CUMBERLAND
RESOURCES LTD.

MEADOWBANK GOLD PROJECT

AQUATIC EFFECTS MANAGEMENT PROGRAM

OCTOBER 2005

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DESCRIPTION OF SUPPORTING DOCUMENTATION

Cumberland Resources Ltd. (Cumberland) is proposing to develop a mine on the Meadowbank property. The property is located in the Kivalliq region approximately 70 km north of the Hamlet of Baker Lake on Inuit-owned surface lands. Cumberland has been actively exploring the Meadowbank area since 1995. Engineering, environmental baseline studies, and community consultations have paralleled these exploration programs and have been integrated to form the basis of current project design.

1. The Meadowbank project is subject to the environmental review and related licensing and permitting processes established by Part 5 of the Nunavut Land Claims Agreement. To complete an environmental impact assessment (EIA) for the Meadowbank Gold project, Cumberland followed the steps listed below:

2. Determined the VECs (air quality, noise, water quality, surface water quantity and distribution, permafrost, fish populations, fish habitat, ungulates, predatory mammals, small mammals, raptors, waterbirds, and other breeding birds) and VSECs (employment, training and business opportunities; traditional ways of life; individual and community wellness; infrastructure and social services; and sites of heritage significance) based on discussions with stakeholders, public meetings, traditional knowledge, and the experience of other mines in the north.

3. Conducted baseline studies for each VEC and compared / contrasted the results with the information gained through traditional knowledge studies (see Columns 1 and 2 on the following page for a list of baseline reports).

4. Used the baseline and traditional knowledge studies to determine the key potential project interactions and impacts for each VEC (see Column 3 for a list of EIA reports).

5. Developed preliminary mitigation strategies for key potential interactions and proposed contingency plans to mitigate unforeseen impacts by applying the precautionary principle (see Columns 4 and 5 for a list of management plans).

6. Developed long-term monitoring programs to identify residual effects and areas in which mitigation measures are non-compliant and require further refinement. These mitigation and monitoring procedures will be integrated into all stages of project development and will assist in identifying how natural changes in the environment can be distinguished from project-related impacts (monitoring plans are also included in Columns 4 and 5).

7. Produced and submitted an EIS report to Nunavut Impact Review Board (NIRB).

As shown on the following page, this report is part of a documentation series that has been produced during this six-stage EIA process.

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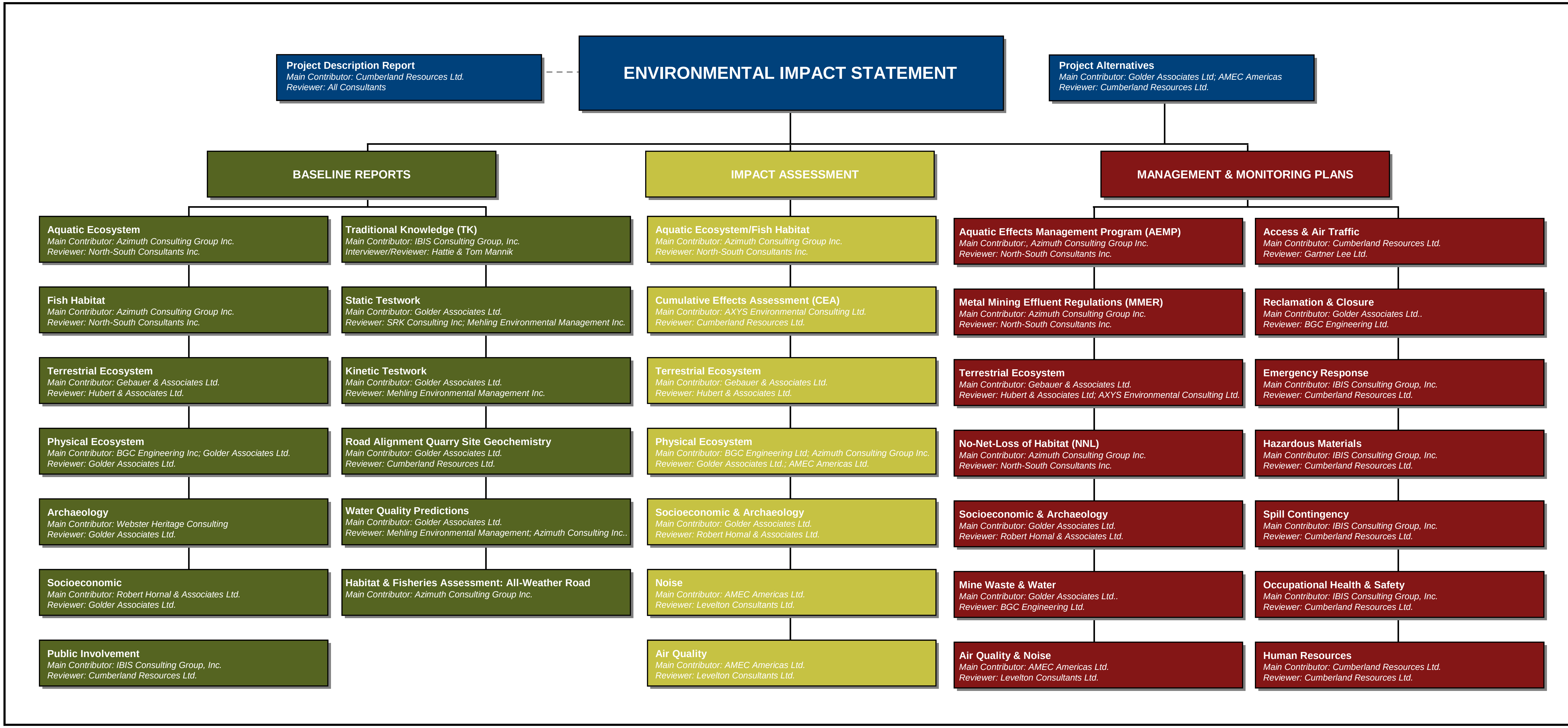
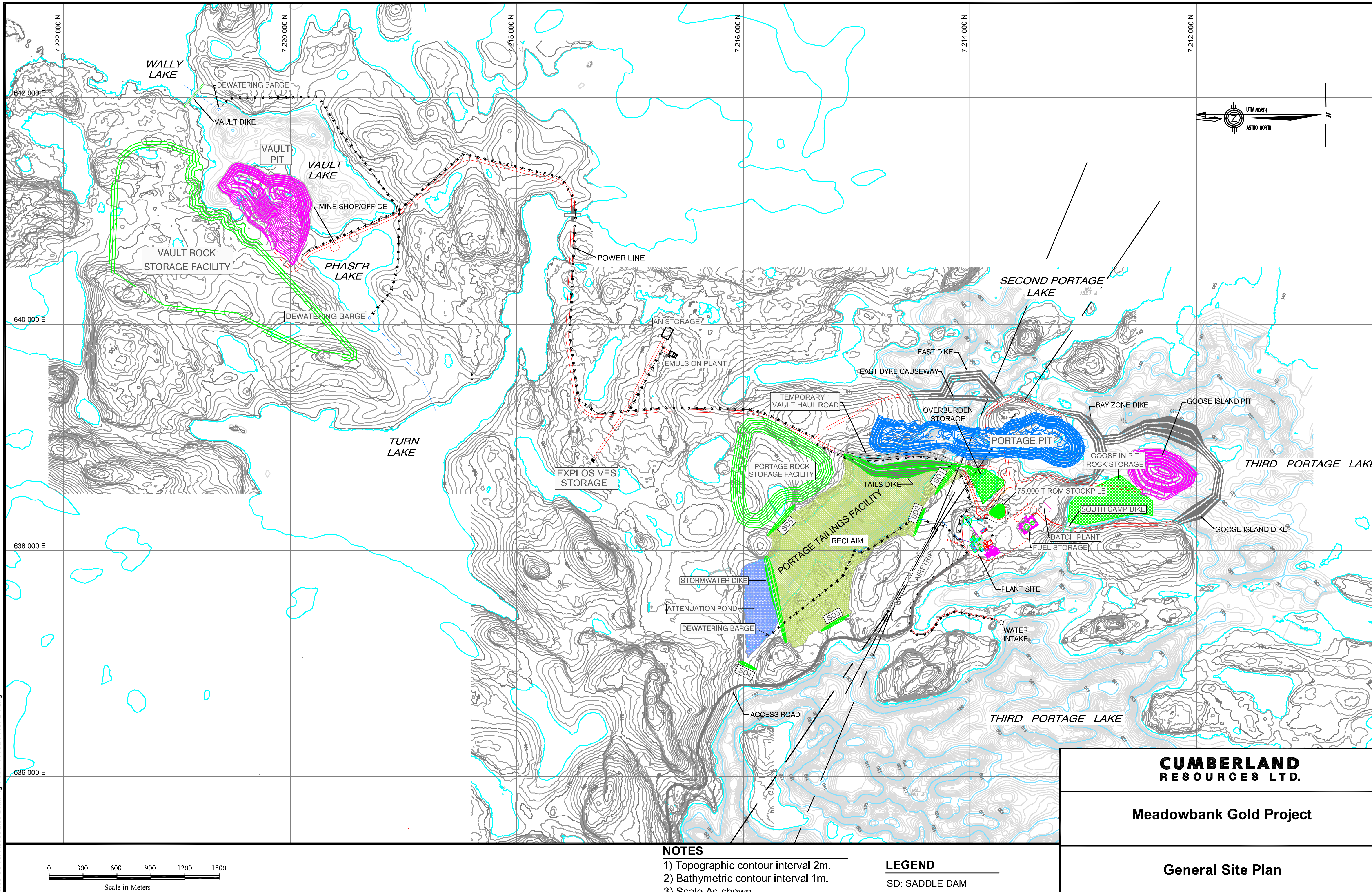
EIA DOCUMENTATION ORGANIZATION CHART



Date: October 2005

PROJECT LOCATION MAP



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Meadowbank Gold Project

General Site Plan

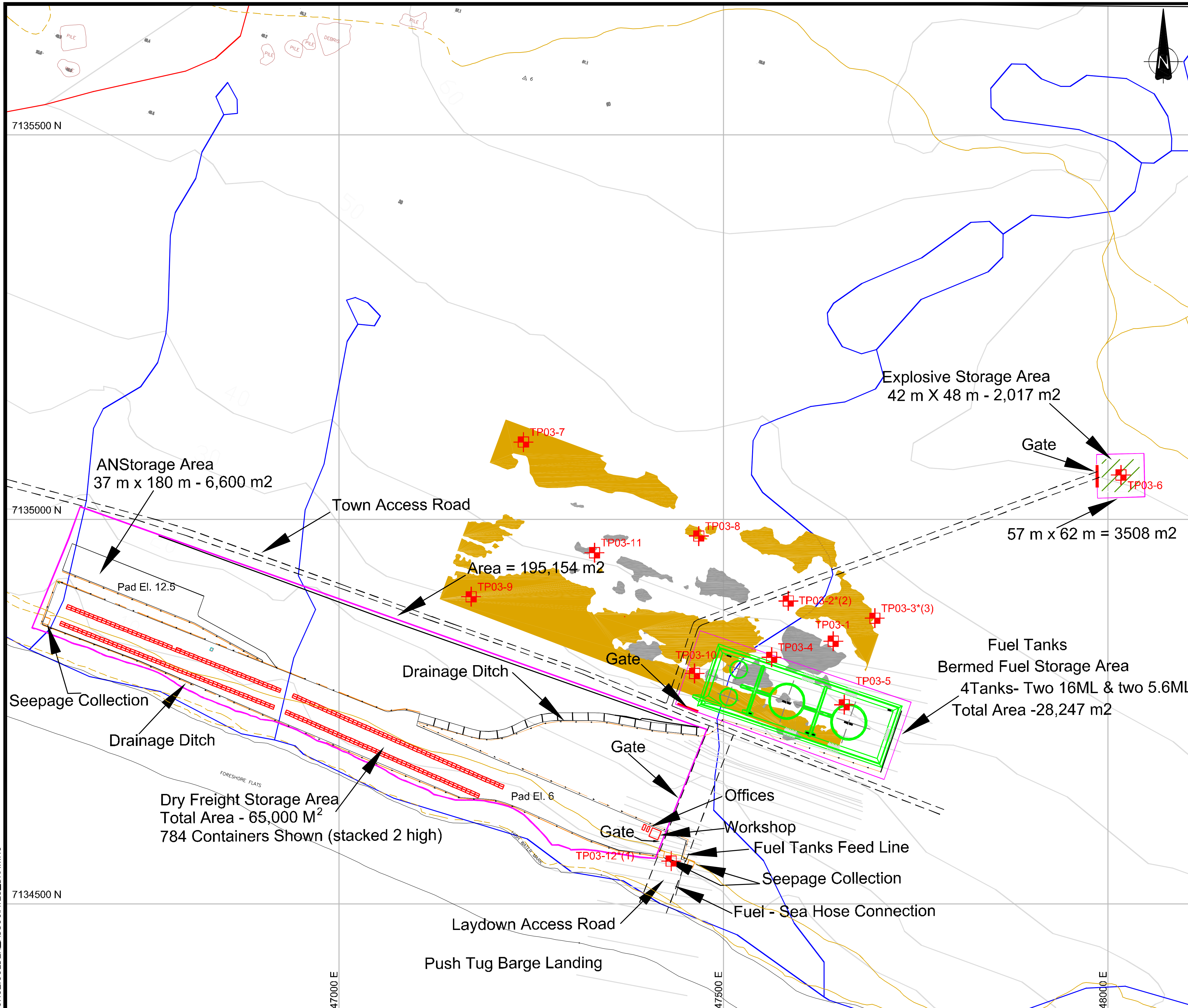
NOTES

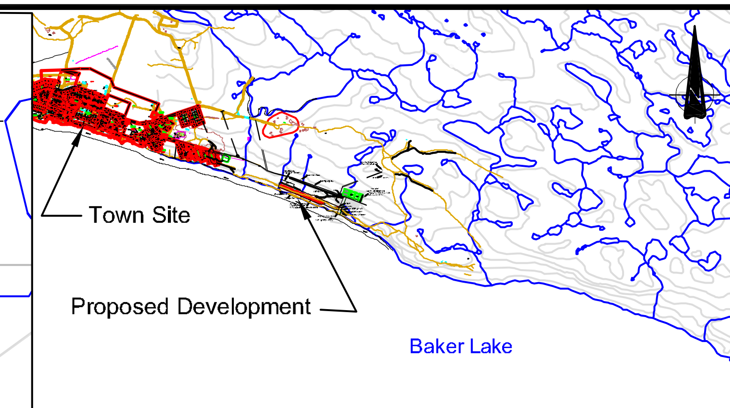
1) Topographic contour interval 2m.
2) Bathymetric contour interval 1m.
3) Scale As shown.

LEGEND

SD: SADDLE DAM

Source:Golder Associates Drawing # 05141303GA-1400-2.1.dwg





LOCATION MAP

LEGEND

- Test Pit Location (Approximate)
- Property Limit
- Contour Interval
- Bedrock Outcrop (Approximate)
- Interpreted Frost-susceptible Ground

NOTES

1) Northing and eastings are in metres referenced to UTM Zone 14, NAD83.

2) Elevations are in metres referenced to geodetic datum.

3) Testpit, bedrock outcrop, seismic line and EM31 survey boundary locations were determined using GPS equipment and are considered approximate.

0 50 100 150 200 250
Scale in Meters

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Meadowbank Gold Project

Baker Lake Storage & Marshalling Area

SECTION 1 • EXECUTIVE SUMMARY

The Aquatic Effects Management Plan (AEMP) describes the management program for the Meadowbank project area lakes as part of Cumberland's EIA. This AEMP describes the rationale, framework, strategy, methodology and scope of management plans to be implemented during mine construction, operation, and post-closure.

Management consists of a range of activities, including mitigation and environmental monitoring. Many of these activities are embedded in the project itself and are integral to its success. Monitoring is designed to detect potential adverse effects on aquatic valued ecosystem components (VECs) arising from any mine-related activity, in order that (further) mitigation can be applied as necessary to eliminate or reduce adverse effects.

The AEMP is a dynamic, working document. It is a practical guide that identifies the source of physical and chemical stressors to the receiving environment, pathways of potential exposure, the ecological receptors at potential risk, mitigation measures, and the specific parameters to be monitored, their frequency, geographic location, and duration.

The AEMP takes an integrated, ecosystem-based approach that links mitigation and monitoring of physical/chemical effects on key ecological receptors in the receiving environment. At its core, this AEMP will address the same key questions that were the focus of the Meadowbank EIA (water quality, fish habitat, and fish population sections). The AEMP has two core components: mitigation and monitoring. Mitigation is incorporated into mine design from the beginning, but it can also be improved/changed or added based on learning and the results of monitoring. The Meadowbank monitoring strategy has two primary components:

Core Monitoring Program – The core program is a general strategy to monitor water and sediment quality, periphyton, benthic invertebrates, and fish that is tailored based on our understanding of mine construction, operation, and infrastructure (e.g., dikes, effluents, stream crossings, all-weather road, etc.). This general design will be implemented prior to and during construction and operation of the mine and will be conducted each year, until closure. Note that requirements under the Metal Mining Effluent Regulations (MMER) are considered part of the foundation to core studies pertaining specifically to mine effluent sources. Given the complexity of MMER monitoring, a separate document (MMER, 2005) has been prepared to complement this AEMP and address effluent and its effects on the receiving environment.

Targeted Studies – Targeted studies are specific studies that typically have narrower temporal or spatial bounds or are designed to address specific questions related to particular components of mine development during construction or operation. These are integrated with, and complementary to, the core monitoring design.

Cumberland fully anticipates that changes to the AEMP will result from the permitting and regulatory processes yet to be completed in respect of the proposed project. Therefore, prior to the initiation of the project construction phase, Cumberland intends to revise the AEMP to incorporate the changes, as required.

SECTION 2 • INTRODUCTION

This document describes the aquatic management program for the Meadowbank project area lakes and all-weather access road as part of the EIA, Meadowbank Gold project (Cumberland, 2004). This AEMP describes the rationale, framework, strategy, methodology and scope of management plans to be implemented during mine construction, operation and post-closure at Meadowbank.

Management consists of a range of activities, including mitigation and environmental monitoring. Many of these activities are embedded in the project itself and are integral to its success. Monitoring is designed to detect potential adverse effects on aquatic Valued Ecosystem Components (VECs) arising from any mine-related activity, in order that (further) mitigation can be applied, if necessary, to eliminate or reduce adverse effects.

The AEMP is a dynamic, working document. It is a practical guide that identifies the source of physical and chemical stressors to the receiving environment, pathways of potential exposure, the ecological receptors at potential risk, mitigation measures, potential residual effects and the specific parameters to be monitored, their frequency, geographic location, and duration.

The AEMP also recognizes and integrates, when appropriate, monitoring requirements under the No-Net-Loss policy of the *Fisheries Act* and the Metal Mining Effluent Regulations (MMER; includes Environmental Effects Monitoring (EEM) for mines). This simplifies and harmonizes monitoring requirements so that an integrated ecosystem approach is taken such that physical, chemical, and biological effects and mitigation and monitoring programs are linked. Note that separate documents outline monitoring programs for Fisheries and Oceans Canada's (DFO) No-Net-Habitat-Loss policy (NNL, 2005) and the MMER (MMER, 2005).

2.1 NIRB TERMS OF REFERENCE

The AEMP for the Meadowbank project provides some of the information required by the NIRB according to the Terms of Reference. This AEMP document largely addresses Sections 4.24 and 4.26 of the NIRB Terms of Reference.

2.2 OBJECTIVES

The overall objective of the AEMP is to document the overall program and plans to protect aquatic resources during construction, operation, and closure of the Meadowbank mine and all-weather access road between the Hamlet of Baker Lake and the mine site. Application of this management program will ensure that project-related adverse impacts are detected and mitigated, so that construction and operational activities do not cause any undue harm to local and regional water quality, sediment quality or biota (invertebrates and fish).

Many of the mitigation measures described herein (and summarized in the EIA) are imbedded in the project design and considered best practice in mine design. One of the specific objectives of this document is to centrally describe mitigation measures in detail.

Another specific objective of the AEMP is to centrally describe the monitoring plans for aquatic systems, including locations of monitoring stations and monitored parameters that will provide an early-warning system, such that any potential adverse effects (unexpected or predicted) can be detected and appropriate mitigation measures implemented.

Finally, The AEMP will also serve to focus and integrate monitoring efforts to ensure compliance with regulatory instruments and agreements, both federally and territorially, such as DFO NNL, NIRB, and MMER policy.

2.3 SCOPE

The scope of the AEMP encompasses all construction, operation, and post-closure activities that have the potential to adversely affect aquatic receiving environments, including water quality, sediment chemistry, lower trophic level biota (periphyton, phytoplankton, benthic invertebrates) and fish. The AEMP also provides a framework for monitoring bank stability, culvert performance, and fish migration in fish-bearing streams crossed by the all-weather road.

It is important to note that the AEMP is dynamic and adaptive (see Section 6.3.2) and will change over time with increasing information about how the mine will be designed, constructed and operated. The management program described here is based on the best information available at the time that this document was written. Specific details, such as proposed mitigation measures, the location of monitoring stations, parameters to be measured, and their frequency, were developed based on our understanding of the baseline environmental conditions, described in the Baseline Environmental Aquatic Environmental Assessment Report (BAEAR, 2005) and on our professional judgment and experience. As the AEMP is applied, its components may change in response to new information, to optimize sampling effort and maximize our ability to detect and respond to potential adverse effects.

2.4 ORGANIZATION OF THIS DOCUMENT

This document is organized so that the various sections can be used almost independently to maximize ease of use. Sections 2 to 5 are background sections, covering introduction, environmental setting, VECs and stressors of potential concern (SOPC), respectively.

Section 6 describes the strategy behind the AEMP; specifically how it is designed to address the key questions posed by the EIA through a program of monitoring and mitigation. Section 5 also details the technical strategy behind each of the monitoring and mitigation plans. Section 7 describes the core monitoring plan.

Sections 8, 9, and 10 describe the specifics of aquatic environment management for each of the construction phase, operational phase, and generic activities, respectively. For each of the key questions, the following information is provided:

- description of activity
- potential effects (physical and ecological)
- mitigation plan

- potential residual effects
- monitoring plan.

Section 11 discuss the NNL document (2005) and its relevance to the AEMP. Section 13 describes a quality assurance/quality control program to support implementation of monitoring within the AEMP. Section 13 discusses the post-closure aquatic management plan.

2.5 APPROACH

The approach to the AEMP is described fully in Section 6. In summary, we have taken an integrated, ecosystem-based approach that links mitigation and monitoring of physical/chemical effects on key ecological receptors in the receiving environment. At its core, this AEMP will address the same key questions (Section 6.1) that were the focus of the Meadowbank EIA (water quality, fish habitat and fish population sections). The AEMP has two core components: mitigation and monitoring. The Meadowbank mitigation strategy (Section 6.4) incorporates mitigation into the mine design from the beginning, but it can also be improved/changed or added based on learning and the results of monitoring. The Meadowbank monitoring strategy (Section 6.5) has two primary components:

Core Monitoring Program – The core program (Section 7) consists of a general strategy to monitor water and sediment quality, periphyton, benthic invertebrates and fish, that is tailored based on our understanding of mine construction, operation and infrastructure (e.g., dikes, effluents, stream crossings, roads, etc.). This general design will be implemented prior to and during construction and operation of the mine and will be conducted each year, until closure. Note that requirements under the MMER are considered part of the foundation to core studies pertaining specifically to mine effluent sources. Given the complexity of MMER monitoring, a separate document (MMER, 2005) has been prepared that is complementary to the AEMP and is specific to effluent monitoring and receiving environment effects.

Targeted Studies – Targeted studies are specific studies that typically have narrower temporal or spatial bounds or are designed to address specific questions related to particular components of mine development during construction or operation. These are integrated with, and complementary to, the core monitoring design, so they are presented together by key questions in Sections 8 to 10.

SECTION 3 • ENVIRONMENTAL SETTING

3.1 GENERAL LOCATION

Meadowbank project lakes are situated in the barren-ground central Arctic region of Nunavut at approximately 65° north latitude, within an area of continuous permafrost. The project lakes are headwater lakes, situated on the watershed boundary that separates two main drainages—the Arctic and Hudson Bay drainages. Only a few hundred meters to the north of Second and Third Portage lakes (e.g., Pipedream, Inuggugayualik lakes), water flows north to the Arctic Ocean via the Meadowbank and the Back River system. The study lakes area falls within the headwaters of the Quoich River system that flows south, through Tehek Lake into Chesterfield Inlet and eventually, to Hudson Bay. On the Quoich River, about 50 km upstream from Chesterfield Inlet is St. Clair Falls, which is a barrier to upstream fish movement, preventing access by anadromous species such as Arctic char.

The landscape consists of rolling hills and relief limited to approximately 50 m, with low growing vegetative cover. There is little soil development. Numerous lakes are interspersed among boulder fields, eskers and bedrock outcrops, resulting in indistinct and complex drainages. Shoreline complexity (i.e., the degree to which a shoreline does not resemble a smooth, circular shape of equal circumference) of all project lakes is high. Information summarized here is described in greater detail within the BAEAR (2005).

3.2 GENERAL HYDROLOGY

The main lakes in the Meadowbank project area include Third Portage Lake (TP), Second Portage Lake (SP), Tehek Lake (TE), Turn Lake (TURN), and the Vault Lake system—Vault, Wally Lake, and Drilltrail Lake. All of the project lakes have small drainage areas relative to the surface area of the lakes themselves. This is a common feature of headwater lakes. Third Portage Lake is relatively large, with a surface area of 36.0 km^2 and a drainage area of 89 km^2, resulting in a low drainage area to surface area of 2.5. Second Portage Lake is much smaller with a surface area of 4.1 km^2 and a drainage area of 14.6 km^2 (ratio of 3.5). Including the additional lakes that drain into the south end of Second Portage Lake (i.e., Turn Lake, Vault Lakes), the lake surface area to drainage area ratio is similar (3.2). Local inflow from surrounding terrain is the predominant influence on water movement within the system.

Hydrology of the project area lakes is highly influenced by geographic location, the headwater nature of the watershed and by season. Because of their headwater nature, small drainage area and near absence of stream habitat, small, ephemeral channels connect project area lakes. There is no flow between lakes during winter. During early spring (June), once connecting channels melt, initial discharge is high and gradually diminishes throughout the summer, reaching base levels by early to mid-August.

Net water flow in the system is south. Third Portage drains into Second Portage Lake via three small, ephemeral channels that, with the exception of early spring freshet, are impassable by fish. The elevation difference between the lakes is 1 m and a narrow spit of land 50 to 150 m wide, separates the lakes. Discharge from the Portage lakes flows south into a small headwater basin of Tehek Lake via a wide connecting channel and small chute about 50 m long.

Vault, Wally, and Drilltrail lakes also drain south to join Second Portage Lake, just upstream of its outlet to Tehek Lake. Thus, water from all project area lakes drain south via this single channel, providing an effective location to detect any changes in hydrology and water quality parameters over time. To take advantage of this feature the general locations of sampling stations from project lakes between 1996 and 2003 included this location to facilitate ease of comparison and interpretation among years (described in BAEAR, 2005).

3.3 GENERAL LIMNOLOGY

Meadowbank project area lakes are ultra-oligotrophic, soft water, nutrient poor, and isothermal with neutral pH and high oxygen concentrations year round. Limnological conditions tend to be very stable, with uniform, vertical temperature, oxygen, and nutrient distributions and only minor, temporary stratification. Water clarity is extremely high with Secchi depth is typically 10 m or more, implying very low suspended solids concentrations. The headwater nature of the project area lakes means that there are no large streams entering or exiting the watershed and the drainage areas are relatively small. Therefore, there are no external sources of nutrients or sediment that will contribute to nutrient enrichment or productivity of the system. Sedimentation rates are typically very low, which partly explains why water clarity is so high and why nutrient concentrations are so low. Other factors contributing to low productivity include low light levels during the winter months, extended periods of ice cover and low water temperatures.

The ice-free season on these lakes is very short, with ice break-up in late-June and ice-up beginning in late September or early October. Maximum ice thickness is at least 2 m by March/April. Because the lakes are ice covered for most of the year, gas exchange with the atmosphere is limited, although oxygen concentrations usually remain high under the ice because of the low rates of biological activity and decomposition of organic material (processes that consume oxygen from the water) (BAEAR, 2005).

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 no fine substrates, such as sand, in shallow water at depths of less than 4 m. Very coarse substrates predominate to depths of at least 4 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. This shallow, coarse material provides abundant habitat for spawning, rearing and foraging by fish. There is also a great deal of offshore, shoal habitat that may also be suitable for spawning and rearing by fish.

Other lakes examined by the BAEAR included Snap Lake (De Beers, 2002), Baker Lake and Kiggavik area lakes (McLeod et al, 1976; Urangesellshaft, 1981; McKee et al, 1989), Koala area lakes (Rescan, 1994), Lac de Gras and Lac du Sauvage (Diavik and Aber, 1998), and lakes from the Great Slave Lake region (Fee et al, 1985). These Arctic lakes have similar limnological characteristics to Meadowbank project lakes and there do not appear to be major differences in important limnological parameters within lakes, among seasons, between lakes, or geographic location.

3.4 LOWER TROPHIC LEVEL BIOTA

The physical and climatic setting of the study lakes strongly influences the chemical as well as the biological features of project area lakes. The headwater nature, lack of nutrients, shallow depth, and similarity in limnological properties of the project lakes helps to explain similarities observed among the lakes. These features also help explain differences in chemical or biological features between project and reference lakes and regional Arctic lakes. In general, the paucity of nutrients and severity of the climate results in low diversity of plants and animals.

Across the project area, there are no macrophytes (i.e., plants that are rooted in the bottom and emerge into the water column, such as grasses or weeds) along shorelines or rooted in shoals.

Periphyton (i.e., unicellular and colonial aquatic algae species attached to rocks) provides an important food source at the base of the aquatic food web. Periphyton is most abundant between the surface and several meters water depth and typically, their biomass reflects the growing season. Ice scouring can limit periphyton abundance in the upper meter or two. Species composition and biomass of periphyton are indirect indicators of lake productivity, reflecting nutrient concentrations in the lake, and are sometimes indicators of the presence of contaminants. Because some periphyton species are sensitive to the presence of metals, reductions in periphyton communities over time can indicate the presence of dissolved metals in the water column.

Phytoplankton are microscopic, unicellular or colonial plant species that are suspended in the water column and provide the basis of the food web, as they convert the sun’s energy to plant tissue. Phytoplankton are primary producers that are grazed on by herbivorous zooplankton (i.e., free swimming invertebrates) species throughout the year, especially during the open water season when primary production within the lake is greatest. Maximum production usually occurs within the upper 10 m of water, where there is the greatest amount of light. Sufficient solar radiation is available for phytoplankton productivity to start increasing as early as April, while there is still ice on the lakes. Annual production can vary widely depending upon water temperature, mixing, nutrient concentration, sunlight, water clarity, and predation by zooplankton. Estimates of phytoplankton biomass are used as gross indicators of productivity from a snapshot perspective, depending on frequency of sampling, and are only useful to detect long-term trends or gross changes in lake production, such as eutrophication as a result of nutrient additions (e.g., from sewage disposal) or addition of nitrites as a result of the use of explosives.

Zooplankton are small, free-swimming animal species that feed on phytoplankton, bacteria, detritus, and smaller zooplankton. Zooplankton are a key food chain species for fish, especially young-of-the-year lake trout, round whitefish, and minnow species. Zooplankton are also the main food source for some adult species, particularly round whitefish and Arctic char. Density, diversity and richness of zooplankton taxa from Meadowbank project lakes are low, but typical of oligotrophic, Arctic lakes in the Northwest Territories and Nunavut (BAEAR, 2005). All of the zooplankton taxa identified from study lakes are common, widespread species that are well known from this region of the Arctic (Patalas et al, 1994).

Benthic invertebrates (collectively referred to as “benthos”) are relatively small animals that live on or in the bottom sediments. Lake benthos communities include many different organisms with a wide variety of feeding mechanisms and ecological niches. 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). The abundance and species composition of benthic invertebrates is strongly affected by water depth, sediment grain size, and organic carbon content. Benthic invertebrates are typically most abundant at depths between approximately 3 to 12 m. Benthic invertebrates are a useful environmental monitor because they are sessile and therefore their exposure regime is predictable. In addition, they are easy to monitor (depending on the substrate) and their ecology is relatively well understood.

3.5 FISH

Fish compose the upper trophic level of aquatic organisms in Arctic lakes. As the top of the food web, fishes exert a degree of control and structure on the lower trophic levels. However, fish biomass is usually ultimately dictated by the level or amount of primary and secondary production of the system. The fish community also exhibits the greatest structural stability of the various members of northern aquatic ecosystems. This stability is derived from fishes being larger, longer-lived, and containing large stores of energy (Johnson, 1976). An important consideration of this is that any changes to chemical or biological features of the project lakes, either natural or mine-related, will be reflected in fish last. That is, changes will be observed in limnological parameters or abundance and biomass of lower trophic level biota long before these changes may be manifest in fish.

The headwater nature of the Meadowbank project area lakes, absence of stream habitat, distance from marine waters of Hudson Bay, and an impassable falls drive the distributions of the various fish species, as described below:

- Lake trout (*Salvelinus namaycush*) and round whitefish (*Prosopium cylindraceum*) dominate abundance (>75%) in all lakes. This is consistent with the typical species composition of Arctic lakes (Scott and Crossman, 1979) and in particular this region of Keewatin District (Lawrence and Davies, 1977).

- Landlocked (i.e., non-anadromous) Arctic char (*Salvelinus alpinus*) are also present in all of the project lakes, although relative abundance differs among lakes; char tend to be more abundant in downstream lakes than upstream lakes. South of Tehek Lake, anadromous char are known to migrate up the Prince River to Whitehills Lake, which is used by Arctic char to overwinter (MacDonald and Stewart, 1980). This drainage basin lies just south of the Quoich River drainage. Second Portage Lake contains a relatively higher proportion of char (28%) than does Third Portage Lake (8%).

- Lake whitefish (*Coregonus clupeaformis*) are known to be present from other watersheds in this region, but are absent from the Quoich River system (Lawrence et al, 1977; MacDonald and Stewart, 1980) including the project lakes.

- Lake cisco (*Coregonus artedii*) are also absent from the study lakes and are not known to occur in this watershed (Lawrence and Davies, 1978; MacDonald and Stewart, 1980).

- The project area is located in the maximum northern range of the distribution of Arctic grayling (Thymallus arcticus) (McPhail and Lindsay, 1970). This species is present in the Quoich River, although it has not been reported in Tehek Lake and has not been observed in the project lakes. Its absence is due to the lack of stream habitat for spawning and the rapid freshet period, which limits spawning.

- Other fish species present in low abundance (<1%) include slimy sculpin (Cottus cognatus), ninespine stickleback (*Pungitius pungitius*) and burbot (*Lota lota*).

Overall, fish species composition and mean size and condition factor of fish among lakes was similar for most lakes (BAEAR, 2005). Lake trout dominated all project, reference and regional lakes and were characterized as being large, old, climax community populations, which are typical of oligotrophic Arctic lakes. Round whitefish and Arctic char were the next dominant species in all lakes. Fewer Arctic char are present in Third Portage Lake than the other project lakes. The project lakes do not support spring spawning species such as Arctic grayling or suckers.

Overall, the Meadowbank project lakes support healthy communities of plankton, benthos, and fish that are typical of oligotrophic Arctic lakes. Biological productivity of the lakes, reflected in growth and biomass of plankton and fish, is limited by nutrient availability and not by availability or abundance of physical habitat features. Results of habitat mapping and quantification of project lakes indicates that all lakes have complex shoreline and shoal features. There appears to be sufficient and abundant habitats for fish to accomplish all major life history functions including spawning, nursery, rearing, foraging, and overwintering.

SECTION 4 • VECS & POTENTIAL RECEPTORS

The AEMP is designed to protect VECs, which are the environmental attributes or components identified as a result of societal values and considerations. Best practice is to identify VECs that also have ecological importance. Therefore, VECs selected for this AEMP represent both (1) environmental values to be protected and (2) important ecological entities.

This AEMP addresses the following aquatic VECs: water quality, fish habitat, and fish populations. These VECs, by inference, cover all related issues, including effluents, sediment quality, and lower trophic level biota.

SECTION 5 • STRESSORS OF POTENTIAL CONCERN

Stressors are any physical, chemical, or biological entity that can induce an adverse effect on environmental systems. There are three groups of project-related SOPC may affect Meadowbank project VECs. These are:

- suspended solids and sedimentation
- contaminants (chemicals, ions, nutrients, etc.)
- particle velocity and noise
- direct habitat impacts.

Each of these stressors is discussed generically in the following sections and then in more detail in subsequent sections, relevant to mitigation and monitoring.

5.1 SUSPENDED SOLIDS & SEDIMENTATION

Suspended sediments and sedimentation are significant environmental stressors since they can result in a wide range of environmental effects, including: disruption of important physiological systems in fish (e.g., gills, mouth), degradation of spawning and nursery habitat, suffocation of eggs and alevins, degradation of periphyton and benthic habitat (which has secondary impacts on fish), and reduction in light penetration (secondary effects include reduced photosynthesis). However, biological systems have a natural resilience to suspended solids and sedimentation. Any given monitoring program should be designed to identify when those tolerance levels are being exceeded.

Water quality guidelines for total suspended solids (TSS) (Caux et al, 1997; CCME, 1999) provide guidelines for short-term exposure (e.g., 24 hours) and longer-term exposure (e.g., 30 days or more). The approach to implementing the guidelines recognizes that exposure duration plays a key role in the ecological response, in the context of background conditions and spatial distribution of TSS.

Mine construction and operation activities can be expected to release suspended solids and cause sedimentation. There are mitigation techniques (discussed in the relevant sections of the AEMP) that will reduce the exposure of receptors to this stressor and minimize adverse effects. TSS concentrations in the project lakes are very low, typical of oligotrophic Arctic lakes.

Water quality measurements related to this stressor group include: TSS, turbidity (NTU), Secchi depth (m), and total dissolved solids (TDS).

5.2 CONTAMINANTS

Contaminants are defined as potentially deleterious substances that are present either where they are not normally found, or at concentrations above those usually measured (i.e., above background). From a regulatory perspective, contaminants can be deleterious in certain situations. Under the federal *Fisheries Act, (Section 36)*, it states that "…no person shall deposit or permit the deposit of a deleterious substance of any type in water frequented by fish." The *Fisheries Act* defines a "deleterious substance" as:

> *(a) any substance that, if added to any water, will degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water, or*
>
> *(b) any water that contains a substance in such quantity or concentration, or that has been so treated, processed or changed, by heat or other means, from a natural state that it will, if added to any other water, degrade or alter or form part of a process of degradation or alteration of the quality of that water so that it is rendered or is likely to be rendered deleterious to fish or fish habitat or to the use by man of fish that frequent that water.*

Mine construction and operation activities have the potential to cause increases in a range of contaminants including suspended solids, metals, petroleum hydrocarbons, nutrients, and sewage constituents (including bacteria). These activities may also influence conventional measures as hardness, ion concentrations, dissolved oxygen, and pH. The study design of the AEMP takes into consideration likely sources of these contaminants and aims to detect any changes before they can cause harm.

Metals are one of the contaminant groups of greatest potential concern. The concentrations of total and dissolved metals in project lakes are consistently measured at low values, often below detection limits and almost never exceeding CCME guidelines (CCME, 1999; BAEAR, 2005). Dissolved metal concentrations comprise the vast majority of total metals concentrations in water, where results exceeded detection limits, indicating that nearly all metals are dissolved and not associated with particulates (BAEAR, 2005). Water quality modeling of the impacts of effluent discharge and metal leaching from dikes determined that there is a risk that a small group of metals may exceed CCME guideline concentrations in the aquatic receiving environment over mine life.

5.3 PARTICLE VELOCITY & VIBRATION FROM BLASTING

The detonation of explosives in or near water produces post-detonation compressive shock waves that can be harmful to fish and fish eggs. The shock waves are characterized by a rapid rise to a "peak pressure" followed by a rapid rebound to below ambient hydrostatic pressure (Wright and Hopky, 1998). The rapid fall in pressure causes most impacts to fish. Vibrations (measured in mm/sec) from the detonation of explosives may cause damage to incubating eggs. DFO (Wright and Hopky, 1998) provides guidance on acceptable levels for both of these measures. This stressor is addressed in Section 10.4.

5.4 DIRECT HABITAT IMPACTS

Habitat impacts (e.g., habitat loss [as defined by DFO], modification, degradation; e.g., lake dewatering, hydrological alternation, stream crossing) may affect all aquatic organisms and, in the specific case of fish: spawning grounds, rearing areas, adult feeding areas, overwintering areas, and migration routes.

Habitat compensation (i.e., no net loss) is not fully considered within this AEMP, but is addressed in the “NNL” (Cumberland, 2005), that quantifies and compensates for project related-impacts to fish habitat during mine construction and exploration. AEMP monitoring and mitigation related to fish and impacts on fish habitat is described in Sections 7 to 10. Monitoring and mitigating the direct impacts on fish and fish habitat are incorporated into the AEMP by examining such project-related activities as worker fishing, stream crossings and culverts, and effects of blasting. The goal is to monitor any impacts to fish habitat so that an appropriate response can be taken should impacts be observed, thus reducing their magnitude and scope.

5.5 INHIBITION OR PREVENTION OF FISH MOVEMENT

An all-weather road has been proposed to provide access to and supply the mine site. This road will cross approximately 25 ephemeral channels and streams. Five of the streams are wide enough and have sufficient flow to warrant bridge crossings. The remaining channels will be crossed with culverts. If culverts are improperly installed or not maintained, they could cause erosion of stream banks and introduction of sediment to downstream spawning habitat. Culverts can also prevent upstream movement or migration of fish because 1) water velocity is too high to allow passage, 2) the elevation of the downstream end of the culvert is higher than the water level, posing an elevation barrier, or 3) fish are deterred from passing through a long, dark corridor. Bridges and culverts will be designed, installed and maintained such that movements and migrations by fish, where they occur, will not be prevented or impaired.

SECTION 6 • AQUATIC ENVIRONMENT MANAGEMENT STRATEGY

The Cumberland EIA is underpinned by a series of environmental management programs that cover the various aspects of the mine, supporting the EIA. Components that are related to plans for environmental management of aquatic systems include:

- No-Net-Loss of Habitat Report (NNL, 2005) – discussed in Section 11.
- Metal Mining Effluent Regulations (MMER), for which a framework document has been prepared (MMER, 2005).
- Aquatic Effects Management Program (AEMP), described herein.

The first two of these components are designed to meet specific regulations and so are “stand-alone” documents. However, the third document (the AEMP) is consistent with these two documents and addresses all other aquatic environment management issues.

At its core, this AEMP will address the same key questions that were the focus of the Meadowbank EIA (water quality, fish habitat and fish population sections). These questions are listed in Section 6.1 and are based on the linkage matrices summarized in Section 6.2.

Section 6.3 describes the overall strategy to the AEMP. The technical basis behind the two core components, mitigation and monitoring, are described in Sections 6.4 and 6.5, respectively. These two sections are important to understand the rationale behind the management plans detailed in Sections 7 to 11.

6.1 KEY QUESTIONS

The approach taken to the EIA for fish and fish habitat has been to focus on *key questions.* These are related to specific operation, construction or post-closure related issues that have the potential to cause adverse effects of a large magnitude, or over large spatial (e.g., widespread) or temporal (e.g., long-term) scales.

For the AEMP, we focus on the same key and generic questions addressed by the EIA but, as described in Sections 6.4 and 6.5, the management program provides a broader framework to monitor, detect and (if necessary) mitigate more than just those issues.

The key questions posed in this assessment during construction of the Portage pit, Goose Island pit, and Vault pit on fish habitat and fish populations are:

- What are the impacts of dike construction?
- What are the impacts of dewatering of impoundments?
- What are the impacts of freshwater intake and effluent pipe installation?
- What are the impacts of mine site infrastructure installation?

Key questions posed during operation of the Portage pit, Goose Island pit, and Vault pit on fish habitat and fish populations are:

- What are the impacts of dike operation?
- What are the impacts of pit development?
- What are the impacts of effluent discharge?

Key questions related to monitoring and management of generic activities that have a similar magnitude and effect and occur during both construction and operation are considered together and include the following:

- What are the impacts of mine site infrastructure facilities?
- What are the impacts of installation and operation of the Turn Lake crossing?
- What are the impacts of construction and operation of rock storage facilities?
- What are the impacts of blasting?
- What is the impact of worker fishing of fish populations?
- What are the impacts of infrastructure facilities at Baker Lake?
- What are the impacts of consumption of freshwater from the lake?
- What are the impacts of construction and operation of culverts and bridges on fish movements and migrations along the all-weather road?

Somewhat less emphasis has been placed on *generic questions*. These are questions for which there is precedent for proven engineering solutions, or for impacts that are easily mitigated, or are expected to have minor or insignificant effects. This tiered approach places greater emphasis on important, site-specific issues rather than generic issues that are common across most mining operations in Nunavut and the Northwest Territories.

6.2 LINKAGE MATRIX

As described in the EIA, key questions have been formulated based on a demonstrated *linkage* between a project-related activity, a physical or chemical effect, and a resultant ecological impact. Relationships between construction, operation, and post-closure activities, physical effects, and ecological consequences have been scoped out and form the basis of the linkage matrix (Appendix A). In turn, the linkage matrix was a starting point for design of the core and targeted monitoring programs.

To illustrate the relationship between a project activity and the AEMP strategy, consider the disturbance of lake habitat during dike construction or introduction of a contaminant to the water column. In the absence of appropriate mitigation, these activities may impair water column productivity and directly affect fish or fish habitat. For the majority of project-related activities, mitigation measures are proposed to minimize, to the extent possible, all impacts to aquatic environments. In some cases, mitigation may completely prevent any adverse effects, thus eliminating any *residual effects* that may adversely affect VECs.

For many key mine-related activities however, complete mitigation is not always possible and there may be residual impacts. The AEMP will monitor the magnitude, spatial and temporal scale of residual impacts with the aim of identifying if problems are occurring and if further mitigation is necessary.

6.3 AEMP STRATEGY

6.3.1 Background

The NIRB Terms of Reference (Section 2.1) lay out a number of requirements that are delivered by the AEMP. Our strategy for the AEMP is fundamentally related to Cumberland's formal Environmental Policy, as stated below:

> "Cumberland is committed to the concept of sustainable development, which requires balancing good stewardship in the protection of human health and the natural environment with the need for economic growth.
>
> - Conduct all activities in compliance with applicable legislation, and other requirements, providing for the protection of the environment, employees, and the public.
> - Apply appropriate good management practices in the absence of legislation or where Cumberland believes more stringent criteria than those required by law are needed to advance environmental protection and to minimize environmental risks.
> - Integrate the management of environmental, social, cultural, and economic issues into company business and planning.
> - Protect the environment through the wise use of resources and prevention of adverse environmental impacts.
> - Implement, maintain, and improve appropriate management systems and programs to achieve environmental objectives and to continually improve environmental performance through a process of regular review.
> - Conduct research and establish programs to conserve resources, minimize wastes, improve processes, and protect the environment.
> - Ensure awareness among employees and contractors of this environmental policy, promote shared responsibility and accountability for environmental obligations, and provide the support and training necessary to achieve these objectives.
> - Communicate openly with governments, employees, local communities, and the public to sustain mutual understanding of environmental, social, and economic issues related to the project."

The Meadowbank AEMP addresses all issues relating to surface water quality, effluents, sediment quality, lower trophic level biota and fish habitat and fish populations. Attention is focused on key project-related activities as they affect valued ecological components, such as water quality and fish. Less attention is placed on routine or generic issues, but they are still mitigated where necessary and, usually, monitored.

6.3.2 Fundamental Concepts

The fundamental concepts behind this AEMP include:

Mitigation is integrated with mine design – Our goal is to build mitigation into the Meadowbank mine design, reflecting best practices and learning from other mines developed in the north.

Monitoring takes an integrated, ecosystem-based approach – The AEMP links and monitors physical/chemical effects on key ecological receptors in the receiving environment (Appendix A). An ecosystem-based approach is used, with various data streams being considered together to provide a biophysical picture of the mine environment over time. Given that water quality and fish habitats/populations have been under study since 1996, there is a good baseline dataset against which to compare monitoring results, and also information about natural variability.

Mitigation & monitoring are related – Mitigation and monitoring are linked, rather than applied in isolation. This allows for synergies between the two processes, with mitigation being monitored for effectiveness – but also the monitoring program has the potential to flag issues that merit mitigation. These will be linked through Cumberland's environmental management systems.

Using adaptive management principles – Mitigation and monitoring strategies and frequencies will be applied using principles of adaptive management (Holling, 1978), in response to learning from mitigation and analysis of sampling data collected during development, operation and closure. The Meadowbank project will have an ongoing process for re-evaluation of the AEMP, resulting in changes and improvements to mitigation and monitoring activities.

No-net-loss policy for fish habitat – Under conditions of the federal *Fisheries Act*, the policy strives to avoid any net loss of the productive capacity of fish habitat as a result of a development project. The policy itself acknowledges the difficult task of precisely measuring the productive capacity of fish habitat in different environments and achieving NNL may depend on proxy data. There will be a net loss of habitat and productive capacity as a result of the project during mine operations. This will be offset by net habitat gain at closure and into the foreseeable future. The NNL (2005) framework report will address the mitigation/compensation program in greater detail than is discussed by the AEMP. Nevertheless, determining and monitoring the direct impacts on fish and fish habitat are incorporated into the AEMP by examining such project-related activities as worker fishing, stream crossings and culverts, and effects of blasting.

Metal mining effluent regulations – The monitoring plans described in the AEMP are dovetailed with those required by the MMER. This provides a seamless approach that is mutually beneficial to both programs. A separate report detailing the monitoring requirements and schedule has been prepared (MMER, 2005) that provides the framework for implementation of these regulations.

Post-closure – Monitoring during post-closure will be continued to ensure that residual mine-related components such as dikes, waste rock piles, and remediated areas are not contaminant sources and continue to provide productive habitat for resident fish populations (see Section 13).

6.3.3 AEMP Outline

Sections 8 to 10 detail management plans (essentially mitigation and monitoring) for the various project phases and each section has the same outline. Within each section are a series of key questions (see Section 6.1) and for each the information is presented in the same format: description of activity, mitigation, potential physical effects, potential ecological effects, and monitoring.

In some cases these headings are expanded (e.g., monitoring) and in others they might be combined (e.g., physical and ecological effects), but every section has the same general organization.

6.4 MITIGATION STRATEGY

Mitigation is incorporated within the mine design, but it can also be improved/changed or added based on learning and the results of monitoring. The mitigation proposed in this AEMP is largely a reflection of best practice and regulatory requirements.

As a critical component of the AEMP, the need for, and performance of, mitigation will be tracked over the life of the project, within the project's environmental management system (EMS; prepared in future). This process will:

- verify effectiveness of mitigation strategies to expedite adaptive management and adjustments in procedures for the protection of aquatic receptors
- coordinate adjustments in operating practices to minimize effects from recurring issues for aquatic receptors
- verify and document effectiveness of mitigation strategies
- provide information to assist in mine closure planning.

Part of Cumberland's initiative to ensure continual improvement of its mitigation activities will includes a process to identify, investigate, record, and correct deficiencies and non-conformances.

6.5 MONITORING STRATEGY

We have taken an integrated, ecosystem-based approach to the AEMP that links and monitors physical/chemical effects on key ecological receptors in the receiving environment. The Meadowbank monitoring strategy has two primary components or layers: (1) *Core Monitoring Program* and (2) *Targeted Studies*. These are described below.

6.5.1 Core Monitoring Program

The core program consists of a general strategy to monitor water and sediment quality, periphyton, benthic invertebrates, and fish that is tailored based on our understanding of mine construction, operation, and infrastructure (e.g., dikes, effluents, stream crossings, roads, etc.). This design will be developed in detail and implemented prior to and during construction and operation of the mine and will be conducted each year, until closure. The core design provides the foundation against which potential mine-related changes in chemical, physical, or biological characteristics of the receiving environment can be detected and acted upon, if necessary. In addition, by its very nature the core monitoring program will help identify unexpected effects. The core monitoring program is described in more detail in Section 7 and summarized in Table 6.1.

6.5.2 Targeted Monitoring Program

Targeted studies are specific studies that typically have narrower temporal or spatial bounds or are designed to address specific questions related to particular components of mine development during construction or operation. These are integrated with and are complementary to the core monitoring design. For example, assessing whether habitat features associated with dikes are functional, or to determine if sedimentation is occurring near sensitive fisheries habitat are considered targeted studies would be targeted studies. Findings from targeted studies will be put in context with our understanding of conditions in the project lakes based on pre-mine conditions (BAEAR, 2005) and current conditions based on findings of the core program. In response to key questions, targeted activity-specific monitoring and event-specific monitoring, along with relevant core monitoring, are described in subsections of Sections 7 to 9. A summary is provided in Table 6.2.

Examples of where targeted monitoring might be appropriate include:

- if a specific activity merits special study, for example, to monitor the performance of mitigation measures during dike construction
- as part of a response to an unforeseen event (e.g., spill, unexpected environmental change)
- where an impact occurs that cannot be fully mitigated, or if there is uncertainty about the magnitude or extent of predicted effects.

In the last case, a targeted study would be designed and carried out to determine if adverse effects are actually occurring. An example might be to study the effects of dissolved metals concentrations emanating from the dike structures and the impact of metals on survival of incubating fish eggs.

For the purposes of communication, the terms used will be “core monitoring program” and “targeted study,” each relevant to construction, operations or closure phase monitoring.

6.5.3 Overall Approach

The monitoring strategy is both proactive (i.e., early detection of any future impacts with targeted monitoring tailored for each situation) and reactive (i.e., if core monitoring detects a change that needs specific evaluation, monitoring in reaction to a specific event such as an unforeseen contaminant release). In this way, the AEMP has the important attribute of being flexible and responsive. By critically examining the ongoing results of the AEMP over time, those components of low value should be eliminated and additional components (to reflect findings or new activities) should be added if required. This streamlining will ensure that the monitoring program focuses on issues that are relevant to the program objectives (Section 2.1).

Table 6.1: Core Monitoring Program[1]

Component	Parameters	Sampling Locations[2]	Sampling Frequency	Sampling Method[3]	Data Evaluation
Water quality	Total and dissolved metals: Aluminum, antimony, arsenic, boron, barium, beryllium, cadmium, cobalt, chromium, copper, iron, lithium, manganese, mercury, molybdenum, nickel, lead, selenium, tin, strontium, titanium, thallium, uranium, vanadium, zinc. Nutrients: Ammonia-N, total kjeldahl nitrogen (TKN), nitrate + nitrite-N, total phosphorus, ortho-phosphate, total organic carbon (TOC), total dissolved organic carbon, reactive silica. Conventionals: Bicarbonate, chloride, carbonate, conductivity, hardness, calcium, potassium, magnesium, sodium, sulphate, pH, total alkalinity, TDS, TSS. Vertical distribution of oxygen, pH, temperature, and conductivity.	Near-field, Far-field, Tehek Lake & References. Ditches and diversion channels to confirm water quality predictions of runoff from waste rock piles, roads, airstrip, and other disturbed areas.	Monthly in ice free season at all stations; monthly throughout year at a smaller core of stations (through ice).	Samples collected by diaphragm pump (depth integrated), preserved and shipped as appropriate. Grab samples of surface water from ditches and diversions during open water.	Comparisons between sampling locations. Comparison with CCME water quality guidelines. Comparison with historical baseline data. Comparison with water quality predictions.
Sediment chemistry	Metals & Conventionals Metals: Aluminum, antimony, arsenic, barium, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, silver, selenium, thallium, tin, vanadium, zinc. Conventionals: TOC, grain size, moisture content, pH, bacteria, oil and grease, BOD, COD.	Depositional areas (as predicted by sediment model). At sampling locations synoptic with benthic.	Annually late summer	Sediment grabs, subsample top 1 cm.	Trend analysis for data from depositional areas. Comparisons between sampling locations. Comparison with historical baseline data.
Benthos	Biomass Taxonomy (to lowest practicable level) Abundance	Near-field, Far-field, Tehek Lake & References – collected 6 to 10 m depth.	Annually late summer/fall	Sediment grabs	Comparisons between sampling locations. Comparison with historical baseline data.
Periphyton	Biomass Abundance Taxonomy (to lowest practicable level)	Near-field, Far-field, Tehek Lake & References. Samples collected <0.5 m depth.	Annually late summer	Rock scraping & extrapolation	Comparisons between sampling locations. Comparison with historical baseline data.

Table 6.1 – Continued

Component	Parameters	Sampling Locations[2]	Sampling Frequency	Sampling Method[3]	Data Evaluation
Phytoplankton	Taxonomy (to lowest practicable level) Abundance Biomass Chlorophyll a	Near-field, Far-field, Tehek Lake & References.	Twice monthly during open-water season.	Samples collected by diaphragm pump (integrated over top ten meters), preserved & shipped as appropriate.	Trends over time (seasonal). Comparisons between sampling locations. Comparison with baseline data.
Fish Fish population survey & health assessment	Fish tissue metals concentrations. Metals: Aluminum, antimony, arsenic, boron, barium, beryllium, cadmium, cobalt, chromium, copper, iron, lithium, manganese, mercury, molybdenum, nickel, lead, selenium, tin, strontium, titanium, thallium, uranium, vanadium, zinc. Lipid concentration	Near-field, Far-field, Tehek Lake & References.	Every three years, late summer.	Use EEM protocols & non-destructive sampling methods, where possible – 100 fish from each species and area, captured and examined for external appearance, parasites, length, weight and condition.	Comparisons between sampling locations. Comparison with historical baseline data.
Assessment of fishing pressure		Interviews should identify lakes with fishing pressure, then data sorted by Near-field, Far-field, Tehek Lake and References. Investigate possible increase in fishing pressure on nearby lakes from operation of the all-weather road.	Opportunistically throughout ice-free season.	Creel survey, staff interviews. Non-destructive sampling and opportunistic sampling methods. Aim for ten whitefish and ten lake trout.	Characterize any fishing (given no fishing policy); compare with baseline.

Notes: 1. See Section 6 for rationale and Section 7 for details. **2.** See Section 7 and Figures 6.1, 7.1, and 7.2 for more information. **3.** See also Appendix A.

Table 6.2: Targeted Monitoring Program Summary

Component	Issue	Targeted Study Component	Sampling Methodology Summary	Sampling Locations	Frequency & Timing	Data Evaluation
Dike Construction – Water Chemistry	Dike construction will release TSS and dissolved metals into the overlying water column behind silt curtains. Monitoring will determine magnitude of impact outside of silt curtains.	Real-time monitoring of TSS, and representative sampling of dissolved metals and nutrients in the water column around perimeter of silt curtains during dike construction.	Moored buoys will continuously monitor turbidity (NTU) at prescribed locations; Multiple daily water samples gathered initially to derive turbidity – TSS relationship; Sediment plume will be monitored if present; Daily dissolved metals at multiple locations during construction of the 1st dike, TSS and nutrients monitored early on in dike construction under worst-case conditions.	Sampling stations will be established at increasing, concentric distances (100 m, 200 m) away from the silt curtain, outwards from toe of dike during construction.	Samples for TSS and turbidity analysis collected multiple times daily during construction period and analysed on-site. Dissolved metals collected using diaphragm pump with inline 0.45 µm filter. Nutrients samples collected and sent for laboratory analysis.	Derive TSS – turbidity relationship early on in project; Determine magnitude of sediment plume, if any; locate depositional areas. Compare with baseline data, CCME guidelines, and reference locations.
Sediment & Benthos	In event of catastrophic silt curtain failure, sediment introduced to the water column will settle in nearby habitat, potentially causing smothering of benthos.	Benthic community analysis in sediments with the greatest potential to be impacted.	Sampling of benthic community using grab sampler to determine recovery of species composition, abundance in affected habitat; acquire sediment chemistry and grain size data.	Sampling in soft bottom substrates within affected areas outside of silt curtain.	Annual survey during late summer during year +1 and year +2 after silt curtain failure.	Compare benthic community structure data from pre-mine development with year +1 and year +2 data to determine rate and extent of recovery of the benthic community.
Drawdown of Impoundments TSS	Introduction of TSS to Third Portage Lake during dewatering of Second Portage Lake.	Monitoring of TSS and dissolved metals in Third Portage Lake North Basin near discharge location.	Water column sampling of TSS, turbidity and dissolved metals. Derive relationship between turbidity and TSS. Install monitoring buoys. Sample at increasing distance from outfall to gauge spatial effect.	At increasing distances from end-of-pipe in Third Portage Lake, measure vertical turbidity profile of water column. Also measure turbidity near intake in Second Portage.	Continuous monitoring during entire period of discharge to Third Portage. Monitoring of water column turbidity in Second Portage prior to intake.	Compare TSS data to baseline and to CCME guideline values.

Table 6.2 – Continued

Component	Issue	Targeted Study Component	Sampling Methodology Summary	Sampling Locations	Frequency & Timing	Data Evaluation
Dike Operation Pore Water Metals	Release of pore water metals from interstitial spaces of dikes could impair fish habitat and cause mortality of fish eggs.	Pore water would be withdrawn from interstitial spaces of dikes and analysed for dissolved metals.	A hose with an in-line filter would be used to siphon water from dike pore spaces to assess metal leaching.	Along dike perimeter of East dike and Goose Island dike at representative locations.	Sampling would be conducted four times in the first year of operation: in early spring, summer, and fall as well as in late winter through the ice as worst-case scenario.	Compare pore water metals data to surface water data from project lakes and to CCME guidelines.
Dike Habitat Periphyton	Metals leaching from dike rock surface could impair colonization by periphyton.	Monitor periphyton colonization, species composition, and biomass.	Quantitatively sample periphyton growth on exterior of dike surfaces (East, Bay Zone, Goose Island, Vault) using scrub sampler.	Sample specific locations along dike exteriors at 1 m depth. Five composite samples at three locations per dike.	Sampling will occur once during late summer at height of periphyton growing season. Rocks of similar depth, aspect, surface area will be selected.	Compare periphyton biomass and composition to baseline data.
Fish	Metal leaching from dike surface could impair fish egg survival during incubation.	Install egg baskets to monitor survival.	Diver assisted placement of egg baskets on candidate dike surfaces and reference areas.	Goose Island dike, East dike and reference spawning area.	During fall lake trout spawning period; retrieve in late winter.	Compare egg survival on dikes with reference areas.
Fish Movement Fish passage and movements along all-weather road between Baker Lake and mine site	Operation of culverts along the all-weather road might impair movement by fish. Bridges will not impair fish movements or migrations.	Monitor fish movement through culverts after installation; only for those few streams where fish are present.	Install hoop nets at up- and downstream locations. Fin clip fish on opposite fins according to movement direction to determine if movement is occurring.	At upstream and downstream locations (entry and exit) of culverts along select streams (see All-Weather Road Fish Movements report).	Monitor periodically during entire open water season in first year after culvert installation.	Evaluate data after year 1 to determine if further monitoring is required in subsequent years.
Blasting Impacts to Fish	Blasting during early mine development may cause overpressure and excessive PPV that could cause mortality to fish.	Monitor PPV and overpressure in receiving environment in proximity to blasting.	Install pressure monitors and digital seismographs at key locations in waterbody adjacent to blasting activity and record data. Observe for presence/mortality of fish.	Opportunistically as required, especially when modeling data shows there is a risk to fish.	Focus on construction phase and evaluate issue. Then monitor opportunistically, as the need arises.	Determine level of risk to fish and fish eggs from PPV and overpressure data. Develop database relating theoretical and empirical data to groundtruth and predict risk.

Table 6.2 – Continued

Component	Issue	Targeted Study Component	Sampling Methodology Summary	Sampling Locations	Frequency & Timing	Data Evaluation
Enhancement Channel Fish Movements	The easternmost channel connecting Third and Second Portage lakes will be enhanced to facilitate flow and to provide access by fish between the lakes during the entire open water period.	Verify that fish movement between the lakes is possible and determine extent or magnitude of movement by fish.	Install hoopnets within stream channel to gauge extent of movement. Tag fish to establish long-term database.	Depending on stream channel configuration, within channel or at entry and exit points; during entire open water season.	Sampling will occur shortly after ice-off and continue throughout summer until near freeze-up during years 1 to 3. Re-evaluate after this time.	Assess fish movement between lakes from hoopnet data; Analyse trends over several years to assess success of mitigation effort.

Where to Monitor? – There are two primary mine areas where aquatic monitoring will be focused (Figure 6.1): Second and Third Portage lakes, adjacent to dike perimeters and one of the two effluent discharges; and in Wally Lake, adjacent to the dike at Vault Lake and the second mine effluent discharge point. Net water flow in this system is south (Section 2.3.2). Effluent or other mine-related discharges or contributions from the Vault area will flow south through Wally and Drilltrail lakes (i.e., the Vault Lake system) to enter Second Portage just before it discharges to Tehek Lake. Similarly, mine-related contributions from the larger development and dike area in the Portage lakes will also flow south, meeting inputs from the Vault Lake system just prior to a common discharge point into Tehek Lake, the ultimate receiving environment for all mine-related, water-borne contaminants. Both the Vault and Portage lake systems will be monitored independently, as well as the entry point into Tehek Lake Available information on Traditional Knowledge (TK) places a high value on water quality, from a human health perspective, as well as for wildlife (Cumberland, 2005b). The AEMP is designed to detect unanticipated potential adverse impacts on downstream water quality, so they can be mitigated to the extent possible. Reference areas are fully described in Section 6.1.1.

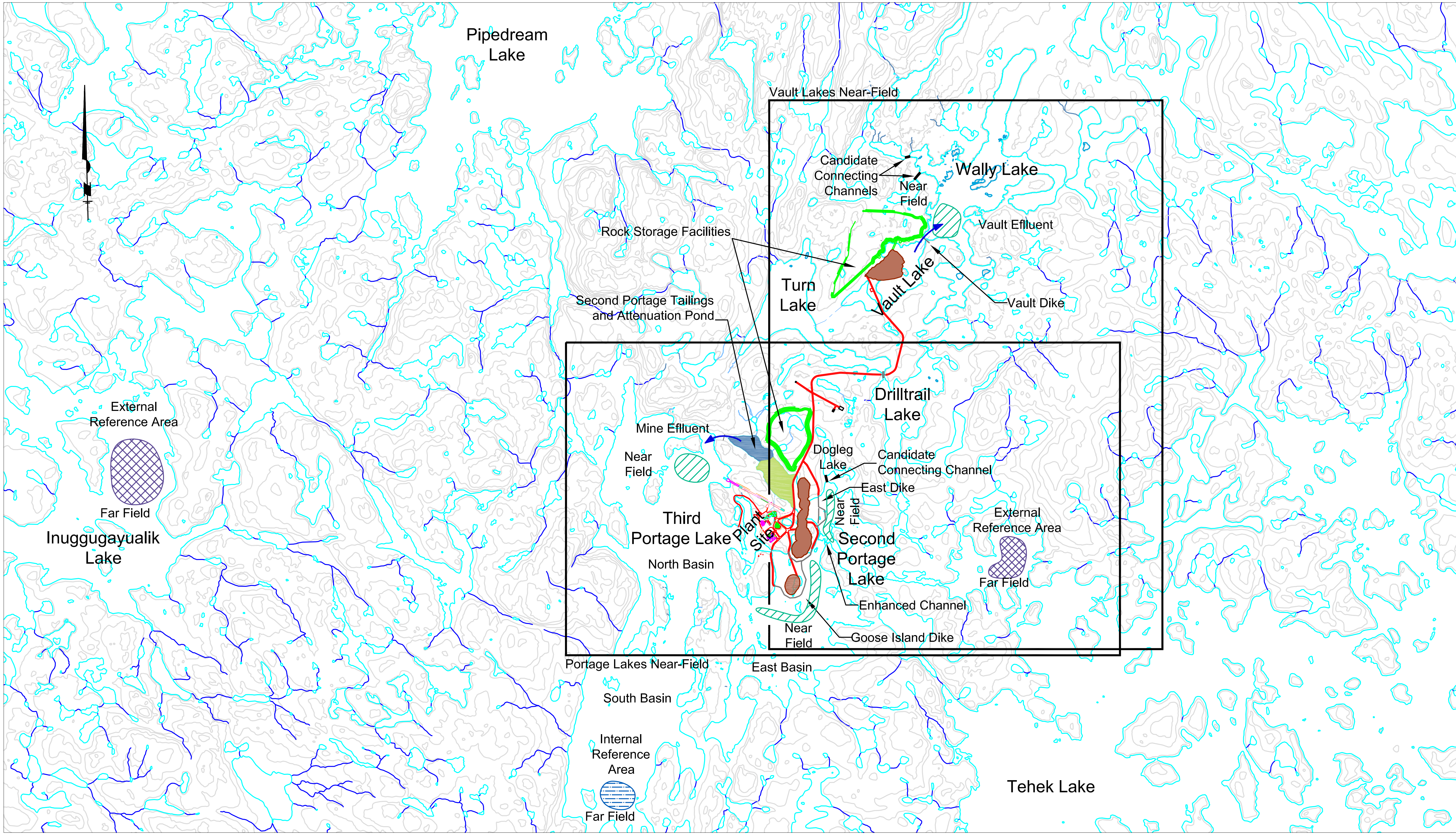
What to Monitor? – The linkage matrix aids in the identification of ecological components for which monitoring should be performed. However, direct measurement of a particular ecological component is not always ideal or possible; therefore, surrogates or indirect measures are often used. The suite of monitoring tools available for aquatic systems is fairly standardized but they must be applied in a manner that supports integrative assessment and is robust.

Integrative assessment – Monitoring data are used in combination to address the key questions. A burden-of-evidence approach looks across all relevant data collected. This is particularly important in light of the difficulties in detecting change at higher levels of biological organization (e.g., in populations of long-lived, slow-growing Arctic fish populations). Due to time lags in detecting change, it is better to monitor multiple components with “early warning” capability. In addition, the sampling effort necessary to detect change in such fish populations is high, possibly causing unacceptable harm to fish populations from sampling itself.

Robustness – Each study component (or combination of components) will be challenged with the following questions to ensure the monitoring program is robust enough to meet its objectives: Are there sufficient data to conclude that there are no project-related effects? Was the sampling design adequate to determine the magnitude and spatial extent of any impacts? The details of what will be monitored are detailed in Sections 6 and 7 and summarized in Tables 6.1 and 6.2.

Details of Monitoring Design – Section 7 through 9 summarize the key elements of monitoring, but they do not provide enough detail for the work to be executed. Once this AEMP is accepted in principle, the details of each monitoring program will be described in a series of Sampling and Analysis Plans (SAPs) that will be prepared prior to mine construction. A single SAP will be prepared for the entire project, with a series of appendices for each phase of mine development, on an as needed basis and based on data collected to that point in time.

The monitoring programs will be designed to measure a statistical difference between measurements taken in potential exposure areas compared to reference areas, using either a gradient design or a “control/impact” design, depending on the monitoring parameter. It will also be designed to look at data over time.



Legend

- Road
- Near Field Monitoring Area
- Internal Reference Area
- External Reference Area
- Pit

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DRAWN BY:	CHECK BY:	DATE:	PROJECT No:
BT	RB	3/7/2004 11:31 AM	CBD-03-03

PROJECT: Meadowbank AEMP

TITLE: **Project Lakes Monitoring Areas**

CLIENT: Cumberland Resources

Figure 6.1

It is recognized that defining an "effect" might be challenging, given natural variation and related sample size issues. *A priori* power analyses will be conducted using baseline data to determine the appropriate level of sampling effort required to test for a pre-determined "effect." This will likely be an iterative process, with power analysis results also being used to select thresholds or triggers that could, in fact, be detected by the core program (i.e., the level of change in a parameter that could be detected using a "reasonable" sampling effort). This information, in combination with existing criteria (e.g., those specified for the project in targeted monitoring, or from CCME and MMER), will be used to establish decision points that would trigger targeted monitoring and/or mitigation.

The SAP prepared prior to mine construction will detail approach and methods, including:

- goals and objectives
- rationale/approach, including definition of effects for each measured parameter
- a summary of baseline information (based on key documents), with a particular focus on identifying any confounding factors that are not related to the mine development, but which may contribute to an observed effect
- statistical design, including hypotheses, selection of statistical techniques, determination of sample size (statistical significance and power analysis)
- sampling locations
- sampling schedule (frequency, timing and responsibility for sampling events)
- operating plans and procedures (sampling, laboratory analysis, data storage, data analysis)
- quality assurance/quality control
- a plan for interpretation and evaluation.

Quality Control/Quality Assurance – An important component of any monitoring program is the quality control/quality assurance (QA/QC) protocols. The objective of QA/QC is to assure that the chemical and biological data collected are representative of the material or populations being sampled, are of known quality, are properly documented, and are defensible. A high standard of QA/QC will be maintained throughout the course of AEMP studies by following accepted, well-known protocols and standards for collection and analysis of environmental media. Basic principles behind QA/QC for the AEMP are summarized in Section 12, but full details will be provided in the SAP.

SECTION 7 • CORE MONITORING PROGRAM

The strategy behind the core monitoring program for aquatic systems is described in Section 6.

7.1 CORE MONITORING LOCATIONS

The core monitoring program will be conducted in four areas to ensure that mine-related impacts (both predicted and unexpected) are detected early and supplemental mitigation can be quickly implemented. The basic premise is to establish a series of stations in two arcs that surround each of the mine developments (Figures 7.1 and 7.2), with near-field and far-field stations as well as Tehek Lake station and reference stations (Figure 6.1). As much as possible, existing stations from baseline work to date (BAEAR, 2005) will be used for continuity. The four areas are as follows:

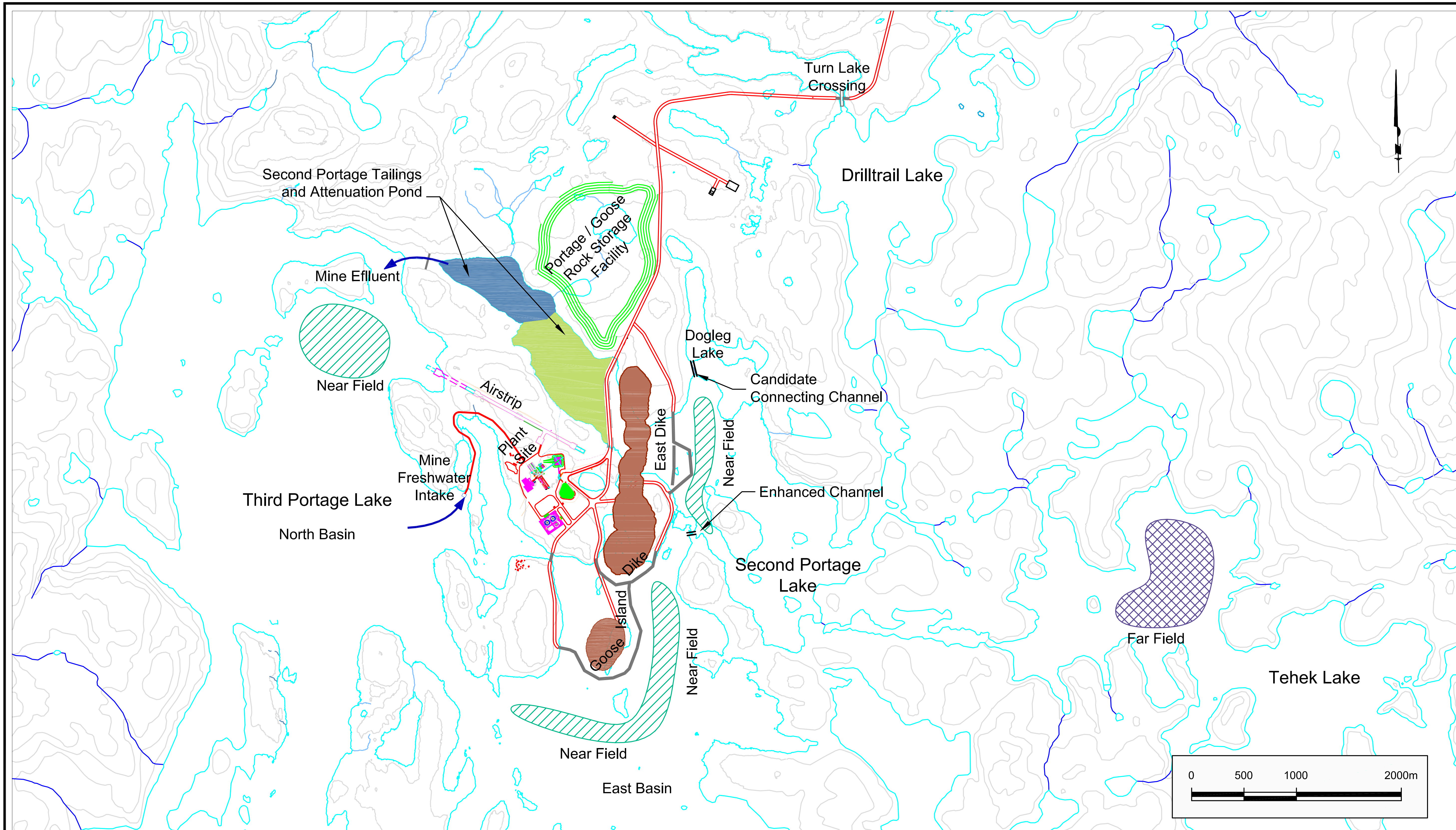
- *Near-field area* – Stations will be situated in close proximity to the development, in particular near dikes and effluent sources. These stations provide the first line of defence or early-warning locations for introductions of stressors into the receiving environment. Note that near-field station locations for water chemistry may not exactly correspond with near-field station locations for benthos or sediment chemistry because of the influence of water depth on these parameters.

- *Mine footprint area* – Contact water quality in ditches and diversions around the mine site will be routinely monitored for TSS and metals concentrations. This is important to verify water quality predictions of contact water from the mine site (e.g., waste rock piles, roads, airstrip) and loading of metals to attenuation ponds, and to determine potential hazards to wildlife that may drink from ditches containing metal-contaminated contact water.

- *Far-field area* – Stations will be situated further offshore or away from the near-field stations encircling the near-field stations. These stations will determine if impacts can be discerned over a wider spatial field, further downstream of the mine-development.

- *The Tehek Lake area* – Tehek stations are key stations that will ultimately determine whether or not contaminants are detectable downstream of the entire mine development. Lake waters from Second and Third Portage lakes and the Vault lakes (Vault, Wally, Drilltrail) meet at the southern end of Second Portage Lake and discharge via a single channel into Tehek Lake. Monitoring the water and sediment quality and benthic invertebrates in the basin adjoining the discharge point from Second Portage Lake will definitively determine if mine-related contaminants or adverse effects can be detected downstream of the project lakes.

- *Reference Lakes area* – By definition, reference stations 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 (south basin of Third Portage Lake) and external reference areas (Inuggugayualik Lake) were chosen for the purposes of making comparisons with the project lakes (BAEAR, 2005). Monitoring of reference areas is important because it is necessary to distinguish between possible mine-related changes in water quality or ecological parameters and natural changes, unrelated to the mine.



Legend

Road

Near Field Monitoring Area

Far Field Monitoring Area

Pit

PREPARED FOR:

CUMBERLAND RESOURCES LTD.

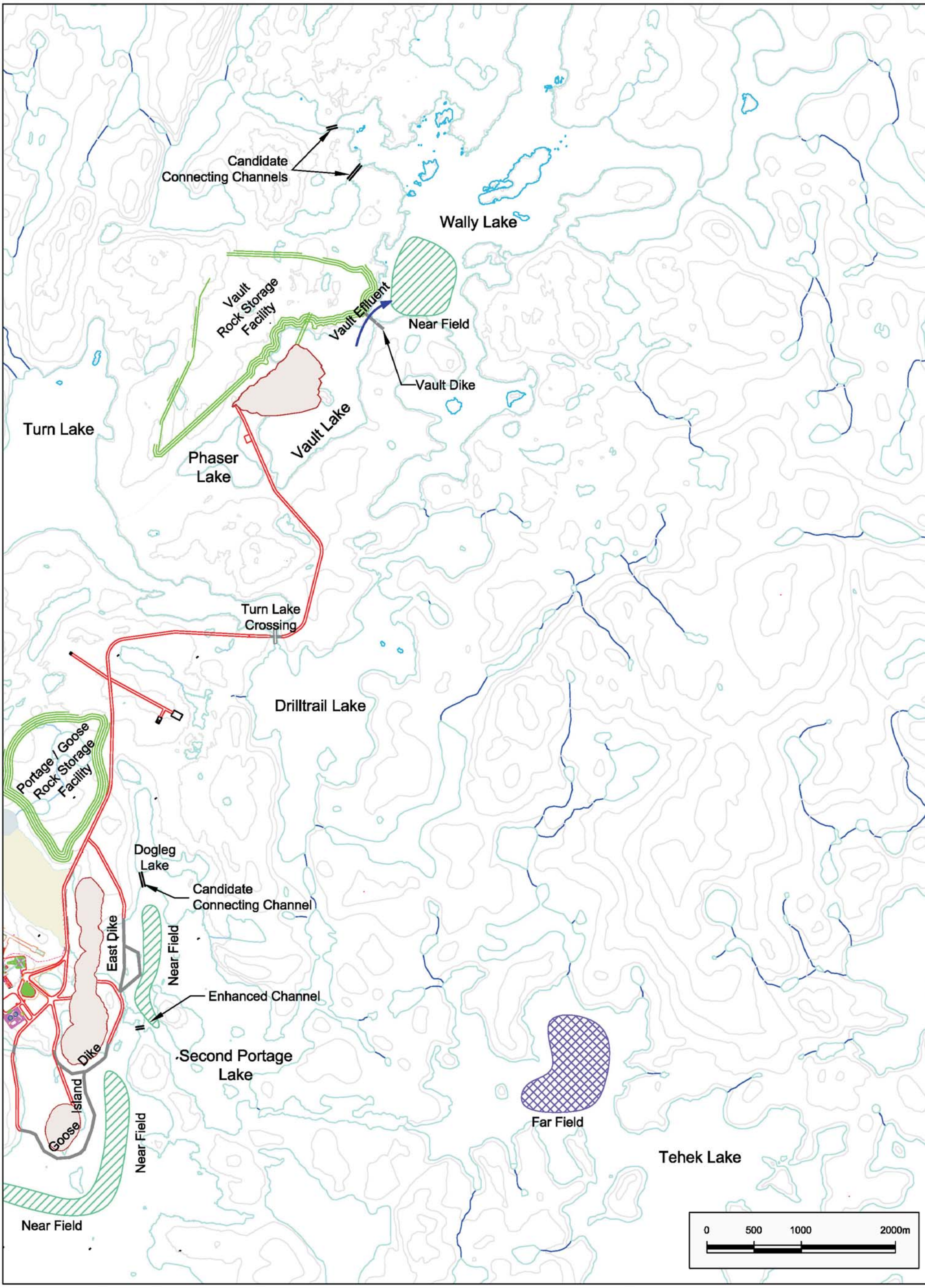
Azimuth Consulting Group Inc.
218-2902 West Broadway
Vancouver BC, V6K 2G8

PROJECT:
Meadowbank Gold Project

TITLE:
Portage Lakes Monitioring Areas

CLIENT:
Cumberland Resources

Figure 7.1



Legend

- Near Field Monitoring Area
- Far Field Monitoring Area
- Pit
- Road

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PREPARED FOR:
CUMBERLAND RESOURCES LTD.

DATE 2/13/2004 11:59 AM
PROJECT No: CBD-03-03

PROJECT: Meadowbank AEMP

TITLE: **Vault Lakes Monitoring Areas**

CLIENT: Cumberland Resources

Figure 7.2

The internal reference area (at the extreme headwaters of Third Portage Lake) is far removed from the mine, upstream of the development area and is removed from the prevailing wind direction. The external reference area (Inuggugayualik Lake) is situated about 16 km west of the mine site (Figure 6.1). Inuggugayualik Lake is a headwater lake of the Meadowbank River system that flows north to the Arctic Ocean. Despite the different drainage basin, Inuggugayualik Lake satisfies the requirements of an external reference lake from a physical/chemical perspective because it is at the same latitude, has similar geology, relief and climate, does not have any significant inflows and has similar limnological parameters and water chemistry as the project lakes (BAEAR, 2005).

It is critical that core information collected from across these four areas is comparable. For example, differences in water depth and sediment grain size composition can tremendously affect benthic invertebrate community composition, relative abundance, and species richness. Therefore benthos sampling stations will be situated in similar water depths (8 to 10 m) and have similar grain size distribution to minimize natural differences among stations that confound data interpretation. It is very important that natural differences be minimized in order that changes over time that may be due to mine-related influences can be distinguished from natural differences.

The components of the core monitoring design are described in the following sections and summarized in Table 6.1. Protocols for each component will be prepared prior to implementation, to standardize methods and sample locations; however, site-specific methods compiled to date are provided in Appendix B.

7.2 WATER CHEMISTRY / QUALITY

The parameters routinely collected as part of water quality monitoring include the following:

- Vertical distribution of temperature, oxygen, pH, and conductivity by depth to determine lake stratification, if any.
- Conventional parameters including pH, total dissolved and suspended solids, anions, dissolved organic carbon, alkalinity, hardness, phosphorus, nitrogen compounds, and chlorophyll *a*.
- Total and dissolved metals concentrations. Note that both total and dissolved metals will be collected during dike construction (Section 7) to distinguish between sediment borne metals and dissolved metals.

These parameters will be collected from each of the five areas, including the mine site footprint ditches and diversions. Because of the tremendous uniformity in lake water chemistry parameters (BAEAR, 2005), water samples will be collected from a subset of stations, rather than at every station. Depending on vertical temperature profiles, water will be collected from discrete layers (e.g., within the epilimnion and the hypolimnion) or integrated over the top 10 m of water during unstratified conditions. Persistent, strong winds typically cause continual mixing, although minor (2 to 3°C), ephemeral (days) stratification is possible, but infrequent.

It is important to note that routine monitoring of water chemistry as part of the core program will be harmonized with requirements to monitor effluent stream and receiving environment chemistry under the MMER program for mines (see MMER, 2005). The MMER program focuses on chemistry, toxicity, and ecological effects related to mine effluents and does not consider other mine-related impacts that are covered by the AEMP core monitoring program.

7.3 SEDIMENT CHEMISTRY

Sediment will be collected from key locations within near-field, far-field, Tehek and reference areas and measured for total metals concentration, grain size and organic carbon content. 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.).

Sediment transport modeling has not been completed for this area. Therefore, in the absence of these data, it must conservatively be assumed that metals adhered to sediment particles will accumulate in depositional areas, which are typically situated in the deepest areas of the lake (below the depth at which wind-induced current may have an effects). Natural sedimentation rate in the project lakes is exceedingly slow. Exacerbation of this rate or changes in metals concentrations in the top sediment layer (e.g., upper 1 cm) will indicate whether or not metals have migrated from the mine site to become deposited in the receiving environment.

To determine if sediment and/or metals have migrated away from the mine site via aquatic or aerial pathways (as dust) and have become elevated in depositional areas within near-field and far-field areas, the top 1 cm of sediment will be collected from deep basins and compared over time and with Tehek Lake and reference area sediment. This will be conducted annually during the life of the mine. Sediment will also be collected as part of the MMER program to support the interpretation of biological monitoring (MMER, 2005).

7.4 PERIPHYTON

Periphyton will be collected by scraping a known surface area of a rock and extrapolating biomass (mg per sampled area) of individual species to a square meter basis for comparison purposes. Species composition and biomass of periphyton are indirect indicators of lake productivity, reflecting nutrient concentrations in the lake, and are sometimes indicators of the presence of contaminants. Because some periphyton species are sensitive to the presence of metals, reductions in periphyton communities over time can indicate the presence of dissolved metals in the water column or on the surfaces of substrates to which periphyton adhere.

7.5 PHYTOPLANKTON

Phytoplankton are microscopic, unicellular or colonial plant species that are suspended in the water column and together with periphyton, form the base of the food web. Maximum production usually occurs within the upper 10 m of water, where there is the greatest amount of light. Seasonal and annual production can vary widely depending upon water temperature, mixing, nutrient concentration, amount of sunlight, water clarity, and predation by zooplankton. Estimates of phytoplankton biomass are used typically as gross indicators of productivity from a snapshot perspective, depending on frequency of sampling, and are only useful to detect long-term trends or gross changes in lake production, such as eutrophication as a result of nutrient additions (e.g., from sewage disposal or as a result of the use of explosives).

To assess if chronic nutrient additions from sewage treatment and grey water disposal, and from use of explosives are increasing primary productivity of receiving environment waters, phytoplankton biomass will be measured twice monthly during the open water season (late June to early October). Integrated water samples (top 10 m) will be collected from near-field, far-field, Tehek, and reference stations to measure seasonal changes in community composition and biomass (mg/m^3).

Meadowbank project area lakes are ultra-oligotrophic and severely nutrient limited. Whether or not increasing nutrient contributions, which ultimately may result in increased productivity and fish biomass, are considered an adverse impact depends on one’s perspective. The ultimate goal of the No Net Habitat Loss policy under the *Fisheries Act* is to ensure that there is no net loss of productive capacity. Increasing nutrient concentrations will increase productive capacity of the project lakes, although this is not a natural phenomenon. Therefore, the degree to which productivity is enhanced in the receiving environment will be important. Minor increases in nutrient additions and productivity may result in detectable increases in plankton growth and possibly growth of fish, without impairing water quality. Gross increases in productivity may cause excessive algal growth that could, for example, impair overwintering success of fish eggs because of oxygen depletion under ice cover. The core monitoring program will ensure that effects of nutrient additions on water quality, aesthetics, and algal growth are detected.

7.6 ZOOPLANKTON

Zooplankton are small, free-swimming animal species that feed on phytoplankton, bacteria, detritus and smaller zooplankton and are a key food chain species for fish, especially young-of-the-year lake trout, and juvenile and adult round whitefish, and Arctic char. Three major groups of zooplankton typically dominate the plankton community in freshwater lakes: rotifers and two subclasses of the Crustacea; Cladocera and Copepoda (within which there are two major orders, calanoid and cyclopoid copepods). Cladocerans and copepods typically dominate zooplankton community biomass because they are abundant and relatively large in size (0.2 to 3.0 mm).

Abundance and distribution of zooplankton populations in project area lakes will not be monitored as part of the core program. Zooplankton populations tend to be patchy in distribution and are subject to variation based on water movements and wind generated currents. Sampling of zooplankton, like water, also represent snapshots in time and do not integrate effects over time, unlike benthos that are sessile. Thus, little useful information will be gained by sampling zooplankton. We favour monitoring of benthic communities, as this group is a better indicator of effects over time.

7.7 BENTHIC INVERTEBRATES

Benthos are relatively small animals that live on or in the bottom sediments and provide an important food source for most juvenile fish species, especially young-of-the-year and juvenile lake trout, and well as juvenile and adult round whitefish, sculpins and stickleback. The abundance and species composition of benthic invertebrates is strongly affected by water depth, sediment grain size, and organic carbon content. Benthic communities in sediments less than about 12 m depth, consist of aquatic larvae of insects (Class Insecta), especially chironomids (Order Diptera), caddisflies (O. Trichoptera), mayflies (O. Ephemeroptera) and stoneflies (O. Plecoptera). In addition to physical factors, abundance and composition of benthic communities are influenced by biological factors, such as foraging by fish and timing of hatch of insect larvae. Significant hatches of chironomids may occur during the course of sampling over a period of days or weeks, resulting in apparent natural differences among areas. Thus, it is important that benthos be collected over a relatively short period. This phenomenon can be overcome by sampling during late fall, after most groups have emerged, laid their eggs and the young have hatched.

Benthic invertebrates will be collected from 5 to 7 stations within each of the near-field, far-field, Tehek and reference areas (1, 2, and 3) to monitor annual changes in benthic community composition and abundance of major taxa. Methods will be as summarized in Table 6.1, Appendix B and consistent with MMER (2005) methods. Some benthic groups are sensitive to metals and their presence or absence can be indicative of local contamination. Excessive inputs of sediment can also result in smothering of benthos, impairing abundance over the short-term. Benthos are, however, quite resilient to sediment deposition and will recolonize disturbed sediments relatively quickly.

To minimize natural differences in community structure and abundance, benthos will be collected from discrete depth ranges (6 to 8 m) within each area. Based on results of field surveys (BAEAR, 2005), sediment grain size below 6 m depth is relatively uniform and consists predominantly of silt/clay. In addition to benthos, synoptic sampling of sediment for metals concentration and grain size (upper 3 cm) will be conducted at each station so that correlations between benthic community abundance and metals concentrations in sediments can be made, to determine if any difference between near-and far-field areas and reference areas are due to mine-related influences.

7.8 FISH

Lake trout, round whitefish, and Arctic char are the dominant fish species in all project lakes. Burbot, ninespine stickleback and sculpins comprise a very small portion of the fish community. In small isolated ponds, lake trout is frequently the only species present. Fish represent the top of the food chain and ultimately provide a food source for some fish eating birds such as loons and infrequently, local residents of Baker Lake. Fish are also the ultimate receptors of changes in fish habitat. For example, reductions in lower trophic level abundance or productivity as a result of mine-related adverse effects will ultimately be reflected as a decline in abundance and biomass of fish.

The fish monitoring component of the core program will parallel MMER requirements (Environment Canada, 2002), but apply over the wider study area. The federal MMER program for mines provides two alternative approaches for monitoring, both of which examine effects of exposure to mining effluent on fish populations. The first approach requires fish to be sacrificed and assesses reproductive parameters (number of eggs, egg weight), liver weight and condition, overall health (parasites, internal and external appearance, condition factor), and metals concentrations in muscle and liver tissue. This approach requires that 80 fish (40 fish x 2 species) from exposure and reference areas be sacrificed.

The second approach does not require that fish be sacrificed, but requires that a larger number of fish (100 from each species and area) be captured and examined for external appearance, parasites, length, weight and condition factor to determine if adverse effects can be discerned relative to control populations. This approach is preferred when there is a concern regarding unnecessary mortality of fish.

Receiving environment and reference area fish populations must be quantitatively sampled ever three years for at least the first two cycles to determine if adverse effects can be detected in the local fish population.

The core program will incorporate all aspects of MMER requirements to determine whether adverse effects on fish are occurring. However, it is often very difficult to definitively answer this question without going to considerable efforts, which involves the capture and mortality (intentionally or accidentally) of large numbers of fish from exposure and reference areas. It is very difficult to detect a change of plus or minus 10% to 15% in fish populations or biomass, even with considerable effort. The risk here is that impacts to fish from sampling may be greater than the impacts of the development project itself, particularly if there are no obvious chemical or physical stressors. There is also consideration for the perception by local resources that fish resources are being wasted from regular, destructive studies. For these reasons, we favour the second approach that attempts to minimize mortality of fish as much as possible. In addition, we have recently developed a non-destructive means of sampling fish tissue for metals concentrations that could be applied in this circumstance, in addition to measuring external, phenotypic characteristics (Baker et al, 2004).

As noted in Section 2, fish are poorly suited as indicator organisms in long-term monitoring programs. Fish are long lived, resilient and situated at the top of the food web, so impacts to fish will be observed last, after impacts to water quality or lower trophic level biota, especially benthos, are observed. Thus, by the time impacts are definitively noted in fish populations, considerable changes may have been imposed on other levels of the food web. However, fish are consumed to some degree by fish-eating birds and infrequently, by humans and are an important VEC. Therefore, protection of fish is best achieved through maintenance of high water quality and by minimizing the introduction of contaminants into the receiving environment.

In addition to the required MMER program, we propose to sample fish carcasses collected by local fishing efforts (see Section 10.5) on an *ad hoc* basis. Although Cumberland is proposing a “no fishing policy,” we recognize that local aboriginal people may periodically exercise their rights to undertake recreational fishing within the study lakes during the life of the project. In addition, core data can also be collected from carcasses collected during fish salvage.

Therefore, where possible, fish will be autopsied to gather all relevant information as stipulated by MMER (2005). As well, tissue samples will be collected to maintain a continuous record of fish tissue metals concentrations. This will provide supplementary information to data gathered by MMER studies.

SECTION 8 • CONSTRUCTION PHASE MONITORING & MITIGATION

Construction of the Meadowbank Gold mine will involve installation of a number of dikes, mine site operation facilities (buildings, pipelines, bridges, ditches) and infrastructure. Construction activities for development of Portage pit, Goose Island pit, and Vault pit are detailed in the EIA and supporting documentation.

Mitigation measures for construction phase activities are described in this section.

Monitoring to evaluate any impacts will be delivered through core environmental monitoring (described in Section 7) combined with targeted monitoring, both of which are summarized herein.

8.1 IMPACTS OF DIKE CONSTRUCTION

Construction of dikes to impound lake areas for open pit mining in Second and Third Portage lakes will alter water quality, sediment deposition, benthic communities, fish, and fish habitat within the immediate vicinity of the construction activity. This section provides a brief description of how the dikes will be constructed, the proposed mitigation, and the residual physical effects and ecological consequences. Individual sections describe monitoring studies of water quality, sediment quality, benthic invertebrates, fish habitat, and fish to ensure that any impacts that , if impacts extend beyond the immediate construction area, they are detected and the activity halted or further mitigation is applied.

Adverse effects on water quality and biological resources will be minimized to the extent possible through the use of silt curtains to control sediment introductions and deter fish. However, the scale of the activity will result in severe impacts over a short term (one to two months during open water) within a localized area that cannot be mitigated. Once the dike has been constructed and is in place, further monitoring of dikes will be addressed during operation (Section 7).

8.1.1 Description of Construction Activity

Development of Meadowbank mine will require construction of four dikes in the following order: East dike (Year -1 or - 2), Portage South dike (Bay Zone) (Year -1), Goose Island dike (Year 5), and Vault dike (Year 4).

The East dike will impound the north arm of Second Portage Lake and isolate this part of the lake from the rest of the system. Between the East dike and the open pit, the West dike will be constructed that will form the southern boundary of the tailings storage facility. When the mine is closed, this part of the lake will not be available to fish. The Goose Island dike and Vault dike will temporarily (i.e., for the life of the mine) isolate the lake areas within the dikes to create open pits. These areas will be re-flooded after mine closure and become part of Third Portage Lake.

All dikes will be constructed by end dumping of large grain size material from an onshore initiation point to create the dike. The materials used to build the dikes will consist of pre-strip materials and a typical dike cross-section could comprise iron formation (IF) in the upstream rockfill, intermediate volcanic (IV) rock in the downstream rockfill and ultramafic (UM) rock as a surface capping cover over the IF material. Sideslopes of rockfill embankments will depend on foundation strength, water depth, and gradation of rockfill. Total footprint width of the dikes will range between 90 and 135 m, depending on water depth.

The construction period will take approximately one to two months for each dike and will occur after ice-off during the open water season. There is a variable amount and depth of fine (silt/clay) sediment that lies on the lake bottom beneath the dike footprint areas. The vertical depth and grain size of this fine material varies according to water depth. Based on habitat mapping and field investigations (BAEAR, 2005), the majority of sediment below 4 to 6 m depth consists primarily of clay (40 to 70%) with lesser amounts of silt (25 to 40%) and sand (<5%). At depths between 2 and 4 m, sediment grain size consists of lesser amounts of silt/clay and greater amounts of sand/gravel. Shallow depth sediment (<2 m) consists of stones and boulders. Thus, water depth has a considerable influence on the amount of fine sediment that will be disturbed and dispersed into the water column during dike construction.

Dikes will be constructed in as shallow water as possible to minimize costs and for engineering design considerations. Mean depth of the East dike, Bay Zone, and Goose Island dikes are approximately 1.5, 2.5, and 5 m respectively. Maximum depth of East, Bay Zone, and Goose Island dikes are 4, 3.6, and 15.5 m respectively. It is estimated that the depth of fine silt/clay and overburden (sand/gravel) sediment beneath the dike footprints to bedrock in water depths greater than 2 m ranges from 1 to 3 m in the Bay Zone, 2 to 6 m in the East dike, and 2 to 5 m in the Goose Island dike. A portion of this sediment will become compacted and fill interstitial spaces between the large grain size material used to construct the dike. Some of the fine sediments will disperse into the water column during end dumping.

8.1.2 Potential Physical Effects

There are a number of stressors and pathways via which dike construction has the potential to adversely influence water quality (reviewed in Section 4 and described in detail in the EIA) within the area bounded by the silt curtains. End dumping of large rock will cause increases in the following SOPC parameters:

- Suspended sediments will be introduced as a result of the impact of end-dumped rock with fine silt/clay sediments on the bottom. Dredging of this fine material is not proposed prior to dumping. Thus, large grain size material introduced into the water will plunge through this fine sediment layer, which may be up more than 2 m thick (depending on water depth), and disperse fine sediment into the water column. A smaller amount of fine material, such as silt and fine sand may also comprise some of the end-dumped material. Silt curtains will be used to contain the vast majority of suspended sediments and restrict impacts to the immediate vicinity of the dike construction area. However, it is possible that episodic releases of sediment may occur beneath or around the silt curtains. It is also possible that the silt curtain could temporarily fail, and release larger amounts of sediment into the water column that will become dispersed into the lake.

- Dissolved metals will be released from pore waters as a result of compaction by the end-dumped dike material. Fine sediments typically have much higher pore water metals concentrations than overlying surface water. Compaction and dispersal of fine sediments into the water column will cause dissolved metals to increase. Although silt curtains will not contain dissolved metals, they will prevent fish from coming in contact with surface waters that may have metals concentrations that exceed surface water quality guidelines during dike construction.

- Release of nitrogen compounds in receiving environment waters may occur as a result of residue from explosives adhered to the external surface of the blasted rock. The project lakes are very nutrient poor and introduction of nitrate, nitrite, and/or ammonia may cause an increase in phytoplankton production, which may result in small, local increases in lake productivity. Whether this is an adverse effect depends on one's perspective. In addition, nitrate, ammonia, and nitrite can also be toxic; guidelines are provided in CCME (1999) and these are affected by water quality parameters such as pH and dissolved oxygen.

Sediments introduced into the water during dike construction will be contained within the area encompassed by the silt curtains and settle. Assuming a given setback distance of the silt curtain from the dike, impacts to water and sediment quality, benthic invertebrates and fish habitat will be restricted to this area. Targeted monitoring will ensure that sediment dispersed outside of this area will be detected.

8.1.3 Potential Ecological Effects

Potential ecological effects of elevated sediment concentrations suspended in the water column are well-documented in the literature and are summarized in Section 5.1. Briefly, high sediment loads in the water column can cause disruption of physiological systems in fish (e.g., gills), degradation of spawning and nursery habitat, suffocation of eggs and alevins, degradation of benthic habitat and reduction in light penetration (secondary effects include reduced photosynthesis). Potential ecological effects of dike construction that will be monitored as part of the AEMP are as follows:

- The physical presence of dikes will cause a direct loss of fish habitat (e.g., smothering of benthos) that is directly related to the length and footprint size of the dikes. Fish may be directly affected by disturbance, noise, and introduction of sediments that will cause fish to disperse and avoid the construction area. Once dikes have been constructed, small areas of lakes will be impounded that will not be available to fish during the life of the mine. Impacts resulting from a net loss of habitat will be addressed as part of the NNL program (NNL, 2005) program as stipulated by the *Fisheries Act*. The AEMP, in conjunction with the federal MMER program (Environment Canada, 2002) will monitor the condition and long-term health of fish.

- Sediment introduced into the water column that is not contained by the silt curtains can cause direct and indirect effects to fish and fish habitat. Direct effects of suspended sediments include impairment of gill function in fish, direct uptake of dissolved metals and reduced visibility impairing foraging ability. Indirect effects include smothering of benthic habitat, smothering of spawning habitat, and a reduction in water transparency, reducing primary production. All of these effects are temporary and confined to the temporal duration of the impact.

- Increased dissolved metals can cause direct toxicity to algae, zooplankton, and fish. Provided the silt curtains are effective, fish will be prevented from encountering water with elevated dissolved metals.

- Increased nutrient concentrations can cause an increase in primary productivity of aquatic systems, ultimately resulting in increased secondary production and increased biomass of fish. Because freshwater systems are not generally limited by nitrogen and because of the relatively brief temporal component to dike construction, any increases in productivity will be small and difficult to detect.

- Potential direct toxicity of nitrogen compounds to aquatic organisms, potentially released by the use of ANFOs, is also a potential issue.

Benthic communities beneath the dike footprint will be eliminated. However, presence of the dike will increase total surface area available to benthos for colonization because of the slope area added and the additional surface area provided by the rocky dike face. The large substrates used for dike construction will increase the three-dimensional surface area and provide a stable substrate for colonization by periphyton which should ultimately increase productivity of benthos on a per m^2 area. Instead of a burrowing community dominated by chironomids, the benthic community will be altered to include a greater diversity of benthos including gastropods, mites, and other insects such as Trichoptera and Ephemeroptera.

Ecological effects outside of the dike footprint area are temporary. Impairment of soft-bottom benthic habitats from sedimentation close to the dike may persist for one or two years after construction until benthos have had an opportunity to recolonize areas that sustained high sediment loads due to sediment dispersion and settling.

8.1.4 Mitigation

For mitigation specific to dike construction, silt curtains will be used to minimize the extent that sediment is suspended and dispersed into the water column. Silt curtains are a well-established, effective mitigation technique. The relatively short time construction period (approximately one to two months) and the shallow nature of the waters in the construction area increase viability of this technique at Meadowbank. The geotextile silt curtain will be suspended from the lake surface to the lake bottom (where possible) and anchored outside of the dike embayment. There is only one area in Third Portage Lake, along the eastern part of Goose Island dike where water depths >10 m and some difficulty in installing and maintaining silt curtains may be encountered. As sections of the dike are completed, the silt curtain will be disassembled and moved.

Provided that the silt curtains operate as designed, very little sediment should enter the water column and be dispersed beyond the dike footprint itself. However, it is recognized that silt curtains can fail (e.g., under high wind conditions, snags, collapse from sediment on bottom). If this occurs, sediment will be dispersed into the water column beyond the curtain perimeter and be deposited into the lake. Actual areas and volumes of deposition will be dictated by the amount of sediment lost from behind the silt curtain, sediment grain size, duration of the impact, direction, and intensity of wind-driven water currents, and local bathymetry. Consequently, this monitoring strategy is designed to detect failure in sediment containment so that the situation can be quickly remedied. The proposed monitoring program is also designed to measure the magnitude and nature of any residual water quality effects, such as elevated suspended solids, metals, or nutrient concentrations in the water column outside of the silt curtains.

In the event that a silt curtain fails, extra panels of curtain will be on hand for rapid deployment. Until mitigation is in place and monitoring indicates that suspended sediment concentrations are acceptable, dike construction would stop.

8.1.5 Water Quality Monitoring

The targeted monitoring strategy for measuring the residual impact of dike construction on water quality and the performance of related mitigation has three main components:

1. Monitor suspended solids in water near dikes during construction.
2. Monitor for changes in total and dissolved metals concentrations in water quality near dikes during construction.
3. Monitor for changes in nutrient concentrations in water quality near dikes during construction.

Monitoring approaches for each of the components are described in the sections below. There is only minor overlap between this targeted program and the core monitoring program (summarized in Table 6.1 and described in Section 7), so the two will be rationalized to avoid any duplication. The core program is conducted less frequently, but over a much larger area, providing information about the entire local watershed as well as reference areas.

8.1.5.1 Monitoring Suspended Solids in Water

Water quality guidelines for TSS (Caux et al, 1997; CCME, 1999) provide guidelines for short-term exposure (e.g., 24 hour) and longer-term exposure (e.g., 30 days or more). The approach to implementing the guidelines recognizes that exposure duration plays a key role in the ecological response, in the context of background conditions and spatial distribution of TSS.

As summarized from CCME (1999), anthropogenic activities should not increase suspended sediment concentrations by more than 25 mg/L over background levels during short-term exposure, or by 5 mg/L for longer-term exposure.

Background concentrations for total suspended solids in project lake surface waters are very low, typically below laboratory detection (<3 mg/L). Total dissolved solids concentrations (10 to 25 mg/L) and turbidity (<1.1 NTU) (BAEAR, 2005) are also very low. Therefore, for the project lakes, we can establish the TSS action trigger to be either 6.5 or 26.5 mg/L (allowing for half the detection limit), depending on the exposure regime.

A site-specific statistical relationship between turbidity and TSS will be developed by collecting paired TSS and turbidity measurements across a broad range of TSS concentrations to provide a rapid field measurement of TSS early in the construction phase. Placement of monitoring locations will be established in the field; GPS coordinates will be recorded for all sampling stations. Monitoring strategies and frequencies will be applied using principles of adaptive management (Holling, 1978), in response to the analysis of sampling data collected during dike construction.

Dike construction monitoring will be conducted through (1) deployment of two continuous turbidity monitoring buoys and (2) direct sampling by field personnel. The two buoys will be placed 200 m outside the silt curtain at 60 and 120° from the silt curtain line (or as sensible given the topography and any sensitive habitats). These buoys will continually monitor turbidity levels at three different depths in the lake, transmitting their data via radio to computers on shore. These data will be used to provide early warning of any failure of the silt curtain and to document exposure patterns to TSS over real-time.

To supplement the continuous monitoring buoys, particularly the early days of construction of each of the consecutive dikes, monitoring effort by Cumberland's on-site environmental monitors will also be deployed. Their basic turbidity monitoring program will sample at three depths (near bottom, middle, near-surface) from the point of dike construction outwards in concentric rings to confirm if the silt curtains are functioning as prescribed by documenting whether a plume is present and if so, the source of the sediment plume. Because the action triggers are based on both concentration and duration of exposure, sampling for TSS and turbidity will be conducted several times a day during the construction period until a trend in concentration over time can be determined and the performance of mitigation evaluated.

The focus of the monitoring program will be outside the silt curtain, most routinely near the silt curtains to evaluate their performance and then at intervals extending from the silt curtain. All manual monitoring will collect turbidity data via meters, with back-up water samples taken to measure TSS as part of a quality assurance/quality control program for both the continuous and manual monitoring programs. The monitoring team will also be able to adapt the basic program to respond to any observed turbidity plumes (e.g., in the event of silt curtain failure) or to document turbidity near sensitive receptors (e.g., spawning habitat).

This monitoring strategy is designed to collect spatial and temporal information over the dike construction period that will permit suitable application of action triggers. In the event of action being triggered, dike construction activities will cease until the likely cause of elevated suspended sediments (as measured by turbidity) is identified and rectified or additional mitigation taken.

8.1.5.2 Monitor Metals Concentrations

Based on baseline studies, total and dissolved metals in surface waters from project lakes from multiple stations, seasons, lakes, and years show a remarkable similarity (BAEAR, 2005). For metals that have a CCME guideline, most were below both detection limits and the CCME guideline values. Only lead marginally exceeded surface water quality guidelines for a few stations in 2003 (BAEAR, 2005). For metals without CCME values, nearly all measurements for these parameters were below their detection limits during all seasons and years. The only exceptions to this were the common salts calcium and magnesium. Dissolved metals concentrations comprised the vast majority of total metals concentrations where results exceeded detection limits, indicating that nearly all metals are dissolved and not associated with particulates.

Given the potential sources and pathways for metals to affect water quality during dike construction, both total metals (likely associated with suspended sediments) and dissolved metals (from porewater release and dissolution) will be monitored during construction of the first dike under worst-case conditions (i.e., when TSS is high) at a subset of stations during the course of turbidity/TSS monitoring. These data will also be used to establish a relationship between TSS and metals.

Decision criteria for metals in surface waters will be provided in the SAP, based upon CCME guidelines and the power of the monitoring program to detect effects.

8.1.5.3 Monitor Nutrients

Water quality guidelines for ammonia, nitrate, and nitrite are provided in CCME (1999). The same sampling stations and monitoring frequency will be used as those for metals concentrations, described above.

Baseline studies (BAEAR, 2005) showed that nutrients were below or very near detection limits in Third Portage Lake. Given the nutrient status of project Lakes, it is not expected that nutrient concentrations will even approach levels of concern for eutrophication or toxicity. Therefore, the need for continued monitoring will be re-evaluated after construction of the first dike.

8.1.6 Sediment Quality Monitoring

The targeted monitoring strategy for measuring the residual impact of dike construction on sediment quality and the performance of related mitigation is restricted to monitoring suspended solids outside of the silt curtains during dike construction as part of the targeted study on water quality (Section 8.1.5). As noted previously, background concentrations for total suspended solids and turbidity in project lake surface waters are very low, typically below laboratory detection limits. The site-specific statistical relationship derived to related turbidity and TSS will provide a rapid field measurement of TSS during construction. Monitoring strategies and frequencies will be applied using principles of adaptive management (Holling, 1978) and will be adapted to target suspended sediment. This monitoring strategy is designed to collect spatial and temporal information over the dike construction period that will permit suitable application of action triggers. In the event of action being triggered, dike construction activities will cease until the likely cause of elevated suspended sediments (as measured by turbidity or TSS) is identified and rectified or additional mitigation taken.

The only additional targeted monitoring that is proposed will occur in the event of a failure of the silt curtain. If the curtain were to fail, sediment will become dispersed across a wider area, possibly resulting in sediment deposition in benthic habitats and foraging areas of fish. Because construction will occur only during the open water period, prior to spawning by fish, no impacts to fish eggs or larvae will occur, although there will be a potential reduction in the quality of nearby fish habitat. Therefore, in the event of a silt curtain failure, additional turbidity and TSS sampling would occur to determine the likely location of depositional areas and extent of deposition. In depositional areas, bedded sediment grain size and metals concentrations would be assessed to see whether physical or chemical parameters have been altered.

8.1.7 Benthic Invertebrate Community Monitoring

The benthic invertebrate community beneath the footprint area of the dike will be eliminated, but ultimately, will be replaced by a benthic community that is typical of hard substrates, similar to what currently exists along shorelines and shoals. Outside of the footprint area, within the area encompassed by the silt curtains, benthic habitats impacted by sedimentation will be recolonized within one to two years after completion of the dike, depending on the extent of burial.

Sampling for benthos is an integral part of the core monitoring program (see Section 7.7). In addition to near-field sampling areas, targeted monitoring will assess recovery of the benthic invertebrate community in areas near to the dike footprints in Second (East dike) and Third Portage (Bay Zone) lakes affected by sediment. Experienced gained from construction of the East and Bay Zone dikes will be employed to assess recovery after construction of the Goose Island dike, five years into the project.

Monitoring will consist of sampling of soft bottom communities along the exterior of the dikes during fall one and two years after completion of the dike construction. The data collected from stations adjacent to the dikes will be compared to near-field and far-field benthos data (i.e., as part of the core program) to assess community recovery.

8.1.8 Fish Habitat Monitoring

Habitat will be created along the corridor occupied by the constructed dikes adjacent to the dike exteriors to replace habitat lost beneath the dike footprint.

8.2 IMPACTS OF DEWATERING OF IMPOUNDMENTS

8.2.1 Description of Construction Activity

There are four construction activities that will result in impoundments (i.e., areas where water bodies are enclosed and then modified for a specific purpose). In every case, a natural lake area is affected and the waters are drawn down (i.e., water elevation reduced or water removed), but the engineered outcome is different as described below:

- The North Arm of Second Portage Lake will become a combination tailings storage facility, reclaim pond, and attenuation storage pond (up to Year 5). The current water level will be reduced by 28 m, which, due to the bathymetry, will result in three ponds (each intended for one of the three uses) divided by natural sills and a stormwater dike. Dewatering of Second Portage Lake will occur the year following construction of the east dike over a period of weeks. Following Year 5 of mine life, the pond's use will change and the attenuation area will be lost as the volume of tailings increases.
- Bay Zone dike, constructed in Year 0, same as described for East dike.
- Waters near Goose Island will be diked in Year 1 and dewatered to create Goose Island pit (one of the three mining pits for the project). Goose Island pit will become operational in Year 2 and will be operated concurrently with the Portage pit for a period of three years (Years 2 to 4). Goose Island pit will be operated as an attenuation and treatment pond from Year 5 until the end of mine life.
- Vault Lake will become an attenuation storage pond for the Vault pit. The majority of Vault Lake will be dewatered, except for two small attenuation ponds that will be connected by a small constructed ditch. Phaser Lake will be drawn down by 1 m, and discharge will be directed to Turn Lake during mine life. This will ensure that water from Phaser Lake cannot discharge to Vault Lake and potentially compromise worker safety in the Vault pit.

To create impoundments, the first step is to build dikes (see Section 8.1), followed by dewatering to reduce or remove water from behind the dikes. The consequential loss of fish habitat and related mitigation is described in the NNL (2005) report. To dewater the impounded areas, a barge will be situated in the center of the deepest section of the basin, with intake at mid-water level to avoid entrainment of suspended sediment. To draw down the desired water depth, it might be necessary to also pump from shallower areas of the present lake into the deepest section. A contingency plan will be developed (e.g., construction of attenuation ponds) in the event that total suspended solids in the discharge increases beyond the permissible concentration.

Pumped water will be discharged to Third Portage Lake near-surface in deep water and away from the shores of the lake to avoid disturbance of sediment.

8.2.2 Potential Physical Effects

The obvious physical effect will be destruction of lake habitat, as the impounded area is dewatered and then used for water and tailings management purposes. This is detailed in the EIA (Cumberland, 2005).

The key water quality concern in Third Portage Lake and Wally Lake, resulting from water pumped from the impoundments, is suspended solids and release of metals from sediment porewaters. Both of these could occur due to disturbance of lake bed sediment. Details of all the volumes, destinations, and impacts are provided in Cumberland (2005).

8.2.3 Potential Ecological Effects

The EIA describes the ecological effects of loss of habitat in Second Portage Lake, Third Portage, and Vault Lake. Relevant to the AEMP are the questions of the impact of dewatering and related water discharge on water quality and impacts on fish and fish habitat.

There are two potential contaminants of concern: (1) suspended sediments from disturbing the lake sediments, and (2) dissolved metals released from porewaters in dewatered impoundments. The potential ecological effects from suspended sediments will be short-lived, but may include reduction in light transmission and burial of benthic communities as the sediments settle. Mitigation measures will be implemented to ensure that minimal amounts of suspended solids are discharged during dewatering. Given the discharge point will be in waters >8 m and well away from high value fish habitat, the potential for ecological effects are minimal. Dissolved metals released via porewaters, if present, will be quickly diluted.

The water quality and biotic composition of the lakes being impounded at the lakes receiving the pumped discharges are very similar, so relocation of mobile groups such as zooplankton and phytoplankton will not be an issue.

With respect to fish in the impounded areas, an intensive fish salvage program will be implemented to salvage as many fish as possible from each of the impoundments, prior to and during dewatering. People from the Hamlet of Baker Lake will ultimately be responsible for the majority of the fishing effort and for receiving the fish from each impoundment prior to drawdown. As the systems are dewatered fish will be concentrated in the remaining water and some may be stranded in shallow residual pools. Fish will be collected by whatever means available at this time to minimize wastage. Fish salvage is addressed separately below.

8.2.4 Mitigation

Mitigation of the potential effects of discharge of water from impounded areas into the receiving water bodies include the following actions: withdrawing water at mid-water level (away from the sediment-water interface), using a water withdrawal rate which does not create currents that will entrain sediments, and discharging near-surface (well away from shorelines and sediment-water interface).

8.2.5 Fish Salvage

Baker Lake community members and a consultant will harvest fish from Portage (135 ha), Bay Zone and Goose Island (73 ha) and Vault (98 ha) impoundment areas prior to and possibly during dewatering of impoundments. The salvage program will be implemented prior to dewatering using gill nets. Small fish are not effectively captured by gill nets; however, so other means such as trapnetting or seining may be considered, depending on water depth and timing. Salvaged fish will be autopsied to recover important core data including fork length (mm), total weight (g), gender, maturity, stomach contents, and general internal and external health. A subsample of fish of different sizes will be analysed for metals concentration in muscle tissue to establish a baseline prior to mining. An additional benefit of this program will be to undertake a research initiative to correlate total fish biomass per unit area (ha) from oligotrophic, headwater lakes in this region of Nunavut. The information gained from this exercise will assist in determining and quantifying actual impacts to fish habitat and biomass as a result of lake impoundment and dewatering on this project and future projects. Collaboration with FAO will be sought prior to undertaking this initiative.

Once fish have been salvaged, a portion of fish can be placed into an adjacent lake system, and/or sacrificed and provided to Baker Lake residents for domestic consumption and for dog food. Whether fish are transferred to adjacent lakes or used as food is ultimately the decision of Baker Lake residents in consultation with FAO. Baker Lake residents have not made a final decision about the destiny of salvaged fish.

Recent experience in fish salvage operations at Diavik by Jacques Whitford Environmental and FAO showed that gillnets were most effective at recovering fish and that overall survival of fish from all capture methods was only 50%, which was primarily due to high survival of fish captured in trap nets (McEachern et al. 2003). Furthermore, the authors showed that using Fraser Recovery boxes (oxygenated recovery units for fish) in 2002 salvage operations did not improve survival of round whitefish and that survival was actually diminished for lake trout.

8.2.6 Monitoring

As drawdown proceeds and water is pumped from the future impoundment to the receiving lake, a monitoring array of calibrated turbidity monitoring buoys meters will be deployed in the discharge area to monitor TSS at “end-of-pipe” during dewatering. To calibrate the data, a site-specific statistical relationship between turbidity and TSS will be developed by collecting paired TSS and turbidity measurements across a broad range of TSS concentrations to provide a rapid field measurement of TSS. In addition to the automatic remote monitoring for suspended sediments, manual measurements will be taken at the early stages of dewatering and also at key stages (e.g., near end of pumping when the draw might be nearer the sediment-water interface, if sediment plumes are observed in the impoundments). The decision criteria for evaluating suspended sediment data are described in Section 5.

8.3 IMPACTS OF FRESHWATER INTAKE & EFFLUENT PIPE INSTALLATION

8.3.1 Description of Construction Activity

The north basin of Third Portage Lake will be the source of all freshwater (mine process water, potable water, etc.) for the project. This will also be the area in which all treated effluent (along with all contact, surface, and grey waters) is discharged from the Portage/Goose Island mining facility. Three pipelines will be constructed:

- a water intake pipe situated west of the plant site on the western shore of the small south facing peninsula
- a water effluent pipe extending from the north end of the Second Portage Lake attenuation pond into Third Portage Lake, discharging between the mainland and the most northerly island
- a water effluent pipe extending from the Vault Lake attenuation pond into Wally Lake.

The freshwater intake pipe will extend from shore and run along the sediment surface along the lake bottom. The pipe will extend approximately 75 m offshore into an area of low habitat value and withdraw water from a depth of 10 to 12 m. The pipe will be constructed of a heavy duty, insulated HDPE and be 1.0 m in diameter.

Effluent will be discharged to each of the receiving environments, Third Portage and Wally lakes via a 0.5 m HDPE pipe. The pipe will be anchored along the bottom and the end of pipe will be situated at least 50 m offshore in low value habitat in at least 10 m of water. The end of pipe will have a diffuser to maximize dilution of effluent into the receiving environment. Effluent will be directed away from any sensitive habitats.

All three pipes will be removed during mine closure (see post-closure section).

8.3.2 Potential Physical & Ecological Effects

Negligible impacts to shorelines are expected from pipeline installation or removal because of the very coarse boulder shorelines that are not subject to erosion or disturbance by the pipes. Localized disturbance of coarse, nearshore substrate may occur to seat the pipes along the bottom. During installation, there is the potential for introduction of fine sediments into the water column that will be dispersed, depending on wind generated currents. This might result in minor, short-term increase in TSS concentration of the water column and disturbance of benthic invertebrates beneath the pipeline footprint. Fish may temporarily avoid the area due to suspended solids and activity levels.

8.3.3 Mitigation

The effects of installing intake and discharge pipes on fish populations and their habitat will be mitigated through careful selection of timing and location of installation. Sensitive periods such as spawning and egg incubation (fall/winter) will be avoided.

The water intake pipeline will extend approximately 75 m into the lake to avoid shoreline effects at the intake/discharge point. For the intake pipe, the mouth diameter will be sized to minimize entrainment of fish (DFO, 1995). The submerged end of the pipeline will be positioned off the bottom to maintain sufficient clearance of the intake to minimize entrainment of sediment or benthos by currents. Care will be taken when placing the pipe onto the bottom to prevent shoreline damage.

Effluent pipes will be installed offshore, above the lake bottom and will not directly affect fish habitat. No disturbance of shoreline or bottom sediments is expected. Effluent pipes and barges will be stored on land over winter, so there is no chance of impacts due to ice.

8.3.4 Monitoring

No targeted monitoring is proposed, due the small scale of impact (spatially and temporally).

8.4 IMPACT OF MINE SITE INFRASTRUCTURE INSTALLATION

8.4.1 Mine Site Activities

Construction of the Meadowbank Gold project will require the installation of various infrastructure facilities including roads (10 km), buildings, fuel storage and power generation facilities, an airstrip (1,525 m), water and sewage treatment and pumping facilities, staff housing, the mill and other buildings and other infrastructure required to supply and operate the mill. The majority of this material must be transported from southern Canada via barge to Baker Lake and transported via the winter road from Baker Lake to camp.

The main sources of stressors on the local aquatic environment of the project lakes are:

- dust and hydrocarbon by-products from vehicles and construction activities, blasting, and use of roads
- metals contaminated water associated with runoff from waste rock and tailings, mine site roads, airstrip, and sewage and water treatment facilities (see Section 8.3)
- increased human presence may exert fishing pressure on local fish populations, despite a no-fishing policy (see Section 9.5).

Construction of the mine site will require approximately 1.5 years and will occur year round, during open water (July to October) and ice-cover (October to June). Dust and hydrocarbon by-products from vehicle emissions, roads, and other sources (e.g., blasting) can enter the local watershed directly via aerial transmission, or indirectly, being deposited on land and dissolved or washed into the aquatic environment during spring melt.

8.4.2 Potential Physical Effects

Introduction of dust and other particulates to the receiving environment can cause local increases in suspended solids concentrations in water, diminishing water quality, and alter sediment chemistry composition by introducing contaminants (e.g., metals, polyaromatic hydrocarbons).

8.4.3 Potential Ecological Effects

Adverse ecological effects from introduction of sediment, particulate bound contaminants (aerially as dust or suspended in effluent), dissolved metals, and increased nutrients include:

- diminished water quality and clarity affecting predation efficiency of visual feeders such as lake trout
- impairment of gill function from high suspended solids concentrations in water
- sedimentation of spawning, rearing and foraging areas of fish, causing direct and indirect (e.g., benthic community affected, resulted in reduction in food abundance) impacts on fish
- increased primary and secondary productivity from nutrient additions, ultimately causing an increase in fish biomass
- uptake of metals and other contaminants by fish either directly or through the food web.

The core monitoring program is designed to detect changes in water quality (TSS, metals) and lower trophic level structure (e.g., benthic community abundance and species composition) and mitigation applied before impacts to fish become manifest.

8.4.4 Mitigation

Physical mine site construction activities with the potential to cause adverse impacts can be mitigated to a large extent by following well-established, proven mitigation procedures, such as:

- store hazardous materials well away from lakes and streams and applying best management practices
- use fuel storage containers with double-lined walls that are stored within a berm with the capacity to hold the container volume [for more information, “Spill Contingency Plan” (Cumberland, 2005)]
- suppress dust on roads and in construction areas to minimize aerial dispersal of contaminants
- ensure runoff from all roads is directed towards ditches that drain into an attenuation pond in Second Portage Lake north arm
- ensure that all water encountering potentially acid generating or metals leaching rock will be directed to the Second Portage attenuation and settling pond (prior to Year 5) or Goose Island pit (after Year 5)
- direct all water discharged from the mine/mill site, self-contained sewage treatment facility, and the attenuation pond through a water treatment facility after Year 5 before it is discharged to Third Portage Lake (see Section 8.2)

- discharge effluent only during the open water season, and ensuring all discharge meets MMER regulations (Environment Canada, 2002)
- discharge to Third Portage Lake will be halted after Year 5 and will instead be directed to the Goose Island pit for in-situ treatment if necessary
- implement a no-fishing policy to minimize fishing pressure on the project lakes. See Section 10.

8.4.5 Monitoring

Provided that best management practices are used and the above mitigation measures are followed and barring any unforeseen events such as spills or accidents, the core monitoring program (Sections 6 and 7) is sufficient to monitor activities related to construction of the physical mine site. Should an accident occur, or if an unforeseen impact should arise, a targeted study will be designed and implemented to determine the extent and magnitude of the impact with a view to implementing appropriate mitigation, as per the principals of adaptive management.

SECTION 9 • OPERATIONS PHASE MONITORING & MITIGATION

Once the mine infrastructure is in place, the dikes have been constructed and the mine is operational, there are key questions for which monitoring is required. Monitoring to evaluate any impacts will be delivered through core environmental monitoring procedures (described in Section 7) combined with targeted monitoring, both of which are summarized herein.

9.1 IMPACTS OF DIKE OPERATION

9.1.1 Description of Activity

Once dikes are operational, they will provide habitat for periphyton and benthic communities, as well for spawning and rearing habitat by fish. The main dike exteriors adjacent to project lakes will be designed to provide optimal habitat for fish during the life of the mine, as well as beyond mine life, as the vast majority of dike habitat will become a permanent feature of the lakes. A series of finger dikes have also been designed and will be constructed into deep water from the south end of the Goose Island dike in Third Portage Lake. These finger dikes will enhance long-term habitat quality and abundance by providing spawning, nursery, and foraging habitat. This section addresses how dikes will be managed and monitored to function as productive fish habitat during mine life.

Management of fish habitat and fish as a result of pit development are assessed within Section 9.2. Furthermore, a detailed accounting of the relative abundance and quality of habitat affected by mine development and habitat replacement is provided in the NNL (2005) report.

9.1.2 Potential Physical & Ecological Effects

Although design specifications can meet life history requirements for fish, other factors must also be satisfied if the dike exteriors are to function as productive habitat for plants, invertebrates, and fish. Metals leached from dikes into overlying pore waters could adversely affect periphyton growth, establishment of a benthic community, and egg survival and/or development of fish larvae during the initial flush shortly after dike construction. A targeted study has been designed to address utilization of spawning habitat by lake trout after dike construction.

Several factors may reduce porewater metal release including: cold water temperatures, use of low metal leaching rock, worst-case assumptions, and dike permeability. Dike permeability is especially important to consider. Because the dike is somewhat permeable to water inflow due to the large hydraulic pressure exerted by the lake against the dike and the pit, there is predicted to be a net inflow of lake water through the dike and into the pits. In addition, dike permeability may diminish over time as permafrost is expected to creep into the dike over time and create a freeze barrier.

Thus, the present estimation of concentration and quantity of metals leached from dikes represents a worst-case scenario. These conditions would only be expected immediately after dike construction. Much lower metal leaching rates and loadings would be expected during dike operation.

9.1.3 Mitigation

The dike design incorporates the optimal features to provide for spawning, egg incubation and nursery habitat for lake trout and round whitefish (Richardson et al, 2001). This will offset, to some degree, habitat lost as a result of mine development (NNL, 2005). Recent research on the topic of fish response to reduced habitat is summarized in Cumberland (2005).

The exterior dike faces of the East dike, Bay Zone, Goose Island, and Vault dikes will be designed and constructed to be stable and erosion-resistant, and will provide suitable features for habitat and fish. Following are the mitigation measures that will be implemented during dike operation:

- Dike slopes will range between 1.4H:1V to 1.8H:1V at water depths of 6 m or less. The slope of dike exteriors is sufficient to ensure that wave action prevents fine sediments from accumulating, thus preventing potential impacts to benthic communities and incubating fish eggs.
- Dikes will be capped with IF rock material that has a lower metal leaching potential than IV or UM rock. Dike slopes beneath the water will be constructed from UM rock, which has low metal leaching potential under neutral conditions.
- Sediment grain size of capping material will consist of a mixture of cobble and boulder that is suitable for spawning by VEC fish species.
- Slope, depth, grain size, and complexity of dike surfaces have been designed to mimic high value habitat as determined from habitat mapping of the project lakes to optimize habitat compensation for lost habitat due to impoundment (NNL, 2005).

9.1.4 Monitoring

In addition to the core monitoring program (Section 7), a number of targeted monitoring studies are planned.

Given the potential for leaching of dissolved metals from the dikes, the interstitial spaces within East dike and Goose Island dike would be sampled for dissolved metals concentrations four times in the first year of operation (Table 6.2). The sampling method would be a hose inserted into spaces within the dike, with water withdrawn through an in-line filter and using a pump.

A targeted monitoring program will also be conducted to evaluate the effects of metals potentially leaching from dikes on periphyton colonization. Species composition, abundance, and biomass of periphyton communities will be measured at discrete locations on the East dike and Goose Island dike and compared with periphyton data from reference areas. This will indicate whether the dikes are functioning as productive fish habitat by determining whether algal growth is impaired to any degree by metals leached from the rock material used to construct the dikes. Periphyton will be collected using a quantitative sampling device used in the core studies (BAEAR, 2005) from multiple locations along the dikes and compared to a similar number of stations from far-field and reference areas. Sampling will be conducted once annually in late summer during the height of periphyton growth from rock surfaces with similar attributes (e.g., depth, exposure to sun, aspect) to minimize inherent variation in periphyton biomass.

A targeted study is also proposed to determine the extent to which dikes are used for spawning by lake trout. The NNL (2005) report quantifies the amount and quality of habitat lost and provides the framework for a habitat compensation plan.

9.2 IMPACTS OF PIT DEVELOPMENT

9.2.1 Description of Activity

Development of the Meadowbank mine will require construction of four dikes that will impound four discrete areas of the project lakes, which will be developed as pits. Pit size and depth will increase over the life of the mine as ore is extracted, for either processing and disposal in the tailings pond, or as waste rock.

Pit inflow water (i.e., water that flows into the pits though the dikes, from groundwater inflow or during precipitation events) will not be directly discharged to the receiving environment for any of the pits. Pit inflow water will be directed to the attenuation pond and treated prior to discharge to Third Portage Lake (Year 0 to 5) or treated within Goose Island pit (> Year 5).

Operation of the Portage pit will result in the permanent loss of one of the westernmost of the three channels connecting Second and Third Portage Lake. Fish passage via the all of the connecting channels, including the westernmost channel is difficult or impossible during the open water season except possibly during spring freshet. The connecting channels are frozen during winter.

9.2.2 Potential Physical & Ecological Effects

The net impact to the project lakes is directly related to the loss of habitat area and relative quality of habitat lost within the pit areas, relative to the remaining habitat area and quality in the affected lakes. The pits themselves have no direct impact on the aquatic receiving environment over the life of the mine once they have been dewatered. The pits and their dimensions are detailed in the EIA (Cumberland, 2005). The NNL (2005) plan quantifies the lake area and habitat quality impacted by the pit developments and determines the overall significance of this habitat loss to the project lakes. The objective of the NNL plan is to achieve a net gain in productive fish habitat at the end of mine life.

Other impacts associated with pit development include the impacts of blasting and pit inflow water. Management related to blasting to develop each pit during mine-life are dealt with independently from this section in Section 10.4.

9.2.3 Mitigation

Mitigation of the loss of habitat area within the Portage, Goose Island, and Vault pits is described in detail in the NNL (2005) report. Mitigation efforts include a combination of the following activities:

- Water entering the Second Portage and Goose Island pits (dike seepage, groundwater infiltration, precipitation, and runoff) will be pumped to the Second Portage attenuation pond and treated prior to discharge.

- The exteriors of the East, Goose Island, and Vault dikes will be engineered to provide optimal habitat requirements to support periphyton and benthic communities, and spawning habitat for fish where other habitat parameters are also favourable (e.g., sufficient depth, grain size, exposure).

- Finger dikes constructed off the south and east ends of Goose Island pit in deep water of Third Portage Lake will provide additional high value habitat during pit operation and beyond, into post-closure.

- At closure, several sections of the Goose Island dike will be breached. Prior to breaching, the dike interiors of the West dike, East dike, and Goose Island dike will be engineered to provide optimal habitat for fish habitat elements and spawning by fish. Information gathered regarding habitat suitability during mine operations will be incorporated into the dike interior design.

- The connecting channel(s) between Second and Third Portage lakes will be enhanced to accommodate the consolidated discharge as well as to improve fish movement between the lakes, especially by Arctic char.

9.2.4 Monitoring

There are a number of targeted monitoring programs for activities related to pit development and these are all described elsewhere. For example:

- Dewatering will result in excess water being directed to the attenuation ponds/tailings pond. Discharge to the receiving environment will be monitored under MMER (2005) as discussed in see Section 9.3.
- Blasting to develop pits will be monitored, as described in Section 10.4.
- The performance of the enhanced connecting channel will be monitored, as described in NNL (2005) framework report.

9.3 EFFECTS OF EFFLUENT DISCHARGE

9.3.1 Description of Activity

There are two attenuation ponds that are sources of effluent that will be discharged to the Meadowbank project area aquatic receiving environments: (1) from the north arm of Second Portage Lake to the North Basin of Third Portage Lake (up to Year 5) and (2) from the Vault attenuation pond to Wally Lake. Monitoring of effluent from both sources is subject to the Federal Metal Mining Effluent Regulations (Environment Canada, 2002). A detailed description of effluent and receiving environment monitoring at Meadowbank is provided in the MMER (2005) framework report which describes routine testing for chemistry, toxicity testing and EEM studies (benthos and fish survey).

Effluent will be discharged to each of the receiving environments via a 0.5 m HDPE pipe. The pipe will be anchored along the bottom and the end of pipe will be situated at least 50 m away from coarse shoreline substrate or shoal habitat in at least 10 m of water. The end of pipe will have a diffuser to maximize dilution of effluent into the receiving environment. Effluent will be directed away from any sensitive habitats.

The Waste and Water Management Plan (Golder, 2005) has resulted in a significant improvement in the management and discharge of contaminated water, especially effluent. Under the revised plan, effluent will not contain water from the processed tailings prior to Year 5, and will be relatively uncontaminated. After Year 5, effluent will no longer be discharged to Third Portage Lake. If for some reason effluent discharge continues beyond Year 5, tailings water will not be discharged during this period. Tailings water will be part of a closed loop at the mill with make-up water obtained from the attenuation pond.

During the first four years of operation, the Second Portage Lake attenuation pond will receive:

- all site contact water from the Portage and Goose Island areas (e.g., from roads and disturbed lands)
- water from interceptor ditches along the eastern and northern ends of the rock storage facilities
- seepage water from waste rock disposal facilities
- treated (if necessary) runoff from pit inflow water
- all water originating from the mill area.

Pit waters will be pumped to a water sump at the process plant and, if necessary, treated with lime and used to meet process water demand. This will also minimize the requirement for freshwater makeup from Third Portage Lake during mine operation. All process water containing mine tailings will be contained within the reclaim pond within the actual tailings impoundment area south of the attenuation pond. A stormwater dike will be constructed between these two areas to prevent mixing. This design isolates metals-contaminated water associated with the tailings disposal facility from the general, site-wide water management plan.

As mining continues through Year 4, the reclaim pond containing mine tailings will advance north towards the attenuation pond. Coincident with filling the main basin of Second Portage north arm with tailings, will be completion of mining within Goose Island pit. At this time, the attenuation pond will act as the reclaim pond for mine process water. Small perimeter saddle dikes will be constructed on land to allow the pond and tailings surface level to be raised so that sufficient storage volume for process water requirements is maintained.

Beyond Year 5, and after the reclaim and attenuation ponds are merged, the Goose Island pit will be used to manage all site water, including all contact water, pit water (from Portage pit), waste rock storage runoff and mill site runoff. Thus, Goose Island pit will gradually be filled between Years 5 and 8, inclusively. No discharge of effluent to Third Portage Lake is forecast beyond Year 5. The available storage volume within the pit is estimated to be 4.2 Mm^3 of water, which is largely sufficient to contain all waters discharged to the pit to the end of mine life. Water quality within Goose Island pit will be monitored and treated in situ if necessary. A water treatment system will be located at the process plant for the operating life of the mine, and will be used to treat pit water as required. At end of mine life, the process circuit will be transformed to a treatment plant to treat the remaining tailings water before what is left of the exposed tailings is drained, graded, and covered with alkaline ultramafic rock.

Effluent discharged to Wally Lake and North Basin Third Portage Lake consists of a mixture of contact water originating from mine infrastructure-related sources (waste rock seepage and runoff, pit inflow water, runoff from waste rock piles, drainage water collected from road and airstrip ditches) and local non-contact drainage as a result of precipitation. In addition, the Second Portage attenuation pond will receive all grey water, sewage, and water discharged to the tailings impoundment area after Year 5.

Prior to Year 5, mine effluent is not expected to contain contaminants or other constituents that exceed MMER water quality guideline concentrations. Thus, no water treatment plant is planned. After Year 5, it is forecast that there will no effluent discharge to Third Portage Lake, therefore, MMER will not apply. MMER will continue to apply in Wally Lake.

All ore processing will be conducted in the Portage area. Consequently, no tailings are discharged to the Vault attenuation pond. Vault attenuation pond decant to Wally Lake is expected to comply with MMER guidelines; therefore, no water treatment plant will be required. Routine monitoring will be conducted in Wally Lake throughout mine life to ensure compliance with MMER guidelines and practices (MMER, 2005).

It is important to note that effluent will be discharged to the receiving environment only during open water season, between early July and mid- to late-October. Effluent will not be discharged under ice.

9.3.2 Potential Physical Effects

Effluent discharged to the North Basin of Portage Lake will consist of a mixture of various waterborne parameters, principally dissolved and particulate-bound metals. All effluent discharged to the receiving environment will meet MMER guidelines and receiving environments will be subject to EEM studies to ensure compliance.

9.3.3 Potential Ecological Effects

Concentrations of total and dissolved metals in the project lakes are very low and are frequently below detection limits and almost never exceed CCME guideline concentrations (CCME, 1999). Dissolved metal concentrations comprise the vast majority of total metals concentrations in project lakes where results exceed detection limits, indicating that nearly all metals are dissolved and not associated with particulates (BAEAR, 2005). Metals can adversely affect fish and lower trophic levels through biochemical, physiological and behavioural pathways causing effects such as reduced growth, survival, and/or reproduction. Potential secondary effects include reductions in fish growth rates due to reduced food supply (e.g., benthos) caused by the effects of contaminants.

Suspended sediments and sedimentation can be significant environmental stressors since they can result in a wide range of environmental effects including: disruption of important physiological systems in fish (e.g., gills, mouth), degradation of spawning and nursery habitat, suffocation of eggs and alevins, degradation of periphyton, and benthic habitat (which has secondary impacts on fish), and reduction in light penetration (secondary effects include reduced photosynthesis).

Nutrients from sewage treatment, residual nitrogen compounds adhered to blasted rock and leaching from dikes and waste rock piles introduced into receiving environment waters can cause an increase in primary and secondary production. This would ultimately be reflected as an increase in fish biomass. At moderate levels, this may be viewed as a positive impact, but in extreme cases, increased algal production during summer could result in anoxic conditions in hypolimnetic water during winter as a result of algal decomposition under an ice cover. However, given the extremely nutrient poor condition of the project lakes, their high dilution capacity and the high water column oxygen concentration year round (BAEAR, 2005), this is highly unlikely. In addition, indirect effects such as increased uptake of metals to biological systems can occur due to increased productivity.

9.3.4 Mitigation

The following major measures are being implemented at Meadowbank to minimize impacts to water quality in the receiving environments of Third Portage and Wally lakes:

- A portion of the north arm of Second Portage Lake will function as an attenuation pond (Years 0 to 5) to reduce suspended solids, and nutrient and metals concentrations in effluent prior to discharge to Third Portage Lake.
- Beyond Year 5, Goose Island pit will be used to receive all potentially contaminated site water and no discharge to Third Portage Lake is forecast. All water will be treated in situ within Goose Island pit if necessary between Year 5 and the end of mine life.
- A portion of Vault Lake will function as an attenuation pond throughout mine life to reduce suspended solids, nutrient and metals concentrations in effluent prior to discharge to Wally Lake. This pond will not contain tailings contaminated water and treatment of water prior to discharge is not necessary.
- Effluent will only be discharged during the open water season.
- Effluent quality will meet or exceed all criteria stipulated under the MMER.
- A diffuser will be installed to maximize effluent dilution.
- Effluent will be directed offshore of Wally Lake and Third Portage Lake, in deep water (>10 m) away from any sensitive habitat.

9.3.5 Monitoring

Under MMER (Environment Canada, 2002), a detailed framework study design has been compiled for the Meadowbank project and has been included as a separate document (MMER, 2005). This document describes how the MMER will be implemented at Meadowbank to ensure compliance with the regulations. This program requires that the mine undertake the following studies:

- weekly chemical analysis of effluent for pH and the suite of deleterious substances listed in Table 2.1 of the MMER (see EIA for more information)
- monthly testing of acute lethality of effluent to rainbow trout (*Oncorhynchus mykiss*) and the water flea *Daphnia magna*
- weekly or continuous measurement of effluent flow rates to derive an estimate of loading

- calculation of mass loadings of deleterious substances to receiving environments.

In addition, the EEM program under MMER requires that regular monitoring of possible impacts to receiving environment waters be carried out. Specifically, the EEM program is comprised of two parts:

- *Part 1* – Effluent and water quality monitoring studies intended to provide background supporting information for the assessment and interpretation of biological monitoring (see below). This component includes effluent characterization, sublethal toxicity testing, and water quality monitoring.

- *Part 2* – Biological monitoring studies, including a site characterization, a fish survey (using indicators of fish population health and fish tissue analysis), and a benthic invertebrate community survey.

In addition to the MMER/EEM monitoring, which focuses on the effluent, the core monitoring and several targeted studies described elsewhere in the AEMP will also be assessing any potential impacts of water quality on biota. These are summarized in Tables 6.1 and 7.1.

SECTION 10 • GENERIC ISSUES MONITORING & MITIGATION

Generic questions can usually be addressed by proven engineering solutions for impacts that are easily mitigated, or are expected to have small or negligible effects. Prevention and mitigation of adverse effects can often be achieved through simple standard procedures.

Monitoring to evaluate any impacts of generic issues will be delivered through core environmental monitoring procedures (described in Section 7) combined with targeted monitoring, both of which are summarized herein.

10.1 IMPACTS OF MINE SITE INFRASTRUCTURE FACILITIES

10.1.1 Description of Activity

After construction, the majority of infrastructure facilities at the mine site continue to pose little or no threat to either fish or fish habitat given that they are situated on land well away from water, thus there is no pathway to cause effects under normal predicted operations. Only under rare circumstances will any of these facilities have the potential to cause significant impacts to the receiving environment (see Spill Contingency Plan, 2005). There are two facilities with a slightly higher potential to cause impact to fish populations or fish habitats during operation: (1) sewage and solid waste disposal, and (2) roads and airstrip.

Sewage will be treated by a self-contained sewage treatment system with the camp. All grey water will be added to the tailings stream, and solids will be incinerated with the ash disposed in the tailings or waste rock. The wastewater will be directed to the tailings pond, so there will be no discharge of sewage to Third Portage Lake during mine life.

The installation and use of roads, the airstrip, and both air- and land-based traffic have the potential to impact fish and fish habitat during both construction and operation phases of the project. Heavy trucks will be used to transport mined ore-bearing rocks to the Portage mill facility throughout the year. However, impacts are expected to be minimal given application of mitigation measures.

Air traffic is the sole transport connection between Baker Lake to the Meadowbank project area during certain periods, when the all-weather road is not useable. Flights will occur more frequently during this period and regularly throughout the year, during all seasons. Drainage ditches will encircle the facility to capture this contact runoff and direct it to the attenuation pond in Second Portage Lake.

10.1.2 Physical & Ecological Effects

The main aquatic effects related to installation and operation of mine infrastructure is dispersion of dust and hydrocarbon byproducts from vehicle/airplane emissions on a continual basis. These contaminants have the potential to enter the local lake system directly via aerial transmission, or indirectly, during spring melt and rain events as surface runoff from land into water bodies. These impacts have been addressed in detail within the EIA.

Sewage is not expected to have measurable effects because it will be treated. Sewage wastewater post-treatment (note that solids will be incinerated) will be discharged and combined with the tailings discharged to the tailings pond. Sewage products will not be discharged to the receiving environment.

10.1.3 Mitigation

The mine infrastructure facilities will all be constructed using standard construction practices for which there are well-established, proven mitigation solutions:

- On-site environmental monitors will be present to ensure that prescribed construction practices are followed routinely, to inspect collection systems and ditches, and to identify potential problems as they may arise.
- Environmental monitoring of the receiving environment (see core program described in Section 7) will allow early detection of any biophysical changes that may occur during construction.
- Construction of adequately sized drainage ditches on both sides of the roads and around the airstrip and buildings will be required to capture particulates/runoff, which will be directed to the Second Portage attenuation pond prior to discharge to Third Portage Lake (prior to Year 5). After Year 5, all contact water will be directed to Goose Island pit and will not be discharged to the receiving environment. This mitigation will eliminate or considerably reduce the potential for introduction of sediment and dissolved to the receiving aquatic environment.
- Refuelling of trucks and other equipment will be conducted at least 100 m away from the nearest water body.
- Spills and contingency plans (Cumberland, 2005) will be implemented if necessary.
- Water will be applied regularly on roads and the airstrip to minimize aerial dispersion of particulate borne contaminants.
- Double-walled tanks will be used to store fuel products. Containers will be surrounded by berms of sufficient capacity to hold the container volume.
- No direct contact of vehicles in lakes or connecting channels will be permitted.

10.1.4 Monitoring

The mitigation measures described above are expected to be successful in reducing the effects of installation and operation of infrastructure facilities. The core monitoring plan (Section 7) will be monitoring the contaminants of greatest concern in this case—suspended sediments and contaminant concentrations in aquatic systems. No targeted study is proposed unless an unforeseen exposure or impact arises, in which case site-specific monitoring will be employed, using principles of adaptive management.

10.2 IMPACTS OF INSTALLATION & OPERATION OF TURN LAKE CROSSING

10.2.1 Description of Construction Activity

Between the main camp and the Vault Deposit, the access road will cross Turn Lake over a narrow constriction of the lake upstream of the discharge point to Drilltrail Lake. This channel will be crossed with a bridge. The bridge will be installed in the dry during winter. Appropriate measures will be taken to ensure that approaches to the bridge do not pose sediment sources or present a barrier to fish movement.

The bridge will be engineered to accommodate the most likely flood event and will at no time present a barrier to movement by fish between Turn Lake and Drilltrail Lake. There are no directed fish migrations between Turn Lake and Drilltrail Lake, as fish movements are small and opportunistic.

10.2.2 Physical & Ecological Effects

Fish movements between Turn and Drilltrail lakes will not be affected. The stream bottom will not be altered and bridge approaches will be armoured to ensure that no erosion occurs and no sediment is introduced into the water column. Lake trout, round whitefish and Arctic char may move between Turn Lake and Drilltrail Lake, however, their movements are occasional and not timed with season or any particular life history requirement such as spawning or over-wintering (BAEAR, 2005).

10.2.3 Mitigation

Installation of a bridge instead of a culvert is the best mitigation where a road crossing over a stream channel is required. Provided that the bridge is properly installed and maintained, no residual adverse effects are anticipated. The following mitigation measures will be implemented.

- Standard construction practices will be employed during bridge installation.
- Construction will take place during winter, when the channel is normally frozen to the bottom, avoiding the open water period.
- Bridge approaches will be lined with riprap to prevent exposure of permafrost and minimize soil erosion.

10.2.4 Monitoring

Stream banks and approaches will be routinely monitored to ensure that integrity of the stream bottom and approaches to the bridge are sound and that no erosion is occurring. Water velocity in the stream will be monitored during spring freshet to ensure that no velocity barrier is being posed.

10.3 IMPACT OF CONSTRUCTION OF THE ALL-WEATHER ROAD

10.3.1 Bridge & Culvert Installation

A 102 km all-weather road is being proposed to provide access between the mine site and the Hamlet of Baker Lake. This road will cross approximately 25 ephemeral drainage channels and streams, which will require that either culverts or bridges be installed. Bridges will be installed at five crossings where there are known, defined migrations by Arctic grayling (*Thymallus arcticus*). There are also small, random, undefined movements by lake trout (*Salvelinus namaycush*) and round whitefish (*Prosopium cylindraceum*). One culverted crossing has a migratory population of grayling.

Five bridges will be installed across stream channels that have good connectivity to lakes upstream and downstream of the planned crossing locations, and within which there are spring spawning migrations of Arctic grayling. Prefabricated steel logging type bridges will be used. These prefabricated bridges are manufactured with pre-determined lengths and have lifting points for moving bridge sections into place so that no instream access is required. Approach ramps will be constructed and comprised of a base layer of coarse rock, a transitional zone of finer rock, and a travel surface of crushed rock. Bridge abutments will be constructed from a variety of materials including rockfilled cribs, gabions, wire mesh baskets, or corrugated steel bins, depending on soil and flow conditions.

Culverts will be installed in the remaining stream or channel connections. At all but one culverted crossing, streamflow is ephemeral and discharge consists of snowmelt or icemelt from shallow, fishless ponds. Connectivity between waterbodies is poor or absent, and there are no defined fish migrations or movements occurring within the streams and channels being crossed by culverts, except for one crossing.

Culverts will be of corrugated galvanized steel or high-density polyethylene, and will be sized to accommodate the maximum expected flow. Because there are no fish present in any stream but one, there are no restrictions to water velocity within the culverts. All culverts will be installed at low points in the roadway profile. The area will be graded to remove cobbles and create a depression for application of a bedding sand cushion. Bridges and culverts will be installed during winter when there is either no flow or the channel is completely frozen. Approaches to culverts will be appropriately armoured to ensure that there is no possibility for erosion.

10.3.2 Potential Physical Effects

Improper installation of culverts and bridges can introduce dust and other particulates to the receiving environment, which can cause a local increase in suspended solids concentration in water, diminish water quality, alter sediment chemistry composition, and cause sedimentation in downstream aquatic habitat.

10.3.3 Potential Ecological Effects

Adverse ecological effects include introduction of sediment (aerially as dust or suspended in effluent), erosion of shorelines, and high water velocity that can prevent fish movements. This can result in the following:

- diminished water quality and clarity affecting predation efficiency
- prevention of upstream movement and spawning by migratory Arctic grayling
- increased fishing by local residents and mine workers

- sedimentation of spawning, rearing and foraging areas of Arctic grayling, causing direct and indirect (e.g., benthic community affected, resulted in reduction in food abundance) impacts on fish populations.

10.3.4 Mitigation

Installation of bridges and culverts is a routine activity, and there are well-established, proven mitigation procedures to ensure that sediment is not introduced during or after installation. The following mitigation measures will be followed during construction of the all-weather access road:

- use bridges to cross all but one stream where there are defined fish migrations
- implement a no-fishing policy for all mine workers
- install bridges and culverts during winter when there is no flow in any of the streams
- minimize in-stream activity to ensure minimal disturbance of stream bottom
- suppress dust on roads to minimize aerial dispersal of dust
- ensure runoff from the all-weather road is directed towards ditches that drain away from the stream
- install appropriate abutments and approaches to bridges and culverts to ensure that erosion of stream banks and exposure of permafrost does not occur.

10.3.5 Monitoring

Provided that best management practices are used and the above mitigation measures are followed, fish movements and migrations should not be impaired and spawning by Arctic grayling will be unaffected. Stream crossings will be visually inspected each spring and summer to ensure that there is no erosion of stream banks upstream of the crossings to prevent any sediment introduction. Stream velocity will be periodically checked, if necessary, to ensure that Arctic grayling can migrate upstream without undue stress. Barring any unforeseen events such as spills or accidents, the presence of the all-weather road should not adversely affect fish populations.

It is possible that fishing activity by residents of Baker Lake could increase along the all-weather road, especially in the vicinity of stream crossings, where access is easily available. Monitoring of fishing activity will be periodically monitored along the road to gauge the level of activity.

10.4 IMPACTS OF CONSTRUCTION & OPERATION OF ROCK STORAGE FACILITIES

10.4.1 Description of Activity

Two areas will be designated as rock storage facilities to contain overburden and waste rock materials:

- Portage/Goose Island (surface area ~150 ha).
- Vault (surface area ~250 ha).

At each area, overburden will be removed, and the ground will be levelled using graders. To initiate construction, two small lakes within the perimeter of the Portage/Goose Island rock storage pile will be dewatered. There are no small lakes within the perimeter of the Vault storage facility, although there are two lakes quite nearby, lying adjacent to the facility. There are several small water-filled depressions in the tundra that will be covered by the rock storage facilities.

The waste rock facilities at Portage/Goose Island and Vault will be constructed and maintained during the life of the mine. Undesired mined rock and overburden of low ore content will be transported by heavy truck and piled in each of these areas. This activity will commence early in the mine’s life. Contact waters from disturbed terrain and rock piles are expected to be of low pH (acidic) and contain elevated concentrations of metals. Drainage ditches will encircle each rock storage facility to collect and redirect all contact water runoff to the attenuation pond at each respective area. It is expected that permafrost beneath the waste rock pile will creep into the piles and freeze the core over time, preventing leachate from flowing into the groundwater.

10.4.2 Potential Physical & Ecological Effects

At Portage/Goose Island rock storage area, two small lakes within the perimeter of the storage pile will be dewatered, with the water directed to the tailings basin. One of the ponds, Lake NP-2, is 9.5 ha in size and contains a small community of isolated lake trout. Loss of fish habitat will be compensated as described in the NNL (2005) framework report.

There are no small lakes within the perimeter of the Vault storage facility, although there are two lakes quite nearby, lying adjacent to the facility.

10.4.3 Mitigation

To minimize impacts to fish and fish habitat from construction of the Vault and Portage/Goose Island rock storage facilities, the following mitigation measures will be implemented:

- All water (rainfall, snowfall, leached materials) encountering potentially acid generating or metals leaching rock will be directed to the Second Portage attenuation pond (Portage/Goose Island facility) or the Vault attenuation pond (Vault facility) using drainage ditches designed to contain runoff under 1:100 year flood conditions.
- Discharge from the Portage/Goose Island attenuation pond will be treated after Year 5 of mine development.
- Lost fish habitat in Lake NP-2 will be compensated for by the connection of Dogleg Lake (fish-bearing) to Second Portage Lake through enhancement of a connector stream. This would improve fish movement between these two lakes and increase net habitat available to fish (see NNL, 2005).
- Fish within Lake NP-2 will be salvaged prior to dewatering and will be provided to elders and residents of Baker Lake.

To minimize impacts to fish and fish habitat due to operation of the Portage/Goose Island and Vault rock storage facilities, the following mitigation will be implemented:

- All rainfall, snowmelt, and leachate from the waste rock piles will be directed to either the Vault or Second Portage attenuation pond via perimeter ditches designed to contain runoff under 1:100 year flood conditions.
- A water treatment plant will be operated from Year 5 onwards to reduce metals contributions to Third Portage Lake.
- Post-closure capping of waste rock piles with low metal leaching and low ARD potential rock.

10.4.4 Monitoring

The core monitoring program will address all monitoring requirements to detect the potential for adverse impact during construction and operation of the rock storage facilities (Section 7). Best management practices for rock storage design and operation are expected to mitigate environmental effects, so a targeted monitoring program is not merited at this time.

10.5 IMPACTS OF BLASTING

10.5.1 Description of Activity

Development and operation of the mine will require intermittent blasting for a number of purposes, including: construction of dikes, road construction, site preparation, development of the pits, and pit mining itself. While some of these activities occur under conditions that will not result in physical or ecological effects on fish and fish habitat, the construction of dewatering dikes and blasting for pit excavation both occur in proximity to fish habitat and fish populations and hence have the greatest potential for impacts.

10.5.2 Potential Physical Effects

The use of explosives in or near fish habitat may result in physical and/or chemical alteration of that habitat, depending on the proximity and nature of blasting. Sedimentation and addition of nitrogen compounds can also result, particularly with blasting in wet conditions in areas beneath the dewatered lakes. However, direct in-water blasting is not anticipated and physical alteration of fish habitat due to blasting is not expected.

PPVs (peak particle velocities) were modeled at points along the proposed dewatering dikes at the Meadowbank project using a US Bureau of Mines' estimate method. The preliminary estimates are based on the current understanding of the proposed mine and its development, and estimate some variables based on published values. The preliminary estimates of PPV vary at different locations (e.g., various dikes, and locations relative to pit center, dike crest, and shoreline) and also with the charge weight per delay. Preliminary estimates of instantaneous pressure change (overpressure; kPa) found that the FAO guidelines should be met for all change weights that are currently being considered for the Meadowbank project.

The main products of the combustion of ammonium nitrate fuel oils (ANFOs) are carbon oxide, carbon dioxide, nitrogen oxide compounds, particulate matter (<10 µm diameter), ammonia, nitrate, nitrites and water. For aquatic systems, the main issue is release of nitrogen compounds, particularly when blasting occurs in wetted conditions and/or excavated rock is contaminated with unexploded ammonium nitrate.

10.5.3 Potential Ecological Effects

The federal *Fisheries Act* includes provisions for the protection of fish and their habitats. The detonation of explosives within or adjacent to fish bearing waters has been demonstrated to cause disturbance, injury and/or death to fish and/or the harmful alternation, disruption, or destruction of their habitats, sometimes at a considerable distance from the point of detonation.

The detonation of explosives in or near water produces post-detonation compressive shock waves that can be harmful to fish and fish eggs. The shock waves are characterized by a rapid rise to a "peak pressure" followed by a rapid rebound to below ambient hydrostatic pressure (Wright and Hopky, 1998). The rapid fall in pressure causes most impacts to fish. Vibrations from the detonation of explosives may cause damage to incubating eggs.

Wright and Hopky (1998) review the impacts and regulatory context and provide specific guidance on guidelines and the review process. In brief, the primary site of damage to finfish is the swimbladder (the gas-filled organ that permits most pelagic fish to maintain neutral buoyancy). The kidney, liver, spleen, and sinus venous may also rupture and haemorrhage. Fish eggs and larvae may also be killed or damaged.

Of specific concern for the Meadowbank project is the Portage Lakes connection channel that links Second and Third Portage Lakes. This fish passage is already limited and blasting will need to be managed so that fish do not avoid that area, thus further reducing fish movement between the lakes.

The DFO Guidelines (Wright and Hopky, 1998) state in Section 9: "No explosive is to be detonated in or near fish habitat that produces, or is likely to produce, an instantaneous pressure change greater than 100 kPa in the swimbladder of a fish." Similarly in Section 10, "No explosive may be used that produces or is likely to produce, a peak particle velocity greater than 13 mm/s in a spawning bed during egg incubation". The degree of damage is related to the type of explosive, size and pattern of charges, method of detonation, distance from the point of detonation, water depth and the species, size and life stage of the fish.

Under conditions where these guidelines could not be met, the proponent will be required to prepare a mitigation plan outlining additional procedures for protecting fish, marine mammals, and their habitat.

While the main environmental concerns related to blasting are physical, there are also chemical issues. For ANFOs, release of nitrogen compounds may increase nutrient levels in the aquatic receiving environment, which in turn can change the rate or nature of primary productivity.

10.5.4 Mitigation

10.5.4.1 Construction Phase

During the construction phase, targeted monitoring will be used in concert with various mitigation strategies to ensure that guidance (Wright and Hopky, 1998) for the two measures (overpressure and vibration) are met at the respective points of compliance (in waters adjacent to dike, in natural spawning habitat and in the connecting channel between Second and Third Portage lakes).

It is anticipated that the present blast design will meet FAO guidelines; however, in the event that monitoring finds that the guidelines are not being met, mitigation strategies will include various combinations of the following measures:

- reduction in the charge weight and blast hole size
- lower bench heights on the face nearest aquatic habitats
- modify the millisecond delays
- increased dike width in areas where the overpressure or vibrations guidance cannot be met, thereby increasing the setback distance from the blasting—in particular, this might be needed in the pit face blasting area, near the aquatic environment (proposed setback is 80 m).

In some cases, it will be impossible from an engineering perspective to construct the proposed dewatering dikes at the minimum setback distances required to protect fish. However, during detailed engineering design, the final alignment of the proposed dewatering dikes can be assessed further to consider, among other items, the minimum setback required to minimize the impact of detonation on the potential fish habitat along the lakeside dike faces.

During blasting, nitrogen compounds released to waters in the blasting area will be captured by pumping and/or ditches and disposed of in the tailings pond. No specific mitigation for potential release of nitrogen compounds from blasted rock is planned.

10.5.4.2 Operation Phase

It is expected that experience from the construction phase will direct mitigation requirements during the operations phase. A benefit of the approach used to monitor blasting in the construction phase is that it will establish, if merited, a defensible targeted monitoring framework during the operational phase of the mine. The implications of various blasting scenarios on PPV and overpressure blasting will be understood, and it is likely that appropriate mitigation will have been identified and already used as standard procedure.

10.5.5 Monitoring

Blast Monitoring – During construction, targeted monitoring will be conducted at times and places coincident with blasting, particularly in areas with the potential to affect fish and/or fish habitat, based on setback distance derived from charge weight and rock type. Even in advance of the construction phase, development/test blasts will be used to collect site-specific information about site factors that will affect PPV and overpressure. This information can be used to calibrate predictions and identify where mitigation actions will need to be used.

PPV will be measured using digital seismographs capable of measuring and recording peak ground vibration levels in each of three orthogonal directions. Overpressure will be measured using a hydrophone sensor and a standard blasting seismograph. Self-triggering data loggers will be used to record data.

The sampling design will be consistent with principles applied throughout this AEMP, specifically, adaptive monitoring, use of trigger levels for more intensive monitoring and use of an array of monitoring stations. Measurement sites will be selected to evaluate both fish habitat (i.e., use of nearby waterbodies by fish for foraging, etc. where overpressure should be monitored) and nursery habitat (use of nearby natural habitat for spawning and rearing where PPV should be monitored).

Early in the construction phase, the monitoring team will work with the blasting crew to design a series of blasts that will be used to test the exposure of fish and fish habitat to representative blasting scenarios. Depending on final desk-based estimates of overpressure and PPV (i.e., do they predict exceedences of guidelines or not?), the scenarios could start conservatively (i.e., worst case areas but with mitigation) and, results dependent, work towards blasting procedures that are efficient but still meet the DFO guidelines. The end result will be an understanding of when/where unacceptable exposures to overpressure and PPV are likely to occur and what mitigation measures are the most effective.

An additional benefit of this approach is that it will establish the targeted monitoring framework for the operational phase of the mine. In the longer term, a targeted monitoring program to determine the effects of explosives on use of habitat enhancement structures may be merited, depending on the outcome of monitoring during the construction phase. Such monitoring could focus on the exteriors of dikes, monitoring both habitat use by adults (e.g., foraging habitat) and impacts on fish eggs.

Nutrient Monitoring – Another consideration is the potential for input of nitrogen compounds to the water column from blasting activity. Chronic inputs to a nutrient deficient system could increase local production of phytoplankton. This is often construed as a positive effect and temporarily at least, can partly offset loss of fish habitat. The core program will be monitoring nutrient levels, chlorophyll *a* and phytoplankton abundance.

Fish Passage Monitoring – An enhanced channel connecting Second and Third Portage lakes will be constructed to allow movement by fish between the lakes throughout the open water season. If this channel is enhanced, monitoring must be conducted to demonstrate that effects of explosives and proximity of the mine to the channel does not deter fish movement. A fish movement study using hoopnets will be needed.

Finally, over time, the potential for deleterious effects of blasting will be expected to diminish (as the blasting face moves deeper and further away from aquatic areas). Therefore, it will be likely that the monitoring effort will be reduced in the operational phase given the guidelines for PPV and overpressure are being met even in worst-case situations.

10.6 IMPACTS OF WORKER FISHING ON FISH POPULATIONS

10.6.1 Description of Activity

During construction and operation of the mine, more than several hundred workers may be on site, many of who may wish to enjoy sport fishing. Past experience at other northern mine sites has shown that angling pressures increase in lakes due to increased access and number of people fishing. In project area lakes, the desired sport fish are lake trout and Arctic char because of their size, taste, and willingness to take a hook (less so for Arctic char; round whitefish do not take hooks). However, because trout and char are slow growing, their populations are susceptible to overfishing.

Cumberland is proposing a “no fishing policy” in accordance with a recommendation made in the Terms or Reference for the project. However, it is recognized that local aboriginal people may periodically exercise their rights to undertake recreational fishing within the study lakes during the life of the project.

10.6.2 Potential Physical & Ecological Effects

Fishing pressure over a period of many years can significantly reduce fish populations in accessible lakes and may be the single largest direct source of mortality of fish during mine operations, greater even than all other mine activities combined. The EIA quantitatively evaluates sustainable levels of fishing for project lakes.

10.6.3 Mitigation

To minimize the number of fish captured and retained by sport-fishers and Inuit workers, the following measures will be implemented:

- Cumberland will enact a no-fishing policy.
- All staff will be informed about the no-fishing policy and provided with an educational presentation targeting conservation issues.

Despite a no fishing policy, and based on the experience gained at other northern mines, there will be a minority of workers who fish despite the policy and First Nations with a right to fish may choose to exercise this privilege. Therefore, the goal of mitigation should be to keep any harvesting at rates below those calculated to be sustainable.

10.6.4 Monitoring

One of the responsibilities of an on-site environmental monitor will be to monitor fishing and build awareness of the no fishing policy. Periodic creel surveys will be carried out to assess harvest rates of fish. This will be accomplished by interviewing local aboriginal fishermen. Data gathered from carcasses, when provided, will be used as part of the core program. Fish will be autopsied (internal and external examination) and tissue samples collected for analysis of tissue metals concentrations using the same procedures as described in MMER (2005).

10.7 IMPACTS OF INFRASTRUCTURE FACILITIES AT BAKER LAKE

10.7.1 Description of Activity

Several facilities will be constructed and operated at Baker Lake to facilitate the construction and operation phases of the Meadowbank project to the north. These include:

- marine barge landing facility
- marine transport
- Baker Lake access roads
- Baker Lake staging facility
- explosives magazine and tank farm.

Equipment and materials to be used at Meadowbank will be shipped in from southern Canada to Baker Lake. These materials will be offloaded from the ships via barge, onto a marine barge landing facility that will be constructed on the shoreline of Baker Lake, within the community.

The marine barge facility will be constructed of a geotextile material, extending from about 1 m depth below water and 10 m offshore towards the shoreline to connect with a road. The approximate area of the barge landing facility is 200 m^2.

The Baker Lake access road will connect the town to the marine barge landing facility, to allow unloading of barge materials for transport to the staging facility, explosives magazine, or tank farm. No significant adverse effects are foreseen during construction or operation of this road. All activities will take place above the waterline.

The Baker Lake staging facility will be built far from waterbodies, and will pose no threat to fish or fish habitat. This warehouse will be the location where all materials brought to Baker Lake by barge are stored and organized prior to transport to the mine site via the winter road.

The explosives magazine and tank farm will likewise not be located proximate to any water bodies, thus there is no pathway between a potential contaminant source and an aquatic receiving environment.

10.7.2 Potential Physical & Ecological Effects

Increased ship traffic in Hudson Bay and Chesterfield Inlet has the potential to increase noise disturbance to fish, especially marine mammals, and increase the risk of a spill of contaminants (e.g., hydrocarbons).

The geotextile material and ramp at the offloading facility will alter a small amount of the shoreline that is normally ice-scoured or frozen in winter. A very small area of benthic habitat foraging habitat may be eliminated.

10.7.3 Mitigation

Each of the infrastructure components listed above will require various forms of mitigation as follows:

- Ships will transport materials from the Port of Churchill to Baker Lake during open water season and will follow all standard safety procedures to minimize the risk of a spill into marine waters.
- The barge landing facility will be constructed during open water season and will avoid sensitive habitats and spawning/nursery periods by fall spawning fish.
- Sediment control measures will be implemented to ensure that sediment is not introduced into Baker Lake.
- Marine barge operators and truck drivers will follow hazardous material handling guidelines, the spill contingency plan, and standard operating procedures.
- Annual monitoring and maintenance of the barge offloading facility will be conducted to maintain structural integrity and ensure that no erosion occurs.
- Standard construction procedures and hazardous material handling guidelines will be followed in constructing and operating the access road.
- Explosives and fuel will be stored well away from aquatic environments at the staging facility.
- Implement Spill Contingency Plan (Cumberland, 2005).

10.7.4 Monitoring

Targeted monitoring is not proposed for this activity, due the localized and small scale of impact. However, monitoring of the standard operating procedures, spill contingency plan, and hazardous materials handling will be provided through Cumberland’s Environmental Management System.

10.8 IMPACTS OF WINTER ROAD UTILIZATION

10.8.1 Description of Activity

Ice roads are critical seasonal links over which virtually all construction equipment, fuel, and supplies must be transported to reach remote exploration and mine sites. The winter ice road into Meadowbank has been used during the exploration phase of the mine. During mine operation, the ice road will be open on average for 12 weeks. Ice roads are widely used to assess mining sites as well as by the Government to provide land access to the vast and sparsely populated regions of the north.

The project’s ice road route was surveyed in August 2002 to determine if impacts from use up to that point could be discerned. The survey concluded that the road has not caused any significant erosion of lake shores or stream crossings and there was no evidence of any adverse impacts to terrestrial or shoreline habitat caused by travel over the ice road.

10.8.2 Potential Physical & Ecological Effects

Use of this road could potentially cause the following types of impacts: erosion, bank instability, permafrost exposure, and compaction of streambed sediments. Secondary effects include sedimentation and habitat damage.

10.8.3 Mitigation

The vehicles that use the road have large tires that distribute the load and there is usually a thick snow pack that further insulates terrestrial habitat from physical damage. The 75 km route is designed to follow frozen lakes as much as possible and often crosses rocky shores and avoids sensitive knolls. Monitoring (see below) will be used to measure the efficacy of this approach and determine if further mitigation (e.g., protection added to crossings, further route alteration) is needed.

10.8.4 Monitoring

The objective is to monitor the ice road route at appropriate intervals so that any environmental impacts from use can be detected and (if needed) mitigation implemented before any impacts become significant. The approach is to repeat the survey completed in August 2002 after the next year of ice road use and then to repeat that survey annually during mine operation (for the first three years). After that time, assuming that any impacts are negligible, the survey will be repeated every five years over the life of the mine to assess cumulative impacts.

The survey consists of flying the ice road at low elevation (200 m and low speed) after ice-off, inspecting the route for impacts, augmented by ground visits at key crossing points (established in 2002 survey). These key points for visual inspection include all significant locations where the ice road exited or entered lakes and where streams were crossed or followed. It will be important for the inspections to discern the cause of any observed impacts, particularly as the ice route approaches both the mine site and the community of Baker Lake, where all-terrain vehicles may be in use.

10.9 IMPACT OF FRESHWATER CONSUMPTION DURING OPERATION

10.9.1 Description of Activity

All freshwater for the Meadowbank project (potable water, mine process water, etc.) will be collected via a submerged intake pipe situated 75 m offshore in 10 m water depth from the north basin of Third Portage Lake, as described in the EIA (Cumberland, 2005). The opening to the pipe will be at least 0.5 m off the bottom. Freshwater will be drawn from the lake at a continual rate of approximately 21 L/s. Maximum potential water withdrawal rate is 130 L/s. The annual withdrawal volume is 667,000 m^3/yr.

10.9.2 Physical & Ecological Effects

Freshwater withdrawal from Third Portage Lake is expected to have negligible effects, particularly with application of mitigation measures.

10.9.3 Mitigation

The following mitigation measures will be implemented to minimize impacts to fish and fish habitat:

- The intake pipe will be situated at least 25 m from the nearest rocky shoal or shoreline. Small or juvenile fish are not usually found away from the protection or rocky shoals or shorelines because of vulnerability to predation by lake trout. Siting the intake in deep water away from cover habitat will minimize the risk of entrainment.

- The intake will operate at a water depth of at least 8 m and sit 0.5 m off the bottom above silt/clay sediment away from shorelines or shoals.

- The intake will incorporate Department of Fisheries and Oceans (1995) design features to minimize entrainment of fish by reducing intake velocity. These guidelines stipulate that, given the predicted maximum intake volume of approximately 0.13 m^3/s (based on instantaneous flow calculated from an average monthly intake volume of 55,600 m^3), the minimum surface area at the intake must be 1.16 m^2, not including additional area to account for the type of mesh screen used at the intake. Assuming that a 1.5 mm wire screen is used, this will increase the minimum intake opening to 1.78 m^2. This is sufficient to reduce intake velocity to allow fish to avoid becoming entrained in the flow.

10.9.4 Monitoring

No monitoring is planned due to the anticipated negligible effects.

SECTION 11 • NO-NET-LOSS OF FISH HABITAT MONITORING

This section will be closely tied to the NNL (NNL, 2005) document supporting the EIA and will summarize monitoring activities related to No Net Loss of fish habitat. Activities will include use of dike habitat enhancement structures by fish, Turn Lake stream-crossing habitat use, enhancement of migration corridors or connecting channels by fish between Second and Third Portage lakes, Dogleg Lake, and possibly other lakes.

This section will be prepared when the NNL document has been completed and a framework for monitoring and assessment has been agreed to. A SAP will be prepared that will outline all monitoring of fish habitat as required under NNL to meet conditions of the DFO habitat authorization.

SECTION 12 • QUALITY ASSURANCE/QUALITY CONTROL (QA/QC)

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 the techniques used to measure and assess data quality and remedial actions to be taken when data quality objectives are not realized. Mines and their consultants must ensure that reliable method of sample tracking, logging, and data recording is practiced and documented to establish continuity between the sample collected and the results reported. Standard operating procedures should also be available, as required, particularly for laboratory activities. Environment Canada (2002) provides detailed guidance regarding QA/QC procedures for MMER study components, which can be used as a cornerstone for the AEMP. Existing guidance will be followed as appropriate and, where deviations are required, the changes will be documented and evaluated for their potential implications for data quality and interpretative value.

The purpose of this section is to briefly outline field and laboratory approaches proposed for the AEMP, but further details will be provided in the SAPs. Complete descriptions of QA/QC procedures followed for collection, transport and analysis of water and sediment chemistry and results will be described within annual monitoring reports.

12.1 FIELD DATA COLLECTION

Standard sampling procedures will be used over the course of construction and operation to maximize comparability among years and with reference areas. An important QA method in the field involves the completion of data sheets to provide a record and hard copy of relevant observations. Descriptions of key information that will be recorded on the data sheets are described for each monitoring component.

The main concerns for sample collection in the field center on the proper use of equipment and prevention of cross-contamination. Consistency in sample collection, proper calibration methods, and collection of appropriate QA samples will be an integral part of the field investigations.

One of the most important aspects of QA/QC is having experienced field personnel on-site. Cumberland intends to staff the AEMP with individuals with the right experience and ensure that they have access to the equipment and support they need to execute the AEMP.

12.2 SHIPPING & TRANSPORT

Along with proper sample packing and shipping methods, the monitoring team will use comprehensive chain-of-custody procedures to ensure that sample integrity is maintained until arrival to the laboratories. Arrangement for sample shipment will be confirmed with the laboratories prior to field work and these 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.

12.3 LABORATORY PROCEDURES

Cumberland will use laboratories that have been certified for analysis of all applicable materials. Every attempt will be made to employ the same analytical laboratory for all chemical parameters over all years, for data consistency. The QA/QC program used will include field duplicates (blind), laboratory and field blanks, swipes, use of certified reference materials, matrix spike duplicates, blind duplicates, and relative percent different standards.

The general data quality objectives (DQOs) for this project will be as follows:

- analytical precision = 25% relative percent difference (RPD) calculations for concentrations that exceed 10x the method detection limit
- analytical accuracy = 80% to 120% recovery of matrix spikes and CRMs
- completeness = 95% valid data obtained.

Cumberland will employ taxonomists who are familiar with taxonomic identification of lower trophic level biota from Canadian Arctic lakes and experience in the identification of local biota. The taxonomists used for the AEMP will maintain a reference collection. Again, every attempt will be made to employ the same analytical laboratory for all chemical parameters over all years, for data consistency.

SECTION 13 • POST-CLOSURE AQUATIC MANAGEMENT PLAN

It will be important for post-closure management to reflect learning over the course of mine development and operation. The monitoring and mitigation strategies emphasize the adaptive nature of the AEMP and this will culminate in design of a post-closure management plan.

While it is difficult to specify the details of post-closure management plans at this point, there are some general expectations:

- Mine decommissioning is essentially a mitigation phase, resulting in an increased potential for the mine site to return to natural conditions. Mine closure planning will begin well before mine closure, and will be negotiated to address key concerns.
- Any post-closure monitoring requirements will focus on:
  - Infrastructure changes such as removal of Turn Lake culverts, dike openings, fish habitat utilization of dike interiors, MMER monitoring of effluents, etc.
  - Any impacts of mine construction and operation that had greater environmentally consequential than was predicted in the EIA (e.g., if there was a significant impact detected where none was anticipated).
- It is possible that a subset of the core program (Section 7) will be retained for long-term monitoring. The choice of where and what to monitor would be made by reviewing the utility of monitoring applied over the course of mine life.
- The overall experience level with mine closure will have increased, resulting in increasingly improved best management practices that will be applied at the time of closure of Meadowbank mine.

SECTION 14 • REFERENCES

AMEC. 2003. Meadowbank Gold Project. Hydrologic monitoring 2003 data report. A report prepared by AMEC Earth and Environmental, Calgary, AB for Cumberland Resources, Vancouver BC.

Baseline Aquatic Environment Assessment Report (BAEAR). 2005. Baseline aquatic environmental assessment report, Meadowbank study area lakes, Nunavut. A report prepared for Cumberland Resources by Azimuth Consulting Group, Vancouver.

Baker, R.F., P.J. Blanchfield, M.J. Paterson, R.J. Flett and L. Wesson. 2004. Evaluation of non-lethal methods for analysis of mercury in fish tissue. Transactions American Fisheries Society. 133:568 – 576.

Canadian Council of Ministers of the Environment. 1999 (with updates, 2001, 2002). Canadian Environmental Quality Guidelines. Canadian Council of Ministers of the Environment, Winnipeg.

Cumberland Resources Ltd. 2005. Meadowbank Gold Project – Spill Contingency Plan.

Cumberland Resources Ltd. 2004. Meadowbank Gold Project – Environmental Impact Statement.

Cumberland Resources Ltd. 2005. Traditional Ecological Knowledge Study.

Caux P.-Y., F.R.J. Moore and D. MacDonald. 1997. Ambient water quality criteria for turbidity, suspended and benthic sediments in British Columbia: Technical Appendix. Prepared for British Columbia Ministry of Environment, Lands and Parks, Water Quality Branch, Victoria, BC.

De Beers Canada Mining Inc. (De Beers). 2002 (February). Snap Lake Diamond Project Environmental Impact Assessment. Chapter 9, Aquatic Resources + App.; p 9-1 to 9-416.

Department of Fisheries and Oceans (DFO) 1992. Introduction to fishway design. C. Katopodis, Freshwater Institute, Department of Fisheries and Oceans, Winnipeg MB.

Department of Fisheries and Oceans (DFO). 1995. Freshwater intake end-of-pipe fish screen guideline. Department of Fisheries and Oceans, Ottawa Report No. 5080. 27 p.

Diavik Diamond Mines Inc. and Aber Resources Ltd. 1998 (March). Diavik Diamonds Project Integrated Environmental and Socio-Economic Baseline Report. Volume I. Chapter D-6, Water Quality; p 154-175, and Chapter D-7, Aquatic Ecosystem; p 176 - 222.

Environment Canada. 2002. Metal Mining Effluent Regulations (MMER). Document for Environmental Effects Monitoring. Document found at www.ec.gc.ca/eem.

Fee, E.J., M.P. Stainton, H.J. Kling. 1985. Primary Production and Related Limnological Data for Some Lakes of the Yellowknife, NWT Area. Canadian Technical Report Fisheries and Aquatic Sciences 1409: v + 55 p.

Findlay, D.L., S.E.M. Kasian, M.T. Turner, and M.P. Stainton. 1999. Responses of phytoplankton and epilithon during acidification and early recovery. Freshwater Biology. 42: 159-175.

Holling, C. S. 1978. Adaptive environmental assessment and management. John Wiley and Sons, NY. 377 pp.

Lawrence, M., S. Davies, G. Collins, F. Hnytka, K. Kroeker, and R. Sie (Environment-Social Program Northern Pipelines). 1977. Aquatic Resources Survey-Keewatin District Preliminary Report 1977. ESCOM No. AI-07. 50 p.

MacDonald, G. and Stewart, D.B. 1980. Arctic land use research program 1980: a survey of the aquatic resources of the central Keewatin region of the Northwest Territories. Northern Affairs Program Environmental Studies Vol. 17. March, 1980. Ottawa, Ontario. 111 p.

Machniak, K. 1975. The effects of hydroelectric development on the biology of northern fishes (reproduction and population dynamics) IV. Lake trout *Salvelinus namaycush* (Walabum). A literature review and bibliography. Fisheries and Marine Services Division Technical Report No. 530. 52p.

McEachern, L.J., M.G. Kennedy and E. Madsen. 2003. Fish salvage activities related to diamond mine construction in the NWT. Prepared by Jacques Whitford Environmental Ltd. Yellowknife, NWT. And Diavik Diamond Mine.

McKee, P., R. Watters, D.L. Lush (Beak Consultants Ltd.). 1989 (December). Supporting Document No.4. Aquatic Baseline Conditions – Kiggavik Project Area, District of Keewatin, Northwest Territories. A report prepared for Urangesellschaft Canada Ltd. Toronto, ON, by Beak Consultants Ltd. Brampton ON. 59 p. + App.

McLeod, C.L., P.J. Wiebe, and R.A. Mohr (Renewable Resources Consulting Services Ltd.). 1976. An Examination of aquatic ecosystems in Baker Lake – Lower Thelon River, N.W.T., Area in Relation to Proposed Polar Gas Pipeline Development. 164 p. + App.

McPhail, J.D. and C.C. Lindsey. 1970. Freshwater fishes of northwestern Canada and Alaska. Fisheries Research Board of Canada. Bulletin 173. 381 p.

Metal Mining Effluent Report (MMER). 2005. Framework for the application of metal mining effluent regulations (MMER) at Meadowbank. A report prepared for Cumberland Resources, Vancouver by Azimuth Consulting Group, Vancouver.

Nauwerck A. 1963. Die Beziehungen zwischen Zooplankton und Phytoplankton in See Erken. Symbolae Botanicae Upsaliensis. 17: 1 – 163.

No-Net-Loss (NNL) Report. 2005. A Framework for No Net Loss of Fish Habitat, Meadowbank Gold Project. A report prepared for Cumberland Resources by Azimuth Consulting Group, Vancouver. 2005.

Patalas, K. J. Patalas and A. Salki. 1994. Planktonic crustaceans in lakes of Canada (Distribution of species, bibliography). Canadian Technical Report of Fisheries and Aquatic Sciences. No. 1954. v + 218 p.

Rescan. 1994. NWT Diamonds Project Environmental Impact Assessment. A report prepared for BHP Environmental. Chapter 3.1, Aquatic Life; p 3.3 – 3.143.

Richardson, E.S., J.D. Reist and C.K. Minns. 2002. Life history characteristics of freshwater fish occurring in the NWT and Nunavut with major emphasis on habitat requirements. Can. M.S. Rept. 2569. vii + 146 pp.

Rott, E. 1981. Some results from phytoplankton counting intercalibrations. Schweiz. Z. Hydrobiologia 43: 43 – 62.

Scott, W.B. and E.J. Crossman. 1979. Freshwater fishes of Canada. Bulletin 184. Fisheries Research Board of Canada. 966 p.

[Urangesellschaft] Urangesellschaft Canada Ltd. 1981 (February). Environmental Studies Report – 1980 (Baker Lake Region). Prepared by Urangesellschaft Canada Ltd. Toronto, ON.

US Environmental Protection Agency (USEPA). 1996. Method 1669 – Method for sampling ambient water for determination of metals at EPA ambient criteria levels. Office of Science and Technology, Engineering and Analysis Division, Washington, DC.

Vollenweider R.A. 1968. Scientific fundamentals of the eutrophication of lakes and flowing waters, with particular reference to nitrogen and phosphorus as factors in eutrophication. Technical Report, Organization for Economic Cooperation and Development, Paris, 27: 1 – 182.

Wright, D.G. and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Canadian Technical Report of Fisheries & Aquatic Sciences 2107. Fisheries and Oceans Canada. 34 pp.

SECTION 15 • LIST OF ABBREVIATIONS

AEMP	Aquatic Effects management program
Anadromous fish	Fish that spend at least part of their adult lives feeding in marine water and making annual or semi-annual migrations into freshwater lakes to over winter and reproduce.
Aquatic	Pertaining to plants or animals that live in freshwater or marine environments
Arctic	The Arctic is a geographic region that is circumpolar in extent and generally characterized as being north of the treeline, in an area of continuous permafrost.
Baseline studies	Initial scientific investigations that determine the present condition of an area to establish a basic reference for future studies. These studies have been conducted to document pre-project conditions.
Benthic	Pertaining to the bottom region of a water body, such as a lake.
Benthic invertebrates / Benthos	Assemblage of organisms living in or on the bottom sediment of a water body and dependent upon the decomposition cycle for most, if not all, of their food supply.
Biomass	The total mass of living organisms usually expressed as a weight per unit area or volume (e.g., mg/m^3 of water).
Bivalves	Molluscs with shells consisting of two halves (i.e., valves) such as clams.
CCME	Canadian Council for Ministers of the Environment
Chironomids	Midges (two-winged insects) in the order Diptera. The aquatic larval form of this insect is typically the most abundant and diverse group of insects found in lakes.
Core monitoring	Consists of general monitoring for water and sediment quality, periphyton, benthic invertebrates, and fish—tailored based on our understanding of mine construction, operation, and infrastructure (e.g., dikes, effluents, stream crossings, roads, etc.). Core monitoring will be implemented prior to and during construction and operation of the mine and will be conducted each year, until closure. Core monitoring is integrated with and complemented by targeted monitoring.

Density of organisms	A term that describes abundance. The total number of living organisms expressed per unit area (e.g., no./m^2) or volume (#/m^3).
Dipteran insects	Insects of the Order Diptera, consisting of flies having two-wings that includes chironomids, flies, and mosquitoes.
Dissolved concentrations (water)	The concentration of chemical parameters in water filtered through a 0.45 µm glass fibre filter. This is operationally defined as the dissolved fraction in water.
Diversity	A measure (e.g., Shannon-Weaver index) of the variety of living organisms in an area (e.g., number or richness of species).
Drainage basin	The term given to a geographic area that contributes surface and groundwater to a particular lake, river, or stream (also see watershed).
Ecosystem	A community of interacting organisms considered together with the chemical and physical factors that make up their environment.
EEM	Environmental effects monitoring
Effect	A change to an ecosystem component due to human activities. The effect may have a negative, positive, or neutral impact.
Environment	Components of the earth including land, water, air, and all layers of the atmosphere. Also included are organic and inorganic matter, living organisms, and all interacting natural systems.
Environmental Impact Assessment (EIA)	A quantitative approach to environmental studies designed to identify, predict, and interpret information about the potential geographic and temporal scale and magnitude of impacts caused by industrial activities directly and indirectly associated with an industrial development on ecological health, and human health and well-being.
Eutrophic	Nutrient-rich waters with high primary productivity.
Fish	The definition of fish in the Fisheries Act (Section 2) includes: "Shellfish, crustaceans, marine animals, the eggs, sperm, spawn, spat and juvenile stages of fish, shellfish, crustaceans, and marine animals."
Food chain	Organisms that are linked together in a series that, by consuming lower level organisms, transfer nutrients and energy from one group to another.
Food web	The concept used to describe the relationships of organisms within an ecosystem that are interconnected through various feeding linkages, resulting in the transfer of nutrients and energy.

Freshet	The increased flow of water over a relatively short period of time, usually during spring, caused by snowmelt.
Global Positioning System (GPS)	A sophisticated system used to define a precise geographic location with the aid of a satellite system. Units are typically expressed as UTM (Universal Transverse Mercator) or in latitude and longitude.
Groundwater	Water found in soil or in pores, and crevices under the ground.
Habitat	The Fisheries Act (Section 34) defines fish habitat as: “spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes.” (see also definition of fish)
Hydrology	The study of the properties of water and its movements in relation to land.
Impact	An effect, either positive or negative, of an activity or process on ecological components of a receiving environment.
Invertebrates	A collective term for all animals without a backbone or spinal column and includes all aquatic animal organisms except fish.
Larva	The immature stage, between egg and pupa, of an insect with complete metamorphosis. Many insect larvae are aquatic, including chironomids, mayflies, stoneflies, and caddisflies.
Limnology	The study of freshwater lakes including biological, geological, physical, and chemical aspects.
Littoral	The region of a lake, including water and sediment, from the surface to a depth at which photosynthesis ceases, usually within the upper 10m of the water column.
Meadowbank project Area lakes	Those lakes that are potentially directly or indirectly affected by mine development and include Third Portage, Second Portage, Turn, Tehek, Vault & Wally lakes.
Micro (µ)	A unit of measurement denoting a factor of one-millionth, such as µg/g.
Milligram (mg)	A unit of measurement denoting a factor of one-thousandth, such as mg/g.
Mitigation	An activity aimed at avoiding, controlling, or reducing the severity or duration of adverse physical, biological, and/or socio-economic impacts of a project activity.

MMER	Metal Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NNL	No Net (Habitat) Loss
NTU	Nephrolometric turbidity units (a measure of turbidity)
Nutrient	Any substance that provides essential nourishment for the maintenance of life (e.g., carbon, nitrogen, and phosphorous).
Nutrient enrichment	The enhancement of nutrients in a water body over and above the concentration that will be considered typical for the region.
Oligochaetes	True worms from the Phylum Annelida (segmented worms) that are common in sediment of freshwater habitats.
Oligotrophic	Nutrient deficient waters with low productivity. The vast majority of Arctic lakes are oligotrophic.
Organic Carbon (sediments)	The non-mineral fraction of the sediments that consists of organic carbon, expressed as a percent (%) of the total weight of sediment. This includes all forms of carbon except carbonates.
Periphyton	The collective name given to the community of algae that exists attached to underwater surfaces, such as rocks, in lakes and streams.
Permafrost	Subsoil that has been frozen for at least two years.
Phytoplankton	Microscopic or small floating plants suspended in the water column of aquatic ecosystems.
Piscivore	Any animal that feeds on fish (e.g., lake trout).
Planktonic	Referring to organisms with limited mobility that are free-floating and living in the water column.
Predator	Any organism that consumes another organism.
Prey	Any organism that is consumed by another organism.
Primary consumers	Organisms such as zooplankton that feed on primary producers (e.g., phytoplankton) for their source of nutrients and energy.
Primary production	Production by photosynthetic organisms, such as algae, phytoplankton and periphyton. Photosynthetic organisms comprise the bottom of the food chain.

Primary productivity	A term given to the rate at which new biomass (i.e., plant tissue) is generated by photosynthetic organisms (i.e., plants) using energy captured from the sun.
Quality Assurance / Quality Control [QA/QC]	Sampling and analytical procedures (such as lab replicate sample analysis) that are integrated in field collection and analytical procedures to ensure acceptable data quality.
Reference lakes	Lakes that are used as controls for comparison to project lakes and include an internal reference lake (Third Portage Lake south basin) and an external reference lake (Inuggugayualik Lake).
Residual effects	Effects that persist after mitigation measures have been applied.
Richness	The number of unique taxa (e.g., species) found at a particular location.
Sampling and analysis plan (SAP)	A detailed description of the approach and methods for sampling, including: goals, rationale/approach, statistical design, sampling schedule, operating plans and procedures, quality assurance/quality control, and a plan for interpretation and evaluation.
Secchi disc	An eight-inch disk with black and white quadrants used to determine water clarity.
Secondary consumer	Organisms such as forage fish that consume primary consumers (e.g., zooplankton) for their source of nutrients and energy.
Secondary productivity	The rate of increase in biomass of organisms that consume plants or other primary producers.
Sediment grain size	Refers to the size and relative size distribution of the particles that make up the sediment. Typically, they are divided into four groups including clay, silt, sand and gravel.
Sediment Quality Guidelines [ISQG]	Reference concentrations of contaminants in sediments that, if exceeded, indicate that organism-level effects may occur.
SOPC	Stressor of potential concern; stressors are any physical, chemical or biological entity that can induce an adverse effect on environmental systems.
Stratification	Vertical differences in water temperature, causing a density difference between warm, less dense surface water and cold, more dense bottom water, retarding or preventing mixing of surface and bottom water.

Targeted monitoring	Targeted studies are specific studies that typically have narrower temporal or spatial bounds (than core monitoring studies) or are designed to address specific questions related to particular components of mine development during construction or operation. Targeted monitoring is integrated with and complementary to the core monitoring design.
Total metals concentrations (water)	The total concentration of a metal in the water, which includes both freely dissolved and particle-bound forms of the metal.
Total Suspended Solids [TSS]	The weight of solids that are suspended in a given volume of water, expressed as weight per unit volume (e.g., mg/L).
Trophic Levels	A functional classification of organisms in an ecosystem according to feeding relationships, from primary producers through primary consumers, through secondary consumers.
Tundra	Habitat typically found in the Arctic north of the treeline that is characterized by cold temperatures, a short growing season, and low precipitation. Typical tundra vegetation includes moss, lichen, Labrador tea, and small shrubs.
Turbidity	A condition of reduced transparency in water caused by suspended colloidal or particulate material; measured by a turbidimeter and recorded as nephrelometric turbidity units (NTU).
Ultra-oligotrophic	Lakes with extremely low nutrient levels, high water clarity, low primary productivity, and a dominance of small unicellular phytoplankton species. Total phosphorous concentrations are typically <0.005ug/L in these lakes (Vollenweider 1968).
VECs	Valued Ecosystem Components; In the NIRB Terms of Reference it states "Valued Ecosystem Components (VECs) have been identified in consultation with regulatory authorities and members of the local community. They include fish and wildlife species populations, habitat, air quality, water quality, surface water quantity and distribution, vegetation cover, and permafrost."
Water Quality Guidelines	Reference concentrations of contaminants in water (e.g., CCME guidelines) that, if exceeded, indicates that organism-level effects may occur.
Watershed	An entire geographic area that contributes surface and groundwater to a particular lake, river, or stream.
Zooplankton	Small, floating or weakly swimming animals found in fresh and marine waters, such as copepods and cladocerans.

APPENDIX A

Linkage Matrices

Table A.1: Linkage Matrices

Mine Activity	Potential Physical Effects	Potential Ecological Effects	Mitigation	Residual Effects	Monitoring Strategy
Dike Installation: Second Portage Lake Third Portage Goose Island Vault Lake	Disturbance of fine bottom sediment causing increased TSS, reduced water column transparency	Impairment of primary production Impairment of gill function Smothering of benthic habitat Smothering of spawning habitat	Use silt curtains	Possible sediment introductions causing smothering of benthos, impaired feeding efficiency by fish	Multiple daily monitoring stations for turbidity and TSS at regular locations – develop turbidity/TSS relationship; Use sediment traps to monitor deposition
	Release of pore water metals from fine, bottom sediments	Potential toxicity to algae, zooplankton and fish	No mitigation possible	Increase in dissolved metals concentrations in water column	Daily monitoring of total and dissolved metals
	Direct introduction of sediment and nitrates from coarse material	Reduced water column transparency. Increase in productivity	Use silt curtains	Increase in nutrient concentrations causing increased productivity	Weekly monitoring of nutrients, chlorophyll *a* Monthly phytoplankton biomass
	Direct disturbance of fish	Avoidance of construction area from noise, disturbance	No mitigation possible	Temporary displacement of fish	None
	Elimination of fish habitat from dike footprint	Reduction in abundance of fish in Second, Third Portage	Enhancement of dike structures to improve spawning, foraging habitat	Net loss of fish habitat; See No Net Loss plan	Use silt curtains to prevent fish from accessing affected lake areas
Lake Drawdown and Dewatering: Second Portage Lake Third Portage Goose Island Vault 1 Lake	Second Portage Lake north arm will be impounded and drawn down Goose Island, Third Portage impounded Vault Lake impounded	Mortality of fish from stranding Increase in sediment introductions will reduce visibility, cause sedimentation in depositional zones of foraging areas Increased predation from crowding	Fish salvage for domestic consumption by Baker Lake residents	Net loss of fish habitat; See No Net Loss plan	Conduct special monitoring program to determine biomass of fish in permanently impounded lake areas. See No Net Loss Program
	Loss of fish habitat	Reduction in fish populations	Create habitat and structures on dikes; Habitat replacement and compensation	New habitat created; Net habitat loss Compensation Program	See No Net Loss Program

Table A.1 – Continued

Mine Activity	Potential Physical Effects	Potential Ecological Effects	Mitigation	Residual Effects	Monitoring Strategy
Physical Mine Site - Sewage and gray water - Process related effluent - Other	Introductions of metals and other contaminants from effluent streams	Toxicity to aquatic biota in receiving environments Alteration to fish tissue quality and increase in metals	Collect and control all effluents in attenuation pond, separate from Tailings Pond (Y1-5); No spatial overlap with metals-contaminated tailings Effluent discharge to Goose Pit >Y5	Possible elevated metals, nutrient concentrations in effluent prior to Year 5; No effect after Year 5	Conduct weekly monitoring for nutrients and metals; select conventional parameters; See MMER, 2005 monitoring program
	Introduction of nutrients	Increase in lake productivity and fish populations	Control nutrient release	Increase in primary productivity and possible increase in aquatic production, increased biomass	Weekly monitoring for chlorophyll *a* Monthly monitoring for phytoplankton
	Introduction of dust and fugitive emissions	Local impairment of water quality	Use dust control procedures	Particulates enter water column and settle in depositional areas	Install sediment traps at key areas along dikes and trout spawning shoals
Surface Water Runoff and Pit seepage	Introduction of sediments, metals, contaminants	Reduced productivity, potential local toxicity to aquatic biota	Collect and control all effluents prior to discharge	Providing the collection system does not fail, there are no long-term residual effects; No discharge to Third Portage Lake after Year 5	Ensure that surface and groundwater sources are being captured
Turn Lake Road Crossing	Impaired fish movement	Loss of access by fish to Drilltrail Lake	Construct during winter when channel is frozen	Nil	Routine monitoring of stability of crossing
	Presence of culvert structure	Possible habitat loss and impaired movement by fish through culverts	Install natural materials in culvert bottom. Enhance existing habitat at approaches and aprons of road access. Create habitat structures at approaches	Short-term lack of use of lake bed. Reduced productivity because of shading. Impaired movement through culverts limits fish movements	Monitor habitat use by lake trout. Install hoopnets at entrances and tag fish to confirm movements through culverts

Table A.1 – Continued

Mine Activity	Potential Physical Effects	Potential Ecological Effects	Mitigation	Residual Effects	Monitoring Strategy
Operation of Dikes Dikes and Fish Passage	Impoundment of Second Portage, Goose Island and Vault 1 Lake areas	Loss of fish habitat and lake. Decreased abundance of fish.	Habitat enhancement of dike exteriors. Post-closure enhancement of dike interior	Net habitat loss; See No Net Loss program	Monitoring of habitat utilization of dike exterior by fish
	Metal Leaching from Dikes. Second Portage. Goose Island	Alteration of fish habitat. Reduced lake productivity	Use of non-metal leaching material on dike exteriors. Install habitat enhancement structures	Impairment of periphyton growth and colonization by benthos	Monthly monitoring of periphyton biomass
		Impaired periphyton and benthos colonization, mortality of fish eggs	Use non metal leaching material on dike exterior	Reduced periphyton growth. Mortality of fish eggs	Determine seasonal periphyton growth. Determine impacts to fish eggs in experimental setting
	Alteration in movement by fish between Second and Third Portage lakes	Impaired movement by fish to access habitat	Improve existing connecting channel between lakes. Construct new connecting channel	Improved movement by fish. Note current utilization by fish is very low	Monitor fish movements in channel using hoopnets. See No Net Loss plan
	Presence of dikes, noise, vibration, blasting.	Impairment or prevention of fish movement between Second and Third Portage lakes	Relocate an engineered connection channel	Improved access by fish, especially Arctic char between Second and Third Portage. Current utilization by fish is very low	Use hoop nets to monitor fish movements
	Habitat alteration of dikes	Increase in habitat quality may enhance productivity, spawning	Habitat improvement of dikes	Enhancement of fish habitat; See No Net Loss program	Monitor habitat utilization of dikes by fish
Water Intake Pipe	Withdrawal of water for consumptive purposes	Entrainment of larval and juvenile fish. Consumptive use of water alters lake drainage pattern	Install intake pipe near lake bottom away from coarse sediments. Design to have low intake velocity to enable avoidance by fish. Follow DFO intake guidelines	Potential entrainment of fish	Periodic monitoring of entrained water flow to determine if entrainment is occurring

Table A.1 – Continued

Mine Activity	Potential Physical Effects	Potential Ecological Effects	Mitigation	Residual Effects	Monitoring Strategy
Use of Explosives	Introduction of nutrients adhered to rock and directly to water column	Potential increase in lake productivity and fish abundance	Minimize inputs of nutrients	Possible increase in abundance of fish; may be viewed as positive impact, depending on perspective	Monitor chlorophyll *a* concentration. Monthly monitoring of phytoplankton
	Percussive force from blasting	Direct mortality to fish and fish eggs	Deter fish from areas susceptible to blasting effects by using lights, noise, bubble curtain. Follow DFO guidelines for blasting	Possible mortality to fish/eggs	Experimental trial to determine egg mortality on dikes if necessary
Baker Lake All-Season Road	Destabilization of stream crossings causing sediment introductions	Stream channel instability; constrained flow; impaired movement by fish	Use bridges where appropriate; construct during winter; armour approaches to eliminate erosion	Possible minor local impacts to specific stream crossings, shorelines. Risk of fuel, contaminant spill. Minimal impairment of movement by fish. Increased access to lakes not typically fished by local residents	Routine monitoring for bank disturbance; Use hoop nets to verify movements by fish, especially Arctic grayling are not impaired
Baker Lake Marine Facility	Loss of fish habitat along shoreline at barge landing	Possible reduction on local littoral habitat quality in Baker Lake	Place rip rap or geotextile ramp to minimize erosion	Possible local erosion and TSS introduction. Risk of fuel, contaminant spill	Routine monitoring of marine facility to maintain shoreline integrity
Worker Fishing	Access to remote lakes that were previously inaccessible	Unsustainable harvest of fish and depletion of lake trout in Project lakes	Education program to deter fishing	Local depletion of fish population	Creel census to determine level of fishing effort, total harvest, CPUE
Loss of Aquatic Habitat from North Portage Rock Storage	Storage or waste rock and elimination of NP-2 Pond	One small pond containing lake trout will be eliminated. This pond has no connection with Second Portage Lake	No mitigation possible	Loss of fish population in isolated pond	None required; See No Net Loss program
Spills and Accidents	Fuel spills, chemical spills, other	Possible direct and indirect impacts to aquatic biota and habitat	Implement EMS procedures for transportation, refueling, handling of contaminants. Implement emergency spill response plan	Potential for local severe impacts in event of uncontained spill	Routine monitoring of potential contaminant sources (fuel tanks, chemical containment areas). Practice emergency spill response. Implement special monitoring if spill is suspected to identify source

APPENDIX B

Summary of Methods

Methods

Approved sampling and analysis methods are cited in this appendix for each of the major study components. These methods are all based on best practice and guidance, and they are consistent with the methods used during baseline assessment at the mine site (for continuity). Where possible and appropriate, MMER guidance (Environment Canada, 2002) will be followed due to its widespread acceptance by the scientific community. However, this appendix describes variations given site-specific considerations and historical use of methods (e.g., sieve size for benthic samples), as well as project-specific details where for data continuity (e.g., depth of sediment subsampling, equipment used, etc.).

Sample Location

Stations will be located based on the study design (see Sections 7 and 8 and Figures 6.1, 7.1 and 7.2) and GPS coordinates (± 10 m UTM coordinates) will be established early in the AEMP process. A chart recording depth sounder will be used to assist navigation (to acquire profiles of the bottom slope) and acquire accurate depth readings for sampling locations.

Water Quality

Field measurement of standard in situ water quality measures over depth will be conducted at each sampling station using calibrated water quality meters for: oxygen, pH, temperature, and conductivity. Optical depth should be measured using a Secchi disk.

> *During water quality studies in 2002 (summarized in BAEAR, 2005), the issue of sampling depths was evaluated. During spring, lake water was very well mixed with no vertical difference in limnological parameters, therefore water was collected from a single depth, 3 m below the surface. Where there was evidence of stratification (vertical differences in water temperature) and incomplete mixing, a stratified sample of water was taken by sampling equal volumes of water between the surface and 8 m depth and composited into a single sample. However, based on the resulting data, at no time was the water column sufficiently stratified to warrant taking water samples at different depths.*

Consistent with studies conducted at the project lakes to date, all water samples will be collected by pumping water from integrated depths using weighted C-flex (food-grade silicone) tubing and a diaphragm pump. Ultraclean techniques (USEPA, 1996) will be employed to minimize contamination. Collection of dissolved metals samples will be accomplished by filtering the pumped water with an inline filter unit (Gelman 0.45µm pore size) discharged directly into the appropriate vessel. Once the dissolved samples are acquired, the filter will be removed and the second vessel filled for analysis of total metals, nutrients, anions, etc.

Sample handling, preservation, shipping, storage, and analysis will be consistent with Environment Canada (2002). Water sample analysis will include the parameters listed in Table 6.1 (core monitoring), and/or as detailed for targeted studies in specific sections of the monitoring plan (summarized in Table 6.2).

Sediment Quality

Assessment of sediment quality will entail use of accepted collection, handling transport and storage techniques (Environment Canada, 2002), consistent with sampling conducted at the project lakes during baseline monitoring. Sediment will be collected from all stations using a petite ponar grab (e.g., 0.26 m^2 capacity). For this project, the top 2 to 3 cm of the sediment will be sampled and retained for analysis, representational of recent sediment contributions. Depending on the sample volumes needed by the analytical laboratory, it might be necessary to collect multiple grabs and composite the samples.

Sediment sample analysis will include the parameters listed in Table 6.1, and/or as detailed in specific sections of the monitoring plan.

Benthic Invertebrate Community Survey

Detailed sampling guidance is provided in Environment Canada (2002). To be consistent with core (Section 7) and the MMER Framework studies at the project lakes, the following site-specific guidance is provided.

Benthic invertebrates should be collected using a petite Ponar grab (0.026 m^2). At least three grabs per station will be acquired and composited to form a single sample to reduce sampling variation within stations and to increase surface area sampled. The MMER guidance recommends a sieve size of 500 µm for all freshwater mines. A smaller sieve size (250 µm) has been used for baseline assessment to-date at the site. In this situation, Environment Canada (2002) suggests that both sieve sizes be used.

Therefore, for the next one to two years, both sieve sizes should be used to assess the implications of increasing the sieve size. For 2004 (and, results dependent, 2005), grab samples should be sieved in the field through a stack of sieves (250 and 500 µm) to remove small sediment particles. All material (sand, organics, organisms) retained in the two sieves will be rinsed into two separate HDPE jars and fixed with a 10% buffered formalin solution. It is anticipated that the AEMP can thereafter use a sieve size of 500 µm, in line with accepted guidance and at a lower cost to the mine.

At the laboratory, all sieved samples will be rinsed in water to remove the formalin and sieved through a series of sieves to make sorting easier (e.g., >1.00 mm and 500 to1.00 mm, corresponding to coarse and fine size fractions). Organisms will be removed, enumerated, and identified to at least family level or lowest practicable level (Environment Canada, 2002). If there was a large number of one or two particular species, and/or there was a lot of debris in the sample, quantitative subsampling will be performed and carefully documented. The following paragraphs document the subsampling methods used at this site to-date, which should be used in the future for continuity.

For subsampling the fine and medium fractions, the sample will be made up to 100 and 10 mL then removed by Hensen-Stempel pipette, leading to a 1/10th sub-sample. This sub-sample will be made up to 100 mL and the process repeated, leading to a 1/100th sub-sample. The 1/100th sample will be analyzed first and the most numerous organisms identified and enumerated. If 10 or fewer of an organism were found, the 1/10th and total samples will be examined for these species (unless they were too small to be found among the larger, more numerous organisms). This technique has been proven to have a very high degree of quality assurance. Sorted samples will be stored in 70% isopropyl alcohol and archived.

For the coarse fraction (or, for very large samples, the entire sample before sieving) the sample will be weighed and the fraction to be analyzed (1/5 or 1/10) measured by weight. Both these methods have been tested by Applied Technical Services for many years and yield accurate extrapolations. All enumerated samples will be stored in 70% isopropyl alcohol and archived.

Density of organisms/grab sample/m^2 will be determined from the total number of organisms enumerated, adjusted for surface area sampled. There are a number of groups that are quite small in size and are not reliably retained by the 250 µm sieve (historically, this size has been used, but over the next two years the transition will likely be made to a 500 µm sieve). Organisms not retained include nematodes and ostracods (very small crustaceans) and they will not be not reported, nor included in density calculations. Similarly, small numbers of planktonic copepods or adult insects (the very abundant and annoying mosquito and blackfly) present in samples will not be included in density calculations because they were not actually part of the bottom sample.

For continuity, the same group will provide taxonomic identification over time (to-date: Applied Technical Services Inc., Victoria, BC).

Periphyton

Periphyton will be collected by scraping a known surface area of a rock and extrapolating density (cells/ cm^2) and biomass (mg per sampled area) of individual species to a square meter basis for comparison purposes. To-date, a quantitative sampler with a diameter of five cm has been used, consisting of a plexiglass tube with a plunger mounted with a wire brush. The wire brush will be used to scrape off the periphyton, which will then be collected by drawing the water within the tube into a syringe. Three field samples will be taken per site.

To obtain unbiased results (e.g., from differential sun exposure or water depth), periphyton sampling stations will be chosen according to the following criteria (also used during baseline assessment): south-facing, depth at 0.5 m below the surface, large, flat rock surface, uniform algal coverage and coverage by periphyton not unusually dense or sparse. This will improve data quality by minimizing natural variability in periphyton abundance associated with differences in each of the above parameters.

In the laboratory, the periphyton samples will be well mixed and two mL subsamples of suspension sonicated for 10 to 20 s using a Sonifer Cell Disruptor (Findlay et al, 1999) and gravity settled for 24 h in an Ütermohl chamber. Cells will be identified, counted, and measured from random fields until 100 cells of the dominant species were found. Cell counts will be converted to wet weight biomass

(mg/m^2) by approximating cell volume. Estimates of cell volume for each species will be obtained by measurements of up to 50 cells of an individual species and applying the geometric formula best fitted to the shape of the cell (Vollenweider, 1968; Rott, 1981). Data will be reported in terms of abundance (number of cells/cm) and biomass (mg/cm^2). Ideally, over time the same taxonomy provider will be used for consistency in methods and equipment (to-date: Algal Taxonomy, Winnipeg).

Given the large natural variability in biomass and potential for sampling bias, it is not useful to make detailed comparisons in biomass among lakes, or over time; however, periphyton sampling will be conducted during targeted studies (see Section 9.1) to assess the effects of potential metals leaching on periphyton growth on the dikes. Care must be taken when collecting periphyton because of the large natural variability in biomass data and because of the confounding effects of different collection and assessment methodologies among studies.

Phytoplankton

Samples (10 to 15 mL) will be collected from a composite of the upper 8 m of water (unfiltered) and preserved in Lugol's solution. To enumerate and identify individual phytoplankton species, 10 mL aliquots of preserved sample will be gravity settled for 24 h. Counts will be performed on an inverted microscope at magnifications of 125X, 400X, and 1200X with phase contrast illumination. Cell counts will be performed using the Ütermohl technique as modified by Nauwerck (1963). Cell counts will be converted to wet weight biomass (mg/m^3) by approximating cell volume. Estimates of cell volume for each species will be obtained by the same method used for periphyton (Vollenweider, 1968; Rott, 1981). A specific gravity of one (1) will be assumed for cellular mass. All biomass estimates should be expressed as mg/m^3 and summed for each taxa to derive biomass estimates by taxa and major group, per station.

Biomass (mg/m^3) will be determined based on species composition and cell density of individual taxa (number of cells/mL). Consideration should be given to using the same taxonomist year-to-year, to minimize variability (to-date: W. Findlay Inc.).

Fish survey

Detailed sampling guidance is provided in Environment Canada (2002). To be consistent with core (Section 7) and MMER studies at the project lakes, the following site-specific guidance is provided. Under the MMER guidance, if effluent concentrations in the discharge environment exceed 1% within 250 m of the discharge points, the MMER program is required to look at the effects of effluent discharge on fish populations every three years. For the core program, regardless of the outcome of the effluent concentration trigger to conduct a fish survey under MMER, a wider fish survey will be conducted.

A representative fish species will be monitored in terms of growth, reproduction, survival and body condition, using non-destructive techniques. The destructive techniques are not recommended for the project lakes, due to their potential deleterious impacts on fish populations.

Round whitefish has been selected as the fish species for population monitoring (see MMER, 2005). A minimum of 100 specimens will be caught/released, aiming for a representative range of sizes. Methods are detailed in Environment Canada (2002) and summarized in Table 6.1.

Fish Tissue

The core program includes assessment of concentrations of metals in fish tissue over time. This assessment is not required for MMER (unless mercury concentrations in the final effluent are >0.05 ug/L), but it will be conducted regardless as part of the core assessment.

Fish tissues will be sampled opportunistically from the following sources of fish, in order of preference: non-surviving fish captured as part of the fish survey, fish captured through recreational fishing, fish collected via angling or gill nets specifically for the purposes of fish tissue collection. A pre-impact baseline will be established from carcasses of important species acquired during salvage operations.

Sampling methods and analysis methods will be as documented in Environment Canada (2002). The metals for analysis are identified in Table 6.1.

It is also possible that non-destructive fish tissue sampling methods could be employed, which may be a substitute for the MMER methods, which require fish sacrifice. This possibility will be explored during preparation for the first field season, specifically evaluating whether this method can net enough fish tissue for metals analysis at the required detection limits. This non-destructive method samples muscle tissue from live fish using Tru-Cut™ tissue biopsy needles, according to the procedure described in Baker et al (2004).