Appendix 39

Whale Tail EEM Cycle 1 Study Design

ENVIRONMENTAL EFFECTS MONITORING:

AGNICO EAGLE MINES LTD.- WHALE TAIL PIT

FIRST BIOLOGICAL MONITORING STUDY DESIGN

Submitted to:

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EXECUTIVE SUMMARY

This document presents the first Environmental Effects Monitoring (EEM) biological study design for Whale Tail Pit. Whale Tail Pit is a new pit, currently under construction, located approximately 50 km northwest of the Vault Pit at Meadowbank Mine, which, in turn, is located approximately 75 km north of Baker Lake, Nunavut. Whale Tail Pit is a satellite pit to the Meadowbank Mine, and the ore will be transported to the Meadowbank Mine for processing.

Dewatering of a portion of Whale Tail Lake was necessary in order to mine Whale Tail Pit. Dike construction to isolate the portion of Whale Tail Lake to be dewatered began in July of 2018. During dike construction, water was pumped from the area enclosed by sediment curtains to create an inflow and thus minimize dispersal of water from within the enclosed area, with increased suspended sediment concentrations, into the rest of Whale Tail Lake. That pumping began on July 27, 2018, at which time Whale Tail Pit was deemed by Environment and Climate Change Canada to be subject to the Metal and Diamond Mining Effluent Regulations (MDMER) under the Fisheries Act. The mine is expected to become operational in Q3 2019.

The study area is in the Garry Lake Lowland ecoregion of the Northern Arctic Ecozone. At Baker Lake, approximately 130 km south of Whale Tail Pit, for the period 2014-2018, the average, minimum and maximum temperatures were −10.5°C, −42.9°C and 20.7°C, respectively. Permafrost is continuous and the ice-free season on the project area lakes is short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is approximately 2 m by March/April.

The bedrock geology in this region consists of Archean and Proterozoic supercrustal sequences and plutonic rocks. Glacial deposits in the region are dominated by till, which has a silty sand matrix and clasts that range from granule gravel to large boulders in size. Eskers and glaciofluvial terraces are also present. Areas of regolith are also found adjacent to exposed bedrock. Numerous lakes, covering about 10% of the landscape in the vicinity of Whale Tail Pit, are interspersed among boulder fields, eskers and bedrock outcrops, with indistinct and complex drainages. Short channels typically connect these lakes, although there is little flow between lakes during most of the year and none during the winter when the channels are frozen.

Whale Tail Pit is located in the headwaters of the Back River watershed, which drains to Chantrey Inlet on the Arctic Ocean. The lakes in the region are ultra-oligotrophic/oligotrophic and very clear. Vertical temperature and dissolved oxygen profiles typically show no vertical stratification during the open water period, although gradients can develop under ice or occur during occasional calm periods. Lake sediment at water depths greater than 8 m is dominated by fine sediments. At shallower depths, sediment grain size increases and the substrate is typically comprised of boulder and cobble at depths less than 5 m, often with a layer of fine sediment draped over coarse materials. Mean total organic carbon (TOC) content of the sediment typically ranges from 2.5% to 5.2%.

The regional fish community includes Lake Trout (*Salvelinus namaycush*), Round Whitefish (*Prosopium cylindraceum*), Arctic Char (*Salvelinus alpinus*) and Burbot (*Lota lota*). Arctic Grayling (*Thymallus arcticus*) are present regionally but have not been captured in lakes or streams at Whale Tail Pit. Two small-bodied

fish species, Ninespine Stickleback (*Pungitius pungitius*) and Slimy Sculpin (*Cottus cognatus*), are present and widely distributed.

The only mine effluent to be discharged at Whale Tail Pit during operations is treated contact water. Contact water from the major mine infrastructure will be directed to the Whale Tail Attenuation Pond WTAP), which will be located in the dewatered north basin of Whale Tail Lake. Contact water will consist primarily of water from the waste rock storage facility and runoff water in the open pit. Camp sewage will be treated in a Newterra™ domestic sewage treatment plant and pumped to the WTAP where it will be mixed with contact water. Other sources of water directed to the WTAP include runoff from developed ground (main sector, industrial sector), runoff from stockpiles (clean materials and ore), and pumped water from the Exploration Camp development.

The excess water will be treated in an Arsenic Water Treatment Plant (AsWTP) to comply with the quality criteria in Type A Water Licence 2AM-WTP1826. The AsWTP has a capacity of 1,600 m^3/hour and is composed of two Actiflo® to remove Total Suspended Solids (TSS) and one Arsenic removal unit (pH adjustment, As oxidation, As precipitation). It also has a sludge dewatering chain with two centrifuges, where the centrate is recirculated to the Actiflo®.

Treated effluent will be discharged to Mammoth Lake from a pair of multi-orifice diffusers, oriented to discharge vertically upward, located approximately 88 to 164 m from shore at a water depth of approximately 9 m. If possible, a plume delineation will be conducted in 2019, using conductivity as a tracer, to determine the extent of the 1% effluent dilution zone. If plume delineation is not possible the extent of the 1% plume will be predicted by modelling. A plume delineation will be conducted immediately prior to the 2020 sample collections.

The EEM fish study uses a control-impact design, using Lake Trout and Slimy Sculpin as sentinel species, with one exposure area, in Mammoth Lake, and two reference areas (Lake D1 and Lake 8). Lethal studies of both species will be conducted, with the Lake Trout component conducted exclusively for EEM and the Slimy Sculpin component integrated with a broader study being conducted by researchers from the University of Waterloo. The EEM benthic invertebrate study will use data collected by the Core Receiving Environment Monitoring Program (CREMP) to test both before-after and before-after-control-impact hypotheses.

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1.0 INTRODUCTION

This document presents the first EEM biological monitoring study design for Whale Tail Pit. Whale Tail Pit is a new pit, currently under construction, located approximately 50 km northwest of the Vault Pit at the Meadowbank Mine, which, in turn, is located approximately 75 km north of Baker Lake, Nunavut (Figure 1-1). Whale Tail Pit is a satellite pit to the Meadowbank Mine, and the ore will be transported to the Meadowbank Mine for processing.

Dewatering of a portion of Whale Tail Lake was necessary in order to mine Whale Tail Pit. Dike construction to isolate the portion of Whale Tail Lake to be dewatered began in July of 2018. During dike construction, water was pumped from the area enclosed by sediment curtains to create an inflow and thus minimize dispersal of water from within the enclosed area, with increased suspended sediment concentrations, into the rest of Whale Tail Lake. That pumping began on July 27, 2018, at which time Whale Tail Pit was deemed by Environment and Climate Change Canada to be subject to the Metal and Diamond Mining Effluent Regulations (MDMER) under the Fisheries Act. The mine is expected to become operational in Q3 2019.

The MDMER requires mines to conduct Environmental Effects Monitoring (EEM) studies that consist of effluent and water quality monitoring studies and biological monitoring studies. The MDMER also impose liquid effluent limits for pH, cyanide, radium, metals and total suspended solids, and prohibits the discharge of a liquid effluent that is acutely lethal to fish. MDMER requires that a first study design for the biological studies be submitted to the Minister of the Environment not later than 12 months after the day on which a mine becomes subject to section 7 of the MDMER.

This Whale Tail Pit study design builds upon the experience with local environmental conditions and biological communities that was garnered during the three EEM cycles completed at the nearby Meadowbank Mine (Azimuth, 2010a, 2012a; C. Portt and Associates and Kilgour & Associates Ltd., 2014, 2015, 2017 and 2018). It is proposed that the same basic design that was used at the Meadowbank Mine, with one exposure area and two reference areas, will also be used in the EEM first biological study for the Whale Tail Pit. The exposure area will be in Mammoth Lake (MAM) which will be the only waterbody where discharge occurs during operations at Whale Tail Pit. (During the construction phase of the mine, dewatering water was initially discharged to Whale Tail Lake South.) It is proposed that the two local reference lakes for the Whale Tail Pit EEM be Lake D1 (LK1) and Lake 8 (LK8; Figure 1-2). Because Lakes D1 and Lake 8 were first sampled in 2018, Pipedream Lake (PDL) and Inuggugayualik Lake (INUG) (Figure 1-1), which have been used as reference lakes for three cycles of EEM at the Meadowbank Mine, may also be used for longer-term elements of discussion or analysis.

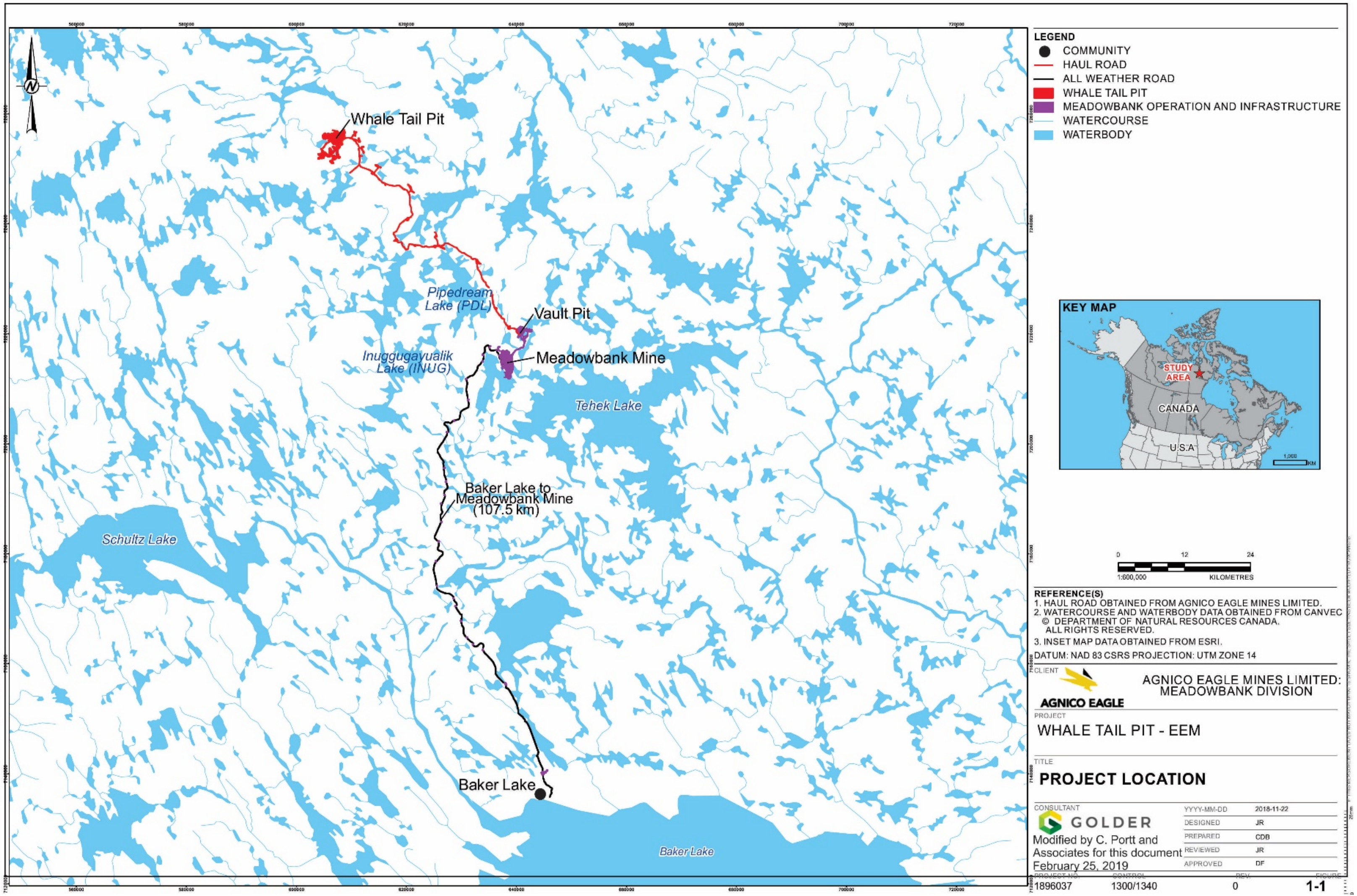

Figure 1-1. Regional map showing Baker Lake, Vault Pit, Meadowbank Mine, and Whale Tail Pit.

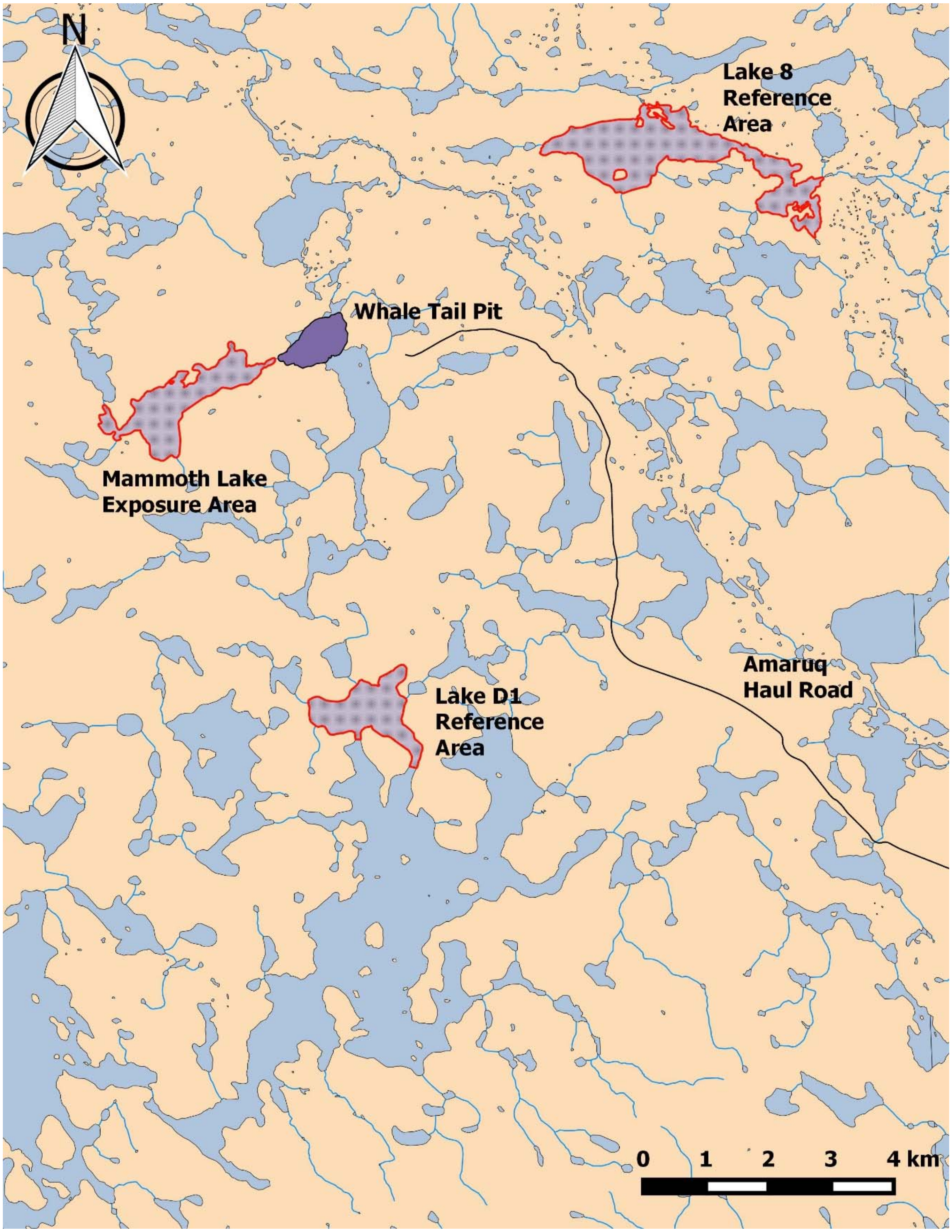

Figure 1-2. Overall study area showing the Mammoth Lake Exposure Area and the Lake D1 and Lake 8 Reference Areas.

2.0 FIRST BIOLOGICAL STUDY REQUIREMENTS

The MDMER requires, for the first biological study, studies that include:

(a) a study respecting fish population, if the highest concentration of effluent in the exposure area, during a period in which there are deposits, is greater than 1% at any location that is 250 m or greater from a point at which the effluent enters the area from a final discharge point, and

(b) a study respecting the benthic invertebrate community, if the highest concentration of effluent in the exposure area, during a period in which there are deposits, is greater than 1% at any location that is 100 m or greater from a point at which the effluent enters the area from a final discharge point, and

(c) a study respecting fish tissue mercury, if

(i) effluent characterization reveals an annual mean concentration of total mercury in the effluent that is equal to or greater than 0.10 µg/L, based on a calendar year, unless the results of the previous two biological monitoring studies indicate no effect on fish tissue from mercury, or

(ii) the method detection limit used in respect of mercury for the analysis of at least two of four effluent samples in a calendar year is equal to or greater than 0.10 µg/L;

(d) a study respecting fish tissue selenium, if

(i) effluent characterization reveals a concentration of total selenium in the effluent that is equal to or greater than 10 µg/L,

(ii) effluent characterization reveals an annual mean concentration of total selenium in the effluent that is equal to or greater than 5 µg/L, based on a calendar year, or

(iii) the method detection limit used in respect of selenium for the analysis of any effluent sample is equal to or greater than 10 µg/L, or the method detection limit used in respect of selenium for the analysis of at least two of four effluent samples in a calendar year is equal to or greater than 5 µg/L.

Based on current knowledge, it is expected that the highest concentration of effluent in the exposure area, during a period in which there are deposits, will be greater than 1% at a location that is 250 m or greater from the point at which the effluent enters the area from a final discharge point. Therefore, both a fish study and a benthic invertebrate study will be required. The only effluent discharged to date has been from lake dewatering and, prior to June 17, 2019, the discharge point was the Phase 1 diffuser in Whale Tail Lake south. Samples taken on March 11 and May 6, 2019, were analyzed for mercury and selenium. The mercury concentration was below the detection limit of 0.01 µg/L in the March 11 sample and was 0.02 µg/L in the May 6 sample. The selenium concentration was below the detection limit of 0.5 µg /L in both samples. Based on these results, there is currently no requirement to conduct a study of fish tissue mercury or fish tissue selenium. The laboratory results for mercury and selenium concentrations in an effluent sample taken on July 3, 2019, are not yet available.

The Metal and Diamond Mining Effluent Regulations (2018) stipulate that the Cycle 1 study design should include the following information:

(a) a site characterization that includes

(i) a description of the manner in which the effluent mixes within each exposure area, during a period in which there are deposits, including an estimate of the concentration of effluent in the exposure area at 100 m and 250 m from every point at which the effluent enters the area from a final discharge point and — in respect of each calendar year — any supporting data, including raw data, for the estimate,

(ii) a description of the exposure and reference areas where the biological monitoring studies would be conducted — whether or not they are required — that includes information on the geological, hydrological, oceanographical, limnological, chemical and biological features of those areas,

(iii) the type of production process used by the mine and the environmental protection practices in place at the mine,

(iv) a description of any anthropogenic, natural or other factors that are not related to the effluent but that may reasonably be expected to affect the results of any biological monitoring study, whether or not it is required, and

(v) any additional information that would enable a determination as to whether studies would be conducted in accordance with generally accepted standards of good scientific practice.

(b) a description of how any required study respecting fish population, fish tissue mercury and fish tissue selenium will be conducted that includes

(i) a description of and the scientific rationale for

(A) the fish species selected, taking into account the abundance of the species most exposed to effluent,
(B) the sampling areas selected within the exposure area and the reference area,
(C) the sampling period selected,
(D) the sample size selected, and
(E) the field and laboratory methodologies selected.

(ii) an explanation as to how, in the case of the study respecting fish population or fish tissue mercury, the study will provide the information necessary to determine if the effluent has an effect on fish population or on fish tissue from mercury;

(c) a description of how any required study respecting the benthic invertebrate community will be conducted that includes

(i) a description of and the scientific rationale for
(A) the sampling areas selected, taking into account the benthic invertebrate diversity and the area most exposed to effluent,
(B) the sampling period selected,
(C) the sample size selected, and
(D) the field and laboratory methodologies selected.

(ii) an explanation as to how the study will provide the information necessary to determine if the effluent has an effect on the benthic invertebrate community;

(d) the month in which the samples will be collected for each required biological monitoring study;

(e) a description of the quality assurance and quality control measures that will be implemented for each required biological monitoring study to ensure the validity of the data that is collected; and

(f) a summary of the results of any studies to determine whether the effluent was causing an effect on the fish population, fish tissue from mercury or the benthic invertebrate community and of any studies in the exposure and reference areas respecting fish tissue selenium completed before the mine becomes subject to section 7 of these Regulations and any scientific data to support the results.

3.0 REGIONAL CHARACTERIZATION

3.1 Ecozone, Ecoregion, and Climate

The exposure lake and the reference lakes are on the Canadian Shield in the barren-ground central Arctic region of Nunavut. The lakes are in the Garry Lake Lowland ecoregion of the Southern Arctic Ecozone. The Garry Lake Lowland ecoregion is described (http://ecozones.ca/english/region/42.html) as an "area of massive granitic Archean rocks, forming a broad, level to gently sloping plain that reaches about 300 m asl in elevation. The mean annual temperature is approximately -lO.5°C with a summer mean of 5.5°C and a winter mean of -26.5°C. The mean annual precipitation ranges 200-275 mm. This ecoregion is classified as having a low arctic ecoclimate. The characteristic vegetation is shrub tundra. Dwarf birch, willow, and alder occur on warm, dry sites; poorly drained sites are dominated by willow, sedge, and moss. The lowland is composed of Turbic and Static Cryosols developed on discontinuous, thin, sandy moraine with Organic Cryosolic soils on level high-centre peat polygons. Permafrost is continuous with low ice content throughout the ecoregion."

According to Environment Canada data, at Baker Lake (https://weather.gc.ca) for the period 2014-2018, the average temperature there was −10.5°C, while the minimum temperature was −42.9°C and the maximum was 20.7°C. Average temperatures in June, July, August, and September, were 6.0°C, 12.7°C, 10.8°C, and 3.5°C respectively. At the Whale Tail Pit location, the time between sunrise and sunset at the summer solstice (June 21) is 22 hours and 42 minutes, and at the winter solstice (December 21) it is 3 hours and 19 minutes.

The ice-free season on the project area lakes is short, with ice break-up in late-June to mid-July and ice-up beginning in late September or early October. Maximum ice thickness is approximately 2 m by March/April (Azimuth, 2019).

3.2 Bedrock Geology

The following description of the bedrock geology of the Whale Tail Pit area is from Golder (2016).

The bedrock geology in this region consists of Archean and Proterozoic supercrustal sequences and plutonic rocks. In the study area the Woodburn Lake Group (Archean supercrustal sequence) was intruded by orogenic granites, which in turn were unconformably overlain by a Proterozoic basin deposit known as the Amer Group (Sherlock et al. 2001; Zaleski, 2005).

The Woodburn Lake Group is a sequence of Archean supercrustal rocks which are thought to have been deposited in a continental rift setting (Zaleski, 2005). The group is composed of:

- a variety of ultramafic to felsic volcanic and volcaniclastic rocks, iron-formation, and related sedimentary rocks;
- quartz arenite, conglomerate, and related sedimentary rocks; and
- arkosic wacke and mudstone that are interlayered with iron formation.

Although the Woodburn Lake Group is Archean, several phases of deformation have affected the stratigraphy, with four events recognized regionally (Sherlock et al. 2001).

The Amer Group was formed during the Early Proterozoic and is a succession of terrestrial and marine sedimentary rocks which outcrop in the north part of the study area near the satellite deposit. This group is composed of quartzarenite, carbonate rock, carbonaceous shale, siltstone, mudstone and sandstone, and tectonized mafic volcanic rock. It overlies the Neoarchean granite and lesser supercrustal rocks of the Woodburn Lake Group.

3.3 Surficial Geology

The description of surficial geology of the Whale Tail Pit below is from Golder (2016).

Glacial deposits in the region are dominated by till, which has a silty sand matrix and clasts that range from granule gravel to large boulders in size. Clast content within the till ranges from 5 to 60%. The till varies in thickness from less than 20 cm overlying bedrock to approximately 10 m; the thicker deposits are found within the satellite deposit study area. The till along the Haul Road tends to be thinner (< 3 m) and the topography is bedrock controlled. In many areas the till is washed (either during deglaciation or by current spring melt events) creating well drained boulder fields.

Glaciofluvial deposits in the form of eskers and terraces are found in the northeast section of the satellite deposit study area and they continue in a southeast direction intersecting the Haul Road study area in several locations. The deposits are composed of well sorted fine- to coarse-grained sand and varying amounts (0 to 95%) of granule, pebble, and cobble gravel. These deposits tend to be thick but are often found adjacent to exposures of bedrock.

Organic and fluvial deposits are rare but where they do exist they are thin (< 1 m) and overlie till. Frost-shattered bedrock forms colluvium at the base of steep bedrock faces. Areas of regolith are also found adjacent to exposed bedrock. The regolith in this area is a jumbled mass of rocky debris formed as glacial ice picked up fragments of bedrock that became detached due to fracturing within the bedrock.

3.4 Regional Hydrology

The broader study area straddles the watershed divide between the Chesterfield Inlet watershed that flows to Hudson Bay, and the Back River watershed which flows north to Chantrey Inlet on the Arctic Ocean. The Whale Tail Pit and the Mammoth Lake exposure area are located in the headwaters of sub-watershed A of the Back River watershed, the proposed EEM reference areas in Lake D1 and Lake 8 are each in different sub-watersheds of the Back River watershed. The main Meadowbank Mine, where the ore is processed and the tailings are stored, is in the Chesterfield Inlet watershed.

Numerous lakes, covering about 10% of the landscape in the vicinity of Whale Tail Pit, are interspersed among boulder fields, eskers and bedrock outcrops, with indistinct and complex drainages. Small channels typically connect these lakes, although there is little flow between lakes during most of the year, likely presenting seasonal barriers to fish movement. In some cases the flow between lakes is always interstitial, and in other cases the flow becomes interstitial during the later summer and fall periods.

3.5 Regional Limnology

The lakes within the broader project area are ultra-oligotrophic/oligotrophic (nutrient poor, unproductive) as is typical of the Arctic. The ice-free season is very short. Ice break-up usually occurs during mid-June to mid-July, and ice begins to form again on the lakes in late September or early October. Complete ice cover is attained by late October, with maximum ice thickness of about 2 m occurring in March/April (Azimuth, 2013).

Vertical temperature (°C) and dissolved oxygen (mg/L) profiles typically show weak (winter; approximately 2 m ice thickness) to no (open water) stratification. During periods of ice cover water temperature is generally near zero at the ice-water interface, increasing to a maximum of approximately 3.5°C at depth, while oxygen concentrations generally decrease slightly with increasing depth.

Cryo-concentration, a phenomenon in which ice formation excludes certain ions and increases their concentration in the non-frozen portion of the mixture, increases the concentration of some ions, such as chloride, in the water near the ice-water interface (Azimuth, 2018b).

3.6 Regional Water Quality

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

Key results were:

- Conventionals - As presented in Azimuth (2010a) total and dissolved solids in surface waters were also low, typically below laboratory detection (<1 mg/L and <10 mg/L, respectively), as was turbidity (<1.1 NTU). Hardness (4.4 to 9.5 mg/L) and dissolved anions (chloride, fluoride, sulphate) were also very low and near detection limits. Surface water had circum-neutral pH (6.6 to 7.7) and low conductivity (5 to 77 µS/cm). Secchi depth of all project lakes frequently exceeded 6 m and on calm days, exceeded 10 m depth. Nutrient concentrations (nitrogen, carbon, phosphorus) in the study lakes were very low and equivalent to values typical of oligotrophic lakes (Wetzel, 1983). Nutrient concentrations did not differ appreciably within or between lakes and seasons, and most values only slightly exceeded laboratory detection limits. Nitrogen nutrients (nitrate, nitrite, ammonia, dissolved phosphate) seldom exceeded 0.001 mg/L, while dissolved phosphate ranged from <0.001 to 0.003 mg/L. Dissolved organic carbon (DOC) values ranged from 1.4 to 2.3 mg/L over all lakes between 1996 and 2002.

- Metals – Mean total antimony, arsenic, cadmium, chromium, copper, mercury, and nickel concentrations from Third Portage, Second Portage, and the other project lakes were all below laboratory detection limits. With the exception of cadmium, the metals were well below CCME

(2001) water quality guidelines for the protection of aquatic life. In the case of cadmium, the detection limit is greater than the CCME (2001) guideline, and therefore it is unknown if the actual cadmium concentration exceeds the guideline. The only metals to exceed detection limits were aluminum (0.006 to 0.014 mg/L), lead (up to 0.0012 mg/L), and zinc (0.001 to 0.019 mg/L). Overall, metals concentrations are typically low and the low frequency of detectable results makes it difficult to identify meaningful differences in baseline conditions among lakes, seasons or years.

3.7 Regional Sediment Quality

The BAER (2005), undertaken prior to the construction and operation of the Meadowbank project, reported that grain size of project lake sediment at water depths greater than 8 m was reasonably consistent between lakes and years and was dominated by fine sediments (clay 50% to 70%; silt 25% to 40%), with some sand (2% to 14%), and no gravel. These general patterns are also evident in the CREMP data (Azimuth, 2008a, b; 2009, 2010b). The consistency in grain size at this depth is consistent with the headwater nature of these lakes; there are no sediment inputs from high-energy stream or river systems. Hydrodynamic regimes are also similar (i.e., low energy) among lakes. At shallower depths, sediment grain size increases and the substrate is typically comprised of boulder and cobble at depths less than 5 m, often with a layer of fine sediment draped over coarse materials.

Mean total organic carbon (TOC) content of the sediment ranged between approximately 2.5% to 5.2% in the BAER (2005). Overall, TOC concentrations are reasonably high for such oligotrophic systems and illustrate the small amount of inorganic contributions to the lakes that might dilute organic materials if sedimentation rates were higher.

The BAER (2005) reported that total metals concentrations in project lake sediment were fairly consistent within and among project lakes and among years. When metal concentrations in the BAER (2005) were compared against CCME (2001) ISQG and PEL guidelines for arsenic, cadmium, chromium, copper, lead, mercury, nickel, and zinc, several guideline concentrations were exceeded, despite the pristine nature of the lakes. Exceedances of these guideline values does not necessarily imply that adverse effects have occurred or are expected to occur, particularly where these occur due to naturally elevated metals. The ISQG and PEL guidelines are relatively conservative and do not reflect site-specific conditions that may limit metals availability to biota. In addition, the guidelines do not consider regional geochemistry or acclimatization by benthic organisms to regional characteristics.

3.8 Regional Fish Fauna

Fish community and population studies were undertaken to establish baseline conditions in the Meadowbank project lakes and candidate reference lakes in advance of mine development. These results were summarized in the BAER (2005). Fish were also sampled by gill netting during the three EEM biological studies that have been conducted at the Meadowbank Mine. (C. Portt and Associates and Kilgour & Associates Ltd., 2015, 2018). The fish community was investigated in the Whale Tail Pit area lakes in 2014, 2015, 2016, and 2018 (C. Portt and Associates, 2018; 2019).

Fish species composition is similar for most lakes in the region. Lake Trout (*Salvelinus namaycush*) dominated gill net catches in all project, reference and regional lakes and were consistent with old, climax community populations that are typical of oligotrophic Arctic lakes. Round Whitefish (*Prosopium cylindraceum*) and Arctic Char (*Salvelinus alpinus*) were the next most abundant species in gill net catches. Burbot (*Lota lota*) are captured occasionally and Arctic Grayling (*Thymallus arcticus*) are present regionally, although not in the Whale Tail Pit area lakes or streams. Two small-bodied fish species, Ninespine Stickleback (*Pungitius pungitius*) and Slimy Sculpin (*Cottus cognatus*), are present and widely distributed. Ninespine Stickleback are frequently present in smaller lakes and ponds where larger species do not occur, provided that either overwintering habitat or seasonal access from larger waterbodies is available.

3.9 Anthropogenic Influences

Apart from mining related impacts associated with the Whale Tail Pit, the only other potential sources of anthropogenic influences in the area are travel along the haul road from Whale Tail Pit to the Meadowbank Mine, which is not open to the public. The Meadowbank Mine is the closest other centre of anthropogenic activity, 50 km to the southeast, and the next nearest community is Baker Lake, 126 km to the south. There are no public recreation zones, roads, docks, wharves, or boat launches in the vicinity of the mine.

4.0 LOCAL AQUATIC ENVIRONMENT AND RESOURCE CHARACTERIZATION

The purpose of this section is to describe known aquatic physical and biological features of the receiving environment at the Whale Tail Pit and Meadowbank Mine areas using historic studies conducted prior to and during construction and operational phases. Pre-development baseline studies describing the physical, chemical, and biological characteristics of the aquatic environment in the vicinity of the Meadowbank project area were initiated in 1995 and continued through 2007 (Azimuth, 2005a; Azimuth 2008a,b). In addition, a comprehensive environmental impact assessment of the aquatic ecosystem (Azimuth, 2005b) and an aquatic effects management program (Azimuth, 2005a; Azimuth, 2012b) were prepared to meet regulatory requirements pertaining to mine construction, operation, and closure.

The Aquatic Effects Management Program (AEMP; Azimuth, 2005a; Azimuth, 2012b) specifically recognized future monitoring obligations under the Metal and Diamond Mining Effluent Regulations (MDMER), which were detailed further in updated AEMP and Core Receiving Environmental Monitoring Program (CREMP) plans (Azimuth, 2012b, c). Note that in current usage, the term CREMP refers to the “core receiving environment monitoring program”; this is synonymous with “core monitoring program” that was conducted in 2006 and 2007. Thus, while the term CREMP was first used for the 2009 annual report, it is meant to encompass the entire core receiving environment monitoring program since 2006. Program details were recently documented in the CREMP and AEMP updates (Azimuth, 2015a, b).

The Core Receiving Environment Monitoring Plan (CREMP) was developed to detect mine-related effects at temporal and spatial scales that are ecologically relevant. CREMP monitoring started in 2006 and in-water mine development started in 2008. The CREMP study design is based on a before-after-control-impact (BACI) approach and monitors “impact” lakes that are directly exposed to mine activities, and “control” or reference lakes that are not. Key mine development activities that could result in changes to the aquatic receiving environment include: East Dike construction (2008), Bay-Goose Dike construction (2009-10), dewatering of lakes and impoundments (2009-11, 2013, 2014, 2016), effluent discharge (2012 to present), and general site-related mining activities that mostly generate dust (e.g., rock crushing, blasting, ore and waste hauling; 2008 to present).

Routine CREMP sampling examines water quality, sediment quality, phytoplankton community, and benthic invertebrate community on an annual basis. Consequently, in addition to data collected expressly to meet the requirements of MDMER, there is a substantial amount of complementary data that is collected in the CREMP on an annual basis that is relevant to addressing MDMER objectives. Fish are not monitored in the CREMP routine sampling. CREMP results are reported annually (Azimuth 2008a, 2008b, 2009, 2010b, 2011b, 2012c, 2013, 2014, 2015c, 2016, 2017, 2018a, 2019).

Pre-development baseline studies describing the physical, chemical, and biological characteristics of the aquatic environment in the vicinity of the Whale Tail Pit were initiated in 2014 and continued through 2016 (Azimuth, 2016b; C. Portt and Associates, 2018) to support the comprehensive environmental impact assessment of the aquatic ecosystem was undertaken (Golder, 2016).

The Core Receiving Environment Monitoring Plan (CREMP) that was developed for the Meadowbank Mine was expanded to include a number of lakes in the vicinity of Whale Tail Pit in 2014 and 2015 as part of baseline data collection for Whale Tail Pit (Azimuth, 2016b; Azimuth 2018c), and those lakes have been sampled annually since. Routine CREMP sampling examines water quality, sediment quality, phytoplankton community, and benthic invertebrate community on an annual basis. Consequently, there is a substantial amount of complementary data that is collected in the CREMP on an annual basis that is relevant to addressing MMER objectives. Fish are not monitored in the CREMP routine sampling. CREMP results are reported annually (Azimuth 2018b, 2019).

This section documents important physical and biological attributes of the Whale Tail Pit study lakes. The information presented comes from the BAER, CREMP, and previous EEM cycles, as well as habitat and fisheries investigations that have been recently undertaken to support agency reviews and approvals of the Whale Tail Pit development.

4.1 Morphology and Bathymetry

Shoreline complexity (i.e., the degree to which a shoreline does not resemble a smooth, circular shape) of all project lakes is moderate to relatively high. Most lakes have large areas of relatively shallow water (i.e. less than 4 meters) with well-defined sub-basins. The maximum depth of the sub-basins in Mammoth Lake range from approximately 10 meters to 16 meters (Figure 4-1) and the maximum depth of the sub-basins in the portion of Lake D1 that is the proposed reference area ranges from 10 meters to 14 meters (Figure 4-2). Preliminary bathymetry for Lake 8 indicates that the maximum depth of its sub-basins ranges from approximately 14 meters to 40 meters.

Substrates along shorelines and shallow shoals consist 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 very few areas dominated by fine substrates, such as sand, in shallow water at depths of less than 4 m. Very coarse substrates are typically predominant to depths of at least 3 m, at which point there is often a transition to finer substrates to about 6 m. At depths greater than 6 to 8 m, substrates are usually silt/clay, though this sometimes overlays coarser material, and can result in boulders or cobble patches protruding from these areas of fine substrate. Figure 4-3 presents the mapped substrates in Mammoth Lake, which was prepared to support the fisheries offsetting plan.

4.2 Limnology

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

Vertical temperature (°C) and dissolved oxygen (mg/L) profiles typically show weak (winter; approximately 2 m ice thickness) to no (open water) stratification. The extent of vertical stratification was most apparent at Mammoth Lake, where concentrations decreased from over 15 mg/L below the ice to approximately

7.5 mg/L at 15 m near the bottom of the lake in May 2018. A similar pattern was observed at INUG in May 2018. Regardless, dissolved oxygen concentrations under the ice usually remain high because of the low rates of biological activity and decomposition of organic material. Any vertical stratification (e.g., due to extended calm periods) during the open water season is very ephemeral and easily broken down and mixed by wind, which is locally frequent and strong, thus maintaining uniform temperature and high dissolved oxygen levels throughout the water column. Once the ice is off by mid-July, water temperatures increase rapidly to reach maximum temperatures of approximately 10 -15°C by late July and early August (Azimuth, 2016a; 2018b; 2019).

4.3 Water Quality

Pipedream Lake and Inuggugayualik Lake have been sampled by the CREMP since its inception. Mammoth Lake has been sampled annually as part of the CREMP beginning in 2014 (1 sample). Lake D1 and Lake 8 were sampled beginning in 2018. CREMP water quality sampling locations in Mammoth Lake are presented in Figure 4-1, with the results provided in Table 4-1, Table 4-2, and Table 4-3. Water quality sampling locations for Lakes D1 and D8 are presented in Figure 4-2 and Figure 4-4, respectively, with the results presented in Table 4-4 and Table 4-5.

Recent (2014-2018) monitoring of Mammoth Lake, Pipedream Lake and Inuggugayualik Lake, as well as the 2018 monitoring of Lakes D1 and D8, show that most parameters in the reference lakes are similar and have remained relatively constant, but in Mammoth Lake several parameters exhibited increases in 2018 that coincide with increased construction activity on site. Azimuth (2019) reports that concentrations of total dissolved solids (TDS), hardness (and major cations), conductivity, nitrate, nitrite, chloride were elevated in Mammoth Lake in the later half of 2018 relative to the baseline period, with concentrations in November 2018 among the highest reported for the lake. Water was still flowing from the north end of Whale Tail Lake into Mammoth Lake at this time, and it is plausible that changes in water quality in Whale Tail Lake resulted in elevated concentrations of some parameters in Mammoth Lake. Also, the highest concentrations were found in samples from the east end of Mammoth Lake, near the connection with Whale Tail Lake. Nitrate, for example, was 0.11 mg/L at the east end of Mammoth compared to <0.005 mg/L at the other end of the lake. Elevated concentrations of nitrate, among other forms of nitrogen, are characteristic of blasting activities during mining construction (BC MOE, 2016).

Metals such as aluminum, chromium, lead, and zinc were also elevated in November at the east end of Mammoth Lake relative to the other end. The development of two quarries around the periphery of the north basin of Whale Tail Lake is consistent with the expected release of blasting residues and the timing of the observed increases in some water quality parameters in Mammoth Lake. However, there were no measured exceedances of the CCME water quality guidelines for parameters with effects-based thresholds. Downstream sampling showed that the construction related changes to water quality did not extend downstream of Mammoth Lake (Azimuth, 2019).

4.4 Sediment Quality

The following summary of sediment quality information is presented in Azimuth (2019).

Lake sediments in the Whale Tail project area are generally similar to those in the Meadowbank Mine area. Particle size distribution in sediment grab samples (top 3-5 cm of sediment surface) is predominantly silt and clay, characteristic of depositional areas in all the lakes sampled in this region. Whale Tail project area lakes are enriched in some metals, with arsenic, cadmium, chromium, copper, and zinc exceeding the interim sediment quality guideline (ISQG) in at least one sample collected in 2018. Of these five metals, arsenic is particularly enriched in sediments throughout the study area lakes, with most samples exceeding the CCME probable effect level (PEL) sediment quality guideline. Chromium also exceeded the PEL in Mammoth as well as two other Whale Tail area lakes. There was considerable within-area variability observed in sediment metals concentrations reported on an annual basis, but as mentioned above, heterogeneity in sediment metals concentrations over a small spatial scale is common in areas of natural mineralization, and has previously been documented under baseline conditions for Meadowbank area lakes. There was no indication of a temporal increase in sediment metals concentrations in the Whale Tail area lakes in 2018, relative to the baseline period. Sediment core samples target the top 1.5 cm of sediment, rather than the 3 to 5 cm targeted in grab samples and are preferentially used in the statistical testing of temporal trends in sediment chemistry.

Baseline toxicity testing was conducted on sediment from Mammoth Lake and Whale Tail Lake in 2018 using *Chironomus dilutus* and *Hyalella azteca*. No difference was noted in *C. dilutus* survival or growth for the sediments from Mammoth or Whale Tail Lakes relative to laboratory or field control treatments. No difference was observed in *H. azteca* survival among the various treatments. There was a significant reduction in amphipod dry weight from the Whale Tail Lake treatment compared to the laboratory control ($p < 0.001$), INUG ($p = 0.0013$), and PDL ($p < 0.001$) at the end of the 14-d test. The reduction in amphipod growth corresponded to a 40% effect relative to the pooled dry weight data from the INUG and PDL field control treatments.

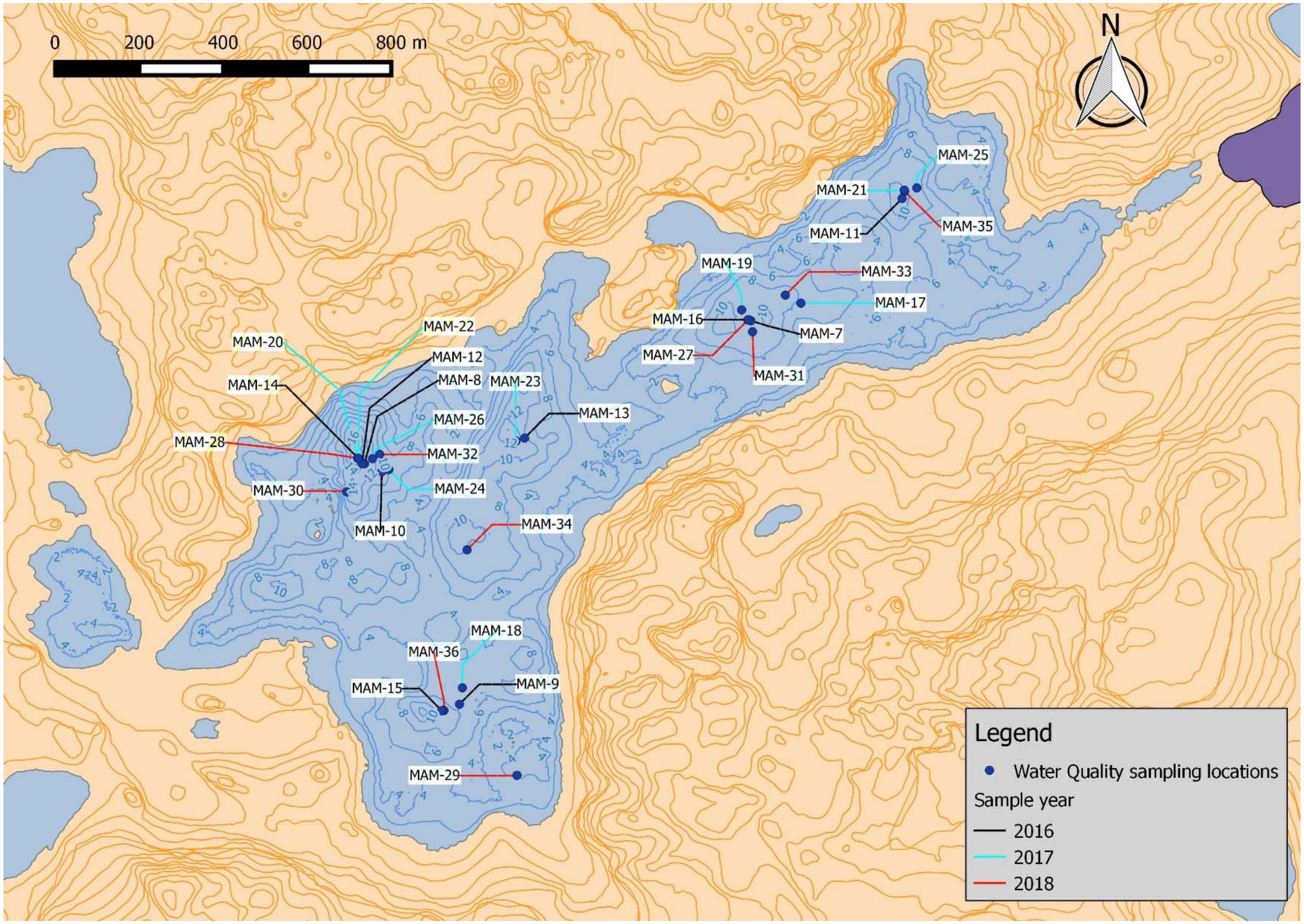

Figure 4-1. Bathymetry (2 m intervals) and CREMP water quality sampling locations in Mammoth Lake for 2016-2018.

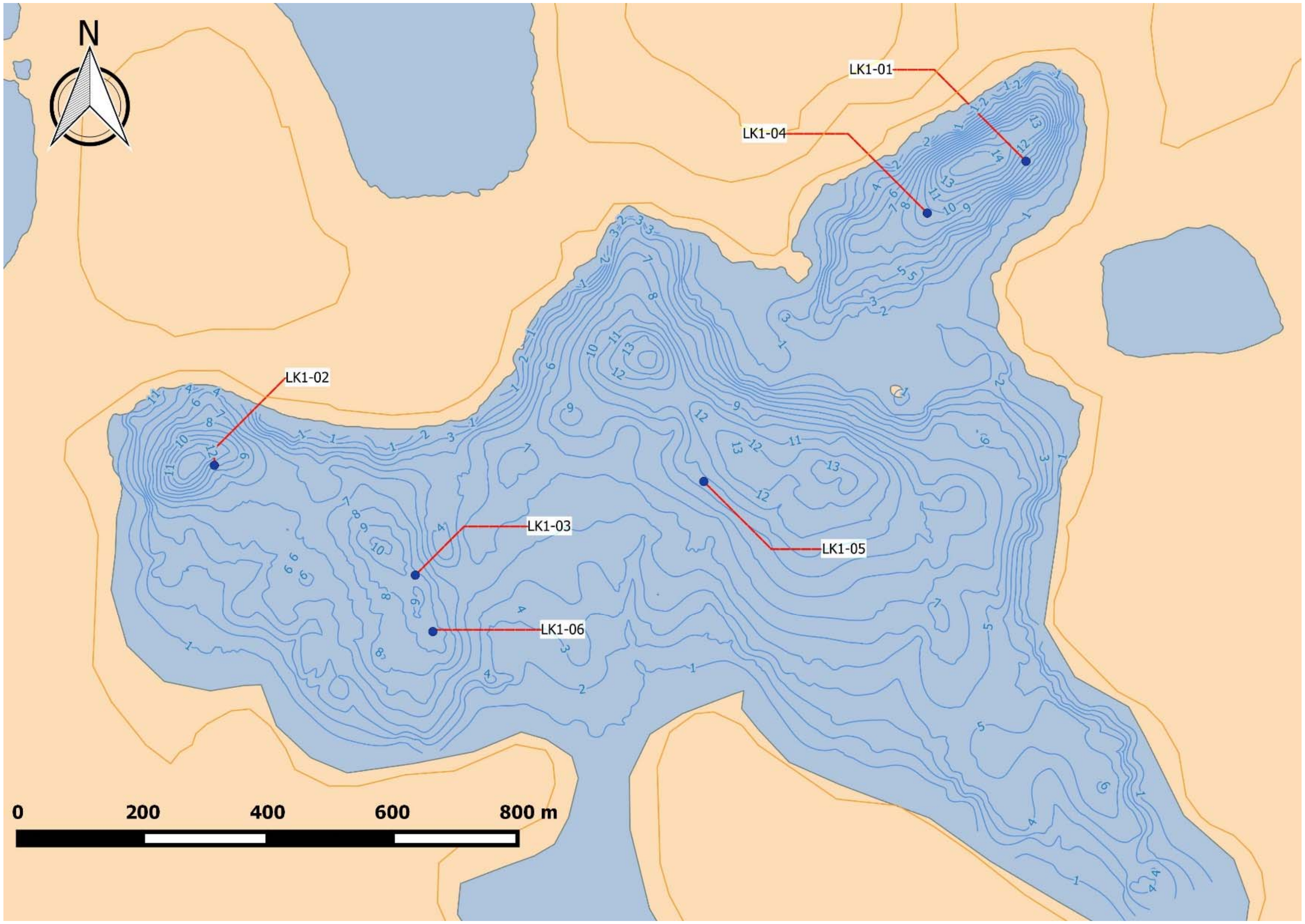

Figure 4-2. Bathymetry (1 m intervals) and CREMP water quality sampling locations in Lake D1 (LK1) for 2018.

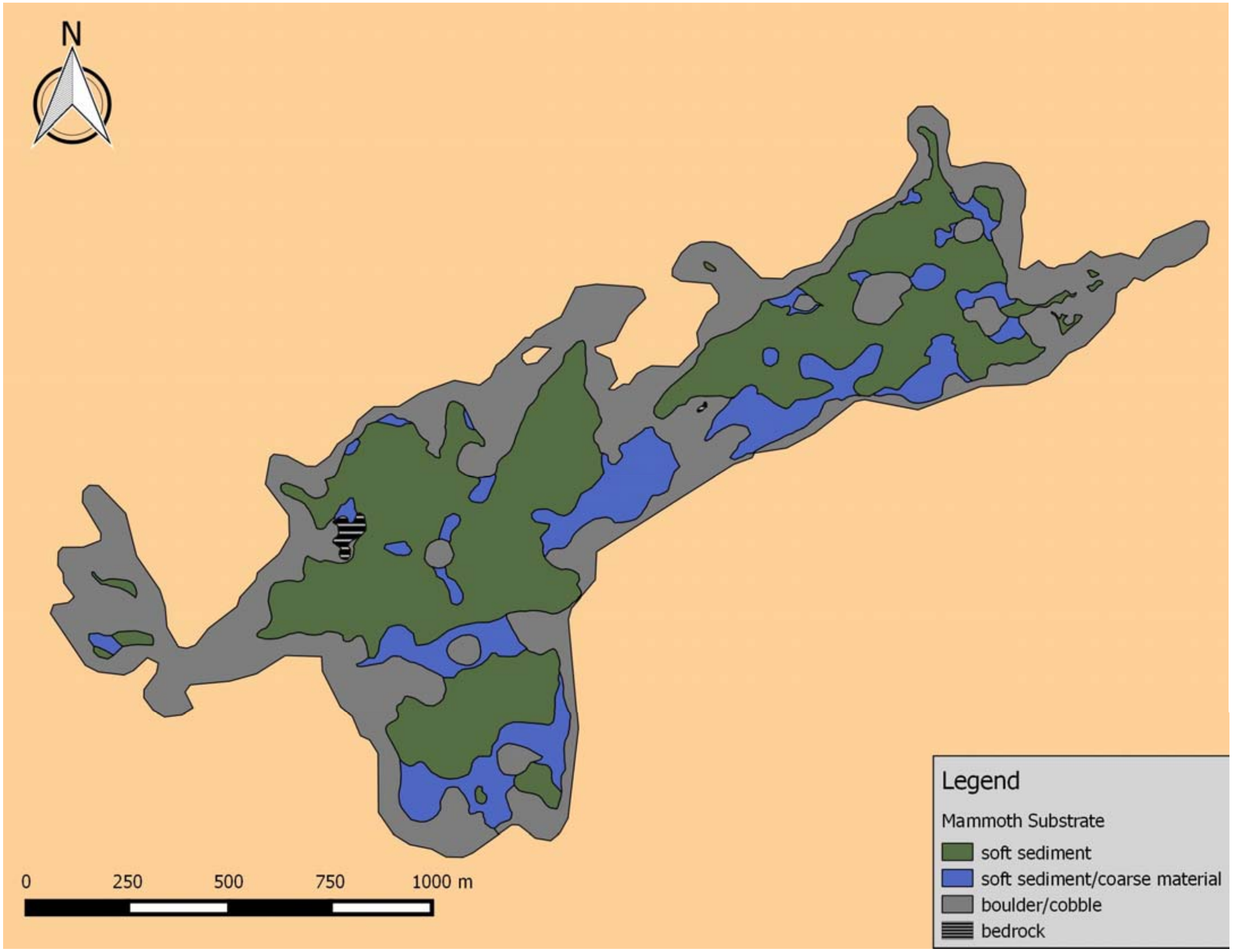

Figure 4-3. Substrate map of the Mammoth Lake exposure area.

Table 4-1. CREMP water quality results for Mammoth Lake (MAM) for 2016.

Lake	Aquatic Life Guidelines	Mammoth Lake (MAM)									
Station											
Area-Replicate ID		MAM-07	MAM-08	MAM-09	MAM-10	MAM-11	MAM-12	MAM-13	MAM-14	MAM-15	MAM-16
Depth (m)	CCME[1]	3	3	3	3	3	3	3	3	3	3
Date		24-Apr-16	24-Apr-16	29-Jul-16	29-Jul-16	13-Aug-16	13-Aug-16	12-Sep-16	12-Sep-16	24-Nov-16	25-Nov-16
Field Measurements (Surface)											
Temperature (°C)		0.7	0.7	12.1	12.2	14.4	14.4	7.0	7.1	1.1	1.5
Specific Conductivity (µS/cm)		51.7	40.7	31.2	31.1	30.2	29.9	35.2	35.2	26.7	29
Dissolved Oxygen (mg/L)		16.0	13.7	10.5	10.4	9.6	9.5	10.0	10.0	13.8	13.2
pH	6.5 - 9.0	6.40	6.39	6.72	6.85	6.69	6.66	6.61	6.70	6.55	6.68
Physical Tests (mg/L)											
Conductivity (µS/cm)		50.6	42.5	33.5	33.8	35.0	34.6	35.2	34.6	39.9	42.2
Hardness		18.4	15.3	12.5	12.7	12.9	12.7	12.6	12.5	14.3	14.6
pH (Laboratory)	6.5 - 9.0	6.93	6.94	6.58	6.58	6.68	6.64	6.81	6.82	6.86	6.82
Total Suspended Solids		*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
Anions and Nutrients (mg/L)											
Alkalinity - Total		8.0	7.7	4.2	4.5	4.7	5.4	4.5	4.2	5.3	5.9
Ammonia (as N)	***equation***	0.012	0.019	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	0.006	0.014
Nitrate (as N)	3.0	*<0.0050*	0.0066	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*
Nitrite (as N)	0.060	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Kjeldahl Nitrogen		0.126	0.132	0.112	0.113	0.136	0.134	0.101	0.107	0.112	0.116
Cyanides											
Total Cyanide		*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Free Cyanide	0.005	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Metals (mg/L)											
Aluminum	***equation***	0.0045	0.0036	0.0086	0.0102	0.0071	0.0068	0.0080	0.0055	0.0040	0.0051
Arsenic	0.005	0.00039	0.00039	0.00039	0.00041	0.00042	0.00037	0.00041	0.00042	0.00027	0.00034
Cadmium	***equation***	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Copper	***equation***	0.0006	0.0005	*<0.00050*	*<0.00050*	0.0006	*<0.00050*	0.0006	*<0.00050*	*<0.00050*	*<0.00050*
Iron	0.3	*<0.010*	*<0.010*	0.017	0.016	0.013	0.012	0.021	0.017	*<0.010*	*<0.010*
Lead	***equation***	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	0.00022	0.00018	*<0.000050*	*<0.000050*
Mercury	0.000026	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Molybdenum	0.073	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	0.0001	0.0001	*<0.000050*	*<0.000050*
Nickel	***equation***	0.0013	0.0009	0.0010	0.0010	0.0007	0.0009	0.0009	0.0008	0.0007	0.0008
Selenium	0.001	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Zinc	***equation***	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*

Notes: [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated to 2018; "*equation*" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH, and the cadmium, copper, lead, nickel and zinc guidelines vary with hardness; Shaded values exceed the CCME guideline; *italicized* values are below detection limits; underline results were given a cautionary flag in the QC assessment.

Table 4-2. CREMP water quality results for Mammoth Lake (MAM) for 2017.

Lake		Mammoth Lake									
(Station)	Aquatic Life	(MAM)									
Area-Replicate ID	Guidelines	MAM-17	MAM-18	MAM-19	MAM-20	MAM-21	MAM-22	MAM-23	MAM-24	MAM-25	MAM-26
Depth (m)	CCME[1]	3	3	3	3	3	3	3	3	3	3
Date		23-Mar-17	23-Mar-17	15-May-17	15-May-17	30-Jul-17	30-Jul-17	16-Aug-17	16-Aug-17	5-Nov-17	5-Nov-17
Field Measurements (Surface)											
Temperature (°C)		1.6	0.8	1.0	2.1	12.0	11.8	13.8	13.7	n/a	n/a
Specific Conductivity (µS/cm)		59.7	57.5	65.5	51.8	40.5	41.2	38.2	38.2	n/a	n/a
Dissolved Oxygen (mg/L)		16.0	17.5	15.4	13.0	10.7	10.7	9.6	9.5	n/a	n/a
pH	6.5 - 9.0	6.41	6.52	6.34	6.32	7.07	7.03	6.95	7.03	n/a	n/a
Physical Tests (mg/L)											
Conductivity (µS/cm)		55.4	52.4	59.2	49.4	37.6	38.5	39.0	38.9	54.1	48.3
Hardness		20.8	19.4	21.2	18.1	14.1	14.2	13.8	13.6	17.5	15.8
pH (Laboratory)	6.5 - 9.0	7.03	7.03	6.99	6.99	6.89	6.90	6.86	6.85	7.00	6.96
Total Suspended Solids		*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
Anions and Nutrients (mg/L)											
Alkalinity - Total		6.9	7.1	7.7	6.5	4.6	4.6	4.6	4.4	6.4	5.8
Ammonia (as N)	***equation***	0.014	0.013	*<0.0050*	0.009	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	0.019	*<0.0050*
Nitrate (as N)	3.0	0.0055	0.0059	*<0.0050*	0.0051	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*
Nitrite (as N)	0.060	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Kjeldahl Nitrogen		0.152	0.142	0.141	0.129	0.105	0.078	0.160	0.138	0.104	0.100
Cyanides											
Total Cyanide		*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Free Cyanide	0.005	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Metals (mg/L)											
Aluminum	***equation***	0.0057	*<0.0030*	*<0.0030*	*<0.0030*	0.0059	0.0055	0.0043	0.0038	*<0.0030*	*<0.0030*
Arsenic	0.005	0.00036	0.00039	0.00035	0.00034	0.00047	0.00035	0.00036	0.00038	0.00041	0.00036
Cadmium	***equation***	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Copper	***equation***	0.0006	0.0005	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*
Iron	0.3	*<0.010*	*<0.010*	*<0.010*	*<0.010*	0.012	0.011	0.011	0.011	*<0.010*	*<0.010*
Lead	***equation***	0.00023	*<0.000050*	*<0.000050*	0.00015	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Mercury	0.000026	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Molybdenum	0.073	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Nickel	***equation***	0.0013	0.0011	0.0012	0.0009	0.0008	0.0008	0.0007	0.0007	0.0008	0.0008
Selenium	0.001	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Zinc	***equation***	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*

Notes: [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated to 2018; "*equation*" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH, and the cadmium, copper, lead, nickel and zinc guidelines vary with hardness; Shaded values exceed the CCME guideline; *italicized* values are below detection limits; underline results were given a cautionary flag in the QC assessment.

Table 4-3. CREMP water quality results for Mammoth Lake (MAM) for 2018.

Lake		**Mammoth Lake**									
(Station)	**Aquatic Life**	**(MAM)**									
Area-Replicate ID	**Guidelines**	MAM-27	MAM-28	MAM-29	MAM-30	MAM-31	MAM-32	MAM-33	MAM-34	MAM-35	MAM-36
Date		1-Jun-18	1-Jun-18	16-Jul-18	16-Jul-18	16-Aug-18	16-Aug-18	1-Sep-18	1-Sep-18	1-Nov-18	1-Nov-18
Time		11:15	12:15	14:30	15:30	14:36	13:39	11:29	11:00	14:05	13:05
ALS Sample ID		L2107814-9	L2107814-10	L2133417-1	L2133417-2	L2152738-3	L2152738-4	L2162149-2	L2162149-1	L2194149-5	L2194149-6
Field Measurements (3 m)											
Temperature (°C)		1.84	1.49	13.33	12.92	9.9	10	8.22	8.12	1.32	1.61
Specific Conductivity (µS/cm)		63.9	58.8	52.8	52.2	62.2	57.3	63.6	58.6	125.7	132.4
Dissolved Oxygen (mg/L)		16.54	17.85	10.73	10.66	10.3	10.6	11.59	11.59	16	16.01
pH	6.5 - 9.0	6.49	6.47	6.42	6.71	7	7	6.43	6.32	6.4	6.63
Physical Tests (mg/L)											
Conductivity (µS/cm)		69.9	63.1	53.7	53.3	64.8	54.7	67.6	62.3	102	71.5
Hardness		24.8	21.4	18.7	18.4	22.1	19.5	22.9	21	38.9	26.1
pH (Laboratory)	6.5 - 9.0	6.96	6.99	6.87	6.92	6.95	6.89	6.95	6.95	7.01	6.94
Total Suspended Solids		*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	1.1	*<1.0*	*<1.0*
Anions and Nutrients (mg/L)											
Alkalinity - Total		9.3	7.9	4.7	5.1	5.3	4.7	5.2	4.8	7.1	5.3
Ammonia (as N)	***equation***	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	0.0065	0.0221	*<0.0050*	0.0107	0.016	*<0.0050*
Nitrate (as N)	3	*<0.0050*	0.0053	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	0.109	*<0.0050*
Nitrite (as N)	0.06	*<0.0010*	0.0013	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	0.0023	*<0.0010*
Total Kjeldahl Nitrogen		0.13	0.187	0.103	0.095	0.098	0.116	0.083	0.085	0.127	0.086
Cyanides											
Total Cyanide		*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Free Cyanide	0.005	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Metals (mg/L)											
Aluminum	***equation***	*<0.0030*	*<0.0030*	*<0.012*	*<0.0090*	0.0064	0.0043	0.0076	0.0034	0.0493	0.0082
Arsenic	0.005	0.00043	0.00042	0.00035	0.00034	0.0004	0.00034	0.00039	0.00037	0.00047	0.0003
Cadmium	***equation***	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Copper	***equation***	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	0.00051	*<0.00050*	*<0.00050*	*<0.00050*
Iron	0.3	*<0.010*	*<0.010*	0.021	0.023	0.017	0.012	0.023	*<0.010*	0.054	0.01
Lead	***equation***	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	0.000061	*<0.000050*
Mercury	0.000026	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Molybdenum	0.073	*<0.000050*	*<0.000050*	*<0.00010*	*<0.00010*	*<0.00040*	*<0.00040*	*<0.000050*	*<0.000050*	0.000274	*<0.000050*
Nickel	***equation***	0.00144	0.00102	*<0.0015*	0.00123	0.00069	0.00069	0.00071	0.00065	0.00116	0.00082
Selenium	0.001	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Zinc	***equation***	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*

Notes: [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated to 2018; "*equation*" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH, and the cadmium, copper, lead, nickel and zinc guidelines vary with hardness; Shaded values exceed the CCME guideline; *italicized* values are below detection limits; underline results were given a cautionary flag in the QC assessment.

Table 4-4. CREMP water quality results for Lake D1 (LK1) for 2018.

Lake		Lake D1					
(Station)	Aquatic Life	(LK1)					
Area-Replicate ID	Guidelines	LK1-01	LK1-02	LK1-03	LK1-04	LK1-05	LK1-06
Date		14-Aug-18	14-Aug-18	23-Sep-18	23-Sep-18	16-Nov-18	16-Nov-18
Time		14:00	15:40	13:15	12:39	10:30	10:30
ALS Sample ID		L2152738-13	L2152738-14	L2173524-7	L2173524-8	L2200253-1	L2200253-2
Field Measurements (3 m)							
Temperature (°C)		10.5	10.6	1.0	0.99	1.5	1.5
Specific Conductivity (µS/cm)		14.5	14.3	15.0	15.1	17.4	17.2
Dissolved Oxygen (mg/L)		10.6	10.7	13.9	13.8	14.3	16.0
pH	6.5 - 9.0	6.2	6.2	6.4	6.4	6.4	6.6
Physical Tests (mg/L)							
Conductivity (µS/cm)		13.8	13.6	14.4	14.4	15.4	14.8
Hardness		5.5	5.4	5.4	5.5	6.6	6.2
pH (Laboratory)	6.5 - 9.0	6.9	6.9	6.9	6.9	6.8	6.8
Total Suspended Solids		*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
Anions and Nutrients (mg/L)							
Alkalinity - Total		4.8	4.9	5.1	5.1	5.2	5.0
Ammonia (as N)	***equation***	0.0064	*<0.0050*	0.029	0.038	0.0075	0.0064
Nitrate (as N)	3	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*	*<0.0050*
Nitrite (as N)	0.06	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Kjeldahl Nitrogen		0.12	0.10	0.12	0.13	0.11	0.11
Cyanides							
Total Cyanide		*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Free Cyanide	0.005	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Metals (mg/L)							
Aluminum	***equation***	0.0083	0.0087	0.0071	0.0068	0.0038	0.0043
Arsenic	0.005	*<0.00010*	*<0.00010*	0.00010	0.00010	*<0.00010*	0.00010
Cadmium	***equation***	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Copper	***equation***	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*
Iron	0.3	0.021	0.023	0.016	0.015	*<0.010*	*<0.010*
Lead	***equation***	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Mercury	0.000026	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Molybdenum	0.073	*<0.00020*	*<0.00020*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Nickel	***equation***	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*
Selenium	0.001	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Zinc	***equation***	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*

Notes: [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated to 2018; "*equation*" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH, and the cadmium, copper, lead, nickel and zinc guidelines vary with hardness; Shaded values exceed the CCME guideline; *italicized* values are below detection limits; underline results were given a cautionary flag in the QC assessment; ~~strikethrough~~ results flagged as unreliable in the QC assessment; na results unavailable due to equipment malfunction.

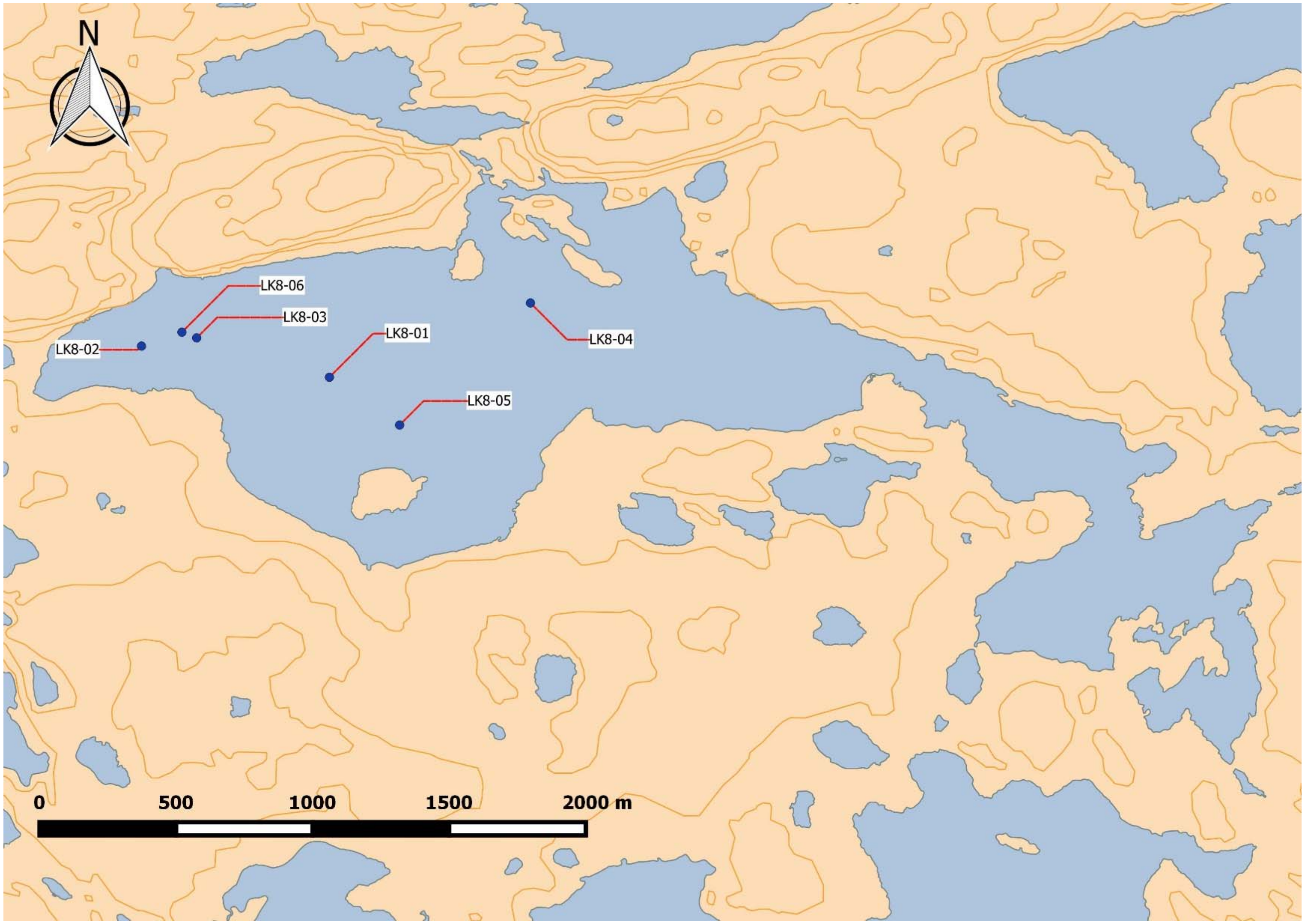

Figure 4-4. CREMP water quality sampling locations in Lake 8 (LK8) for 2018.

Table 4-5. CREMP water quality results for Lake 8 (LK8) for 2018.

Lake		Lake D8					
(Station)	Aquatic Life	(LK8)					
Area-Replicate ID	Guidelines	LK8-01	LK8-02	LK8-03	LK8-04	LK8-05	LK8-06
Date		17-Aug-18	17-Aug-18	22-Sep-18	22-Sep-18	27-Nov-18	27-Nov-18
Time		18:37	19:00	15:10	16:05	11:25	10:40
ALS Sample ID		L2152738-17	L2152738-18	L2173524-1	L2173524-2	L2205457-5	L2205457-6
Field Measurements (3 m)							
Temperature (°C)		10.39	10.28	3.1	3.02	1.59	1.58
Specific Conductivity (µS/cm)		13.5	13.5	14.8	14.8	15.8	15.7
Dissolved Oxygen (mg/L)		10.79	10.75	12.79	12.86	16.6	17.7
pH	6.5 - 9.0	6.21	6.17	6.35	6.26	6.78	7
Physical Tests (mg/L)							
Conductivity (µS/cm)		12.9	12.8	14.3	14	13.9	13.8
Hardness		4.92	4.84	5.15	5.07	5.18	5.25
pH (Laboratory)	6.5 - 9.0	6.9	6.9	6.87	6.87	6.86	6.84
Total Suspended Solids		*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*	*<1.0*
Anions and Nutrients (mg/L)							
Alkalinity - Total		4.3	4.4	4.5	4.4	4.8	4.4
Ammonia (as N)	***equation***	*<0.0050*	0.008	0.0157	0.0343	0.0068	0.0056
Nitrate (as N)	3	*<0.0050*	*<0.0050*	*<0.0050*	0.0127	*<0.0050*	*<0.0050*
Nitrite (as N)	0.06	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Kjeldahl Nitrogen		0.098	0.107	0.102	0.111	0.072	0.083
Cyanides							
Total Cyanide		*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Free Cyanide	0.005	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*	*<0.0010*
Total Metals (mg/L)							
Aluminum	***equation***	0.0033	0.0038	0.0038	0.0038	0.0031	*<0.0030*
Arsenic	0.005	0.00011	0.00012	0.00015	0.00017	0.00015	0.00014
Cadmium	***equation***	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Copper	***equation***	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*
Iron	0.3	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*	*<0.010*
Lead	***equation***	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Mercury	0.000026	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*	*<0.0000050*
Molybdenum	0.073	*<0.00020*	*<0.00020*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Nickel	***equation***	*<0.00050*	*<0.00050*	*<0.00050*	*<0.00050*	0.00068	0.00064
Selenium	0.001	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*	*<0.000050*
Zinc	***equation***	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	*<0.0030*	0.0033

Notes: [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated to 2018; "*equation*" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH, and the cadmium, copper, lead, nickel and zinc guidelines vary with hardness; Shaded values exceed the CCME guideline; *italicized* values are below detection limits; underline results were given a cautionary flag in the QC assessment; strikethrough results flagged as unreliable in the QC assessment; na results unavailable due to equipment malfunction.

4.5 Aquatic Resource Characterization

4.5.1 Primary Productivity

Baseline phytoplankton sampling was completed in 2014 and 2015 according to the Meadowbank CREMP SOP (Azimuth 2015b). Six major taxonomic groups of phytoplankton are present in the study lakes, namely blue green algae (Cyanophyta), green algae (Chlorophyta), golden-brown algae (Chrysophyta), diatoms, Cryptophyta and Dinoflagellata. Richness was somewhat variable between sampling events, but the number of taxa present was generally between 30 and 40 in the 2014. Phytoplankton density ranged between approximately 2.0 million individuals per litre and 3.7 million individuals per litre with total biomass ranging between 137 mg/m3 and 286 mg/ m3. These results are consistent with results from other lakes in the area sampled as part of the Meadowbank CREMP (Azimuth 2015b). Phytoplankton density in the summer is typically greater than 1 million individuals per liter, with average total biomass of approximately 200 mg/m3 (Azimuth 2015b). Within the Whale Tail Pit Study Area, density and biomass were lowest in Nemo Lake and highest in Whale Tail Lake and Mammoth Lake in the 2014 and 2015 base line studies.

Phytoplankton species composition varies throughout the year depending upon water temperature, nutrient concentration, time of year, water clarity and amount of sunlight, and predation by zooplankton. A more diverse Phytoplankton community is present during the open water season, compared to when ice covers the lakes. Chlorophyll-a concentrations were typically less than 1 µg/L, indicative of oligotrophic systems and representative of baseline trophic status in the various lakes (Azimuth, 2019).

There was no indication of changes in primary productivity in the Whale Tail study area lakes in 2018 based upon chlorophyll-a concentrations. Also, the pattern of seasonal variability in species richness observed in 2018 was similar to previous years for the various lakes. These results suggest that dike construction and the associated changes in water quality had not adversely affected phytoplankton community diversity (Azimuth, 2019).

There have been no rooted aquatic macrophytes observed along shorelines or in shoals.

4.5.2 Zooplankton

Zooplankton samples were collected from Mammoth Lake (and Whale Tail and Nemo Lakes) on three occasions in 2015, in support of the Whale Tail Pit EIA (Azimuth, 2016b). Samples contained Cladocera, Calanoida, Cyclopoda, Copepod nauplii and Rotifera and taxa richness by major taxa group ranged from six to nine. Total density ranged from 18,509 to 144,949 organisms per m^3 and total biomass ranged from 11 to 304 mg per m^3. Biomass and species composition varied both spatially and temporally. Rotifers were most abundant in terms of numbers and biomass in July and September, but calanoids dominated in terms of biomass in July.

4.5.3 Benthic Invertebrates

The following information is taken from Azimuth (2019).

Benthic invertebrate community structure (taxa richness) and function (abundance) is typical of northern headwaters lakes in the region (i.e., low abundance and few taxa). Benthos communities in these lakes have, by virtue of their presence, adapted to the naturally-elevated concentrations of metals in sediment. Insects are the dominant taxa group in terms of richness. Molluscs are the next most dominant taxa group in terms of the number species, particularly when the abundance of insects and other taxa groups are low.

Although total abundance tends to be low, within-area variability can be substantial. Taxa richness, unlike abundance, is more consistent with inter-annual variability quite low for the various areas. The normal range of species identified among the various study areas is 10 to 15; in 2018 there were between 13 and 20 taxa identified at Whale Tail Lake (south basin). The comparatively high taxa richness, combined with no apparent change in abundance, demonstrates that dike construction did not alter the structure or function of the benthos community in 2018. The benthic community is discussed in more detail in Section 8.1.

4.5.4 Fish

A total of six fish species are present in the lakes in the Whale Tail Pit study area, comprised of four large-bodied species (Lake Trout, Arctic Char, Round Whitefish and Burbot) and two small-bodied species (Slimy Sculpin and Ninespine Stickleback). Arctic Grayling occur farther downstream in the watershed but have not been captured in any of the study lakes or either of the proposed reference lakes (C. Portt and Associates, 2018).

Lake Trout was the most abundant species in gill net catches in lakes in the vicinity of the Whale Tail Project, followed by Round Whitefish and Arctic Char (Table 4-6). Few Burbot were captured. Gill netting catch per unit effort was low for all species. In Mammoth, Whale Tail and Nemo Lakes combined, average catch per unit effort in gill nets, calculated as the number of individuals captured per hour of soak time using a standard AEM gill net was 0.5, 0.1 and 0.01 for Lake Trout, Round Whitefish and Arctic Char, respectively.

Table 4-6. Summary of gill net catches and catch per unit effort (CPUE; number of fish caught per hour of soak time), by lake, year, set duration and species.

Lake and year	Set duration	Number of sets	Total soak time (hours)	Lake Trout		Arctic Char		Round Whitefish	
				catch	CPUE	catch	CPUE	catch	CPUE
Whale Tail 2014	miscellaneous	2	12.7	5	0.39	1	0.08	0	0.00
Mammoth 2014	miscellaneous	2	13.2	13	0.98	0	0.00	0	0.00
Nemo 2014	miscellaneous	2	13.3	15	1.13	0	0.00	0	0.00
Whale Tail 2015	short-duration	14	30.5	5	0.15	1	0.03	3	0.09
	overnight	2	34.1	23	0.67	0	0.00	2	0.06
	miscellaneous	3	12.2	1	0.08	0	0.00	0	0.00
	total	19	76.8	29	0.38	1	0.01	5	0.07
Mammoth 2015	short-duration	14	32.5	8	0.25	0	0.00	16	0.59
	overnight	2	35.8	24	0.67	0	0.00	4	0.11
	miscellaneous	2	10.9	4	0.37	0	0.00	0	0.00
	total	18	79.2	36	0.45	0	0.00	20	0.25
Nemo 2015	miscellaneous	4	14.06	7	0.50	0	0.00	0	0.00
Lake D1, 2018	short-duration	2	13.0	4	0.31	0	0.00	1	0.08
Lake 8, 2018	overnight	2	35.2	23	0.65	1	0.03	0	0.00

Shoreline electrofishing in 2015 in Whale Tail and Mammoth Lakes captured, in order of abundance, Ninespine Stickleback, Slimy Sculpin, and juvenile *Salvelinus* (Table 4-7). In 2018, however, Slimy Sculpin was the most abundant species in shoreline electrofishing catches in Mammoth Lake, Lake D1 and Lake 8 (Table 4-8).

Table 4-7. Number of individuals captured by electrofishing ten 25-meter long segments (250 m total) of shoreline in Whale Tail Lake and Mammoth Lake on July 26-27 and July 29-30, 2015, respectively. The juvenile salmonids were most likely Arctic Char.

Lake	Electro-seconds	Ninespine Stickleback	Slimy Sculpin	juvenile *Salvelinus*
Mammoth	3922	41	13	1
Whale Tail	3403	55	14	2

Table 4-8. Electrofishing catches in Mammoth Lake, Lake D1 and Lake 8, in 2018.

Lake	Electro-seconds	juvenile Burbot	Slimy Sculpin	Ninespine Stickleback	Round Whitefish	juvenile *Salvelinus*
Lake D1	2460	1	27	0	0	7
Lake 8	5869	0	100	0	0	11
Mammoth	6309	0	69	9	3	3
Total	14,638	1	196	9	3	21

5.0 WHALE TAIL PIT SETTING AND OPERATIONS

5.1 Background

As indicated previously, Whale Tail Pit (65.4°N, 96.7°W) is a satellite deposit to the Meadowbank Mine. The Meadowbank Mine (65.0°N, 96.0°W) is one of Canada's most northerly operating mines, located approximately 75 km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut. Mine construction began in 2008 under Nunavut Water Board Type A License 2AM-MEA0815, subsequently changed to License 2AM-MEA1525. Meadowbank has been in operation since 2009, with mining activities formally underway since March 2010, and projected to continue until September 2019.

The Meadowbank license has been amended to License 2AM-MEA1526 and the mine will continue to operate by using ore from the Whale Tail Pit. The Whale Tail Pit, located approximately 50 km northwest of the Meadowbank site, will begin to supply ore to the Meadowbank milling and tailings storage facility in 2019. On July 11, 2018, Type A Water License 2AM-WTP1826 was approved by the Minister to begin construction and operation of the Whale Tail Pit and hauling ore to the Meadowbank Mill. Fisheries and Oceans Canada Authorization 16-HCAA-00370, issued on July 23, 2018, allows works or undertakings affecting fish habitat at the Whale Tail Pit.

Excavation has begun at the Whale Tail Pit mine, with initial production of ore expected to begin in the third quarter of 2019. As mentioned previously, extracted ore will be stockpiled on site if necessary, but will be trucked along the Haul Road for processing at the Meadowbank site, located approximately 50 km to the southeast. Mine tailings will be stored at the existing tailings storage facilities at Meadowbank. A chronology of major mine-related activities at the Whale Tail Pit is provided in Table 5-1.

Table 5-1. Chronology of mine-related activities at the Whale Tail Pit site.

Year	Major Mine-Related Activities at the Whale Tail Pit site.
2013	● Start of prospecting in the Whale Tail Pit area. Ore deposit discovered.
2014	● Establishment of Amaruq Exploration Camp on the northeast side of Whale Tail Lake. ● Exploratory drilling commences. ● First baseline biological investigations occur.
2015	● Expansion of Amaruq Exploration Camp. ● Exploratory drilling expands in intensity and extent. ● Baseline field investigations of fish and fish habitat undertaken.
2016	● Construction of an on-site airstrip at the Amaruq Exploration Camp. ● Exploratory drilling continues. ● Amaruq exploration road construction (km 25 at end of 2016). ● Baseline field investigations of fish and fish habitat.
2017	● Exploratory drilling continues. ● Amaruq exploration road construction completed in August 2017.
2018	● Exploratory drilling continues. ● Newterra™ wastewater treatment system becomes operational in March. ● Amaruq exploration road widened for ore haulage over June - November 2018. ● Decommissioning of the airstrip at the Amaruq Exploration Camp.

Year	Major Mine-Related Activities at the Whale Tail Pit site.
	● Construction of the Whale Tail Dike begins in July. Water was pumped from within the sediment curtains surrounding the Whale Tail dike construction area, treated for TSS, and discharged to the north basin of Whale Tail Lake from July 27 to August 27. ● Fish-out of isolated north portion of Whale Tail Lake occurs August 13 to September 28, with fish that were relocated transferred to the south basin of Whale Tail Lake. ● Freshwater intake from Nemo Lake started October 28.
2019	● Exploratory drilling continues. ● Construction of dykes in the northern part of Whale Tail Lake and the eastern end of Mammoth Lake. Mammoth Dike was completed in March 2019. Completion of Whale Tail Dike expected in August 2019. ● Water management system constructed. ● Dewatering of the North Basin of Whale Tail Lake, where the Whale Tail Pit will be located, began on March 5 and is ongoing. ● Discharge of treated effluent from the attenuation pond to the permanent discharge location in Mammoth Lake is expected to commence in Q3, 2019. ● Initial production from the Whale Tail Pit is expected to begin in the third quarter of 2019.

5.2 Water Management During Construction and Operations

5.2.1 Dike Construction and Surface Water Diversions to Allow Mine Construction

The natural drainage in the study area is from Whale Tail Lake to Mammoth Lake. Part of Whale Tail Pit is located beneath what was, formerly, the north basin of Whale Tail Lake and in order to mine the deposit it was necessary to dewater that basin. The water management structures required to achieve this are shown in Figure 5-1. Three dikes were constructed to isolate the north basin of Whale Tail Lake so that dewatering could occur. Whale Tail dike was built across Whale Tail Lake, between its north and south basins. Mammoth dike was built across the east end of Mammoth Lake to prevent water from Mammoth Lake from draining to Whale Tail Pit. The North East dike was built north of Whale Tail Lake to prevent drainage from the area north and east reaching the pit.

The water elevation south of the Whale Tail dike will rise during operations and flow will be conveyed to Mammoth Lake via a constructed channel, passing through Lake A45 (Figure 5-1). The water level in the North East Pond will rise during operations and the water will flow north to Nemo Lake. The watercourse from Lake A53 will be realigned so that it flows into the south basin of Whale Tail Lake.

5.2.2 Dewatering for Mine Construction

Dewatering of the north basin of Whale Tail Lake began on March 5, 2019 and is ongoing. Initially the untreated water was pumped and discharged to South Whale Tail Lake via the Phase 1 diffuser (Figure 5-1). Beginning on June 17, 2019, the water pumped from the north basin of Whale Tail Lake was treated for TSS in the water treatment plant and discharged to Mammoth Lake, via the Phase 2 diffuser (Figure 5-1). Beginning in early July of 2019, after it was determined that TSS limits were being met without treatment, untreated dewatering water has been discharged to Mammoth Lake via the Phase 2 diffuser.

The Phase 1 and Phase 2 diffusers are single pipes with holes, suspended vertically from the water's surface. They were installed on the ice, with a floatation collar to maintain the upper end at the water's surface once the ice melts. It is anticipated that dewatering will be completed in Q3, 2019.

5.2.3 Facilities, Mining, and Processing

The Whale Tail Pit mine site is shown in Figure 5-1. Some of the key features include a living facility (Exploration Camp) for on-site workers, maintenance shop, heli-pad, core shack, core storage area, power generation plant, sewage treatment plant, incinerator, compost site, constructed dikes and pits, waste rock storage areas, and ore stockpile areas. Some of these features are in transition. For example, a new Exploration Camp is partially completed and occupied, and the old Exploration Camp is partially dismantled.

Personnel are marshalled at the Meadowbank Mine by direct flight to the Meadowbank airstrip, or driven from Baker Lake via the All-Weather Access Road (AWAR). Then those that work at the Whale Tail Pit are driven to that location via the 62.5 km Haul Road. Equipment and goods can be barged into Baker Lake during the open water season and then trucked to the Whale Tail Pit site via the AWAR and then the Haul Road, or flown directly to Meadowbank airstrip all year round and then trucked to the Whale Tail Pit via the Haul Road.

The Whale Tail Pit mine operates year-round, using conventional drilling, blasting, truck and loading methods. Explosives are produced at an on-site plant and used to blast rock. The ore can be stockpiled on site but is eventually taken by truck along the 62.5 km Haul Road to Meadowbank, for processing. No tailings will be created or disposed of at the Whale Tail Pit site. The waste rock is hauled to waste storage facilities (Figure 5-1). To minimize acid generation, any sulphide-bearing waste rock is encapsulated in permafrost and capped with an insulating layer of neutralizing rock.

Fresh water is obtained from Nemo Lake (Figure 5-1) for any operational and camp requirements and treated at the on-site water treatment plant.

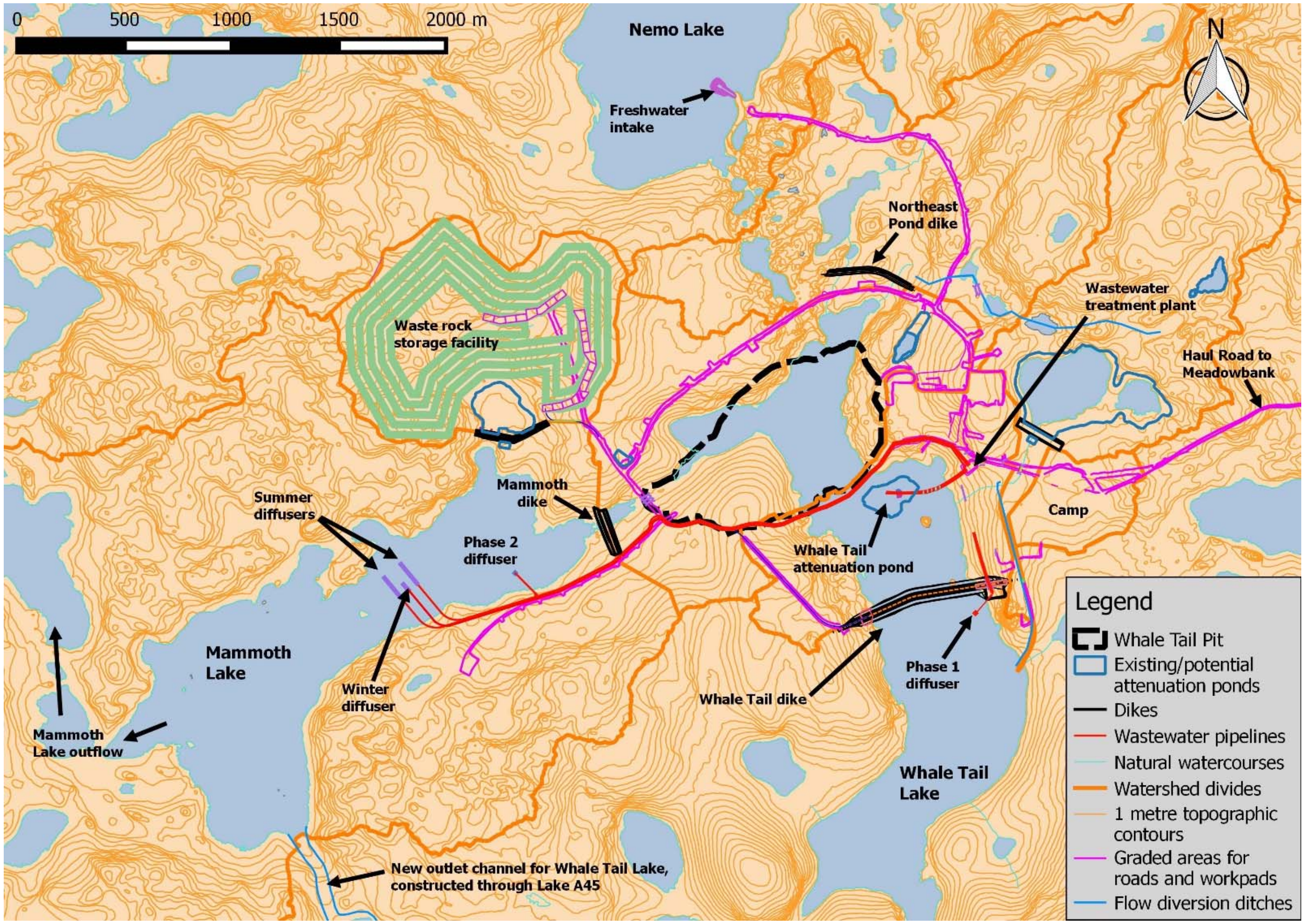

Figure 5-1. Whale Tail Pit layout showing features that are constructed, developing, or planned for the near future at the time of writing.

5.2.4 Water and effluent treatment and management during operations

During operations, non-contact water will be diverted from the site through a combination of channels, dikes, and pumps. Contact water from the major mine infrastructure will be directed to the Whale Tail Attenuation Pond, which will be located in the dewatered north basin of Whale Tail Lake (Figure 5-1). Contact water will consist primarily of water from the Whale Tail Waste Rock Storage Facility (WRSF) Pond and runoff water in the open pit, which will be collected by sumps and pumped to the Whale Tail Attenuation Pond. Camp sewage will be treated in a Newterra™ domestic sewage treatment plant and pumped to the Whale Tail Attenuation Pond where it will be mixed with contact water. Other sources of water directed to the Whale Tail Attenuation Pond include runoff from developed ground (main sector, industrial sector), runoff from stockpiles (clean materials and ore), and pumped water from the Exploration Camp development.

The water from the attenuation pond will be treated in an Arsenic Water Treatment Plant (AsWTP) to comply with the quality criteria in Type A Water Licence 2AM-WTP1826 and MDMER prior to discharge. The AsWTP has a capacity of 1,600 m^3/hour and is composed of two Actiflo® to remove Total Suspended Solids (TSS) and one Arsenic removal unit (pH adjustment, As oxidation, As precipitation). It also has a sludge dewatering chain with two centrifuges, where the centrate is recirculated to the Actiflo®.

The treated effluent will be discharged to the east end of Mammoth Lake via diffusers (Figure 5-1). During the open water period (approximately July to October) the treated effluent will be directed to a pair of permanent, submerged summer diffusers with a maximum flow capacity of 800 m^3/h per diffuser (1600 m^3/h total). The diffusers will be anchored on the bottom of Mammoth Lake with boulders (Figure 5-1). The approximate location of the east diffuser is at 65°23'56.31" N and 96°44'17.55" W, and the approximate location of the west diffuser is at 65°23'54.33" N and 96°44'23.68" W. Each of these diffusers will be constructed as follows:

- 10 discharge ports spaced at 12.5 m intervals starting at the end of the line on a 14-in DR17 HDPE pipeline;
- each port consists of an 80 mm diameter pipe mounted on a saddle with a total length of 725 mm. The end of the pipe is equipped with an orifice plate with an opening of 61 to 62 mm.

During the ice-cover period (approximately October to May) treated effluent will be discharged to Mammoth Lake through a specially constructed winter diffuser with a total flow capacity of 84-105 m^3/h. It is currently proposed to be located between the two open water diffusers, at 65°23'55.33" N and 96°44'20.67" W, and anchored to the bottom with boulders (Figure 5-1). This diffuser will be constructed as follows:

- 3 discharge ports spaced at 14.0 m intervals starting at the end of the line on a 14-in DR17 HDPE pipeline;
- each port consists of an 80mm diameter pipe mounted on a saddle with a total length of 725 mm. The end of the pipe is equipped with an orifice plate with an opening of 61 to 62 mm.

5.2.5 Effluent Mixing

During operations, the summer and winter diffusers in the east half of Mammoth Lake (Figure 5-1) will be the final discharge points for Whale Tail Pit. Installation of these diffusers is expected to occur in Q3, 2019. Modelling using the CORMIX model indicates that the effluent will be fully mixed and a dilution of 27, which equals an effluent concentration of 3.7%, will be achieved within 37 m of each summer diffuser at a discharge rate of 400 m^3/hour and within 59 m at the maximum discharge rate of 800 m^3/hour (Golder, 2019). The CORMIX model indicates that, at a TDS concentration of 157 mg/L, a dilution of 27 will be achieved within 36 m from the winter diffuser at the maximum discharge rate of 105 m^3/hour (Golder, 2019). Based on the predicted distances to reach a dilution of 27, the summer diffusers will be the final discharge points that are the subject of the EEM biological study.

If the summer diffusers are installed and effluent is discharged in Q3 of 2019, a plume delineation study will be undertaken using specific conductance as a tracer. If this is not possible, after the diffusers are installed and their exact locations are known, the effluent concentrations at 100 m and 250 m from the diffusers will be predicted using the CORMIX model. The results of this plume delineation or the modelling will be used to refine the exposure zones for the EEM fish and benthic invertebrate studies and will be reported to Environment and Climate Change Canada by December 31, 2019. The effluent concentration is expected to exceed 1% at 250 m from the diffuser. A plume delineation will be conducted in 2020, using specific conductance as a tracer, immediately before the benthic invertebrate and fish collections.

6.0 FIRST BIOLOGICAL STUDY DESIGN OVERVIEW

The EEM First Biological study design for the Whale Tail Pit will examine one exposure area, Mammoth Lake, and two reference areas, Lake D1 and Lake 8. (see Figure 1-2 for map and Table 6-1 for general UTM coordinates). The reference areas, Lake D1 and Lake 8, were selected based on the following merits.

1. Both of the lakes are situated in the Back River watershed, but they are in the headwaters of different sub-watersheds than the Whale Tail Pit, and therefore not subject to either mine effluent or flooding that will occur as a result of water management.

2. The reference lakes are also in different sub-watersheds from each other and represent a range of background conditions.

3. Neither of the reference lakes is exposed to any known anthropogenic influences (mining or otherwise).

4. The lakes are proximate to Mammoth Lake and to each other, and therefore will experience similar weather.

5. Both lakes are physically similar to the exposure area (Mammoth Lake), with a range of depths and substrates present.

6. Both reference areas were targeted in baseline studies, confirming that the sentinel fish species are present and, based on 2018 data, sufficiently abundant for adequate sample sizes to be collected for the fish study.

7. Both reference lakes were monitored in the CREMP in 2018, and will be monitored again in 2019, providing some temporal context.

8. Both reference areas are accessible by helicopter for field crews.

As discussed in Section 5.2.5, during the open water period, discharge in Mammoth Lake will be from a pair of multi-orifice diffusers. The sampling locations in Mammoth Lake will be within the 1% effluent plume, as determined by plume delineation(s), supported by predictions using the CORMIX model, if necessary. The specific approaches for the fish study and benthic invertebrate study are discussed in greater detail in Sections 7 and 8, respectively.

Table 6-1. Location of EEM exposure and reference sampling areas.

EEM Sampling Area		UTM location (14NAD83)*	
Type	**Name**	**Latitude (E)**	**Longitude (N)**
Exposure	Mammoth Lake (MAM)	605376	7254977
Reference	Lake D1 (LK1)	607485	7249710
Reference	Lake 8 (LK8)	611538	7258627

* UTM indicates the approximate centre of the sampling area.

7.0 FISH SURVEY

7.1 Sentinel Species Selection

Based on the results of previous sampling (refer to Section 4.5.4), Lake Trout and Slimy Sculpin are the appropriate sentinel species for the Whale Tail Pit fish survey. Lake Trout were the most abundant large-bodied fish captured in gill nets in Mammoth Lake and the two reference lakes during baseline studies. This is consistent with the gill netting results from all regional lakes where Lake Trout are present. Slimy Sculpin was the most abundant small-bodied fish species in electrofishing catches during baseline work in 2018 and, based on those results, is the only small-bodied species that could be captured in sufficient numbers for a fish study with a reasonable amount of effort. Lake Trout have been widely used in EEM fish studies including the first, second and third EEM biological studies at the Meadowbank Mine. Slimy Sculpin are also widely used as a sentinel species in environmental monitoring studies, including EEM studies (Arciszewski at al, 2010; Gray et al, 2018).

7.2 Lake Trout Study Methods

7.2.1 Overall Approach and Sample Size

In the ultra-oligotrophic lakes of the region, Lake Trout mature at a relatively old age and only a portion of mature individuals spawn each year. For example, only 4 of 70 Lake Trout sampled in the 3rd EEM study at Meadowbank were mature females that would have spawned in the current year (C. Portt and Associates and Kilgour & Associates Ltd, 2018). Therefore, it is not feasible or acceptable to assess reproductive investment in the Lake Trout due to the large number of fish that would need to be killed.

Lake Trout has been used as a sentinel species in the EEM studies at the Meadowbank Mine, where the fish study design has evolved as knowledge has increased and, as shown in Table 7-1, the number of fish mortalities has decreased substantially as a result. All of the EEM fish studies at Meadowbank have examined one exposure area and two reference areas. The first EEM biological study design at Meadowbank was designed to be a sub-lethal study of Lake Trout and lethal study of Round Whitefish (Azimuth, 2012a). Due to insufficient numbers of Round Whitefish being captured, the fish survey was modified, in consultation with Environment Canada, to focus only on a sub-lethal study of Lake Trout (Azimuth, 2012a). For the second biological study at Meadowbank, the fish study was a non-lethal study using Lake Trout as the only sentinel species (C. Portt and Associates and Kilgour Associates, 2014). This study also resulted in a substantial number of fish mortalities. In the third biological study at Meadowbank, a lethal study of Lake Trout was conducted (C. Portt and Associates and Kilgour Associates, 2018). The number of fish mortalities was reduced and the number of fish captured and released was greatly reduced. That lethal study examined weight adjusted for length, liver weight adjusted for weight and length, weight at age and length at age, as well as size distribution and age distribution.

Table 7-1. Number of fish released and number of mortalities in three successive EEM biological studies examining one exposure area and two reference areas at the Meadowbank Mine.

EEM study	Lake Trout		Arctic Char		Round Whitefish	
	released	mortalities	released	mortalities	released	mortalities
1st	133	138	22	24	1	47
2nd	185	107	9	4	5	12
3rd	6	70	4	17	3	4

The Lake Trout study approach employed in the third biological study at Meadowbank will be used in the first biological study for Whale Tail Pit. It will be a lethal study, with one exposure area (Mammoth Lake) and two reference areas (Lakes D1 and Lake 8)(Figure 7-1. Fish reference areas Lake D1 (LK1) and Lake 8 (LK8), and exposure area Mammoth Lake (MAM).) and will examine relationships and distributions based on length, weight, liver weight and age.

Power analysis based on the results of the Cycle 2 Meadowbank study indicated that a sample size of less than 20 Lake Trout per site would be adequate to detect the critical effect sizes for the weight versus length, liver weight versus weight, liver weight versus length, and length versus age relationships with α and β both equal to 0.1. Power analysis based on the results of the Cycle 3 study at Meadowbank indicated that a sample size of 21 fish per site would be adequate. Approximately twice as many fish per site would be required to achieve this power for the weight versus age relationships. Given the difficulties in aging old Lake Trout and the acknowledged error in aging fish generally, any relationship with age is likely to be suspect. Therefore, it is recommended that the 1st Biological Study for Whale Tail Pit be a lethal study with a target sample size of 25 Lake Trout per lake, which would be an adequate sample size to assess the relationships that are not age-related.

7.2.2 Lake Trout Collections

7.2.2.1 Timing

Sampling for the Whale Tail Pit EEM Cycle 1 will be conducted in August, 2020. Timing, however, is not considered critical, as reproductive endpoints are not being examined.

7.2.2.2 Gear

Index gill nets comprised of six panels of stretched mesh (sizes 126, 102, 76, 51, 38, and 25 mm) will be used as the primary means of fish capture for this study. Each panel of gill net is 1.8 m (6 feet) deep by 22.7 m (25 yards) long, so that the length of a six-panel gang is 136.4 m (150 yards). This is the gear that was used in EEM Cycle 2 and EEM Cycle 3 at the Meadowbank Mine, as well as in fish-outs at Meadowbank and Whale Tail.

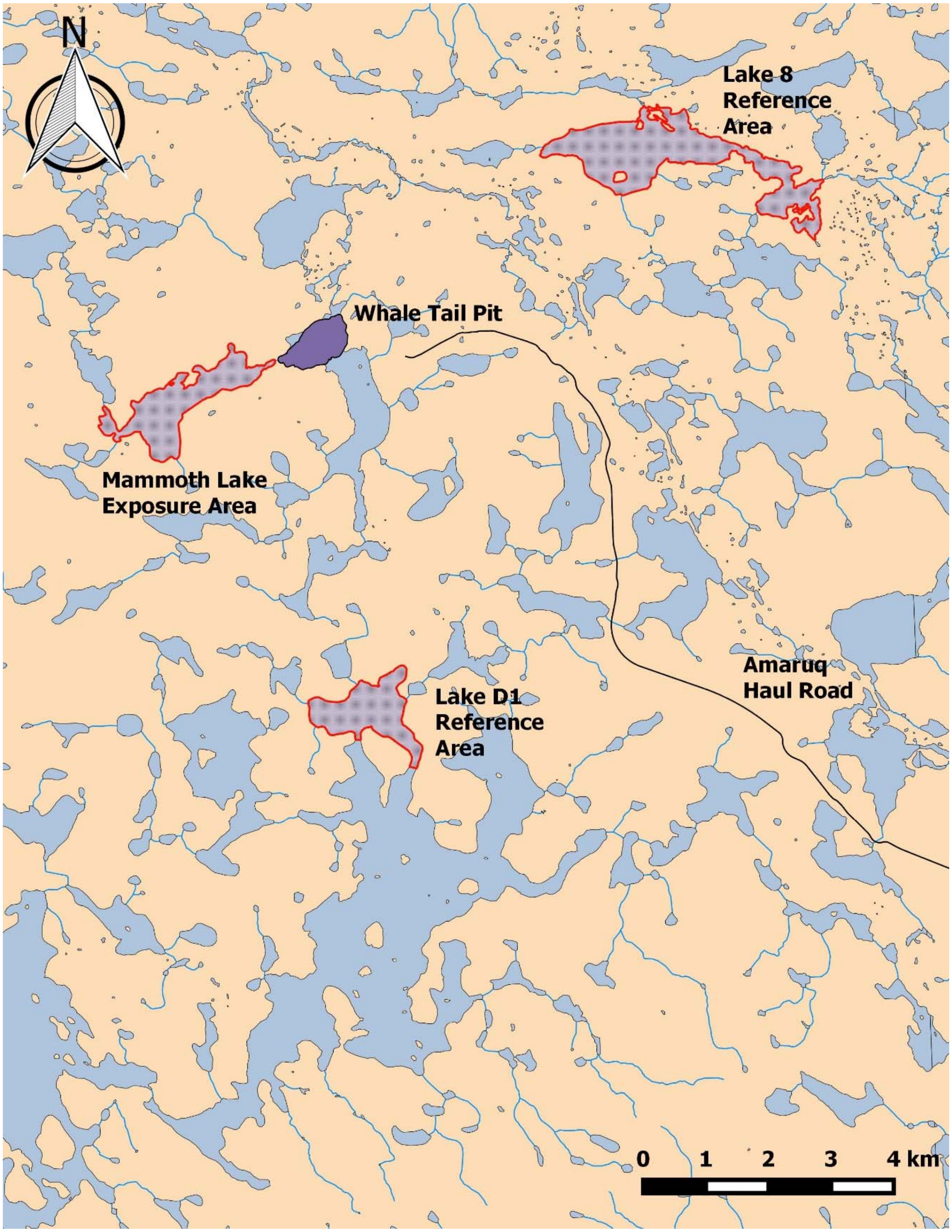

Figure 7-1. Fish reference areas Lake D1 (LK1) and Lake 8 (LK8), and exposure area Mammoth Lake (MAM).

7.2.2.3 Net Deployment and Retrieval

Gill nets will be set, targeting lake trout, within each of the three sampling areas (Figure 7-1. Fish reference areas Lake D1 (LK1) and Lake 8 (LK8), and exposure area Mammoth Lake (MAM).), with the specific locations determined based on local habitat conditions and, in the exposure area, the extent of the 1% plume. The UTM coordinates of each end of each net will be recorded, as will depth and the date and time of deployment and retrieval. Set duration will be determined in the field based on local conditions, with the objective of capturing 25 Lake Trout and minimizing the mortality of additional Lake Trout and incidental catch. The number of individuals of each species captured in each net will be recorded.

7.2.2.4 Supporting Environmental Variables

Specific conductance (µS/cm), pH, dissolved oxygen (mg/L and % saturation) and temperature (°C) will be determined in the field within the Exposure and Reference Areas.

7.2.3 Lake Trout Measurements

The following information will be determined for each Lake Trout that is part of the lethal sample:

- fork length in millimetres
- total weight in grams
- presence of external deformities, lesions, tumours, or parasites.
- liver weight in grams
- sex, gonad condition and gonad weight in grams
- presence of internal deformities, lesions, tumours, or parasites.

Otoliths will be collected and placed in envelopes labeled with the sampling area, date, species, and specimen number. Otoliths will be mounted whole on a glass slide, ground to the core on one side, flipped to adhere the core area to the glass, and then ground to a thin section on the other side. Age will be estimated based on the number of annuli counted using transmitted light and a stereo microscope. As a QA/QC measure, annuli will be counted by a second person for at least 10% of the otoliths.

7.2.4 Statistical Analysis

Data assessment and interpretation will be conducted following the guidelines presented in Environment Canada (2012).

7.2.4.1 Initial Data QA/QC

Data will be entered into an Excel© spreadsheet. The entered data will be compared with the original data sheets, and any data entry errors that are identified will be corrected. Scatterplots of length versus weight will be prepared. If aberrant values are identified, the original data sheets will be re-checked to ensure that these are not due to transcription errors. Any transcription errors found will be corrected. If clearly aberrant values for length or weight occur in the original data, these will be eliminated from the dataset.

7.2.4.2 Calculated Indices

Condition (K) will be calculated using the formula:

$$K = \frac{100 \bullet \text{weight}}{\text{length}^3}$$

Gonado-somatic index (GSI) will be calculated using the formula:

$$GSI = \frac{100 \bullet \text{gonad weight}}{\text{total weight}}$$

Hepato-somatic index (HSI) will be calculated using the formula:

$$HSI = \frac{100 \bullet \text{liver weight}}{\text{total weight}}$$

7.2.4.3 Summary Statistics and Comparisons of Size

Summary statistics (sample size, mean, minimum, maximum, standard deviation, standard error) will be generated for length, weight, condition, HIS and GSI. Skewness and kurtosis will be determined for both raw and $\log_{10}$ transformed length and weight at each area and divided by their respective standard errors. A value greater than two will be taken to indicate that a distribution deviates significantly from normal. As normality is an assumption of ANOVA, if either the raw or the transformed data have values of skewness or kurtosis divided by their respective standard errors that are less than two at all areas then the data will be analyzed using ANOVA. Otherwise, the two-sample Kolmogorov-Smirnov (K-S) test, which is recommended for comparing length-frequency distributions between areas (Environment Canada, 2007), will be used to compare length and weight distributions between pair of areas.

7.2.4.4 ANCOVA Analyses

ANCOVA will be used to investigate whether or not significant differences occur in the following relationships:

- total weight versus length
- liver weight versus total weight
- liver weight versus length
- length versus age.

Using log-transformed values, ANCOVA will first be used to test for significant differences in slopes among the three areas. If none exist then ANCOVA will be used to test for significant differences in intercepts between areas. In cases where the interaction term accounts for < 2% of the total variation in the response variable, the reduced model will be considered to be appropriate and used to assess significance and effect sizes, as per Barrett *et al*. (2010). If differences in either slopes or intercepts exist, then pair-wise comparisons will be used to determine which pairs differ.

Residuals from each ANCOVA will be examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) will be removed from the data set, and the analyses repeated and any changes in conclusions considered. This process will be continued until no additional outliers are identified.

The percent difference in least-square means between Mammoth Lake and the reference lakes will be calculated as:

$$\%\,\text{Difference} = \frac{\overline{x}_{\text{exp osure}} - \overline{x}_{\text{reference}}}{\overline{x}_{\text{reference}}}$$

When log transformed data are analyzed, the least-mean square values used will be antilogs of the calculated values.

7.2.4.5 Power Analysis

Post-hoc power analysis will be conducted to determine the ability of the EEM First Biological to detect the specified critical effect size for each of the parameters examined.

7.3 Slimy Sculpin Study Methods

7.3.1 Current Study, Overall Approach and Sample Size

A study currently underway by the University of Waterloo, is using Slimy Sculpin to examine the effects of flooding at Whale Tail Pit. The study began in 2018. In 2018, during the period July 26 – August 2, Slimy Sculpin were collected from six lakes: Mammoth Lake; Whale Tail Lake, a portion of which will be dewatered in 2019 and a portion of which will experience a water level increase in 2019 and 2020; three lakes upstream from Whale Tail Lake where water levels will also increase during Whale Tail Pit operations (A20, A63, A65), and one reference lake in a different sub-watershed (Lake 8). Slimy Sculpin were also captured in Lake D1 in 2018, as part of baseline investigations, but none were retained. The CPUE data from 2018 indicate that it is feasible to collect Slimy Sculpin by backpack electrofishing in Mammoth Lake and in the two reference lakes, Lakes D1 and 8 (Table 7-2).

No young-of-the-year Slimy Sculpin were captured by electrofishing in 2018, which is consistent with results in other northern lakes (Arciszweski et al, 2010). Initial analyses of the 2018 Slimy Sculpin data, presented in Ellenor *et al.* (2019; see Appendix A), demonstrate that there is considerable natural variability in Slimy Sculpin populations among lakes in the Whale Tail Pit area. Size and age distributions varied among lakes and, based on ANCOVA, there were significant differences in the weight versus length relationship (P<0.001) among lakes. Comparisons of weight at various lengths using estimated marginal means indicated that there were differences among lakes at lengths of 30 mm and 35 mm length, but not at 45 mm or 50 mm. Sex and maturity were not determined, but it is expected that the majority of the individuals were not sexually mature.

Table 7-2. Catch of Slimy Sculpin, electroseconds of effort, and catch per unit effort (CPUE) expressed as number of Slimy Sculpin captured per 1000 electroseconds for lakes in the Whale Tail Pit study area in 2018.

Lake	Slimy Sculpin caught	Electro-seconds	CPUE (fish/1000 electroseconds)
Mammoth	69	7,124	9.7
Lake 8	100	5,869	17.0
Lake D1	27	2460	11.0
A20	71	8,044	9.5
A63	84	2,664	31.5
A65	29	1,658	17.5
Whale Tail	87	4,363	19.9

Slimy Sculpin collections are planned as part of this project in 2019 and 2020. The removal of even relatively low numbers of adult Slimy Sculpin may not be sustainable in northern unproductive lakes (Arciszweski et al, 2010). Therefore, to maximize the use of fish collected and to avoid possible study interference, it is proposed that the First Whale Tail Pit EEM biological study use the data collected by the University of Waterloo study on Slimy Sculpin from Mammoth Lake and Lake 8 in 2020, combined with comparable data collected from Slimy Sculpin captured in Lake D1. Data from Slimy Sculpin collected in other waterbodies as part of the University of Waterloo study may ultimately inform interpretations, but it is not proposed that it be reported in the EEM interpretive report, as timelines may not be compatible. Likewise, the mercury concentration study, which is designed to examine the effects of flooding, will not be reported in the first EEM biological study report.

Approximately 30 Slimy Sculpin will be collected from each location to examine the weight versus length relationship (condition), length at age, and mercury concentrations, (Professor Heidi Swanson, University of Waterloo. Personal communication with C. Portt, July 5, 2019). The samples will be frozen upon collection and taken to the laboratory where lengths and weights will be determined, and otoliths will be removed and aged. In summary, the proposed Slimy Sculpin study is a lethal study with one exposure area (Mammoth Lake) and two reference areas (Lake D1 and Lake 8) that will determine length, weight, and age of approximately 30 individuals from each lake, and compare the relationships between length at the exposure and reference areas.

7.3.2 Slimy Sculpin Collections

7.3.2.1 Timing

Slimy Sculpin sampling for the Whale Tail Pit EEM Cycle 1 will be conducted in late July or in August, 2020, consistent with the timing of the University of Waterloo sampling in 2018 and 2019.

7.3.2.2 Gear

Slimy Sculpin will be collected using a backpack electrofisher and standard electrofishing dip nets. The electrofisher settings and electroseconds of effort will be recorded for each sampling location.

7.3.2.3 Locations

Electrofishing locations will be selected by University of Waterloo researchers, with the caveat that the locations sampled in Mammoth Lake will be within the area occupied by the 1% effluent plume. The coordinates of electrofishing locations will be determined using hand-held GPS.

7.3.2.4 Supporting Environmental Variables

Specific conductance (µS/cm), pH, dissolved oxygen (mg/L and % saturation) and temperature (°C) will be determined in the field within the Exposure and Reference Areas.

7.3.3 Slimy Sculpin Measurements

The following information will be determined for each Slimy Sculpin that is part of the lethal sample:

- fork length in millimeters to the nearest millimeter
- total weight in grams, to the nearest 0.01 gram,
- presence of external deformities, lesions, tumours, or parasites.
- presence of internal deformities, lesions, tumours, or parasites.

Otoliths will be collected and placed in envelopes labeled with the sampling area, date, species, and specimen number. Age will be estimated based on the number of annuli counted in whole otoliths using transmitted light and a stereo microscope. As a QA/QC measure, annuli will be counted by a second person for at least 10% of the otoliths.

7.3.4 Statistical Analysis

Data assessment and interpretation will be conducted following the guidelines presented in Environment Canada (2012).

7.3.4.1 Initial Data QA/QC

Data will be entered into an Excel© spreadsheet. The entered data will be compared with the original data sheets, and any data entry errors that are identified will be corrected. Scatterplots of length versus weight will be prepared. If aberrant values are identified, the original data sheets will be re-checked to ensure that these are not due to transcription errors. Any transcription errors found will be corrected. If clearly aberrant values for length or weight occur in the original data, these will be eliminated from the dataset.

7.3.4.2 Calculated Indices

Condition (K) will be calculated using the formula:

$$K = \frac{100 \bullet \text{weight}}{\text{length}^3}$$

7.3.4.3 Summary Statistics and Comparisons of Size

Summary statistics (sample size, mean, minimum, maximum, standard deviation, standard error) will be generated for length, weight, condition and age. Skewness and kurtosis will be determined for both raw and $\log_{10}$ transformed length and weight at each area and divided by their respective standard errors. A value greater than two will be taken to indicate that a distribution deviates significantly from normal. As normality is an assumption of ANOVA, if either the raw or the transformed data have values of skewness or kurtosis divided by their respective standard errors that are less than two at all areas, then the data will be analyzed using ANOVA. Otherwise, the two-sample Kolmogorov-Smirnov (K-S) test, which is recommended for comparing length-frequency distributions between areas (Environment Canada, 2007), will be used to compare length and weight distributions between pair of areas.

7.3.4.4 ANCOVA Analyses

ANCOVA will be used to investigate if significant differences occur in the following relationships:

- total weight versus length;
- length versus age.

Using log-transformed values, ANCOVA will first be used to test for significant differences in slopes among the three areas. If none exist then ANCOVA will be used to test for significant differences in intercepts between areas. In cases where the interaction term accounts for < 2% of the total variation in the response variable, the reduced model will be considered to be appropriate and used to assess significance and effect sizes, as per Barrett *et al*. (2010). If differences in either slopes or intercepts exist, then pair-wise comparisons will be used to determine which pairs differ.

Residuals from each ANCOVA will be examined for normality and outliers. Observations producing large Studentized residuals (i.e., > 4) will be removed from the data set, and the analyses repeated and any changes in conclusions considered. This process will be continued until no additional outliers are identified.

The percent difference in least-square means between Mammoth Lake and the reference lakes will be calculated as:

$$\%\,\text{Difference} = \frac{\overline{x}_{\text{exp osure}} - \overline{x}_{\text{reference}}}{\overline{x}_{\text{reference}}}$$

When log transformed data are analyzed, the least-mean square values used will be antilogs of the calculated values.

7.3.4.5 Power Analysis

Post-hoc power analysis will be conducted to determine the ability of the EEM First Biological to detect the specified critical effect size for each of the parameters examined.

8.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

8.1 Pre-Design Information

Agnico Eagle Mines has been sampling benthic macroinvertebrates annually from various reference and exposed lakes in the Meadowbank study area since 2006 (Table 8-1). Benthic invertebrates were first sampled in Whale Tail Pit lakes in 2014, but a different taxonomist identified those samples than has identified the subsequent samples from the Whale Tail Pit area and all other CREMP samples to date. Therefore, it is not proposed to include those samples in the EEM analyses. The benthos of Mammoth Lake were sampled using the standard CREMP methodology annually beginning in 2015 and will continue to be sampled annually. The sampling area in Mammoth Lake (MAM) was in a ‘control’, reference or baseline condition prior to 2019, and will be considered to be in an ‘impact’ or ‘exposed’ condition beginning in 2019.

There are two reference lake areas proposed for this EEM program: Lake D1 (LK1); Lake 8 (LK8). Both Lake D1 and Lake 8 were sampled in 2018, and will be sampled in 2019. They are both close to (a few km) Mammoth Lake. These two lakes are proposed as local reference lakes (reference areas), on which to construct and test formal hypotheses related to before-after-control-impact (BACI) effects.

The benthos in MAM, LK1 and LK8 are typical of what is found in Holarctic regions, in the water depths and substrates sampled. Sampling depths have typically been in the 7 to 9 m range (Table 8-2). The sediments in MAM, LK1 and LK8 are fine, mainly comprised of silt and clay (Table 8-2). The lakes vary somewhat in the organic content of sediments, but sediments in each lake are significantly organic (9% in LK1, 24% in LK8 and ~ 2% in MAM; Table 8-2).

The benthic communities have been most recently documented in the 2018 CREMP report (Azimuth, 2019). Benthic communities in the proposed three study areas have historically had low abundances (as with the other lakes in the area) of between about 2,000 and 5,000 organisms per m^2 (Table 8-2), and with typically 7 to 9 families of benthos (Table 8-2). Benthic communities in the three sampling areas are dominated by Chironomidae and Sphaeriidae fingernail clams, with lesser abundances of aquatic worms (Naididae, Nematodes; Table 8-2). Chironomids in MAM, LK1 and LK8 have generally included many common forms. *Micropsectra*, *Procladius* and *Tanytarsus* (all common) were each found in relatively high abundances in the three lakes in August 2018. *Corynocera* was abundant in MAM but not in the other two lakes. All of the chironomids occurring in MAM, LK1, LK8, Inuggugayualik Lake (INUG) and Pipedream Lake (PDL) are relatively commonly distributed across the north and south of Canada (Thorp and Covich, 2001). The fingernail clams were represented by *Pisidium* and *Sphaerium nitidum* (Arctic fingernail clam), both common (Clarke, 1981). Ostracods were relatively common, as were nematodes.

Table 8-1. Benthic invertebrate community monitoring, 2006 through 2020.

Year	Potential Regional Reference		Local Reference		Exposure
	INUG	PDL	Lake D1	Lake 8	Mammoth
2006	C				
2007	C				
2008	C				
2009	C	C			
2010	C	C			
2011	C	C			
2012	C	C			
2013	C	C			
2014	C	C			
2015	C	C			C
2016	C	C			C
2017	C	C			C
2018	C	C	C	C	C
2019	C	C	C	C	I
2020	C	C	C	C	I
Total C Years	15	12	3	3	2

Table Note: the letter “C” denotes a control, or baseline, year; the letter I indicates the lake is impacted.

Table 8-2. Benthic community composition, effect indicators and sediment depth and character in Lake D1, Lake 8 and Mammoth Lake, 2017 and 2018.

Family	LK1	LK8	MAM	
	2018	2018	2017	2018
Nemata	3	8	<1	7
Platyhelminthes	<1	<1	<1	1
Naididae	<1	1	1	1
Lumbriculidae	2	1	<1	2
Acarina		<1		
Acalyptonotidae	1	1	<1	
Lebertiidae	1	1	1	1
Oxidae	2	1	1	1
Pionidae			<1	<1
Limnephilidae			<1	
Chironomidae	70	39	64	61
Empididae		<1		
Sphaeriidae	18	25	18	17
Ostracoda	4	24	13	9
Notostraca			<1	<1
EEM Effect Indicators				
Abundance (#/m^2)	2326	3296	5148	4604
Family Richness	6.6	8.2	8.2	8.6
Family Equitability	0.32	0.44	0.28	0.30
Sediment Character				
% Sand	4	1	11	9
% Silt	79	66	81	85
% Clay	12	10	17	13
% TOC	8.7	24.0	2.1	1.7
Depth of sample (m)	7.7	7.7	8.1	8.2

8.2 Benthic Invertebrate Community Survey

8.2.1 Statistical Design

The design for the First EEM benthic invertebrate community survey for Mammoth Lake is proposed to be an extension of the annual monitoring that has already been undertaken by the CREMP and, except for the change in exposure and reference areas, similar to the Cycle 2 and 3 EEM studies at the Meadowbank Mine (C. Portt and Associates and Kilgour & Associates Ltd, 2015, 2017). There will be two reference areas, one in Lake D1 and one in Lake 8, and one exposure area in Mammoth Lake (Figure 8-1). Five stations will be nested within each of the two reference areas and the one exposure area. Two sub-samples of the benthic community will be collected from each sampling station and composited. Depths will be approximately 7 to 9 m, per the depths that have been sampled in recent CREMP programs. Sampling stations will be a minimum of 20 m apart to ensure a minimum of independence of stations.

Variability among stations will be used to judge the significance of variations among areas. Stations are therefore the unit of replication. Stations have been randomly selected each year that the sampling has been carried out under CREMP; that is, stations are a random assortment each year. Sampling in MAM, LK1, and LK8 for the EEM program will be similarly undertaken, with five sampling stations somewhat 'randomly' selected by the field crew, but given the constraints of depth and spatial separation per the previous paragraph. Proposed sampling areas are defined by the circles in Figure 8-1.

8.2.2 Sampling Method

Samples of sediment (and benthos) will be collected with a 0.023 m^2 Petite Ponar grab, as per what was used in the CREMP and EEM studies previously. Samples will consist of composites of two individual grabs per station. Grabs will be washed on site using 500 μm mesh to retain organisms and debris and preserved on site using 10% buffered formalin.

The rationale for collecting duplicate samples per station, and compositing them, is based on the following: Benthos sampling at Meadowbank under the CREMP has always involved the compositing of duplicate samples (see Azimuth, 2019). The collection and compositing of duplicate samples will thus allow the 2020 EEM program to use and compare observations for Mammoth Lake to historical data for Mammoth Lake, to historical and current data for Lake D1 and Lake 8, as well as potentially to other lakes in the general area (such as INUG and PDL, which have both been used previously by Agnico to estimate reference conditions for lakes exposed to mine effluent under the federal EEM program; C. Portt and Associates and Kilgour & Associates Ltd, 2015, 2018), and that represent reference conditions (Table 8-1). Further, the study design for the last EEM program for Third Portage North (C. Portt and Associates and Kilgour & Associates Ltd., 2014) demonstrated that the within-station precision for estimates of abundance and family richness were each of a magnitude that either 1 or 2 grabs would achieve a precision of 0.2 or better (and therefore deemed acceptable per the guidance document, Environment Canada, 2012). Consequently, the duplicate sample method was approved by Environment Canada for use in the EEM Cycle 2 for Third Portage North.

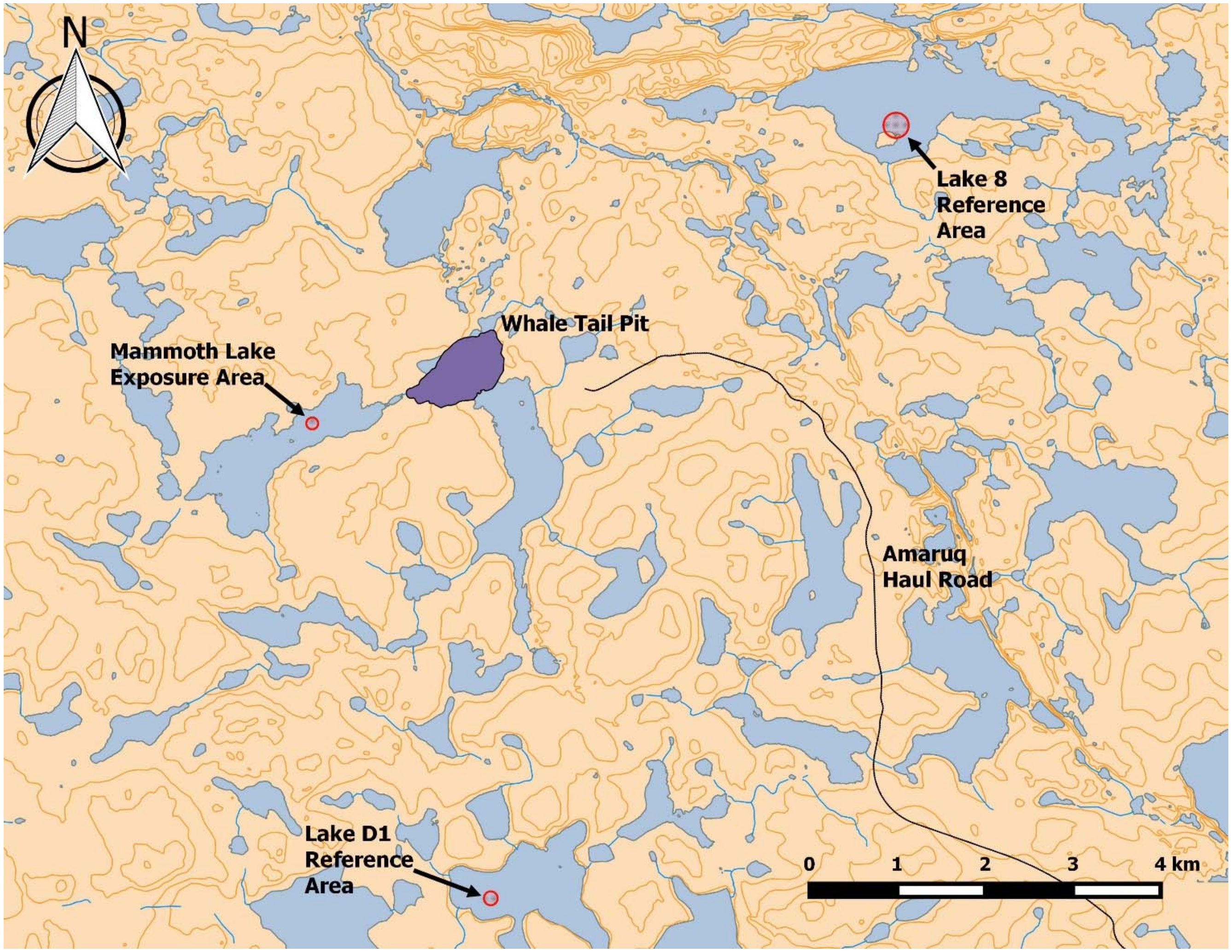

Figure 8-1. EEM Sediment and Benthos Sampling Areas. Samples will be taken within the circled areas, consistent with CREMP sediment and benthos sampling.

8.2.3 Supporting Environmental Variables

A variety of supporting environmental variables will be characterized within the three study areas.

8.2.3.1 General

Calibrated electronic field meters will be used to measure the following parameters, each day that biological samples are collected:

- pH
- dissolved oxygen
- temperature; and,
- conductivity.

These parameters will be measured at 1 m intervals from surface to 1 m off bottom, at each sampling station. This will document the level of stratification at the time of sampling.

Water depth at the point of sampling will be determined using an electronic sonar device.

8.2.3.2 Water Quality

Water samples will be collected under Agnico Eagle Mine's CREMP water quality monitoring program, as per the Azimuth Standard Operating Procedure (Appendix B). Water will be collected from two randomly selected locations (stations) within each sampling area. If the water at a station is NOT thermally or chemically (determined by conductivity) stratified, water will be collected from 3 m below surface. If the water at a station IS thermally or chemically stratified, water will be collected from three depths: (1) surface (2) 3 m below surface; and (3) 3 m above the bottom; as well as an integrated sample from 0.5 to 8 m.

Water will be analyzed for the following analytes determined by a certified (CAEAL accredited) laboratory, consistent with what is routinely measured as part of Agnico's CREMP:

- Physical tests (conductivity, hardness, pH, total suspended solids, turbidity);
- Metals (aluminum, cadmium, iron, molybdenum, arsenic, copper, lead, nickel, zinc, radium 226, cyanide, selenium);
- Anions and Nutrients (alkalinity, ammonia, bromide, chloride, fluoride, nitrate, nitrite, total Kjeldahl nitrogen, ortho phosphate, silicate, sulfate); and
- Other (dissolved organic carbon, total organic carbon)

Detection limits for water quality parameters are provided in the table below (Table 8-3).

Table 8-3. Water Quality Detection Limits.

Parameter	Detection Limit	Units
Conductivity	2	µs/cm
Hardness	1.1	mg/L
pH	0.1	
Total suspended solids	1	mg/L
Turbidity	0.1	NTU
Alkalinity	2	mg/L
Ammonia	0.02	mg/L
Bromide	0.05	mg/L
Chloride	0.5	mg/L
Fluoride	0.02	mg/L
Nitrate	0.005	mg/L
Nitrite	0.001	mg/L
Total Kjeldahl Nitrogen	0.05	mg/L
Ortho Phosphate	0.001	mg/L
Total Phosphate	0.002	mg/L
Silicate	1	mg/L
Sulfate	0.5	mg/L
Aluminum	0.005	mg/L
Cadmium	0.000017	mg/L
Iron	0.03	mg/L
Molybdenum	0.001	mg/L
Arsenic	0.0005	mg/L
Copper	0.001	mg/L
Lead	0.0005	mg/L
Nickel	0.001	mg/L
Zinc	0.005	mg/L
Radium 226	0.002	Bq/L
Cyanide	0.005	mg/L
Selenium	0.001	mg/L
Dissolved Organic Carbon	0.5	mg/L
Total Organic Carbon	0.5	mg/L

8.2.3.3 Sediment Quality

Sediment samples will be collected from each benthic invertebrate sampling station and analyzed for:

- Total organic carbon (%) and,
- Sediment particle size (% gravel, sand, silt/clay), as per the Wentworth Classification (Wentworth, 1922).

Detection limits for sediment quality measures are provided in Table 8-4. Sediments will be collected at the same time as the benthic community samples, using the same petite Ponar grab. The grab will be washed between lakes and rinsed between sampling stations.

Table 8-4. Sediment Measures Detection Limits.

Parameter	Detection Limit	Units
% Gravel (> 2 mm)	1	%
% Sand (2 mm to 0.063 mm)	1	%
% Silt (0.063 mm to 4 µm)	1	%
% Clay (<4 µm)	1	%
Total Organic Carbon	0.1	%

8.2.4 Timing

Benthic invertebrate sample collection (and collection of ancillary supporting data) will occur in mid to late August of 2020, similar to the time period for the CREMP sampling. The specific timing of sampling for individual lakes in 2020 will be determined through coordination with staff at the Meadowbank Mine and Whale Tail Pit.

8.2.5 Laboratory Protocol

Upon arrival to the laboratory, samples will be logged and inspected to ensure adequate preservation, and correct labeling. Prior to sorting, excess formalin and dye will be washed from the samples using a 500-µm mesh sieve. Samples will be sorted using 7 to 10 x magnification. Samples may be stained with a protein dye to facilitate the visual inspection of samples.

Organisms will be identified to lowest practical levels. Whenever possible, complete samples will be sorted and all organisms identified.

If sub-sampling is necessary for sorting, samples will be separated into fractions by volume. A variety of extra floatation and screening methods will be used to maximize the amount of material that is processed. A minimum of ¼ of each sample will be processed, ensuring that 300 organisms are identified. If a full sample does not contain 300 organisms, the full sample will be processed.

Ten percent of the samples will be re-sorted by independent taxonomists to confirm a 90% recovery of benthic organisms. Organisms that are difficult to identify will be sent to government or academic experts in taxonomy for confirmation of identification.

The following laboratory data will be recorded:

- raw data for each replicate sample listing taxa present and number of individuals
- degree of sorting efficiency achieved
- method of and level of sub-sampling applied and sub-sampling precision
- taxonomic authorities used

- location of reference collection and report on taxonomic verification

8.2.6 Data Analysis

8.2.6.1 Effect Variables

The required indices of benthic community composition will be computed for each sample: total abundance, taxa richness, and Simpson's Evenness (Equitability) will be calculated, per the Guidance Document (Environment Canada, 2012).

Bray-Curtis distances will be computed between all possible pairs of samples using:

$$BC = \frac{\sum |y_{i1} - y_{i2}|}{\sum |y_{i1} + y_{i2}|}$$

Where

- BC = Bray-Curtis distance;
- y_{i1} is the count for taxon *i* in station 1; and,
- y_{i2} is the count for taxon *i* at site 2;

8.2.6.2 Basic Statistics

Mean, median, standard deviation, standard error, minimum and maximum values for abundance, family richness, and equitability will be provided for each sample area using 2020 data. Mean, median, SD, SE, and minimum and maximum Bray Curtis distances within MAM, LK1 and LK8, and between MAM and LK1 and LK8, will also be provided, again using only the 2020 data.

8.2.6.3 Data Ordination

Bray-Curtis distances provide only an indication that there are differences in composition among samples, sample areas and years, but do not indicate the 'nature' of those variations. It can be difficult to interpret variations in Bray-Curtis therefore, without additional supporting analysis of those variations. Ordination is generally the follow-up to the computation of Bray-Curtis distance (Gauch, 1982). Non-metric Multidimensional Scaling (NMDS) will be used to ordinate the benthic community count data. The NMDS will use Bray-Curtis distances computed from either raw count data or $\log_{10}$ (x+1, where x is abundance) count data, depending on which count value results in an ordination with less visually obvious skew in axis scores. The ordination will produce 2 (or 3) ordination axes that will be used as derived variables to illustrate the nature of variability in community composition.

8.2.6.4 Hypothesis Testing for Conventional Variables

To determine if variation in benthic community structure is associated with mine effluent, a combination of graphical and hypothesis testing procedures will be used (Analysis of Variance, ANOVA). Classical

ANOVA will be used to test for changes in differences in average values of compositional indices between reference and exposure areas of the conventional effect variables abundance, richness and equitability.

To comply with the Regulation, conventional ANOVA will be used to test that the mean of indices in Mammoth Lake in 2020 are equal to the mean of index values from Lake D1 and Lake 8. Natural differences among lakes can be anticipated (Underwood, 1989, 1991, 1993, 1994). Therefore, the full complement of baseline and exposure period data (see Table 8-1) will be used in an analysis of variance with Planned Linear Orthogonal Contrasts (or PLOC; see Hoke *et al*., 1990; Department of Fisheries and Oceans and Environment Canada, 1995). PLOC can test very specific hypotheses that are likely to be of interest and that take into account that within a time period there are likely to be natural differences between reference and exposure areas. Specifically, the hypothesis articulated by the contrasts provided in Table 8-5, and using the ANOVA structure as illustrated in Table 8-6, will be tested.

Two sets of ANOVAs will be conducted. In the first set of ANOVAs, data only from Mammoth Lake would be used, comparing data from the baseline period (2015 through 2018) to data from the exposure period (2019 and 2020) in a before-after context. Hypothesis BA-1 will test for a difference between the mean of the baseline period data (2015 through 2018) and the mean of the exposure period data (2019+2020). Hypothesis BA-2 will test for a difference between the mean of the baseline period data (2015 through 2018) and the 2020 data. This second version of the BA contrast is proposed because data in 2019 will represent a 'newly' exposed condition that may not yet fully reflect the degree of effects that may occur. Hypothesis BA-1 may therefore not demonstrate effects because of a potential dilution of effects from 2019.

In a second set of ANOVA's, data from Mammoth Lake, Lake D1 and Lake 8 will be used in a classic before-after-control-impact (BACI) design, and where there is 1 year of baseline data (2018) and two years of exposure data (2019 and 2020, with 2019 being a partial exposure and 2020 being a full exposure). Because there are no data from Lake D1 or Lake 8 in 2017, that year (in Mammoth Lake) cannot be used in this analysis. The proposed contrast coefficients are provided in Table 8-5.

In total, two ANOVAs, each with two sub-hypotheses that will be tested with the contrast coefficients indicated in Table 8-5, will be conducted. For these ANOVA's, the variation among stations will be used to judge the significance of the contrasts per Table 8-6. The mean squared error term will be estimated through an omnibus ANOVA that incorporates data from all sample areas and years. Doing that ensures the most robust estimate of among station variability (i.e., among station SD), and therefore the most robust evaluation of the hypotheses.

Table 8-5. Potential linear contrasts that could be used to analyze the 2020 benthic community data from Mammoth Lake, Lake D1 and Lake 8.

Condition	Lake	Year	Condition	Before-After		BACI	
				BA-1	BA-2	BACI-1	BACI-2
Reference	Lake D1	2017	no sample				
		2018	C			2	1
		2019	C			-1	0
		2020	C			-1	-1
	Lake 8	2017	no sample				
		2018	C			2	1
		2019	C			-1	0
		2020	C			-1	-1
Exposure	Mammoth	2017	C	-1	-1		
		2018	C	-1	-1	-4	-2
		2019	I	1	0	2	0
		2020	I	1	2	2	2

Note: C = control; I = impact.

Table 8-6. ANOVA table to analyze linear contrasts in Table 8-5.

Source	df	MS	F
Year x Lake Combinations (Y x L)	(Y x L) -1	MS (YxL)	
Contrast	1	MS (contrast)	MS (contrast) / MS (E)
Error	(Y x L x n)-1	MS (E)	

8.2.6.5 Assessment of Covariable Effects

Prior to 'running' ANOVA's, the associations between benthos and potential modifying factors (e.g., water depth, substrate texture, sediment TOC) will be examined. If I is established that variations in benthic community composition were influenced by a modifying factor, and if standardization of the benthos indices can be accommodated, this will be done using general linear models based on reference data, with application of the models to exposure data. Standardized benthos indices (i.e., standardized to a common depth, grain size, etc., as appropriate) would then be the inputs to the ANOVA's.

8.2.6.6 Assessment of Bray-Curtis Distances

Partial Mantel tests or simple Mantel tests will be used to test the hypotheses listed in Table 8-6, and using the methods described by Borcard and Legendre (2013). Mantel (1967) tests will be completed in *R*. Partial Mantel tests will be used if data evaluation indicates that physical or chemical variables (unrelated to mine effluent exposure) are covarying with benthic community composition.

8.2.6.7 Effect Sizes

Effect sizes for the more conventional effect endpoints: abundance, richness and equitability will be computed in the following manner, with the equations below specifying the null hypotheses in Table 8-5.

For Hypotheses BA-1, the effect size (ES) is computed as:

$$ES = \frac{|M_{19+20} - M_{17+18}|}{SD_w}$$

Where

- M_{19+20} is the average benthic community index value in the after period (2019 and 2020) in Mammoth Lake;
- $M_{17+18}$is the average benthic community index value in the before period (2017 and 2018) in Mammoth Lake; and,
- SD_w is the pooled within area/year standard deviation.

For Hypotheses BA-2 the effect size (ES) is computed as:

$$ES = \frac{|M_{20} - M_{17+18}|}{SD_w}$$

Where

- M_{20} is the average benthic community index value in 2020 in Mammoth Lake.

For Hypotheses BACI-1, effect size (ES) is computed as:

$$ES = \frac{|M_{19+20-18} - (L1_{19+20-18} + L8_{19+20-18})|}{SD_w}$$

Where

- $M_{19+20-18}$ is the change from 2018 to the mean of 2019+2020 in benthic community index values in Mammoth Lake; and,
- $L8_{19+20-18}$ is the change from 2018 to the mean of 2019+2020 in benthic community index values in Lakes D1 and 8.

For Hypotheses BACI-2, the effect size (ES) is computed as:

$$ES = \frac{|(M_{20} - M_{18}) - [(L1_{20} - L1_{18}) + (L8_{20} - L8_{18})]/2|}{SD_w}$$

Where

- $M1_{20} - M1_{18}$ is the change from 2018 to 2020 in benthic community index values in Mammoth Lake;
- $L1_{20} - L1_{18}$ is the change from 2018 to 2020 in benthic community index values in Lake D1;
- $L8_{20} - L8_{18}$ is the change from 2018 to 2020 in benthic community index values in Lake 8;

The effect sizes above will be computed from within-group (within year x lake) residual error, and can be used to also estimate normal ranges of variation as approximately the mean of the reference data plus/minus 2 standard deviations (Kilgour et al., 1998, 2017). In addition to the pooled SD_w term, whether there is a difference in residual error between reference and exposure areas will be assessed, before carrying on with the pooled term. Effect sizes will be computed using a within-reference variance term (SD_{ref}) if there is a significant difference in the reference and exposure area variances, as determined by an *F* test.

These normal ranges for the effect variables will be illustrated in relation to variations among lakes and years in scatter plots or box plots of the data. Plots of combinations of NMDS axis scores (2 vs 1, 3 vs 1, 3 vs 1, as appropriate) will illustrate normal ranges for reference data using ellipses, with the ellipses sized to represent the normal range that includes 95% of reference data. These normal ranges will assist in the interpretation of the magnitude and nature of variations between reference and exposure benthic communities.

9.0 GENERAL QA/QC PROGRAM

The quality assurance and quality control program for this EEM will include the following elements.

Highly trained and experienced personnel will carry out the field sampling program for the biological components. It is expected that Cameron Portt (M.Sc., 45 years of experience), George Coker (B.Sc., 45 years of experience), Bruce Kilgour (PhD, 35 years of experience) and Anthony Francis (PhD, 20 years) will comprise the principal field crew.

Electronic meters for measuring dissolved oxygen, pH and conductivity will be calibrated daily.

Water and sediment samples will be processed by a CAEAL accredited laboratory. In addition to triplicate water samples from each sampling area, a field blank and a trip blank will also be collected during the field program, and analyzed for all measurement endpoints. Water samples will be collected following the Standard Operating Procedure provided in Appendix B.

Results from duplicate laboratory samples will be assessed using the relative percent difference (RPD) formula:

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

Where: A = analytical result; B is the result for the duplicate. The laboratory data quality objective for this project will be:

- Analytical precision of 25% RPD, for concentrations that exceed 10x the method detection limit; and,
- 95% valid data obtained.

For measurements on fish and fish tissues, the following procedures and controls will be put in place. Measurements and weights will be obtained on site. Electronic balances will be calibrated daily. Weights and lengths will be recorded in hard copy and later entered into a digital spreadsheet. Plots of lengths and weights will be undertaken while the crew is still on site, to identify data outliers, and determine if any additional samples are required, prior to leaving the site.

For the benthic invertebrate community component, the following procedures and controls will be put in place. Zaranko Environmental Assessment Services (ZEAS) will process and identify the benthos samples. ZEAS processed and identified the benthic samples in the Cycle 1, Cycle 2, and Cycle 3 EEM studies at the Meadowbank Mine and the CREMP, therefore, use of ZEAS in this study will provide consistency. Ten percent of the benthic invertebrate community samples will be re-sorted to confirm recovery of 90% of organisms. In the event of that the QA/QC fails, all of the samples will be re-sorted.

Data analysis will be carried out by the senior staff. Fish morphometric and benthic invertebrate community indices will be examined using visual graphing techniques to check for outliers and unusual observations. Data will be logarithm transformed, as appropriate, to control error variances, and to ensure that parametric analyses meet assumptions of parametric statistical tests as much as is feasible. Violation of assumptions will be reported as appropriate, and the potential consequences of violations to the interpretation of the data provided. Where there are unusual or outlier values, analyses will be carried out with and without those values, and the differences in interpretation provided.

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APPENDIX A

ELLENOR *ET AL.* 2019

Variation in Slimy Sculpin (*Cottus cognatus*) monitoring endpoints at six Barrenland lakes in central Nunavut

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Slimy Sculpin and Environmental Effects Monitoring

- Due to their small home range, relatively high abundance, short life span, and broad distribution Slimy Sculpin are often used as a sentinel species for environmental effects monitoring, including in Northern regions of Canada. [1]
- High costs associated with northern monitoring programs, along with a short field season and overall low fish abundance, mean that sound study designs are essential
- Monitoring endpoints are selected based on study objectives and may include length, weight, condition, age, catch per unit effort, weight-at-age, etc. [1], [2], [3], [4]
- Understanding natural variability in Slimy Sculpin monitoring endpoints among lake systems within a region will aide in the selection of appropriate reference sites and inform sample size requirements to achieve a suitable power to detect effects.

Objective and Methods

To compare commonly used monitoring endpoints, including: catch-per-unit effort, length, weight, condition, and weight-at-age of Slimy Sculpin across six proximate lakes in a Barrenland region of central Nunavut.

- Fish captured by electrofishing.
- Retained 70 -100 individuals per lake .
- Measured length (± 1 mm) and weight (± 0.001 g).
- Aged 12 individuals per lake using otoliths.

Study Area

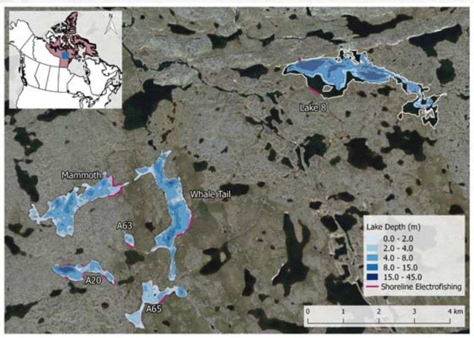

Figure 1. Map of Study Area

- Region of continuous permafrost
- Headwater lakes of varying surface area (0.07 – 2.91 km²) and depth (6.0 – 44.1 m maximum depth) (Figure 1)
- Lakes are nutrient poor and unproductive (oligotrophic)

Catch Per Unit Effort

- Slimy Sculpin were consistently the most abundant species, based on electrofishing catches.
- No young-of-year captured; youngest age class is year 1.
- Catch per unit effort (CPUE) highly variable among lakes, possibly related to substrate (more analysis necessary).

Table 1. CPUE among lakes

Lake	n[1]	Seconds of Electrofishing	CPUE (fish/1000 s of electrofishing)
A20	71	8,044	9.5
A63	84	2,664	31.5
A65	29	1,658	17.5
Lake 8	100	5,869	17.0
Mammoth	69	7,124	9.7
Whale Tail	87	4,363	19.9

[1] Number of individuals included in the CPUE metric

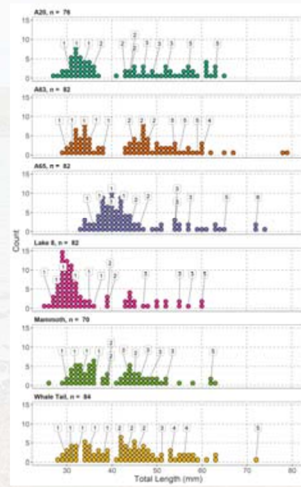

Figure 2. Length-frequency distributions among lakes. Aged fish are identified.

Weight-at-Age

- Mean weight-at-age based on estimated marginal means of linear model using aged individuals .
- Variability in mean weight-at-age among lakes.
- Weight consistently greatest in Lake A65 and least in Lake 8 for ages 1 through 3.

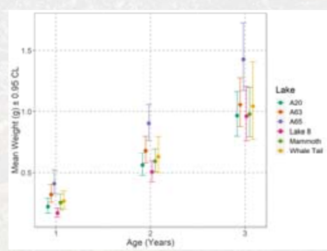

Figure 3. Mean weight-at-age among lakes

Length and Weight

- Linear regression of log transformed weight and length used to investigate condition (Figure 4).
- Significant difference ($p < 0.001$) in weight versus length relationship among lakes based on ANCOVA.
- Differences in condition among lakes are only observed at smaller sizes (Figure 5).

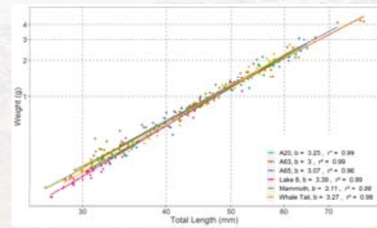

Figure 4. Log weight versus log length relationships among lakes.

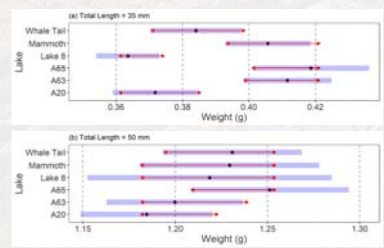

Figure 5. Estimated marginal mean weight in each lake at a total length of (a) 35 mm and (b) 50 mm. Blue bars are 95% confidence levels; red arrows are comparisons among lakes (Tukey), where non-overlapping arrows indicate a significant difference between lakes.

Findings / Next Steps

- Significant differences in weight versus length relationships and variability in size at age among lakes suggest that local conditions (i.e., independent of anthropogenic effects) influence monitoring endpoints, which is important to consider during study design.
- Significant differences among lakes in weight-at-length (condition) in Slimy Sculpin were observed at lengths of 30 mm, 35 mm, and to some extent 40 mm, but not at 45 mm or 50 mm. This has important implications for selection of monitoring endpoints.
- Understanding factors that lead to natural variation in monitoring endpoints will lead to improved reference system selection and increased confidence in inferences related to effects of development.

Acknowledgements

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APPENDIX B

STANDARD OPERATING PROCEDURES

The following Standard Operating Procedures were adapted from Azimuth (2010a). The sampling will follow the same procedures as the Meadowbank Project Lakes & Baker Lake CREMP Sampling, to ensure data compatibility. Equipment brands and personnel may differ from those indicated.

Standard Operating Procedure
Water Sampling

Samples will be taken by qualified environmental staff at the same time and location as the biological monitoring data are collected.

Sample locations:
Three (3) sampling stations have been chosen for water quality monitoring in the Whale Tail Pit project lakes:

- Mammoth Lake (MAM)
- Lake D1 (LK1)
- Lake 8 (LK8)

Water quality and limnology sampling protocol:

1) Prior to leaving camp gather the appropriate type and number of sampling vessels and acid vials for preservation unless bottles are pre-preserved. Prepare appropriate labels for containers, affix them to the appropriate bottle (see below), and wrap label with packing tape. Use the following information:
    - Company name
    - Station abbreviation (e.g. MAM, LK1, LK8)
    - Date of sample collection
    - Parameters to be measured from individual bottle (TOC, total metals, etc.)

2) Gather **field collection materials**:
   In the boat:
    - Field collection data forms, pencils, waterproof markers & clipboard
    - GPS unit, batteries
    - Water pump & 12V battery
    - Tubing (4 meter length and 1 meter length) & weight (& extra C-clamps and cable ties)
    - In-line filter and a spare
    - Water quality meter, batteries
    - Secchi disk
    - Hand held pH meter, batteries
    - Depth meter, batteries
    - Rope
    - Sampling gloves
    - Field sample bottles & preservatives (as provided by laboratory):
    - Extra sample bottles in case of breakage or loss
    - QA/QC field duplicate sampling containers & preservatives (same as above).

- Take one set of Travel Blank bottles into the field and transport and treat as other samples.

Note that the Travel Blank bottles are not to be opened and no preservatives added.

In camp:

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

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

Sampling Container	**Parameters to be Measured**	**Preservatives to be added if not pre-added**
2 - 1 L plastic	Conventionals*	None
250 mL amber glass	TKN, Ammonia	1 vial of sulfuric acid
250 mL plastic	Total Metals	1 vial of nitric acid
250 mL plastic	Dissolved Metals	1 vial of nitric acid
125 mL amber glass	TOC	1 vial of hydrochloric acid
125 mL amber glass	DOC	1 vial of hydrochloric acid

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

3. Calibrate the water quality probe prior to going into the field; confirm elevation (m) of sampling environment. Check the DO calibration (adjust barometric pressure based on airport data) but also check the DO membrane (it may need to be replaced). At Meadowbank DO readings should be about 8 – 12mg/L; if meter is reading much lower/higher than this, membrane likely needs to be replaced. Keep a calibration log which includes date and time, type of calibration, results, and troubleshooting.

4) For **QAQC** purposes three kinds of samples are required:

Field duplicate: All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected at random and labeled as station CREMP [month] DUP-

1, -2, -3, -4, etc. Prepare the QAQC labels and affix to the sampling containers, as described in step 2.

Travel blank: These are to be carried into the field and treated like the other sampling vessels except that the bottles are not to be opened or anything added to them. Ship back to the lab, each set with different shipment.

Equipment blank:

To collect an equipment blank, set up the water sampling equipment as if a routine sample was to be collected except that the hoses are placed into the same opening of a container (find an empty and CLEAN container, large enough for >4L; pour 4L of ***tap water from site*** into the clean container). Pump for 2 minutes (just like in the field) to flush site water from the equipment (also attach the filter to flush for 30 seconds). Flush and discard the 4L of tap water, this time with the excurrent hose placed in sink or empty bucket.

Set up the water sampling equipment again as in **STEP 1** except use 4L of ***de-ionized water sent from ALS laboratories***. Pump for 2 minutes (just like in the field) to flush tap water from the equipment (also attach the filter to flush for 30 seconds). Flush and discard 4L of DI water, this time with the excurrent hose placed in sink or empty bucket.

Now with fresh DI water from ALS, fill all bottles listed on the 2015 CREMP Water sampling sheet (except for chlorophyll and phytoplankton). Preserve and treat as other samples, including filtering where necessary. Label as station CREMP [month] EB-1, -2, -3, -4, etc.

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

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

7) Measure water depth at the sampling station using the 'Hawkeye' hand-held depth meter (or transom-mounted sonar). Hold the meter in the water, facing the lake bottom, until the meter measures the depth. Record this information on the field data form. If you are in water that is too shallow (i.e., must have at least 5 meters depth), move to deeper water near the assigned station.

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

9) Measure the pH of the water at the sampling station using the pH meter (unless the YSI includes this parameter). Hold the probe portion of the meter in the lake until the meter measures the pH. Record this information on the field data form.

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

11) Set up the water pump in the boat; attach the tubing to the pump using the C-clamps and attach the 12-V battery. Attach the 4 meter length of tubing to the intake valve, and the 1 meter length to the output valve. Attach the plastic coated ball weight to the end of the 4 meter length of tubing. Lower the 4 meter length of tubing into the water to *3 meters depth* and place the 1 meter length of tubing over the edge of the boat. Run the pump for *2 minutes* to flush the sampling device.

12) For each sampling station, fill the required pre-labeled sampling containers with water from the 1 meter length of tubing.

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

14) Add the specified preservatives to the appropriate sampling containers as needed (according to the information on the labels), seal and mix thoroughly by turning upside down and then upright a number of times.

15) If this sampling station is selected as the QAQC field duplicate, collect a second set of water samples, fill the pre-labeled sampling containers. Record which sampling station the QAQC samples are collected from on the appropriate field data form.

16) Fill out a chain-of-custody form for the water samples and filters being sent to the laboratory. The COC form must be completed carefully and in its entirety to ensure proper analysis. This includes listing all of the specific conventional parameters (see table in step 2), contact names, and

checking off all of the specific boxes for requested analyses. The laboratory quote number must be printed on the COC form to ensure proper billing. A digital COC form is most commonly used; this form can be filled out in advance to ensure accuracy and efficiency and amended in the field as required. Note that using a digital copy of the COC requires printing 2 copies of the document in the field (one for the laboratory, one for Agnico Eagle). Put the completed COC form in a sealed ziploc plastic bag in a cooler with the water samples.

Packaging and shipping samples:

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

2) Ensure the COC form is enclosed and then seal the cooler(s). Label the cooler(s) to ensure the bottles arrive at the laboratory.

3) Ship the water samples to the laboratory as quickly as possible.

Standard Operating Procedure
Benthos & Sediment Sampling

Field activities are scheduled for once per year, in **mid/late August**. The **target water depth** at each sampling station is approximately **8 meters +/- 1.5 m.**

1. Gather field collection materials:

In the boat:

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

In camp:

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

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

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

Affix the labels to the sediment jars and then wrap packing tape around the labels to ensure a waterproof seal. For the benthos containers, print the following information directly onto both the jar and jar lid using a permanent waterproof marker:

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

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

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

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

Transport Canada allows the free transport of formalin at concentrations less than 25% formaldehyde. Consequently, the formalin transported up to Meadowbank will be diluted in half (18.5% formaldehyde / 50% formalin solution). To prepare the neutral buffered formalin, add a small amount of calcium carbonate powder or pellets to the 50% formalin solution, seal the container and shake until mixed.

Check the pH of the solution using the pH pen. Continue adding the powder/pellets until the pH of the solution reaches approximately 7.0. Store at room temperature until ready to use. Only prepare the required volume of neutral buffered formalin for that sampling event. Buffered formalin will not store for long periods of time. Follow all safety precautions when preparing the formalin solution. Formalin is a carcinogen and irritant. Wear sampling gloves and safety glasses when mixing the solution and prepare the solution in a well ventilated area.

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

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

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

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

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

10. Lower the Ponar to within 1 meter of the bottom of the lake. Lower the Ponar very slowly over the last meter and allow the rope to go slack. Raise the Ponar to the edge of the boat and check the grab for acceptability. The grab is acceptable if the sample:

- does not contain large foreign objects;
- has adequate penetration depth (i.e., 10-15 centimeters);
- is not overfilled (sediment surface must not be touching the top of the Ponar);
- did not leak (there is overlying water present in Ponar); and
- is undisturbed (sediment surface relatively flat).

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

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

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

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

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

15. Repeat steps 10-14 four more times; there must be a separation of 20 meters or more from other replicate stations. Record the depth and GPS coordinates of each replicate station on the field data form. Put the samples from each replicate in pre-labeled station replicate jars 2 through 5. In total, 10 Ponar grabs will be collected for benthos collection, two grabs per replicate.

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

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

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

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

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

21. If this station is selected as the QAQC field duplicate, using the tweezers and a set of clean sampling gloves, swipe the stainless steel bowl and spoon with one piece of ashless filter paper and store in the pre-labeled 125 mL glass jar. Collect the duplicate sediment sample from the same sediment collected in

steps 17-20. Fill the sampling containers labeled as station DUP. Record that the QAQC samples were collected from this sampling station on the field data form.

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

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

24. Until ready for shipping, store the sediment samples and QAQC filter paper chilled (on ice) in a cooler or in a refrigerator in camp, if space is available. The sediment sampling containers may be put in plastic bags prior to storage on ice to further protect the labels from water damage. Benthos samples are stored in a cooler or action packer at room temperature.

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

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

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

PACKAGING &SHIPPING SAMPLES:

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

2. Ensure the COC form is enclosed and then seal the cooler(s). Label the cooler(s) with the following address (example):
ALS Environmental
101-8081 Lougheed Hwy.
Burnaby, BC, Canada
V5A 1W9

Tel: 604-253-4188
Attention: Natasha Marcovic-Mirovic

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

4. Ensure the COC form is enclosed and then seal the cooler(s). Label the cooler(s) with the following address:
Zaranko Environmental Assessment Services
36 McCutcheon Avenue
P.O. Box 1045
Nobleton, ON
L0G 1N0 Tel: _____________

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

6. Send completed COC forms and field data forms to Azimuth Consulting Group Partnership, attention the project coordinator