from one year to another, indicating there can be expected to be abrupt jumps in the temperature followed by equally rapid falls the following year. The rise in mean temperature of 4.7°C over the period of the future climate predictions would amount to a much earlier and more rapid thaw of the accumulated snow in the future climate regime. With a similar rate of warming predicted for the month of May, this would also mean the ice road connecting Diavik and Yellowknife would be expected to disintegrate much earlier in the future climate regime. The climate model predictions still show outlying abnormally cool and warm years but there is clear evidence in these predictions for a move into a consistently significantly warmer climate.

July

The predicted changes in maximum, mean and minimum temperatures for the warmest time of the year at Diavik, July, are shown in Figures DT21a, b and c. The ensemble mean of the model predictions can be seen to go through cycles of increased then decreased inter-annual variability through the future climate period, indicating the nature of the climate variability is not expected to be uniform through the future climate period. This variability appears to affect both maximum and minimum temperature predictions. There are also marked multi-decadal signals in the temperature predictions, as illustrated by the series of step-like increases in temperature predicted through to the year 2060.

Using the linear trend lines for the analysis, the predicted temperature changes, from 1970 to 2060, are as follows:

- Maxima: from 18.2^{o}C to 20.0^{o}C, a rise of 1.8^{o}C over the 90-year period. This equates to an annual maximum temperature increase of 0.020^{o}C.
- Mean temperatures: from 13.6^{o}C to 15.7^{o}C, a rise of 2.1^{o}C over the 90-year period. This equates to an annual mean temperature increase of 0.023^{o}C.
- Minima: from 9.0^{o}C to 10.9^{o}C, a rise of 1.9^{o}C over the 90-year period. This equates to an annual minimum temperature increase of 0.021^{o}C.

Again applying bias corrections to these datasets based upon the observations, which have reduced to a modest 1.5^{o}C (minimum) to 2.5^{o}C (maximum) for this month, as shown in Figures DT8a, b and c, adjusts the predicted temperature changes for the month of January for the period from 1970 to 2060 to the following values:

- Maxima: from 15.7^{o}C to 17.5^{o}C, a rise of 1.8^{o}C over the 90-year period.
- Mean temperatures: from 11.6^{o}C to 13.7^{o}C, a rise of 2.1^{o}C over the 90-year period.
- Minima: from 7.5^{o}C to 9.4^{o}C, a rise of 1.9^{o}C over the 90-year period.

From these predictions it can be seen that the ensemble mean climate model forecasts a relatively uniform increase in maximum and minimum temperatures through the summer period, although the rate of increase in temperatures are predicted to be very slow in comparison to the winter and spring months. Although the predictions are for ongoing warming, there continue to be a reasonably number of years, sometimes several years in succession as for the period from 2022-2025, when there are Julys with maximum temperatures a couple of degrees cooler than the long term average trend would indicate as being the normal conditions. The variability is predicted to similar for both maximum and minimum temperatures.

October

The predicted changes in maximum, mean and minimum temperatures for Diavik for the central month of fall, October, are shown in Figures DT24a, b and c. October represents the start of the transition from the mild to warm season into the time of year when snowfalls become more frequent. Hence it is an inherently changeable time of the year and one when the accumulation of snow on the ground can be expected to commence as the mean daily temperatures historically drops below freezing during this month.

Once again the linear trend lines are used to quantify the expected changes in the temperature for this time of the year. On this basis, the predicted temperature changes, from 1970 to 2060, are as follows:

- Maxima: from -3.8^{o}C to 0.4^{o}C, a rise of 4.2^{o}C over the 90-year period. This equates to an annual maximum temperature increase of 0.047^{o}C.
- Mean temperatures: from -6.9^{o}C to -2.0^{o}C, a rise of 4.9^{o}C over the 90-year period. This equates to an annual mean temperature increase of 0.054^{o}C.
- Minima: from -9.9^{o}C to -4.4^{o}C, a rise of 5.5^{o}C over the 90-year period. This equates to an annual minimum temperature increase of 0.061^{o}C.

Again applying bias corrections to these datasets based upon the observations, which have reduced to very small values of zero ^{o}C (minimum) to 1.0^{o}C (maximum) for this month, as shown in Figures DT11a, b and c, adjusts the predicted temperature changes for the month of January for the period from 1970 to 2060 to the following values:

- Maxima: from -4.8^{o}C to -0.6^{o}C, a rise of 4.2^{o}C over the 90-year period.
- Mean temperatures: from -7.4^{o}C to -2.5^{o}C, a rise of 4.9^{o}C over the 90-year period.
- Minima: from -9.9^{o}C to -4.4^{o}C, a rise of 5.5^{o}C over the 90-year period.

The climate models show an important shift in the temperature regime at this time of the year as the warming becomes significantly faster than for the summer months. The climate model indicates there would be significant delays in the starting time for snow accumulations and for the lakes to start to freeze. Although the modelling does show there will still be some years in the future when the mean monthly temperature is close to the current values, they become increasingly less common. By around the year 2020 there are indications that the mean monthly temperature could be within 1^{o}C of freezing, which is a significant warming within only just over a decade. It would become increasingly likely that less snow would accumulate on the ground during this month through the future climate period due to these rapid rises in temperature. The predicted rises in minimum temperature are also faster than those forecast for the maximum temperatures which would exacerbate this effect. Towards the end of the future climate period, mean monthly temperatures are no longer expected to drop below -3^{o}C and are likely to start to be above zero for some years.

Based upon the predicted temperature rises, the expectation would be for fewer snow events with more precipitation falling as rain, which is also harmful for snow and ice formation.

Annual

Finally, the trends in the annual minimum, mean and maximum temperatures for Diavik are shown in Figure DT27a for the ensemble mean of the models and in Figure DT27b for the model closest to the ensemble mean. Both of these approaches give very similar trends for this location. These are the trends normally used to quantify, in the simplest of terms, the effects of climate change at a given location. Smoothed over an entire year, the predictions show a relatively constant rate of increase in temperature over the coming decades, although periods of climate variability are evident throughout the climate predictions. The inter-annual and multi-decadal oscillations are not as pronounced as they are for the individual months as they are not aligned throughout the entire year and tend to cancel each other out over time. On almost all occasions the annual temperatures (maximum, mean and minimum) lie within 2^{o}C of the expected temperature, as indicated by the linear trend line.

The linear trend line provides a good estimate of the long-term warming trend. Using this trend line, the predicted temperature changes, from 1970 to 2060, can be quantified as follows:

- Maxima: from -4.8^{o}C to 0.7^{o}C, a rise of 5.5^{o}C over the 90-year period. This equates to an annual maximum temperature increase of 0.061^{o}C.
- Mean temperatures: from -8.0^{o}C to -3.0^{o}C, a rise of 5.0^{o}C over the 90-year period. This equates to an annual mean temperature increase of approximately 0.056^{o}C.
- Minima: from -12.2^{o}C to -6.8^{o}C, a rise of 5.4^{o}C over the 90-year period. This equates to an annual minimum temperature increase of approximately 0.060^{o}C.

Applying the annualized bias corrections to these dataset, again based upon the observations, shown in Figures DT14a, b and c, adjusts the predicted temperature changes for the month of January for the period from 1970 to 2060 to the following values:

- Maxima: from -8.3^{o}C to -2.8^{o}C, a rise of 5.5^{o}C over the 90-year period.
- Mean temperatures: from -11.0^{o}C to -6.0^{o}C, a rise of 5.0^{o}C over the 90-year period.
- Minima: from -14.7^{o}C to -9.3^{o}C, a rise of 5.4^{o}C over the 90-year period.

These temperature rises are likely to have a significant impact upon the way of life and ecology of the Diavik Yellowknife region as this still amounts to a significant warming, one of the highest in the world, and one that would greatly reduce the length of the very cold snow season. The length of time that the lakes would be frozen to sufficient depth to be used as ice roads would almost certainly be greatly reduced. Someone more familiar with ice roads should be consulted to quantify the extent of these reductions based upon the data provided here.

It should be emphasized that, as marked as these temperature rises are, these are not the end points of climate change. Beyond this period of time, the temperatures would be expected to continue to rise, although the rate at which they rise will be determined, to a large extent, by what happens to the global rate of greenhouse gas and aerosol emissions over the next couple of decades. For the future climate scenario used in this series of climate predictions, which is the one considered to be the most likely future climate outcome, the region surrounding Diavik are showing a marked trend towards increasing temperatures, particularly for minimum temperatures, with sustained and increasing impacts to be expected upon the communities and ecology of the region.

Climate Periodicities – Wavelet Analysis

The periodicities and oscillations in the temperature record for Diavik have been analyzed through the use of wavelet analyses. These analyses and their interpretations are to be found in the document entitled Diavik Wavelet (Appendix A).

2.2 Future Precipitation Changes

In the following sections the results of a series of analyses using data from all six of the ensemble members are presented, covering precipitation predictions from 1970 through to 2060. In the first section the results of the models are validated against the observed rainfalls for the Diavik area using Environment Canada's climatological data for the Ekati and Lupin A weather stations, and the limited Rio Tinto Diavik weather station data. In the following section the future climate predictions are presented.

2.2.1 Precipitation Validation

In this section the ensemble control mean rainfall for the period 1970-2006 for the Diavik grid box is used as the principle reference precipitation for trend analysis purposes. The precipitation used is the total precipitation from liquid rainfall and the water equivalent of snow fall and is the values obtained from across the grid box, rather than being a point measurement, which is the observed precipitation. Results from all six of the model members are also shown in the form of the driest and the wettest of the climate model predictions in order to provide an indication of the variability of the rainfall at this location and the potential extreme precipitation events, both wet and dry, on monthly time scales.

The lowest line shows the predictions from the driest of the six models for each of the model validation years with one graph for every month of the year. The lowest predicted precipitation for any given year could come from any one of the six models and is almost certain to change from one model to another from one year to the next. The lowest precipitation, labeled “Driest Model” on the graphs, therefore identifies what is likely to be the lower bounds for the rainfall regime for that month in any given year. It can be seen from the plots that there can be a large separation between the highest and lowest precipitation for many of the model years, indicating the Diavik area experiences a quite variable precipitation regime with very large fluctuations possible from one year to the next. The highest line on the graphs, labeled “Wettest Model”, shows the heaviest predicted precipitation for that month and year from the six ensemble model members. Again the highest precipitation could be from any one of the six climate models and the highest predictions could and does vary from one model member to another from one year to the next and from one month to the next. A detailed analysis of the model outputs shows that some of the climate model members are better able to predict the precipitation climate of this region than the others. The heaviest precipitation is normally predicted best by those models with the cloud physics that is best able to simulate frontal precipitation processes that produce the heaviest precipitation at this location. Conversely, the models that predict the lightest rainfall (for example drizzle, snow and ice crystals) would be from a different set of climate models. The area between the highest and lowest model predictions is shaded light blue in order to show the model spread of the rainfall predictions.

In the earlier section on observed precipitation for the Diavik area, the precipitation regime was shown to be highly seasonal with considerable variability from month to month and year to year. The difficulty in accurately measuring snowfall in a location exposed to wind was also noted. The mean values of the models and the spread of the six model members are used to quantify the rainfall regime throughout the validation periods. Ideally the observed precipitation would lie within the envelope of predictions from the wettest to the driest of the climate model members and the mean of the two distributions would be identical. Precipitation is a highly variable quantity in both space and time, subject to geographically-produced very localised enhancements or reductions (rain shadow and lake snow enhancement effects). Hence it is to be expected that the simplified physics employed within the climate model would not be able to replicate the finer detail of the precipitation climate. However, the trends identified by the climate model predictions should serve as a useful guide as to the likely future nature of the precipitation regime in this region, with bias corrections applied to the model data where these can be identified with confidence.

In Figures D2 to D14 comparisons are presented in graphical form between the modelled precipitations for the 20km square grid box surrounding Diavik against the corresponding observed precipitation, where there are sufficient observational records available, for each of the twelve months of the year and annually. The Ekati precipitation data is shown as the red dots connected by red lines, Lupin A as the purple lines and dots and the Ekati data as orange lines and dots. The ensemble mean model data represented in dark green dots on the graph. The spread between the highest and lowest model predictions is coloured pale blue. Linear trend lines are also included for both the observed Lupin A precipitation, being the only station of the three with a reasonable length of climate record, and the data from the ensemble mean of the climate model runs.

The heaviest observed precipitation at Diavik would be expected to generally lie below a curve connecting the highest points from the wettest of the climate models, with the exception that the one or two most extreme precipitation events could be expected to lie above this curve. This is because the precipitation measured at the three observation stations used in this comparison are from point locations whereas the model produces rainfall across a region 20km x 20km, or over approximately 400km^2. Running the model at very high horizontal resolution (e.g. 500m) and with complex cloud physics would better define the true nature of the potential rainfall extremes but this is computationally too expensive at the present time.

The best way to quantify the model predictions of precipitation is through the use of the ensemble mean rainfall or, in cases where one of the climate model members is very well configured to represent the precipitation regime experienced at Diavik, the model closest to the ensemble mean. The ensemble mean precipitation is the average precipitation from the six climate models, calculated on a monthly basis throughout the entire period of the climate model runs. Although the ensemble means smoothes out the variability caused by the heavy and light precipitation events that are a feature of the climate of this region, experience has shown that it normally provides a very good estimate of the typical precipitation of the region under investigation on monthly and annual bases. The middle month of each season will now be discussed in detail, although there will be a little discussion of some of the intermediate months as well.

In January, the comparisons between the climate models and the Diavik region (i.e. Ekati, Diavik and Lupin A) precipitation observations are shown in Figure D2. From the graph it can be seen that the ensemble mean quantity of total precipitation tends to be above the Lupin A and Ekati precipitation records but is closer to the limited data available for Diavik itself. Of the 8 Januarys of data available there are three years above the average and five below. The lowest Diavik precipitation record is similar to the lowest precipitation of the driest climate model and the highest precipitation matches the wettest model well. Lupin A tends to be consistently drier, as does Ekati. This could be a feature of the precipitation regime of the area or it could be related to the catch efficiency of the snow gauges at this time of the year. The trend line for Lupin A shows a decline although with heavier rainfalls indicated in the Diavik data for 2007 and 2008 (no data available for Lupin A for these two years) the trend line would most likely flatten out and possibly increase if there was a corresponding increase in precipitation. There is also a change from rapidly fluctuating relatively high then low then high precipitation values at Lupin A through to 1993 after which time the plot changes to one of remarkably small year to year fluctuations. This is often a sign of changing instrumentation exposure or a site change rather than a true climate change. However, the siting and exposure history for these stations are unknown and hence this cannot be confirmed. There is insufficient data for Ekati and Diavik for any form of trend analysis, although it is interesting to note Diavik has had a run of relatively wet Januarys in recent years, noting that this is a very dry month overall. The climate model predicts a gradual increase in precipitation from near 17mm in 1970 up to 19mm in 2008, a rise of 10.5%, with similar increases for both the wettest and driest of the climate models. The observed total precipitation in the graph, which is the recorded quantity of melted snow from the Environment Canada records, needs to be treated with caution, partially for the reasons mentioned previously, but also due to the way in which recorded snow fall is converted into equivalent precipitation.

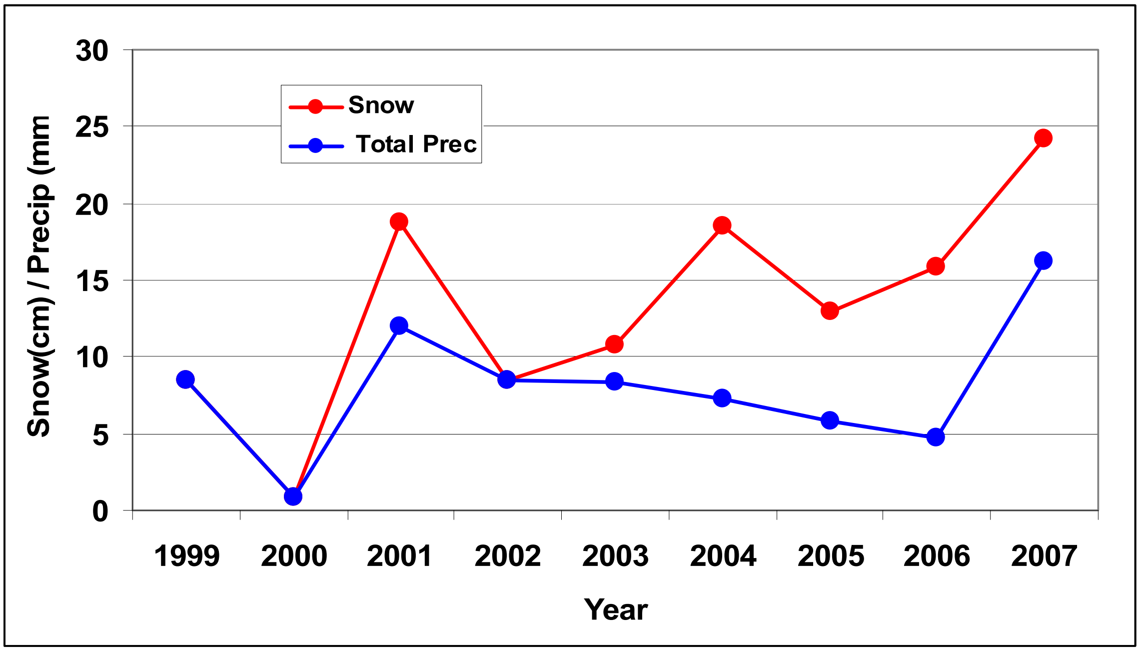


Figure 5: Observed snow and the corresponding melted snow (total precipitation) for January for Ekati from 1999 to 2007. Data courtesy of Environment Canada.

At Ekati, for example, this conversion has been handled differently from month to month and year to year, as the graph in Figure 5 and the data in Table 3 shows. Although the technique could make allowances for changes in snow density, it is more likely there have been a variety of techniques used in the way the snow is gathered and melted through the observational record through to the current time. The original snow measurements show a marked increasing trend in snowfall whereas the snow converted into liquid precipitation shows a much lower trend. The snow to liquid precipitation ratio has a remarkably large range, from 1.0 up to 3.4 (in January 2006). The same issues were noted at some other locations across Canada and for other months. It should be noted the climate model does not suffer from altered observational practices as do the original observations. Hence the trends and model biases based upon precipitation measurements which include a snowfall component have to be treated very cautiously. From this information it would be concluded the climate model replicates the Diavik January total precipitation very well.

Year	Snow	Total Precipitation	Ratio
1999	**8.5**	**8.5**	**1.0**
2000	**0.8**	**0.8**	**1.0**
2001	**18.7**	**12**	**1.6**
2002	**8.5**	**8.5**	**1.0**
2003	**10.8**	**8.4**	**1.3**
2004	**18.5**	**7.2**	**2.6**
2005	**13**	**5.8**	**2.2**
2006	**15.9**	**4.7**	**3.4**
2007	**24.2**	**16.2**	**1.5**

Table 3: Observed snowfall and subsequently derived total liquid precipitation for Ekati for January, together with the snow to liquid precipitation ratio. Data courtesy of Environment Canada.

For the month of February the limited Diavik total precipitation record fits in well with the ensemble mean modelled precipitation with the wettest and driest months also fitting within the range of ensemble model predictions. It is apparent that Lupin A tends to have more dry months than the other two locations. The Ekati data continues to be affected by an inconsistent approach to the conversion of snow into liquid precipitation. For this month, arguably the driest time of the year, the climate model predicts a smaller increase in precipitation, being a rise of just under 1 mm over the 38 years of the validation period. The reliability of the trend from Lupin A is still subject to an insufficient length of good quality data as the trend is reversed for the following month of March. Diavik data is again well calibrated to the model mean data for the month of March. The heaviest recorded precipitation events for Lupin A and Ekati appear to match the predictions from the wettest climate model well.

The same issues affect the Ekati comparisons for April with most of the precipitation falling as snow. Table 4 shows how great the variations are in the conversion of snow into liquid precipitation for this month, which makes the Ekati plot in the graph open to question as a conversion rate close to 1.0 would have removed the apparent low bias in this dataset. The limited Diavik data fits in well with the ensemble mean and spread once more. For this month the trend for the Lupin A data is almost identical to that of the driest of the climate model members, indicating there could be a believable trend starting to emerge from the observational data at this time of the year. The heaviest Lupin A and Diavik falls also match those of the wettest climate model well.

Year	Snow	Total Precipitation	Ratio
1999	11.8	11.8	1.0
2000	5.4	5.1*	1.1
2001	8.7	2.4	3.6
2002	5.0	4.4	1.1
2003	21.1	8.8	2.4
2004	9.2	2.5	3.7
2005	10.7	9.9*	1.1
2006	17.5	7.3*	2.4
2007	10.9	9.2*	1.2

Table 4: Observed snowfall and subsequently derived total liquid precipitation for Ekati for April, together with the snow to liquid precipitation ratio. Data courtesy of Environment Canada. * indicates rain has been added to this total for consistency purposes.

For the month of May the precipitation at Diavik is becoming dominated by liquid rainfall with the problems associated with snowfall becoming less of an issue. The Diavik observations show a high level of year to year variability, including one fall heavier than anything recorded at Ekati and Lupin A for this month. It is also slightly higher, around 4mm, than the highest precipitation predicted by the wettest of the climate model members. The Lupin A data continues to be consistently drier than Diavik and the ensemble mean model with little trend through the future climate period. Of significance are the large variations between the observed precipitations for the three stations at times when there is an overlap of their observations, confirming the inherently variable nature of the precipitation in the Diavik region at this time of the year. Overall the ensemble mean provides a realistic representation of the likely precipitation for this area, although probably with a slight wet bias.

For June the available Lupin A data more closely matches the ensemble mean, wettest and driest rainfall data and shows a similar trend of little change in precipitation over the available length of record. In contrast to the Lupin A data, the limited Diavik rainfall record indicates the development of a dry bias with Ekati also generally being drier than the ensemble mean model, apart from a lone very heavy rainfall event. If the Diavik data is considered a true indication of the long term average then a bias correction should be applied to the ensemble mean model data. However, the ensemble mean average precipitation is relatively close to that of Lupin A (30mm) and Fort Reliance (30.5mm) and so the difference between the two datasets could be a function of natural climate variability or a localised micro-climatic effect at Diavik.

For the mid summer month of July the ensemble mean of the climate models appears to be quite close to the mean of the observed Diavik rainfall with the wettest and driest models also matching the available observations well. The Lupin A mean rainfall also agrees well with the model data although the linear trend line is unrealistic, biased by the combination of three wet years near the start of the observational record and three dry ones at the end. This trend is markedly different to that seen in June and August. The Ekati data also seems close to both the Diavik and model data for this month, one in which snowfall plays no role.

In August the model data appears to have a dry bias of approximately 15mm when compared to the Diavik rainfall data. Lupin A appears to be even wetter, although it is interesting to note that the Lupin A data appears to be markedly different to both Diavik and Ekati for many of the years where the datasets overlap, indicating this location may not truly represent the Diavik region’s precipitation regime.

There is a reduced dry bias in the model data for the month of September, down to around 10mm for the three observation stations. The observations also show greater variability than the wettest and driest climate models, indicating the model is likely to underestimate the magnitude of extreme precipitation events at this time of the year. Both the model and Lupin A data show an almost horizontal trend, or no change in the rainfall regime for this month through the validation period.

October is the month when snowfall once again dominates the precipitation figures. The model bias appears to vanish at this time of the year with the ensemble mean precipitation close to that of the observed Diavik precipitation, slightly below that of Lupin A and above that of Ekati, which appears to have problems with conversion into liquid precipitation for months when snowfall is a significant part of the record. The Lupin A trend is again almost flat, although it shows an increase in November. The ensemble mean model data indicates a gradually increasing trend, primarily due to greater amounts of precipitation predicted through the 2000's. This trend returns to one of little change in November, indicating this could be a function of natural climate variability rather than a true long term rise.

It is difficult to determine if there is a model bias at Diavik for the month of November. The limited observations at Diavik show good agreement with the ensemble mean precipitation until three wet years appear from 2005 through to 2007. Ekati and Lupin A remain well below Diavik for months where there is data and either match or are below the ensemble mean model data, raising a question as to whether these were atypical very heavy falls, local effects or a true reflection of the Diavik climate. These extremes of rainfall do not appear in the Diavik December precipitation record with all three observing stations tending to be around 5mm drier than the modelled precipitation. This could be considered a wet model bias for this month of the year. The trends and the observed extremes in precipitation match those of the climate models to a pleasing extent. The problems associated with increasing quantities of snowfall have to be considered at this time of the year, of course.

The annual climate model predictions of total precipitation for Diavik and the observed rainfalls for the three observing stations are shown in Figure D14, together with linear trend lines for the model and Lupin A data. The climate model predictions are for very slightly increasing precipitation, in good agreement with the annual trend for Lupin A. The limited Diavik data is in very good agreement with the ensemble mean model data with a minor dry bias evident in the Lupin A data. Ekati appears drier than the model but this could be attributed to the inconsistent conversion procedure used for snowfall.

So it can be concluded that, provided the observational record is treated correctly and with appropriate caution, the historical precipitation data and the climate model data agree to a satisfying degree. Bias corrections improve the correlations between the climate model data and individual months, although these bias corrections change in sign and magnitude from month to month with several months requiring no bias correction at all. The level of agreement between the observations and the climate models is best when viewed on seasonal and annual time scales as the effects of natural climate variability on time scales as short as a month can provide misleading trends, even when twenty five years of records are used.

2.2.2 Future Climate Precipitation Predictions

Next the future climate rainfall predictions out to the year 2060 are analyzed. Once again the data from the six ensemble models and the ensemble mean were used. The time series of modelled monthly rainfalls from 1970 through to 2060 are shown in Figures D15a (model closest to the ensemble mean) and D15b (ensemble mean, wettest and driest of the climate models) through to D27 for Diavik. Both sets of graphs have linear and polynomial trend lines included for the model mean data. The same colour schemes are used for these future climate predictions as were used for the validation period. No bias corrections have been applied to these datasets to adjust them to match the observed data precisely as some of the values to use for the bias corrections are subject to interpretation and also it is the trends that are important.

The data shows strong evidence of inter-annual and decadal variability with the sixth order polynomial trend line highlighting the multi-decadal oscillations in the rainfall climate. The wavelet analysis discussions for Diavik should also be consulted when looking at trends in the climate oscillations. Overall, despite the presence of these oscillations, the linear trend line appears to represent the long-term changes in the monthly total precipitation well, even though the linear trend lines have been shown to be misleading even over periods of close to 40 years duration in some circumstances. The climate model predictions for all twelve months are shown in the Attachments and spreadsheets. For brevity, the discussions that follow will again focus on the middle month of each season, with references to the other months where these illustrate a point of particular interest.

January

The climate model predictions for Diavik show a continuation of a highly variable, though relatively low, rainfall regime for the winter months with an identifiable multi-decadal signal, illustrated by the polynomial trend line. This oscillation continues through to the end of the future climate prediction period and is super-imposed upon the linear trend. The linear trend line from the ensemble mean model shows an increasing trend although the polynomial trend line shows a plateauing of the precipitation from around 2020 onwards with a very minor decline towards the end of the prediction. The ensemble minimum rainfall predictions show a slight upwards trend as well with the largest change indicated by the wettest of the model members with more frequent heavier falls predicted. The driest year of all is a predicted fall of near 5mm in climate model year 1970 and it is not until model year 2026 when this low precipitation prediction is approached with a fall of 5.5mm forecast.

Using the linear trend line as the reference for the long-term trend in precipitation, it can be seen that the mean monthly precipitation is predicted to be around 17 mm in the year 1970, increasing to around 21 mm by the year 2060. This represents a rise of 4 mm per January by the year 2060, which equates to an increase in the mean precipitation by the year 2060 of close to 24%, compared to that of the years near 1970. In average terms this is a very slow increase of around 0.04mm for each successive January. The climate models show an increase in the quantity of the heaviest precipitation events through the future climate period from around 32mm for the validation period out to 2007 up to 41mm for the future climate period. There is also a predicted increase in their frequency. For example, looking at the events where 30mm or more precipitation is predicted by the wettest of the climate models, only three events are indicated for the first 30 years of the predictions, nine events are predicted for the next 30 years and ten events of 30mm or more are predicted from 2030 onwards. The differences in their magnitudes are considered to be modest in modelling terms but with some confidence in the increasing trend. This indicates the future climate regime will support heavier snowfalls than does the current climate regime for January, with an increasing frequency of these heavier snowfalls in the future climate.

For the month of February, the predicted increases in Diavik's mean and extreme precipitation is similar to that for January whereas in March the slight increasing trend continues for the mean precipitation but the changes in the extreme snowfalls are less compelling.

April

April is still in a precipitation regime dominated by snowfall but one where rainfall starts to become more important for the Diavik region. With the predicted warming of the temperatures through the future climate period rainfall can be expected to increase in frequency and intensity as time progresses. The driest of the climate model members indicates little change in the lowest of the precipitation events with predictions in the future equal to, even slightly less than, those for the validation period. The linear trend line for the ensemble mean model predictions shows a gradual increase from around 19.5 mm in the year 1970 to around 22.5 mm by the year 2060. This represents a rise of 3 mm per April by the year 2060, which, due to the low precipitation quantities involved, equates to an increase in the mean precipitation by the year 2060 of close to 15%, compared to that of the years near 1970. The wettest of the ensemble model members does predict a heavier precipitation event in the future (44mm) than those for the model validation period (37mm) with a slight increase in the frequency of these more extreme events.

These trends appear to accelerate for May, the first month there liquid precipitation dominates at Diavik with the climate models predicting a future climate of gradually increasing mean and extreme precipitation totals. The mean precipitation is predicted to rise from near 26mm in 1970 up to around 34mm in 2060, an increase of 8mm or 31% over the length of the climate prediction. The extreme monthly rainfall is predicted to climb from around 57mm through the validation period to around 65mm in the future climate environment with a corresponding increase in frequency.

For June the long term mean is not predicted to change significantly through the future climate period although the wettest months are forecast to increase from around 65mm up to 83mm into the future.

July

The future climate model predictions for July for Diavik reverse the trends of the earlier months with a gradual decline in mean precipitation forecast. The climate model predictions are for a decrease in rainfall from an average of near 38mm in 1970 to near 35mm by 2060. This 3mm decrease in rainfall amounts to an 8% decline in precipitation over 90 years, an annual rate of decrease of a very small 0.03mm/year. The climate model predictions indicate a decreasing frequency of extreme heavy rainfall events, although the two heaviest July rainfall predictions lie in the future climate period, indicating new extremes of heavy rainfall are possible in the future climate period. The wettest of the climate models predicts a fall of near 95mm in the future climate period near model year 2052 compared to 84mm in the validation period. Although not a major trend, the driest of the climate model predictions tend to indicate dry months slightly drier than those of the historical past are likely in the future climate regime.

This reduction in future rainfall appears to be confined to the month of July as in August the ensemble mean model predictions return to one of increasing mean and heavier rainfalls.

October

October is one of the transition months back into a regime where snowfall becomes increasingly important. At Diavik the driest of the climate models predicts a gradual increase in the lowest rainfalls, indicating extremely dry Octobers are likely to become less frequent than those experienced in the past. The linear trend is for a gradual increase in total precipitation with the average rising from near 30mm in 1970 to around 40mm by the year 2060. This 10mm increase amounts to a significant 33% change in mean monthly precipitation over 90 years, or an annual rise of 0.11mm/year. The wettest of the climate models predicts an increase in the frequency of the wettest Octobers in the future although the quantity of precipitation is not shown to rise. The change in driest Octobers is predicted to be slight through the future climate period.

In November a similar increasing trend is predicted with the extreme wet years also forecast to increase in both frequency and intensity.

December is predicted to have one of the greatest change with the ensemble mean precipitation forecast to rise from around 18mm in 1970 up to 25.5mm by the year 2060, an increase of 7.5mm, which equates to a very large, in percentage terms, rise of near 42% for the month. The wettest December is also predicted to jump from around 45mm through the validation period up to around 65mm in the future climate.

Annual Precipitation

The Diavik annual precipitation trends from the ensemble mean of the climate models is shown in Figure D27. The ensemble mean model prediction is for an increase in precipitation from around 310mm in the year 1970 up to around 360mm by the year 2060, an increase in annual precipitation of around 50mm, or approximately 16%. There is a marked multi-decadal oscillation in the future climate predictions, indicating this change will not be a steady increase but rather one interrupted by large excursions from the mean. There is a marked leveling off of the precipitation increases indicated through the future climate period beyond around model year 2025. The predictions indicate there will be fewer dry years in the future and a trend towards gradually increasing extremely wet years, by Diavik standards, although this region will still only have relatively modest precipitation through the future climate period in comparison to warmer regions of the world. The wettest years tend to occur as lone events, as are the predicted driest years.

2.2.3 Precipitation Periodicities

A separate appendix has been prepared that summarizes the periodicities in the precipitation climate record for Diavik. This should be referred to in order to identify climate model predicted changes to the variability of this record.

3.0 Conclusions

An ensemble of six future Coupled Global Climate Model runs were analyzed and the mean used for determining likely future trends in the climate for the northern Canadian region, specifically Diavik and the ice road connecting it to the Great Slave Lake. The results of these analyses are detailed in the body of this report and its' attachments. The Executive Summary contains a summary of the more important findings of these analyses.

Appendix X-9

Diavik Underground Backfill

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October 8, 2010

Re: Diavik Underground Backfill

Diavik Diamond Mines Inc. (DDMI) would like to advise you of our immediate plans for underground backfilling. As you are aware different underground mining methods and different kimberlite pipes have different geotechnical requirements for backfilling mine openings in the kimberlite ore. The specific composition of each type of backfill will be determined based on the specific geotechnical requirements. A large component of backfill is mine wasterock.

For the next 12-18 months DDMI is planning to use the wasterock, from underground development work, to prepare a cemented rock fill (CRF). DDMI has identified possible concerns with cement curing when mixed with low temperature wasterock. To eliminate the need to warm the wasterock from the open-pit or wasterock pile, and the associated energy consumption, use of wasterock from underground that is already above 0^{o}C has been proposed. To meet the tonnage requirements both Type I and Type III underground wasterock will be required.

DDMI has previously evaluated the geochemical implications of using Type III wasterock in underground backfill. These evaluations were conducted because over the long term it is preferable geochemically to encapsulate Type III material in cement and place it underground as compared with having it exposed on the surface. However, DDMI also wanted to ensure there would not be any significant impacts on operational water quality.

The evaluation consisted of two phases; a) geochemical testing, and b) water quality modeling.

Geochemical Testing

Wasterock samples were taken from the Type I and Type III dump areas, crushed to < 2" diameter and mixed with 5% cement. After 28 days of curing the samples were sent to CEMI in Vancouver B.C for the following analysis:

- Acid-Base Accounting (ABA)

- Whole rock and Bulk metal Analysis on Solids
- Short Term Leach Testing
- Mineralogical Analysis

The short term leach testing results were used in the water quality modeling.

Water Quality Modeling

A mass-balance geochemical model was used to estimate the mine water quality once the seepage water from underground workings and the water from the open pit sumps have been mixed to produce a final mine water. The model consists of a number of source components (i.e. underground seepage, open-pit sumps, etc.) that are linked together to define a mass transport system. Each source component was assigned a flow (based on flow modeling) and water chemistries that together define the load contribution from each component.

The following Tables provide the model inputs used to define each source component. These inputs remained constant in all model scenarios.

Table 2 – Flow rates assumed for open-pits, ramps, vents and drainage drifts and the water origin (groundwater versus lake water).
Table 3C – Groundwater quality assumed for groundwater inflows.
Table 3D – Lake water quality assumed for lake water inflows.
Table 4 – Pit sump water quality assumed for open-pit sump inputs

Numerous scenarios were run using the inputs as defined above but varying the quality of the leach water from the backfill material. Table 1 lists all the backfill scenarios that were modeled. Several different types of backfill were modeled using both a high seepage rate from the backfill and a low seepage rate. Of relevance here are Scenarios 2, 9, and 18. Scenarios 9 and 18 use the leaching rates from the geochemical testing of the cemented rock fills (CRF) made with material from the Type I and Type III stockpiles respectively (see above) and the higher seepage rates (worst-case).

As it turns out, results of the out whole rock testing of the samples collected from the Type I and Type III stockpiles both had sulphur contents of 0.06%S meaning they are both actually representative of Type II rock using DDMI's classification. However, they are ideal for the purpose of evaluating implications of the plan to use a mixture of Type I and Type III wasterock from underground as 0.06%S would likely be a reasonable estimate of the bulk sulphur content for the underground waste material.

Scenario 2 is a worst-case geochemical scenario. It assumes a backfill leach quality estimated from the baseline long-term kinetic tests run on biotite schist with a sulphur content of 0.16%S. It is included to both illustrate a worst-case condition but also the relative insensitivity of the final water quality to the backfill leach quality. Table 5 lists the actual backfill leach water quality used to represent each of the backfill material types.

Table 6 shows the predicted mine water quality for each of the backfill options modeled. Despite differences in backfill leach water quality, the final mine water quality is unchanged because the final chemistry is dominated by the groundwater reporting to the drainage galleries.

Conclusion

There are environmental benefits to including Type III wasterock from underground to prepare backfill material for underground. This includes both the reduction in potential for poor quality surface runoff from surface exposure of Type III rock and elimination of short-term energy required to warm rock for use in underground. No impact on operational mine water quality has been predicted.

Please let me know if you require any further information.

Regards,

Gord Macdonald

Attachments:

- Table 1 – Description of Backfill Scenarios Modeled
- Table 2 – Flow rates assumed for open-pits, ramps, vents and drainage drifts.
- Table 3C – Groundwater quality assumed for groundwater inflows.
- Table 3D – Lake water quality assumed for lake water inflows.
- Table 4 – Pit sump water quality assumed for open-pit sump inputs
- Table 5 – Backfill leach water quality assumed for modeling.
- Table 6 – Modeling results for various backfill materials.

TABLE 1
SCENARIOS MODELED: BACKFILL TYPES AND PERCENTAGE OF BACKFILL SEEPAGE
DIAVIK DIAMOND MINE

Backfill Type	Percentage of Water from Backfill [(1)]	Scenario Number
Acid Generating (AG) Rock - Sulphide-rich Biotite Schist	0.1%	Scenario 1
	10%	Scenario 2
Type I Stockpile - Coarse Rock	0.1%	Scenario 3
	10%	Scenario 4
Type I Stockpile - Paste Fill w/ 5% Cement	0.1%	Scenario 5
	10%	Scenario 6
Type I Stockpile - Paste Fill w/ 5% Intercem	0.1%	Scenario 7
	10%	Scenario 8
Type I Stockpile - Rock Fill	0.1%	Scenario 9
	10%	Scenario 10
Type III Stockpile - Coarse Rock	0.1%	Scenario 11
	10%	Scenario 12
Type III Stockpile - Paste Fill w/ 5% Cement	0.1%	Scenario 13
	10%	Scenario 14
Type III Stockpile - Paste Fill w/ 5% Intercem	0.1%	Scenario 15
	10%	Scenario 16
Type III Stockpile - Rock Fill	0.1%	Scenario 17
	10%	Scenario 18 (2)

Notes:

(1) Percentage of water from backfill:

(i) 0.1% Low flow − assumes that consolidation of backfill seepage will result in release of 0.1% of the total flow reporting to the drainage galleries.

(ii) 10% High flow − assumes that consolidation of backfill seepage will result in release of 10% of the total flow reporting to the drainage galleries.

(2) Scenario 18 was also simulated with the effect of upwelling of saline groundwater to the drainage galleries.

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TABLE 2
FLOW RATE SCHEDULE FOR OPEN PITS, RAMPS, VENTS AND DRAINAGE DRIFTS
DIAVIK DIAMOND MINE

Flow Source	Annual Average Flow Rates (m^3/d)														
	2008	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
A154 Pit	16000	1600	1200	1100	1100	1100	1000	1000	1000	1000	900	900	1000	900	900
A418 Pit	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Ramps	1500	1600	1500	1400	1400	1800	2300	2200	2600	2500	2400	2400	2400	2500	2500
Vents	1800	1700	1300	1200	1100	1000	900	700	600	500	500	500	600	500	500
A154N Drifts															
9225 m	500	1700	1000	800	700	700	700	700	700	600	600	600	700	700	700
9150 m	900	15900	15200	11600	11500	11500	11400	11300	11300	11200	11200	11200	11300	11300	11300
9075 m	300	400	1000	8900	9000	9000	8900	8900	8800	8800	8800	8800	8900	8900	8900
9000 m	0	900	1000	700	700	700	700	600	600	600	600	600	600	600	600
8925 m	0	0	0	5900	5400	5100	3900	1700	1600	1400	1300	1400	2400	2900	2800
8850 m	0	0	0	0	0	0	1200	1900	1800	800	1000	1100	1500	1600	1600
8775 m	0	0	0	0	0	0	0	500	600	900	900	1200	2100	2100	2200
8700 m	0	0	0	0	0	0	0	1300	1200	1300	1300	2700	1100	1200	1200
8685 m	0	0	0	0	0	0	0	0	0	4300	4000	0	0	0	0
A154S Drifts															
9075 m	100	600	400	400	400	300	300	200	200	200	200	200	0	0	0
9000 m	100	9000	7800	700	600	600	400	300	200	300	300	300	0	0	0
8925 m	0	0	0	300	500	500	400	400	300	300	600	900	0	0	0
8850 m	0	0	0	0	0	100	900	1100	1000	1300	300	300	0	0	0
8835 m	0	0	0	0	0	0	0	2000	1800	0	0	0	0	0	0
A418 Drifts															
9165 m	1200	1200	800	700	700	700	600	600	600	500	500	500	500	500	500
9105 m	1800	1800	1500	1500	1500	1500	1300	1200	1200	1200	1200	1200	1200	1200	1200
9045 m	2700	2700	2300	2200	2200	2000	700	700	700	700	700	600	600	600	600
8980 m	0	0	0	0	0	0	1700	1200	500	500	500	500	500	500	500
8915 m	0	0	0	0	0	0	300	300	1000	900	900	900	900	900	900
8850 m	0	0	0	0	0	0	0	600	700	400	400	400	400	300	300
8785 m	0	0	0	0	0	0	0	0	700	700	700	600	300	300	300
8760 m	0	0	0	0	0	0	0	0	100	100	100	0	900	800	800
Underground Sources															
Total Flow	10900	37500	33800	36300	35700	35500	36600	38400	38800	40000	39000	36900	36900	37400	37400
% Lake Water	73	75	86	88	90	91	90	86	88	84	89	92	93	93	94
All Sources															
Total Flow	**27900**	**40100**	**36000**	**38400**	**37800**	**37600**	**38600**	**40400**	**40800**	**42000**	**40900**	**38800**	**38900**	**39300**	**39300**
% Underground	**39**	**94**	**94**	**95**	**94**	**94**	**95**	**95**	**95**	**95**	**95**	**95**	**95**	**95**	**95**

Note:

− Flow rates are derived from the July 2007 hydrogeologic numerical model.

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TABLE 3C
SUMMARY OF MODEL INPUT WATER QUALITY: GROUNDWATER
DIAVIK DIAMOND MINE

Parameter	Units	Groundwater Quality (1)
Total Dissolved Solids (TDS)(2)	**mg/L**	**500–2800**
Total Dissolved Solids (TDS)(3)	**mg/L**	**271–2313**
Aluminum (Al)	mg/L	0.03
Ammonia (NH_4+NH_3)	mg/L as N	0.06
Arsenic (As)	mg/L	0.005
Chromium (Cr)	mg/L	*0.005*
Cobalt (Co)	mg/L	*0.0002*
Copper (Cu)	mg/L	*0.0008*
Iron (Fe)	mg/L	0.2
Lead (Pb)	mg/L	*0.00008*
Manganese (Mn)	mg/L	0.09
Molybdenum (Mo)	mg/L	0.009
Nickel (Ni)	mg/L	0.002
Nitrate (NO_3)	mg/L as N	0.01
Nitrite (NO_2)	mg/L as N	*0.002*
Phosphorus (P)(4)	mg/L	0.00005–0.2
Sulphate (SO_4)	mg/L	5
Uranium (U)	mg/L	0.0002
Vanadium (V)	mg/L	0.0008
Zinc (Zn)	mg/L	0.007

Notes:

0.0025 – denotes a value that is one half of the detection limit. Concentrations below detection were input into the model as one half of the detection limit.

(1) Groundwater Quality – taken from monitoring data collected from a depth of about 150 mbsl during a pumping test in 2006.

(2) Total Dissolved Solids – determined from the numerical hydrogeological model and considers the effect of upwelling of saline groundwater (Table 3B).

(3) Total Dissolved Solids – determined from the relationship between TDS and depth at Diavik and Lupin Mine sites (Table 3A; Figure 1).

(4) Phosphorous – determined from the relationship between P and depth (Table 3A; Figure 2).

TABLE 3D
SUMMARY OF MODEL INPUT WATER QUALITY: LAKE WATER DIAVIK DIAMOND MINE

Parameter	Units	Lake Water Quality (1)
Total Dissolved Solids (TDS)	**mg/L**	**30**
Aluminum (Al)	mg/L	0.02
Ammonia (NH_4+NH_3)	mg/L as N	0.05
Arsenic (As)	mg/L	0.0003
Chromium (Cr)	mg/L	0.0001
Cobalt (Co)	mg/L	0.0003
Copper (Cu)	mg/L	0.001
Iron (Fe)	mg/L	0.01
Lead (Pb)	mg/L	0.0004
Manganese (Mn)	mg/L	0.004
Molybdenum (Mo)	mg/L	0.001
Nickel (Ni)	mg/L	0.002
Nitrate (NO_3)	mg/L as N	0.03
Nitrite (NO_2)	mg/L as N	0.01
Phosphorus (P)	mg/L	0.6 (2)
Sulphate (SO_4)	mg/L	1
Uranium (U)	mg/L	0.0004
Vanadium (V)	mg/L	0.0004
Zinc (Zn)	mg/L	0.005

Notes:

(1) Lake Water Quality − taken from Table 6-16 in DDMI (1998).

(2) Concentration of phosphorous assumed to be 0.6 mg/L. This assumption is based on observations of concentrations of phosphorous from previous pumping test data.

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TABLE 4
SUMMARY OF MODEL INPUT WATER QUALITY: OPEN PIT SUMPS
DIAVIK DIAMOND MINE

Parameter	Units	Water Quality Monitoring Data						Average Open Pit Sump Water Quality (1)
		SUMP 1 2003	SUMP 1 2004	SUMP 1 2005	NEW SUMP 1 8/26/2006	NEW SUMP 2 8/28/2006	NEW SUMP 2B 8/28/2006	
Total Dissolved Solids (TDS)	**mg/L**	**360**	**360**	**270**	**–**	**–**	**–**	**330**
Aluminum (Al)	mg/L	7	7	0.3	0.6	1	1	3
Ammonia (NH_4+NH_3)	mg/L as N	–	–	3	5	9	9	7
Arsenic (As)	mg/L	0.003	0.003	0.003	0.003	0.004	0.004	0.003
Chromium (Cr)	mg/L	0.02	0.02	0.003	0.01	0.03	0.03	0.02
Cobalt (Co)	mg/L	0.005	0.005	0.001	0.003	0.007	0.007	0.005
Copper (Cu)	mg/L	0.04	0.04	0.003	0.007	0.009	0.009	0.02
Iron (Fe)	mg/L	7	7	0.5	1	3	3	4
Lead (Pb)	mg/L	0.003	0.003	0.0005	0.004	0.001	0.001	0.002
Manganese (Mn)	mg/L	0.4	0.4	0.1	0.04	0.1	0.1	0.2
Molybdenum (Mo)	mg/L	0.03	0.03	0.02	0.05	0.03	0.04	0.03
Nickel (Ni)	mg/L	0.03	0.03	0.02	0.06	0.1	0.1	0.07
Nitrate (NO_3)	mg/L as N	9	9	5	12	16	17	11
Nitrite (NO_2)	mg/L as N	0.2	0.2	0.1	0.8	1.0	0.9	0.5
Phosphorus (P)	mg/L	–	–	0.4	0.3	0.2	0.2	0.3
Sulphate (SO_4)	mg/L	8	8	6	22	19	19	14
Uranium (U)	mg/L	0.03	0.03	0.01	0.005	0.007	0.007	0.02
Vanadium (V)	mg/L	0.02	0.02	0.003	0.003	0.005	0.006	0.008
Zinc (Zn)	mg/L	0.02	0.02	0.02	0.02	0.006	0.008	0.02

Notes:

0.0025 – denotes a value that is one half of the detection limit. Concentrations below detection were input into the model as one half of the detection limit.

(1) Average Open Pit Sump Water Quality – calculated from monitoring data collected from the open pit sumps from 2003 to 2006. Assumed to represent the water quality of the mixed water from the sumps in A154 and A418 pits.

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TABLE 5
SUMMARY OF MODEL INPUT WATER QUALITY:
BACKFILL LEACH
DIAVIK DIAMOND MINE

Parameter	Units	Acid Generating Rock	Type I Stockpile Samples				Type III Stockpile Samples			
		Sulphide-rich Biotite Schist [(2)]	Coarse Rock	Paste Fill 5% Cement	Paste Fill 5% Intercem	Rock Fill	Coarse Rock	Paste Fill 5% Cement	Paste Fill 5% Intercem	Rock Fill
Total Dissolved Solids (TDS)	**mg/L**	**536**	**96**	**473**	**230**	**1518**	**102**	**348**	**243**	**1665**
Aluminum (Al)	mg/L	19	1	2	0.7	0.6	1	2	1.0	0.4
Ammonia (NH_4+NH_3)	mg/L as N	0.005	–	–	–	–	–	–	–	–
Arsenic (As)	mg/L	*0.0001*	0.0008	0.0003	0.001	*0.00005*	0.0008	0.0004	0.001	*0.00005*
Chromium (Cr)	mg/L	0.007	0.004	0.05	0.01	0.07	0.003	0.01	0.003	0.04
Cobalt (Co)	mg/L	0.4	*0.00001*	0.0008	0.00002	0.001	*0.00001*	0.0002	*0.00001*	0.001
Copper (Cu)	mg/L	2	0.0006	0.005	0.001	0.007	0.0003	0.003	0.0004	0.007
Iron (Fe)	mg/L	*3*	0.006	0.01	*0.0025*	*0.0025*	*0.0025*	0.01	*0.0025*	*0.0025*
Lead (Pb)	mg/L	0.02	*0.00001*	0.0003	0.0002	0.0002	*0.00001*	0.002	*0.00001*	0.0003
Manganese (Mn)	mg/L	0.6	0.00008	0.00005	0.0002	0.00004	0.00003	0.0001	0.00003	0.00007
Molybdenum (Mo)	mg/L	0.010	0.001	0.007	0.006	0.009	0.01	0.02	0.02	0.02
Nickel (Ni)	mg/L	2	*0.00025*	0.004	0.0008	0.006	*0.00025*	0.003	*0.00025*	0.008
Nitrate (NO_3)	mg/L as N	0.005	–	–	–	–	–	–	–	–
Nitrite (NO_2)	mg/L as N	0.01	–	–	–	–	–	–	–	–
Phosphorus (P)	mg/L	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*	*0.05*
Sulphate (SO_4)	mg/L	451	17	69	83	208	21	90	97	6
Uranium (U)	mg/L	*0.02*	0.0002	*0.000005*	*0.000005*	*0.000005*	0.00007	*0.000005*	*0.000005*	*0.000005*
Vanadium (V)	mg/L	0.003	0.009	0.003	0.004	0.001	0.009	0.01	0.007	0.0006
Zinc (Zn)	mg/L	2	*0.00025*	*0.00025*	*0.00025*	*0.00025*	*0.00025*	*0.00025*	*0.00025*	*0.00025*

Notes:

0.0025 − denotes a value that is one half of the detection limit. Concentrations below detection were input into the model as one half of the detection limit.

(1) Backfill Leachate Water Quality− SPLP leach testing results conducted on samples of Type I and Type III coarse rock, rock fill and paste fill. The leach testing results are described in detail in Golder (2007).

(2) Biotite Schist − represents the acid generating rock material with relatively high concentrations of metals. These concentrations are an average of the last five weeks of kinetic testing of sample VR17699A as reported in the geochemistry baseline study by Sala/Geochimica (1998).

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TABLE 6
SIMULATION RESULTS:
AVERAGE CONCENTRATIONS OVER LOM
DIAVIK DIAMOND MINE

Parameter	Units	Simulated Concentrations for Mine Discharge Water (Underground Sump Water + Open Pit Sump Water)																		DDMI Water License Criteria (1)
		Simulation Scenarios																		
		Acid Generating Rock		Type I - Stockpile Samples								Type III - Stockpile Samples								
		Sulphide-rich Biotite Schist		Coarse Rock		Paste Fill w/ 5% Cement		Paste Fill w/ 5% Intercem		Rock Fill		Coarse Rock		Paste Fill w/ 5% Cement		Paste Fill w/ 5% Intercem		Rock Fill		
		0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	0.1%	10%	
Total Dissolved Solids (TDS)	**mg/L**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**175**	**174**	**174**	**174**	**174**	**174**	**174**	**174**	**175**	**–**
Aluminum (Al)	mg/L	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	1.5
Ammonia (NH_4+NH_3)	mg/L	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3	10
Arsenic (As)	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	0.001	0.001	0.001	0.001	0.05
Chromium (Cr)	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.02
Cobalt (Co)	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	0.001	0.001	0.001	0.001	–
Copper (Cu)	mg/L	0.003	0.005	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.02
Iron (Fe)	mg/L	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	–
Lead (Pb)	mg/L	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.01
Manganese (Mn)	mg/L	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.03	–
Molybdenum (Mo)	mg/L	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	0.004	–
Nickel (Ni)	mg/L	0.008	0.009	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.05
Nitrate (NO_3)	mg/L	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6	–
Nitrite (NO_2)	mg/L	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	1
Phosphorous (P)	mg/L	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	0.52	– (2)
Sulphate (SO_4)	mg/L	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	–
Uranium (U)	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	–
Vanadium (V)	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	0.001	0.001	0.001	0.001	–
Zinc (Zn)	mg/L	0.006	0.009	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.006	0.01

Notes:

− All 18 scenarios are presented, including 9 different backfill types that were modeled using two backfill flow rates (0.1% and 10% of the total flow reporting to the drainage galleries).

(1) DDMI Water License Criteria are compliance limits outlined in the site water license N7L2-1645.

(2) Water license criteria for total phosphorous is defined as a load, not a concentration, at 1000 kg/year.

Appendix X-10

North Inlet Sediment Investigation

April 1, 2011

NORTH INLET SEDIMENT INVESTIGATION

Diavik Diamond Mine

Submitted to:
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REPORT

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Golder Associates

Executive Summary

Prior to development of the Diavik Diamond Mine, North Inlet was a natural feature of the east island of Lac de Gras. During mine development, a dike was constructed across the mouth of North Inlet to isolate it from Lac de Gras. North Inlet currently operates as: (i) a final settling basin for mine water, prior to treatment by the North Inlet Water Treatment Plan (NIWTP) and release to Lac de Gras; and, (ii) a repository for sludge from the NIWTP, which is currently discharged near the head of North Inlet.

Diavik Diamond Mines Inc. (DDMI) is considering the ongoing closure of North Inlet (*i.e.,* continued physical separation from Lac de Gras), and actions that might be taken at mine closure. In June 2010, Golder Associates Ltd. (Golder) was requested by DDMI to conduct an investigation of sediment quality in North Inlet. The objective of this investigation was to answer the following two questions:

1) At mine closure, could North Inlet be opened up and allowed to naturally return to fish habitat?
2) If not, what management/remediation activities would be required to make this possible?

The study design involved sampling five stations within North Inlet and three reference stations in Lac de Gras. Surface sediments from each station were assessed for sediment chemistry, toxicity and benthic invertebrate community structure; sub-surface sediments from the North Inlet stations were assessed for sediment chemistry. NIWTP sludge was also assessed for sediment chemistry and toxicity. Sediment toxicity tests were performed on whole-sediment and sludge samples using a shrimp-like species (the amphipod *Hyalella azteca*) that lives on the sediment surface, and midge larvae (the chironomid *Chironomus tentans*) that live in the sediment during larval development before emerging as adult insects. The benthic invertebrate community was assessed by examining the number and type of invertebrates in sediment grab samples from North Inlet and Lac de Gras.

Assessment and measurement endpoints were developed as shown below. Assessment endpoints are defined as the environmental values that are to be protected. Measurement endpoints are the measureable ecological characteristics related to the assessment endpoint.

- Assessment Endpoint - Maintenance of the health and ecological integrity of the benthic invertebrate community, productivity in Lac de Gras, and fish populations.
- Measurement Endpoints - Lethal and sublethal effects of sediments and sludge on representative benthic invertebrates in laboratory toxicity tests, measuring *in situ* changes in benthic community structure, and comparing sludge, sediment and water chemistry data to applicable CCME (or other jurisdiction) guidelines for protection of aquatic life.

Results of this assessment indicate that the NIWTP sludge, four of the five North Inlet samples, and all three reference sediment samples contained elevated concentrations of some parameters that were identified as being potentially toxic to aquatic biota based on screening of data against representative, conservative environmental quality guidelines for sediment and water. However, elevated concentrations present in reference

sediments were not associated with adverse biological effects, and therefore corresponding elevated concentrations could not always be clearly associated with the adverse biological effects that were observed for the sludge and North Inlet sediments.

Results of the sediment toxicity tests and benthic taxonomy analyses showed that NIWTP sludge was toxic in standard sediment toxicity tests, and that sediments from four of the North Inlet stations (NI-1 to NI-4) were also classified as toxic and had impoverished benthic invertebrate communities. In contrast, the North Inlet station located closest to the mouth of the inlet (NI-5) was generally not classified as toxic relative to the reference stations (it was only classified as potentially toxic with respect to chironomid dry weight when compared to the pooled mean reference station response), and had a benthic invertebrate community composition that was more similar to the reference stations in terms of total density and biomass (but not taxa richness) than to the other North Inlet stations. The physical characteristics of the NI-1 to NI-4 sediments were also different from NI-5, the former having varying amounts of a viscous unconsolidated algal material on the sediment surface.

Toxicity of the NIWTP sludge sample was likely (at least in part) due to the elevated total sulphide concentration in interstitial water, which was higher than the acute LC50s reported for several freshwater invertebrate species. However the sludge sample used for this study was collected from the NIWTP clarifier tank, and it is therefore possible that the elevated sulphide concentration is an artefact of sludge storage conditions and not representative of sulphide concentrations in the sludge slurry that is discharged to North Inlet. In addition, elevated TOC and total phosphorus concentrations may also have contributed to the sludge toxicity.

The NI-5 sediments had concentrations of several parameters that were above the lower-bound sediment quality guidelines (SQGs), but none that were above the upper-bound SQGs used in this assessment. In contrast, the other four North Inlet sediments had concentrations of at least one parameter that were above the upper-bound SQGs. This indicates that metals cannot be definitively excluded from consideration as stressors of potential concern.

Nutrient enrichment (elevated total phosphorus) may have contributed to the observed adverse biological effects at NI-1. However, given the low percentage of available phosphorus, and the fact that the thickest observed layer of unconsolidated material was found at this station, the substrate condition (and associated micro-habitat) appears to be a strong candidate for explaining the observed responses. Concentrations of arsenic, chromium, and nickel were elevated at this station. However, the strong responses observed for both toxicity and benthic community structure suggest a causal factor that is pronounced in influence, in contrast to the weak to moderate evidence for metal-mediated responses.

Organic or nutrient enrichment (total organic carbon [TOC] or total phosphorus) were less likely to be contributing to the observed biological effects at NI-2, NI-3 and NI-4. Nickel concentrations were above an upper-bound SQG at all three stations, and chromium concentrations were above upper-bound SQGs at two stations and could have contributed to the observed biological effects.

Although the three reference stations generally had better performance in the sediment toxicity tests and healthier benthic invertebrate communities than at least four of the North Inlet stations, concentrations of arsenic, beryllium, iron and manganese were above their respective upper-bound SQGs and were higher than concentrations reported for most North Inlet sediment samples. These comparisons indicated that arsenic, beryllium, iron, and manganese were unlikely to explain the observed pattern of responses, reducing the number of candidate contaminants of potential concern (COPCs). Accordingly, the list of primary COPCs was refined to

TOC, chromium, nickel, and total phosphorus (*i.e.,* by removing background contaminants from the preliminary list identified through screening to SQGs). Sulphide was not included as a COPC as its association with sludge toxicity may have been an artefact of sludge storage conditions.

In conclusion, the adverse biological effects (sediment toxicity and/or benthic invertebrate impoverishment) observed for the NIWTP sludge and sediments from four North Inlet stations were not attributable to a single stressor. In addition to the sulphide toxicity associated with the sludge sample, it appears that a combination of organic or nutrient enrichment contributed to adverse biological effects at some stations whereas metals may have been a contributing factor at other stations. The lack of suitable benthic habitat in areas where the layer of unconsolidated material on the sediment surface was relatively thick was also a factor. Near the mouth of North Inlet, sediment quality was similar to that observed at reference stations in Lac de Gras. Despite the adverse biological effects associated with some North Inlet sediments, there was evidence of a resident zooplankton community in the water column within North Inlet.

Although effects were observed within North Inlet, it is unlikely that opening North Inlet to Lac de Gras would adversely affect the water quality of Lac de Gras. However, with respect to whether North Inlet could be opened up at mine closure and allowed to return naturally to fish habitat, the results obtained from the 2010 study were insufficient to adequately address that question, and follow-up studies and testing will be necessary to reduce uncertainty about the suitability of North Inlet as fish habitat. It would be premature to begin to consider what management or remediation activities might be required until that question has been answered.

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APPENDICES

1.0 INTRODUCTION

Prior to development of the Diavik Diamond Mine, North Inlet was a natural feature of the east island of Lac de Gras. During mine development, a dike was constructed across the mouth of North Inlet to isolate it from Lac de Gras. North Inlet currently operates as: (i) a final settling basin for mine water, prior to treatment by the North Inlet Water Treatment Plan (NIWTP) and release to Lac de Gras; and, (ii) a repository for sludge from the NIWTP, which is currently discharged near the head of North Inlet.

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1) At mine closure, could North Inlet be opened up and allowed to naturally return to fish habitat?

2) If not, what management/remediation activities would be required to make this possible?

Available information regarding North Inlet sediment quality and exposure pathways was reviewed and compiled, and a conceptual site model, and a sampling and analysis plan were developed to address the above questions (Golder 2010). The study design involved sampling a series of five stations located within North Inlet, as well as three reference stations in Lac de Gras. Surficial sediments from each station were assessed for sediment chemistry, toxicity and benthic invertebrate community structure; sub-surface sediments from North Inlet were also assessed for sediment chemistry. NIWTP sludge was also assessed for sediment chemistry and toxicity. Sediment toxicity tests were performed on whole-sediment and sludge samples using a shrimp-like species (the amphipod *Hyalella azteca*) that lives on the sediment surface, and midge larvae (the chironomid *Chironomus tentans*) that live in the sediment during larval development before emerging as adult insects. The benthic invertebrate community was assessed by examining the number and type of invertebrates present in grab samples of surficial sediments from North Inlet and Lac de Gras.

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- Assessment Endpoint - Maintenance of the health and ecological integrity of the benthic invertebrate community, productivity in Lac de Gras, and fish populations.
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2.0 METHODS

2.1 Sample Collection

Field sampling was conducted in early September 2010, and station locations are shown in Figure 1. Sediment grab samples (*i.e.,* surface sediments) were collected from five exposure stations in North Inlet (NI-1, NI-2, NI-3, NI-4 and NI-5) and three reference stations (REF-1, REF-2, REF-3) in Lac de Gras, northwest of the Mine Site. Water depths at these locations ranged from 8 to 13 m. Sediment core samples (*i.e.,* subsurface sediments) were collected from the five North Inlet stations, and a sample of whole sludge was collected from the NIWTP. Field datasheets are provided in Appendix A.

The North Inlet stations were spaced more closely together near the point of sludge discharge to North Inlet, to facilitate delineation of sludge-impacted sediments and to attempt to characterize gradient(s) in chemical conditions and biological responses related to the sludge. Further away from the sludge discharge, station spacing was greater because it was expected that sediment conditions would be less variable outside the sludge-impacted zone and that less intensive sampling would therefore be required. Prior to conducting the actual sediment collections, a preliminary reconnaissance survey was performed in North Inlet to determine the extent of sludge deposition and confirm the suitability of the proposed station locations. Individual grab samples were collected at eight locations along the length of the inlet. These reconnaissance grabs were photographed (Appendix A) and assessed in the field for water depth and sediment characteristics, and then discarded.

Lac de Gras reference stations were selected to match water depth, proximity to shoreline, and sediment particle size relative to the stations in North Inlet. Matching of water depth (and sediment characteristics) was essential for making meaningful comparisons of benthic invertebrate community structure, and was the reason that the existing reference stations used for DDMI's annual aquatic environmental monitoring program AEMP; Rio Tinto 2010) were not suitable for this North Inlet sediment assessment. The reference stations for this study were located in the general area of the FF-1 reference stations used for the AEMP; however, for the purposes of this study, samples were collected closer to shore in order to match conditions expected within North Inlet.

After suitable station locations were identified through the reconnaissance survey, samples were collected by DDMI personnel with a Golder representative initially present to provide assistance and guidance as needed. The boat and sampling equipment used for sediment collection were supplied by DDMI.

NIWTP sludge discharge occurs as a slurry near the head of North Inlet, and the sludge was primarily sand. During 2010 field sampling, this discharge had a distinctive green colour and DDMI personnel advised that it typically contained a large amount of algae. Sludge deposition within North Inlet was indicated by the presence on the sediment surface of dark black-green viscous unconsolidated material that contained large amounts of algae. During sediment core sampling, the thickness of this unconsolidated layer varied with increasing distance from the discharge: 23 cm at NI-1 near the head of North Inlet, 5 to 7 cm at NI-2, 3 to 4 cm at NI-3 and NI-4, and 1 cm at NI-5 closest to the dike at the mouth of North Inlet. In contrast, sediments collected at NI-5 and at the three Lac de Gras reference stations were much more consolidated.

Following completion of the field program, sediment and sludge samples intended for chemistry analyses and toxicity testing were shipped to Maxxam Analytics (Burnaby, BC) and HydroQual Laboratories (Calgary, AB), respectively. Preserved benthic invertebrate samples were shipped to Dr. Jack Zloty (Summerland, BC).

2.1.1 Surface Sediment Collection

Grab samples of surface sediment for chemistry, toxicity, and benthic community analyses were collected from each exposure and reference station (total of eight stations) using an Ekman grab sampler (15 x 15 cm; 0.023-m^2 surface area). A minimum of 10 grabs were collected at each station: five for chemistry/toxicity, and five for benthic invertebrate analyses. At each station, these grabs were collected at random positions within a few metres of each other.

Collection procedures were the same for the chemistry/toxicity and benthic grabs, but sample processing was different (see below). Once the boat was confirmed to be on station and the GPS coordinates had been recorded, the grab sampler was deployed. Only those grab samples that met the following acceptability criteria were retained:

- The sampler was fully closed and did not contain large rocks or other debris;
- There was adequate penetration depth (*i.e.,* at least 10 cm);
- The sample was not overfilled or disturbed, and the sampler was not deployed on an angle (sediment surface did not touch the top of the sampler, and was relatively flat); and,
- The sampler was not leaking (there was overlying water present and no visible leaks).

If the grab was classified as acceptable, then sample processing proceeded as described below. Upon acceptance, the overlying water in the grab was removed using a siphon and a description of the sediment with respect to colour, particle size, odour, and presence of non-sediment materials (*e.g.,* shells, debris, biota) was recorded.

Chemistry and Toxicity — At each station, five grab samples were collected to generate one composite sediment sample for chemistry analyses and five field replicate samples for sediment toxicity testing. Pre-cleaned bowls and utensils were used for subsampling and compositing these sediments. The top 5 cm of surface sediment from the first grab was removed and placed in the “replicate” bowl. This material was mixed until the sediment was homogeneous in colour and texture; one 500-mL glass jar was filled with a subsample of this homogenized sediment (Toxicity Tests Rep 1) and the remainder was transferred to the “composite” bowl. The empty “replicate” bowl was rinsed with site water, and then the process was repeated with the remaining four grabs, resulting in five 500-mL jars of sediment (Toxicity Tests Reps 1 to 5) and the “composite” bowl containing the remaining top 5 cm of sediment from the five grabs. The contents of the “composite” bowl were mixed until homogeneous in colour and texture, and then distributed to the sample containers (two 250-mL glass jars, one 500-mL glass jar[1], and one 1-L Ziploc plastic bag) for chemistry analyses. Each sample container was filled completely, sealed immediately, and placed in a cooler with ice packs.

A field duplicate sample was collected at Station NI-1 for chemistry analyses only, using a separate set of freshly collected grab samples. Once the main sampling was completed at that station, five additional grab samples were collected, the top 5 cm of surface sediment was subsampled from each grab and homogenized to generate one composite sample for chemistry analyses, and the sediment was transferred to sample containers (two 250-mL glass jars, and one 1-L Ziploc plastic bag).

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[1] The 500-mL glass jar of sediment from the composite sample was submitted to HydroQual for measurement of total ammonia in interstitial water as part of the sediment toxicity tests (this needed to be measured at each station but not on each field replicate). This jar was labelled “Toxicity Tests Ammonia Composite”.

Benthic Community Structure — At each station, five grab samples were collected for benthic invertebrate community analyses. Each grab was processed separately to generate five replicate samples per station. The contents of each acceptable grab were gently rinsed through a 500-µm mesh sieve with filtered site water. The material remaining on the sieve was transferred into a 1-L plastic container using a minimal volume of filtered site water. Containers were not filled more than two-thirds full with organisms and debris. A 10% solution of buffered formalin was added to the sample to preserve all tissues; the container was sealed and then inverted repeatedly to allow proper mixing of the contents with the formalin solution.

2.1.2 Subsurface Sediment Collection

Sediment core samples were collected at the five North Inlet stations, using a KB gravity feed corer lined with polyacrylic core tubes (7.5-cm diameter; 0.9-m length).

The sediment quality triad (*i.e.,* chemistry, toxicity and benthos) focussed on surface sediment only. Toxicity testing was not conducted on sediment core samples because they were likely to have physical/chemical properties (*i.e.,* anoxia, elevated sulphides) that could confound toxicological results. Therefore, only chemical analyses were conducted, to assess the vertical gradient in chemical contamination at each North Inlet location. Inferences concerning the potential toxic effects of sediments at depth were based on extrapolation from the observed relationship between surface sediment chemistry and toxicity.

Three core samples were collected at each station, to generate the required sample volume for chemical analyses. Each sediment core was inspected before being accepted based on the following acceptability criteria:

- The sediment retention was at least 50% of the penetration depth;
- The sample core appeared to be undisturbed; and,
- The sample was not exposed to any contamination during handling.

Once the core was accepted, sediments from the following discrete depth intervals were subsampled:

- Top (0 – 5 cm);
- Middle (5-cm section from middle of core); and,
- Bottom (5-cm section from bottom of core).

Three sets of pre-cleaned bowls and utensils were used for subsampling and compositing these sediments, one set for each depth interval. At each station, each core sample was extruded from the core tube, measured and photographed. The applicable 5-cm depth intervals were sectioned from each core and transferred to the applicable bowl for compositing. For each depth interval, sediments from the multiple core sections were mixed until sediments were homogeneous in colour and texture, and then distributed to sample containers for chemistry analyses. Sample containers were filled completely, sealed immediately, and placed in a cooler with ice packs.

2.1.3 NIWTP Sludge Collection

DDMI requested that whole sludge from the NIWTP be included for chemistry analyses and sediment toxicity testing in conjunction with this North Inlet sediment investigation, to characterize the sludge and provide a comparison with the findings from the de Rosemond and Liber (2005) study. A 20-L plastic bucket of sludge was collected from the clarifier tank and shipped to HydroQual. This sludge sample was allowed to settle undisturbed for four days (at 4°C in the dark), and then the overlying water (approximately 3 L) was siphoned off and discarded. The remaining 12 L of sludge was homogenized, subsamples were collected and submitted to Maxxam for chemistry analyses, and the remainder was retained by HydroQual for toxicity testing.

2.1.4 Quality Assurance/Quality Control (QA/QC) - Field Program

The generation of quality data begins with sample collection; therefore, the integrity of the sample collection process is of utmost importance to the success of the investigation. To confirm sample integrity, the following were undertaken:

- Samples were collected and processed by qualified experienced personnel;
- Samples were collected in such a way that no foreign material was introduced to the sample and no material of interest escaped from the sample prior to analyses;
- Sample handling or contact with contaminating materials/surfaces was minimized;
- Samples were placed in appropriate clean containers and preserved (where appropriate) so that no material of interest was lost due to adsorption, degradation, or volatilization;
- Sufficient sample volumes were collected so that required detection limits could be met and quality control samples analyzed (including a field duplicate sample for chemistry analyses); and,
- Samples were packaged and shipped to the laboratories by appropriate means, so that holding times and storage conditions for the analyses were met.

2.2 Chemical Analyses

Chemical analyses were performed on samples of sediment and NIWTP sludge, and on water samples generated from the laboratory toxicity tests, as described below. Quality control (QC) measures included with these sample analyses were: a method blank, a laboratory duplicate, a spiked blank, a matrix spike, and/or a QC standard. Details of the analytical methods are available from the laboratory (Maxxam) upon request.

2.2.1 Sediment and Sludge Samples

Surface and subsurface sediment samples (composites prepared from grabs and cores), and the NIWTP sludge sample, were submitted to Maxxam and analysed for the following suite of parameters:

- Moisture content, sediment pH (performed on a 2:1 deionized water extract), particle size, total organic carbon (TOC);

- Acid volatile sulphides (AVS) and simultaneously extractable metals (SEM);
- Total metals[2], and total and available phosphorus; and,
- Reagents (alum and lime).

2.2.2 Water Samples Generated From Sediment Toxicity Tests

HydroQual measured routine water quality parameters (temperature, pH, conductivity, dissolved oxygen, alkalinity and hardness) during the sediment toxicity tests with both test species. Total ammonia and total sulphide were measured in interstitial water at the start of the *H. azteca* toxicity tests, and in overlying water at the start of both toxicity tests. Total ammonia was also measured in overlying water at the end of both toxicity tests.

In addition, HydroQual collected composite samples of overlying water from test containers at the start and end of each sediment toxicity test and submitted these to Maxxam for analyses of dissolved metals (including calcium and magnesium), and dissolved phosphorus.

2.3 Laboratory Toxicity Tests

Sediment toxicity tests were conducted on eight surface sediment samples (five North Inlet stations and three Lac de Gras reference stations) and one NIWTP sludge sample using the freshwater amphipod *H. azteca* and the freshwater midge *C. tentans*.

Quality control (QC) procedures incorporated into the toxicity test methods were: concurrent testing of negative (clean) controls, reference toxicant testing, maintenance of water quality conditions, use of test organisms from known sources, instrument calibration, and use of standard operating procedures.

2.3.1 Sediment Toxicity Tests with *Hyalella azteca*

The 14-d *H. azteca* survival and growth tests were conducted as described in Environment Canada (1997a) using the following experimental design:

- The negative control sediment was clean sand, and the control/dilution water was the standard laboratory water used by HydroQual for *H. azteca* sediment toxicity tests. Laboratory dilution water was used rather than one prepared to mimic Lac de Gras characteristics in order to avoid potential problems with test organism health associated with acclimation to Lac de Gras water.
- Test containers were 375-mL glass jars, each containing 100 mL of sediment (or sludge) and 175 mL of overlying dilution/control water.
- Five replicates were prepared per treatment, and each replicate contained 10 amphipods (2 to 9 days old at test initiation).

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[2] In this document, “metals” refers to metals as well as metalloids (such as arsenic and selenium) and other elements included in the Maxxam ICPMS scan.

- The tests were conducted for 14 days at 23 ± 1°C under a 16:8 h light:dark photoperiod.
- Overlying water was not renewed during the test; gentle aeration (2 to 3 bubbles/sec) was provided throughout the exposure period, and each test container received 3.5 mL of a mixture of fermented trout chow, yeast and alfalfa powder three times per week.
- Temperature and dissolved oxygen (DO) were measured in overlying water daily in the 5th replicate (Replicate E) of each treatment; pH, conductivity, hardness, alkalinity, and total ammonia were measured in overlying water at the start and end of the tests; total sulphide was measured in overlying water at the start of the tests.
- Final counts of survival were made on Day 14, and average individual dry weight was determined for surviving organisms from each replicate. The *H. azteca* test was considered valid if mean control survival was ≥80% and mean control individual dry weight was ≥0.1 mg/amphipod.
- A 96-h water-only reference toxicant test with copper was tested concurrently.
- Composite samples of overlying water were collected at the start and end of the tests for analyses of dissolved metals and dissolved phosphorus.

2.3.2 Sediment Toxicity Tests with *Chironomus tentans*

The 10-d *C. tentans* survival and growth tests were conducted as described in Environment Canada (1997b) using the following experimental design:

- The negative control sediment was clean sand, and the control/dilution water was the standard laboratory water used by HydroQual for *C. tentans* sediment toxicity tests. Laboratory dilution water was used rather than one prepared to mimic Lac de Gras characteristics in order to avoid potential problems with test organism health associated with acclimation to Lac de Gras water.
- Test containers were 375-mL glass jars, each containing 100 mL of sediment (or sludge) and 175 mL of overlying dilution/control water.
- Five replicates were prepared per treatment, and each replicate contained 10 chironomid larvae (third instar at test initiation).
- The tests were conducted for 10 days at 23 ± 1°C under a 16:8 h light:dark photoperiod.
- Overlying water was not renewed during the test; gentle aeration (2 to 3 bubbles/sec) was provided throughout the exposure period, and each test container received 3.75 mL of a ground Nutrafin(TM) fish flake slurry three times per week.
- Temperature and dissolved oxygen (DO) were measured in overlying water daily in the 5th replicate (Replicate E) of each treatment; pH, conductivity, hardness, alkalinity, and total ammonia were measured in overlying water at the start and end of the tests; total sulphide was measured in overlying water at the start of the tests.

- Final counts of survival were made on Day 10, and average individual dry weight was determined for surviving organisms from each replicate. The *C. tentans* test was considered valid if mean control survival was ≥70% and mean control individual dry weight was ≥0.6 mg/chironomid.
- A 96-h water-only reference toxicant test with potassium chloride (KCl) was tested concurrently.
- Composite samples of overlying water were collected at the start and end of the tests for analyses of dissolved metals and dissolved phosphorus.

2.4 Benthic Invertebrate Community

Five replicate grab samples were collected from each sampling station, screened (500-µm mesh) and preserved in the field for benthic community analysis, and then shipped to Dr. Jack Zloty for taxonomic processing and analysis according to standard procedures based on recommendations in Environment Canada (2002) and Gibbons *et al.* (1993). All samples were enumerated in their entirety, and no subsampling was required. Four samples were re-sorted as a QC check; no organisms were recovered during re-sorting, indicating 100% sorting efficiency.

Invertebrates were counted and identified to the lower practical taxonomic level (typically genus or species) using recognized taxonomic keys. The biomass of each replicate sample was estimated as total wet weight of the preserved organisms (including any non-benthic taxa present in the sample) in each grab sample. Invertebrate abundance data (individuals per 0.023/m^2 grab sample) were converted to density data (individuals per m^2) to facilitate comparisons with benthic data from DDMI's AEMP.

3.0 RESULTS

3.1 Chemical Analyses

3.1.1 Surface Sediments and NIWTP Sludge

Results of chemical analyses performed on the sludge and surface sediment grab samples are provided in Table 1. All results are presented on a dry weight basis. Detailed results are provided in the Maxxam laboratory reports in Appendix B.

Consistent with the approach used for DDMI's AEMP, sediment chemistry data were compared to sediment quality guidelines (SQGs) published by the Canadian Council of Ministers of the Environment (CCME 2002) and Ontario Ministry of Environment and Energy (OMOEE 1993). In addition, freshwater sediment quality values developed for Washington State (Avocet Consulting 2003) were used in this comparison. Sediment concentrations exceeding these SQGs are highlighted in Table 1. The OMOEE and Washington State SQGs were included because they encompass more inorganic parameters than the CCME SQGs. These Washington State values represent lowest Apparent Effect Thresholds (LAETs) derived from amphipod, chironomid or Microtox® sediment toxicity data; for this application, only the LAETs derived from amphipod or chironomid test data were used. The CCME Interim Sediment Quality Guideline (ISQG) and OMOEE Lowest Effect Level (LEL) represent lower-bound SQGs, concentrations at which adverse biological effects are rare or not expected to occur in the majority of sediment-dwelling organisms. Conversely, the CCME Probable Effect Level (PEL) and OMOEE Severe Effect Level (SEL) represent concentrations at or above which adverse biological effects often occurred in the toxicity database. The Washington State LAETs represent the highest concentration at which the biological response in the sediment toxicity test was not statistically different from the negative control.

The approach of using SQGs from multiple jurisdictions was intended to provide an indication of the uncertainty associated with these guidelines, and also to evaluate where North Inlet sediments fall along the continuum of available guidelines. As guidelines were developed for the purpose of screening, and not for quantitative evaluation of ecological risk, exceedances of one or more guidelines should not be interpreted as a direct indication of probability or magnitude of harm.

The sludge sample consisted mostly of sand-sized particles and only 24% fines (silt and clay). The North Inlet sediments consisted of 56 to 99% fines, and the reference sediments were 69 to 93% fines. Total organic carbon content (TOC) was highest in the sludge (9.94%), and ranged from 0.44 to 1.67% in the North Inlet sediments (TOC was lowest at NI-5), and from 1.6 to 2.43% in the reference sediments. Such TOC concentrations are typical of freshwater sediments and are considered appropriate for the application of laboratory toxicity tests. Sediment pH values (measured on a 2:1 deionised water extract) were: 7.14 in sludge, 7.50 to 8.34 in the North Inlet sediments, and 5.68 to 6.16 in the reference sediments.

Concentrations of most total metals and other substances were lower in the sludge sample than in the North Inlet and/or reference sediments, with the exception of: aluminum, arsenic, molybdenum, total phosphorus, sodium, strontium, and zirconium. Concentrations of most total metals were lower in reference sediments than in all or most North Inlet sediments, with the exception of: arsenic, beryllium, cobalt, copper, iron, manganese, and vanadium. Among the North Inlet sediments, NI-5 either had the lowest concentrations of most total metals or had concentrations within the range bracketed by the other four stations; bismuth was the only measured parameter that was highest at NI-5.

Samples with an excess of AVS relative to ∑SEM were assumed to have no bioavailability for divalent metal cations (*e.g.*, cadmium, copper, lead, nickel and zinc), which are typically sequestered as insoluble metal-sulphide complexes thus lowering their bioavailability to aquatic biota. The sludge and NI-1 samples had elevated AVS concentrations relative to other stations; these two samples also exhibited an excess of AVS relative to ∑SEM, and therefore divalent metals were not expected to be bioavailable. The other North Inlet and reference station samples exhibited an excess of ∑SEM (primarily due to nickel, zinc and copper); these results do not necessarily indicate toxicity of sediments, but indicate that the extractable metals have potential to cause toxicity based on potential bioavailability.

Although the total phosphorus concentration was higher in the sludge sample than in the North Inlet and reference sediments, available phosphate (orthophosphate) concentrations were orders of magnitude lower than total phosphorus in all samples and were lower in the sludge sample than in the sediment samples. The latter finding is indicative of a reduced potential for the phosphorus to exert nutrient enrichment responses on the resident biota. For the reagents, the sludge sample had the lowest lime concentration, and the calculated alum concentrations were higher in three North Inlet samples than in the sludge sample.

As shown in Table 1, concentrations of 10 parameters were above the lower-bound CCME ISQG and/or OMOEE LEL values in one or more of the sludge or surface sediment samples: TOC, arsenic, cadmium, chromium, copper, iron, lead, manganese, nickel, and total phosphorus. Other contaminants can be confidently excluded from consideration as potential toxicants based on the inherent conservatism in the development of these lower-bound sediment quality values. Concentrations that were above the upper-bound CCME PEL and/or OMOEE SEL values, or the Washington State LAETs derived from amphipod or chironomid toxicity data, are noted below:

- TOC concentration above the LAET and very close to the SEL in the sludge;
- arsenic concentrations above the PEL, SEL and LAET in the sludge, NI-1 and all three reference station samples, with the highest concentration occurring at REF-3;
- beryllium concentrations slightly above the LAET in the three reference station samples;
- chromium concentrations above the PEL, SEL and/or LAET in the NI-1, NI-2 and NI-4 samples;
- iron concentrations above the SEL in the three reference station samples;
- manganese concentrations above the SEL in the three reference station samples;
- nickel concentrations above the SEL and LAET in the NI-1, NI-2, NI-3 and NI-4 samples; and,
- total phosphorus concentrations above the SEL in the sludge and NI-1 samples.

The above analytes were considered as potential toxicants, and the distributions of these substances (over space, and in relation to biological and toxicological endpoints) were evaluated. The magnitude by which these eight analytes exceeded their respective upper-bound SQGs ranged from a factor of less than two to a factor of six.

3.1.2 Subsurface Sediments

Results of chemical analyses performed on the subsurface sediment core samples are provided in Table 2; core samples were only collected from the five North Inlet stations. All results are presented on a dry weight basis. Detailed results are provided in the Maxxam laboratory reports in Appendix B.

Core penetration depths ranged from 33 to 57 cm. Results for the top 5-cm depth intervals from the core samples were generally similar to the results obtained for the surficial sediment grabs, which were composites of the top 5 cm of sediment from multiple grabs, although there were some differences. As with the sludge and surface sediment data summarized above and in Table 1, data from these sediment core samples were also compared to applicable SQGs.

Moisture content in the core sections ranged from 30 to 96%. Percent fines (silt plus clay) ranged from 12 to 98%. TOC concentrations ranged from 0.6 to 4.2%. Sediment pH values (measured on a 2:1 deionised water extract) ranged from 5.38 to 8.21.

Concentrations of most total metals appeared to be increasing over time (*i.e.,* concentrations in the top or middle 5-cm depth intervals were higher than in the bottom 5-cm depth interval) at the majority of North Inlet stations. Exceptions to this profile were observed for beryllium, cadmium, copper and manganese, which had concentrations that appeared to be decreasing over time (*i.e.,* concentrations in the top 5-cm depth interval were lower than in the middle or bottom 5-cm depth intervals) at the majority of North Inlet stations.

The top 5-cm depth interval from NI-2 had an elevated AVS concentration compared to all other samples; this was the only core sample with an excess of AVS relative to ∑SEM and therefore divalent metals were not expected to be bioavailable in this sample. All other core samples exhibited an excess of ∑SEM (primarily due to copper, nickel, and zinc). For the latter samples, these results do not necessarily indicate toxicity of sediments, but indicate that the extractable metals have potential to cause responses based on likely bioavailability.

Total phosphorus concentrations were either similar among depth intervals or decreased with increasing sediment depth. Available phosphate (orthophosphate) concentrations were orders of magnitude lower than total phosphorus in all samples; concentrations generally increased with depth at NI-1 and NI-5, and decreased with depth at the other three North Inlet stations. For the reagents, the lime and calculated alum concentrations generally decreased with increasing sediment depth.

As shown in Table 2, concentrations of 10 parameters were above the lower-bound CCME ISQG and/or OMOEE LEL values in one or more of the depth interval samples from North Inlet stations: TOC, arsenic, chromium, copper, iron, lead, manganese, nickel, total phosphorus, and zinc. Concentrations that were above the upper-bound CCME PEL and/or OMOEE SEL values, or the Washington State LAETs derived from amphipod or chironomid toxicity data, are noted below:

- Arsenic concentrations above the PEL, SEL and/or LAET at one or more depth intervals in the NI-1, NI-2, NI-3 and NI-4 samples;
- Beryllium concentrations above the LAET at one or more depth intervals in the NI-1, NI-3, NI-4 and NI-5 samples;
- Chromium concentrations above the PEL, SEL and/or LAET at one or more depth intervals in the NI-1, NI-2, NI-3 and NI-4 samples;

- Iron concentrations above the SEL at one depth interval in the NI-4 sample;
- Manganese concentrations above the SEL at one depth interval in the NI-1 and NI-2 samples;
- Nickel concentrations above the SEL and LAET at one or more depth intervals in the NI-1, NI-2, NI-3 and NI-4 samples; and,
- Total phosphorus concentrations above the SEL at one or more depth intervals in the NI-1 and NI-2 samples.

The magnitude by which these seven analytes exceeded their respective upper-bound SQGs ranged from a factor of less than two to a factor of eight.

3.1.3 Water Samples Generated From Sediment Toxicity Tests

Results of chemical analyses performed on water samples collected from the sediment toxicity tests are provided in Table 3 (hardness, dissolved metals, dissolved phosphorus) and Table 4 (total ammonia, total sulphide, routine water quality parameters). Detailed results are provided in the Maxxam and HydroQual laboratory reports in Appendix C and D, respectively.

Table 3 provides the water chemistry data for each of the two sediment toxicity test methods, for samples of overlying water collected at the start and end of the toxicity tests. Concentration ranges are also included for each group of water chemistry samples. There were some differences between the water chemistry results obtained for the two toxicity test methods. Overall, water hardness increased during testing; concentrations of some parameters increased during testing, whereas others decreased or remained similar.

Dissolved metals concentrations were conservatively compared to CCME water quality guidelines (WQGs) for the protection of aquatic life (CCME 2007), even though the CCME WQGs apply to total metals concentrations. Emphasis on dissolved metal exposures helped to focus the analysis on the bioavailable fractions, which are relevant to assessing potential causes of observed responses. Dissolved metals concentrations that were above CCME WQGs in overlying water samples are noted below:

- Aluminum concentrations in the sludge, all North Inlet samples, and some reference station samples;
- Arsenic concentrations in the sludge, most North Inlet samples, and some reference station samples;
- Cadmium concentrations in all North Inlet and reference station samples;
- Chromium in some North Inlet station samples;
- Copper concentrations in some or all North Inlet and reference station samples, depending on sampling event;
- Iron concentrations in some or all North Inlet and reference station samples, depending on sampling event;
- Lead concentrations in some North Inlet samples; and,

- Aluminum, cadmium, copper, iron, and mercury concentrations in one or more negative control samples.

The magnitude by which these analytes exceeded their respective upper-bound SQGs ranged from a factor of less than 2 to a factor of close to 50 (for aluminum). Also WQGs and SQGs are derived using different methods and different test species, the occurrence of exceedances of these guidelines was compared. Concentrations of arsenic, cadmium, chromium, copper, iron and lead exceeded their respective WQGs and SQGs at one or more of the North Inlet or reference stations, although not necessarily at the same stations. For example, dissolved cadmium concentrations in water samples were above the WQG in overlying water samples collected at the start and end of both toxicity tests for all North Inlet and reference stations, but sediment cadmium concentrations were only above the SQG in the NI-1 surface sediment sample. Aluminum concentrations exceeded the WQG but there was no corresponding aluminum SQG. Nickel and zinc concentrations were above their respective SQGs in surface and/or subsurface sediment samples, but dissolved water concentrations were not above the WQGs.

3.1.4 Quality Assurance/Quality Control (QA/QC) – Chemistry Analyses

Results of the QA/QC review of the sludge and sediment chemistry analyses showed that target analytes were not detected in the method blanks, except that barium, titanium and sulphide were measured at their respective detection limits in one method blank. The relative percent difference (RPD) values for the laboratory duplicates were within the acceptable limits of 20 to 35% RPD (depending on the parameter), and ranged from 0.1 to 13.1% RPD. Percent recovery for the spiked blanks ranged from 87 to 111%, which was within the acceptable range of 75 to 125%. Percent recovery for the matrix spikes ranged from 95 to 113% (acceptable range of 75 to 125%), except that percent recoveries for two sulphide matrix spikes were 3.9 and 38%. These low recoveries were attributed to matrix interference, and re-analyses yielded similar results. Percent recovery for the QC standard ranged from 75 to 120% (acceptable range of 70 to 130%), except that percent recovery for silver was 66 to 67%.

Results of the QA/QC review of the water chemistry analyses showed that target analytes were not detected in the method blanks, except that total aluminum, total copper and total iron were detected at concentrations slightly above their detection limits in one method blank. RPDs for laboratory duplicates were within the acceptable limit of 20% RPD. Percent recoveries for the spiked blanks (85 to 122%) and matrix spikes (85 to 115%) were within the acceptable ranges of 80 to 120%, except that percent recovery for one spiked blank for lithium was 122%.

3.2 Laboratory Toxicity Tests

Results of the sediment toxicity tests, and associated water quality data, are summarized in Table 4. Detailed results are provided in the HydroQual laboratory reports in Appendix D.

Test acceptability criteria for control performance were met for both sediment toxicity test methods. The sludge and North Inlet sediment samples were considered to be toxic if there was a ≥20% reduction in mean response (survival or dry weight) in the sample relative to the reference sediments. Since three reference sediments were used in this study, and the results for each were variable, these comparisons were made using the pooled mean for all three reference sediments.

3.2.1 Sediment Toxicity Tests With *Hyalella azteca*

Mean control survival was 94%. Mean survival for the test samples was: 12% for the sludge sample, 18 to 80% for the North Inlet sediments, and 64 to 74% for the reference sediments. Among the North Inlet sediments, mean survival was highest (80%) for NI-5 and ranged from 18 to 36% for the other four samples.

Mean control dry weight was 0.21 mg/amphipod. Mean dry weight for the test samples was: 0.13 mg/amphipod for the sludge sample, 0.06 to 0.12 mg/amphipod for the North Inlet sediments, and 0.09 to 0.20 mg/amphipod for the reference sediments. Among the North Inlet sediments, mean dry weight was greatest (0.12 mg/amphipod) for NI-5 and ranged from 0.06 to 0.10 mg/amphipod for the other four samples.

Mean results for the sludge and North Inlet sediment samples were compared to the pooled mean results for the three reference sediments, to identify the samples that were considered toxic based on a ≥20% reduction in mean response. For the survival endpoint, the sludge sample and the NI-1 to NI-4 sediment samples were classified as toxic. For the dry weight endpoint, the NI-1 to NI-4 sediment samples were classified as toxic.

The 96-h LC50 for the water-only copper reference toxicant test was 2.27 log µg/L Cu, which was within the warming limits (mean ± 2SD) reported by HydroQual for historical test performance.

Water quality parameters measured in overlying water during the 14-d *H. azteca* tests were within the following ranges: temperature (23 to 24°C), DO (0.7 to 8.0 mg/L), pH (6.5 to 8.2), conductivity (343 to 1,089 µS/cm), alkalinity (40 to >240 mg/L $CaCO_3$), and hardness (120 to 425 mg/L as $CaCO_3$). DO concentrations in the replicates used for water quality monitoring were ≥2.1 mg/L except for isolated measurements that ranged from 0.7 to 1.7 mg/L in the sludge, NI-1, NI-2, NI-4, REF-1 and REF-3 treatments. Aeration was provided at the prescribed rate of 2 to 3 bubbles/sec during the test; Environment Canada (1997a) does not specify a lower limit for DO that would invalidate the test. Survival in these replicates ranged from 10 to 90%, and was similar to the other replicates for each treatment. *Hyalella azteca* are able to tolerate conditions of low DO concentrations (Environment Canada 1997a); Nebeker *et al.* (1992) reported 96-h and 30-d LC50s of <0.3 mg/L DO for adult *H. azteca,* but Irving *et al.* (2004) reported that 80% mortality occurred when juveniles were exposed to 1.2 mg/L DO for five days. The short periods of time during which DO concentrations were low were not likely long enough that this could account for the observed mortality.

Total ammonia concentrations measured in interstitial water samples collected at the start of the *H. azteca* sediment toxicity tests ranged from 0.35 to 3.51 mg/L N, and were 0.1 mg/L N in the negative control. Concentrations were higher among the North Inlet sediments, than for the sludge or reference sediment samples. Concentrations of total ammonia measured in overlying water samples collected at the start and end of these tests ranged from <0.05 to 3.79 mg/L N. Ankley *et al.* (1995) reported 96-h LC50s for total ammonia of 105 and 64 mg/L N in tests with *H. azteca* at the range of pH and water hardness used for this study; therefore, it is unlikely that ammonia contributed to the observed sediment toxicity. This differed from the findings of de Rosemond and Liber (2005), who identified ammonia as a COPC with respect to NIWTP sludge toxicity.

Total sulphide concentrations measured in interstitial water samples collected at the start of the *H. azteca* sediment toxicity tests ranged from <0.005 to 0.047 mg/L S in the North Inlet and reference sediment samples, and were 27.3 mg/L S in the sludge sample. Total sulphide concentrations measured in overlying water at the start of both toxicity tests ranged from <0.005 to 0.032 mg/L S. Wang and Chapman (1999) reported 96-h LC50s for total sulphide ranging from 0.02 to 1.07 mg/L S for several freshwater invertebrates other than *H. azteca* and

C. tentans. Based on that information, it is likely that sulphide contributed to the observed toxicity of the sludge sample, but probably not in the North Inlet sediments.

3.2.2 Sediment Toxicity Tests With *Chironomus tentans*

Mean control survival was 82%. Mean survival for the test samples was: 10% for the sludge sample, 42 to 70% for the North Inlet sediments, and 46 to 60% for the reference sediments. Among the North Inlet sediments, mean survival was higher for NI-5 (70%) than for the other four samples (42 to 54%).

Mean control dry weight was 2.71 mg/chironomid. Mean dry weights for the test samples were: 0.65 mg/chironomid for the sludge sample, 0.30 to 1.42 mg/chironomid for the North Inlet sediments, and 1.66 to 2.22 mg/chironomid for the reference sediments. Among the North Inlet sediments, mean dry weights were 1.42 mg/chironomid for NI-5 and ranged from 0.30 to 0.48 mg/chironomid for the other four samples.

Mean results for the sludge and North Inlet sediment samples were compared to the pooled mean results for the three reference sediments, to identify the samples that were considered toxic based on a ≥20% reduction in mean response. For the survival endpoint, the sludge and NI-4 samples were classified as toxic. For the dry weight endpoint, the sludge sample and all five North Inlet sediment samples were classified as toxic.

The 96-h LC50 for the water-only KCl reference toxicant test was 0.68 log mg/L KCl, which was within the warming limits (mean ± 2SD) reported by HydroQual for historical test performance.

Water quality parameters measured in overlying water during the 10-d *C. tentans* tests were within the following ranges: temperature (23 to 24°C), DO (1.2 to 7.8 mg/L), pH (7.4 to 8.4), conductivity (253 to 690 µS/cm), alkalinity (40 to >240 mg/L $CaCO_3$), and hardness (120 to >425 mg/L as $CaCO_3$). DO concentrations in the replicates used for water quality monitoring were ≥2.2 mg/L except for isolated measurements that ranged from 1.2 to 1.7 mg/L in the sludge, NI-1, NI-2, NI-4 and REF-1 treatments. Aeration was provided at the prescribed rate of 2 to 3 bubbles/sec during the test; Environment Canada (1997b) does not specify a lower limit for DO that would invalidate the test. Survival in these replicates ranged from 0 to 80%, and was similar to the other replicates for each treatment. *Chironomus tentans* are able to tolerate conditions of low DO concentrations (Environment Canada 1997b); for example, Irving *et al.* (2004) reported that *C. tentans* survival and growth were not adversely affected in 10-d exposures to 1.2 mg/L DO. It is unlikely that low DO was the cause of the observed mortality.

At previously reported, total ammonia concentrations in interstitial water at the start of the *H. azteca* toxicity tests ranged from 0.35 to 3.51 mg/L N. Concentrations of total ammonia in overlying water at the start and end of the *C. tentans* tests ranged from <0.05 to 3.72 mg/L N. Schubauer-Berigan *et al.* (1995) reported a 10-d LC50 for total ammonia of 186 mg/L for *C. tentans* at the pH and hardness used for this study; therefore, it is unlikely that ammonia contributed to the observed sediment toxicity.

Total sulphide concentrations in interstitial water at the start of the *H. azteca* toxicity tests ranged from <0.005 to 0.047 mg/L S in the North Inlet and reference sediment samples, and were 27.3 mg/L S in the sludge sample. Total sulphide concentrations measured in overlying water at the start of the *C. tentans* tests ranged from <0.005 to 0.029 mg/L S. Based on the 96-h LC50s for total sulphide reported by Wang and Chapman (1999) that ranged from 0.02 to 1.07 mg/L S for several freshwater invertebrates other than *H. azteca* and *C. tentans,* it is likely that sulphide contributed to the observed toxicity of the sludge sample but not the North Inlet sediments.

3.2.3 Quality Assurance/Quality Control (QA/QC) – Toxicity Tests

A QA/QC review was performed on the data for the two sediment toxicity test methods. Sediment and sludge samples were tested within holding time limits, test acceptability criteria were met for all negative (clean) controls, reference toxicant test results were within warning limits (mean ± 2SD) reported for historical laboratory performance, and water quality parameters measured during testing were within acceptable limits with the exception of some isolated low DO measurements in both tests.

3.3 Benthic Invertebrate Community Structure

Results of the benthic invertebrate taxonomy analyses are summarized in Table 5 (A-D). Raw data for abundance and biomass are provided in Appendix E.

Two replicates from NI-5 contained unusually high numbers of Tubificidae (a family of oligochaete worms) relative to the other stations (this was also the only benthic taxon present in those two samples), so data for NI-5 were presented with and without data from those two replicates.

Table 5 (A) shows the total density (converted from abundance data) of all taxa for each replicate sample, as well as the mean total density for each station. These data include all the taxa that were recovered, including benthic taxa, meiofauna, and non-benthic taxa. Among the North Inlet samples, mean total density ranged from 198 to 784 individuals/m^2 for the NI-1 to NI-4 stations and was 27,966 individuals/m^2 for NI-5 (1,112 individuals/m^2 with the two anomalous tubificid replicates excluded). Mean total density ranged from 1,129 to 4,810 individuals/m^2 for the three reference stations.

When benthic invertebrate data have been enumerated and tabulated, one of the first steps in data processing is normally to remove the data for meiofauna (in this case nematodes) and any non-benthic taxa. Meiofauna are typically excluded because their small size means that they may not have been representatively sampled during field collection, and non-benthic taxa are excluded because they are not representative of the ecological compartment under investigation (*i.e.,* sediment-dwelling organisms). Meiofauna abundance may vary, but non-benthic taxa do not typically account for a large portion of the total taxa numbers in benthic samples. However, as shown in Table 5 (B), this was not the case for the 2010 North Inlet study. Non-benthic taxa (and meiofauna to a lesser extent) accounted for the majority of taxa recovered from the NI-1 to NI-4 samples. Only 8 to 17% of the organisms recovered from the NI-1 to NI-4 samples were benthic taxa, whereas >90% of the organisms recovered from NI-5 and the reference sediments were benthic taxa. Most of the non-benthic taxa were calanoid and cyclopoid copepods, and the presence of these non-benthic taxa within North Inlet indicated the existence of a resident plankton community in the water column of North Inlet. In addition, the relative lack of benthic-dwelling species is indicative of an environment that is relatively inhospitable to burrowing or epibenthic organisms.

Mean taxa richness was low (≤2 benthic taxa/grab) for all five North Inlet stations, and ranged from 9 to 13 benthic taxa/grab for the three reference stations (Table 5C). Station totals (number of benthic taxa/station) were also calculated for taxa richness, as is done for DDMI's annual AEMP (*e.g.,* Rio Tinto 2010), by adding all the different taxa present among replicates at a particular station; these station totals ranged from one to six benthic taxa/station for all five North Inlet stations, and from 16 to 23 benthic taxa/station for the three reference stations.

Mean total biomass was low (0.5 to 3.0 mg/grab) for the NI-1 to NI-4 stations, and much higher for NI-5 (818 mg/grab with all taxa included, or 26 mg/grab with the two anomalous tubificid replicates excluded). Mean total biomass ranged from 32 to 57 mg/grab for the three reference stations (Table 5; Panel D). Station totals were also calculated for total biomass.

Overall, the benthic invertebrate analyses showed that the NI-1 to NI-4 stations were impoverished with respect to total density, taxa richness, and biomass. The benthic community at NI-5 was more similar to the reference stations in terms of total density and biomass, but had low taxa richness similar to the other North Inlet stations. The three reference stations had higher mean total densities, but similar taxa richness and biomass, when compared to the FF-1 reference stations used for the 2009 AEMP (Rio Tinto 2010). Chironomids accounted for approximately half the total abundance among all stations, when the two NI-5 samples with high tubificid counts were excluded.

4.0 CONCLUSIONS

Results of this assessment indicate that the NIWTP sludge, four of the five North Inlet samples, and all three reference sediment samples contained elevated concentrations of some parameters that were identified as being potentially toxic to aquatic biota based on screening of data against representative, conservative environmental quality guidelines for sediment and water. However, elevated concentrations were not associated with adverse biological effects in reference station sediments, and therefore could not always be clearly associated with the adverse biological effects that were for the sludge and North Inlet sediments.

Results of the sediment toxicity tests and benthic taxonomy analyses showed that NIWTP sludge was toxic in standard sediment toxicity tests, and that sediments from four of the North Inlet stations (NI-1 to NI-4) were also classified as toxic and had impoverished benthic invertebrate communities. In contrast, the North Inlet station located closest to the mouth of the inlet (NI-5) was generally not classified as toxic relative to the reference stations (it was only classified as potentially toxic with respect to chironomid dry weight when compared to the pooled mean reference station response), and had a benthic invertebrate community composition that was more similar to the reference stations in terms of total density and biomass (but not taxa richness) than to the other North Inlet stations. The physical characteristics of the NI-1 to NI-4 sediments were also different from NI-5, the former having varying amounts of the previously described viscous unconsolidated algal material on the sediment surface.

Toxicity of the NIWTP sludge sample was likely (at least in part) due to the elevated total sulphide concentration in interstitial water, which was higher than the acute LC50s reported for several freshwater invertebrate species. However the sludge sample used for this study was collected from the NIWTP clarifier tank and it is therefore possible that the elevated sulphide concentration is an artefact of sludge storage conditions and not representative of sulphide concentrations in the sludge slurry that is discharged to North Inlet. Elevated TOC and total phosphorus concentrations may also have contributed to the sludge toxicity. Although the arsenic concentration was high in the sludge sample, it was not as high as REF-3 (which had better performance in the sediment toxicity tests). The sludge sample also had an excess of AVS relative to ∑SEM, indicating that divalent metals would not be bioavailable.

The NI-5 sediments had concentrations of five metals (arsenic, chromium, copper, iron and nickel) and total phosphorus that were above the lower-bound SQGs (ISQG and LEL), but none that were above the upper-bound SQGs (PEL, SEL and/or LAET) used in this assessment. In contrast, the other four North Inlet sediments had concentrations of up to three metals (arsenic, chromium and nickel), and total phosphorus at NI-1, that were above the upper-bound SQGs. This indicates that metals and total phosphorus cannot be definitively excluded from consideration as COPCs.

At NI-1, nutrient enrichment (elevated total phosphorus) may have contributed to the observed biological effects. However, given the low percentage of available phosphorus, and the fact that the thickest observed layer of unconsolidated material was found at this station, the substrate condition (and associated micro-habitat) appears to be a strong candidate for explaining the observed responses. Although concentrations of arsenic, chromium, and nickel were elevated at this station, the NI-1 sample also had an excess of AVS relative to ∑SEM, indicating that divalent metals were not bioavailable; bioavailability of arsenic would also have been reduced. The strong responses observed for both toxicity and benthic community structure suggest a causal factor that is pronounced in influence, in contrast to the weak to moderate evidence for metal-mediated responses.

At NI-2 to NI-4, organic or nutrient enrichment (TOC or total phosphorus) were less likely to be contributing to the observed biological effects. Nickel concentrations were above LAET values at all three stations, and chromium concentrations were above upper-bound SQGs or LAETs at two stations. The molar difference for AVS - ∑SEM was negative for sediments from the NI-2 to NI-4 stations, so metals could have been bioavailable.

Although the three reference stations generally had better performance in the sediment toxicity tests and healthier benthic invertebrate communities than at least four of the North Inlet stations, concentrations of four metals were above their respective upper-bound SQGs and/or LAETs (arsenic, beryllium, iron, and manganese) and higher than concentrations reported for most North Inlet sediment samples. These comparisons indicate that arsenic, beryllium, iron, and manganese are unlikely to explain the observed pattern of responses, reducing the number of candidate chemical stressors. Accordingly, the list of primary COPCs can be refined to include only TOC, chromium, nickel, and total phosphorus (*i.e.,* by removing background contaminants from the preliminary list identified through screening to SQGs).

In conclusion, the adverse biological effects (sediment toxicity and/or benthic invertebrate impoverishment) observed for the NIWTP sludge and sediments from four North Inlet stations could not be attributed to a single stressor. In addition to the sulphide toxicity observed for the sludge sample, it appears that a combination of organic or nutrient enrichment contributed to adverse biological effects at some stations whereas metals may have been a contributing factor at other stations. The lack of suitable benthic habitat in areas where the layer of unconsolidated material on the sediment surface was relatively thick was also a factor. Near the mouth of North Inlet, sediment quality was similar to that observed at reference stations in Lac de Gras. Despite the adverse biological effects associated with some North Inlet sediments, there was evidence of a resident zooplankton community in the water column within North Inlet, indicating that water quality conditions in North Inlet were far from inimical to aquatic life.

Although adverse effects were observed associated with North Inlet sediments to organisms living in or placed in those sediments, it is unlikely that opening North Inlet to Lac de Gras would adversely affect water quality conditions in Lac de Gras. However, with respect to whether North Inlet could be opened up at mine closure and allowed to return naturally to fish habitat, the results obtained from the 2010 study were insufficient to adequately address that question, and follow-up studies and testing will be necessary to reduce uncertainty about the suitability of North Inlet as fish habitat. It would be premature to begin to consider what management or remediation activities might be required until that question has been answered.

5.0 CLOSURE

We trust that the information contained in this report is sufficient for your present needs. Should you have any additional questions regarding this study, please do not hesitate to contact the undersigned.

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Table 1. Chemistry Results For Sludge and Surficial Sediment Grab Samples

Sediment Parameter	Units (dry wt)	CCME SQGs (ISQG / PEL)	OMOEE SQGs (LEL / SEL)	WDOE LAET	NIWTP Sludge	NI-1	NI-2	NI-3	NI-4	NI-5	REF-1	REF-2	REF-3	Field Duplicate (NI-1)	Min	Max	NI Mean	REF Mean
Moisture Content	%				97	78	78	71	70	40	74	68	78	94	40	97	67	73
Particle Size																		
% sand by hydrometer	%				76	44	2	3	<2	28	7	21	31	50	<2	76	19	20
% silt by hydrometer	%				10	49	78	77	79	59	75	67	61	43	<2	79	68	68
Clay Content	%				14	7	20	20	20	13	18	11	8	8	7	20	16	12
Gravel	%				<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2		
% Silt+Clay	%				24	56	98	97	99	72	93	78	69	51	24	99	84	80
Total Organic Carbon (TOC)	%		1 / 10	9.82	9.94	1.67	1.63	1.3	1.55	0.44	1.84	1.6	2.43	1.78	0.44	9.94	1.32	1.96
pH (2:1 DI Water Extract)	pH Units				7.14	7.62	8.24	8.34	7.56	7.50	6.16	6.02	5.68	8.00	5.68	8.34	7.9	6.0
Total Metals (by ICPMS)																		
Aluminum (Al)	mg/kg				150,000	32,400	26,100	19,900	22,100	14,100	18,600	15,900	15,000	31,500	14,100	150,000	22,920	16,500
Antimony (Sb)	mg/kg			0.6	1.0	0.4	0.3	0.3	0.3	0.1	<0.1	<0.1	<0.1	0.3	<0.1	1.0	0.28	0.05
Arsenic (As)	mg/kg	5.9 / 17	6 / 33	31.4	**136**	**37.2**	10.0	2.9	7.1	10.9	**85.0**	**71.7**	**195**	20.1	2.9	195	14	117
Barium (Ba)	mg/kg				98.2	322	386	264	381	102	149	127	123	309	98.2	386	291	133
Beryllium (Be)	mg/kg			0.46	<0.1	0.4	0.3	0.3	0.4	0.3	0.5	0.6	0.5	0.3	0.05	0.6	0.3	0.5
Bismuth (Bi)	mg/kg				0.3	0.7	0.8	1.0	1.2	1.7	0.3	0.3	0.2	0.8	0.2	1.7	1.1	0.3
Cadmium (Cd)	mg/kg	0.6 / 3.5	0.6 / 10	2.39	0.14	0.71	0.27	0.17	0.21	0.15	0.22	0.26	0.27	0.20	0.14	0.71	0.30	0.25
Calcium (Ca)	mg/kg				3,110	8,910	11,000	8,160	7,660	3,990	1,430	1,320	1,090	8,580	1,090	11,000	7,944	1,280
Chromium (Cr)	mg/kg	37.3 / 90	26 / 110	133	14	**129**	**171**	87	**113**	47	66	58	50	**127**	14	171	109	58
Cobalt (Co)	mg/kg				4.8	26.3	30.7	18.5	23.6	11.2	35.9	20.6	32.6	22.9	4.8	35.9	22	30
Copper (Cu)	mg/kg	35.7 / 197	16 / 110	619	12.7	36.7	32.9	31.1	35.6	33.9	34.9	33.1	42.8	29.1	12.7	42.8	34	37
Iron (Fe)	mg/kg		20,000 / 40,000		3,150	31,600	31,900	26,700	28,700	22,000	**63,800**	**46,800**	**72,400**	28,800	3,150	72,400	28,180	61,000
Lead (Pb)	mg/kg	35 / 91.3	31 / 250	335	4.7	23.9	23.4	32.6	32.0	25.4	5.7	5.9	4.6	21.4	4.6	32.6	27	5.4
Magnesium (Mg)	mg/kg				4,940	35,900	48,000	21,600	31,800	8,190	9,590	8,410	6,910	33,900	4,940	48,000	29,098	8,303
Manganese (Mn)	mg/kg		460 / 1,100		637	576	667	454	678	286	**3,500**	**1,220**	**1,930**	567	286	3,500	532	2,217
Mercury (Hg)	mg/kg	0.17 / 0.49	0.2 / 2	0.8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg				68.8	6.2	8.7	8.2	10.5	2.8	2.9	1.8	3.0	6.6	1.8	68.8	7.3	2.6
Nickel (Ni)	mg/kg		16 / 75	113	56.9	**286**	**419**	**169**	**260**	51.4	62.5	57.0	72.1	**277**	51.4	419	237	64
Phosphorus (P)	mg/kg		600 / 2,000		**6,150**	**3,360**	1,940	1,520	1,700	1,590	1,220	1,230	1,810	**3,090**	1,220	6,150	2,022	1,420
Potassium (K)	mg/kg				1,500	9,730	8,610	9,990	9,200	6,960	4,960	4,750	3,740	9,340	1,500	9,990	8,898	4,483
Selenium (Se)	mg/kg				<2	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	0.6	<0.5
Silver (Ag)	mg/kg			3.5	<0.05	0.24	0.22	0.25	0.25	0.14	0.06	0.06	0.06	0.24	<0.05	0.25	0.22	0.06
Sodium (Na)	mg/kg				993	661	626	615	738	268	212	202	162	598	162	993	582	192
Strontium (Sr)	mg/kg				96.5	113	143	66.1	82.1	21.1	11.0	10.0	9.2	115	9.2	143	85	10
Thallium (Tl)	mg/kg				<0.05	0.53	0.50	0.57	0.51	0.43	0.34	0.27	0.30	0.52	<0.05	0.57	0.51	0.30
Tin (Sn)	mg/kg				0.7	2.0	1.1	1.3	1.7	1.3	0.8	1.2	0.7	1.3	0.7	2	1.5	0.9
Titanium (Ti)	mg/kg				100	1,150	973	1,430	1,220	1,010	872	876	528	1,260	100	1,430	1,157	759
Vanadium (V)	mg/kg				15	46	53	40	42	31	54	46	43	45	15	54	42	48
Zinc (Zn)	mg/kg	123 / 315	120 / 820	683	16	110	102	113	116	81	91	79	83	102	16	116	104	84
Zirconium (Zr)	mg/kg				3.1	5.8	4.4	10.5	9.7	4.6	1.1	1.0	0.5	7.0	0.5	10.5	7.0	0.9
Acid Volatile Sulphide (AVS)	umole/g				9.1	14.4	0.35	0.79	0.37	0.043	<0.02	0.01	0.05	0.56	0.01	14.4	3.19	0.02
Simultaneously Extractable Metals (SEM)																		
Cadmium (Cd)	umole/g				<0.0002	0.0006	0.0008	0.0014	0.0005	0.0007	0.0014	0.0006	0.0021	0.0016	0.0005	0.0021	0.0008	0.0014
Copper (Cu)	umole/g				0.006	0.117	0.113	0.317	0.120	0.232	0.322	0.185	0.565	0.283	0.006	0.565	0.180	0.357
Lead (Pb)	umole/g				0.0021	0.0371	0.0346	0.137	0.0493	0.0792	0.0165	0.0080	0.0177	0.0692	0.0021	0.137	0.067	0.014
Mercury (Hg)	umole/g				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Nickel (Ni)	umole/g				0.077	1.19	1.51	2.00	0.923	0.504	0.578	0.335	1.01	3.12	0.077	2	1.225	0.641
Zinc (Zn)	umole/g				0.021	0.525	0.464	1.47	0.564	0.802	0.632	0.438	0.996	0.979	0.021	1.47	0.765	0.689
∑SEM (umoles/g)	umole/g				0.1	1.9	2.1	3.9	1.7	1.6	1.5	1.0	2.6	4.5	0.1	3.9	2.2	1.7
AVS - ∑SEM (umoles/g)	umole/g				9.0	12.5	-1.8	-3.1	-1.3	-1.6	-1.5	-1.0	-2.5	-3.9	-3.1	12.5	1.0	-1.7
Available Phosphate																		
Orthophosphate (P)	mg/kg				28.2	67.0	70.8	60.9	71.0	67.9	68.3	68.0	67.4	60.9	28.2	71	68	68
Reagents																		
Lime (CaO)	%				0.46	1.6	2.01	1.66	1.51	1.12	1.19	1.31	1.13	1.6	0.46	2.01	1.58	1.21
Alum (calculated)	mg/kg				0.84	1.32	1.41	0.51	1.78	0.47	0.16	0.16	0.26	0.86	0.16	1.78	1.10	0.19

Legend:

Concentration above CCME ISQG	🟨
Concentration above CCME PEL	🟧
Concentration above OMOEE LEL	☐
Concentration above OMOEE SEL	xx
Concentration above WDOE LAET	☐

Table 2. Chemistry Results for Subsurface Sediment Core Samples From North Inlet Stations

Sediment Parameter	Units (dry wt)	CCME SQGs (ISQG / PEL)	OMOEE SQGs (LEL / SEL)	WDOE LAET	NI-1 Surface	NI-1 Middle	NI-1 Bottom	NI-2 Surface	NI-2 Middle	NI-2 Bottom	NI-3 Surface	NI-3 Middle	NI-3 Bottom	NI-4 Surface	NI-4 Middle	NI-4 Bottom	NI-5 Surface	NI-5 Middle	NI-5 Bottom	Min	Max
Moisture	%				96	44	30	88	39	43	77	68	68	69	78	66	59	73	74	30	96
Particle Size																					
% sand by hydrometer	%				87	5	22	42	26	27	-	<2	<2	32	68	58	28	69	76	<2	87
% silt by hydrometer	%				11	72	68	46	59	64	-	68	77	49	28	36	52	28	19	<2	77
Clay Content	%				<2	24	11	12	15	9	-	30	21	19	4	6	21	2	4	2	30
Gravel	%				<2	<2	<2	<2	<2	<2	-	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
% Silt+Clay	%				12	96	79	58	74	73	-	98	98	68	32	42	73	30	23	12	98
Total Organic Carbon (TOC)	%		1 / 10	9.82	4.15		0.77	2.95	0.76	0.65	1.44	1.57	3.14	1.57	3.79	2.73	0.73	3.77	3.57	0.65	4.15
pH (2:1 DI Water Extract)	pH Units				8.20	8.12	7.17	8.21	7.22	5.74	8.20	8.13	6.38	7.99	6.47	5.38	7.97	6.54	6.10	5.38	8.21
Total Metals (by ICPMS)																					
Aluminum (Al)	mg/kg				57,000	32,000	12,700	37,600	12,700	12,700	20,100	25,100	15,100	23,400	19,400	18,800	16,900	15,300	17,200	12,700	57,000
Antimony (Sb)	mg/kg			0.6	0.4	0.3	<0.1	0.4	<0.1	<0.1	0.3	0.2	<0.1	0.3	<0.1	<0.1	0.2	<0.1	<0.1	<0.1	0.4
Arsenic (As)	mg/kg	5.9 / 17	6 / 33	31.4	29.7	14.5	25.1	15.7	**101**	13.4	3.5	13.0	31.9	6.4	**72.0**	**46.8**	11.6	13.1	11.2	3.5	101
Barium (Ba)	mg/kg				485	414	90.8	443	143	119	259	451	129	395	170	155	179	125	136	90.8	485
Beryllium (Be)	mg/kg			0.46	0.3	0.5	0.5	0.4	0.4	0.4	0.3	0.7	0.6	0.5	0.8	0.7	0.5	0.7	0.7	0.3	0.8
Bismuth (Bi)	mg/kg				0.6	1.0	0.3	0.9	0.9	0.3	1.0	1.7	0.4	0.9	0.5	0.5	2.1	1.5	0.6	0.3	2.1
Cadmium (Cd)	mg/kg	0.6 / 3.5	0.6 / 10	2.39	0.18	0.25	0.09	0.27	0.11	0.19	0.20	0.35	0.27	0.19	0.57	0.45	0.18	0.29	0.40	0.09	0.57
Calcium (Ca)	mg/kg				14,000	9,730	1,290	11,500	1,750	916	8,110	8,670	1,680	8,030	1,590	1,260	4,440	1,770	1,520	916	14,000
Chromium (Cr)	mg/kg	37.3 / 90	26 / 110	133	**137**	**143**	43	**152**	46	47	87	**203**	50	**120**	65	64	65	55	60	43	203
Cobalt (Co)	mg/kg				23.9	27.5	23.0	26.9	20.5	15.3	18.2	39.8	13.5	24.1	38.2	40.8	14.6	13.4	13.6	13.4	40.8
Copper (Cu)	mg/kg	35.7 / 197	16 / 110	619	28.7	37.0	25.5	35.6	29.2	29.2	31.9	79.5	48.5	36.9	80.3	74.0	35.9	51.0	64.4	25.5	80.3
Iron (Fe)	mg/kg		20,000 / 40,000		26,100	30,200	24,600	32,200	32,200	21,600	26,500	35,000	25,300	29,300	**48,900**	38,700	25,900	20,500	21,100	20,500	48,900
Lead (Pb)	mg/kg	35 / 91.3	31 / 250	335	18.1	26.2	4.2	23.2	6.3	4.6	34.2	27.9	5.3	32.0	7.4	6.0	28.8	7.6	6.3	4.2	34.2
Magnesium (Mg)	mg/kg				46,900	41,100	5,770	45,500	6,830	6,190	22,300	53,800	6,810	33,400	8,610	8,240	13,600	7,060	7,650	5,770	53,800
Manganese (Mn)	mg/kg		460 / 1,100		898	803	**1,370**	855	**4,110**	526	499	775	281	770	641	429	410	283	264	264	4,110
Mercury (Hg)	mg/kg	0.17 / 0.49	0.2 / 2	0.8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg				8.0	7.0	1.6	10.4	2.2	1.1	11.5	10.7	2.6	11.9	4.1	3.4	4.9	1.9	2.2	1.1	11.9
Nickel (Ni)	mg/kg		16 / 75	113	**337**	**345**	30.2	**345**	39.8	39.8	**165**	**559**	44.1	**276**	**117**	**122**	91.1	47.8	56.8	30.2	559
Phosphorus (P)	mg/kg		600 / 2,000		**4,150**	**2,320**	704	**2,780**	784	758	1,670	1,880	982	1,540	1,690	1,420	1,740	804	824	704	4,150
Potassium (K)	mg/kg				7,590	8,480	3,420	9,610	3,860	3,860	9,860	6,800	3,900	9,150	4,510	4,530	7,170	4,440	4,680	3,420	9,860
Selenium (Se)	mg/kg				<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	0.5	<0.5	<0.5	<0.5	<0.5	0.7
Silver (Ag)	mg/kg			3.5	0.12	0.20	<0.05	0.21	0.07	<0.05	0.23	0.24	0.09	0.21	0.10	0.11	0.14	0.08	0.08	<0.05	0.24
Sodium (Na)	mg/kg				1,140	715	199	771	221	179	674	562	254	778	467	274	396	319	295	179	1,140
Strontium (Sr)	mg/kg				224	132	11.3	161	15.4	6.1	69.5	111	11.1	90.3	17.6	10.8	36.2	16.6	11.3	6.1	224
Thallium (Tl)	mg/kg				0.44	0.49	0.20	0.57	0.20	0.22	0.54	0.40	0.26	0.49	0.42	0.38	0.46	0.24	0.30	<0.4	0.57
Tin (Sn)	mg/kg				1.4	1.1	0.4	1.4	0.4	0.5	1.4	0.9	0.5	1.2	0.6	0.6	1.1	1.0	0.5	0.4	1.4
Titanium (Ti)	mg/kg				773	939	638	769	635	732	1,340	983	668	910	704	833	969	667	692	635	1,340
Vanadium (V)	mg/kg				42	49	36	55	37	38	40	54	42	43	56	56	36	46	54	36	56
Zinc (Zn)	mg/kg	123 / 315	120 / 820	683	83	104	49	109	51	63	111	101	86	115	146	133	95	80	109	49	146
Zirconium (Zr)	mg/kg				4.1	4.1	0.8	2.6	1.8	1.6	8.4	9.7	1.2	4.1	1.5	2.0	4.1	0.8	1.2	0.8	9.7
Acid Volatile Sulphide (AVS)	umole/g				0.4	1.49	0.008	26.3	0.012	0.031	0.33	0.05	<0.01	0.14	0.05	<0.02	0.07	0.12	0.05	<0.01	26.3
Simultaneously Extractable Metals (SEM)																					
Cadmium (Cd)	umole/g				0.0012	0.0007	0.0004	0.0005	0.0010	0.0010	0.0128	0.0031	0.0010	0.0007	0.0062	0.0033	0.0015	0.0007	0.0008	0.0004	0.0128
Copper (Cu)	umole/g				0.172	0.132	0.196	0.066	0.418	0.263	0.693	0.915	0.267	0.161	1.21	0.845	0.416	0.206	0.257	0.066	1.21
Lead (Pb)	umole/g				0.0564	0.0409	0.0085	0.0206	0.0263	0.0107	0.672	0.0912	0.0094	0.0556	0.0299	0.0203	0.134	0.0078	0.0078	0.0078	0.672
Mercury (Hg)	umole/g				<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Nickel (Ni)	umole/g				3.71	1.31	0.229	0.781	0.579	0.362	2.08	6.12	0.271	1.15	1.93	1.53	1.19	0.192	0.241	0.192	6.12
Zinc (Zn)	umole/g				0.488	0.492	0.332	0.320	0.687	0.524	2.39	0.982	0.502	0.633	2.18	1.55	1.30	0.311	0.403	0.311	2.39
∑SEM (umoles/g)	umole/g				4.4	2.0	0.8	1.2	1.7	1.2	5.8	8.1	1.1	2.0	5.4	3.9	3.0	0.7	0.9	0.7	8.1
AVS - ∑SEM (umoles/g)	umole/g				-4.0	-0.5	-0.8	25.1	-1.7	-1.1	-5.5	-8.1	-1.0	-1.9	-5.3	-3.9	-3.0	-0.6	-0.9	-8.1	25.1
Available Phosphate																					
Orthophosphate (P)	mg/kg				70.4	77.4	72.9	94.5	69.0	61.2	75.8	91.3	68.2	79.5	77.7	72.7	69.8	75.8	80.9	61.2	94.5
Reagents																					
Lime (CaO)	%				2.2	NM	1.49	1.87	1.54	1.51	1.65	1.58	1.36	1.48	1.19	1.26	1.12	1.26	1.22	1.12	2.2
Alum (calculated)	mg/kg				NM	NM	0.4198	3.1852	0.3704	0.4444	0.9259	1.4445	0.6173	2.0000	0.6049	0.5309	0.8272	0.3580	0.2346	0.23	3.19

Legend:

Concentration above CCME ISQG	🟨
Concentration above CCME PEL	🟧
Concentration above OMOEE LEL	☐
Concentration above OMOEE SEL	**xx**
Concentration above WDOE LAET	☐

NM = not measured

Table 3. Chemistry Results For Water Samples Collected From Sediment Toxicity Tests

A. Results For Water Samples Collected From *Hyalella azteca* Sediment Toxicity Tests

Parameter	Units	CCME WQG	Day 0 Results												Day 14 Results											
			Negative Control	NIWTP Sludge	NI-1	NI-2	NI-3	NI-4	NI-5	REF-1	REF-2	REF-3	Min	Max	Negative Control	NIWTP Sludge	NI-1	NI-2	NI-3	NI-4	NI-5	REF-1	REF-2	REF-3	Min	Max
Hardness (calculated as CaCO3)	mg/L		331	194	301	278	268	223	197	113	105	98.5	98.5	331	357	228	380	386	344	324	264	188	150	149	149	386
Dissolved Metals (by ICPMS)																										
Aluminum (Al)	µg/L	100	1230	2510	766	562	327	417	202	167	291	1530	167	2510	228	429	896	206	137	139	456	294	51	108	51	896
Antimony (Sb)	µg/L		<0.5	<0.5	0.5	0.6	0.7	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.7	<0.5	0.7	0.9	0.5	0.7	0.6	0.6	<0.5	<0.5	<0.5	<0.5	0.9
Arsenic (As)	µg/L	5	1	18.3	25	14.1	10.3	8.9	9.9	0.9	1.7	6.8	0.9	25	1.6	12.2	8.5	11.4	4.7	2.3	7.5	1.6	1.8	5.7	1.6	12.2
Barium (Ba)	µg/L		179	106	195	280	186	341	100	54	70	116	54	341	163	99	216	332	198	369	116	110	104	142	99	369
Beryllium (Be)	µg/L		<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth (Bi)	µg/L		<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron (B)	µg/L		<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	<50	50	50	<50	<50	<50	<50	<50	<50	50
Cadmium (Cd)	µg/L	0.017	0.12	<0.01	0.03	0.04	0.04	0.03	0.03	0.15	0.22	0.3	<0.01	0.3	0.04	0.01	0.03	0.03	0.03	0.03	0.03	0.22	0.36	0.4	0.01	0.4
Calcium (Ca)	µg/L		90,900	56,700	59,700	61,100	63,900	53,500	54,200	35,400	33,500	30,800	30800	90900	98,600	70,200	91,800	95,000	88,400	87,600	75,300	57,900	47,000	47,100	47000	98600
Chromium (Cr)	µg/L	8.9	3	<1	2	3	1	2	<1	<1	1	5	<1	5	1	<1	2	<1	<1	<1	1	<1	<1	<1	<1	2
Cobalt (Co)	µg/L		1.4	<0.5	0.6	1	0.5	1	0.6	2.4	5.7	23.1	<0.5	23.1	0.6	<0.5	0.8	0.8	0.6	1.2	1	1.3	2.7	7.5	<0.5	7.5
Copper (Cu)	µg/L	4	3.1	0.5	1.1	5.4	4	1.4	1.7	2	2.1	7.7	0.5	7.7	3.4	0.3	1.5	1.4	1.3	1	4.7	4.8	5.6	7.2	0.3	7.2
Iron (Fe)	µg/L	300	2050	101	409	569	331	546	305	385	832	4280	101	4280	248	15	426	146	77	76	575	545	184	306	15	575
Lead (Pb)	µg/L	7	1.9	0.2	0.8	0.9	2.5	1.1	1.4	0.3	0.3	0.7	0.2	2.5	0.4	<0.2	0.7	0.3	0.4	0.3	2.5	0.3	<0.2	0.2	<0.2	2.5
Lithium (Li)	µg/L		8	5	7	10	25	17	21	<5	<5	7	<5	25	7	<5	<5	6	22	13	18	6	6	6	<5	22
Magnesium (Mg)	µg/L		25,300	12,600	37,000	30,500	26,400	21,700	15,100	6,070	5,150	5,270	5150	37000	27,000	12,700	36,600	36,200	29,900	25,700	18,400	10,600	8,000	7,590	7590	36600
Manganese (Mn)	µg/L		154	3140	416	363	325	1620	566	4260	5940	8350	154	8350	19	2220	98	273	128	1080	61	2200	6130	9240	19	9240
Mercury (Hg)	µg/L	0.026	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	<0.02	<0.02	<0.02	<0.02	0.04	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Molybdenum (Mo)	µg/L		6	5	23	29	41	34	11	<1	<1	<1	<1	41	6	19	31	28	30	39	15	<1	<1	<1	<1	39
Nickel (Ni)	µg/L	150	4	3	14	27	14	28	8	19	32	55	3	55	2	5	27	39	31	53	17	29	65	63	2	65
Potassium (K)	µg/L		4,750	13,200	21,000	22,000	19,900	16,600	13,700	3,020	2,940	3,340	2940	22000	8,390	13,000	19,700	22,000	19,100	15,900	15,400	7,560	7,160	8,210	7160	22000
Selenium (Se)	µg/L	1	0.2	0.3	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.3	0.2	0.1	<0.1	0.1	0.1	0.1	0.1	<0.1	0.1	0.1	<0.1	0.2
Silicon (Si)	µg/L		5000	1100	3200	4500	6700	7900	7800	2800	4000	8100	1100	8100	4100	400	2600	4400	7300	6900	9000	5300	6500	11600	400	11600
Silver (Ag)	µg/L	0.1	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	0.03	<0.02	<0.02	<0.02	<0.02	<0.02	0.03
Sodium (Na)	µg/L		36,400	32,400	41,300	40,100	40,200	39,000	33,800	16,600	16,100	16,500	16100	41300	45,400	35,500	54,300	54,100	51,300	47,100	41,000	29,300	26,700	29,700	26700	54300
Strontium (Sr)	µg/L		263	206	810	824	732	626	510	85	67	66	66	824	322	157	831	991	782	739	596	162	108	104	104	991
Sulphur (S)	µg/L		19,000	35,000	5,000	9,000	10,000	12,000	6,000	7,000	8,000	6,000	5000	35000	21,000	48,000	19,000	17,000	19,000	29,000	13,000	12,000	12,000	13,000	12000	48000
Thallium (Tl)	µg/L	0.8	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	0.18	<0.05	0.18	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.1	0.13	0.23	<0.05	0.23
Tin (Sn)	µg/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Titanium (Ti)	µg/L		14	<5	13	23	19	25	12	12	23	111	<5	111	<5	<5	24	5	<5	<5	22	17	<5	6	<5	24
Uranium (U)	µg/L		0.7	5.8	62.3	51.4	29.6	28	13.2	<0.1	<0.1	0.5	<0.1	62.3	0.7	3.3	78.9	46.8	23.9	36.7	24.1	0.3	<0.1	<0.1	<0.1	78.9
Vanadium (V)	µg/L		<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Zinc (Zn)	µg/L	30	10	<5	<5	<5	<5	<5	<5	<5	<5	16	<5	16	<5	<5	<5	<5	<5	<5	<5	<5	9	9	<5	9
Zirconium (Zr)	µg/L		0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	1.1
Phosphorus-P (Dissolved)	µg/L		820	510	381	231	386	409	148	41	17	10	10	820	189	53	98	101	128	95	207	93	174	158	53	207

B. Results For Water Samples Collected From *Chironomus tentans* Sediment Toxicity Tests

Parameter	Units	CCME WQG	Day 0 Results												Day 10 Results											
			Negative Control	NIWTP Sludge	NI-1	NI-2	NI-3	NI-4	NI-5	REF-1	REF-2	REF-3	Min	Max	Negative Control	NIWTP Sludge	NI-1	NI-2	NI-3	NI-4	NI-5	REF-1	REF-2	REF-3	Min	Max
Hardness (calculated as CaCO3)	mg/L		NA	177	253	286	274	196	187	89.5	89.1	70.3	70.3	286	235	190	249	258	273	225	217	102	103	82.2	82.2	273
Dissolved Metals (by ICPMS)																										
Aluminum (Al)	µg/L	100	NA	3260	1370	4080	2890	1950	1180	1340	1580	1770	1180	4080	279	4660	565	1080	589	488	838	300	91	57	57	4660
Antimony (Sb)	µg/L		NA	<0.5	0.5	0.5	0.8	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.8	<0.5	0.6	<0.5	0.8	<0.5	0.6	0.7	<0.5	<0.5	<0.5	<0.5	0.8
Arsenic (As)	µg/L	5	NA	21.3	28.3	25.6	16.2	15.3	20.4	2.9	4.6	11.6	2.9	28.3	1.8	27.1	15.7	10	6.5	4.8	15.3	2.2	3.4	10.6	1.8	27.1
Barium (Ba)	µg/L		NA	91	154	318	223	331	104	38	45	55	38	331	84	79	119	215	143	255	90	30	34	42	30	255
Beryllium (Be)	µg/L		NA	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Bismuth (Bi)	µg/L		NA	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Boron (B)	µg/L		NA	<50	<50	<50	<50	<50	50	<50	<50	<50	<50	50	<50	<50	<50	<50	50	<50	<50	<50	<50	<50	<50	50
Cadmium (Cd)	µg/L	0.017	NA	0.01	0.03	0.09	0.08	0.05	0.04	0.08	0.07	0.08	0.01	0.09	0.05	0.01	0.02	0.04	0.02	0.03	0.03	0.04	0.04	0.04	0.01	0.05
Calcium (Ca)	µg/L		NA	40,400	41,900	51,700	57,500	35,800	39,600	21,300	21,200	15,800	15800	57500	53,500	41,600	50,700	54,400	62,500	50,800	50,000	23,900	24,300	19,400	19400	62500
Chromium (Cr)	µg/L	8.9	NA	<1	3	23	12	10	3	5	7	6	<1	23	<1	<1	<1	5	3	2	3	1	<1	<1	<1	5
Cobalt (Co)	µg/L		NA	<0.5	0.9	5.1	2.8	2.5	1.6	3.1	4.6	8.5	<0.5	8.5	0.8	<0.5	0.7	1.7	1.1	1.3	1.7	1.8	1.9	2.7	<0.5	2.7
Copper (Cu)	µg/L	4	NA	0.5	1.7	4.8	3.7	3.2	4.1	7.5	6.3	8.7	0.5	8.7	5.3	0.5	0.8	1.4	1.2	1.3	4.4	5.4	6.4	5	0.5	6.4
Iron (Fe)	µg/L	300	NA	136	823	4350	3560	2230	1630	2870	4560	5740	136	5740	423	90	120	1020	559	491	1090	456	346	593	90	1090
Lead (Pb)	µg/L	7	NA	0.2	1.6	5.6	11.9	3.8	7.4	0.7	0.7	0.9	0.2	11.9	0.5	0.3	0.3	1.1	1.2	0.9	3.6	0.6	<0.2	<0.2	<0.2	3.6
Lithium (Li)	µg/L		NA	6	8	17	33	22	32	<5	6	7	<5	33	8	6	<5	8	18	12	17	<5	<5	<5	<5	18
Magnesium (Mg)	µg/L		NA	18,500	36,100	38,100	31,700	25,800	21,400	8,820	8,810	7,510	7510	38100	24,600	21,000	29,700	29,800	28,500	23,900	22,300	10,300	10,300	8,180	8180	29800
Manganese (Mn)	µg/L		NA	2460	279	464	456	1730	526	3060	3550	3280	279	3550	27	1750	159	170	116	835	148	2990	3150	2570	27	3150
Mercury (Hg)	µg/L	0.026	NA	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04	0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0.04
Molybdenum (Mo)	µg/L		NA	15	23	29	45	36	15	<1	<1	<1	15	45	7	14	18	34	23	37	20	1	2	1	1	37
Nickel (Ni)	µg/L	150	NA	5	19	78	33	44	13	11	14	18	5	78	4	6	26	56	38	51	22	14	14	14	4	56
Potassium (K)	µg/L		NA	11,400	17,800	20,800	19,400	16,200	15,200	2,260	2,570	2,370	2260	20800	4,530	10,800	12,700	14,400	13,700	11,200	11,500	3,400	3,150	3,350	3150	14400
Selenium (Se)	µg/L	1	NA	0.3	0.2	0.2	0.2	0.1	0.1	0.3	0.3	0.2	0.1	0.3	0.7	0.2	0.2	0.2	0.2	0.2	0.3	0.3	0.3	0.3	0.2	0.7
Silicon (Si)	µg/L		NA	1200	3700	10000	11300	9100	10700	4800	6800	7800	1200	11300	4900	1100	2500	4500	6900	6800	8700	4700	5300	8600	1100	8700
Silver (Ag)	µg/L	0.1	NA	<0.02	<0.02	0.04	0.05	0.02	0.03	0.02	<0.02	<0.02	<0.02	0.05	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	0
Sodium (Na)	µg/L		NA	18,700	24,600	26,600	26,800	27,000	26,400	4,690	4,780	4,540	4540	27000	18,900	20,900	21,500	23,600	24,600	23,100	22,400	9,680	9,620	10,000	9620	24600
Strontium (Sr)	µg/L		NA	337	700	823	753	631	636	147	126	111	111	823	371	262	607	771	692	603	603	167	165	132	132	771
Sulphur (S)	µg/L		NA	40,000	11,000	17,000	18,000	20,000	14,000	18,000	17,000	16,000	11000	40000	34,000	55,000	16,000	24,000	22,000	28,000	27,000	25,000	26,000	26,000	16000	55000
Thallium (Tl)	µg/L	0.8	NA	<0.05	<0.05	0.08	0.08	0.05	<0.05	<0.05	0.06	0.08	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.07	<0.05	0.07
Tin (Sn)	µg/L		NA	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Titanium (Ti)	µg/L		NA	<5	28	154	191	125	58	102	134	121	28	191	<5	<5	<5	51	30	25	50	18	<5	<5	<5	51
Uranium (U)	µg/L		NA	9	62.9	58.7	35.7	40.7	24.7	0.5	0.4	0.5	0.4	62.9	1.4	10.8	69.4	60.9	24.6	46.1	52.2	0.6	0.3	<0.1	<0.1	69.4
Vanadium (V)	µg/L		NA	<5	<5	7	7	<5	<5	<5	5	5	<5	7	<5	<5	<5	<5	<5	<5	5	<5	<5	<5	<5	5
Zinc (Zn)	µg/L	30	NA	<5	<5	16	18	11	7	9	11	13	<5	18	<5	<5	<5	5	<5	<5	6	<5	<5	<5	<5	6
Zirconium (Zr)	µg/L		NA	<0.5	<0.5	1.1	0.8	1	0.8	<0.5	<0.5	<0.5	<0.5	1.1	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	<0.5	<0.5	0.6
Phosphorus-P (Dissolved)	µg/L		34	960	241	182	370	184	192	64	39	35	34	960	104	430	255	255	372	137	325	115	138	160	104	430

Legend

NA = not applicable. Water sample from Chironomid test (Control - Initial) was not filtered and preserved at time of sampling; sample was analysed for total metals and hardness (see original lab report) but results not comparable to dissolved data.

Concentration above CCME WQG 🟨

Table 4. Summary of Sediment Toxicity Test Results and Associated Water Quality Data

A. Sediment Toxicity Test Results - *Hyalella azteca*

Sample ID	Survival (%)		Dry Weight (mg/ind)		Total Ammonia (mg/L)			Sulphide (mg/L)		Hardness (mg/L CaCO3)		Alkalinity (mg/L CaCO3)		pH		Conductivity (µS/cm)	
	Mean	**SD**	**Mean**	**SD**	**Interstitial**	**Day 0**	**Day 14**	**Interstitial**	**Day 0**	**Day 0**	**Day 14**	**Day 0**	**Day 14**	**Day 0**	**Day 14**	**Day 0**	**Day 14**
Sludge	12	4	0.13	0.05	0.62	3.76	3.79	27.3	0.032	120	425	80	40	6.6	6.7	667	836
NI-1	36	18	0.10	0.02	1.35	3.37	2.83	<0.005	0.009	250	425	>240	240	7.9	6.9	787	1085
NI-2	30	10	0.09	0.03	1.81	3.13	<0.05	<0.005	0.006	250	425	>240	240	8	7.1	764	1089
NI-3	18	8	0.10	0.03	1.8	3.48	<0.05	<0.005	0.009	425	425	>240	240	8.2	7.1	710	942
NI-4	22	18	0.06	0.04	3.21	<0.05	<0.05	0.047	0.005	250	425	180	120	8	7.1	649	900
NI-5	80	10	0.12	0.03	3.51	2.07	<0.05	0.007	0.006	250	425	240	120	7.9	7.1	619	816
REF-1	74	18	0.20	0.03	0.49	<0.05	0.47	0.01	0.006	120	425	66	66	7.9	7.1	354	662
REF-2	66	36	0.15	0.02	0.4	0.18	2.48	0.006	0.005	120	425	66	66	7.7	6.7	371	637
REF-3	64	17	0.09	0.02	0.35	0.23	1.93	0.007	<0.005	250	425	66	66	7.5	6.5	354	662
Control	94	5	0.21	0.03	0.1	<0.05	0.32	NM	<0.005	250	425	80	120	7.6	6.9	343	958

B. Sediment Toxicity Test Results - *Chironomus tentans*

Sample ID	Survival (%)		Dry Weight (mg/ind)		Total Ammonia (mg/L)			Sulphide (mg/L)		Hardness (mg/L CaCO3)		Alkalinity (mg/L CaCO3)		pH		Conductivity (µS/cm)	
	Mean	**SD**	**Mean**	**SD**	**Interstitial**	**Day 0**	**Day 10**	**Interstitial**	**Day 0**	**Day 0**	**Day 10**	**Day 0**	**Day 10**	**Day 0**	**Day 10**	**Day 0**	**Day 10**
Sludge	10	10	0.65	0.29	0.62	3.72	3.59	27.3	0.029	250	425	240	>240	7.7	7	598	632
NI-1	48	27	0.43	0.20	1.35	3.43	2.83	<0.005	0.015	250	425	240	>240	8.1	8.4	640	554
NI-2	54	22	0.48	0.25	1.81	3.39	1.25	<0.005	0.006	250	425	>240	>240	8.2	8.2	690	570
NI-3	48	16	0.30	0.10	1.8	3.33	2.3	<0.005	0.01	250	425	>240	>240	8.3	8.3	684	571
NI-4	42	20	0.41	0.29	3.21	0.61	0.1	0.047	<0.005	250	425	>240	>240	8.2	8.3	565	586
NI-5	70	19	1.42	0.44	3.51	2.28	0.09	0.007	<0.005	250	425	>240	>240	8.1	7.7	547	547
REF-1	46	17	2.22	0.30	0.49	0.14	1.9	0.01	<0.005	120	100	40	80	8.2	7.9	253	339
REF-2	60	19	2.02	0.29	0.4	0.18	2.48	0.006	<0.005	120	100	80	80	7.9	7.3	257	292
REF-3	56	9	1.66	0.34	0.35	0.17	2.52	0.007	<0.005	120	100	40	80	7.8	7.4	598	632
Control	82	8	2.71	0.47	0.1	0.16	1.52	NM	<0.005	>425	425	>180	>240	7.9	8.3	485	541

Table 5. Summary of Benthic Invertebrate Taxonomy Results

A. Total Density (no./m^2) - Benthic and Non-benthic Taxa

Rep	NI-1	NI-2	NI-3	NI-4	NI-5	NI-5 (excluding Tubificidae)	REF-1	REF-2	REF-3
A	1,164	259	517	345	71,595	0	3,147	2,716	1,336
B	0	259	86	991	3,190	3,190	1,121	733	2,974
C	345	43	43	431	948	948	4,612	991	3,793
D	43	216	43	1,078	1,422	1,422	3,017	948	3,922
E	474	216	388	1,078	62,672	0	12,155	259	2,802
Mean	405	198	216	784	27,966	1,112	4,810	1,129	2,966
SD	469	89	222	365	35,904	1,315	4,289	933	1,035

B. Total Density (no./m^2) - Benthic Taxa Only

Rep	NI-1	NI-2	NI-3	NI-4	NI-5	NI-5 (excluding Tubificidae)	REF-1	REF-2	REF-3
A	86	43	43	86	71,466	0	3,103	2,586	1,293
B	0	43	43	43	2,457	2,457	1,034	690	2,759
C	172	0	0	0	733	733	4,483	991	3,319
D	43	0	0	172	1,422	1,422	2,845	733	3,405
E	43	0	0	86	62,543	0	11,897	259	2,716
Mean	69	17	17	78	27,724	922	4,672	1,052	2,698
SD	65	24	24	64	36,001	1,042	4,221	897	846

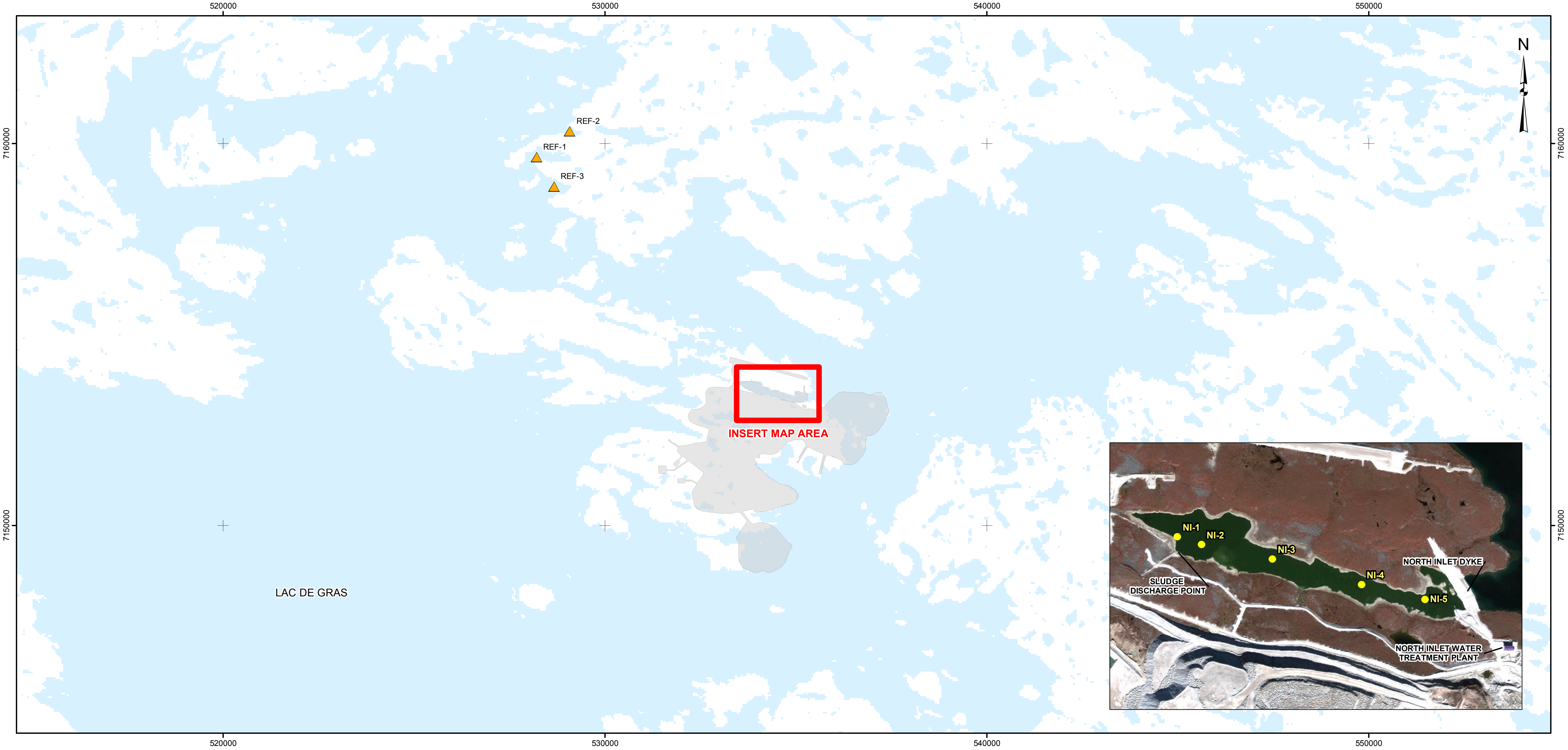
C. Taxa Richness (taxa/0.023 m2 grab) - Benthic Taxa Only

Rep	NI-1	NI-2	NI-3	NI-4	NI-5	NI-5 (excluding Tubificidae)	REF-1	REF-2	REF-3
A	2	1	1	2	1	0	13	14	10
B	0	1	1	1	3	3	8	8	10
C	4	0	0	0	1	1	13	8	10
D	1	0	0	2	2	2	13	9	11
E	1	0	0	1	1	0	19	4	6
Mean	1.6	0.4	0.4	1.2	1.6	1.2	13.2	8.6	9.4
SD	1.5	0.5	0.5	0.8	0.9	1.3	3.9	3.6	1.9
Station Total	6	2	1	3	3	3	23	18	16

D. Total Biomass (mg/0.023 m^2 grab) - All Taxa

Rep	NI-1	NI-2	NI-3	NI-4	NI-5	NI-5 (excluding Tubificidae)	REF-1	REF-2	REF-3
A	2.0	0.5	1.2	2.7	2128.1	0	128.1	38.8	85.0
B	0.0	1.1	2.6	4.2	61.4	61.4	17.2	32.6	47.9
C	5.2	0.1	0.1	0.6	12.8	12.8	33.7	10.2	102.4
D	2.6	0.8	0.1	4.6	56.0	56.0	29.4	25.7	26.7
E	0.9	0.2	2.8	2.7	1833.8	0	61.6	53.0	20.8
Mean	2.1	0.5	1.3	3.0	818.4	26.0	54.0	32.1	56.6
SD	2.0	0.4	1.3	1.6	1066.5	30.3	44.5	15.8	35.9
Station Total	10.7	2.7	6.7	14.8	4092	130	270	160	283

N:\Bur-Graphics\Projects\2010\1328\10-1328-0028\GIS\projects\figure-01_sample-locations-north-inlet.mxd



2.5 0 2.5
SCALE 1:100,000 KILOMETRES

LEGEND

- ▲ Reference Area
- ▨ Predicted Diavik Footprint
- 🟦 Waterbody

Station	Easting	Northing
NI-1	533797	7153657
NI-2	533923	7153618
NI-3	534295	7153541
NI-4	534761	7153408
NI-5	535093	7153329
REF-1	528209	7159644
REF-2	529076	7160323
REF-3	528669	7158872

DRAFT

REFERENCE

Orthophoto obtained from Google Earth, 2009.
Projection: UTM Zone 12 Datum: NAD 83

PROJECT
DIAVIK
DIAMOND MINES INC.

TITLE
SAMPLING LOCATIONS FOR NORTH INLET AND LAC DE GRAS REFERENCE STATIONS

Golder Associates
Greater Vancouver Office, B.C.

PROJECT NO. 10-1328-0028			PHASE No. 7000/7300	
DESIGN	CM	10 Nov. 2010	SCALE AS SHOWN	REV. 0
GIS	CDB	10 Nov. 2010	FIGURE 1	
CHECK				
REVIEW				

APPENDIX A

Field Records

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID: ~~[illegible]~~ NI-1

Date: SEPT 1/2010

Start Time: 3:08 pm

Stop Time: 5:25

GPS (NAD83): 533797 ~~[illegible]~~ 7153657 UTM ZONE 12

Water Depth: 12m

Weather: SUN + MODERATE BREEZE

Sample Collection Gear: EKMAN + KB CORER

Sampled By: TWJ + DARCY (DDMI

Sediment Characteristics

Colour: DARK GREY

Odour: MODERATE AMMONIA(?)

Grain Size: SILT/CLAY

Benthos: OBSERVED AMPHIPODS + SMALL WORMS

Debris: NONE

Vis Contam: NONE

Redox Depth: UNKNOWN

Other

Photos Taken PHOTO 1] GRAB CHARACTERISTICS
PHOTO 2]

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	YES	YES	Yes	2010.09.06
Toxicity	YES	YES	Yes	2010.09.06
Benthic Taxonomy	YES	~~[illegible]~~ Yes	Yes	2010.09.06
Subsurface Chem-Top	Yes (Dark-Moist Loose.)	yes	Yes	2010.09.06
Subsurface Chem-Mid	Yes	yes	Yes	2010.09.06
Subsurface Chem-Bot	Yes Silt/Clay/Grey	yes	Yes	2010.09.06

Photos Taken Sediment have high water content.

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: [✓ yes] no

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID) FIELD REPLICATE

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate	YES	YES	Yes	2010.09.06

Notes

CORE 1: ~~3~~ 44cm PENETRATION : PHOTO 3

CORE 2: 46cm PENETRATION : PHOTO 4

CORE 3: 36cm PENETRATION : PHOTO 5 + 23cm DARK LOOSE LAYER AT SURFACE

Sample Checklist

Surface Chemistry **Composite of 5 grabs at each station**

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☑ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity **5 replicate grabs from each station**

☑ toxicity = 5x500m glass

Benthos **5 replicate grabs from each station**

☐ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry **Composites of at least 2 cores per station** USE 125ml GLASS

NI only

Surface (0-5 cm)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Middle (5 cm from middle)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Bottom (5 cm from bottom)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Reference Sediment **Collect Additional Sediment at One Reference Station**

☐ Additional Reference Sediment for Kimberlite Study = 5L

- MODERATE AMMONIA(?) ODOUR IN TOXICITY GRABS

- FIELD REPLICATE DONE AT THIS STATION
  = 5 NEW GRABS AND COMPOSITE FOR CHEMISTRY
  ANALYSES.

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID: [redacted] NI-2
Date: SEPT 1/2010
Start Time: 1230pm
Stop Time: 3pm
GPS (NAD83): 0533923 7153618 UTM ZONE 12
Water Depth: 13 m
Weather: SUN + MODERATE BREEZE
Sample Collection Gear: EKMAN + KB CORER
Sampled By: PWS + DARCY (DDMI)

Sediment Characteristics

Colour: DARK+LIGHT GRAY
Odour: NO SULPHIDE ODOUR
Grain Size: SILT + CLAY
Benthos: NONE OBSERVED
Debris: NONE
Vis Contam: NONE
Redox Depth: UNABLE TO TELL
Other

Photos Taken: PHOTO 1 (FOLLOWING TRANSECT PHOTOS) = COMPOSITE
PHOTO 2 = INLET OF SLUDGE SLURRY TO NI

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	YES	YES	Yes	2010.09.06
Toxicity	YES	YES	Yes	2010.09.06
Benthic Taxonomy	YES (X5)	Yes	Yes	2010.09.06
Subsurface Chem-Top	YES - DARK + MOIST/LOOSE	YES	Yes	2010.09.06
Subsurface Chem-Mid	YES	YES	Yes	2010.09.06
Subsurface Chem-Bot	SILT/GRAY/GRAY	YES	Yes	2010.09.06

Photos Taken: SEDIMENTS HAVE HIGH WATER CONTENT ~~BUT~~ AND
FINE GRAIN SIZE

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

CORE 1 = 57cm PENETRATION : PHOTO 3
CORE 2 = 51cm PENETRATION : PHOTO 4 / ~5cm OF DARKER UNCONSOLIDATED MATERIAL AT SURFACE
CORE 3 = 56cm PENETRATION : PHOTO 5 / ~7cm OF DARKER LOOSE MATERIAL AT SURFACE
PHOTO 6 -

Sample Checklist

Surface Chemistry — **Composite of 5 grabs at each station**

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☑ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity — **5 replicate grabs from each station**

☑ toxicity = 5x500m glass

Benthos — **5 replicate grabs from each station**

☐ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry — **Composites of at least 2 cores per station** [illegible]

NI only

Surface (0-5 cm)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Middle (5 cm from middle)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☐ particle size = 1x1L whirlpack bag

Bottom (5 cm from bottom)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Reference Sediment — **Collect Additional Sediment at One Reference Station**

☐ Additional Reference Sediment for Kimberlite Study = 5L

- MODERATE AMMONIA(?) ODOUR IN SURFACE CORE COMPOSITE

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID:	NI-3	Date:	2010.09.03
Start Time:	09:20	Stop Time:	11:20
GPS (NAD83):	0534295	7153541	UTM 12
Water Depth:	11m	Weather:	

Sample Collection Gear: Ekman dredge + KB corer

Sampled By: Darcy B, James M

Sediment Characteristics

Colour:	Dark + Light grey	Odour:	No Sulphide Odor
Grain Size:	Silt + Clay	Benthos:	None Observed
Debris:	None	Vis Contam:	None
Redox Depth:	unable to tell		

Other

Photos Taken

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	Yes	Yes	Yes	2010.09.06
Toxicity	Yes	Yes	Yes	2010.09.06
Benthic Taxonomy	Yes (x5)	Yes	Yes	2010.09.06
Subsurface Chem-Top	Yes - Moist - Dark	Yes	Yes	2010.09.06
Subsurface Chem-Mid	Yes	Yes	Yes	2010.09.06
Subsurface Chem-Bot	Silt/Gray/Gray	Yes	Yes	2010.09.06

Photos Taken Sediment has high water content

Grain size is small.

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

Core 1: 47cm Penetration : Photo 1 - 3 cm of dark loose material @surfa

Core 2: 50cm Penetration : Photo 2 -4 cm of dark lose material @surfa

Core 3: 51 cm Penetration = Photo 3 -4cm of dark lose material @ surfa

Sample Checklist

Surface Chemistry

Composite of 5 grabs at each station

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☑ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity

5 replicate grabs from each station

☑ toxicity = 5x500m glass

Benthos

5 replicate grabs from each station

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry

NI only

Composites of at least 2 cores per station

USE 125 ml GLASS

Surface (0-5 cm)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Middle (5 cm from middle)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Bottom (5 cm from bottom)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Reference Sediment

Collect Additional Sediment at One Reference Station

☐ Additional Reference Sediment for Kimberlite Study = 5L

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID:	NI-4	Date:	2010.09.03
Start Time:	12:01	Stop Time:	13:37
GPS (NAD83):	0534761 -7153408		
Water Depth:	8.2 m	Weather:	

Sample Collection Gear: Ekman + KB Corer

Sampled By: DB / JM

Sediment Characteristics

Colour:	Dark + light Gray	Odour:	No ODOUR
Grain Size:	Silt + Clay	Benthos:	NO OBS
Debris:	None	Vis Contam:	NONE
Redox Depth:	Unknown		

Other

Photos Taken

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	Yes	Yes	Yes	2010.09.06
Toxicity	Yes	Yes	Yes	2010.09.06
Benthic Taxonomy	Yes (x5)	Yes	Yes	2010-09.06
Subsurface Chem-Top	Yes (moist-dark)	Yes	Yes	2010.09.06
Subsurface Chem-Mid	Yes	Yes	Yes	2010.09.06
Subsurface Chem-Bot	Silt/Gray/Gray	Yes	Yes	2010.09.06

Photos Taken

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Core 1 : 43cm Penetration - Photo 4 **Notes** ~3 cm of dark loose material @ surface

Core 2 = 48cm Penetration - Photo 5 ~3 cm of dark loose material @ surface

Core 3 - 41cm Penetration Photo 6 ~4 cm of dark loose material @ surface

Site was moved (20 m east of Map coordinates. Depth was not good.

Sample Checklist

Surface Chemistry — Composite of 5 grabs at each station

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☑ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity — 5 replicate grabs from each station

☑ toxicity = 5x500m glass

Benthos — 5 replicate grabs from each station

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry — Composites of at least 2 cores per station

use 125 ml GLASS

NI only

Surface (0-5 cm)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Middle (5 cm from middle)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Bottom (5 cm from bottom)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Reference Sediment — Collect Additional Sediment at One Reference Station

☐ Additional Reference Sediment for Kimberlite Study = 5L

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID:	NI-5	Date:	2010.09.03
Start Time:	13:56	Stop Time:	15:39
GPS (NAD83):	0535093 7153329		
Water Depth:	10 m	Weather:	
Sample Collection Gear:	Ekman + KB corer		
Sampled By:	Dorey + James		

Sediment Characteristics

Colour:	Dark + light Gray	Odour:	None Sulphide odor
Grain Size:	Silt + clay + [illegible]	Benthos:	None observed
Debris:	None	Vis Contam:	None
Redox Depth:	Unable to tell		
Other			
Photos Taken			

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	Yes	Yes	Yes	2010.09.06
Toxicity	Yes	Yes	Yes	2010.09.06
Benthic Taxonomy	Yes (x5)	Yes	Yes	2010.09.06
Subsurface Chem-Top	Yes - moist - dark	Yes	Yes	2010.09.06
Subsurface Chem-Mid	Yes	Yes	Yes	2010.09.06
Subsurface Chem-Bot	Silt - gray - sandy	Yes	Yes	2010.09.06

Photos Taken

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

Core #1 = 36 cm - 1cm of dark loose material @ top Photo 7

Core #2 = 33 cm - 1cm of dark loose material @ ~~top~~surface Photo 8

Core #3 = 35 cm -1cm of dark loose material @ surface Photo 9

Sample Checklist

Surface Chemistry

Composite of 5 grabs at each station

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☑ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity

5 replicate grabs from each station

☑ toxicity = 5x500m glass

Benthos

5 replicate grabs from each station

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry
NI only

Composites of at least 2 cores per station use 125 ml Glass

Surface (0-5 cm)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Middle (5 cm from middle)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Bottom (5 cm from bottom)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ ~~backup = 1x250ml glass~~
☑ particle size = 1x1L whirlpack bag

Reference Sediment

Collect Additional Sediment at One Reference Station

☐ Additional Reference Sediment for Kimberlite Study = 5L

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID: REF-1
Date: SEPT 2/2010
Start Time: 1130 pm
Stop Time: 1230 pm
GPS (NAD83): 528209 7159644 (UTM ZONE 12)
Water Depth: 10 m
Weather: SUN/CLEAR + MODERATE BREEZE
Sample Collection Gear: EKMAN GRAB
Sampled By: TRNS / DARCY (DDMI)

Sediment Characteristics

Colour: BROWN SURFACE + GREY
Odour: NONE
Grain Size: MOSTLY FINES + CLAY
Benthos: NONE OBSERVED
Debris: NONE
Vis Contam: NONE
Redox Depth: UNKNOWN
Other

Photos Taken: PHOTO 1 = GRAB CONDITIONS

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	YES (BUT NO ARCHIVE FORM) COMPOSITE	YES	Yes	2010.09.06
Toxicity	YES	YES	Yes	2010.09.06
Benthic Taxonomy	YES	Yes	Yes	2010.09.06
~~Subsurface Chem-Top~~				
~~Subsurface Chem-Mid~~				
~~Subsurface Chem-Bot~~				

Photos Taken

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

THIN SURFACE LAYER OF BROWN FINE SAND OVERLYING MEDIUM GREY SILT/CLAY

* Location was moved because of wx constraints + Logistical constraints. DB.

Sample Checklist

Surface Chemistry — **Composite of 5 grabs at each station**

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ backup = 1x250ml glass NO (NOT ENOUGH SEDIMENT)
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity — **5 replicate grabs from each station**

☑ toxicity = 5x500m glass

Benthos — **5 replicate grabs from each station**

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin) (NEED TO BE SIEVED)

Subsurface Chemistry — **~~Composites of at least 2 cores per station~~**

NI only

~~*Surface (0-5 cm)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~*Middle (5 cm from middle)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~*Bottom (5 cm from bottom)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

Reference Sediment — **Collect Additional Sediment at One Reference Station**

☐ Additional Reference Sediment for Kimberlite Study = 5L

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID:	REF-2	Date:	2010. 09. 04
Start Time:	15:15	Stop Time:	16:45
GPS (NAD83):	0529076	7160323	UTM 12
Water Depth:	9.5	Weather:	

Sample Collection Gear: Ekman 4+

Sampled By: James (DDMI), Dary (AMI)

Sediment Characteristics

Colour:	Brown surface - gray	Odour:	None
Grain Size:	mostly fine; silts/clays	Benthos:	None Observed
Debris:	None	Vis Contam:	None
Redox Depth:	Unknown		

Other

Photos Taken

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	Yes	Yes	Yes	2010.09.06
Toxicity	Yes	Yes	Yes	2010.09.06
Benthic Taxonomy	Yes	Yes	Yes	2010.09.06
Subsurface Chem-Top				
Subsurface Chem-Mid				
Subsurface Chem-Bot				

Photos Taken

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

Extra Grabs for Kimberlite toxicity was completed @ this site

Sample Checklist

Surface Chemistry **Composite of 5 grabs at each station**

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ backup = 1x250ml glass (not enough sediment in composite)
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity **5 replicate grabs from each station**

☑ toxicity = 5x500m glass

Benthos **5 replicate grabs from each station**

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry **Composites of at least 2 cores per station**

NI only

~~*Surface (0-5 cm)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~*Middle (5 cm from middle)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~*Bottom (5 cm from bottom)*~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

Reference Sediment **Collect Additional Sediment at One Reference Station**

☑ Additional Reference Sediment for Kimberlite Study = 5L

DIAVIK NORTH INLET SEDIMENT QUALITY (10-1328-0028/7000/7200)

Station Information

Station ID:	Ref-3	Date:	2010.09.04
Start Time:	16:03	Stop Time:	16:42
GPS (NAD83):	0528669 7158872		
Water Depth:	11 m	Weather:	
Sample Collection Gear:	Ekman Dredge		
Sampled By:	James / Davy		

Sediment Characteristics

Colour:	brown surface + grey.	Odour:	None
Grain Size:	Mostly clay + silt sand sand	Benthos:	None Observed
Debris:	None	Vis Contam:	None
Redox Depth:	Unknown		
Other			
Photos Taken			

Sample Processing Record

Type	Collected	Processed	Checked on COC	Shipped
Surface Chemistry	Yes (no archive from composite)	Yes	Yes	2010.09.06
Toxicity	Yes	Yes	Yes	2010.09.06
Benthic Taxonomy	Yes	Yes	Yes	2010.09.06
Subsurface Chem-Top				
Subsurface Chem-Mid				
Subsurface Chem-Bot				

Photos Taken

Quality Control Samples Collected (Chemistry Only)

Field Duplicate: yes [✓ no]

Duplicate is composite from 5 new grabs

(if yes, assign Sample ID)

Analyze for: Surface Chemistry parameters only

Type	Collected	Processed	Checked on COC	Shipped
Duplicate				

Notes

Not enough sample to fill archive from composite

*Reference

Sample Checklist

Surface Chemistry — **Composite of 5 grabs at each station**

(composite remaining sediment after toxicity sample removed)

☑ AVS-SEM = 1x250ml glass
☑ metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass
☐ backup = 1x250ml glass
☑ particle size = 1x1L whirlpack bag
☑ ammonia analysis = 1x500ml glass (during toxicity testing)

Toxicity — **5 replicate grabs from each station**

☑ toxicity = 5x500m glass

Benthos — **5 replicate grabs from each station**

☑ benthos = 5x1L plastic (500 micron sieve, preserve in 10% formalin)

Subsurface Chemistry — **Composites of at least 2 cores per station**

NI only

~~***Surface (0-5 cm)***~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~***Middle (5 cm from middle)***~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

~~***Bottom (5 cm from bottom)***~~
☐ ~~AVS-SEM = 1x250ml glass~~
☐ ~~metals, TOC, total phosphorus, reagents, and moisture content = 1x250ml glass~~
☐ ~~backup = 1x250ml glass~~
☐ ~~particle size = 1x1L whirlpack bag~~

Reference Sediment — **Collect Additional Sediment at One Reference Station**

☐ Additional Reference Sediment for Kimberlite Study = 5L

Figure 1: First discharge pipe to North Inlet from direction of NIWTP. Discharge water appears to contain light brown / grey suspended solids that settle out onto bottom sediment once discharge enters North Inlet. UTM coordinates (UTM Zone 12): 533749 easting, 7153478 northing.

Figure 2: Overland flow from first discharge pipe to North Inlet.

Figure 3: Suspended solids at point where first discharge enters North Inlet. Very fine sediment suspended in water and on bottom surface. UTM coordinates (UTM Zone 12): 533789 easting, 7153560 northing.

Figure 4: Second discharge pipe to North Inlet from direction of NIWTP. Discharge water contains green suspended material, presumed to be algae. UTM coordinates (UTM Zone 12): 533672 easting, 7153536 northing.

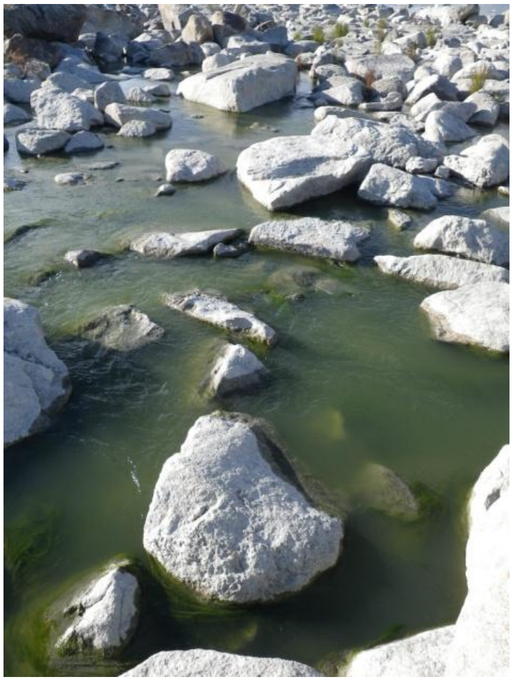


Figure 5: Algae present in overland flow from second discharge pipe; green material settles out as discharge flows overland.

Figure 6: Fine material and algae setting out at point where second discharge enters North Inlet. UTM coordinates (UTM Zone 12): 533719 easting, 7153610 northing.

Figure 7: North Inlet reconnaissance: grab at transect location 1. Grab collected west of Station NI-1. Green/black algae and slime layer overlying very fine silt and clay. UTM coordinates (UTM Zone 12): 533617 easting, 7153717 northing.

Figure 8: North Inlet reconnaissance: grab at transect location 2. Grab collected west of Station NI-1. Black/green slime layer approximately 2 cm thick overlying grey and brown silt and clay. UTM coordinates (UTM Zone 12): 533717 easting, 7153704 northing.

Figure 9: North Inlet reconnaissance: grab at transect location 3. Grab collected near Station NI-1. Black/green layer (1 to 2 cm thick) overlying grey silt/clay; high water content in upper layer. UTM coordinates (UTM Zone 12): 533806 easting, 7153649 northing.

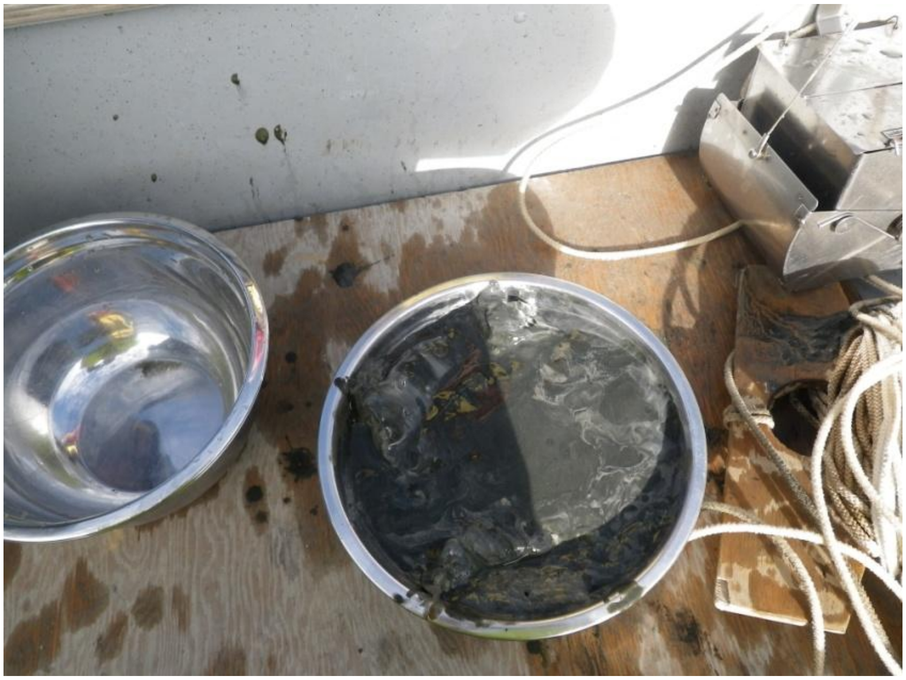


Figure 10: North Inlet reconnaissance: grab at transect location 4. Grab collected between Stations NI-1 and NI-2. Black/green layer (1 to 2 cm thick) overlying grey silt/clay; high water content in upper layer. UTM coordinates (UTM Zone 12): 533876 easting, 7153586 northing.

Figure 11: North Inlet reconnaissance: grab at transect location 5. Grab collected at east end of North Inlet near Station NI-5. Grey sediments (silt and clay) with thin brown surface layer; sediments more consolidated than at transect locations 1 to 4, with less moisture. Lower grab penetration. UTM coordinates (UTM Zone 12): 535063 easting, 7153300 northing.

Figure 12: North Inlet reconnaissance: grab at transect location 6. Grab collected between Stations NI-2 and NI-5. UTM coordinates and grab description not available.

Figure 13: North Inlet reconnaissance: grab at transect location 7. Grab collected between Stations NI-2 and NI-5. UTM coordinates and grab description not available.

Figure 14: North Inlet reconnaissance: grab at transect location 8. Grab collected between Stations NI-2 and NI-5. UTM coordinates and grab description not available.

Figure 15: Station NI-1 sediment grab collected for toxicity testing. Dark unconsolidated sediment with greenish tinge (possibly algae) overlying grey sediment.

Figure 16: Station NI-1, first sediment core sample. Penetration depth: 44 cm.

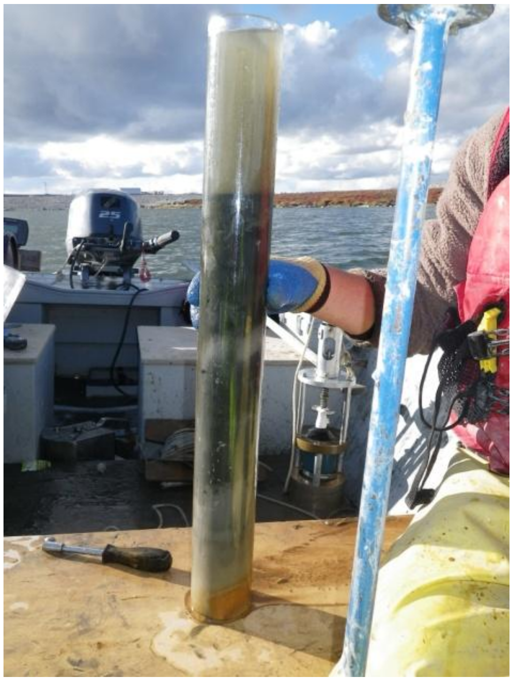


Figure 17: Station NI-1, second sediment core sample. Penetration depth: 46 cm.

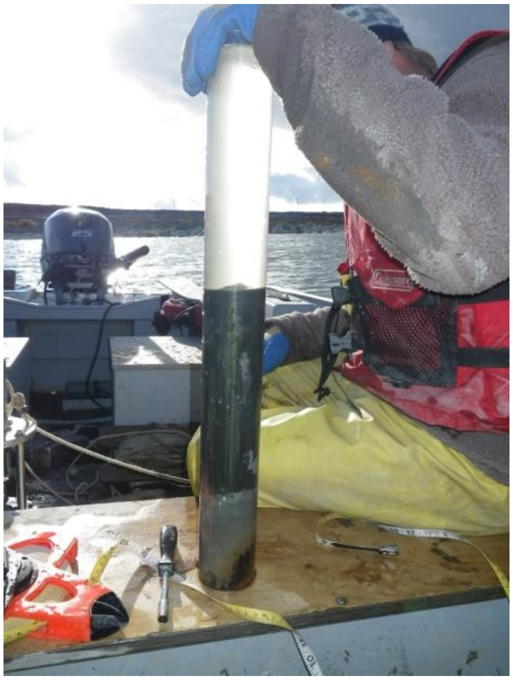


Figure 18: Station NI-1, third sediment core sample. Penetration depth: 36 cm. Approximately 23 cm of darker loose layer at sediment surface.

Figure 19: Station NI-2. Homogenized composite from sediment grab samples. Sediments have high water content; fine grain size; mixture of silt and clay, with dark layer overlying medium grey sediments.

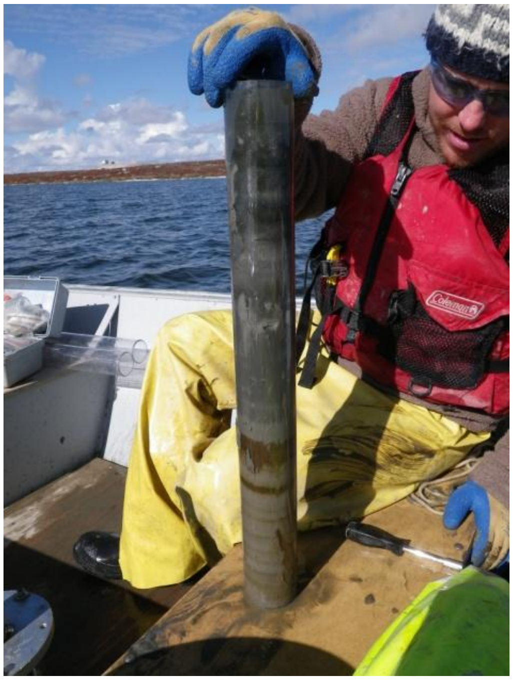


Figure 20: Station NI-2, first sediment core sample. Penetration depth: 57 cm.

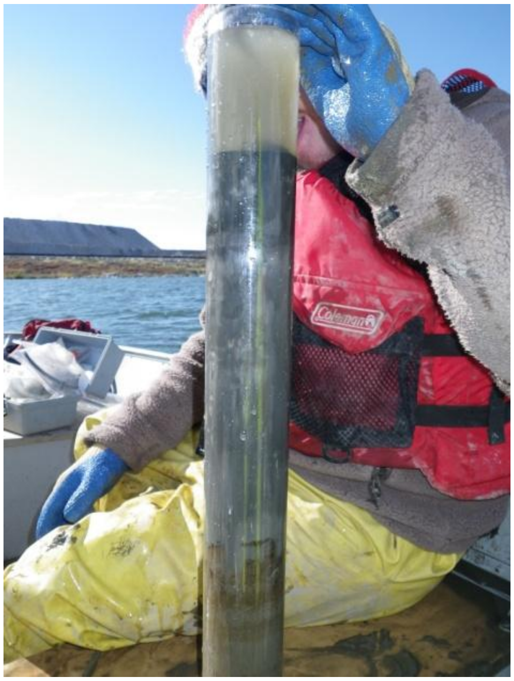


Figure 21: Station NI-2, second sediment core sample. Penetration depth: 51 cm. Approximately 5 cm of darker unconsolidated material at surface.

Figure 22: Station NI-2, third sediment core sample. Penetration depth: 56 cm. Approximately 7 cm of darker loose material at surface.

Figure 23: Station REF-1. Thin layer of brown sand overlying light grey silt/clay. Multiple exploratory grabs were collected near this station, and all had similar characteristics.

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APPENDIX B

Laboratory Report - Sediment and Sludge Chemistry (Maxxam Analytics)

Maxxam

Success Through Science®

Your P.O. #: 10-1328-0028/700
Your Project #: DIAVIK NORTH INLET
Your C.O.C. #: 5455, 5452, 5451

Attention: Ryan Stevenson
GOLDER ASSOCIATES LTD
4260 STILL CREEK DRIVE
Suite 500
BURNABY, BC
Canada V5C 6C6

Report Date: 2010/11/03
This report supersedes all previous reports with the same Maxxam job number

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B082579
Received: 2010/09/08, 09:30

Sample Matrix: Soil
Samples Received: 27

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	11	2010/09/17	2010/09/17	BRN SOP-00203 R5.0	Based on EPA 200.8
Elements by ICPMS (total)	13	2010/09/18	2010/09/20	BRN SOP-00203 R5.0	Based on EPA 200.8
Simultaneously Extractable Metals-ICPMS	24	2010/09/20	2010/09/20	BRN SOP-00203 5.0	Based on EPA 200.8
Moisture	24	N/A	2010/09/22	BRN SOP-00321 R5.0	Ont MOE -E 3139
pH (2:1 DI Water Extract)	11	2010/09/17	2010/09/17	BRN SOP-00266 R6.0	Carter, SSMA 16.2
pH (2:1 DI Water Extract)	13	2010/09/18	2010/09/20	BRN SOP-00266 R6.0	Carter, SSMA 16.2
Available Phosphate	24	2010/09/20	2010/09/20	BRN SOP-00235 R5.0	SM SECTION 4500 PE
Sulfide (AVS) (soil) - Calc for umole/g	13	2010/09/10	2010/09/22	BRN SOP-00229 R2.0	Based EPA821-R91-100
Sulfide (AVS) (soil) - Calc for umole/g	11	2010/09/16	2010/09/22	BRN SOP-00229 R2.0	Based EPA821-R91-100
Sulfide (AVS) (soil)	24	2010/09/20	2010/09/20	BRN SOP-00229 R2.0	Based EPA821-R91-100
Texture by Hydrometer, incl Gravel (Wet) (1)	23	2010/09/20	2010/09/21	EENVSOP-00076	MMFSPA Ch9
Texture by Hydrometer, incl Gravel (Wet) (1)	1	2010/10/13	2010/10/13	EENVSOP-00076	MMFSPA Ch9

* Results relate only to the items tested.

(1) This test was performed by Maxxam Edmonton Environmental

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VJ OCO, Burnaby Customer Service
Email: VOco@maxxam.ca
Phone# (604) 639-8422

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		W82387		W82388			W82389	W82390		W82391		W82392		
Sampling Date		2010/09/01		2010/09/01			2010/09/03	2010/09/03		2010/09/03		2010/09/03		
	Units	**NI-2 BOTTOM**	**RDL**	**FIELD REPLICATE**	**RDL**	**QC Batch**	**NI-3**	**NI-3**	**RDL**	**NI-3 SURFACE**	**RDL**	**NI-3 MIDDLE**	**RDL**	**QC Batch**
Calculated Parameters														
Sulphide	umole/g	0.031	0.007	0.56	0.09	4256070	0.79		0.02	0.33	0.02	0.05	0.02	4266646
MISCELLANEOUS														
Sulphide	ug/g	1.0(1)	0.2	18	3	4273873	25.3		0.6	10.6	0.7	1.7(1)	0.6	4273873
Nutrients														
Available (KCl) Orthophosphate (P)	ug/g	61.2	0.5	60.9	0.5	4273892	60.9		0.5	75.8	0.5	91.3	0.5	4273892
Physical Properties														
% sand by hydrometer	%	27	2	50	2	4275367		3	2			<2	2	4275367
% silt by hydrometer	%	64	2	43	2	4275367		77	2			68	2	4275367
Clay Content	%	9	2	8	2	4275367		20	2			30	2	4275367
Gravel	%	<2	2	<2	2	4275367		<2	2			<2	2	4275367

Maxxam ID		W82393		W82394		W82395			W82396		W82419		
Sampling Date		2010/09/03		2010/09/03		2010/09/03			2010/09/03		2010/09/03		
	Units	**NI-3 BOTTOM**	**RDL**	**NI-4**	**RDL**	**NI-4 SURFACE**	**RDL**	**QC Batch**	**NI-4 MIDDLE**	**RDL**	**NI-4 BOTTOM**	**RDL**	**QC Batch**
Calculated Parameters													
Sulphide	umole/g	<0.01	0.01	0.37	0.02	0.14	0.01	4256070	0.05	0.02	<0.02	0.02	4266646
MISCELLANEOUS													
Sulphide	ug/g	<0.4(1)	0.4	11.7	0.5	4.5	0.4	4273873	1.5(1)	0.7	0.6(1)	0.6	4273873
Nutrients													
Available (KCl) Orthophosphate (P)	ug/g	68.2	0.5	71.0	0.5	79.5	0.5	4273892	77.7	0.5	72.7	0.5	4273892
Physical Properties													
% sand by hydrometer	%	<2	2	<2	2	32	2	4275367	68	2	58	2	4275367
% silt by hydrometer	%	77	2	79	2	49	2	4275367	28	2	36	2	4275367
Clay Content	%	21	2	20	2	19	2	4275367	4	2	6	2	4275367
Gravel	%	<2	2	<2	2	<2	2	4275367	<2	2	<2	2	4275367

RDL = Reportable Detection Limit
(1) - RDL raised due to sample dilution.

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		W82420			W82421			W82422	W82423		
Sampling Date		2010/09/03			2010/09/03			2010/09/03	2010/09/03		
	Units	**NI-5**	**RDL**	**QC Batch**	**NI-5 SURFACE**	**RDL**	**QC Batch**	**NI-5 MIDDLE**	**NI-5 BOTTOM**	**RDL**	**QC Batch**
Calculated Parameters											
Sulphide	umole/g	0.043	0.008	4256070	0.07	0.01	4266646	0.12	0.05	0.02	4256070
MISCELLANEOUS											
Sulphide	ug/g	1.4	0.3	4273873	2.1	0.4	4273873	4.0	1.7(1)	0.6	4273873
Nutrients											
Available (KCl) Orthophosphate (P)	ug/g	67.9	0.5	4273892	69.8	0.5	4273892	75.8	80.9	0.5	4273892
Physical Properties											
% sand by hydrometer	%	28	2	4275367	28	2	4275367	69	76	2	4275367
% silt by hydrometer	%	59	2	4275367	52	2	4275367	28	19	2	4275367
Clay Content	%	13	2	4275367	21	2	4275367	2	4	2	4275367
Gravel	%	<2	2	4275367	<2	2	4275367	<2	<2	2	4275367

Maxxam ID		W82424			W82425			W82426			W82440		
Sampling Date		2010/09/02			2010/09/04			2010/09/04			2010/09/01		
	Units	**REF-1**	**RDL**	**QC Batch**	**REF-2**	**RDL**	**QC Batch**	**REF-3**	**RDL**	**QC Batch**	**NI-1**	**RDL**	**QC Batch**
Calculated Parameters													
Sulphide	umole/g	<0.02	0.02	4266646	0.01	0.01	4256070	0.05	0.03	4266646	14.4	0.3	4256070
MISCELLANEOUS													
Sulphide	ug/g	<0.7(1)	0.7	4273873	0.5(1)	0.4	4273873	1.6(2)	0.8	4273873	461	10	4273873
Nutrients													
Available (KCl) Orthophosphate (P)	ug/g	68.3	0.5	4273892	68.0	0.5	4273892	67.4	0.5	4273892	67.0	0.5	4273892
Physical Properties													
% sand by hydrometer	%	7	2	4275367	21	2	4275367	31	2	4275367			
% silt by hydrometer	%	75	2	4275367	67	2	4275367	61	2	4275367			
Clay Content	%	18	2	4275367	11	2	4275367	8	2	4275367			
Gravel	%	<2	2	4275367	<2	2	4275367	<2	2	4275367			

RDL = Reportable Detection Limit
(1) - RDL raised due to sample dilution.
(2) - Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.
RDL raised due to sample dilution.

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		W82441			W82442		W82443		W82444		
Sampling Date		2010/09/01			2010/09/01		2010/09/01		2010/09/01		
	Units	**NI-1 SURFACE**	**RDL**	**QC Batch**	**NI-1 MIDDLE**	**RDL**	**NI-1 BOTTOM**	**RDL**	**NI-2**	**RDL**	**QC Batch**
Calculated Parameters											
Sulphide	umole/g	0.4	0.1	4266646	1.49	0.07	0.008	0.007	0.35	0.02	4256070
MISCELLANEOUS											
Sulphide	ug/g	14(1)	5	4273873	48	2	0.3(1)	0.2	11.2	0.7	4273873
Nutrients											
Available (KCl) Orthophosphate (P)	ug/g	70.4	0.5	4273892	77.4	0.5	72.9	0.5	70.8	0.5	4273892
Physical Properties											
% sand by hydrometer	%	87	2	4275367	5	2	22	2	2	2	4275727
% silt by hydrometer	%	11	2	4275367	72	2	68	2	78	2	4275727
Clay Content	%	<2	2	4275367	24	2	11	2	20	2	4275727
Gravel	%	<2	2	4275367	<2	2	<2	2	<2	2	4275727

Maxxam ID		W82446		W82447	W82448		X10994		
Sampling Date		2010/09/01		2010/09/01	2010/09/01		2010/09/03		
	Units	**NI-2 SURFACE**	**RDL**	**NI-2 MIDDLE**	**NI-1**	**QC Batch**	**NI-3 BOTTOM (B)**	**RDL**	**QC Batch**
Calculated Parameters									
Sulphide	umole/g	26.3	0.7	0.012		4266646		0.009	
MISCELLANEOUS									
Sulphide	ug/g	844	20	0.4(2)		4273873		0.3	
Nutrients									
Available (KCl) Orthophosphate (P)	ug/g	94.5	0.5	69.0		4273892		0.5	
Physical Properties									
% sand by hydrometer	%	42	2	26	44	4275727	22	2	4332191
% silt by hydrometer	%	46	2	59	49	4275727	69	2	4332191
Clay Content	%	12	2	15	7	4275727	9	2	4332191
Gravel	%	<2	2	<2	<2	4275727	<2	2	4332191

RDL = Reportable Detection Limit
(1) - RDL raised due to sample dilution.
(2) - Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.
RDL raised due to sample dilution.

PHYSICAL TESTING (SOIL)

Maxxam ID		W82387	W82388	W82389	W82391	W82392	W82393	W82394	W82395	W82396	W82419		
Sampling Date		2010/09/01	2010/09/01	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03		
	Units	**NI-2 BOTTOM**	**FIELD REPLICATE**	**NI-3**	**NI-3 SURFACE**	**NI-3 MIDDLE**	**NI-3 BOTTOM**	**NI-4**	**NI-4 SURFACE**	**NI-4 MIDDLE**	**NI-4 BOTTOM**	**RDL**	**QC Batch**
Physical Properties													
Moisture	%	43	94	71	77	68	68	70	69	78	66	0.3	4282662

Maxxam ID		W82420	W82421	W82422	W82423		W82424	W82425	W82426	W82440		
Sampling Date		2010/09/03	2010/09/03	2010/09/03	2010/09/03		2010/09/02	2010/09/04	2010/09/04	2010/09/01		
	Units	**NI-5**	**NI-5 SURFACE**	**NI-5 MIDDLE**	**NI-5 BOTTOM**	**QC Batch**	**REF-1**	**REF-2**	**REF-3**	**NI-1**	**RDL**	**QC Batch**
Physical Properties												
Moisture	%	40	59	73	74	4282662	74	68	78	78	0.3	4282769

Maxxam ID		W82441	W82442	W82443	W82444	W82446	W82447		
Sampling Date		2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01		
	Units	**NI-1 SURFACE**	**NI-1 MIDDLE**	**NI-1 BOTTOM**	**NI-2**	**NI-2 SURFACE**	**NI-2 MIDDLE**	**RDL**	**QC Batch**
Physical Properties									
Moisture	%	96	44	30	78	88	39	0.3	4282769

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		W82387	W82388	W82389	W82391	W82392	W82393	W82394	W82395	W82396		
Sampling Date		2010/09/01	2010/09/01	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03		
	Units	**NI-2 BOTTOM**	**FIELD REPLICATE**	**NI-3**	**NI-3 SURFACE**	**NI-3 MIDDLE**	**NI-3 BOTTOM**	**NI-4**	**NI-4 SURFACE**	**NI-4 MIDDLE**	**RDL**	**QC Batch**
SEM Metals by ICPMS												
SEM Cadmium (Cd)	umole/g	0.0010	0.0016	0.0014	0.0128	0.0031	0.0010	0.0005	0.0007	0.0062	0.0002	4275750
SEM Copper (Cu)	umole/g	0.263	0.283	0.317	0.693	0.915	0.267	0.120	0.161	1.21	0.004	4275750
SEM Lead (Pb)	umole/g	0.0107	0.0692	0.137	0.672	0.0912	0.0094	0.0493	0.0556	0.0299	0.0002	4275750
SEM Mercury (Hg)	umole/g	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.0003	4275750
SEM Nickel (Ni)	umole/g	0.362	3.12	2.00	2.08	6.12	0.271	0.923	1.15	1.93	0.004	4275750
SEM Zinc (Zn)	umole/g	0.524	0.979	1.47	2.39	0.982	0.502	0.564	0.633	2.18	0.008	4275750

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		W82419	W82420	W82421	W82422	W82423	W82424	W82425	W82426	W82440		
Sampling Date		2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/02	2010/09/04	2010/09/04	2010/09/01		
	Units	**NI-4 BOTTOM**	**NI-5**	**NI-5 SURFACE**	**NI-5 MIDDLE**	**NI-5 BOTTOM**	**REF-1**	**REF-2**	**REF-3**	**NI-1**	**RDL**	**QC Batch**
SEM Metals by ICPMS												
SEM Cadmium (Cd)	umole/g	0.0033	0.0007	0.0015	0.0007	0.0008	0.0014	0.0006	0.0021	0.0006	0.0002	4275750
SEM Copper (Cu)	umole/g	0.845	0.232	0.416	0.206	0.257	0.322	0.185	0.565	0.117	0.004	4275750
SEM Lead (Pb)	umole/g	0.0203	0.0792	0.134	0.0078	0.0078	0.0165	0.0080	0.0177	0.0371	0.0002	4275750
SEM Mercury (Hg)	umole/g	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.0003	4275750
SEM Nickel (Ni)	umole/g	1.53	0.504	1.19	0.192	0.241	0.578	0.335	1.01	1.19	0.004	4275750
SEM Zinc (Zn)	umole/g	1.55	0.802	1.30	0.311	0.403	0.632	0.438	0.996	0.525	0.008	4275750

Maxxam ID		W82441	W82442	W82443	W82444	W82446	W82447		
Sampling Date		2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01		
	Units	**NI-1 SURFACE**	**NI-1 MIDDLE**	**NI-1 BOTTOM**	**NI-2**	**NI-2 SURFACE**	**NI-2 MIDDLE**	**RDL**	**QC Batch**
SEM Metals by ICPMS									
SEM Cadmium (Cd)	umole/g	0.0012	0.0007	0.0004	0.0008	0.0005	0.0010	0.0002	4275750
SEM Copper (Cu)	umole/g	0.172	0.132	0.196	0.113	0.066	0.418	0.004	4275750
SEM Lead (Pb)	umole/g	0.0564	0.0409	0.0085	0.0346	0.0206	0.0263	0.0002	4275750
SEM Mercury (Hg)	umole/g	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	0.0003	4275750
SEM Nickel (Ni)	umole/g	3.71	1.31	0.229	1.51	0.781	0.579	0.004	4275750
SEM Zinc (Zn)	umole/g	0.488	0.492	0.332	0.464	0.320	0.687	0.008	4275750

RDL = Reportable Detection Limit

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		W82387	W82388	W82389	W82391	W82392	W82393	W82394		W82395		
Sampling Date		2010/09/01	2010/09/01	2010/09/03	2010/09/03	2010/09/03	2010/09/03	2010/09/03		2010/09/03		
	Units	**NI-2 BOTTOM**	**FIELD REPLICATE**	**NI-3**	**NI-3 SURFACE**	**NI-3 MIDDLE**	**NI-3 BOTTOM**	**NI-4**	**QC Batch**	**NI-4 SURFACE**	**RDL**	**QC Batch**
Physical Properties												
Soluble (2:1) pH	pH Units	5.74	8.00	8.34	8.20	8.13	6.38	7.56	4268744	7.99	0.01	4271680
Total Metals by ICPMS												
Total Aluminum (Al)	mg/kg	12700	31500	19900	20100	25100	15100	22100	4268700	23400	100	4271670
Total Antimony (Sb)	mg/kg	<0.1	0.3	0.3	0.3	0.2	<0.1	0.3	4268700	0.3	0.1	4271670
Total Arsenic (As)	mg/kg	13.4	20.1	2.9	3.5	13.0	31.9	7.1	4268700	6.4	0.2	4271670
Total Barium (Ba)	mg/kg	119	309	264	259	451	129	381	4268700	395	0.1	4271670
Total Beryllium (Be)	mg/kg	0.4	0.3	0.3	0.3	0.7	0.6	0.4	4268700	0.5	0.1	4271670
Total Bismuth (Bi)	mg/kg	0.3	0.8	1.0	1.0	1.7	0.4	1.2	4268700	0.9	0.1	4271670
Total Cadmium (Cd)	mg/kg	0.19	0.20	0.17	0.20	0.35	0.27	0.21	4268700	0.19	0.05	4271670
Total Calcium (Ca)	mg/kg	916	8580	8160	8110	8670	1680	7660	4268700	8030	100	4271670
Total Chromium (Cr)	mg/kg	47	127	87	87	203	50	113	4268700	120	1	4271670
Total Cobalt (Co)	mg/kg	15.3	22.9	18.5	18.2	39.8	13.5	23.6	4268700	24.1	0.3	4271670
Total Copper (Cu)	mg/kg	29.2	29.1	31.1	31.9	79.5	48.5	35.6	4268700	36.9	0.5	4271670
Total Iron (Fe)	mg/kg	21600	28800	26700	26500	35000	25300	28700	4268700	29300	100	4271670
Total Lead (Pb)	mg/kg	4.6	21.4	32.6	34.2	27.9	5.3	32.0	4268700	32.0	0.1	4271670
Total Magnesium (Mg)	mg/kg	6190	33900	21600	22300	53800	6810	31800	4268700	33400	100	4271670
Total Manganese (Mn)	mg/kg	526	567	454	499	775	281	678	4268700	770	0.2	4271670
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	4268700	<0.05	0.05	4271670
Total Molybdenum (Mo)	mg/kg	1.1	6.6	8.2	11.5	10.7	2.6	10.5	4268700	11.9	0.1	4271670
Total Nickel (Ni)	mg/kg	39.8	277	169	165	559	44.1	260	4268700	276	0.8	4271670
Total Phosphorus (P)	mg/kg	758	3090	1520	1670	1880	982	1700	4268700	1540	10	4271670
Total Potassium (K)	mg/kg	3860	9340	9990	9860	6800	3900	9200	4268700	9150	100	4271670
Total Selenium (Se)	mg/kg	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	4268700	<0.5	0.5	4271670
Total Silver (Ag)	mg/kg	<0.05	0.24	0.25	0.23	0.24	0.09	0.25	4268700	0.21	0.05	4271670
Total Sodium (Na)	mg/kg	179	598	615	674	562	254	738	4268700	778	100	4271670
Total Strontium (Sr)	mg/kg	6.1	115	66.1	69.5	111	11.1	82.1	4268700	90.3	0.1	4271670
Total Thallium (Tl)	mg/kg	0.22	0.52	0.57	0.54	0.40	0.26	0.51	4268700	0.49	0.05	4271670
Total Tin (Sn)	mg/kg	0.5	1.3	1.3	1.4	0.9	0.5	1.7	4268700	1.2	0.1	4271670
Total Titanium (Ti)	mg/kg	732	1260	1430	1340	983	668	1220	4268700	910	1	4271670
Total Vanadium (V)	mg/kg	38	45	40	40	54	42	42	4268700	43	2	4271670
Total Zinc (Zn)	mg/kg	63	102	113	111	101	86	116	4268700	115	1	4271670
Total Zirconium (Zr)	mg/kg	1.6	7.0	10.5	8.4	9.7	1.2	9.7	4268700	4.1	0.5	4271670

RDL = Reportable Detection Limit

GOLDER ASSOCIATES LTD
Client Project #: DIAVIK NORTH INLET

Your P.O. #: 10-1328-0028/700

Maxxam Job #: B082579
Report Date: 2010/11/03

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		W82396	W82419		W82420		W82421		W82422		W82423		
Sampling Date		2010/09/03	2010/09/03		2010/09/03		2010/09/03		2010/09/03		2010/09/03		
	Units	**NI-4 MIDDLE**	**NI-4 BOTTOM**	**QC Batch**	**NI-5**	**QC Batch**	**NI-5 SURFACE**	**QC Batch**	**NI-5 MIDDLE**	**QC Batch**	**NI-5 BOTTOM**	**RDL**	**QC Batch**
Physical Properties													
Soluble (2:1) pH	pH Units	6.47	5.38	4271543	7.50	4268744	7.97	4271543	6.54	4268744	6.10	0.01	4271543
Total Metals by ICPMS													
Total Aluminum (Al)	mg/kg	19400	18800	4271536	14100	4268700	16900	4271536	15300	4268700	17200	100	4271536
Total Antimony (Sb)	mg/kg	<0.1	<0.1	4271536	0.1	4268700	0.2	4271536	<0.1	4268700	<0.1	0.1	4271536
Total Arsenic (As)	mg/kg	72.0	46.8	4271536	10.9	4268700	11.6	4271536	13.1	4268700	11.2	0.2	4271536
Total Barium (Ba)	mg/kg	170	155	4271536	102	4268700	179	4271536	125	4268700	136	0.1	4271536
Total Beryllium (Be)	mg/kg	0.8	0.7	4271536	0.3	4268700	0.5	4271536	0.7	4268700	0.7	0.1	4271536
Total Bismuth (Bi)	mg/kg	0.5	0.5	4271536	1.7	4268700	2.1	4271536	1.5	4268700	0.6	0.1	4271536
Total Cadmium (Cd)	mg/kg	0.57	0.45	4271536	0.15	4268700	0.18	4271536	0.29	4268700	0.40	0.05	4271536
Total Calcium (Ca)	mg/kg	1590	1260	4271536	3990	4268700	4440	4271536	1770	4268700	1520	100	4271536
Total Chromium (Cr)	mg/kg	65	64	4271536	47	4268700	65	4271536	55	4268700	60	1	4271536
Total Cobalt (Co)	mg/kg	38.2	40.8	4271536	11.2	4268700	14.6	4271536	13.4	4268700	13.6	0.3	4271536
Total Copper (Cu)	mg/kg	80.3	74.0	4271536	33.9	4268700	35.9	4271536	51.0	4268700	64.4	0.5	4271536
Total Iron (Fe)	mg/kg	48900	38700	4271536	22000	4268700	25900	4271536	20500	4268700	21100	100	4271536
Total Lead (Pb)	mg/kg	7.4	6.0	4271536	25.4	4268700	28.8	4271536	7.6	4268700	6.3	0.1	4271536
Total Magnesium (Mg)	mg/kg	8610	8240	4271536	8190	4268700	13600	4271536	7060	4268700	7650	100	4271536
Total Manganese (Mn)	mg/kg	641	429	4271536	286	4268700	410	4271536	283	4268700	264	0.2	4271536
Total Mercury (Hg)	mg/kg	<0.05	<0.05	4271536	<0.05	4268700	<0.05	4271536	<0.05	4268700	<0.05	0.05	4271536
Total Molybdenum (Mo)	mg/kg	4.1	3.4	4271536	2.8	4268700	4.9	4271536	1.9	4268700	2.2	0.1	4271536
Total Nickel (Ni)	mg/kg	117	122	4271536	51.4	4268700	91.1	4271536	47.8	4268700	56.8	0.8	4271536
Total Phosphorus (P)	mg/kg	1690	1420	4271536	1590	4268700	1740	4271536	804	4268700	824	10	4271536
Total Potassium (K)	mg/kg	4510	4530	4271536	6960	4268700	7170	4271536	4440	4268700	4680	100	4271536
Total Selenium (Se)	mg/kg	0.7	0.5	4271536	<0.5	4268700	<0.5	4271536	<0.5	4268700	<0.5	0.5	4271536
Total Silver (Ag)	mg/kg	0.10	0.11	4271536	0.14	4268700	0.14	4271536	0.08	4268700	0.08	0.05	4271536
Total Sodium (Na)	mg/kg	467	274	4271536	268	4268700	396	4271536	319	4268700	295	100	4271536
Total Strontium (Sr)	mg/kg	17.6	10.8	4271536	21.1	4268700	36.2	4271536	16.6	4268700	11.3	0.1	4271536
Total Thallium (Tl)	mg/kg	0.42	0.38	4271536	0.43	4268700	0.46	4271536	0.24	4268700	0.30	0.05	4271536
Total Tin (Sn)	mg/kg	0.6	0.6	4271536	1.3	4268700	1.1	4271536	1.0	4268700	0.5	0.1	4271536
Total Titanium (Ti)	mg/kg	704	833	4271536	1010	4268700	969	4271536	667	4268700	692	1	4271536
Total Vanadium (V)	mg/kg	56	56	4271536	31	4268700	36	4271536	46	4268700	54	2	4271536
Total Zinc (Zn)	mg/kg	146	133	4271536	81	4268700	95	4271536	80	4268700	109	1	4271536
Total Zirconium (Zr)	mg/kg	1.5	2.0	4271536	4.6	4268700	4.1	4271536	0.8	4268700	1.2	0.5	4271536

RDL = Reportable Detection Limit

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		W82424		W82425		W82426		W82440		
Sampling Date		2010/09/02		2010/09/04		2010/09/04		2010/09/01		
	Units	**REF-1**	**QC Batch**	**REF-2**	**QC Batch**	**REF-3**	**QC Batch**	**NI-1**	**RDL**	**QC Batch**
Physical Properties										
Soluble (2:1) pH	pH Units	6.16	4271543	6.02	4268744	5.68	4271543	7.62	0.01	4268744
Total Metals by ICPMS										
Total Aluminum (Al)	mg/kg	18600	4271536	15900	4268700	15000	4271536	32400	100	4268700
Total Antimony (Sb)	mg/kg	<0.1	4271536	<0.1	4268700	<0.1	4271536	0.4	0.1	4268700
Total Arsenic (As)	mg/kg	85.0	4271536	71.7	4268700	195	4271536	37.2	0.2	4268700
Total Barium (Ba)	mg/kg	149	4271536	127	4268700	123	4271536	322	0.1	4268700
Total Beryllium (Be)	mg/kg	0.5	4271536	0.6	4268700	0.5	4271536	0.4	0.1	4268700
Total Bismuth (Bi)	mg/kg	0.3	4271536	0.3	4268700	0.2	4271536	0.7	0.1	4268700
Total Cadmium (Cd)	mg/kg	0.22	4271536	0.26	4268700	0.27	4271536	0.71	0.05	4268700
Total Calcium (Ca)	mg/kg	1430	4271536	1320	4268700	1090	4271536	8910	100	4268700
Total Chromium (Cr)	mg/kg	66	4271536	58	4268700	50	4271536	129	1	4268700
Total Cobalt (Co)	mg/kg	35.9	4271536	20.6	4268700	32.6	4271536	26.3	0.3	4268700
Total Copper (Cu)	mg/kg	34.9	4271536	33.1	4268700	42.8	4271536	36.7	0.5	4268700
Total Iron (Fe)	mg/kg	63800	4271536	46800	4268700	72400	4271536	31600	100	4268700
Total Lead (Pb)	mg/kg	5.7	4271536	5.9	4268700	4.6	4271536	23.9	0.1	4268700
Total Magnesium (Mg)	mg/kg	9590	4271536	8410	4268700	6910	4271536	35900	100	4268700
Total Manganese (Mn)	mg/kg	3500	4271536	1220	4268700	1930	4271536	576	0.2	4268700
Total Mercury (Hg)	mg/kg	<0.05	4271536	<0.05	4268700	<0.05	4271536	<0.05	0.05	4268700
Total Molybdenum (Mo)	mg/kg	2.9	4271536	1.8	4268700	3.0	4271536	6.2	0.1	4268700
Total Nickel (Ni)	mg/kg	62.5	4271536	57.0	4268700	72.1	4271536	286	0.8	4268700
Total Phosphorus (P)	mg/kg	1220	4271536	1230	4268700	1810	4271536	3360	10	4268700
Total Potassium (K)	mg/kg	4960	4271536	4750	4268700	3740	4271536	9730	100	4268700
Total Selenium (Se)	mg/kg	<0.5	4271536	<0.5	4268700	<0.5	4271536	<0.5	0.5	4268700
Total Silver (Ag)	mg/kg	0.06	4271536	0.06	4268700	0.06	4271536	0.24	0.05	4268700
Total Sodium (Na)	mg/kg	212	4271536	202	4268700	162	4271536	661	100	4268700
Total Strontium (Sr)	mg/kg	11.0	4271536	10.0	4268700	9.2	4271536	113	0.1	4268700
Total Thallium (Tl)	mg/kg	0.34	4271536	0.27	4268700	0.30	4271536	0.53	0.05	4268700
Total Tin (Sn)	mg/kg	0.8	4271536	1.2	4268700	0.7	4271536	2.0	0.1	4268700
Total Titanium (Ti)	mg/kg	872	4271536	876	4268700	528	4271536	1150	1	4268700
Total Vanadium (V)	mg/kg	54	4271536	46	4268700	43	4271536	46	2	4268700
Total Zinc (Zn)	mg/kg	91	4271536	79	4268700	83	4271536	110	1	4268700
Total Zirconium (Zr)	mg/kg	1.1	4271536	1.0	4268700	0.5	4271536	5.8	0.5	4268700

RDL = Reportable Detection Limit

CSR/CCME METALS IN SOIL (SOIL)

Maxxam ID		W82441	W82442	W82443	W82444	W82446	W82447		
Sampling Date		2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01	2010/09/01		
	Units	**NI-1 SURFACE**	**NI-1 MIDDLE**	**NI-1 BOTTOM**	**NI-2**	**NI-2 SURFACE**	**NI-2 MIDDLE**	**RDL**	**QC Batch**
Physical Properties									
Soluble (2:1) pH	pH Units	8.20	8.12	7.17	8.24	8.21	7.22	0.01	4271543
Total Metals by ICPMS									
Total Aluminum (Al)	mg/kg	57000	32000	12700	26100	37600	12700	100	4271536
Total Antimony (Sb)	mg/kg	0.4	0.3	<0.1	0.3	0.4	<0.1	0.1	4271536
Total Arsenic (As)	mg/kg	29.7	14.5	25.1	10.0	15.7	101	0.2	4271536
Total Barium (Ba)	mg/kg	485	414	90.8	386	443	143	0.1	4271536
Total Beryllium (Be)	mg/kg	0.3	0.5	0.5	0.3	0.4	0.4	0.1	4271536
Total Bismuth (Bi)	mg/kg	0.6	1.0	0.3	0.8	0.9	0.9	0.1	4271536
Total Cadmium (Cd)	mg/kg	0.18	0.25	0.09	0.27	0.27	0.11	0.05	4271536
Total Calcium (Ca)	mg/kg	14000	9730	1290	11000	11500	1750	100	4271536
Total Chromium (Cr)	mg/kg	137	143	43	171	152	46	1	4271536
Total Cobalt (Co)	mg/kg	23.9	27.5	23.0	30.7	26.9	20.5	0.3	4271536
Total Copper (Cu)	mg/kg	28.7	37.0	25.5	32.9	35.6	29.2	0.5	4271536
Total Iron (Fe)	mg/kg	26100	30200	24600	31900	32200	32200	100	4271536
Total Lead (Pb)	mg/kg	18.1	26.2	4.2	23.4	23.2	6.3	0.1	4271536
Total Magnesium (Mg)	mg/kg	46900	41100	5770	48000	45500	6830	100	4271536
Total Manganese (Mn)	mg/kg	898	803	1370	667	855	4110	0.2	4271536
Total Mercury (Hg)	mg/kg	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4271536
Total Molybdenum (Mo)	mg/kg	8.0	7.0	1.6	8.7	10.4	2.2	0.1	4271536
Total Nickel (Ni)	mg/kg	337	345	30.2	419	345	39.8	0.8	4271536
Total Phosphorus (P)	mg/kg	4150	2320	704	1940	2780	784	10	4271536
Total Potassium (K)	mg/kg	7590	8480	3420	8610	9610	3860	100	4271536
Total Selenium (Se)	mg/kg	<0.5	<0.5	<0.5	0.6	<0.5	<0.5	0.5	4271536
Total Silver (Ag)	mg/kg	0.12	0.20	<0.05	0.22	0.21	0.07	0.05	4271536
Total Sodium (Na)	mg/kg	1140	715	199	626	771	221	100	4271536
Total Strontium (Sr)	mg/kg	224	132	11.3	143	161	15.4	0.1	4271536
Total Thallium (Tl)	mg/kg	0.44	0.49	0.20	0.50	0.57	0.20	0.05	4271536
Total Tin (Sn)	mg/kg	1.4	1.1	0.4	1.1	1.4	0.4	0.1	4271536
Total Titanium (Ti)	mg/kg	773	939	638	973	769	635	1	4271536
Total Vanadium (V)	mg/kg	42	49	36	53	55	37	2	4271536
Total Zinc (Zn)	mg/kg	83	104	49	102	109	51	1	4271536
Total Zirconium (Zr)	mg/kg	4.1	4.1	0.8	4.4	2.6	1.8	0.5	4271536

RDL = Reportable Detection Limit

General Comments

Sample W82387-01: ** SEM/AVS = 37.24 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82388-01: ** SEM/AVS = 7.94 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82389-01: ** SEM/AVS = 4.97 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82391-01: ** SEM/AVS = 17.62 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82392-01: ** SEM/AVS = 157.24 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82393-01: ** SEM/AVS RATIO CAN NOT BE CALCULATED DUE TO NON-DETECTABLE AVS **

Sample W82394-01: ** SEM/AVS = 4.54 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82395-01: ** SEM/AVS = 14.28 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82396-01: ** SEM/AVS = 110.74 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82419-01: ** SEM/AVS = 202.12 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82420-01: ** SEM/AVS = 37.83 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82421-01: ** SEM/AVS = 45.88 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82422-01: ** SEM/AVS = 5.82 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82423-01: ** SEM/AVS = 16.78 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82424-01: ** SEM/AVS RATIO CAN NOT BE CALCULATED DUE TO NON-DETECTABLE AVS **

Sample W82425-01: ** SEM/AVS = 66.60 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82426-01: ** SEM/AVS = 51.23 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82440-01: ** SEM/AVS = 0.13 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82441-01: ** SEM/AVS = 10.19 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82442-01: ** SEM/AVS = 1.33 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82443-01: ** SEM/AVS = 92.38 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82444-01: ** SEM/AVS = 6.10 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82446-01: ** SEM/AVS = 0.05 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

Sample W82447-01: ** SEM/AVS = 145.62 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4268700	Total Arsenic (As)	2010/09/17	107	75 - 125	98	75 - 125	<0.2	mg/kg	NC	30	100	70 - 130
4268700	Total Beryllium (Be)	2010/09/17	112	75 - 125	99	75 - 125	<0.1	mg/kg	NC	30		
4268700	Total Cadmium (Cd)	2010/09/17	109	75 - 125	100	75 - 125	<0.05	mg/kg	NC	30	100	70 - 130
4268700	Total Chromium (Cr)	2010/09/17	104	75 - 125	95	75 - 125	<1	mg/kg	NC	30	105	70 - 130
4268700	Total Cobalt (Co)	2010/09/17	105	75 - 125	96	75 - 125	<0.3	mg/kg	NC	30	101	70 - 130
4268700	Total Copper (Cu)	2010/09/17	106	75 - 125	100	75 - 125	<0.5	mg/kg	NC	30	98	70 - 130
4268700	Total Lead (Pb)	2010/09/17	107	75 - 125	101	75 - 125	<0.1	mg/kg	5.5	35	107	70 - 130
4268700	Total Mercury (Hg)	2010/09/17	95	75 - 125	92	75 - 125	<0.05	mg/kg	NC	35		
4268700	Total Nickel (Ni)	2010/09/17	105	75 - 125	97	75 - 125	<0.8	mg/kg	NC	30	106	70 - 130
4268700	Total Selenium (Se)	2010/09/17	106	75 - 125	102	75 - 125	<0.5	mg/kg	NC	30		
4268700	Total Vanadium (V)	2010/09/17	103	75 - 125	97	75 - 125	<2	mg/kg	NC	30	106	70 - 130
4268700	Total Zinc (Zn)	2010/09/17	110	75 - 125	103	75 - 125	<1	mg/kg	1.1	30	98	70 - 130
4268700	Total Aluminum (Al)	2010/09/17					<100	mg/kg	1.1	35	103	70 - 130
4268700	Total Antimony (Sb)	2010/09/17					<0.1	mg/kg	NC	30	95	70 - 130
4268700	Total Barium (Ba)	2010/09/17					0.1, RDL=0.1	mg/kg	3.3	35	109	70 - 130
4268700	Total Calcium (Ca)	2010/09/17					<100	mg/kg	4.2	30	100	70 - 130
4268700	Total Iron (Fe)	2010/09/17					<100	mg/kg	0.2	30	100	70 - 130
4268700	Total Magnesium (Mg)	2010/09/17					<100	mg/kg	2.1	30	99	70 - 130
4268700	Total Manganese (Mn)	2010/09/17					<0.2	mg/kg	0.5	30	103	70 - 130
4268700	Total Molybdenum (Mo)	2010/09/17					<0.1	mg/kg	NC	35	107	70 - 130
4268700	Total Phosphorus (P)	2010/09/17					<10	mg/kg	0.2	30	101	70 - 130
4268700	Total Silver (Ag)	2010/09/17					<0.05	mg/kg	NC	35	67 (1)	N/A
4268700	Total Strontium (Sr)	2010/09/17					<0.1	mg/kg	1.9	35	99	70 - 130
4268700	Total Thallium (Tl)	2010/09/17					<0.05	mg/kg	NC	30	90	70 - 130
4268700	Total Titanium (Ti)	2010/09/17					<1	mg/kg	1.8	35	104	70 - 130
4268700	Total Bismuth (Bi)	2010/09/17					<0.1	mg/kg	NC	30		
4268700	Total Potassium (K)	2010/09/17					<100	mg/kg	NC	35		
4268700	Total Sodium (Na)	2010/09/17					<100	mg/kg	NC	35		
4268700	Total Tin (Sn)	2010/09/17					<0.1	mg/kg	NC	35		
4268700	Total Zirconium (Zr)	2010/09/17					<0.5	mg/kg	NC	30		
4268744	Soluble (2:1) pH	2010/09/17			101	96 - 104			1.1	20		
4271536	Total Arsenic (As)	2010/09/20	NC	75 - 125	99	75 - 125	<0.2	mg/kg	1.9	30	86	70 - 130
4271536	Total Beryllium (Be)	2010/09/20	106	75 - 125	102	75 - 125	<0.1	mg/kg	11.7	30		
4271536	Total Cadmium (Cd)	2010/09/20	108	75 - 125	103	75 - 125	<0.05	mg/kg	4.0	30	99	70 - 130
4271536	Total Chromium (Cr)	2010/09/20	NC	75 - 125	101	75 - 125	<1	mg/kg	2.3	30	92	70 - 130
4271536	Total Cobalt (Co)	2010/09/20	NC	75 - 125	101	75 - 125	<0.3	mg/kg	0.9	30	90	70 - 130
4271536	Total Copper (Cu)	2010/09/20	NC	75 - 125	105	75 - 125	<0.5	mg/kg	2.0	30	92	70 - 130
4271536	Total Lead (Pb)	2010/09/20	108	75 - 125	106	75 - 125	<0.1	mg/kg	2.2	35	100	70 - 130
4271536	Total Mercury (Hg)	2010/09/20	98	75 - 125	95	75 - 125	<0.05	mg/kg	NC	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
4271536	Total Nickel (Ni)	2010/09/20	NC	75 - 125	102	75 - 125	<0.8	mg/kg	2.2	30	94	70 - 130
4271536	Total Selenium (Se)	2010/09/20	110	75 - 125	106	75 - 125	<0.5	mg/kg	NC	30		
4271536	Total Vanadium (V)	2010/09/20	NC	75 - 125	104	75 - 125	<2	mg/kg	3.9	30	93	70 - 130
4271536	Total Zinc (Zn)	2010/09/20	NC	75 - 125	108	75 - 125	<1	mg/kg	2.0	30	95	70 - 130
4271536	Total Aluminum (Al)	2010/09/20					<100	mg/kg	3.0	35	91	70 - 130
4271536	Total Antimony (Sb)	2010/09/20					<0.1	mg/kg	NC	30	75	70 - 130
4271536	Total Barium (Ba)	2010/09/20					<0.1	mg/kg	1.7	35	104	70 - 130
4271536	Total Calcium (Ca)	2010/09/20					<100	mg/kg	2.5	30	98	70 - 130
4271536	Total Iron (Fe)	2010/09/20					<100	mg/kg	1.1	30	88	70 - 130
4271536	Total Magnesium (Mg)	2010/09/20					<100	mg/kg	2.7	30	92	70 - 130
4271536	Total Manganese (Mn)	2010/09/20					<0.2	mg/kg	1.5	30	98	70 - 130
4271536	Total Molybdenum (Mo)	2010/09/20					<0.1	mg/kg	1.4	35	81	70 - 130
4271536	Total Phosphorus (P)	2010/09/20					<10	mg/kg	3.6	30	95	70 - 130
4271536	Total Silver (Ag)	2010/09/20					<0.05	mg/kg	NC	35	66(1)	N/A
4271536	Total Strontium (Sr)	2010/09/20					<0.1	mg/kg	1.3	35	97	70 - 130
4271536	Total Thallium (Tl)	2010/09/20					<0.05	mg/kg	1.8	30	78	70 - 130
4271536	Total Titanium (Ti)	2010/09/20					2, RDL=1	mg/kg	0.08	35	85	70 - 130
4271536	Total Bismuth (Bi)	2010/09/20					<0.1	mg/kg	12.0	30		
4271536	Total Potassium (K)	2010/09/20					<100	mg/kg	4.8	35		
4271536	Total Sodium (Na)	2010/09/20					<100	mg/kg	NC	35		
4271536	Total Tin (Sn)	2010/09/20					<0.1	mg/kg	4.3	35		
4271536	Total Zirconium (Zr)	2010/09/20					<0.5	mg/kg	NC	30		
4271543	Soluble (2:1) pH	2010/09/20			102	96 - 104			2.2	20		
4271670	Total Arsenic (As)	2010/09/20	108	75 - 125	104	75 - 125	<0.2	mg/kg	NC	30	99	70 - 130
4271670	Total Beryllium (Be)	2010/09/20	107	75 - 125	106	75 - 125	<0.1	mg/kg	NC	30		
4271670	Total Cadmium (Cd)	2010/09/20	112	75 - 125	111	75 - 125	<0.05	mg/kg	NC	30	103	70 - 130
4271670	Total Chromium (Cr)	2010/09/20	107	75 - 125	106	75 - 125	<1	mg/kg	NC	30	106	70 - 130
4271670	Total Cobalt (Co)	2010/09/20	105	75 - 125	106	75 - 125	<0.3	mg/kg	NC	30	102	70 - 130
4271670	Total Copper (Cu)	2010/09/20	106	75 - 125	109	75 - 125	<0.5	mg/kg	NC	30	97	70 - 130
4271670	Total Lead (Pb)	2010/09/20	108	75 - 125	109	75 - 125	<0.1	mg/kg	7.6	35	106	70 - 130
4271670	Total Mercury (Hg)	2010/09/20	98	75 - 125	93	75 - 125	<0.05	mg/kg	NC	35		
4271670	Total Nickel (Ni)	2010/09/20	109	75 - 125	108	75 - 125	<0.8	mg/kg	NC	30	103	70 - 130
4271670	Total Selenium (Se)	2010/09/20	110	75 - 125	108	75 - 125	<0.5	mg/kg	NC	30		
4271670	Total Vanadium (V)	2010/09/20	107	75 - 125	106	75 - 125	<2	mg/kg	NC	30	111	70 - 130
4271670	Total Zinc (Zn)	2010/09/20	113	75 - 125	111	75 - 125	<1	mg/kg	1.9	30	99	70 - 130
4271670	Total Aluminum (Al)	2010/09/20					<100	mg/kg	13.0	35	113	70 - 130
4271670	Total Antimony (Sb)	2010/09/20					<0.1	mg/kg	NC	30	93	70 - 130
4271670	Total Barium (Ba)	2010/09/20					<0.1	mg/kg	7.3	35	109	70 - 130
4271670	Total Calcium (Ca)	2010/09/20					<100	mg/kg	3.1	30	107	70 - 130

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
4271670	Total Iron (Fe)	2010/09/20					<100	mg/kg	1.3	30	102	70 - 130
4271670	Total Magnesium (Mg)	2010/09/20					<100	mg/kg	10.0	30	105	70 - 130
4271670	Total Manganese (Mn)	2010/09/20					<0.2	mg/kg	1	30	107	70 - 130
4271670	Total Molybdenum (Mo)	2010/09/20					<0.1	mg/kg	NC	35	120	70 - 130
4271670	Total Phosphorus (P)	2010/09/20					<10	mg/kg	0.5	30	103	70 - 130
4271670	Total Silver (Ag)	2010/09/20					<0.05	mg/kg	NC	35	67(1)	N/A
4271670	Total Strontium (Sr)	2010/09/20					<0.1	mg/kg	0.4	35	106	70 - 130
4271670	Total Thallium (Tl)	2010/09/20					<0.05	mg/kg	NC	30	87	70 - 130
4271670	Total Titanium (Ti)	2010/09/20					<1	mg/kg	6.7	35	105	70 - 130
4271670	Total Bismuth (Bi)	2010/09/20					<0.1	mg/kg	NC	30		
4271670	Total Potassium (K)	2010/09/20					<100	mg/kg	NC	35		
4271670	Total Sodium (Na)	2010/09/20					<100	mg/kg	NC	35		
4271670	Total Tin (Sn)	2010/09/20					<0.1	mg/kg	NC	35		
4271670	Total Zirconium (Zr)	2010/09/20					<0.5	mg/kg	NC	30		
4271680	Soluble (2:1) pH	2010/09/20			101	96 - 104			2.9	20		
4273873	Sulphide	2010/09/20	3.9(1)	75 - 125	102	75 - 125	0.2, RDL=0.2	ug/g	NC(2)	30		
4273892	Available (KCl) Orthophosphate (P)	2010/09/20	NC	75 - 125	98	75 - 125	<0.5	ug/g	1	30		
4275367	% sand by hydrometer	2010/09/21					<2	%	1.9	25	93	75 - 125
4275367	% silt by hydrometer	2010/09/21					<2	%	1.4	25	108	75 - 125
4275367	Clay Content	2010/09/21					<2	%	0.3	25	99	75 - 125
4275367	Gravel	2010/09/21					<2	%	NC	25		
4275727	% sand by hydrometer	2010/09/21					<2	%	0.4	25	100	75 - 125
4275727	% silt by hydrometer	2010/09/21					<2	%	0.2	25	102	75 - 125
4275727	Clay Content	2010/09/21					<2	%	0	25	101	75 - 125
4275727	Gravel	2010/09/21					<2	%	NC	25		
4275750	SEM Cadmium (Cd)	2010/09/20					<0.0002	umole/g	NC	30		
4275750	SEM Copper (Cu)	2010/09/20					<0.004	umole/g	4.3	30		
4275750	SEM Lead (Pb)	2010/09/20					<0.0002	umole/g	2.2	30		
4275750	SEM Mercury (Hg)	2010/09/20					<0.0003	umole/g	NC	30		
4275750	SEM Nickel (Ni)	2010/09/20					<0.004	umole/g	0.07	30		
4275750	SEM Zinc (Zn)	2010/09/20					<0.008	umole/g	1.7	30		
4332191	% sand by hydrometer	2010/10/13					<2	%	11.0	25	87	75 - 125
4332191	% silt by hydrometer	2010/10/13					<2	%	3.4	25	108	75 - 125

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits	% Recovery	QC Limits
4332191	Clay Content	2010/10/13					<2	%	NC	25	107	75 - 125
4332191	Gravel	2010/10/13					<2	%	NC	25		

N/A = Not Applicable
RDL = Reportable Detection Limit
RPD = Relative Percent Difference
Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.
(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.
(2) - Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.
RDL raised due to sample dilution.

B082579

CHAIN-OF-CUSTODY / TEST REQUEST FORM

Golder Associates

№ 5455

500 - 4260 Still Creek Drive
Burnaby, B.C.
Canada V5C 6C6

Tel: 604-296-4200
Fax: 604-298-5253
www.golder.com

Client Name DDMI /Golder
Address Ryan Steverson
500-4260 StillcreekDr.
Burnaby V5C 6C6

Client Contact Ryan stevenson + Cathy mcpherson
Phone 604 297 2006/604 297 2007
Fax 604 298 5253
Sampled by RWS

Ship to Maxxam
4606 Canada way
Burnaby BC
Attn. Kristen Pelvde 604 638 8050
Shipping Date 2010.09.06

Collection Date (DD/MMM/YYYY) 1	Time (24-h clock) 1	Sample Identification	Type of Each Sample 2	Material Safety Data Sheet Attached? (✓)	Sample Collection Method G=grab C=composite	Number of Sample Containers x Volume of Sample Containers (1 x 20L)	Sample Container Type by Code 3	Test(s) Requested: AVS-SEM	Metals, TOC, TP, Reagents, Moisture	Archive /Backup	Grain Size		Sample Notes (preserved, saltwater, freshwater, may contain sewage...) 4
01/SEP/2010		NI-2 Bottom	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
01/Sept/2010		Field Replicate	Sed		C	3x250mL 1x500mL	GJ BAG	✓	✓	✓	✓		
03/Sept/2010		NI-3 ~~Bott~~ Surface	Sed		C	3x250mL	GJ	✓	✓	✓			
03/Sept/2010		NI-3	Sed		C	1x500mL	BAJ				✓		
03/Sept/2010		NI-3 Surface	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-3 Middle	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-3 Bottom	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept 2010		NI-4	Sed		C	3x250mL 1x500mL	GJ BAG	✓	✓	✓	✓		
03/Sept/2010		NI-4 surface	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-4 Middle	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		

PO/Reference No. 10-1328-0028/700
Project Title Diavik - North Inlet
Results Needed By Standard TAT

Comments/Instructions

1) Released by:
Date:
Company:
Time:
Courier Name:

2) Released by:
Date:
Company:
Time:
Courier Name:

3) Released by:
Date:
Company:
Time:
Courier Name:

1) Received by: C. ROSEN
Date: 080910
Company: 14,13,14 | 14,12,14
Time: 930

2) Received by:
Date:
Company:
Time:

3) Received by:
Date:
Company:
Time:

1 For composite effluent or water samples, the sample collection date/time is the end of the compositing period.
2 Receiving Water (RW): Effluent (E); Elutriate (ELU); Sediment (SED); Chemical (CHEM); Stormwater (SW); Other (Please Specify)
3 Collapsible Carboy (CC); glass jar (GJ); Jerry Can (JC); Plastic HDPE (P); Other (Please Specify)
4 Please note any conditions the lab should be aware of for safety and storage concerns

Please see instructions for completion on back of form

Distribution of copies:
White, Yellow—accompany the shipment
Pink—kept by consignor (e.g. shipper)
Yellow—kept by consignee (e.g. receiver)
White—returned to consignor by consignee

Revision Date: March 20, 2009

B082579

CHAIN-OF-CUSTODY / TEST REQUEST FORM

Golder Associates

№ 5452

500 - 4260 Still Creek Drive
Burnaby, B.C.
Canada V5C 6C6

Tel: 604-296-4200
Fax: 604-298-5253
www.golder.com

Client Name DDMI/Golder
Address Ryan Stevenson
503-4260 stillcrk Dr.
Burnaby V5C 6C6

Client Contact Ryan Stevenson
Phone 604 297 2006
Fax 604 298 5253
Sampled by RWS

Ship to Maxxam
4606 Canada Way
Burnaby BC
Attn. Kristen Pelude 604 638 8050

Shipping Date 2010.09.06

Collection Date (DD/MMM/YYYY) 1	Time (24-h clock) 1	Sample Identification	Type of Each Sample 2	Material Safety Data Sheet Attached? (✓)	Sample Collection Method G=grab C=composite	Number of Sample Containers x Volume of Sample Containers (1 x 20L)	Sample Container Type by Code 3	Test(s) Requested: AVS - SEM	Metals, TOC, TP Reagents, Moisture	Archive / Backup	Grain size		Sample Notes (preserved, saltwater, freshwater, may contain sewage...) 4
03/Sept/2010		NI-4 Bottom	Sed		CORE	2x250mL 1x500 mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-5	Sed		C	3x250mL 1x500mL	GJ BAG	✓	✓	✓	✓		
03/Sept/2010		NI-5 Surface	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-5 Middle	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		NI-5 Bottom	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
03/Sept/2010		REF-1	Sed		C	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
04/Sept/2010		REF-2	Sed		C	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
04/Sept/2010		REF-3	Sed		C	2x250mL 1x500mL	GJ BAG	✓	✓		✓		

PO/Reference No. 10-1328-0028/700
Project Title Diavik-North Inlet
Results Needed By Standard TAT

Comments/Instructions

1) Released by: Date: Company: Time: Courier Name:	2) Released by: Date: Company: Time: Courier Name:	3) Released by: Date: Company: Time: Courier Name:
1) Received by: C. ROSEN Date: 080910 Company: 141314 141214 Time: 0930	2) Received by: Date: Company: Time:	3) Received by: Date: Company: Time:

1 For composite effluent or water samples, the sample collection date/time is the **end** of the compositing period.
2 Receiving Water (RW): Effluent (E); Elutriate (ELU); Sediment (SED); Chemical (CHEM); Stormwater (SW); Other (Please Specify)
3 Collapsible Carboy (CC); glass jar (GJ); Jerry Can (JC); Plastic HDPE (P); Other (Please Specify)
4 Please note any conditions the lab should be aware of for safety and storage concerns

Distribution of copies:
White, Yellow—accompany the shipment
Pink—kept by consignor (e.g. shipper)
Yellow—kept by consignee (e.g. receiver)
White—returned to consignor by consignee

Please see instructions for completion on back of form

Revision Date: March 20, 2009

000014

CHAIN-OF-CUSTODY / TEST REQUEST FORM

Golder Associates

№ 5451

500 - 4260 Still Creek Drive
Burnaby, B.C.
Canada V5C 6C6

Tel: 604-296-4200
Fax: 604-298-5253
www.golder.com

Client Name ~~DDMI / GOLDER~~ DDMI / GOLDER
Address # RYAN STEVENSON
500-4260 STILL CRIK DRIVE
BURNABY V5C 6C6

Client Contact RYAN STEVENSON + CATHY MCPHERSON
Phone 604 297 2006 / 604 297 2007
Fax 604 298 5253
Sampled by RWS

Ship to MAXXAM
4606 CANADA WAY
BURNABY BC
Attn. KRISTA PERVOE 604 638 8020

Shipping Date 2010.09.06

Collection Date (DD/MMM/YYYY) 1	Time (24-h clock) 1	Sample Identification	Type of Each Sample 2	Material Safety Data Sheet Attached? (✓)	Sample Collection Method G=grab C=composite	Number of Sample Containers x Volume of Sample Containers (1 x 20L)	Sample Container Type by Code 3	Test(s) Requested: AVS-SEM	Test(s) Requested: METALS, TOC, TP, [illegible], MOISTURE	Test(s) Requested: ARCHIVE/BACKUP	Test(s) Requested: ~~[illegible]~~ GRAIN SIZE	Test(s) Requested	Sample Notes (preserved, saltwater, freshwater, may contain sewage...) 4
01/SEP/2010		NI-1	SED		~~G~~C	3x250ml	GJ	✓	✓	✓			
~~"~~		~~"~~	~~"~~		~~C~~	~~1x500ml~~	~~GJ~~						
"		"	"		C	1x500ml	BAG				✓		
"		NI-1 SURFACE	"		CORE	2x250ml 1x500ml	GJ BAG	✓	✓		✓		
"		NI-1 MIDDLE	"		CORE	2x250ml 1x500ml	GJ BAG	✓	✓		✓		
"		NI-1 BOTTOM	"		CORE	2x250ml 1x500ml	GJ BAG	✓	✓		✓		
02/Sep/2010		NI-2	Sed		C	3x250mL	GJ	✓	✓	✓			
01/Sep/2010		NI-2	Sed		C	1x500mL	BAG				✓		
"		NI-2 Surface	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		
"		NI-2 Middle	Sed		CORE	2x250mL 1x500mL	GJ BAG	✓	✓		✓		

PO/Reference No. 10-1328-0028 / 7000
Project Title DIAVIK - NORTH INLET
Results Needed By STANDARD TAT

Comments/Instructions MDLS TO MEET CCME SEDIMENT QUALITY GUIDELINES

1) Released by: Date:	2) Released by: Date:	3) Released by: Date:
Company: Time:	Company: Time:	Company: Time:
Courier Name:	Courier Name:	Courier Name:
1) Received by: C. ROSEN Date: 080910	2) Received by: Date:	3) Received by: Date:
Company: 141314 141214 Time: 0930	Company: Time:	Company: Time:

1 For composite effluent or water samples, the sample collection date/time is the **end** of the compositing period.
2 Receiving Water (RW); Effluent (E); Elutriate (ELU); Sediment (SED); Chemical (CHEM); Stormwater (SW); Other (Please Specify)
3 Collapsible Carboy (CC); glass jar (GJ); Jerry Can (JC); Plastic HDPE (P); Other (Please Specify)
4 Please note any conditions the lab should be aware of for safety and storage concerns

Distribution of copies:
White, Yellow—accompany the shipment
Pink—kept by consignor (e.g. shipper)
Yellow—kept by consignee (e.g. receiver)
White—returned to consignor by consignee

Please see instructions for completion on back of form

Revision Date: March 20, 2009

AcmeLabs Acme Analytical Laboratories (Vancouver) Ltd.
1020 Cordova St. East Vancouver BC V6A 4A3 Canada

www.acmelab.com

Client:	**Maxxam Analytics** 4606 Canada Way Burnaby BC V5G 1K5 Canada
Submitted By:	Ivy Rajan
Receiving Lab:	Canada-Vancouver
Received:	September 17, 2010
Report Date:	October 12, 2010
Page:	1 of 2

CERTIFICATE OF ANALYSIS VAN10004725.1

CLIENT JOB INFORMATION

Project:	2-21-900
Shipment ID:	
P.O. Number	Proj. Golder Diavik North Inlet 2-21-900
Number of Samples:	24

SAMPLE DISPOSAL

DISP-PLP	Dispose of Pulp After 90 days

Acme does not accept responsibility for samples left at the laboratory after 90 days without prior written instructions for sample storage or return.

Invoice To: Maxxam Analytics
4606 Canada Way
Burnaby BC V5G 1K5
Canada

CC:

SAMPLE PREPARATION AND ANALYTICAL PROCEDURES

Method Code	Number of Samples	Code Description	Test Wgt (g)	Report Status	Lab
No Prep	23	Sorting of samples on arrival and labeling			VAN
4A	23	LiBO2/LiB4O7 fusion ICP-ES analysis	0.2	Completed	VAN
2A10	23	Org/C - Total C minus Graphite C & CO2	0.1	Completed	VAN

ADDITIONAL COMMENTS

BRITISH COLUMBIA CERTIFIED ASSAYER
CLARENCE LEONG
GENERAL MANAGER

AcmeLabs Acme Analytical Laboratories (Vancouver) Ltd.
1020 Cordova St. East Vancouver BC V6A 4A3 Canada
Phone (604) 253-3158 Fax (604) 253-1716
www.acmelab.com

Client: **Maxxam Analytics**
4606 Canada Way
Burnaby BC V5G 1K5 Canada

Project: 2-21-900
Report Date: October 12, 2010

CERTIFICATE OF ANALYSIS VAN10004725.1

	Method	4A	2A-C
	Analyte	CaO	C/ORG
	Unit	%	%
	MDL	0.01	0.02
NI-2 BOTTOM	Rock Pulp	1.51	0.65
FIELD REPLICATE	Rock Pulp	1.60	1.78
NI-3	Rock Pulp	1.66	1.30
NI-3 SURFACE	Rock Pulp	1.65	1.44
NI-3 MIDDLE	Rock Pulp	1.58	1.57
NI-3 BOTTOM	Rock Pulp	1.36	3.14
NI-4	Rock Pulp	1.51	1.55
NI-4 SURFACE	Rock Pulp	1.48	1.57
NI-4 MIDDLE	Rock Pulp	1.19	3.79
NI-4 BOTTOM	Rock Pulp	1.26	2.73
NI-5	Rock Pulp	1.12	0.44
NI-5 SURFACE	Rock Pulp	1.12	0.73
NI-5 MIDDLE	Rock Pulp	1.26	3.77
NI-5 BOTTOM	Rock Pulp	1.22	3.57
REF 1	Rock Pulp	1.19	1.84
REF 2	Rock Pulp	1.31	1.60
REF 3	Rock Pulp	1.13	2.43
NI-1	Rock Pulp	1.60	1.67
NI-1 SURFACE	Rock Pulp	2.20	4.15
NI-1 MIDDLE	Rock Pulp	L.N.R.	L.N.R.
NI-1 BOTTOM	Rock Pulp	1.49	0.77
NI-2	Rock Pulp	2.01	1.63
NI-2 SURFACE	Rock Pulp	1.87	2.95
NI-2 MIDDLE	Rock Pulp	1.54	0.76

AcmeLabs Acme Analytical Laboratories (Vancouver) Ltd.
1020 Cordova St. East Vancouver BC V6A 4A3 Canada
Phone (604) 253-3158 Fax (604) 253-1716
www.acmelab.com

Client: **Maxxam Analytics**
4606 Canada Way
Burnaby BC V5G 1K5 Canada

Project: 2-21-900
Report Date: October 12, 2010

Page: 1 of 1 Part 1

QUALITY CONTROL REPORT VAN10004725.1

	Method	4A	2A-C
	Analyte	CaO	C/ORG
	Unit	%	%
	MDL	0.01	0.02
NI-3 MIDDLE	Rock Pulp	1.58	1.57
Pulp Duplicates			
NI-3	Rock Pulp	1.66	1.30
REP NI-3	QC		
NI-4	Rock Pulp	1.51	1.55
REP NI-4	QC	1.53	
NI-4 MIDDLE	Rock Pulp	1.19	3.79
REP NI-4 MIDDLE	QC	1.20	
Reference Materials			
STD CSC	Standard		
STD CSC	Standard		
STD SO-18	Standard	6.38	
STD SO-18	Standard	6.32	
STD SO-18	Standard	6.36	
STD SO-18	Standard	6.31	
STD CSC Expected			0.71
STD SO-18 Expected		6.42	
BLK	Blank	<0.01	
BLK	Blank		
BLK	Blank	<0.01	

Maxxam

Success Through Science®

Your Project #: DIAVIK NORTH INLET
Your C.O.C. #: G035843, 40216

Attention: Cathy McPherson
GOLDER ASSOCIATES LTD
4260 STILL CREEK DRIVE
Suite 500
BURNABY, BC
Canada V5C 6C6

Report Date: 2010/11/03
This report supersedes all previous reports with the same Maxxam job number

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B089603
Received: 2010/09/20, 12:45

Sample Matrix: Soil
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Texture by Hydrometer, incl Gravel (Wet) (1)	1	2010/09/29	2010/09/29	EENVSOP-00076	MMFSPA Ch9

Sample Matrix: SLUDGE
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	1	2010/09/29	2010/09/30	BRN SOP-00203 R5.0	Based on EPA 200.8
Simultaneously Extractable Metals-ICPMS	1	2010/09/29	2010/09/30	BRN SOP-00203 5.0	Based on EPA 200.8
Moisture	1	N/A	2010/09/23	BRN SOP-00321 R5.0	Ont MOE -E 3139
pH (2:1 DI Water Extract)	1	2010/09/29	2010/09/30	BRN SOP-00266 R6.0	Carter, SSMA 16.2
Available Phosphate	1	2010/10/04	2010/10/04	BRN SOP-00235 R5.0	SM SECTION 4500 PE
Sulfide (AVS) (soil) - Calc for umole/g	1	2010/09/21	2010/09/29	BRN SOP-00229 R2.0	Based EPA821-R91-100
Sulfide (AVS) (soil)	1	2010/09/29	2010/09/29	BRN SOP-00229 R2.0	Based EPA821-R91-100

* Results relate only to the items tested.

(1) This test was performed by Maxxam Edmonton Environmental

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VJ OCO, Burnaby Customer Service
Email: VOco@maxxam.ca
Phone# (604) 639-8422

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		X23347		
Sampling Date		2010/09/02		
	Units	**NIWTP SLUDGE (0-13CM)**	**RDL**	**QC Batch**
Physical Properties				
% sand by hydrometer	%	76	2	4289760
% silt by hydrometer	%	10	2	4289760
Clay Content	%	14	2	4289760
Gravel	%	<2	2	4289760

RESULTS OF CHEMICAL ANALYSES OF SLUDGE

Maxxam ID		X11743		
Sampling Date		2010/09/03		
	Units	**NIWTP SLUDGE**	**RDL**	**QC Batch**
Calculated Parameters				
Sulphide	umole/g	9.1	0.6	4278727
MISCELLANEOUS				
Sulphide	ug/g	291	20	4299314
Nutrients				
Available (KCl) Orthophosphate (P)	ug/g	28.2	0.5	4308463

PHYSICAL TESTING (SLUDGE)

Maxxam ID		X11743		
Sampling Date		2010/09/03		
	Units	**NIWTP SLUDGE**	**RDL**	**QC Batch**
Physical Properties				
Moisture	%	97	0.3	4281990

RDL = Reportable Detection Limit

ELEMENTS BY ATOMIC SPECTROSCOPY (SLUDGE)

Maxxam ID		X11743		
Sampling Date		2010/09/03		
	Units	**NIWTP SLUDGE**	**RDL**	**QC Batch**
SEM Metals by ICPMS				
SEM Cadmium (Cd)	umole/g	<0.0002	0.0002	4297156
SEM Copper (Cu)	umole/g	0.006	0.004	4297156
SEM Lead (Pb)	umole/g	0.0021	0.0002	4297156
SEM Mercury (Hg)	umole/g	<0.0003	0.0003	4297156
SEM Nickel (Ni)	umole/g	0.077	0.004	4297156
SEM Zinc (Zn)	umole/g	0.021	0.008	4297156

RDL = Reportable Detection Limit

CSR/CCME METALS IN SOIL (SLUDGE)

Maxxam ID		X11743		
Sampling Date		2010/09/03		
	Units	**NIWTP SLUDGE**	**RDL**	**QC Batch**
Physical Properties				
Soluble (2:1) pH	pH Units	7.14	0.01	4299322
Total Metals by ICPMS				
Total Aluminum (Al)	mg/kg	150000	100	4299317
Total Antimony (Sb)	mg/kg	1.0	0.1	4299317
Total Arsenic (As)	mg/kg	136	0.2	4299317
Total Barium (Ba)	mg/kg	98.2	0.1	4299317
Total Beryllium (Be)	mg/kg	<0.1	0.1	4299317
Total Bismuth (Bi)	mg/kg	0.3	0.1	4299317
Total Cadmium (Cd)	mg/kg	0.14	0.05	4299317
Total Calcium (Ca)	mg/kg	3110	100	4299317
Total Chromium (Cr)	mg/kg	14	1	4299317
Total Cobalt (Co)	mg/kg	4.8	0.3	4299317
Total Copper (Cu)	mg/kg	12.7	0.5	4299317
Total Iron (Fe)	mg/kg	3150	100	4299317
Total Lead (Pb)	mg/kg	4.7	0.1	4299317
Total Magnesium (Mg)	mg/kg	4940	100	4299317
Total Manganese (Mn)	mg/kg	637	0.2	4299317
Total Mercury (Hg)	mg/kg	<0.05	0.05	4299317
Total Molybdenum (Mo)	mg/kg	68.8	0.1	4299317
Total Nickel (Ni)	mg/kg	56.9	0.8	4299317
Total Phosphorus (P)	mg/kg	6150	10	4299317
Total Potassium (K)	mg/kg	1500	100	4299317
Total Selenium (Se)	mg/kg	<2(1)	2	4299317
Total Silver (Ag)	mg/kg	<0.05	0.05	4299317
Total Sodium (Na)	mg/kg	993	100	4299317
Total Strontium (Sr)	mg/kg	96.5	0.1	4299317
Total Thallium (Tl)	mg/kg	<0.05	0.05	4299317
Total Tin (Sn)	mg/kg	0.7	0.1	4299317
Total Titanium (Ti)	mg/kg	100	1	4299317
Total Vanadium (V)	mg/kg	15	2	4299317
Total Zinc (Zn)	mg/kg	16	1	4299317
Total Zirconium (Zr)	mg/kg	3.1	0.5	4299317

RDL = Reportable Detection Limit
(1) - RDL raised for Se due to sample matrix interference.

General Comments

Sample X11743-01: ** SEM/AVS = 0.01 [SEM IS THE SUM OF CD CU HG NI PB AND ZN] **

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
4281990	Moisture	2010/09/23					<0.3	%	2.5	20		
4289760	% sand by hydrometer	2010/09/27					<2	%	9.3	25	96	75 - 125
4289760	% silt by hydrometer	2010/09/27					<2	%	12.0	25	106	75 - 125
4289760	Clay Content	2010/09/27					<2	%			99	75 - 125
4289760	Gravel	2010/09/27					<2	%	7.0	25		
4297156	SEM Cadmium (Cd)	2010/09/30					<0.0002	umole/g				
4297156	SEM Copper (Cu)	2010/09/30					<0.004	umole/g				
4297156	SEM Lead (Pb)	2010/09/30					<0.0002	umole/g				
4297156	SEM Mercury (Hg)	2010/09/30					<0.0003	umole/g				
4297156	SEM Nickel (Ni)	2010/09/30					<0.004	umole/g				
4297156	SEM Zinc (Zn)	2010/09/30					<0.008	umole/g				
4299314	Sulphide	2010/09/29	38(1)	75 - 125	106	75 - 125	<0.2	ug/g	3.7(2)	30		
4299317	Total Arsenic (As)	2010/09/30	105	75 - 125	93	75 - 125	<0.2	mg/kg	1.6	30	95	70 - 130
4299317	Total Beryllium (Be)	2010/09/30	110	75 - 125	96	75 - 125	<0.1	mg/kg	NC	30		
4299317	Total Cadmium (Cd)	2010/09/30	106	75 - 125	97	75 - 125	<0.05	mg/kg	6.0	30	88	70 - 130
4299317	Total Chromium (Cr)	2010/09/30	100	75 - 125	87	75 - 125	<1	mg/kg	7.4	30	89	70 - 130
4299317	Total Cobalt (Co)	2010/09/30	99	75 - 125	88	75 - 125	<0.3	mg/kg	3.2	30	88	70 - 130
4299317	Total Copper (Cu)	2010/09/30	102	75 - 125	92	75 - 125	<0.5	mg/kg	13.1	30	86	70 - 130
4299317	Total Lead (Pb)	2010/09/30	NC	75 - 125	94	75 - 125	<0.1	mg/kg	0.9	35	98	70 - 130
4299317	Total Mercury (Hg)	2010/09/30	87	75 - 125	88	75 - 125	<0.05	mg/kg	NC	35		
4299317	Total Nickel (Ni)	2010/09/30	105	75 - 125	89	75 - 125	<0.8	mg/kg	1.4	30	90	70 - 130
4299317	Total Selenium (Se)	2010/09/30	107	75 - 125	99	75 - 125	<0.5	mg/kg	NC	30		
4299317	Total Vanadium (V)	2010/09/30	NC	75 - 125	88	75 - 125	<2	mg/kg	2.7	30	91	70 - 130
4299317	Total Zinc (Zn)	2010/09/30	NC	75 - 125	94	75 - 125	<1	mg/kg	0.8	30	86	70 - 130
4299317	Total Aluminum (Al)	2010/09/30					<100	mg/kg	5.1	35	89	70 - 130
4299317	Total Antimony (Sb)	2010/09/30					<0.1	mg/kg	NC	30	82	70 - 130
4299317	Total Barium (Ba)	2010/09/30					<0.1	mg/kg	2.0	35	102	70 - 130
4299317	Total Calcium (Ca)	2010/09/30					<100	mg/kg	1.4	30	90	70 - 130
4299317	Total Iron (Fe)	2010/09/30					<100	mg/kg	3.6	30	87	70 - 130
4299317	Total Magnesium (Mg)	2010/09/30					<100	mg/kg	6.4	30	86	70 - 130
4299317	Total Manganese (Mn)	2010/09/30					<0.2	mg/kg	0.4	30	90	70 - 130
4299317	Total Molybdenum (Mo)	2010/09/30					<0.1	mg/kg	4.8	35	84	70 - 130
4299317	Total Phosphorus (P)	2010/09/30					<10	mg/kg	3.7	30	90	70 - 130
4299317	Total Silver (Ag)	2010/09/30					<0.05	mg/kg	NC	35	59(1)	N/A
4299317	Total Strontium (Sr)	2010/09/30					<0.1	mg/kg	9.6	35	90	70 - 130
4299317	Total Thallium (Tl)	2010/09/30					<0.05	mg/kg	NC	30	79	70 - 130
4299317	Total Titanium (Ti)	2010/09/30					<1	mg/kg	4.9	35	91	70 - 130
4299317	Total Bismuth (Bi)	2010/09/30					<0.1	mg/kg	NC	30		
4299317	Total Potassium (K)	2010/09/30					<100	mg/kg	NC	35		
4299317	Total Sodium (Na)	2010/09/30					<100	mg/kg	NC	35		

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD		QC Standard	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**	**% Recovery**	**QC Limits**
4299317	Total Tin (Sn)	2010/09/30					<0.1	mg/kg	NC	35		
4299317	Total Zirconium (Zr)	2010/09/30					<0.5	mg/kg	NC	30		
4299322	Soluble (2:1) pH	2010/09/30			102	96 - 104			0.3	20		
4308463	Available (KCl) Orthophosphate (P)	2010/10/04	NC	75 - 125	106	75 - 125	<0.5	ug/g	0.1	30		

N/A = Not Applicable

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) - Matrix spike exceeds acceptance limits due to matrix interference. Re-analysis yields similar results.

Maxxam

4606 Canada Way, Burnaby, BC Canada V5G 1K5 Ph: 604 734 7276 Toll Free: 1 800 665 8566 Fax: 604 731 2386

Maxxam Job#: B089603

CHAIN OF CUSTODY RECORD

Page: ___ of ___

G 035843

Invoice To: Require Report? Yes ☐ No ☐
Company Name: GOLDER BURNABY
Contact Name: CATHY McPHERSON
Address:
BURNABY PC: V5C 6C6
Phone / Fax#: Ph: 604 297 2007 Fax:
E-mail: cmcpherson@golder.com

Report To:
Company Name:
Contact Name:
Address: Same
PC:
Phone / Fax#: Ph: Fax:
E-mail:

PO #:
Quotation #:
Project #:
Proj. Name: Diavik North In.
Location:
Sampled By:

REGULATORY REQUIREMENTS SERVICE REQUESTED:

☐ CSR
☒ CCME
☐ BC Water Quality
☐ Other
☐ DRINKING WATER

☒ Regular Turn Around Time (TAT) (5 days for most tests)
☐ RUSH (Please contact the lab)
☐ 1 Day ☐ 2 Day ☐ 3 Day
Date Required:

Special Instructions:
Return Cooler ☐ Ship Sample Bottles (please specify) ☐

ANALYSIS REQUESTED

	Sample Identification	Lab Identification	Sample Type	Date/Time Sampled	BTEX/VPH ☐ MTBE ☐	VOC/VPH ☐	EPH ☐ TEH ☐	PAH ☐ LEPH/HEPH ☐	CCME-PHC (Fractions 1-4 Plus BTEX)	CCME-PHC (Fractions F4)	CCME BTEX (Fraction 1 Plus BTEX)	PCB ☐	Phenols by 4AAP ☐ Phenols by GCMS ☐	TOG ☐ MOG ☐ SWOG ☐	Dissolved Metals: Field Filtered? Y ☐ N ☐	Dissolved Metals: Free Acidified? Y ☐ N ☐	Total Metals Field Acidified? Y ☐ N ☐	Nitrate ☐ Nitrite ☐ Ammonia ☐	Chlorine ☐ Fluoride ☐ Sulphate ☐	Total Suspended Solids-TSS ☐ TDS ☐	pH ☐ Conductivity ☐ Alkalinity ☐	BOD ☐	COD ☐	Coliform, Total & E.coli ☐ Fecal ☐	Asbestos ☐	AusSem (1JAR)	ARD PREP - sub2oz (ext V)	(metals logs	to Billas)		HOLD ☐
1	NIWTP Sludge		Sludge	Sept. 3/10																						X	X				
2																															
3																															
4																															
5																															
6																															
7																															
8																															
9																															
10																															
11																															
12																															

Samples are from a Drinking Water Source? YES ☐ NO ☐
Does source supply multiple households? YES ☐ NO ☐

Laboratory Use Only

*Relinquished by:	Date (YY/MM/DD):	Time:	Received by:	Date (YY/MM/DD):	Time:	Time Sensitive	Temperature on Receipt (°C)	Custody Seal Intact on Cooler?
			NICK SANDIK	10/09/20	12:45	☐	18/17/18	~~Yes~~ ~~No~~

*IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: Maxxam Yellow: Client

COC-1020 (03/10)

Maxxam International Corporation o/a Maxxam Analytics

N/A.

ACME ANALYTICAL LABORATORIES LTD. **Final Report**

Client: Maxxam Analytics
File Created: 22-Oct-2010
Job Number: VAN10005127
Number of Samples: 1
Project: 2-21-900
P.O. Number: Proj. Golder-Diavik North Inlet 2-21-900
Received: 01-Oct-2010

		Method	4A	2A-C
		Analyte	CaO	C/ORG
		Unit	%	%
		MDL	0.01	0.02
Sample	**Type**			
NI WTP SLUDGE	Rock Pulp		0.46	9.94
QAQC				
Pulp Duplicates				
Reference Materials				
STD SO-18	STD		6.35	
STD SO-18	STD		6.32	
BLK	BLK		<0.01	

C/Org is Total Organic Carbon

APPENDIX C

Laboratory Report - Water Chemistry (Maxxam Analytics)

Your C.O.C. #: A017489, A017490, A017491, A017492

Attention: Cathy McPherson
GOLDER ASSOCIATES LTD
4260 STILL CREEK DRIVE
Suite 500
BURNABY, BC
Canada V5C 6C6

Report Date: 2010/10/26

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B099438
Received: 2010/10/15, 08:55

Sample Matrix: Water
Samples Received: 40

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Hardness Total (calculated as CaCO3)	1	N/A	2010/10/26		
Hardness (calculated as CaCO3)	39	N/A	2010/10/22		
Na, K, Ca, Mg, S by CRC ICPMS (diss.)	39	N/A	2010/10/22	BRN SOP-00206	Based on EPA 200.8
Elements by CRC ICPMS (dissolved)	19	N/A	2010/10/21	BRN SOP-00206	Based on EPA 200.8
Elements by CRC ICPMS (dissolved)	20	N/A	2010/10/22	BRN SOP-00206	Based on EPA 200.8
Na, K, Ca, Mg, S by CRC ICPMS (total)	1	2010/10/18	2010/10/26	BRN SOP-00206	Based on EPA 200.8
Elements by CRC ICPMS (total)	1	2010/10/20	2010/10/26	BRN SOP-00206	Based on EPA 200.8
Filter and HNO3 Preserve for Metals	39	N/A	2010/10/15	BRN WI-00006 R1.0	Based on EPA 200.2

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VJ OCO, Burnaby Customer Service
Email: VOco@maxxam.ca
Phone# (604) 639-8422

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		X69563	X69564	X69565	X69566	X69567	X69568	X69569	X69570	X69571	X69572	X69573		
	Units	**10-1356 CTL CT FINAL**	**10-1356 CTL HA INITIAL**	**10-1356 CTL HA FINAL**	**10-1356-1 CTL CT INITIAL**	**10-1356-1 CTL CT FINAL**	**10-1356-1 CTL HA INITIAL**	**10-1356-1 CTL HA FINAL**	**10-1356-2 CTL CT INITIAL**	**10-1356-2 CTL CT FINAL**	**10-1356-2 CTL HA INITIAL**	**10-1356-2 CTL HA FINAL**	**RDL**	**QC Batch**
Calculated Parameters														
Filter and HNO3 Preservation	N/A	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	N/A	ONSITE

Maxxam ID		X69590	X69591	X69592	X69593	X69594	X69595	X69596	X69597	X69598	X69599		
	Units	**10-1356-3 CT INITIAL**	**10-1356-3 CT FINAL**	**10-1356-3 HA INITIAL**	**10-1356-3 HA FINAL**	**10-1356-4 CT INITIAL**	**10-1356-4 CT FINAL**	**10-1356-4 HA INITIAL**	**10-1356-4 HA FINAL**	**10-1356-5 CT INITIAL**	**10-1356-5 HA INITIAL**	**RDL**	**QC Batch**
Calculated Parameters													
Filter and HNO3 Preservation	N/A	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	N/A	ONSITE

Maxxam ID		X69600	X69601	X69613	X69614	X69615	X69616	X69617	X69618	X69619	X69620		
	Units	**10-1356-5 CT FINAL**	**10-1356-5 HA FINAL**	**10-1356-6 CT INITIAL**	**10-1356-6 CT FINAL**	**10-1356-6 HA INITIAL**	**10-1356-6 HA FINAL**	**10-1356-7 CT INITIAL**	**10-1356-7 CT FINAL**	**10-1356-7 HA INITIAL**	**10-1356-7 HA FINAL**	**RDL**	**QC Batch**
Calculated Parameters													
Filter and HNO3 Preservation	N/A	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	N/A	ONSITE

Maxxam ID		X69621	X69622	X69623	X69624	X69633	X69634	X69635	X69636		
	Units	**10-1356-8 CT INITIAL**	**10-1356-8 CT FINAL**	**10-1356-8 HA INITIAL**	**10-1356-8 HA FINAL**	**10-1392 CT INITIAL**	**10-1392 CT FINAL**	**10-1392 HA INITIAL**	**10-1392 HA FINAL**	**RDL**	**QC Batch**
Calculated Parameters											
Filter and HNO3 Preservation	N/A	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	FIELD	N/A	ONSITE

N/A = Not Applicable
RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69563	X69564	X69565	X69566	X69567	X69568	X69569	X69570	X69571	X69572		
	Units	**10-1356 CTL CT FINAL**	**10-1356 CTL HA INITIAL**	**10-1356 CTL HA FINAL**	**10-1356-1 CTL CT INITIAL**	**10-1356-1 CTL CT FINAL**	**10-1356-1 CTL HA INITIAL**	**10-1356-1 CTL HA FINAL**	**10-1356-2 CTL CT INITIAL**	**10-1356-2 CTL CT FINAL**	**10-1356-2 CTL HA INITIAL**	**RDL**	**QC Batch**
Misc. Inorganics													
Dissolved Hardness (CaCO3)	mg/L	235	331	357	253	249	301	380	286	258	278	0.5	4342718

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69563	X69564	X69565	X69566	X69567	X69568	X69569	X69570	X69571	X69572		
	Units	**10-1356 CTL CT FINAL**	**10-1356 CTL HA INITIAL**	**10-1356 CTL HA FINAL**	**10-1356-1 CTL CT INITIAL**	**10-1356-1 CTL CT FINAL**	**10-1356-1 CTL HA INITIAL**	**10-1356-1 CTL HA FINAL**	**10-1356-2 CTL CT INITIAL**	**10-1356-2 CTL CT FINAL**	**10-1356-2 CTL HA INITIAL**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS													
Dissolved Aluminum (Al)	mg/L	0.279	1.23	0.228	1.37	0.565	0.766	0.896	4.08	1.08	0.562	0.003	4348791
Dissolved Antimony (Sb)	mg/L	<0.0005	<0.0005	<0.0005	0.0005	<0.0005	0.0005	0.0009	0.0005	0.0008	0.0006	0.0005	4348791
Dissolved Arsenic (As)	mg/L	0.0018	0.0010	0.0016	0.0283	0.0157	0.0250	0.0085	0.0256	0.0100	0.0141	0.0001	4348791
Dissolved Barium (Ba)	mg/L	0.084	0.179	0.163	0.154	0.119	0.195	0.216	0.318	0.215	0.280	0.001	4348791
Dissolved Beryllium (Be)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	4348791
Dissolved Bismuth (Bi)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	4348791
Dissolved Boron (B)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4348791
Dissolved Cadmium (Cd)	mg/L	0.00005	0.00012	0.00004	0.00003	0.00002	0.00003	0.00003	0.00009	0.00004	0.00004	0.00001	4348791
Dissolved Chromium (Cr)	mg/L	<0.001	0.003	0.001	0.003	<0.001	0.002	0.002	0.023	0.005	0.003	0.001	4348791
Dissolved Cobalt (Co)	mg/L	0.0008	0.0014	0.0006	0.0009	0.0007	0.0006	0.0008	0.0051	0.0017	0.0010	0.0005	4348791
Dissolved Copper (Cu)	mg/L	0.0053	0.0031	0.0034	0.0017	0.0008	0.0011	0.0015	0.0048	0.0014	0.0054	0.0002	4348791
Dissolved Iron (Fe)	mg/L	0.423	2.05	0.248	0.823	0.120	0.409	0.426	4.35	1.02	0.569	0.005	4348791
Dissolved Lead (Pb)	mg/L	0.0005	0.0019	0.0004	0.0016	0.0003	0.0008	0.0007	0.0056	0.0011	0.0009	0.0002	4348791
Dissolved Lithium (Li)	mg/L	0.008	0.008	0.007	0.008	<0.005	0.007	<0.005	0.017	0.008	0.010	0.005	4348791
Dissolved Manganese (Mn)	mg/L	0.027	0.154	0.019	0.279	0.159	0.416	0.098	0.464	0.170	0.363	0.001	4348791
Dissolved Mercury (Hg)	mg/L	0.00004	0.00002	0.00003	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00002	4348791
Dissolved Molybdenum (Mo)	mg/L	0.007	0.006	0.006	0.023	0.018	0.023	0.031	0.029	0.034	0.029	0.001	4348791
Dissolved Nickel (Ni)	mg/L	0.004	0.004	0.002	0.019	0.026	0.014	0.027	0.078	0.056	0.027	0.001	4348791
Dissolved Selenium (Se)	mg/L	0.0007	0.0002	0.0002	0.0002	0.0002	0.0001	<0.0001	0.0002	0.0002	<0.0001	0.0001	4348791
Dissolved Silicon (Si)	mg/L	4.9	5.0	4.1	3.7	2.5	3.2	2.6	10.0	4.5	4.5	0.1	4348791
Dissolved Silver (Ag)	mg/L	<0.00002	0.00003	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00004	<0.00002	<0.00002	0.00002	4348791
Dissolved Strontium (Sr)	mg/L	0.371	0.263	0.322	0.700	0.607	0.810	0.831	0.823	0.771	0.824	0.001	4348791
Dissolved Thallium (Tl)	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00008	<0.00005	<0.00005	0.00005	4348791
Dissolved Tin (Sn)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	4348791
Dissolved Titanium (Ti)	mg/L	<0.005	0.014	<0.005	0.028	<0.005	0.013	0.024	0.154	0.051	0.023	0.005	4348791
Dissolved Uranium (U)	mg/L	0.0014	0.0007	0.0007	0.0629	0.0694	0.0623	0.0789	0.0587	0.0609	0.0514	0.0001	4348791
Dissolved Vanadium (V)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.007	<0.005	<0.005	0.005	4348791
Dissolved Zinc (Zn)	mg/L	<0.005	0.010	<0.005	<0.005	<0.005	<0.005	<0.005	0.016	0.005	<0.005	0.005	4348791
Dissolved Zirconium (Zr)	mg/L	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0011	<0.0005	<0.0005	0.0005	4348791
Dissolved Calcium (Ca)	mg/L	53.5	90.9	98.6	41.9	50.7	59.7	91.8	51.7	54.4	61.1	0.05	4339906
Dissolved Magnesium (Mg)	mg/L	24.6	25.3	27.0	36.1	29.7	37.0	36.6	38.1	29.8	30.5	0.05	4339906
Dissolved Potassium (K)	mg/L	4.53	4.75	8.39	17.8	12.7	21.0	19.7	20.8	14.4	22.0	0.05	4339906
Dissolved Sodium (Na)	mg/L	18.9	36.4	45.4	24.6	21.5	41.3	54.3	26.6	23.6	40.1	0.05	4339906
Dissolved Sulphur (S)	mg/L	34	19	21	11	16	5	19	17	24	9	3	4339906

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69573	X69590	X69591	X69592	X69593	X69594	X69595	X69596	X69597	X69598		
	Units	**10-1356-2 CTL HA FINAL**	**10-1356-3 CT INITIAL**	**10-1356-3 CT FINAL**	**10-1356-3 HA INITIAL**	**10-1356-3 HA FINAL**	**10-1356-4 CT INITIAL**	**10-1356-4 CT FINAL**	**10-1356-4 HA INITIAL**	**10-1356-4 HA FINAL**	**10-1356-5 CT INITIAL**	**RDL**	**QC Batch**
Misc. Inorganics													
Dissolved Hardness (CaCO3)	mg/L	386	274	273	268	344	196	225	223	324	187	0.5	4342718

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69573	X69590	X69591	X69592	X69593	X69594	X69595	X69596	X69597	X69598		
	Units	**10-1356-2 CTL HA FINAL**	**10-1356-3 CT INITIAL**	**10-1356-3 CT FINAL**	**10-1356-3 HA INITIAL**	**10-1356-3 HA FINAL**	**10-1356-4 CT INITIAL**	**10-1356-4 CT FINAL**	**10-1356-4 HA INITIAL**	**10-1356-4 HA FINAL**	**10-1356-5 CT INITIAL**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS													
Dissolved Aluminum (Al)	mg/L	0.206	2.89	0.589	0.327	0.137	1.95	0.488	0.417	0.139	1.18	0.003	4348791
Dissolved Antimony (Sb)	mg/L	0.0005	0.0008	<0.0005	0.0007	0.0007	<0.0005	0.0006	<0.0005	0.0006	<0.0005	0.0005	4348791
Dissolved Arsenic (As)	mg/L	0.0114	0.0162	0.0065	0.0103	0.0047	0.0153	0.0048	0.0089	0.0023	0.0204	0.0001	4348791
Dissolved Barium (Ba)	mg/L	0.332	0.223	0.143	0.186	0.198	0.331	0.255	0.341	0.369	0.104	0.001	4348791
Dissolved Beryllium (Be)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	4348791
Dissolved Bismuth (Bi)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	4348791
Dissolved Boron (B)	mg/L	0.05	<0.05	0.05	<0.05	0.05	<0.05	<0.05	<0.05	<0.05	0.05	0.05	4348791
Dissolved Cadmium (Cd)	mg/L	0.00003	0.00008	0.00002	0.00004	0.00003	0.00005	0.00003	0.00003	0.00003	0.00004	0.00001	4348791
Dissolved Chromium (Cr)	mg/L	<0.001	0.012	0.003	0.001	<0.001	0.010	0.002	0.002	<0.001	0.003	0.001	4348791
Dissolved Cobalt (Co)	mg/L	0.0008	0.0028	0.0011	0.0005	0.0006	0.0025	0.0013	0.0010	0.0012	0.0016	0.0005	4348791
Dissolved Copper (Cu)	mg/L	0.0014	0.0037	0.0012	0.0040	0.0013	0.0032	0.0013	0.0014	0.0010	0.0041	0.0002	4348791
Dissolved Iron (Fe)	mg/L	0.146	3.56	0.559	0.331	0.077	2.23	0.491	0.546	0.076	1.63	0.005	4348791
Dissolved Lead (Pb)	mg/L	0.0003	0.0119	0.0012	0.0025	0.0004	0.0038	0.0009	0.0011	0.0003	0.0074	0.0002	4348791
Dissolved Lithium (Li)	mg/L	0.006	0.033	0.018	0.025	0.022	0.022	0.012	0.017	0.013	0.032	0.005	4348791
Dissolved Manganese (Mn)	mg/L	0.273	0.456	0.116	0.325	0.128	1.73	0.835	1.62	1.08	0.526	0.001	4348791
Dissolved Mercury (Hg)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00002	4348791
Dissolved Molybdenum (Mo)	mg/L	0.028	0.045	0.023	0.041	0.030	0.036	0.037	0.034	0.039	0.015	0.001	4348791
Dissolved Nickel (Ni)	mg/L	0.039	0.033	0.038	0.014	0.031	0.044	0.051	0.028	0.053	0.013	0.001	4348791
Dissolved Selenium (Se)	mg/L	0.0001	0.0002	0.0002	<0.0001	0.0001	0.0001	0.0002	<0.0001	0.0001	0.0001	0.0001	4348791
Dissolved Silicon (Si)	mg/L	4.4	11.3	6.9	6.7	7.3	9.1	6.8	7.9	6.9	10.7	0.1	4348791
Dissolved Silver (Ag)	mg/L	<0.00002	0.00005	<0.00002	<0.00002	<0.00002	0.00002	<0.00002	<0.00002	0.00003	0.00003	0.00002	4348791
Dissolved Strontium (Sr)	mg/L	0.991	0.753	0.692	0.732	0.782	0.631	0.603	0.626	0.739	0.636	0.001	4348791
Dissolved Thallium (Tl)	mg/L	<0.00005	0.00008	<0.00005	<0.00005	<0.00005	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00005	4348791
Dissolved Tin (Sn)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	4348791
Dissolved Titanium (Ti)	mg/L	0.005	0.191	0.030	0.019	<0.005	0.125	0.025	0.025	<0.005	0.058	0.005	4348791
Dissolved Uranium (U)	mg/L	0.0468	0.0357	0.0246	0.0296	0.0239	0.0407	0.0461	0.0280	0.0367	0.0247	0.0001	4348791
Dissolved Vanadium (V)	mg/L	<0.005	0.007	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	4348791
Dissolved Zinc (Zn)	mg/L	<0.005	0.018	<0.005	<0.005	<0.005	0.011	<0.005	<0.005	<0.005	0.007	0.005	4348791
Dissolved Zirconium (Zr)	mg/L	<0.0005	0.0008	<0.0005	<0.0005	<0.0005	0.0010	<0.0005	<0.0005	<0.0005	0.0008	0.0005	4348791
Dissolved Calcium (Ca)	mg/L	95.0	57.5	62.5	63.9	88.4	35.8	50.8	53.5	87.6	39.6	0.05	4339906
Dissolved Magnesium (Mg)	mg/L	36.2	31.7	28.5	26.4	29.9	25.8	23.9	21.7	25.7	21.4	0.05	4339906
Dissolved Potassium (K)	mg/L	22.0	19.4	13.7	19.9	19.1	16.2	11.2	16.6	15.9	15.2	0.05	4339906
Dissolved Sodium (Na)	mg/L	54.1	26.8	24.6	40.2	51.3	27.0	23.1	39.0	47.1	26.4	0.05	4339906
Dissolved Sulphur (S)	mg/L	17	18	22	10	19	20	28	12	29	14	3	4339906

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69599	X69600	X69601	X69613	X69614	X69615	X69616		X69617	X69618		
	Units	**10-1356-5 HA INITIAL**	**10-1356-5 CT FINAL**	**10-1356-5 HA FINAL**	**10-1356-6 CT INITIAL**	**10-1356-6 CT FINAL**	**10-1356-6 HA INITIAL**	**10-1356-6 HA FINAL**	**QC Batch**	**10-1356-7 CT INITIAL**	**10-1356-7 CT FINAL**	**RDL**	**QC Batch**
Misc. Inorganics													
Dissolved Hardness (CaCO3)	mg/L	197	217	264	89.5	102	113	188	4342718	89.1	103	0.5	4342718

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69599	X69600	X69601	X69613	X69614	X69615	X69616		X69617	X69618		
	Units	**10-1356-5 HA INITIAL**	**10-1356-5 CT FINAL**	**10-1356-5 HA FINAL**	**10-1356-6 CT INITIAL**	**10-1356-6 CT FINAL**	**10-1356-6 HA INITIAL**	**10-1356-6 HA FINAL**	**QC Batch**	**10-1356-7 CT INITIAL**	**10-1356-7 CT FINAL**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS													
Dissolved Aluminum (Al)	mg/L	0.202	0.838	0.456	1.34	0.300	0.167	0.294	4348796	1.58	0.091	0.003	4348796
Dissolved Antimony (Sb)	mg/L	<0.0005	0.0007	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	4348796	<0.0005	<0.0005	0.0005	4348796
Dissolved Arsenic (As)	mg/L	0.0099	0.0153	0.0075	0.0029	0.0022	0.0009	0.0016	4348796	0.0046	0.0034	0.0001	4348796
Dissolved Barium (Ba)	mg/L	0.100	0.090	0.116	0.038	0.030	0.054	0.110	4348796	0.045	0.034	0.001	4348796
Dissolved Beryllium (Be)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	4348796	<0.0001	<0.0001	0.0001	4348796
Dissolved Bismuth (Bi)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	4348796	<0.001	<0.001	0.001	4348796
Dissolved Boron (B)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	4348796	<0.05	<0.05	0.05	4348796
Dissolved Cadmium (Cd)	mg/L	0.00003	0.00003	0.00003	0.00008	0.00004	0.00015	0.00022	4348796	0.00007	0.00004	0.00001	4348796
Dissolved Chromium (Cr)	mg/L	<0.001	0.003	0.001	0.005	0.001	<0.001	<0.001	4348796	0.007	<0.001	0.001	4348796
Dissolved Cobalt (Co)	mg/L	0.0006	0.0017	0.0010	0.0031	0.0018	0.0024	0.0013	4348796	0.0046	0.0019	0.0005	4348796
Dissolved Copper (Cu)	mg/L	0.0017	0.0044	0.0047	0.0075	0.0054	0.0020	0.0048	4348796	0.0063	0.0064	0.0002	4348796
Dissolved Iron (Fe)	mg/L	0.305	1.09	0.575	2.87	0.456	0.385	0.545	4348796	4.56	0.346	0.005	4348796
Dissolved Lead (Pb)	mg/L	0.0014	0.0036	0.0025	0.0007	0.0006	0.0003	0.0003	4348796	0.0007	<0.0002	0.0002	4348796
Dissolved Lithium (Li)	mg/L	0.021	0.017	0.018	<0.005	<0.005	<0.005	0.006	4348796	0.006	<0.005	0.005	4348796
Dissolved Manganese (Mn)	mg/L	0.566	0.148	0.061	3.06	2.99	4.26	2.20	4348796	3.55	3.15	0.001	4348796
Dissolved Mercury (Hg)	mg/L	0.00004	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	4348796	<0.00002	<0.00002	0.00002	4348796
Dissolved Molybdenum (Mo)	mg/L	0.011	0.020	0.015	<0.001	0.001	<0.001	<0.001	4348796	<0.001	0.002	0.001	4348796
Dissolved Nickel (Ni)	mg/L	0.008	0.022	0.017	0.011	0.014	0.019	0.029	4348796	0.014	0.014	0.001	4348796
Dissolved Selenium (Se)	mg/L	<0.0001	0.0003	0.0001	0.0003	0.0003	<0.0001	<0.0001	4348796	0.0003	0.0003	0.0001	4348796
Dissolved Silicon (Si)	mg/L	7.8	8.7	9.0	4.8	4.7	2.8	5.3	4348796	6.8	5.3	0.1	4348796
Dissolved Silver (Ag)	mg/L	<0.00002	<0.00002	<0.00002	0.00002	<0.00002	<0.00002	<0.00002	4348796	<0.00002	<0.00002	0.00002	4348796
Dissolved Strontium (Sr)	mg/L	0.510	0.603	0.596	0.147	0.167	0.085	0.162	4348796	0.126	0.165	0.001	4348796
Dissolved Thallium (Tl)	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00010	4348796	0.00006	<0.00005	0.00005	4348796
Dissolved Tin (Sn)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	4348796	<0.005	<0.005	0.005	4348796
Dissolved Titanium (Ti)	mg/L	0.012	0.050	0.022	0.102	0.018	0.012	0.017	4348796	0.134	<0.005	0.005	4348796
Dissolved Uranium (U)	mg/L	0.0132	0.0522	0.0241	0.0005	0.0006	<0.0001	0.0003	4348796	0.0004	0.0003	0.0001	4348796
Dissolved Vanadium (V)	mg/L	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	4348796	0.005	<0.005	0.005	4348796
Dissolved Zinc (Zn)	mg/L	<0.005	0.006	<0.005	0.009	<0.005	<0.005	<0.005	4348796	0.011	<0.005	0.005	4348796
Dissolved Zirconium (Zr)	mg/L	<0.0005	0.0006	0.0011	<0.0005	<0.0005	<0.0005	<0.0005	4348796	<0.0005	<0.0005	0.0005	4348796
Dissolved Calcium (Ca)	mg/L	54.2	50.0	75.3	21.3	23.9	35.4	57.9	4339906	21.2	24.3	0.05	4342789
Dissolved Magnesium (Mg)	mg/L	15.1	22.3	18.4	8.82	10.3	6.07	10.6	4339906	8.81	10.3	0.05	4342789
Dissolved Potassium (K)	mg/L	13.7	11.5	15.4	2.26	3.40	3.02	7.56	4339906	2.57	3.15	0.05	4342789
Dissolved Sodium (Na)	mg/L	33.8	22.4	41.0	4.69	9.68	16.6	29.3	4339906	4.78	9.62	0.05	4342789
Dissolved Sulphur (S)	mg/L	6	27	13	18	25	7	12	4339906	17	26	3	4342789

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69619	X69620	X69621	X69622	X69623	X69624	X69633	X69634	X69635	X69636		
	Units	**10-1356-7 HA INITIAL**	**10-1356-7 HA FINAL**	**10-1356-8 CT INITIAL**	**10-1356-8 CT FINAL**	**10-1356-8 HA INITIAL**	**10-1356-8 HA FINAL**	**10-1392 CT INITIAL**	**10-1392 CT FINAL**	**10-1392 HA INITIAL**	**10-1392 HA FINAL**	**RDL**	**QC Batch**
Misc. Inorganics													
Dissolved Hardness (CaCO3)	mg/L	105	150	70.3	82.2	98.5	149	177	190	194	228	0.5	4342718

RDL = Reportable Detection Limit

CCME DISSOLVED METALS IN WATER (WATER)

Maxxam ID		X69619	X69620	X69621	X69622	X69623	X69624	X69633	X69634	X69635	X69636		
	Units	**10-1356-7 HA INITIAL**	**10-1356-7 HA FINAL**	**10-1356-8 CT INITIAL**	**10-1356-8 CT FINAL**	**10-1356-8 HA INITIAL**	**10-1356-8 HA FINAL**	**10-1392 CT INITIAL**	**10-1392 CT FINAL**	**10-1392 HA INITIAL**	**10-1392 HA FINAL**	**RDL**	**QC Batch**
Dissolved Metals by ICPMS													
Dissolved Aluminum (Al)	mg/L	0.291	0.051	1.77	0.057	1.53	0.108	3.26	4.66	2.51	0.429	0.003	4348796
Dissolved Antimony (Sb)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	0.0007	0.0005	4348796
Dissolved Arsenic (As)	mg/L	0.0017	0.0018	0.0116	0.0106	0.0068	0.0057	0.0213	0.0271	0.0183	0.0122	0.0001	4348796
Dissolved Barium (Ba)	mg/L	0.070	0.104	0.055	0.042	0.116	0.142	0.091	0.079	0.106	0.099	0.001	4348796
Dissolved Beryllium (Be)	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	4348796
Dissolved Bismuth (Bi)	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	4348796
Dissolved Boron (B)	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.05	4348796
Dissolved Cadmium (Cd)	mg/L	0.00022	0.00036	0.00008	0.00004	0.00030	0.00040	0.00001	0.00001	<0.00001	0.00001	0.00001	4348796
Dissolved Chromium (Cr)	mg/L	0.001	<0.001	0.006	<0.001	0.005	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	4348796
Dissolved Cobalt (Co)	mg/L	0.0057	0.0027	0.0085	0.0027	0.0231	0.0075	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	4348796
Dissolved Copper (Cu)	mg/L	0.0021	0.0056	0.0087	0.0050	0.0077	0.0072	0.0005	0.0005	0.0005	0.0003	0.0002	4348796
Dissolved Iron (Fe)	mg/L	0.832	0.184	5.74	0.593	4.28	0.306	0.136	0.090	0.101	0.015	0.005	4348796
Dissolved Lead (Pb)	mg/L	0.0003	<0.0002	0.0009	<0.0002	0.0007	0.0002	0.0002	0.0003	0.0002	<0.0002	0.0002	4348796
Dissolved Lithium (Li)	mg/L	<0.005	0.006	0.007	<0.005	0.007	0.006	0.006	0.006	0.005	<0.005	0.005	4348796
Dissolved Manganese (Mn)	mg/L	5.94	6.13	3.28	2.57	8.35	9.24	2.46	1.75	3.14	2.22	0.001	4348796
Dissolved Mercury (Hg)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00002	<0.00002	<0.00002	0.00002	4348796
Dissolved Molybdenum (Mo)	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.015	0.014	0.005	0.019	0.001	4348796
Dissolved Nickel (Ni)	mg/L	0.032	0.065	0.018	0.014	0.055	0.063	0.005	0.006	0.003	0.005	0.001	4348796
Dissolved Selenium (Se)	mg/L	<0.0001	0.0001	0.0002	0.0003	<0.0001	0.0001	0.0003	0.0002	0.0003	0.0001	0.0001	4348796
Dissolved Silicon (Si)	mg/L	4.0	6.5	7.8	8.6	8.1	11.6	1.2	1.1	1.1	0.4	0.1	4348796
Dissolved Silver (Ag)	mg/L	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00002	4348796
Dissolved Strontium (Sr)	mg/L	0.067	0.108	0.111	0.132	0.066	0.104	0.337	0.262	0.206	0.157	0.001	4348796
Dissolved Thallium (Tl)	mg/L	0.00007	0.00013	0.00008	0.00007	0.00018	0.00023	<0.00005	<0.00005	<0.00005	<0.00005	0.00005	4348796
Dissolved Tin (Sn)	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	4348796
Dissolved Titanium (Ti)	mg/L	0.023	<0.005	0.121	<0.005	0.111	0.006	<0.005	<0.005	<0.005	<0.005	0.005	4348796
Dissolved Uranium (U)	mg/L	<0.0001	<0.0001	0.0005	<0.0001	0.0005	<0.0001	0.0090	0.0108	0.0058	0.0033	0.0001	4348796
Dissolved Vanadium (V)	mg/L	<0.005	<0.005	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.005	4348796
Dissolved Zinc (Zn)	mg/L	<0.005	0.009	0.013	<0.005	0.016	0.009	<0.005	<0.005	<0.005	<0.005	0.005	4348796
Dissolved Zirconium (Zr)	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	4348796
Dissolved Calcium (Ca)	mg/L	33.5	47.0	15.8	19.4	30.8	47.1	40.4	41.6	56.7	70.2	0.05	4342789
Dissolved Magnesium (Mg)	mg/L	5.15	8.00	7.51	8.18	5.27	7.59	18.5	21.0	12.6	12.7	0.05	4342789
Dissolved Potassium (K)	mg/L	2.94	7.16	2.37	3.35	3.34	8.21	11.4	10.8	13.2	13.0	0.05	4342789
Dissolved Sodium (Na)	mg/L	16.1	26.7	4.54	10.0	16.5	29.7	18.7	20.9	32.4	35.5	0.05	4342789
Dissolved Sulphur (S)	mg/L	8	12	16	26	6	13	40	55	35	48	3	4342789

RDL = Reportable Detection Limit

CCME TOTAL METALS IN WATER (WATER)

Maxxam ID		X69562		
	Units	**10-1356 CTL CT INITIAL**	**RDL**	**QC Batch**
Calculated Parameters				
Total Hardness (CaCO3)	mg/L	1040	0.5	4343719
Total Metals by ICPMS				
Total Aluminum (Al)	mg/L	20.7	0.003	4356678
Total Antimony (Sb)	mg/L	0.0008	0.0005	4356678
Total Arsenic (As)	mg/L	0.0138	0.0001	4356678
Total Barium (Ba)	mg/L	0.888	0.001	4356678
Total Beryllium (Be)	mg/L	0.0011	0.0001	4356678
Total Bismuth (Bi)	mg/L	<0.001	0.001	4356678
Total Boron (B)	mg/L	0.06	0.05	4356678
Total Cadmium (Cd)	mg/L	0.00095	0.00001	4356678
Total Chromium (Cr)	mg/L	0.038	0.001	4356678
Total Cobalt (Co)	mg/L	0.0142	0.0005	4356678
Total Copper (Cu)	mg/L	0.0489	0.0002	4356678
Total Iron (Fe)	mg/L	32.8	0.005	4356678
Total Lead (Pb)	mg/L	0.0189	0.0002	4356678
Total Lithium (Li)	mg/L	0.035	0.005	4356678
Total Manganese (Mn)	mg/L	1.44	0.001	4356678
Total Mercury (Hg)	mg/L	0.00008	0.00002	4356678
Total Molybdenum (Mo)	mg/L	0.011	0.001	4356678
Total Nickel (Ni)	mg/L	0.041	0.001	4356678
Total Selenium (Se)	mg/L	0.0012	0.0001	4356678
Total Silicon (Si)	mg/L	37.3	0.1	4356678
Total Silver (Ag)	mg/L	0.00020	0.00002	4356678
Total Strontium (Sr)	mg/L	0.604	0.001	4356678
Total Thallium (Tl)	mg/L	0.00043	0.00005	4356678
Total Tin (Sn)	mg/L	<0.005	0.005	4356678
Total Titanium (Ti)	mg/L	0.195	0.005	4356678
Total Uranium (U)	mg/L	0.0030	0.0001	4356678
Total Vanadium (V)	mg/L	0.048	0.005	4356678
Total Zinc (Zn)	mg/L	0.113	0.005	4356678
Total Zirconium (Zr)	mg/L	0.0047	0.0005	4356678
Total Calcium (Ca)	mg/L	287	0.05	4343722
Total Magnesium (Mg)	mg/L	79.3	0.05	4343722
Total Potassium (K)	mg/L	7.10	0.05	4343722
Total Sodium (Na)	mg/L	21.6	0.05	4343722
Total Sulphur (S)	mg/L	33	3	4343722

RDL = Reportable Detection Limit

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**
4348791	Dissolved Arsenic (As)	2010/10/22	93	80 - 120	97	80 - 120	<0.0001	mg/L	0.6	20
4348791	Dissolved Beryllium (Be)	2010/10/22	86	80 - 120	92	80 - 120	<0.0001	mg/L	NC	20
4348791	Dissolved Cadmium (Cd)	2010/10/22	89	80 - 120	98	80 - 120	<0.00001	mg/L	NC	20
4348791	Dissolved Chromium (Cr)	2010/10/22	95	80 - 120	98	80 - 120	<0.001	mg/L	NC	20
4348791	Dissolved Cobalt (Co)	2010/10/22	96	80 - 120	100	80 - 120	<0.0005	mg/L	NC	20
4348791	Dissolved Copper (Cu)	2010/10/22	NC	80 - 120	99	80 - 120	<0.0002	mg/L	3.2	20
4348791	Dissolved Lead (Pb)	2010/10/22	86	80 - 120	97	80 - 120	<0.0002	mg/L	NC	20
4348791	Dissolved Lithium (Li)	2010/10/22	NC	80 - 120	89	80 - 120	<0.005	mg/L	NC	20
4348791	Dissolved Nickel (Ni)	2010/10/22	95	80 - 120	96	80 - 120	<0.001	mg/L	NC	20
4348791	Dissolved Selenium (Se)	2010/10/22	93	80 - 120	99	80 - 120	<0.0001	mg/L	10.4	20
4348791	Dissolved Uranium (U)	2010/10/22	85	80 - 120	94	80 - 120	<0.0001	mg/L	3.6	20
4348791	Dissolved Vanadium (V)	2010/10/22	97	80 - 120	99	80 - 120	<0.005	mg/L	NC	20
4348791	Dissolved Zinc (Zn)	2010/10/22	95	80 - 120	95	80 - 120	<0.005	mg/L	NC	20
4348791	Dissolved Aluminum (Al)	2010/10/22					<0.003	mg/L	5.9	20
4348791	Dissolved Antimony (Sb)	2010/10/22					<0.0005	mg/L	NC	20
4348791	Dissolved Barium (Ba)	2010/10/22					<0.001	mg/L	1.9	20
4348791	Dissolved Bismuth (Bi)	2010/10/22					<0.001	mg/L	NC	20
4348791	Dissolved Boron (B)	2010/10/22					<0.05	mg/L	NC	20
4348791	Dissolved Iron (Fe)	2010/10/22					<0.005	mg/L	14.4	20
4348791	Dissolved Manganese (Mn)	2010/10/22					<0.001	mg/L	2.0	20
4348791	Dissolved Mercury (Hg)	2010/10/22					<0.00002	mg/L	NC	20
4348791	Dissolved Molybdenum (Mo)	2010/10/22					<0.001	mg/L	1.9	20
4348791	Dissolved Silicon (Si)	2010/10/22					<0.1	mg/L	14.3	20
4348791	Dissolved Silver (Ag)	2010/10/22					<0.00002	mg/L	NC	20
4348791	Dissolved Strontium (Sr)	2010/10/22					<0.001	mg/L	0.9	20
4348791	Dissolved Thallium (Tl)	2010/10/22					<0.00005	mg/L	NC	20
4348791	Dissolved Tin (Sn)	2010/10/22					<0.005	mg/L	NC	20
4348791	Dissolved Titanium (Ti)	2010/10/22					<0.005	mg/L	NC	20
4348791	Dissolved Zirconium (Zr)	2010/10/22					<0.0005	mg/L	NC	20
4348796	Dissolved Arsenic (As)	2010/10/21	NC	80 - 120	100	80 - 120	<0.0001	mg/L	0.8	20
4348796	Dissolved Beryllium (Be)	2010/10/21	87	80 - 120	88	80 - 120	<0.0001	mg/L	NC	20
4348796	Dissolved Cadmium (Cd)	2010/10/21	91	80 - 120	100	80 - 120	<0.00001	mg/L	NC	20
4348796	Dissolved Chromium (Cr)	2010/10/21	95	80 - 120	100	80 - 120	<0.001	mg/L	NC	20
4348796	Dissolved Cobalt (Co)	2010/10/21	94	80 - 120	103	80 - 120	<0.0005	mg/L	NC	20
4348796	Dissolved Copper (Cu)	2010/10/21	92	80 - 120	102	80 - 120	<0.0002	mg/L	0.6	20
4348796	Dissolved Lead (Pb)	2010/10/21	88	80 - 120	98	80 - 120	<0.0002	mg/L	1.3	20
4348796	Dissolved Lithium (Li)	2010/10/21	NC	80 - 120	85	80 - 120	<0.005	mg/L	NC	20
4348796	Dissolved Nickel (Ni)	2010/10/21	NC	80 - 120	100	80 - 120	<0.001	mg/L	3.4	20
4348796	Dissolved Selenium (Se)	2010/10/21	96	80 - 120	100	80 - 120	<0.0001	mg/L	NC	20
4348796	Dissolved Uranium (U)	2010/10/21	NC	80 - 120	95	80 - 120	<0.0001	mg/L	0.9	20

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4348796	Dissolved Vanadium (V)	2010/10/21	99	80 - 120	100	80 - 120	<0.005	mg/L	NC	20
4348796	Dissolved Zinc (Zn)	2010/10/21	104	80 - 120	98	80 - 120	<0.005	mg/L	NC	20
4348796	Dissolved Aluminum (Al)	2010/10/21					<0.003	mg/L	1.3	20
4348796	Dissolved Antimony (Sb)	2010/10/21					<0.0005	mg/L	NC	20
4348796	Dissolved Barium (Ba)	2010/10/21					<0.001	mg/L	0.2	20
4348796	Dissolved Bismuth (Bi)	2010/10/21					<0.001	mg/L	NC	20
4348796	Dissolved Boron (B)	2010/10/21					<0.05	mg/L	NC	20
4348796	Dissolved Iron (Fe)	2010/10/21					<0.005	mg/L	1.4	20
4348796	Dissolved Manganese (Mn)	2010/10/21					<0.001	mg/L	3.2	20
4348796	Dissolved Mercury (Hg)	2010/10/21					<0.00002	mg/L	NC	20
4348796	Dissolved Molybdenum (Mo)	2010/10/21					<0.001	mg/L	0.2	20
4348796	Dissolved Silicon (Si)	2010/10/21					<0.1	mg/L	0.5	20
4348796	Dissolved Silver (Ag)	2010/10/21					<0.00002	mg/L	NC	20
4348796	Dissolved Strontium (Sr)	2010/10/21					<0.001	mg/L	0.9	20
4348796	Dissolved Thallium (Tl)	2010/10/21					<0.00005	mg/L	NC	20
4348796	Dissolved Tin (Sn)	2010/10/21					<0.005	mg/L	NC	20
4348796	Dissolved Titanium (Ti)	2010/10/21					<0.005	mg/L	NC	20
4348796	Dissolved Zirconium (Zr)	2010/10/21					<0.0005	mg/L	NC	20
4356678	Total Arsenic (As)	2010/10/26	108	80 - 120	104	80 - 120	<0.0001	mg/L	NC	20
4356678	Total Beryllium (Be)	2010/10/26	115	80 - 120	114	80 - 120	<0.0001	mg/L	NC	20
4356678	Total Cadmium (Cd)	2010/10/26	110	80 - 120	94	80 - 120	<0.00001	mg/L	NC	20
4356678	Total Chromium (Cr)	2010/10/26	112	80 - 120	109	80 - 120	<0.001	mg/L	NC	20
4356678	Total Cobalt (Co)	2010/10/26	109	80 - 120	105	80 - 120	<0.0005	mg/L	NC	20
4356678	Total Copper (Cu)	2010/10/26	98	80 - 120	104	80 - 120	0.0004, RDL=0.0002	mg/L	11.8	20
4356678	Total Lead (Pb)	2010/10/26	111	80 - 120	111	80 - 120	<0.0002	mg/L	NC	20
4356678	Total Lithium (Li)	2010/10/26	114	80 - 120	122 (1, 2)	80 - 120	<0.005	mg/L		
4356678	Total Nickel (Ni)	2010/10/26	100	80 - 120	111	80 - 120	<0.001	mg/L	NC	20
4356678	Total Selenium (Se)	2010/10/26	104	80 - 120	103	80 - 120	<0.0001	mg/L	NC	20
4356678	Total Uranium (U)	2010/10/26	110	80 - 120	105	80 - 120	<0.0001	mg/L	NC	20
4356678	Total Vanadium (V)	2010/10/26	111	80 - 120	101	80 - 120	<0.005	mg/L	NC	20
4356678	Total Zinc (Zn)	2010/10/26	NC	80 - 120	115	80 - 120	<0.005	mg/L	NC	20
4356678	Total Aluminum (Al)	2010/10/26					0.004, RDL=0.003	mg/L	16.4	20
4356678	Total Antimony (Sb)	2010/10/26					<0.0005	mg/L	NC	20
4356678	Total Barium (Ba)	2010/10/26					<0.001	mg/L	7.7	20
4356678	Total Bismuth (Bi)	2010/10/26					<0.001	mg/L	NC	20
4356678	Total Boron (B)	2010/10/26					<0.05	mg/L	NC	20
4356678	Total Iron (Fe)	2010/10/26					0.008, RDL=0.005	mg/L	4.9	20
4356678	Total Manganese (Mn)	2010/10/26					<0.001	mg/L	7.5	20
4356678	Total Mercury (Hg)	2010/10/26					<0.00002	mg/L		
4356678	Total Molybdenum (Mo)	2010/10/26					<0.001	mg/L	0.7	20

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4356678	Total Silicon (Si)	2010/10/26					<0.1	mg/L	0.9	20
4356678	Total Silver (Ag)	2010/10/26					<0.00002	mg/L	NC	20
4356678	Total Strontium (Sr)	2010/10/26					<0.001	mg/L	5.3	20
4356678	Total Thallium (Tl)	2010/10/26					<0.00005	mg/L	NC	20
4356678	Total Tin (Sn)	2010/10/26					<0.005	mg/L	NC	20
4356678	Total Titanium (Ti)	2010/10/26					<0.005	mg/L	NC	20
4356678	Total Zirconium (Zr)	2010/10/26					<0.0005	mg/L	NC	20

N/A = Not Applicable

RDL = Reportable Detection Limit

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was not sufficiently significant to permit a reliable recovery calculation.

NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

(1) - Recovery or RPD for this parameter is outside control limits. The overall quality control for this analysis meets acceptability criteria.

(2) - Blank Spike outside acceptance criteria (10% of analytes failure allowed)

Maxxam

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Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
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Chain of Custody A017489

B099438

Page: 1 of 4

	Invoice To: C/O Report Address ☐
Company:	Golder Associates Ltd.
Contact:	Cathy McPherson
Address:	500-4260 Still Creek Drive
	Prov: Burnaby, BC PC: V5C 6C6
Contact #s:	Ph: 1-604-297-2007 Cell:

Report To: Same as Invoice ☑

Prov: PC:
Ph: Cell:

Report Distribution (E-Mail):
cmcpherson@golder.com

REGULATORY GUIDELINES:

☐ AT1
☐ CCME
☐ Regulated Drinking Water
☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: contact Cathy.
Project # / Name: Diavik North Inlet.
Site Location: DN1
Quote #: B10-145-KP
Sampled By:

SERVICE REQUESTED:
☐ **RUSH** (Contact lab to reserve)
Date Required:
☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill				WATER: ☐BTEX F1 ☐VOCs	☐BTEX F1-F2 ☐BTEX F1-F4	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME/AT1) Total	Regulated Metals (CCME/AT1) Dissolved	Mercury ☐ Total ☐ Dissolved	Other Analysis											HOLD - Do not Analyze	# of Containers Submitted
1	10-1356 CTL CT initial		sedmt																✓														
2	10-1356 CTL CT final		↓																✓														
3	10-1356 CTL HA initial																		✓														
4	10-1356 CTL HA final																		✓														
5	10-1356-1 CT initial																		✓														
6	10-1356-1 CT final																		✓														
7	10-1356-1 HA initial																		✓														
8	10-1356-1 HA final																		✓														
9	10-1356-2 CT initial																		✓														
10	10-1356-2 CT final																		✓														
11	10-1356-2 HA initial																		✓														
12	10-1356-2 HA final		↓																✓														
	Please indicate Filtered, Preserved or Both (F, P, F/P) →																		P														F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:	Date:	Time:	Maxxam Job #:		
		0855	Custody Seal	Temperature	Ice
Lab Comments: C Rosen	10 10 15			14 13 14	

Maxxam

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Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
www.maxxamanalytics.com

Chain of Custody A017490

Page: 2 of 4

Invoice To: C/O Report Address ☐
Company: Golder Associates Ltd.
Contact: Cathy McPherson
Address: 500-4260 Still Creek Drive
Prov: Burnaby, BC PC: V5C 6C6
Contact #s: Ph: 1-604-297-2007 Cell:

Report To: Same as Invoice ☑
Prov:
PC:
Ph:
Cell:

Report Distribution (E-Mail): cmcpherson@golder.com

REGULATORY GUIDELINES:
- ☐ AT1
- ☐ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: Contact Cathy
Project # / Name: Diavik North Inlet
Site Location: DN1
Quote #: B10-145-KP
Sampled By:

SERVICE REQUESTED: ☐ RUSH (Contact lab to reserve)
Date Required:
☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	SOIL: Sieve (75 micron)	SOIL: Regulated Metals (CCME / AT1)	SOIL: Salinity 4	SOIL: Assessment ICP Metals	SOIL: Basic Class II Landfill	WATER: ☐ BTEX F1 / ☐ VOCs	WATER: ☐ BTEX F1-F2 / ☐ BTEX F1-F4	WATER: ☐ Routine Water ☐ Turb ☐ F	WATER: ☐ TOC / ☐ DOC	WATER: Regulated Metals (CCME / AT1): Total	WATER: Regulated Metals (CCME / AT1): Dissolved	WATER: Mercury ☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	10-1356-3 CT initial		Sediment													✓				
2	10-1356-3 CT final															✓				
3	10-1356-3 HA initial															✓				
4	10-1356-3 HA final															✓				
5	10-1356-4 CT initial															✓				
6	10-1356-4 CT final															✓				
7	10-1356-4 HA initial															✓				
8	10-1356-4 HA final															✓				
9	10-1356-5 CT initial															✓				
10	10-1356-5 HA initial															✓				
11	10-1356-5 CT final															✓				
12	10-1356-5 HA final															✓				
	Please indicate Filtered, Preserved or Both (F, P, F/P) →															P				F/P

Relinquished By (Signature/Print): Date (YY/MM/DD): Time (24:00):

Relinquished By (Signature/Print): Date (YY/MM/DD): Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By: **Date:** **Time:** 0855

Maxxam Job #:

Lab Comments: C Rosen 10/10/15

Custody Seal	Temperature	Ice
	14 13 14	

AB FCD-00331 Rev3 2010/05

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam

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Chain of Custody A017491

Page: 3 of 4

Company:	**Invoice To:** **C/O Report Address** ☐	Golder Associates Ltd.
Contact:	Cathy McPherson	
Address:	500-4260 Still Creek Dr.	
	Prov: Burnaby, BC	PC: V5C 6C6
Contact #s:	Ph: 1604-297-2007	Cell:

Report To: Same as Invoice ☑
Prov:
PC:
Ph:
Cell:

Report Distribution (E-Mail): cmcpherson@golder.com

REGULATORY GUIDELINES:
☐ AT1
☐ CCME
☐ Regulated Drinking Water
☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #: contact Cathy
Project # / Name: Diavik North Inlet
Site Location: DNI
Quote #: B10-145-KP.
Sampled By:

SERVICE REQUESTED:
☐ **RUSH** (Contact lab to reserve)
Date Required:
☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill			
1	10-1356-6 CT initial		sedmnt										
2	10-1356-6 CT final												
3	10-1356-6 HA initial												
4	10-1356-6 HA final												
5	10-1356-7 CT initial												
6	10-1356-7 CT final												
7	10-1356-7 HA initial												
8	10-1356-7 HA final												
9	10-1356-8 CT initial												
10	10-1356-8 CT final												
11	10-1356-8 HA initial		✓										
12	10-1356-8 HA final												

	WATER: ☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	☐ Routine Water ☐ Turb ☐ F	☐ TOC ☐ DOC	Regulated Metals (CCME / AT1): Total	Regulated Metals (CCME / AT1): Dissolved	Mercury ☐ Total ☐ Dissolved	Other Analysis											HOLD - Do not Analyze	# of Containers Submitted
1						✓														
2						✓														
3						✓														
4						✓														
5						✓														
6						✓														
7						✓														
8						✓														
9						✓														
10						✓														
11						✓														
12						✓														
Please indicate Filtered, Preserved or Both (F, P, F/P) →						P														F/P

Relinquished By (Signature/Print):
Date (YY/MM/DD):
Time (24:00):

Relinquished By (Signature/Print):
Date (YY/MM/DD):
Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:
Date:
Time: 0855

Maxxam Job #:

Custody Seal	Temperature	Ice
	14 | 13 | 14	

Lab Comments: C.ROSEN 10/6/15

Page 17 of 18

Maxxam

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Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
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Chain of Custody A017492

Page: 4 of 4

	Invoice To:	C/O Report Address ☐
Company:	Golder Associates Ltd.	
Contact:		
Address:		
	Prov:	PC:
Contact #s:	Ph:	Cell:

Report To: Same as Invoice ☐

Prov: PC:

Ph: Cell:

Report Distribution (E-Mail):

REGULATORY GUIDELINES:
- ☐ AT1
- ☐ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:
Project # / Name:
Site Location:
Quote #:
Sampled By:

SERVICE REQUESTED: ☐ **RUSH** (Contact lab to reserve) **Date Required:** ☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	SOIL: Sieve (75 micron)	SOIL: Regulated Metals (CCME / AT1)	SOIL: Salinity 4	SOIL: Assessment ICP Metals	SOIL: Basic Class II Landfill	WATER: ☐ BTEX/F1 ☐ [illegible]	WATER: ☐ BTEX/F2-F4 ☐ [illegible]	WATER: ☐ Routine Water ☐ [illegible]	WATER: ☐ TOC ☐ DOC	WATER: Regulated Metals (CCME/AT1) Total	WATER: Regulated Metals (CCME/AT1) Dissolved	WATER: Mercury ☐ Total ☐ Dissolved	Other Analysis	HOLD - Do not Analyze	# of Containers Submitted
1	10-1392 CT initial															✓				
2	10-1392 CT final															✓				
3	10-1392 HA initial															✓				
4	10-1392 HA final															✓				
5																				
6																				
7																				
8																				
9																				
10																				
11																				
12																				
	Please indicate Filtered, Preserved or Both (F, P, F/P) →															P			F/P	

Relinquished By (Signature/Print): Date (YY/MM/DD): Time (24:00):

Relinquished By (Signature/Print): Date (YY/MM/DD): Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:	Date:	Time:	Maxxam Job #:		
		C855	Custody Seal	Temperature	Ice
Lab Comments: C Rosen 101015				14 / 13 / 14	

AB FCD-00331 Rev3 2010/05

Maxxam Analytics International Corporation o/a Maxxam Analytics

Your Project #: DIAVIK NORTH INLET
Site: DN1
Your C.O.C. #: A017493, 71368, 71367, A017494

Attention: Cathy McPherson
GOLDER ASSOCIATES LTD
4260 STILL CREEK DRIVE
Suite 500
BURNABY, BC
Canada V5C 6C6

Report Date: 2010/10/21

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B099496
Received: 2010/10/15, 08:55

Sample Matrix: Water
Samples Received: 40

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Phosphorus-P (Total, dissolved)	40	2010/10/18	2010/10/19	BRN SOP-00236 R6.0	SM-4500PF

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VJ OCO, Burnaby Customer Service
Email: VJ.Oco@MaxxamAnalytics.com
Phone# (604) 639-8422

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		X69965	X69966		X69967		X69968	X69969	X69970	X69971	X69972	X69973	X69974		
	Units	**10-1356 CTL CT INITIAL**	**10-1356 CTL CT FINAL**	**RDL**	**10-1356 CTL HA INITIAL**	**RDL**	**10-1356 CTL HA FINAL**	**10-1356-1 CT INITIAL**	**10-1356-1 CT FINAL**	**10-1356-1 HA INITIAL**	**10-1356-1 HA FINAL**	**10-1356-2 CT INITIAL**	**10-1356-2 CT FINAL**	**RDL**	**QC Batch**
Nutrients															
Dissolved Phosphorus (P)	mg/L	0.034	0.104	0.005	0.82	0.05	0.189	0.241	0.255	0.381	0.098	0.182	0.255	0.005	4348150

Maxxam ID		X69975	X69976	X69977	X69978	X69979	X69980	X69981	X69982	X69983	X69984		
	Units	**10-1356-2 HA INITIAL**	**10-1356-2 HA FINAL**	**10-1356-3 CT INITIAL**	**10-1356-3 CT FINAL**	**10-1356-3 HA INITIAL**	**10-1356-3 HA FINAL**	**10-1356-4 CT INITIAL**	**10-1356-4 CT FINAL**	**10-1356-4 HA INITIAL**	**10-1356-4 HA FINAL**	**RDL**	**QC Batch**
Nutrients													
Dissolved Phosphorus (P)	mg/L	0.231	0.101	0.370	0.372	0.386	0.128	0.184	0.137	0.409	0.095	0.005	4348150

Maxxam ID		X69985	X69986	X69987	X69988	X69999	X70000	X70001	X70002	X70003	X70004		
	Units	**10-1356-5 CT INITIAL**	**10-1356-5 CT FINAL**	**10-1356-5 HA INITIAL**	**10-1356-5 HA FINAL**	**10-1356-6 CT INITIAL**	**10-1356-6 CT FINAL**	**10-1356-6 HA INITIAL**	**10-1356-6 HA FINAL**	**10-1356-7 CT INITIAL**	**10-1356-7 CT FINAL**	**RDL**	**QC Batch**
Nutrients													
Dissolved Phosphorus (P)	mg/L	0.192	0.325	0.148	0.207	0.064	0.115	0.041	0.093	0.039	0.138	0.005	4348150

Maxxam ID		X70005	X70006	X70007	X70008	X70009	X70010		X70013		X70014		
	Units	**10-1356-7 HA INITIAL**	**10-1356-7 HA FINAL**	**10-1356-8 CT INITIAL**	**10-1356-8 CT FINAL**	**10-1356-8 HA INITIAL**	**10-1356-8 HA FINAL**	**RDL**	**10-1392 CT INITIAL**	**RDL**	**10-1392 CT FINAL**	**RDL**	**QC Batch**
Nutrients													
Dissolved Phosphorus (P)	mg/L	0.017	0.174	0.035	0.160	0.010	0.158	0.005	0.96	0.05	0.430	0.005	4348150

Maxxam ID		X70015		X70016		
	Units	**10-1392 HA INITIAL**	**RDL**	**10-1392 HA FINAL**	**RDL**	**QC Batch**
Nutrients						
Dissolved Phosphorus (P)	mg/L	0.51	0.05	0.053	0.005	4348150

RDL = Reportable Detection Limit

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	**Parameter**	**Date**	**% Recovery**	**QC Limits**	**% Recovery**	**QC Limits**	**Value**	**Units**	**Value (%)**	**QC Limits**
4348150	Dissolved Phosphorus (P)	2010/10/19	99	80 - 120	90	80 - 120	<0.005	mg/L	2.9	20

N/A = Not Applicable

RPD = Relative Percent Difference

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

Maxxam

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Edmonton: 9331 - 48 Street, T6B 2R4. Ph: (780) 577-7100, Fax: (780) 450-4187, Toll free: (877) 465-8889
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Chain of Custody A017493

Page: 1 of 4

Company:	**Invoice To:** Golder Associates Ltd	**C/O Report Address** ☐	
Contact:	Cathy McPherson		
Address:	500-4260 Still creek Dr.		
	Prov: Burnaby, BC	PC: V5C 6C6	
Contact #s:	Ph: 1-604-297-2007	Cell:	

Report To: Same as Invoice ☑
Prov: PC:
Ph: Cell:

Report Distribution (E-Mail): cmcpherson@golder.com

REGULATORY GUIDELINES:
- ☐ AT1
- ☐ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:	
Project # / Name:	Diavik North Inlet
Site Location:	DN1
Quote #:	B10-145-FP
Sampled By:	

SERVICE REQUESTED:
☐ **RUSH** (Contact lab to reserve)
Date Required:
☐ REGULAR (5 to 7 Days)

See reverse for package specifics

	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	SOIL: BTEX F1-F4	SOIL: Sieve (75 micron)	SOIL: Regulated Metals (CCME / AT1)	SOIL: Salinity 4	SOIL: Assessment ICP Metals	SOIL: Basic Class II Landfill	WATER: [illegible]	Other Analysis: Dissolved Phosphorus	HOLD - Do not Analyze	# of Containers Submitted
1	10-1356 CTL CT initial											✓		
2	10-1356 CTL CT final											✓		
3	10-1356 CTL HA initial											✓		
4	10-1356 CTL HA final											✓		
5	10-1356-1 CT initial											✓		
6	10-1356-1 CT final											✓		
7	10-1356-1 HA initial											✓		
8	10-1356-1 HA final											✓		
9	10-1356-2 CT initial											✓		
10	10-1356-2 CT final											✓		
11	10-1356-2 HA initial											✓		
12	10-1356-2 HA final											✓		
	Please indicate Filtered, Preserved or Both (F, P, F/P) →											P		F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
Special Instructions:		**# of Jars Used & Not Submitted**

LAB USE ONLY

Received By:	**Date:**	**Time:**	Maxxam Job #: B099446		
			Custody Seal	Temperature	Ice
Lab Comments: C. Rosen 101015 0855					

14 11 15

Maxxam Analytics International Corporation o/a Maxxam Analytics

Maxxam Analytics

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71368 **CHAIN OF CUSTODY**

Page: 2 of 4

Invoice To: Require Report? Yes ☐ No ☐
Company Name:
Contact Name:
Address:
Prov: **PC:**
Contact #s: **Ph:** **Fax:**

Report To:
Prov: **PC:**
Ph: **Fax:**

PO # / AFE #:
Quotation #:
Project #:
Project Name:
Location:
Sampler's Initials:

DETECTION LIMIT REQUIREMENTS:
Check the applicable criterion and indicate land use
☐ AT1
☐ CCME
☐ OTHER

REPORT DISTRIBUTION:
EMAIL ADDRESS(S):

SERVICE REQUESTED:
☐ **RUSH** (Please ensure you contact the lab to reserve)
Date Required:
☐ REGULAR Turnaround (5 to 7 Days)

	Sample Identification	Matrix S/W	Date & Time Sampled Year/Month/Day	SOILS (footnotes defined on back): BTEX F1-F4	Sieve (75 micron)	Salinity 4	Regulated Metals (CCME / AT1)¹	Assessment ICP Metals²	☐ Paint Filter ☐ Flashpoint ☐ pH (1:1)	TCLP ☐ BTEX ☐ Metals				WATERS (footnotes defined on back): ☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	Routine Water Package ☐ Turb ☐ F	REGULATED METALS (CCME / AT1)¹: Total ☐ Preserved ☐ Not Preserved	REGULATED METALS (CCME / AT1)¹: Dissolved ☐ Preserved ☐ Not Preserved ☐ Filtered ☐ Not Filtered	Mercury ☐ Total ☐ Dissolved	☐ Ammonia ☐ TKN ☐ COD	☐ TOC ☐ DOC	OTHER TEST(S): Dissolved Phosphorus							*HOLD for 60 Days	# of Containers Submitted
1	10-1356-3 CT initial																					✓								
2	10-1356-3 CT final																					✓								
3	10-1356-3 HA initial																					✓								
4	10-1356-3 HA final																					✓								
5	10-1356-4 CT initial																					✓								
6	10-1356-4 CT final																					✓								
7	10-1356-4 HA initial																					✓								
8	10-1356-4 HA final																					✓								
9	10-1356-5 CT initial																					✓								
10	10-1356-5 CT final																					✓								
11	10-1356-5 HA initial																					✓								
12	10-1356-5 HA final																					✓								

**All samples are held for 60 calendar days after sample receipt. For long term storage please contact your project manager.*

P **Maxxam Job #:** B0[illegible]496

Relinquished By: **Date/Time:**
Sign and Print:
COMMENTS/SPECIAL INSTRUCTIONS:

# JARS USED & NOT SUBMITTED	Received By	Temperature			Ice
	10 1015 0855 C. Rosen	14	14	15	
	CUSTODY SEAL YES / NO				

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71367 **CHAIN OF CUSTODY**

Page: 3 of 4

Invoice To: Require Report? Yes ☐ No ☐
Company Name:
Contact Name:
Address:
Prov: **PC:**
Contact #s: **Ph:** **Fax:**

Report To:
Prov: **PC:**
Ph: **Fax:**

PO # / AFE #:
Quotation #:
Project #:
Project Name:
Location:
Sampler's Initials:

DETECTION LIMIT REQUIREMENTS:
Check the applicable criterion and indicate land use
☐ AT1
☐ CCME
☐ OTHER

REPORT DISTRIBUTION:
EMAIL ADDRESS(S):

SERVICE REQUESTED:
☐ **RUSH** (Please ensure you contact the lab to reserve)
Date Required:
☐ REGULAR Turnaround (5 to 7 Days)

				SOILS (footnotes defined on back)										**WATERS** (footnotes defined on back)								**OTHER TEST(S)**								
	Sample Identification	Matrix S/W	Date & Time Sampled Year/Month/Day	BTEX F1-F4	Sieve (75 micron)	Salinity 4	Regulated Metals (CCME / AT1)¹	Assessment ICP Metals²	☐ Paint Filter ☐ Flashpoint ☐ pH (1:1)	TCLP ☐ BTEX ☐ Metals				☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	Routine Water Package ☐ Turb ☐ F	REGULATED METALS (CCME / AT1)³ Total ☐ Preserved ☐ Not Preserved	Dissolved ☐ Preserved ☐ Not Preserved ☐ Filtered ☐ Not Filtered	Mercury ☐ Total ☐ Dissolved	☐ Ammonia ☐ TKN ☐ COD	☐ TOC ☐ DOC	DISSOLVED PHOSPHORUS							*HOLD for 60 Days	# of Containers Submitted
1	10-1356-6 CT initial																					✓								
2	10-1356-6 CT final																					✓								
3	10-1356-6 HA initial																					✓								
4	10-1356-6 CT initial																					✓								
5	10-1356-7 CT initial																					✓								
6	10-1356-7 CT final																					✓								
7	10-1356-7 HA initial																					✓								
8	10-1356-7 HA final																					✓								
9	10-1356-8 CT initial																					✓								
10	10-1356-8 CT final																					✓								
11	10-1356-8 HA initial																					✓								
12	10-1356-8 HA final																					✓								

All samples are held for 60 calendar days after sample receipt. For long term storage please contact your project manager.

Maxxam Job #: B099496

Relinquished By: **Date/Time:**
Sign and Print:
COMMENTS/SPECIAL INSTRUCTIONS:

# JARS USED & NOT SUBMITTED	Received By	Temperature			Ice
	10 10 15 C. Rosen 0855	14	14	15	
	CUSTODY SEAL YES / NO				

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Chain of Custody A017494

Page: 4 of 4

	Invoice To: C/O Report Address ☐	Report To: Same as Invoice ☐	Report Distribution (E-Mail):
Company:			
Contact:			
Address:			
	Prov: PC:	Prov: PC:	
Contact #s:	Ph: Cell:	Ph: Cell:	

REGULATORY GUIDELINES:
- ☐ AT1
- ☐ CCME
- ☐ Regulated Drinking Water
- ☐ Other:

All samples are held for 60 calendar days after sample receipt, unless specified otherwise.

PO #:
Project # / Name:
Site Location:
Quote #:
Sampled By:

SERVICE REQUESTED:
- ☐ **RUSH** (Contact lab to reserve)
- **Date Required:**
- ☐ REGULAR (5 to 7 Days)

See reverse for package specifics

					SOIL									WATER							Other Analysis											
	Sample ID	Depth (unit)	Matrix GW / SW Soil	Date/Time Sampled YY/MM/DD 24:00	BTEX F1-F4	Sieve (75 micron)	Regulated Metals (CCME / AT1)	Salinity 4	Assessment ICP Metals	Basic Class II Landfill				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	DISSOLVED PHOSPHORUS											HOLD - Do not Analyze	# of Containers Submitted
1	10-1392 CT initial																				✓												
2	10-1392 CT final																				✓												
3	10-1392 HA initial																				✓												
4	10-1392 HA final																				✓												
5																																	
6																																	
7																																	
8																																	
9																																	
10																																	
11																																	
12																																	
	Please indicate Filtered, Preserved or Both (F, P, F/P) →																				P.												F/P

Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):
Relinquished By (Signature/Print):	Date (YY/MM/DD):	Time (24:00):

Special Instructions:

# of Jars Used & Not Submitted

LAB USE ONLY

Received By:	**Date:**	**Time:**	Maxxam Job #: B099496		
	101015	0855	Custody Seal	Temperature	Ice
Lab Comments: C. Risew			14	14 15	

Your Project #: DIAVIK NORTH INLET
Your C.O.C. #: 097117, 097116, 097113

Attention: Cathy McPherson
GOLDER ASSOCIATES LTD
4260 STILL CREEK DRIVE
Suite 500
BURNABY, BC
Canada V5C 6C6

Report Date: 2010/10/21

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B099458
Received: 2010/10/15, 08:55

Sample Matrix: Water
Samples Received: 29

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Sulphide	29	N/A	2010/10/20	BRN SOP-00228 R5.0	SM - 4500 S2 D

* Results relate only to the items tested.

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

VJ OCO, Burnaby Customer Service
Email: VJ.Oco@MaxxamAnalytics.com
Phone# (604) 639-8422

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Total cover pages: 1

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		X69731	X69732	X69733	X69734	X69735	X69736	X69737	X69738	X69739		
Sampling Date		2010/09/28	2010/09/30	2010/09/28	2010/09/30	2010/09/28	2010/09/28	2010/09/30	2010/09/28	2010/09/28		
	Units	**10-1356 CTL CT INITIAL**	**10-1356 CTL HA INITIAL**	**10-1356-1 CT INITIAL**	**10-1356-1 HA INITIAL**	**10-1356-1-INT**	**10-1356-2 CT INITIAL**	**10-1356-2 HA INITIAL**	**10-1356-2-INT**	**10-1356-3 CT INITIAL**	**RDL**	**QC Batch**
MISCELLANEOUS												
Sulphide	mg/L	<0.005	<0.005	0.015	0.009	<0.005	0.006	0.006	<0.005	0.010	0.005	4353558

Maxxam ID		X69740	X69741	X69742	X69756	X69757	X69758	X69759	X69760	X69761		
Sampling Date		2010/09/30	2010/09/28	2010/09/28	2010/09/30	2010/09/28	2010/09/28	2010/09/30	2010/09/28	2010/09/28		
	Units	**10-1356-3 HA INITIAL**	**10-1356-3-INT**	**10-1356-4 CT INITIAL**	**10-1356-4 HA INITIAL**	**10-1356-4-INT**	**10-1356-5 CT INITIAL**	**10-1356-5 HA INITIAL**	**10-1356-5-INT**	**10-1356-6 CT INITIAL**	**RDL**	**QC Batch**
MISCELLANEOUS												
Sulphide	mg/L	0.009	<0.005	<0.005	0.005	0.047	<0.005	0.006	0.007	<0.005	0.005	4353558

Maxxam ID		X69762	X69763	X69764	X69765	X69766	X69767		
Sampling Date		2010/09/30	2010/09/28	2010/09/28	2010/09/30	2010/09/28	2010/09/28		
	Units	**10-1356-6 HA INITIAL**	**10-1356-6-INT**	**10-1356-7 CT INITIAL**	**10-1356-7 HA INITIAL**	**10-1356-7-INT**	**10-1356-8 CT INITIAL**	**RDL**	**QC Batch**
MISCELLANEOUS									
Sulphide	mg/L	0.006	0.010	<0.005	0.005	0.006	<0.005	0.005	4353558

Maxxam ID		X69769	X69770	X69771	X69772		X69773		
Sampling Date		2010/09/30	2010/09/28	2010/09/30	2010/09/28		2010/09/28		
	Units	**10-1356-8 HA INITIAL**	**10-1356-8-INT**	**10-1392 HA INITIAL**	**10-1392 CT INITIAL**	**RDL**	**10-1392-INT**	**RDL**	**QC Batch**
MISCELLANEOUS									
Sulphide	mg/L	<0.005	0.007	0.032	0.029	0.005	27.3	0.5	4353558

RDL = Reportable Detection Limit

QUALITY ASSURANCE REPORT

			Matrix Spike		Spiked Blank		Method Blank		RPD	
QC Batch	Parameter	Date	% Recovery	QC Limits	% Recovery	QC Limits	Value	Units	Value (%)	QC Limits
4353558	Sulphide	2010/10/20	87	80 - 120	104	80 - 120	<0.005	mg/L	NC	20

N/A = Not Applicable
RPD = Relative Percent Difference
Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.
Spiked Blank: A blank matrix to which a known amount of the analyte has been added. Used to evaluate analyte recovery.
Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.
NC (RPD): The RPD was not calculated. The level of analyte detected in the parent sample and its duplicate was not sufficiently significant to permit a reliable calculation.

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097117 **CHAIN OF CUSTODY**

Page: 1 of 3

Invoice To: Require Report? Yes ☑ No ☐
Company Name: Golder Associates Ltd.
Contact Name: Cathy McPherson
Address: 300-4260 Still Creek Dr. Burnaby
Prov: BC **PC:** V5C 6C6
Contact #s: **Ph:** 604-297-2007 **Fax:**

Report To: SAME AS INVOICE
Prov: **PC:**
Ph: **Fax:**

PO # / AFE #: CONTACT CATHY
Quotation #: B10-145-KP
Project #:
Project Name: DIAVIK NORTH INLET
Location: DNI
Sampler's Initials:

DETECTION LIMIT REQUIREMENTS:
Check the applicable criterion and indicate land use
☐ AT1
☐ CCME
☐ OTHER

REPORT DISTRIBUTION:
EMAIL ADDRESS(S):

SERVICE REQUESTED:
☐ **RUSH** (Please ensure you contact the lab to reserve)
Date Required:
☐ REGULAR Turnaround (5 to 7 Days)

				SOILS (footnotes defined on back)										WATERS (footnotes defined on back)								OTHER TEST(S)								
	Sample Identification	Matrix S/W	Date & Time Sampled Year/Month/Day	BTEX F1-F4	Sieve (75 micron)	Salinity 4	Regulated Metals (CCME / AT1)[1]	Assessment ICP Metals[2]	☐ Paint Filter ☐ Flashpoint ☐ pH (1:1)	TCLP ☐ BTEX ☐ Metals				☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	Routine Water Package ☐ Turb ☐ F	REGULATED METALS (CCME / AT1)[2] Total ☐ Preserved ☐ Not Preserved	REGULATED METALS (CCME / AT1)[2] Dissolved ☐ Preserved ☐ Not Preserved ☐ Filtered ☐ Not Filtered	Mercury ☐ Total ☐ Dissolved	☒ Ammonia ☐ TKN ☐ COD	☐ TOC ☐ DOC	Sulphide							*HOLD for 60 Days	# of Containers Submitted
1	10-1356 CTL CT initial	gnd water																				✓								
2	10-1356 CTL HA initial																					✓								
3	10-1356-1 CT initial																					✓								
4	10-1356-1 HA initial																					✓								
5	10-1356-1-INT																					✓								
6	10-1356-2 CT initial																					✓								
7	10-1356-2 HA initial																					✓								
8	10-1356-2-INT																					✓								
9	10-1356-3 CT initial																					✓								
10	10-1356-3 HA initial																					✓								
11	10-1356-3-INT																					✓								
12	10-1356-4 CT initial																					✓								

All samples are held for 60 calendar days after sample receipt. For long term storage please contact your project manager.

P **Maxxam Job #:** B099458

Relinquished By: **Date/Time:**
Sign and Print:
COMMENTS/SPECIAL INSTRUCTIONS:

# JARS USED & NOT SUBMITTED	Received By	Temperature			Ice
	101015 C. Rosen 0855	11	12	11	
	CUSTODY SEAL YES / NO				

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www.maxxamanalytics.com

097116 **CHAIN OF CUS**

Page: 2 of

Invoice To: Require Report? Yes ☐ No ☐
Company Name:
Contact Name:
Address:
Prov: **PC:**
Contact #s: **Ph:** **Fax:**

Report To:
Prov: **PC:**
Ph: **Fax:**

PO # / AFE #:
Quotation #:
Project #:
Project Name:
Location:
Sampler's Initials:

DETECTION LIMIT REQUIREMENTS:
Check the applicable criterion and indicate land use
☐ AT1
☐ CCME
☐ OTHER

REPORT DISTRIBUTION:
EMAIL ADDRESS(S):

SERVICE REQUESTED:
☐ **RUSH** (Please ensure you contact the lab to reserve)
Date Required:
☐ REGULAR Turnaround (5 to 7 Days)

				SOILS (footnotes defined on back)							WATERS (footnotes defined on back)								OTHER TEST(S)
	Sample Identification	Matrix S/W	Date & Time Sampled Year/Month/Day	BTEX F1-F4	Sieve (75 micron)	Salinity 4	Regulated Metals (CCME / AT1)[1]	Assessment ICP Metals[2]	☐ Paint Filter ☐ Flashpoint ☐ pH (1:1)	TCLP ☐ BTEX ☐ Metals	☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	Routine Water Package ☐ Turb ☐ F	REGULATED METALS (CCME / AT1)[3] Total ☐ Preserved ☐ Not Preserved	Dissolved ☐ Preserved ☐ Not Preserved ☐ Filtered ☐ Not Filtered	Mercury ☐ Total ☐ Dissolved	☐ Ammonia ☐ TKN ☐ COD	☐ TOC ☐ DOC	Sulphide
1	10-1356-4 HA initial	Sea water																	✓
2	10-1356-4-INT	↓																	✓
3	10-1356-5 CT initial	↓																	✓
4	10-1356-5 HA initial	↓																	✓
5	10-1356-5-INT	↓																	✓
6	10-1356-6 CT initial	↓																	✓
7	10-1356-6-HA initial	↓																	✓
8	10-1356-6-INT	↓																	✓
9	10-1356-7 CT initial	↓																	✓
10	10-1356-7 HA initial	↓																	✓
11	10-1356-7-INT	↓																	✓
12	10-1356-8 CT initial	↓																	✓

All samples are held for 60 calendar days after sample receipt. For long term storage please contact your project manager.

P **Maxxam Job #:** B099

Relinquished By: **Date/Time:**
Sign and Print:
COMMENTS/SPECIAL INSTRUCTIONS:

JARS USED & NOT SUBMITTED

Received By
10 10 15 0855
C. Rosen

CUSTODY SEAL YES / NO

Temperature
11	12	11

Page 5 of 6

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097113 **CHAIN OF CUS**

Page: 3 of

Invoice To: Require Report? Yes ☐ No ☐
Company Name:
Contact Name:
Address:
Prov: **PC:**
Contact #s: **Ph:** **Fax:**

Report To:
Prov: **PC:**
Ph: **Fax:**

PO # / AFE #:
Quotation #:
Project #:
Project Name:
Location:
Sampler's Initials:

DETECTION LIMIT REQUIREMENTS:
Check the applicable criterion and indicate land use
☐ AT1
☐ CCME
☐ OTHER

REPORT DISTRIBUTION:
EMAIL ADDRESS(S):

SERVICE REQUESTED:
☐ **RUSH** (Please ensure you contact the lab to reserve)
Date Required:
☐ REGULAR Turnaround (5 to 7 Days)

				SOILS (footnotes defined on back)										**WATERS** (footnotes defined on back)								**OTHER TEST(S)**						
	Sample Identification	Matrix S/W	Date & Time Sampled Year/Month/Day	BTEX F1-F4	Sieve (75 micron)	Salinity 4	Regulated Metals (CCME / AT1)[1]	Assessment ICP Metals[2]	☐ Paint Filter ☐ Flashpoint ☐ pH (1:1)	TCLP ☐ BTEX ☐ Metals				☐ BTEX F1 ☐ VOCs	☐ BTEX F1-F2 ☐ BTEX F1-F4	Routine Water Package ☐ Turb ☐ F	REGULATED METALS (CCME / AT1)[3] Total ☐ Preserved ☐ Not Preserved	REGULATED METALS (CCME / AT1)[3] Dissolved ☐ Preserved ☐ Not Preserved ☐ Filtered ☐ Not Filtered	Mercury ☐ Total ☐ Dissolved	☐ Ammonia ☐ TKN ☐ COD	☐ TOC. ☐ DOC	Sulphide						
1	10-1356-8 HA initial	Water																				✓						
2	10-1356-8-INT																					✓						
3	10-1392 HA initial																					✓						
4	10-1392 CT initial																					✓						
5	10-1392-INT																					✓						
6																												
7																												
8																												
9																												
10																												
11																												
12																												

**All samples are held for 60 calendar days after sample receipt. For long term storage please contact your project manager.*

P **Maxxam Job #:** B0994

Relinquished By: **Date/Time:**
Sign and Print:
COMMENTS/SPECIAL INSTRUCTIONS:

# JARS USED & NOT SUBMITTED	10 10 15 Received By OESS C. Rosen	Temperature		
	CUSTODY SEAL YES / NO	11	12	11

APPENDIX D

Laboratory Report - Sediment Toxicity Tests (HydroQual Laboratories)

HydroQual Laboratories Ltd.

Hyalella (single concentration) Test Report

Client: DIA102
Reference: 10-1356-HAS

Contents

Result Summary

Client: Diavik Diamond Mines; operation Yellowknife

Sample: NI-1, NI-2, NI-3, NI-4, NI-5

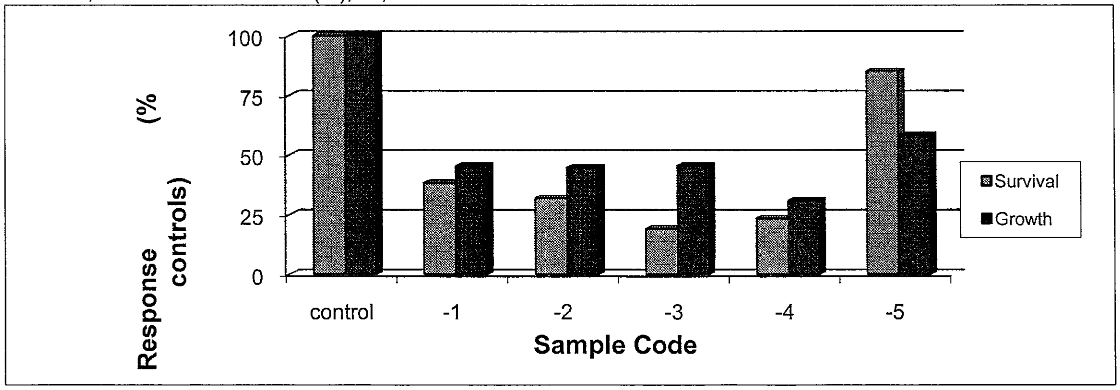
Collection: collected on 2010/09/03 at not given by SED
Receipt: received on 2010/09/05 at 1400 by H. Stewart
Containers: received 48 x 500 ml glass jars at 14 °C, in good condition* (see test comments) with no seals and no
Description: type: sediment, collection method: not given

Test: started on 2010/09/30 ; ended on 2010/10/15

Result:

Sample	Description	Survival			Growth (dry wt (mg) / organism)		
		mean	sd	cv(%)	mean	sd	cv(%)
	lab control	9	0.5	6	0.2	0.03	15
1	NI-1	4	1.8	50	0.1	0.02	25
2	NI-2	3	1.0	33	0.1	0.03	35
3	NI-3	2	0.8	46	0.1	0.03	33
4	NI-4	2	1.8	81	0.1	0.04	56
5	NI-5	8	1.0	13	0.1	0.03	22

Notes: cv, coefficient of variation (%); sd, standard deviation



Technical Lead

Quality Coordinator

Test Conditions

Client: DIA102
Reference: 10-1356-HAS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Freshwater Amphipod *Hyalella azteca,* 1997. Environment Canada EPS 1/RM/33.

Test type: 14 day Static *Hyalella azteca* Survival and Growth Test (4.4.3.5)
Species: *Hyalella azteca*
Age: 3-4 days old; 1.2-1.4 mm
Organism source: Chesapeake Cultures Inc., Hayes, Virginia (Batch 20100928HA)
Shipped: 2010/09/27
Organisms upon receipt: mortality, < 1 %; temperature, 22°C: dissolved oxygen, 22.8 mg/L
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition.
Acclimation: 2 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 27 days (must be ≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness

Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was moderately hard reconstitued dechlorinated water (Borgmann's); used within 4 weeks
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <0.1)
Test concentrations: Undiluted sample plus a negative control
Test replicates: 5 field replicates of each concentration tested as received; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.5 mL daily a mixture of fermented trout chow, yeast and alfalfa powder.

Note: Outlined sections are protocol deviations explained on the comment page

Test Conditions

Client: DIA102
Reference: 10-1356-HAS

Measurements:	pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination
Sample pre-treatment:	The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second. The sample was not filtered or seived prior to testing.
Lighting:	Overhead full spectrum fluorescent lights; 500-1000 lux at surface
Photoperiod:	16h light:8h dark
Test temperature:	23 ± 1°C
Endpoints:	Survival at 14-d Growth, average individual dry weight at 14-d
Test validity:	The control had 94% survival (must ≥ 80%); The control had mean dry weight of 0.21 mg/amphipod (must ≥ 0.1 mg/amphipod)
Reference toxicant:	96 hour test with $CuSO_4$ initiated September 28, 2010; current results: (96 hour LC50 and 95% confidence limits) = 2.27 (2.11-2.46) log µg/L CuSO4

Note: Outlined sections are protocol deviations explained on the comment page

Test Data

Client: DIA102
Reference: 10-1356-HAS

Test Log:

Date	Day	Time	Technicians
2010/09/30	0	1100	E. Petho/T. Kloschinsky
2010/10/01	1	1545	E. Petho/R. McCurdy
2010/10/02	2	1050	E. Blais/C. Velasco
2010/10/03	3	1120	E.Blais/C. Velasco
2010/10/04	4	1220	R. McCurdy/H. Stewart
2010/10/05	5	1345	R. McCurdy/H. Stewart
2010/10/06	6	1530	R. McCurdy/H. Stewart
2010/10/07	7	1500	R. McCurdy/H. Stewart
2010/10/08	8	1220	R. McCurdy/H. Stewart
2010/10/09	9	1200	E. Blais/H. Stewart
2010/10/10	10	1140	E. Blais/H. Stewart
2010/10/11	11	1055	E. Blais/A. Hart
2010/10/12	12	1500	R. McCurdy/H. Stewart
2010/10/13	13	1430	E. Petho/T. Kloschinsky
2010/10/14	14	1000	E. Petho/T. Kloschinsky

Physical & Chemical Data:

Parameter	Sample					
	control	-1	-2	-3	-4	-5
porewater ammonia (mg/L)	0.10	1.35	1.81	1.80	3.21	3.51
overlying ammonia (mg/L)						
Day 0	<0.05	3.37	3.13	3.48	<0.05	2.07
Day 14	0.32	2.83	<0.05	<0.05	<0.05	<0.05
hardness (mg/L)						
initial	250	250	250	425	250	250
final	425	425	425	425	425	425
alkalinity (mg/L)						
initial	80	>240	>240	>240	180	240
final	120	240	240	240	120	120
average daily values						
pH	7.3	7.4	7.6	7.7	7.6	7.5
EC (µS/cm)	651	936	927	826	775	718
DO (mg/L)	7.0	5.7	5.5	6.2	5.9	5.7
temp (°C)	23	23	23	23	23	23

Test Data

Client: DIA102
Reference: 10-1356-HAS

Biology Summary Data:

	Sample					
replicate	control	-1	-2	-3	-4	-5

Survival (number of live organisms in each replicate)

a	10	3	2	1	2	8
b	9	2	4	3	1	9
c	9	6	2	2	4	9
d	10	5	3	2	4	7
e	9	2	4	1	0	7

average	9	4	3	2	2.2	8.0
sd	0.5	1.8	1.0	0.8	1.8	1.0
cv (%)	6	50	33	46	81	13
% survival	94	36	30	18	22	80
% controls	100	38	32	19	23	85

Growth (dry weight)

Total dry weight per replicate (mg)

a	2.05	0.31	0.15	0.11	0.17	1.16
b	2.15	0.13	0.27	0.40	0.08	1.30
c	1.46	0.50	0.30	0.10	0.31	1.22
d	2.35	0.48	0.26	0.21	0.32	0.64
e	1.87	0.26	0.36	0.08	0.00	0.66

Average dry weight per live organism (mg/organism)

a	0.21	0.10	0.07	0.11	0.09	0.15
b	0.24	0.06	0.07	0.13	0.08	0.14
c	0.16	0.08	0.15	0.05	0.08	0.14
d	0.24	0.10	0.09	0.11	0.08	0.09
e	0.21	0.13	0.09	0.08	0.00	0.09

average	0.21	0.10	0.09	0.10	0.06	0.12
sd	0.03	0.02	0.03	0.03	0.04	0.03
cv (%)	15	25	35	33	56	22
% controls	100	46	45	46	31	58

Notes: cv, coefficient of variation (%); sd, standard deviation

Test Data

Client: DIA102
Reference: 10-1356-HAS

Chemistry:

		Sample					
	day	control	-1	-2	-3	-4	-5
pH (units)	0	7.6	7.9	8.0	8.2	8.0	7.9
	14	6.9	6.9	7.1	7.1	7.1	7.1
EC (µS/cm)	0	343	787	764	710	649	619
	14	958	1085	1089	942	900	816
DO (mg/L)	0	7.9	7.9	7.6	7.5	7.6	7.7
	1	8.0	7.0	6.3	6.3	6.8	7.4
	2	7.1	7.1	6.7	6.5	6.5	7.1
	3	6.3	6.3	6.8	6.3	6.1	6.9
	4	6.8	4.0	3.4	2.7	7.9	2.5
	5	6.6	5.9	3.0	6.4	5.6	6.2
	6	7.3	1.0	1.7	6.4	4.0	5.6
	7	6.5	4.5	4.4	5.2	5.4	5.6
	8	7.4	3.9	3.5	6.2	2.6	3.5
	9	6.9	6.7	5.3	5.8	4.9	4.7
	10	7.1	6.8	6.3	6.4	5.2	5.3
	11	6.6	6.5	5.8	5.9	5.4	6.1
	12	5.5	3.2	6.8	7.0	6.8	2.4
	13	7.3	7.2	7.0	7.1	7.1	7.1
	14	8.4	7.8	7.4	7.2	6.9	6.7
temp. (°C)	0	24	24	24	24	24	24
	1	24	24	24	24	24	24
	2	23	23	23	23	23	23
	3	23	23	23	23	23	23
	4	23	23	23	23	23	23
	5	23	23	23	23	23	23
	6	23	23	23	23	23	23
	7	24	24	24	24	24	24
	8	24	24	24	24	24	24
	9	23	23	23	23	23	23
	10	23	23	23	23	23	23
	11	23	23	23	23	23	23
	12	23	23	23	23	23	23
	13	24	24	24	24	24	24
	14	23	23	23	23	23	23

Comments/Statistics

Client: DIA102	
Reference: 10-1356-HAS	

Test Result Comments:
NI-3-TOX-D replicate arrived broken so the NI-3-Ammonia sample replaced this field replicate.

Data Analysis:
None

Protocol Deviations:
None

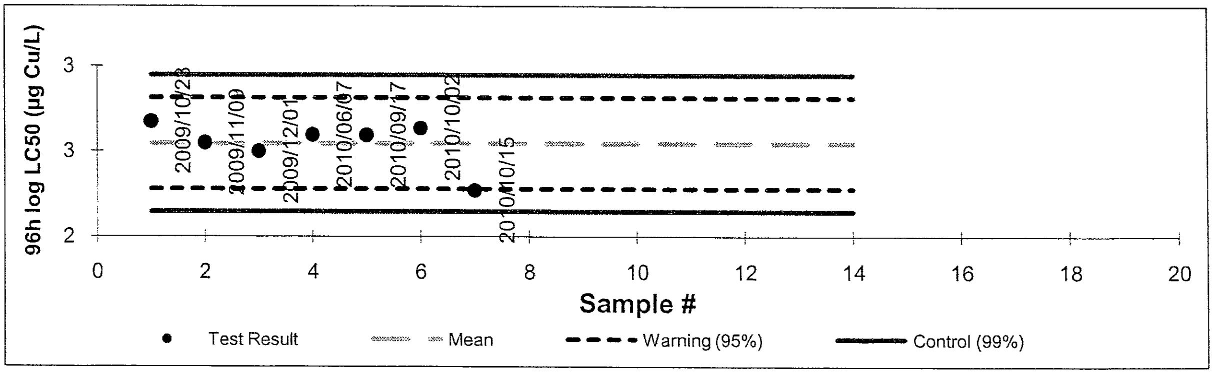
Quality Assurance Information

Test Method: 96 hours Acute Lethality Test with *Hyalella azteca*
HydroQual Test Method Manual, section: 4.4.3.5
Reference: Biological Test Method: Acute Test for Sediment Toxicity using the Freshwater Amphipod *Hyalella azteca*, 1997. Environment Canada, EPS 1/RM/33.

Test Organism:	
test species:	*Hyalella azteca*
culture source:	Chesapeake Cultures Inc. Hayes, VA, USA
culture vessels:	10 L glass aquarium
dilution water:	Borgmann's Water
control sediment:	sterile cotton gauze
organism age:	3-4 days
food source:	YAT
culture batch:	20101013HA

Test Design:	**Reftox**
test duration (d):	4
toxicant:	copper sulfate ($CuSO_4 \times H_2O$)
test temperature:	23 ± 1°C
test jar volume:	375mL
sediment volume:	3 cm^2 mesh
water volume:	200mL
light levels (lux):	500-1000
photoperiod (h):	16 h light: 8 h dark
reps./treatment:	1
organisms/replicates:	10
feeding:	0.5mL/jar on day 0 and 2

Warning Chart: mortality LC50 at 96 hours
toxicant: Copper (Cu)
Current Test: started on 2010/09/28 ended on 2010/10/02
result (96 h LC50): 2.27 (2.11-2.46) log µg Cu/L (95% confidence limits are in brackets)
Historical: mean: 2.5 std.dev: 0.1 CV(%): 5
warning limits: 2.3 2.8 (lower and upper 95% confidence limit, two standard deviations)
control limits: 2.1 2.9 (lower and upper 99% confidence limit, three standard deviations)



The data and results are authorized and verified correct.

Technical Lead

Quality Coordinator

HydroQual
Laboratories Ltd.

Hyalella (single concentration) Test Report

Result Summary

Client: DIA102
Reference: 10-1392-HAS

Contents

Client: Diavik Diamond Mines; operation Yellowknife

Sample: sludge

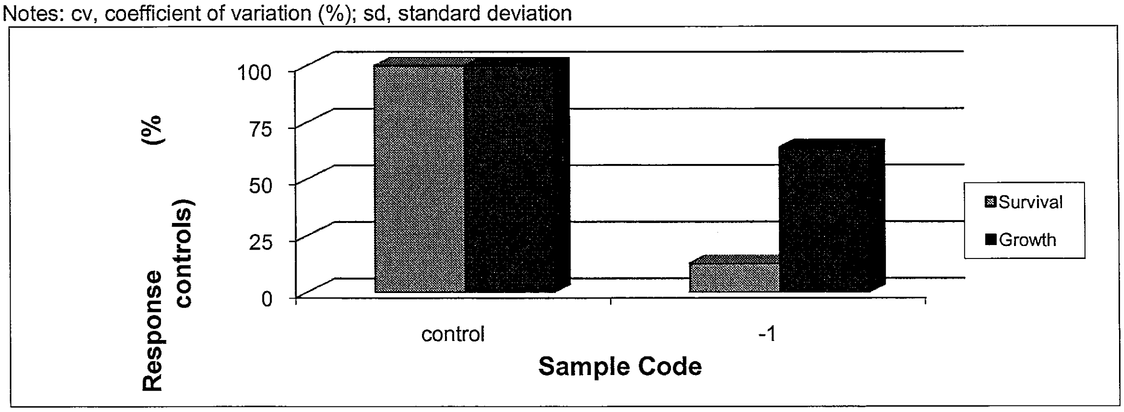
Collection: collected on 2010/09/02 at not given by not given
Receipt: received on 2010/09/13 at 1330 by C. Ehman
Containers: received 1 x 20L pail at 14 °C, in good with no seals and no initials
Description: type: sludge, collection method: not given

Test: started on 2010/09/30 ; ended on 2010/10/14

Result:

Sample	Description	Survival mean	Survival sd	Survival cv(%)	Growth (dry wt (mg) / organism) mean	Growth sd	Growth cv(%)
	lab control	9	0.5	6	0.2	0.03	15
1	sludge	1	0.4	37	0.1	0.05	35

Notes: cv, coefficient of variation (%); sd, standard deviation



Technical Lead

Quality Coordinator

Test Conditions

Client: DIA102
Reference: 10-1392-HAS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Freshwater Amphipod *Hyalella azteca,* 1997. Environment Canada EPS 1/RM/33.

Test type: 14 day Static *Hyalella azteca* Survival and Growth Test (4.4.3.5)
Species: *Hyalella azteca*
Age: 3-4 days old; 1.2-1.4 mm
Organism source: Chesapeake Cultures Inc., Hayes, Virginia (Batch 20100928HA)
Shipped: 2010/09/27
Organisms upon receipt: mortality, < 1 %; temperature, 22°C: dissolved oxygen, 22.8 mg/L
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition
Acclimation: 2 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 28 days (≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness

Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was moderately hard reconstitued dechlorinated water (Borgmann's); used within 4 weeks
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <1)
Test concentrations: Undiluted sample plus a negative control
Test replicates: 5 replicates of each concentration; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.5 mL daily a mixture of fermented trout chow, yeast and alfalfa powder.

Note: Outlined sections are protocol deviations explained on the comment page

Test Conditions

Client: DIA102
Reference: 10-1392-HAS

Measurements: pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination

Sample pre-treatment: The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second.
The sample was not filtered or seived prior to testing.

Lighting: Overhead full spectrum fluorescent lights; 500-1000 lux at surface

Photoperiod: 16h light:8h dark

Test temperature: 23 ± 1°C

Endpoints: Survival at 14-d
Growth, average individual dry weight at 14-d

Test validity: The control had 94% survival (must ≥ 80%);
The control had mean dry weight of 0.21 mg/amphipod (must ≥ 0.1 mg/amphipod)

Reference toxicant: 96 hour test with $CuSO_4$ initiated September 28, 2010;
current results: (96 hour LC50 and 95% confidence limits) =
2.27 (2.11-2.46) log µg/L CuSO4

Note: Outlined sections are protocol deviations explained on the comment page

Test Data

Client: DIA102	
Reference: 10-1392-HAS	

Test Log:

Date	Day	Time	Technicians
2010/09/30	0	1100	E. Petho/T. Kloschinsky
2010/10/01	1	1545	E. Petho/R. McCurdy
2010/10/02	2	1050	E. Blais/C. Velasco
2010/10/03	3	1120	E.Blais/C. Velasco
2010/10/04	4	1220	R. McCurdy/H. Stewart
2010/10/05	5	1345	R. McCurdy/H. Stewart
2010/10/06	6	1530	R. McCurdy/H. Stewart
2010/10/07	7	1500	R. McCurdy/H. Stewart
2010/10/08	8	1220	R. McCurdy/H. Stewart
2010/10/09	9	1200	E. Blais/H. Stewart
2010/10/10	10	1140	E. Blais/H. Stewart
2010/10/11	11	1055	E. Blais/A. Hart
2010/10/12	12	1500	R. McCurdy/H. Stewart
2010/10/13	13	1430	E. Petho/T. Kloschinsky
2010/10/14	14	1000	E. Petho/T. Kloschinsky

Physical & Chemical Data:

Parameter	Sample					
	control	-1				
porewater ammonia (mg/L)	0.16	0.62				
overlying ammonia (mg/L)						
Day 0	<0.05	3.76				
Day 14	0.32	3.79				
hardness (mg/L)						
initial	250	120				
final	425	425				
alkalinity (mg/L)						
initial	80	80				
final	120	40				
average daily values						
pH	7.3	6.7				
EC (µS/cm)	651	752				
DO (mg/L)	7.0	5.3				
temp (°C)	23	23				

Test Data

Client: DIA102
Reference: 10-1392-HAS

Biology Summary Data:

	Sample					
replicate	control	-1				

Survival (number of live organisms in each replicate)

a	10	2				
b	9	1				
c	9	1				
d	10	1				
e	9	1				

average	9	1				
sd	0.5	0.4				
cv (%)	6	37				
% survival	94	12				
% controls	100	13				

Growth (dry weight)

Total dry weight per replicate (mg)

a	2.05	0.24				
b	2.15	0.15				
c	1.46	0.07				
d	2.35	0.13				
e	1.87	0.20				

Average dry weight per live organism (mg/organism)

a	0.21	0.12				
b	0.24	0.15				
c	0.16	0.07				
d	0.24	0.13				
e	0.21	0.20				

average	0.21	0.13				
sd	0.03	0.05				
cv (%)	15	35				
% controls	100	64				

Notes: cv, coefficient of variation (%); sd, standard deviation

Test Data

Client: DIA102
Reference: 10-1392-HAS

Chemistry:

		Sample					
	day	control	-1				
pH (units)	0	7.6	6.6				
	14	6.9	6.7				
EC (µS/cm)	0	343	667				
	14	958	836				
DO (mg/L)	0	7.9	7.3				
	1	8.0	7.1				
	2	7.1	6.6				
	3	6.3	6.6				
	4	6.8	0.7				
	5	6.6	3.9				
	6	7.3	1.6				
	7	6.5	5.2				
	8	7.4	7.0				
	9	6.9	6.1				
	10	7.1	5.9				
	11	6.6	5.3				
	12	5.5	1.1				
	13	7.3	7.0				
	14	8.4	7.4				
temp. (°C)	0	24	24				
	1	24	24				
	2	23	23				
	3	23	23				
	4	23	23				
	5	23	23				
	6	23	23				
	7	24	24				
	8	24	24				
	9	23	23				
	10	23	23				
	11	23	23				
	12	23	23				
	13	24	24				
	14	23	23				

Comments/Statistics

Client: DIA102
Reference: 10-1392-HAS

Test Result Comments:
None

Data Analysis:

Protocol Deviations:
None

HydroQual
Laboratories Ltd.

Hyalella Test Report

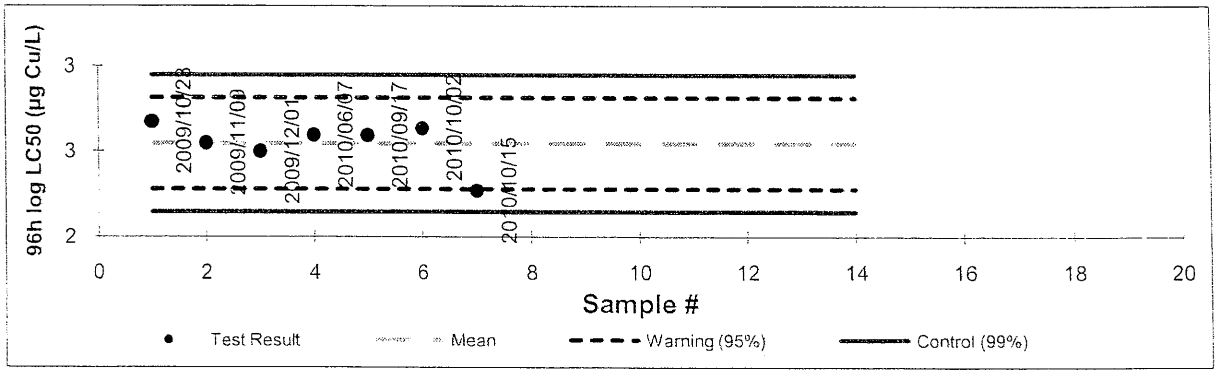
Quality Assurance Information

Test Method: 96 hours Acute Lethality Test with *Hyalella azteca*
HydroQual Test Method Manual, section: 4.4.3.5
Reference: Biological Test Method: Acute Test for Sediment Toxicity using the Freshwater Amphipod *Hyalella azteca* , 1997. Environment Canada, EPS 1/RM/33.

Test Organism:
test species: *Hyalella azteca*
culture source: Chesapeake Cultures Inc.
Hayes, VA, USA
culture vessels: 10 L glass aquarium
dilution water: Borgmann's Water
control sediment: sterile cotton gauze
organism age: 3-4 days
food source: YAT
culture batch: 20101013HA

Test Design: **Reftox**
test duration (d): 4
toxicant: copper sulfate ($CuSO_4 \times H_2O$)
test temperature: 23 ± 1°C
test jar volume: 375mL
sediment volume: 3 cm^2 mesh
water volume: 200mL
light levels (lux): 500-1000
photoperiod (h): 16 h light: 8 h dark
reps./treatment: 1
organisms/replicates: 10
feeding: 0.5mL/jar on day 0 and 2

Warning Chart: mortality LC50 at 96 hours
toxicant: Copper (Cu)
Current Test: started on 2010/09/28 ended on 2010/10/02
result (96 h LC50): 2.27 (2.11-2.46) log µg Cu/L (95% confidence limits are in brackets)
Historical: mean: 2.5 std.dev: 0.1 CV(%): 5
warning limits: 2.3 2.8 (lower and upper 95% confidence limit, two standard deviations)
control limits: 2.1 2.9 (lower and upper 99% confidence limit, three standard deviations)



The data and results are authorized and verified correct.

Technical Lead

Quality Coordinator

HydroQual
Laboratories Ltd.

Hyalella (single concentration) Test Report

Client: DIA102
Reference: 10-1356-HAS

Contents

Result Summary

Client: Diavik Diamond Mines; operation Yellowknife

Sample: REF-1, REF-2, REF-3

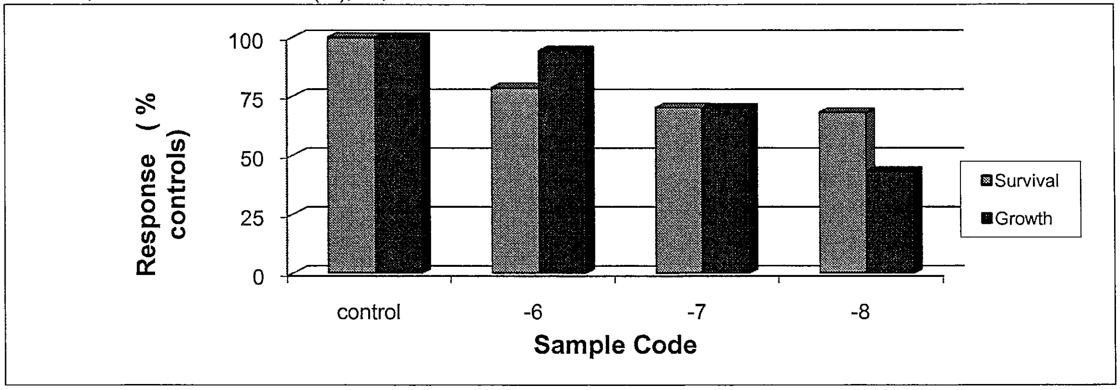
Collection: collected on 2010/09/03 at not given by SED
Receipt: received on 2010/09/05 at 1400 by H. Stewart
Containers: received 48 x 500 ml glass jars at 14 °C, in good condition* (see test comments) with no seals and no
Description: type: sediment, collection method: not given

Test: started on 2010/09/30 ; ended on 2010/10/15

Result:

Sample	Description	Survival mean	Survival sd	Survival cv(%)	Growth (dry wt (mg) / organism) mean	Growth sd	Growth cv(%)
	lab control	9	0.5	6	0.2	0.03	15
6	REF-1	7	1.8	25	0.2	0.03	18
7	REF-2	7	3.6	54	0.1	0.02	16
8	REF-3	6	1.7	26	0.1	0.02	27

Notes: cv, coefficient of variation (%); sd, standard deviation



Technical Lead

Quality Coordinator

Test Conditions

Client: DIA102
Reference: 10-1356-HAS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Freshwater Amphipod *Hyalella azteca,* 1997. Environment Canada EPS 1/RM/33.

Test type: 14 day Static *Hyalella azteca* Survival and Growth Test (4.4.3.5)
Species: *Hyalella azteca*
Age: 3-4 days old; 1.2-1.4 mm
Organism source: Chesapeake Cultures Inc., Hayes, Virginia (Batch 20100928HA)
Shipped: 2010/09/27
Organisms upon receipt: mortality, < 1 %; temperature, 22°C: dissolved oxygen, 22.8 mg/L
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition
Acclimation: 2 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 27 days (must be ≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness

Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was moderately hard reconstitued dechlorinated water (Borgmann's); used within 4 weeks
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <0.1)
Test concentrations: Undiluted sample plus a negative control
Test replicates: 5 field replicates of each concentration tested as received; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.5 mL daily a mixture of fermented trout chow, yeast and alfalfa powder.

Note: Outlined sections are protocol deviations explained on the comment page

Test Conditions

Client: DIA102
Reference: 10-1356-HAS

Measurements: pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination

Sample pre-treatment: The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second.
The sample was not filtered or seived prior to testing.

Lighting: Overhead full spectrum fluorescent lights; 500-1000 lux at surface

Photoperiod: 16h light:8h dark

Test temperature: 23 ± 1°C

Endpoints: Survival at 14-d
Growth, average individual dry weight at 14-d

Test validity: The control had 94% survival (must ≥ 80%);
The control had mean dry weight of 0.21 mg/amphipod (must ≥ 0.1 mg/amphipod)

Reference toxicant: 96 hour test with $CuSO_4$ initiated September 28, 2010;
current results: (96 hour LC50 and 95% confidence limits) =
2.27 (2.11-2.46) log µg/L CuSO4

Note: Outlined sections are protocol deviations explained on the comment page

Test Data

Client: DIA102
Reference: 10-1356-HAS

Test Log:

Date	Day	Time	Technicians
2010/09/30	0	1100	E. Petho/T. Kloschinsky
2010/10/01	1	1545	E. Petho/R. McCurdy
2010/10/02	2	1050	E. Blais/C. Velasco
2010/10/03	3	1120	E.Blais/C. Velasco
2010/10/04	4	1220	R. McCurdy/H. Stewart
2010/10/05	5	1345	R. McCurdy/H. Stewart
2010/10/06	6	1530	R. McCurdy/H. Stewart
2010/10/07	7	1500	R. McCurdy/H. Stewart
2010/10/08	8	1220	R. McCurdy/H. Stewart
2010/10/09	9	1200	E. Blais/H. Stewart
2010/10/10	10	1140	E. Blais/H. Stewart
2010/10/11	11	1055	E. Blais/A. Hart
2010/10/12	12	1500	R. McCurdy/H. Stewart
2010/10/13	13	1430	E. Petho/T. Kloschinsky
2010/10/14	14	1000	E. Petho/T. Kloschinsky

Physical & Chemical Data:

Parameter	Sample					
	control	-6	-7	-8		
porewater ammonia (mg/L)	0.10	0.49	0.40	0.35		
overlying ammonia (mg/L)						
Day 0	<0.05	<0.05	0.18	0.23		
Day 14	0.32	0.47	2.48	1.93		
hardness (mg/L)						
initial	250	120	120	250		
final	425	425	425	425		
alkalinity (mg/L)						
initial	80	66	66	66		
final	120	66	66	66		
average daily values						
pH	7.8	7.5	7.2	7.0		
EC (µS/cm)	651	508	504	508		
DO (mg/L)	7.0	5.6	6.1	5.7		
temp (°C)	23	23	23	23		

Test Data

Client: DIA102
Reference: 10-1356-HAS

Biology Summary Data:

	Sample					
replicate	control	-6	-7	-8		

Survival (number of live organisms in each replicate)

a	10	9	9	6		
b	9	8	9	5		
c	9	5	5	9		
d	10	6	1	7		
e	9	9	9	5		

average	9	7	7	6		
sd	0.5	1.8	3.6	1.7		
cv (%)	6	25	54	26		
% survival	94	74	66	64		
% controls	100	79	70	68		

Growth (dry weight)

Total dry weight per replicate (mg)

a	2.05	2.14	1.17	0.64		
b	2.15	1.85	1.56	0.29		
c	1.46	0.86	0.65	0.98		
d	2.35	0.96	0.13	0.76		
e	1.87	1.70	1.53	0.36		

Average dry weight per live organism (mg/organism)

a	0.21	0.24	0.13	0.11		
b	0.24	0.23	0.17	0.06		
c	0.16	0.17	0.13	0.11		
d	0.24	0.16	0.13	0.11		
e	0.21	0.19	0.17	0.07		

average	0.21	0.20	0.15	0.09		
sd	0.03	0.03	0.02	0.02		
cv (%)	15	18	16	27		
% controls	100	94	70	43		

Notes: cv, coefficient of variation (%); sd, standard deviation

Test Data

Client: DIA102
Reference: 10-1356-HAS

Chemistry:

		Sample					
	day	control	-6	-7	-8		
pH (units)	0	7.9	7.9	7.7	7.5		
	14	7.6	7.1	6.7	6.5		
EC (µS/cm)	0	343	354	371	354		
	14	958	662	637	662		
DO (mg/L)	0	7.9	7.7	7.7	7.7		
	1	8.0	7.5	7.6	7.6		
	2	7.1	7.0	6.8	6.8		
	3	6.3	6.9	6.6	6.8		
	4	6.8	3.7	3.9	2.1		
	5	6.6	6.9	5.3	6.1		
	6	7.3	2.1	3.6	5.4		
	7	6.5	4.0	6.3	3.5		
	8	7.4	6.1	7.0	6.8		
	9	6.9	5.8	6.9	6.4		
	10	7.1	5.8	5.4	6.1		
	11	6.6	5.9	6.1	5.5		
	12	5.5	1.4	5.1	1.2		
	13	7.3	7.0	7.0	6.6		
	14	8.4	6.7	6.7	6.6		
temp. (^{o}C)	0	24	24	24	24		
	1	24	24	24	24		
	2	23	23	23	23		
	3	23	23	23	23		
	4	23	23	23	23		
	5	23	23	23	23		
	6	23	23	23	23		
	7	24	24	24	24		
	8	24	24	24	24		
	9	23	23	23	23		
	10	23	23	23	23		
	11	23	23	23	23		
	12	23	23	23	23		
	13	24	24	24	24		
	14	23	23	23	23		

Comments/Statistics

Client: DIA102	
Reference: 10-1356-HAS	

Test Result Comments:
None

Data Analysis:
None

Protocol Deviations:
None

HydroQual
Laboratories Ltd.

Hyalella Test Report

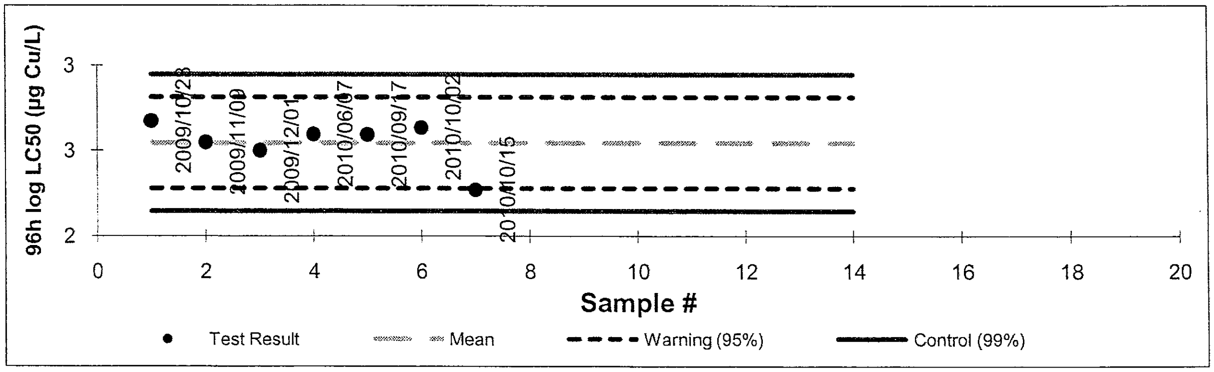
Quality Assurance Information

Test Method: 96 hours Acute Lethality Test with *Hyalella azteca*
HydroQual Test Method Manual, section: 4.4.3.5
Reference: Biological Test Method: Acute Test for Sediment Toxicity using the Freshwater Amphipod *Hyalella azteca*, 1997. Environment Canada, EPS 1/RM/33.

Test Organism:	
test species:	*Hyalella azteca*
culture source:	Chesapeake Cultures Inc. Hayes, VA, USA
culture vessels:	10 L glass aquarium
dilution water:	Borgmann's Water
control sediment:	sterile cotton gauze
organism age:	3-4 days
food source:	YAT
culture batch:	20101013HA

Test Design:	**Reftox**
test duration (d):	4
toxicant:	copper sulfate ($CuSO_4 \times H_2O$)
test temperature:	23 ± 1°C
test jar volume:	375mL
sediment volume:	3 cm^2 mesh
water volume:	200mL
light levels (lux):	500-1000
photoperiod (h):	16 h light: 8 h dark
reps./treatment:	1
organisms/replicates:	10
feeding:	0.5mL/jar on day 0 and 2

Warning Chart: mortality LC50 at 96 hours
toxicant: Copper (Cu)
Current Test: started on 2010/09/28 ended on 2010/10/02
result (96 h LC50): 2.27 (2.11-2.46) log µg Cu/L (95% confidence limits are in brackets)
Historical: mean: 2.5 std.dev: 0.1 CV(%): 5
warning limits: 2.3 2.8 (lower and upper 95% confidence limit, two standard deviations)
control limits: 2.1 2.9 (lower and upper 99% confidence limit, three standard deviations)



The data and results are authorized and verified correct.

Technical Lead

Quality Coordinator

Chironomid (single concentration) Test Report

Re-issued 2011/03/07

Test Conditions

Client: DIA102
Reference: 10-1356-CTS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1/RM/32.

Test type: 10 day Static Chironomid Survival and Growth Test (4.4.3.16)
Species: *Chironomus dilutus*
Age: third instar; 12 days after hatching; average head capsule width 0.40 mm
Organism source: Aquatic Biosystems Inc., Fort Collins, Co, USA (Batch 20100924CT)
Shipped: 2010/09/23
Organisms upon receipt: mortality, < 1 %; temperature, 23°C: dissolved oxygen, 10.6 mg/L The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition
Acclimation: 4 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 25 days (must be ≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness
Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was dechlorinated City of Calgary tap water preaerated for at least 24 hours.
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <0.1)
Test concentrations: Undiluted samples plus a negative control
Test replicates: 5 field replicates of each concentration tested as received; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.75 mL of a ground Nutrafin™ slurry
Measurements: pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination
Sample pre-treatment: The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second.
The sample was not filtered or seived prior to testing.
Lighting: Overhead full spectrum fluorescent lights; 500-1000 lux at surface
Photoperiod: 16h light:8h dark
Test temperature: 23 ± 1°C

Note: Outlined sections are protocol deviations explained on the comment page

Test Conditions

Client: DIA102
Reference: 10-1356-CTS

Endpoints:	Survival at 10-d Growth, average individual dry weight at 10-d
Test validity:	The control had 82% survival (must > 70%); The control had mean dry weight of 2.71 mg/organism (must > 0.6 mg/organism)
Reference toxicant:	96 hour test with KCl initiated September 28, 2010; current results: (96 hour LC50 and 95% confidence limits) = 0.68 (0.54-0.81) log (g KCl/L)

Test Data

Client: DIA102
Reference: 10-1356-CTS

Test Log:

Date	Day	Time	Technicians
2010/09/28	0	1530	E. Petho/H. Stewart
2010/09/29	1	1100	E.Petho/G. Diaz
2010/09/30	2	1100	R. McCurdy/E. Petho
2010/10/01	3	1515	R. McCurdy/E. Petho
2010/10/02	4	1050	E. Blais/C. Velasco
2010/10/03	5	1120	E. Blais/C. Velasco
2010/10/04	6	1220	H. Stewart/R. McCurdy
2010/10/05	7	1340	H. Stewart/R. McCurdy
2010/10/06	8	1530	H. Stewart/R. McCurdy
2010/10/07	9	1430	H. Stewart/R. McCurdy
2010/10/08	10	1010	T. Kloschinsky/R. McCurdy

Physical & Chemical Data:

Parameter	Sample					
	control	-1	-2	-3	-4	-5
porewater ammonia (mg/L)	0.10	1.35	1.81	1.80	3.21	3.51
overlying ammonia (mg/L)						
Day 0	0.16	3.43	3.39	3.33	0.61	2.28
Day 10	1.52	2.83	1.25	2.30	0.10	0.09
hardness (mg/L)						
initial	>425	250	250	250	250	250
final	425	425	425	425	425	425
alkalinity (mg/L)						
initial	>180	240	>240	>240	>240	>240
final	>240	>240	>240	>240	>240	>240
average daily values						
pH	8.1	8.3	8.2	8.3	8.3	7.9
EC (µS/cm)	513	597	630	628	576	547
DO (mg/L)	6.4	5.5	5.6	5.5	5.7	5.2
temp (°C)	24	24	24	24	24	24

Test Data

Client: DIA102
Reference: 10-1356-CTS

Biology Summary Data:

	Sample					
replicate	control	-1	-2	-3	-4	-5

Survival (number of live organisms in each replicate)

replicate	control	-1	-2	-3	-4	-5
a	8	2	2	5	2	5
b	9	5	6	6	5	6
c	9	9	6	2	6	7
d	7	3	5	6	2	10
e	8	5	8	5	6	7

	control	-1	-2	-3	-4	-5
average	8	5	5	5	4.2	7.0
sd	0.8	2.7	2.2	1.6	2.0	1.9
cv (%)	10	56	41	34	49	27
% survival	82	48	54	48	42	70
% controls	100	59	66	59	51	85

Growth (dry weight)

Total dry weight per replicate (mg)

replicate	control	-1	-2	-3	-4	-5
a	17.86	0.31	1.80	1.31	1.77	9.82
b	21.62	1.76	2.62	1.20	2.34	10.54
c	21.56	5.57	2.64	0.91	1.20	9.72
d	24.70	1.85	1.21	1.93	0.30	8.83
e	19.04	1.99	3.02	1.33	1.97	7.89

Average dry weight per live organism (mg/organism)

replicate	control	-1	-2	-3	-4	-5
a	2.55	0.16	0.90	0.26	0.89	1.96
b	2.40	0.35	0.44	0.20	0.47	1.76
c	2.70	0.62	0.44	0.45	0.20	1.39
d	3.53	0.62	0.24	0.32	0.15	0.88
e	2.38	0.40	0.38	0.27	0.33	1.13

	control	-1	-2	-3	-4	-5
average	2.71	0.43	0.48	0.30	0.41	1.42
sd	0.47	0.20	0.25	0.10	0.29	0.44
cv (%)	17	46	52	32	73	31
% controls	100	16	18	11	15	53

Notes: cv, coefficient of variation (%); sd, standard deviation

Our liability is limited to the cost of the test requested on the sample as received. No liability in whole or in part is assumed for the collection, handling or transport of the sample, application or interpretation of the test data or results in part or in whole.

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HydroQual Laboratories Ltd., #4, 6125 12th Street SE, Calgary, Alberta, Canada T2H 2K1
tel (403) 253-7121 fax (403) 252-9363 www.hydroqual.ca

Form: F093 v 4.0

Test Data

Client: DIA102
Reference: 10-1356-CTS

Chemistry:

		Sample					
	day	control	-1	-2	-3	-4	-5
pH (units)	0	7.9	8.1	8.2	8.3	8.2	8.1
	10	8.3	8.4	8.2	8.3	8.3	7.7
EC (µS/cm)	0	485	640	690	684	565	547
	10	541	554	570	571	586	547
DO (mg/L)	0	7.8	7.8	7.7	7.7	7.7	7.7
	1	7.8	7.6	7.5	7.2	7.4	7.4
	2	7.9	6.9	7.0	6.9	7.0	5.1
	3	3.0	4.8	5.0	6.1	6.1	5.0
	4	5.1	5.4	5.5	5.9	6.0	6.0
	5	6.2	5.0	5.8	5.9	6.1	6.3
	6	7.0	2.1	3.0	3.0	1.7	2.4
	7	7.0	5.1	5.4	3.0	2.4	3.4
	8	5.0	1.2	1.5	2.5	5.4	5.8
	9	6.5	6.7	6.7	6.8	6.8	4.0
	10	7.5	7.4	6.6	5.4	5.7	4.1
temp. (°C)	0	24	24	24	24	24	24
	1	24	24	24	24	24	24
	2	23	23	23	23	23	23
	3	24	24	24	24	24	24
	4	23	23	23	23	23	23
	5	23	23	23	23	23	23
	6	23	23	23	23	23	23
	7	23	23	23	23	23	23
	8	24	24	24	24	24	24
	9	24	24	24	24	24	24
	10	24	24	24	24	24	24

Comments/Statistics

Client: DIA102
Reference: 10-1356-CTS

Test Result Comments:
NI-3-TOX-D replicate arrived broken so the NI-3-Ammonia sample replaced this field replicate.

Data Analysis:
One fly was found in each of control replicates 'a' and 'c'. These were included in the survival calculations, but were not included in the dry weight.

Protocol Deviations:
None

Chironomid Test Report

Quality Assurance Information

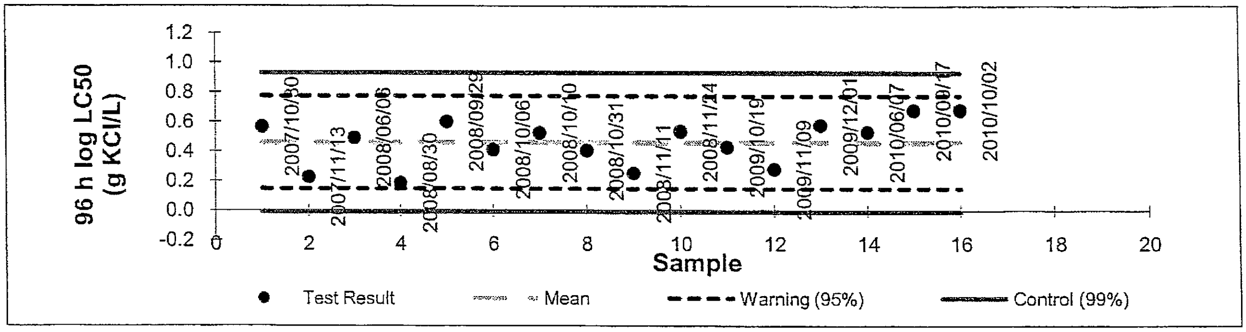
Test Method: 96 hours Acute Lethality Test with *Chironomus dilutus*
Reference: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1RM/32.

Test Organism:
test species: *Chironomus dilutus (formerly Chironomus tentans)*
culture source: Aquatic Biosystems, Inc. Fort Collins, CO, USA
culture batch 20100928CT
culture vessels: 15 L glass aquaria
dilution water: dechlorinated tap water
control sediment: silica sand or formulated soil
organism age: third instar (9 days old)
food source: Nutrafin (4g/L)

Test Design:	**Reftox**
test duration (days):	4
test temperature:	23 ± 1°C
test jar volume:	375mL
sediment volume:	N/A
water volume:	200mL
light levels (lux):	500-1000
photoperiod (hours):	16 hours light: 8 hours dark
replicates/treatment:	1
organisms/replicate:	10
feeding:	1.25 mL/jar on day 0 and 2

Warning Chart: mortality LC50 at 96 hours
toxicant: Potassium chloride (KCl)
Current Test: started on 2010/09/28 ended on 2010/10/02
result (96 h LC50): 0.68 (0.54-0.81) log (g KCl/L) (95% confidence limits are in brackets)

Historical Mean: mean: 0.5 std.dev: 0.2 cv(%): 34
warning limits: 0.1 0.8 (lower and upper 95% confidence limit, two standard deviations)
control limits: 0.0 0.9 (lower and upper 99% confidence limit, three standard deviations)



The data and results are authorized and verified correct.

E. Blais, B.Sc., Technical Lead

S. Krishnappa, B.Sc., Quality Coordinator

HydroQual
Laboratories Ltd.

Chironomid (single concentration) Test Report

Re-issued 2011/03/07

Client: DIA102
Reference: 10-1356-CTS

Result Summary

Contents

Client: Diavik Diamond Mines; operation Yellowknife

Sample: REF-1, REF-2, REF-3

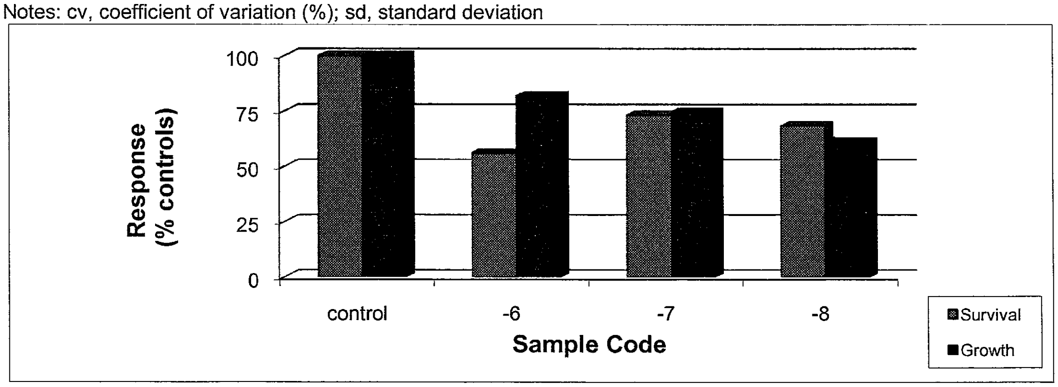
Collection: collected on 2010/09/03 at not given by SED
Receipt: received on 2010/09/05 at 1400 by H. Stewart
Containers: received 48 x 500 ml glass jars at 14 °C, in good condition* (see test comments) with no seals and no
Description: type: sediment, collection method: not given

Test: started on 2010/09/28 ; ended on 2010/10/08

Result:

Sample	Description	Survival			Growth (dry wt (mg) / organism)		
		mean	sd	cv(%)	mean	sd	cv(%)
	lab control	8	0.8	10	2.7	0.47	17
6	REF-1	5	1.7	36	2.2	0.30	14
7	REF-2	6	1.9	31	2.0	0.29	14
8	REF-3	6	0.9	16	1.7	0.34	21

Notes: cv, coefficient of variation (%); sd, standard deviation



E.Henson
Technical Lead

Quality Coordinator

Test Conditions

Client: DIA102
Reference: 10-1356-CTS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1/RM/32.

Test type: 10 day Static Chironomid Survival and Growth Test (4.4.3.16)
Species: *Chironomus dilutus*
Age: third instar; 12 days after hatching; average head capsule width 0.40 mm
Organism source: Aquatic Biosystems Inc., Fort Collins, Co, USA (Batch 20100924CT)
Shipped: 2010/09/23
Organisms upon receipt: mortality, < 1 %; temperature, 23°C: dissolved oxygen, 10.6 mg/L
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition
Acclimation: 4 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 25 days (must be ≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness
Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was dechlorinated City of Calgary tap water preaerated for at least 24 hours.
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <0.1)
Test concentrations: Undiluted samples plus a negative control
Test replicates: 5 field replicates of each concentration tested as received; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.75 mL of a ground Nutrafin™ slurry
Measurements: pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination
Sample pre-treatment: The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second.
The sample was not filtered or seived prior to testing.
Lighting: Overhead full spectrum fluorescent lights; 500-1000 lux at surface
Photoperiod: 16h light:8h dark
Test temperature: 23 ± 1°C

Note: Outlined sections are protocol deviations explained on the comment page

Client: DIA102
Reference: 10-1356-CTS

Test Conditions

Endpoints: Survival at 10-d
Growth, average individual dry weight at 10-d

Test validity: The control had 82% survival (must > 70%);
The control had mean dry weight of 2.71 mg/organism (must > 0.6 mg/organism)

Reference toxicant: 96 hour test with KCl initiated September 28, 2010;
current results: (96 hour LC50 and 95% confidence limits) =
0.68 (0.54-0.81) log (g KCl/L)

Test Data

Client: DIA102
Reference: 10-1356-CTS

Test Log:

Date	Day	Time	Technicians
2010/09/28	0	1530	E. Petho/H. Stewart
2010/09/29	1	1100	E.Petho/G. Diaz
2010/09/30	2	1100	R. McCurdy/E. Petho
2010/10/01	3	1515	R. McCurdy/E. Petho
2010/10/02	4	1050	E. Blais/C. Velasco
2010/10/03	5	1120	E. Blais/C. Velasco
2010/10/04	6	1220	H. Stewart/R. McCurdy
2010/10/05	7	1340	H. Stewart/R. McCurdy
2010/10/06	8	1530	H. Stewart/R. McCurdy
2010/10/07	9	1430	H. Stewart/R. McCurdy
2010/10/08	10	1010	T. Kloschinsky/R. McCurdy

Physical & Chemical Data:

Parameter	Sample					
	control	-6	-7	-8		
porewater ammonia (mg/L)	0.10	0.49	0.40	0.35		
overlying ammonia (mg/L)						
Day 0	0.16	0.14	0.18	0.17		
Day 10	1.52	1.90	2.48	2.52		
hardness (mg/L)						
initial	>425	120	120	120		
final	425	100	100	100		
alkalinity (mg/L)						
initial	>180	40	80	40		
final	>240	80	80	80		
average daily values						
pH	8.1	8.1	7.6	7.6		
EC (µS/cm)	513	296	275	615		
DO (mg/L)	6.4	5.5	5.3	5.4		
temp (^{o}C)	24	24	24	24		

Test Data

Client: DIA102
Reference: 10-1356-CTS

Biology Summary Data:

	Sample					
replicate	control	-6	-7	-8		

Survival (number of live organisms in each replicate)

a	8	2	6	7		
b	9	6	8	6		
c	9	5	6	5		
d	7	6	3	5		
e	8	4	7	5		

average	8	5	6	6		
sd	0.8	1.7	1.9	0.9		
cv (%)	10	36	31	16		
% survival	82	46	60	56		
% controls	100	56	73	68		

Growth (dry weight)

Total dry weight per replicate (mg)

a	17.86	4.86	10.02	8.30		
b	21.62	11.77	16.08	12.20		
c	21.56	9.27	11.56	8.75		
d	24.70	13.71	7.41	7.27		
e	19.04	10.24	14.17	9.49		

Average dry weight per live organism (mg/organism)

a	2.55	2.43	1.67	1.19		
b	2.40	1.96	2.01	2.03		
c	2.70	1.85	1.93	1.75		
d	3.53	2.29	2.47	1.45		
e	2.38	2.56	2.02	1.90		

average	2.71	2.22	2.02	1.66		
sd	0.47	0.30	0.29	0.34		
cv (%)	17	14	14	21		
% controls	100	82	75	61		

Notes: cv, coefficient of variation (%); sd, standard deviation

Test Data

Client: DIA102
Reference: 10-1356-CTS

Chemistry:

		Sample					
	day	control	-6	-7	-8		
pH (units)	0	7.9	8.2	7.9	7.8		
	10	8.3	7.9	7.3	7.4		
EC (µS/cm)	0	485	253	257	598		
	10	541	339	292	632		
DO (mg/L)	0	7.8	7.7	7.7	7.7		
	1	7.8	7.4	7.4	7.1		
	2	7.9	5.4	5.6	5.6		
	3	3.0	4.0	3.1	4.3		
	4	5.1	5.8	5.3	5.0		
	5	6.2	6.1	6.1	5.7		
	6	7.0	1.2	2.2	2.2		
	7	7.0	2.8	3.2	2.8		
	8	5.0	6.4	6.5	6.9		
	9	6.5	4.5	6.3	6.7		
	10	7.5	8.9	5.2	5.4		
temp. (°C)	0	24	24	24	24		
	1	24	24	24	24		
	2	23	23	23	23		
	3	24	24	24	24		
	4	23	23	23	23		
	5	23	23	23	23		
	6	23	23	23	23		
	7	23	23	23	23		
	8	24	24	24	24		
	9	24	24	24	24		
	10	24	24	24	24		

Comments/Statistics

Client: DIA102	
Reference: 10-1356-CTS	

Test Result Comments:
None

Data Analysis:
One fly was found in each of control replicates 'a' and 'c'. These were included in the survival calculations, but were not included in the dry weight.

Protocol Deviations:
None

Chironomid Test Report

Quality Assurance Information

Test Method: 96 hours Acute Lethality Test with *Chironomus dilutus*

Reference: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1RM/32.

Test Organism:		**Test Design:**	**Reftox**
test species:	*Chironomus dilutus (formerly Chironomus tentans)*	test duration (days):	4
		test temperature:	23 ± 1°C
culture source:	Aquatic Biosystems, Inc. Fort Collins, CO, USA	test jar volume:	375mL
		sediment volume:	N/A
culture batch	20100928CT	water volume:	200mL
culture vessels:	15 L glass aquaria	light levels (lux):	500-1000
dilution water:	dechlorinated tap water	photoperiod (hours):	16 hours light: 8 hours dark
control sediment:	silica sand or formulated soil	replicates/treatment:	1
organism age:	third instar (9 days old)	organisms/replicate:	10
food source:	Nutrafin (4g/L)	feeding:	1.25 mL/jar on day 0 and 2

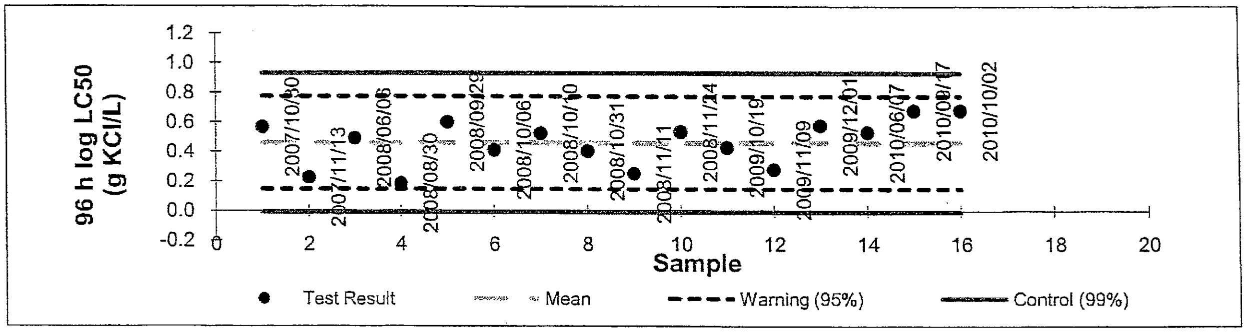
Warning Chart: mortality LC50 at 96 hours

toxicant: Potassium chloride (KCl)

Current Test: started on 2010/09/28 ended on 2010/10/02

result (96 h LC50): 0.68 (0.54-0.81) log (g KCl/L) (95% confidence limits are in brackets)

Historical Mean:	mean:	0.5	std.dev: 0.2	cv(%): 34
warning limits:	0.1	0.8	(lower and upper 95% confidence limit, two standard deviations)	
control limits:	0.0	0.9	(lower and upper 99% confidence limit, three standard deviations)	



The data and results are authorized and verified correct.

E. Kenson for

E. Blais, B.Sc., Technical Lead

S. Krishnappa, B.Sc., Quality Coordinator

HydroQual
Laboratories Ltd.

Chironomid (single concentration) Test Report

Re-issued 2011/03/07

Client: DIA102
Reference: 10-1392-CTS

Contents

Result Summary

Client: Diavik Diamond Mines; operation Yellowknife

Sample: sludge

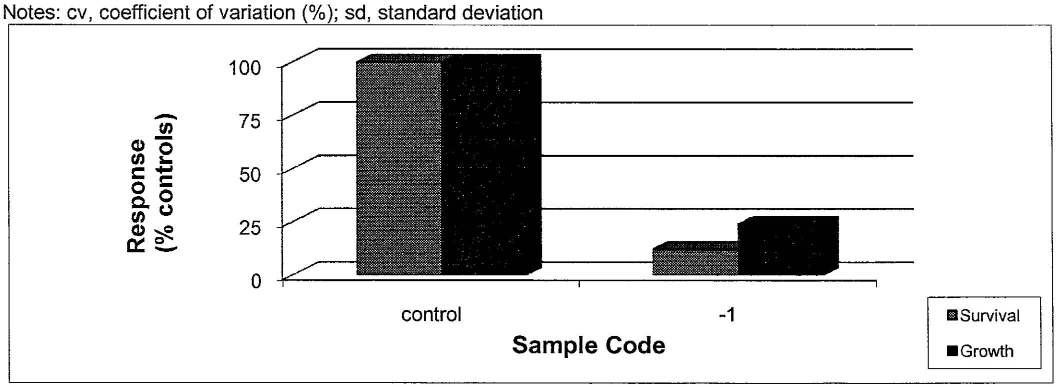
Collection: collected on 2010/09/02 at not given by not given
Receipt: received on 2010/09/13 at 1330 by C. Ehman
Containers: received 1 x 20L pail at 14 °C, in good with no seals and no initials
Description: type: sludge, collection method: not given

Test: started on 2010/09/28 ; ended on 2010/10/08

Result:

Sample	Description	Survival mean	Survival sd	Survival cv(%)	Growth (dry wt (mg) / organism) mean	Growth sd	Growth cv(%)
	lab control	8	0.8	10	2.7	0.47	17
1	sludge	1	1.0	100	0.7	0.29	44

Notes: cv, coefficient of variation (%); sd, standard deviation



E. Henson
Technical Lead

Quality Coordinator

Test Conditions

Client: DIA102
Reference: 10-1392-CTS

Method: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1/RM/32.

Test type: 10 day Static Chironomid Survival and Growth Test (4.4.3.16)
Species: *Chironomus dilutus*
Age: third instar; 12 days after hatching; average head capsule width 0.40 mm
Organism source: Aquatic Biosystems Inc., Fort Collins, Co, USA (Batch 20100924CT)
Shipped: 2010/09/23
Organisms upon receipt: mortality, < 1 %; temperature, 23.4°C: dissolved oxygen, 10.6 mg/L
The EC guidance document on the importation of test organisms (1999) has been followed. Test organisms were received in good condition
Acclimation: 4 days prior to testing at 23 ± 1°C
Organism observation: No unusual behaviour or appearance or treatment of test organisms was noted prior to shipping, upon arrival, preceding or during the test.

Initial Sample Characterization:

	control
Total Organic Carbon (%)	0.6
% Water	1.4
Particle Size: (% sand)	84.5
(% silt)	15.5
(% Clay)	<0.1

Sample holding time: 26 days (≤ 6 weeks)
Sample storage: 4 ± 2°C in darkness

Test vessel: The tests were conducted in 375 mL glass jars;
Test volume: 100 mL of sediment; 175 mL of overlying dilution/control water; no replenishing
Control/dilution water: The control water was dechlorinated City of Calgary tap water preaerated for at least 24 hours.
Control sediment: Sediment (%sand: 84.5, %silt: 15.5, %clay: <1)
Test concentrations: Undiluted sample plus a negative control
Test replicates: 5 replicates of each concentration; 10 organisms per replicate
Feeding: The test organisms were fed three times per week (on non-consecutive days) 3.75 mL of a ground Nutrafin™ slurry
Measurements: pH, conductivity, dissolved oxygen and temperature were measured daily on replicate 'E'; overlying hardness, alkalinity and ammonia at test initiation and termination
Sample pre-treatment: The sample was homogenized with hand mixing, dispensed into test vessels and allowed to settle overnight with aeration ~ 2-3 bubbles per second.
The sample was not filtered or seived prior to testing.
Lighting: Overhead full spectrum fluorescent lights; 500-1000 lux at surface
Photoperiod: 16h light:8h dark
Test temperature: 23 ± 1°C

Note: Outlined sections are protocol deviations explained on the comment page

Test Conditions

Client: DIA102	
Reference: 10-1392-CTS	

Endpoints:	Survival at 10-d Growth, average individual dry weight at 10-d
Test validity:	The control had 82% survival (must > 70%); The control had mean dry weight of 2.71 mg/organism (must > 0.6 mg/organism)
Reference toxicant:	96 hour test with KCl initiated September 28, 2010; current results: (96 hour LC50 and 95% confidence limits) = 0.68 (0.54-0.81) log (g KCl/L)

Note: Outlined sections are protocol deviations explained on the comment page

Test Data

Client: DIA102
Reference: 10-1392-CTS

Test Log:

Date	Day	Time	Technicians
2010/09/28	0	1530	E. Petho/H. Stewart
2010/09/29	1	1100	E.Petho/G. Diaz
2010/09/30	2	1100	R. McCurdy/E. Petho
2010/10/01	3	1515	R. McCurdy/E. Petho
2010/10/02	4	1050	E. Blais/C. Velasco
2010/10/03	5	1120	E. Blais/C. Velasco
2010/10/04	6	1220	H. Stewart/R. McCurdy
2010/10/05	7	1340	H. Stewart/R. McCurdy
2010/10/06	8	1530	H. Stewart/R. McCurdy
2010/10/07	9	1430	H. Stewart/R. McCurdy
2010/10/08	10	1010	T. Kloschinsky/R. McCurdy

Physical & Chemical Data:

Parameter	Sample					
	control	-1				
porewater ammonia (mg/L)	0.16	0.62				
overlying ammonia (mg/L)						
Day 0	0.16	3.72				
Day 10	1.52	3.59				
hardness (mg/L)						
initial	>425	250				
final	425	425				
alkalinity (mg/L)						
initial	>180	240				
final	>240	>240				
average daily values						
pH	8.1	7.4				
EC (µS/cm)	513	615				
DO (mg/L)	6.4	5.0				
temp (°C)	24	24				

Test Data

Client: DIA102
Reference: 10-1392-CTS

Biology Summary Data:

	Sample					
replicate	control	-1				

Survival (number of live organisms in each replicate)

a	8	2				
b	9	0				
c	9	2				
d	7	1				
e	8	0				

average	8	1				
sd	0.8	1.0				
cv (%)	10	100				
% survival	82	10				
% controls	100	12				

Growth (dry weight)

Total dry weight per replicate (mg)

a	17.86	0.72				
b	21.62	0.00				
c	21.56	1.34				
d	24.70	0.93				
e	19.04	0.00				

Average dry weight per live organism (mg/organism)

a	2.55	0.36				
b	2.40	-				
c	2.70	0.67				
d	3.53	0.93				
e	2.38	-				

average	2.71	0.65				
sd	0.47	0.29				
cv (%)	17	44				
% controls	100	24				

Notes: cv, coefficient of variation (%); sd, standard deviation

Client: DIA102
Reference: 10-1392-CTS

Chemistry:

		Sample					
	day	control	-1				
pH (units)	0	7.9	7.7				
	10	8.3	7.0				
EC (µS/cm)	0	485	598				
	10	541	632				
DO (mg/L)	0	7.8	6.9				
	1	7.8	4.0				
	2	7.9	4.3				
	3	3.0	5.0				
	4	5.1	5.0				
	5	6.2	5.1				
	6	7.0	1.6				
	7	7.0	1.5				
	8	5.0	7.3				
	9	6.5	7.0				
	10	7.5	7.2				
temp. (°C)	0	24	24				
	1	24	24				
	2	23	23				
	3	24	24				
	4	23	23				
	5	23	23				
	6	23	23				
	7	23	23				
	8	24	24				
	9	24	24				
	10	24	24				

Comments/Statistics

Client: DIA102
Reference: 10-1392-CTS

Test Result Comments:
None

Data Analysis:
One fly was found in each of control replicates 'a' and 'c'. These were included in the survival calculations, but were not included in the dry weight.

Protocol Deviations:
None

Chironomid Test Report

Quality Assurance Information

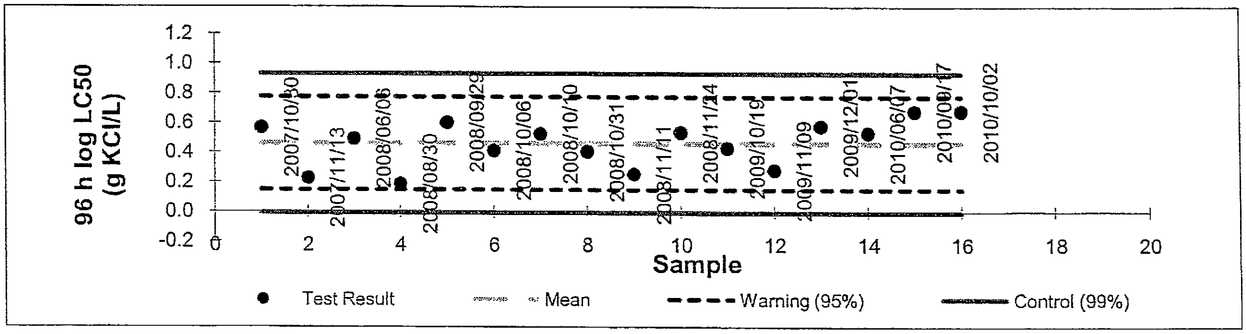
Test Method: 96 hours Acute Lethality Test with *Chironomus dilutus*
Reference: Biological Test Method: Test for Survival and Growth in Sediment Using the Larvae of Freshwater Midges (*Chironomus dilutus* or *Chironomus riparius*), 1997. Environment Canada EPS 1RM/32.

Test Organism:
test species: *Chironomus dilutus (formerly Chironomus tentans)*
culture source: Aquatic Biosystems, Inc. Fort Collins, CO, USA
culture batch 20100928CT
culture vessels: 15 L glass aquaria
dilution water: dechlorinated tap water
control sediment: silica sand or formulated soil
organism age: third instar (9 days old)
food source: Nutrafin (4g/L)

Test Design:	**Reftox**
test duration (days):	4
test temperature:	23 ± 1°C
test jar volume:	375mL
sediment volume:	N/A
water volume:	200mL
light levels (lux):	500-1000
photoperiod (hours):	16 hours light: 8 hours dark
replicates/treatment:	1
organisms/replicate:	10
feeding:	1.25 mL/jar on day 0 and 2

Warning Chart: mortality LC50 at 96 hours
toxicant: Potassium chloride (KCl)
Current Test: started on 2010/09/28 ended on 2010/10/02
result (96 h LC50): 0.68 (0.54-0.81) log (g KCl/L) (95% confidence limits are in brackets)

Historical Mean: mean: 0.5 std.dev: 0.2 cv(%): 34
warning limits: 0.1 0.8 (lower and upper 95% confidence limit, two standard deviations)
control limits: 0.0 0.9 (lower and upper 99% confidence limit, three standard deviations)



The data and results are authorized and verified correct.

E. Blais, B.Sc., Technical Lead

S. Krishnappa, B.Sc., Quality Coordinator

APPENDIX E

Benthic Invertebrate Taxonomy and Biomass Data (Dr. Jack Zloty)

DDMI 2010, North Inlet - Benthic Invertebrate Data

					NI-1					NI-2				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Turbellaria	Typhloplanidae	-	-	*Mesostoma*										
Nematoda	-	-	-	-										
Oligochaeta	Enchytraeidae	-	-	-										
	Lumbriculidae	-	-	-										
	Naididae	-	-	-										
	Tubificidae	-	-	-										
Pelecypoda	Pisidiidae	-	-	(i/d)										
		-	-	*Sphaerium*										
Hydracarina	-	-	-	-										
Copepoda - Calanoida	-	-	-	-			1						1	
Copepoda - Cyclopoida	-	-	-	-	25		3		10	5	4	1	3	5
Copepoda - Harpacticoida	-	-	-	-										
Ostracoda	-	-	-	-	1									
Cladocera	Chydoridae	-	-	*Eurycercus*										
	Daphniidae	-	-	*Daphnia*										
Trichoptera	Limnephilidae	Limnephilinae	Chilostigmini	*Grensia praeterita*										
Diptera	Chironomidae	Tanypodinae	Procladiini	*Procladius*										
		Diamesinae	Protanypini	*Protanypus*										
		Prodiamesinae	-	*Monodiamesa*			1							
		Orthocladiinae	-	(i/d)										
				Abiskomyia										
				Cricotopus/Orthocladius			1				1			
				Heterotrissocladius										
				Psectrocladius			1	1	1					
				Pseudosmittia										
				Zalutschia										
		Chironominae	Chironomini	*Dicrotendipes*										
				Endochironomus						1				
				Microtendipes	1									
				Stictochironomus										
			Tanytarsini	*Micropsectra*										
				Micropsectra/Tanytarsus										
				Paratanytarsus			1							
				Stempellina ?										
				Tanytarsus										
Terrestrial	-	-	-	-		0					1		1	
Total					***27***	***0***	***8***	***1***	***11***	***6***	***6***	***1***	***5***	***5***

Biomass (g)

Chironomidae	0.0001		0.0050	0.0026	0.0002	0.0002	0.0001			
Other taxa	0.0019	0.0000	0.0002		0.0007	0.0003	0.0010	0.00005	0.0008	0.0002
Total	***0.0020***	***0.0000***	***0.0052***	***0.0026***	***0.0009***	***0.0005***	***0.0011***	***0.0001***	***0.0008***	***0.0002***

DDMI 2010, North Inlet - Benthic Invertebrate Data

					NI									
					NI-3					NI-4				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Turbellaria	Typhloplanidae	-	-	*Mesostoma*										
Nematoda	-	-	-	-										
Oligochaeta	Enchytraeidae	-	-	-										
	Lumbriculidae	-	-	-										
	Naididae	-	-	-										
	Tubificidae	-	-	-	1	1							3	2
Pelecypoda	Pisidiidae	-	-	(i/d)										
		-	-	*Sphaerium*										
Hydracarina	-	-	-	-										
Copepoda - Calanoida	-	-	-	-	6		1		1		11	9	15	19
Copepoda - Cyclopoida	-	-	-	-	5	1		1	6	5	11	1	6	4
Copepoda - Harpacticoida	-	-	-	-										
Ostracoda	-	-	-	-										
Cladocera	Chydoridae	-	-	*Eurycercus*										
	Daphniidae	-	-	*Daphnia*						1				
Trichoptera	Limnephilidae	Limnephilinae	Chilostigmini	*Grensia praeterita*										
Diptera	Chironomidae	Tanypodinae	Procladiini	*Procladius*										
		Diamesinae	Protanypini	*Protanypus*										
		Prodiamesinae	-	*Monodiamesa*										
		Orthocladiinae	-	(i/d)										
				Abiskomyia										
				Cricotopus/Orthocladius										
				Heterotrissocladius										
				Psectrocladius						1	1		1	
				Pseudosmittia						1				
				Zalutschia										
		Chironominae	Chironomini	*Dicrotendipes*										
				Endochironomus										
				Microtendipes										
				Stictochironomus										
			Tanytarsini	*Micropsectra*										
				Micropsectra/Tanytarsus										
				Paratanytarsus										
				Stempellina ?										
				Tanytarsus										
Terrestrial	-	-	-	-					2					
Total					***12***	***2***	***1***	***1***	***9***	***8***	***23***	***10***	***25***	***25***

Biomass (g)

Chironomidae						0.0023	0.0027		0.0001	
Other taxa	0.0012	0.0026	0.00005	0.00005	0.0028	0.0004	0.0015	0.0006	0.0045	0.0027
Total	***0.0012***	***0.0026***	***0.0001***	***0.0001***	***0.0028***	***0.0027***	***0.0042***	***0.0006***	***0.0046***	***0.0027***

DDMI 2010, North Inlet - Benthic Invertebrate Data

					NI-5					REF-1				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Turbellaria	Typhloplanidae	-	-	*Mesostoma*						3		1	1	6
Nematoda	-	-	-	-						1		1	4	3
Oligochaeta	Enchytraeidae	-	-	-							1	1	11	11
	Lumbriculidae	-	-	-										
	Naididae	-	-	-						9				
	Tubificidae	-	-	-	1658	55	17	32	1451		3	1	1	1
Pelecypoda	Pisidiidae	-	-	(i/d)						10	1	4	4	10
		-	-	*Sphaerium*						1				
Hydracarina	-	-	-	-						1		1		4
Copepoda - Calanoida	-	-	-	-		1	1				2	1		
Copepoda - Cyclopoida	-	-	-	-	3	16	4		3					
Copepoda - Harpacticoida	-	-	-	-										2
Ostracoda	-	-	-	-								2	1	3
Cladocera	Chydoridae	-	-	*Eurycercus*										1
	Daphniidae	-	-	*Daphnia*										
Trichoptera	Limnephilidae	Limnephilinae	Chilostigmini	*Grensia praeterita*										
Diptera	Chironomidae	Tanypodinae	Procladiini	*Procladius*						4	1	2	3	7
		Diamesinae	Protanypini	*Protanypus*						2	2	3	1	10
		Prodiamesinae	-	*Monodiamesa*						1		2		1
		Orthocladiinae	-	(i/d)										2
				Abiskomyia										1
				Cricotopus/Orthocladius		1				1				
				Heterotrissocladius						2		3	3	10
				Psectrocladius		1		1						2
				Pseudosmittia										
				Zalutschia						6	4	8	3	24
		Chironominae	Chironomini	*Dicrotendipes*										
				Endochironomus										
				Microtendipes						31	11	75	34	167
				Stictochironomus									1	2
			Tanytarsini	*Micropsectra*									2	12
				Micropsectra/Tanytarsus									1	1
				Paratanytarsus							1	1		2
				Stempellina ?										
				Tanytarsus						1				
Terrestrial	-	-	-	-								1		
Total					***1661***	***74***	***22***	***33***	***1454***	***73***	***26***	***107***	***70***	***282***

Biomass (g)										
Chironomidae		0.0003		0.0020		0.0313	0.0121	0.0279	0.0221	0.0424
Other taxa	2.1281	0.0611	0.0128	0.0540	1.8338	0.0968	0.0051	0.0058	0.0073	0.0192
Total	***2.1281***	***0.0614***	***0.0128***	***0.0560***	***1.8338***	***0.1281***	***0.0172***	***0.0337***	***0.0294***	***0.0616***

DDMI 2010, North Inlet - Benthic Invertebrate Data

					REF									
					REF-2					REF-3				
Major Group	**Family**	**Subfamily**	**Tribe**	**Genus**	**A**	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Turbellaria	Typhloplanidae	-	-	*Mesostoma*										
Nematoda	-	-	-	-	1			3			4	9	2	
Oligochaeta	Enchytraeidae	-	-	-	6								1	
	Lumbriculidae	-	-	-		1		1		2	1	2	1	
	Naididae	-	-	-										
	Tubificidae	-	-	-	3		3			2	1	1		
Pelecypoda	Pisidiidae	-	-	(i/d)	7	2					6	4	1	1
		-	-	*Sphaerium*							1			
Hydracarina	-	-	-	-				1					1	
Copepoda - Calanoida	-	-	-	-	2			2			1	1	3	2
Copepoda - Cyclopoida	-	-	-	-								1	6	
Copepoda - Harpacticoida	-	-	-	-										
Ostracoda	-	-	-	-					2	1	1	1		
Cladocera	Chydoridae	-	-	*Eurycercus*						1			1	
	Daphniidae	-	-	*Daphnia*		1								
Trichoptera	Limnephilidae	Limnephilinae	Chilostigmini	*Grensia praeterita*					1					
Diptera	Chironomidae	Tanypodinae	Procladiini	*Procladius*	4	4	1	7		3	12	4	2	1
		Diamesinae	Protanypini	*Protanypus*	3	2	2	2		1	2	3	1	4
		Prodiamesinae	-	*Monodiamesa*	4	1	2	1			12	1	1	8
		Orthocladiinae	-	(i/d)										
				Abiskomyia										
				Cricotopus/Orthocladius										
				Heterotrissocladius	1			1						
				Psectrocladius										
				Pseudosmittia										
				Zalutschia	6		2		1	1		5	8	3
		Chironominae	Chironomini	*Dicrotendipes*						1			1	
				Endochironomus										
				Microtendipes	9	1	2	1		14	27	54	59	46
				Stictochironomus	1	4	9			4		2		
			Tanytarsini	*Micropsectra*	7	1	2	2	2					
				Micropsectra/Tanytarsus										
				Paratanytarsus	6			1			1		3	
				Stempellina ?	1									
				Tanytarsus	2					1				
Terrestrial	-	-	-	-										
Total					***63***	***17***	***23***	***22***	***6***	***31***	***69***	***88***	***91***	***65***

Biomass (g)

Chironomidae	0.0309	0.0127	0.0087	0.0079	0.0002	0.0379	0.0237	0.0826	0.0142	0.0192
Other taxa	0.0079	0.0199	0.0015	0.0178	0.0528	0.0471	0.0242	0.0198	0.0125	0.0016
Total	***0.0388***	***0.0326***	***0.0102***	***0.0257***	***0.0530***	***0.0850***	***0.0479***	***0.1024***	***0.0267***	***0.0208***

DDMI 2010, North Inlet - Benthic Invertebrate Data

QA/QC data for re-sorted sample

Major Group	Family	Subfamily	NI-1-A (C)	NI-1-A (1/1F)	NI-3-E (C)	NI-3-E (1/1F)	REF-1-C (C)	REF-1-C (1/1F)	REF-3-D (C)	REF-3-D (1/1F)
	-	-	0	0	0	0	0	0	0	0
Total missed (accounting for subsampling factor)				**0**		**0**		**0**		**0**
Total in sample				**27**		**9**		**108**		**91**
% missed				**0.0**		**0.0**		**0.0**		**0.0**
Sorting efficiency				**100.0**		**100.0**		**100.0**		**100.0**

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APPENDIX XI

DEVIATIONS FROM WEK’ÈEZHÌI LAND AND WATER BOARD TEMPLATE

Appendix XI – Deviations from WLWB Report Outline

As directed by the WLWB, this ICRP was developed to conform with a new *Annotated Outline for Interim and Final Closure and Reclamation Plans*. This reporting template was developed by the Mackenzie Valley Land and Water Board (MVLWB) Standard Procedures and Consistency Working Group. Although it has not been approved by the MVLWB it has been reviewed by the WLWB and meets their expectations for this Interim Closure and Reclamation Plan (WLWB 2009).

In some areas this ICRP has deviated from the outline to improve readability. The deviations of note are:

1. The template uses “reclamation” and “closure” interchangeably. To avoid any confusion we will identify in the introduction that we will use “closure” to mean closure, reclamation or closure and reclamation.

2. *5.2.3 Alternative Closure Options, Identified Risks and Contingencies* – was changed to *Preferred and Alternative Closure Options* it is important to let the reader know where to find the preferred closure option.

3. *Risks* have been moved from 5.2.3 to 5.2.6 and renamed 5.2.6 *Uncertainties, Risks and Research Plans*. While risks are discussed in 5.2.3 they are in relation to advantages/disadvantages of closure options. Whereas 5.2.6 is specific to risks associated with the preferred closure option.

4. *Contingencies* have been moved from 5.2.3 to 5.2.9 which is already titled *Contingencies*. In 5.2.3 the contingencies are effectively the options. In 5.2.9 specific contingencies are identified that could be applied if the preferred option is not successful.

5. In section 5.2.5 *Residual Effects* the expected environmental effects that would remain post-closure for that specific closure area are listed. In Section 9 we provide an overall assessment of the combined environmental effects from all mine components.

APPENDIX XII

CONFORMANCE TABLES

Table XII-1 Conformance Table with Class "A" Water Licence W2007L2-0003 Requirements. Part L, Conditions Applying to Closure and Reclamation

Water License Item #	Requirement(s) of the Interim Closure and Reclamation Plan	December 2009 ICRP Update
1 a)	Specific closure and restoration objectives and criteria and an evaluation of alternatives for the closure of each mine component, including, but not limited to: i) open pits, water retention dikes, and related structures; ii) underground workings; iii) Processed Kimberlite Containment Facility, including the placement of coarse kimberlite material over PKC slimes, and water handling during placement; iv) Waste Rock Storage Facilities and the Drainage Control and Collection System; v) water management structures (dams, intake and delivery systems, treatment plants); vi) Dredged Sediment Containment Facility; vii) North Inlet Facility including, sediment containment, and water management; viii) borrow pits, ore storage stockpiles, and other disturbed areas; ix) surface infrastructure (Process Plant, camp, roads, and airstrip); x) all petroleum and chemical storage areas; xi) any other areas potentially contaminated with hazardous materials; xii) any facilities or areas, which may have been affected by development such that a potential pollution problem exists; xiii) contingencies for pit water treatment during closure; xiv) dike breach locations and sizes; and xv) restoration of aquatic habitat in all areas.	S. 2, S. 5 and Appendix V
1 b)	A description of the detailed plans for reclamation, measures required, or actions to be taken, to achieve the objectives stated in the Board's Guidelines and Part L, Item 1 for each mine component.	S. 5,
1 c)	A detailed description, including maps and other visual representation, of the pre-disturbance conditions for each site, accompanied by a detailed description of the proposed final landscape, with emphasis on the restoration of surface drainage over the restored units.	S. 5
1 d)	A comprehensive assessment of materials suitability, including geochemical and physical characterization, and schedule of availability for restoration needs, with attention to top-dressing materials, including maps where appropriate, showing sources and stockpile locations of all reclamation construction materials.	S. 4, S. 5
1 e)	A description of the procedure to be employed for progressive reclamation, including details of restoration scheduling and procedures for coordinating restoration activities within the overall mining sequence and materials balance.	S. 6
1 f)	A description of any post-closure treatment that may be required for drainage water that is not acceptable for discharge from any of the reclaimed mine components including a description for handling and disposing of post-closure treatment facility sludges.	S. 5.2, S. 5.2.4.3
1 g)	A description of the plan to assess and monitor any ground water contamination during post-closure.	S.5 and S 9
1 h)	An evaluation of the potential to re-vegetate disturbed sites that includes the identification of criteria to be used to determine technical feasibility and alternative restoration options.	S 5.2.5 and Appendix VIII-10

Water License Item #	Requirement(s) of the Interim Closure and Reclamation Plan	December 2009 ICRP Update
1 i)	An identification of the research needs for restoration.	S. 5 and Appendix VIII
1 j)	A description of how progressive reclamation will be monitored throughout the life of the mine, including an evaluation of the effectiveness of any reclaimed areas.	S.5 and S.6
1 k)	Details of closure measures proposed in the event of a premature or temporary shutdown at any time throughout mine life.	Ch. 7
1 l)	A description of proposed means to provide long term maintenance of collection system and treatment plant.	S. 5
6	A restoration monitoring program to evaluate the effectiveness of all progressive reclamation and to identify any modifications required to facilitate landscape restoration.	S.5 and Appendix VIII

Table XII-2 Conformance table: Water Licence Requirements Not Met in the 2006 Version of the ICRP (according to WL N7L2-1645)

#	Deficiencies in 2006 ICRP	Location Addressed in 2009 ICRP Update
1	There are no criteria presented that would indicate and/or measure the success or failure of closure for each mine component.	Appendix V
2	DDMI has not provided evidence of ongoing community engagement with respect to the development of the ICRP	S.2.4
3	Include contingency plan for re-sloping of country rock and till storage	S. 5.2.2.9
4	Address North Inlet rehabilitation potential for fish habitat and how backwash sediments from NIWTP may impact on NI use of fish habitat	S. 5.2.4.3 and Appendix VIII-9
5	Address how much backwash sediments from NIWTP might impact the quality of discharges from NI to Lac de Gras	S. 5.2.4.3 and Appendix VIII-9
6	Include alternatives for storage for NI backwash sediments	S. 5.2.4.3
7	In chapter 8 of DDMI's 2006 ICRP, each mine component has "closure strategies" which touch on the goals for closure for that component but lacks a clear and explicit objective	S. 5.2 and Appendix V
8	There are no evaluations of alternatives discussed for the closure of each mine component, only a "Closure Strategy" and the "Proposed Closure Method" in chapters 7 and 8 of the 2006 ICRP	S. 5.2
9	There are no detailed reclamation plans presented. DDMI has produced "Closure Factors" and "Closure Strategies" within the 2006 ICRP but they lack a focused objective which may attribute to the lack of a clear link between what action will be taken to fulfill which objective.	S 5.2 and Appendix V
10	A map which illustrates the pre and post operational condition at a general level (Figure 2-1 and 9-1) is present in the 2006 ICRP, but does not show surface drainage throughout the site or the final landscape for each altered site.	S 5.2
11	A schedule of major operational activities has been included in Table 11-2, and some general reclamation events are listed in Figures 2-2 and 2-3, however there is no detailed schedule or description which outlines the dates for the commencement, completion and evaluation of all progressive reclamation studies and activities	S 5.2 and S.8
12	A description of the processes that will be used during closure to treat unsafe water for each mine component has been provided. However, no contingency has been provided in the event that the remaining water does not meet discharge criteria post-closure. These details should be included in the ICRP. Also, additional detail is needed regarding the process for specific handling and disposal of facility sludges during closure and post-closure	S.5.2
13	How will contaminated groundwater be assessed after closure? Plan not found.	S. 9

#	Deficiencies in 2006 ICRP	Location Addressed in 2009 ICRP Update
14	Objectives of revegetation have been listed in 10.3-3 and alternative strategies for revegetation are listed in 3.2.1, however, no indication of the criteria that will be used to evaluate the success of the studies have been discussed. Much more investigation and detail is needed in section 3.2.	Appendix V and Appendix VIII-10
15	Some areas of necessary research have been identified but it is not clear if it was with the participation of outside parties. DDMI has not provided evidence that parties have given input into the development of research gaps and requirements that will be investigated	S. 2.4 and Appendix IX-4
16	In section 10.3, DDMI explains the current monitoring that is taking place within each mine component. However, no description of how reclamation activities will be monitored or evaluated during or after mine operations has been discussed	S.5.2, S.9 and Appendix VI
17	DFO are concerned that no specific habitat thresholds and criteria have been identified within the plan so how can reviewers be confident that the proposed restored aquatic habitat will support fish populations and components of the aquatic ecosystem.	Appendix V
18	LKDFN are concerned that Aboriginal Parties were not consulted on either version of the reclamation plan and the development of closure criteria. They also believe that EKATI and Diavik should collaborate on closure programs and develop consistent closure criteria to address the cumulative effects on the Lac de Gras ecosystem.	S.2.4
19	The NSMA strongly encourage a public review process so interveners are given the opportunity to participate, whereas some of their compensation claim allows for funding to specifically be part of such a process.	S.2.4
20	The Tlicho observed that the ‘PKC Monitoring Plan’ has never been carried out and submitted and thus relevant monitoring activities might not fulfil requirements set out in Schedule 2 of the Licence. Additional research needs and monitoring details have not been addressed and include areas such as: PKC Cover (technical feasibility of this strategy has not been assessed), Water Quality in the flooded pits (the impact of soluble metals on the pits walls has not been studied for this issue) and the breaching of dikes to meet water quality objectives	S.5.2, Appendix VIII-1, and VIII-5
21	EMAB identified several uncertainties within the 2006 ICRP, most of which were not adequately addressed throughout the plan. This observation of remaining uncertainties is consistent with other reviewers conclusions.	S.5.2

APPENDIX XIII

EXCERPTS FROM:

ENVIRONMENT CANADA. 2009. ENVIRONMENT CANADA CODE OF PRACTICE FOR METAL MINES. PRS, 1/MM/17 E. APRIL 2009.

AND

INAC (INDIAN AND NORTHERN AFFAIRS CANADA). 2007. *MINE SITE RECLAMATION GUIDELINES FOR THE NORTHWEST TERRITORIES*. JANUARY 2007.

Table 1-A. General guidance on closure objectives relevant to the open-pit and underground areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 1-B. Recommendations for decommissioning of underground and open-pit mine workings from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

Table 1-C. Guidance for generic options for closure of open-pits and underground mine workings from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 1-D. General guidance on post-closure monitoring of the open-pit and underground areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 2A. General guidance on closure objectives relevant to waste rock and till areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 2B. Recommendations for decommissioning of waste rock piles from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

Table 2C. Guidance for generic options for closure of waste rock and overburden areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 2-D. General guidance on post-closure monitoring of the waste rock and till areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 3A. General guidance on closure objectives relevant to the processed kimberlite containment area from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 3B. Recommendations for decommissioning of the processed kimberlite containment from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

Table 3C. Guidance for generic options for closure of the processed kimberlite containment area from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 3-D. General guidance on post-closure monitoring of the processed kimberlite containment facility from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 4A. General guidance on closure objectives relevant to the North Inlet areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 4B. Recommendations for decommissioning of water management and treatment systems from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

Table 4C. Guidance for generic options for closure of water management facilities from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 4-D. General guidance on post-closure monitoring of the North Inlet from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 5A. General guidance on closure objectives relevant to mine infrastructure areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 5B. Recommendations for decommissioning of mine infrastructure from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

Table 5C. Guidance for generic options for closure of mine infrastructure areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 5-D. General guidance on post-closure monitoring of the Infrastructure Areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Table 1-A. General guidance on closure objectives relevant to the open-pit and underground areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Minimize access to open-pits to protect human and wildlife safety
- Allow emergency access and escape routes from flooded pits
- Implement water management strategies to minimize and control migration and discharge of contaminated drainage, and if required, collect and treat contaminated water
- Meet water quality objectives for any discharge from pits
- Stabilize slopes to minimize erosion and slumping
- Meet end land use target for resulting surface expression
- Establish original or desired new surface drainage patterns
- Establish in-pit water habitat where feasible for flooded pits
- Minimize access to underground workings and surface openings to protect human and wildlife safety
- Maximize the stability of underground workings so that there is no surface expression of underground failure
- Prevent collapse, stress transfer and flooding of adjacent mines
- Ensure that underground workings do not become a source of contamination to the surface environment
- Minimize potential for contamination and, if required, collect and treat
- Resurface, re-slope and contour surface disturbance as required to blend with surrounding topography or desired end land-use targets
- Minimize erosion, thaw settlement, slope failure, collapse or the release of contaminants or sediment
- Build to blend in with current topography, be compatible with wildlife use, and/or meet future land use targets
- Build to minimize the overall project footprint

Table 1-B. Recommendations for decommissioning of underground and open-pit mine workings from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

- R506: If it is technically and economically feasible to do so, underground or in-pit infrastructure (e.g. crushers, rails, metal structures, water and air pipes) and equipment (e.g. fans and pumps) should be removed from the site. Any equipment to be left underground or in pit should be inspected and remediated as appropriate to ensure that there is no risk of leakage of any contaminants.
- R507: During the decommissioning of underground and open pit mines, any contamination associated with vehicles and equipment operations and maintenance should be identified and remediated, as appropriate.
- R508: Underground mine workings should be secured and signs should be posted warning the public of potential dangers associated with the facility.
- R509: The risk of subsidence in underground mines should be assessed. Appropriate measures should be taken to prevent subsidence in cases where the risk of subsidence is determined to be significant. The primary measure used to prevent subsidence is the backfilling of underground voids.
- R510: Open pits should be backfilled or flooded to the extent practicable to prevent unauthorized access and to protect public safety. In all cases, signs should be posted warning the public of potential dangers associated with the site.

Table 1-C. Guidance for generic options for closure of open-pits and underground mine workings from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Open Pit Workings

- for multiple pits, sequentially backfill with wasterock and/or tailings as operations proceed
- backfill open pits with appropriate materials (e.g. waste rock, tailings)
- flood the pit (natural or accelerated)
- allow gradual slope failure of pits involving rock masses, or slope pit walls
- block open-pit access routes with boulder fences, berms and/or inulshuks (guidance from local communities and Elders should be sought)
- post warning signs (with visible symbols placed close enough so they are visible from one to another) and fences or berms around the perimeter for actively managed sites (not acceptable for remote sites into the long-term)
- long-term fencing to prevent access may only be appropriate if the mine site is located close to a community where regular access for maintenance is possible and where there is a higher risk of access by the general population
- clover slopes with rip rap thick enough to provide insulation or stabilization to minimize erosion or permafrost degradation
- Stabilize exposed soil along the pit crest or underlying poor quality bedrock that threatens to undermine the soil slope above the final pit water level
- Backbrush area to improve visibility
- Plug drill holes
- Maintain an access/egress ramp down to water level for flooded pits
- Contour to discourage or encourage surface water drainage into pits where appropriate
- Cover exposed pit walls to control reactions where necessary
- Collect waters in pit that do not meet the discharge criteria and treat passively (active treatment is not acceptable for the long term) or passively treat waters in the pit
- Breach diversion ditches and establish new water drainage channel
- Establish aquatic life in flooded pits

Underground Workings

- Seal all drill holes and other surface openings, especially those connecting the underground workings to the surface
- Backfill underground with benign tailings and wasterock
- Secure underground shafts and raise openings using concrete to ensure permanent closure;

wooden barricades are only suitable for temporary closure

- Construct a reinforced concrete wall or a plug of weakly cemented waste if the barricade is for access control only
- Flood and plug workings to control acid generation and associated reactions if appropriate (engineering designs must consider hydrostatic heads and rock mass conditions – reinforced slabs should be avoided)
- Construct pillars to retain long-term structural stability after mining activities cease and to sustain their own weight and, if applicable, the weight of unconsolidated deposits, water bodies and all other surface loads
- Permanent support boundary pillar if practical and necessary
- Avoid the use of fencing for barricades in remote northern mine sites where regular inspection is not feasible
- Use ditches or berms as barricades except in areas of continuous permafrost; where continuous permafrost exists, inukshuks, fencing or some other method may need to be considered
- Remove all hazardous materials from the underground shops, equipment and magazines (fuels, oils, glycol, batteries, explosives, etc.)
- Contour to establish natural drainage patterns and blend in with the surrounding topography or re-contour the surface to prevent natural surface and groundwater flows from becoming contaminated by mine water where appropriate

Table 1-D. General guidance on post-closure monitoring of the open-pit and underground areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

Underground Workings

- Inspect sealed areas
- Check for surface expression (subsidence) of underground failure
- Conduct geotechnical assessment of the overall safety and risk within the subsidence zone.
- Install and check thermistors where appropriate to monitor freeze-back in permafrost areas and to confirm that the ground thermal regime is not degraded
- Periodic backfilling of areas of subsidence may be required
- Inspect groundwater plumes and hydrogeology

Open-pit

- Identify areas that are not stable
- Check ground conditions to confirm permafrost conditions are being re-established as predicted
- Sample surface water and profiles of flooded ponds/pits
- Ensure that there is sufficient water supplied to maintain an appropriate water depth for flooded pits
- Sample quality of groundwater seeping from pit walls to assess potential for contamination of mine water due to melting permafrost and ARD/MLch from pit walls.
- Identify and test water management points (including seepage) that were not anticipated
- Inspect barriers such as berms, fences, signs and inukshuks

Inspect fish habitat in flooded pits where applicable

Table 2A. General guidance on closure objectives relevant to wasterock and till areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Minimize erosion, thaw settlement, slope failure, collapse or the release of contaminants or sediment
- Build to blend in with current topography, be compatible with wildlife use, and/or meet future land use targets
- Build to minimize the overall project footprint
- Develop and implement preventative and control strategies to effectively minimize the potential for ARD and ML to occur
- Where ARD and ML are occurring as a result of mine activities, mitigate and minimize impacts to the environment
- No reliance on long-term treatment as a management tool (e.g. effluent treatment facilities are not appropriate for final reclamation but may be used as a progressive reclamation tool)
- Minimal maintenance requirements in the long-term

Table 2B. Recommendations for decommissioning of wasterock piles from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

- R 524: At the end of the mine operations phase, detailed inspections and assessments of wasterock piles and tailings management facilities, particularly dams and other containment structures, should be carried out. The objective of these inspections and assessments is to evaluate the actual performance against design projections related to anticipated post-closure conditions. Factors that should be considered include:
  - the extent of deformation;
  - the rate and quality of seepage;
  - the condition of foundations and sidewalls; and
  - design loads, which may be different after mine closure.
- R 525: At the end of the mine operations phase, comprehensive risk assessment should be conducted for mine closure to:
  - evaluate the long-term risk associated with possible failure modes for wasterock piles and tailings management facilities;
  - identify possible impacts on the environment and human health and safety in the event of a failure;
  - determine parameters critical to these failure modes and possible impacts; and
  - develop and implement long-term control strategies to manage the identified risks.
- R 527: At the end of mine operations phase, plans for management of wasterock and tailings to prevent, control and treat metal leaching and acidic drainage should be re-evaluated and revised as necessary, to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
  - the results of the re-evaluation of the performance of these facilities;
  - the performance of progressive reclamation to date; and
  - possible alternative technologies for closure.

- R 529: At all mines that exist in permafrost conditions, downstream slopes of tailings containment structures should be revegetated.

Table 2C. Guidance for generic options for closure of wasterock and overburden areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Doze down crest if required or construct toe berm to flatten overall slope
- Remove weak or unstable materials from slopes and foundations
- Off-load materials from crest of the slope
- Leave waste piles composed of durable rock “as is” at the end of mining if there is no concern for deep-seated failure or erosion, and if the end land use targets can be achieved
- Cover to control reactions and/or migration (re-slope to allow for cover placement if necessary)
- Place riprap insulation/stabilization layer
- Freeze waste into permafrost
- Place potentially acid generating rock underwater or underground if available
- Place potentially acid generating within the centre of the waste pile so it is encapsulated be permafrost if conditions permit and underwater or underground disposal are not viable options
- Construct collection system to collect contaminated runoff or leachate
- Construct diversion ditches to divert uncontaminated runoff
- Install horizontal drains or pump leachate from relief wells at the toe of the slope
- Passively treat contaminated waters where necessary, active treatment is not acceptable for the long term
- Use benign waste rock as backfill in underground mine workings, to seal portals, to fill open-pits, or for construction material such as ramps or covers
- Revegetate using indigenous species or use other biotechnical measures (use of living organisms or other biological systems for environmental management) to reduce surface erosion
- Reslope, contour and/or construct ramps to facilitate wildlife access
- Use inukshuks to deter wildlife where appropriate (guidance from local communities and Elders should be sought)
- Include records of construction drawings, as-built drawings, location of landfill sites, and potential ARD material and other contaminated materials which are contained within the rock pile in the reclamation research plan.
- Control acid water at the source, preventing contaminated water flows, and allow contaminated water to be collected and treated (this would be incorporated into water management system)
- Divert or intercept surface and groundwater from ARD source

- Install covers and seals to prevent or reduce infiltration
- Induce or maintain freezing conditions to limit the formation and discharge of leachate
- Place acid generating materials in topographic lows or depressions where they are most likely to be submerged under water under natural conditions
- Mitigate consequences of ARD by the use of passive and active treatment systems, as appropriate for in-situ conditions
- Passive treatment measures include:
    - Chemical (alkali trenches, attenuation along flow path)
    - Biological (sulphate reduction, wetlands, metal uptake in plants)
    - Physical (physical removal – filtration by plants, attenuation)
- Active treatment measures may include:
    - Chemical (Lime neutralization, adsorptive process)
    - Biological (Sulphate reduction)
    - Physical (Solid/liquid separation)

Table 2-D. General guidance on post-closure monitoring of the wasterock and till areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Periodically inspect areas where stabilization measures may be required
- Periodic inspections by a geotechnical engineer to visually assess stability and performance of waste pile and cover(s)
- Periodically inspect ditches and diversion berms
- Examine ground conditions to confirm predicted permafrost conditions are being established as predicted
- Check thermistor data to determine thermal conditions within waste piles to confirm predicted permafrost aggradation/encapsulation where applicable
- Test water quality and measure volume from controlled discharge points of workings to confirm that drainage is performing as predicted and not adversely affecting the environment
- Identify water discharge areas (including volume and quality) that were not anticipated
- Inspect physical stability of the mine site to confirm that no erosion, slumping or subsidence that may expose potentially ARD/ML material to air and water are occurring
- Inspect any preventative and control measures (e.g. covers) to confirm that they minimize water and/or air exposure
- Confirm that predicted water quality and quantity of chemical reactions is occurring
- Develop monitoring locations and frequency on a site by site basis, incorporating locations where possible contaminated drainage may be generated, and where drainage may be released to the water management system or to the environment (also include downstream/down gradient locations)

Table 3A. General guidance on closure objectives relevant to the processed kimberlite containment area from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Stabilize slopes surrounding the tailings impoundment or containment system for flooded and/or dewatered conditions
- Minimize catastrophic and/or chronic release of the tailings based on associated risk
- Minimize wind migration of tailings dust
- Minimize the threat that the impoundment becomes a source of contamination (e.g. tailings migration outside of contained area, contamination of water outside of contained area)
- Blend with local topography and vegetation were appropriate
- Discourage human and wildlife access from physically and chemically unstable tailings sites

Table 3B. Recommendations for decommissioning of the processed kimberlite containment from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

- R 524: At the end of the mine operations phase, detailed inspections and assessments of wasterock piles and tailings management facilities, particularly dams and other containment structures, should be carried out. The objective of these inspections and assessments is to evaluate the actual performance against design projections related to anticipated post-closure conditions. Factors that should be considered include:
    - the extent of deformation;
    - the rate and quality of seepage;
    - the condition of foundations and sidewalls; and
    - design loads, which may be different after mine closure.
- R 525: At the end of the mine operations phase, comprehensive risk assessment should be conducted for mine closure to:
    - evaluate the long-term risk associated with possible failure modes for wasterock piles and tailings management facilities;
    - identify possible impacts on the environment and human health and safety in the event of a failure;
    - determine parameters critical to these failure modes and possible impacts; and
    - develop and implement long-term control strategies to manage the identified risks.
- R 527: At the end of mine operations phase, plans for management of wasterock and tailings to prevent, control and treat metal leaching and acidic drainage should be re-evaluated and revised as necessary, to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
    - the results of the re-evaluation of the performance of these facilities;
    - the performance of progressive reclamation to date; and
    - possible alternative technologies for closure.
- R 529: At all mines that exist in permafrost conditions, downstream slopes of tailings containment structures should be revegetated.

Table 3C. Guidance for generic options for closure of the processed kimberlite containment area from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Stabilize embankments by removing weak or unstable materials from slopes and foundations and/or construct toe berms to flatten overall slope
- Breach water retention dams and drain impoundments, avoid post closure impoundment of water when possible
- Use a natural body of water that has sufficient storage capacity to hold the tailings and also a natural unimpeded flow via the drainage outlet if a permanent water cover is used (this may not be viable if the supernatant water quality does not meet discharge water quality standards)
- Increase freeboard and/or upgrade spillway to prevent overtopping and possible erosion by extreme events
- Relocate and/or deposit tailings into underground mine workings or into flooded pits, depending on water quality considerations
- Flood to control acid generation and related reactions
- Cover to control acid generation and related reaction and surface erosion
- Promote neutralization reactions by use of alkaline materials for acid tailings
- Divert non-contact runoff away from the tailings facility to avoid contamination
- Promote freezing of tailings mass into permafrost if suitable conditions exits.
- Collect waters that do not meet the discharge criteria and treat passively, active treatment is not acceptable for the long term
- Remove structures, decant towers, pipes and drains where they already exist
- Plug decant towers, pipes, and drains with high slump (relatively liquid concrete which will flow to fill all voids) or preferably, expansive concrete, as a last resort
- Assess the soil around pipes for stability under the hydraulic gradients through the embankment, as this may be a potential zone of piping failure
- Avoid using diversion structures and ditching, especially in permafrost soils (diversion structures are not the preferred option into the long-term)
- Where diversion dams and channels are necessary, maintain them indefinitely to meet long term stability and hydraulic design requirements; design diversions and spillways for extreme events suitable for long term stability
- Provide frost protection cap over the phreatic surface for water-retaining dams
- Ditch, berm, fence or use alternative methods to deter access to motorized vehicles if compatible with end-use plans
- Establish indigenous vegetation, soil, riprap or water cover to control erosion

Table 3-D. General guidance on post-closure monitoring of the processed kimberlite containment facility from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- conduct periodic dam safety and stability reviews of structures that remain after closure
- Inspect seepage collection system for water quality flows
- Check for degradation or aggradation of permafrost for tailings containment structures where permafrost was used in the design
- Assess dust dispersion and vegetation uptake with wind dispersion of tailings

Table 4A. General guidance on closure objectives relevant to the North Inlet areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Dismantle and remove/dispose of as much of the system as possible and restore natural or establish new drainage patterns
- Stabilize and protect from erosion and failure for the long term
- Maintain controlled release from water dams, ditches and all points of water discharge to the environment
- Achieve approved water quality limits, and in the case of existing mines, implement long term treatment only if necessary and ensure that minimal maintenance is required.

Table 4B. Recommendations for decommissioning of water management and treatment systems from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

- R531: At the end of the mine operations phase, water management plans should be evaluated and revised as necessary to ensure that they are consistent with the objectives and plans for mine closure and post closure. This evaluation should consider:
    - The results of an evaluation of the performance of the existing water management plan;
    - Expected changes in water flow and water balance on site; and
    - Expected changes in wastewater volume and composition

Based on this evaluation, the following should be identified:

- Water management structures, such as dams and diversion ditches, that will no longer be needed, methods to be used for decommissioning these structures, and the timing of decommissioning;
- Water management structures that will continue to be needed and any long-term maintenance or replacement requirements associated with these structures;
- Water management structures that will need to be modified, methods to be used to modify these structures, the timing of modification, and any long-term maintenance requirements associated with these structures; and
- Long-term monitoring requirements to ensure that the water management system continues to function as designed.

- R532: At sites where it is determined that long-term treatment of wastewater will be necessary during post closure, a long-term wastewater treatment plan should be developed and implemented. This plan should include the following elements:
    - Identification of roles and responsibilities of persons to be involved in operation and maintenance of the treatment system;
    - Identification of the types of treatment system to be used;
    - Identification of any by-products from the treatment system, such as treatment sludge and management plans for the disposal of those by-products;
    - Identification of routine maintenance activities to be conducted on the treatment system and the frequency;
    - Identification of monitoring to assess ongoing performance of the treatment system and the frequency;
    - Identification of reporting requirements for internal management and regulatory agencies; and
    - Description of contingency plans to address any problems associated with the treatment system.

Table 4C. Guidance for generic options for closure of water management facilities from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Water management facilities including ditching and settling ponds that are not required for long-term use should be treated and discharged, sediment should be removed and disposed of properly, and the embankments, dams and culverts should be breached if not required
- Use passive treatment systems as the preferred method for dealing with contaminated waters if it can be demonstrated to be effective
- Locate permanent spillways in competent rock
- Drain, dismantle and remove tanks and pipelines from the site or fill and cover them with appropriate materials if they are approved to remain
- Cover embankments, ditches, culverts, and other drainage channel slopes with erosion resistant material (e.g. soil, riprap, vegetation)

Table 4-D. General guidance on post-closure monitoring of the North Inlet from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Periodically inspections are required in the post-closure period to assess the performance of the existing water management structures
- Check the performance of erosion protection on embankment structures such as rip rap or vegetation and the physical stability of water management systems including permafrost integrity where applicable
- Check water quality and flows to ensure system is working as predicted
- Conduct ongoing inspection and maintenance of passive or active water treatment facilities associated with non-compliant mine water or runoff discharges
- Sample surface and groundwater if site specific conditions dictate
- Check the smell and taste of water and fish (guidance from local communities and Elders should be sought)

Table 5A. General guidance on closure objectives relevant to mine infrastructure areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Ensure buildings and equipment do not become a source of contamination or a safety hazard to wildlife and humans
- Return area to its original state or to a condition compatible with the end-use targets
- Remediate any sources of contamination that may have been created during the development and operation of the mine site in order to protect humans, wildlife and environmental health
- Prevent significant releases of substances that could damage the receiving environment
- Remediate contaminated soil such that the area is compatible with future uses of the surrounding local area
- Re-establish the pre-mining ground cover, which may involve encouraging self-sustaining indigenous vegetation growth
- Provide wildlife habitat where appropriate and feasible
- Assist with providing physical stability of mine components

Table 5B. Recommendations for decommissioning of mine infrastructure from *Environment Canada Code of Practice for Metal Mines* (Environment Canada 2009).

- R514: On-site facilities and equipment that are no longer needed should be removed and disposed of in a safe manner, unless facilities or equipment are to be preserved for post-closure land use. Efforts should be made to sell equipment for reuse elsewhere or to send equipment for recycling, rather than disposing of it in landfill facilities.
- R515: The walls of on-site buildings should be razed to the ground, except in cases where they are to be preserved for post-closure land use. Foundations should be removed or covered with a sufficient thick layer of soil to support revegetation.
- R516: If buildings are to be preserved, either as a heritage resource or for some other post-closure land use, structures and foundations should be inspected to ensure that no contamination is present. If the structures or foundations are contaminated, they should be remediated as necessary to ensure public health and safety for post-closure land use.
- R517: Support infrastructure, such as fuel storage tanks, pipelines, conveyors and underground services should be removed, except in cases where it is to be preserved for post-closure land use.
- R518: The main access road to the site (or runway in the case of remote sites) and other on-site roads, as appropriate, should be preserved in a sufficient condition to allow post-closure access for monitoring, inspection and maintenance activities.
- R519: Roads, runways or railways that will not be preserved for post-closure should be reclaimed:
    - Bridges, culverts and pipes should be removed, natural stream flow should be restored, and stream banks should be stabilized by revegetating or by using rip-rap.
    - Surfaces, shoulders, escarpments, steep slopes, regular and irregular benches, etc. should be rehabilitated to prevent erosion; and
    - Surfaces and shoulders should be scarified, blended into natural contours, and revegetated.
- R520: electrical infrastructure, including pylons, electric cables and transformers should be dismantled and removed, except in cases where this infrastructure is to be preserved for post-closure land use or will be needed for post-closure monitoring, inspection and maintenance. This includes infrastructure on site, as well as any off-site infrastructure owned by the mining company.
- R522: Waste from the decommissioning of ore processing facilities and site infrastructure, such as waste from the demolition of buildings and the removal of equipment, should be removed from the site and stored in an appropriate waste disposal site or disposed of on site in an appropriate manner in accordance with relevant regulatory requirements. If material is disposed of on site, the location and contents of the disposal site should be documented.
- R523: Sampling and analysis of soils and other materials should be conducted to ensure that none of the material is contaminated, e.g. with asbestos and mercury from buildings. If

contaminated materials are identified, they should be handled and disposed of in an appropriate manner in accordance with all applicable regulatory requirements.

Table 5C. Guidance for generic options for closure of mine infrastructure areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Dismantling all buildings that are not necessary to achieve the future land use target
- Raze/level all walls to the ground and remove foundations
- Cover remaining foundations with materials conducive to vegetation growth
- Remove buildings and equipment during the winter to minimize damage to the land where appropriate
- remove and dispose concrete in an approved landfill if it contains contaminants such as hydrocarbons or PCB’s that may pose a hazard over time
- where approved, break or perforate concrete floor slabs and walls to create a free draining condition in order that vegetation can be established
- backfill all excavations below final grade to achieve the final desired surface contours to restore the natural drainage or a new acceptable drainage
- cover excavated sites which have exposed permafrost with a rock cap to prevent thermokarst erosion
- Bury materials in the unsaturated zone or below the active layer
- Decontaminate equipment (free of any batteries, fuels, oils or other deleterious substances) and reuse or sell (local communities may have interest in some of the materials)
- If sale or salvage or equipment is not possible, dispose of decontaminated equipment in an approved landfill or as recommended by the regulatory authorities
- Cut, shred or crush and break demolition debris to minimize the void volume during disposal
- Maintain photographic records of major items placed into landfills, as well as a plan showing the location of various classes of demolition debris (e.g. concrete, structural steel, piping, metal sheeting and cladding)
- Leave non-salvageable materials and equipment from underground operations in the underground mine upon approval from the regulatory authorities
- Remove all hazardous materials and chemicals prior to demolition to national approved hazardous material treatment facilities, recycle, reuse, or dispose of in a appropriate manner upon approval from the regulatory authorities (check for PCBs in fluorescent light fixtures, lead-based paints, mercury switches or radioactive instrument controls)
- Backhaul materials for recycling or disposal to a southern location
- Excavate and remove contaminated soil and place into a designated and properly managed containment area on-site
- Treat contaminated soil in-situ (bioremediation, soil leaching, washing, etc.)
- Immobilize contaminated soil (cement solidification, lime/silicate stabilization, etc.)

- Excavate and relocate contaminated soil to approved facilities off-site.
- Some low level contaminated soil may be used progressively to cover landfills if the entire landfill is designed to be ultimately encapsulated in permafrost
- Dispose of wastes in quarries, borrow pits, underground mine workings, tailings impoundments, and waste rock piles
- Burn domestic waste in an incinerator during operations and at closure as part of camp maintenance
- Burn waste oils, solvents and other hydrocarbons on-site with an incinerator if approved (chlorinated substances should not be burned)
- Cover landfills and other waste disposal areas with erosion resistant material (e.g. soil, riprap, vegetation)
- Divert runoff with ditches or covers
- Ditch, berm, fence or use alternative methods to limit access to waste storage areas
- Contour/blend to match the natural topography or a new desired topography and re-vegetate with indigenous species to meet end use land targets
- Consider surface application of sewage for re-vegetation
- Begin revegetation efforts as soon as possible for mine site areas/components (progressively reclaim)
- Contour, scarify, and seed are using native seed mixes to establish vegetative cover
- Apply gravel barriers or other underlying cover systems where desired to control or limit the upward movement of acidic pore water or heavy metals that may inhibit plant growth or for moisture retention near the surface
- Apply stripped/stockpiled soil or growth medium to a depth sufficient to maintain root growth and nutrient enrichments
- Incorporate organic materials, mulches, fertilizers, or other amendments based upon local soil assessment
- Establish appropriate temporary or permanent wind breaks where necessary to establish vegetation
- Transplant vegetation that would otherwise be lost to mine disturbance where feasible
- Select indigenous vegetation for reclaimed sites that have a low potential for metal accumulation
- Re-vegetate with indigenous vegetation not used by wildlife or people if uptake of metals is a concern
- Place a gravel or coarse cover to discourage vegetation growth where desired

Table 5-D. General guidance on post-closure monitoring of the Infrastructure Areas from *Mine Site Reclamation Guidelines for the Northwest Territories* (INAC 2007).

- Maintain all buildings and equipment left onsite
- Inspect disposal areas periodically to establish if buried materials are being pushed to surface as a result of frost heaving
- Maintain access infrastructure to support on-going reclamation and closure monitoring
- Monitor wildlife/fish use of area to ensure mitigation measures are successful
- Monitor other land users access and activity in the area
- Check stream crossing remediation and any degradation associated with decommissioned roads such as erosion and ponding of water.
- Carry out periodic inspections to investigate the quality of air, groundwater, discharge water, and water body sediment where contaminated soils have occurred
- Carry out periodic inspections to investigate thermal degradation, and physical stability where contaminants have occurred
- An assessment of residual contamination should be carried out to confirm the success of the remediation
- Inspect re-vegetation areas periodically following initial planting until vegetation is successfully established and self sustaining in accordance with the agreed criteria
- Conduct soil analysis for nutrients an pH until the vegetation is successfully established and self-sustaining
- Inspect vegetated areas that may be obscuring possible cracks and other problems on dams and embankments
- Inspect for root systems that are penetrating protective covers or decaying/rotting providing tunnels for water to pass through protective covers
- Identify excessive vegetation stress or poorly established areas and implement contingency measures if required.
- Sample water treatment sludge periodically to determine the chemical characteristics, sludge stability, and leachability under the proposed long-term storage conditions
- Test water quality and quantity to measure the success of the mitigation measures for waste disposal areas
- Identify and unpredicted sources of potential contamination
- Check the ground thermal regime (by means of thermistors) and cover performance to check if permafrost has aggraded into the landfill and if the seasonal active zone remains within the cover
- Check for cracking or slumping of the cover and for underlying waste material pushing its way

up through the cover