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Environmental Effects Monitoring (EEM): Cycle 1 Study Design

Meadowbank Division, Nunavut

Prepared for:

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Meadowbank Division

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- Gary Mann and Laura Bekar (Azimuth) – Gary provided overall project management and co-authored the report. Laura provided project coordination and co-authored the report.
- Randy Baker (Azimuth) – Randy provided senior technical review of the report.
- Ryan Hill (Azimuth) – Ryan served as a technical advisor to the project team.
- Ryan Vanengen (AEM) – Ryan participated in this project on many levels, from helping with mine-specific information for the site characterization to imparting his broad knowledge of local fisheries resources into discussions related to target species and reference area selection. Ryan also reviewed the report for AEM. of the documentation of the study design, to collecting benthic invertebrate samples, to providing background literature, to reviewing the report for AEM.
- Paula Siwik (Environment Canada) – Paula provided insights into the regulatory process and expectations regarding the EEM program. We appreciate the effort she made to visit the site and better understand some of the challenges faced by the project team.

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ACRONYMS

ABA – Acid-base accounting

AEM – Agnico-Eagle Mines Ltd.

AEMP – Aquatic Effects Monitoring Program

ANOVA – Analysis of Variance

ANCOVA – Analysis of co-variance

ARD – Acid Rock Drainage

AWR – All Weather Road

BACI – Before-after-control-impact

BAER – Baseline Aquatic Effects Report

CCME – Canadian Council of Ministers of the Environment

CEPA – Canadian Environmental Protection Act

CIP – Carbon-in-Pulp

CPUE – Catch per unit effort

CREMP – Core Receiving Environmental Monitoring Program

DBA – Detailed biological assessment

DELT – Deformities, erosions, lesions, tumors

DQO – Data Quality Objective

DOC – Dissolved oxygen content

EAS – Effects Assessment Study

EC – Environment Canada

EIA – Environmental Impact Assessment

EEM – Environmental Effects Monitoring

FF – Far field

GPS – Global Positioning System

GSI – Gonadosomatic Index

HCM – Habitat Compensation Monitoring

HDD – Heating degree days

HSI – Hepatosomatic Index

IF – Iron Formation

INAC – Indian and Northern Affairs Canada

INUG – Inuggugayualik Lake, reference area

ISQG – Interim sediment quality guidelines

IV – Intermediate Volcanic

MDL – Method Detection Limit

ML – Metal Leachate

MMER – Metal Mining Effluent Regulations

NF – Near field

NPAG – non-Potentially acid generating

NPR – Neutralizing potential ratio

NWB – Nunavut water board

PAG – Potentially acid generating

PDL – Pipedream Lake, reference area

PEL – Probable effects level

QA/QC – Quality Assurance / Quality Control

QZ - Quartzite

RPD – Relative Percent Difference

RSF – Rock storage facility

SD – Standard deviation

SFE – Shake flask extraction

SOP – Standard Operating Procedure

SP – Second Portage Lake

TE – Tehek Lake

TGD – Technical guidance document

TPE – Third Portage Lake – East Basin

TPN – Third Portage Lake – North Basin, high exposure area

TPS – Third Portage Lake – South Basin

TSF – Tailings storage facility

TSS – Total suspended solids

UM - Ultramafic

UTM – Universel Transverse Mercator

1. INTRODUCTION

1.1. Background

The Meadowbank Mine (65°N, 96°W), owned by Agnico Eagle Mines Ltd. (AEM), is one of Canada's most northerly operating mines, located approximately 75-km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut (**Figure 1-1**). Mine construction began in 2008 under Nunavut Water Board *A License* 2AM-Mead0815 (hereafter referred to as the "NWB A License") and Fisheries and Oceans Canada *Authorization for Works or Undertaking Affecting Fish Habitat* NU-03-0191 (hereafter referred to as the "Authorization"). Meadowbank is an open pit mine and produced its first gold bar in February 2010. Mine status formally changed to "operational" March 1, 2010.

Several lakes are located directly within and adjacent to the boundaries of the target mineral zones on the Meadowbank property. Baseline studies describing the physical, chemical, and biological characteristics of the aquatic environment in the vicinity of the project area were initiated in 1995 and continued through 2007 (BAER 2005; Azimuth 2008a,b). In addition, a comprehensive environmental impact assessment of the aquatic ecosystem (Azimuth, 2005a) and an aquatic effects management program (AEMP, 2005) were prepared to meet regulatory requirements pertaining to mine construction, operation, and closure. A range of monitoring activities have continued through the mine's construction phase and into the operational phase.

The AEMP (2005) specifically recognized future monitoring obligations under the *Metal Mining Effluent Regulations* (MMER), which were detailed further in a companion management plan (Azimuth, 2005b). While these MMER-related efforts were useful for planning environmental monitoring programs for Meadowbank, this report supersedes these efforts and should be considered as a stand-alone document.

Mine construction activities to date have included the isolation of portions of two lakes using dikes. Dewatering of these impoundments into adjacent lakes started in 2009. Environment Canada (EC) notified AEM that the Meadowbank Mine is subject to MMER as of December 31, 2009. The focus of this report is meeting AEM's obligation to submit an Environmental Effects Monitoring (EEM) Cycle 1 Study Design report for the Meadowbank Mine by December 31, 2010.

It is important to note that, at present, effluent discharge from the Meadowbank Mine consists of natural lake water being dewatered from the isolated impoundments into the north basin of Third Portage Lake. As dewatering progressed, wave action, rain events and other disturbances of the now exposed lake sediments have increased total suspended solids content of the water. Mining activities have formally been underway since March 2010; however, "mining-related" water (e.g., water used in the mining process) has not been discharged into the receiving environment. While discharge of mining-related water will likely occur in the future (i.e., it is a component of mine development plans), this report addresses present discharges only (i.e., effluent from the dewatering process).

1.2. Regulatory Context

The MMER were promulgated under the *Fisheries Act* in 2002 and have undergone several amendments, most notably in 2006 with the *Regulations Amending the Metal Mining Effluent Regulations* (hereafter referred to as the MMER). The MMER stipulate the conditions under which deleterious substances may be discharged to the aquatic environment by metal mines in Canada.

Requirements of the MMER include three main components:

1. Routine effluent monitoring (hereafter referred to as the routine MMER program), which includes:
    - chemical analyses of effluent
    - acute lethal toxicity testing of effluent
    - effluent volume and flow rate measurements
    - calculation of mass loadings of deleterious substances to receiving waters.
2. Emergency response plan, which includes:
    - site risk analysis
    - organization scheme for emergency responses
    - altering and notification procedures
    - inventory of spill-response equipment, including the location of that equipment
    - training plan for mine personnel.
3. Environmental effects monitoring (EEM), which includes:
    - **Part 1** – Effluent and water quality monitoring studies
    - **Part 2** – Biological monitoring studies, including a site characterization, a fish survey, and a benthic invertebrate community survey.

The EEM Program is a cyclical receiving-environment monitoring program conducted to evaluate the effects of metal mining effluents on fish, fish habitat and the use of fisheries resources. Studies are carried out in cycles ranging from 2 to 6 years. This report has been prepared to meet the Cycle 1 study design submission requirements of Part 2 of the EEM.

1.3. Objectives

The *Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring* (hereafter referred to as the TGD, Environment Canada, 2002) stipulates that Cycle 1 study designs outline the following information:

- Site characterization information
- A description of how the fish survey will be conducted (if the concentration of effluent in the exposure area is greater than 1% in the area located 250 m of any final discharge point). Predicted for Meadowbank.
- A description of how the fish tissue analysis will be conducted (if during effluent characterization the concentration of total mercury in the effluent is equal to or greater than 0.1 µg/L). Not predicted for Meadowbank.
- A description of how the benthic invertebrate community survey will be conducted.
- The dates that samples will be collected for biological monitoring.
- A description of the quality assurance/quality control measures that will need to be implemented to ensure the validity of the data collected.
- A summary of the results of any previous biological monitoring studies.

The MMER (Amended to 2010) and TGD (Environment Canada, 2002) cover these requirements in great detail; these information sources were relied on heavily to ensure that this Cycle 1 Study Design report meets the expectations of Environment Canada.

1.4. Approach

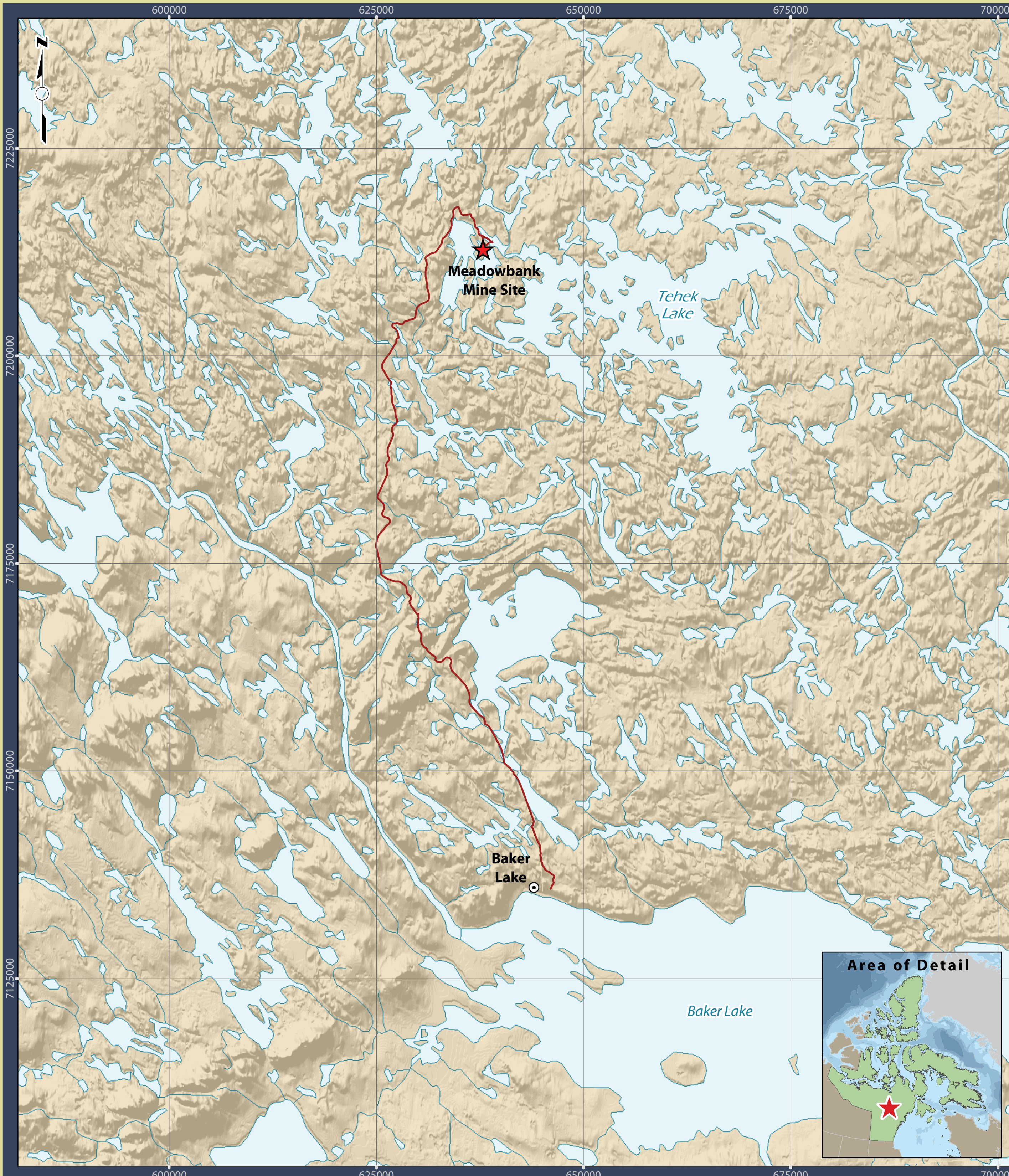
The guiding principles of the EEM program are that the studies are scientifically defensible, cost effective, flexible, and safe. As stated in **Section 1.1**, the eventual need to meet EEM requirements was taken into consideration in developing the overall monitoring strategy for aquatic receiving environments at Meadowbank.

The Aquatic Effects Management Program (AEMP) for Meadowbank was revised in 2010 to address requirements of the NWB A License (Azimuth, 2010a). The revised program was developed in consultation with participants representing a number of different organizations, including Environment Canada's Authorization Officer for Meadowbank. Part of the re-design was the development of the Core Receiving

Environment Monitoring Program (CREMP). Two 1-day workshops (March 2010 in Yellowknife and June 2010 in Edmonton) were held to facilitate the re-design process and focused on ways of reducing redundancy among AEMP-related monitoring programs, particularly between EEM and CREMP. Where practical and appropriate, data required by both the CREMP and EEM programs will be shared to avoid duplication of effort. This aspect has been explicitly integrated into this report to provide transparency regarding study design details for all parameters relevant to EEM. To that end, relevant details regarding the CREMP have been included throughout this report, with a detailed discussion in **Section 2.6**.

The remainder of this study design report is organized into the following sections:

- Site characterization (**Section 2**).
- EEM cycle one study design (**Section 3**).
- Fish survey and tissue analysis (**Section 4**).
- Benthic invertebrate community survey (**Section 5**).
- Supporting environmental variables (**Section 6**).
- Quality Assurance, Quality Control measures (**Section 7**)



Legend

All-Weather Private Access Road

0 5 10 15

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Figure 1-1: Regional map showing Baker Lake and Meadowbank Gold Mine

Meadowbank Mine

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

2. SITE CHARACTERIZATION

The purpose of this section is to summarize key information relevant to developing a study design for the Meadowbank Mine. This information will include:

- Relevant environmental legislation and monitoring programs
- General site characteristics
- Mine operations
- Anthropogenic influences
- Effluent mixing
- Local limnology and aquatic resource characterization

2.1. Relevant Environmental Legislation and Monitoring Programs

There are several environmental acts that are relevant to effluent and environmental monitoring at Meadowbank Mine:

- *Fisheries Act* and the *MMER*.
- *Canadian Environmental Protection Act, 1999* and the Toxic Substances Lists (CEPA, 1999).
- *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA, 2002) (including the *Territories Waters Regulation* [1993] made pursuant to the *Northwest Territories Waters Act* [1993], which apply until such time as they are replaced or repealed under the NWNSRTA).

As described in **Section 1.1**, the Meadowbank Mine is being developed and operated subject to a Class A Water License issued by the Nunavut Water Board (under the NWNSRTA). Compliance and enforcement of water licenses fall under the jurisdiction of the Indian and Northern Affairs Canada (INAC). Once implemented, the revised AEMP[1] (Azimuth, 2010a) will integrate the results of all monitoring programs informing

[1] The original AEMP (2005) described the general monitoring strategy, which relied on two components: the core monitoring program (which is now referred to as the CREMP) and targeted studies. The latter refers to monitoring studies to address activities or issues that required more intensive spatial and/or temporal monitoring and possibly more specialized techniques. Dike construction monitoring, effects assessment studies (EAS) and habitat compensation monitoring (HCM) are examples of targeted studies undertaken at Meadowbank.

environmental management of the aquatic receiving environment, including the following key monitoring programs (among others):

- Habitat Compensation Monitoring (Azimuth, 2008c), as required under the Authorization (see **Section 1.1**) issued by Fisheries and Oceans Canada. This monitoring is largely focused on confirming that constructed habitat compensation features are capable of performing as intended.
- MMER/EEM – as discussed in **Section 1.2**, this monitoring targets the potential effects of effluent discharges to the receiving environment. AEM was notified in December 2009 that Meadowbank was officially subject to MMER requirements as a result of initiation of dewatering activities from the Northwest Arm of Second Portage Lake; this document reports on the study design for Cycle 1 of the EEM Program for Meadowbank Mine.
- CREMP (Azimuth, 2010b) – this program was designed to monitor issues identified during the EIA process that could potentially impact the aquatic receiving environments surrounding the mine development. Given that there is some overlap between the EEM and CREMP programs (and that they are meant to be complementary), a brief overview of the CREMP program is provided in **Section 2.6**.

2.2. General Site Characteristics

As shown in **Figure 1-1**, the Meadowbank Mine is located approximately 75-km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut. Several lakes, namely Second Portage and Third Portage Lake, the “Vault Lakes”, Tern Lake and Farside Lake (hereafter referred to as “Project lakes”), are located directly within the boundaries of the mineral zones being explored and mined on the Meadowbank property (65° N, 96° W) and may be subject to direct or indirect environmental impacts related to mine development. The mine site is typically accessed as follows:

- Personnel are typically flown directly to the Mine site, landing on the onsite airstrip (**Figure 2-1**) or driven from Baker Lake via the All-Weather Private Access Road (AWPAR, **Figure 1-1**), the longest road of its kind in Nunavut.
- Equipment and goods are barged in via Baker Lake and then trucked to site via the AWPAR, or flown directly to site.

2.2.1. Facilities, Mining, and Processing

Meadowbank mine site is shown in **Figure 2-1**. Some of the key features include: 1.2 km airstrip, mill, power house, fuel tank, constructed dikes, and pits.

The mine works year-round, using conventional drilling, blasting, truck and shovel methods. The 8,500-tonne/day gold processing plant is designed to operate year-round using conventional technology adjusted to the Arctic climate.

Explosives are produced at an on-site plant and used to blast rock. Trucks haul the material to a gyratory crusher. The ore is crushed and milled to ensure that the majority of the ground ore is of sufficiently small size. Gold is removed from the ore by two means, depending on whether it is free or combined with other minerals. See **Appendix A** for more details.

The plant includes both a cyanide recycling thickener and an air-sulphur dioxide cyanide destruction circuit to ensure that no cyanide escapes to the environment. After leaching, the ground ore is essentially barren of gold, so it is pumped to the nearby tailings pond for disposal. Site water that is contaminated is prevented from contacting fresh water by diversion ditches, and is collected in the tailings pond. All water from the tailings pond is pumped back to the plant for reuse, making it a zero-discharge system and reducing the need for fresh water. **This water is not currently being discharged off site.** The waste rock is hauled to locations where it is needed for construction, placed in waste storage sites and/or previously mined-out areas. To minimize acid generation, the sulphide-bearing waste rock is encapsulated in permafrost and capped with an insulating layer of neutralizing rock. See **Appendix A** for more details.

2.2.2. Surficial and Bedrock Geology

The Meadowbank project is located in the Canadian Shield, the largest physiographic region of Canada. The Shield hosts the largest area of Archean rocks (>2.5 billion years old) in the world, including the oldest rocks, dated at 4 billion years. All rock units at the project site are of Archean age.

Laterally extensive deposits of glacial till cover the project area (**Figure 2-2**). In general terms, the till can be described as a silty sand/gravel till, with between about 30% and 40% fines (silt and clay). The material also contains up to boulder-sized particles. The material that has been recovered from beneath the lakes during geotechnical drilling along the dike alignments is generally described as cobbles and gravel with traces of sand, silt, and clay.

The Meadowbank project is underlain by a sequence of Archean greenstone (ultramafic and mafic flow sequences) and metasedimentary rocks that have undergone polyphase deformation resulting in the superposition of at least two major structural events. Enclosed within the greenstone are volcaniclastic sediments, felsic-to-intermediate flows and tuffs, sediments (greywackes), and oxide iron formations. The sequence also contains sericite schists, which are believed to be altered felsic flows or dykes. The ultramafic rocks are variably altered, containing serpentinite, chlorite, actinolite, and talc. The ore in the Vault deposit is hosted in intermediate volcanic rocks. The ore in the Portage deposit is hosted in iron formation rocks.

2.2.3. Climatology

The Meadowbank Mine project is located within a Low Arctic ecoclimate of continuous permafrost (**Figure 2-3**), one of the coldest and driest regions of Canada. Baker Lake climatology data has been compiled by EC from 1971 to 2000, and can be viewed in **Table 2-1** (EC, 2010). Baker Lake records an average monthly mean temperature of -11.8°C. The ice-free season on the project area lakes is very short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is at least 2 m by March/April. Daylight hours range from 5-hrs (Dec-Jan) to 21-hrs (June). Yearly snowfall is greater than precipitation, though both are low compared to the rest of the country. Average annual precipitation is <350 mm (**Figure 2-4**).

2.2.4. Regional Hydrology

The Meadowbank Project lakes are headwater lakes that are ultra-oligotrophic/ oligotrophic (nutrient poor and unproductive) lakes characteristic of the Arctic. Only a few hundred meters to the northwest of Second and Third Portage lakes is the divide between the Chesterfield Inlet watershed that flows south to Chesterfield Inlet and Hudson Bay, and the Back River watershed that flows north to the Arctic Ocean (**Figure 2-5)** The project area lakes are part of the Chesterfield watershed, flowing south via Tehek Lake in the Quoich River system into Chesterfield Inlet and eventually, Hudson Bay. St. Clair Falls is about 50 km upstream from Chesterfield Inlet on the Quoich River and is believed to be impassable to fish and is a barrier to any fish wishing to move upstream. Inuggugayualik and Pipedream Lakes are historical reference areas for environmental monitoring at Meadowbank Mine and proposed reference areas for the EEM study. They are headwater lakes of the Back watershed, flowing north to the Arctic Ocean.

The Project area and surrounding landscape consists of rolling hills and relief with low-growing vegetative cover and poor soil development (**Figure 2-6**). Numerous lakes are interspersed among boulder fields, eskers and bedrock outcrops, with indistinct and complex drainages. Small channels connect the Project area lakes (**Figure 2-7)**, although there is little flow between lakes during most of the year and likely present a barrier to fish movement between Second Portage and Third Portage Lakes. As is common of headwater lakes, all of the Project lakes have small drainage areas relative to the surface area of the lakes themselves. Local inflow from surrounding terrain is the predominant influence on water movement within the system. These headwater lakes have no large streams associated with them, so there is a paucity of stream habitat in the area and organisms that typically inhabit streams.

2.3. Mine Operations

This section would normally provide detailed information regarding mine operations, including discussion of key environmental control measures related to mining (e.g., waste rock management) and ore processing (e.g., process cycle and tailings deposition). In the interests of streamlining this document and focusing on aspects directly relevant to the effluent in question (i.e., dewatering from the northwest arm of Second Portage Lake), the aforementioned details have been moved to **Appendix A**. A brief summary of mine development and current operations is provided below for context.

Since 2008, on-site activities have been focused on construction, commissioning, start-up operations and processing. On-site infrastructure construction is nearing its completion and the primary focus for operations is on optimization (**Figure 2-8**).

The Meadowbank Mine project consists of several gold-bearing open-pit deposits that will be mined for approximately 9 years (**Figure 2-9**). Specifically, the Portage Pit (South, Centre and North Portage Deposits) is presently being mined and will continue until 2016, Goose-Island Pit which will begin to be mined in 2011 until 2014, and Vault Pit which will be mined from 2014 until 2018. Much of the infrastructure is located in close proximity to one-another with the exception for the Vault Pit which is approximately 10 km northeast of the site. The open pit mineral reserve is 3.64 million ounces of gold with a mine throughput of approximately 8,500 tonnes/day.

The northwest arm of Second Portage Lake was isolated in 2008 after construction of the East Dike. The arm contained three distinct basins (i.e., the western basin, the very deep central basin and the eastern basin), each separated by a fairly shallow sill zone. The western basin is now used as the Tailings Storage Facility (TSF) and is contained by the Stormwater Dike (see **Figure 2-1**). After dewatering is complete, the central basin will be used as the Portage Attenuation Pond (to be contained by the Central Dike) and much of the eastern basin will be mined as part of the Portage Pit.

Dewatering of the northwest arm of Second Portage Lake has been ongoing since 2009. The process is currently targeting the deep central basin. Once sufficient water has been removed, the Central Dike will be constructed (scheduled for 2011), which is required prior to extending the Portage Pit further south. Discharge of dewatering water to the north basin of Third Portage Lake was the trigger for initiation of EEM studies at the mine site.

2.3.1. Effluent Management

It is important to distinguish between the two major water-related "processes" currently in operation at the Meadowbank Mine:

- *Reclaim Water* – All mining-related, or "contact" water (e.g., from plant site, Portage Pit, or anywhere else that water has come into contact with active mine areas containing potentially acid generating [PAG] materials), is segregated and stored in either the reclaim pond (currently located within the TSF) or Tear Drop Lake for use as process make-up water as required (**Figure 2-10**). **This water is not currently being discharged off site.**
- *Dewatering Water* – the Portage Attenuation Pond (situated in the central basin of the northwest arm of Second Portage Lake) primarily contains residual natural lake water (i.e., mostly left over from the northwest arm of Second Portage Lake, but also some from the Bay-Goose Pit area that was pumped as a mitigative measure during dike construction)[2]. Localized site drainage that has not contacted PAG material is also directed to the attenuation pond. As dewatering progressed and water levels lowered in 2009 and 2010, newly exposed sediments along the shoreline became a source of suspended solids (i.e., total suspended solids [TSS]) and turbidity, resulting in elevated TSS and turbidity. In order to meet permitted discharge concentrations for TSS and turbidity, AEM installed a water treatment facility (see details below). Water quality is monitored on a routine basis to determine whether effluent requires treatment prior to discharge to the north basin of Third Portage Lake (see location of the final discharge point in **Figure 2-12**).

Thus, at present, discharges from the mine (i.e., the dewatering effluent) do not contain water that has come into contact with milled tailings, waste rock, ARD or any other source of water containing elevated metals concentrations. The only contaminant of potential concern is suspended sediments.

The water treatment facility is a John Meunier Actiflo ACP Packaged Plant that uses microsand and flocculant in a series of coagulation, injection, maturation and settling tanks to clarify and enhance settling of total suspended solids (**Figure 2-11**). Raw water and coagulant are added using a mechanical feeding system or manually added by trained technicians. The flocculent and microsand are then added to the coagulated water to form flocs. Through mixing, a polymer bridge between the floc, suspended solids and

[2] Currently the Bay- Goose Dike construction is being completed and dewatering of the goose-island pit area will begin in April 2011. This pit water will be sent to the Portage Attenuation Pond, decanted and treated if necessary and discharged into Third Portage Lake.

microsand form large heavy flocs. The ballasting system allows for the flocs to settle in the lamellar tube area. Clarified water is collected in series of troughs and discharged. The settled sludge is continually pumped to a hydrocyclone, where sand and sludge are separated to allow the microsand to be recycled. Turbidity, pH and sludge are monitored by environment technicians. Sludge is manually removed and stored in the Waste Rock Storage Facility.

2.3.2. Effluent and Receiving Environment Monitoring

MMER (Part 2; Division 2) requires effluent quality monitoring on a weekly basis to ensure that MMER discharge limits are met. Weekly monitoring results for the dewatering effluent for 2010 (through August 2010) are provided in **Appendix B**. Monthly mean concentrations and loadings are shown in **Table 2-2**. TSS exceeded the monthly limits on two occasions: in April due to a single elevated measure, and in June due to consistently elevated (~ 20 mg/L) readings throughout the month. One pH value was also below 6.0 in July. All other parameters were well below monthly discharge limits. Total mercury concentrations in the dewatering effluent conducted under Part 1 of MMER Schedule 5 (EEM) never exceeded the tissue analysis trigger of 0.1 µg/L (**Table 2-2**). Monthly loadings show 2460 – 17320 kg of sediment discharged monthly into the north basin of Third Portage Lake (**Table 2-3**).

Receiving environment water quality monitoring results (EEM Part 1) are presented in **Table 2-4** relative to the CCME guidelines. Sampling locations are the Third Portage North (TPN) exposure area and the Third Portage South (TPS[3]) reference area. Reliable laboratory pH measurements were not available for July and August, so field pH results are used for pH-dependent screening values for those months. (The receiving environment water quality was tested at an exposure area (TPN) and a reference area and results were screened against CCME water quality guidelines. All values were laboratory measures; however, the pH laboratory measure was delayed in the July and August samples and therefore was not acceptable for analysis. Therefore, the field measured pH is reported and used for pH dependent screening values. Total cyanide and total lead were the only two parameters to exceed CCMEs guidelines; however, in all cases the reference area had higher concentrations than the exposure area. Given the distance between TPN and TPS (see **Figure 2-13**) and the low TSS concentrations (all <MDL), it would be difficult to attribute these results to the dewatering effluent.

[3] This area was originally designated as an "internal" reference area in the south basin of Third Portage Lake (i.e., due to its location well away from localized mine inputs). However, for the purposes of the EEM program we have chosen other areas to ensure isolation from exposure

Apart from these irregularities, water quality in both the reference and exposure areas was good. Given the very low (i.e., many parameters consistently below method detection limits) concentrations of most deleterious substances, it should be fairly easy to track plume behaviour in the field.

Toxicity test results for acute lethality (MMER Part 2) and sublethal endpoints are presented in **Table 2-5**. Apart from an uncharacteristically low survival for the water flea, *Daphnia magna*, in the March 2010 sample, the dewatering effluent has not been acutely toxic. The sublethal test results provide even greater confidence regarding the lack of direct effects, particularly to invertebrates and fish. It is difficult to interpret the potential minor effects observed (i.e., IC25 of 81.4% effluent) in the duckweed, *Lemna minor*, test for August 2008 without firsthand review of the test results. Overall, these results are consistent with expectations for this type of effluent (i.e., natural lake water with elevated TSS).

Effluent mixing in the TPN receiving environment is discussed in **Section 2.5**.

2.4. Anthropogenic Influences

Apart from the Meadowbank Mine itself, there are no other significant anthropogenic influences to the receiving environment. In fact, there is virtually nothing within a 75-km radius of the site. The nearest community if Baker Lake, 75 km to the south as the crow flies (over 100 km by AWPAR; see **Figure 1-1**). There has been limited historic or traditional use of local aquatic or terrestrial resources by the residents of Baker Lake on or near the Meadowbank Mine site. As such there are no public recreation zones, docks, wharves, or boat launches in the near vicinity.

The only possible confounding factors to an investigation of effluent-related effects would be the potential influence of development and/or operation of the Meadowbank Mine. For example, dike construction was conducted at various locations in 2008, 2009 and 2010. This activity resulted in elevated TSS across significant portions of Second Portage Lake (with East Dike construction in 2008) and the east basin of Third Portage Lake (with construction of the Bay-Goose Dike in 2009 and 2010)[4]. However, no major in-water construction activities are planned for 2011, so this should not confound the planned EEM biological monitoring studies[5]. Furthermore, given the location of the final

[4] The ecological significance of construction-related sediment inputs has been the focus of a multi-year study at the Meadowbank Mine, the TSS Effects Assessment Studies (EAS; Azimuth, 2009; 2010).

[5] A plan has been proposed to extend the current on-site airstrip into Third Portage Lake. If this plan were to be approved by Fisheries and Oceans Canada, construction would likely commence in 2011. This would present an anthropogenic influence to the aquatic ecosystem at the Meadowbank Mine site during 2011.

discharge point relative to the mine site (i.e., to the NW of the site) and the prevailing winds (i.e., from the NW), site-related dust inputs should not be significant.

2.5. Effluent Mixing

Effluent mixing in the north basin of Third Portage Lake was modeled by Golder Associates (**Appendix C**). They used the CORMIX model to predict plume mixing and dilution for 24 different sets of conditions covering the range of possible conditions: four scenarios of lake current (i.e., near stagnant, average 4-day low wind, average daily wind, and 10-year peak hourly wind), multiplied by two current directions (i.e., co-flowing and cross-flowing), multiplied by three effluent buoyancy scenarios (i.e., neutral, positive and negative). Key results were as follows:

- For most cases, effluent dilution of 100:1 was not achieved within 250-m of the dewatering discharge outfall (this triggers the fish study).
- Cross-flowing current and effluent resulted in greater dilution relative to co-flowing conditions.
- The exposure area was defined as an ellipsoid centered at the final discharge point and the radii based on plume behaviour (i.e., location of the 100:1 dilution contour) under both cross- and co-flowing conditions (**Figure 2-12**).

2.6. Local Limnology and Aquatic Resource Characterization

The purpose of this section is to describe known features of aquatic biological community in the receiving environment at Meadowbank Mine using historic studies conducted prior to and during construction/mining activities.

Studies targeting the physical (e.g., water depth, temperature and substrate type), chemical (e.g., metals concentrations in water, sediment and fish tissue) and/or ecological (e.g., phytoplankton, zooplankton, periphyton, benthic invertebrates, and fish) characteristics of the aquatic environment in the vicinity of the Meadowbank Project have been conducted since 1991. Prior to 2005, the objective of these studies was to describe baseline environmental conditions of these pristine lakes prior to any disturbances as a result of mine-related development and operational activities; the results of these studies were compiled into a single *Baseline Aquatic Ecosystem Report* (BAER). Baseline data were used to support the development of the CREMP (see **Textbox 2-1** below for details relevant to EEM), which has been conducted annually since 2006.

This section documents important physical and biological attributes of the Meadowbank study lakes. The discussions focus mostly on the commonalities that prevail among the study lakes. Where relevant, information is presented specific to exposure or reference areas. The information presented comes from both the BAER and CREMP.

Textbox 2-1: CREMP Overview

The CREMP focuses on monitoring limnological, chemical and biological characteristics of the Meadowbank project lakes (i.e., the aquatic receiving environments surrounding the mine development) with the objective of detecting any mine-related change in receiving environment condition. The program is implemented on a yearly basis, ongoing since 2006, with sampling frequency ranging from monthly (for water quality) to yearly (for sediment quality). The CREMP sampling stations are shown in **Figure 2-13**. The study design, contemplated with EEM requirements in mind, consists of a number of near-field exposure areas (i.e., targeting existing or future effluent discharge locations or in-water mine infrastructure [e.g., dikes]), far-field exposure areas (i.e., to provide information on the spatial extent of potential effects) and reference areas. The near-field and reference areas relevant to this EEM Study Design are discussed below:

- *Near-field (NF) areas* – These areas provide the first line of early-warning for introductions of stressors into the receiving environment. The Third Portage Lake North (TPN) area targets the dewatering effluent discharge is considered the exposure area for the EEM study (see **Section 3.2**). The Third Portage Lake East (TPE) and Second Portage Lake (SP) areas target existing dikes, so might provide some information to document the occurrence, or lack thereof, of potential confound factors.
- *Reference (Ref) areas* – By definition, reference areas are sufficiently removed from the mine that they are presumed to be unaffected by any infrastructure (roads, dikes, runways) and point sources (aerial and aquatic) associated with mine development. Internal (Third Portage Lake South [TPS]) and external (Inuggugayualik Lake [INUG] and Pipedream Lake [PDL]) reference areas are included in the CREMP to help distinguish between possible mine-related changes in water quality or ecological parameters and natural changes, unrelated to the mine. INUG and PDL are the two reference areas for this EEM study (see **Section 3.2**).

The CREMP program was implemented for two full years prior to the onset of construction activities at Meadowbank Mine. Consequently, the program allows for a before-after-control-impact (BACI) approach, which is generally considered more robust for detecting changes related to environmental perturbations.

The CREMP includes many explanatory environmental variables (for both water and sediment) and a benthic community survey, but does not directly target fish. Where practical and appropriate, data required by both the CREMP and EEM programs will be shared to avoid duplication of effort.

2.6.1. Morphology and Bathymetry

Shoreline complexity (i.e., the degree to which a shoreline does not resemble a smooth, circular shape) of all project lakes is moderate to relatively high. There are no macrophytes along shorelines or rooted in shoals. Substrate along shorelines and shallow shoals consists of a heterogeneous mixture of large boulder and cobble, areas of sloping, fractured bedrock shelves, and occasional patches of cobble and coarse gravel. There are little to no areas dominated by fine substrates, such as sand, in shallow water at depths of less than 4 m. Very coarse substrates predominate to depths of at least 3 m, at which point there is a transition to finer substrates to about 6 m. At depths greater than 6 to 8 m, substrate is predominantly silt/clay with a few partially buried individual boulders or cobble patches.

The shoreline complexity described above often results in the presence of well-defined basins within many of the lakes. Where appropriate, these features have been used as the foundation of the CREMP (see **Textbox 2-1**) in order to provide information on the spatial extent of exposure and effects endpoints. The basins do vary substantially in bathymetry (see **Figure 2-7**), which is likely responsible for some of the observed inter-basin and inter-lake differences in productivity (see **Section 2.6.5.1** for more discussion).

2.6.2. Limnology

The Meadowbank project lakes can be generally described as ultra-oligotrophic, nutrient poor and isothermal with neutral pH and high oxygen concentrations year round. The headwater nature of the lakes, lack of tributary streams, and small drainage area strongly influence limnology of the project lakes. Given the absence of streams and low sediment and nutrient additions into the lakes, limnological conditions tend to be very stable, with uniform vertical temperature, oxygen, and nutrient distributions.

Vertical temperature (°C) and oxygen (mg/L) profiles (e.g., results for TPN, INUG, and PDL in 2009 are shown in **Figures 2-14 to 2-16**) typically show weak (winter; approximately 2 m ice thickness) to no (open water) stratification. Any vertical stratification (e.g., due to extended calm periods) during the open water season is very ephemeral and easily broken down and mixed by wind, which is locally frequent and strong.

Oxygen is generally completely saturated, with concentrations varying with temperature. Interestingly, during winter months oxygen concentrations just below the ice were elevated relative to other depths; this is attributed to photosynthesis by algae living at the ice-water interface. Although there is a thick ice and snow layer above the water, sufficient light penetrates in late winter/early spring to stimulate algal growth, thus increasing oxygen concentrations near the bottom of the ice surface.

Water temperature is generally low (0 to 2°C) under ice cover and then peaks during open water in August (8 to 12°C). Deeper basins (e.g., TPS) typically contained cooler water. While temperature profiles were isothermal during the open water period, a slightly different pattern was seen under ice. Temperatures were coldest (near 0°C) at the ice-water interface and increased slowly and gradually with increasing depth. This profile is typical of freshwater lakes during the winter and is driven by water density (highest at 4°C).

2.6.3. Water Quality

A suite of parameters was usually analyzed in the project lakes, including: pH, hardness, anions, total and dissolved solids concentrations, nutrients (dissolved organic carbon [DOC], nitrogen nutrients [ammonia, nitrate, and nitrite], and phosphorus [total phosphorus, dissolved phosphorus]). The BAER (2005) reported water quality results for all project lakes (**Table 2-6**) between 1996 and 2002. The results were remarkably similar among lakes and years and are typical of oligotrophic, Arctic lakes (Wetzel, 1983). There were no obvious differences in any parameter related to season or among lakes and years. In fact, many parameters were at or below detection limits.

Key results were:

- *Conventionals* - As seen in **Table 2-6**, total and dissolved solids in surface waters were also low, typically below laboratory detection (<1 mg/L and <10 mg/L, respectively), as was turbidity (<1.1 NTU). Hardness (4.4 to 9.5 mg/L) and dissolved anions (chloride, fluoride, sulphate) were also very low and near detection limits. Surface water had circum-neutral pH (6.6 to 7.7) and low conductivity (5 to 77 µS/cm). Secchi depth of all project lakes frequently exceeded 6 m and on calm days, exceeded 10 m depth. Nutrient concentrations (nitrogen, carbon, phosphorus) in the study lakes were very low and equivalent to values typical of oligotrophic lakes (Wetzel, 1983). Nutrient concentrations did not differ appreciably within or between lakes and seasons, and most values only slightly exceeded laboratory detection limits. Nitrogen nutrients (nitrate, nitrite, ammonia, dissolved phosphate) seldom exceeded 0.001 mg/L, while dissolved phosphate ranged from <0.001 to 0.003 mg/L. Dissolved organic carbon (DOC) values ranged from 1.4 to 2.3 mg/L over all lakes between 1996 and 2002.
- *Metals* –Mean total antimony, arsenic, chromium, copper, mercury, and nickel concentrations from Third Portage, Second Portage, and the other project lakes were all below laboratory detection limits and, with the exception of cadmium, were well below CCME (2007) water quality guidelines for the protection of aquatic life. The only metals to exceed detection limits were aluminum (0.006 to 0.014 mg/L), lead (up to 0.0012 mg/L), and zinc (0.001 to 0.019 mg/L). Overall, metals concentrations are typically low and the low frequency of detectable results makes it difficult to identify meaningful differences in baseline conditions among lakes, seasons or years.

Apart from changes at certain areas related to dike construction sediment inputs (e.g., SP and TE in 2008; TPE, SP and TE in 2009), these results are fairly consistent with CREMP results (Azimuth, 2009a, 2010b). Given that dike construction is now over and would not be expected to affect any EEM-related monitoring areas, no further discussion of those data are included in this Study Design. As discussed in **Section 2.3.2**, the low concentrations of most parameters should facilitate the identification of effluent-related constituents present at concentrations of potential concern.

2.6.4. Sediment Quality

Sediment is an important sink for most contaminants, including metals. Contaminants entering aquatic systems via tributary streams or directly from local sources are often associated with suspended particulate matter in the water column. Particulates eventually settle in depositional areas as sediment, especially in deeper areas of lakes. Measuring water for the presence of contaminants, such as metals, is not necessarily as indicative as measuring sediments, because sediments provide a long-term, temporal record of deposition, integrating concentrations over time and provide more than just snapshots of water quality. Low concentrations of water-borne contaminants that may meet relevant water quality criteria can be associated with elevated concentrations in sediments that exceed sediment quality guidelines. Sediments, therefore, act as accumulators of contaminants over time in aquatic systems and can become a sink as well as potential source of contaminants within a system. The degree to which sediments function this way depends on the contaminant and physical condition of the environment (temperature, redox, pH, grain size, etc.).

The BAER (2005) reported that grain size of project lake sediment at water depths greater than 8 m was reasonably consistent between lakes and years and was dominated by fine sediments (clay 50% to 70%; silt 25% to 40%), with some sand (2% to 14%), and no gravel (**Table 2-7**). These general patterns are also evident in the CREMP data (Azimuth, 2008a, b; 2009a, 2010b). The consistency in grain size within the project lakes is likely due to the following:

- The headwater nature of these lakes means that there are no sediment inputs from high-energy stream or river systems.
- Hydrodynamic regimes are similar (i.e., low energy) among lakes.
- Sediment was acquired from consistent depths, especially in 2002 (i.e., between 8 and 10 m). At shallower depths, sediment grain size increased and was comprised of boulder and cobble at depths less than 5 m and often had a layer of fine sediment draped over coarse materials.

Mean total organic carbon (TOC) content of the sediment ranged between approximately 2.5% to 5.2% in the BAER (2005; **Table 2-7**); more recent CREMP results show TOC just below 9% in the shallower and more productive Wally Lake (Azimuth, 2010b). Overall, TOC concentrations are reasonably high for such an oligotrophic system and illustrate the small amount of inorganic contributions to the lakes that might dilute organic materials if sedimentation rates were higher.

The BAER (2005) reported that total metals concentrations in project lake sediment were fairly consistent within and among project lakes and among years (**Table 2-7**). Interestingly, the results of a coring study conducted in 2008 and 2009 (i.e., before and after construction of the East Dike; Azimuth, 2010c) showed a large increase in arsenic concentrations (mean of 15 samples changed from 32 mg/kg to 117 mg/kg) at the INUG reference area (i.e., one of the two study areas not exposed to dike construction) between the two years. Given the general lack of sediment input sources, conditions would not have been expected to change at this reference area over the time period. It was postulated that localized heterogeneity in chemistry due to mineralization may have been responsible. This highlights the challenges of characterizing sediment chemistry in close proximity to highly-mineralized bedrock.

When metals concentrations in the BAER(2005; **Table 2-7**) were compared against CCME (2007) ISQG and PEL guidelines for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc, several guideline concentrations were exceeded, despite the pristine nature of the lakes. Exceedences of these guideline values does not necessarily imply that adverse effects have occurred or are expect to occur, particularly where these occur to due naturally elevated metals. The ISQG and PEL guidelines are relatively conservative and do not reflect site-specific conditions that may limit metals availability to biota. In addition, the guidelines do not consider regional geochemistry or acclimatization by benthic organisms to regional characteristics.

2.6.5. Aquatic Resource Characterization

2.6.5.1. Primary Productivity

Characterization of baseline primary productivity in the Meadowbank study lakes has targeted both periphyton (i.e., algae that grow attached to rocks) and phytoplankton (i.e., algae that are suspended in the water column), but with greater emphasis on the latter. Key results for both are discussed below.

- *Periphyton* – The BAER (2005) reported on the limited sampling conducted in 1998 and 2002, with a focus on community composition. **Figure 2-17** shows the relative biomass to major periphyton taxa in key lakes. Due to high variability, even among rocks and aspects at the same location, this tool was not recommended for application in the CREMP. However, it was included in the 2006 and 2007 CREMP studies (Azimuth, 2008a, b) to help characterize local communities to support the assessment community development on habitat compensation features. It has also been used as a tool in the Effects Assessment Studies (EAS) characterizing the effects of sedimentation events related to dike construction.

- *Phytoplankton* – Estimates of phytoplankton biomass are used as gross indicators of productivity from a "snap-shot" perspective, depending on frequency of sampling. They are particularly useful for detecting long-term trends or gross changes in lake production (e.g., changes in nutrient regime from sewage- or blasting-related nutrient additions). **Figure 2-18** shows total biomass and relative community composition as reported in the BAER (2005). Total phytoplankton biomass was also used to provide insights into the ecological significance of sedimentation from dike construction. **Figure 2-19** shows phytoplankton biomass (ww) results for Third Portage Lake CREMP areas (TPE, TPN, TPS) from July 2006 to September 2009 in relation to the onset of Bay-Goose Dike construction in the east basin of the lake (i.e., near TPE). Data through the rest of the year showed the recovery relative to the other basins (**Figure 2-20**).

2.6.5.2. Zooplankton

Zooplankton are a key food chain species for fish, especially young-of-the-year lake trout, round whitefish, lake cisco, and minnow species. Zooplankton are also the main food source for adults of some species, particularly round whitefish and Arctic char. Their importance in the food chains of the Meadowbank project lakes is discussed in greater detail in **Section 2.6.5.6**.

Zooplankton were quantitatively sampled from specific Meadowbank project lakes in 1997, 1998, 2002, and 2003 to help characterize baseline conditions (BAER, 2005). Diversity and abundance of the zooplankton community of the Meadowbank project lakes was generally low, but typical of oligotrophic Arctic lakes. There were no unusual or uncommon species identified from any of the lakes.

As shown in **Figure 2-21**, zooplankton community was generally dominated by calanoid copepods (55% of all enumerated organisms), followed by cyclopoid copepods (40%) and cladocerans (5%). While zooplankton have been included in the focused EAS studies targeting sedimentation events (Azimuth, 2009b,c, 2010d), little is known regarding seasonal and spatial dynamics as this group was not originally included in the CREMP. However, additional sampling was included in the CREMP in 2010, so information will be forthcoming.

2.6.5.3. Benthic Invertebrates

Benthic invertebrates provide an important food source for most fish species, especially young-of-the-year and juvenile lake trout, round whitefish, lake whitefish, sculpins, and stickleback (Machniak, 1975; Scott and Crossman, 1979). As lake trout get larger, they gradually shift from a diet dominated by invertebrates to one dominated by fish (Scott and Crossman, 1979). Food chain modeling is explored in **Section 2.6.5.6**.

As reported in the BAER (2005), the abundance and species composition of benthic invertebrates is strongly affected by water depth, sediment grain size, and organic carbon content of the sediment. Benthic invertebrates are typically most abundant at depths between approximately 3 m and 12 m. Benthic invertebrates are not abundant at shallower depths because of ice scouring and coarse substrate consisting primarily of boulder. Below a depth of about 12 m, light penetration is much reduced and algal productivity is lower. The vast majority of benthic invertebrates in deeper sediments consist of oligochaete worms (true worms) and chironomid (midge) larvae, which live primarily in the sediment (i.e., infauna), as opposed to organisms that live on top of the sediment (epifauna). In shallower sediments (<12 m), the major invertebrate groups consist of aquatic larvae of insects (Class Insecta), especially chironomids (Order Diptera), caddisflies (O. Trichoptera), mayflies (O. Ephemeroptera), and stoneflies (O. Plecoptera). Other major taxa include amphipods (Crustacea; O. Amphipoda), mites (O. Acarina), fingernail clams (Class Bivalvia; *Pisidium* or Sphaeridae), harpacticoid copepods (Crustacea; O. Harpacticoida), and tadpole shrimp (O. Notostraca).

Baseline characterization studies of the project lakes (BAER, 2005) showed that the benthic invertebrate community was numerically dominated by the aquatic larval stages of insects, especially chironomids, in terms of relative abundance (**Figure 2-22**), density (**Figure 2-23**), and species diversity, which is typical of most Arctic and temperate lakes. The predominance of chironomids was consistent during all studies conducted between 1996 and 2003. However, anyone familiar with the Arctic will certainly not notice chironomids for the mosquitoes and blackflies! Mosquito larvae are usually found in small ponds, not in bottom sediments, and not on the water surface of large lakes. Blackfly larvae are associated with bottom substrates, but are typically found in moving water such as streams, not in large lakes, and thus are usually poorly represented in benthic samples. Therefore, despite the apparent abundance of mosquito and blackflies, chironomids typically compose the majority of the food source for young lake trout, young Arctic char, whitefish, and minnow species.

The amount of organic carbon, a food source, in the sediment will also influence abundance of benthic infauna that feed on the organic particles. Generally, sediment with a high proportion of organic material (>5%) will have greater abundance and diversity of benthos than sediments with small amounts (<1%) of organic carbon.

In addition to physical factors, abundance and composition of benthic communities are also influenced by biological factors, such as foraging by fish and timing of hatch of insect larvae. Because sampling cannot be conducted on all lakes at the same time, significant hatches of chironomids may occur during the course of sampling (a period of days or weeks). This may result in a particular species being very abundant in one lake, and much less abundant in another, because of hatching of larvae into the terrestrial adult.

This can be partly overcome by sampling during late fall, after the emergence of most groups.

The predominance of chironomids is all project lakes can be clearly seen in **Figure 2-23.** Chironomid larvae comprised between 50% and 86% of organisms in benthic samples from all study lakes and ponds between 1997 and 2003. Chironomids also dominated abundance in reference and regional lakes and is typical of Arctic lakes. Other important insect taxa such as mayflies (Ephemeroptera) and stoneflies (Plecoptera) are uncommon or absent in many Arctic lakes.

The average number of genera identified in benthic samples from project and reference lakes ranged from 11 to 20 taxa and was reasonably consistent among stations and seasons (**Table 2-8**). Chironomids were the most diverse group taxonomically, with 20 genera identified over all stations. Within stations, an average of 10 to 12 chironomid genera were identified per station, with most common chironomid taxa being present in all lakes. Overall, there were no large differences in species diversity among lakes as the total number of taxa identified in each lake was quite similar.

As shown in **Figure 2-24,** the core receiving environment studies of the project lakes from 2006 to present (Azimuth 2008a,b, 2009a, 2010b)AEMP 2006, AEMP 2007, AEMP 2008, CREMP 2009) showed largely the same trends as those seen in the baseline data (BAEAR, 2005); however, inter-annual variability in benthos abundance and diversity can be naturally high. For example, prior to major construction related events, mean abundance at Third Portage Lake East changed substantially between 2006 (3261/m^2), 2007 (1578/m^2), 2008 (5,626/m^2), and 2009 (1713/m^2). Changes in benthic community metrics can also occur as a result of exposure to mine-related stressors. A marginal effect trend (i.e., not statistically significant, but a fairly large effect size) was identified for benthos abundance in Second Portage Lake, but not in Tehek Lake, in region of elevated TSS from East Dike construction.

Benthic invertebrate abundance can be patchy, depending on the specific location of sampling that can differ from year to year within the sampling area, water depth, organic carbon, water temperature and development time of larvae and time of year. All of these factors contribute to variability both within and between stations and years, and emphasize the need to standardize sampling methods so as to minimize variability between years and stations. Several years of data are required to refine the range in abundance that might be considered to be 'typical' for a particular station. The year 2010 marks the 5th year of the AEMP/CREMP program.

2.6.5.4. Fish

Fish studies at Meadowbank primarily fall into two categories: baseline and fish out. The former are similar in nature to most fisheries studies in that they were typically conducted using indexed gillnets over a period of less than a week; as a result, data represent a snapshot of the underlying populations and/or communities. The latter were conducted as part of the fish removal process in advance of dewatering (i.e., for the northwest arm of Second Portage Lake in 2008 and for the Bay-Goose portion of Third Portage Lake in 2010) and provided a unique opportunity to collect detailed information to better understand the ecology of the project lakes.

Baseline Studies

These studies were undertaken to establish baseline conditions in advance of mine development and focused on characterizing the fish communities (i.e., species composition) and population structures (e.g., length frequency distributions for each species) of the project lakes and candidate reference lakes (**Figure 2-25**); these results were summarized in the BAER (2005).

Fish species composition and mean size and condition factor of fish among lakes was similar for most lakes (**Figure 2-26**). Lake trout (*Salvelinus namaycush*) dominated all project, reference and regional lakes and were characterized as being large, old, climax community populations, and are typical of oligotrophic, Arctic lakes. Round whitefish (*Prosopium cylindraceum*) and Arctic char (*Salvelinus alpinus*) were the next most abundant species in all lakes, with small numbers of burbot (*Lota lota*), ninespine stickleback (*Pungitius pungitius*) and sculpins (*Cottus* sp.) present. While abundant in many local small streams and ponds along the all-weather road, the latter species were infrequently found in the larger lakes during baseline studies despite deployment of baited minnow traps (see **Section 4.1** for information on more recent attempts to find small-bodied species).

Targeted studies using hoop-nets showed that the magnitude of fish movement among project lakes is small and opportunistic. The primary reason for this is that most of these headwater lakes are only connected by small, ephemeral channels, making passage difficult to impossible over much of the year

Fish-out Studies

Fish-out studies, while using similar collection methods, were conducted over a much longer period with the ultimate goal of removing all fish. As such, they provided a rare opportunity to collect detailed information on fish from a community, population and individual perspective. It also provided an opportunity to collect data relating fish biomass to a range of potential indicator variables (e.g., nutrient concentrations, benthic biomass). As discussed further in **Section 4.1**, an interesting outcome of the fish-out studies is that they highlighted size- and species-related differences in catchability over time. The end result is that short-term estimates of fish community and population statistics are likely biased due to differences in catchability over time.

Details of the 2010 Bay-Goose fish-out study had not been finalized when this study design document was being prepared. Consequently, the following information is an overview of the 2008 fish-out of the northwest arm of Second Portage Lake. The program was developed and implemented in accordance with a draft Protocol provided by the Department of Fisheries and Oceans. Fishing removed a total of 3079 fish from the impoundment weighing 1123 kg. About two-thirds of the fish were lake trout, followed in abundance by arctic char, round whitefish and burbot. Detailed biological data for a subset of fish included lengths and weights, sex, maturity, fecundity, stomach contents and aging structures.

2.6.5.5. Habitat Mapping

Habitat mapping was conducted during baseline studies to document local resources and to quantify habitat losses related to mine development (i.e., in support of the No-Net-Loss Plan). GIS was used to map a variety of habitat features based on aerial photograph (1:10,000) interpretation coupled with underwater video (for ground-truthing specific features). Details of the methods are provided in Azimuth (2005a). The results for primary physical features are shown in **Figure 2-27**. A habitat suitability index was derived for the site to convert physical habitat types into high, moderate or low value based their relative contribution and importance as spawning, nursery, shelter, foraging and overwintering for fish (**Table 2-9** and **Figure 2-28**; Azimuth, 2005a).

2.6.5.6. Food Chain Characterization

Stable isotope analysis was used in 2008 to assess the Second Portage Lake food web by measuring ratios of carbon and nitrogen isotopes in organisms (e.g., benthic invertebrates, zooplankton and fish) to discern “who is eating who” in the lake. This information provides insights into the relative importance of the pelagic (phytoplankton to zooplankton to fish) and benthic (algae/detritus to invertebrates to fish) pathways in the food web. Stable isotope signatures in muscle tissue of fish indicate that both are actually important (**Figure 2-29**). Arctic char preferentially exploit pelagic food sources (i.e., zooplankton), while round whitefish target benthic food sources. Lake trout, the dominant species in the lake, feeds on both these fish species (in addition to other lake trout) in approximately equal proportions. This is understandable given the nutrient-driven productivity limitations characteristic of ultra-oligotrophic lakes. These results should be fairly applicable to all the project area lakes.

Table 2-1. Canadian Climate Normals 1971-2000, Baker Lake Airport, Nunavut.

	Month												Year
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Temperature													
Daily Average (°C)	-32.3	-31.5	-27.2	-17.4	-5.8	4.9	11.4	9.5	2.6	-7.5	-20.1	-28.4	-11.8
Standard Deviation	3.4	3.4	2.8	2.6	2.2	2.2	1.7	1.5	1.9	2.8	3.1	3.1	1.3
Daily Maximum (°C)	-28.7	-27.9	-22.9	-12.6	-2.2	9.2	16.7	14	5.9	-4.2	-16.3	-24.8	-7.8
Daily Minimum (°C)	-35.8	-35.1	-31.5	-22.1	-9.4	0.5	6	5	-0.6	-10.7	-23.9	-31.9	-15.8
Degree Days													
Above 24 °C	0	0	0	0	0	0	0	0	0	0	0	0	0
Above 18 °C	0	0	0	0	0	0	1.4	0.8	0	0	0	0	2.3
Above 15 °C	0	0	0	0	0	0.4	8.7	4.7	0	0	0	0	13.8
Above 10 °C	0	0	0	0	0	7.4	65.3	39.6	1.5	0	0	0	113.9
Above 5 °C	0	0	0	0	0.2	49.5	196.9	144.8	21.5	0	0	0	413
Above 0 °C	0	0	0	0.1	8.4	153.4	351.6	294.6	100	4.7	0	0	912.7
Below 0 °C	1000.1	893.9	838.9	523.2	184.8	9	0	0	21.4	240.2	604.1	879.9	5195.6
Below 5 °C	1155.1	1035.2	993.9	673.1	331.7	55.1	0.4	5.2	93	390.5	754.1	1034.9	6522
Below 10 °C	1310.1	1176.4	1148.9	823.1	486.4	163	23.8	55	223	545.5	904.1	1189.9	8049.2
Below 15 °C	1465.1	1317.7	1303.9	973.1	641.4	306	122.1	175.2	371.4	700.5	1054.1	1344.9	9775.4
Below 18 °C	1558.1	1402.4	1396.9	1063.1	734.4	395.6	207.8	264.2	461.4	793.5	1144.1	1437.9	10859.6
Precipitation													
Rainfall (mm)	0	0	0	0.5	6.7	20.8	41.8	45.7	35.8	5.3	0.1	0	156.7
Snowfall (cm)	8.4	8.4	12.8	15.3	10.2	3.3	0	1.3	8.1	29.4	21.3	12.2	130.7
Precipitation (mm)	7.5	7.2	10.5	13.6	15.6	24.1	41.8	47	44.1	32.1	17	10.2	270.4
Average Snow Depth (cm)	40	45	51	55	41	6	0	0	0	7	23	34	25
Median Snow Depth (cm)	40	44	51	55	42	4	0	0	0	6	24	34	25
Snow Depth at Month-end (cm)	42	47	54	53	22	0	0	0	2	15	30	38	25
Days with Rainfall													
>= 0.2 mm	0	0	0.03	0.33	2.4	6.6	9.2	11.8	9.8	2.5	0.03	0.03	42.7
>= 5 mm	0	0	0	0.03	0.47	1.3	2.3	2.8	2.1	0.31	0	0	9.4
>= 10 mm	0	0	0	0	0.13	0.5	1.4	1.3	1.1	0.07	0	0	4.5
>= 25 mm	0	0	0	0	0	0.03	0.23	0.23	0.07	0	0	0	0.56
Days with Snowfall													
>= 0.2 cm	6.9	7.3	8.3	8.1	5.6	1.7	0.03	0.43	5	13.3	10.5	8.6	75.8
>= 5 cm	0.2	0.29	0.59	0.7	0.67	0.23	0	0.1	0.33	1.8	1.1	0.39	6.3
>= 10 cm	0.03	0	0	0.1	0.1	0.07	0	0.03	0.13	0.25	0.07	0.07	0.85
>= 25 cm	0	0	0	0	0	0	0	0	0	0.04	0.03	0	0.07
Days with Precipitation													
>= 0.2 mm	6.7	7	7.8	8	6.9	7.5	9.3	11.8	13.3	14.5	9.6	8.3	110.7
>= 5 mm	0.13	0.25	0.41	0.57	0.93	1.5	2.3	2.8	2.5	1.7	0.66	0.29	14.1
>= 10 mm	0	0	0	0.03	0.3	0.57	1.4	1.3	1.3	0.36	0.03	0.04	5.3
>= 25 mm	0	0	0	0	0.03	0.03	0.23	0.27	0.1	0.07	0.03	0	0.76
Days with Snow Depth													
>= 1 cm	31	28.3	31	30	31	14.3	0.6	0.07	2	22.1	29.7	31	251
>= 5 cm	31	28.3	31	30	30.3	10.2	0	0.03	0.69	13.4	28.5	31	234.4
>= 10 cm	31	28.3	31	30	29.6	6.4	0	0	0.24	8	25.2	30.4	220
>= 20 cm	26.5	27.1	31	30	26.1	3	0	0	0.14	2.9	13.6	23.5	183.9
Wind													
Speed (km/h)	23.7	22.9	21.6	20.5	19.4	16.5	16.6	17.7	19.4	21.8	22.3	22.7	20.4
Most Frequent Direction	NW	NW	NW	NW	NW	E	N	NW	NW	NW	NW	NW	NW
Maximum Hourly Speed (km/h)	105	124	93	80	91	121	67	81	78	106	97	100	
Date (yyyy/dd)	1963/22	1959/19	1970/20	1961/21	2002/21	1970/06	1994/23	1982/23	1992/27	1955/22	1960/19	1985/27	
Direction of Maximum Hourly	N	SE	W	N	NW	W	N	W	N	N	N	NW	SE
Maximum Gust Speed (km/h)	140	133	121	100	102	177	91	137	103	109	121	128	
Date (yyyy/dd)	1963/22	1988/21	1970/20	1989/17	1986/28	1970/06	1982/20	1982/23	1970/16	1997/14	1969/13	1985/27	
Direction of Maximum Gust	N	NW	W	NW	NW	W	N	W	W	NW	N	NW	W
Days with Winds >= 52 km/h	7.8	7.3	5.9	3.4	2.2	1	1	1.3	1.8	3.9	5.2	5.9	46.8
Days with Winds >= 63 km/h	3	2.3	2	1	0.6	0.3	0.1	0.2	0.6	0.9	1.7	2	14.8
Wind Chill													
Extreme Wind Chill	-71.5	-70.5	-66.1	-58.5	-42.3	-23.5	-6.2	-10.2	-23	-46.9	-59.2	-64	
Date (yyyy/dd)	1970/27	1972/27	1972/03	1964/10	1966/04	1972/02	1978/05	1979/30	1965/28	1978/20	1958/27	1980/31	
Days with Wind Chill < -20	31	28.3	30.7	26.5	10.2	0.1	0	0	0.1	12.8	27.8	30.9	198.2
Days with Wind Chill < -30	30.5	27.8	28.6	18.4	2.2	0	0	0	0	3.6	21.9	29	161.9
Days with Wind Chill < -40	28	24.6	23.1	7.6	0	0	0	0	0	0.4	10.6	24.2	118.6

Source: Environment Canada

Table 2-2. Concentrations of substances in effluent monitored under MMER.

	Date	
Parameter	**2010-04-19**	**2010-08-24**
Aluminum (mg/L)	0.630	0.484
Ammonia (mg N/L)	0.17	0.47
Cadmium (mg/L)	< 0.00008	11.4
Iron (mg/L)	0.15	0.33
Mercury (mg/L)*	< 0.00001	< 0.00001
Molybdenum (mg/L)	0.0014	0.0036
Nitrate (mg N/L)	0.52	0.03

** Mercury must be < 0.10 µg/L in 12 consecutive samples before sampling can be discontinued. Also, mercury must be < 0.1 µg/L to strike down the necessity to conduct a fish tissue survey.*

Table 2-3. Monthly mean concentrations and loadings of deleterious substances in effluent.

Concentrations (mg/L)

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	Lowest	Highest	Effluent Volume (monthly total)
	unit								(Bq/L)	pH	pH	(m^3)
	max/month	0.5	0.3	1	0.2	0.5	0.5	15	0.37			
Jan.		0.0005	0.0012	na	0.000575	0.0015	0.00175	9	0.004	7.06	7.42	808439
Feb.		0.00195	0.000975	na	0.005775	0.00165	0.00425	7	0.00525	6.76	7.24	955861
Mar.		0.00085	0.001175	0.0055	0.000575	0.001425	0.00325	8.5	0.004	6.87	7.08	1104674
Apr.		0.010875	0.0027	0.0185	0.000975	0.002225	0.01025	**21.25**	0.01375	6.8	7.75	815525
May		0.0005	0.0027667	0.013	0.0003	0.0027	0.004667	13	0.007	6.43	6.98	778312
June		0.00066	0.00308	0.0124	0.0024	0.00426	0.0066	**22**	na	6.36	6.97	718745
July		0.00135	0.001225	0.005	0.00435	0.0042	0.002	11.8	0.013	**5.85**	6.94	411657
Aug.		0.001133	0.0024333	0.005333	0.0055	0.003667	0.011	6.6666667	na	6.28	6.53	369048
Sep.		na	na	na	na	na	na	na	na	na	na	na
Oct.		na	na	na	na	na	na	na	na	na	na	na
Nov.		na	na	na	na	na	na	na	na	na	na	na
Dec.		na	na	na	na	na	na	na	na	na	na	na

Loadings (kg/month)

Month	Monthly total effluent volume (L)	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226 (MBq/L)
Jan.	8.08E+08	0.40	0.97	na	0.46	1.17	1.41	7275.95	2.83
Feb.	9.56E+08	1.86	0.93	na	5.52	1.58	4.06	6691.03	5.02
Mar.	1.10E+09	0.94	1.30	6.08	0.64	1.57	3.59	9389.73	4.42
Apr.	8.16E+08	8.87	2.20	15.09	0.80	1.81	8.36	17329.91	11.21
May	7.78E+08	0.39	2.15	10.12	0.23	2.10	3.63	10118.06	5.45
June	7.19E+08	0.47	2.21	8.91	1.72	3.06	4.74	15812.39	na
July	4.12E+08	0.56	0.50	2.06	1.79	1.73	0.82	4857.55	5.35
Aug.	3.69E+08	0.42	0.90	1.97	2.03	1.35	4.06	2460.32	na
Sep.	na	na	na	na	na	na	na	na	na
Oct.	na	na	na	na	na	na	na	na	na
Nov.	na	na	na	na	na	na	na	na	na
Dec.	na	na	na	na	na	na	na	na	na

Shaded **bold** values exceed the Schedule 4 MMER per month guideline.

Table 2-4. EEM receiving environment monitoring results, 2010.

Parameter	CCME (2007) Guideline[1]	Date 2010-04-19	2010-05-22	2010-07-28	2010-08-31
TPN (Exposure Area)					
Alkalinity mg CaCO3/L	NG	6	6	40	6
Aluminium (mg/L)[2]	0.1	0.026	0.027	0.019	0.01
Arsenic (As) mg/L	0.0050	0.0023	<0.0005	<0.0005	<0.0005
Ammonia (mg N/L)[3]	10.3 - 23.1	0.16	0.31	0.07	0.06
Cadmium (Cd) mg/L*	0.0000025 - 0.0000029	<0.00008	<0.00008	<0.00008	<0.00008
Copper (Cu) mg/L*	0.0020	<0.0005	<0.0005	<0.0005	0.0006
Total Cyanide (CNt) mg/L	0.005	**0.008**	**	<0.005	<0.005
Hardness mg CaCO3/L	NG	5	6	5	5
Iron (Fe) mg/L	0.300	<0.01	<0.01	<0.01	<0.01
Total suspended solid mg/L	NG	<1	<1	<1	<1
Mercury (Hg) mg/L	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Mo) mg/L	0.073	<0.0005	<0.0005	<0.0005	<0.001
Nickel (Ni) mg/L*	0.025	<0.0005	0.0006	0.0012	0.0013
Nitrate (NO3) mg/L N/L	2.9	<0.01	0.08	0.03	0.03
Dissolved oxygen (DO) mg/L	NG	10.16	**		9.48
pH[4]	6.5 - 9.0	6.64	**	6.72	6.88
Lead (Pb) mg/L*	0.0010	<0.0003	**0.0068**	<0.0003	<0.0003
Radium (Ra 226) Becquerels/L	NG	<0.002	<0.002	<0.003	<0.003
Zinc (Zn) mg/L	0.030	<0.001	0.006	<0.001	<0.001
Temperature (°C)	NG	**	0.74		
TPS (Reference Area)					
Alkalinity mg CaCO3/L	NG	7	4	27	5
Aluminium (mg/L)[2]	0.005 - 0.100	0.019	0.024	<0.002	0.018
Arsenic (As) mg/L	0.0050	0.0033	<0.0005	<0.0005	<0.0005
Ammonia (mg N/L)[3]	8.24 - 10.3	0.17	0.29	0.07	0.06
Cadmium (Cd) mg/L*	0.0000021 - 0.0000025	<0.00008	<0.00008	<0.00008	<0.00008
Copper (Cu) mg/L*	0.0020	<0.0005	<0.0005	<0.0005	<0.0005
Total Cyanide (CNt) mg/L	0.005	**0.020**	**	<0.005	<0.005
Hardness mg CaCO3/L	NG	4	5	5	5
Iron (Fe) mg/L	0.300	<0.01	<0.01	<0.01	<0.01
Total suspended solid mg/L	NG	<1	<1	<1	<1
Mercury (Hg) mg/L	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (Mo) mg/L	0.073	<0.0005	<0.0005	<0.0005	<0.0005
Nickel (Ni) mg/L*	0.025	<0.0005	<0.0005	<0.0005	0.0013
Nitrate (NO3) mg/L N/L	2.9	<0.01	<0.01	0.03	0.05
Dissolved oxygene mg/L	NG	9.48	**		9.72
pH[4]	6.5 - 9.0	6.73	**	7.06	6.91
Lead (Pb) mg/L*	0.0010	<0.0003	**0.0108**	<0.0003	**0.0069**
Radium (Ra 226) Becquerels/L	NG	<0.002	0.003	<0.003	0.003
Zinc (Zn) mg/L	0.030	<0.001	0.006	0.003	<0.001
Temperature (°C)	NG	0.52	0.22		

Notes:

NG = no guideline.

[1]CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007.

[2]Aluminum guideline is pH dependent.

[3]Ammonia guidelines are temperature and pH dependent.

[4] pH values are field measured, as laboratory measures were delayed and therefore not acceptable.

*Cadmium, copper, lead and nickel guidelines are hardness dependent.

** Parameter erroneously not requested for analysis.

Shaded bold concentrations exceed the CCME guideline.

Table 2-5. Lethal and sublethal toxicity test results.

MMER Acute Lethality Toxicity Testing Results

Month (2010)	% v/v	
	Daphnia magna LC50 (48h)	**Rainbow trout LC50 (96h)**
January	> 100	> 100
February	> 100	> 100
March	46	> 100
April	> 100	> 100
May	> 100	> 100
June	> 100	> 100
July	> 100	> 100
August	> 100	> 100
September	na	na
October	na	na
November	na	na
December	na	na

Note:

Toxic unit (TU) always < 1, with the exception of the Daphnia magna test in March, where TU = 2.

"na" indicates data has not yet been analyzed.

EEM Sublethal Toxicity Testing Results

Date	04/19/2010	08/24/2010
Test	**% v/v**	
Rainbow trout CL-50	-	> 100
Daphnia magna CL-50	-	> 100
Fathead Minnow IC25	> 100	> 100
Fathead Minnow LC50	> 100	> 100
Ceriodaphnia dubia IC25	> 100	> 100
Ceriodaphnia dubia LC50	> 100	> 100
Freshwater Alga IC25	> 90.9	> 90.9
Lemna minor IC25	> 97	81.4
Lemna minor LC50	> 97	> 97

Table 2-6. Mean conventional water chemistry parameters and selected total metals concentrations in project, reference and regional Arctic lakes, BAER 2005.

	CCME Drinking Water Quality Guidelines	CCME (2002) Aquatic Life Guidelines	PROJECT LAKES																				REFERENCE LAKES								
			Third Portage Lake							Second Portage Lake							Other Project Lakes*						Third Portage South Basin				Inuggugayualik Lake				Amarulik
			1996	1997	1998	2002(J)	2002(A)	2003(M)	2003(A)	1996	1997	1998	2002(J)	2002(A)	2003(M)	2003(A)	1997	1998	2002(J)	2002(A)	2003(M)	2003(A)	1997	2002(J)	2002(A)	2003(M)	1998	2002(J)	2002(A)	2003(M)	1998
			(n=1)	(n=2)	(n=1)	(n=5)	(n=5)	(n=3)	(n=1)	(n=1)	(n=1)	(n=2)	(n=3)	(n=4)	(n=2)	(n=1)	2 Lakes (n=2)	1 Lakes (n=3)	6 Lakes (n=7)	6 Lakes (n=7)	5 Lakes (n=5)	3 Lakes (n=3)	(n=1)	(n=1)	(n=1)	(n=1)	(n=1)	(n=1)	(n=1)	(n=1)	(n=1)
CONVENTIONAL PARAMETERS																															
PH	6.5 – 8.5	6.5 - 9.0	6.92	6.85	6.52	6.62	6.93	6.84	7.34	7.14	6.50	6.79	7.86	7.29	7.19	7.26	6.60	–	6.96	7.25	7.29	7.61	6.70	6.64	6.92	6.61	7.2	6.82	7.07	6.67	6.61
Total Dissolved Solids (mg/L)			<10	<10	<10	–	10	12	13	11	<10	17	–	12	14	11	11	–	–	18	26	27	12	–	<10	<10	12	–	<10	13	10
Total Suspended Solids (mg/L)			<1	<1	<1	–	<3	<3	<3	<1	<1	<1	–	3	<3	<3	1	–	–	<3	3	3	<1	–	<3	<3	<1	–	<3	<3	<1
Hardness (mg/L)			4.57	4.71	4.41	4.7	4.6	6.4	4.8	6.94	5.19	7.61	7.9	8.5	10.7	8.7	8.63	4.90	10.61	10.18	17.38	19.90	4.38	4.9	4.7	5.1	4.5	5.3	5.3	6.2	5.66
Nutrients (mg/L)																															
Ammonia Nitrogen			<0.005	0.03	<0.02	0.02	0.02	0.005	<0.02	<0.005	0.03	<0.02	0.02	0.036	0.005	<0.02	0.02	<0.02	0.03	0.03	0.01	0.02	0.03	<0.02	<0.02	0.006	<0.02	<0.02	0.03	0.015	<0.02
Nitrate Nitrogen			<0.005	<0.005	<0.005	<0.005	<0.005	0.008	<0.005	<0.005	<0.005	<0.005	<0.005	0.012	0.005	<0.005	<0.005	<0.005	0.04	<0.005	0.02	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.009	<0.005
Total Phosphorus			0.002	0.002	0.002	0.002	0.003	0.002	<0.002	0.001	0.005	0.002	0.003	0.002	0.002	0.002	0.002	0.004	0.003	0.003	0.003	0.003	0.002	0.002	0.003	<0.002	<0.001	0.002	0.003	0.002	0.004
Total Dissolved Phosphorus			<0.001	0.003	0.001	–	–	<0.002		<0.001	0.001	0.002	–	–	<0.002		0.001	0.002	–	–	<0.002	-	0.002	–	–	<0.002	<0.001	–	–	<0.002	0.001
Organic Parameters (mg/L)																															
Dissolved Organic Carbon			2.3	2.2	1.8	1.2	1.4	1.8	0.8	2.1	1.9	2.2	1.5	1.7	1.8	-	2.3	1.8	1.8	1.9	2.5	2.0	1.9	1.2	1.3	1.5	2.4	1.9	2.2	2.1	3.1
TOTAL METALS (mg/L)																															
Aluminum	NG	0.1	0.011	0.008	0.012	0.006	0.006	<0.005	0.008	0.020	0.008	0.010	0.007	0.008	<0.005	0.005	0.011	0.016	0.010	0.005	0.006	0.009	0.006	<0.005	<0.005	<0.005	0.012	0.01	0.007	<0.005	0.013
Antimony	0.006	NG[A]	<0.0001	<0.00005	<0.00005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.00005	<0.00005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00005	<0.00005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00005	<0.0005	<0.0005	<0.0005	<0.00005	<0.0005	<0.0005	<0.0005	<0.00005
Arsenic	0.025	0.005	<0.0001	<0.0001	<0.0001	<0.0005	<0.0005	<0.0005	<0.0005	<0.0001	<0.0001	0.0001	<0.0005	<0.0005	<0.0005	<0.0005	0.00015	<0.0001	<0.0005	<0.0005	<0.0005	0.000633	<0.0001	<0.0005	<0.0005	<0.0005	<0.0001	<0.0005	<0.0005	<0.0005	<0.0001
Cadmium[B]	0.005	0.000026	<0.0002	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.0002	<0.00005	<0.00005	<0.00005	0.00005	<0.00005	<0.00005	<0.00005	0.00005	0.00005	0.00019	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.0001	<0.00005	<0.00005	<0.00005	<0.00005
Chromium[C]	0.05	0.001	<0.001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.0005	<0.001	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.0005	<0.001	<0.001	<0.001	<0.0005
Copper	<1.0	0.002	<0.001	0.0004	0.0004	<0.001	<0.001	<0.001	<0.001	<0.001	<0.0005	0.0005	<0.001	<0.001	<0.001	<0.001	0.0008	0.0004	<0.001	<0.001	0.0015	<0.001	0.0004	<0.001	<0.001	<0.001	0.0004	<0.001	<0.001	<0.001	0.0010
Lead	0.01	0.001	<0.001	0.0001	<0.00005	<0.0005	0.0005	<0.0005	<0.0005	<0.001	0.0001	<0.00005	<0.0005	0.0012	0.0006	<0.0005	0.0001	0.0001	0.0013	0.0007	0.0010	<0.0005	<0.00005	<0.0005	<0.0005	<0.0005	0.00005	<0.0005	<0.0006	<0.0005	<0.00005
Mercury	0.001	0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel	NG	0.025	<0.001	0.0004	0.0003	<0.001	<0.001	<0.001	<0.001	<0.001	0.0002	0.0003	<0.001	<0.001	<0.001	<0.001	0.0006	0.0002	<0.001	<0.001	0.0015	0.0017	0.0004	<0.001	<0.001	0.0020	0.0003	<0.001	<0.001	<0.001	0.0005
Zinc	<5.0	0.03	<0.005	0.004	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	0.019	<0.001	<0.005	<0.005	<0.005	<0.005	0.005	0.001	0.010	<0.005	0.009	<0.005	0.002	<0.005	<0.005	<0.005	0.002	<0.005	<0.005	<0.005	0.001

Notes: A. NG = no guideline. **B.** Cadmium guideline developed using the lowest hardness value. **C.** Chromium guideline is for Cr VI. **B** and **C** give the most conservative guidelines. **D.** Candidate Reference Lake. Shaded concentrations exceed CCME guideline.

* **1997**: Tehek, Vault 3. **1998**: Tehek. **2002(J):** Tehek, Tern, Vault 1,2,3, Farside. **2002(A):** Tehek, Tern, Vault 1, 2, 3, Farside. **2003(M):** Tehek, Tern, Vault 1, 2, 3. **2003(A):** North Port1, North Port2, North Port3.

References: 1. Urangesellschaft, 1981. **2.** McKee et al, 1989. **3.** McLeod et al, 1976. **4.** Diavik and Aber, 1998. **5.** De Beers, 2002.

Table 2-6 continued.

	CCME Drinking Water Guidelines	CCME (2002) Aquatic Life Guidelines	REGIONAL LAKES														
			Kiggavik Region**				Baker Lake		Lac de Gras[4]			Lac du Sauvage[4]			Snap Lake[5]		
			1980 [1]	1986 [2]	1988 [2]	1989 [2]	1975 [3]	1989 [2]	Sep-94	Aug-95	Aug-96	Sep-94	Aug-95	Aug-96	1998	1999	2001
			6 Lakes (n=6)	5 Lakes (n=5)	5 Lakes (n=8)	4 Lakes (n=6)	(n=13)	(n=3)	(n=8)	(n=23)	(n=9)	(n=1)	(n=2)	(n=3)	(n=8)	(n=16)	(n=9)
CONVENTIONAL PARAMETERS																	
PH	6.5 – 8.50	6.5 – 9.0	5.92	6.10	6.67	6.66	6.86	7.17	5.84	6.22	6.06	5.86	6.11	6.03	6.8	6.5	6.7
Total Dissolved Solids (mg/L)			-	23	<10	24	77	73	6	8	7	10	9	6	13	15	30
Total Suspended Solids (mg/L)			-	-	2	4	1.3	4	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4	<3	<3	<3
Hardness (mg/L)			-	-	5.4	5.3	25	18.8	-	-	4.5	-	-	4.4	4	6	6
Nutrients (mg/L)																	
Ammonia Nitrogen			-	-	0.052	0.041	-	0.034	<0.01	<0.01	0.05	<0.01	<0.01	0.05	0.004	0.028	<0.005
Nitrate Nitrogen			-	0.009	0.14	0.01	-	0.03	<0.003	<0.003	-	<0.003	<0.003	-	-	-	0.02
Total Phosphorus			-	0.002	0.007	0.003	0.06	0.007	0.003	0.004	<0.003	0.003	0.011	<0.003	0.004	0.011	0.003
Total Dissolved Phosphorus															-	0.009	<0.001
Organic Parameters (mg/L)																	
Dissolved Organic Carbon			-	-	4.98	2.69	-	2.6	2.2	2	2.1	2.3	2.4	2.5	-	3	4
TOTAL METALS (mg/L)																	
Aluminum	NG	0.1	-	0.024	0.038	0.021	-	0.015	0.040	<0.01	0.044	0.090	0.010	0.042	0.0069	<0.0300	0.0095
Antimony	0.006	NG[A]	-	-	-	-	-	-	-	-	-	-	-	-	0.001	0.001	<0.00003
Arsenic	0.025	0.005	<0.0002	<0.001	<0.001	<0.001	-	<0.001	<0.0002	-	<0.0002	0.0002	-	<0.0002	-	<0.0002	<0.00003
Cadmium[B]	0.005	0.000026	0.00200	<0.01	0.00030	0.00080	-	0.00030	<0.003	<0.003	<0.0002	<0.003	<0.003	<0.0002	<0.0001	<0.0001	<0.0001
Chromium[C]	0.05	0.001	<0.5	<0.01	0.003	0.001	-	<0.001	0.003	<0.002	0.007	0.016	<0.002	0.007	0.0003	<0.002	<0.00006
Copper	<1.0	0.002	0.0010	0.0050	0.0013	0.0008	-	<0.0005	<0.001	<0.001	0.0015	<0.001	0.0030	0.0010	0.0014	0.0010	0.0006
Lead	0.01	0.001	0.0020	<0.05	0.0008	0.0008	-	<0.0005	<0.02	<0.02	<0.0003	<0.02	<0.02	<0.0003	0.0003	0.0008	0.0002
Mercury	0.001	0.0001	0.00002	0.00003	<0.00005	0.00005	-	<0.00005	<0.00005	-	<0.00005	<0.00005	-	<0.00005	<0.00001	<0.00001	<0.00002
Nickel	NG	0.25	-	<0.01	0.0018	<0.001	-	<0.001	0.0060	<0.005	0.0038	0.0250	<0.005	0.0025	0.0002	0.0004	0.0002
Zinc	<5.0	0.03	0.003	<0.01	<0.005	<0.005	-	<0.005	0.005	0.007	<0.0006	0.006	0.013	0.001	0.0024	<0.010	0.0013

Notes: A. NG = no guideline. **B.** Cadmium guideline developed using the lowest hardness value. **C.** Chromium guideline is for Cr VI. **B** and **C** give the most conservative guidelines. **D.** Candidate Reference Lake. Shaded concentrations exceed CCME guideline.

** **1980**: Jaeger, Kavisilik, Pointer, Scotch, Sissons, Squiggly. **1986**: Caribou, Pointer, Scotch, Sissons, Skinny. **1988**: Jaeger, Pointer, Scotch, Sissons, Skinny. **1989**: Jaeger, Pointer, Sissons, Skinny.

References: 1. Urangesellschaft, 1981. **2.** McKee et al, 1989. **3.** McLeod et al, 1976. **4.** Diavik and Aber, 1998. **5.** De Beers, 2002.

Table 2-7. Mean conventional and total metals concentrations in sediments from project, reference and regional Arctic lakes.

	Sediment Quality Guidelines		PROJECT LAKES												REFERENCE LAKES					REGIONAL LAKES						
			Third Portage Lake				Second Portage Lake				Other Project Lakes*				Third Portage South Basin		Inuggugayualik		Amarulik[B]	Kiggavik Study Area[1] **			Lac de Gras[2]	Lac du Sauvage[2]	Snap Lake[3]	Snap Ref. Lake[3]
			1996	1997	1998	2002	1996	1997	1998	2002	1997	1998	2002	2003	1997	2002	1998	2002	1998	1979	1986	1988	Sep-96	Sep-96	1999	1999
	ISQG	PEL									2 Lakes	1 Lakes	5 Lakes	3 Lakes						4 Lakes	4 Lakes	2 Lakes	Range	Range		
	(CCME, 2001)		(n=1)	(n=2)	(n=1)	(n=5)	(n=1)	(n=1)	(n=2)	(n=3)	(n=2)	(n=2)	(n=11)	(n=3)	(n=1)	(n=1)	(n=1)	(n=2)	(n=1)	(n=4)	(n=4)	(n=5)	(n=6)	(n=3)	(n=4)	(n=4)
CONVENTIONAL PARAMETERS																										
Organic Parameters																										
Total Organic Carbon (% dw)	NA	NA	2.59	2.62	3.28	2.87	0.79	2.88	2.50	5.19	3.56	3.56	4.64	7.97	2.13	0.96	2.37	3.79	1.63	-	7.53	13.8	0.38 -2.05	0.95 - 1.47	12.5	16.0
Particle Size																										
Gravel (>2.00 mm) (%)	NA	NA	-	-	<0.1	0.1	-	<0.1	<0.1	<0.1	<0.1	<0.1	0.73	<0.1	<0.1	0.8	<0.1	0.1	<0.1	-	-	-		-	-	-
Sand (2.00 mm - 0.063 mm) (%)	NA	NA	-	3.1	4.1	6.1	-	6.5	14.2	5.5	3.3	9.1	7.2	4.0	2.1	42.6	9.9	6.2	46.9	-	-	46.9		-	77.5	76.5
Silt (0.063 mm - 4 µm) (%)	NA	NA	-	28.2	25.9	31.1	-	26.0	34.4	35.8	30.9	40.6	38.5	39.5	26.7	24.9	50.6	36.3	27.1	-	-	41.6		-	21.5	22.5
Clay (<4 µm) (%)	NA	NA	-	68.8	70.0	62.8	-	67.5	49.9	58.7	65.9	50.4	53.9	56.5	71.2	31.7	39.5	57.6	26.0	-	-	11.5		-	1.0	1.0
TOTAL METALS (mg/kg dw)																										
Aluminum	NG[A]	NG	-	-	-	-	-	-	-	-	-	-	-	-						-	9,550	12,975	5,627 - 14,500	9,562 - 16,533	12,500	12,000
Antimony	NG	NG	0.39	<40	<40	<10	0.21	<40	<40	<20	<40	<40	<20	<20	<20	<10	<40	<10	<40	2.32	3	3.4	<0.02 - 0.03	<0.02 - <0.02	<0.2	<0.2
Arsenic	5.9	17	27	103.9	21	26.6	**11.2**	53.5	28	68	30.8	**12.9**	39.3	72.7	31.0	20.0	18.0	24.0	**10.0**	-	187.3	234.9	**8.1** - 99.6	3.5 - 85.9	1.4	0.75
Cadmium	0.6	3.5	0.12	<0.2	0.35	<0.5	0.10	<0.2	**1.10**	**0.77**	0.30	1.80	**<1**	**<1**	<0.1	<0.5	0.27	<0.5	0.20	<0.5	**<1**	0.2	0.03 - 0.16	0.06 - 0.22	**0.7**	0.3
Chromium	37.3	90	158	136	113	120	**84**	101	**90**	98	105	**80**	96	117	157	97	111	125	**64**	**88**	29	34	23 - **61.0**	**44.3 - 69.0**	29.7	25.3
Copper	35.7	197	**96.0**	**89.0**	**74.0**	**70.0**	**45.8**	**121**	**73.5**	**94.7**	**91.5**	**98.0**	**87.0**	**115.7**	**91.0**	**56.0**	**42.0**	**55.5**	**51.0**	17	17	25	11.3 - **54.8**	19.4 - **37.5**	**69.6**	35.6
Lead	35.0	91.3	22.7	<100	24.0	30.2	16.3	<100	21.5	<30	<100	29.5	49.5	<60	**<50**	0.0	14.0	<30	15.0	<5.0	10	11.9	2.29 - 5.24	2.48 - 4.6	4.9	4.7
Mercury	0.17	0.49	-	0.015	0.023	0.020	-	0.015	0.023	0.047	0.036	0.029	0.035	0.081	0.015	0.009	0.023	0.023	0.015	0.02	0.04	0.05	<0.02 - 0.03	<0.02 - 0.02	0.050	0.060
Nickel	18	36	86	82	76	90	51	66	63	93	71	119	64	167	80	49	70	87	41	-	17	**22**	0.05 -**23.5**	4.8 - **33.53**	38	**20**
Zinc	123	315	**128**	**128**	**135**	115	107	**176**	**136**	**133**	**140**	**197**	114	**133**	**127**	74	89	99	84	-	48	59	30.5 - 79.0	48.6 - 86.1	**176**	99

Note: A. NG = no guideline. **B.** Candidate Reference Lake. **Bold:** Concentrations exceed ISQG. Shaded concentrations exceed PEL.

* **1997**: Tehek, Vault. **1998**: Tehek. **2002**: Tehek, Turn, Vault, Farside. **2003**: North Port1, North Port2, North Port3. ** **1979**: Jaeger, Pointer, Scotch, Sissons. **1986**: Boulder, Caribou, Sissons, Skinny. **1988**: Jaeger, Pointer.

References: 1. McKee et al, 1989. **2.** Diavik, 1998; **3.** De Beers, 2002.

Table 2-8. Mean density & richness of major benthic invertebrate taxa from project & reference lakes, 1997-2003 (250 µm Sieve), BAER 2005.

Year/Lake/Depth (m)	No. of Sample Stations	Mean Density (# organisms/m²)					Mean Richness (# taxa)
		Oligochaetes	Bivalves	Chironomids	Other Taxa	Total	
August 1997							
Project Lakes							
Third Portage Lake (14 – 20)	(n=3)	29	196	566	109	657	13
Second Portage Lake (9)	(n=1)	15	44	218	0	276	5
Tehek Lake (6)	(n=1)	-	73	203	58	334	10
Turn Lake (9)	(n=1)	44	73	73	44	232	9
Reference Lakes							
Third Portage South Basin (21)	(n=1)	-	102	58	15	174	4
August 1998							
Project Lakes							
Third Portage Lake	(n=2)	73	450	2,001	102	2,625	12
Second Portage Lake	(n=2)	145	928	1,218	160	2,451	15
Reference Lakes							
Inuggugayualik Lake	(n=1)	334	638	7,671	308	8,950	19
Amarulik Lake	(n=1)	261	638	2,233	334	3,466	20
July 2002							
Project Lakes							
Third Portage Lake (8 – 11)	(n=5)	113	377	4,971	49	5,510	15
Second Portage Lake (9 – 10)	(n=3)	73	319	5,355	82	5,829	11
Tehek Lake (7 – 10)	(n=2)	-	358	2,837	135	3,330	15
Turn Lake (8 – 11)	(n=2)	36	363	2,697	51	3,147	16
Vault Lakes (8 – 11)	(n=3)	68	947	4,986	331	6,332	14
Farside Lake (10)	(n=1)	58	370	3,016	15	3,458	15
Reference Lakes							
Third Portage South Basin (9)	(n=1)	15	116	783	15	928	11
Inuggugayualik Lake (8 – 9)	(n=1)	138	1,327	8,642	196	10,302	15
August 2002 (Summer and Fall Samples)							
Project Lakes							
Third Portage Lake (9 – 10)	(n=5)	41	476	2,242	102	2,859	15
Second Portage Lake (9)	(n=3)	34	276	2,692	300	3,301	14
Tehek Lake (9 – 10)	(n=3)	15	218	972	155	1,358	12
Turn Lake (9.5)	(n=2)	7	370	479	58	914	6
Vault Lakes (8 – 10)	(n=4)	151	586	7,273	374	8,384	15
Farside Lake (8 – 10)	(n=1)	29	348	6,518	261	7,156	15
Reference Lakes							
Third Portage South Basin (9)	(n=1)	44	218	421	-	682	11
Inuggugayualik Lake (7)	(n=1)	29	44	841	29	943	11
August 2003							
Project Lakes							
North Portage 1 (Dogleg) (6)	(n=2)	15	471	3,197	22	3,705	12
North Portage 2 (4)	(n=2)	54	1,671	3,537	966	6,228	15
North Portage 3 (5)	(n=2)	-	597	1,617	65	2,279	8

Table 2-9. Habitat suitability indices (HS I) per species per life stage for high, medium, and low areas, NNLP 2006.

Species	Habitat Value	Spawning/ Nursery (4)	Rearing (2)	Foraging (3)	Overwintering (1)	Total Score (10)
Lake trout	High	4	1.75	2.5	1	9.25
	Medium	1	2	2.5	0.5	6
	Low	0	0.5	1	0.75	2.25
Round whitefish	High	3	1.5	2	1	7.5
	Medium	2	2	2.5	0.5	7
	Low	0	0.5	1.5	0.5	2.5
Arctic char	High	3.5	1.5	2.5	1	8.5
	Medium	1	1.5	2	0.5	5
	Low	0	0.5	1.5	0.75	2.75
Burbot	High	3	1.5	2	0.5	7
	Medium	2	1.5	2	0.25	5.75
	Low	1	0.5	2	1	4.5
Slimy sculpin	High	2	1.5	2	0.75	6.25
	Medium	1	2	2.5	0.25	5.75
	Low	0.5	1	1.5	0.5	3.5
Ninespine stickleback	High	2	2	2	1	7
	Medium	1	2	2.5	0.5	6
	Low	0	0	0.5	0	0.5

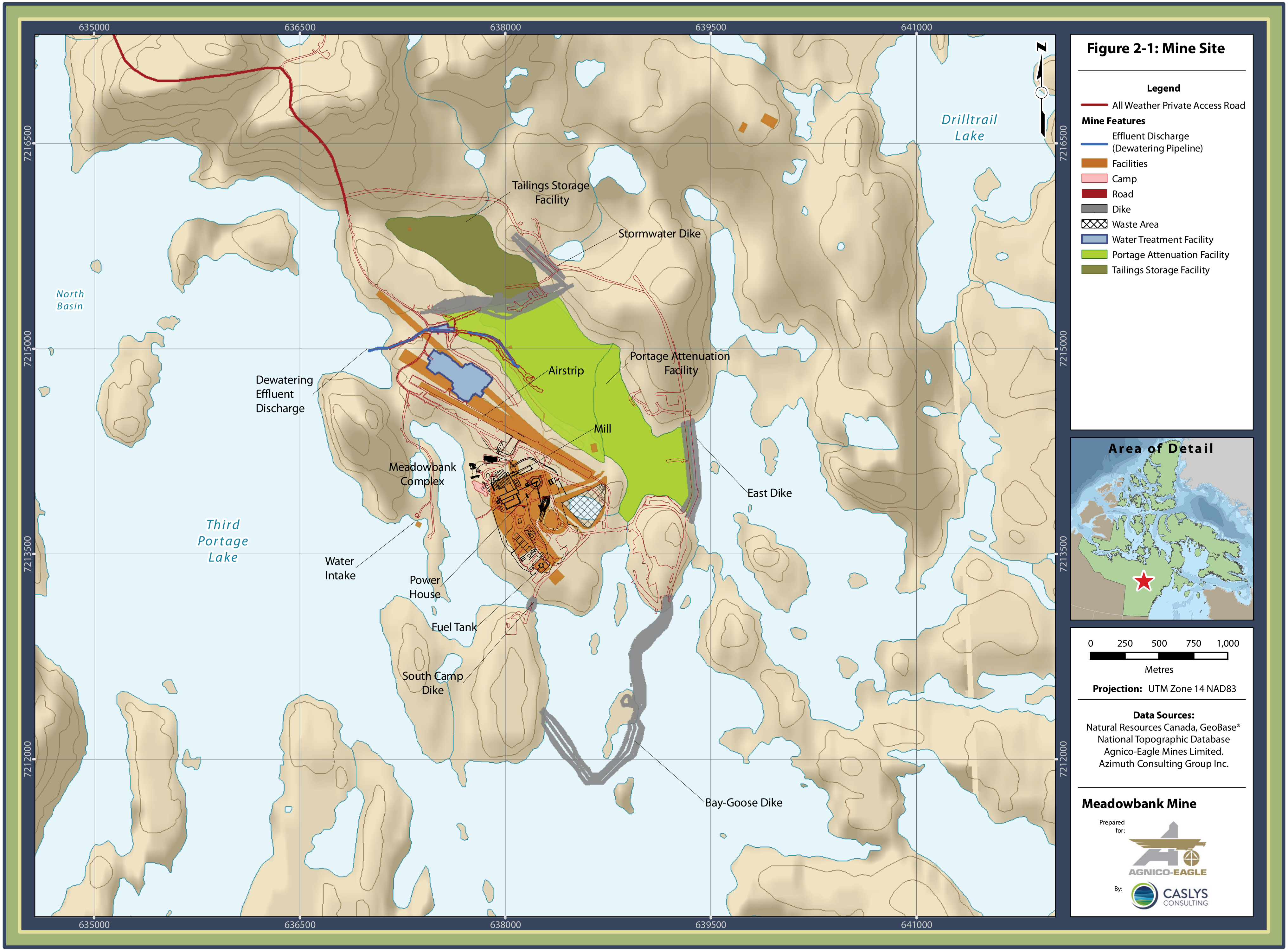


Figure 2-1: Mine Site

0 100 200 300 400

Kilometres

Projection:
Canada Lambert Conformal Conic

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Surficial Materials of Canada,
Geological Survey of Canada

Figure 2-2: Arctic Surficial Geology

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

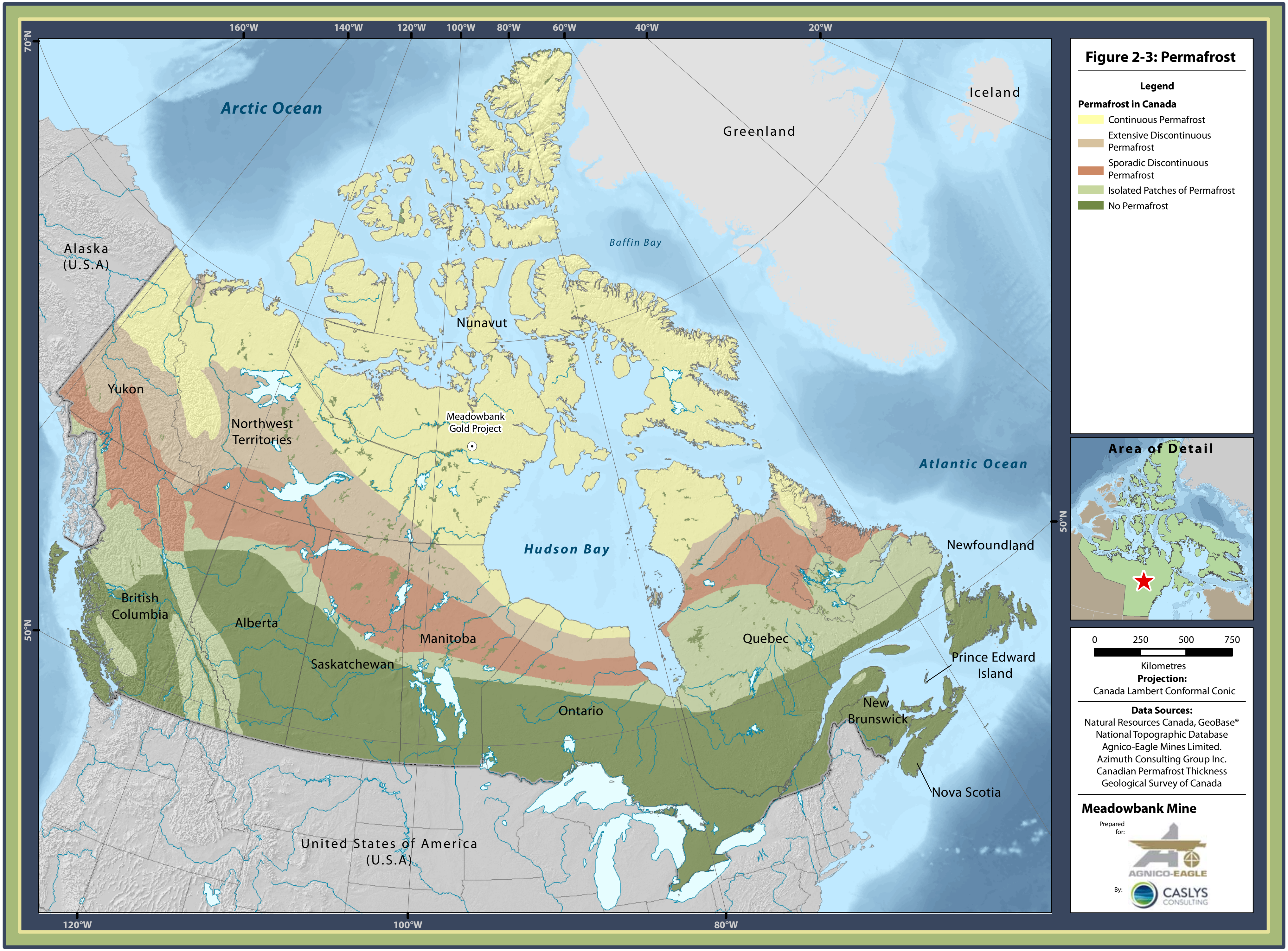


Figure 2-3: Permafrost
Legend
Permafrost in Canada
Continuous Permafrost
Extensive Discontinuous Permafrost
Sporadic Discontinuous Permafrost
Isolated Patches of Permafrost
No Permafrost
Area of Detail
0 250 500 750
Kilometres
Projection:
Canada Lambert Conformal Conic
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Canadian Permafrost Thickness
Geological Survey of Canada
Meadowbank Mine
Prepared for:
By:
160°W
140°W
120°W
100°W
80°W
60°W
40°W
20°W
70°N
50°N
120°W
100°W
80°W
Arctic Ocean
Greenland
Iceland
Baffin Bay
Alaska (U.S.A)
Nunavut
Yukon
Northwest Territories
Meadowbank Gold Project
Atlantic Ocean
Hudson Bay
Newfoundland
British Columbia
Alberta
Manitoba
Saskatchewan
Quebec
Prince Edward Island
New Brunswick
Ontario
Nova Scotia
United States of America (U.S.A)

Legend

Total Annual Precipitation (mm)

- < 50
- 51 - 100
- 101 - 150
- 151 - 200
- 201 - 250
- 251 - 350
- 351 - 400
- > 400

0 100 200 300 400

Kilometres

Projection:
Canada Lambert Conformal Conic

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
EcoAtlas, Government of Canada

Figure 2-4: Annual Arctic Precipitation

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

Legend

Arctic Drainage Basins

* Drainage basins are labeled with their name

0 100 200 300 400

Kilometres

Projection:
Canada Lambert Conformal Conic

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Atlas of Canada 1,000,000 National Frameworks Data

Figure 2-5: Arctic Drainages

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

Projection:
Canada Lambert Conformal Conic

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Northern Land Cover of Canada,
Government of Canada

Figure 2-6: Arctic Landcover

Meadowbank Gold Project

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

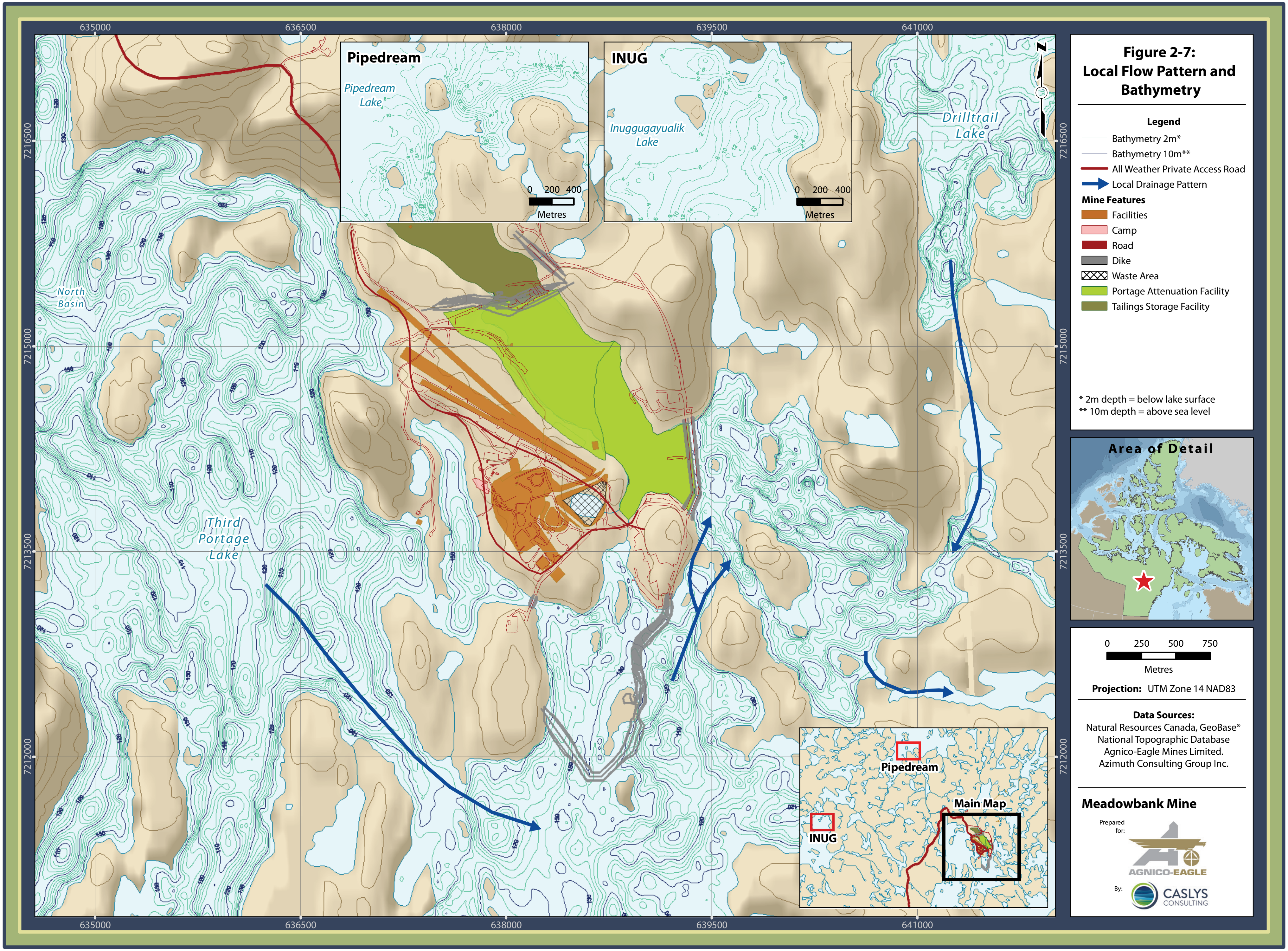
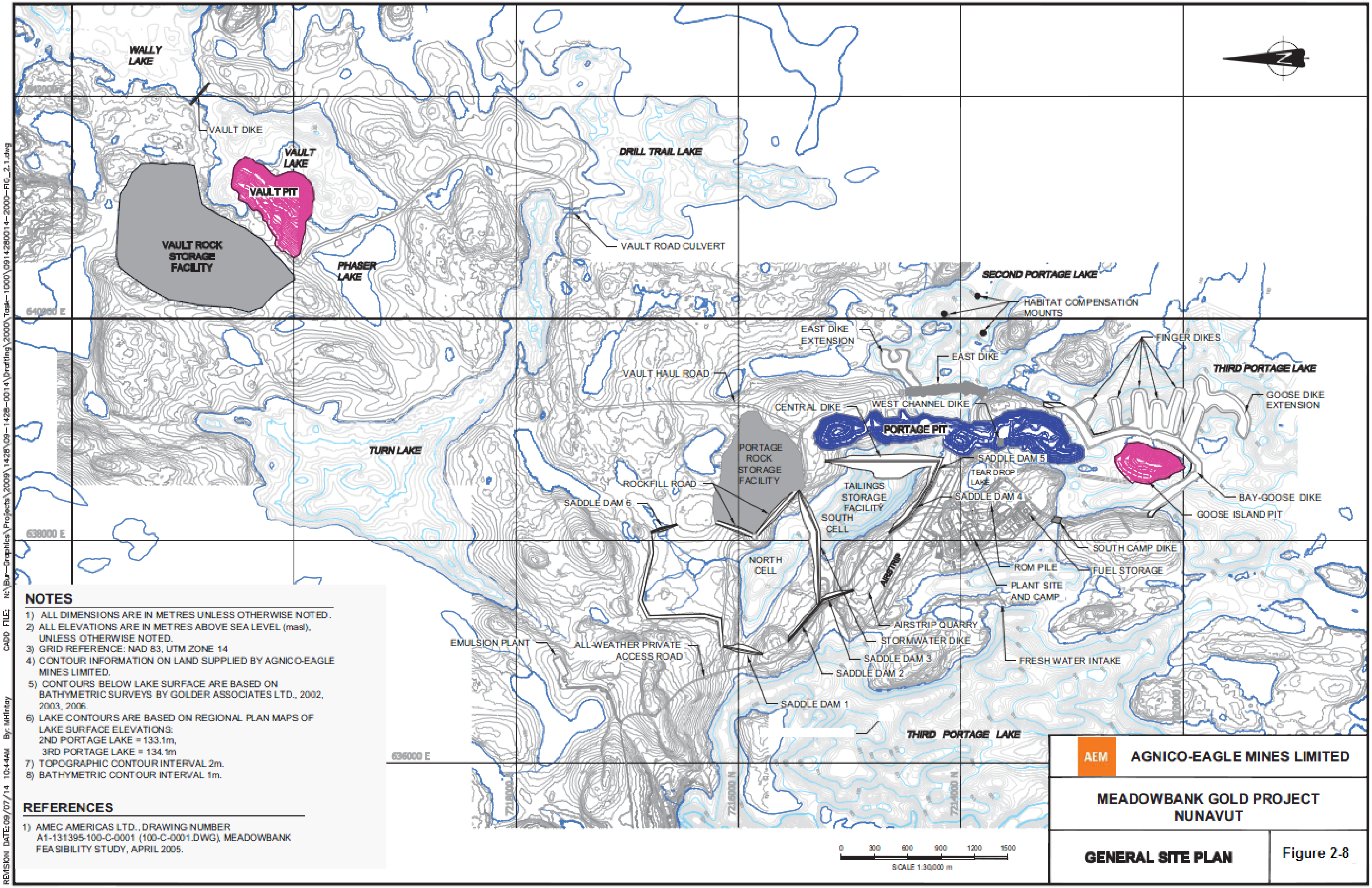


Figure 2-7: Local Flow Pattern and Bathymetry



NOTES

1) ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
2) ALL ELEVATIONS ARE IN METRES ABOVE SEA LEVEL (masl), UNLESS OTHERWISE NOTED.
3) GRID REFERENCE: NAD 83, UTM ZONE 14
4) CONTOUR INFORMATION ON LAND SUPPLIED BY AGNICO-EAGLE MINES LIMITED.
5) CONTOURS BELOW LAKE SURFACE ARE BASED ON BATHYMETRIC SURVEYS BY GOLDER ASSOCIATES LTD., 2002, 2003, 2006.
6) LAKE CONTOURS ARE BASED ON REGIONAL PLAN MAPS OF LAKE SURFACE ELEVATIONS:
   2ND PORTAGE LAKE = 133.1m,
   3RD PORTAGE LAKE = 134.1m
7) TOPOGRAPHIC CONTOUR INTERVAL 2m.
8) BATHYMETRIC CONTOUR INTERVAL 1m.

REFERENCES

1) AMEC AMERICAS LTD., DRAWING NUMBER A1-131395-100-C-0001 (100-C-0001.DWG), MEADOWBANK FEASIBILITY STUDY, APRIL 2005.

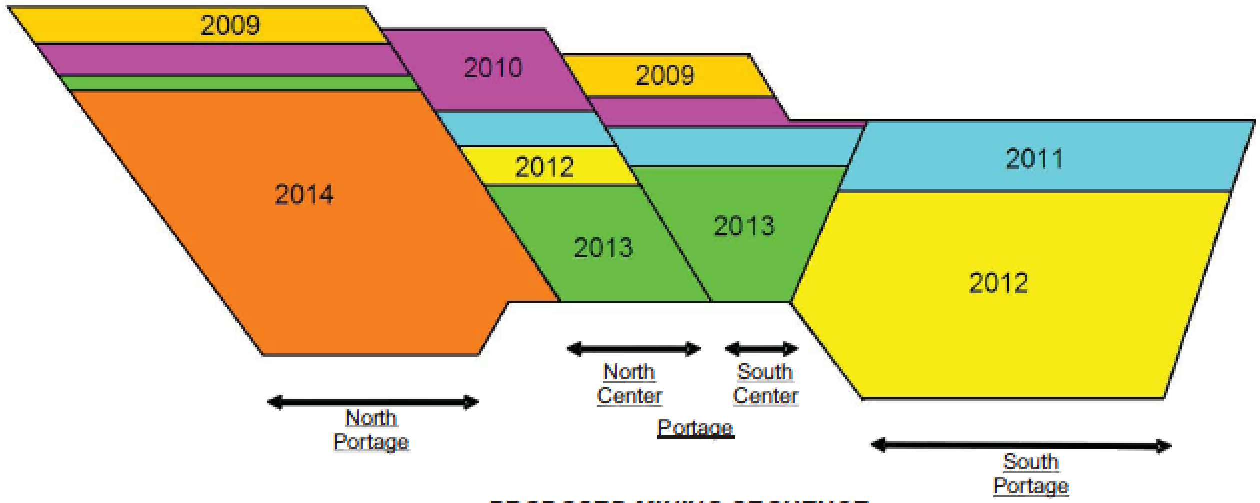
AEM AGNICO-EAGLE MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

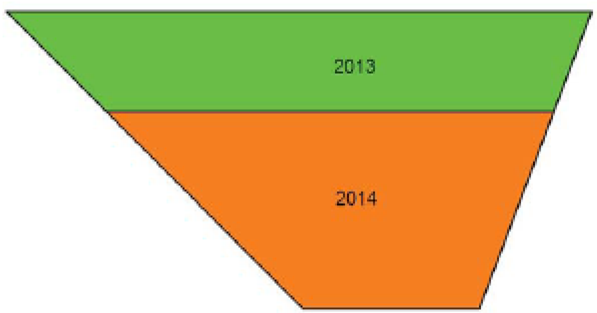
GENERAL SITE PLAN

Figure 2-8

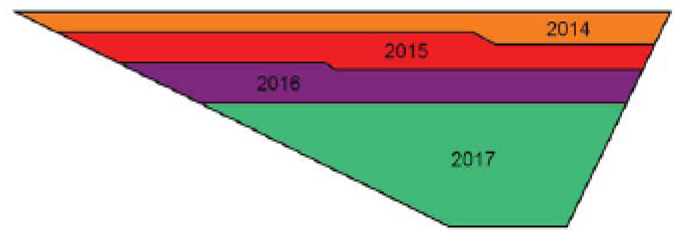
REVISION DATE: 09/07/14 10:44AM By: MHintay CADD FILE: N:\Bur-Graphics\Projects\2009\1428\09-1428-0014\Drafting\2000\Task-1000\0914280014-2000-FIG_2_1.dwg



**PROPOSED MINING SEQUENCE
PORTAGE PIT**



**PROPOSED MINING SEQUENCE
GOOSE PIT**



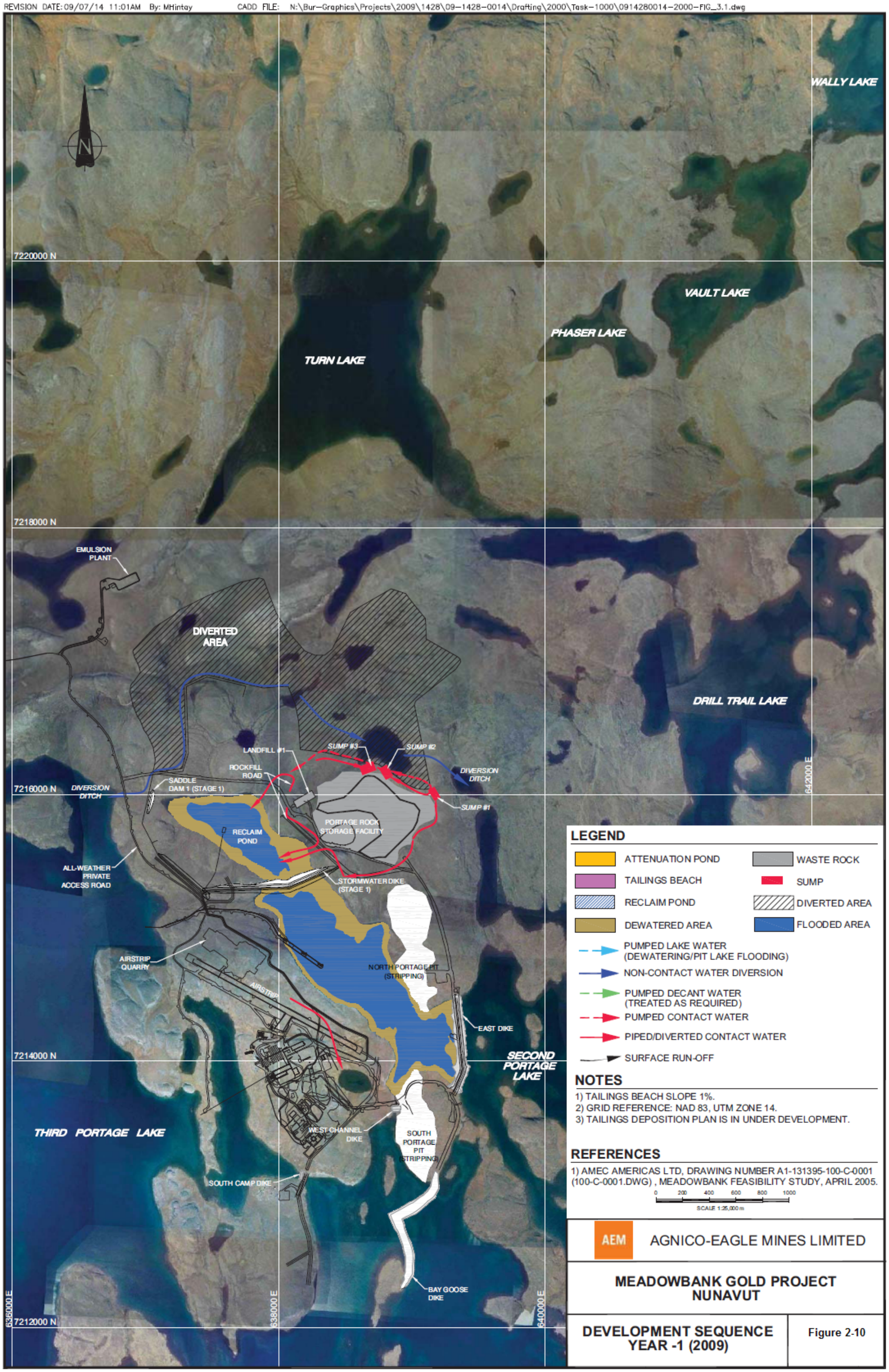
**PROPOSED MINING SEQUENCE
VAULT PIT**

AEM AGNICO-EAGLES MINES LIMITED

MEADOWBANK GOLD PROJECT
NUNAVUT

CONCEPTUAL MINING SEQUENCE | Figure 2-9

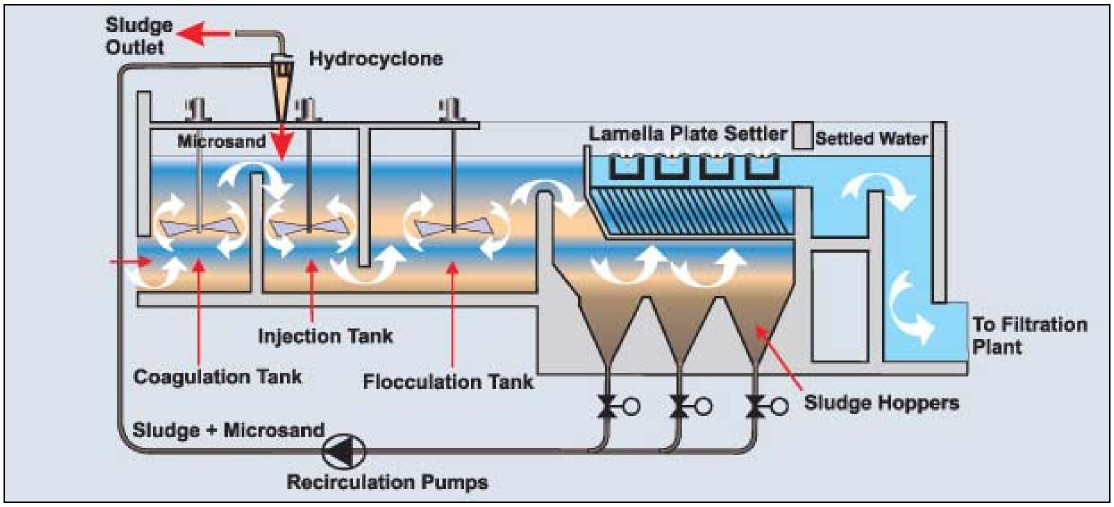
REVISION DATE: 09/07/14 11:01AM By: MHintay CADD FILE: N:\Bur-Graphics\Projects\2009\1428\09-1428-0014\Drafting\2000\Task-1000\0914280014-2000-FIG_3.1.dwg



DEVELOPMENT SEQUENCE YEAR -1 (2009)

Figure 2-10

Figure 2-11. Clarification system, Meadowbank Mine.



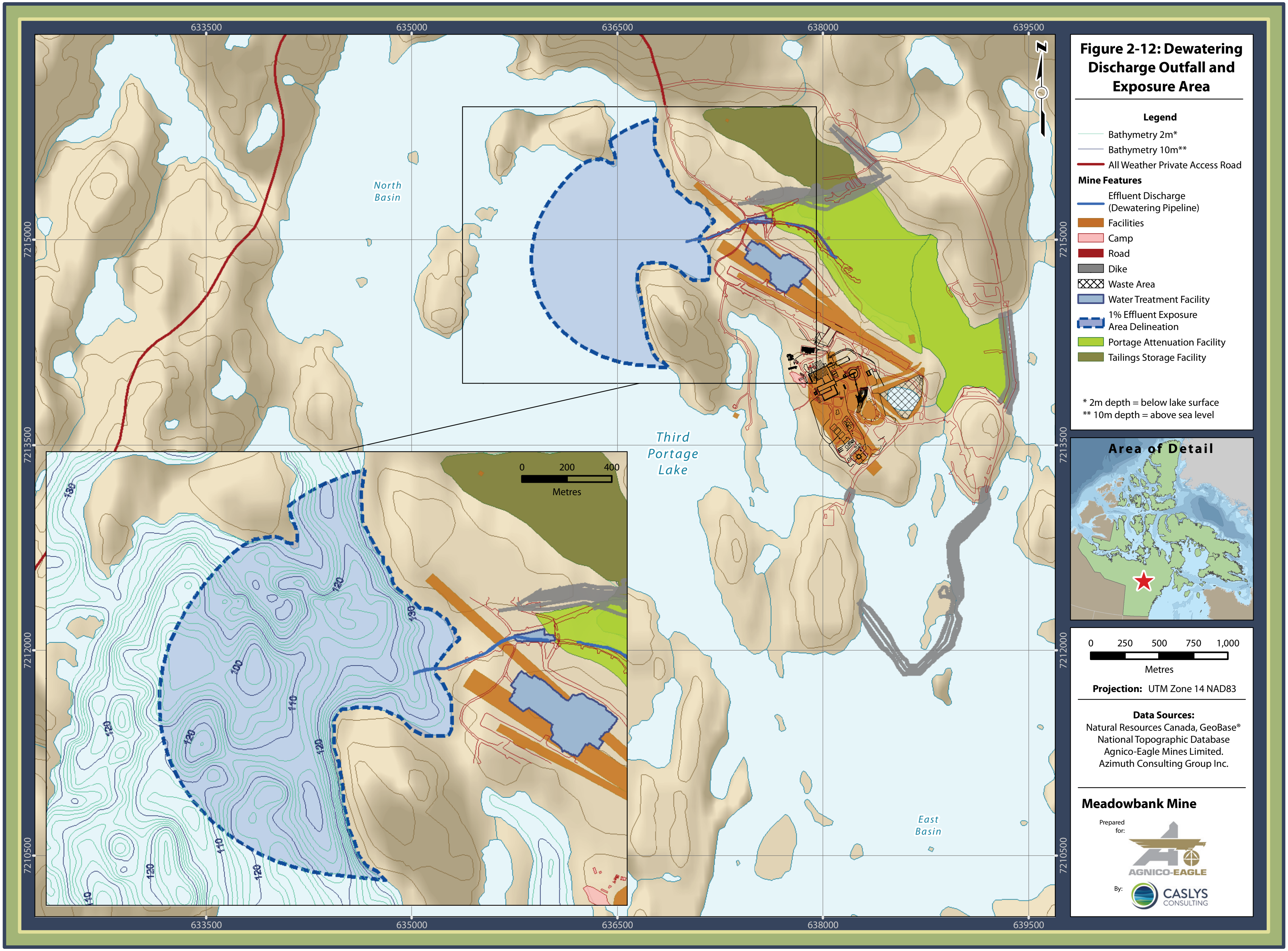


Figure 2-12: Dewatering Discharge Outfall and Exposure Area
Legend
Bathymetry 2m*
Bathymetry 10m**
All Weather Private Access Road
Mine Features
Effluent Discharge (Dewatering Pipeline)
Facilities
Camp
Road
Dike
Waste Area
Water Treatment Facility
1% Effluent Exposure Area Delineation
Portage Attenuation Facility
Tailings Storage Facility
* 2m depth = below lake surface
** 10m depth = above sea level
Area of Detail
0 250 500 750 1,000
Metres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Meadowbank Mine
Prepared for:
AGNICO-EAGLE
By:
CASLYS CONSULTING
North Basin
Third Portage Lake
East Basin
0 200 400
Metres
633500
635000
636500
638000
639500
7215000
7213500
7212000
7210500

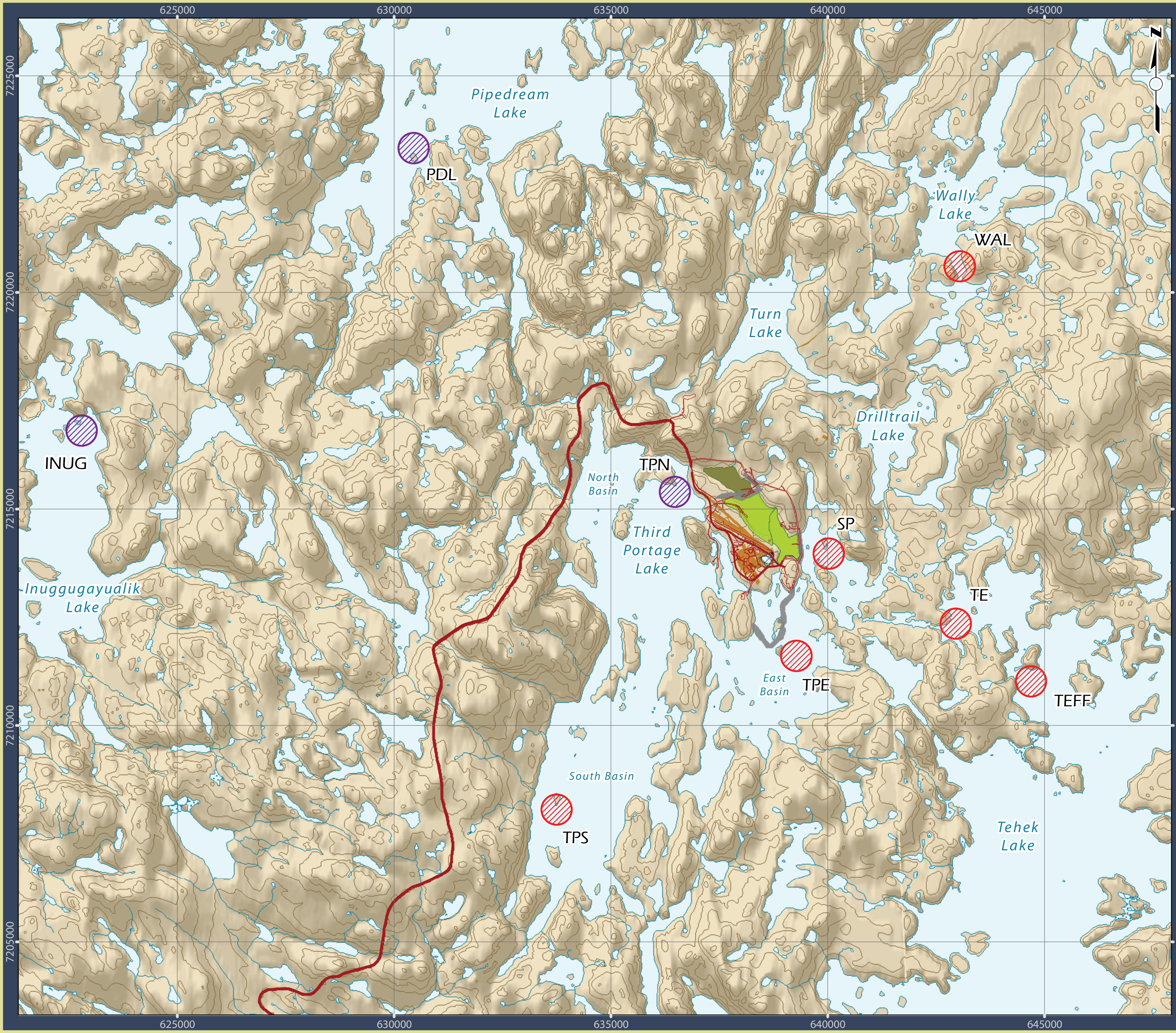


Figure 2-13: CREMP Sediment Quality and Benthic Invertebrate Sampling Stations - 2010

Legend

- All Weather Private Access Road
- CREMP Sampling Station
- EEM/CREMP Sampling Station

Mine Features

- Facilities
- Camp
- Road
- Dike
- Waste Area
- Portage Attenuation Facility
- Tailings Storage Facility

0 1 2 3

Kilometres

Projection: UTM Zone 14 NAD83

Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.

Meadowbank Mine

Prepared for: AGNICO-EAGLE

By: CASLYS CONSULTING

Figure 2-14. Temperature (°C) and dissolved oxygen (mg/L) profiles for Third Portage Lake– North Basin, 2009.

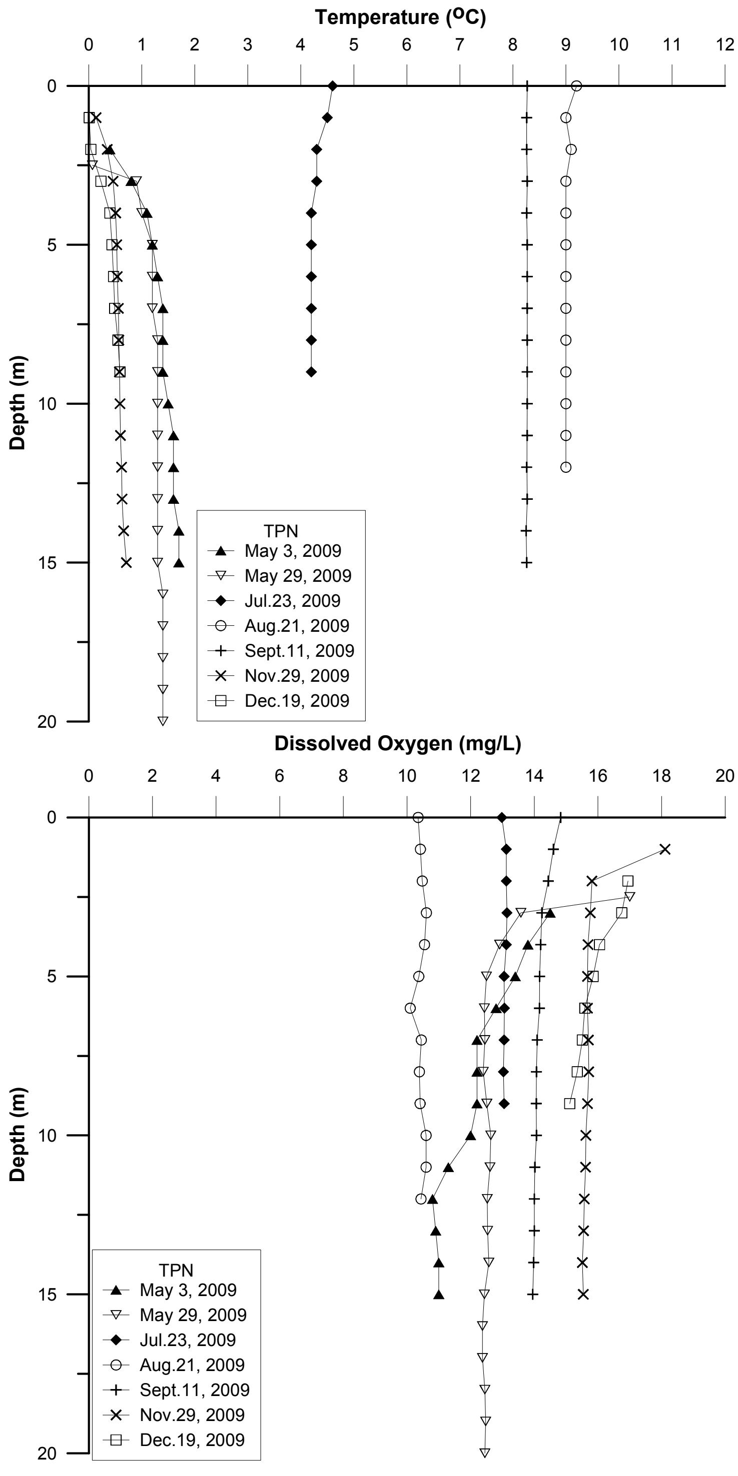
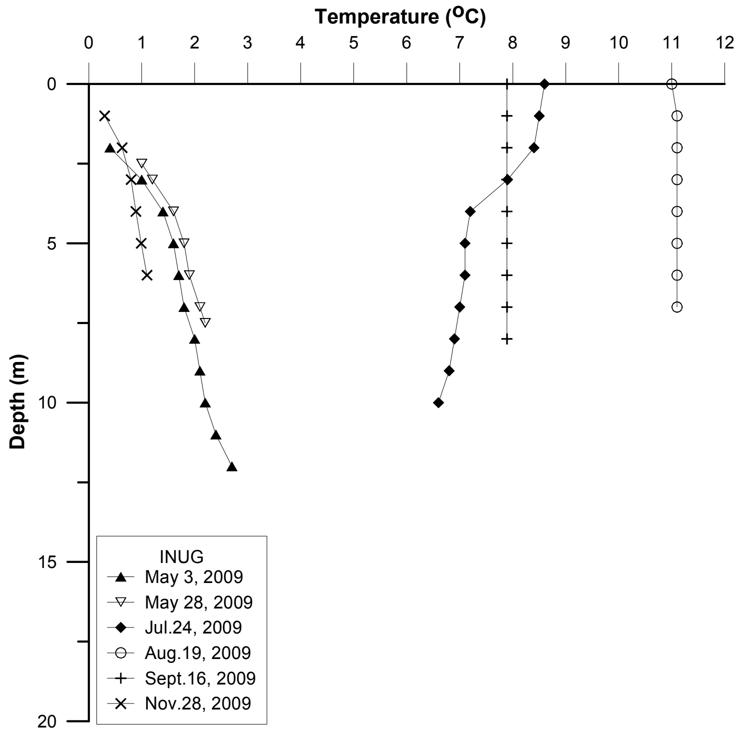


Figure 2-15. Temperature (°C) and dissolved oxygen (mg/L) profiles for Inuggugayualik Lake, 2009.



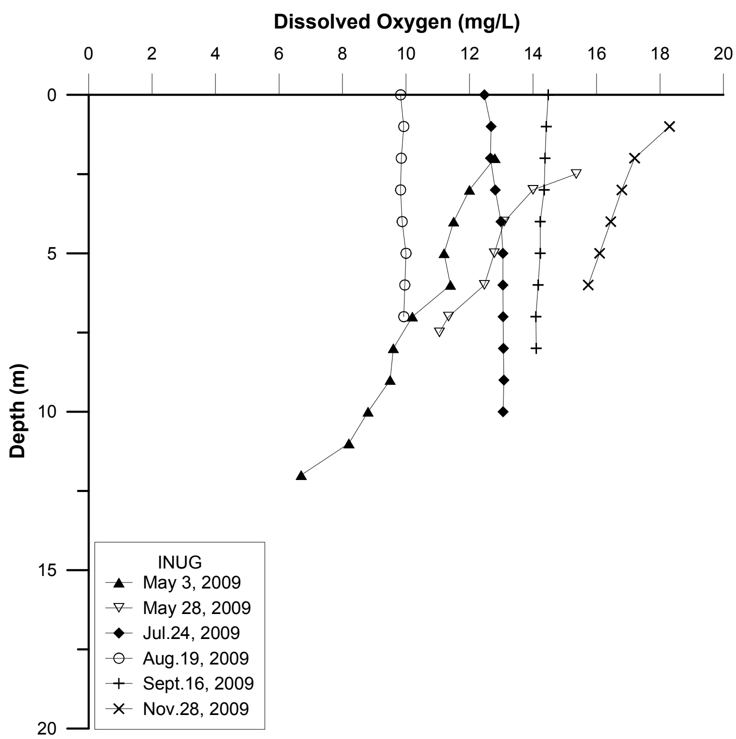


Figure 2-16. Temperature (°C) and dissolved oxygen (mg/L) profiles for Pipedream Lake, 2009.

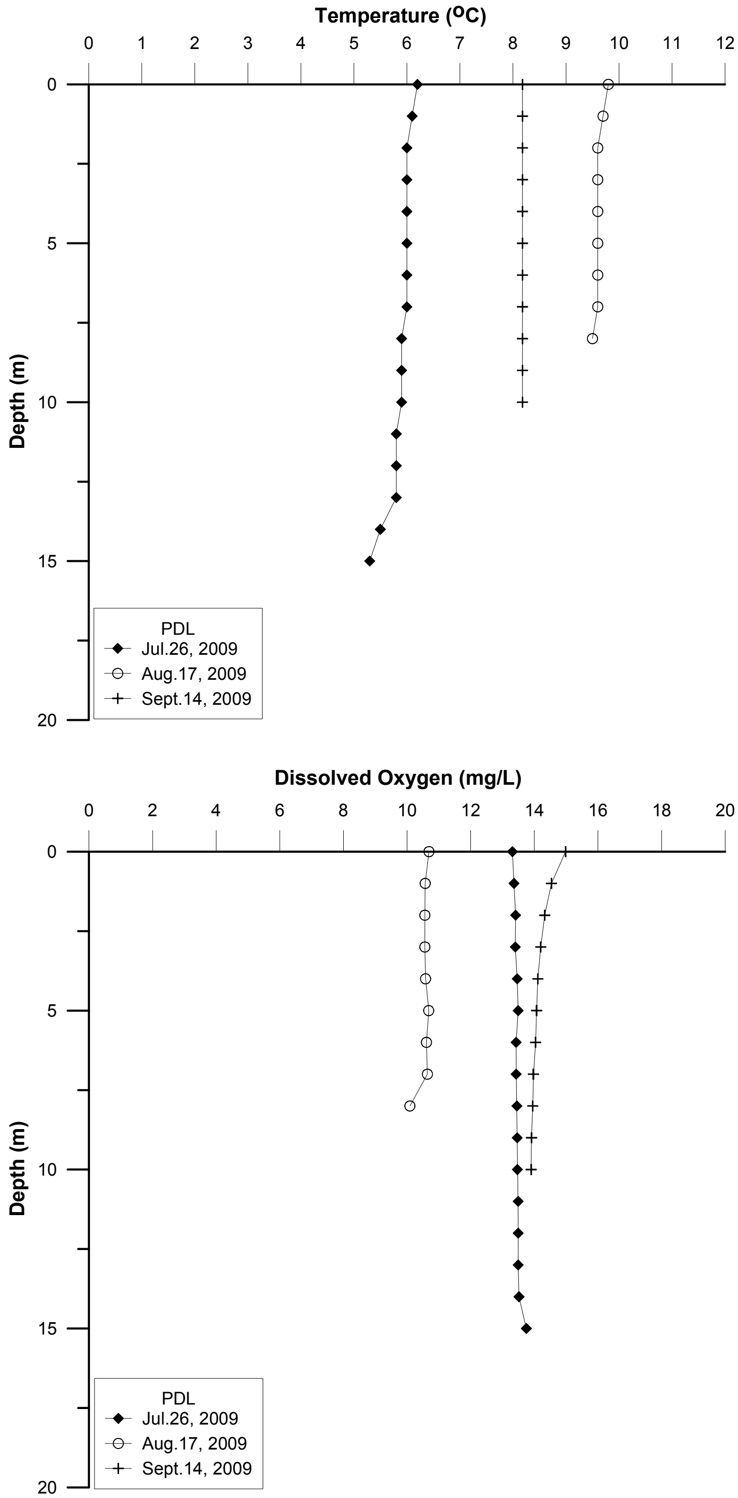


Figure 2-17. Relative biomass (%) of periphyton taxa, Meadowbank Lakes.

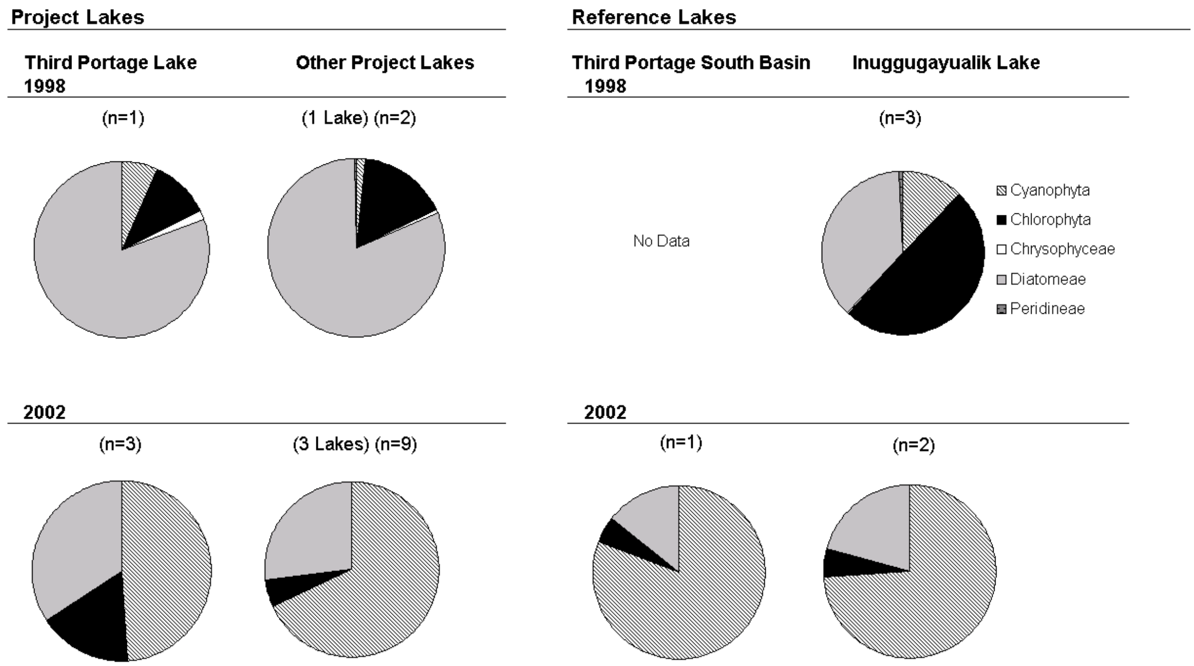


Figure 2-18. Comparison of mean phytoplankton biomass (mg/m3) by major taxa group, Meadowbank and Regional Arctic Lakes.

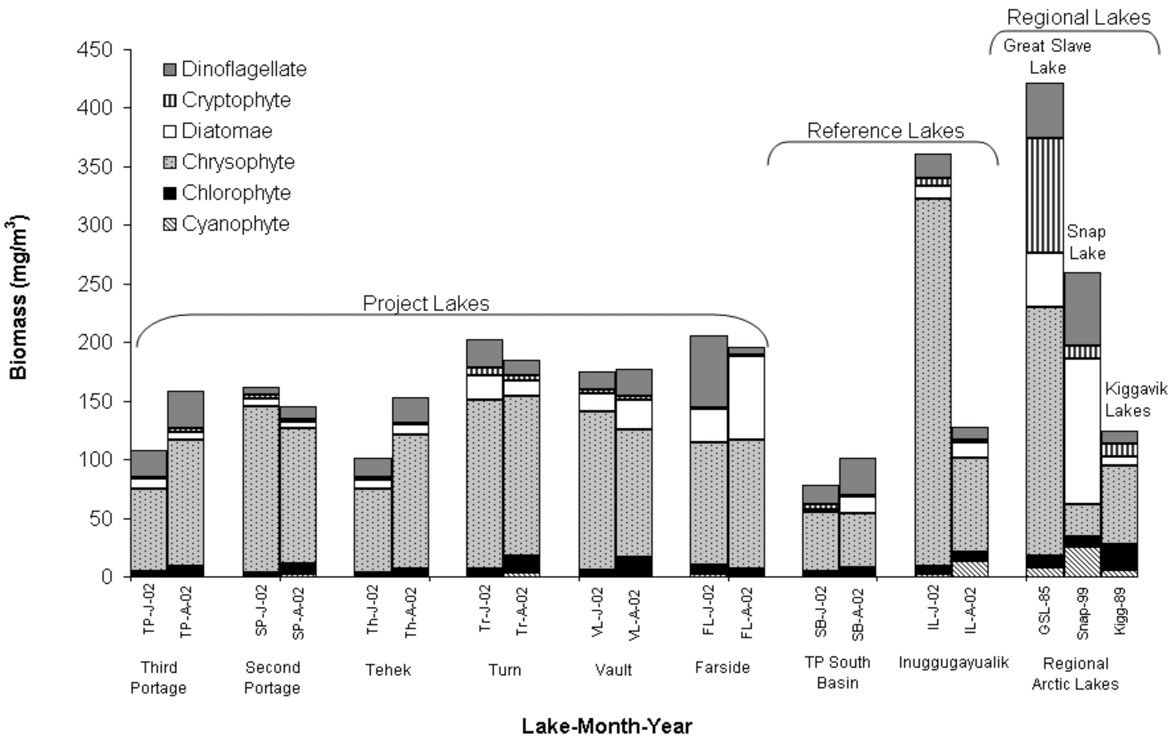


Figure 2-19. Phytoplankton biomass (ww) results for Third Portage Lake areas (TPE, TPN, TPS) from July 2006 to September 2009 (CREMP data set). Dashed line shows approximate onset of Bay-Goose Dike construction.

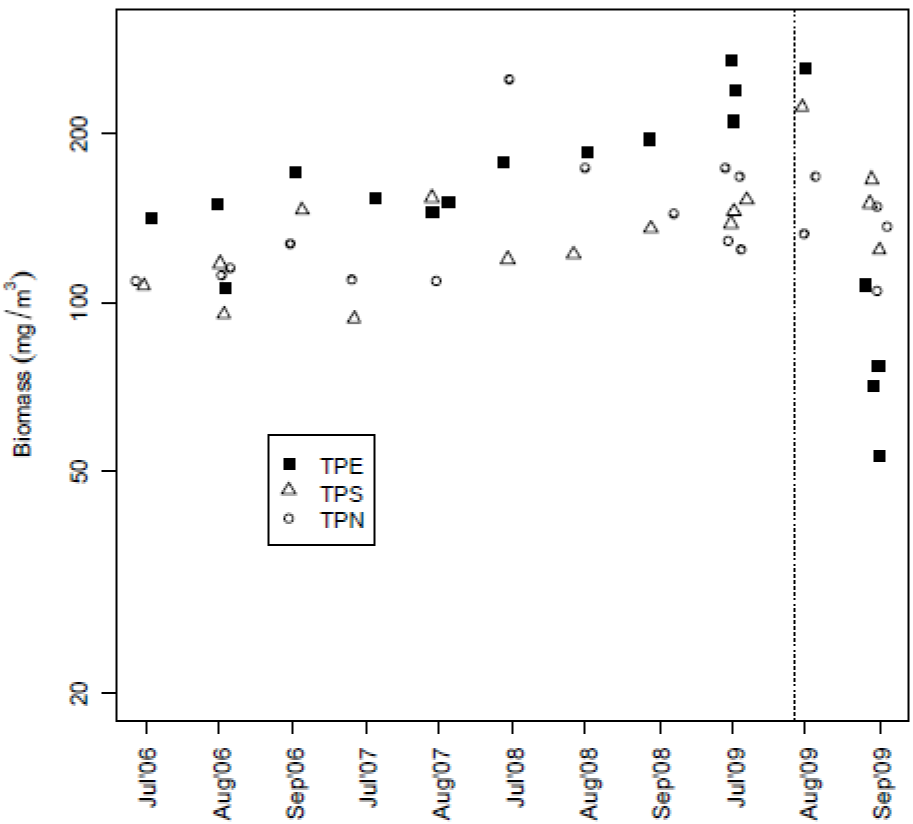


Figure 2-20. Phytoplankton CREMP.Phytoplankton biomass (ww) results for Third Portage Lake areas (TPE, TPN, TPS) from September 2009 to December 2009 (CREMP data set).

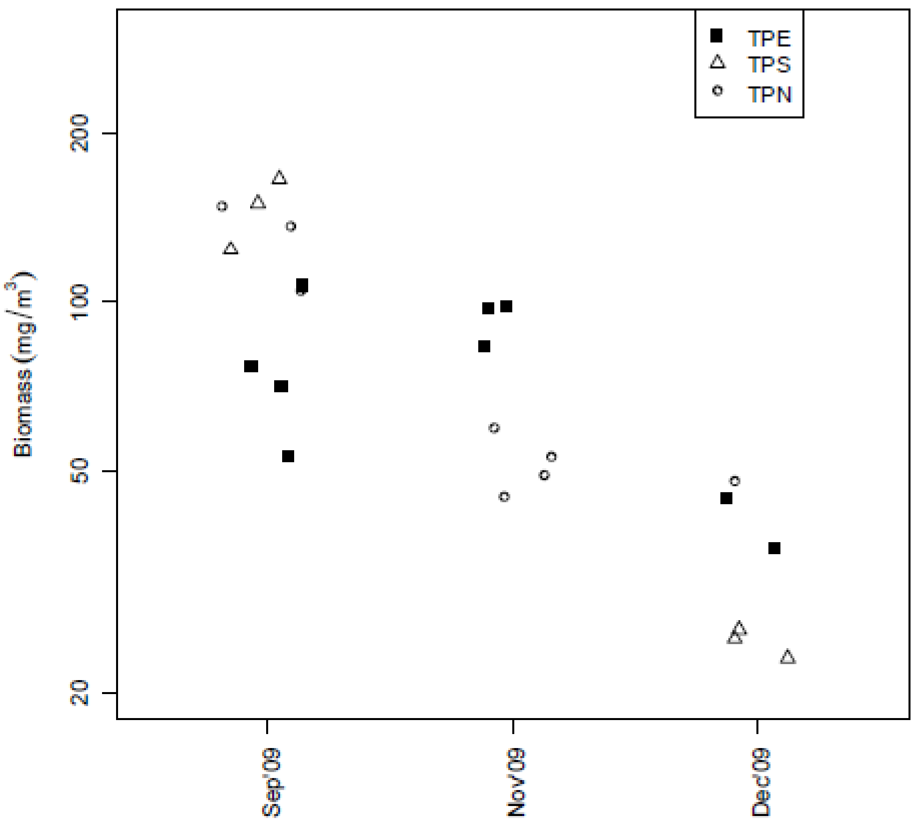


Figure 2-21. Relative abundance (%) of major zooplankton taxa from 1997 to 2002, Meadowbank Project Lakes.

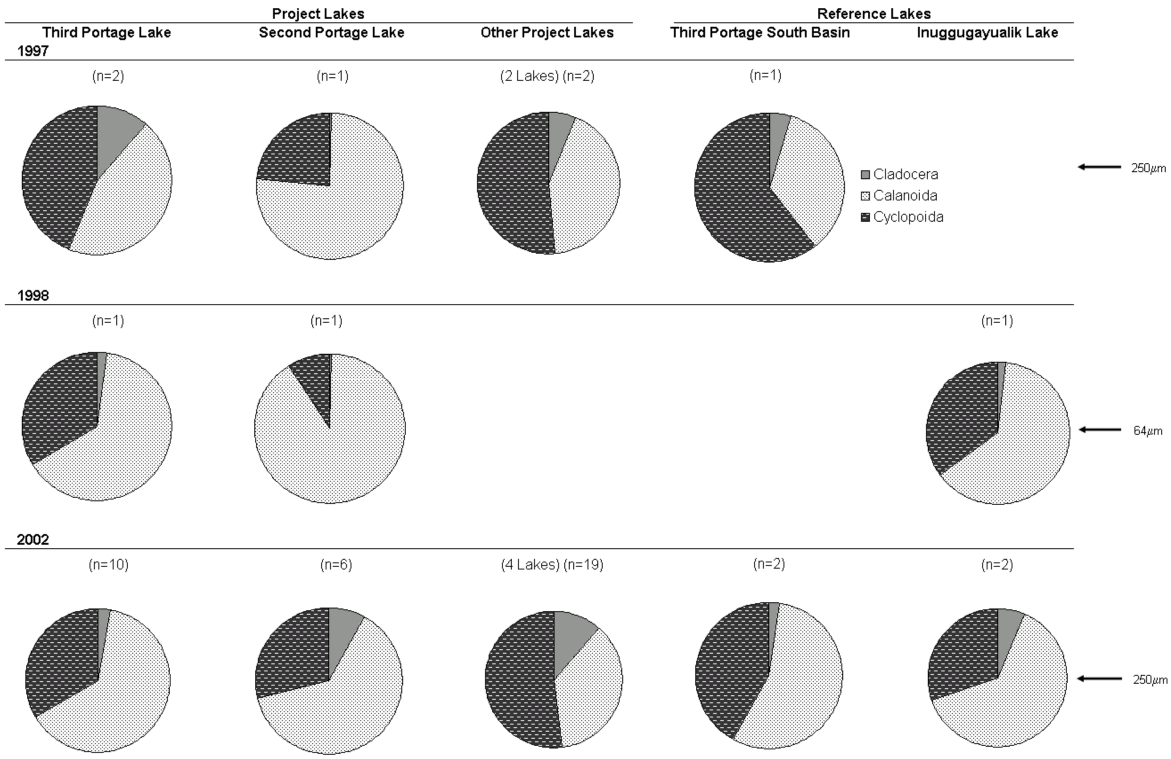


Figure 2-22. Relative Abundance (%) of Major Benthic Invertebrate Taxa in Project & Reference Lakes, 1997– 2002 (250 µm sieve).

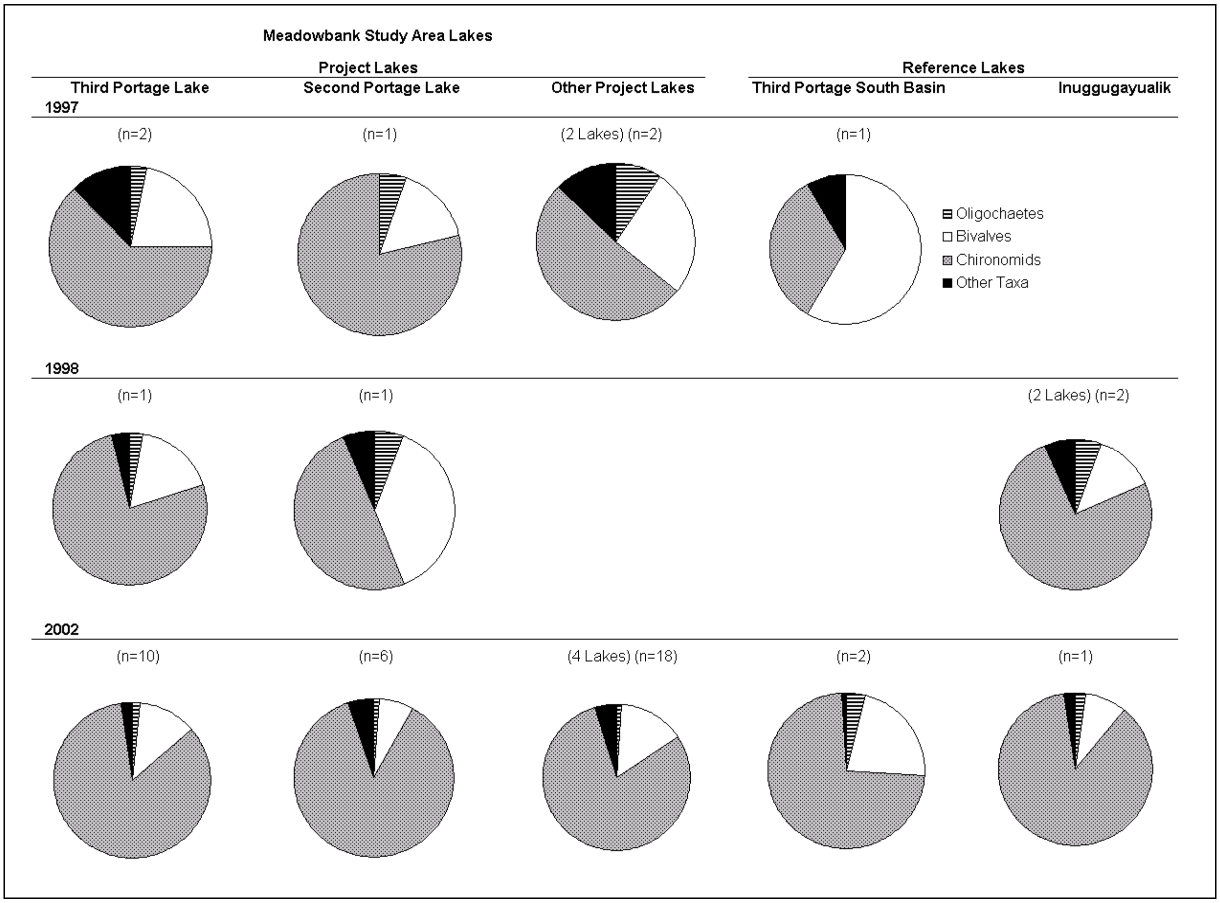


Figure 2-23. Comparison of mean benthic invertebrate density by major taxa group, Meadowbank project and regional lakes.

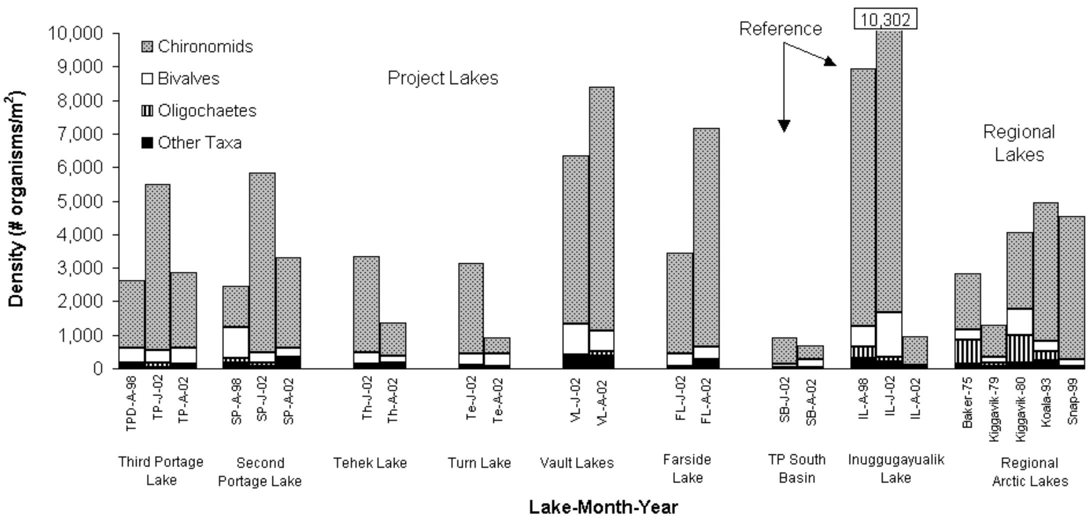


Figure 2-24. Benthic invertebrate replicates of abundance by major taxa group for the CREMP data set, August 2006 - 2009.

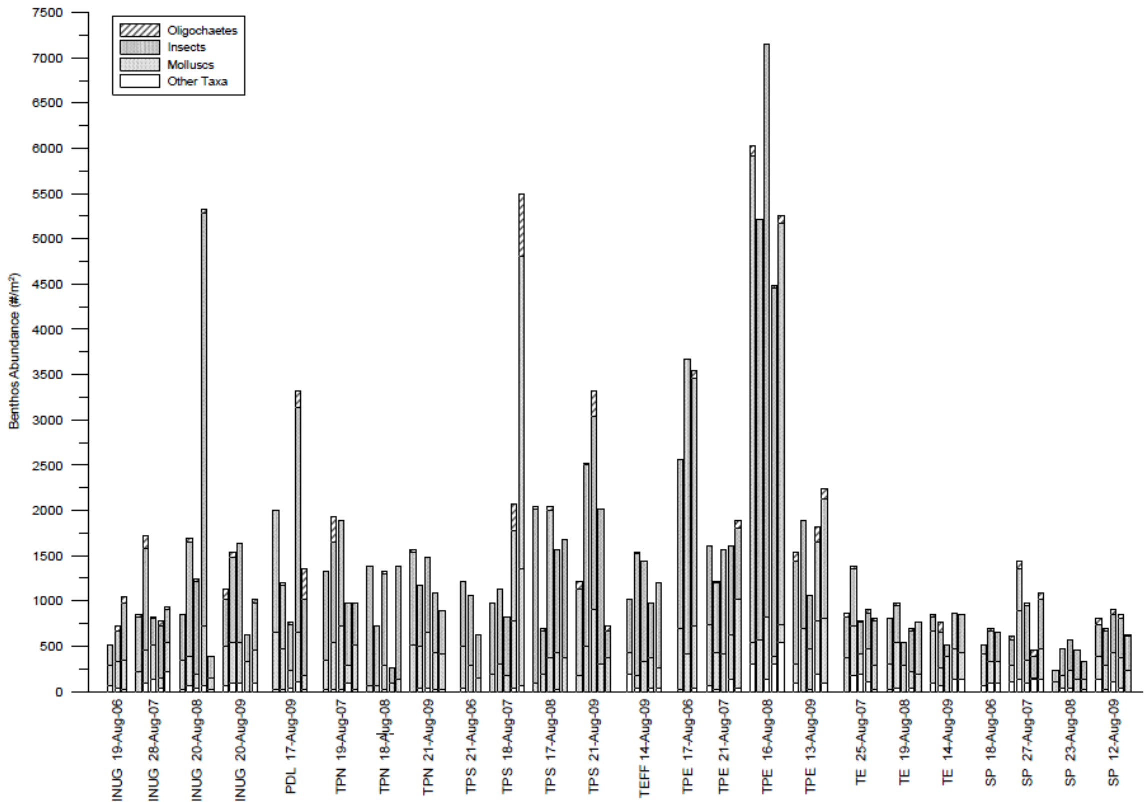


Figure 2-25. Historical baseline fish surveys, Meadowbank Mine, BAER 2005.

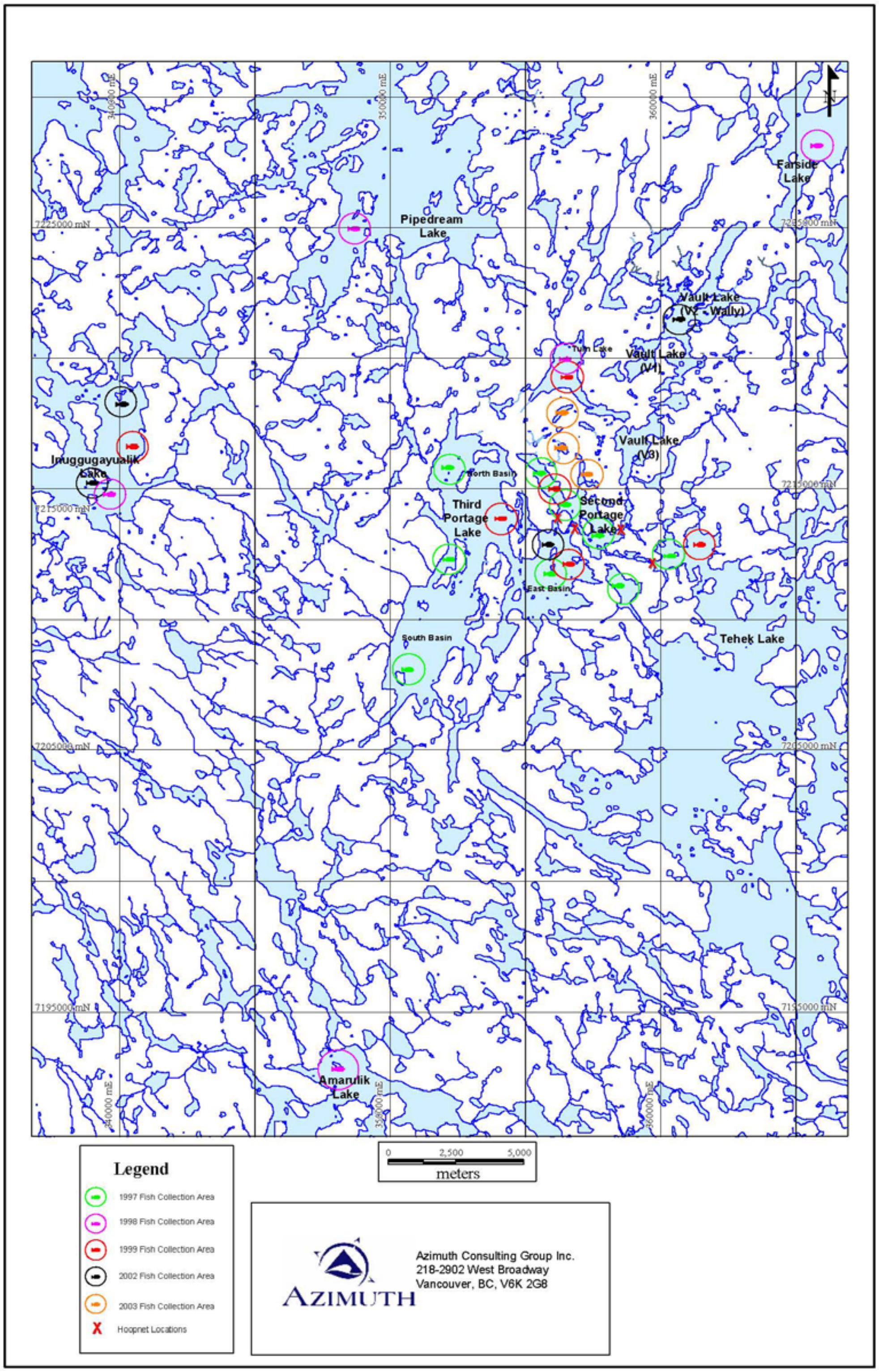
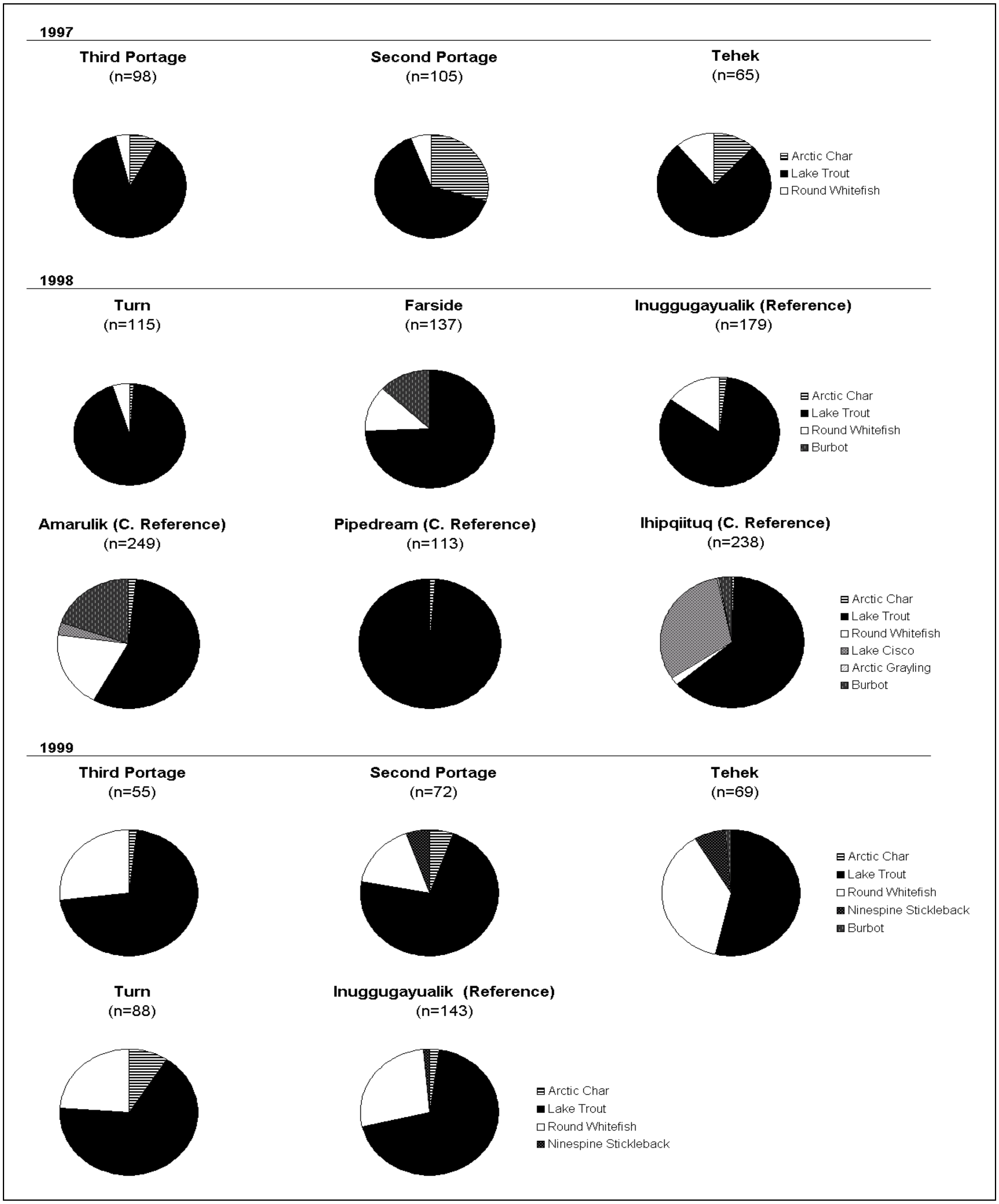


Figure 2-26. Relative abundance of fish species in Meadowbank study area lakes, 1997 to 1999.



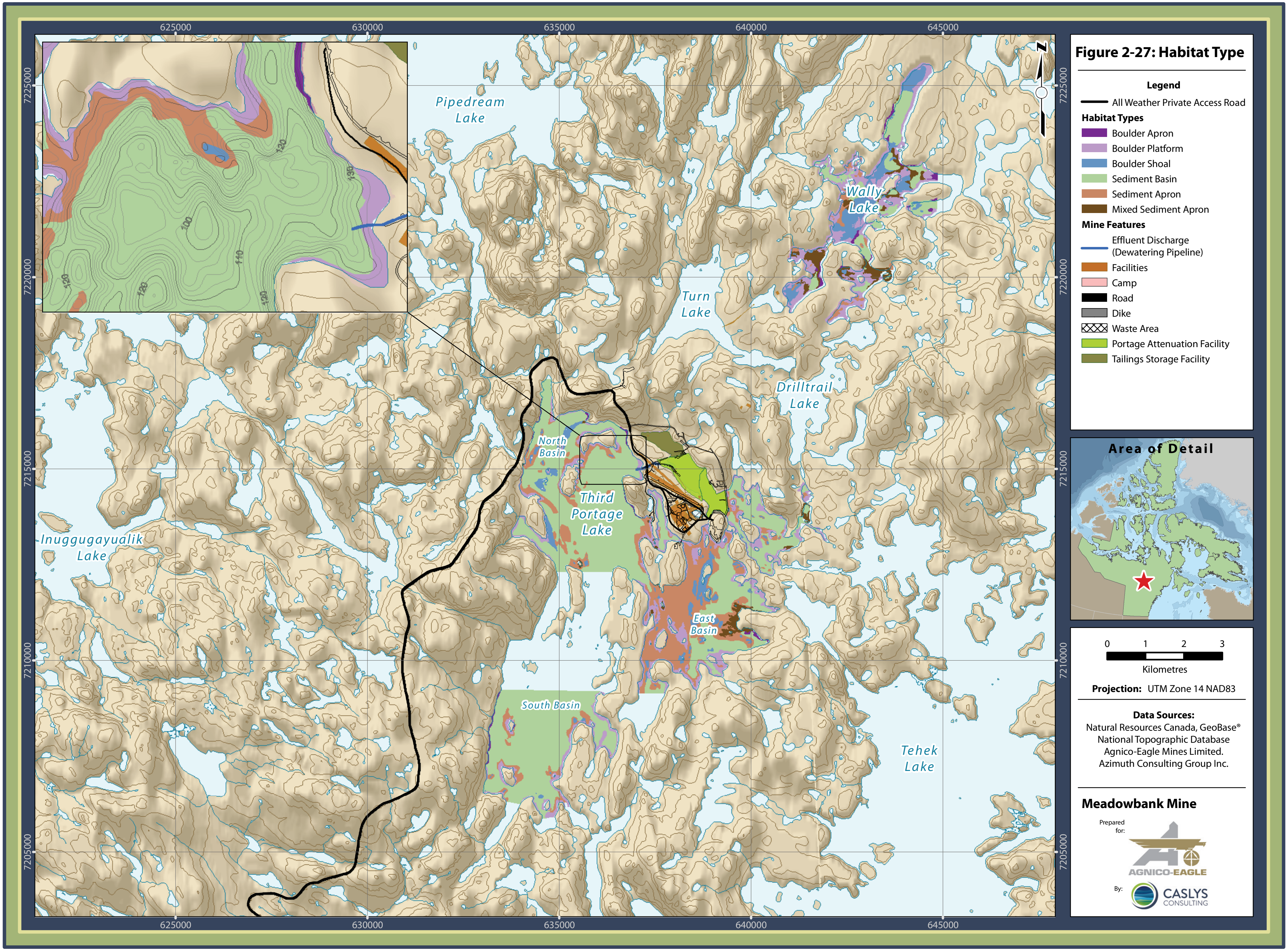


Figure 2-27: Habitat Type

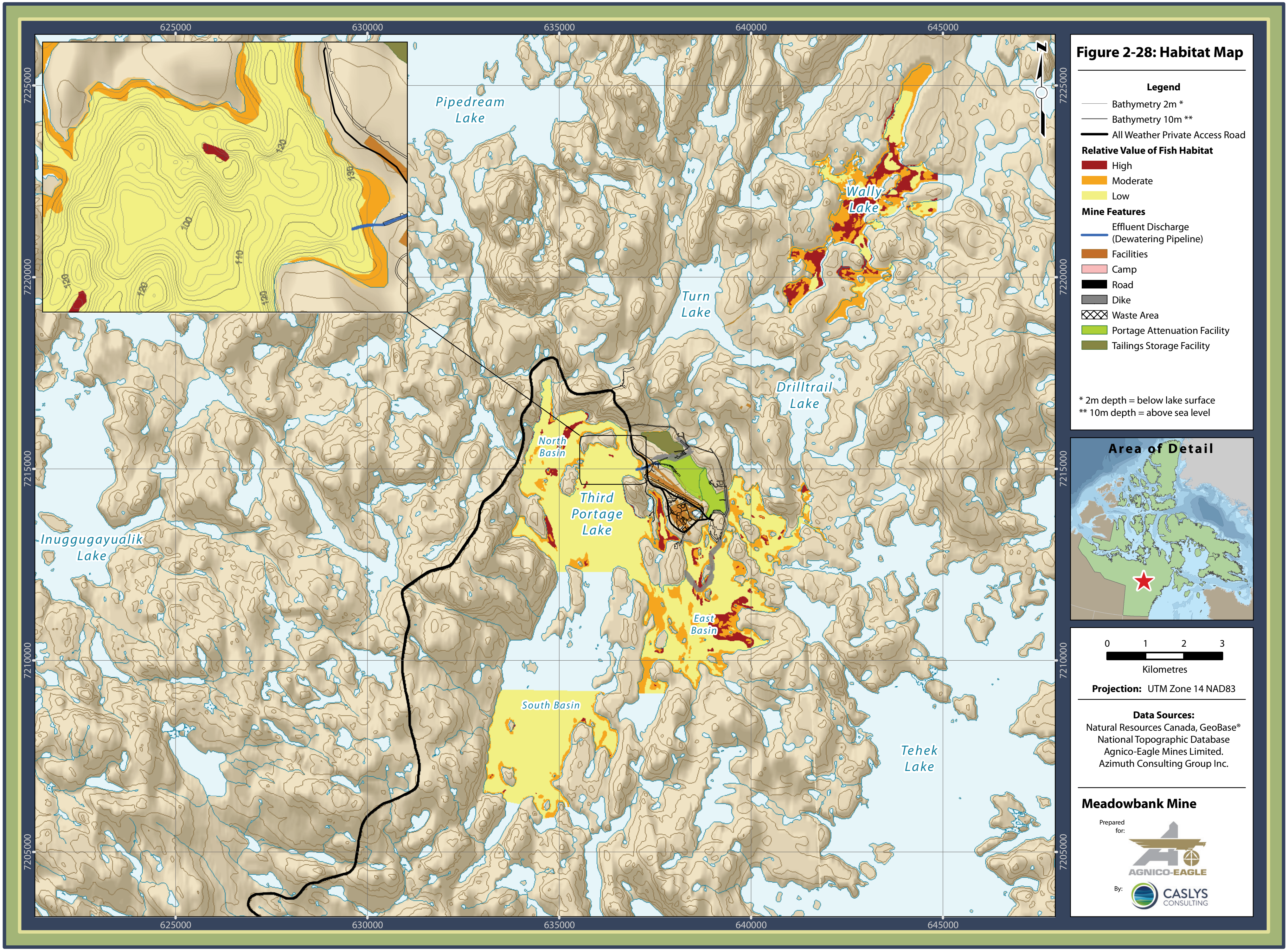
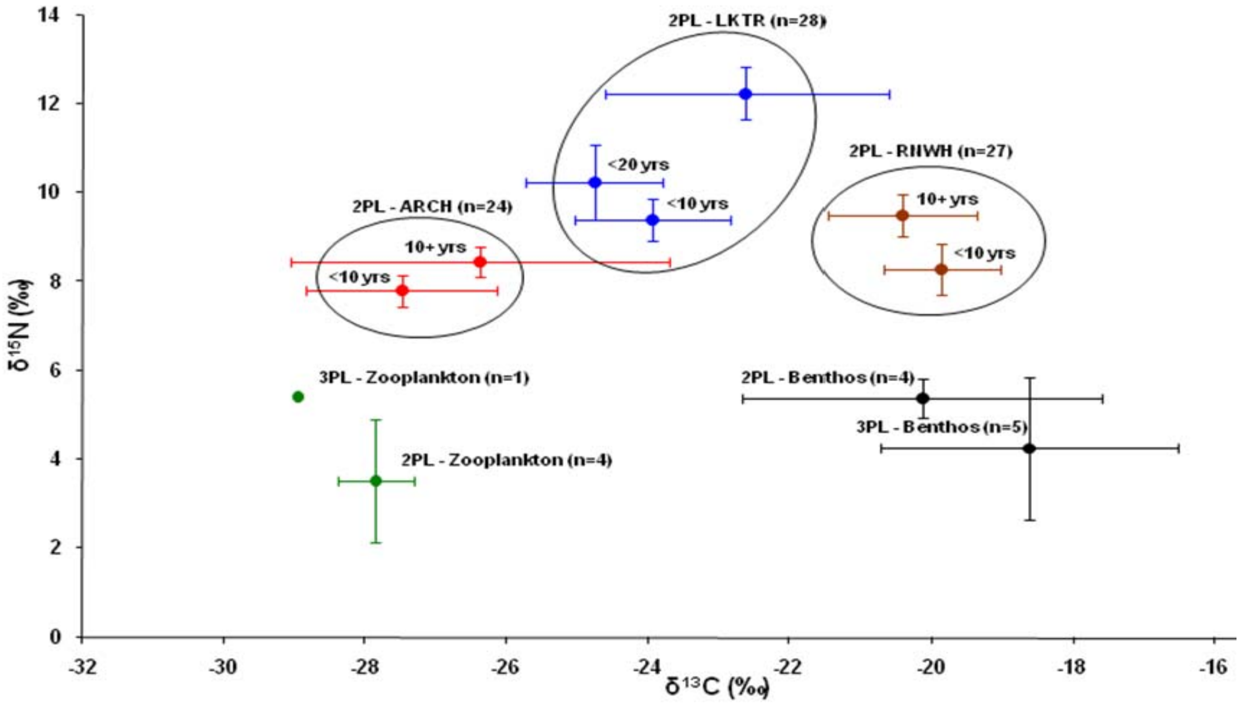


Figure 2-28: Habitat Map

Figure 2-29. Mean (±SD) benthos, zooplankton and fish δ15N (‰) and δ13C (‰) value plots for Second and Third Portage Lakes, 2008.



Note: 2PL=Second Portage Lake; 3PL=Third Portage Lake; ARCH=arctic char; LKTR=lake trout; RNWH=round whitefish.

3. EEM CYCLE ONE STUDY DESIGN OVERVIEW

3.1. Study Design Considerations

The presence of anthropogenic-related adverse ecological effects in the field is usually determined using spatial (e.g., comparisons between an exposure [impact = “I”] area and one or more reference [control = “C”] areas) and/or temporal (e.g., comparison of pre- [before = “B”] and post- [after = “A”] exposure conditions at the same location) comparisons. Generally, expanded designs including replication at the area level (i.e., multiple reference and exposure areas) or time level (multiple before and after events) make the design more robust. However, such replication may not be possible in the real world (e.g., with a single effluent outfall, there can only be one exposure area). Without at least some replication at the area or time level, results of both the CI and BA designs can be clouded by uncertainty (i.e., are detected effects due to the effluent or to inherent differences in space or time). The designs are improved by combining spatial and temporal elements into a BACI.

An additional study design improvement is the incorporation of multiple reference areas to capture natural variation in biological communities inherent to the study area lakes. Although the current recommendation for EEM is the use of a single reference area, the use of multiple references can strengthen the interpretation of differences. For example, a single reference area may differ from the exposure area(s) with respect to several natural variables in addition to effluent exposure. This may lead to making erroneous conclusions that differences among areas are mine-related. The use of multiple references offers a greater ability to discern meaningful differences.

3.2. EEM Study Design

Sampling areas for the Meadowbank EEM study are as follows (see **Figure 3-1** for map and **Table 3-1** for general UTM coordinates):

- *Exposure Area* – the NW portion of the north basin of Third Portage Lake (TPN) is situated within the zone of 1% effluent dilution defining the exposure area (see **Section 2.5**). The exact sampling locations within the exposure area will be dictated by the study component: fish will be sampled in the entire exposure area (and potentially beyond, if necessary to catch sufficient numbers); benthos (and sediment quality) will be sampled at the location of the CREMP TPN sediment and benthos sampling area (i.e., see blue circles on **Figure 3-1**) over a depth range of 8 to 11 m (to be consistent with historical CREMP data; see **Section 5** for more details); routine EEM water quality monitoring will also be conducted at the same time (see **Section 6** for more details).

- *Reference Areas* – The reference areas, Inuggugayualik Lake (INUG) and Pipedream Lake (PDL), have been selected for the EEM study on a number of merits:
    1. Neither lakes, which are situated in the adjacent Back River watershed, are exposed to any anthropogenic influences (mining or otherwise).
    2. Both lakes are fairly similar in ecoregion, geology, morphometry, and habitat and substrate types to TPN. While habitat value for fish use has not been specifically evaluated for INUG or PDL, the physical habitat (slope and depth; **Figure 3-1**) and limnology (temperature, and dissolved oxygen; see **Figure 2-14 to 2-16**) are similar to TPN. As described in **Section 2.6.5.4**, there are some differences in fish species composition; these are discussed in more detail in **Section 4**.
    3. Both areas were targeted in baseline studies (**Section 2.6**), providing some temporal context for interpreting study results.
    4. Both areas are monitored on a routine basis in the CREMP.
    5. In addition to being utilized as reference areas in historic biological studies at Meadowbank Mine, INUG and PDL have reference area characteristics that are key for identifying effects on the high exposure area. Neither reference area is exposed to effluent as both are in a separate drainage basin to the location of the dewatering effluent discharge. While the reference areas are in a different watershed (Back River watershed) to the exposure area (Chesterfield Inlet watershed) the lakes are all similar in. They are also located within 15 km of the exposure area, and are relatively accessible for field crews.

Where baseline data exists and is appropriate to support a BACI approach, we will incorporate historical data into the analyses. Where such data area unavailable or unsuitable, we will follow the CI design with multiple reference areas. The specific approaches for the fish study and benthic invertebrate study are discussed in greater detail in **Sections 4.4 and 5.3,** respectively.

Table 3-1. Location of EEM exposure and reference sampling areas.

EEM Sampling Area		UTM location (14NAD83)*	
Type	**Name**	**Latitude (E)**	**Longitude (N)**
Exposure	Third Portage Lake North (TPN)	636473.86	7215394.92
Reference	Inuggugayualik Lake (INUG)	622797.39	7216811.12
Reference	Pipedream Lake (PDL)	630450.73	7223330.63

** UTM indicates the centre of the sampling area circle, with a radius of ~350 m.*

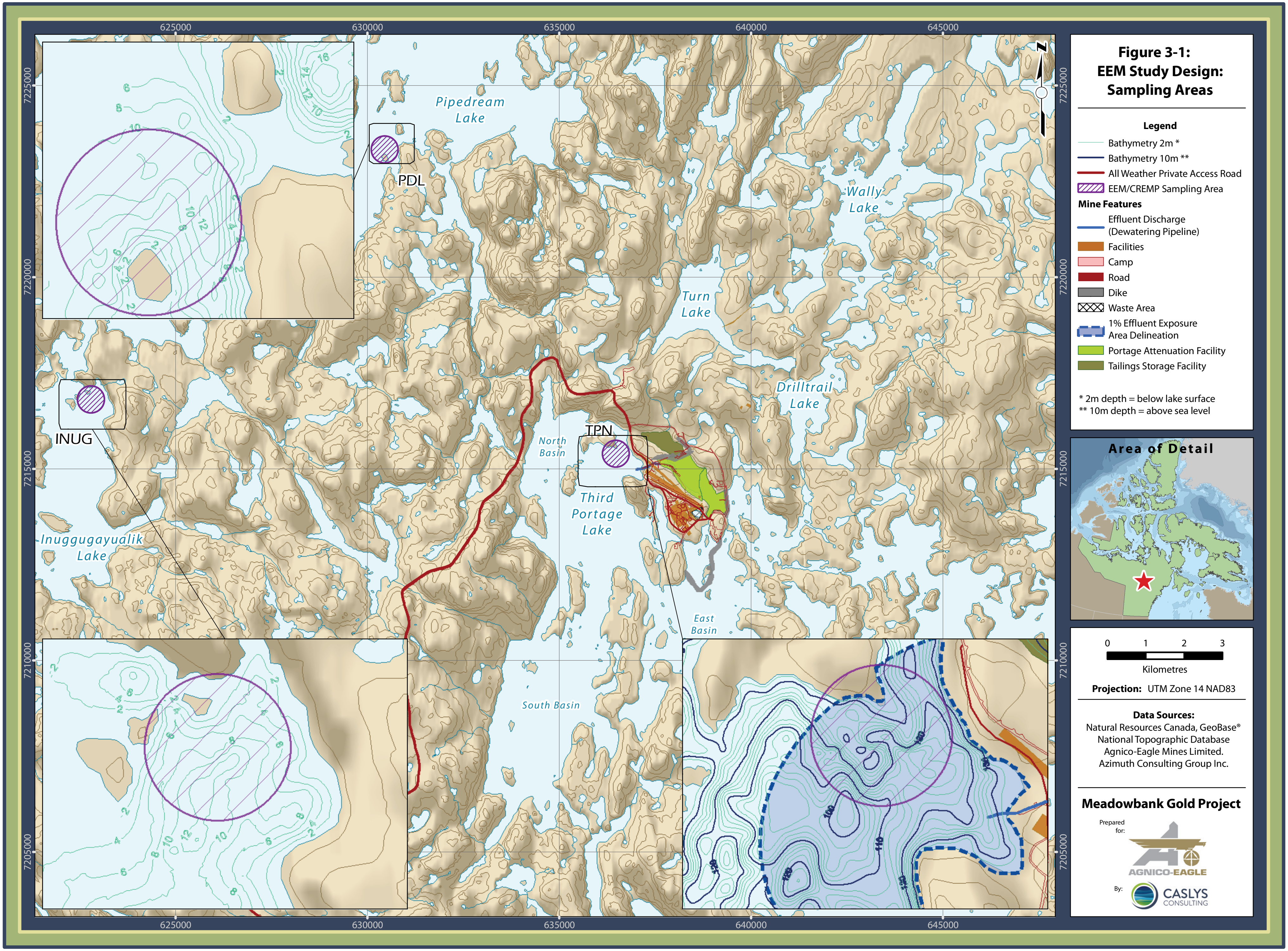


Figure 3-1:
EEM Study Design:
Sampling Areas
Legend
Bathymetry 2m *
Bathymetry 10m **
All Weather Private Access Road
EEM/CREMP Sampling Area
Mine Features
Effluent Discharge (Dewatering Pipeline)
Facilities
Camp
Road
Dike
Waste Area
1% Effluent Exposure Area Delineation
Portage Attenuation Facility
Tailings Storage Facility
* 2m depth = below lake surface
** 10m depth = above sea level
Area of Detail
0 1 2 3
Kilometres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase® National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Meadowbank Gold Project
Prepared for:
AGNICO-EAGLE
By:
CASLYS CONSULTING
Pipedream Lake
PDL
Wally Lake
Turn Lake
Drilltrail Lake
INUG
TPN
North Basin
Third Portage Lake
Inuggugayualik Lake
East Basin
South Basin
625000
630000
635000
640000
645000
7225000
7220000
7215000
7210000
7205000

4. FISH SURVEY

This section outlines our strategy for conducting a fish survey at the Meadowbank Mine. As discussed in **Section 2.3.2**, tissue analysis is not required for this Study Design as mercury concentrations in effluent have not exceeded the tissue analysis trigger of 0.1 µg/L. Based on an effluent modeling study (**Section 2.5**); however, effluent concentrations at 250 m from the discharge point are expected to be higher than 1%, thus triggering the fish survey. The survey will target lake trout (*Salvelinus namaycush*) and round whitefish (*Prosopium cylindraceum*); rationale for this selection is presented in **Section 4.3**.

The remainder of this chapter is organized as follows:

- Historical data
- Overview and Site-specific Information
- Fish Species Selection
- Sampling Area and Sample Size
- Proposed Methods

4.1. Historical Data

As described in **Section 2.6.5.4**, fish studies at Meadowbank fall into two categories: baseline and fish out. The former are similar in nature to most fisheries studies in that they were typically conducted using bottom-set indexed gillnets (1" – 6") over a period of less than a week; as a result, data represent a snapshot of the underlying populations and/or communities. Fish-out studies, while using similar collection methods, were conducted over a much longer period with the ultimate goal of removing all fish.

Figure 4-1 and 4-2 show density plots of length for lake trout and round whitefish, respectively, for all baseline and fish-out studies conducted to date. The fish-out studies, conducted in the northwest arm of Second Portage Lake (2008) and in the Bay-Goose portion of Third Portage Lake (2009), show a considerably different size structure in both the lake trout (*Salvelinus namaycush*) and round whitefish (*Prosopium cylindraceum*) populations of each lake compared to the baseline studies. This is due to size-related differences in catchability over time. In general, the index gill netting surveys catch proportionately larger fish with a greater focus on lake trout and whitefish. Fish-out studies confirmed that proportionately more large fish are caught in the earlier stages of the program while smaller fish and greater proportions of small Arctic char and burbot are captured later in the program. Thus, the results of the shorter baseline studies are biased to over-estimating larger size classes in the population.

Figure 4-3 shows the fish community composition in study area lakes based on the combined baseline and fish-out studies. In general, the community compositions of Third Portage and Second Portage lakes do not appear much different than the baseline-only results discussed in **Section 2.6.5.4**. Both lakes are dominated, in descending order of relative abundance, by lake trout, Arctic char (*Salvelinus alpinus*) and round whitefish. While rarely captured in any of the project lakes during baseline studies, a number of burbot (*Lota lota*) were caught during both fish-out studies. Small-bodied species such as sculpin (*Cottus* sp.) and ninespine stickleback (*Pungitius pungitius*) were infrequently caught despite a number of targeted attempts using minnow traps (1999, 2008, 2009) and electro-shocking (2010; **Appendix D**).

A summary of fish sampled by species, lake and year is presented in **Table 4-1**. Additional discussion of baseline data as it pertains to the two target species is presented in **Section 4.3**.

4.2. Overview and Site-specific Considerations

A fish survey is required by EC for MMER if the discharged effluent concentration is >1% at 250 m from the effluent discharge point, which is predicted for this mine.

It is important to note that this requirement does not reflect effluent quality. As discussed in **Section 2.3.1**, the discharge into the north basin of Third Portage Lake consists of turbid lake water (treated to reduce suspended solids) from dewatering activities in the northwest arm of Second Portage Lake. As discussed in **Section 2.3.2**, dewatering effluent quality is generally good, with TSS as the only deleterious substance routinely elevated. Metals concentrations are typically well below discharge limits.

In support of designing an effective EEM study it is important to understand the potential effects of TSS into perspective, the following As discussed in **Section 2.4**, dike construction activities resulted in elevated TSS concentrations across large portions of Second Portage Lake (2008) and the east basin of Third Portage Lake (primarily 2009). In advance of dike construction (in support of the development of a water quality monitoring program for dike construction), a detailed review of the potential effects of suspended solids to fish and other aquatic life was conducted (AEM, 2008). The review entailed a re-analysis of the more than 300 data sets compiled by Caux et al. (1997), upon which the CCME TSS guidelines were based. The early life stages of salmonids were identified as the group most sensitive to the direct effects of TSS exposure. However, direct effects were only associated with much higher TSS concentrations than those found in the TPN exposure area (see **Section 2.4**), which were generally < 1 mg/L.

In order to better understand the ecological significance of construction-related elevations in TSS, AEM initiated a TSS Effects Assessment Study (EAS) in 2008 (Azimuth, 2009) to address concerns regarding potential impacts of TSS to the aquatic environment. The

EAS targeted a wide range of ecosystem elements, including fish, and was essentially repeated in 2009. A suite of toxicity tests was conducted to address direct effects to various life stages of fish (i.e., 96-hr rainbow trout juvenile survival; 7-day rainbow trout embryo development; 7-day rainbow trout larvae survival and growth). Results of toxicity tests support the literature findings in that no adverse direct effects were detected (samples tested contained approximately 10 mg/L TSS). The EAS studies did find depressed phytoplankton biomass in both 2008 (Second Portage Lake) and 2009 (east basin of Third Portage Lake) in association with elevated TSS. However, this trend did not cascade up the food chain to zooplankton biomass during the one-month exposure period (Azimuth, 2009b, c; 2010d).

Based on the low (< 1 mg/L) measured exposure area TSS concentrations to date and the EAS results, we would not expect direct effects to fish. The most plausible potential effects would be indirect, via suppression of primary production and concomitant reductions to zooplankton biomass, or via reduced benthic invertebrate biomass from sediment-related smothering. Reduced food supply could result in changes to fish growth patterns over time.

One challenge that this situation poses is the lack of a good exposure indicator for TSS. Ideally, the EEM study would include either small-bodied fish (i.e., a species with a limited home range) or a good quantitative measure of exposure (e.g., metallothionein for a metals-rich effluent). Given the lack of small-bodied fish and the large size of Third Portage Lake, there will be some uncertainty as to the degree to which the target species are exposed to the Meadowbank Mine effluent.

Another point to consider is the community's sensitivity to lethal sampling of fish[6]. This sensitivity was addressed to some degree by minimizing destructive sampling of fish during subsequent baseline fisheries programs and especially during the 2008 fish-out program when all fish were distributed to the community (i.e., for consumption by humans or by dogs) after processing for scientific purposes.

4.3. Fish Species Selection

According to Environment Canada (2002), selection of fish species for monitoring purposes must be based on a number of criteria including exposure to effluent, relevance to the study area, and sensitivity to effluent, with the objective of determining population

[6] This became apparent during the baseline fish studies when an older Inuit field assistant broke down into tears after dead fish were placed back into a lake. "Where were these fish when my people were dying?" This was a direct reference to the serious famine that occurred in the late 1950s and was the impetus for the creation of the Hamlet of Baker Lake in the 1960s by the Government of Canada (and incidentally, to development of non-lethal tissue sampling by Baker et al., 2004).

level effects and usability of fish. Selected fish should be resident, easy to age, of high fecundity, include mature individuals, be relevant to the food chain, relatively sedentary, and be exposed to effluent over a long period.

There are multiple species of fish residing in the project area lakes (see **Figure 4-3** and **Table 4-1**). A summary of key characteristics of candidate species relevant to selecting the two target species is presented in **Table 4-2**. The major uncertainty with the recommended species, lake trout and round whitefish, is that their degree of exposure is unknown. While inter-lake movements were virtually nil (BAER, 2005), it is likely that both species will range extensively within and even among discrete basins of Third Portage Lake. Despite the limited occurrence of small-bodied fish, additional effort was expended in 2010, based on preliminary discussions with Environment Canada, to sample small-bodied fish in Third Portage Lake (See **Appendix D** for full documentation of the field effort). Electrofishing and baited minnow traps were used in an attempt to capture fish from nearshore areas where fish might be exposed to effluent. In 6323 seconds of electroshocking effort (102 minutes) only 3 slimy sculpin were captured. Minnow traps were equally ineffective with two sculpin and two ninespine stickleback collected from multiple traps set over multiple days. Lack of electrofishing success was attributable to low water conductivity and small body size of fish whereby the electrical field was ineffective at tetanizing fish. These results combined with historic fishing efforts for small bodied fish and the paucity of small body fish in the gut contents of predatory fish suggest that abundance of sculpin and stickleback is very low. In conclusion, there are too few small-bodied fish to use as a target species for the EEM program.

In summary, lake trout and round whitefish have been selected as target species for this EEM study. Lake trout are the top predator and dominant species in the project area lakes, feeding on other fish and smaller conspecifics. Round whitefish are smaller and faster growing, feeding primarily on benthic invertebrates (see **Figure 2-29**).

4.4. Sampling Area and Sample Size

A study design overview was presented in **Section 3.2**. This section provides additional details for key aspects of the program:

- **Sampling areas** – the design will include a single exposure area (TPN) and two reference areas (INUG and PDL[7]) (these areas were shown in **Figure 3-1, Table 3-1**).

[7] As shown in **Figure 4-3**, round whitefish were not found in PDL during the limited baseline sampling. However, based on regional patterns among lakes, we anticipate finding round whitefish in PDL with the

- **Lethal vs. Non-lethal** – the approach will vary by target species. For lake trout, we recommend conducting non-lethal sampling for the following reasons: (1) the effluent is primarily lake water with elevated TSS (see **Section 2.3.2**), (2) combined with baseline fish survey results (more than 100 lake trout were captured in each lake; see **Table 4-1**), a more robust BACI design could be used (see below), (3) survival of gill-net-captured lake trout was good in the 2010 fish-out transfers, (4) fish-out study results identified only 9% of the population as "current year spawners" and 8% were resting (Azimuth, 2009d), resulting in either high variability (i.e., if not addressed) or increased mortality as more fish would likely need to be opened to verify current reproductive status, and (5) this approach would address community sensitivity to wasting fish (see **Section 4.2**). For round whitefish, however, we recommend a lethal study because: (1) they do not survive capture in gillnets well, (2) they have a higher potential to experience adverse effects (as discussed in **Section 4.2**) so the wider range of endpoints resulting from a lethal study will make a more robust study.
- **Sample Size** – The sample size requirements differ for non-lethal and lethal studies. As per Environment Canada (2002), the non-lethal study for lake trout will require a minimum of 100 fish per area (i.e., 300 or more in total) and the lethal round whitefish study requires a minimum of 20 sexually mature fish of each sex at each area (i.e., 120 fish in total). Any incidental lake trout mortalities will be processed according to the methods used in the lethal study (e.g., age structures collected and gonads/liver weighed). *A priori* power analysis was conducted to ensure that the EEM-recommended sample sizes were adequate, details were as follows:
    - *General Procedures* – A simulation approach was used to test the power of the proposed study design. Existing data were used to derive key relationships (i.e., linear regression of log-transformed data) for round whitefish (gonad weight [ovary weight on body weight] from the 2008 fish-out data set for Second Portage Lake) and lake trout (condition [body weight on length] from baseline studies in Third Portage Lake). Using a one-sided target effect size of a 20% (i.e., focused on detected a drop in gonad weight[8]) and the coefficients and residual error of the linear models,

added fishing effort of the EEM study. Should they not be found, the INUG reference area will be the only used for assessing endpoints related to the lethal round whitefish study.

[8] The expected direction of adverse effects is a reduction in either relative gonad weight (round whitefish) or condition (lake trout). Consequently, power analyses were conducted based on a one-tailed significance test. While this assumption would not hold for pulp and paper EEM, where effluent constituents often cause "positive" effects (e.g., fatter fish; Environment Canada, 2007), we believe that it does for metal

new data sets were simulated and tested in an ANCOVA model. A thousand simulations were run to assess the frequency that the 20% change was statistically significant (i.e., $p<0.1$, to balance the β target of 0.1); that frequency is the statistical power of the ANCOVA. Results are reported below for each species.

- *Round Whitefish* – The ovary weight-to-body weight relationship for round whitefish from the 2008 fish-out study in Second Portage Lake is shown in **Figure 4-4** (solid line; $R^2 = 0.95$; n = 10; $p<0.001$). The dashed line in **Figure 4-4** represents a 20% drop in ovary weight, which is at the low end of the 20 to 30% effect size range recommended in the EC TGD (2002). Using the simulation approach described above, statistical power ($1-\beta$) was estimated for several *n* values as follows: *n* = 5 (0.93), *n* = 10 (0.99), *n* = 15 (0.999), and *n* = 20 (0.999). Thus, the proposed study design has very high statistical power to detect the targeted 20% drop in gonad weight in round whitefish.
- *Lake trout* – The body weight to fork length relationship for lake trout from the baseline studies in Third Portage Lake is shown in **Figure 4-5** (solid line; $R^2 = 0.99$; n = 130; $p<0.001$). The dashed line in **Figure 4-5** represents a 20% drop in body weight, which is at the low end of the 20 to 30% effect size range recommended in the EC TGD (2002). Using the simulation approach described above, statistical power ($1-\beta$) exceeded the target of 0.9 with fewer than 20 fish. This result is not surprising given the strength of the underlying relationship. Thus, the proposed study design has very high statistical power to detect the targeted 20% drop in body weight in lake trout.

Supporting water and sediment chemistry sampling will also be conducted to assist in the interpretation of the fish study (**Section 6**).

mining effluents. Notwithstanding, both the endpoints examined in this assessment have tight underlying relationships and would have high power for the proposed sampling effort even if a two-tailed significance test was ued.

4.5. Proposed Methods

4.5.1. Sample Collection

Timing

Sampling will be conducted in August to early September 2011. Based on the fish-out studies, this period should be well in advance of the onset of spawning.

Gear

Index sized gill nets configured with six panels of stretched mesh (sizes 126, 102, 76, 51, 38, and 25 mm) will be used as the primary means of fish capture for this study. Each panel of gill net is 6 feet (1.8 m) deep by 25 yds (22.7 m) long, so that the maximum length of a six-panel gang is 150 yds (136.4 m).

Deployment

Conditions (weather, air and water temperature), location (x, y and z coordinates for each end), timing, duration and net configuration will be recorded for each set. Catch details will be recorded to allow the estimation of catch-per-unit-effort (CPUE) for each area. Panel configuration may be changed to target specific size classes of round whitefish (see below) and minimize by-catch and incidental mortality of non-target size classes and species. Sets duration will be determined in the field based on local conditions, with the objective of minimizing incidental mortality of lake trout (and Arctic char). Longer sets may be possible in colder water. Overnight sets will be used as they were more effective during fish-out studies.

Lake Trout Measurements

During the duration of sampling at each area, the following parameters will be measured for all lake trout (except those caught more than once), prior to release:

- Fork length (L) in millimetres
- Total weight (W) in grams
- Age (pelvic fin ray; see below for discussion)
- External condition survey for deformities, erosions, lesions, tumours (DELT), and parasites. Determination of sex if possible (e.g., milking).

- Tag installed for future identification and to ensure recaptured fish are not re-measured.

It should be noted that aging lake trout using pelvic fin rays will likely be highly uncertain, particularly for older fish. Consequently, opportunistic aging of lake trout otoliths (see below) will be used to assess data quality for ages estimated from pelvic fin rays.

Mortality of fish will be minimized as much as possible by checking nets regularly to remove captured fish; however, inadvertent mortalities will be autopsied to determine internal condition and parasite load, sex and gender ratio, diet from examination of stomach contents, and verification of ageing by sampling the otoliths.

The potential lack of reliable age data may not be a significant limitation of this study design. Based on the meta-analysis presented in the *National Assessment of Phase 1 Data from the Metal Mining Environmental Effects Monitoring Program* (Environment Canada, 2007), condition was identified as the most sensitive fish endpoint across the EEM program (i.e., based on mean response across metal mines).

Round Whitefish Measurements

Based on the size range of fish captured in the baseline studies (i.e., the range most likely to be caught during a week-long index gillnet study) and the approximate size at maturity[9] based on the fish-out studies, the following size class ranges will be targeted for the round whitefish lethal sampling program (5 fish of each sex in each category):

- 270 to 400 mm
- 401 to 550 mm
- 551 to 700 mm
- 701 to 1000 mm

The following parameters will be collected for round whitefish retained for complete analysis (i.e., those falling within the aforementioned size classes):

- Fork length (mm)
- Total weight (g)

[9] Note that one interesting finding of the 2008 fish-out study was the discovery of small round whitefish (5 o 7 gm, ~90 mm, age 3 or 4) with ripe ovaries (~150 eggs) or testes. These fish were not directly caught, but were found in the stomachs of lake trout. These fish had GSI% of 10 to 18%, much higher than the normally mature fish (6 to 8%); they appeared to be allocating all their resources to reproduction (Azimuth, 2009).

- Age (yr) – otoliths will be collected from all fish
- Gonad weight (g) and appearance
- Egg weight and fecundity (total # eggs) based on multiple 100 egg weight sub-samples
- Liver weight (g) and appearance
- External and internal condition, appearance, parasites, tumours
- Sex (male, female, immature)
- Reproductive status - determined according to the following categories: undeveloped (i.e., immature fish that have never spawned); ripe, running, spent (i.e., all sexually mature, current year fall spawners), resting (i.e., fish that have spawned in previous years but are not current year fall spawners and have undeveloped gonads); and unknown.[10]
- Stomach contents – stomachs will be opened and examined in the field laboratory and identifiable contents noted.

All other round whitefish caught but not falling into the desired classes (or falling into an already-filled size class) will be processed as per the lake trout and released back into the lake.

Incidental Catch

By-catch (i.e., non-target species, primarily Arctic char) will be released back into the lake after the following basic information recorded:

- Catch details (see above under deployment)
- Species
- Fork length (L) in millimetres

General

Details of field sampling activities will be recorded on project-specific data sheets (or a field notebook) containing the following information:

[10] Previous studies have shown that mature fish do not spawn every year. Documenting reproductive status for mature fish will help understand (and minimize if used to stratify the population) variability in gonad weights among the population. However, this may not be as important in this EEM study as the occurrence of resting mature round whitefish was much less common than for lake trout (Azimuth, 2009).

- Date and time of sampling
- Area identification and location (UTM coordinates)
- General observations (depth, biota, other relevant information)
- Gillnet dimensions (length, mesh size for each panel), set number and duration
- Individual identification and fish-specific biological measurements (see above)
- Level of effort
- Details of paired ancillary measurements
- Photographs

Sample Storage and Transportation to the Laboratory

The following procedures will be used for each sample type:

- **Aging structures** – Fin rays will be placed in labeled whirl-pack bags and frozen prior to shipment. Otoliths will be placed in labeled sample envelopes and stored together prior to shipping. Samples will be carefully packaged and shipped on ice via air to North/South Consultants in Winnipeg, Manitoba.

4.5.2. Laboratory Analyses

Methods for aging vary among structures, species and potential age of fish (e.g., based on the size of the otoliths). The options are available for otoliths and fin rays are described below.

Otoliths

A number of procedures could be applied in the aging of otoliths, as described below.

Viewing Whole:

- The otolith is placed in a shallow dish/well plate filled with a 'clearing medium' (i.e., oil of wintergreen).
- Using a dissecting microscope (Leica MS5) and reflected light, the otolith is viewed. Light intensity, magnification, and angle of otolith are adjusted throughout the viewing process.

Polishing:

- Larger otoliths often require surface polishing to reveal the underlying annuli.

- The convex surface of the otolith is wet polished on a carborundum stone to improve visibility, then viewed in a clearing medium as described for whole otoliths.

Crack and Toast:

- The otolith can either be toasted whole (where otoliths are either small, difficult to section, or cannot be ground) or cracked and then toasted.
- To toast an otolith whole, it is first placed a fine mesh screen. Using an alcohol filled Bunsen burner the screen is then slowly passed through the tip of the flame. Caution needs to be exercised at this point such that the otolith does not burn. If the otolith burns it is often becomes brittle and the annuli are obscured.
- Once cooled, the toasted otolith can be placed in a shallow dish/well plate filled with a 'clearing medium' (i.e., oil of wintergreen) and aged.
- To crack an otolith they are typically placed on a hard surface but seated on a piece of paper towel. The technician then places his/her thumb nail on the center of the otolith (length wise). A firm pressure is placed on the otolith until it snaps. The cracked otolith can then be toasted as described above.
- To age a cracked otolith it is typically inserted into plasticine. A drop of clearing medium is placed on the cracked surface and viewed under a dissecting microscope with reflected light.

Thin Sectioning or Focus Sectioned:

- Otoliths can be thin sectioned in the same manner as fin rays (see sectioning of fins below). The sectioning of otoliths depends on the size of the fish (relative age).
- Otoliths may also be set in epoxy and sectioned at/near the focus. This is conducted if the otolith in question is small, brittle, or at the request of the client. The epoxy holds the otolith together and allows it to be manipulated by the ageing technician.

Otolith ageing is species dependant; the most appropriate method is determined with consultation of the client after a review of the structures and life history of the fish in question.

Fins and/or Dorsal Rays

Pectoral fins, pelvic fins, and dorsal rays can be prepared in the same manner, as follows (generally referred to as "fins" below):

- The fins are first dipped in an epoxy resin (Cold Cure™) and allowed to harden.

- Sections of fins are taken using a Struers Minitom™ (low speed sectioning saw). Sections can vary between 0.5 and 0.75 mm in thickness.
- The sections are then permanently mounted to a labeled glass slide using Cytoseal-60™.
- The mounted sections are then viewed under a dissecting microscope with transmitted light. Light intensity and magnification are adjusted throughout the viewing process.

Age Determination and Quality Control

Regardless of the preparation method used, all structures are viewed (read) a minimum of two times, and, if consistency was not met between the first two reads, a third is undertaken. If consistency cannot be accomplished within three reads the structure will be deemed un-ageable and no age will be assigned. All readings are conducted as "blind" (independent from each other). Quality control and quality assurance is then conducted by an alternate ageing technician on 10% of randomly selected structures. The QA/QC readings are also conducted "blind" to determine consistency and accuracy.

4.5.3. Data Analyses

Data assessment and interpretation will be conducted following the guidelines presented in Environment Canada (2002). All statistical analyses were conducted using R software (v. 2.9.0). In addition to Environment Canada (2002), the following resources (among others) will be used to support data analysis: Dalgaard (2008), Pinheiro and Bates (2000), Venables and Ripley (2002), Gelman and Hill (2006), and Zar (1984). In general, data analysis will be conducted in the following order (as per Environment Canada, 2002):

- **Preparing for analysis** – checking for data entry errors and other outliers, conducting preliminary calculations (e.g., CPUE), and constructing data files for analysis.
- **Summary statistics** – data will be tabulated and graphed to further assess potential outliers and to examine their distribution.
- **ANOVA analyses** – these will be used to test for differences for endpoints without covariates. Depending on the specifics of the study design, either a CI- or BACI-based statistical model will be used (see **Section 3.2** for more details).
- **ANCOVA analyses** – as described above, but for endpoints with covariates.
- **Power analyses** – use of *post-hoc* power analyses will be used where required; in general, effect sizes and associated confidence limits will be reported.

Table 4-1. Summary of fish species caught in project lakes in baseline and fish-out studies by lake.

Lake	Study Type	ARCH	BURB	CISCO	LKTR	NSST	RNWH	SCULP
Third Portage	Baseline	10	0	0	135	0	29	0
Second Portage	Baseline	37	1	0	122	4	18	0
Inuggugayualik	Baseline	7	0	0	260	2	65	0
Pipedream	Baseline	1	0	0	112	0	0	0
Tehek	Baseline	8	1	0	87	5	33	0
Turn	Baseline	9	0	0	167	0	27	0
Amarulik	Baseline	4	1	10	175	0	59	0
Farside	Baseline	0	1	0	117	0	19	0
Ihipqiituq	Baseline	1	6	73	152	0	5	0
Wally	Baseline	0	0	0	6	0	6	0
Third Portage	Fish-out	748	209	0	611	5	476	5
Second Portage	Fish-out	485	279	0	2015	1	294	0

Note: ARCH = Arctic char; BURB = burbot; LKTR = Lake trout; NSST = Ninespined stickleback; RNWH = round whitefish; SCULP = sculpin.

Table 4-2. Summary of key characteristics for potential target species.

Species	Resident	Relevant to Food Chain	Sedentary	Exposed to Effluent	Target Species?
Lake trout	Found in all lakes; usually dominant.	Yes, top predator	No	Yes, but to what degree?	Yes
Arctic char	Good numbers in Third Portage Lake, but not in Inuggugayualik or Pipedream.	Yes, pelagic feeder primarily targeting zooplankton.	No	Yes, but to what degree?	No
Round whitefish	Good numbers in Third Portage Lake and Inuggugayualik, but none found in Pipedream.	Yes, typically benthivorous.	No	Yes, but to what degree? Typically less mobile than trout or char	Yes
Burbot	Rarely found during baseline studies; higher than expected in fish-out studies.	Uncertain due to low numbers. Typically demersal predator.	Somewhat	Yes, but to what degree?	No
Ninespine stickleback	Rarely found during baseline studies in any lake.	No, rarely found in any fish stomachs during fish-out programs.	Yes	Uncertain due to low numbers.	No
Sculpin	Rarely found during baseline studies in any lake.	No, rarely found in any fish stomachs during fish-out programs.	Yes	Uncertain due to low numbers.	No
Cisco	Only found in two lakes; not found in key project lakes.	Yes, but only in some lakes.	No	No, not found in Third Portage Lake.	No

Figure 4-1. Density plots for lake trout length (mm) for baseline (black) and fish-out (red) studies in lakes of interest at Meadowbank Mine.

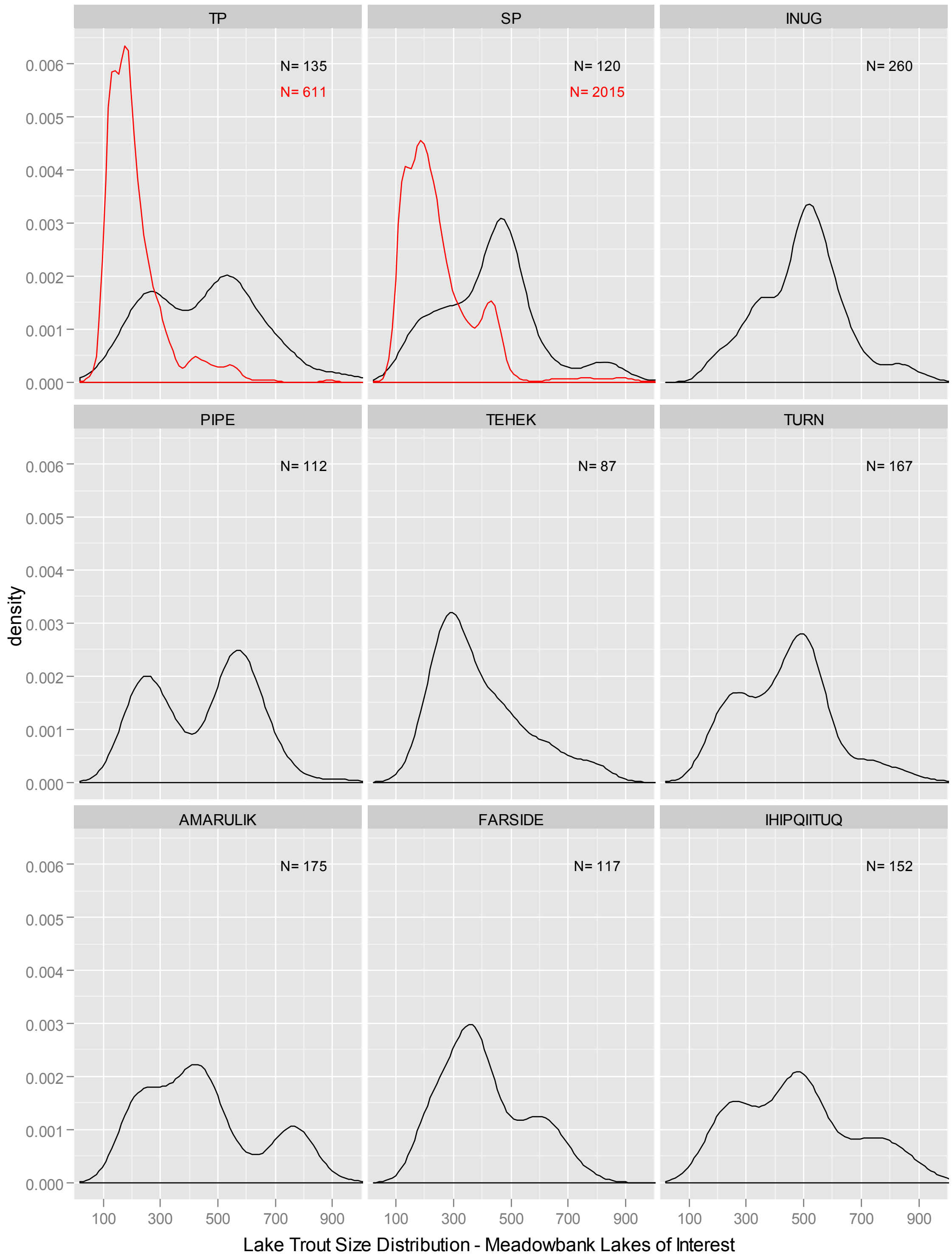


Figure 4-2. Density plots for round whitefish length (mm) for baseline (black) and fish-out (red) studies in lakes of interest at Meadowbank Mine.

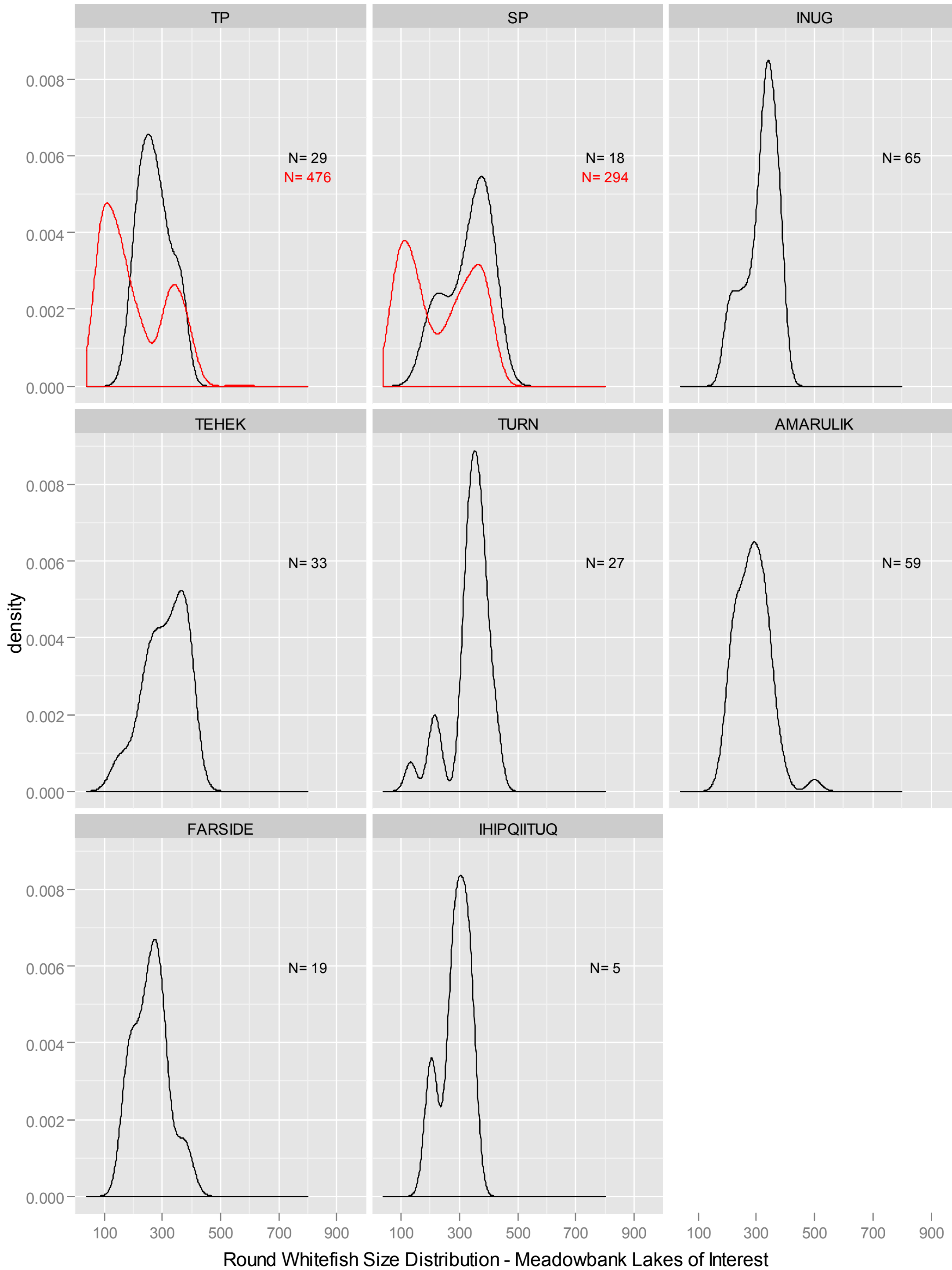


Figure 4-3. Fish community composition by lake of interest, Meadowbank study area.

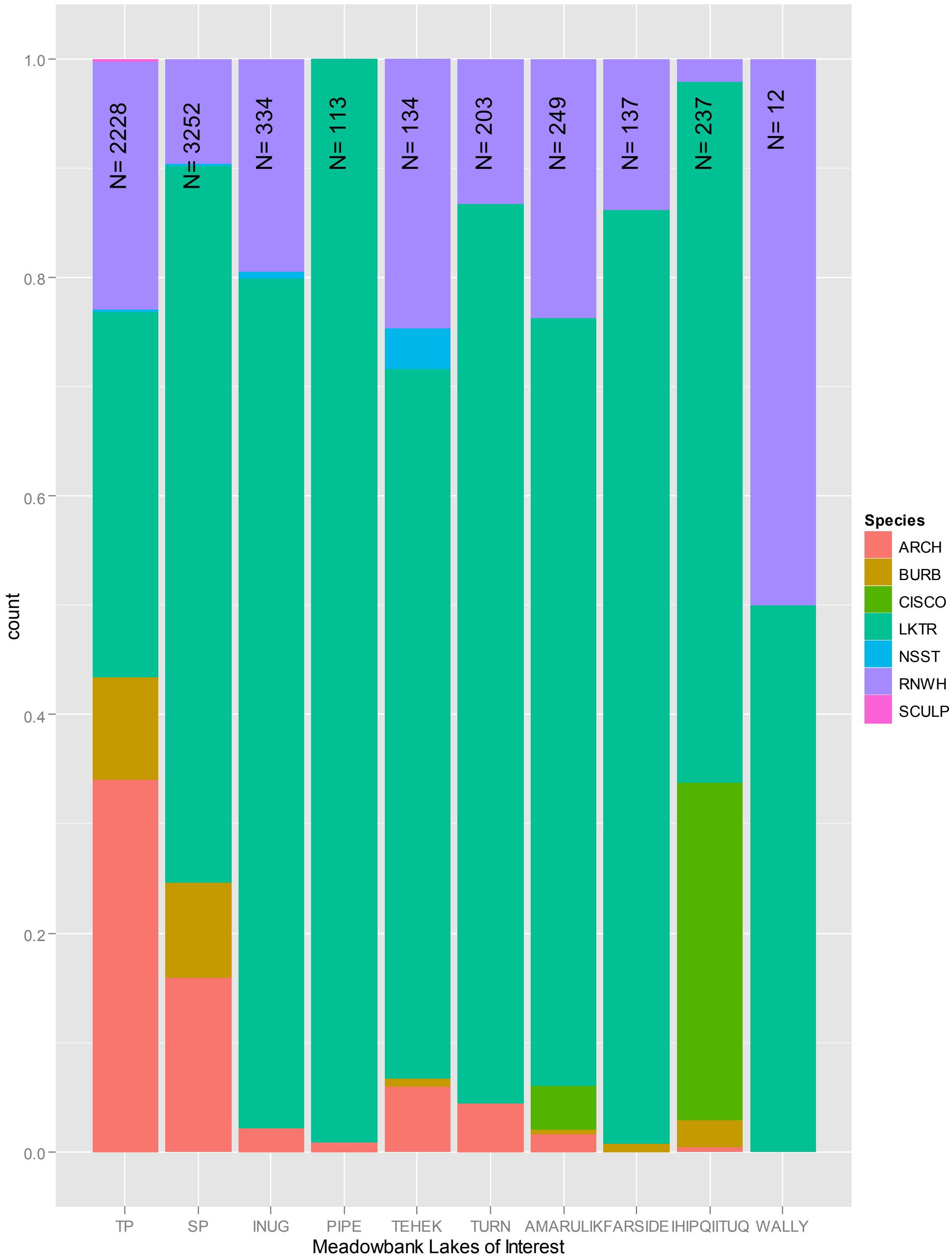
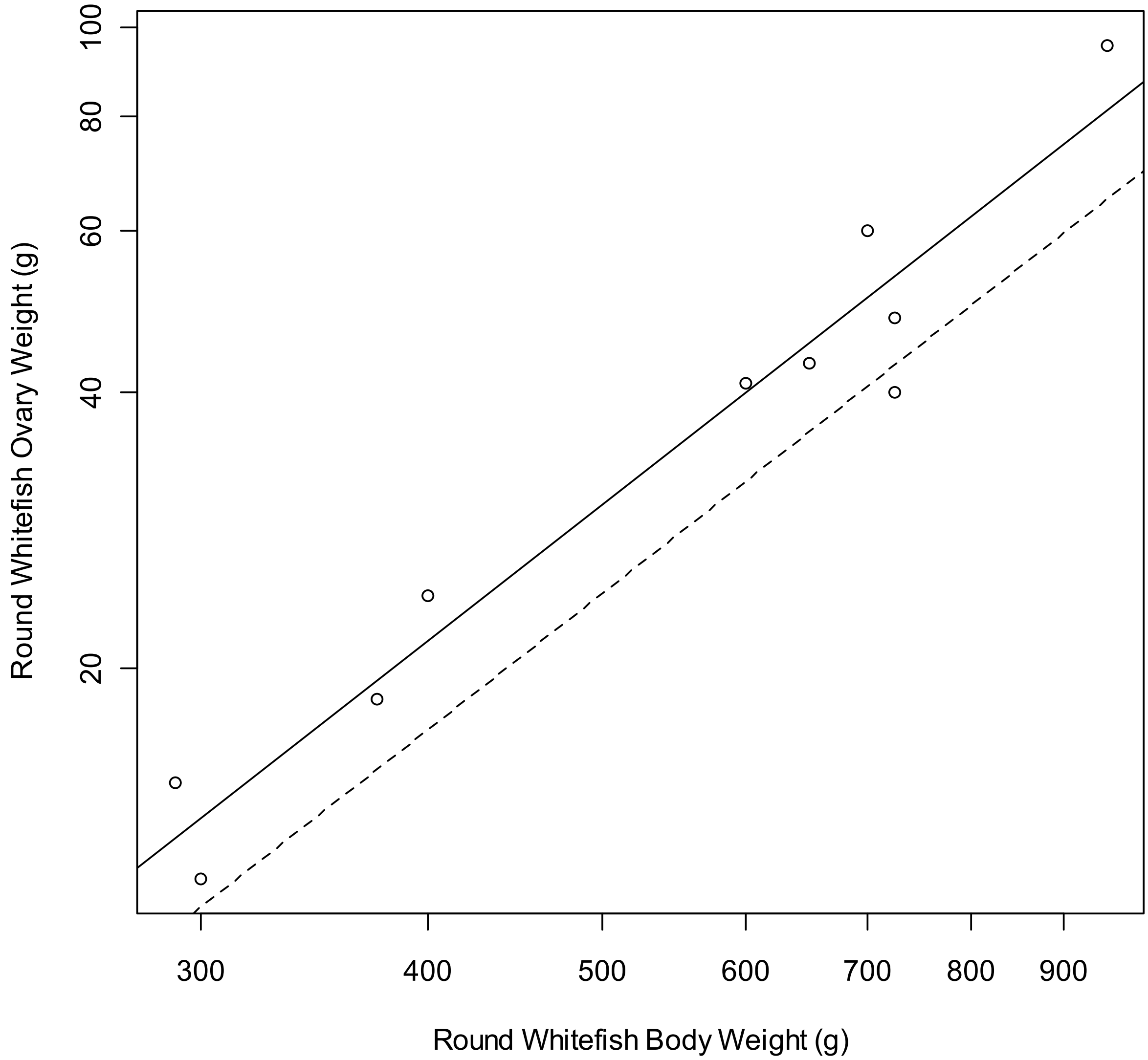
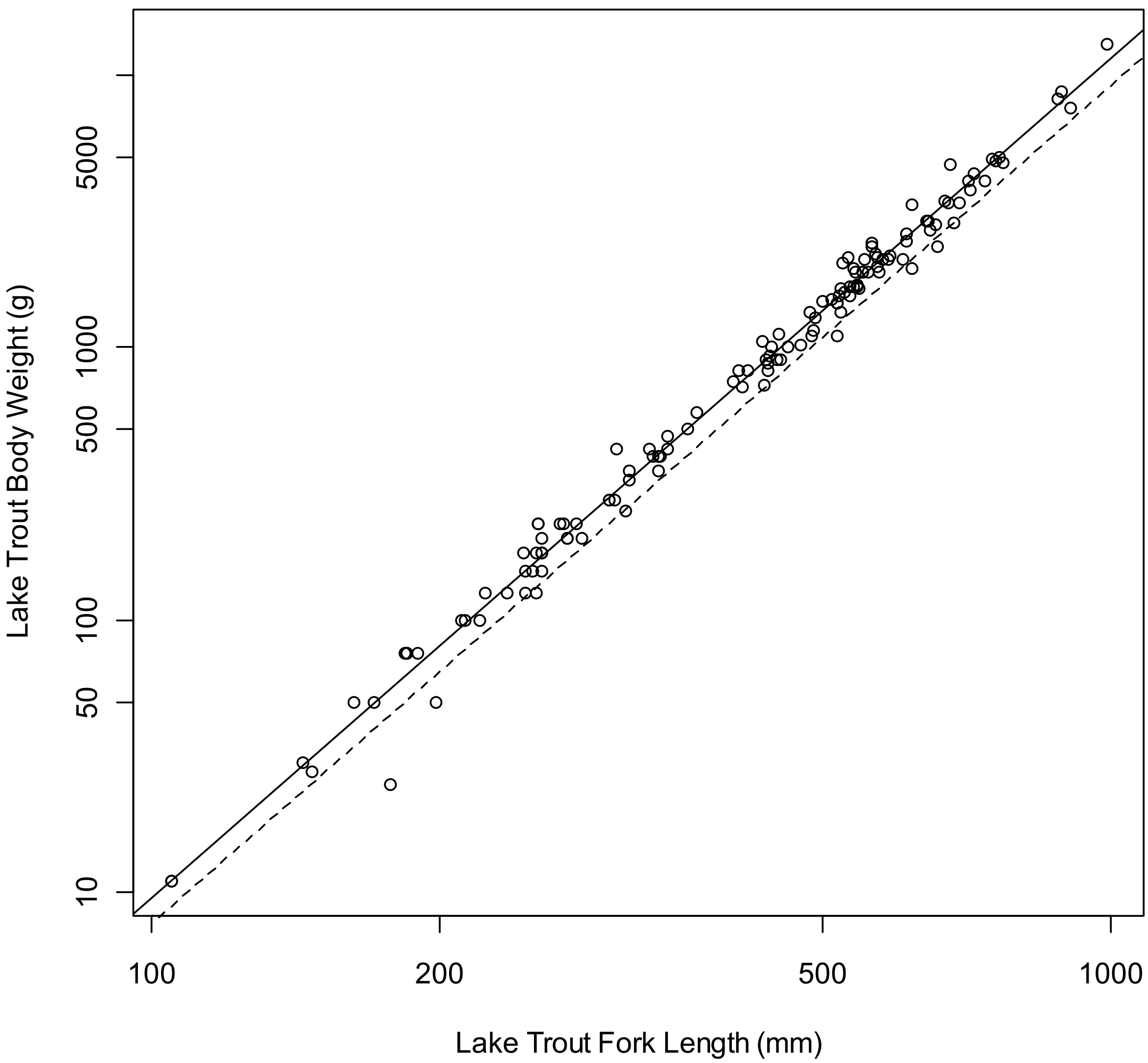


Figure 4-4. Relationship between ovary weigth and body weight (solid line) and target effect size (dashed line) for round whitefish.



Note: axes shown on log scale.

Figure 4-5. Relationship between body weight and fork length (solid line) and target effect size (dashed line) for lake trout.



Note: axes shown on log scale.

5. BENTHIC INVERTEBRATE COMMUNITY SURVEY

This section outlines our strategy for conducting a benthic invertebrate survey at the Meadowbank Mine. As discussed in **Section 1.4**, components of the CREMP (see overview in **Textbox 2-1** in **Section 2.6**) that are compatible with the EEM MMER regulations will be combined to avoid duplication of effort. This is the case for the benthic invertebrate community survey.

The remainder of this chapter is organized as follows:

- Historical data (focusing on documenting compatibility with the EEM program)
- Overview and Site-specific Information
- Sampling Area and Sample Size
- Proposed Methods

5.1. Historical Data

The baseline benthic community characterization for the Meadowbank Mine project area lakes and regional lakes was summarized in **Section 2.6.5.3.** Given that historical benthic invertebrate results have been discussed previously, this section focuses on assessing the suitability of integrating the CREMP benthic invertebrate studies into the EEM program.

The CREMP focuses on monitoring limnological, chemical and biological characteristics of the Meadowbank project lakes (i.e., the aquatic receiving environments surrounding the mine development) and was specifically designed in consideration of EEM requirements, so that CREMP studies could be applied to the EEM program to avoid duplication of effort. From a study design perspective, the decision is easily supported as the broader-ranging CREMP includes our key areas of interest (i.e., the TPN exposure area and reference areas INUG and PDL). The availability of baseline data for these areas from the CREMP would allow the more robust BACI approach to be used rather than relying only on the CI design (see **Section 3.2** for more details). Thus, the remainder of this section looks at key aspects of sample collection and processing of the CREMP program from an EEM perspective.

Key EEM regulations that were considered in the CREMP study design (with the CREMP method following) are listed below:

- *EEM targets one ecologically relevant sampling event per year* – the CREMP is conducted once a year in August.

- *EEM recommends five replicate stations per sampling area as the default* – the CREMP has 5 replicate stations (not closer than 20 m to each other) per area.
- *EEM recommends three sub-samples per replicate station as a default* – the CREMP has two sub-samples (composited into a single sample for analysis) per replicate station. The implications of this difference are addressed in **Section 5.3**.
- *EEM recommends the Standard Ponar (volume = 0.05 m^2) or Ekman (0.02 to 0.09 m^2) grab samplers for use in freshwater depositional environments* - the CREMP uses a Petit Ponar grab sampler (volume = 0.023 m^2). A number of grab types have been tried at the site. The Ekman grab was considered too light to consistently sample under the often-windy conditions at the site. Given that the sampling areas of the Petit Ponar and small Ekman are essentially the same, and that the EEM program recommends the Standard Ponar, the Petit Ponar should be considered suitable for EEM.
- *EEM requires a 500-µm mesh size for sieving benthos* – the CREMP has used a 500-µm sieve exclusively since 2007. Up until 2006, a 250-µm mesh size was used for sieving benthos.
- *EEM recommends taxonomic identification to the family level or lower* – the CREMP samples are analyzed to lowest practical level, which is often to species.

Discrepancies between the CREMP and EEM are addressed below in the proposed study design (**Section 5.3**) and methods (**Section 5.4**) for the EEM benthic invertebrate study.

5.2. Overview and Site-specific Information

The dewatering effluent consists of natural lake water with elevated TSS and is not anticipated to be detrimental to aquatic biota through direct contact (see **Section 2.3.2** and **Section 4.2**). However, the TSS Effects Assessment Study (EAS; Azimuth, 2010a) discussed in **Section 4.2** also looked at the effects of construction-related TSS inputs to the local benthic invertebrate community. The results of that study suggested that the benthic community was susceptible to TSS inputs in areas of high sediment deposition (i.e., through physical smothering[11]), but that the effects were reversible. It should be noted that TSS concentrations measured in plumes during dike construction monitoring were often well above 10 to 20 mg/L (Azimuth, 2009c; 2010c), far greater than any receiving environment concentrations measured (i.e., all < mg/L; see **Section 2.3.2**) at the TPN exposure area associated with the dewatering effluent discharge. Consequently, we

[11] Sediment toxicity testing conducted as part of the TSS EAS in 2010 did not find any exposure-related effects to chironomids or amphipods (Azimuth, in progress), thus confirming the physical nature of the initially-observed response relative to potential chemical effects.

would anticipate that potential effects due to physical smothering could occur in areas with high sediment deposition. That said, given the measured TSS in the exposure area, such effects would seem unlikely based on comparison to the TSS EAS results (Azimuth, 2010).

Benthic communities are known to be strongly influenced by a number of natural environmental factors (e.g., grain size, depth, sediment organic content, lake productivity, water temperature, slope, ice scour etc.). For the most part, these factors have been controlled to the extent possible by stratifying sampling to specific depth and substrate zones (i.e., soft bottom areas in 8 to 11 m depth).

It is also important to note that weather and other factors may affect sampling; confounding factors include wind events and seasonal temperature regimes. Wind events can be powerful in this region, and have caused fairly long delays in sampling programs in past years as it was unsafe for field crews to work the project area lakes. If wind events occur during the proposed sampling time, then sampling may be delayed. This may hamper the comparability of data between stations and years, as benthic invertebrate community composition can change noticeably in a short time if considerable emergence occurs.

5.3. Sampling Areas and Sample Size

As discussed in **Section 3.2**, a BACI design will be used to examine potential effects of the present-day effluent on the benthic invertebrate community in the Meadowbank Mine high exposure area. The objective of this design is to evaluate whether there are detectable differences in invertebrate community structure between the exposure and reference areas (locations shown in **Figure 3-1**; general UTM coordinates provided in **Table 3-1**).

Benthic sampling will be conducted within the CREMP sediment and benthos sampling zones at each area (i.e., within the blue circles shown in **Figure 3-1**). As per EEM recommendations, there will be 5 replicate stations randomly located within each of the three are, but within the sampling area bounds. The proposed sampling effort for the study is based on generic power analysis results provided by the Environment Canada technical guidance document (EC, 2002). Table 5-5 in The EC TGD (2002) indicates that five replicate stations should be sufficient to achieve a statistical power ($1-\beta$) of 0.9, with α=0.1and an effect size of two standard deviations (SD)[12].

[12] As part of the CREMP re-design process, we are looking at analyzing the data to determine a more ecologically relevant effect size. However, to-date, these analyses have not been conducted.

Each replicate station will be comprised of the composite of two independent grabs or sub-samples. The MMER regulations recommend 3 sub-samples, however, historic benthic invertebrate samples have been collected as 2 sub-samples, as mentioned in **Section 5.1**) and the intention is to continue with this number for the EEM cycle one study, with justification in the textbox below.

Textbox 5-1: Number of Sub-sample Grabs

To explore the significance of the differing numbers of sub-samples, a benthic invertebrate data set was collected specifically for determining the effect of number of sub-sample grabs on community characterization. Five sub-samples were collected at each of two replicate stations within two of the CREMP areas (TPE, INUG), making up a total of 20 samples. These samples were individually analyzed for benthic invertebrate abundance and richness. The results of the number of species obtained versus number of individuals for different numbers of pooled replicates are plotted in **Figure 5-1**.

The Elliot (1977) equation was used to analyze the data to determine the number of sub-samples sufficient to capture the benthic community within 20% precision, the results of which are presented in **Table 5-1**.

The Elliot equation: $n = s^2/D^2*(\text{sample mean})^2$

EC (2002) recommends employing the number of sub-samples that the highest sample requires, which in this case was n = 2.4. However, we believe this was due to one sub-sample that appeared to be improperly preserved as it had a very low count. All other Elliot equation results for both abundance and richness descriptors yielded a recommendation of < 2 sub-samples. Therefore, we feel confident that two sub-samples from each replicate station are satisfactory for achieving the collection of a true representation of the benthic community.

5.4. Proposed Methods

5.4.1. Sample Collection

Timing of Collection

Samples will be collected once, in August 2011. The primary reasons for selecting this time period are:

- The ice-free season is limited to about 3 months at Meadowbank Mine site, including August.
- The historical CREMP data set was always collected in August.
- This period is optimal for the fish study, to avoid sampling during the active spawning period (see **Section 4.4**).

Sample Collection

Sediment samples will be collected according to the existing CREMP standard operating procedures (SOP; **Appendix E**[13]). Sediment samples for chemical and physical analysis will be collected concurrently with sediment samples of benthic invertebrate analysis and is discussed in more detail in **Section 6**. Details will be recorded on program-specific data sheets to ensure that all relevant information is collected and recorded.

5.4.2. Laboratory Methods

Laboratory procedures will follow guidance from EC (2002). Briefly, samples will be washed in a 500-µm sieve, and preserved in 80% ethanol. If necessary, samples will be divided into appropriate size fractions to expedite the sorting process. All fractions will then be sorted by trained technicians using a dissecting microscope.

If the samples are large, then sub-sampling may be necessary, in which case, a minimum of ¼ of the sample will be sorted. 10% of all samples should be sorted in their entirety, so as to estimate the error associated with sub-sampling. Full QA/QC procedures are described in **Section 7**.

As requested by EC (2002), a reference collection of all benthic invertebrate species will be preserved for future reference. Several specimens of representative-sized individuals from each taxon from each sample area will be compiled and archived.

Taxonomic level of identification will be to the lowest practical level as has been done for the CREMP benthic invertebrate community survey. EC (2002) recommends sorting to family level, which provides sufficient taxonomic resolution to detect community responses to human disturbances. Therefore, all summary statistics and descriptive metrics will be calculated and reported at the family level. Organisms that can only be recognized at taxonomic levels higher than family will be reported separately from the main data set.

[13] Details the SOP for the entire CREMP and only a portion applies for the EEM program.

5.4.3. Data Analysis

The benthic invertebrate community descriptors which will be calculated, reported, and used as endpoints in determination of effects at the high exposure area include:

- Total invertebrate density
- Taxon richness
- Simpson's diversity index
- Bray-Curtis index
- Evenness
- Family level density
- Family level proportion
- Family level presence/absence

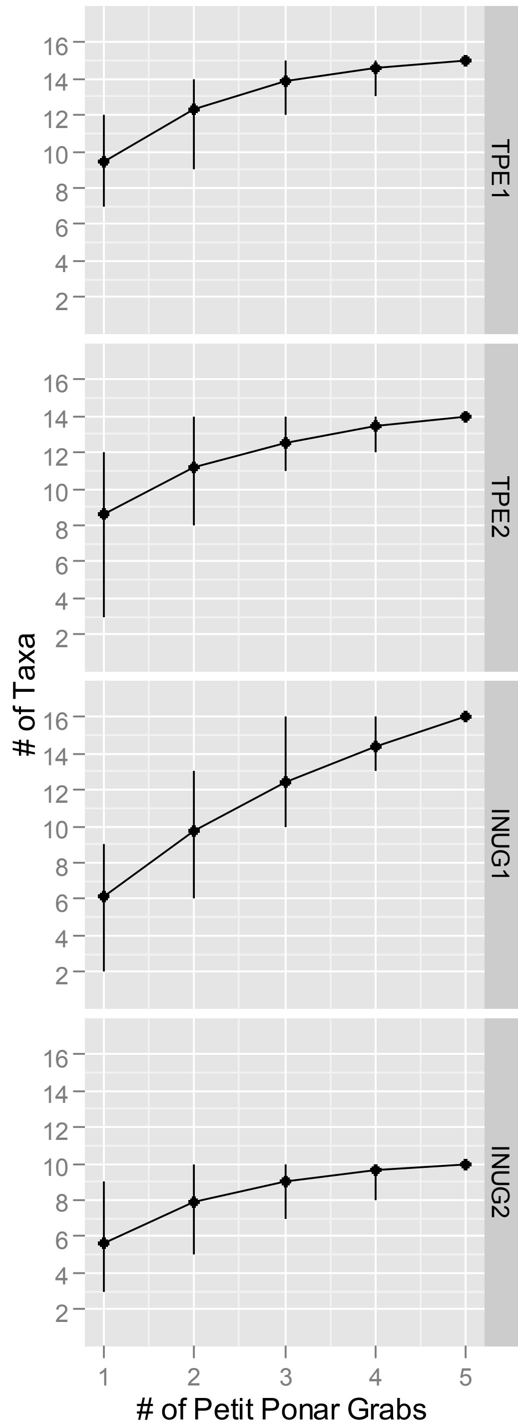
Appropriate statistical analyses (e.g., analysis of variance and analysis of contrasts for BACI design; multidimensional scaling) will be used in conjunction with tabular and graphical presentations of the data.

Table 5-1. Results of the Elliot equation for determining a suitable number of sub-samples.

Replicate Station #	mean	SD	N[3]	Elliot Equation Result (# of grabs)
Abundance[1]				
1	1.42	0.24	5	0.75
2	1.49	0.46	5	2.38
3	1.38	0.10	4	0.12
4	1.27	0.28	4	1.24
Richness[2]				
1	4.20	0.45	5	0.28
2	3.60	0.55	5	0.58
3	2.75	0.50	4	0.83
4	2.50	0.58	4	1.33

[1] Data is log transformed.
[2] Richness evaluated at the family level.
[3] Five grabs were collected at each station, however some samples were deemed to have been improperly preserved and therefore were excluded

Figure 5-1. Taxa-Area curves for four stations (TPE1, TPE1, INUG1, INUG2) showing total number of taxa per multiples of Petit Ponar grabs.



6. SUPPORTING ENVIRONMENTAL VARIABLES

The following section summarizes our approach for conducting water and sediment quality monitoring that will specifically support the biological monitoring studies; details of routine effluent characterization and routine water quality monitoring studies were not included as part of the study design (Environment Canada, 2002). A summary of parameters to be measured in water and sediment is provided in **Table 6-1**.

6.1. Water Quality Monitoring

It is important to note the CREMP and EEM water quality monitoring programs are essentially complementary:

- *CREMP* – focuses on a basin-wide approach for assessing water quality. To that end, three stations are randomly situated throughout each of the three basins (i.e., TPN, INUG and PDL), covering a fairly large spatial area.
- *EEM* – focuses on characterizing conditions within the exposure area (i.e., zone of 1% effluent dilution), which is situated in the NW portion of the north basin of Third Portage Lake.

When considered together, these two programs will provide insights into water quality across a wider spatial scale than if conducting the EEM program in isolation. As noted above, further information is limited only to CREMP water sampling.

CREMP sampling will include the EEM areas (i.e., TPN, INUG and PDL) and will be conducted following an SOP for water sampling (**Appendix F**[14]).

In short, CREMP water quality monitoring will target the laboratory parameters listed in **Table 6-1**, and the following field parameters: depth profiles for dissolved oxygen (DO), pH, conductivity, and water temperature. Total water depth and transparency will also be recorded.

Detailed notes for field measurements and water samples will be recorded in a field log book, contents of which are outlined in the QAQC section of this report (**Section 7**).

Water samples will be kept refrigerated at 4°C and shipped in coolers with ice packs via express courier service to ALS Environmental, Vancouver BC. **Appendix G** provides a

[14] Details the SOP for the entire CREMP and some portions do not apply to the EEM program, such as phytoplankton sampling and all 12 sampling areas.

quality management program for ALS. Note that all efforts will be made to ensure that water samples are analyzed within appropriate holding times.

6.2. Sediment Quality Monitoring

The comprehensive CREMP sediment monitoring data will be used to support the EEM study (i.e., no EEM-specific sediment quality monitoring will be conducted). As noted in **Section 5.4.1**, samples will be collected according to an existing CREMP SOP (**Appendix E**).

Sediment samples for chemical and physical analysis will be collected synoptically with the benthic community samples. The CREMP approach composites three grab samples (i.e., sub-samples) into a single sample for each area. This is consistent with the EEM water quality monitoring approach, where a single sample is collected from each area.

As is the case for all EEM study components, sampling and analysis methods will follow Environment Canada (2002) guidance which states that:

"*The selection of parameters for sediment chemistry analysis [should] be determined on a site specific basis. Where historical data exists on sediment quality, it should be used in conjunction with effluent characterization and water quality data to help determine parameters to analyse*."

As such, the parameters chosen for analysis based on historical data are listed in **Table 6-1**. Full QAQC procedures are provided in **Section 7**.

Sediment samples, placed in their appropriate containers will be shipped by courier to ALS Environmental, Vancouver BC. Samples will be stored in a covered ice chest with frozen gel packs or ice and transferred to 4^{o}C storage until analysis by the laboratory. These will include grain size, total organic carbon (TOC), and metals. **Appendix G** provides a quality management program for ALS.

Table 6-1. CREMP water and sediment parameters and associated laboratory detection limits (DLs).

Parameters	Water		Sediment	
	DLs	Units	DLs	Units
Physical Tests				
Conductivity	2	uS/cm	-	-
Hardness (as $CaCO_3$)	1.1	mg/L	-	-
pH	0.1	pH	0.1	
Total Suspended Solids	1	mg/L	-	-
Total Dissolved Solids	10	mg/L	-	-
Turbidity	0.1	NTU	-	-
% Moisture	-	-	0.1	%
Anions and Nutrients				
Alkalinity, Bicarbonate (as $CaCO_3$)	2	mg/L	-	-
Alkalinity, Carbonate (as $CaCO_3$)	2	mg/L	-	-
Alkalinity, Hydroxide (as $CaCO_3$)	2	mg/L	-	-
Alkalinity, Total (as $CaCO_3$)	2	mg/L	-	-
Ammonia as N	0.02	mg/L	-	-
Bromide (Br)	0.05	mg/L	-	-
Chloride (Cl)	0.5	mg/L	-	-
Fluoride (F)	0.02	mg/L	-	-
Nitrate (as N)	0.005	mg/L	-	-
Nitrite (as N)	0.001	mg/L	-	-
Total Kjeldahl Nitrogen	0.05	mg/L	-	-
Ortho Phosphate as P	0.001	mg/L	-	-
Total Phosphate as P	0.002	mg/L	-	-
Silicate (as SIO_2)	1	mg/L	-	-
Sulfate (SO_4)	0.5	mg/L	-	-
Particle Size				
% Gravel (>2mm)	-	-	1	%
% Sand (2.0mm - 0.063mm)	-	-	1	%
% Silt (0.063mm - 4µm)	-	-	1	%
% Clay (<4µm)	-	-	1	%
Organic / Inorganic Carbon				
Dissolved Organic Carbon	0.5	mg/L	-	-
Total Organic Carbon	0.5	mg/L	0.1	%

7. GENERAL QA/QC PROGRAM

Quality assurance (QA) encompasses a wide range of management and technical practices designed to ensure an end product of known quality commensurate with the intended use of the product. Quality control (QC) is an internal aspect of QA. It includes techniques used to measure and assess data quality and remedial actions to be taken when data quality objectives are not realized.

Reliable sample tracking, logging, and data recording will be practiced and documented to establish continuity between the sample collected and the results reported. Standard operating procedures and laboratory activities will be made available, as required. Environment Canada (2002) provides detailed guidance regarding QA/QC procedures for most aspects of the EEM program. It is our intent to follow this guidance as much as possible and, where deviations are required, document the changes and evaluate potential implications for data quality and interpretative value.

For the Meadowbank Mine Project's EEM program, the primary QA method in the field involves the completion of data sheets to provide a record and hard copy of relevant observations and to ensure that all relevant information is collected in the field. Key information for the benthos, fish and supporting variables that will be recorded on data sheets is described in the relevant sections to follow.

The main concerns for sample collection in the field centre on the proper use of equipment and prevention of cross-contamination. Consistency in sample collection/storage, proper calibration methods, proper instruction/training and experience of qualified technicians, and collection of appropriate QA samples will be an integral part of the field investigations. All safety measures should be identified, understood and adhered to. Collection equipment should be appropriate for the specific water body and selected invertebrate group or fish species, and must be checked frequently and maintained on a regular schedule.

Along with proper sample packing and shipping methods, we will use comprehensive chain-of-custody procedures to ensure that sample integrity is maintained until arrival at the laboratories. Arrangement for sample shipment will be confirmed with the laboratories prior to field work and these laboratories will be advised of the shipping information (e.g., carrier, date sent and waybill number) so they can track the samples during shipment in case there are any delays. Chain-of-custody documentation will be used for all samples shipped from or received by the laboratories.

Analytical procedures (i.e., chemistry, toxicity, benthos taxonomy) will follow guidance from Environment Canada (2002).

7.1. Field QA/QC:

Detailed field notes for all biological and physical samples should be maintained in a bound notebook, and include the following:

- sample number, replicate number, station number, site identification (e.g., name);
- time and date of the collection of the sample;
- ambient weather conditions, including wind speed and direction, wave action, current, tide, vessel traffic, temperature of both the air and water, thickness of ice if present;
- station location (e.g., positioning information) and location of any replicate samples;
- type of platform/vessel used for sampling (e.g., size, power, type of engine);
- type of collection equipment and any modifications made during sampling;
- the water depth at each sampling station and the sampling depth;
- name of personnel collecting the samples;
- deviations from SOPs
- unusual or unpredicted events

Fish

- Initiate and maintain communication with local government agencies (e.g., fishing license, dates of fish collection, location of collection, etc.)
- Habitat descriptions including possible modifying factors (water depth and current, dissolved oxygen, temperature, substrate classification, evidence of pollution [discoloration, odour, residues], salinity, conductivity, etc.)
- Location of sampling stations and fish collection areas documented; photograph collection location
- Record of the number of fish species and incidental species caught per collection stations
- Estimate of catch per unit effort
- Samples from fish (e.g., ovaries, age structures,) should be placed in appropriate containers
- Suitable preservatives/fixatives (e.g., ovaries - frozen or formalin,) should be used
- Ensure field-scales and measuring devices are calibrated.

Benthic Invertebrates

- A visual description of benthic grab samples should be recorded to describe sediment color, odour, texture and debris.
- Field sieving, if necessary, should be done as soon as possible after retrieval of samples.
- Suitable preservatives/fixatives (10% formalin) should be used

Sediment

- Sediment samples should be collected at the same time as benthic invertebrate samples. Grab samples for benthic invertebrates should always be collected prior to grab samples for sediment.
- Description of the sediment including texture and consistency, colour, odour, presence of biota, estimate of quantity of recovered sediment by a grab sampler, or length and appearance of recovered cores (photographs provide a good permanent record of a retrieved sample).
- Collection of field QC samples including a field duplicate and equipment swipe blank (see **Appendix E**[15]).

Ponar Grab

Summary of recommended operations and procedures for grab devices, applicable to both benthic invertebrate and sediment sampling:

- A minimum penetration depth of 6-8 cm is recommended for surficial sediment sampling; however, a depth of 10-15 cm is preferred;
- If sediments adhere to the outside of the sampler, the external surface of the sampler should be carefully washed/rinsed with clean water upon retrieval before the sample is transferred to a storage container;
- The sampler should be rinsed thoroughly with water at the sampling station between within-station samples, and rinsed with water from the next sampling station before collecting a sample. Equipment used in the handling of sediment should also be washed thoroughly between samples;
- A sample should meet the criteria of acceptability (see below) before it is considered adequate. These include:
    - does not contain large foreign objects;
    - has adequate penetration depth (i.e., 10-15 centimeters);

[15] Details the SOP for the entire CREMP and only a portion applies for the EEM program.

- is not overfilled (sediment surface must not be touching the top of the Ponar);
- did not leak (there is overlying water present in Ponar); and
- is undisturbed (sediment surface relatively flat).

Water

The standard QA/QC procedures include thoroughly flushing water collection equipment (i.e., flexible tubing and diaphragm pump) to prevent cross-contamination between stations and thoroughly rinsing the sample containers with site water prior to sample collection. Equipment blanks will be measured at a sub-set of stations by pumping distilled water through the pump and filtering equipment. This ensures that any contamination within the water collection system does not go undetected.

Travel blanks will be carried into the field and consist of samples of distilled water provided by the laboratory that will be subjected to field conditions, but never opened. These samples are returned to the laboratory and analyzed for the general suite of analytes to ensure that any inadvertent accidental contamination during transport of sampling containers to and from the site does not go undetected.

A field duplicate at a subset of stations (generally 10% of effort) will be collected to assess sampling variability and sample homogeneity; a relative percent difference (RPD) of 50% for concentrations that are less than 10x the method detection limit (MDL) is considered acceptable.

7.2. Laboratory QA/QC

Chemical and Physical Analyses

ALS laboratories will be the primary company analyzing water, sediment and tissue (if necessary) chemistry samples. Their national quality management document is provided in **Appendix G**.

Data Quality Objectives (DQOs) are numerically definable measures of analytical precision and completeness. Analytical precision is a measurement of the variability associated with duplicate analyses of the same sample in the laboratory. Completeness for the EEM study is defined as the percentage of valid analytical results.

Results from duplicate laboratory and field samples will be assessed using the relative percent difference (RPD) formula between measurements. The equation used to calculate a RPD is:

$$RPD = \frac{(A - B)}{((A + B)/2)} \times 100$$

Where: A = analytical result; B = duplicate result.

The laboratory DQOs for this project will be:

- Analytical Precision = 25% RPD for concentrations that exceed 10x the method detection limit (MDL).

- Completeness = 95% valid data obtained.

RPD values may be either positive or negative, and ideally should provide a mix of the two, clustered around zero. Consistently positive or negative values may indicate a bias. Large variations in RPD values are often observed between duplicate samples when the concentrations of analytes are very low and approaching the detection limit. The reason for this is apparent if one considers duplicate samples with concentrations of an analyte of 0.0005 and 0.0007 mg/L. In absolute terms, the concentration difference between the two is only 0.0002 mg/L, a very tiny amount; however, the RPD value is 33.3%. This may sometimes lead to a belief that the level of precision is less than it actually is.

Detailed sample processing and laboratory notes should be maintained in a bound notebook. All personnel involved in the sample processing and analyses should have appropriate training.

Fish

Although much of the survey information is collected while in the field, variables such as gonad and liver weights and fecundity/egg size will be determined at an on-site "laboratory" facility. With each measurement, the primary concern of the laboratory QA/QC program is to ensure consistency (precision) and accuracy of the data. The following issues should be considered as part of the measurement procedures:

- Measurements should be conducted using recognized protocols and methods (these should be documented) all instruments used should be properly calibrated and maintained (records, methods available)
- Record of fish measurements recorded for each fish (target species)
- Record of external lesions, tumours and parasites, etc.
- Record of evidence of parasitism
- Fecundity data including methods and sub-sampling precision (if applicable)
- Records should be kept describing the sample, measurement, and responsible personnel. If possible, a minimum number of individuals should conduct a particular measurement to maintain consistency and reduce measurement error (especially for age determination)

- If sub-sampling is necessary (e.g., fecundity, egg size), information describing the efficiency and accuracy of the sub-sampling technique should be documented.
- This information should also be used to calculate appropriate correction or scaling factors (if needed) to minimize possible differences in methods and efficiency.
- All data should be verified. For example, measurements such as fecundity and egg size should be replicated to ensure precision and accuracy. A recognized expert should verify estimates of age.
- Literature and taxonomic keys used for fish identification should be documented
- Maintain detailed sample processing and laboratory notes in a bound notebook.
- Details for fish aging determination are presented in **Section 4.5.2**.

Benthic Invertebrates

ZEAS will be used to conduct taxonomic analysis of the benthic invertebrate samples. They are familiar with the site and also do the CREMP samples. ZEAS incorporates the following set of QA/QC procedures in all benthic projects undertaken by the company to ensure the generation of high quality and reliable data:

- Samples are logged upon arrival, inspected, and enumerated
- Samples are checked for proper preservation
- Samples are stained to facilitate sorting
- Taxonomic identifications are based on the most updated and widely used keys
- 10% of the samples are randomly re-sorted to document recovery
- Unsorted and sorted fractions are to be retained until taxonomy and sorting efficiency are confirmed.
- Precision and accuracy estimates are calculated
- A voucher is compiled
- Sorted sediments and debris are re-preserved in 10% formalin and are retained for up to three months. For samples subject to sub-sampling, sorted and unsorted fractions were re-preserved separately
- A complete reference collection for the mine has been compiled for the site. Verification will be obtained from an external taxonomic expert.

7.3. Data Analysis QA/QC

QA/QC procedures for data analysis will follow guidance from Environment Canada (2002). Particular emphasis will be placed on the following:

- **Data errors and outliers** – careful screening of data will be conducted to identify (and potentially correct) errors in the data set. Outliers (i.e., data outside the expected range of results, but for which there are no known errors) can substantially reduce statistical power, but may be natural. They are typically handled by conducting the statistical models both with and without the outlying values to test the robustness of conclusions.
- **Validity of assumptions –** statistical models are based on key assumptions. These will be reviewed carefully for each model to minimize deviations and understand their implications on resulting conclusions from the model outputs.

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APPENDICES

APPENDIX A

AEM MINE OPERATIONS.

AEM'S MEADOWBANK GOLD PROJECT: SUMMARY OF DEVELOPMENT AND OPERATIONS

The Agnico-Eagle Mines Limited – Meadowbank Division's Meadowbank Gold Project is located 70 km north of the Hamlet of Baker Lake, Nunavut. The mine became operational in March, 2010 and triggered Metal Mining Effluent Regulations (MMER) during the same year when the dewatering of Second Portage Lake impoundment commenced, discharging to Third Portage Lake.

True mine effluent is waste water used in the process of separating the metal from the ore and as a result will have compounds used in the processing, such as cyanide and arsenic. Dewatering effluent would not be expected to have these compounds as it is non-contact water that has not been part of ore processing. In other words, dewatering effluent does not come in contact with the mill tailings or mill processing fluids. Suspended solids are predicted to be the only contaminant of concern in dewatering effluent at Meadowbank Mine.

This document details the components of the operations of AEM's Meadownbank Mine including:

- mine development plan
- mining and waste rock segregation process
- ore processing and tailings

While this document provides a general overview of the mill processing and tailings management, it is not meant to imply that processing technologies have any impact on effluent characteristics. As stated above, the dewatering effluent will not be in contact with processing fluids or tailings.

Mine Development Plan Overview

Since 2008, on-site activities have been focused on construction, commissioning, start-up operations and processing. On-site infrastructure construction is nearing its completion and the primary focus for operations is on optimization.

The Meadowbank Gold project consists of several gold-bearing open-pit deposits that will be mined for approximately 9 years (**Figure 1**). Specifically, the Portage Pit (South, Centre and North Portage Deposits) is presently being mined and will continue until 2016, Goose-Island Pit which will begin to be mined in 2011 until 2014, and Vault Pit which will be mined from 2014 until 2018. Much of the infrastructure is located in close proximity to one-another with the exception for the Vault Pit which is approximately 10 km northeast of the site. The open pit mineral reserve is 3.64 million ounces of gold with a mine throughput of approximately 8,500 tonnes/day.

Presently mine pit operations are primarily a truck-and-shovel open pit operation focused on the Portage pit. A total of over 21 million tonnes of rock were hauled from this pit in 2010 comprising of 18 million tonnes of waste rock and 3 tonnes of ore (AEM, 2009a). Increased haulage is expected for 2011. Waste Rock from the Portage and Goose Island pits are stored in the Portage Rock Storage Facility. Following the completion of mining, waste rock will be placed in the South Portage Pit. During the construction period non-potentially acid generating (NPAG) rock is used for dikes and roads and the potentially acid generating (PAG) waste rock is sent to the Portage waste rock area. The Portage Rock Storage Facility is constructed to minimize the disturbed area and will be capped with a layer of non-acid-generating rock (AEM 2009b). Waste Rock from the Vault Pit will be stored in the Vault Rock Storage Facility. The ore is either processed in the mill or presently stockpiled.

Tailings will be stored in the Tailings Storage Facility (TFS), defined by the series of dikes built around and across the basin of the dewatered northwest arm of Second Portage Lake (**Figure 2**). Much of the construction activity in 2010 and in 2011 is related to Saddle-dam completion for tailings storage and Bay-Goose dike completion for pit access. All of the rock for the construction of the dikes will be NPAG from the Portage Pit.

Dewatering of the northwest arm of Second Portage Lake has been ongoing since 2009 and will allow for mine operations to continue in the Portage Pit and the construction of the central dike. Discharge of water from this impoundment to the north basin of Third Portage Lake was the trigger for initiation of EEM studies at the mine site.

The mine currently operates separate reclaim water and portage attenuation ponds. The portage pit water and plant site water are directed and pumped to Tear Drop Lake or the reclaim pond (Sump 4) for use as process make-up water as required (**Figure 3**). The Portage Attenuation Pond water is decanted, monitored and if necessary treated in the water treatment plant to ensure that the licensed TSS and turbidity limits are not exceeded. Currently the Bay- Goose Dike construction is being completed and dewatering of the goose-island pit area will begin in April 2011. This pit water will be sent to the attenuation area, decanted and treated if necessary and discharged into Third Portage Lake.

Mining and Waste Rock Segregation

Waste rock from the open pits will be trucked to the waste rock storage facility. Due to the distance between the Portage mining area and the Vault mining area, two waste rock storage facilities (RSFs) are required. Waste rock from the Portage and Goose Island pits will be stored in a storage facility located near to these pits (Portage RSF), while waste rock from the Vault open pit will be stored in a separate storage facility adjacent to the Vault Pit (Vault RSF). Excess waste rock will also be placed within the South Portage Pit to be submerged during pit flooding (subaqueous disposal) (AEM 2009b).

The quantities of waste rock to be excavated during mining of the open pits and the estimated quantities by waste rock type to be stored in each of the RSFs are summarized in **Table 1**.

An operational acid rock drainage (ARD) and metal leaching (ML) sampling and testing plan (AEM 2008) guides the determination and ultimately the segregation of waste rock and till at Meadowbank. There are four major bedrock types or lithologies found at Meadowbank: intermediate volcanic (IV), iron formation (IF), ultramafic (UM) and quartzite (QZ); the ARD and ML potential of waste rock and overburden. Previous ARD potential for mine planning and licensing, determined the acid generating potential and neutralizing potential of all the on-site material through both static and kinetic testing. Total sulphur and acid-base accounting analysis (ABA testing) are analyzed onsite from an accredited on-site assay lab. A Total Sulphur and Neutralizing Potential Ratio (NPR) correlation curve has been developed for all five lithologies. This curve is used to predict the NPR of any given sample of that lithology value based on the total sulphur content. The NPR value from any given production drill hole will be used to determine whether the block of rock is potentially acid generating rock (PAG) or non-potentially acid generating rock (NPAG).

Furthermore, waste rock is classified based on its potential to leach metals when in contact with snow and precipitation run-off. ML potential can occur with non acid generating rock therefore it is important to segregate overburden and rock materials accordingly. Leach testing, including shake flask extraction (SFE) and humidity cells have previously evaluated the ML potential at Meadowbank (Golder, 2005). Golder (2005) indicated that the potential for metal leaching was typically low. Due to the low levels of leaching and difficulty in developing a correlation between rock type and leaching potential, Meadowbank uses a specific metals analysis in the drill hole cuttings as a partial surrogate for SFE and humidity cell testing to characterize ML potential (AEM 2009b). Specific decision criteria based on the pit location and lithology is used to guide mine engineering and geology staff on waste rock segregation and storage. Portage pit and goose-island PAG rock and material with metal leaching potential are stored in the Portage RSF. Vault PAG rock will be stored in the Vault RSF.

Waste rock within the Vault and Portage RSFs will be disposed of on land using a total freezing control strategy. Based on the results of thermal modeling, it is expected that the material within the RSFs will freeze within two years of placement (BGC, 2004). Conceptual waste rock deposition plan for the Portage and Vault RSF's are shown in **Figure 4**. Placement of waste rock within the Portage RSF will commence closest to the Portage Pit and will generally proceed westward over the entire footprint, then upward to further benches during development of the mine. Placement of waste rock within the Vault RSF will commence closest to the Vault Pit and will proceed in a north-westerly direction during development of the pit.

As a further ARD control measure, the Portage RSF will be capped with a 4-m thick cover of NPAG rock at closure. The depth of cover was selected based on thermistor data, which indicates the depth of thaw (active layer depth) to be on the order of 1.5 m. The cover material would be coarse to allow the development of convective cooling during winter, and insulation through trapped air within voids during summer. Given the high evaporation rate and low annual average precipitation at the site, the average annual infiltration into the pile is expected to be low.

The Operational ARD/ML sampling and testing plan is the primary tool for deciding waste rock segregation to prevent future release of contaminants from the RSF and overburden stockpiles into the receiving environment. To ensure the guidelines of the plan are met, the water quality of the drainage coming from the Portage RSF, the Vault RSF, the UM and Overburden stockpile areas and from the Portage Pit are sampled by environment staff in accordance with the NWB A license and the Meadowbank Water Quality and Flow Monitoring Plan (AEM, 2009).

Ore Processing and Tailings

The following section outlines the ore processing and tailings storage plan at Meadowbank. It is important to note that the effluent under consideration in this study design is from dewatering and is non-contact water. That is, water that does not come in contact with the mill tailings or mill processing fluids. The purpose of this section is to simply provide a general overview of the mill processing and tailings management and is not meant to imply that processing technologies have any impact on effluent characteristics.

As stated earlier, Meadowbank mine operations are primarily a truck-and-shovel open pit operation. The waste rock is segregated and the ore is hauled to the gyratory crusher where it is then stockpiled. The material is then sent to the SAG mill and operated in a closed circuit with a pebble crusher where the grinding process is completed (**Figure 5**). The SAG mill operates together with the ball mill. Lime is added to the SAG mill for pH control. The ball mill operates in a closed circuit with cyclones. The cyclone overflow is thickened prior to a pre-aeration and leaching circuit that consists of three pre-aeration tanks followed by eight cyanide leach tanks. The product is then sent to the Carbon-in-Pulp (CIP). Gold in solution from leaching is recovered on carbon and subsequently stripped and recovered from the strip solution by electrowining, followed by smelting and the production of a dore bar. The byproduct of the CIP is sent through the CN Recovery thickener and the CN is destroyed using the standard SO2/air process to destroy residual cyanide. The tailings are pumped from the process plant to the Tailings Storage Facility (TSF). The processing reagents used include: Activated Carbon, Copper Sulphate, Hydrochloric Acid, Nitric Acid, Sodium Cyanide, Sodium Hydroxide, Sodium Nitrate and Sulfur.

Tailings, which are material by-product of the gold recovery process, are stored in the TSF which has a capacity of 29 million tonnes, is defined by a series of dikes built around and across the dewatered northwest arm of Second Portage Lake (see **Figure 3**). The TSF is divided into North and South Cells (AEM 2009b). During Years 1 to approximately Year 3 tailings will be deposited in the North Cell of the TSF. Once the North Cell is full, deposition will switch to the South Cell until mine operations cease in Year 9. The division of the TSF into cells allows tailings to be managed in smaller areas with shorter beach lengths, which reduces the amount of water that is trapped and permanently stored as ice. Operation in cells also allows progressive closure and cover trials of the North Cell during operation of the South Cell.

Tailings are placed sub-aerially as slurry and a water reclaim pond is operated during deposition (AEM 2009b). The tailings deposition strategy is to build beaches against the faces of the perimeter dikes to push the pond away, and ultimately produce a tailings surface that directs drainage toward the western abutment of the Storm-water Dike. Following mine operations, a minimum 2-m thick cover of NPAG rockfill will be placed over the tailings as an insulating convective layer to confine the active layer within relatively inert materials. The final thickness of rockfill cover layer will be confirmed based on thermal monitoring to be completed during operations. The control strategy to minimize water infiltration into the TSF and the migration of constituents out of the facility includes freeze control of the tailings through permafrost encapsulation.

References

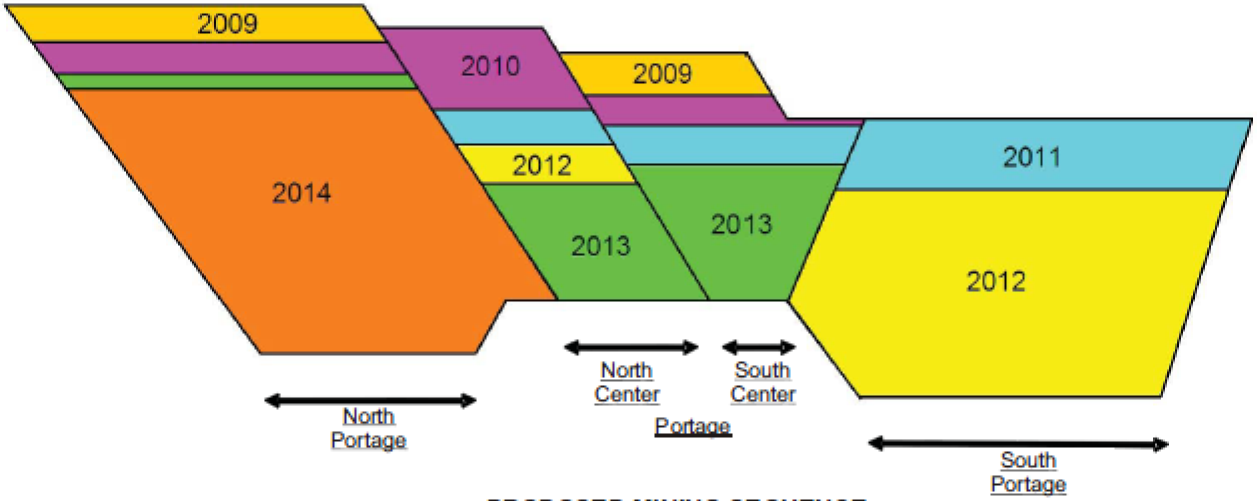
AEM. 2008. Meadowbank Gold Project: Operation ARD/ML Testing and Sampling Plan. In accordance with Water License 2AM-MEA0815. August 2008.

AEM. 2009a. Meadowbank Gold Project: Production Lease KVP08D280 2010 Mine Plan. December 2009.

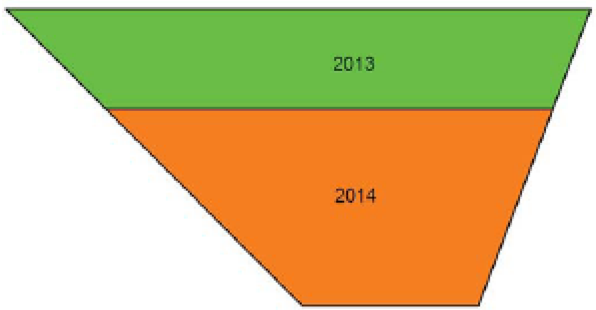
AEM. 2009b. Meadowbank Gold Project: Mine waste Management Plan. October 2009.

BGC Engineering Inc. 2004. Meadowbank Gold Project Preliminary Geothermal and Slope Stability Modelling of Rock Storage Facilities. March 31, 2004.

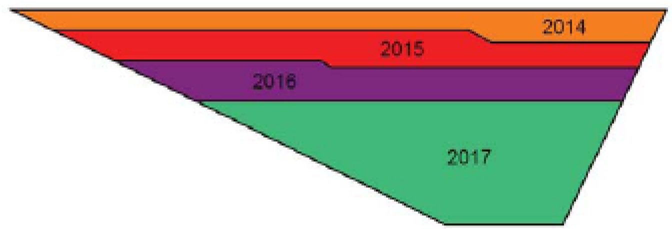
Golder. 2005. Static testing results of Overburden, Mine Site Infrastructure Rock, Pit Rock and Tailings, Meadowbank Gold Project Nunavut. September 2005



**PROPOSED MINING SEQUENCE
PORTAGE PIT**



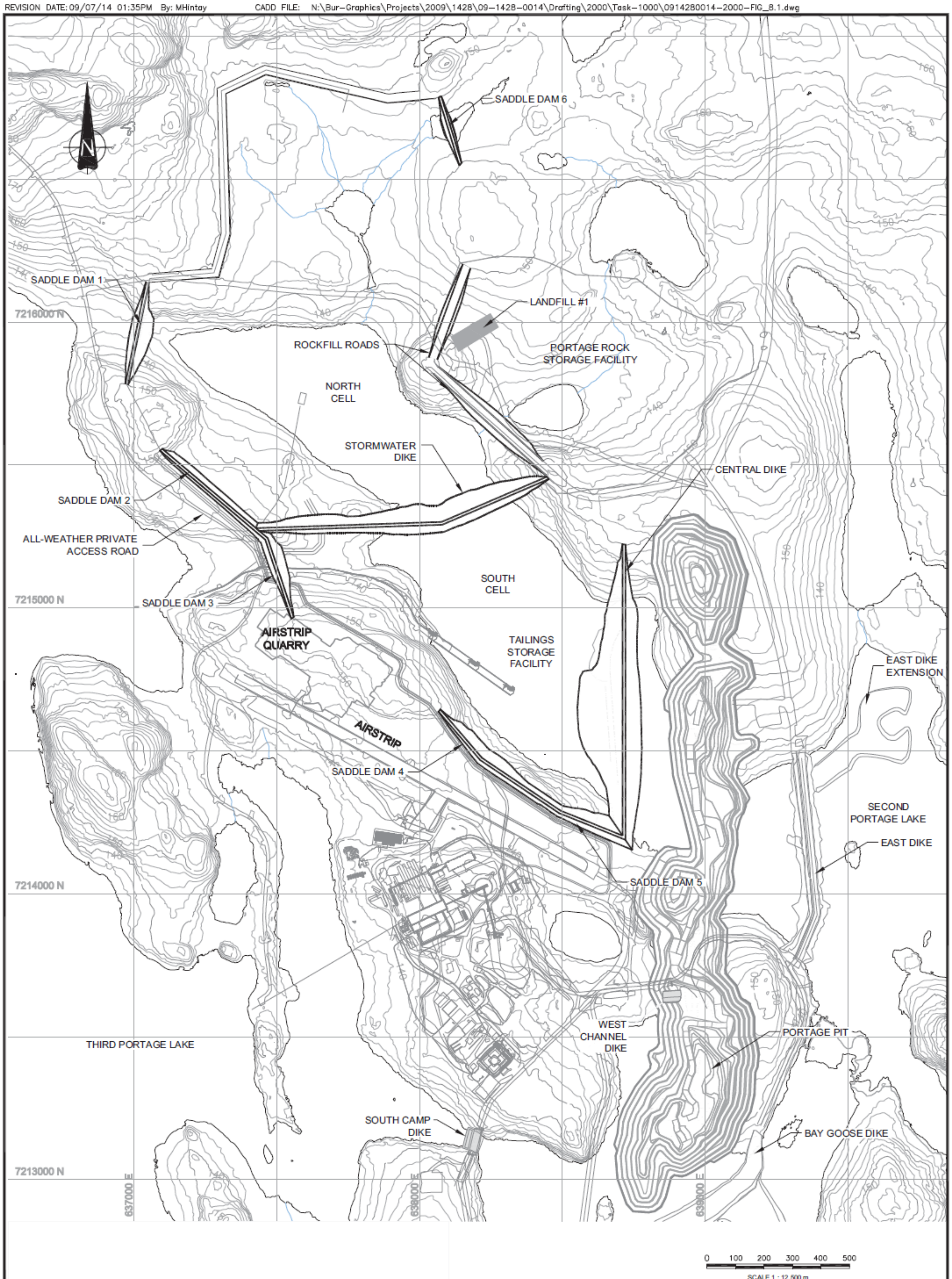
**PROPOSED MINING SEQUENCE
GOOSE PIT**



**PROPOSED MINING SEQUENCE
VAULT PIT**

AEM AGNICO-EAGLES MINES LIMITED	
MEADOWBANK GOLD PROJECT NUNAVUT	
CONCEPTUAL MINING SEQUENCE	Figure 1

REVISION DATE: 09/07/14 01:35PM By: MHintay CADD FILE: N:\Bur-Graphics\Projects\2009\1428\09-1428-0014\Drafting\2000\Task-1000\0914280014-2000-FIG_8.1.dwg



NOTES

1) TOPOGRAPHIC CONTOUR INTERVAL 2M.
2) GRID REFERENCE: NAD 83, UTM ZONE 14

REFERENCES

1) AMEC AMERICAS LTD., DRAWING NUMBER A1-131395-100-C-0001 (100- C-0001.DWG), MEADOWBANK FEASIBILITY STUDY, APRIL 2005.

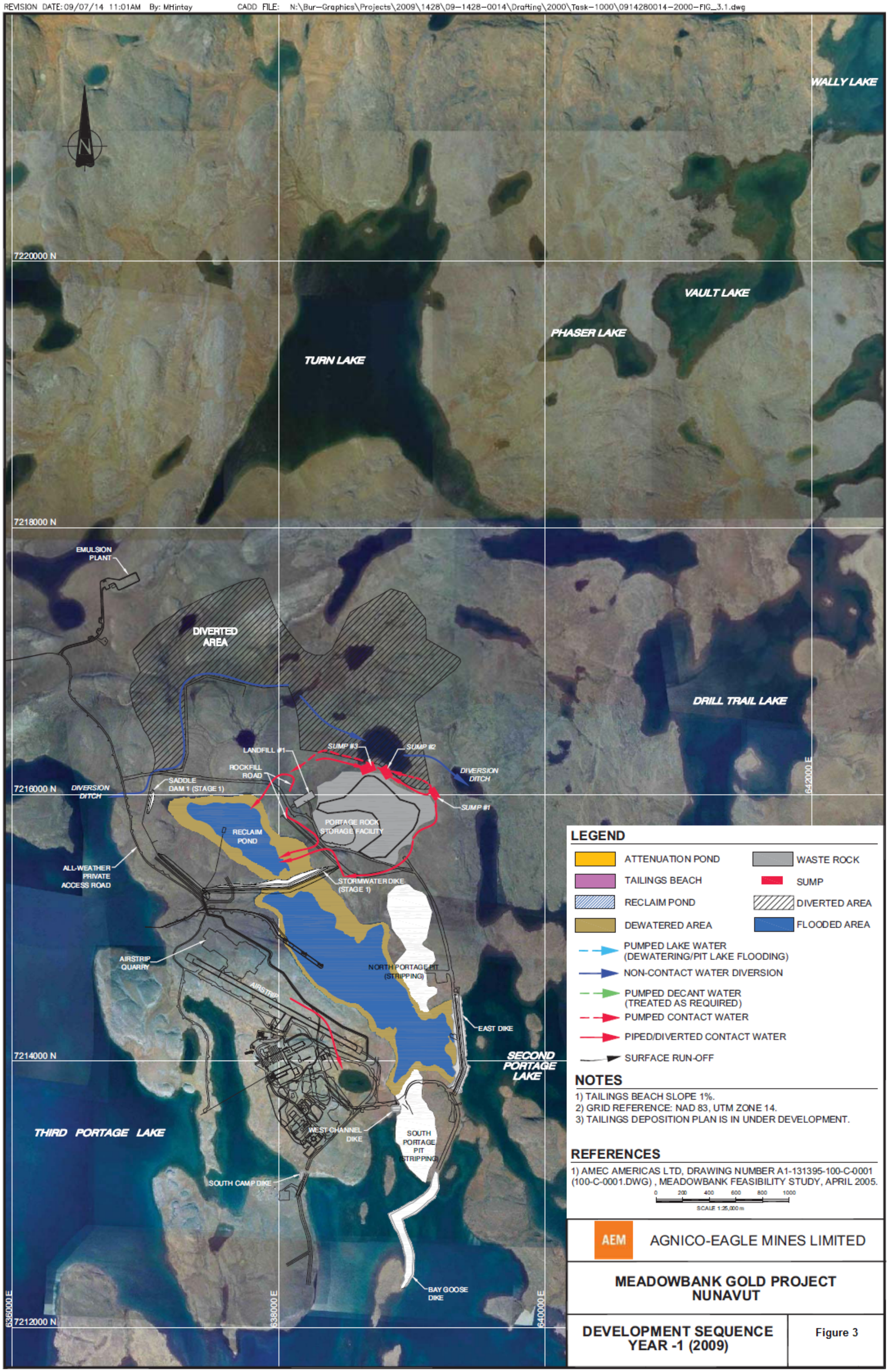
PROJECT: AEM AGNICO-EAGLE MINES LIMITED

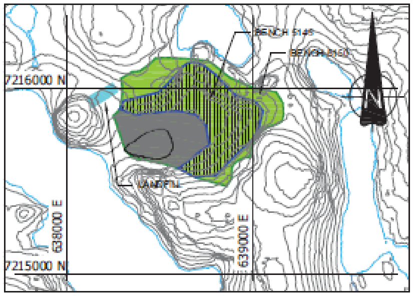
TITLE: MEADOWBANK GOLD PROJECT NUNAVUT

TAILINGS STORAGE FACILITY MAIN COMPONENTS

Figure 2

REVISION DATE: 09/07/14 11:01AM By: MHintay CADD FILE: N:\Bur-Graphics\Projects\2009\1428\09-1428-0014\Drafting\2000\Task-1000\0914280014-2000-FIG_3.1.dwg





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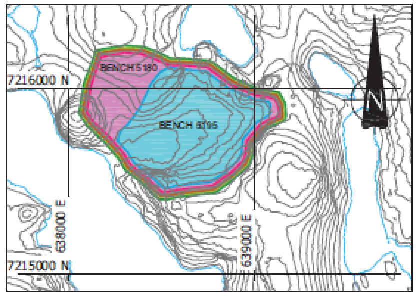

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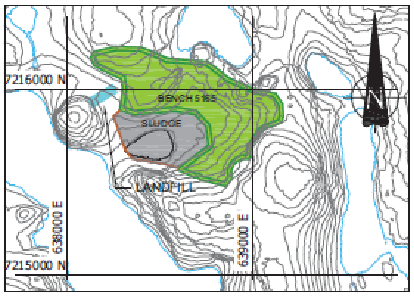

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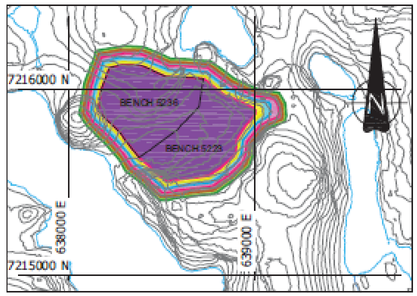

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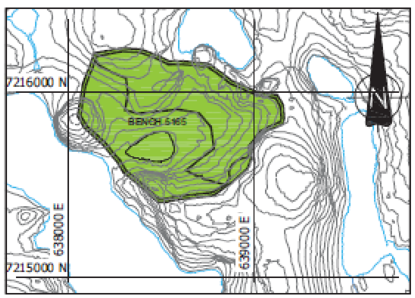

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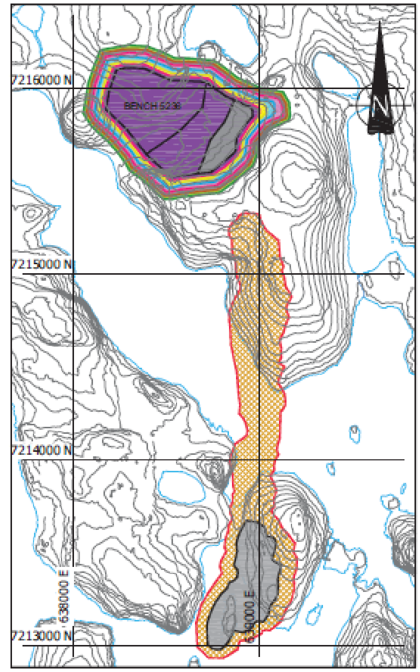

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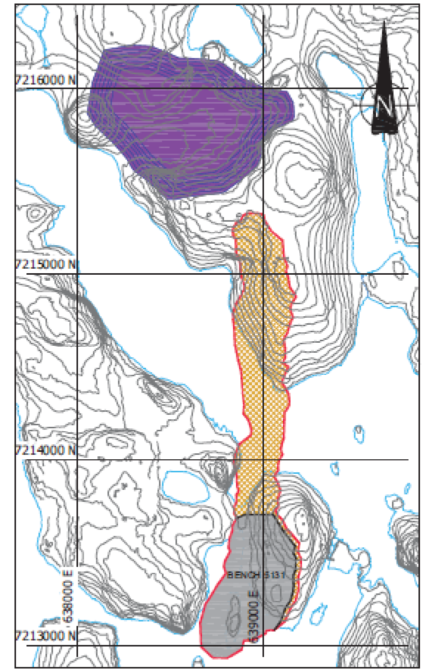

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NOTES

1. GRID REFERENCE: NAD 83, UTM ZONE 4.
2. BENCH ELEVATIONS IN MINE DATUM.

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SCALE: 1: 25,000

AEM **AGNICO-EAGLE MINES LIMITED**

MEADOWBANK GOLD PROJECT NUNAVUT

CONCEPTUAL WASTE ROCK DEPOSITION PLAN PORTAGE ROCK STORAGE FACILITY	**Figure 4**

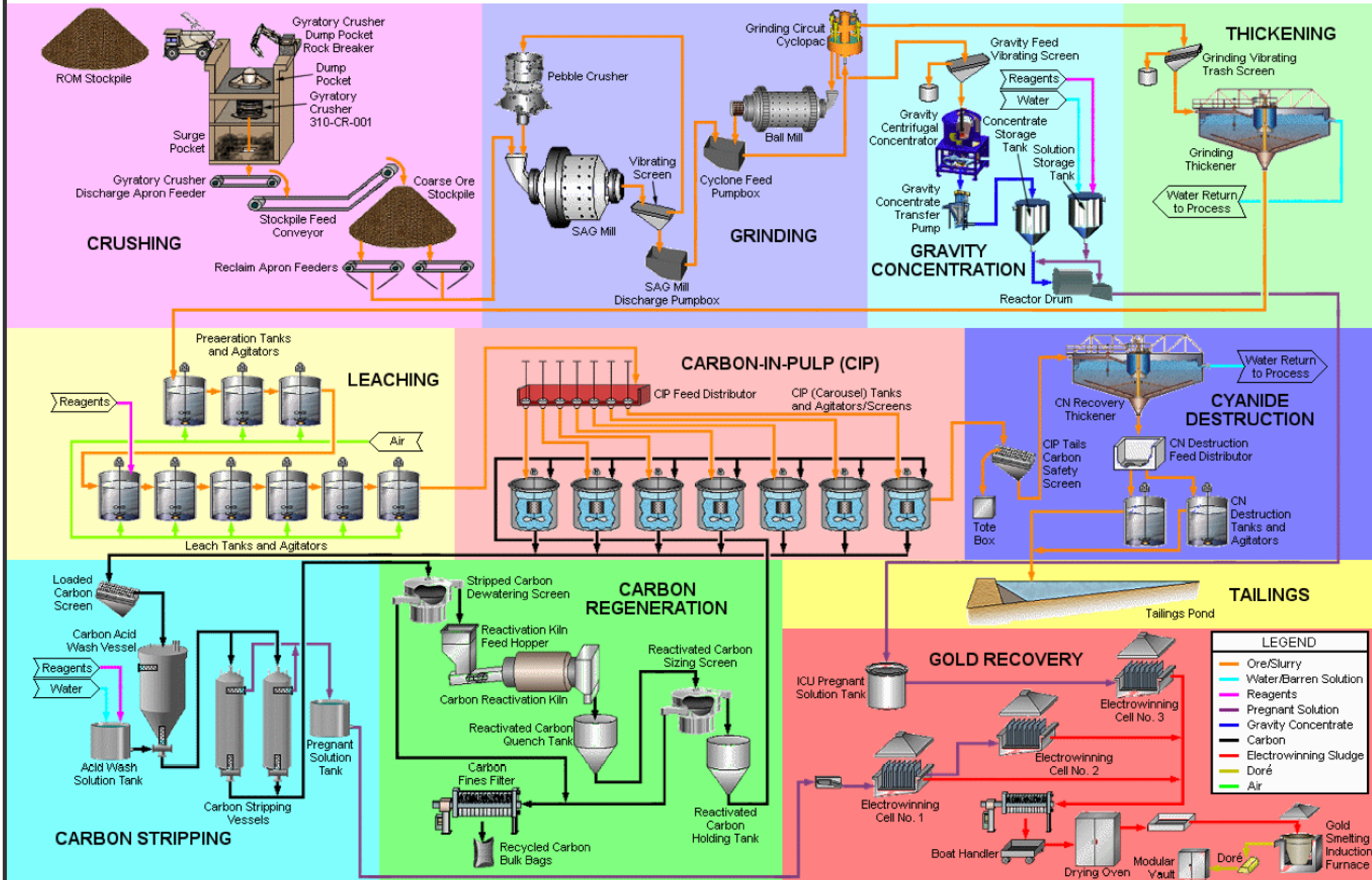
ROM Stockpile
Gyratory Crusher Dump Pocket Rock Breaker
Dump Pocket
Gyratory Crusher 310-CR-001
Surge Pocket
Gyratory Crusher Discharge Apron Feeder
Stockpile Feed Conveyor
Coarse Ore Stockpile
CRUSHING
Reclaim Apron Feeders
Pebble Crusher
SAG Mill
Vibrating Screen
SAG Mill Discharge Pumpbox
Grinding Circuit Cyclopac
Ball Mill
Cyclone Feed Pumpbox
GRINDING
Gravity Feed Vibrating Screen
Reagents
Water
Gravity Centrifugal Concentrator
Concentrate Storage Tank
Solution Storage Tank
Gravity Concentrate Transfer Pump
GRAVITY CONCENTRATION
Reactor Drum
THICKENING
Grinding Vibrating Trash Screen
Grinding Thickener
Water Return to Process
Preaeration Tanks and Agitators
LEACHING
Reagents
Air
Leach Tanks and Agitators
CARBON-IN-PULP (CIP)
CIP Feed Distributor
CIP (Carousel) Tanks and Agitators/Screens
Water Return to Process
CN Recovery Thickener
CYANIDE DESTRUCTION
CIP Tails Carbon Safety Screen
CN Destruction Feed Distributor
Tote Box
CN Destruction Tanks and Agitators
Loaded Carbon Screen
Carbon Acid Wash Vessel
Reagents
Water
Acid Wash Solution Tank
Carbon Stripping Vessels
Pregnant Solution Tank
CARBON STRIPPING
Stripped Carbon Dewatering Screen
CARBON REGENERATION
Reactivation Kiln Feed Hopper
Carbon Reactivation Kiln
Reactivated Carbon Sizing Screen
Reactivated Carbon Quench Tank
Carbon Fines Filter
Reactivated Carbon Holding Tank
Recycled Carbon Bulk Bags
TAILINGS
Tailings Pond
GOLD RECOVERY
ICU Pregnant Solution Tank
Electrowinning Cell No. 3
Electrowinning Cell No. 2
Electrowinning Cell No. 1
Boat Handler
Drying Oven
Modular Vault
Doré
Gold Smelting Induction Furnace
LEGEND
Ore/Slurry
Water/Barren Solution
Reagents
Pregnant Solution
Gravity Concentrate
Carbon
Electrowinning Sludge
Doré
Air

Figure 5

APPENDIX B

DELETERIOUS SUBSTANCE CONCENTRATIONS IN WEEKLY EFFLUENT GRAB SAMPLES, 2010.

Name of the mine	Agnico-Eagle Mines, Division Meadowbank
Address of the mine	P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine	Denis Gourde, General mine manager
Operator's telephone number	867-793-4610 X 6725
Operator's e-mail address	dgourde@agnico-eagle.com
Reporting period	January 2010
Date of report	
Location of final discharge point:	MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Jan.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											31727				
2											31558				
3											29789				
4											20121				
5		< 0.0005	< 0.0005		< 0.0005	0.0012	< 0.001	9	< 0.002	7.42	21143				
6											20003				
7											20813				
8											20943				
9											22507				
10											20229				
11		< 0.0005	0.0017		< 0.0005	0.0021	< 0.001	16	0.007	7.15	19131	> 100	< 1	> 100	< 1
12											21513				
13											21592				
14											22963				
15											23563				
16											22039				
17											21923				
18											pumps moved				
19		< 0.0005	0.0008		0.0008	0.0010	< 0.001	4	< 0.002	7.07	22626				
20											23606				
21											24723				
22											24821				
23											26898				
24											36155				
25											35126				
26											31383				
27		< 0.0005	0.0018		< 0.0005	0.0015	0.004	7	0.003	7.06	35098				
28											34572				
29											37632				
30											42242				
31											42000				
	Max	0.0005	0.0018	0	0.0008	0.0021	0.004	16	0.007	7.42	42242	> 100	< 1	> 100	< 1
	Min	0.0005	0.0005	0	0.0005	0.0010	0.001	4	0.002	7.06	19131	> 100	< 1	> 100	< 1
	Mean	0.0005	0.0012	#DIV/0!	0.000575	0.0015	0.00175	9.0	0.004	7.18	26948	> 100	< 1	> 100	< 1
										Total	808439				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).

Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending

No sample taken

Name of the mine	Agnico-Eagle Mines, Division Meadowbank
Address of the mine	P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine	Denis Gourde, General mine manager
Operator's telephone number	867-793-4610 X 6725
Operator's e-mail address	dgourde@agnico-eagle.com
Reporting period	February 2010
Date of report	
Location of final discharge point:	MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Feb	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											30297				
2		0.0034	< 0.0005		0.0162	0.0014	< 0.001	5	0.003	7.2	33385	> 100	< 1	> 100	< 1
3											43972				
4											43609				
5											44001				
6											40350				
7											43808				
8											43677				
9											43456				
10		< 0.0005	0.0011		0.0027	0.0014	0.006	10	0.005	7.24	44506				
11											39693				
12											42796				
13											32889				
14											32883				
15											42136				
16											24356				
17											34269				
18		< 0.0005	0.0013		< 0.0005	0.0019	0.006	7	0.008	7.21	42880				
19											26485				
20											33355				
21											41879				
22											38987				
23											38544				
24		0.0034	0.0010		0.0037	0.0019	0.004	6	0.005	6.76	25584				
25											23151				
26											21633				
27											2203				
28											1077				
	Max	0.0034	0.0013	0	0.0162	0.0019	0.006	10	0.008	7.24	44506	> 100	< 1	> 100	< 1
	Min	0.0005	0.0005	0	0.0005	0	0.001	5	0.003	6.76	1077	> 100	< 1	> 100	< 1
	Mean	0.00195	0.0010	#DIV/0!	0.005775	0.0017	0.00425	7.0	0.005	7.10	34138	> 100	< 1	> 100	< 1
										Total	955861				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).

Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending

No sample taken

Name of the mine — Agnico-Eagle Mines, Division Meadowbank
Address of the mine — P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine — Denis Gourde, General mine manager
Operator's telephone number — 867-793-4610 X 6725
Operator's e-mail address — dgourde@agnico-eagle.com

Reporting period — March 2010
Date of report

Location of final discharge point: MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Mar.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											23789				
2											35249				
3		0.0017	0.0010	0.005	< 0.0005	0.0012	0.006	4	< 0.002	7.07	43849	46.19	2.16	> 100	< 1
4											42101				
5											43027				
6											35535				
7											28570				
8											43255				
9											41834				
10		< 0.0005	0.0008	0.006	< 0.0005	0.0015	0.003	9	0.006	7.03	42301				
11											35815				
12											42661				
13											30846				
14											42765				
15											41519				
16											40027				
17		< 0.0005	0.0012		< 0.0005	0.0015	< 0.001	5	0.004	6.87	42368				
18											34775				
19											39758				
20											41341				
21											11806				
22											40079				
23											41607				
24											40375				
25		0.0007	0.0017		0.0008	0.0015	0.003	16	0.004	7.08	36986				
26											35339				
27											31891				
28											26373				
29											25659				
30											14061				
31											29113				
	Max	0.0017	0.0017	0.006	0.0008	0.0015	0.006	16	0.006	7.08	43849	46.19	2.16	> 100	< 1
	Min	0.0005	0.0008	0.005	0.0005	0.0012	0.001	4	0.002	6.87	11806	46.19	2.16	> 100	< 1
	Mean	0.00085	0.0012	0.0055	0.000575	0.0014	0.00325	8.5	0.004	7.01	35635	46	2	> 100	< 1
										Total	1104674				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending (yellow)
No sample taken (blue)

Name of the mine	Agnico-Eagle Mines, Division Meadowbank
Address of the mine	P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine	Denis Gourde, General mine manager
Operator's telephone number	867-793-4610 X 6725
Operator's e-mail address	dgourde@agnico-eagle.com
Reporting period	April 2010
Date of report	
Location of final discharge point:	MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna LC$_{50}$ (48h)	Daphnia magna Toxic unit	Rainbow trout LC50 (96h)	Rainbow trout Toxic unit
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	% v/v		% v/v	
Apr.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L						
1											15867				
2											36727				
3											37252				
4											39735				
5											39336				
6											38530				
7		< 0.0005	0.0063	0.005	0.0004	0.0017	0.029	58	0.038	6.89	36358	> 100	< 1	> 100	< 1
8											2149				
9											0				
10											34037				
11											32790				
12											37955				
13											16993				
14		< 0.0005	0.001	0.017	0.0029	0.0019	< 0.001	9	0.006	6.80	9120				
15											14930				
16											12041				
17											7616				
18											8234				
19											9874				
20											27923				
21		0.042	0.002	0.023	< 0.0003	0.0026	0.004	6	0.005	7.08	25887				
22											32865				
23											45274				
24											28245				
25											38454				
26											34324				
27											35538				
28		< 0.0005	0.0015	0.029	< 0.0003	0.0027	0.007	12	0.006	7.75	38476				
29											39777				
30											39218				
	Max	0.042	0.0063	0.029	0.0029	0.0027	0.029	58	0.038	7.75	45274	> 100	< 1	> 100	< 1
	Min	0.0005	0.001	0.005	0.0003	0.0017	0.001	6	0.005	6.8	0	> 100	< 1	> 100	< 1
	Mean	0.010875	0.0027	0.0185	0.000975	0.0022	0.01025	21.3	0.014	7.13	27184	> 100	< 1	> 100	< 1
											815525	Total			

Any measurement not t Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).

Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending

No sample taken

Name of the mine	Agnico-Eagle Mines, Division Meadowbank
Address of the mine	P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine	Denis Gourde, General mine manager
Operator's telephone number	867-793-4610 X 6725
Operator's e-mail address	dgourde@agnico-eagle.com
Reporting period	May 2010
Date of report	
Location of final discharge point:	MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
May	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											39939				
2											39219				
3											37531				
4											39563				
5		< 0.0005	0.0048	0.006	< 0.0003	0.002	0.008	13	0.007	6.59	39137	> 100	< 1	> 100	< 1
6											39484				
7											39821				
8											38695				
9											37825				
10											39343				
11											38677				
12		No effluent :Blizzard condition									28423				
13											6566				
14											13203				
15		< 0.0005	0.0016	0.021	< 0.0003	0.0027	0.003	14		6.43	19153				
16											1296				
17*											0				
18											0				
19		No effluent : System adjustment and pump displacement									0				
20											0				
21											0				
22											0				
23											0				
24											10863				
25											37662				
26											39168				
27		< 0.0005	0.0019	0.012	< 0.0003	0.0034	0.003	12		6.98	38247				
28											39437				
29											38553				
30											38946				
31											37561				
	Max	0.0005	0.0048	0.021	0.0003	0.0034	0.008	14	0.007	6.98	39939	> 100	< 1	> 100	< 1
	Min	0.0005	0.0016	0.006	0.0003	0.0020	0.003	12	0.007	6.43	0	> 100	< 1	> 100	< 1
	Mean	0.0005	0.0028	0.013	0.0003	0.0027	0.004667	13.0	0.007	6.67	25107	> 100	< 1	> 100	< 1
										Total	778312				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending

No sample taken

* Couldn't take the sample the 12th, the TSS plant was in recirculation, on the 13th we had a blizzard and on the 14th, the TSS plant was once again in recirculation.
To keep the samples in the analysis delay, we had to take our samples Monday the 17th

Name of the mine — Agnico-Eagle Mines, Division Meadowbank
Address of the mine — P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine — Denis Gourde, General mine manager
Operator's telephone number — 867-793-4610 X 6725
Operator's e-mail address — dgourde@agnico-eagle.com

Reporting period — June 2010
Date of report

Location of final discharge point: MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Jun.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											39550				
2		< 0.0005	0.0031	0.014	0.0011	0.0045	0.011	25		6.97	39295				
3											38848				
4											36052				
5											37745				
6											38367				
7											26306				
8											29114				
9		0.0013	0.0028	0.012	0.0004	0.004	0.001	22		6.8	34645	> 100	< 1	> 100	< 1
10											29381				
11											19454				
12											19595				
13											19173				
14											19677				
15											19555				
16		< 0.0005	0.0035	0.015	0.0099	0.0046	0.006	25		6.81	19013				
17											14042				
18											14053				
19											19132				
20											17070				
21		< 0.0005	0.0027	0.008	< 0.0003	0.0039	0.002	18		6.67	19904				
22											19531				
23											17724				
24											18131				
25											17028				
26											18795				
27											20006				
28		< 0.0005	0.0033	0.013	< 0.0003	0.0043	0.013	20		6.36	20042				
29											19554				
30											17963				
	Max	0.0013	0.0035	0.015	0.0099	0.0046	0.013	25	0	6.97	39550	> 100	< 1	> 100	< 1
	Min	0.0005	0.0027	0.008	0.0003	0.0039	0.001	18	0	6.36	14042	> 100	< 1	> 100	< 1
	Mean	0.00066	0.0031	0.0124	0.0024	0.0043	0.0066	22.0	#DIV/0!	6.72	23958	> 100	< 1	> 100	< 1
										Total	718745				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Reduced frequency
Analysis pending
No sample taken

Name of the mine — Agnico-Eagle Mines, Division Meadowbank
Address of the mine — P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine — Denis Gourde, General mine manager
Operator's telephone number — 867-793-4610 X 6725
Operator's e-mail address — dgourde@agnico-eagle.com

Reporting period — July 2010
Date of report

Location of final discharge point: MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Jul.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L			% v/v		% v/v	
1											19793				
2											19962				
3											19087				
4											20055				
5											9563				
6											9542				
7		< 0.0005	0.0013	< 0.005	0.0005	0.0038	< 0.001	17	0.013	6.94	17383	> 100	< 1	> 100	< 1
8											20058				
9											13377				
10											19744				
11											14677				
12											12823				
13											12673				
14		0.0039	0.0011	< 0.005	0.0163	0.005	< 0.001	9.2		6.54	12812				
15											12710				
16											10946				
17											11258				
18											11516				
19											12080				
20											12140				
21		< 0.0005	0.0017	< 0.005	< 0.0003	0.0046	0.002	7		5.85	12176				
22											6732				
23											10830				
24											10959				
25											10980				
26											11150				
27											11063				
28		< 0.0005	0.0008	< 0.005	< 0.0003	0.0034	0.004	14		6.37	14571				
29											7454				
30											14388				
31											9155				
	Max	0.0039	0.0017	0.005	0.0163	0.005	0.004	17	0.013	6.94	20058	> 100	< 1	> 100	< 1
	Min	0.0005	0.0008	0.005	0.0003	0.0034	0.001	7	0.013	5.85	6732	> 100	< 1	> 100	< 1
	Mean	0.00135	0.0012	0.005	0.00435	0.0042	0.002	11.8	0.013	6.43	13279	> 100	< 1	> 100	< 1
										Total	411657				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending
No sample taken

Name of the mine: Agnico-Eagle Mines, Division Meadowbank
Address of the mine: P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine: Denis Gourde, General mine manager
Operator's telephone number: 867-793-4610 X 6725
Operator's e-mail address: dgourde@agnico-eagle.com

Reporting period: August 2010
Date of report:

Location of final discharge point: MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna LC$_{50}$ (48h)	Daphnia magna Toxic unit	Rainbow trout LC50 (96h)	Rainbow trout Toxic unit
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	% v/v		% v/v	
Aug.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L						
1											17081				
2											17287				
3											16878				
4											14360				
5											7990				
6											3350				
7											7970				
8											7081				
9		< 0.0005	0.002	0.005	< 0.0003	0.0034	< 0.001	7		6.53	15350	> 100	< 1	> 100	< 1
10											16417				
11		< 0.0005	0.0036	0.006	0.0159	0.0038	0.031	8		6.28	16017				
12											15307				
13											16781				
14											11631				
15											10962				
16											10170				
17											7628				
18											4545				
19											11726				
20											17352				
21											19777				
22											19433				
23											5180				
24											16164				
25		0.0024	0.0017	0.005	< 0.0003	0.0038	< 0.001	1		6.28	15288				
26											16847				
27											16288				
28											16728				
29											16798				
30											16420				
31											15258				
	Max	0.0024	0.0036	0.006	0.0159	0.0038	0.031	8	0	6.53	19777	> 100	< 1	> 100	< 1
	Min	0.0005	0.0017	0.005	0.0003	0.0034	0.001	1	0	6.28	3350	> 100	< 1	> 100	< 1
	Mean	0.001133	0.0024	0.005333	0.0055	0.0037	0.011	5.3	#DIV/0!	6.36	13550	> 100	< 1	> 100	< 1
										Total	420064				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending
No sample taken

Name of the mine — Agnico-Eagle Mines, Division Meadowbank
Address of the mine — P.O. Box 540, Baker Lake Nunavut, X0C 0A0
Name of the operator of the mine — Denis Gourde, General mine manager
Operator's telephone number — 867-793-4610 X 6725
Operator's e-mail address — dgourde@agnico-eagle.com

Reporting period — September 2010
Date of report

Location of final discharge point: MMER-1

Month	Parameter	As	Cu	CN	Pb	Ni	Zn	TSS	Ra226	pH	Effluent Volume	Daphnia magna		Rainbow trout	
	unit	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(mg/L)	(Bq/L)	pH	(m^3)	LC_{50} (48h)	Toxic unit	LC50 (96h)	Toxic unit
Sep.	Max conc. Per grab	1.00 mg/L	0.60 mg/L	2.00 mg/L	0.40 mg/L	1.00 mg/L	1.00 mg/L	30.00 mg/L	1.11 Bq/L	( ) = Env. Readings		% v/v		% v/v	
1		< 0.0005	0.001	< 0.005	< 0.0003	0.0055	< 0.001	9		(6,68) - 6.36	10180	> 100	< 1	> 100	< 1
2											9700				
3															
4															
5															
6															
7															
8		< 0.0005	0.0009	< 0.005	< 0.0003	0.0042	0.003	8		(6,37) - 6,33					
9															
10															
11															
12															
13															
14															
15		< 0.0005	< 0.0005	0.005	0.0004	0.0053	0.001	8		(6.44) - 6,67					
16															
17															
18															
19															
20															
21															
22										(6.55)					
23															
24															
25															
26															
27															
28															
29															
30															
	Max	0.0005	0.001	0.005	0.0004	0.0055	0.003	9	0	0	10180	> 100	< 1	> 100	< 1
	Min	0.0005	0.0005	0.005	0.0003	0.0042	0.001	8	0	0	9700	> 100	< 1	> 100	< 1
	Mean	0.0005	0.0008	0.005	0.000333	0.0050	0.001667	8.3	#DIV/0!	#DIV/0!	9940	> 100	< 1	> 100	< 1
										Total	19880				

Any measurement not taken because there was no deposit from the final discharge point shall be identified by the letters "NDEP" (No Deposit).
Any measurement not taken because no measurement was required in accordance with the conditions set out in section 12 or 13 of the Metal Mining Effluent Regulations shall be identified by the letters "NMR" (No Measurement Required).

Analysis pending
No sample taken

APPENDIX C

EFFLUENT PLUME DELINEATION: TECHNICAL MEMORANDUM.

APPENDIX D

SMALL BODIED FISH RECONNAISSANCE STUDY, 2010.

AGNICO-EAGLE MINES: MEADOWBANK DIVISION

ENVIRONMENT DEPARTMENT

SMALL BODIED FISH RECONNAISSANCE STUDIED IN SUPPORT OF ENVIRONMENTAL EFFECTS MONITORING BIOLOGICAL STUDY DEVELOPMENT

OCTOBER 2010

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LIST OF APPENDICES

SECTION 1 • INTRODUCTION

In 2010, a small bodied fish reconnaissance study was conducted by Agnico-Eagle Mines Limited Meadowbank Division: Environment Department (Jessica Fang BSc, Tom Thomson and Ryan VanEngen, BSc) to evaluate the suitability of electrofishing and minnow trapping in Third Portage Lake at Meadowbank. Ultimately, the goal of the reconnaissance was to determine the possibility of utilizing slimy sculpin (*Cottus cognatus*) as a candidate monitoring species for Environmental Effects Monitoring (EEM). The slimy sculpin study protocol developed in 2007 for Diavik Diamond Mines Inc. in Northwest Territories (Baron et al., 2007) was used as a guideline for this electrofishing reconnaissance. According to the protocol, slimy sculpin could be chosen as a monitoring species for lakes in the Arctic region because they are typically local to an area and are non-migratory; consequently, an assessment of their health can be used as an indicator of local aquatic conditions. The position of slimy sculpin in the food chain, being benthic invertebrate feeders and are themselves then preyed upon by other fish, namely lake trout, makes them a suitable sentinel species for early detection of local changes in an aquatic system (Baron et al., 2007).

SECTION 2 • METHODOLOGY

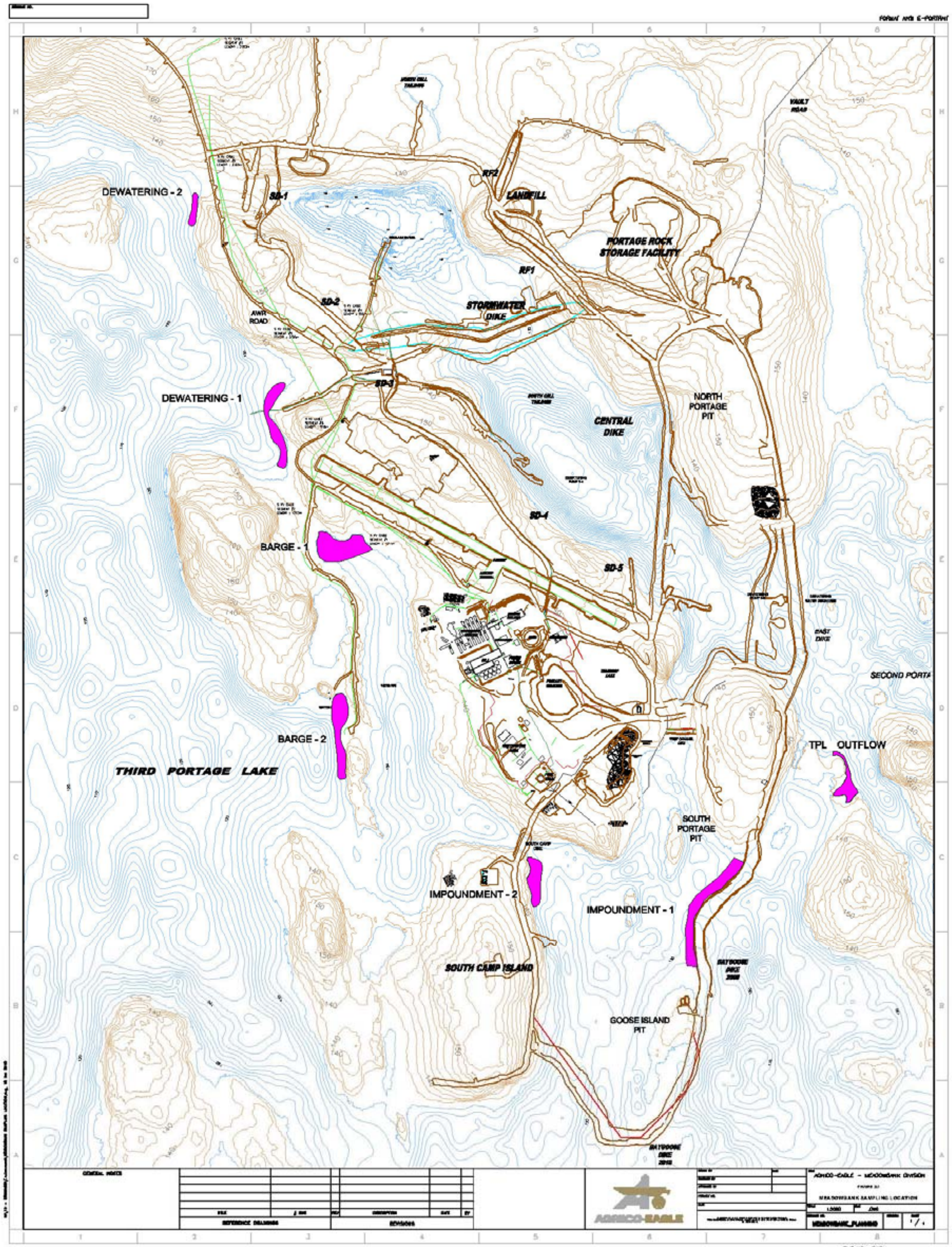
2.1 STUDY AREA

Electrofishing and Minnow Trap sampling was completed in four areas in Third Portage Lake at Meadowbank. Three "reference" areas were selected in locations considered ideal slimy sculpin habitat and selected based on their ease of accessibility. These areas included a location upstream side of Third Portage outflow to Second Portage Lake (Station TPL Outflow); close to the fresh water intake barge (Station Barge 1 and 2); and the third area was located inside the Bay Goose Dike impoundment (Station Impoundment 1 and 2). The exposure area monitored was located close to the dewatering discharge pipe (Station Dewatering 1 and 2), which is the candidate area for future EEM exposure-area-effluent-monitoring. The locations of these stations are illustrated in Figure 2.1 and the exact GPS coordinates are presented in Table 2.1.

Table 2.1 : Electrofishing and Minnow Trap Sampling Locations, 2010

Area	Station ID	Station description	GPS Coordinates	Sampling Method
Barge	Barge - 1	Fresh water in-take Trial	14 W 0639001 UTM 7212467	Electrofishing Minnow traps
	Barge - 2	Fresh water in-take pipe	14 W 0637357 UTM 7213782	Electrofishing Minnow traps
Impoundment	Impoundment - 1	Impoundment East – Old dock	14 W 0638935 UTM 7213288	Electrofishing Minnow traps
	Impoundment - 2	Impoundment West – South Camp	14 W 0638212 UTM 7213011	Electrofishing
Third Portage Lake Outflow	TPL outflow	Third Portage Lake outflow (into Second Portage Lake)	14 W 0639517 UTM 7213424	Electrofishing
Dewatering	Dewatering - 1	Dewatering Discharge pipe	14 W 0637096 UTM 7214976	Electrofishing Minnow traps
	Dewatering - 2	Dewatering Discharge	14 W 0639639 UTM 7215068	Minnow traps

Figure 2.1 Electrofishing and Minnow Trap Sampling Locations



2.2 SAMPLE COLLECTION BY ELECTROFISHING

Fish collection using backpack electrofishing techniques was conducted from late July 2010 through until late August 2010. All of the procedures were based on the use of a Halltech model HT-2000 battery backpack electrofishing unit with an 18 inch anode ring. Electrofishing standard operating procedures were followed at Meadowbank. The collections were undertaken by a certified electrofishing crew leader accompanied by at least one other crew member. The exact GPS coordinates were recorded in each sampling area. Water quality measurements such as water temperature, dissolved oxygen, conductivity and pH were also recorded before each sampling. The substrate and water depth in each sampling area were carefully evaluated to maximize the chance of capturing slimy sculpin. It has been shown that backpack electrofishing sampling of slimy sculpin in Lac de Gras, Northwest Territories has been most successful when targeting areas of natural rock with smaller cobble in less than 40 cm water depth (Gray et al., 2004).

Trial runs were conducted in low value habitat areas near the target areas before the actual sampling events in order to determine the appropriate voltage and frequency settings. During the trial run, an initial low voltage and low frequency setting was used. Voltage and frequency was increased as necessary.

Total shocking time (in seconds) was recorded in each sampling area at the end of sampling. All of the captured fish were measured for length (to the nearest 1mm) and weighed (to the nearest 0.1g). The captured slimy sculpin were placed in individually labelled plastic bags and placed in a freezer. Fish captured inside the impoundment area were released outside of the impoundment. All of the other fish were released in the area proximate to where they were captured.

2.3 SAMPLE COLLECTIN BY MINNOW-TRAP

Fish collection by minnow trapping was conducted in August and September 2010 as an extension of the effort to capture small bodied fish. Two to four minnow traps were deployed at each sampling station for each sampling event. Minnow traps were deployed for 2-3 days at each station and were typically checked daily for fish. Traps were baited with standard-store-bought cat food. The exact GPS coordinates were recorded at each sampling station. All of the captured fish were field measured as described in *Section 2.2*.

SECTION 3 • RESULTS

3.1 ELECTROFISHING

Three slimy sculpin and three lake trout were collected by electrofishing techniques in Third Portage Lake. Two slimy sculpin and one juvenile lake trout were collected in the fresh water in-take barge area; the other slimy sculpin and two juvenile lake trout were collected inside the impoundment area; no fish were successfully collected at the Dewatering Discharge area or in the Third Portage Lake Outflow area. A small number (<3) of fish were spotted in all four sampling areas during electrofishing sampling; however, the fish did not appear to be affected by the electrical current and escaped. All of the captured slimy sculpin were kept and frozen, and all the captured lake trout were measured and released. Table 3.1 provides a summary of these results.

Table 3.1 : Summary of Fish Collection by Electrofishing in Third Portage Lake, 2010

Fish #	Species	Date	Station ID	Length (mm)	Weight (g)	Notes
1	Slimy sculpin	07/22/2010	Barge - 1	61	2.8	Specimen #1
2	Lake trout	07/27/2010	Impoundment-1	63	4.1	Released
3	Lake trout	07/27/2010	Impoundment-1	69	5.0	Released
4	Slimy sculpin	07/27/2010	Impoundment-2	52	2.3	Specimen #2
5	Lake trout	07/28/2010	Barge - 2	67	4.3	Released
6	Slimy sculpin	08/11/2010	Barge - 2	80	3.5	Specimen #3

3.1.1 SLIMY SCULPIN CATCH PER UNIT EFFORT (CPUE)

A total of three slimy sculpins were collected after 6323 seconds of shocking time. Catch Per Unit Effort (CPUE) was 1.71 fish of electro-shocking time. Table 3.1.1 provides a summary of shocking time and number of slimy sculpin captured at each sampling station.

Table 3.1.1: Summary of Electrofishing Catch Per Unit Effort (CPUE) for Slimy Sculpin at Meadowbank, 2010

Station ID	Date	Shocking Time (second)	# of SLSC
Barge – 1	07/22/2010	706	1
Barge – 2	07/28/2010 08/11/2010	1567	1
Impoundment – 1	07/27/2010	1623	0
Impoundment – 2	07/27/2010	651	1
Dewatering - 1	08/29/2010	1067	0
TPL Outflow	07/30/2010	709	0
Total		6323	3
CPUE	1.71		

3.2 MINNOW TRAP RESULTS

Two minnow traps were deployed at Station Barge 1 and four minnow traps were deployed at Station- Barge 2 from August 18 to August 21, 2010; two slimy sculpin were captured in minnow traps at Station Barge 2. Four minnow traps were deployed at Station Impoundment 1 from August 29 to August 31, 2010; two nine-spine sticklebacks were captured inside the impoundment area near the old dock. Four Minnow traps were set at Station Dewatering 2 from September 14 to September 17; no fish were captured at the Dewatering Discharge Station. Both of the captured slimy sculpin were kept and frozen; the nine-spine sticklebacks captured were released. Table 3.2 provides a summary of the results of the fish collected by minnow traps.

Table 3.2 : Summary of Fish Collection by Minnow Trap in Third Portage Lake, 2010

Fish #	Species	Date	Station ID	Length (mm)	Weight (g)	Notes
7	Slimy sculpin	08/20/2010	Barge - 2	74	3.4	Specimen #4
8	Slimy sculpin	08/21/2010	Barge - 2	55	2.7	Specimen #5
9	Nine-spine stickleback	08/30/2010	Impoundment-1	54	1.8	Released
10	Nine-spine stickleback	08/31/2010	Impoundment-1	56	1.8	Released

SECTION 4 • DISCUSSION AND CONCLUSIONS

Five slimy sculpin specimens, three juvenile lake trout and two nine-spine sticklebacks were collected during the small bodied reconnaissance that involved a combination of electrofishing and minnow trap collection. Slimy sculpin were not found in selected areas in high numbers for possible use in Environmental Effects Monitoring (EEM); a CPUE value of 1.71 fish/hour of shocking, given that that is the amount of time shocking and does not account for all of the labour, this time is considered a low return for the amount of effort. The poor success of electrofishing on-site may be due to:

- Low water conductivity: the project lakes have low conductivity (ranged from 0.01 to 0.03 ms/cm), therefore the water is not able to carry the electrical current sent out by the backpack electrofishing unit which significantly reduces the effective shocking zone. It was noted that during the field trials it appeared that the effective zone was less than 6 inches from the 18 inch anode. Essentially the backpack shocker needed to walk *on-top* of the slimy sculpin in order to capture it.
- The small size of the target species: as documented in Baron et al. (2007) small-bodied fish and in particular slimy sculpin tend to be quite resistant to electro-shock because the electro-current passes through their small bodies very quickly. It was also observed in the field that the stunned fish had a very quick recovery time (<10 seconds), therefore if the fish were stunned they were likely very quick to recover and were likely to find refuge in nearby rock crevices.
- Lack of abundance: the small bodied population and particularly slimy sculpin have never been formally surveyed on-site using electrofishing or minnow trapping. Therefore, it is possible that the reconnaissance data is representative of the low population abundance of slimy sculpin in Third Portage Lake. This is noted in and supported by the 2008 fishout data (AEM, 2009) that did not collect any slimy sculpin in Second Portage lake and few slimy sculpin or ninespine stickleback collected in gut contents of lake trout.

The results of the reconnaissance study indicated that small bodied fish collection via backpack electrofishing or minnow trapping are not feasible to meet future study requirments. If slimy sculpin were found in the exposure area and selected reference areas in high numbers (approximately 40) the objective was to determine the usefulness in adopting slimy sculpin as the target species in support of the EEM biological study design. However, due to the overall low capture success, particularly in the exposure area, slimy sculpin are not recommended to be used at Meadowbank as a sentinel EEM monitoring species.

SECTION 5 • REFERENCES

AEM. 2009. 2008 Meadowbank Annual Report: C6 2008 Fishout Summary Report, March 2009.

Baron, C.L., V.P. Palace and J. Dahl. 2007. Study Protocol – Use of Slimy Sculpin as a Lake Monitoring Species.

Gray, M., K. Munkittrick, V.P. Palace, C.L. Baron. 2005. Assessment of slimy sculpin (*Cottus cognatus*) collected from East Island, Lac de Gras, NWT. Report prepared for Diavik Diamond Mines Inc.

Appendix A:

Photo Presentation

October 2010

Photo 1: Electrofishing with a backpack electrofishing unit.

Photo 2: Water quality data recorded before sampling with YSI meter.

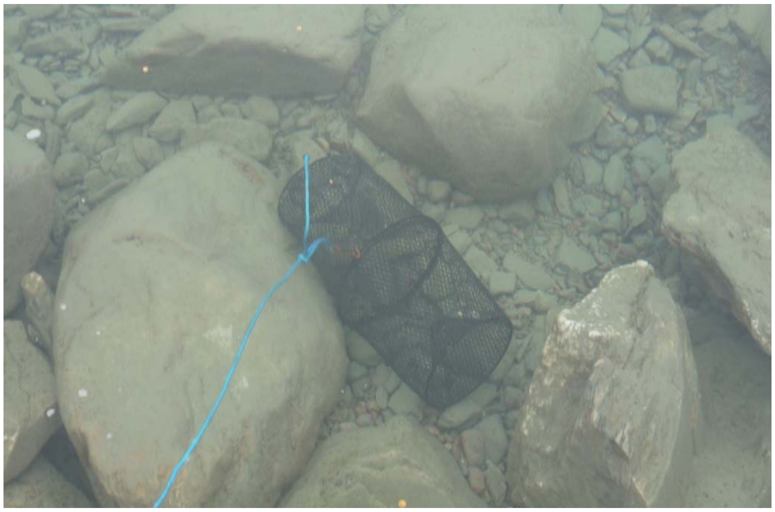


Photo 3: Minnow trap used in this reconnaissance. Photo taken at Dewatering Discharge Station 2.

Photo 4: Captured slimy sculpin.

Photo 5: Captured juvenile lake trout. These fish were later release back to where they were captured.

APPENDIX B:

FIELD DATA AND SHEETS

OCTOBER 2010

Trial - Barge.

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake
Date: July 22. 2010
Crew leader: Jessica Fang
Weather: Overcast, 15°C
Time: 4:15 PM - 5:00 PM
Crew members: ~~Stuart~~ Stuart A.

Field Station: Barge - 1
GPS Coordinates: 14 W 0638001 UTM 7217467
Water temperature: 10.93°C
Water conductivity: 0.010 ms/cm
Dissolved Oxygen: 9.66 mg/L
Effort (total shocking time/distance): 8 min 4 sec
Waypoint #:
Initial second counter reading: 3941
Final second counter reading: 4325
pH: 6.87
Settings and Time: 550 V / 40 Hz : 1 min
750 V / 60 Hz : 30 sec.
950 V / 100 Hz : 6 min 34 sec.

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	Slimy Sculpin	1	61	2.75 g	< 15 sec. Recovery time

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

Note: The trial at the original trial 1 area was not attempted because of the area is not suitable for shocking!

AGNICO-EAGLE

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake
Weather: Sunny . Windy
Date: July 28 2010
Time: 10:30AM - 11:20AM
Crew leader: Jessica Fang
Crew members: TT. PA

Field Station: Barge - 2
GPS Coordinates: 14 W 0637835 7214002
Waypoint #: 032
Water temperature: 8.67 °C
Initial second counter reading: 9055
Water conductivity: 0.016 ms/cm
Final second counter reading: 10007
Dissolved Oxygen: 10.65 mg/L
pH: 6.95
Effort (total shocking time/distance): 15 min 52 sec
Settings and Time: 950 V . 250 Hz → 15 min 52 sec.

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	Lake Trout	1	67	4.3	quick recovery time

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

AGNICO-EAGLE

Electrofishing Field Sheet

Agnico-Eagle Mines Ltd - Meadowbank Division

Water Body: TPN	Weather:
Date: Aug 11/10	Time: 15:05 – 16:00
Crew leader: RV	Crew members: RV M.T.

Field Station: I Barge

GPS Coordinates: 14W 0637357 7213782	Waypoint #:
Water temperature: 9.74	Initial second counter reading: 10716
Water conductivity: 0.015	Final second counter reading: 11331
Dissolved Oxygen: 9.89	pH: 7.73
Effort (total shocking time/distance):	Settings and Time:

10716 sec – 11331 = 615 sec
950 V 750 V
250 Hz 160 Hz

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	SLSC	-1	80	3.5	950V 250Hz

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

SLSC #3

* Inside the dike

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake	**Weather:** Sunny, wind 10km/h
Date: July 27. 2010	**Time:** 3:40 PM
Crew leader: Jessica Fang	**Crew members:** Morgan F.

Field Station: Old dock

GPS Coordinates: ~~[illegible]~~	**Waypoint #:** ~~[illegible]~~
Water temperature: 16.5°C	**Initial second counter reading:** 6781
Water conductivity: 0.030 ms/cm	**Final second counter reading:** 8404
Dissolved Oxygen: 10.089	**pH:** 6.92
Effort (total shocking time/distance): 27min 3 sec	**Settings and Time:**
14W 0638935	950V / 160Hz : 1min 5 sec.
UTM 7213288	950V / 250Hz : 25min 58sec.

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	Lake trout	1	63	4.06	Released!
2	Lake trout	1	69	4.95	
3	Lake trout	1			Not stunned enough → escaped.

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

* Inside the dike

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake
Date: July 27, 2010
Crew leader: Jessica Fang
Weather: Sunny wind = 10km/h
Time: 5:40 PM
Crew members: Morgan F. Samuel T.

Field Station: South Camp
GPS Coordinates: 14 W 0638212 7213011
Water temperature: 16.2°C
Water conductivity: 0.029 ms/cm
Dissolved Oxygen: 10.11 mg/L
Effort (total shocking time/distance): 10 min 51 sec
Waypoint #: 031
Initial second counter reading: 8404
Final second counter reading: 9055
pH: 6.87
Settings and Time:
950 V / 250 Hz 10 min 51 sec.

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	Slimy Sculpin	1	52	2.29	Freeze Specimen #2

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake (N)
Weather: Sunny
Date: August 29 2010
Time: 3:00 PM
Crew leader: Jessica Fang
Crew members: Tom Thomson

Field Station: DWD (Dewatering Discharge)
GPS Coordinates: 14W 0637096 UTM 7212424
Waypoint #: 115 - 116 117 Minnow Traps.
Water temperature: ~~10.14°C~~ 10.94°C
Initial second counter reading: 11331
Water conductivity: 0.019 mS/cm
Final second counter reading: 12398
Dissolved Oxygen: 9.87
pH: 7.36
Effort (total shocking time/distance):
Settings and Time: 950V 250 HZ

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
1	SLSC	1			Escaped
2	LT	1			Escaped

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

Electrofishing Field Sheet

AGNICO-EAGLE MINES LTD - MEADOWBANK DIVISION

Water Body: Third Portage Lake
Weather: Sunny, 17°C
Date: July 30 2010
Time: ~~4 PM~~ 5:30 PM
Crew leader: Jessica Fang
Crew members: Martin Theriault, DAMBUIN Cote.

Field Station: BGE (Target Area #2)
GPS Coordinates: 14 W 0639517 7213424
Waypoint #: 633
Water temperature: 15.54 °C
Initial second counter reading: 10007
Water conductivity: 0.021 mS/cm
Final second counter reading: 10716
Dissolved Oxygen: 8.98
pH: 7.04
Effort (total shocking time/distance): 11 min 49 sec
Settings and Time: 950V/250Hz : 11min 49 sec

Fish #	Species	Condition	Length(mm)	Weight (g)	Note:
Three - Four Slimy Scalpin spoted but unable to catch them.					

Fish Conditions:

1 - no visible signs of injury

2 - signs of minor Haemorrhage

3 -signs of moderate to serious Haemorrage and spinal injuries

4 -Fish mortality

Minnow Trap log.

Date		location	Note
Aug 19	2010	Barge 1	4 traps set
		Barge 2	4 traps set
Aug 20	2010	Slimy sculpin x 1	
		74 mm 3.4 g	at Barge 2
		(Specimen #4)	
Aug 21	2010	Slimy sculpin x 1	
		55 mm 2.7 g	at Barge 2
		(Specimen #5)	

Aug 21 Pull all traps at Barge 1 and 2

Aug 29	2010	Impoundment 1 (Old dock)	4 traps set
		Dewatering pipe	4 traps set

Aug 30 9-spine stickleback
54 mm 1.8 g
→ let go outside of the impounded area

Aug 31 9-spine stickleback
56 mm 1.8 g.
released outside of the impounded area

Pulled traps.
No fish caught at DWD

Sept. 15	DWD 2	4 traps set.
Sept. 16	No fish	
Sept. 17	No fish	
Sept. 17	pulled traps	

APPENDIX E

STANDARD OPERATING PROCEDURES FOR SEDIMENT AND BENTHOS SAMPLING.

APPENDIX E
Standard Operating Procedure
Meadowbank Study Lakes & Baker Lake
CREMP Benthos & Sediment Sampling

GENERAL:

Project Coordinator:
Maggie McConnell
Azimuth Consulting Group Inc.
218-2902 West Broadway
Vancouver, BC, V6K 2G8
Telephone: 604-730-1220
Fax: 604-739-8511
Email: mmcconnell@azimuthgroup.ca

In case of **emergency**, contact Gary Mann (Azimuth telephone number 604-730-1220 or cell phone 604-908-0601).

LOCATION AND TIMING FOR FIELD ACTIVITIES:

Twelve sampling stations have been chosen for benthos and sediment quality monitoring in the Meadowbank study lakes area. These stations (with their corresponding abbreviation) are:

- Third Portage Lake – North Basin (TPN)
- Third Portage Lake – East Basin (TPE)
- Third Portage Lake – South Basin (TPS)
- Second Portage Lake (SP)
- Tehek Lake (TE)
- Wally Lake (WAL)
- Inuggugayualik Lake (INUG)
- Tehek far-field (TEFF)
- Pipedream Lake (PDL)
- Baker Lake – Barge Dock (BBD)
- Baker Lake – Proposed Jetty (BPJ)
- Baker Lake – Akilahaarjuk Point (BAP)

Field activities are scheduled for once per year, in **mid/late August**. The **target water depth** at each sampling station is approximately **8 meters +/- 1.5 m**; Wally Lake is the exception, with a total water depth of approximately 6 meters (target water depth is 5 to 6 meters).

BENTHOS & SEDIMENT CHEMISTRY SAMPLING:

1. Gather **field collection materials**:
   In the boat:
   - Field collection data forms, waterproof paper, pencils, waterproof markers & clipboard

- GPS unit, batteries
- Depth meter, batteries
- pH meter, batteries
- Rope
- Petite Ponar grab and rope
- 500 micron sieve bag
- 2 stainless steel bowls
- 2 stainless steel spoons
- Liquinox detergent and dish cleaning brush
- Plastic squirt bottle
- Bucket
- Sampling gloves
- Safety glasses
- Field sample jars & preservatives (per sampling station):
    - 3 – 125 mL glass jars (sediment samples)
    - 5 – 500 mL plastic jars (benthos)
- QA/QC field duplicate sediment jars
- Ashless filter paper & tweezers; 1-125 mL glass jar

In camp:

- Formalin (10% Formaldehyde)
- Labels for sampling containers
- Coolers, action packers (for storing and shipping samples)
- Ice packs (for shipping sediment samples to lab)
- Address labels for coolers
- Chain-of-custody forms
- Large Ziploc bags (for sending chain-of-custody form in coolers)
- Electrical tape (for sealing benthos jars)
- Packing tape (for affixing labels to sediment sample containers & sealing coolers)

2. Before going into the field, **label the lids** of all sampling containers using a permanent waterproof marker. After sampling, prepare appropriate labels for containers and affix them when bottles are dry enough to stick to. Use the following information:

- Azimuth company name
- Station abbreviation (e.g. TPE-1, INUG-3)
- Date of sample collection
- Parameters to be measured from individual jar (2 x 125 mL – total metals, pH, moisture, PAHs, Oil&Grease; 1 x 125 mL – grain size (PSA), TOC)

Affix the labels to the sediment jars and then wrap packing tape around the labels to ensure a waterproof seal.

For the **benthos containers**, print the following information directly onto both the jar and jar lid using a permanent waterproof marker:

- Azimuth company name
- Station abbreviation (e.g. TPE, INUG) and replicate number (e.g. TPE-1, TPE-2); there are a total of 5 replicates per sampling station
- Date of sample collection

Prepare **internal labels** for each of the benthos containers. On a small piece of waterproof paper, write, using a lead pencil, the station abbreviation and replicate number (e.g. TPE-1). If no waterproof paper is available, use regular paper. Store the labels in their corresponding sampling container.

3. For **QAQC** purposes, sediment samples are collected in duplicate from one station every sampling event. All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected randomly from one of the ten stations, and labeled as station DUP. Prepare the QAQC labels and affix to the sediment jars, as described in step 2. Label one new 125 mL glass jar with the Azimuth company name, date, QAQC filter and total metals.

4. A 100% formalin solution is equivalent to a solution of 37% formaldehyde. The **target formalin concentration** in each of the sampling containers is 10%. A neutral buffered formalin solution is achieved by adding a sufficient amount of calcium carbonate powder or pellets to render the solution pH neutral (pH = 7.0). Borax powder may be substituted for calcium carbonate powder if necessary.

   Transport Canada allows the free transport of formalin at concentrations less than 25% formaldehyde. Consequently, the formalin transported up to Meadowbank will be diluted in half (18.5% formaldehyde / 50% formalin solution).

   To **prepare** the **neutral buffered formalin**, add a small amount of calcium carbonate powder or pellets to the 50% formalin solution, seal the container and shake until mixed. Check the pH of the solution using the pH pen. Continue adding the powder/pellets until the pH of the solution reaches approximately 7.0. Store at room temperature until ready to use. Only prepare the required volume of neutral buffered formalin for that sampling event. Buffered formalin will not store for long periods of time.

   Follow all **safety precautions** when preparing the formalin solution. Formalin is a carcinogen and irritant. Wear sampling gloves and safety glasses when mixing the solution and prepare the solution in a well ventilated area.

5. Before and during the benthos and sediment sampling fill in the requested information on the **field data form**; complete one field data form in its entirety for each sampling station and sampling event. Forms are made of waterproof paper; **print** all information on the form using a **lead pencil** or write-in-the-rain pen.

6. With the aid of a GPS unit, **navigate the boat** to the sampling station using the UTM coordinates (in NAD 83) provided. Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the boat remains within a 50 meter radius of the position. Do not allow the anchor to drag through the sampling station. Record the exact UTM coordinates on the field data form.

7. Measure the **water depth** at the sampling station using the ‘Hawkeye’ hand-held depth meter (note: place depth meter in water ***before*** pushing ON button). Hold the meter in the water, facing the lake bottom, until the meter measures the depth. Record this information on the field data form.

8. Begin collecting the benthos samples. Collecting the sediment first would disturb the benthic community.

9. Ensure the rope is securely attached to the **Ponar**. Rinse the Ponar grab, stainless steel bowl and spoon with lake water. **Wash** each of these items with liquinox soap by scrubbing with the dish cleaning brush and then thoroughly rinse with lake water. Put aside the stainless steel bowl and spoon until later (step 18).

10. Lower the **Ponar** to within 1 meter of the bottom of the lake. Lower the Ponar very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability**. The grab is acceptable if the sample:
    - does not contain large foreign objects;
    - has adequate penetration depth (i.e., 10-15 centimeters);
    - is not overfilled (sediment surface must not be touching the top of the Ponar);
    - did not leak (there is overlying water present in Ponar); and
    - is undisturbed (sediment surface relatively flat).

    Once the grab is deemed acceptable, open the Ponar jaws and drop the sample into a stainless steel bowl. Rinse the ponar with squirt bottles to make sure all of the material is in the bowl. Gently pour the contents of the bowl into the 500 micron sieve bag.

11. **Sieve the sample** in the lake water until only the benthic organisms and coarse materials remain. Care must be taken to ensure the benthic organisms are not damaged or crushed. Do not disturb the sample to the point that it is splashing out of the sieve. Do not forcibly push materials through the sieve; gently break apart any small clay balls. Rinse off any pieces of larger plant material or rocks in the sample and discard.

12. **Flush** the **remaining sample** in the bottom of the sieve into the pre-labeled plastic sampling container (i.e. station-1 jar). A plastic squirt bottle filled with lake water is useful for this purpose.

13. **Repeat steps 10-12**, flushing the sample into the same pre-labeled plastic sampling container (i.e., station-1 jar). Ensure the sample is collected in an area not previously disturbed by the Ponar. The two independent grabs (per replicate) are composited to increase the surface area sampled.

14. **Rinse the sieve** bag to clear out any debris in the screen. To rinse, hold the sieve upside down and raise and lower the sieve into the water.

15. **Repeat steps 10-14** four more times; there must be a separation of ***20 meters*** or more from other replicate stations. Record the depth and GPS coordinates of each replicate station on the field data form. Put the samples from each replicate in pre-labeled station replicate jars 2

through 5. In total, 10 Ponar grabs will be collected for benthos collection, two grabs per replicate.

16. Ensure internal labels are in each sample container. Shake the formalin to ensure all of the calcium carbonate powder is in solution. **Add** a sufficient volume of **formalin** to each sampling container to make a corresponding formalin solution of approximately 10%. Volumes of formalin are added by ‘eye’ (for a 10% solution, a ratio of 4 parts water and 1 part 50% formalin solution). Overall, there must be enough liquid in the jar to cover the entire sample. Seal the sample container securely and gently roll the container to mix the sample and formalin solution. Do not shake the sample container; this will crush the benthic organisms inside.

17. Begin collecting the sediment samples. Lower the **Ponar** to within 1 meter of the bottom of the lake, in an area not previously disturbed by the Ponar. Lower the Ponar very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for **acceptability** (see step 10 for criteria).

18. Once the grab is deemed acceptable, open the top of the Ponar and remove any overlying water. Using the pre-cleaned stainless steel spoon, scoop out the **top 3-5 centimeters** of **sediment** and place in the pre-cleaned stainless steel bowl. Empty the remainder of the grab sample into a bucket in the boat, not directly into the lake, to ensure the area is not disturbed.

19. **Repeat steps 17** and **18** one or two more times, placing the sediment into the bowl with the other sediment sample(s).

20. **Homogenize** the sediment samples in the stainless steel bowl (by stirring with the spoon) until the sediment is thoroughly mixed. Scoop the sediment into pre-labeled sediment sampling containers. **Fill the jars** to the top and seal securely.

21. If this station is selected as the QAQC **field duplicate**, using the tweezers and a set of clean sampling gloves, **swipe** the stainless steel bowl and spoon with one piece of ashless **filter paper** and store in the pre-labeled 125 mL glass jar. Collect the duplicate sediment sample from the same sediment collected in steps 17-20. Fill the sampling containers labeled as station DUP. Record that the QAQC samples were collected from this sampling station on the field data form.

22. **Complete** the **field data form**, including a description of the sediment (grain size, consistency, colour, presence of biota, sheen, unusual appearance) and the sampling effort (equipment failure, control of vertical descent of sampler) required to collect the benthos and sediment samples.

23. **Rinse** out the Ponar, stainless steel bowl and spoon with lake water. Dump the sediment and water from the plastic bin into the lake.

24. Until ready for shipping, store the **sediment samples and QAQC filter paper chilled** (on ice) in a cooler or in a refrigerator in camp, if space is available. The sediment sampling

containers may be put in plastic bags prior to storage on ice to further protect the labels from water damage. **Benthos samples** are stored in a cooler or action packer at **room temperature**.

25. Fill out a **chain-of-custody** form for the sediment samples being sent to **ALS Environmental**. The COC form must be completed carefully and in its entirety to ensure proper analysis. This includes listing all of the specific parameters to be analyzed (see step 2), Azimuth and ALS contact names, and checking off all of the specific boxes for requested analyses. The ALS laboratory quote number must be printed on the COC form to ensure proper billing.

    A **digital COC** form is available; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. However, using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Azimuth). Ensure printing services are available in camp prior to using the digital version of the form. Any questions regarding the COC form should be directed to the Azimuth project coordinator – Maggie McConnell. Put the completed COC form in a sealed ziploc plastic bag in the cooler with the samples.

26. Fill out a **chain-of-custody** form for the benthos samples being sent to **Zaranko Environmental Assessment Services** (ZEAS). Complete all of the required fields and then put the form in a sealed ziploc plastic bag in the cooler with the benthos samples.

PACKAGING & SHIPPING SAMPLES:

1. Ensure all **sediment samples** are **sealed** securely. **Pack** sediment sampling containers upright in a cooler with ice packs, and packing material, to ensure containers do not break during transport. (Ideal storage and transport temperature is 4°C).

2. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

   ALS Environmental
   101-8081 Lougheed Hwy.
   Burnaby, BC, Canada
   V5A 1W9
   Tel: 604-253-4188
   Attention: Natasha Marcovic-Mirovic

3. Ensure **benthos samples** are **sealed** securely. Wrap electrical tape around the edge of the lids to ensure a tight seal. **Pack** benthos sampling containers upright in a cooler or action packer; ensure the cooler/action packer is well packed so the jars are not able to move around.

4. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

   Zaranko Environmental Assessment Services
   36 McCutcheon Avenue
   P.O. Box 1045
   Nobleton, ON
   L0G 1N0
   Tel: 905-859-7976

5. **Ship** the sediment **samples** to ALS Environmental as quickly as possible. Ship the benthos samples to ZEAS when convenient. Coordinate shipping with the camp manager.

6. Send completed **COC forms** and **field data forms** to **Azimuth** Consulting Group Inc., attention the project coordinator – Maggie McConnell.

APPENDIX F

STANDARD OPERATING PROCEDURES FOR WATER SAMPLING.

APPENDIX F
Standard Operating Procedure
Meadowbank Study Lakes & Baker Lake
CREMP Water & Phytoplankton Sampling

GENERAL:

Project Coordinator:
Maggie McConnell
Azimuth Consulting Group Inc.
218-2902 West Broadway
Vancouver, BC, V6K 2G8
Telephone: 604-730-1220
Fax: 604-739-8511
Email: mmcconnell@azimuthgroup.ca

In case of **emergency**, contact Gary Mann (Azimuth telephone number 604-730-1220 or cell phone 604-908-0601).

LOCATION AND TIMING FOR FIELD ACTIVITIES:

Up to Twelve sampling stations have been chosen for water quality monitoring in the Meadowbank study lakes and Baker Lake. Water samples are collected monthly during open water and during ice-cover, except for November and June, when ice conditions are unsafe for sampling The 12 stations (with their corresponding abbreviation) are:

- Third Portage Lake – North Basin (TPN)
- Third Portage Lake – East Basin (TPE)
- Third Portage Lake – South Basin (TPS)
- Second Portage Lake (SP)
- Tehek Lake (TE)
- Tehek far-field (TEFF)
- Wally Lake (WAL)
- Inuggugayualik Lake (INUG)
- Pipedream Lake (PDL)
- Baker Lake – Barge Dock (BBD)
- Baker Lake – Proposed Jetty (BPJ)
- Baker Lake – Akilahaarjuk Point (BAP)

There are four levels of sampling intensity over the course of the year, depending on whether under ice or in open water; and whether multiple depths or single depths are sampled. High and Low Intensity. The intensity of water sampling depends on whether open water or under ice, and further, by month. Check the monthly water sampling schedule to confirm the lakes, locations and water depths from which water samples are to be collected BEFORE going into the field.

There are up to three different depths from which water will be collected. Routine samples where there is no depth-stratified sampling shall be from **3 m below the water surface**. Where there is depth-stratified sampling, three water samples will be collected from discrete depths (1) Surface (***S***) = **3 m below surface**; (2) Deep (***D***) = **3 m above the bottom** (e.g., if 15 m deep total, water shall be collected from 12 m); and (3) Integrated (***INT***) = **integrated from just below surface (0.5 m) to 8 m** (or to "deep" location). Target locations for each sampling station have been randomly pre-determined and recorded in MapSource and in the hand-held GPS units (NAD 83). Confirm before going into the field.

Field activities are scheduled roughly once a month, including winter ice sampling. Sampling through the ice will take place in January, February, March, April, May, November, and December. Open water sampling will take place in July, August, and September. Sampling will not be conducted in June and November because of thin ice conditions.

MONTHLY CREMP WATER CHEMISTRY & PHYTOPLANKTON SAMPLING:

1. Prior to leaving camp gather the appropriate type and number of sampling vessels and acid vials for preservation. Prepare appropriate labels for containers, affix them to the appropriate bottle (see below), and wrap label with packing tape. Use the following information:
   - Azimuth company name
   - Station abbreviation (e.g. TPE-S, INUG-INT)
   - Date of sample collection
   - Parameters to be measured from individual bottle (conventionals, total metals, etc.)

2. Gather **field collection materials**:
   In the boat:
   - Field collection data forms, pencils, waterproof markers & clipboard
   - GPS unit, batteries
   - Water pump & 12V battery
   - Tubing (2 – 3 x 8 meter length and 1 meter length) & weight (& extra C-clamps and cable ties). Longer tubing is required in the event that deep samples are being collected.
   - In-line filter and a spare
   - YSI meter, batteries
   - Secchi disk
   - Hand held pH meter, batteries
   - Depth meter, batteries
   - Bucket
   - Rope
   - Sampling gloves
   - Field sample bottles & preservatives (per sample):
     - 2 – 1 L plastic (TSS and Conventionals)
     - 1 – 250 mL amber glass (TKN, Ammonia)
     - 2 – 125 ml amber glass (TOC & DOC)
     - 2 – 250 mL plastic (total and dissolved metals)
     - 1 – 50 mL vial for phytoplankton

- 1 vial sulfuric acid
- 2 vial hydrochloric acid
- 2 vial nitric acid
- 1 syringe & magnesium carbonate slurry
- 1 syringe & Lugol's solution

- Extra sample bottles in case of breakage or loss
- QA/QC field duplicate sampling containers & preservatives (same as above), at one randomly selected sampling station per sampling event
- Take one set of Travel Blank bottles into the field and transport and treat as other samples. Note that the Travel Blank bottles are not to be opened and no preservatives added.

In camp:

- Hand pump, filters, tweezers, tinfoil and magnesium carbonate for phytoplankton
- De-ionized water for rinsing equipment and collected field equipment blank
- Coolers (for storing and shipping samples)
- Ice packs (for shipping samples to laboratories)
- Address labels for coolers
- Chain-of-custody forms
- Large Ziploc bags (for sending chain-of-custody form in cooler)
- Packing tape (for affixing labels to sampling containers & sealing cooler)

The following table lists the specific bottles to be filled, parameters to be measured and preservatives required for each. Affix the labels to the sampling containers and then prior to shipping, wrap packing tape around the labels to ensure a waterproof seal.

Sampling Container	Parameters to be Measured	Preservatives to be Added
2 - 1 L plastic	Conventionals*	None
250 mL amber glass	TKN, Ammonia	1 vial of sulfuric acid
250 mL plastic	Total Metals	1 vial of nitric acid
250 mL plastic	Dissolved Metals	1 vial of nitric acid
125 mL amber glass	TOC	1 vial of hydrochloric acid
125 mL amber glass	DOC	1 vial of hydrochloric acid
50 mL vial	Phytoplankton	**1/4 mL** of Lugol's solution per 50 mL sample

* includes: hardness, conductivity, pH, TDS, TSS-low, turbidity, alkalinity (speciated), orthophosphate and total phosphate, chloride, fluoride, bromide, sulfate, nitrate-nitrogen, nitrite-nitrogen, silicate.

** **do not use filtrate water** for any sample. Use the in-line filters for collecting dissolved metals and dissolved organic carbon samples.

3. For **QAQC** purposes three kinds of samples are required; one set per 10 field samples as follows:

A: One field duplicate is collected for every 10 sample per event (i.e., 10%). All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected randomly from one of the stations, and labeled as station CREMP [month] DUP-1, -2, -3, -4, etc. Prepare the QAQC labels and affix to the sampling containers, as described in step 2.

B: One set of travel blanks are to be carried into the field and treated like the other sampling vessels except that the bottles are not to be opened or anything added to them.

C: One equipment blank will be acquired per every 10 field samples. To collect an equipment blank set up the water sampling equipment as if a routine sample was to be collected except that the incurrent and excurrent hoses are placed into a 4L container of distilled water (available on site). Pump for 2 minutes (just like in the field) to flush site water from the equipment (also attach the filter to flush for 30 seconds). Using a second 4L jug, flush another approx. 1L (this time excurrent hose is placed in sink) and then use the remaining 2L fill all bottles, except for Turbidity, TSS-low and chlorophyll, preserve and treat as other samples, including filtering where necessary. Label as station CREMP [month] EB-1, -2, -3, -4, etc. Finally, fill a new suite of bottles directly from a third 4L jug to test for any problems with the distilled water itself. Label theses as CREMP [month] DIS-1, -2, -3, -4.

4. Before and during sampling fill in the requested information on the field data form; complete one field data form in its entirety for each sampling station and sampling event. Forms are made of waterproof paper; print all information on the form using a lead pencil or a write-in-the-rain pen.

5. With the aid of a GPS unit, navigate the boat to the sampling station using the UTM coordinates (in NAD 83) provided. Approach the station from downstream of the wind direction. In windy conditions, anchor the boat upstream of the station and drift back; it is not necessary to anchor the boat in calm conditions providing the boat remains in the same position. Do not allow the anchor to drag through the sampling station. Record the exact **UTM coordinates** on the field data form.

6. Measure **water depth** at the sampling station using the 'Hawkeye' hand-held depth meter (note: place depth meter in water *before* pushing ON button). Hold the meter in the water, facing the lake bottom, until the meter measures the depth. Record this information on the field data form. If you are in water that is too shallow (i.e., **must have at least 5 m for S stations only or 8 m for D/INT stations**), move to deeper water near the assigned station.

7. Measure the light attenuation at the sampling station using the **Secchi disk**. Lower the disk into the water, on the shady side of the boat, so that you can no longer see it. Slowly raise the disk to the point that you can see it and measure this depth using the markings on the disk rope.

8. Measure the pH of the water at the sampling station using the **pH meter**. Hold the probe portion of the meter in the lake until the meter measures the pH. Record this information on the field data form.

9. Calibrate the YSI probe prior to going into the field; confirm elevation (m) of sampling environment. Lower the **YSI probe** into the lake to just below the water surface level.

Measure the temperature (^oC), specific conductance (i.e., temperature corrected) (uS/cm) and dissolved oxygen concentration (mg/L) in the water and record on the field data form. Lower the meter to a depth of 1 m and record the field measurements. Allow the concentrations on the meter to stabilize for 10 to 15 seconds before recording the concentrations. Continue recording the field measurements at 1 m depth intervals until you reach the whole metre mark above the lake bottom (i.e. if the lake depth is 9.3 meters, record field measurements up to a depth of 9 meters). Use the **turbidity probe** in a similar manner to record a turbidity profile.

10. Set up the **water pump** in the boat; attach the tubing to the pump using the C-clamps and attach the 12V battery. Attach the 8 meter length of tubing to the intake valve, and the 1 meter length to the output valve. Attach the plastic coated ball weight to the end of the 8 meter length of tubing. Lower the 8 meter length of tubing into the water to 3 m depth and place the 1 meter length of tubing over the edge of the boat. Run the pump for **2 minutes** to flush the sampling device. If sampling from a deep depth (i.e., 3 m from the bottom), lower the tube to 3 m from the bottom (confirm with hawkeye sounder) and again allow to flush for 2 minutes before taking a sample.

    When collecting an 'integrated' depth sample water is to be discharged into a CLEAN 5 gal HDPE bucket. To collect an integrated sample lower the incurrent hose to 0.5 m below the water surface and allow to rinse for 2 minutes. After flushing, place the excurrent hose into the bucket and slowly lower the hose through the water column to 8 m depth and back again to just below the surface. Repeat. Once sufficient water has been collected, place the incurrent tube into the HDPE bucket and pump water from the bucket into the appropriate collection vessel.

11. For each sampling station, **fill** the required **pre-labeled sampling containers** with water from the 1 meter length of tubing either directly from the lake or from the bucket as appropriate.

12. Dissolved metals and dissolved organic carbon samples are to be collected with an in-line high capacity filter with 0.45 um pore size. After all unfiltered samples have been collected, disconnect the battery from the pump and fix the filter onto the end of the discharge hose. Re-connect the pump and allow the water to discharge and flush through the filter for 15 – 20 seconds. Direct filtered water into the DOC and dissolved metals bottles. Flow from the hose can be controlled by pinching the incurrent end of the tube (not the excurrent). Once filtered samples have been collected remove the filter and place into a plastic or zip-loc bag for re-use. In the Meadowbank environment where the amount of suspended solids is low, filters can be re-used for up to 10 stations. Remember to use the same filter when collecting equipment blank samples, not a new filter.

13. **Add** the **specified preservatives** to the appropriate sampling containers (according to the information on the labels and table in step 2), seal and mix thoroughly by turning upside down and then upright a number of times.

14. To collect a phytoplankton sample, add site water from appropriate depth (i.e., shallow, integrated or deep) into the 50 mL vial provided. Make sure that site information is appropriately labeled on the jar. In the field or the lab, add a few drops of Lugol's solution to the sample so that it has the color of weak tea.

15. Rinse all sections of the water filter apparatus with site water.

16. Back in the office, to process the phytoplankton sample, use the hand-held pump apparatus and filters. Using the tweezers, place an ashless filter paper on the screen in the water filter apparatus, and, prior to filtering, add 1 – 2 drops of magnesium carbonate slurry directly onto the filter, then screw the two sections together and attach the hand-held vacuum pump. **Filter 1 L of water** through the water filter apparatus. Wrap the filter paper in a piece of tinfoil, then place the filter in the pre-labeled ziploc bag. Mark on the COCs and on the field collection data sheet the volume of water filtered. In some cases it is not possible to filter up to 1L. In such cases it is critical to note the actual volume filtered. After filtering remove the filter with clean tweezers, place on a piece of tin foil and double wrap. With a sharpie pen, write the appropriate sampling information on a label and stick to the tin foil. Place the folded tinfoil in a zip loc bag and put into the freezer.

17. Until ready for shipping, the **water samples** are stored **chilled** in a refrigerator in camp, if space is available. The **filter** for chlorophyll-a analysis must be **frozen**; store this bag in a deep freezer in the camp. Bottles should be put in plastic bubble bags prior to storage on ice to protect the labels from water damage. The **phytoplankton samples** are stored at **room temperature**.

18. If this sampling station is selected as the QAQC **field duplicate**, collect a second set of water samples (repeat step 10), fill the pre-labeled sampling containers (repeat step 11) and collect a second filtered chlorophyll-a sample (step 12). Record which sampling station the QAQC samples are collected from on the appropriate field data form.

19. Fill out a **chain-of-custody** form for the water samples and filters being sent to **ALS Environmental**. The COC form must be completed carefully and in its entirety to ensure proper analysis. This includes listing all of the specific conventional parameters (see table in step 2), Azimuth and ALS contact names, and checking off all of the specific boxes for requested analyses. The ALS laboratory quote number must be printed on the COC form to ensure proper billing.

    A **digital COC** form is available; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. Note that using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Azimuth). Ensure printing services are available in camp prior to using the digital version of the form. Any questions regarding the COC form should be directed to the Azimuth project coordinator – Maggie McConnell. Put the completed COC form in a sealed ziploc plastic bag in a cooler with the water samples.

20. Fill out a **chain-of-custody** form for the phytoplankton samples being sent to **Plankton R Us Inc.**, Winnipeg, MB. Complete all of the required fields and then put the form in a sealed ziploc plastic bag in the cooler with the phytoplankton samples.

PACKAGING & SHIPPING SAMPLES:

1. Ensure all **water samples** are **sealed** securely. Prior to shipping, it is advisable to wrap the label of each sample bottle with clear tape to make sure that the label does not come off during shipping and handling. Dry the water bottle and wrap with tape. **Pack** water sampling containers upright in coolers with ice packs, and packing material, to ensure samples do not spill or break during transport. (Ideal storage and transport temperature is 4°C).

2. Ensure the COC form is enclosed and then seal the cooler(s). **Label the cooler**(s) with the following address:

   ALS Environmental
   101-8081 Lougheed Hwy.
   Burnaby, BC, Canada
   V5A 1W9
   Tel: 604-253-4188
   Attention: Natasha Marcovic-Mirovic

3. Ensure **phytoplankton samples** are **sealed** securely and **pack** in a cooler with packing material to ensure samples do not break during transport. It is not necessary to keep samples cool.

4. Ensure the COC form is enclosed and then seal the cooler. **Label the cooler** with the following address:

   Plankton R Us Inc.
   Dave Findlay
   39 Alburg Drive
   Winnipeg, MB
   R2N 1M1
   Tel: 204-254-7952

5. **Ship** the water **samples** to ALS Environmental as quickly as possible. Ship the phytoplankton samples to Dave Findlay at the end of each month or event.

6. Send completed **COC forms** and **field data forms** to **Azimuth** Consulting Group Inc., attention the project coordinator – Maggie McConnell.

APPENDIX G

ALS LABORATORY GROUP – NATIONAL QUALITY MANUAL.

ALS Laboratory Group – Environmental Division (Canada) National Quality Manual

National Authorizations

Authorized By:	Linda Neimor National Quality Manager	Date:	June 01, 2009
Authorized By:	Mark Hugdahl Technical Services Director	Date:	June 01, 2009
Authorized By:	Raj Naran Vice President Environmental Division, North America	Date:	June 03, 2009

Local Authorization

VANCOUVER
Laboratory Location

Authorized By: Joyce Chow (Laboratory Manager) Effective Date: June 8, 2009

TABLE OF CONTENTS

1.0 SCOPE

This Quality Manual describes the Quality Management System of the ALS Laboratory Group Environmental Division locations in Canada. Where appropriate, it refers to other documents for additional information. Throughout this manual, whenever ALS is used alone, it refers to the Environmental Division of the ALS Laboratory Group in Canada.

2.0 LOCATIONS, ACCREDITATIONS AND RECOGNITIONS

ALS has laboratories across Canada. Addresses and contact information are available by following the location links at our web site: www.alsenviro.com.

Labs within our network are accredited or recognized for specific tests by the following agencies, as appropriate to their fields of testing and geographic sectors.

- Canadian Association for Laboratory Accreditation (CALA, previously CAEAL) – www.cala.ca
- Standards Council of Canada (SCC) – www.scc.ca
- American Industrial Hygiene Association (AIHA) – IHLAP – www.aiha.org
- American Industrial Hygiene Association (AIHA) – EMLAP – www.aiha.org
- State of Washington Department of Ecology (WADOE) – www.ecy.wa.gov
- United States National Environmental Laboratory Accreditation Program (NELAP) – www.nj.gov/dep/oqa
- British Columbia Provincial Health Officer – EWQA – www.pathology.ubc.ca
- British Columbia Ministry of Environment – EDQA – www.env.gov.bc.ca
- Ontario Ministry of Environment – MOE – www.ene.gov.on.ca
- Health Canada Good Manufacturing Practices (GMP) - Establishment License – www.hc-sc.gc.ca

Copies of scopes of accreditation, certificates, and licenses applicable to these programs contain the details of the each location's membership, and list the accredited or recognized tests. ALS Quality staff and Quality Contacts maintain this information by forwarding all updates to the National Quality Manager.

3.0 TERMS AND DEFINITIONS

The terms and definitions relevant to the national quality management system are described in a nationally controlled file. For instances where local and national documents describe similar terms and definitions, the local document takes precedence.

Refer to:

- ➢ Local Master List: DEFINITIONS OF KEY TERMS

4.0 MANAGEMENT PROTOCOLS

4.1 ORGANIZATION AND RESPONSIBLITIES

4.1.1 The ALS Laboratory Group is a global laboratory organization which is solely owned by the Australian publicly traded company Campbell Brothers Limited. In Canada, ALS Laboratory Group operates environmental testing laboratories under the trade name ALS Laboratory Group Environmental Division, and the legal names ALS Canada Ltd., and the Manitoba Technology Centre Ltd.

Through our Environmental Division lab network, the ALS Laboratory Group offers the following testing services:

- Water Quality Testing
- Inorganic Analysis
- Organic Analysis
- Pesticide and Herbicide Analysis
- Dioxin Testing
- Toxicological Testing
- Biological Examination Analysis
- Microbiological Testing
- Air Testing
- Agricultural Soil Analysis
- Industrial Hygiene Testing

Matrices tested include drinking water, ground and surface water, effluent, soil, sediment, solid waste, air, and biota, including food, vegetation, and animal and fish tissue.

Our clients include private individuals, consultants, government, and industry.

4.1.2 ALS accepts responsibility to carry out its environmental testing activities in such a way as to meet the requirements of clients, regulatory authorities, ISO/IEC 17025:2005, and organizations providing accreditation and recognition.

To ensure the terms and conditions of accrediting body publicity policies are met, all publications or advertisements that refer to accreditation, proficiency testing performance, or compliance to regulations are reviewed prior to release by the Technical Services Director and/or the National Quality Manager.

4.1.3 This Quality Manual covers the laboratory management system work carried out in the laboratory's permanent facilities and associated mobile facilities in Canada.

4.1.4 The responsibilities of key corporate personnel that have an involvement and influence on testing activities have been defined to identify potential conflicts of interest. Refer to the Organization and Management Structure in section 4.1.5.

4.1.5 ALS has the following organizational practices:

a) Managerial and technical personnel have the authority and resources needed to carry out the duties assigned to them. Such duties include the implementation, maintenance, and improvement of the management system, and where applicable, identifying the occurrence of departures from the management system or procedures and methods for conducting tests. Managerial personnel also have the ability to initiate actions to prevent departures from outlined procedures. Also refer to Organization and Management Structure below.

b) Arrangements are in place to ensure management and personnel are free from undue internal and external commercial, financial, and other pressures and influences that may adversely affect the quality of their work. Refer to section 5.2.1 for the ALS Code of Conduct Policy.

c) Policies and procedures are in place to ensure the protection of customers' confidential information and proprietary rights, the electronic storage of data, and the electronic transmission of results – refer to policy objectives in section 4.2.

d) Policies and procedures are in place to avoid involvement in activities that would diminish confidence in the competence, impartiality, judgment or operational integrity of an ALS Laboratory or its staff – refer to section 5.2.1 for the Code of Conduct and Data Integrity Policies.

e) The organizational and management structure is well defined, including the relationships between quality management, technical operations and support services - refer to Organization and Management Structure and organization charts referenced below.

f) Responsibilities, authorities and interrelationships are specified for all personnel who manage, perform or verify work affecting the quality of tests - refer to Organization and Management Structure below.

g) Adequate supervision is provided to all staff and trainees by persons familiar with test methods and procedures, and with the purposes of these tests and the assessment of test results - refer to Organization and Management Structure below, and section 5.2.

h) Senior management has overall responsibility for the technical operations and provision of resources needed to ensure the quality of laboratory operations - refer to Organization and Management Structure below.

i) The National Quality Manager has defined responsibility and authority for ensuring that the management system related to quality is implemented and followed at all times. This individual has direct access to the highest level of management at which decisions are made. Refer to Organization and Management Structure below.

j) Personnel are appointed to substitute as needed in the absence of key managerial personnel. Such substitutions must be flexible due to the variety of demands on individuals. Refer to details available at locations. The Organization and Management Structure table below summarizes routine practices.

k) Personnel are aware of the relevance and importance of their activities and how they contribute to the achievement of the objectives of the management system – refer to section 5.2.

ORGANIZATION AND MANAGEMENT STRUCTURE

The management system in Canada is divided between laboratory specific, regional and national functions. An appropriate number of managerial positions support the management system. The responsibility, authority and interrelationships of key Environmental Division positions are defined and outlined in the table below. Corporate cross-divisional roles (not specifically listed below) include human resources, finance, accounting, compliance, purchasing, and management of information technology.

KEY ENVIRONMENTAL DIVISION ROLES AND ALTERNATES

Title	Role and Alternate Where Applicable
Vice President, Environmental Division, North America	Responsibility for and authority over operations at all locations within North America. Fills Director roles as needed. Reports to the ALS Laboratory Group CEO.
Regional Operations Directors	Responsibility for and authority over operations within designated regions (Western Canada, Eastern Canada). Positions report to the Vice President. May be designated to fill VP role when necessary.
Director of Sales and Marketing, North America	Responsibility for oversight and management of the sales and marketing divisions in Canada, the US, and Mexico. Reports to the Vice President.
Director of Sales, Canada	Responsibility for oversight and management of the sales division in Canada. Reports to the Director of Sales and Marketing, North America.
Technical Services Director, Canada	Responsibility for oversight and management of technology, best practices, and nationally harmonized test methods, and for the ALS Canada Quality Management System. Reports to the Vice President. Fills National Quality Manager role as needed.
National Quality Manager (NQM)	Responsibility for managing the ALS Canada Quality Systems staff and for overseeing the development, documentation, implementation and oversight of a harmonized quality management system. Reports to the Technical Services Director. Fills QSM and QSC roles as needed.
National Technical Manager	Responsibility for managing a group of national technical specialists and for overseeing the development, documentation and implementation of nationally harmonized best practices and technical initiatives. Also fills role of National LIMS Administrator. Reports to the Technical Services Director.
Laboratory Managers	Responsibility for and authority over operations for a single location. Reports to a Regional Director. In labs without full-time quality staff, this position has direct responsibility for implementation of the nationally defined quality management system under the guidance of the NQM. Fills location specific Dept Manager, Supervisor or support roles as needed.
Quality Systems Managers (QSM)	Responsibility for the management of a team of Quality Systems staff at a single location, undertaking the organization, implementation, maintenance and monitoring of the nationally defined quality management system. Reports to the National Quality Manager. Fills QSC role as needed.
Laboratory Dept. Managers, Client Services Managers, Supervisors, and Team Leaders	Responsibility for and authority over selected operations and for providing adequate supervision of a department or section within a single location. Reports to Laboratory Manager or Supervisor. Fills Laboratory Manager and each other's roles as designated.
Quality Systems Coordinators (QSC)	Responsibility for the organization, implementation, maintenance and monitoring of the nationally defined quality management system in one or more locations. Reports to a senior QSC, QSM, NQM, or to the Lab Manager when not a full-time position. May fill other roles as designated when not a full-time position.

Title	Role and Alternate Where Applicable
Analysts, Support Staff, Administrative Staff, Sales and Marketing Staff	Responsibility for and authority over assigned work. Reports to Dept. Manager or Supervisor. Fills Supervisor or Manager roles as designated.
Quality Contacts	Individuals in small labs to whom the Lab Manager has delegated specific QA tasks, and who has been fully trained to fulfill this role by Quality Department staff who provides the main support for quality systems in these locations.

4.1.6 Senior management communicates the ongoing effectiveness of the management system to all staff throughout the network. This is primarily accomplished through meetings and reports communicated as appropriate to all levels of the organization. Management system goals related to quality are developed by the management team and communicated to all affected division personnel. The status of management system goals is reported monthly to national, divisional and location management through National Quality Reports and Key Performance Indicator reports in the LIMS. National Quality Reports are posted on the ALS network and are available to staff in all locations.

Refer to:

- Organization Charts: maintained on the ALS North America intranet site (http:/alsna) by the Human Resources Department.
- Location specific organization charts (if not available as above) are maintained by Quality staff at: L: \Organization Charts.
- Local File: Substitution of Key Staff.
- Reports: National Quality Reports located at: L:\Quality System Documents\National Quality Reports.

4.2 MANAGEMENT SYSTEM

4.2.1 The ALS management system is appropriate to the type, range, and volume of environmental testing activities undertaken at each location. Policies, systems, programs, procedures, and instructions are documented to ensure the quality of test results. ALS ensures all staff understand the quality management system and that all required documentation is available to and implemented by staff.

4.2.2 MANAGEMENT SYSTEM POLICIES, POLICY STATEMENT AND OBJECTIVES

ALS management is committed to good professional practice, and to providing a superior level of service and quality in its testing activities that exceeds the industry norm. Our management system is designed to comply with the requirements of ISO/IEC 17025:2005, the program requirements of all applicable accrediting bodies, ALS corporate goals, and to satisfy the needs of clients, regulatory authorities, and organizations providing recognition. All staff are required to be familiar with ALS quality system documentation and to implement its policies and procedures in their work. ALS management is committed to complying with these policies and to continually improving the effectiveness of the management system.

This policy statement and the entire Quality Manual are issued under the authority of senior management in Canada, as is evident by the authorizations provided on the front cover.

The policy objectives of the management system are listed below and are reviewed during management reviews:

- ALS protects its customers' confidential information and proprietary rights. We require all employees to review and sign a Code of Conduct policy that communicates the ALS confidentiality policy (refer to section 5.2.1 for Code of Conduct). The electronic storage of information is protected by a national computer network backup system (refer to section 5.1). Test results are protected during communication and transmission by ensuring only the correct individual receives results, and by identifying transmissions as confidential (refer to section 5.10).

- ALS employees avoid involvement in activities that would diminish confidence in their competence, impartiality, judgment or operational integrity by complying with the ALS Code of Conduct and Data Integrity Policy (refer to section 5.2.1).

- The quality policy statement heading this section is issued under the authority of senior management, and complies with the policy requirements of ISO/IEC 17025:2005. The policy statement includes measurable objectives that are reviewed during management reviews, as identified in the following points (refer to section 4.15).

- Appropriate personnel are involved with the provision of quotations and contracts to the degree necessary to understand our clients' needs, to determine if a location can manage projected workloads, to identify the correct test methods to be used, and to maintain appropriate communications with the client during testing. Records of client communications are maintained and all changes to work plans are communicated to those involved (refer to section 4.4).

- Suppliers of goods and services are pre-approved using national protocols where they could have an affect on the quality of tests. The national purchasing system ensures control over selection and purchasing, while systems for reception, storage and handling of supplies ensure we receive what was ordered, that appropriate storage is provided, and that records of verification are maintained where needed (refer to section 4.6).

- All complaints, whether received by direct communication or during survey activities, are managed and resolved. Records are maintained of the complaint, including discussions with the client, and its resolution. When deviations from ALS policies and/or procedures are identified, corrective action reports are initiated (refer to section 4.8).

- When any of our services fail to conform to ALS policies or procedures or to the requirements of our customer, a nonconformance is recorded. A national procedure defines the responsibilities and authorities for handling nonconformances, including documentation, work stoppage, work resumption, and for evaluating the significance of the nonconformance. Correction, evaluation and customer notification are initiated where applicable (refer to section 4.9).

- When nonconforming work is identified, cause analysis and selection and implementation of corrective action that will prevent recurrence occurs and is documented in the LIMS CAR

System. Monitoring is performed both locally and nationally, and additional audits are performed as needed (refer to section 4.11).

- All new employees receive an orientation and job-specific training. Training needs are reviewed during annual performance evaluations to ensure appropriate training is provided. The effectiveness of training actions is evaluated during a six-month follow-up where appropriate. Additional training can be requested by anyone at any time for LIMS, quality systems or specific technical topics (refer to section 5.2).

4.2.3 Evidence of commitment to the development and implementation of the management system and to its continual improvement is available in the procedures and records referred to throughout this document, and include the approval and implementation of the systems described in this manual.

4.2.4 ALS senior management's communication of the importance of meeting customer, statutory and regulatory requirements is provided through employment polices, business goals, and the training program (refer to section 5.2). In addition, goals set through management reviews (as described in section 4.15), and various planning meetings are communicated as appropriate.

4.2.5 This Quality Manual includes or references relevant support and technical procedures and outlines the structure of documentation used in the management system.

4.2.6 Roles and responsibilities of technical and quality management staff are summarized in section 4.1.5. Responsibilities for ensuring compliance with ISO/IEC 17025:2005 are defined as:

- The National Quality Manager is responsible for building a national quality management system in compliance with, ISO/IEC 17025:2005 and for reporting on the status of national and local implementation to the Directors and Vice President.

- Local quality staff are responsible for implementing the national quality management system in their locations, and for reporting on the status to the local Lab Manager and National Quality Manager.

- Local Lab Managers are responsible for ensuring implementation of the national quality management system in their locations, and for addressing reported deficiencies.

- Directors and the Vice President are responsible for supporting and enforcing compliance to the national quality management system.

4.2.7 Senior management ensures integrity of the management system is maintained when changes to the system are planned and implemented. This is achieved by assigning the planning and implementation of changes to staff who have the appropriate training, qualifications, and authority to manage these changes, and by ensuring planned changes have adequate review and oversight by personnel who understand the implications. Planned changes to the management system are reported to and discussed with the national management team prior to implementation during regular management meetings.

4.3 DOCUMENT CONTROL

4.3.1 STRUCTURE OF MANAGEMENT SYSTEM DOCUMENTATION

ALS maintains procedures to control all documents that form part of its quality management system, including those of internal and external origins.

- Internal documents are those originating within ALS. Some internal documents are national in scope and are intended to be used at multiple lab locations, others are local and are intended to be used at a specific location. The documentation structure is outlined below:

Document Type	Origin
Quality Manual	National
Support Procedure	National or Local
Test Method	National or Local
Test Procedure	National or Local
Work Instruction	National or Local
Form	National or Local

- In instances where local and national Support Procedure documents both describe similar activities or information, the local document takes precedence only when the policies specified in the national document are fulfilled as intended.

- External documents originate from sources external to ALS. External documents that are important to the operation of our laboratories include, for example, instrument manuals, reference methods, regulations, standards, software manuals, accrediting body policies, etc.

4.3.2 DOCUMENT APPROVAL AND ISSUE

4.3.2.1 All documents used in the laboratory as part of the management system are reviewed and approved for use by authorized personnel prior to issue. These authorities are personnel with knowledge appropriate to the content of the document.

MASTER LIST

Master Lists of internal and external, and national and local documentation are maintained and are available to staff at each location, to prevent the use of invalid and/or obsolete documents and references. For each referenced quality system document, the Master List contains at a minimum: document name and identification code, version number, date authorized, status, date distributed, location of original file and copies, roles responsible for authorization and review, and review period. In addition, the Support Procedure Master List correlates the generic names referenced in this document to the corresponding national and/or local procedures used at the location.

4.3.2.2 Authorized versions of documents are available at all locations where essential to the effective functioning of the laboratory. Documents and their related forms are reviewed on a one to three year cycle as related in the Master List. The cycle is correlated to the internal audit schedule (refer to 4.14), and is dependant on the performance and stability of the system described in the document and accreditation requirements. Documents are revised as necessary to ensure continuing suitability and compliance with requirements. Invalid or obsolete documents are removed from use. The original electronic file and the original signed hard copy are clearly identified and maintained as historical quality system records.

Original electronic files of national documents are maintained on our computer network at L:\Quality System Documents\Documentation\National Documents. The folders contain authorized documents, copies of e-mailed approvals and distributions, and master lists for each document type.

When requested to distribute an ALS document externally, confidentiality can be maintained by issuing the document electronically with a CONFIDENTIAL watermark, or by photocopying the document onto watermarked paper. A template is provided at L:\Quality System Document\Documentation.

4.3.2.3 Documents generated by ALS Laboratories are uniquely identified, including:

- Document name and identification number.
- Version number.
- Issuing authorities.
- Date (date of last change made to the version).
- Effective date (date the documented procedure was implemented at the location).
- Page numbering and total number of pages.

4.3.3 DOCUMENT CHANGES

4.3.3.1 Changes to documents are reviewed and approved by the same authorities as the original document, unless otherwise delegated. All involved in this process have access to pertinent information upon which to base their approval.

4.3.3.2 A summary of revisions is provided in each document to relate significant alterations or new text.

4.3.3.3 Where the location specific document control system allows for the amendment of documents by hand, pending re-issue of the documents, the location specific procedures must include the following:

- hand written amendments have authorizations from both technical staff and quality staff, as per the original document.
- a requirement that the amendments are clearly legible, initialed and dated.
- the process for formally re-issuing the document no later than the next internal audit.

Hand written amendments are not performed on national documents.

4.3.3.4 Procedures are established to describe how changes to documents maintained in computerized systems are made and controlled.

Refer to:

- Local Master List: DOCUMENT CONTROL

4.4 REVIEW OF AGREEMENTS, QUOTATIONS AND CONTRACTS

4.4.1 Agreements, quotations and contracts are reviewed to ensure understanding of defined and documented requirements. Information is shared to ensure the location has the capability, resource availability, and the appropriate test methods to meet applicable requirements. Differences that occur between a quotation and the final contract are resolved prior to commencing work.

4.4.2 Records of reviews, including communications and significant changes to the customer's requirements or the laboratory's capabilities are maintained.

For routine and simple tasks, the date and initials of the laboratory staff responsible for carrying out the work is an adequate record of review. For repetitive routine tasks, a review at the initial inquiry stage is adequate as long as the requirements do not change. For new or complex testing tasks, a more comprehensive record is maintained.

Records are also maintained of all pertinent discussions with clients during the life span of the contracted work.

4.4.3 The reviews performed include reviews of tests subcontracted by ALS. Refer to section 4.5.

4.4.4 The customer is informed of any proposed deviation from the contract.

4.4.5 If changes are made during the contract, the new requirements are subject to the same review process as the original contract. Any amendments are communicated to all affected personnel. If, due to unforeseen circumstances, the laboratory is unable to comply with a condition of the contract (e.g. turnaround time, equipment failure) the client is notified as soon as possible and contingency plans are developed.

Refer to:

- Local Master List: QUOTATIONS AND CONTRACTS
- CLIENT PRICE QUOTING POLICY (FIN 510): maintained on the ALS North America site at: http://alsna/Policies%20and%20Procedures/Forms/AllItems.aspx

4.5 SUBCONTRACTING TESTS

4.5.1 Testing is subcontracted to another ALS location or external organization when it cannot be carried out at the receiving location. ALS has policies and procedures that govern the handling and transfer of subcontracted samples. ALS selects subcontractors through a qualification process that includes an evaluation of the test method, detection limit, accreditation status, agreement to notify of status changes, and insurance information. Labs holding ISO/IEC 17025:2005 accreditation by a recognized accrediting body for the tests in question are given first consideration when subcontracting both accredited and non-accredited tests. If an accredited lab is unavailable, impractical or does not meet test method criteria, ALS will choose laboratories that at minimum fulfill the other components of the qualification process.

4.5.2 The client is notified in writing of subcontract arrangements. Client written approval is obtained whenever possible, and records of approval are kept. When notified of subcontracting by quote, the submission of samples is deemed as acceptance of the subcontract laboratory.

4.5.3 ALS is responsible for all subcontracted work. Although clients or regulatory authorities sometimes specify the subcontractor to be used, the ALS qualification procedure applies to these subcontractors as well.

4.5.4 ALS laboratories maintain lists of approved subcontract lab tests and records of their qualifications.

Refer to:

Local Master List: SUBCONTRACTING TESTS

4.6 PURCHASING AND HANDLING SUPPLIES AND SERVICES

4.6.1 ALS polices (refer to 4.2.2) and procedures describe the procurement of services and supplies. Documented procedures exist for the purchasing, reception, and storage of materials relevant to the tests performed at each location.

4.6.2 Supplies that affect the quality of test results are not used until they are inspected to verify the received items conform to the specifications or requirements as ordered. Upon receipt, supplies are compared to the packing slip to establish the order was filled correctly. The packing slip is initialed and dated as a record of the receipt and verification. Certificates of traceability and/or analysis are maintained for certified supplies such as certified reference materials and standards, stock cultures and other consumables where specifications are critical. When additional verification is needed such as testing, procedures at the location describe the testing performed and records maintained.

4.6.3 Purchasing requisitions are initiated and reviewed for technical content at each location to ensure required specifications are met. Requisitions are further reviewed by purchasing staff to ensure correctness, and to determine the most appropriate supplier for each item.

4.6.4 The ALS Purchasing Department evaluates suppliers of critical services and supplies for North American ALS labs. The ALS Vendor List is the end result of the evaluation process. The ALS purchasing system requires the use of pre-approved suppliers (from the ALS Vendor List) for all orders.

Refer to:

- Local Master List: PURCHASING AND APPROVED SUPPLIERS
- Local Master List: RECEIVING SUPPLIES

4.7 SERVICE TO THE CUSTOMER

4.7.1 ALS cooperates closely with its customers to ensure their testing needs are understood, and allows them reasonable access to relevant areas of the laboratories to audit the management system or to witness test work being undertaken on their behalf.

ALS assists customers to develop audit objectives when appropriate. An ALS staff member accompanies any client while on-site, and steps are taken to protect the confidentiality of other customers in accordance with ethics, confidentiality, and privacy policies (refer to 5.2.1). ALS records and addresses all customer audit findings.

ALS has assigned staff the task of ensuring good communication with customers regarding technical issues and the status of testing being conducted on their behalf. Customers are informed of delays or deviations in the conduct of their tests.

4.7.2 Periodically, ALS prepares and distributes surveys to its customers. The purpose of these surveys is to ensure ALS continues to meet clients' needs and to identify areas for improvement. The surveys are evaluated by national and regional management teams and are used to define initiatives for improvements. In addition to various senior management planning meetings, the survey results and actions taken are evaluated during Management Reviews (refer to section 4.15).

Refer to:

- Network File: L:\Client Surveys

4.8 COMPLAINTS

ALS has a policy (refer to section 4.2.2) and procedures for the resolution of complaints received from customers or other parties. All complaints received by ALS are initially recorded as nonconformances, and follow the investigation and resolution processes refer to in sections 4.9 and 4.11.

Refer to:

- Local Master List: NONCONFORMANCE AND CORRECTIVE ACTION

4.9 CONTROL OF NONCONFORMANCES

ALS has a policy (refer to section 4.2.2) and procedures that are implemented whenever a nonconformance is identified from any source. When any work conducted by ALS does not conform to a requirement, including noncompliance with ALS or local polices and procedures, the nonconformance is recorded and reviewed by an appropriate authority.

Nonconformance procedures define responsibilities and authorities for:

- halting work and withholding reports where appropriate
- the evaluation of the significance of the nonconformance
- ensuring immediate correction / remedial actions
- customer notification where applicable

- authorizing the resumption of work

Where the evaluation indicates it is appropriate to prevent recurrence, root cause analysis and corrective action are implemented – refer to section 4.11.

Single event data quality objective failures or other isolated occurrences during testing activities are initially recorded on a test method nonconformance record which includes corrective action or technical justification and authorization. When recurrence is observed, the issue is transferred to the LIMS System for Corrective Action Reports (CARs). All other sources of nonconformance are recorded directly into the LIMS CAR system.

Refer to:

- Local Master List: NONCONFORMANCE AND CORRECTIVE ACTION

4.10 IMPROVEMENT

Management's commitment to continuously improving the effectiveness of the management system is demonstrated by the use of various management system tools to identify areas of needed improvement. Regular evaluations of each of the following are used to identify areas for improvement: internal and external audits, corrective and preventive action reports, management reviews and various management reports and meetings, client feedback, proficiency test results, reviews of test method performance and data quality objectives, client surveys, and input from personnel. Documentation and follow-up is defined in the Quality Manual sections specific to these functions and activities.

4.11 CORRECTIVE ACTION

ALS has a policy (refer to section 4.2.2) and procedures that are implemented whenever evaluation of a nonconformance indicates prevention of recurrence is needed. Responsibilities and authorities are defined for implementing and documenting corrective actions based on an analysis of the causes and identification where possible of the root cause. Corrective actions that are most likely to prevent recurrence of the nonconformance are initiated. Actions taken are monitored for effectiveness. Internal audits are performed when the nonconformance casts doubt on the compliance with location or national ALS polices and procedures or compliance with ISO/IEC 17025:2005.

Refer to:

- Local Master List: NONCONFORMANCE AND CORRECTIVE ACTION

4.12 PREVENTIVE ACTION

Needed improvements and potential sources of nonconformance, either technical or concerning the management system, are identified from various sources (see also section 4.10). When improvement opportunities are identified or when preventive actions are needed, action plans are developed, implemented and monitored to reduce the likelihood of a nonconformance. The investigation and record keeping system is the same as for nonconformance and corrective action. Refer to sections 4.9 and 4.11.

4.13 CONTROL OF RECORDS

4.13.1 General

4.13.1.1 ALS has procedures for identifying, collecting, indexing, accessing, filing, storing, maintaining and disposing of quality and technical records. Quality records include but are not limited to reports from site assessments, customer audits, internal audits, management reviews, corrective actions, and preventive actions.

4.13.1.2 All records are legible, readily retrievable and stored in an environment that protects them from damage or deterioration for a minimum of five years, unless contractual obligations dictate a longer retention period. Records may be recorded and stored on paper, microfiche, or digital medium.

4.13.1.3 All records are held secure and in confidence, in compliance with polices for confidentiality and non-disclosure.

4.13.1.4 Procedures exist for the back-up and protection of records stored electronically, and to prevent unauthorized access to or amendment of these records – refer to section 5.1

4.13.2 Technical Records

4.13.2.1 Technical records include all original observations and derived data recorded at the time they are made. Technical records include sufficient information to establish an audit trail, such as equipment records, calibration records, method validation records, staff records, copies of each test report issued, and the identities of the individuals responsible for performing each test and for checking results. Records for each test contain enough information to identify factors affecting uncertainty and to enable the test to be repeated under conditions as close as possible to the original.

4.13.2.2 All observations, data and calculations are recorded at the time they are made in a manner identifiable to the specific task.

4.13.2.3 When a mistake is identified in a hard copy record, the original record is left legible with a line drawn through it, and hand-written corrections are recorded alongside, together with the date and initials of the person making the change. Where not intuitive, all reasons for corrections are documented where the edits are made. Data changes in LIMS are tracked using a Good Automated Laboratory Process (GALP) function that includes the identity of the individual and the reason for the modification.

Refer to:

- Local Master List: TECHNICAL AND QUALITY RECORDS

4.14 INTERNAL AUDITS

4.14.1 Internal audits are performed at each facility following pre-determined schedules and procedures to ensure operations comply with the requirements of the management system, the program requirements of all applicable accrediting and recognition bodies, and ISO/IEC 17025:2005. Management system audits are scheduled annually and managed nationally. Test method audits are scheduled on a one to three year cycle depending on the performance and stability of the test, and on accreditation program requirements. Test method audits are managed by Quality representatives for each location. Audits are conducted by individuals who are trained in internal auditing techniques, and who are independent of the activity being audited.

4.14.2 When audit findings cast doubt on the effectiveness of operations or the validity of test results, ALS takes timely corrective action and notifies customers in writing if investigations show test results may have been affected.

4.14.3 Records of internal audits, findings and corrective actions are maintained on-site.

4.14.4 The implementation and effectiveness of corrective actions implemented due to audit findings are verified and recorded.

Refer to:

- Local Master List: INTERNAL AUDITS

4.15 MANAGEMENT REVIEWS

4.15.1 Management conducts a review of the management system at least annually to ensure the management system is effective and continues to be suitable for its operations, and to identify necessary changes or improvements. Senior management is included in the review process for all locations.

The review may be a series of events or meetings that percolate up through the management structure that are summarized at year-end, or may be an annual event or meeting. Determining the format and setting the schedule is the responsibility of the local Laboratory Manager. The schedule is maintained and the review facilitated by Quality staff.

The intent is to evaluate the status and adequacy of local systems by examining the following items from the time period between reviews:

- suitability of the Quality Policy Statement, objectives and procedures (refer to section 4.2.2)
- reports from managers and supervisors
- outcomes of internal and external audits
- corrective and preventive action reports
- proficiency testing results
- changes in the volume and type of work
- complaints and other client feedback from all sources including surveys
- recommendations for improvement

- other relevant topics such as management objectives related in lab metrics and key performance indicators, new tests under development, new recognition programs being sought, etc.

4.15.2 Findings from the reviews and identified actions are recorded and carried out in an appropriate and agreed upon timeframe.

4.15.3 In addition, the Quality Department provides status reports each month to the location and to senior management. These reports include reviews of internal and external audits, proficiency testing programs, nonconformances, corrective and preventive actions, training initiatives, and any other information needed to inform management of the status of the quality system.

Refer to:

- Local Master List: MANAGEMENT REVIEW
- Reports: National Quality reports located at: L:\Quality System Documents\National Quality Reports

5.0 TECHNICAL PROTOCOLS

5.1 COMPUTER SYSTEMS

A comprehensive network of computers and information management systems interface specific instrumentation and workstations into Local Area Networks (LANs). The LANs are potentially subdivided into a trusted region, and an un-trusted region. The trusted region is a segment of the network which contains computers and devices that are only accessible from within the computing boundaries of ALS (global). The un-trusted region is the segment of the network that contains computers and devices which are accessible, either from within the computing boundaries of ALS (global) OR the Internet. All LANs from each laboratory within the global ALS Environmental laboratory network are connected to the Internet.

The LIMS can be accessed through terminals, workstations and Personal Computers (PCs) attached directly to the LANs located within each facility. Data stored on the electronic database carries the identification of individuals who make entries or modifications.

Security for the computer systems and electronic database is achieved through a combination of passwords, permissions, firewalls and Virtual Private Network (VPN) systems. ALS Environmental has established and implemented procedures for protecting electronic data in terms of data entry, collection, storage, transmission, and processing. Electronic data security extends to prevention of unauthorized access and unauthorized amendment of computer records.

The ALS North America IT Group manages regular computer network backups. All ALS Environmental Division network drive files are backed-up onto a tape medium at an alternate location incrementally and on a continuous basis. A confirmed electronic log of backups is maintained to ensure files can be located if a restoration is needed. Copies of these logs are available upon request from the IT Department. Tapes are maintained in a secure area for a minimum of five years. This system provides secure off-site storage of back-ups on a routine basis. All back-ups are conducted off-site, either at the Edmonton or North Vancouver facilities.

Computer systems and automated equipment are provided with adequate maintenance and environmental conditions to maintain the integrity of analytical results.

5.2 PERSONNEL

5.2.1 ALS ensures the competence of all personnel who operate specific equipment, perform specific tests, evaluate procedures, sign test reports, and supervise or manage lab operations. Staff are qualified on the basis of education, training, experience, and/or demonstrated skills necessary for performing assigned functions. Staff undergoing training are supervised by assigned trainers.

Position descriptions specify the minimum qualifications for each position, which are a combination of education and experience appropriate for the role. Records of educational backgrounds are maintained in personnel files.

Upon hiring, all staff are provided an orientation to safety programs, human resource policies, and management system policies, including the ALS Code of Conduct and Data Integrity Policies.

CODE OF CONDUCT AND DATA INTEGRITY POLICIES

Campbell Brothers Limited and the ALS Laboratory Group are committed to achieving the highest standards of ethical conduct. Acceptance of employment is an implicit commitment to observe the company's standards of conduct and performance. In return, the company acknowledges obligations and undertakings to all employees and contractors. Two mechanisms have been designed to achieve these goals: the Code of Conduct employment agreement, and the Data Integrity Policy.

The Code of Conduct agreement provides a framework for decisions and actions in relation to conduct in employment. It underpins commitment to a duty of care to all employees and to customers receiving our services. The Code of Conduct covers the following topics:

- Personal and Professional Behavior
- Conflicts of Interest
- Gifts and Entertainment
- Anti-Bribery
- Confidentiality
- Protection and Proper Use of Company Assets
- Legal Compliance
- Insider Trading (concerning both Campbell Brothers and client company shares)
- Public Comment
- Security of Information
- Privacy
- Discrimination, Harassment, and Bullying
- Equity
- Occupational Health and Safety
- Drugs and Alcohol

- Environmental Protection
- Charities and Donations
- Breaches of the Code of Conduct
- Reporting Breaches
- Training and Development

This agreement is provided to, reviewed by, and signed by all employees upon accepting employment with ALS. Original signed policies are maintained in personnel files.

In addition, the Data Integrity Policy and training is provided to all personnel upon hiring and annually throughout their employment with ALS. Training is provided by local Quality staff or through regularly scheduled, nationally coordinated NetMeeting training sessions. The intent is to highlight and confirm specific topics of personal and professional behavior related to the Code of Conduct agreement that specifically pertain to data produced by the lab. Signed original Data Integrity policy agreements are maintained in personnel files by the Human Resources Department. Records of new employee training and annual updates are maintained by Quality staff.

Together, these agreements ensure freedom from undue internal and external commercial, financial, and other pressures or influences that could adversely affect the quality of work. They protect customers' confidential information and ALS' proprietary rights. They ensure avoidance of activities that would diminish confidence in the competence, impartiality, judgment or integrity of any ALS laboratory and staff.

5.2.2 ALS identifies on-going training needs and plans for the provision of training to personnel during annual performance reviews, based on present and anticipated future responsibilities. Training provided includes quality systems, LIMS applications, the management system, safety requirements, and instructions for the performance of specific tests, for operating specific equipment, for giving opinions and interpretations where applicable, and for issuing test reports. The effectiveness of training is evaluated during a six-month follow-up where applicable.

5.2.3 Periodically, contract personnel may be hired to fulfill specific project requirements. Contract personnel are subject to the same qualifications, supervision, orientation, and training procedures as permanent staff.

5.2.4 The Human Resources Department maintains position descriptions for managerial, technical and key support personnel involved in performing tests. Position descriptions are used for job postings to ensure prospective employees are aware of position requirements prior to applying.

5.2.5 Management authorizes personnel to perform specific tasks by the provision of an internal training program. Procedures describe the process for demonstrating analyst proficiency and comply with applicable accrediting body policies regarding training duration, content and record keeping, where specified. On-going proficiency is monitored using proficiency testing samples. Analysts who predate current proficiency policies and procedures are grandfathered into the current system. Records are maintained of the relevant authorizations, competence, educational and professional qualifications, training, skills and experience, and of the dates competence is confirmed.

Refer to:

- Code of Conduct Policy (ADM 202): maintained on the ALS North America Sharepoint site at http://alsna/Policies%20and%20Procedures/Forms/AllItems.aspx
- Data Integrity Policy and Training Presentation: L:\Data Integrity
- Performance Review Template maintained on the North America Sharepoint site at: http://alsna/Human%20Resources/Forms/AllItems.aspx
- Local Master List: ORIENTATION AND TRAINING

5.3 ACCOMMODATIONS AND ENVIRONMENTAL CONDITIONS

ALS facilities and their environmental conditions, including energy sources, lighting, and temperatures are appropriate for the correct performance of tests conducted at each location.

All instrumentation and electrical equipment used within ALS facilities must meet or exceed the relevant Canadian Standards Association (CSA) or Underwriters Laboratory (UL) requirements. Any equipment or instrumentation containing a radioactive source must meet or exceed the safety and licensing requirements specified by the Canadian Nuclear Safety Commission.

Environmental requirements necessary for the performance of specific tests are site-specific and are documented, monitored, and recorded. When such requirements are out of compliance, appropriate action is taken that may include suspension of testing where applicable, in accordance with the location documents.

Incompatible activities are separated and steps are taken to prevent cross-contamination. Refer to site specific floor plans.

Each ALS location has procedures to ensure that access to laboratory and office areas is monitored and restricted to authorized individuals only.

Housekeeping is conducted to maintain appropriate environmental conditions within each facility.

SAFETY

ALS has an extensive safety program managed by the Corporate Compliance Department for ALS North America. The program is designed to meet corporate, national, and provincial regulations as applicable. The Safety Program includes task specific safety requirements, regular safety meetings, and compliance and incident reporting mechanisms. Management and staff are responsible for implementing and adhering to the Safety Program, Safety Policies, and related procedures. Refer to safety information available at each location.

All fire safety equipment within the ALS Environmental facilities meets or exceeds local fire safety regulations.

All shipments of supplies and samples are carried out in accordance with the appropriate local, regional, federal, or international ordinances, including the Transportation of Dangerous Goods (TDG). Staff responsible for the shipment of Dangerous Goods have received TDG training.

WASTE MANAGEMENT

Waste management procedures are developed by each ALS location for all wastes designated as hazardous, and to ensure that all waste disposal practices meet local regulatory requirements. Refer to site-specific procedures.

FUME HOODS

Fume hoods are available in all laboratory sections where required to meet safety needs. Fume hood face velocities are monitored twice per year if not alarmed and annually if alarmed. Refer to site-specific procedures and/or records.

Refer to:

- Local Master List: FACILITY PROCEDURES

5.4 TEST METHODS AND METHOD VALIDATION

5.4.1 General

All ALS locations use appropriate, documented methods for all tests performed. Templates for national and local test methods specify the minimum documentation requirements. Test method instructions and support information is kept current and accessible where needed.

Deviations from test methods occur only if the deviation has been documented, technically justified, authorized, and accepted by the customer where applicable. Analytical department supervisors and managers have the authority to approve method deviations for the analysis of samples and to impose appropriate quality control into the analysis. If the deviation is judged to alter the outcome of a test, client acceptance of the deviation will be obtained prior to approval. Test method deviations are recorded and maintained as test method non-conformance records.

5.4.2 Selection of Methods

Customers rely on ALS to select test methods that are scientifically valid, defensible, and appropriate to meet their needs. Where possible, ALS uses the latest versions of published standard methods developed by organizations such as the American Public Health Association, the United States Environmental Protection Agency, NIOSH, Environment Canada, and other international, regional, or regulatory organizations, or equipment manufacturers. When needed, standard methods are supplemented with additional instructions to ensure consistency of application and performance. Where an appropriate standard method is not available, ALS may develop and validate an in-house test method, or may adopt a third party validated method. ALS provides method information to clients on test reports, and upon request.

For published reference methods, each ALS location confirms it can properly operate the standard method before introducing the test into the laboratory. If the standard method changes in a manner that may affect test results, the confirmation is repeated.

Unique circumstances may occur where a customer specifies the methodology to be used. The customer will be notified if ALS deems the recommended method to be inappropriate or out of date.

5.4.3 Laboratory Developed Methods

When in-house development of a test procedure is needed, qualified individuals are assigned to the planning and development stages of the project. The plan is updated as development progresses and all changes are effectively communicated among all involved to ensure that objectives are met.

5.4.4 Non-standard Methods

If it is necessary to use methods not covered by standard methods, customer agreement will be obtained. The test methods will include or reference clear specification of the requirements and the purpose of the test. The developed method will be appropriately validated before use.

5.4.5 Validation of Methods

Method validations are conducted to confirm that the developed methods are fit for their intended use. The validations are as extensive as necessary to meet the needs of the given application. The extent depends on the source of the method. For example, standard methods used for their intended application require a less extensive validation than non-standard methods or standard methods used outside of their intended scope.

All results relating to the validation of a given method, including the procedure used for validation and a statement of whether the method is fit for the intended use are retained in method validation records.

As appropriate, the validation studies performed will verify the range and accuracy of the test method, including measurement uncertainty, detection limit, selectivity (i.e. sensitivity to interference), linearity, repeatability and/or reproducibility, and robustness. Measurement uncertainty values are reviewed to ensure they are sufficient to meet customers' needs.

Chemistry test methods are revalidated periodically to ensure continued suitability and fitness for purpose. Revalidation frequency is correlated to the internal audit schedule and is based on test method stability and performance. The minimum revalidation frequency is every three years. Revalidation may also occur at any time when the performance of a test method is under investigation. At minimum, revalidation includes an examination of precision and bias data, an evaluation of detection and reporting limits and an estimation of measurement uncertainty.

5.4.6 Estimation of Measurement Uncertainty

ALS has procedures for estimating measurement uncertainty. The procedures are based on accepted practices of identifying components contributing to uncertainty, compiling data that represents or includes these components, evaluating the data using appropriate statistical calculations, and reporting in a manner that prevents misunderstanding of the result. In those cases where the nature of the test precludes calculation of uncertainty, ALS will at minimum identify the components of uncertainty and make a reasonable estimation where needed. This estimation will be based on available validation data and other sources of information about the test method's performance.

5.4.7 Control of Data

Automated calculations and data transfer systems are checked in a systematic manner when first programmed and are re-verified appropriately when changes are made.

When computers and automated equipment are used for the acquisition, processing, recording, reporting, storage or retrieval of test data, ALS ensures:

- In-house developed software is sufficiently documented and validated.
- Procedures are implemented for protecting data, including integrity and confidentiality of entry, collection, storage, transmission, and processing – refer to sections 4.13, 5.1 and 5.10.
- Computers and automated equipment are maintained to ensure proper functioning and adequate environmental conditions – refer to section 5.1.

Refer to:

- Document Templates: L:\QUALITY SYSTEM DOCUMENTS\DOCUMENTATION\
- Local Master List: METHOD VALIDATION
- Local Master List: MU PRINCIPLES
- Local Master List: METHOD REVALIDATION AND MEASUREMENT UNCERTAINTY
- Local Master List: LIMS CALCULATIONS AND DATA TRANSFERS
- Local Master List: SOFTWARE DEVELOPED IN-HOUSE

5.5 EQUIPMENT

5.5.1 ALS laboratories ensure that appropriate sampling and testing equipment and instrumentation is obtained and maintained to ensure test method performance meets client needs. If ALS locations use equipment outside their permanent control, the laboratories are responsible for ensuring the equipment meets the requirements of this section.

5.5.2 All equipment and its software needed for testing meets required performance specifications. Equipment is calibrated at the frequency stated in specific test methods and is confirmed to achieve required accuracy. Calibration programs are established where appropriate.

5.5.3 Authorized staff use documented test methods and procedures to operate, calibrate and maintain equipment. Relevant operating manuals or other work instructions are available where needed.

5.5.4 Equipment and its software are uniquely identified where practicable. Inventory lists are maintained of all equipment with a new or replacement value of greater then $500.00 CAD, excluding consumables, vehicles, and furniture.

5.5.5 Instrument logbooks contain or reference records relating to instrumentation and software, including:

- equipment and software identification
- manufacturer's name, model and serial number
- performance check records
- current location where appropriate
- manufacturer instructions (alternatively referenced in test method)

- calibration history, adjustments, acceptance criteria (alternatively referenced in test method), and due date of next calibration (except for equipment calibrated on an as-used basis)
- maintenance schedules (alternatively referenced in test methods), and records of maintenance
- records of damage, malfunction, repair, or modification

5.5.6 Documented instructions describe the management of measuring equipment and instrumentation including:

- safe handling, transport where applicable, storage and use
- planned maintenance
- intermediate calibration checks
- the application of correction factors and updating of software or other records, where applicable

5.5.7 Any equipment known or suspected to be defective is removed from service, isolated where practicable, and clearly labeled as being out of service. The equipment is not returned into use until it is examined, necessary repairs have been completed, and it has been verified to meet performance specifications. Records are maintained in equipment logs. Where the defect has called reported analytical results into question, corrective action will be implemented – refer to sections 4.9 and 4.11.

5.5.8 Where practicable, equipment under the control of the laboratory will be labeled to identify its calibration status. The label will include the date last calibrated and the expiration criteria or other indication of when re-calibration is due. Labels are not practicable when the equipment is calibrated on a daily basis or when labels will interfere with the operation of the equipment. In such cases, other tracking mechanisms are implemented.

5.5.9 When it is necessary for equipment to go outside of the direct control of a laboratory, it will not be returned to service until it is demonstrated to meet performance specifications. Records are maintained in equipment logs.

5.5.10 When intermediary checks are needed to maintain confidence in the calibration status, the checks are carried out according to documented procedures. Refer to section 5.5.6.

5.5.11 Where calibrations result in correction factors, procedures for applying the corrections are documented. Refer to section 5.5.6.

5.5.12 Equipment is situated in the lab in a manner that will protect it from inadvertent adjustments. Specific equipment settings are documented, where these settings can affect analytical results. Correct equipment adjustment is part of the training for individuals working with equipment.

Refer to:

- Local Master List: EQUIPMENT INVENTORY
- Local Master List: INSTRUMENTATION AND EQUIPMENT RECORDS

5.6 MEASUREMENT TRACEABILITY

5.6.1 Wherever possible, ALS measurement and testing equipment that can have a significant effect on the accuracy or validity of test results is calibrated using established procedures. Calibration procedures ensure traceability through an unbroken chain of calibrations or by comparison to national measurement standards.

When using external calibration services, traceability of measurement is assured by the use of laboratories that can demonstrate competence, measurement capability and traceability. The calibration certificates issued by these laboratories shall contain the measurement results, including the measurement uncertainty and/or a statement of compliance with an identified metrological specification.

5.6.2 Where traceability of measurements to SI units is not possible and/or not relevant, traceability is provided by the use certified reference materials and/or consensus standards.

5.6.3 Reference Standards and Reference Materials

5.6.3.1 Reference Standards

Reference standards such as reference thermometers are calibrated by service providers that have demonstrated competence by being accredited to ISO/IEC 17025:2005 for the required calibrations. This equipment is used for no purpose other than demonstrating equipment is within calibration specifications, unless it can be demonstrated that their performance is not invalidated by the other uses. Where adjustments are needed, re-calibration is performed.

5.6.3.2 Reference Materials

Reference materials purchased by ALS are traceable to SI units where possible or to other certified reference materials. Internally prepared reference materials are checked as far as technically and economically feasible. Refer to individual test methods for information on the use of reference materials.

5.6.3.3 Intermediate Checks

Where checks are needed to maintain confidence in the calibration status of reference standards, primary standards, working standards, or reference materials, such checks will be carried out according to defined procedures and schedules.

5.6.3.4 Transportation and Storage

Reference standards and materials are handled, stored and transported in a manner that protects their integrity and operation. A support procedure relates criteria for reference standards. Refer to individual test methods for handling and storage of reference materials. ALS laboratories do not normally transport reference materials. If needed by specific locations, transportation procedures will be available on-site.

Refer to:

- Local Master List: CALIBRATION AND VERIFICATION
- Local Master List (where applicable): REFERENCE STANDARDS
- Local Master List (where applicable): REFERENCE MATERIALS – TRANSPORTATION

5.7 SAMPLING

5.7.1 ALS laboratories have plans and procedures for field sampling and for sub-sampling test materials in the laboratory, where such procedures are needed. When reasonable, sampling plans are based on appropriate statistical methods. The sampling process addresses the factors to be controlled to ensure the validity of the test and calibration results.

Sub-sampling from submitted sample containers is conducted in a manner to obtain representative sub-samples. The error associated with sub-sampling is statistically monitored by collecting duplicate sub-samples for test procedures where sub-sampling occurs. Sub-sampling instructions are included or referenced in test methods where applicable.

5.7.2 Where a client requires deviations, additions or exclusions from our documented sampling procedures, they are recorded in detail with the appropriate sampling data, are communicated to all appropriate personnel, and are indicated in all our final test reports.

5.7.3 Where applicable, ALS laboratories have procedures for recording relevant data and operations relating to sampling. The records include the sampling procedure used, the identification of the sampler, environmental conditions where relevant, a means to identify the sampling location as necessary and, if appropriate, the statistics the sampling procedures are based upon.

Refer to:

- Local Master List (where applicable): FIELD SAMPLING

5.8 HANDLING OF SAMPLES

ALS procedures for sample handling include transportation conditions, receipt, handling, protection, storage, retention, and disposal. The procedures are designed to protect the integrity of the test samples and the interests of the customer and ALS.

ALS requests that our customers use our Chain of Custody (COC) form for every shipment of samples. The form includes sufficient space to record field sampling date, time and location of sampling, sample ID and information relating to the integrity of the sample as collected. COCs are shipped with field supplies, and are also available on the alsenviro.com web site.

Samples are given a unique identification upon receipt. The identification is retained by the sample throughout its life in the laboratory, and ensures samples are not confused either physically or in records or reports. Where appropriate, the system allows for subdivision of test items and transfer within and between laboratories.

Abnormalities or other departures from specified sampling or transportation procedures are documented. Where there is doubt concerning the integrity of the sample, its identification or suitability for testing, or the requested tests, the customer is consulted for further instructions before proceeding, and the discussion is documented.

All ALS locations have appropriate facilities to securely maintain sample integrity, both before testing and where archiving for future testing is required. Sample storage and handling criteria are identified in test methods. Where important to protecting sample integrity, storage conditions are monitored and recorded.

Refer to:

- Local Master List: SAMPLE RECEIPT AND LOGIN
- Local Master List: SAMPLE STORAGE

5.9 ASSURING THE QUALITY OF TEST RESULTS

ALS has established quality control (QC) procedures for monitoring the validity of tests performed by its laboratories. Individual test methods specify quality control requirements, including frequency of use and data quality objectives (DQOs). DQOs are based on a combination of reference method objectives, customer requirements and historical test method performance. Where applicable, regulatory requirements or prescriptive elements of reference methods take precedence over internal DQOs.

Where appropriate, QC results are recorded on control charts to detect trends, and statistical techniques are used to monitor method performance. Planned action is taken to correct problems and to prevent incorrect results from being reported. QC elements utilized include but are not limited to reference samples, control samples, verification standards, blanks, duplicates, surrogates and matrix spikes as appropriate to the field of testing.

ALS laboratories participate in an extensive range of proficiency testing (PT) programs. PT samples are treated and analyzed on-site in a manner as close to customer samples as possible, to ensure the test results represent customer test results. When various locations analyze the same PT samples, test results are not discussed or compared in any manner prior to the publication of the PT evaluation. Each accrediting body has specific polices regarding the analysis of proficiency testing samples. Where needed, local procedures describe the different approaches used.

Samples may be maintained for retesting where the integrity of the test result will not be compromised by the additional storage time. Where retesting identifies a nonconformance to policies and/or procedures, a nonconformance (refer to section 4.9) and corrective action (refer to section 4.11) is initiated in LIMS.

All ALS test results proceed through several reviews prior to the release of final reports. Our data validation process includes test result validation, inter-parameter validation and report validation. Test result validation involves an independent peer review of raw and calculated test results. Inter-parameter validation occurs when all department specific parameters for a sample are completed, and involves an overall review of test results within each sample for consistency among any related test parameters. Report validation occurs when all the requested test results for a work order are completed, and involves a review of the final report before it is sent to the customer.

The reporting of PT sample results requires additional data conversion and transfer steps after our final test report is approved. A peer review and transcription check of the additional reporting steps occurs whenever possible. When a peer review is not possible, a self transcription check is required at minimum. A record is maintained in either case.

Refer to:

- ➢ Local Master List: QUALITY CONTROL
- ➢ Local Master List: RECHECKS
- ➢ Local Master List: PROFICIENCY TESTING PROGRAMS
- ➢ Local Master List: DATA VALIDATION

5.10 REPORTING RESULTS

All information listed below is either included in the final report or kept on file at ALS in the case of abbreviated or customized reports, and can be provided to clients upon request.

- Title of report
- Name and address of the laboratory issuing the report
- Location where each test was conducted
- Unique identification of the test report on each page, and the total number of pages
- Customer name and address
- Identification of test method(s) used
- Unique identification of each sample, description of the sample such as matrix and customer identification, and condition where applicable
- Date of sample receipt
- Date of analysis
- Test results and units
- Report Qualifiers
- Name, function, and signature of the person authorizing the report
- Statement that the results relate only to the samples identified in the report

Other information necessary for the interpretation of results or requested by the customer may also be included in reports, such as test method deviations or exclusions, specific test conditions, measurement uncertainty estimations, date of sampling, location of sampling and other sampling information.

Statements of compliance, opinions, and interpretations may be included on test reports for specific analyses. In all such cases, the basis on which they have been made will be documented and clearly identified in the test report.

ALS obtains subcontract laboratory results in hard or electronic reports. When these results are presented to the customer in ALS reports, the identification of the subcontractor is clearly indicated on the final report.

When test reports are transmitted by telephone, facsimile, e-mail or other electronic means, the procedure for protecting the integrity and confidentiality of data includes:

- ➢ only providing results to those individuals specified by the client for each sample submission
- ➢ use of a standardized facsimile cover page that relates the procedures to follow if received in error
- ➢ use of an e-mail footer that relates the procedures to follow if received in error

It is ALS practice to never disclose information about a client's test results to a third party without the prior consent of the client, or unless compelled to by law. If we are obligated by law to disclose such information, we will inform the client prior to doing so.

Final results are reported in a manner that minimizes the possibility of misunderstanding or misuse.

Test report amendment(s) are made by issuing a replacement report identifying that a revision was made and describing all changes in the cover page comment section.

Refer to:

- Local Master List: REPORTING TEST RESULTS

6.0 REFERENCES

ISO/IEC 17025:2005(E) General Requirements for the competence of testing and calibration laboratories, Second Edition, 2005-05-15. L:\Quality System Documents\External Documents\17025 (E) 2005.pdf

Program, policy and guidance documents of the following accreditation bodies:

- Canadian Association for Laboratory Accreditation Inc. (CALA, formerly CAEAL), located at: www.cala.ca
- Standards Council of Canada (SCC), located at: www.scc.ca
- American Industrial Hygiene Association (AIHA), located at: www.aiha.org
- National Environmental Laboratory Accreditation Conference (NELAC), located at: http://www.nelac-institute.org

7.0 VERSION HISTORY

Doc ID	Version Date	Version No.	Author(s)	Reason
NAQM1	18-Feb-07	01	L. Neimor & P. Mueller	Defining the harmonized ALS management system
NAQM1	07-Sep-07	02	L. Neimor	General: reorganization and clarifications throughout document intended to clarify rather then change policies, based on input of v01 from Quality Department Staff (Refer to v02 for more detailed change list).

Doc ID	Version Date	Version No.	Author(s)	Reason
NA-QM-1	01-Jun-09	03	L. Neimor	4.1.2) Added review of publications & advertisements. 4.1.5) Updated Roles & Alternates table. 4.1.6) Expanded senior mgmt communication. 4.2.2) Added corporate goals to policy statement; expanded objectives. 4.3.1) Added table for document structure; clarified that when national & local SPs exist, local takes precedence only if it meets national policies. 4.3.2) Expanded contents of Master Lists; changed review cycle to 1-3 years; added criteria for cycle; clarified storage of retired docs; clarified the meaning of document dates; added watermark for external distribution. 4.5) Updated to reflect national SP qualification. 4.7.2) Added review of survey results. 4.9) Added noncompliance with internal polices & procedures; expanded on DQO failures. 4.14) Changed cycle to 1-3 years. 5.1) Added that back-up log is available, updated back-up locations. 5.2.1) Added QA responsibility for data integrity training and records. 5.9) Added source of DQOs; policies for handling PT samples and accrediting body polices; added link to NC & CARs for nonconforming rechecks; reworded data validations section to relate national SP; added PT reporting peer review; referenced QC SP.