Appendix 35

Meadowbank EEM Cycle 4 Study Design

ENVIRONMENTAL EFFECTS MONITORING:

AGNICO EAGLE MINES LTD.- MEADOWBANK DIVISION

CYCLE 4 STUDY DESIGN

Submitted to:

Agnico Eagle Mines Ltd: Meadowbank Division
Regional Office - 93, Rue Arseneault, suite 202,
Val-d'Or, Québec, J9P 0E9

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C. PORTT and ASSOCIATES
63 Waterloo Avenue
Guelph, Ontario, N1H 3H5
cportt@sentex.net

KILGOUR & ASSOCIATES LTD.
16-2285C St. Laurent Boulevard
Ottawa, Ontario, K1G 4Z6

EXECUTIVE SUMMARY

Agnico Eagle Mines Meadowbank Division is required to conduct the Cycle 4 Environmental Effects Monitoring (EEM) study for its Meadowbank Mine in 2020 pursuant to the companies' requirements under the Metal and Diamond Mining Effluent Regulations (MDMER). The mine (65°N, 96°W) is located approximately 75-km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut. Cycle 1, Cycle 2 and Cycle 3 EEM Biological Monitoring Studies were conducted in 2011, 2014, and 2017, respectively.

Mine reclaim or tailings water has never been discharged at the Meadowbank Mine. The mine discharged treated effluent into Third Portage Lake from 2009 to July 2012 (i.e. during Cycle 1); that effluent consisted of natural lake water that was pumped from an impounded area that was being dewatered. After July, 2012, when dewatering of the impounded area was completed, the mine effluent consisted of treated mine contact water, which is local drainage that may have been in contact with potentially acid generating (PAG) material (i.e. waste rock and local mine site drainage water), as well as water that is collected and pumped from the mine pits. During EEM Cycles 1 and 2 the exposure area was associated with this discharge point in Third Portage Lake. Treated effluent was last discharged into Third Portage Lake in July of 2014 and will not resume.

In 2017, for the Cycle 3 EEM biological study, the discharge point with the largest volume and that potentially had the most adverse impact on the environment was in Wally Lake. Dewatering of Vault Lake into Wally Lake began in 2013. Final dewatering of Vault Lake into Wally Lake occurred in the latter half of June 2014. Subsequently, contact water, mainly from pit water pumping and local mine site drainage water, was stored in the Vault Attenuation Pond. Discharge from the Vault Attenuation Pond into Wally Lake began in 2014. In 2016, Phaser Lake was dewatered into Wally Lake via the Vault Attenuation Pond. Discharge to Wally Lake ceased in October of 2017 and is not expected to resume.

Beginning in 2014, water that seeps through the East Dike from Second Portage Lake into Portage Pit is collected at two points, combined, and pumped back to Second Portage Lake. Until discharge to Wally Lake ceased, this, constituted a second discharge point, but of a much lower volume and with lower potential to impact the environment than Vault Attenuation Pond discharge into Wally Lake. Now, the discharge to Second Portage Lake is the only discharge point at the Meadowbank site, so it is the exposure area for the Cycle 4 EEM biological study.

Effluent is discharged from a single orifice diffuser, oriented to discharge vertically upward, located approximately 45 m from shore and anchored on the bottom at a water depth of approximately 5 m. The diffuser was designed and built to be capable of discharging effluent at the rate of 12 L/sec which equals a discharge volume of 1037 m^3/day. The actual rate of discharge has always been less; the maximum recorded rate is 935 m^3/day.

Effluent mixing and the plume extent were modelled for Second Portage Lake using the CORMIX model. The plume extent was modelled for both summer (ice-free) and winter (ice-covered) conditions. Initial model runs were made using the design flow, which provides a theoretical worst-case scenario. Both summer and winter model runs were conducted for three plume buoyancy scenarios (negative, neutral, positive). For the summer scenario wind conditions were also varied (near stagnant, low, median, high).

For the winter scenarios ice thickness was varied (negligible, 0.5 m, 1 m and 2 m). For all scenarios, at the design flow, which is the theoretical maximum, the effluent concentration 250 m from the outfall is less than 1%. A sensitivity analysis conducted by rerunning the model for typical and worst-case winter and summer conditions at the minimum, mean, and maximum discharge rates during the period February 18, 2017, through December 31, 2019, confirmed that result.

A fish study is required if the 1% effluent plume extends 250 m or more from the discharge point. CORMIX modeling indicated that there are no scenarios when the 1% effluent plume extends to or beyond 250 m from the point of discharge. A fish study is, therefore, not required based on the 1% plume extent and a fish study is not proposed. The mercury concentration and the selenium concentration in the effluent have consistently been less than the concentrations that would require a fish tissue study; therefore, a study respecting fish tissue mercury or fish tissue selenium is not required.

A benthic invertebrate community study is required if the 1% effluent plume extends to or beyond 100 meters from the discharge point, unless the results of the previous two biological monitoring studies indicate:

(i) for all effect indicators with no assigned critical effect size, no effect on the benthic invertebrate community, and
(ii) for all effect indicators with an assigned critical effect size, no effect on the benthic invertebrate community, or an effect on the benthic invertebrate community where the absolute value of the magnitude of which is less than the absolute value of its assigned critical effect size.

CORMIX modeling indicated that the 1% effluent plume will not extend to 100 m when there is ice-cover, but may at times (neutrally buoyant, minimum flow of 4.4 L/s; negatively buoyant, maximum flow of 10.8L/s) exceed 100 m during the ice-free season. From February 18, 2017 through December 31, 2019, effluent was discharged on 96 days during the estimated ice-free period (June 1 – October 31). Based on flow volumes during that period, the effluent plume may have extended more than 100 m from the discharge point on some of the 'ice-free' days. In Cycle 3, when the exposure area was Wally Lake, there was a significant effect on benthos density with an effect size of > 3 SD. Therefore, the criteria for not requiring a benthic invertebrate community study due to the plume extent or to the results of the previous two EEM studies are not met. A study respecting the benthic invertebrate community is, therefore, proposed in this study design.

The Cycle 4 EEM benthic invertebrate community study design utilizes the same overall design structure as the Cycle 1, Cycle 2 and Cycle 3 EEM studies, but the exposure area is now in Second Portage Lake. The two reference areas, Inuggugayualik Lake and Pipedream Lake, remain the same as in previous EEM studies. The design for the Cycle 4 EEM benthic invertebrate community proposes two exposure areas (nearfield and farfield) in Second Portage Lake, with a simple reference-exposure design. The analysis will include use of the extensive benthic invertebrate data collected by the Core Receiving Environment Monitoring Program (CREMP), including data from prior to effluent being discharged into Second Portage Lake.

TABLE OF CONTENTS

List of Tables

List of Figures

List of Appendices

1.0 INTRODUCTION

The Meadowbank Mine is located approximately 75 km north of Baker Lake, Nunavut (Figure 1-1). The Metal and Diamond Mining Effluent Regulations (MDMER), under the Fisheries Act, imposes liquid effluent limits for pH, arsenic, copper, cyanide, lead, nickel, zinc, radium, and total suspended solids, and prohibits the discharge of a liquid effluent that is acutely lethal to fish. The MDMER also requires mines to conduct Environmental Effects Monitoring (EEM) studies of fish, fish habitat and the use of fisheries resources in aquatic receiving environments.

During EEM Cycles 1 and 2, the primary effluent discharge location for Agnico Eagle Mines- Meadowbank Division (Agnico Eagle), was Third Portage Lake and that was where the exposure area was located. Effluent was last discharged to Third Portage Lake on July 5, 2014. For Cycle 3 the primary receiver of effluent was Wally Lake, where Agnico began to discharge effluent from the Vault Attenuation Pond on July 24, 2014. Discharge to Wally Lake ceased on October 9, 2017.

Seepage water is collected along the East Dike and discharged to Second Portage Lake via outfall MDMER 3, but during Cycles 1, 2 and 3, the volume of that effluent was much less than that discharged to Third Portage or Wally Lakes, and so EEMs focused on those other discharges. Since the effluent discharge to Wally Lake ceased on October 9, 2017, the seepage water discharged to Second Portage Lake is the only final discharge point and is, by default, the Cycle 4 EEM exposure area under the MDMER.

Schedule 5 of the MDMER describes the Environmental Effects Monitoring studies requirements. Part 1 of the MDMER describes the requirements related to effluent and water quality monitoring studies which include effluent characterization, sublethal toxicity testing and water quality monitoring. Schedule 5, Part 2, describes the Biological Monitoring studies, which are the subject of this study design.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.

The focus of this report is to meet Agnico's obligation to submit an EEM Cycle 4 Study Design report for the Meadowbank Mine, six months prior to field work for the fourth EEM biological study, which is anticipated to begin on or about August 20, 2020. The change in effluent discharge location notwithstanding, this EEM Cycle 4 Study Design builds upon the results of the previous 3 EEM cycles (Azimuth, 2010a, 2012a; C. Portt and Associates and Kilgour & Associates Ltd., 2014, 2015, 2017, 2018). It is proposed that the same basic design, with one exposure area and two reference areas will be used in EEM Cycle 4. While the EEM exposure area for Cycle 4 will be in Second Portage Lake for the first time, the proposed reference areas are unchanged from previous Cycles.

Much of the background information presented in this study design has been incorporated from the EEM Cycle 1 Study Design (Azimuth, 2010a) and EEM Cycle 1 Interpretive Report (Azimuth, 2012a), updated where appropriate. The Meadowbank general site plan is presented in Figure 1-2.

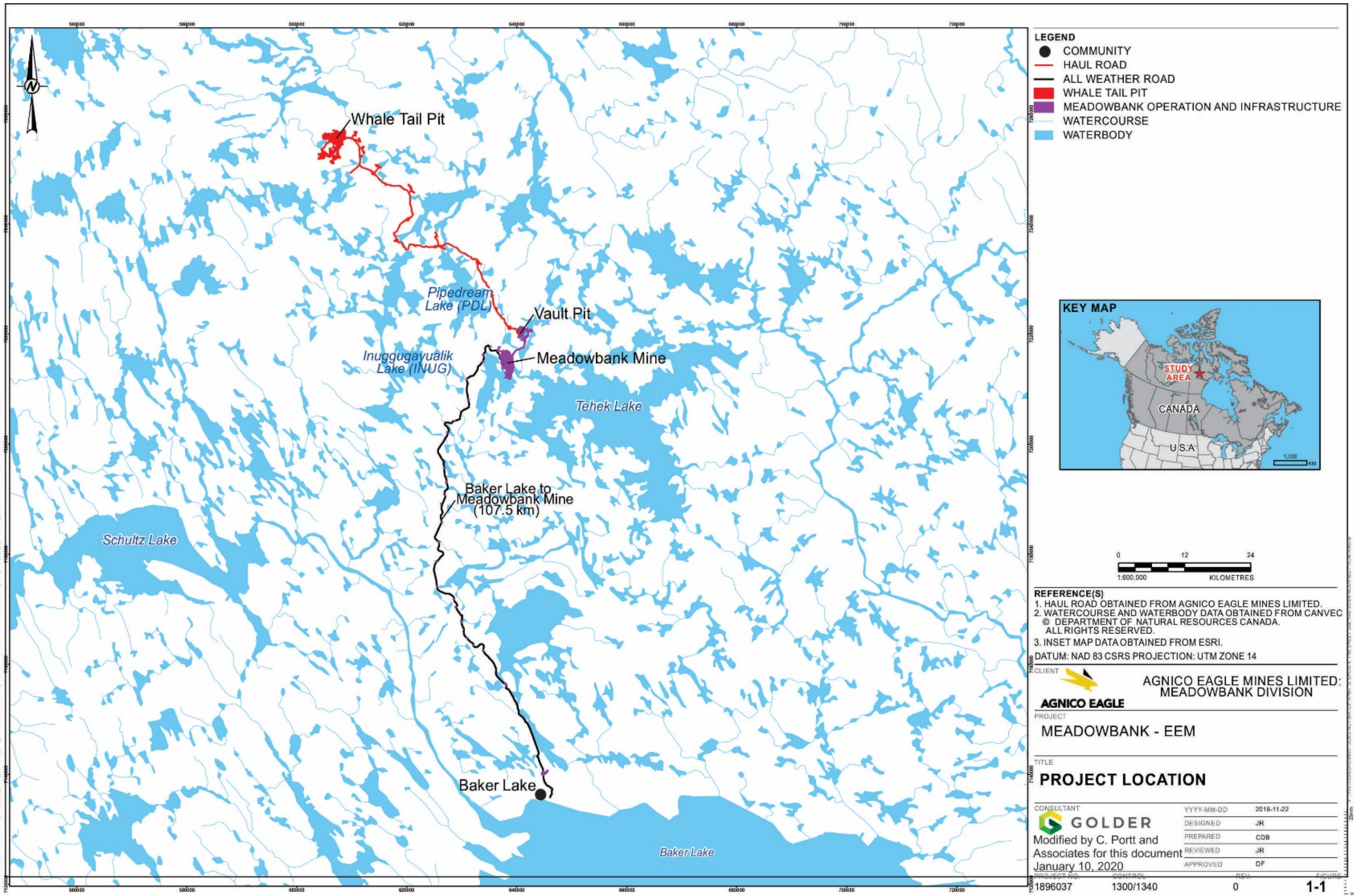

Figure 1-1. Regional map showing Baker Lake and Meadowbank Gold Mine.

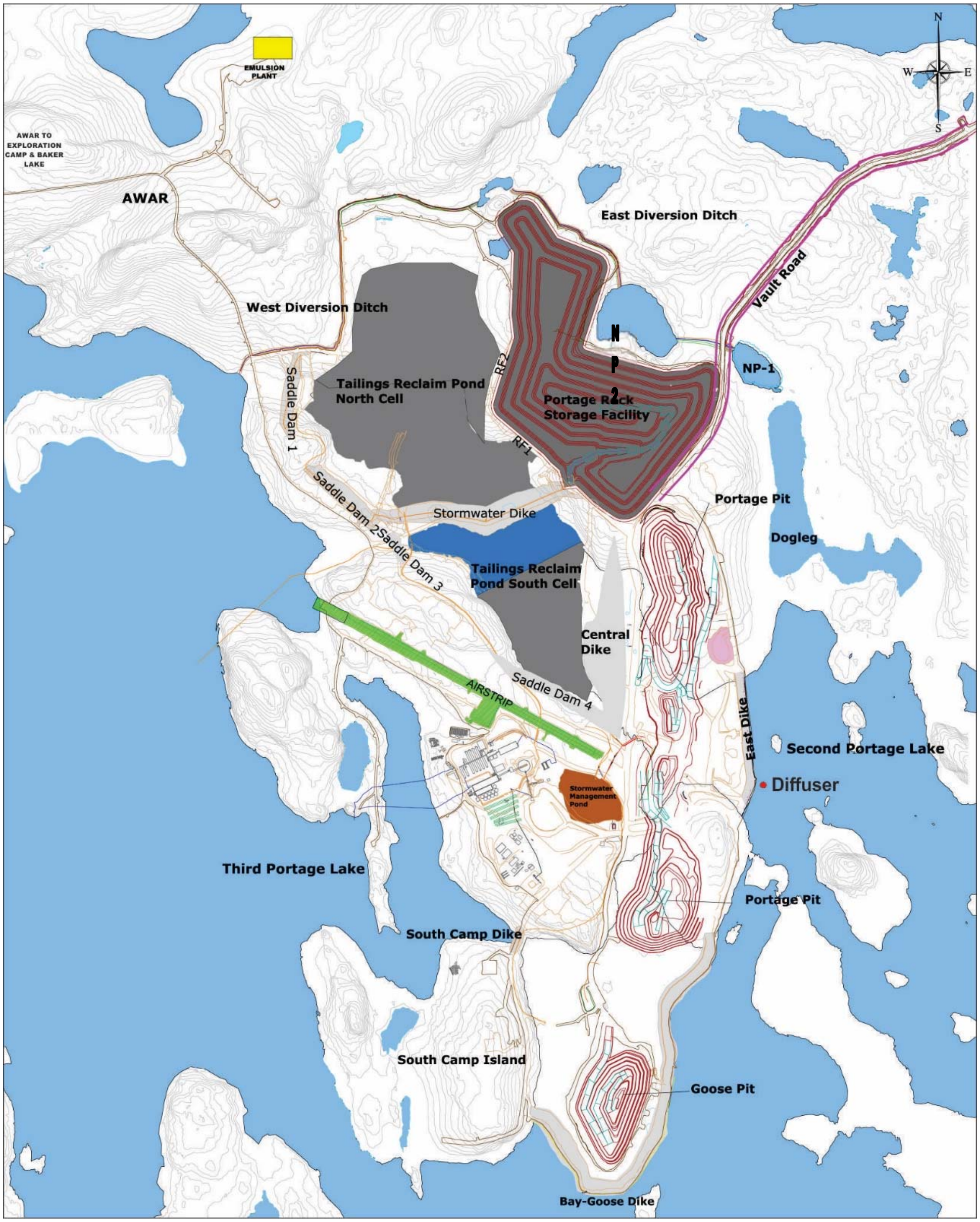

Figure 1-2. Meadowbank General site plan, showing the Cycle 4 diffuser (MDMER 3) location.

1.1 Background

The Meadowbank Mine (65°N, 96°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 (new license 2AM-MEA1526) and Fisheries and Oceans Canada Authorization for Works or Undertaking Affecting Fish Habitat NU-03-0191.3 and NU-03-0191.4. Meadowbank started operation in 2009, with mining activities formally underway by March 2010. However, since October 2019, mining operations have ceased at Meadowbank, but the Meadowbank milling and processing facilities, along with the storage of tailings, continue to operate with ore mined and transported from the Whale Tail Pit which is located approximately 50 km north of the Meadowbank site.

A chronology of mine development and operational activities is presented in Table 1-1. The Meadowbank general site plan is presented in Figure 1-2.

Table 1-1. Chronology of mine-related activities at the Meadowbank site.

Year	Major Mine-Related Activities at the Meadowbank site.
2008	● Major in-water construction activities included the East Dike (located in Second Portage Lake) and the Western Channel Dike (located between Third Portage Lake and Second Portage Lake). ● Other site-related activities included rock crushing, road building, pit blasting, ground preparation, and infrastructure construction.
2009	● Dewatering discharges (i.e., impounded Second Portage Lake (SP) water) were directed primarily into the north basin of Third Portage Lake (TPN), but also into Second Portage Lake (March to July and Oct to Dec, 2009). ● Bay-Goose Dike construction started in late July 2009. ● Most of the site preparation and road infrastructure was completed in 2009. ● North Portage Pit was the primary focus of blasting and mine operations.
2010	● Bay-Goose Dike construction completed using additional mitigation measures. ● Mine officially opened on 27 Feb 2010, marking the start of the operations period. ● Pit development focused on North Portage and South Portage pits. ● Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). Contact water from operations not discharged to receiving environment. ● Dewatering of SP impoundment to TPN continued, with discharge now subject to MMER.
2011	● Mining operations focus on North Portage and South Portage pits. ● Waste rock to rock storage facility (RSF). Tailings to impoundment area (TIA). ● Construction activities limited to mine footprint. ● Dewatering of SP and TPE to TPN continued, with treatment added to reduce fine sediment and turbidity.

Year	**Major Mine-Related Activities at the Meadowbank site.**
2012	● SP and TPE dewatering discharges to TPN finished by spring. Diffuser installed and effluent (mix of residual Bay-Goose water, contact water, East Dike seepage and run-off) discharge to TPN commences; treatment (for fine sediment, turbidity) continues. ● North cell non-contact water diversion ditches completed in August (intercepting run-off prior to the tailings and waste rock areas and diverting to pond NP2 and Dogleg ponds). ● Vault access road constructed and site preparation activities for the Vault Pit and Vault Dike commence.
2013	● Effluent discharge to TPN continued. ● Fish-out of Vault lake from July –Sept. 24. Fish transferred to Wally Lake. ● Vault lake was dewatered into Wally Lake (ongoing) and did not require TSS treatment. ● Minor construction modifications to north cell diversion ditches completed. ● Completion of the Airstrip extension (18m) into Third Portage Lake in March. ● Seepage from Rock Storage Facility (ST-16) through the road into pond NP2 identified (additional monitoring in pond NP2 to evaluate near-shore water quality).
2014	● Effluent discharge to TPN from the Portage Attenuation Pond occurred only from June 10 to July 5. Discharge to TPN is now complete. The former Portage Attenuation Pond has now become the South Cell for tailings deposition. ● EEM Cycle 2 Field Study was conducted at the end of August through the beginning of September (no TPN discharge at the time). ● Vault dewatering into Wally Lake from June 20 to 29 (now complete); discharge from what is now referred to as the Vault Attenuation Pond into Wally Lake from July 24 to August 14. No TSS treatment for Vault Discharge. ● New discharge into Second Portage Lake during all of 2014 (except from May 3 to July 28). Two seepage collection points (North and South) are situated on west side of the East Dike to collect seepage through dike from SP. Water is pumped from both collection points, which are connected together before discharging back into Second Portage Lake through a diffuser. No TSS treatment for East Dike Discharge. ● No seepage water from Rock Storage Facility (ST-16) reaching the pond NP2 Lake in 2014. ● Commercial mining in Vault Pit started at the beginning of 2014. No major construction or modifications in 2014.
2015	● No discharge to TPN in 2015. ● Vault discharge to Wally from July 7th to September 10th. No TSS treatment needed. ● East dike (North-South) discharge to SP all year except from June 16th to August 10th. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to Second Portage Lake was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to pond NP2. Monitoring ongoing. ● Habitat Compensation Monitoring Program (HCMP) work completed for TP, SP and Dogleg lakes and at water crossing R02 along the all-weather access road.

Year	Major Mine-Related Activities at the Meadowbank site.
	● One incident of elevated TSS from Vault road culverts to NP-1, early June, during freshet. Barriers installed. No impacts observed to Dogleg Lake.
2016	● Vault discharge to Wally from June to September. No TSS treatment needed. ● East dike (North-South) discharge to SP all year. ● No seepage water from Rock Storage Facility to NP-2. Monitoring ongoing. ● Phaser Lake dewatering - August 26th to September 10th and September 15th to October 4th. ● Phaser Lake fish-out from August 13th to 31st and September 10th to 25th. ● No Goose Pit reflooding activities. ● Pit E and pushback assessment. ● Mining focused on Vault Pit and Pit A. ● Amaruq exploration road construction (km 25 at end of 2016).
2017	● Vault discharge to Wally from June to October. No TSS treatment needed ● East dike (North-South) discharge to SP all year except from May 12th to September 5. Discharge was also stopped from September 23rd to October 29th. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to SP was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to NP-2. Monitoring ongoing. ● No Goose Pit reflooding activities. ● Mining focused on Vault Pit and Pit A, Pit E and Phaser Pit. ● Amaruq exploration road completed. ● Phaser Pit started in November. ● HCMP work completed for TP, SP and Dogleg lakes and at water crossing R02 along the AWAR. ● One incident of elevated TSS from Vault road to NP-1, early June, during freshet. Barriers installed. No impacts observed to Dogleg Lake.
2018	● East dike (North-South) discharge to SP all year except from June 4th to August 21st. Discharge was stopped for increasing TSS levels as no treatment is available for this location. The discharge from East Dike that was not directed to SP was discharged in the Portage Pit and then pumped to the South Cell TSF (Tailings Storage Facility). ● No seepage water from Rock Storage Facility to NP-2; monitoring ongoing. ● No Goose Pit reflooding activities. ● Mining focused on Vault Pit and Pit A, Pit E and Phaser Pit. ● No discharge to Wally in 2018.

Year	**Major Mine-Related Activities at the Meadowbank site.**
2019	● East dike (North-South) discharge to SP was stopped on March 30. Restarted on November 13th. ● No seepage water from Rock Storage Facility to NP-2; monitoring ongoing ● Goose Pit water transfer from South Cell to Goose started on June 11th. ● Tailings in-pit deposition started in July 2019 at Goose Pit. ● End of mine production at Phaser Pit and Vault (Q1), Pit E (Q4). ● No discharge to Wally in 2019.

Mine construction activities near the Goose Pit and Portage Pit from 2008 to 2012 included the isolation of portions of two lakes using dikes. Dewatering of these impoundments into adjacent lakes started in 2009 and on December 31, 2009, Environment Canada notified Agnico Eagle that the Meadowbank Mine is subject to MMER. Subsequently, a study design for an EEM Cycle 1 was submitted to Environment Canada and approved by the TAP, and in June 2012 Agnico Eagle submitted the EEM Cycle 1 Interpretive Report to Environment Canada. The Cycle 2 EEM study design was submitted in February, 2014, and approved in July, 2014. The Cycle 2 field work was conducted in August, 2014, and the interpretive report was submitted in June, 2015. As indicated previously, the exposure area for both the Cycle 1 and Cycle 2 EEM was in Third Portage Lake. Due to a change in discharge location, the Cycle 3 EEM exposure area was in Wally Lake. The Cycle 3 study design was submitted in February, 2017, and approved in July, 2017. The Cycle 3 field work was conducted in August, 2017, and the interpretive report was submitted in June, 2018.

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 Mining Effluent Regulations (MMER), 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 documented in the CREMP and AEMP updates (Azimuth, 2015a, b).

The Core Receiving Environment Monitoring Plan (CREMP) has been 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 (2009-2010), dewatering of lakes and impoundments (2009-2011, 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, 2011, 2012c, 2013, 2014, 2015c, 2016, 2017, 2018, and 2019).

1.2 Approach

The MDMER stipulates that study designs subsequent to Cycle 1 should describe the information as summarized below:

- A summary of the site characterization information that was provided in the previous cycle and, where applicable, a detailed description of any changes to that information since the submission of the most recent study design.
- A summary of the results of effluent characterization, sublethal toxicity testing and water quality monitoring.
- 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.
- A description of the exposure and reference areas where the biological monitoring studies would be conducted.
- A description of how the fish survey will be conducted (if the concentration of effluent in the exposure area is greater than 1% in the area located 250 m of any final discharge point).
- A description of how the fish tissue analysis will be conducted (if during effluent characterization the concentration of total mercury in the effluent is equal to or greater than 0.1 µg/L, or the annual mean concentration of total Selenium is equal to or greater than 5 µg/L). Not the case for Meadowbank.

- A description of how the benthic invertebrate community survey will be conducted (if the concentration of effluent in the exposure area is greater than 1% in the area located 100 m of any final discharge point).

- The dates and times that samples will be collected for biological monitoring.

- A description of the quality assurance/quality control measures that will need to be implemented to ensure the validity of the data collected.

- A summary of the results of any previous biological monitoring studies respecting the fish population, fish tissue analyses, and the benthic invertebrate community.

- A description of one or more additional sampling areas within the exposure area that shall be used to assess the magnitude and geographic extent of an effect (if the results of the two previous biological monitoring studies indicate a similar type of effect on the fish population, on fish tissue or on the benthic invertebrate community). The guiding principles of the EEM program are that the studies are scientifically defensible, cost effective, flexible, and safe. The eventual need to meet EEM requirements was taken into consideration in developing the overall monitoring strategy for aquatic receiving environments at Meadowbank.

The Aquatic Effects Management Program (AEMP) for Meadowbank was revised in 2010 to address requirements of the NWB A License (Azimuth, 2012b) and a second minor update occurred in 2015 (Azimuth, 2015b). The revised program in 2010 was developed in consultation with participants representing a number of different organizations, including Environment Canada's Authorization Officer for Meadowbank. Part of the re-design was the development of the Core Receiving Environment Monitoring Program (CREMP). Where practical and appropriate, data required by both the CREMP and EEM programs will be shared to avoid duplication of effort. Relevant information regarding the CREMP have been included throughout this report, and an outline of the CREMP design is provided in Appendix A.

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

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

2.0 SITE CHARACTERIZATION

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

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

2.1 Relevant Environmental Legislation and Monitoring Programs

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

- *Fisheries Act* and the MDMER.
- *Canadian Environmental Protection Act, 1999* and the Toxic Substances Lists (CEPA, 1999).
- *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA, 2002) (including the Northwest Territories Waters Regulation [NTWR, 1993] made pursuant to the Northwest Territories Waters Act [NTWA, 1992], which apply until such time as they are replaced or repealed under the NWNSRTA).

As described in Section 1.1, the Meadowbank Mine is being developed and operated subject to a Type A Water License issued by the Nunavut Water Board (under the NWNSRTA). Compliance and enforcement of water licenses fall under the jurisdiction of Crown-Indigenous Relations and Northern Affairs Canada (CIRNAC; previously Aboriginal Affairs and Northern Development of Canada). As per NWB Type A License, Part I Section 1, the AEMP (Azimuth 2015b) integrates the results of all monitoring programs informing environmental management of the aquatic receiving environment, including the following relevant monitoring programs (among others):

- MDMER/EEM – as discussed in **Section 1.2**, this monitoring targets the potential effects of effluent discharges to the receiving environment. Agnico was notified in December 2009 that Meadowbank was officially subject to MMER (now MDMER) requirements as a result of initiation of dewatering activities from the Northwest Arm of Second Portage Lake; this document reports on the study design for Cycle 4 of the EEM Program for Meadowbank Mine.
- CREMP (Azimuth, 2012c; 2015a) – this program was designed to monitor issues identified during the Environmental Impact Assessment process that could potentially impact the aquatic receiving

environments surrounding the mine development. Given that there is some overlap between the EEM and CREMP programs (and that they are meant to be complementary), a brief overview of the CREMP program is provided in Appendix A.

2.2 General Site Characteristics

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

- Personnel are flown directly to the Mine site, landing on the onsite airstrip (Figure 1-2) or driven from Baker Lake via the All-Weather Access Road (AWAR).
- Equipment and goods are barged in via Baker Lake and then trucked to site via the AWAR, or flown directly to site.

2.2.1 Facilities, Mining, and Processing

Meadowbank mine site is shown in Figure 1-2. Some of the key features include a 1.752 km airstrip, mill, constructed dikes, and pits.

The mine operates year-round, using conventional drilling, blasting, truck and loading methods. The 13,800-tonne/day gold processing plant is designed to operate year-round using conventional technology adjusted to the Arctic climate.

Explosives are produced at an on-site plant and used to blast rock. Trucks haul the material to a crusher. The ore is crushed and milled to ensure that 80% of the ground ore is less than 60 to 90 microns diameter. Gold is removed from the ore by two means, depending on whether it is free or combined with other minerals. See Azimuth (2010a) for more detail.

The plant includes both a cyanide recycling thickener and an Inco SO_2 cyanide destruction unit, with the use of sodium metabisulphate as backup, to ensure that no cyanide escapes to the environment. After leaching, the ground ore is essentially barren of gold, so it is pumped to the nearby tailings pond for disposal. Non-contact water is prevented from contacting fresh water by diversion ditches, and the contact water is collected and sent to the tailings reclaim pond. Water from the tailings pond is pumped back to the plant for reuse, making it a zero process water discharge system and ultimately reducing the need for fresh water. The waste rock is hauled to waste storage facilities and/or previously mined-out areas. To minimize acid generation, the sulphide-bearing waste rock is encapsulated in permafrost and capped with an insulating layer of neutralizing rock.

Tailings water is ponded within the reclaim pond within the South Cell of the Tailings Storage Facility (TSF). This water is continuously recycled and pumped from the reclaim barge to the ore processing mill within a closed circuit. Fresh water is obtained from Third Portage Lake to make up the balance of mill and camp fresh water requirements. Beginning in 2014, water that seeps through the East Dike from Second Portage Lake into Portage Pit is collected at two points, combined, and pumped back to Second Portage Lake, which is the subject discharge for this Cycle 4 EEM.

2.2.2 Surficial and Bedrock Geology

The Meadowbank Mine is located on the Canadian Shield. Additional detail regarding surficial and bedrock geology is provided in the Cycle 1 EEM study design report (Azimuth, 2010a).

2.2.3 Climatology

The Meadowbank Mine is located within a Low Arctic ecoclimate of continuous permafrost, which is one of the coldest and driest regions of Canada. Additional detail regarding climatology is provided in the Cycle 1 EEM study design report (Azimuth, 2010a).

2.2.4 Regional Hydrology

The lakes within the Meadowbank project area are ultra-oligotrophic/oligotrophic (nutrient poor, unproductive) headwater lakes that are typical of the Arctic. The current receiving water (EEM exposure area) of the Meadowbank Mine is Second Portage Lake, which is a headwater lake just within the Chesterfield Inlet watershed that flows to Hudson Bay. Second Portage Lake is approximately 7 kilometres from the boundary with the Back River watershed which flows north to the Arctic Ocean. The two EEM reference areas, Innugugayualik Lake (INUG) and Pipedream Lake (PDL), are headwater lakes within the Back River watershed. Additional detail regarding Regional Hydrology is provided in the Cycle 1 EEM study design report (Azimuth, 2010a).

2.3 Mine Operations

This section provides information regarding mine operations, including discussion of key environmental control measures related to mining activities and tailings deposition. A chronology of major mine-related activities at the Meadowbank site is provided in Table 1-1 and the mine site is shown in Figure 1-2.

In general, the Meadowbank Gold project consists of 8 main areas. Of these, Portage Pit, Goose Pit, North Cell tailings storage, South Cell tailings storage, waste rock storage and the mill area, are in relatively close proximity to the exposure area in Second Portage Lake (Figure 1-2), while the Vault Pit is located approximately 3.5 km to the northeast, and Whale Tail Pit is located approximately 50 km north. Several gold-bearing open-pit deposits were mined at the Meadowbank site. Goose Pit was completely depleted in 2014. In 2019, commercial production occurred at the Vault and BB Phaser Pits, until exhaustion of mineral reserves in June 2019. With the mining of Portage Pit East completed in October 2019, only the Whale Tail Pit is presently being mined. The Meadowbank milling and processing facilities, along with the storage of tailings, continue to operate with ore mined and transported from the Whale Tail Pit, which is the subject of its own Environmental Effects Monitoring Study.

Discharge of dewatering water to the north basin of Third Portage Lake was the trigger for initiation of EEM studies at the mine site. The north cell was used as the Tailings Storage Facility (TSF) and is contained by the Stormwater Dike. The North Cell is currently at full capacity and the tailings were disposed of in the South Cell until July 2019. The Central Dike, which has not reached its final elevation, contains, to the East, the South Cell. After receiving authorization, in-pit deposition of tailings was initiated in July 2019 in Goose Pit and is still ongoing.

2.3.1 Effluent Management

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

- *Reclaim Water* – All mining-related water (e.g., from the mill and/ or stormwater management pond, is segregated, and stored or actively pumped into the reclaim pond as make-up water. Presently, the reclaim pond is located within the South Cell of the TSF. **This water is not currently being discharged.**

- *Contact Water* – contains residual localized mine site drainage that may have been in contact with PAG material (i.e. from the Portage Waste Rock facility drainage which is directed to south cell) and water that is collected and actively pumped from the mine pits, either from groundwater sources, from dike water seepage to the South Cell or from the natural re-flooding of Goose Pit.

Presently, mine effluent does not contain water that has come into contact with milled tailings. As previously described, Agnico presently has only one (1) active effluent. Non-contact water originating from the seepage at the East Dike is discharged into Second Portage Lake and has not required water treatment to date.

2.3.2 Effluent and Receiving Environment Monitoring

Effluent is presently discharged to the receiving waters at one location. This discharge occurs near the East Dike, where water that seeps through the dike from Second Portage Lake is collected and pumped via a diffuser back into Second Portage Lake. Approximately 144,000 m^3 in 2014 and 163,000 m^3 in 2015, were discharged intermittently. During 2016 this discharge was almost continuous, totalling approximately 180,000 m^3. Discharge was intermittent again during 2017 through 2019, totalling approximately 100,000 m^3 in 2017, 141,000 m^3 in 2018, and 33,000 m^3 in 2019. It is expected that future daily effluent volumes will be similar those in 2019. Daily discharge to the Second Portage Lake receiving environment is provided in Appendix B (Tables B1 to B6). Effluent mixing in the Second Portage Lake receiving environment is discussed in **Section 2.5**.

MDMER (Part 2; Division 2) requires effluent quality monitoring on a weekly basis to ensure that MDMER discharge limits are met. Weekly effluent monitoring results, including effluent toxicity test results for acute lethality, for the East Dike diffuser discharge to Second Portage Lake, from January 7, 2014, to December 28, 2019, are provided in Appendix B (Table B-7). Second Portage Lake effluent sublethal endpoints for 2014 - 2019, along with associated chemical and physical parameters, are presented in Table 2-1, Table 2-2, Table 2-3 Table 2-4, Table 2-5, Table 2-4, and Table 2-5.

The mine has been in reduced frequency for testing of deleterious substances that is set out in any of items 1 to 6 [arsenic, copper, cyanide, lead, nickel, zinc] in column 1 of Schedule 4 since September 19, 2016, because that final discharge point effluent was less than 10% of the value set out in column 2 [maximum authorized monthly mean concentration] of that Schedule for the 12 months immediately preceding the most recent test - August 2015 and July 2016.

The mine as been in reduced frequency of testing for Radium 226 since March 29, 2016, because that substance's concentration in the effluent was less than 0.037 Bq/L in 10 consecutive tests conducted under section 12 between December 1, 2015 and February 1, 2016.

The mine has been in reduced frequency of testing for acute lethality since September 19, 2016, because the effluent was determined not to be acutely lethal for the 12-month period between August 2015 and July 2016.

Receiving environment water quality monitoring results (EEM Part 1), for Second Portage Lake (SP) are presented in Table 2-6, Table 2-7, Table 2-8, and Table 2-9. Reference area water quality monitoring results (EEM Part 1), for Third Portage Lake South (TPS) are presented in Table 2-10, Table 2-11, Table 2-12, and Table 2-13. CREMP sampling areas for the Meadowbank Mine, including the two areas for which data are provided in this report, are presented in Figure 2-1.

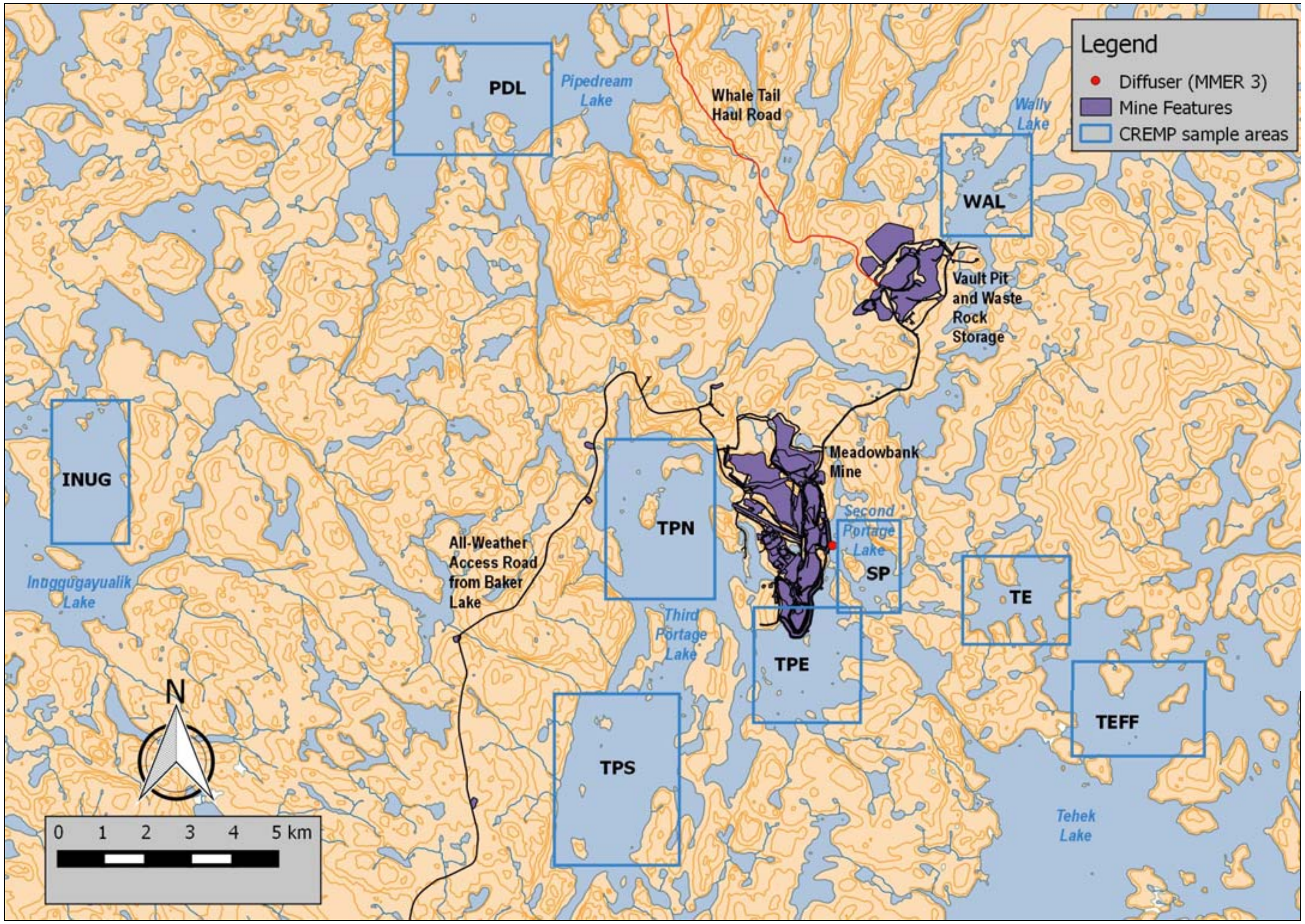

Figure 2-1. CREMP sampling areas.

Table 2-1. Chemical and physical parameters for final effluent (outfall MDMER 3) to Second Portage Lake in 2014. No Sub-lethal testing was conducted on this effluent in 2014 because there was discharge first to Third Portage Lake North, and then to Vault Lake, that was considered most likely to cause an adverse impact.

Date **Parameter**	07/01/2014	26/08/2014	28/09/2014	30/11/2014
Alkalinity (mg CaCO3/L)	50	34	24	26
Aluminium (mg/L)	0.108	0.073	0.038	0.051
Ammonia nitrogen (NH3-NH4) (mg N/L)	0.04	<0.01	0.04	0.03
Cadmium (mg/L)	<0.00002	< 0.00002	< 0.00002	<0.00002
Hardness (mg CaCO3/L)	23	34	22	22
Iron (mg/L)	0.08	0.06	0.02	0.06
Mercury (mg/L) (max allowance of 10µg/L)	0.00002	< 0.00001	< 0.00001	< 0.00001
Molybdenum (mg/L)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Nitrate (mg N/L)	0.03	0.42	0.28	0.05
Selenium (mg/L)	< 0.001	< 0.001	< 0.001	< 0.001
Conductivity (µs/cm)	69.7	44.8	76.0	45.0
Temperature (ºC)	0.60	13.90	4.70	3.30

Table 2-2. Chemical and physical parameters for final effluent (outfall MDMER 3) to Second Portage Lake in 2015 and 2016. No Sub-lethal testing was conducted on this effluent in 2015 and 2016 because there was discharge to Vault Lake that was considered most likely to cause an adverse impact.

Date	19/01/2015	7/04/2015	17/08/2015	22/09/2015	18/01/2016	14/03/2016	6/06/2016	28/09/2016
Parameters								
Alkalinity (mg CaCO3/L)	48	29	32	34	24	28	25	29
Aluminium (mg/L)	0.061	0.064	0.037	0.059	0.29	0.028	0.057	0.057
Ammonia nitrogen (NH3-NH4) (mg N/L)	<0.01	<0.01	0.03	<0.01	0.13	0.4	0.06	0.07
Cadmium (mg/L)	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	0.00004	<0.00002	0.0001
Hardness (mg CaCO3/L)	25	28	41	42	30	32	23	48
Iron (mg/L)	<0.01	0.08	0.05	0.07	0.04	0.03	0.11	0.06
Mercury (mg/L) (max allowance of 10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	<0.005	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005	0.001
Ammonia (mg N/L)	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	0.01	<0.01
Nitrate (mg N/L)	0.05	0.08	0.73	0.55	0.07	0.1	0.12	0.52
Selenium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (µs/cm)	62.4	74.9	61.2	108.2	73.6	57.5	70.7	-
Temperature (ºC)	12.3	3.6	15.8	10.8	5.3	15.2	12.2	-

Table 2-3. Chemical and physical parameters for final effluent (outfall MDMER 3) to Second Portage Lake in 2017. No Sub-lethal testing was conducted on this effluent in 2017 because there was discharge to Vault Lake that was considered most likely to cause an adverse impact.

Date **Parameter**	09/01/2017	4/04/2017	19/11/2017	19/12/2017
Alkalinity (mg CaCO3/L)	25	32	26	27
Aluminium (mg/L)	0.052	0.064	0.05	0.052
Ammonia nitrogen (NH3-NH4) (mg N/L)	<0.01	0.03	0.02	0.02
Cadmium (mg/L)	<0.00002	< 0.00002	< 0.00002	<0.00002
Hardness (mg CaCO3/L)	24	25	25	24
Iron (mg/L)	0.05	0.05	0.06	0.041
Mercury (mg/L) (max allowance of 10μg/L)	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Molybdenum (mg/L)	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Nitrate (mg N/L)	0.06	0.08	0.05	0.07
Selenium (mg/L)	< 0.001	< 0.001	< 0.001	< 0.001
Conductivity (μs/cm)	178	87.2	72.8	75.3
Temperature (ºC)	7.6	2.8	2.9	9.3

Table 2-4. Sub-lethal endpoints and associated chemical and physical parameters for final effluent (outfall MDMER 3) to Second Portage Lake in 2018.

Date	06/02/2018	10/09/2018	15/10/2018	19/11/2018
Parameter				
Alkalinity (mg $CaCO_3$/L)	28	28	26	28
Aluminium (mg/L)	0.042	0.031	<0.005	0.037
Ammonia nitrogen (NH3-NH4) (mg N/L)	0.01	<0.01	<0.01	<0.01
Cadmium (mg/L)	<0.00002	<0.00002	<0.00002	<0.00002
Hardness (mg $CaCO_3$/L)	22	40	21	26
Iron (mg/L)	0.08	0.02	<0.01	0.04
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005
Nitrate (mg N/L)	0.07	0.27	0.40	0.06
Selenium (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005
Conductivity (µs/cm)	87.5	108.9	70.9	76.2
Temperature (^{0}C)	0.50	8.90	3.80	4.10
Fathead Minnow IC25	-	No SE	-	No SE
Fathead Minnow LC50	-	No AL	-	No AL
Ceriodaphnia dubia IC25	-	No SE	-	SE
Ceriodaphnia dubia LC50	-	No AL	-	No AL
Freshwater Alga (*Pseudokirchneriella subcapitata* IC25	-	No SE	-	No SE
Lemna minor IC25 dry weight %v/v	-	No SE	-	No SE
Lemna minor IC25 frond number %v/v	-	No SE	-	No SE

SE = Sublethal effects.

AL = Acute lethality.

Table 2-5. Sub-lethal endpoints and associated chemical and physical parameters for final effluent (outfall MDMER 3) to Second Portage Lake in 2019.

Date	07/01/2019	18/03/2019	18/11/2019	25/11/2019	23/12/2019	28/12/2019
Parameter						
Alkalinity (mg $CaCO_3$/L)	29	39	22	23	28	30
Aluminium (mg/L)	0.027	0.031	0.023	0.02	0.039	0.023
Ammonia nitrogen (NH3-NH4) (mg N/L)	<0.01	<0.01	0.13	<0.01	0.01	0.01
Cadmium (mg/L)	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Hardness (mg $CaCO_3$/L)	27	36	28	29	30	35
Iron (mg/L)	0.02	0.04	0.02	0.07	0.02	0.02
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nitrate (mg N/L)	0.04	<0.01	0.04	0.06	0.04	<0.01
Selenium (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Chloride (mg/L)	0.9	1.5	0.8	0.8	0.8	0.9
Chromium (mg/L)	0.0006	<0.0006	0.0006	<0.0006	0.0007	0.0024
Cobalt (mg/L)	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Sulphate (mg/L)	7.9	12.4	7.6	9.7	7.1	6
Thallium (mg/L)	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Uranium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Phosphorus (mg/L)	0.01	<0.01	<0.01	0.01	<0.01	<0.01
Manganese (mg/L)	<0.0005	0.0009	0.0007	<0.0005	0.001	<0.0005
Conductivity (µs/cm)	93.9	87.0	78.5	82.5	78.9	78.3
Temperature (^{0}C)	7.20	4.50	6.50	7.70	8.40	7.30
Fathead Minnow IC25	-	No SE	-	No SE	-	-
Fathead Minnow LC50	-	No AL	-	No AL	-	-
Ceriodaphnia dubia IC25	-	No SE	-	No SE	-	-
Ceriodaphnia dubia LC50	-	No AL	-	No AL	-	-
Freshwater Alga (*Pseudokirchneriella subcapitata* IC25	-	No SE	-	No SE	-	-
Lemna minor IC25 dry weight %v/v	-	No SE	-	SE	-	-
Lemna minor IC25 frond number %v/v	-	No SE	-	SE	-	-

SE = Sublethal effects; AL = Acute lethality.

Table 2-6. EEM water quality results at Second Portage Lake (SP) for 2014.

Parameter	CCME (2007) Guideline[1]	2014			
		27-Jan	26-Aug	28-Sep	30-Nov
SP (Exposure Area)					
Alkalinity (mg $CaCO_3$/L)	NG	25	38	13	16
Aluminium-Total (mg/L)[2]	0.100 - 0.100	0.007	0.025	0.01	0.012
Ammonia-Total (mg N/L)[2,3]	2.608 - 8.2	0.09	0.03	0.07	<0.01
Arsenic-Total (mg/L)	0.0050	<0.0005	<0.0005	<0.0005	<0.0005
Cadmium-Total (mg/L)[4]	0.00004	0.00007	0.00018	<0.00002	0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	0.0011	0.0013	<0.0005	<0.0005
Cyanide-Total (mg/L)	NG	<0.005	<0.005	<0.005	<0.005
Dissolved oxygen-Field (mg/L)	NG	15.9	10.4	11.7	13.7
Hardness (mg $CaCO_3$/L)	NG	13	12	10	13
Iron-Total (mg/L)	0.3	<0.01	0.02	<0.01	0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003	0.0021	<0.0003
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	0.0005	0.0009	<0.0005	<0.0005
Nitrate-Total (mg N/L)	2.9	<0.01	0.01	<0.01	0.01
pH-Field	6.5 - 9.0	7.16	7.52	6.55	7.04
Radium-226 (Bq/L)	NG	<0.002	0.002	<0.002	<0.002
Selenium-Total (mg/l)	0.001	<0.001	<0.001	<0.001	<0.001
Temperature-Field (^oC)	NG	0.3	11.8	1.7	0.9
Total suspended solid (mg/L)	NG	4	<1	<1	2
Zinc-Total (mg/L)	0.030	<0.001	<0.001	0.003	0.004
Conductivity (µs/cm)	NG	66	86	33	9

Notes: NG = no guideline; [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007; [2] Guideline is pH dependent; [3] Guideline is temperature dependent; [4] Guideline is hardness dependent; Shaded values exceed the CCME guideline; Parameters that have been added to the required monitoring list include: field measured conductivity and laboratory measured total selenium (MMER, 2012)

Table 2-7. EEM water quality results at Second Portage Lake (SP) for 2015 and 2016.

Parameter	CCME (2007) Guideline[1]	2015				2016			
		17-May	2-Sep	15-Nov	16-Dec	6-Apr	19-Jul	22-Aug	27-Sep
SP (Exposure Area)									
Alkalinity (mg $CaCO_3$/L)	NG	18	16	17	51	13	12	8	11
Aluminium-Total (mg/L)[2]	0.100 - 0.100	0.006	<0.006	0.0014	<0.006	<0.006	0.012	0.021	0.017
Ammonia-Total (mg N/L)[2,3]	0.832 - 2.61	0.11	<0.01	0.03	0.05	0.05	0.04	<0.01	0.05
Arsenic-Total (mg/L)	0.0050	<0.0005	<0.0005	<0.0005	<0.0005	0.0009	<0.0005	<0.0005	<0.0005
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002	<0.00002	0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	<0.0005	0.0007
Cyanide-Total (mg/L)	NG	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	NG	14.26	14.78	10.3	13.1	9.4	-	-	-
Hardness (mg $CaCO_3$/L)	NG	18	11	10	12	13	11	8	13
Iron-Total (mg/L)	0.3	<0.01	0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	0.0122	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	0.0006	<0.0005	0.0188	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nitrate-Total (mg N/L)	2.9	<0.01	<0.01	<0.01	<0.01	0.04	0.01	0.04	<0.01
pH-Field	6.5 - 9.0	7.57	6.93	7.56	7.31	7.78	7.38	7.71	7.39
Radium-226 (Bq/L)	NG	<0.002	<0.002	<0.002	0.002	-	-	-	-
Selenium-Total (mg/l)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Temperature-Field (°C)	NG	1.11	9.94	6.39	2.03	3	11.97	16.4	-
Total suspended solid (mg/L)	NG	<1	4	<1	<1	<1	2	5	2
Zinc-Total (mg/L)	0.030	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (µs/cm)	NG	47	61	45.4	39	55.1	27	49.9	54

Notes: NG = no guideline; [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007; [2] Guideline is pH dependent; [3] Guideline is temperature dependent; [4] Guideline is hardness dependent; Shaded values exceed the CCME guideline; Parameters that have been added to the required monitoring list include: field measured conductivity and laboratory measured total selenium (MMER, 2012)

Table 2-8. EEM water quality results at Second Portage Lake (SP) for 2017 - 2018.

	CCME (2020)	2017				2018			
Parameter	**Guideline[1]**	**10-Jan**	**3-Apr**	**19-Nov**	**19-Dec**	**5-Feb**	**13-May**	**10-Sep**	**18-Nov**
SP (Exposure Area)									
Alkalinity (mg $CaCO_3$/L)	NG	13	19	13	15	15	18	14	16
Aluminium-Total (mg/L)[2]	0.100 - 0.100	0.007	<0.006	<0.006	<0.006	<0.005	0.012	< 0.005	< 0.005
Ammonia-Total (mg/L)[2,3]	1.2 - 19	0.07	0.03	0.02	0.03	< 0.01	0.03	< 0.01	< 0.01
Arsenic-Total (mg/L)	0.005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0021	< 0.0005	< 0.0005
Cadmium-Total (mg/L)[4]	0.00004	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	< 0.0005	< 0.0005	0.0007	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Cyanide-Total (mg/L)	0.005	< 0.001	0.001	< 0.001	< 0.001	<0.001	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	11.20	11.40	15.43	15.68	14.18	17.78	11.86	15.36
Hardness (mg $CaCO_3$/L)	NG	12	13	13	16	16	18	13	15
Iron-Total (mg/L)	0.3	< 0.01	0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Mercury-Total (mg/L)	0.000026	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Molybdenum-Total (mg/L)	0.073	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0025	0.0007	< 0.0005	< 0.0005
Nitrate-Total (mg N/L)	13.0	<0.01	0.2	< 0.01	0.03	0.01	< 0.01	< 0.01	< 0.01
pH-Field	6.5 - 9.0	7.79	7.79	7.18	7.17	7.05	7.01	7.12	7.65
Radium-226 (Bq/L)	NG	-	-	-	-	-	-	-	-
Selenium-Total (mg/l)	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	<0.0005	<0.0005
Temperature-Field (^{o}C)	NG	3.5	3.2	0.6	0.1	0.35	0.57	8.8	1.49
Total suspended solid (mg/L)	5 - 25	< 1	< 2	2	< 1	2	24	< 1	< 1
Zinc-Total (mg/L)	0.007	< 0.001	< 0.001	< 0.001	< 0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (µs/cm)	NG	42.6	46.5	40.4	44.0	46.6	58.3	48.5	41.9

Notes: NG = no guideline; [1] CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; [2] Guideline is pH dependent; [3] Guideline is temperature dependent; [4] Guideline is hardness dependent; [5] Guideline is relative to background values; Shaded values exceed the CCME guideline.

Table 2-9. EEM water quality results at Second Portage Lake (SP) for 2019.

Parameter	CCME (2020) Guideline[1]	2019			
		6-Jan	12-Mar	14-Nov	15-Dec
SP (Exposure Area)					
Alkalinity (mg $CaCO_3$/L)	NG	17	22	12	19
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.005	<0.005	<0.005	<0.005
Ammonia-Total (mg/L)[2,3]	1.2 - 19	<0.01	<0.01	0.02	0.02
Arsenic-Total (mg/L)	0.005	<0.0005	<0.0005	0.0016	0.0006
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002	<0.00002	<0.00002
Chloride-Total (mg/L)	120	0.9	1.3	0.9	0.9
Chromium-Total (mg/L)	NG	0.0008	<0.0006	<0.0006	<0.0006
Cobalt-Total (mg/L)	NG	<0.0005	<0.0005	<0.0005	<0.0005
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	<0.0005	0.0008	0.0007
Cyanide-Total (mg/L)	0.005	<0.001	<0.001	0.001	0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	15.96	17.54	16.23	15.53
Hardness (mg $CaCO_3$/L)	NG	16	16	17	15
Iron-Total (mg/L)	0.3	<0.01	<0.01	0.04	0.05
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003	<0.0003	<0.0003
Manganese-Total (mg/L)	0.210 - 0.520	<0.0005	0.0006	0.0009	<0.0005
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	<0.0005	<0.0005	0.0006	0.0018
Nitrate-Total (mg N/L)	13.0	<0.01	<0.01	0.05	<0.01
Phosphorus-Total (mg/L)	NG	<0.01	<0.01	<0.01	0.01
pH-Field	6.5 - 9.0	7.83	8.04	7.21	6.76
Radium-226 (Bq/L)	NG	-	-	<0.002	<0.002
Selenium-Total (mg/l)	0.001	<0.0005	<0.0005	<0.0005	<0.0005
Sulphate-Total (mg/L)	NG	6.7	6.8	6.7	7.1
Temperature-Field (^{o}C)	NG	1.55	1.39	1.2	1.25
Thalium-Total (mg/L)	0.0008	<0.0002	<0.0002	<0.0002	<0.0002
Total suspended solid (mg/L)[5]	5 - 25	6	1	3	<1
Uranium-Total (mg/L)	0.015	<0.001	<0.001	<0.001	<0.001
Zinc-Total (mg/L)	0.007	<0.001	<0.001	0.001	<0.001
Conductivity (µs/cm)	NG	20.9	51.3	37.6	40.3

Notes: NG = no guideline; **1** CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; **2** Guideline is pH dependent; **3** Guideline is temperature dependent; **4** Guideline is hardness dependent; **5** Guideline is relative to background values; Shaded values exceed the CCME guideline.

Table 2-10. EEM water quality results at Third Portage Lake South (TPS) for 2014.

Parameter	CCME (2007) Guideline[1]	2014 27-Jan	2014 26-Aug	2014 28-Sep	2014 30-Nov
TPS (Reference Area)					
Alkalinity (mg $CaCO_3$/L)	NG	27	30	8	12
Aluminium-Total (mg/L)[2]	0.100 - 0.100	0.102	0.01	0.021	0.011
Ammonia-Total (mg N/L)[2,3]	2.610 - 8.24	0.25	0.05	0.05	0.07
Arsenic-Total (mg/L)	0.0050	0.0021	<0.0005	<0.0005	<0.0005
Cadmium-Total (mg/L)[4]	0.00004	0.00004	<0.00002	<0.00002	<0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	<0.0005	<0.0005	<0.0005
Cyanide-Total (mg/L)	NG	<0.005	<0.005	<0.005	<0.005
Dissolved oxygen-Field (mg/L)	NG	13.7	10.4	11.0	14.0
Hardness (mg $CaCO_3$/L)	NG	9	7	6	8
Iron-Total (mg/L)	0.3	0.07	<0.01	<0.01	<0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003	0.0028	<0.0003
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	0.0009	<0.0005	<0.0005	<0.0005
Nitrate-Total (mg N/L)	2.9	0.1	0.05	0.05	0.06
pH-Field	6.5 - 9.0	6.95	7.52	6.67	6.84
Radium-226 (Bq/L)	NG	<0.002	<0.002	0.002	<0.002
Selenium-Total (mg/l)	0.001	<0.001	<0.001	<0.001	<0.001
Temperature-Field (^{o}C)	NG	0.8	11.8	5.0	0.7
Total suspended solid (mg/L)	NG	10	3	<1	11
Zinc-Total (mg/L)	0.030	<0.001	<0.001	0.014	0.003
Conductivity (µs/cm)	NG	60	86	25	6

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; Shaded values exceed the CCME guideline; Parameters that have been added to the required monitoring list include: field measured conductivity and laboratory measured total selenium (MMER, 2012)

Table 2-11. EEM water quality results at Third Portage Lake South (TPS) for 2015 and 2016.

Parameter	CCME (2007) Guideline[1]	2015					2016			
		17-May	27-Jul	2-Sep	15-Nov	16-Dec	6-Apr	19-Jul	22-Aug	27-Sep
TPS (Reference Area)										
Alkalinity (mg $CaCO_3$/L)	NG	9	9	13	12	42	8	7	12	7
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.006	<0.006	<0.006	0.014	<0.006	<0.006	<0.006	<0.006	0.012
Ammonia-Total (mg N/L)[2,3]	0.274 - 2.61	0.12	<0.01	<0.01	<0.01	0.06	0.03	0.01	0.01	0.08
Arsenic-Total (mg/L)	0.0050	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002	<0.00002	<0.00002	0.00005	<0.00002	<0.00002	<0.00002	0.00003
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0005	<0.0005
Cyanide-Total (mg/L)	NG	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	NG	13.49	11.67	15.83	9.9	13.3	9.1	-	-	-
Hardness (mg $CaCO_3$/L)	NG	9	8	8	6	8	8	8	12	8
Iron-Total (mg/L)	0.3	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003	<0.0003
Mercury-Total (mg/L)	0.000026	<0.00001	0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	<0.0005	<0.0005	0.0005	0.0179	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Nitrate-Total (mg N/L)	2.9	0.06	0.07	0.04	0.04	0.02	0.06	0.06	<0.01	0.03
pH-Field	6.5 - 9.0	7.6	7.28	7.89	7.56	7.43	8.35	7.38	7.46	7.36
Radium-226 (Bq/L)	NG	<0.002	<0.002	<0.002	<0.002	0.002	-	-	-	-
Selenium-Total (mg/l)	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Temperature-Field (°C)	NG	1.04	5.34	9.66	6.58	0.5	2.9	7.47	15.9	-
Total suspended solid (mg/L)	NG	<1	1	3	3	1	2	<1	4	8
Zinc-Total (mg/L)	0.030	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (μs/cm)	NG	30	28	212	41.6	42.3	41.3	20	36.7	27

Notes: NG = no guideline; **1** CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 1999, updated December 2007; **2** Guideline is pH dependent; **3** Guideline is temperature dependent; **4** Guideline is hardness dependent; Shaded values exceed the CCME guideline; Parameters that have been added to the required monitoring list include: field measured conductivity and laboratory measured total selenium (MMER, 2012)

Table 2-12. EEM water quality results at Third Portage Lake South (TPS) for 2017 - 2018.

	CCME (2020)	2017				2018			
Parameter	Guideline[1]	10-Jan	3-Apr	19-Nov	19-Dec	5-Feb	13-May	11-Sep	18-Nov
TPS (Reference Area)									
Alkalinity (mg $CaCO_3$/L)	NG	11	15	9	9	10	9	9	11
Aluminium-Total (mg/L)[2]	0.100 - 0.100	< 0.006	0.02	< 0.006	0.007	<0.005	0.032	< 0.005	< 0.005
Ammonia-Total (mg/L)[2,3]	1.3 - 19	0.02	0.03	0.03	0.03	0.03	0.04	< 0.01	< 0.01
Arsenic-Total (mg/L)	0.005	0.0006	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.001	< 0.0005	< 0.0005
Cadmium-Total (mg/L)[4]	0.00004	< 0.00002	< 0.00002	< 0.00002	< 0.00002	< 0.00002	0.00002	< 0.00002	< 0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	< 0.0005	< 0.0005	0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Cyanide-Total (mg/L)	0.005	0.002	< 0.001	< 0.001	< 0.001	<0.001	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	13.60	11.60	14.53	15.35	14.76	14.58	11.70	17.26
Hardness (mg $CaCO_3$/L)	NG	9	9	9	9	12	8	7	8
Iron-Total (mg/L)	0.3	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01	< 0.01
Lead-Total (mg/L)[4]	0.001 - 0.001	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003	< 0.0003
Mercury-Total (mg/L)	0.000026	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Molybdenum-Total (mg/L)	0.073	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Nitrate-Total (mg N/L)	13.0	0.02	0.04	0.01	0.04	0.03	0.01	0.02	0.01
pH-Field	6.5 - 9.0	7.42	7.72	7.07	7.27	7.16	7.11	7.20	6.76
Radium-226 (Bq/L)	NG	-	-	-	-	-	-	-	-
Selenium-Total (mg/l)	0.001	< 0.001	< 0.001	< 0.001	< 0.001	<0.0005	<0.0005	<0.0005	<0.0005
Temperature-Field (°C)	NG	8.6	3.0	0.6	0.4	0.2	1.2	8.5	0.5
Total suspended solid (mg/L)	5 - 25	< 1	3	< 1	< 1	1	1	1	1
Zinc-Total (mg/L)	0.007	< 0.001	< 0.001	< 0.001	0.003	<0.001	0.002	<0.001	<0.001
Conductivity (µs/cm)	NG	28.0	42.8	32.2	28.5	34.5	68.8	31.4	28.7

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; 5 Guideline is relative to background values; Shaded values exceed the CCME guideline.

Table 2-13. EEM water quality results at Third Portage Lake South (TPS) for 2019.

Parameter	CCME (2020) Guideline[1]	2019			
		6-Jan	12-Mar	13-Nov	15-Dec
TPS (Reference Area)					
Alkalinity (mg $CaCO_3$/L)	NG	12	16	9	16
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.005	<0.005	<0.005	<0.005
Ammonia-Total (mg/L)[2,3]	6 - 19	0.01	<0.01	0.02	0.02
Arsenic-Total (mg/L)	0.005	<0.0005	<0.0005	0.0023	0.0011
Cadmium-Total (mg/L)[4]	0.00004	<0.00002	<0.00002	<0.00002	<0.00002
Chloride-Total (mg/L)	120	0.7	1	0.8	0.7
Chromium-Total (mg/L)	NG	<0.0006	<0.0006	<0.0006	0.0009
Cobalt-Total (mg/L)	NG	<0.0005	<0.0005	<0.0005	<0.0005
Copper-Total (mg/L)[4]	0.002 - 0.002	<0.0005	<0.0005	<0.0005	<0.0005
Cyanide-Total (mg/L)	0.005	<0.001	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	6.5 - 9.5	17.89	19.12	15.98	16.79
Hardness (mg $CaCO_3$/L)	NG	9	10	11	10
Iron-Total (mg/L)	0.3	<0.01	<0.01	0.02	0.08
Lead-Total (mg/L)[4]	0.001 - 0.001	<0.0003	<0.0003	<0.0003	<0.0003
Manganese-Total (mg/L)	0.230 - 0.860	<0.0005	<0.0005	0.0007	<0.0005
Mercury-Total (mg/L)	0.000026	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum-Total (mg/L)	0.073	<0.0005	<0.0005	<0.0005	<0.0005
Nickel-Total (mg/L)[4]	0.025 - 0.025	<0.0005	<0.0005	0.0006	<0.0005
Nitrate-Total (mg N/L)	13.0	<0.01	<0.01	<0.01	<0.01
Phosphorus-Total (mg/L)	NG	<0.01	<0.01	<0.01	<0.01
pH-Field	6.5 - 9.0	7.35	6.82	7.28	7.45
Radium-226 (Bq/L)	NG	-	-	<0.002	0.005
Selenium-Total (mg/l)	0.001	<0.0005	<0.0005	<0.0005	<0.0005
Sulphate-Total (mg/L)	NG	6.1	7.8	4.9	4.5
Temperature-Field (^oC)	NG	0.53	0.61	0.78	0.82
Thalium-Total (mg/L)	0.0008	<0.0002	<0.0002	<0.0002	<0.0002
Total suspended solid (mg/L)[5]	5 - 25	16	<1	<1	1
Uranium-Total (mg/L)	0.015	<0.001	<0.001	<0.001	<0.001
Zinc-Total (mg/L)	0.007	<0.001	<0.001	0.001	<0.001
Conductivity (µs/cm)	NG	15.3	36.7	27.4	30.9

Notes: NG = no guideline; 1 CCME (Canadian Council of Ministers of the Environment) Canadian Water Quality Guidelines for the Protection of Aquatic Life, 2020; 2 Guideline is pH dependent; 3 Guideline is temperature dependent; 4 Guideline is hardness dependent; 5 Guideline is relative to background values; Shaded values exceed the CCME guideline.

2.4 Anthropogenic Influences

Apart from the Meadowbank Mine itself, there are no other significant anthropogenic influences to the receiving environment. The nearest community is Baker Lake, 75 km south. There are no public recreation zones, docks, wharves, or boat launches in the vicinity of the mine.

The activities and conditions at the Meadowbank Mine have not significantly changed since the EEM Cycle 1 biological study in 2011. As a result, there are no significant confounding factors to an evaluation of effluent-related effects. Specifically, there are no major construction activities or operational changes planned for 2020 that may confound the planned EEM biological monitoring studies. Given the location of the final discharge point relative to the main mine site (i.e., to the east and southeast of the main site) and the prevailing winds (i.e., from the NW), site-related dust inputs from the main site may be the only potential confounding “mine-related” factor in the Cycle 4 study.

2.5 Effluent Mixing

As discussed previously, with the cession of discharge to Wally Lake on October 9, 2017, the East Dike discharge to Second Portage Lake (MDMER 3) is the only final discharge at the Meadowbank site and is the subject of the EEM Cycle 4 study. The diffuser location is shown in Figure 2-1 and Figure 2-2. When discharge to Second Portage Lake first began, in 2014, during the winter period a diffuser was suspended down through a hole in the ice at the same location as the summer diffuser. In recent years the ‘summer’ diffuser has been used throughout the year.

Discharge is from a single orifice diffuser, oriented to discharge vertically upward, located approximately 45 m from shore and anchored on the bottom at a water depth of approximately 5 m. The diffuser was designed and built to be capable of discharging effluent at the rate of 12 L/sec which equals a discharge volume of 1037 m^3/day. The actual rate of discharge has always been less; the maximum recorded rate is 935 m^3/day.

Effluent mixing and the plume extent were modelled for Second Portage Lake by W.F. Baird & Associates Coastal Engineers Ltd. (Baird), using the CORMIX model. The Baird report is provided as Appendix C, and the results are summarized here. The plume extent was modelled for both summer (ice-free) and winter (ice-covered) conditions. Initial model runs were made using the design flow, which provides a theoretical worst-case scenario. Both summer and winter model runs were conducted for three plume buoyancy scenarios (negative, neutral, positive). For the summer scenario wind conditions were also varied (near stagnant, low, median, high). For the winter scenarios ice thickness was varied (negligible, 0.5 m, 1 m and 2 m). The results of the initial model runs were used to determine the scenario that would result in the largest plume under both summer and winter conditions.

The plume extent was then modelled at minimum, maximum and mean flow rates for the scenario that would result in the largest plume under both summer and winter conditions and for the ‘typical’ summer and winter conditions (Figure 2-2). ‘Typical’ summer condition is a neutrally buoyant plume, because plume temperature and lake temperature are similar, and median wind. ‘Typical’ winter condition is a positively buoyant plume, because a heat-trace cable is installed along the pipe to prevent freezing, and 2 meters of lake ice. The worst-case scenario for summer conditions is a negatively buoyant plume and low wind. The worst-case scenario for the winter conditions is a negatively buoyant plume and two meters of lake ice.

The maximum, minimum, and mean daily discharge rates were determined from the daily effluent volumes during the period February 18, 2017 (the day after the Cycle 3 study design was submitted) and December 31, 2019. Flow rates were determined separately for June 1 to October 31, which approximates the ice-free period, and November 30 – May 31, which approximates the period when there is ice-cover. When effluent is being discharged, the pump typically runs continuously. The first and last day of each discharge period were excluded from the calculation of daily means because on those days there was typically only discharge for part of a day. Three additional days when flows were too small to represent a full 24 hours of discharge were also excluded. The instantaneous discharge rates used in the CORMIX model were calculated from the daily discharge rates by converting cubic meters to liters and dividing by the number of seconds in a day (daily discharge in $m^3*1000/86400$).

The flow rates used in the CORMIX model were as follows:

- design flow –12L/sec, which corresponds to a daily discharge of 1,037 m^3/day;
- maximum summer flow – 935 m^3/day = 10.8 L/sec;
- mean summer flow - 518 m3/day = 6.0 L/sec;
- minimum summer flow –379 m^3/day = 4.4 L/sec;
- maximum winter flow - 680 m3/day = 7.9 L/sec;
- mean winter flow - 463 m3/day = 5.4 L/sec;
- minimum winter flow – 300 m^3/day = 3.5 L/sec

It is important to note that the design flow has never been attained. It is provided as a theoretical maximum.

The following are the key results of the plume modelling:

- For all scenarios, at the design flow, which is the theoretical maximum, the effluent concentration 250 meters from the outfall is less than 1%.
- For winter scenarios (ice cover present) the plume is predicted to be largest if the effluent is negatively buoyant and the ice thickness is two meters. The maximum extent of the 1% plume under this scenario, at the maximum reported winter flow rate, is 86 m (Figure 2-2). In other words, the 1% plume is predicted to not reach to or beyond 100 m when there is ice cover.
- For summer conditions, at the design flow, the 1% plume extends beyond 100 m for a number of scenarios.
- Under what are considered typical summer conditions, which are a neutrally buoyant plume and median wind, at the mean summer effluent discharge rate the maximum predicted extent of the 1% plume is 84 m (Figure 2-2). Under the same conditions, at the minimum discharge rate the 1% plume extends 162 meters. The plume is larger at lower discharge rates due to the lower velocity of the effluent jet as it exits the diffuser.

- The largest plume extent under summer conditions is predicted for a negatively buoyant plume and low wind condition. At the mean summer discharge rate, under these conditions the 1% plume only extends for 18 meters. At the maximum reported summer discharge rate, however, under these conditions the 1% plume extends for 220 meters (Figure 2-2).
- The plume will attach to the shoreline for all cases.

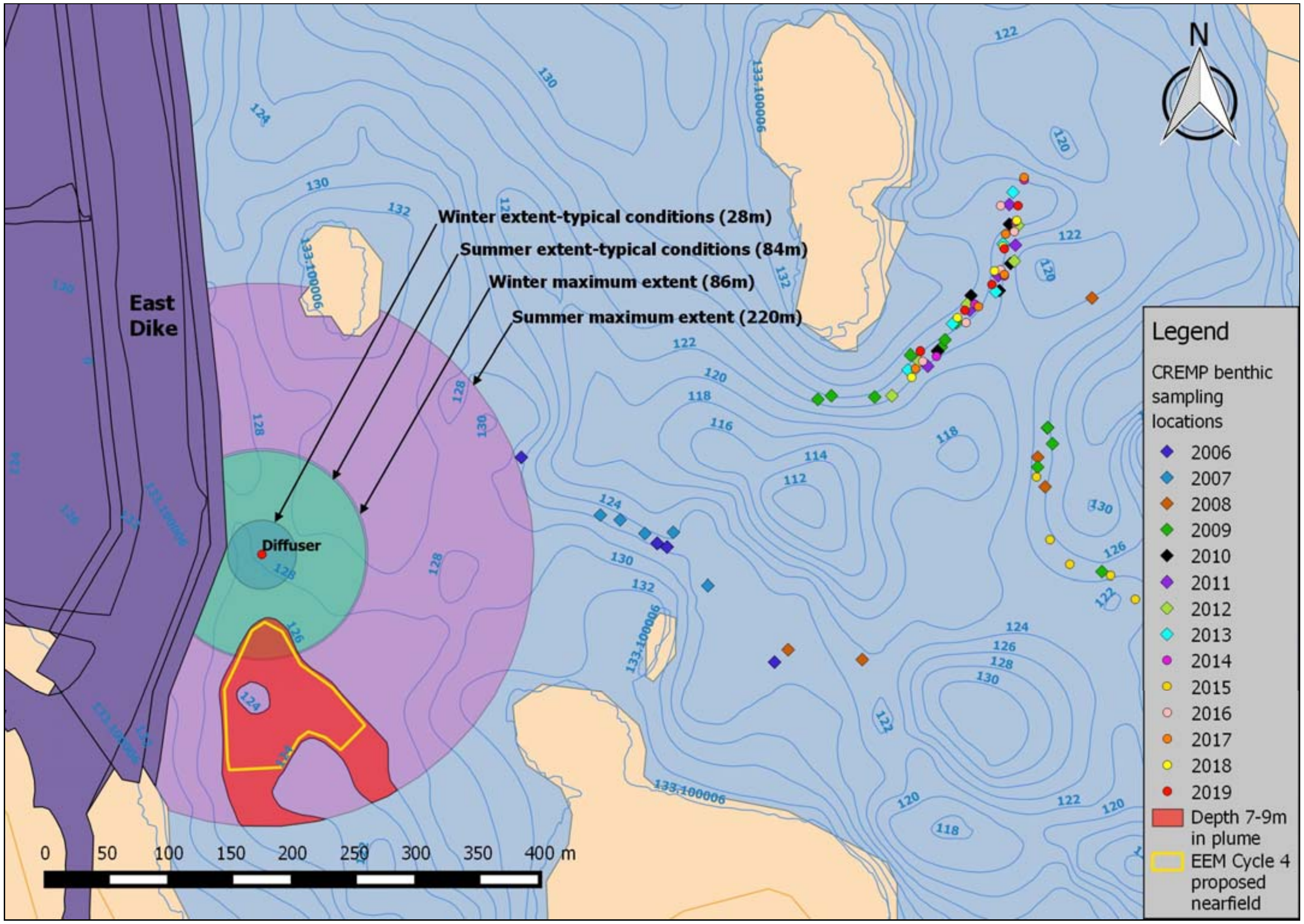

Figure 2-2. Diffuser (discharge point) location and modeled plume extents under typical conditions and worst-case conditions at the maximum measured discharge rate for the period February 18, 2017, through December 31, 2019.

2.6 Local Limnology and Aquatic Resource Characterization

The purpose of this section is to describe known aquatic physical and biological features of the receiving environment at Meadowbank Mine using historic studies conducted prior to and during construction and operational phases.

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

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

2.6.1 Morphology and Bathymetry

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

The shoreline complexity described above often results in the presence of well-defined basins within many of the lakes. Where appropriate, these features have been used as the foundation of the CREMP (Appendix A) in order to provide information on the spatial extent of exposure and effects endpoints. The basins do vary substantially in bathymetry (Figure 2-3), which is likely responsible for some of the observed inter-basin and inter-lake differences in productivity (see Section 2.6.5 for further discussion).

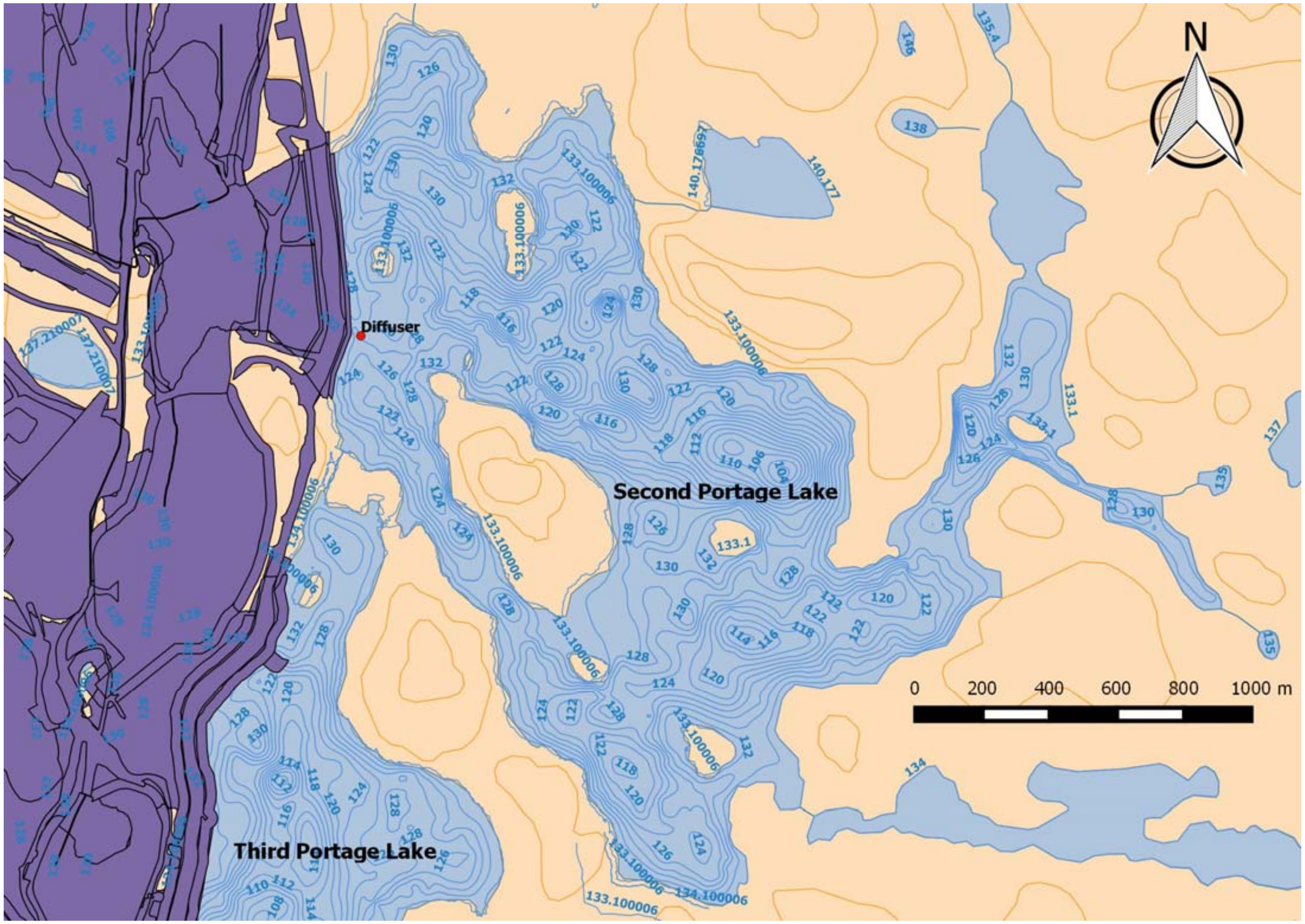

Figure 2-3. Second Portage Lake, illustrating the typical complex shorelines and bathymetric variability of study area lakes.

2.6.2 Limnology

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

The ice-free season on the Meadowbank project lakes is very short. Ice break-up usually occurs during mid- to late-June, 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, 2019).

Vertical temperature (°C) and 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 3.5°C at depth, while oxygen concentrations generally decrease slightly with increasing depth. 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. Once the ice is off by mid-July, water temperatures increase rapidly to reach maximum temperatures of about 15°C by late July and early August (Azimuth, 2019).

Oxygen is generally completely saturated, with concentrations varying with temperature. Interestingly, during winter months oxygen concentrations just below the ice were elevated relative to other depths; this is attributed to photosynthesis by algae living at the ice-water interface. Although there is a thick ice and snow layer above the water, sufficient light penetrates in late winter/early spring to stimulate algal growth, thus increasing oxygen concentrations near the ice-water interface. 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, 2019).

Monthly/annual profiles at control areas (INUG, PDL), up to 2018, had similar patterns to those seen in the near-field and mid-field impact areas. Overall, vertical temperature and oxygen profiles among near-field, mid-field and reference lakes in 2018 were consistent with what has been observed in the past (Azimuth, 2019).

Additional detail regarding Limnology is provided in the Cycle 1 EEM study design report (Azimuth, 2010a) and the CREMP 2018 Annual Report (Azimuth, 2019).

2.6.3 Water Quality

A suite of parameters analyzed in the project lakes, including: pH, hardness, anions, total and dissolved solids concentrations, nutrients (dissolved organic carbon [DOC], nitrogen nutrients [ammonia, nitrate, and nitrite], and phosphorus [total phosphorus, dissolved phosphorus]). The BAER (2005) reported water quality results for all project lakes between 1996 and 2002, prior to any significant site development. 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 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.

During EEM Cycles 1 and 2 the exposure area was Third Portage Lake North (TPN). Effluent discharge to TPN ceased on July 5, 2014 and will not resume. The exposure area was then located in Wally Lake which until 2013, in the context of CREMP, had “control” status because it had not been directly impacted by mine construction or operations. In 2013, dewatering of Vault Lake into Wally Lake began and since then, in the CREMP context, Wally Lake has had “impact” status. Discharge to Wally Lake ceased on October 9, 2017, leaving the existing discharge to Second Portage Lake (MDMER 3) as the sole effluent for which impact must be assessed under EEM. It is important to keep in mind that impact status does not necessarily mean that there is an impact or effect; only that there is the potential for mining-related changes that may occur at that area after that time. The Second Portage Lake discharge results from water from Second Portage Lake seeping through the east dike into Portage Pit, and then being collected and pumped back into Second Portage Lake via a diffuser.

The most recent CREMP results that have been reported are from 2018 (Azimuth, 2019). The 2018 CREMP identified statistically significant increases in Second Portage Lake, relative to baseline conditions, using a BACI statistical model, for conductivity, alkalinity, hardness, calcium, potassium, sodium, magnesium, and TDS. These increases appear to be related to mining activities. There are no CCME guidelines for these parameters and the observed concentrations, while above baseline/reference conditions, are not thought to be increasing year over year, or to pose a threat to aquatic life (Azimuth, 2019). Most metals are below detection limits and none are at concentrations which are thought to pose a threat to aquatic life.

2.6.4 Sediment Quality

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

The BAER (2005), 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. Interestingly, the results of a coring study conducted in 2008 and 2009 (i.e., before and after construction of the East Dike; Azimuth, 2010c) showed a large increase in arsenic concentrations (mean of 15 samples changed from 32 mg/kg to 117 mg/kg) at the INUG reference area (i.e., one of the two study areas not exposed to dike construction) between the two years.

Given the general lack of sediment input sources, conditions would not have been expected to change at this reference area over the time period. It was postulated that localized heterogeneity in chemistry due to mineralization may have been responsible. This highlights the challenges of characterizing sediment chemistry in close proximity to highly-mineralized bedrock.

When 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.

Grab samples for sediment chemistry are collected synoptically with benthos community samples at Second Portage Lake as part of the CREMP (Azimuth, 2019). Sediment coring is conducted on a three-year cycle to coincide with EEM field studies. In the 2018 samples, the only analyte exceeding trigger or threshold values at Second Portage Lake was zinc, but zinc concentrations in 2018 were within the range of baseline concentrations observed between 2006 and 2008. The variable historical pattern for Second Portage suggests the influence of small-scale, natural spatial heterogeneity in zinc rather than mining-related changes in sediment quality (Azimuth, 2019).

2.6.5 Aquatic Resource Characterization

2.6.5.1 Primary Productivity

Characterization of baseline primary productivity in the Meadowbank study lakes has targeted both periphyton (i.e., algae that grow attached to rocks) and phytoplankton (i.e., algae that are suspended in the water column), but with greater emphasis on the latter. The BAER (2005) reported on the limited periphyton sampling conducted in 1998 and 2002, with a focus on community composition. Phytoplankton sampling has continued to the present. The phytoplankton results from 2018 were within the range of reference/baseline conditions in each area (Azimuth, 2019). Additional detail regarding primary productivity and phytoplankton is provided, respectively, in the Cycle 1 EEM study design report (Azimuth, 2010a) and the CREMP Annual Reports (Azimuth 2008a, 2008b, 2009, 2010b, 2011, 2012c, 2013, 2014, 2015b, 2016, 2017, 2018, 2019). Before-after-control-impact (BACI) tests reported in the most recent CREMP report (Azimuth, 2019) found no significant differences in phytoplankton total biomass or taxa richness in Second Portage Lake.

2.6.5.2 Zooplankton

Zooplankton are a key food chain species for fish, especially young-of-the-year Lake Trout, Round Whitefish, Lake Cisco, and minnow species. Zooplankton are also the main food source for adults of some species, particularly Round Whitefish and Arctic Char. Additional detail regarding zooplankton is provided in the Cycle 1 EEM study design report (Azimuth, 2010a).

2.6.5.3 Benthic Invertebrates

Benthic invertebrates provide an important food source for most fish species, especially young-of-the-year and juvenile Lake Trout, Round Whitefish, Lake Whitefish, sculpins, and sticklebacks (Machniak, 1975; Scott and Crossman, 1979). As Lake Trout get larger, they gradually shift from a diet dominated by invertebrates to one dominated by fish (Scott and Crossman, 1979).

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

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

In addition to physical factors, abundance and composition of benthic communities are also influenced by biological factors, such as foraging by fish and timing of hatch of insect larvae. Because sampling cannot be conducted on all lakes at the same time, significant hatches of chironomids may occur during the course of sampling (a period of days or weeks). This may result in a particular species being very abundant in one lake, and much less abundant in another, because of hatching of larvae into the terrestrial adult. This can be partly overcome by sampling during late fall, after the emergence of most groups. Even then, benthic invertebrate abundance can be patchy, varying over small distances within a particular sampling area due to the patchy nature of sediment organic matter, particle size, or other parameters that may influence the invertebrate community.

Baseline characterization studies of the project lakes (BAER, 2005) showed that the benthic invertebrate community was numerically dominated by the aquatic larval stages of insects, especially chironomids, in terms of relative abundance, density, and species diversity, which is typical of most Arctic and temperate lakes. During the baseline investigations between 1997 and 2003, chironomid larvae comprised from 50% to 86% of organisms in benthic samples from all study lakes and ponds. Chironomids typically compose the majority of the food source for young Lake Trout, young Arctic Char, Whitefish, and minnow species.

Other typically important insect taxa such as mayflies (Ephemeroptera) and stoneflies (Plecoptera) are uncommon or absent in many Arctic lakes.

The average number of genera identified in benthic samples from project and reference lakes ranged from 11 to 20 taxa and was reasonably consistent among stations and seasons (see BAER, 2005, for more detail). Chironomids were the most diverse group taxonomically, with 20 genera identified over all stations. Within stations, an average of 10 to 12 chironomid genera were identified per station, with most common chironomid taxa being present in all lakes. Overall, there were no large differences in species diversity among lakes as the total number of taxa identified in each lake was quite similar.

The core receiving environment studies of the project lakes (Azimuth 2008a, 2008b, 2009, 2010b, 2011, 2012c, 2013, 2014, 2015b, 2016, 2017, 2018, 2019) showed largely the same benthic invertebrate patterns as those seen in the baseline data (BAER, 2005); however, inter-annual variability in benthos abundance and diversity can be naturally high. For example, prior to major construction related events, mean abundance at Third Portage Lake East changed substantially between 2006 (3261/m^2), 2007 (1578/m^2), 2008 (5,626/m^2), and 2009 (1713/m^2). Changes in benthic community metrics can also occur as a result of exposure to mine-related stressors. A marginal effect trend (i.e., not statistically significant, but a fairly large effect size) was identified for benthos abundance in an area of Second Portage Lake with elevated TSS from the East Dike construction, but not in nearby Tehek Lake. BACI analyses incorporating the 2018 CREMP sampling results found no significant differences in benthic invertebrate abundance or taxa richness associated with effluent discharge into Second Portage Lake (Azimuth, 2019).

The Cycle 2 EEM study (C. Portt and Associates and Kilgour & Associates Ltd., 2015) undertook a survey of benthic invertebrates in 2014, focused on the exposure area in Third Portage North Lake (TPN), with INUG and PDL as local reference areas. Total abundances in 2014 were generally <1,000 organisms per m^2, similar to what was observed during the Cycle 1 EEM study in 2011. Benthic communities within each of the three study areas were similar in 2014, and similar to what had been described in previous years, including those from the baseline period 2006 to 2008. The communities were dominated numerically by chironomids (50 to 80%) and Sphaeriid clams (16 to 32%). Sub-dominant taxa in each of the three sample areas were, variously, Nematoda, Naididae, Tubificidae, Lumbriculidae and Acarina. The composition of the benthic communities, their index values and associated statistics are consistent with a conclusion that there were no effects of mine effluent exposure on benthos of TPN (C. Portt and Associates and Kilgour & Associates Ltd., 2015).

The Cycle 3 EEM study (C. Portt and Associates and Kilgour & Associates Ltd., 2018) undertook a survey of benthic invertebrates in 2017, focused on the exposure area in Wally Lake (WAL), with INUG and PDL as local reference areas. Total abundances in Wally Lake have been generally higher and more variable than abundances in INUG or PDL. Abundances in Wally Lake in 2017 varied between about 3000 and 8000 individuals per m^2, whereas abundances in INUG varied between about 1000 and 3000 individuals per m^2, and abundances in PDL varied between about 500 and 1500 individuals per m^2. Abundances in Wally Lake have typically ranged up to about 5000 individuals per m^2, with the exception of samples collected in 2016 when abundances varied between 13000 and 32000 individuals per m^2. The benthic community of WAL, in 2017, largely consisted of chironomids and sphaeriid fingernail clams, similar to what the community consisted of in all other surveys, including those from the baseline period 2006 to 2012. Generally, and despite some of the statistically significant variations observed, the composition of benthic community of WAL was very similar to what is observed in the reference lakes, and in WAL during baseline periods, and further contained fauna indicative of high water quality. WAL benthos contained 10 genera of chironomid in 2017, similar to what had been observed in the other lakes. Further, the dominant chironomids in WAL were similar to what were also dominant in the other lakes (i.e. *Cladotanytarsus*, *Constempellina* and *Sergentia*). Overall, the benthic community of WAL did not indicate a degraded condition relative to the baseline period in WAL, and contained an assemblage of organisms that are typical for these Arctic systems (C. Portt and Associates and Kilgour & Associates Ltd., 2018).

2.6.5.4 Fish

Fish community and population studies were undertaken to establish baseline conditions in the project lakes and candidate reference lakes in advance of mine development. These results were summarized in the BAER (2005).

Fish species composition and mean size and condition factor of fish among lakes was similar for most lakes. Lake Trout (*Salvelinus namaycush*) dominated all project, reference and regional lakes and were characterized as being large, old, climax community populations, and are typical of oligotrophic, Arctic lakes. Round Whitefish (*Prosopium cylindraceum*) and Arctic Char (*Salvelinus alpinus*) were the next most abundant species in all lakes, with small numbers of Burbot (*Lota lota*), Ninespine Stickleback (*Pungitius pungitius*) and sculpins (*Cottus* sp.) present. While abundant in many local small streams and ponds along the all-weather road, the latter species were infrequently found in the larger lakes during baseline studies despite deployment of baited minnow traps. A backpack electrofisher was employed in 2010 to evaluate the potential of using sculpins as an EEM sentinel species, but only 3 were captured during 6323 electroseconds of effort.

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

The Cycle 2 EEM study (C. Portt and Associates and Kilgour & Associates Ltd., 2015) collected fish by gillnet in the exposure area in Third Portage North Lake (TPN), and in the reference lakes INUG and PDL. A total of 292 Lake Trout were captured, dominating the catch in all three lakes (87% - 96%), followed by Round Whitefish (1% - 12%) and Arctic Char (2% - 7%). One Arctic Grayling was captured in INUG Lake. Small-bodied fishes were sparse, with only 6 juvenile Lake Trout, 22 Slimy Sculpin (*Cottus cognatus*), and 1 juvenile Burbot captured during 7176 electroseconds of shoreline electrofishing (C. Portt and Associates and Kilgour & Associates Ltd., 2015).

The Cycle 3 EEM study (C. Portt and Associates and Kilgour & Associates Ltd., 2018) collected fish by gillnet in the exposure area in Wally Lake (WAL), and in the reference lakes INUG and PDL. A total of 76 Lake Trout were captured, dominating the catch in all three lakes (49% - 91%), followed by Round Whitefish (0% - 38%) and Arctic Char (0% - 13%) (C. Portt and Associates and Kilgour & Associates Ltd., 2018).

3.0 EEM CYCLE 4 STUDY DESIGN OVERVIEW

3.1 Fish Study

As discussed in previous sections, the exposure area for Cycle 4 is Second Portage Lake, which is now the only effluent discharge point at the Meadowbank site. Under the MDMER, there are two factors that determine whether a fish study is required in each EEM cycle. The first is whether the 1% effluent plume extends to or beyond 250 m from the final discharge point. If it does not, a fish survey is not required. If the 1% effluent plume extends 250 m or more from the final discharge point, a fish survey is required unless the results of the previous two biological monitoring studies indicate:

(i) for all effect indicators with no assigned critical effect size, no effect on the fish population, and
(ii) for all effect indicators with an assigned critical effect size, no effect on the fish population or an effect on the fish population where the absolute value of the magnitude of which is less than the absolute value of its assigned critical effect size.

As described in Section 2.5, the effluent plume is not predicted to extend to or beyond 250 m from the final discharge point under any of the modelled environmental conditions. Based on this, a fish study is not required in Cycle 4.

The results of the previous two EEM fish studies at the Meadowbank site for the MDMER critical endpoints are summarized in Table 3-1. Neither the Cycle 2 nor Cycle 3 EEM fish studies examined gonad weight, because the number of fish that would need to be killed in order to sample enough mature fish that would spawn in the current year was considered unacceptable. For the critical endpoints that were evaluated, a significant difference was only observed for the total body weight versus length relationship and only in Cycle 2. Those differences were less than the critical effect size. Therefore, based on the results of the two preceding EEM fish studies, a fish study is not required in Cycle 4.

Both criteria for not requiring a fish study in Cycle 4 are met, and a fish study is not proposed.

Table 3-1. Summary of Cycle 2 and 3 exposed lake versus reference lake comparisons calculated with no outliers removed. Critical end points and effect sizes are from MDMR. Exposed lake was Third Portage in Cycle 2 and Wally in Cycle 3.

dependent variable	EEM cycle	p-value	Exposed vs INUG % difference	Exposed vs PDL % difference	critical effect size
total body weight at age	2	0.573	-6.5	-1.8	25%
	3	0.835	7.2	4.0	
gonad weight at total body weight		not available			
liver weight at total body weight	2	0.102	23.0	17.8	25%
	3	0.125	-13.7	-10.5	
total body weight at length (condition)	2	0.000	5.7	4.2	10%
	3	0.528	0.5	-3.6	
age[1]			7 (0.79)	36 (0.68)	25%

The MDMER requires that a study respecting fish tissue mercury be conducted, 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;

The mercury concentration in the effluent has consistently been less than 0.10 µg/L and in all samples except 1 has been below the detection limit of 0.01 µg/L. Therefore a study respecting fish tissue mercury is not required.

The MDMER requires that a study respecting fish tissue selenium be conducted, 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.

The selenium detection limit was 1 µg/L for the years 2014 through 2017 and 0.5 µg/L in 2018 and 2019. The selenium concentration has never exceeded the detection limit. Therefore, a study respecting fish tissue selenium is not required.

3.2 Benthic Invertebrate Community Study

Under the MDMER, there are two factors that determine whether a benthic invertebrate community study is required in each EEM cycle. The first is whether the 1% effluent plume extends 100 m or more from the final discharge point. If it does not, a benthic invertebrate study is not required. If the 1% effluent plume extends for 100 m or more from the final discharge point, a benthic invertebrate community study is required unless the results of the previous two biological monitoring studies indicate:

(i) for all effect indicators with no assigned critical effect size, no effect on the benthic invertebrate community, and
(ii) for all effect indicators with an assigned critical effect size, no effect on the benthic invertebrate community, or an effect on the benthic invertebrate community where the absolute value of the magnitude of which is less than the absolute value of its assigned critical effect size.

The Cycle 3 study design was submitted on February 17, 2017. From February 18, 2017, through December 31, 2019, effluent was discharged on 446 days during the period when ice cover is expected to be present (November 1 through May 31). The plume modelling (refer to Appendix C) predicts that, under the conditions predicted to result in the largest 1% plume (negatively buoyant effluent, 2 meters of ice), at the maximum effluent flow rate measured during this period (7.9 L/sec), the 1% effluent plume will extend 86 meters from the discharge point. Under typical winter conditions (positively buoyant plume, 2 meters of ice), at the mean effluent flow rate measured during this period (5.4 L/sec) the 1% plume is predicted to extend 28 meters from the discharge point. Based on this, the effluent plume is not expected to have extended to or beyond 100 meters from the discharge point when there was ice-cover.

The plume modelling (refer to Appendix C) predicts that, under ice-free conditions, the 1% plume would extend more than 100 meters from the discharge point under some plume buoyancy and wind velocity scenarios at the maximum effluent discharge rate during that period (10.8 L/sec). The plume modelling also predicts that the 1% plume would extend more than 100 meters from the discharge point under typical summer conditions (neutrally buoyant effluent, median wind) at the minimum effluent discharge rate during that period (4.4 L/sec). From February 18, 2017, through December 31, 2019, effluent was discharged on 96 days during the period from June 1 through October 31, which approximates the ice-free period. Based on the plume modelling results, the 1% effluent plume may have extended more than 100 meters from the discharge point on occasion during that period.

Based on the plume modelling results, a benthic invertebrate study is required in this EEM Cycle 4, unless the results of the previous two EEM cycles meet the criteria regarding the previous two EEM studies. In Cycle 3, when the exposure area was WAL, there was a significant effect on benthos density with an effect size of > 3 SD. Therefore the criteria for not requiring a benthic invertebrate community study due to the results of the previous two EEM studies are not met. Consequently, a benthic invertebrate community study is required in Cycle 4.

The Cycle 4 EEM benthic invertebrate community study design utilizes the same overall design structure as the Cycle 1, Cycle 2 and Cycle 3 EEM studies, but the exposure area is now in Second Portage Lake (SP). The two reference areas, Inuggugayualik Lake (INUG) and Pipedream Lake (PDL), remain the same (see Figure 2-1 for map and Table 3-2 for general coordinates).

Table 3-2. Location of EEM exposure and reference sampling areas.

EEM Sampling Area		Location (NAD83)*	
Type	**Name**	**Latitude**	**Longitude**
Exposure	Second Portage Lake (SP)	65° 1.17991'	-96° 2.37728'
Reference	Inuggugayualik Lake (INUG)	65° 3.13339'	-96° 23.41809'
Reference	Pipedream Lake (PDL)	65° 6.46399'	-96° 13.30640'

* Indicates the approximate centre of the sampling area.

The reference areas, INUG and PDL, were selected during the Cycle 1 EEM study design on the following merits (summarized from Azimuth, 2010a), which still apply:

1. Neither of the lakes, which are situated in the adjacent Back River watershed, is exposed to any anthropogenic influences (mining or otherwise).
2. Both lakes are fairly similar in ecoregion, geology, morphometry, and habitat and substrate types to the exposure area (TPN during EEM Cycles 1 and 2, WAL during Cycle 3, and SP proposed for Cycle 4).
3. Both reference areas were targeted in baseline studies, providing some temporal context for interpreting study results.
4. Both reference areas are monitored on a routine basis in the CREMP.
5. Both reference areas are accessible by helicopter or ATV for field crews.

The specific approach for the benthic invertebrate community study is discussed in greater detail in **Sections 5**.

4.0 FISH SURVEY

As discussed in Section 3, no fish survey is required for this Cycle 4 EEM biological study. The results of the previous three EEM cycles are summarized in Sections 4.1, 4.2 and 4.3.

4.1 Cycle 1 Survey

4.1.1 Overview

The EEM Cycle 1 Study Design (Azimuth, 2010a), proposed a non-lethal study of Lake Trout (*Salvelinus namaycush*) and a lethal study of Round Whitefish (*Prosopium cylindraceum*). Fish were to be captured by gill netting in one exposure area (TPN) and two reference areas (INUG and PDL; Figure 2-1). The design was developed with knowledge gained through baseline studies and fish-out studies, the latter conducted to remove fish from the diked (and eventually dewatered) areas.

4.1.2 Fish sampling results

The results of the Cycle 1 fish sampling are reported in the Cycle 1 Interpretive report (Azimuth, 2012a). Cycle 1 sampling began at the exposure area and Lake Trout were readily captured but the mortality rate was higher than expected. Catches of Round Whitefish were much lower than expected and, after consultation with Environment Canada, the use of larger mesh sizes was discontinued in the hope that Lake Trout mortalities would decrease and sufficient numbers of either Arctic Char or Round Whitefish would be caught to allow the use of one or the other as a second sentinel species. The change in mesh sizes used did not have the desired effect, neither increasing the catch of Arctic Char or Round Whitefish nor reducing Lake Trout mortalities.

After six days of sampling at the exposed site, effort was switched to the reference sites, INUG and PDL. During three days of sampling, large numbers of Lake Trout were captured with higher than expected mortality, but few sexually mature Round Whitefish and Arctic Char were caught. After consultation with Environment Canada and determining that the Lake Trout catch at INUG and PDL was sufficient to reach targeted statistical power (i.e., $1 - \beta = 0.9$) for the non-lethal condition (weight versus length) endpoint, the gill netting was terminated. The catches of each species at each sampling location are provided in Table 4-1.Table 4-1. Number of fish captured by gill netting in Cycle 1 at each location and the number of Lake Trout that were released alive or were dead. Lake Trout was the only species for which sufficient numbers for analysis were captured at both the exposed site and a reference site. Slightly more than half of the Lake Trout captured died and this may be an underestimate of mortality, as some fish may have died after their release, as a consequence of handling.

Table 4-1. Number of fish captured by gill netting in Cycle 1 at each location and the number of Lake Trout that were released alive or were dead.

	Lake Trout				
Location	**released alive**	**dead**	**total**	**Round Whitefish**	**Arctic Char**
TPN (exposed)	62	63	125	2	33
INUG (reference)	45	43	88	39	5
PDL (reference)	26	32	58	7	8
total	133	138	271	48	46

4.1.3 Statistical Analysis

The results of the Cycle 1 analyses of the Lake Trout data, presented in the EEM Cycle 1 Interpretive Report (Azimuth, 2012a), are summarized in Table 4-2. The data were analyzed in the usual manner for a non-lethal survey, except that a correction factor was applied to ages obtained from fin rays. Both otoliths and fin rays were collected from most of the Lake Trout that died, and fin rays were collected from most of those that were released alive. Comparison of ages determined from both structures for the same fish showed that ages determined from otoliths were older than those determined from fin rays, which is a common situation. A correction factor was calculated from the otolith age versus fin ray age relationship and applied to the fin ray ages for the individuals from which otoliths were not available. No effects were detected (Table 4-2).

Table 4-2. Summary of Cycle 1 statistical analysis for Lake Trout. (Source: Azimuth, 2012a).

Endpoint Type	Effect Indicator	Non-lethal Endpoints for Meadowbank Fish Survey	Recommended Statistical Procedures	Effect?	Confidence in Result?
Primary	Growth (*Energy Use*)	Size-at-age (body weight against age)	ANCOVA	No	High
	Condition (*Energy Storage*)	Body weight against length	ANCOVA	No	High
	Survival	Age frequency distribution	Kolmogorov-Smirnov	No	High
		Length frequency distribution	Kolmogorov-Smirnov	No	High
Supporting	(*Energy Use*)	Size-at-age (length against age)	ANCOVA	No	High

Based on the Cycle 1 results, the sample size required to achieve the desired power (α=β=.1) and to detect a 10% difference in mean weight adjusted for length is 21. The sample sizes required to meet the targeted power (α=β=.1) to detect a 25% difference in length or weight adjusted for age are 60 and 61 respectively. (In preparation for the Cycle 2 study design, a re-analysis of the Cycle 1 data found that the power analysis for weight at age was calculated using 0.0032 instead of 0.032 in the Cycle 1 interpretive report, which gave an incorrect required sample size of 7)

4.2 Cycle 2 Survey

4.2.1 Overview

The Cycle 2 study design report (C. Portt and Associates, and Kilgour & Associates Ltd., 2014) proposed a non-lethal study of Lake Trout (*Salvelinus namaycush*) captured by gill netting in one exposure area (TPN) and two reference areas (INUG and PDL) (Figure 2-1), assessing the weight versus length relationship (condition), with a target sample size of 25 fish per area. Following discussions with Environment Canada, it was agreed that age-related relationships would be examined using age determinations based on pectoral fin rays collected from released Lake Trout and that the target sample size would be 60 fish per site. It was also agreed that Lake Trout liver weight and gonad weight and status would be determined, and otoliths would also be used for age determinations for Lake Trout which died. These data were also to be included in the Cycle 2 assessment. The feasibility of collecting a small-bodied fish was also assessed during the Cycle 2 study as requested by Environment Canada during discussions following the submission of the study design report.

4.2.2 Fish sampling results

The results of the Cycle 2 fish sampling are reported in the Cycle 2 Interpretive report (C. Portt and Associates, and Kilgour & Associates Ltd., 2015). The catches of each species at each sampling location are provided in Table 4-3. Lake Trout was the most abundant species in the gill net catches in all three lakes and, as expected, was the only species captured in sufficient numbers for use as a sentinel species. Overall, thirty-seven percent of the Lake Trout captured died and this may be an underestimate of mortality, as some fish may have died after their release, as a consequence of handling and pectoral fin ray removal.

Table 4-3. Numbers of fish that were released alive or were dead in Cycle 2 gill net catches, by lake and species.

	Lake Trout		Arctic Char		Round Whitefish		Arctic Grayling	
waterbody	**alive**	**dead**	**alive**	**dead**	**alive**	**dead**	**alive**	**dead**
INUG	77	42	2	2	1	11	0	1
PDL	64	41	5	2	3	1	0	0
TPN	44	24	2	0	1	0	0	0
total	185	107	9	4	5	12	0	1

Alternative means of capture had little success. No fish were captured by 4 person-hours of angling in TPN. Electrofishing catches were low. In TPN, two Lake Trout and eleven Slimy Sculpin were captured with 5715 electroseconds of effort covering 1.10 km of shoreline. In PDL, 2 Lake Trout and 11 Slimy Sculpin were captured with 1461 electroseconds of effort covering 0.53 km of shoreline.

Sex could not be determined visually in 43% of the Lake Trout that were examined internally because the gonads were not sufficiently developed. Of the 104 individuals that were examined internally, only six females contained eggs that were developed to the stage that they would be expected to spawn that year and 20 males had testes developed to the stage that they would have been expected to spawn that year. This confirmed that an unacceptable number of Lake Trout would have to be killed in order to obtain sufficient numbers for meaningful analysis of gonad weight.

4.2.3 Statistical Analysis

The results of the Cycle 2 analyses of the Lake Trout data, presented in the EEM Cycle 2 Interpretive report (C. Portt and Associates, and Kilgour & Associates Ltd., 2015), are summarized in Table 4-4. The parameters examined were size distribution, age distribution, weight adjusted for length, liver weight adjusted for weight and length, weight at age and length at age. The Lake Trout from TPN were similar to those from PDL with a significant difference ($P<0.05$) only for the weight versus length relationship. Lake Trout from TPN were 4.2% heavier than Lake Trout from PDL when adjusted for length. Compared to Lake Trout from the INUG reference area, those from TPN significantly ($P<0.05$) heavier when adjusted for length, shorter when adjusted for age determined from otoliths, and lighter when adjusted for age determined from otoliths. None of the differences exceeded the EEM critical effect sizes. The power of tests involving otolith age was low due to the small sample sizes, which increased the potential for both false positives and false negatives.

4.2.4 Recommendations for Future Fish Surveys

Based on the Cycle 1 and Cycle 2 catches, Lake Trout is the only feasible sentinel fish species. It is not feasible to assess reproductive investment in the Lake Trout because, in the study area, only a portion of mature individuals spawn each year. Therefore, fish surveys are limited to examining relationships based on length, weight, liver weight and age. Power analysis based on the results of the Cycle 2 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. More than 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 known underestimation of the ages of older individuals using fin rays, which is the most accurate structure that can be used for aging in a non-lethal survey, it was recommended that any future EEM study be a lethal study with a target sample size of 20 Lake Trout per lake. It was also recommended that if TPN was the subject of future study, only PDL be sampled as a reference area, as it is more similar to TPN than INUG in nearly all of the effect and supporting endpoints that were examined for fish.

Table 4-4. Summary of Cycle 2 between-lake comparisons using ANCOVA.

Depend-ent variable	Independ-ent variable	Outliers excluded	Procedure	Error MS	Interaction *p*-Value	Area *p*-value	r^2	LS Mean INUG	LS Mean PDL	LS Mean TPN	% Difference from TPN (p-value) INUG	% Difference from TPN (p-value) PDL	Power (ES)	N[1] to achieve 90% Power
log of body weight	log of length	none	ANCOVA	0.002	0.170		0.996							
			Reduced ANCOVA	0.002		**0.000**	0.996	767	778	811	5.7 **(0.000)**	4.2 **(0.009)**	100 (10%)	16
log of liver weight	log of body weight	none	ANCOVA	0.012	0.013		0.979							
			Reduced ANCOVA	0.013		0.102	0.976	3.17	3.29	3.75	18.3	14.0	97.8 (25%)	19
	log of length	none	ANCOVA	0.014	0.005		0.974							
			Reduced ANCOVA	0.016		0.058	0.971	3.14	3.28	3.86	23.0 **(0.046)**	17.8 (0.167)	95.2 (25%)	16
log of length	log of otolith age	none	ANCOVA	0.003	0.114		0.949							
			Reduced ANCOVA	0.003		**0.001**	0.946	340	310	301	-11.3 **(0.015)**	-2.7 (0.752)	100 (25%)	5
log of weight	log of otolith age	none	ANCOVA	0.029	0.046		0.947							
			Reduced ANCOVA	0.030		**0.000**	0.943	395	301	283	-28.4 **(0.010)**	-6.0 (0.857)	77.6 (25%)	42
log of length	log of adjusted age	none	ANCOVA	0.004	0.085		0.912							
			Reduced ANCOVA	0.004		0.201	0.911	432	424	415	-3.8	-2.1	100 (25%)	7
		fish 76	ANCOVA	0.003	0.031		0.922							
			Reduced ANCOVA	0.004		0.141	0.920	433	421	416	-3.8	-1.1	100 (25%)	7
log of weight	log of adjusted age	none	ANCOVA	0.038	0.034		0.909							
			Reduced ANCOVA	0.039		0.573	0.907	830	791	776	-6.5	-1.8	67.8 (25%)	55
		fish 76, 30	ANCOVA	0.033	0.001		0.922							
			Reduced ANCOVA	0.033		0.324	0.918	847	794	773	-8.8	-2.7	66.4 (25%)	46

1. Number of fish required per location when there is one exposed area and two reference areas.

4.3 Cycle 3 Survey

4.3.1 Overview

The exposure area for the Cycle 3 EEM study was Wally Lake (WAL); no previous EEM or similar fish studies had been conducted there. Fish from Vault Lake were transferred to Wally Lake in 2014 and fish from Phaser Lake were transferred to Wally Lake in 2016 during fish-outs prior to each of those lakes being drained and this was recognized as a potential confounding factor.

The Cycle 3 study design report (C. Portt and Associates, and Kilgour & Associates Ltd., 2017) proposed a lethal study with a target sample size of 20 Lake Trout per lake, as recommended in the Cycle 2 interpretive report (C. Portt and Associates, and Kilgour & Associates Ltd., 2015). Environment Canada supported this study design for future EEM studies in their review of the Cycle 2 EEM interpretive report (letter from Suzanne Forbrich, Environment Canada, to Stephane Robert, Agnico Eagle, dated January 20, 2017). Although the EEM exposure area was Wally Lake in Cycle 3, instead of Third Portage North as it was in Cycles 1 and 2, the rationale for concluding that any future EEM study should be a lethal study with a target sample size of 20 Lake Trout per lake (refer to Section 4.2.4) remained valid. In their review, Environment Canada recommended that otoliths and fins rays be collected and aged from the lethally sampled Lake Trout in order to further develop the database comparing the two methods of age determination. That recommendation was incorporated into the study design.

Environment Canada has also recommended in their comments on the Cycle 2 EEM interpretive report that non-lethal measurements (length, weight) be taken and fin rays be collected prior to the release of Lake Trout that are already caught in the nets after 20 lethal samples had been collected. Measurement of length and weight of released individuals was incorporated into the Cycle 3 study design. The removal of pectoral fin rays from fish prior to release was rejected, for the following reasons:

- Ages determined from fin rays underestimate age, particularly for older fish, and a correction factor based on a fin-ray otolith relationship does not eliminate that error; it just adjusts based on the average difference between the two methods.
- The acquisition of a small number of ages based solely on fin rays is of negligible value, given that the sample size of 20 fish with otolith ages will be more than adequate to assess the length versus age relationship and a that much larger sample size is required to assess the weight versus age relationship (refer to Table 4-4).
- Based on observations during Cycle 2, removal of the pectoral fin ray is not inconsequential with respect to the discomfort that the fish experience. Agnico are of the opinion that subjecting released fish to this discomfort, and possible post-release complications, is not justified by benefits to the study.

Given that the exposure area for the Cycle 3 EEM study was Wally Lake (WAL), for which there are no previous EEM fish survey data, the study design proposed that two reference areas, Pipedream (PDL) and INUG Lakes (Figure 2-1), be used for the study, as was done in Cycles 1 and 2. ANCOVA would 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.

Reproductive endpoints would not be examined because many of the fish would be immature and the proportion of mature fish that spawn in any given year is low; therefore, meaningful comparisons involving gonad weight would not be possible. It was also recognized that the sample size of 20 individuals would not achieve the desired power for comparisons involving fish weight versus age, and therefore the study design did not propose those comparisons.

The two-sample Kolmogorov-Smirnov (K-S) test, which is recommended for comparing length-frequency distributions between areas (Environment Canada, 2012), would be used to compare length and age distributions between pairs of areas.

In summary, the proposed Cycle 3 adult fish survey was a lethal study of Lake Trout captured by gill netting in one exposure area (WAL) and two reference areas (INUG and PDL) with a target sample size of 20 fish per area, with length and weight determined for any additional Lake Trout that were released.

4.3.2 Fish sampling results

The adult fish survey was completed during the period August 23 – 26, 2017. In total, 70 Lake Trout were sampled, 41 of which were immature (Table 4-5). Based on egg size, one female from each of WAL and INUG and two from PDL would have spawned in the fall of 2017. The number of males that would have spawned in the fall of 2017 was 2 for PDL, 4 for INUG and 10 for WAL. This confirmed, once again, that an unacceptable number of Lake Trout would have to be killed in order to obtain sufficient numbers for meaningful analyses of gonad weight.

Table 4-5. Number of Lake Trout examined from each waterbody, by sex and maturity, during Cycle 3.

waterbody	sex	immature	mature	total
INUG	female	10	1	11
	male	4	4	8
	unknown	2		2
	total	16	5	21
PDL	female	7	5	12
	male	1	7	8
	unknown	7		7
	total	15	12	27
WAL	female	9	2	11
	male		10	10
	unknown	1		1
	total	10	12	22
Total		41	29	70

4.3.3 Statistical Analysis

The results of the Cycle 3 ANCOVA analyses of the Lake Trout data, presented in the EEM Cycle 3 Interpretive report (C. Portt and Associates, and Kilgour & Associates Ltd., 2018), are summarized in Table 4-6. The 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. When all of the data were included there were no significant differences (P>0.05) in the slopes for any of the relationships examined using ANCOVA, although significant differences did occur when one outlier was removed from the log of body weight versus log of length analysis and when three outliers were removed from the log of liver weight versus log of length relationship. There were no significant differences in intercepts (P>0.1) for any of the relationships examined using ANCOVA except for the log of body weight versus log of length relationship when three outliers were removed (P=0.0981). This relationship was investigated further during preparation of responses to the Technical Advisory Panel review of the Cycle 3 interpretive report. Post-hoc pairwise comparisons were performed based on the reduced ANCOVA with the three outliers removed. The results of both Tukey's Honestly-Significant-Difference Test and Bonferroni Test indicate that there is no significant difference between Wally Lake and either of the reference lakes (P>0.1). There is a significant difference (p<0.1) between the two reference lakes. There were no significant differences in the length or age distributions between lakes based on analyses using the two-sample Kolmogorov-Smirnov test of raw data to compare each pair of sites.

Table 4-6. Summary of between-lake comparisons using ANCOVA. P-values ≤0.05 are in bold.

Dependent variable	Independent variable	Data excluded	ANCOVA Procedure	Error MS	Interaction *p*-Value	Area *p*-value	r^2	LS Mean INUG	LS Mean PDL	LS Mean WAL	% Difference INUG	% Difference PDL
log of body weight	log of length	none	Full	0.0025	0.0532		0.99					
			Reduced	0.0027		0.528	0.99	956	997	961	0.5	-3.6
		fish 50	Full	0.0019	**0.0189**		0.99					
			Reduced	0.002		0.1938	0.99	945	998	964	2.0	-3.4
		fish 50, 25	Full	0.0016	0.0532		0.99					
			Reduced	0.0018		0.3376	0.99	942	983	961	2.0	-2.2
		fish 50, 25, 53	Full	0.0014	0.0550		0.99					
			Reduced	0.0015		0.0981	0.99	958	1016	992	3.5	-2.4
log of liver weight	log of body weight	none	Full	0.011	0.1350		0.97					
			Reduced	0.011		0.1247	0.97	9.2	8.87	7.94	-13.7	-10.5
		fish 62	Full	0.0085	0.0691		0.98					
			Reduced	0.009		0.2083	0.97	8.57	8.65	7.78	-9.2	-10.1
		fish 62,27	Full	0.0072	0.2723		0.98					
			Reduced	0.0073		0.3325	0.98	8.2	8.07	7.53	-8.2	-6.7
	log of length	none	Full	0.013	0.0647		0.97					
			Reduced	0.014		0.1123	0.96	9.11	9.05	7.82	-14.2	-13.6
		fish 62	Full	0.0108	**0.0150**		0.97					
			Reduced	0.012		0.1502	0.97	8.51	8.81	7.65	-10.1	-13.2
		fish 62,27	Full	0.0092	0.0852		0.97					
			Reduced	0.0097		0.2799	0.97	8.16	8.2	7.43	-8.9	-9.4
		fish 62,27, 5	Full	0.008	**0.0259**		0.98					
			Reduced	0.0087		0.1152	0.97	7.95	8	7.06	-11.2	-11.8

Dependent variable	Independent variable	Data excluded	ANCOVA Procedure	Error MS	Interaction *p*-Value	Area *p*-value	r^2	LS Mean INUG	LS Mean PDL	LS Mean WAL	% Difference INUG	% Difference PDL
log of length	log of otolith age	none	Full	0.0027	0.1284		0.94					
			Reduced	0.0028		0.7424	0.93	448	448	459	2.5	2.5
log of weight	log of otolith age	none	Full	0.0251	0.057		0.94					
			Reduced	0.0266		0.8351	0.93	943	971	1010	7.2	4.0

4.3.4 Recommendations for Future Fish Surveys

The Cycle 3 interpretive report (C. Portt and Associates, and Kilgour & Associates Ltd., 2018) recommended that, if a future fish study was required, the Cycle 3 study design, that is a lethal study using Lake Trout as the sentinel fish species with a sample size of 20 individuals per sampling area, be used in future EEM adult fish surveys at the Meadowbank Mine. Based on the power analysis for the body weight versus length relationship, however, the recommended sample size should have been 21 (Table 4-7). Given the uncertainty in determining age and interpreting the weight versus age relationship, the collection of additional fish to achieve the required power was not recommended.

Table 4-7. Cycle 3 power analysis results. P is the probability that the effect size, from Environment Canada (2012), could be detected with the sample sizes and variance observed in the Cycle 3 study with α=β=0.1, N is the number of samples per site required to detect a difference equal to the critical effect size assuming the variance observed in the Cycle 3 study.

Relationship	Critical Effect Size (%)	Statistic	
Body weight versus length	10	P	92.1
		N	21
Liver weight versus body weight	25	P	97.0
		N	16
Liver weight versus length	25	P	94.7
		N	19
Length versus age	25	P	100
		N	5
Weight versus age	25	P	76.1
		N	36

5.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

5.1 Historical EEM Programs

Agnico Eagle Mines has completed three prior benthic invertebrate community (BIC) monitoring programs under the EEM; Cycle 1 in 2011, Cycle 2 in 2014 and Cycle 3 in 2017. The results are summarized in Table 5-1.

Cycles 1 and 2 EEM programs compared benthos of the exposure area in TPN to reference areas in INUG and PDL. The Cycle 1 benthic invertebrate community study in TPN found no significant differences between the exposure area in TPN and the reference areas in INUG and PDL in total abundance or Evenness. Taxa richness (reported at lowest practical levels) was lower ($p = 0.082$) in the exposure area than the reference areas with the difference equivalent to -0.9 x the within-area standard deviation. Bray-Curtis distances to the median reference community were significantly greater in the exposure area than in the reference areas.

During Cycle 2, the Cycle 1 Bray-Curtis distances were analyzed using a Mantel test, as was recommended in a review of the statistical methods used to compare Bray-Curtis distances in EEM (Borcard and Legendre, 2013). The reanalysis found that Bray-Curtis distances and reference-exposure classification was no different than a random assignment of stations to exposure class ($p\sim 0.27$). The communities in Cycle 2 were dominated numerically by Chironomidae (50 to 80%) and Sphaeriidae (16 to 32%). Sub-dominant taxa in each of the three sample areas were, variously, Nematoda, Naididae, Tubificidae, Lumbriculidae and Acarina. None of the BACI or Time Trend contrasts for log of abundance, log of richness and equitability was statistically significant. BACI and time trend ANOVA's always explained < 1% of the variation of the total variation (i.e., potential mine-related effects were trivially small). Mantel tests on Bray-Curtis distances likewise produced non-statistically significant p values.

The Cycle 3 EEM program moved to Wally Lake (WAL) because effluent was no longer being discharged to TPN. The benthic community of WAL, in 2017, largely consisted of chironomids and sphaeriid fingernail clams, similar to what the community consisted of in all other surveys, including those from the baseline period 2006 to 2012. The community of WAL was, further, very similar to what has been described from INUG and from PDL. Some of the observed variations in core indices of composition (abundance, family richness, equitability, scores on NMDS axes 1 and 2) were related to variations in substrate total organic carbon and grain size, and sample depth. Testing for spatio-temporal variations, therefore, was carried out on residuals of the core indices, after taking into account the variations related to underlying physical variables. Generally, and despite some of the statistically significant variations observed, the composition of benthic community of WAL was very similar to what is observed in the reference lakes, and in WAL during baseline periods, and further contained fauna indicative of high water quality. The benthic community of WAL did not indicate a degraded condition relative to the baseline period in WAL and contained an assemblage of organisms that are typical for these Arctic systems.

Table 5-1. Summary of the results of previous EEM benthic invertebrate community studies.

Effect indicator	Hypothesis tested	Cycle						Critical Effect Size
		1		2		3		
		2011		2014		2017		
		Lake						
		TPN				WAL		
		p value	ES	p value	ES	p value	ES	
Density	Ref vs Exp in EEM Year	0.10	0.86	0.42	0.43	**<0.001**	3.64	2SD
	BACI: EXP vs INUG					0.348	0.43	
	BACI: EXP vs Ref			**0.09**	0.86	0.012	1.42	
	Change in time trends during exposure			0.27	-0.59	<0.001	3.05	
	Change in EEM Year vs prior exposed					<0.001	1.28	
Richness	Ref vs Exp in EEM Year	**0.08**	0.94	**0.05**	1.27	**0.009**	1.71	
	BACI: EXP vs INUG					0.912	-0.08	
	BACI: EXP vs Ref			0.40	-0.40	0.56	-0.2	
	Change in time trends during exposure			0.44	-0.09	0.919	-0.85	
	Change in EEM Year vs prior exposed					0.241	-1.01	
Equitability	Ref vs Exp in EEM Year	0.41	-0.62	0.53	0.43	**0.044**	0.75	
	BACI: EXP vs INUG					**0.053**	0.6	
	BACI: EXP vs Ref			0.84	0.10	**<0.001**	-0.46	
	Change in time trends during exposure			0.33	-0.99	0.196	-0.01	
	Change in EEM Year vs prior exposed					**0.002**	-0.82	
Bray Curtis	Ref vs Exp in EEM Year	**0.02**	NA	0.22	NA	0.14	NA	significant difference
	BACI: EXP vs INUG							
	BACI: EXP vs Ref			0.31				
	Change in time trends during exposure			**0.08**				
	Change in EEM Year vs prior exposed							

Table Notes: bold values were statistically significant. Highlighted cells exceed a critical effect size. For Bray-Curtis values, there are no critical effect sizes, and so bold values are considered a trigger (of a subsequent study, or confirmation).

5.2 Cycle 4 Design

5.2.1 Background Information

Agnico Eagle has been sampling benthic macroinvertebrates annually from various reference and exposed lakes in the general study area, including Second Portage Lake (SP), since 2006 (Table 5-2). SP was considered to be in a baseline condition in 2006 and 2007. The dike along the west side of SP was constructed in 2008. SP has been considered to be in an 'impacted' condition from 2008 to present. The lake was demonstrated in 2008, 2009 and 2010 to be significantly influenced by a release of suspended solids associated with dike construction in 2008 (Azimuth, 2011). Commencing in 2014, water that seeps through the East Dike from Second Portage Lake into Portage Pit is collected at two points, combined, and pumped back to Second Portage Lake, which is the subject discharge for this Cycle 4 EEM.

Benthos in SP have been sampled from a variety of areas that are generally situated about 400 m due east of the current effluent discharge point. The 1% mixing zone of the effluent is anticipated to extend only approximately 220 m. The historical benthos sampling areas, therefore, are not appropriate as exposure-area sampling locations for this EEM program. As such, a new nearfield sampling area is proposed in this Cycle 4 EEM study design that lies within a radius of 220 m from the effluent discharge point (Figure 2-2). The historical benthos sampling area in SP will be sampled again in 2020 concurrent with the EEM program. The historical sampling areas in SP (Figure 2-2) will therefore be explicitly carried forward in this Cycle 4 EEM program as a farfield control that has the potential to control for potential historical influences related to dike construction or effluent discharge.

This Cycle 4 EEM program will use two lakes, Inuggugayualik Lake (INUG) and Pipedream Lake (PDL) as benthos reference sampling areas. Benthos from these two reference lakes were used in the two EEM studies (Cycles 1 and 2) completed for the Meadowbank Mine when the mine was discharging to Third Portage Lake North (TPN), and in the Cycle 3 study in Wally Lake (WAL). INUG has been sampled annually since 2006, whereas PDL has been sampled annually since 2009. Agnico Eagle also collects benthic invertebrates annually from additional control lakes in the broader study area including from Tehek Lake, and the South Basin of Third Portage Lake (Azimuth, 2019; Figure 2-1).

The benthos in INUG, PDL and SP 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 (Figure 5-1), where the sediments are fine (typically < 5% fine sand with the remainder silt and clay) and have reasonably high organic carbon content (typically ~ 3.3% in SP, ~3.5% in INUG, and ~ 2.5% in PDL) based on 2018 data (Azimuth, 2019).

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 500 and 2,500 organisms per m^2 (Figure 5-2), and with ~10 to 20 unique kinds (genera) of benthic taxa (Figure 5-3). Benthic communities in the three sampling areas are dominated by Chironomidae and Sphaeriidae fingernail clams, with lesser abundances of aquatic worms (Tubificidae, Naididae, Nematodes, Lumbriculidae), and Ostracods (Figure 5-4, and see Azimuth 2019).

Chironomids in INUG, PDL and SP have generally included many common forms. *Procladius* and *Stichtochironomus* were both found in relatively high abundances in each of the three lakes in August 2018. *Micropsectra* was abundant in INUG and SP, but not PDL in 2015. *Monodiamesa* (a classic indicator of oligotrophic conditions) was present in all three lakes, but in low numbers (in 2018) in PDL (it was relatively abundant in SP). All of the chironomids occurring in SP, INUG and PDL are relatively commonly distributed across the north and south of Canada (Thorp and Covich, 2001). The limnephilid caddisfly *Grensia praeterita*, has been found in each lake, but abundances have always been low and detection infrequent. It was last collected from SP in 2016. The fingernail clams were represented by *Pisidium* sp. and *Sphaerium nitidum* (Arctic fingernail clam), two relatively common forms (Clarke, 1981).

Table 5-2. CREMP benthic invertebrate community monitoring relevant to this Cycle 4 EEM program.

Year	Reference		Exposure
	INUG	PDL	SP
2006	C		C
2007	C		C
2008	C		I
2009	C	C	I
2010	C	C	I
2011	C	C	I
2012	C	C	I
2013	C	C	I
2014	C	C	IE
2015	C	C	IE
2016	C	C	IE
2017	C	C	IE
2018	C	C	IE
2019	C	C	IE
Total C Years	14	11	2

Table Note: the letter “C” denotes a control, or baseline, year. The letter “I” denotes an ‘impact’ year, in this case related to dike construction and use. “IE” indicates impacted by the dike, and ‘exposed’ to mine effluent. A blank indicates data were not collected.

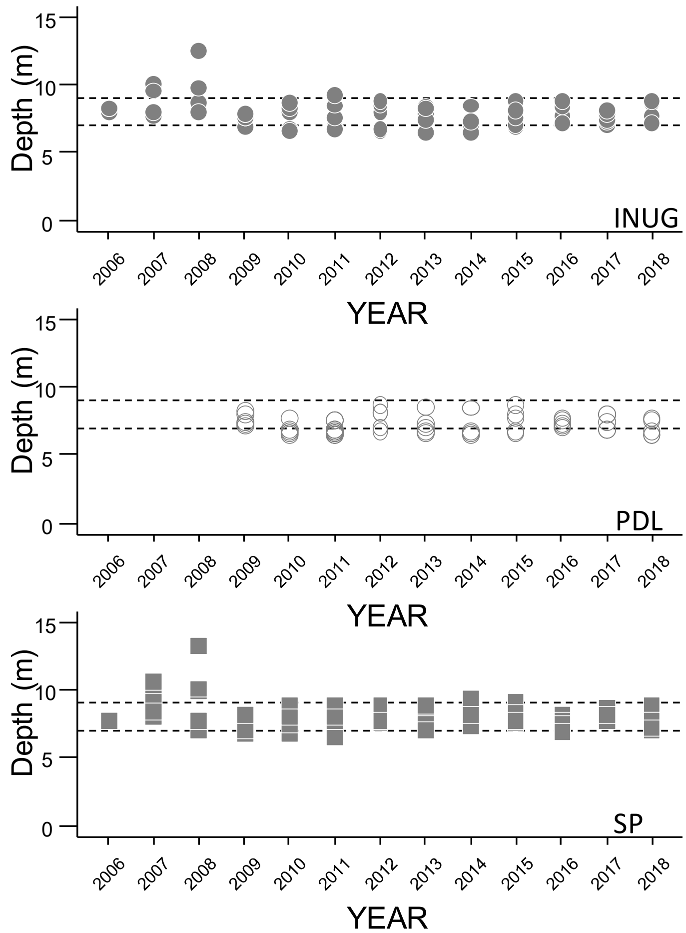

Figure 5-1. Variations in depths of sampled benthic macroinvertebrate communities from 2006 to 2018 in INUG, PDL and SP, at the proposed sampling areas. (Source: Azimuth, 2019)

Figure Note: SP was considered to be ‘impacted’ by dike construction beginning in 2008 and was ‘exposed’ to mine effluent beginning in 2014.

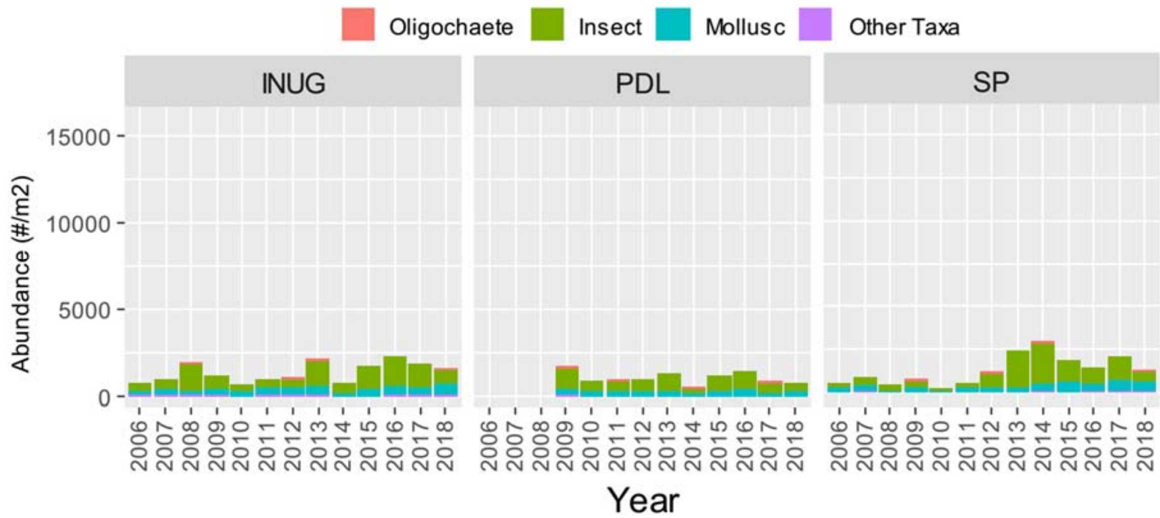

Figure 5-2. Variations in total abundances of benthic macroinvertebrates in INUG, PDL and SP from 2006 to 2018. (Source: Azimuth, 2019).

Figure Note: SP was considered to be 'impacted' by dike construction beginning in 2008 and was 'exposed' to mine effluent beginning in 2014.

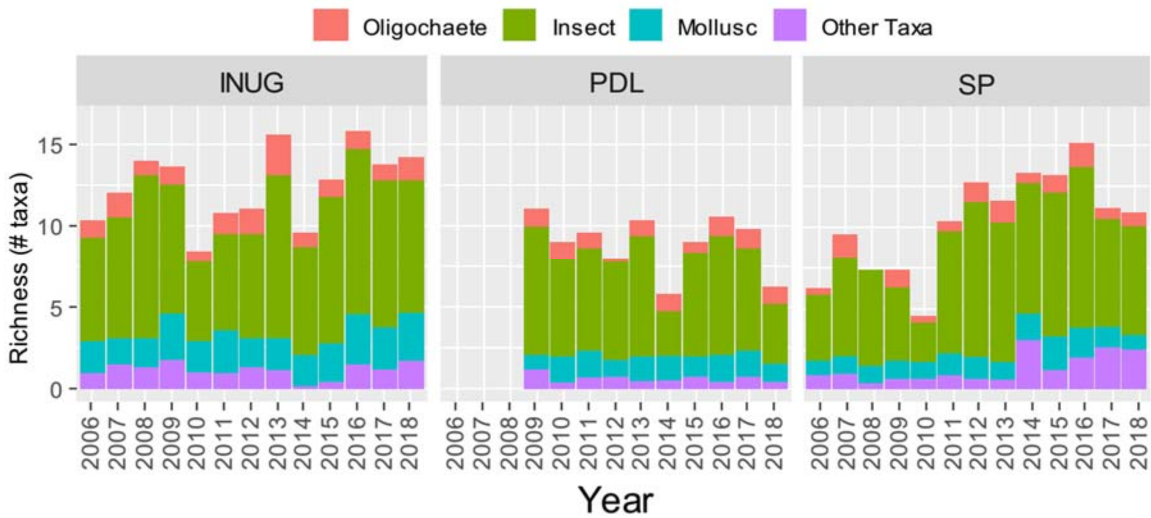

Figure 5-3. Variations in taxa richness of benthic macroinvertebrates in INUG, PDL and SP from 2006 to 2018.

Figure Note: that taxa richness in this figure is based on identification to lowest practical taxonomic level, and is higher than will be reported in the EEM report (which will report Family richness). (Source: Azimuth, 2019). Figure Note: SP was considered to be 'impacted' by dike construction beginning in 2008 and was 'exposed' to mine effluent beginning in 2014.

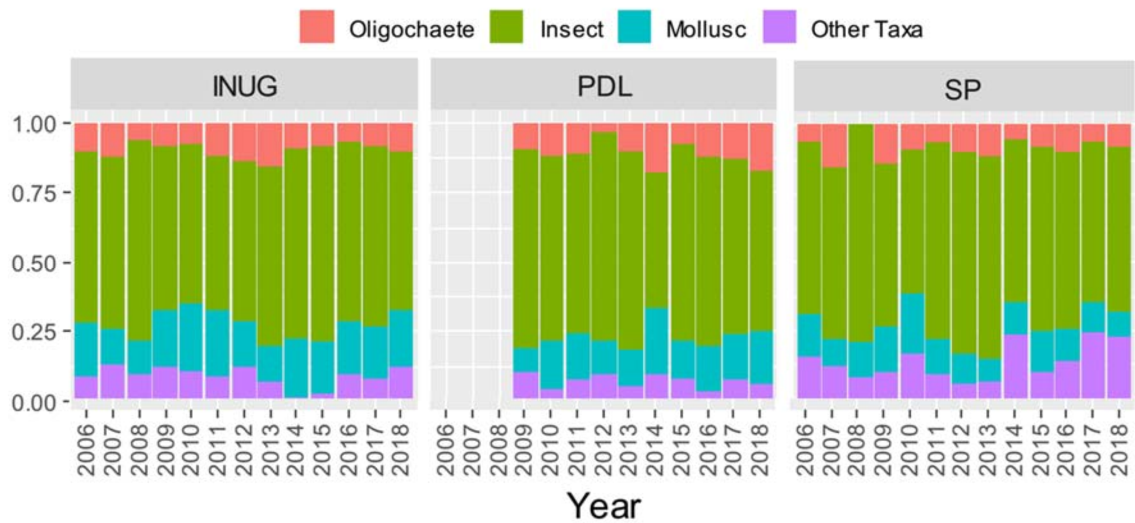

Figure 5-4. Variations in relative composition of benthic macroinvertebrate communities in INUG, PDL and SP from 2006 to 2018. (Source: Azimuth, 2019)

Figure Note: Figure Note: SP was considered to be 'impacted' by dike construction beginning in 2008 and was 'exposed' to mine effluent beginning in 2014.

5.2.2 Statistical Design

The design for the first EEM benthic invertebrate community survey for Second Portage Lake is proposed to be an extension of the annual monitoring that is undertaken by the CREMP and, except for the change in exposure area, similar to the Cycle 2 and Cycle 3 EEM studies. There will be two reference areas (one each in PDL and INUG). There will be two exposure areas in SP; (1) a nearfield sampling area within a 220 m radius of the effluent discharge point (Figure 2-2); and (2) a farfield area where benthic collections have traditionally occurred (Figure 2-2) that has the potential to control for historical influences of dike construction, and ongoing influences of dike operation (Figure 2-1).

Five benthos sampling stations will be nested within each reference and exposure area. Two sub-samples of the benthic community will be collected from each sampling station and composited. Depths will be approximately 7 to 8 m, which are the depths that have been sampled in recent CREMP programs (**Error! Reference source not found.**). Sampling stations within areas will be a minimum of 20 m apart to ensure a minimum of statistical independence of stations.

Variability in indices of benthic community composition among stations will be used to judge the significance of variations among areas. Stations will therefore be the unit of replication. Stations have been randomly selected each year that the sampling has been carried out under CREMP; that is, the locations of stations have been and are ‘randomly’ selected each year. Sampling in 2020 in SP, INUG and PDL will be similarly undertaken, with five sampling stations somewhat ‘randomly’ selected by the field crew, but also constrained by depth and spatial separation per the previous paragraph. Sampling areas are illustrated and approximately defined by the rectangular areas in Figure 2-1.

5.2.3 Sampling Methods

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. A sample at a Station will consist of composites of two individual petite Ponar 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 SP to historical data for SP, and to historical data for INUG, PDL and, potentially, other lakes that are or were in a reference condition (Table 5-2). Further, the study design for the Cycle 2 EEM program for TPN (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 according to the guidance document, Environment Canada, 2012). Consequently, the duplicate sample method was approved by Environment Canada for use in the Cycle 2 EEM and Cycle 3 programs.

5.2.4 Timing

The timing of the benthic invertebrate sample collection (and collection of ancillary supporting data) is anticipated to begin on or about August 20, 2020; aligned with the timing of the CREMP sampling. The specific timing of sampling for individual lakes in 2020 will be determined through coordination with staff at the Meadowbank Mine.

5.2.5 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

5.2.6 Data Analysis

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). 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.

Agnico proposes using the full complement of baseline and exposure period data (see Table 5-2) in an ANOVA 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. Agnico propose, specifically, to test the hypotheses listed below with the contrasts in Table 5-3.

With this EEM program, sampling areas represent three levels of exposure: (1) reference; (2) nearfield; and (3) farfield. There are also three time periods to consider: (1) Baseline Period 1 which was before the dike was constructed (i.e., 2006 and 2007); (2) Baseline Period 2 which was after the dike, and before effluent exposure in SP (i.e., 2008 to 2013); and (3) Effluent Exposure Period in SP (i.e., 2014 to present). The nearfield sampling area has been influenced by dike construction/operation in addition to effluent release. The farfield sampling area was influenced by dike construction (Azimuth, 2011). The farfield sampling area is outside the 1% mixing zone and so is much less likely to have been influenced by mine effluent. Comparison of the nearfield and farfield sampling areas has the potential to identify mine-effluent effects, with the caveat that differences between nearfield and farfield sampling areas may also be natural; there are no data in the nearfield sampling area prior to effluent exposure.

ANOVA 1 (Table 5-3) will test the hypothesis that there are no differences in indices of benthic community composition between SP and the two reference lakes in 2020. This is the conventional EEM ANOVA. Data from all other baseline periods will be used to put observed differences, if significant, into context of (1) natural variations (i.e., as observed in the reference lakes and in SP during baseline 1), or (2) dike related influences (i.e., as observed in SP during baseline 2). Acceptance of the null hypothesis, i.e., no significant differences, would support a conclusion that there are no effluent-related effects. Rejection of the null hypothesis, i.e., of no differences, would suggest the potential for effluent related effects, and would prompt ANOVA 2.

ANOVA 2 (Table 5-3) would test the simple hypothesis that there are no significant differences in indices of benthic community composition between the nearfield exposure area and the farfield exposure area during the exposure period. Version (a) of this test will use effluent exposure period data from 2014 through 2020 in the farfield exposure area with contrast to the nearfield exposure-area data; while version (b) of this test will use only the farfield effluent exposure period data from 2020 as a contrast to the nearfield data. No significant difference would support a conclusion that the reference-exposure difference from ANOVA 1 was potentially a function of the dike, and not effluent. A significant difference would suggest an effluent-related effect or would imply that the nearfield and farfield areas had natural differences in index values, prompting ANOVA 3.

ANOVA 3 (Table 5-3) would test the hypothesis that indices of benthic community composition in the farfield exposure area was the same in the baseline period as in the effluent exposure period. Agnico suggest there are two versions of this test (a and b). In version (a) of this test Agnico would use the effluent exposure period data from 2014 to 2020 as a contrast to the baseline period data of 2006 and 2007. In version (b) of this test Agnico would use the data only from 2020 as a contrast to the baseline period data.

If the hypothesis is accepted in both versions of the test, then differences between the nearfield and exposure area benthos can be concluded to have been related to effluent exposure.

For these ANOVA's, the variation among stations will be used to judge the significance of the contrasts, per Table 5-4. The mean squared error term (MSE) 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 5-3. Potential linear contrasts that could be used to analyze the 2020 benthic community data from Second Portage, INUG and PDL (Meadowbank Mine).

Year	Exposure Period	ANOVA 1				ANOVA 2a				ANOVA 2b			
		Nearfield vs Reference in 2020 (evaluate reference vs combined effects of berm and effluent)				Nearfield vs Farfield in 2020 (evaluate effluent vs effects of berm)				Nearfield vs Farfield in 2020 (evaluate effluent vs effects of berm)			
		Reference		Nearfield	Farfield	Reference		Nearfield	Farfield	Reference		Nearfield	Farfield
		INUG	PDL	Second Portage		INUG	PDL	Second Portage		INUG	PDL	Second Portage	
2006	Baseline Period 1 (before the berm)		no data	no data			no data	no data			no data	no data	
2007													
2008	Baseline Period 2 (before effluent exposure)												
2009													
2010													
2011													
2012													
2013													
2014	Exposure Period								-1				
2015									-1				
2016									-1				
2017									-1				
2018									-1				
2019									-1				
2020		1	1	-2				7	-1			1	-1

Year	Exposure Period	ANOVA 3a				ANOVA 3b			
		Farfield baseline vs Farfield exposure				Farfield baseline vs Farfield exposure			
		Reference		Nearfield	Farfield	Reference		Nearfield	Farfield
		INUG	PDL	Second Portage		INUG	PDL	Second Portage	
2006	Baseline Period 1 (before the berm)		no data	no data	3.5		no data	no data	1
2007					3.5				1
2008	Baseline Period 2 (before effluent exposure)								
2009									
2010									
2011									
2012									
2013									
2014	Exposure Period				-1				
2015					-1				
2016					-1				
2017					-1				
2018					-1				
2019					-1				
2020					-1				-2

Table 5-4. ANOVA table to analyze linear contrasts in Table 5-3.

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

Table Notes: HOx refers to the xth hypothesis.

Assessment of Covariable Effects

Prior to 'running' ANOVAs, Agnico will examine the associations between benthos and potential modifying factors (e.g., depth, substrate texture, sediment TOC). If Agnico establish that variations in benthic community composition were influenced by a modifying factor, and if standardization of the benthos indices can be accommodated, Agnico will do so 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 ANOVAs.

Comparison to Reference Normal Ranges

Variations tested by HO1, HO2 and HO3 will be put into context using normal ranges computed from reference data. Normal ranges will involve the calculation of tolerance limits as described by Smith (2002). Smith's tolerance limits (TLs) are:

$$TL = \bar{x} \pm k_{p,\alpha} SD$$

Where

$\bar{x}$ is the grand mean of the reference data set;

$k_{p,\alpha}$ is a tolerance factor, for the p^{th} percentile, and with 1-α confidence; and,

SD is the standard deviation of the mean, which reflects the variance within and among areas per Bagui et al. (1996), and as described in Equation 3.3 in Smith (2002):

$$SD = \sqrt{\frac{n_1\sigma_\alpha^2 + n_1\sigma_\beta^2 + n_1\sigma_\varepsilon^2}{n^2}},$$

$$n_1 = \sum_{i=1}^{l} n_{i.}^2,$$

$$n_2 = \sum_{j=1}^{y} n_{2.}^2$$

$$n_3 = \sum_{i=1}^{l}\sum_{j=1}^{y} n_{ij}^2,$$

$$n = \sum_{i=1}^{l}\sum_{j=1}^{y} n_{ij},$$

and, where, l is the number of lakes, y is the number of years.

Assessment of Bray-Curtis Distances

Variations in the Bray Curtis distance measure will be evaluated differently. Bray-Curtis distances will be computed between all possible pairs of samples used in the above ANOVAs. Distances will be computed 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;

Agnico will use partial Mantel tests or simple Mantel tests to test the hypotheses listed in Table 5-3, and using the methods described by Borcard and Legendre (2013). Mantel tests will be completed in Excel or *R*.

Presentation of Basic Statistics

Agnico will provide mean, median, standard deviation, standard error, minimum and maximum values for abundance, family richness, and equitability for each sample area using 2020 data. Agnico will provide mean, median, SD, SE, and minimum and maximum Bray Curtis distances within SP, INUG and PDL, and between SP and INUG and PDL, again using only the 2020 data.

Agnico will compute effect sizes for the various hypotheses, for abundance, richness and equitability.

Effect sizes

The first null hypothesis (HO1) is: no difference between exposure and reference areas in mean responses in 2020.

The effect size for HO1 will be:

$$ES_{HO1} = \frac{\left(\bar{x}_{SP(2020)} - [\bar{x}_{INUG(2020)} + \bar{x}_{PDL(2020)}]/2\right)}{SD_{Pooled\ (INUG\ and\ PDL\ 2020)}}$$

Where;

- $\bar{x}_{SP(2020)}$is the grand mean of the SP data in 2020;
- $\bar{x}_{INUG(2020)}$ is the grand mean of the INUG data in 2020;
- $\bar{x}_{PDL(020)}$ is the grand mean of the PDL data in 2020;

- $SD_{Pooled\ (INUG\ and\ PDL\ 2020)}$ is the standard deviation for INUG and PDL, pooled, in 2020.

Similar effect-size constructs will be used to estimate effect sizes for subsequent hypotheses, should they be tested. In all cases the SD in the denominator will be calculated using the reference data.

6.0 SUPPORTING ENVIRONMENTAL VARIABLES

A variety of environmental variables will be characterized within the sampling areas, to support the interpretation of fish population and benthic community data.

6.1 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.

6.2 Water Quality

Water samples will be collected under Agnico Eagle's CREMP water quality monitoring program, as per the Azimuth Standard Operating Procedure (Appendix D). Water will be collected from two randomly selected locations (stations) within each benthic 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; (2) deep (D) = 3 m above the bottom; and (3) integrated (INT) = integrated from just below surface (0.5 to 8 m). It is anticipated that the waters will be vertically mixed and thermally homogenous top to bottom, as they historically have been. Samples from the benthic sampling areas are anticipated to be relevant to all of the benthic sampling stations within areas, in addition to the collected fish from those general areas. This strategy for characterizing water quality was used for the previous three EEM programs at the Meadowbank Mine.

Water will be analyzed for the following analytes determined by a certified (CAEAL accredited) laboratory:

- Physical tests (conductivity, hardness, pH, total suspended solids, turbidity);
- Metals (aluminum, cadmium, iron, molybdenum, arsenic, copper, lead, nickel, zinc, radium 226, cyanide, selenium); and,

- Anions and Nutrients (alkalinity, ammonia, bromide, chloride, fluoride, nitrate, nitrite, total Kjeldahl nitrogen, ortho phosphate, silicate, sulfate).
- Other (dissolved organic carbon, total organic carbon)

Detection limits for water quality parameters are provided in the table below (**Error! Reference source not found.**).

Table 6-1. 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

6.3 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 **Error! Reference source not found.**. 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 6-2. 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	%

7.0 QA/QC PROGRAM

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

- Highly qualified staff to collect and interpret data;
- Routine calibration and verification of electronic meters;
- Use of accredited laboratories, as appropriate; and,
- Adherence to specified data quality objectives.

7.1 Use of Highly Qualified Staff

Highly trained and experienced personnel will carry out the field sampling program for the biological components. It is expected that Cameron Portt (M.Sc., 40 years of experience), George Coker (B.Sc., 40 years of experience), and Bruce Kilgour (PhD, 30 years of experience) will comprise the principal field crew.

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.

7.2 Use of Calibrated and Verified Electronic Meters

Electronic meters for measuring dissolved oxygen, pH and conductivity will be calibrated daily. Additional Winkler kits may be used to confirm dissolved oxygen measurements if they appear to be unusual.

7.3 Use of CAEAL Accredited Laboratories

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 D.

7.4 Adherence to Specified Data Quality Objectives

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

$$RPD = \frac{(A - B)}{((A + B)/2)} x100$$

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. Ages for a minimum of 10% of individuals will be evaluated independently by a second person experienced in fish aging.

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 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.

8.0 LITERATURE CITED

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APPENDIX A
CORE RECEIVING ENVIRONMENT MONITORING PLAN (CREMP) OVERVIEW

Core Receiving Environment Monitoring Plan (CREMP) Overview

(adapted from Azimuth, 2016)

The Core Receiving Environment Monitoring Plan (CREMP) focuses on monitoring limnological, chemical and biological characteristics of the Meadowbank project lakes (i.e., the aquatic receiving environments surrounding the mine development) with the objective of detecting any mine-related change in receiving environment condition. The program is implemented on a yearly basis, ongoing since 2006. The study design, developed with EEM requirements in mind, is based on a before-after-control-impact (BACI) approach, but in some cases has also incorporated the concept of gradients in exposure.

The 2015 program consisted of 13 sampling areas, each categorized into one of the four main types of areas described below:

Near-field (NF) areas – Areas are situated in close proximity to the development (planned or constructed), in particular, near dikes, dewatering discharge, and proposed effluent sources. These areas provide the first line of early-warning for introductions of stressors into the receiving environment. In the Meadowbank study lakes, these areas include: Third Portage Lake North (TPN), Third Portage Lake East (TPE), Second Portage (SP), and Wally Lake (WAL); note that planned mining activity started there in July 2013.

Mid-field (MF) area – This area designation was added in 2011 to be consistent with the area categorizations used in the CREMP: Design Document 2012 (Azimuth, 2012c) and includes Tehek Lake (TE) and Third Portage Lake South (TPS). TE is adjacent to the inlet from Second Portage Lake and was exposed to elevated TSS during construction of the East Dike in 2008, prompting the addition of a new far-field area (Tehek far-field) in 2009. Consequently, MF designation is more accurate for TE. TPS was initially envisioned as an internal reference area in the 2005 AEMP. However, given the connectivity to TPN and the slight changes in hardness-related parameters, it is more appropriately considered a MF area. That said, given the degree (i.e., relatively minor) and nature (i.e., limited to certain non-metal parameters only) of the observed changes and the termination of discharges to TPN, TPS should still be appropriate as a reference area for EEM water quality monitoring.

Far-field (FF) area – The intent of this area is to monitor water and sediment quality downstream of project infrastructure to provide insights into the spatial extent of any effects observed at the near-field areas. The Tehek far-field (TEFF) area is a key location that will ultimately determine whether or not contaminants are detectable downstream of the entire mine development. Lake waters from Second and Third Portage Lakes and the Vault Lakes (Vault, Wally, Drilltrail) meet at the southern end of Second Portage Lake and discharge via a single channel into Tehek Lake . Monitoring the water and sediment quality and the health of the benthic invertebrate community in the basin adjoining the discharge point from Second Portage Lake will help determine if any effects identified at SP are extending into TE and beyond into TEFF.

Reference (Ref) areas – By definition, reference areas are sufficiently removed from the mine that they are presumed to be unaffected by any infrastructure (roads, dikes, runways) and point sources (aerial and aquatic) associated with mine development. Inuggugayualik Lake (INUG) and Pipedream Lake (PDL) are external reference areas chosen for the purposes of making comparisons with the project lakes (EVS, 1999; Azimuth, 2005b). Monitoring of reference areas is important in order to distinguish between possible mine-related changes in water quality or ecological parameters and natural changes, unrelated to the mine. The reference areas are situated about 16 km west (INUG) and 12 km northwest (PDL) of the mine site. They are both headwater lakes and flow north into the Arctic Ocean. Despite the different drainage basin, these lakes satisfy the requirements of an external reference lake from a physical/chemical perspective because they are at similar in latitude, have similar geology, relief and climate, do not have any significant inflows and have generally similar limnological features, water chemistry and aquatic biological community structure to the project lakes (Azimuth, 2005b).

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

The CREMP includes many explanatory environmental variables (for both water and sediment) and a benthic community survey, but does not directly target fish.

APPENDIX B
EFFLUENT VOLUMES AND ANALYTICAL RESULTS

Table B-1. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2014.

Date	Jan-14	Feb-14	Mar-14	Apr-14	May-14	Jun-14	Jul-14	Aug-14	Sep-14	Oct-14	Nov-14	Dec-14
1	0	460	449	363	264	0	0	695	696	601	552	475
2	0	469	448	370	264	0	0	692	689	617	555	610
3	0	459	449	388	0	0	0	684	692	593	555	569
4	0	460	447	380	0	0	0	685	686	593	546	591
5	0	459	445	389	0	0	0	686	686	592	554	622
6	298	457	444	396	0	0	0	725	681	603	552	574
7	502	456	442	396	0	0	0	698	688	636	555	551
8	500	459	442	396	0	0	0	691	696	608	553	551
9	496	455	441	396	0	0	0	692	700	585	577	551
10	492	456	441	0	0	0	0	686	681	581	569	598
11	485	459	441	0	0	0	0	688	676	575	540	622
12	484	459	441	167	0	0	0	690	664	578	556	561
13	485	461	440	423	0	0	0	669	664	575	561	586
14	178	458	441	412	0	0	0	703	661	573	551	549
15	271	457	440	422	0	0	0	696	654	571	553	547
16	358	454	438	413	0	0	0	689	647	554	547	551
17	684	453	437	408	0	0	0	744	648	572	547	558
18	391	450	433	418	0	0	0	773	640	571	545	535
19	480	448	426	315	0	0	0	763	658	569	542	524
20	479	448	418	405	0	0	0	752	651	565	556	528
21	476	446	413	408	0	0	0	763	646	568	550	523
22	500	446	401	411	0	0	0	762	629	567	544	512
23	505	448	392	334	0	0	0	703	693	566	549	512
24	468	447	376	365	0	0	0	704	702	564	538	510
25	468	454	365	457	0	0	0	695	656	562	541	523
26	467	450	354	408	0	0	0	691	637	557	543	504
27	465	449	348	384	0	0	0	707	626	563	532	494
28	463	453	380	371	0	0	0	757	620	556	532	521
29	464		408	369	0	0	376	759	619	566	564	516
30	461		375	376	0	0	669	704	630	554	491	502
31	460		355		0		671	704		555		512
Total	**11,779**	**12,729**	**12,971**	**10,737**	**528**	**0**	**1,716**	**22,049**	**19,914**	**17,880**	**16,453**	**16,881**

Table B-2. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2015.

Date	Jan-15	Feb-15	Mar-15	Apr-15	May-15*	Jun-15*	Jul-15*	Aug-15*	Sep-15*	Oct-15*	Nov-15*	Dec-15
1	506	460	515	561		424.8	0	0	621.6			497
2	501	469	510	547			0	0		559.2	537.6	497
3	492	459	500	552			0	0				490
4	562	460	571	550			0	0				495
5	497	459	505	556	415		0	0	595.0			497
6	486	457	495	535			0	0		544.8		498
7	495	456	503	537			0	0				493
8	491	459	499	540			0	600.0			547.0	498
9	478	455	487	711		559.0	0					356
10	482	456	491	598			0	595.0			499.0	350
11	481	459	489	643	410		0					674
12	480	459	488	568			0					495
13	495	461	504	556			0				544.0	495
14	481	458	489	566			0					493
15	483	457	491	573			0					493
16	504	454	513	563		0	0		624.0	661.0		493
17	482	453	490	576		0	0	629.0				501
18	478	450	486	551	413	0	0					499
19	482	448	490	547		0	0				540.0	496
20	486	448	495	551		0	0					498
21	478	446	486	579		0	0					495
22	523	446	532	528		0	0					496
23	492	448	501	541		0	0			520.8	535.2	488
24	468	447	476	563		0	0	604.8				493
25	470	454	477	549		0	0	607.0				486
26	472	450	480	566	408	0	0		703.0	523.0		491
27	621	449	632	550		0	0				511.0	493
28	462	453	469	552		0	0		588.0			492
29	473		481	546		0	0					492
30	492		500	563		0	0			667.0		490
31	474		482				0					487
Total	**15,269**	**12,729**	**15,526**	**16,918**	**12,755****	**7,521****	**0**	**14,586****	**18,792****	**17,959****	**15,917****	**15,211**

*Flowmeter not functioning properly and was sent for repair. Instant readings were taken when collecting samples.

**Monthly total effluent volume was estimated by summing instant flow measurements and using average for days when no flow measurement was taken.

Table B-3. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2016.

Date	Jan-16	Feb-16	Mar-16	Apr-16	May-16	Jun-16	Jul-16	Aug-16	Sep-16	Oct-16	Nov-16	Dec-16
1	488	485	459	454	447	555	551	580	549	524	452	440
2	488	468	459	456	445	560	566	579	543	524	453	437
3	487	468	458	455	441	589	576	651	542	524	453	439
4	487	467	456	454	443	520	571	785	545	524	453	439
5	485	467	457	454	441	521	570	683	561	524	453	439
6	490	467	524	454	443	534	572	637	540	524	452	438
7	488	463	457	453	443	556	577	622	535	509	452	437
8	484	466	456	448	310	573	572	607	591	497	452	431
9	383	466	456	453	443	587	583	595	543	490	453	437
10	267	465	455	453	441	592	589	589	545	489	452	436
11	482	465	457	452	442	573	596	580	545	486	453	435
12	480	463	455	451	443	592	599	582	541	480	452	434
13	479	456	454	451	442	580	598	579	527	479	443	433
14	479	464	454	446	440	560	384	576	571	475	452	433
15	478	463	456	449	442	551	414	581	517	471	451	428
16	478	463	454	450	441	551	781	584	516	469	447	432
17	476	461	453	449	442	561	783	593	512	466	448	431
18	477	461	328	449	446	576	624	595	510	461	447	427
19	476	461	457	449	438	612	612	576	512	462	446	430
20	476	461	456	450	438	605	607	471	567	462	446	430
21	475	462	454	451	448	577	602	743	530	461	446	429
22	476	461	456	450	551	555	593	578	512	461	445	427
23	475	461	455	451	640	556	612	581	510	461	444	427
24	473	460	187	448	512	568	603	581	515	459	443	425
25	473	461	0	450	459	561	607	577	524	459	443	425
26	472	469	0	446	447	553	598	575	524	455	443	423
27	472	459	285	448	564	547	590	563	524	457	443	423
28	471	456	456	449	710	546	586	568	524	455	441	422
29	463	459	456	448	685	548	581	561	524	454	440	421
30	470		452	448	662	554	584	556	524	454	440	418
31	469		456		507		579	549		450		419
Total	**14,514**	**13,446**	**12,720**	**13,517**	**14,897**	**16,914**	**18,262**	**18,476**	**16,020**	**14,867**	**13,439**	**13,344**

Table B-4. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2017.

Date	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
1	444	400	435	399	404	0	0	0	0	0	495	381
2	429	400	431	421	405	0	0	0	0	0	495	559
3	417	400	436	406	405	0	0	0	0	0	495	461
4	415	400	428	405	404	0	0	0	0	0	495	380
5	417	400	431	403	404	0	0	0	187	0	495	378
6	416	400	429	405	404	0	0	0	612	0	395	378
7	415	400	430	405	396	0	0	0	909	0	395	375
8	431	398	431	406	404	0	0	0	906	0	396	467
9	425	398	432	405	403	0	0	0	931	0	399	470
10	413	397	433	406	403	0	0	0	918	0	400	628
11	426	396	413	405	403	0	0	0	935	0	485	627
12	429	391	399	405	0	0	0	0	914	0	680	628
13	403	396	411	406	0	0	0	0	916	0	661	624
14	410	395	428	405	0	0	0	0	882	0	661	623
15	410	393	416	402	0	0	0	0	901	0	666	608
16	409	393	400	406	0	0	0	0	872	0	497	605
17	408	396	394	405	0	0	0	0	807	0	401	629
18	407	394	400	406	0	0	0	0	793	0	479	623
19	406	396	401	401	0	0	0	0	745	0	656	633
20	406	396	399	405	0	0	0	0	707	0	430	453
21	406	396	401	404	0	0	0	0	734	0	387	369
22	403	396	401	404	0	0	0	0	485	0	388	370
23	405	395	400	404	0	0	0	0	0	0	476	374
24	405	396	400	402	0	0	0	0	0	0	576	373
25	405	396	397	404	0	0	0	0	0	0	646	374
26	404	394	381	405	0	0	0	0	0	0	470	379
27	416	419	363	404	0	0	0	0	0	0	521	632
28	424	434	341	404	0	0	0	0	0	0	399	617
29	414		293	404	0	0	0	0	0	433	415	617
30	415		254	400	0	0	0	0	0	799	482	619
31	413		314		0		0			799		616
Total	**12,848**	**11,162**	**12,321**	**12,141**	**4,435**	**0**	**0**	**0**	**14,154**	**2,031**	**14,836**	**15,870**

Table B-5. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2018.

Date	Jan-18	Feb-18	Mar-18	Apr-18	May-18	Jun-18	Jul-18	Aug-18	Sep-18	Oct-18	Nov-18	Dec-18
1	616	509	587	429	612	932	0	0	465	401	382	366
2	537	349	605	420	620	914	0	0	462	403	381	365
3	537	356	611	377	615	809	0	0	454	400	381	356
4	537	339	599	233	584	0	0	0	458	399	381	364
5	537	341	515	414	625	0	0	0	481	397	381	363
6	537	473	604	647	624	0	0	0	474	396	380	358
7	537	574	613	620	622	0	0	0	479	395	380	362
8	678	495	606	620	613	0	0	0	474	390	376	357
9	617	531	608	591	624	0	0	0	469	388	380	360
10	611	565	618	590	630	0	0	0	468	393	379	359
11	651	594	618	596	621	0	0	0	467	393	378	358
12	620	554	617	570	631	0	0	0	464	387	378	349
13	616	488	621	608	633	0	0	0	461	391	377	357
14	615	454	625	616	630	0	0	0	450	391	376	349
15	607	335	619	611	620	0	0	0	451	390	376	355
16	633	558	626	609	623	0	0	0	448	390	376	355
17	612	501	598	599	627	0	0	0	444	389	375	346
18	536	413	612	574	627	0	0	0	435	388	367	354
19	527	521	612	590	628	0	0	0	438	388	374	354
20	593	415	603	600	617	0	0	0	436	383	374	352
21	544	370	515	611	608	0	0	254	433	389	372	352
22	607	596	602	616	607	0	0	501	431	387	372	346
23	496	603	614	615	595	0	0	500	428	387	371	350
24	360	601	619	617	594	0	0	496	425	386	366	350
25	345	594	615	616	597	0	0	491	422	385	368	349
26	380	604	615	611	572	0	0	485	412	380	368	349
27	420	604	625	619	607	0	0	480	415	385	361	345
28	499	600	610	617	618	0	0	470	413	384	367	348
29	513		601	613	622	0	0	472	410	383	366	348
30	343		562	614	623	0	0	468	408	379	365	347
31	380		498		611		0	467		383		347
Total	**16,638**	**13,937**	**18,592**	**17,062**	**19,078**	**2,654**	**0**	**5,084**	**13,372**	**12,078**	**11,226**	**10,968**

Table B-6. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MDMER 3 for 2019.

Date	Jan-19	Feb-19	Mar-19	Apr-19	May-19	Jun-19	Jul-19	Aug-19	Sep-19	Oct-19	Nov-19	Dec-19
1	347	0	0	0	0	0	0	0	0	0	0	381
2	347	0	0	0	0	0	0	0	0	0	0	404
3	345	0	0	0	0	0	0	0	0	0	0	415
4	344	0	0	0	0	0	0	0	0	0	0	410
5	339	0	0	0	0	0	0	0	0	0	0	412
6	342	0	0	0	0	0	0	0	0	0	0	415
7	342	0	0	0	0	0	0	0	0	0	0	420
8	341	0	0	0	0	0	0	0	0	0	0	412
9	340	0	0	0	0	0	0	0	0	0	0	421
10	339	0	140	0	0	0	0	0	0	0	0	428
11	340	0	302	0	0	0	0	0	0	0	0	416
12	339	0	308	0	0	0	0	0	0	0	0	420
13	339	0	309	0	0	0	0	0	0	0	448	416
14	69	0	310	0	0	0	0	0	0	0	432	417
15	0	0	307	0	0	0	0	0	0	0	432	402
16	0	0	307	0	0	0	0	0	0	0	416	407
17	0	0	312	0	0	0	0	0	0	0	421	395
18	0	0	313	0	0	0	0	0	0	0	423	398
19	0	0	313	0	0	0	0	0	0	0	395	405
20	54	0	310	0	0	0	0	0	0	0	393	396
21	393	0	311	0	0	0	0	0	0	0	395	370
22	655	0	315	0	0	0	0	0	0	0	401	404
23	518	0	316	0	0	0	0	0	0	0	390	419
24	361	0	311	0	0	0	0	0	0	0	389	390
25	162	0	317	0	0	0	0	0	0	0	380	367
26	0	0	320	0	0	0	0	0	0	0	390	422
27	0	0	315	0	0	0	0	0	0	0	381	448
28	0	0	321	0	0	0	0	0	0	0	382	461
29	0		321	0	0	0	0	0	0	0	390	468
30	0		215	0	0	0	0	0	0	0	381	458
31	0		0		0		0	0		0		441
Total	**6,657**	**0**	**6,294**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**7,239**	**12,837**

Table B-7. Final effluent analytical results for East Dike seepage discharged to Second Portage Lake via outfall MDMER 3 (10 pages).

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
Max allowable month avg Conc	0.50	0.30	1	0.20	0.50	0.50	15	0.37	6-9.5		
Max allowable grab Conc	1.00	0.60	2	0.40	1.00	1.00	30	1.11	6-9.5		
Date											
7-Jan-14	<0,0005	0.0066	<0.005	<0.0003	0.0007	0.012	19	<0.002	6.78	NMR	NMR
14-Jan-14	0.053	0.02	0.005	0.0021	0.014	0.0088	11	0.002	6.89	>100	>100
20-Jan-14	<0.001	0.002	<0.005	<0.0005	0.0023	<0.007	20	<0.002	6.83	NMR	NMR
27-Jan-14	0.0033	0.0235	<0.005	0.0653	0.0031	0.042	5	<0.002	7.56	NMR	NMR
4-Feb-14	<0.0005	<0.0005	<0.005	<0.0003	0.0013	0.003	13	0.005	6.74	NMR	NMR
10-Feb-14	0.0022	0.0022	<0.005	0.0072	0.0008	0.007	3	<0.002	6.85	NMR	NMR
18-Feb-14	0.0022	0.0079	<0.005	<0.0003	0.003	0.008	13	0.062	6.86	>100	>100
27-Feb-14	0.0011	0.0026	<0.005	<0.0003	0.0023	<0.001	10	<0.002	6.64	NMR	NMR
5-Mar-14	0.0005	<0.0005	<0.005	<0.0003	0.0009	<0.001	8	0.009	8.1	>100	>100
11-Mar-14	<0.0005	<0.0005	<0.005	0.0006	0.0008	<0.001	11	0.02	8.47	NMR	NMR
17-Mar-14	0.0008	0.001	<0.005	0.0032	0.0008	0.002	14	0.013	6.51	NMR	NMR
24-Mar-14	0.0057	0.0012	<0.005	<0.0003	0.0023	<0.001	21	0.022	6.72	NMR	NMR
1-Apr-14	0.0081	0.0027	<0.005	<0.0003	0.0034	0.002	30	<0.002	6.81	NMR	NMR
8-Apr-14	0.0038	0.0014	<0.005	0.0087	0.0017	0.003	14	0.003	6.62	>100	>100
15-Apr-14	0.0022	0.0014	<0.005	<0.0003	0.0016	0.002	12	0.024	6.63	NMR	NMR
19-Apr-14	-	-	-	-	-	-	10	-	6.72	NMR	NMR
22-Apr-14	0.0016	0.001	<0.005	<0.0003	0.0012	0.003	8	<0.002	6.58	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
29-Apr-14	0.0016	0.0015	<0.005	0.0013	0.0012	0.008	12	0.005	6.56	NMR	NMR
May	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP
June	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP	NDEP
31-Jul-14	0.0016	0.0009	<0.005	<0.0003	0.0018	0.005	2	<0.002	7.4	>100	>100
6-Aug-14	0.0042	0.0015	<0.005	<0.0003	0.0034	0.003	7	<0.002	7.16	NMR	NMR
12-Aug-14	0.0019	<0.0005	<0.005	<0.0003	0.001	<0.001	6	<0.002	7.51	>100	>100
19-Aug-14	0.0022	0.0017	<0.005	<0.0003	0.0032	0.003	13	<0.002	7.55	NMR	NMR
26-Aug-14	0.0009	0.0008	<0.005	<0.0003	<0.0005	<0.001	7	<0.002	7.54	NMR	NMR
2-Sep-14	<0.0005	0.0008	<0.005	<0.0003	0.0011	0.002	4	0.002	7.71	>100	>100
9-Sep-14	0.0019	0.0019	0.007	<0.0003	0.0031	0.008	4	0.005	7.9	NMR	NMR
17-Sep-14	<0.0005	<0.0005	<0.005	0.0155	0.0009	0.007	7	0.003	7.54	NMR	NMR
24-Sep-14	0.0027	0.0123	<0.005	0.0052	0.004	0.003	14	0.006	7.2	NMR	NMR
28-Sep-14	<0.0005	0.0008	<0.005	<0.0003	0.0005	0.017	<1	0.003	7.31	NMR	NMR
8-Oct-14	0.0009	0.0008	<0.005	<0.0003	0.0012	<0.001	8	<0.002	7.45	>100	>100
15-Oct-14	<0.0005	0.0011	<0.005	<0.0003	<0.0005	<0.001	24	0.002	7.42	NMR	NMR
21-Oct-14	<0.0005	0.0008	<0.005	<0.0003	<0.0005	0.001	12	0.003	7.02	NMR	NMR
27-Oct-14	<0.0005	0.0007	0.005	<0.0003	<0.0005	0.002	3	<0.002	7.92	NMR	NMR
4-Nov-14	<0.0005	0.0007	<0.005	<0.0003	<0.0005	0.002	6	0.002	7.04	>100	>100
10-Nov-14	<0.0005	0.0006	<0.005	<0.0003	<0.0005	<0.001	11	0.002	7.42	NMR	NMR
18-Nov-14	<0.0005	0.0008	<0.005	<0.0003	<0.0005	<0.001	<1	<0.002	7.19	NMR	NMR
25-Nov-14	0.0005	0.0008	0.005	0.0003	0.0005	0.002	5	0.002	7.17	NMR	NMR
30-Nov-14	<0.0005	<0.0005	<0.005	<0.0003	0.0005	0.003	7	<0.002	7.31	NMR	NMR
8-Dec-14	0.0006	0.0007	0.01	<0.0003	<0.0005	<0.001	<1	<0.002	7.36	>100	>100
16-Dec-14	0.0007	0.0009	<0.005	<0.0003	<0.0005	<0.001	6	<0.002	7.44	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
22-Dec-14	<0.0005	<0.0005	<0.005	<0.0003	<0.0005	0.001	3	<0.002	7.16	NMR	NMR
29-Dec-14	<0.0005	0.2995	<0.005	0.4001	<0.0005	0.2663	3	<0.002	7.26	NMR	NMR
6-Jan-15	0.0080	0.0009	<0.005	<0.0003	0.0007	0.001	8.0	<0.002	6.87	NMR	NMR
13-Jan-15	<0.0005	0.0009	<0.005	<0.0003	0.0005	<0.001	3.0	<0.002	6.43	NMR	NMR
19-Jan-15	0.0007	0.0009	<0.005	<0.0003	0.0005	0.004	12.0	<0.002	7.31	NMR	NMR
26-Jan-15	0.0016	0.0009	<0.005	<0.0003	<0.0005	0.002	5.0	<0.002	7.52	>100	>100
4-Feb-15	<0.0005	0.0011	<0.005	<0.0003	0.0008	0.026	8.0	<0.002	7.35	NMR	NMR
10-Feb-15	<0.0005	0.0026	<0.005	<0.0003	<0.0005	0.011	9.0	<0.002	7.06	>100	>100
16-Feb-15	<0.0005	<0.0005	<0.005	<0.0003	0.0006	0.008	9.0	<0.002	7.26	NMR	NMR
23-Feb-15	<0.0005	0.0009	<0.0005	<0.0003	0.0007	0.003	7.0	0.0020	7.17	NMR	NMR
3-Mar-15	<0.0005	0.0012	<0.0005	<0.0003	<0.0005	0.0120	4.0	<0.0020	7.09	>100	>100
10-Mar-15	<0.0005	0.0014	<0.0050	<0.0003	<0.0005	0.0060	<1.0	<0.0020	7.86	NMR	NMR
18-Mar-15	0.0497	0.0008	<0.0050	<0.0003	0.0007	0.0060	1.0	<0.0020	7.23	NMR	NMR
23-Mar-15	<0.0005	<0.0005	<0.0050	<0.0003	<0.0005	<0.001	8.0	<0.0020	6.96	>100	>100
30-Mar-15	<0.0005	0.0009	<0.0050	<0.0003	0.0006	0.0020	5.0	<0.0020	6.92	NMR	NMR
7-Apr-15	<0.0005	0.0046	<0.0050	<0.0003	0.0006	0.0020	5.0	<0.0020	7.56	>100	>100
13-Apr-15	<0.0005	0.0010	<0.0050	<0.0003	0.0009	0.0030	11.0	<0.0020	7.40	NMR	NMR
20-Apr-15	<0.0005	0.0014	<0.0050	<0.0003	0.0017	<0.001	5.0	<0.0020	7.32	NMR	NMR
28-Apr-15	<0.0005	0.0005	<0.0050	<0.0003	<0.0005	0.0060	5.0	<0.0020	6.84	NMR	NMR
5-May-15	<0.0005	0.0024	<0.0050	<0.0003	<0.0005	<0.001	1.0	<0.0020	6.89	NMR	NMR
11-May-15	<0.0005	0.0008	<0.0050	<0.0003	0.0005	0.0050	3.0	<0.0020	7.65	>100	>100
18-May-15	<0.0005	<0.0005	<0.0050	<0.0003	0.0006	0.0110	1.0	<0.0020	7.69	NMR	NMR
26-May-15	<0.0005	0.0005	<0.0050	0.0054	0.0008	<0.001	1.0	<0.0020	7.30	NMR	NMR
1-Jun-15	<0.0005	<0.0005	<0.0050	0.0008	0.0016	0.0010	4.0	-	8.56	>100	>100

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
9-Jun-15	<0.0005	0.0016	<0.0050	<0.0003	0.0064	0.0010	20.0	0.0040	7.20	NMR	NMR
8-Aug-15	0.0099	0.0007	<0.0050	<0.0003	0.0038	0.0080	4.0	<0.0020	6.98	NMR	NMR
10-Aug-15	0.0064	0.0006	<0.0050	<0.0003	0.0027	0.0150	2.0	<0.0020	8.00	NMR	NMR
17-Aug-15	<0.0005	<0.0005	<0.0050	0.0214	0.0019	0.0030	<1.0	<0.0020	7.12	NMR	NMR
25-Aug-15	<0.0005	<0.0005	<0.0050	<0.0003	0.0011	<0.001	2.0	<0.0020	8.04	>100	>100
1-Sep-15	<0.0005	<0.0005	<0.0050	0.0158	0.0013	<0.001	5.0	<0.0020	8.02	NMR	NMR
8-Sep-15	<0.0005	0.0007	<0.0050	<0.0003	<0.0005	<0.001	<1.0	<0.0020	7.67	>100	>100
16-Sep-15	<0.0005	0.0006	<0.0050	<0.0003	<0.0005	0.0060	4.0	<0.0020	7.99	NMR	NMR
22-Sep-15	<0.0005	0.0007	<0.0050	<0.0003	0.0016	0.0010	6.0	0.0030	7.11	NMR	NMR
28-Sep-15	<0.0005	0.0005	<0.0050	<0.0003	0.0011	<0.001	2.0	<0.0020	7.47	NMR	NMR
6-Oct-15	0.0065	0.0007	<0.0050	<0.0003	<0.0005	<0.001	<1.0	0.0020	8.02	>100	>100
13-Oct-15	0.0137	0.0008	<0.0050	<0.0003	<0.0005	0.0020	7.0	<0.0020	8.76	NMR	NMR
20-Oct-15	0.0007	0.0007	<0.0050	<0.0003	<0.0005	<0.001	<1.2	<0.0020	6.89	NMR	NMR
25-Oct-15	0.0024	0.0007	<0.0050	0.0007	0.0008	0.0020	4.0	0.0020	7.61	NMR	NMR
30-Oct-15	-	-	-	-	-	-	4.0	-	8.01	NMR	NMR
2-Nov-15	0.0207	0.0020	<0.0050	<0.0003	<0.0005	<0.001	2.0	<0.0020	7.96	>100	>100
10-Nov-15	0.0038	0.0183	<0.0050	<0.0003	<0.0005	0.0120	11.0	<0.0020	7.57	NMR	NMR
19-Nov-15	<0.0005	0.0007	<0.0050	<0.0003	<0.0005	0.0010	5.0	<0.0020	7.62	NMR	NMR
23-Nov-15	<0.0005	0.0013	<0.0050	<0.0003	<0.0005	0.0010	3.0	<0.0020	7.28	NMR	NMR
27-Nov-15	-	-	-	-	-	-	2.2	-	7.57	NMR	NMR
1-Dec-15	<0.0005	0.0065	<0.0050	<0.0003	<0.0005	0.0010	<1.2	<0.0020	8.37	>100	>100
9-Dec-15	0.0433	0.0006	<0.0050	<0.0003	0.0005	0.0030	1.0	0.0020	8.21	NMR	NMR
15-Dec-15	<0.0005	0.0009	<0.0050	<0.0003	0.0006	<0.0010	1.0	0.0050	7.58	NMR	NMR
21-Dec-15	0.0036	0.0055	<0.0050	<0.0003	0.0027	0.0340	26.0	<0.0020	6.58	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
29-Dec-15	<0.0005	0.0009	<0.0050	<0.0003	<0.0005	0.0190	4.0	<0.0020	7.60	NMR	NMR
5-Jan-16	<0.0005	0.0005	<0.0050	<0.0003	0.0005	0.0030	1.0	<0.0020	7.32	>100	>100
14-Jan-16	<0.0005	0.0032	<0.0050	<0.0003	0.0198	0.0090	9.0	<0.0020	7.38	NMR	NMR
18-Jan-16	<0.0005	0.0006	<0.0050	<0.0003	<0.0005	0.0070	1.0	<0.0020	7.61	NMR	NMR
25-Jan-16	0.0029	0.0005	<0.0050	<0.0003	<0.0005	<0.0010	2.0	0.0020	7.45	NMR	NMR
1-Feb-16	<0.0005	<0.0005	<0.0050	<0.0003	<0.0005	0.0060	10.0	0.0040	6.80	>100	>100
9-Feb-16	<0.0005	<0.0005	<0.0050	<0.0003	0.0006	0.0010	11.0	<0.0020	7.88	NMR	NMR
16-Feb-16	<0.0005	<0.0005	<0.0050	<0.0003	<0.0005	<0.0010	5.0	<0.0020	7.72	NMR	NMR
22-Feb-16	<0.0005	0.0249	<0.0050	<0.0003	0.0116	0.0130	17.0	<0.0020	7.43	NMR	NMR
1-Mar-16	<0.0005	0.0006	<0.0050	<0.0003	0.0006	0.0010	1.0	0.0020	7.58	>100	>100
8-Mar-16	<0.0005	<0.0005	<0.0050	<0.0003	<0.0005	<0.0010	11.0	<0.0020	7.05	NMR	NMR
14-Mar-16	0.0060	0.0008	<0.0050	<0.0003	0.0007	0.0040	6.0	<0.0020	8.48	NMR	NMR
21-Mar-16	<0.0005	0.0006	<0.0050	<0.0003	<0.0005	0.0010	7.0	<0.0020	7.49	NMR	NMR
29-Mar-16	0.0029	0.0009	<0.0050	0.0012	0.0009	0.0040	<1.0	<0.0020	7.63	NMR	NMR
5-Apr-16	<0.0005	0.0022	<0.0050	<0.0003	<0.0005	<0.0010	<1.0	-	8.52	NMR	NMR
11-Apr-16	<0.0005	0.0005	<0.0050	<0.0003	0.0005	0.0010	5.0	-	8.01	>100	>100
19-Apr-16	0.0040	<0.0005	<0.0050	<0.0003	0.0006	0.0010	2.0	-	7.69	NMR	NMR
26-Apr-16	0.0017	0.0039	<0.0050	<0.0003	0.0011	0.0010	2.0	<0.0020	7.91	NMR	NMR
3-May-16	0.0008	<0.0005	<0.0050	<0.0003	<0.0005	<0.0010	5.0	<0.0020	8.93	>100	>100
9-May-16	0.0009	0.0010	<0.0050	<0.0003	<0.0005	0.0010	15.0	-	6.60	NMR	NMR
16-May-16	0.0029	0.0005	<0.0050	0.0009	<0.0005	<0.0010	<1.0	-	8.64	NMR	NMR
24-May-16	0.0029	0.0007	<0.0050	<0.0003	0.0010	0.0020	<1.0	-	7.62	NMR	NMR
31-May-16	<0.0005	0.0024	0.0050	<0.0003	0.0013	0.0050	17.0	-	7.57	NMR	NMR
6-Jun-16	0.0008	0.0009	<0.0050	<0.0003	0.0013	<0.0010	<1.0	-	7.72	>100	>100

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
13-Jun-16	<0.0005	0.0030	<0.0050	<0.0003	0.0017	0.0040	<1.0	<0.0020	7.66	NMR	NMR
21-Jun-16	0.0103	0.0008	<0.0050	<0.0003	0.0016	<0.0010	<1.0	-	7.60	NMR	NMR
28-Jun-16	0.0015	0.0054	<0.0050	<0.0003	0.0013	0.0040	<1.0	-	7.08	NMR	NMR
4-Jul-16	0.0038	<0.0005	<0.0050	<0.0003	0.0018	0.0010	7.0	-	7.83	NMR	NMR
11-Jul-16	0.0029	0.0010	<0.0050	<0.0003	<0.0005	<0.0010	9.4	-	7.73	NMR	NMR
18-Jul-16	0.0012	0.0010	0.0060	<0.0003	0.0026	<0.0010	6.0	-	7.96	>100	>100
25-Jul-16	<0.0005	0.0040	<0.0050	<0.0003	0.0034	0.0050	17.0	-	7.76	NMR	NMR
1-Aug-16	<0.0005	0.0009	<0.0050	<0.0003	0.0019	0.0010	1.0	-	7.85	NMR	NMR
8-Aug-16	<0.0005	0.0008	<0.0050	<0.0003	0.0022	<0.0010	<1.0	<0.0020	7.75	NMR	NMR
15-Aug-16	<0.0005	<0.0005	<0.0050	<0.0003	0.0024	<0.0010	3.0	-	7.50	NMR	NMR
22-Aug-16	<0.0005	0.0009	<0.0050	<0.0003	0.0021	<0.0010	4.0	-	7.84	>100	>100
29-Aug-16	<0.0005	0.0008	0.0010	0.0038	0.0012	<0.0010	<1.0	-	7.71	NMR	NMR
5-Sep-16	<0.0005	0.0009	0.0560	<0.0003	<0.0005	<0.0010	3.0	-	8.31	NMR	NMR
12-Sep-16	<0.0005	0.0005	<0.0010	<0.0003	0.0009	<0.0010	<1.0	-	7.11	NMR	NMR
20-Sep-16	<0.0005	0.0009	<0.0010	<0.0003	<0.0005	<0.0010	4.0	-	6.61	NMR	NMR
28-Sep-16	<0.0005	0.0012	0.0140	<0.0003	0.0024	0.0020	7.0	0.0040	7.69	>100	>100
3-Oct-16	-	-	-	-	-	-	2.0	-	7.87	NMR	NMR
10-Oct-16	<0.0005	0.0008	<0.0010	<0.0003	0.0008	0.0010	1.0	0.0020	7.41	>100	>100
17-Oct-16	<0.0005	0.0073	0.0030	<0.0003	<0.0005	0.0030	4.0	-	6.86	NMR	NMR
24-Oct-16	-	-	-	-	-	-	<1.0	-	8.65	>100	>100
31-Oct-16	-	-	-	-	-	-	<1.0	-	7.96	NMR	NMR
7-Nov-16	-	-	-	-	-	-	6.0	-	8.35	NMR	NMR
14-Nov-16	-	-	-	-	-	-	5.0	-	8.58	NMR	NMR
22-Nov-16	-	-	-	-	-	-	2.0	-	8.57	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
28-Nov-16	<0.0005	0.0008	<0.0010	<0.0003	0.0006	<0.0010	2.0	<0.0020	7.92	NMR	NMR
5-Dec-16	<0.0005	0.0013	<0.0010	<0.0003	0.0010	0.0070	1.0	<0.0020	8.40	NMR	NMR
12-Dec-16	-	-	-	-	-	-	2.0	-	8.23	NMR	NMR
19-Dec-16	-	-	-	-	-	-	<1.0	-	7.69	NMR	NMR
27-Dec-16	-	-	-	-	-	-	2.0	-	8.36	NMR	NMR
3-Jan-17	-	-	-	-	-	-	11	-	8.18	NMR	NMR
9-Jan-17	0.0009	0.0012	0.005	<0.0003	0.0006	<0.001	6	0.0030	7.65	>100	>100
16-Jan-17	-	-	-	-	-	-	5	-	8.15	NMR	NMR
23-Jan-17	-	-	-	-	-	-	3	-	7.71	NMR	NMR
30-Jan-17	-	-	-	-	-	-	3	-	7.81	NMR	NMR
6-Feb-17	-	-	-	-	-	-	4	-	7.95	NMR	NMR
13-Feb-17	-	-	-	-	-	-	6	-	7.97	NMR	NMR
21-Feb-17	-	-	-	-	-	-	7	-	8.02	NMR	NMR
27-Feb-17	-	-	-	-	-	-	8	-	7.66	NMR	NMR
6-Mar-17	-	-	-	-	-	-	14	-	8.42	NMR	NMR
13-Mar-17	-	-	-	-	-	-	3	-	7.38	NMR	NMR
22-Mar-17	-	-	-	-	-	-	3	-	7.50	NMR	NMR
29-Mar-17	-	-	-	-	-	-	9	-	7.70	NMR	NMR
3-Apr-17	<0.0005	0.0018	0.002	<0.0003	0.0007	<0.001	8	<0.002	7.85	>100	>100
12-Apr-17	-	-	-	-	-	-	11	-	8.55	NMR	NMR
17-Apr-17	-	-	-	-	-	-	11	-	7.62	NMR	NMR
24-Apr-17	-	-	-	-	-	-	4	-	8	NMR	NMR
1-May-17	-	-	-	-	-	-	1	-	7.54	NMR	NMR
9-May-17	-	-	-	-	-	-	34	-	8.11	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
6-Sep-17	<0.0005	0.0008	0.003	<0.0003	0.0008	<0.001	3	<0.002	7.72	>100	>100
11-Sep-17	-	-	-	-	-	-	3	-	7.60	NMR	NMR
18-Sep-17	-	-	-	-	-	-	32	-	8.57	NMR	NMR
30-Oct-17	-	-	-	-	-	-	4	-	7.34	NMR	NMR
6-Nov-17	<0.0005	0.0005	<0.001	<0.0003	0.0009	0.001	5	<0.002	7.2	>100	>100
14-Nov-17	-	-	-	-	-	-	1	-	7.1	NMR	NMR
20-Nov-17	-	-	-	-	-	-	8	-	7.52	NMR	NMR
27-Nov-17	-	-	-	-	-	-	5	-	8.26	NMR	NMR
4-Dec-17	-	-	-	-	-	-	8	-	9.01	NMR	NMR
11-Dec-17	-	-	-	-	-	-	10	-	7.74	NMR	NMR
19-Dec-17	-	-	-	-	-	-	2	-	7.93	NMR	NMR
27-Dec-17	-	-	-	-	-	-	4	-	8.77	NMR	NMR
3-Jan-18	0.0025	0.0023	<0.001	<0.0003	0.0005	0.005	3	-	8.53	NMR	NMR
8-Jan-18	-	-	-	-	-	-	7	-	7.59	NMR	NMR
15-Jan-18	-	-	-	-	-	-	4	-	7.74	NMR	NMR
23-Jan-18	-	-	-	-	-	-	9	-	8.21	NMR	NMR
29-Jan-18	-	-	-	-	-	-	4	-	7.52	NMR	NMR
6-Feb-18	<0.0005	0.001	<0.001	0.0041	0.0015	<0.001	4	<0.002	8.31	NMR	NMR
13-Feb-18	-	-	-	-	-	-	6	-	7.29	>100	>100
21-Feb-18	-	-	-	-	-	-	22	-	7.68	NMR	NMR
26-Feb-18	-	-	-	-	-	-	13	-	7.93	NMR	NMR
5-Mar-18	<0.0005	0.0013	0.002	0.0008	<0.0005	0.002	6	-	7.39	NMR	NMR
11-Mar-18	-	-	-	-	-	-	5	-	7.57	NMR	NMR
15-Mar-18	-	-	-	-	-	-	7	-	7.34	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
19-Mar-18	-	-	-	-	-	-	8	-	7.26	NMR	NMR
27-Mar-18	-	-	-	-	-	-	1	-	7.41	NMR	NMR
2-Apr-18	0.0009	0.0023	<0.001	<0.0003	0.0014	0.015	12	<0.002	7.82	>100	>100
9-Apr-18	-	-	-	-	-	-	3	-	7.56	NMR	NMR
17-Apr-18	-	-	-	-	-	-	3	-	7.08	NMR	NMR
22-Apr-18	-	-	-	-	-	-	10	-	7.60	NMR	NMR
30-Apr-18	-	-	-	-	-	-	15	-	7.13	NMR	NMR
8-May-18	-	-	-	-	-	-	6	-	7.31	NMR	NMR
14-May-18	-	-	-	-	-	-	1	-	NA1	NMR	NMR
21-May-18	-	-	-	-	-	-	1	-	7.24	NMR	NMR
28-May-18	-	-	-	-	-	-	1	-	6.67	NMR	NMR
22-Aug-18	<0.0005	0.0008	0.001	<0.0003	0.0015	0.001	<1	0.005	7.69	NMR	NMR
27-Aug-18	-	-	-	-	-	-	1	-	7.50	NMR	NMR
3-Sep-18	-	-	-	-	-	-	1	-	7.37	NMR	NMR
10-Sep-18	<0.0005	<0.0005	0.001	<0.0003	<0.0005	<0.001	1	0.006	7.24	>100	>100
17-Sep-18	-	-	-	-	-	-	<1	-	7.55	NMR	NMR
24-Sep-18	-	-	-	-	-	-	2	-	7.38	NMR	NMR
1-Oct-18	-	-	-	-	-	-	<1	-	7.15	NMR	NMR
8-Oct-18	-	-	-	-	-	-	<1	-	6.30	NMR	NMR
15-Oct-18	<0.0005	<0.0005	<0.001	<0.0003	<0.0005	<0.001	5	0.005	7.38	NMR	NMR
22-Oct-18	-	-	-	-	-	-	2	-	7.33	NMR	NMR
29-Oct-18	-	-	-	-	-	-	<1	-	6.95	NMR	NMR
5-Nov-18	-	-	-	-	-	-	<1	-	7.24	NMR	NMR
12-Nov-18	-	-	-	-	-	-	4	-	7.66	NMR	NMR

	Arsenic	Copper	Cyanide	Lead	Nickel	Zinc	Total Suspended Solids	Radium 226	pH	Daphnia magna	Rainbow trout
Units	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**mg/L**	**Bq/L**	**units**	**LC50 %**	**LC50 %**
19-Nov-18	<0.0005	0.0006	<0.001	<0.0003	<0.0005	<0.001	2	<0.002	7.35	NA2	NA2
26-Nov-18	-	-	-	-	-	-	2	-	7.03	NMR	NMR
3-Dec-18	-	-	-	-	-	-	NA3	-	NA3	NMR	NMR
10-Dec-18	-	-	-	-	-	-	3	-	7.76	NMR	NMR
17-Dec-18	-	-	-	-	-	-	1	-	7.66	NMR	NMR
27-Dec-18	-	-	-	-	-	-	3	-	8.01	NMR	NMR
2-Jan-19	-	-	-	-	-	-	1	-	7.71	NMR	NMR
7-Jan-19	<0.0005	<0.0005	0.002	<0.0003	<0.0005	<0.001	2	<0.002	7.24	>100	>100
14-Jan-19	-	-	-	-	-	-	NA4	-	NA4	NMR	NMR
22-Jan-19	-	-	-	-	-	-	25	-	8.44	NMR	NMR
12-Mar-19	-	-	-	-	-	-	1	-	7.82	NMR	NMR
18-Mar-19	0.0006	0.0010	0.003	<0.0003	<0.0005	<0.001	3	<0.002	7.85	>100	>100
25-Mar-19	-	-	-	-	-	-	1	-	7.89	NMR	NMR
13-Nov-19	0.0011	0.0020	0.001	<0.0003	0.0008	0.006	2	<0.002	7.84	NMR	NMR
18-Nov-19	0.0019	0.0010	0.003	<0.0003	0.0006	0.002	1	0.009	7.59	>100	>100
25-Nov-19	0.0025	0.0026	0.001	0.0069	0.0010	0.016	2	<0.002	8.04	NMR	NMR
2-Dec-19	-	-	-	-	-	-	4	-	7.80	NMR	NMR
9-Dec-19	-	-	-	-	-	-	1	-	7.67	NMR	NMR
16-Dec-19	0.0017	0.0015	<0.001	<0.0003	<0.0005	0.004	4	<0.002	7.50	>100	>100
23-Dec-19	-	-	-	-	-	-	1	-	7.74	NMR	NMR
28-Dec-19	-	-	-	-	-	-	1	-	7.93	NMR	NMR

NMR = No measurement required; ANYC = Analysis not yet completed; NA1 = Technician omission.
NA2 = Sample frozen during transport. Test could not be performed; NA3 = Sample not taken due to plane delay;
NA4 = No sample collected due to extreme cold that froze the discharge pipe.

APPENDIX C

PLUME MODELLING STUDY

W.F. Baird & ASSOCIATES

Second Portage Lake Effluent Plume Modelling Study

Meadowbank Gold Project, Nunavut

February 19, 2020 | 13333.101.R1.Rev0

Innovation Engineered.

baird.com

Second Portage Lake Effluent Plume Modelling Study

Meadowbank Gold Project, Nunavut

Prepared for: Prepared by:

C. Portt & Associates
56 Waterloo Avenue
Guelph, ON
N1H 3H5

W.F. Baird & Associates Coastal Engineers Ltd

For further information, please contact
Josh Wiebe at +1 613 731 8900
jwiebe@baird.com
www.baird.com

13333.101.R1.Rev0

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Revision	Date	Status	Comments	Prepared	Reviewed	Approved
RevA	13 Feb 2020	Draft	Client review	SES	JDW	DMF
Rev0	19 Feb 2020	Final	Final report	SES	JDW	DMF

Table of Contents

Tables

Figures

1. Introduction

This report describes the results of an effluent plume modelling study for the Second Portage Lake East Dike outfall at the Meadowbank Gold Project, Nunavut. The effluent is water from Second Portage Lake that seeps through the East Dike. The seepage water is collected at two pump stations and discharged back into the lake using a single-port diffuser system. The location of the outfall and general overview of the study area is shown in Figure 1.1.

The objective of this study is to predict the exposure area in Second Portage Lake where the effluent concentration is 1% or greater (Environment Canada, 2003). The near-field mixing and dilution of the plume were simulated using the mixing zone model CORMIX (Doneker and Jirka, 2007) for different lake currents, relative buoyancy, and ice thickness conditions. The results of the study may be used to assist in the selection of sampling locations for the environmental effects monitoring (EEM) study.

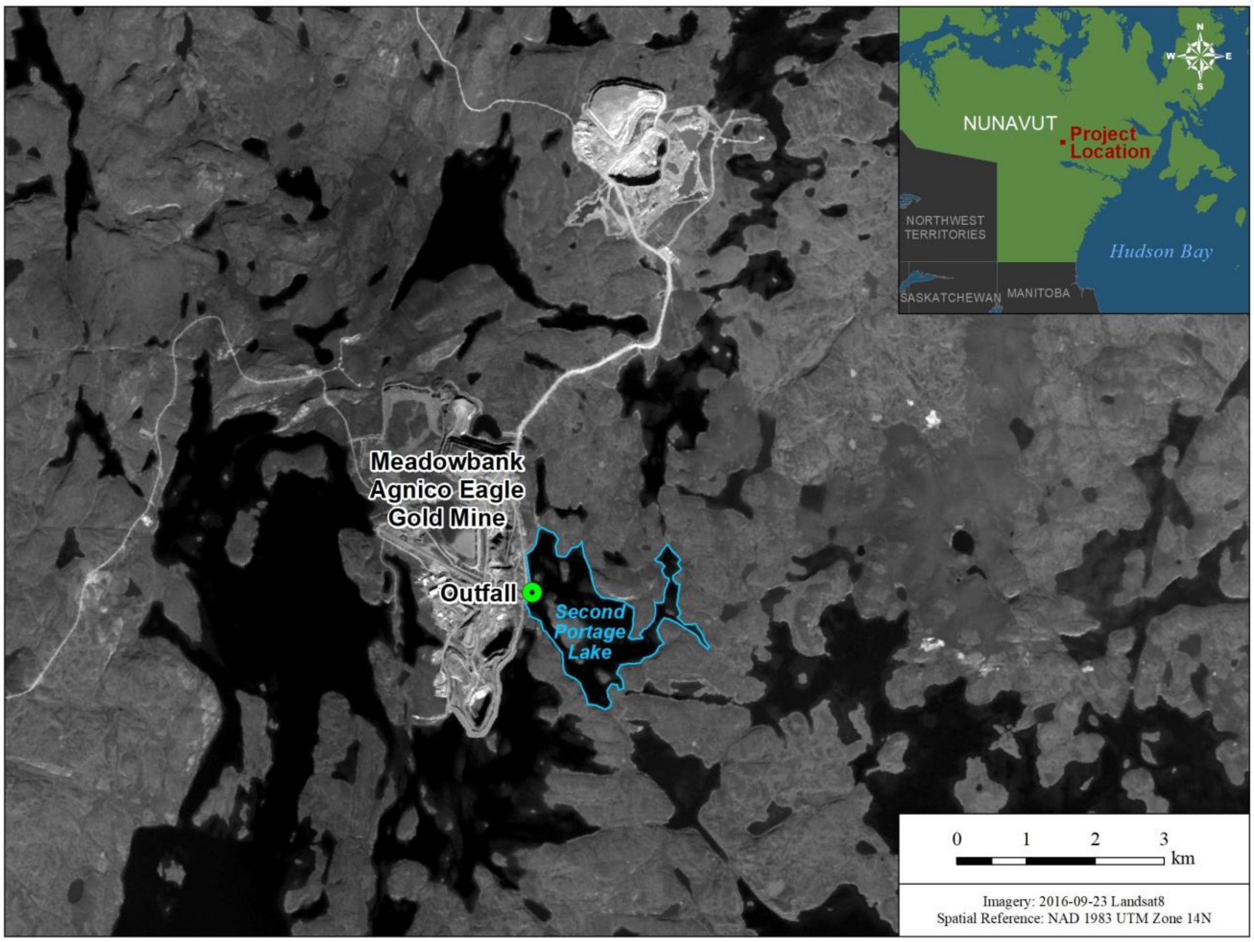

Figure 1.1: Location of the Second Portage Lake East Dike Outfall

2. Data Review

Data pertaining to the effluent and receiving water characteristics, effluent discharge rates, outfall diffuser configuration, and lake bathymetry were provided by C. Portt & Associates (Portt) and Agnico Eagle Mines (Agnico). Additional parameters required for the CORMIX modelling were derived from the measured data. Wind-induced currents in Second Portage Lake were estimated from long-term wind data from the Baker Lake Airport.

2.1 Second Portage Lake Ambient Water Characteristics

Water chemistry data from various sample locations on Second Portage Lake were provided by Portt and Agnico. The measured data included conductivity, total dissolved solids (TDS) concentration, and total suspended solids (TSS) concentration. The 2016 to 2019 data were used to define the ambient water chemistry for the CORMIX modelling. Conductivity measurements ranged between 33 and 56 µS/cm, TDS ranged between 15 and 46 mg/L, and TSS ranged between the detection limit and 1.1 mg/L. The conductivity measurements tended to be higher in March, April and May than in the summer and fall. Water temperature was not provided in the water chemistry dataset.

Water quality and chemistry data were also provided at the outfall location (ST-MMER-3-EEM-SPLE). The data includes water temperature, conductivity and TSS. Water temperatures ranged between 0.4 and 16°C, conductivity measurements ranged between 21 and 58 µS/cm, and TSS ranged between <1 to 24 mg/L in the 2016 to 2019 data.

2.2 Effluent Water Characteristics

Effluent water is discharged into Second Portage Lake throughout the year. Typical daily flow volumes are between 350 and 700 m^3 in the winter. Daily flow volumes varied more during the ice-free season. Daily volumes of 400 to 550 m^3 are typical, but volumes greater than 800 m^3 occurred on 14 days (2017 to 2019 data). In recent years very little effluent was discharged between May and September.

Water quality and chemistry data were provided at the effluent characterization site (ST-MMER-3-EEM). The effluent data included water temperature, conductivity and TSS. The 2016 to 2019 data were used to define the effluent water characteristics for the CORMIX modelling. Water temperatures ranged between 0.5 and 15°C, conductivity measurements ranged between 58 and 121 µS/cm, and TSS ranged between the detection limit and 11 mg/L. In general, the water temperatures were similar at the effluent and exposure area sites in the summer, and the effluent was warmer than the exposure area in the winter. This is because a heat trace cable is installed along the pipe to prevent it from freezing between October and April (Agnico, 2014).

2.3 Diffuser Configuration

The single port diffuser is located about 45 m offshore in a water depth of approximately 5 m. The diffuser is a vertically-oriented port with a diameter of 4 inches (0.1 m). The diffuser configuration is shown in Figure 2.1. Baird has assumed that the diffuser opening is located about 1.5 m above the lakebed based on the figure. The design flow rate for the system is 12 L/s, which corresponds to a daily volume of 1,000 m^3. The diffuser is designed to have a high exit velocity to promote turbulent mixing of the effluent with the receiving waters. As mentioned previously, a heat trace cable is installed along the pipe to prevent it from freezing between October and April (Agnico, 2014). The lake ice thickness reaches a maximum of approximately 2 m during the winter (Agnico, 2014).

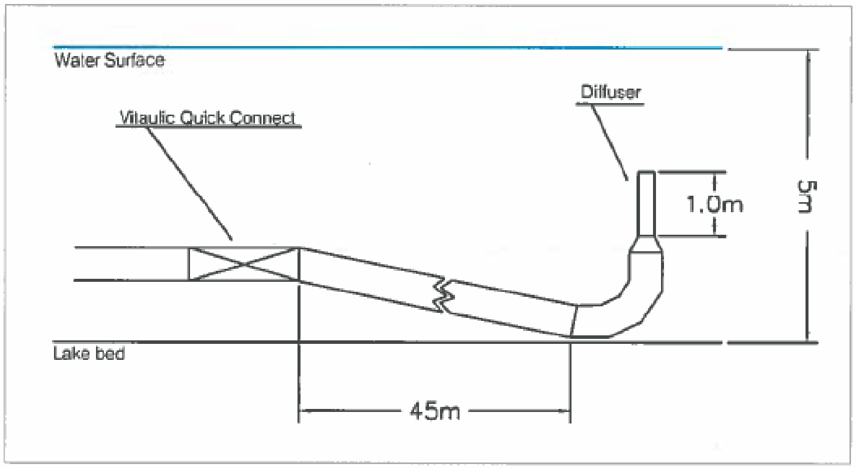

Figure 2.1: Schematic of Diffuser and Discharge Pipe (Agnico, 2014)

2.4 Wind Data

Hourly wind speed data from the Baker Lake Airport (1953 to 2019) was acquired from Environment Canada to estimate the wind-induced currents in Second Portage Lake. Seasonal wind data (June 1 – October 31) are summarized in the wind speed rose (Figure 2.2) and in Table 2.1. In Figure 2.2, the length of the directional bins indicates the frequency of wind from that direction and the colours denote the wind speed range. Winds during these months are primarily from the north and northwest. Wind data during the winter months was excluded from the analysis because the ice cover would prevent the development of wind-induced lake currents.

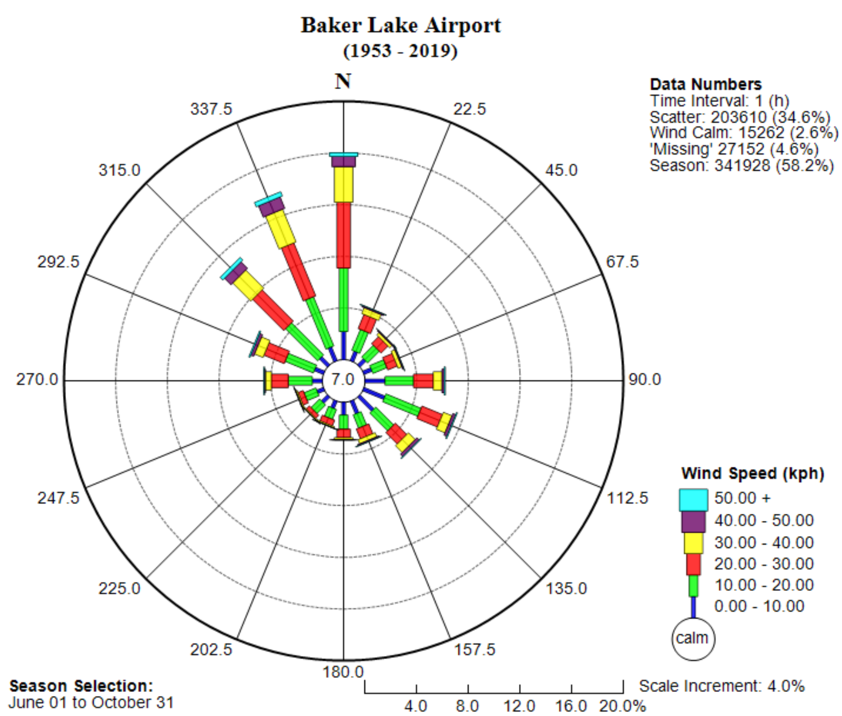

Figure 2.2: Wind Speed Rose for Baker Lake, Nunavut (June 1 to October 31)

Table 2.1: Occurrence of Wind Speeds by Month for Baker Lake, Nunavut (June 1 to October 31)

Wind Speed (kph)	Jun	Jul	Aug	Sep	Oct	Total
0-10	4%	4%	4%	3%	3%	18%
10-20	7%	7%	8%	7%	6%	35%
20-30	5%	6%	6%	6%	6%	28%
30-40	2%	2%	2%	3%	4%	13%
40-50	0.6%	0.5%	0.7%	0.9%	1.5%	4.1%
>50	0.1%	0.1%	0.2%	0.3%	0.6%	1.3%

2.5 Wind-induced Currents

Lake currents depend on the wind speed and open-water fetch distance. At small fetches, currents are primarily caused by wind shear, while at larger fetches currents are mainly driven by wave motions. Fetches from the more exposed east and southeast directions are in the order of 1 to 1.5 km. At this fetch, the total drift current is estimated to be between 3.1 to 3.5% of the wind speed (Wu, 1983). This information was used to define the current conditions used in the CORMIX model.

3. Plume Modelling

The plume modelling was carried out using the Cornell Mixing Zone Expert System (CORMIX). The model system is based on semi-empirical and physically-based formulations which are selected automatically based on the classification of the ambient and effluent flow conditions (Doneker and Jirka, 2007). CORMIX is used extensively for predicting the mixing and dilution of pollutants in surface waters to support regulatory approvals.

3.1 Model Setup

Near-field mixing and dilution processes calculated by CORMIX are influenced by the relative buoyancy of the effluent, momentum of the effluent jet, and ambient lake currents. The following lake current and relative density conditions were selected to further understand the behavior of the plume for the range of conditions likely experienced during the operation of the outfall system:

Summer (ice-free season):

- Lake current: near stagnant, low wind, average wind, high wind
- Relative density: negatively buoyant, neutrally buoyant, positively buoyant

Winter (ice season):

- Lake current: near stagnant
- Relative density: negatively buoyant, neutrally buoyant, positively buoyant
- Ice thickness (reduction in water depth): thin/negligible, 0.5 m, 1 m, 2 m

3.1.1 Wind-induced Lake Currents

The ambient lake currents selected for the summer modelling scenarios were based on the exceedance probability of seasonal wind speed data from the Baker Lake Airport. The current speeds were estimated to be between 3.1 to 3.5% of the wind speed (Wu, 1983). These selections, in Table 3.1, are intended to represent the range of conditions experienced on the lake and provide an indication of the sensitivity of the model results to these conditions.

Table 3.1: Summary of Wind Conditions and Lake Currents Selected for Modelling

Description	Exceedance	Wind Speed (kph)	Estimated Surface Current Speed (m/s)
Near Stagnant*	93%	1	0.01
Low Wind	90%	4	0.03
Median	50%	18	0.17
High Wind	1%	52	0.50

*Calm wind conditions 7% of occurrences

3.1.2 Effluent and Ambient Water Density

The relative densities of the effluent and receiving waters selected for modelling were based on the water temperature, TDS, TSS, and conductivity from the water quality samples from 2016 to 2019. Relations between the physical water characteristics (temperature, TDS, and TSS) and density were drawn from Ji (2008). Total Dissolved solids (TDS) for the effluent were estimated from the conductivity measurements using the following empirical relationship (see e.g. Rusydi, 2018):

$$Total\ Dissolved\ Solids\ (mg/L)\ =\ 0.64 * Conductivity\ (\mu S/cm) \qquad \text{[Eqn. 1]}$$

Measured TDS and measured conductivity at various locations in Second Portage Lake (from the water chemistry dataset) are shown in Figure 3.1. The empirical relationship compared quite well with the measured data. The two higher TDS and conductivity measurements occurred on May 11, 2019 and were located 600 m and 1,500 m from the diffuser.

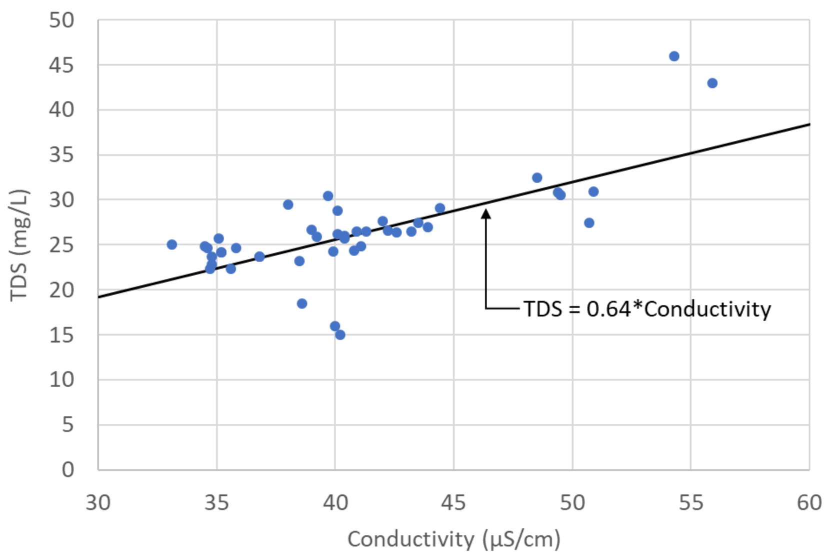

Figure 3.1: Measured TDS and Measured Conductivity in Second Portage Lake

The effluent temperature, conductivity, and TSS measurements are summarized in Table 3.2. Given the limited data available for analysis, total dissolved solids (estimated from conductivity), total suspended solids, and effluent water temperature were conservatively selected for the negatively and positively buoyant scenarios to cover the range of possible conditions. Table 3.3 and Table 3.4 provide a summary of the effluent and ambient density conditions for the summer and winter modelling scenarios.

Table 3.2: Effluent Characteristics for Summer and Winter Conditions

Season	Temperature (°C)			Conductivity (µS/cm)			TSS (mg/L)		
	Minimum	Mean	Maximum	Minimum	Mean	Maximum	Minimum	Mean	Maximum
Summer	3.8	8.3	12.2	71	93	121	0.5	2.6	9.8
Winter	0.5	6.7	15.2	58	79	94	1.3	4.8	11.3

Table 3.3: Summer Season – Summary of Ambient and Effluent Densities for the Model

Scenario	Ambient Water		Effluent Water				Comments
	Temp (°C)	Density (kg/m³)	Temp (°C)	TDS (mg/L)	TSS (mg/L)	Density (kg/m³)	
Negatively Buoyant (sinking)	12	999.52	8	77*	9	999.93	TDS estimated from maximum summer effluent conductivity (121 µS/cm). TSS from maximum of summer measurements.
Neutrally Buoyant	12	999.52	12	45*	0.5	999.55	TDS estimated from minimum summer effluent conductivity (71 µS/cm). TSS from minimum of summer measurements.
Positively Buoyant (floating)	12	999.52	14	45*	0.5	999.30	Effluent assumed to be 2°C warmer than lake to achieve positively buoyant plume. Same TDS and TSS as neutrally buoyant case.

*Estimated from conductivity

Table 3.4: Winter Season – Summary of Ambient and Effluent Densities for the Model

Scenario	Ambient Water		Effluent Water				Comments
	Temp (°C)	Density (kg/m³)	Temp (°C)	TDS (mg/L)	TSS (mg/L)	Density (kg/m³)	
Negatively Buoyant (sinking)	2	999.96	5	60*	11	1000.04	TDS estimated from maximum winter effluent conductivity (94 µS/cm). TSS from maximum of winter measurements. Typical winter effluent temperature.
Neutrally Buoyant	2	999.96	7	36*	3	999.95	TDS, TSS, and temperature selected from range of measured winter values to achieve neutrally buoyant plume.
Positively Buoyant (floating)	2	999.96	15	36*	3	999.15	Maximum measured winter effluent temperature and minimum winter conductivity to achieve positively buoyant plume.

*Estimated from conductivity

3.2 Model Results

3.2.1 Summer Scenarios

The summer scenarios were modelled using four lake current conditions and three relative buoyancy conditions for a total of twelve scenarios. The modelling was carried out using the design flow rate of 12 L/s (1,000 m^3/day). Sensitivity tests were conducted using the minimum, mean and maximum daily flows during the summer (2017 to 2019 data) for the typical conditions and largest plume extent scenarios (see Section 3.3). Note that due to the vertical orientation of the diffuser, the direction of the current does not affect the mixing distance (i.e. the lake current always acts perpendicular to the effluent jet).

The distances from the outfall to the 1% mixing zone, and dilution ratios 100 m and 250 m from the outfall are summarized in Table 3.5. Note that the 1% mixing zone represents the distance from the outfall where a dilution of 100:1 is achieved. The mixing and dilution of the effluent calculated by CORMIX are strongly influenced by the flow classification. For example, a small change in relative buoyancy, discharge, current speed, or water depth may result in a different flow classification and a different set of formulas used to calculate the mixing and dilution of the effluent. For this reason, the mixing distances shown in Table 3.5 do not follow a linear relationship.

Table 3.5: CORMIX Model Results – Summer Season

Scenario #	Relative Buoyancy	Wind Condition	1% Mixing Distance (m)	100m from Diffuser		250m from Diffuser	
				Concentration (%)	Dilution Ratio	Concentration (%)	Dilution Ratio
1	negative	Near stagnant	133	1.4	67	0.2	457
2*	**negative**	**Low Wind**	**235**	**3.0**	**33**	**0.9**	**112**
3	negative	Median wind	54	0.5	204	0.1	894
4	negative	High Wind	167	1.8	56	0.6	167
5	neutral	Near stagnant	32	0.3	501	0.1	1415
6	neutral	Low Wind	45	0.3	318	0.1	1188
7†	**neutral**	**Median wind**	**47**	**0.4**	**308**	**0.1**	**913**
8	neutral	High Wind	186	1.4	72	0.9	118
9	positive	Near stagnant	144	1.8	58	0.4	257
10	positive	Low Wind	205	2.8	36	0.7	147
11	positive	Median wind	77	0.8	127	0.3	388
12	positive	High Wind	118	1.1	88	0.3	614

* conditions causing largest predicted plume extent

† typical conditions

A profile view demonstrating the different behaviours of positively and negatively buoyant plumes is shown in Figure 3.2 for the summer season. A neutrally buoyant plume is not shown as these plumes tend to be re-entrained by the diffuser jet and become mixed throughout the water column.

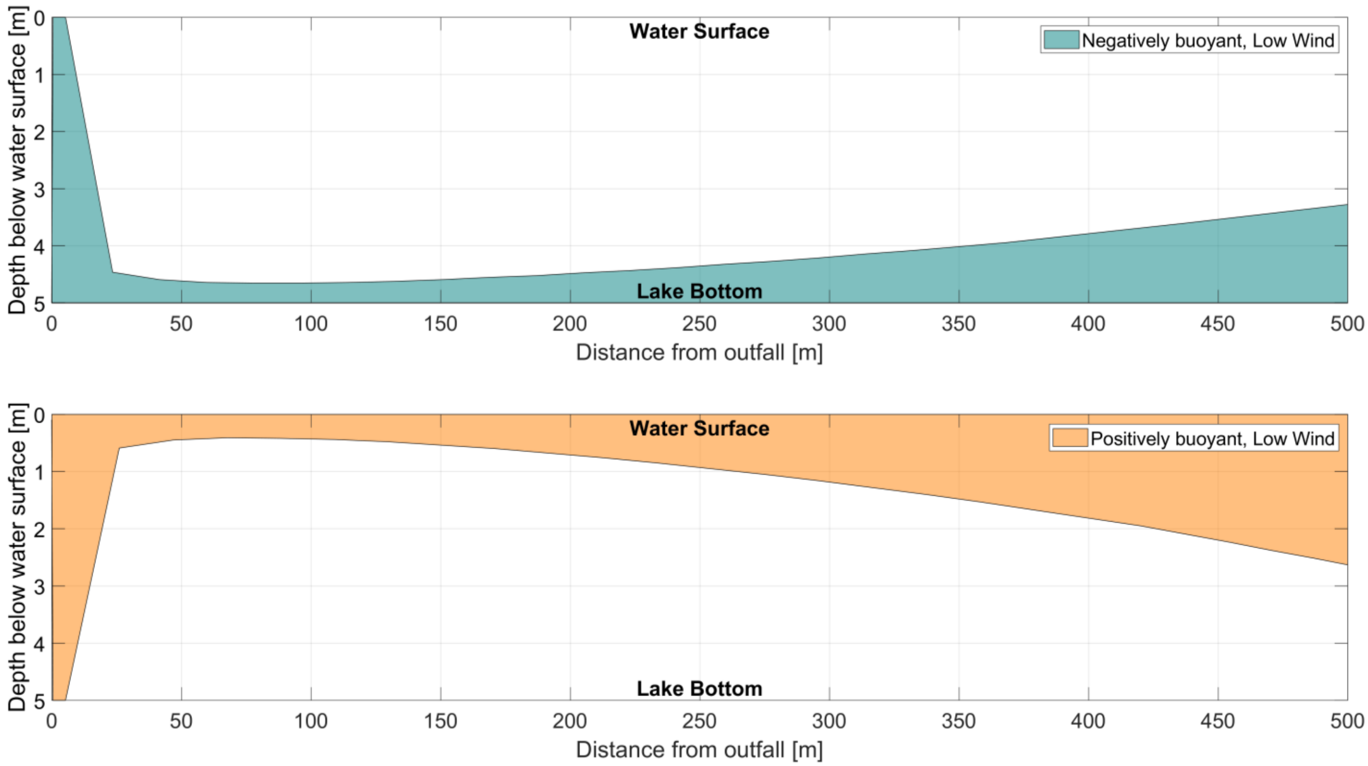

Figure 3.2: Profile View of the Predicted Plumes for Positively and Negatively Buoyant Summer Cases

3.2.2 Winter Scenarios

The winter scenarios were modelled using three relative buoyancy conditions and four ice thicknesses (water depths) for a total of twelve scenarios. The modelling was carried out using near-stagnant lake currents and the design flow rate of 12 L/s (1,000 m^3/day). Sensitivity tests were conducted using the minimum, mean and maximum daily flows during the winter (2017 to 2019 data) for the typical conditions and largest plume extent scenarios (see Section 3.3).

The distances from the outfall to the 1% mixing zone, and dilution ratios 100 m and 250 m from the outfall are summarized in Table 3.6. Note that the 1% mixing zone represents the distance from the outfall where a dilution of 100:1 is achieved.

Table 3.6: CORMIX Model Results – Winter Season

Model Run #	Effluent Buoyancy	Ice Thickness (m)	Water Depth (m)	1% Mixing Distance (m)	100m from Diffuser		250m from Diffuser	
					Concentration (%)	Dilution Ratio	Concentration (%)	Dilution Ratio
1*	**negative**	**2**	**3**	**119**	**1.91**	**52**	**0.32**	**655**
2	negative	1	4	99	0.98	102	0.20	852
3	negative	0.5	4.5	91	0.81	125	0.17	933
4	negative	negligible	5	88	0.71	144	0.14	993
5	neutral	2	3	35	0.69	386	0.20	1051
6	neutral	1	4	30	0.52	509	0.15	1396
7	neutral	0.5	4.5	28	0.46	569	0.14	1567
8	neutral	negligible	5	27	0.42	628	0.12	1737
9†	**positive**	**2**	**3**	**41**	**0.37**	**269**	**0.20**	**503**
10	positive	1	4	42	0.29	344	0.16	612
11	positive	0.5	4.5	43	0.24	428	0.13	741
12	positive	negligible	5	43	0.25	401	0.14	698

* conditions causing largest predicted plume extent

† typical conditions

3.3 Model Sensitivity

Near-field mixing is strongly dependent on the exit velocity and momentum of the effluent jet. The sensitivity of the model results to the effluent flow rate was assessed by re-running the model using the minimum, mean and maximum daily flow volumes from February 18, 2017 through December 31, 2019. The sensitivity tests were conducted for typical conditions and the conditions that result in the largest predicted plume for the summer and winter scenarios. The results of the sensitivity tests are provided in Table 3.7 and Table 3.8.

A map of the extents of the 1% mixing zone under typical conditions and conditions which produce the largest mixing zone are presented in Appendix A. The maps depict the 1% mixing zone for the maximum flow rate during the summer and winter seasons (2017 to 2019 data).

The sensitivity tests indicate that the 1% mixing distance decreases at lower flow rates for scenarios where there is a buoyancy differential. For neutrally buoyant conditions, the tests indicated that the mixing distance could increase or decrease depending on the wind speed. The predicted 1% mixing distance did not exceed 250 m for the range of flows that were tested.

Table 3.7: CORMIX Model Results – Summer Season Sensitivity Tests

Scenario	Description	Flow Rate	1% Mixing Distance (m)	100m from Diffuser		250m from Diffuser	
				Concentration (%)	Dilution Ratio	Concentration (%)	Dilution Ratio
Largest predicted plume extent	Negatively buoyant, low wind	Minimum 4.4 L/s	18	0.4	251	0.2	605
		Mean 6.0 L/s	18	0.5	196	0.2	433
		Maximum 10.8 L/s	220	2.8	36	0.8	126
		Design 12.0 L/s	235	3.0	33	0.9	112
Typical conditions	Neutrally buoyant, median wind	Minimum 4.4 L/s	162	1.3	77	0.8	127
		Mean 6.0 L/s	84	0.6	229	0.1	1316
		Maximum 10.8 L/s	43	0.3	337	0.1	1011
		Design 12.0 L/s	47	0.4	308	0.1	913

*minimum, mean and maximum daily flows 2017-2019

Table 3.8: CORMIX Model Results – Winter Season Sensitivity Tests

Scenario	Description	Flow Rate	1% Mixing Distance (m)	100m from Diffuser		250m from Diffuser	
				Concentration (%)	Dilution Ratio	Concentration (%)	Dilution Ratio
Largest predicted plume extent	Negatively buoyant, 2 m ice thickness	Minimum 3.5 L/s	49	0.18	938	0.07	3295
		Mean 5.4 L/s	65	0.3	460	0.1	1994
		Maximum 7.9 L/s	86	0.6	177	0.2	1226
		Design 12.0 L/s	119	1.91	52	0.32	655
Typical conditions	Positively buoyant, 2 m ice thickness	Minimum 3.5 L/s	23	0.28	359	0.08	1793
		Mean 5.4 L/s	28	0.3	325	0.1	1104
		Maximum* 7.9 L/s	31	0.3	308	0.1	756
		Design 12.0 L/s	41	0.4	269	0.2	503

*minimum, mean and maximum daily flows 2017-2019

3.4 Discussion

The following observations were noted from the CORMIX simulations:

- For all scenarios, the effluent concentration 250 metres from the outfall is less than 1%; that is, predicted dilution ratios are greater than 100:1 at a distance 250 m from the outfall.
- For several scenarios, the effluent concentration 100 metres from the outfall is greater than 1%; that is, predicted dilution ratios are less than 100:1 at a distance 100 m from the outfall.
- The mixing zones are generally larger for the summer conditions than the winter conditions.
- The largest mixing zone is predicted for a negatively buoyant low wind condition in the summer.
- Lower discharge rates generally result in smaller mixing zones. However, larger mixing zones were predicted for the neutrally buoyant median wind scenario under lower flows (e.g. 4.4 L/s).
- For negatively buoyant conditions, the plume falls to the lake bottom, resulting in lower dilution values.
- For neutrally buoyant conditions, the plume mixes through the water column as buoyant spreading is not present.
- For positively buoyant conditions, the plume rises to the water surface, resulting in more lateral spreading.
- For stagnant and low wind conditions, mixing is dominated by the momentum of the effluent jet. Neutral or negatively buoyant plumes are re-entrained by the diffuser, resulting in a recirculation zone around the outfall. These conditions are the most complicated to simulate and result in the highest uncertainties.
- For median to high wind conditions, the effluent plume spreads by advection and shear flow mixing. The dilution potential increases with current speed resulting in a smaller mixing zone.
- The plume will attach to the shoreline for all cases.

4. Conclusion

A total of thirty-six scenarios were simulated for the Second Portage Lake East Dike outfall using the CORMIX model (Doneker and Jirka, 2007). During the summer, the seepage water is anticipated to be a similar temperature as Second Portage Lake, resulting in a neutrally buoyant plume. During the winter, the outfall pipe is heated, and the effluent will be warmer than the lake, resulting in a positively buoyant plume. The predicted plume extents are generally less than 50 m under the most likely summer and winter scenarios. Scenarios with a greater buoyancy differential (e.g. higher TDS concentration) or higher wind speeds are predicted to result in mixing zones between about 100 and 200 m. The largest predicted 1% mixing zone for the summer conditions is 235 m and the largest predicted 1% mixing zone for the winter conditions is 119 m for the design flow rate of 12 L/s. Somewhat smaller mixing zones are predicted for smaller flow rates corresponding to the minimum, mean and maximum daily effluent volumes from 2017 to 2019.

5. References

Agnico Eagle (2014). Letter to Nunavut Water Board, “Re: Water License 2AM-MEA0815 Part D, Item 26 - Submission of East Dike Seepage As-built Report.” October 7, 2014.

Doneker, R., & Jirka, G. (2007). “CORMIX User Manual: A Hydrodynamic Mixing Zone Model and Decision Support System for Pollutant Discharges into Surface Waters”, EPA-823-K-07-001, Dec. 2007.

Environment Canada (2003). "Revised technical guidance on how to conduct effluent plume delineation studies." National Environmental Effects Monitoring Office, March 2003.

Ji, Z. (2008). Hydrodynamics and water quality: modeling rivers, lakes, and estuaries. Wiley, Hoboken, New Jersey.

Rusydi, A. (2018). “Correlation between conductivity and total dissolved solids in varied type of water.” *IOP Conf. Series: Earth Environ. Sci.*, vol. 118, conf.1, pp. 012019.

Wu, J. (1983). “Sea-surface drift currents induced by wind and waves.” *Journal of Physical Oceanography*, vol. 13, pp. 1441-1451.

Appendix A

Extents of Predicted Effluent Plumes

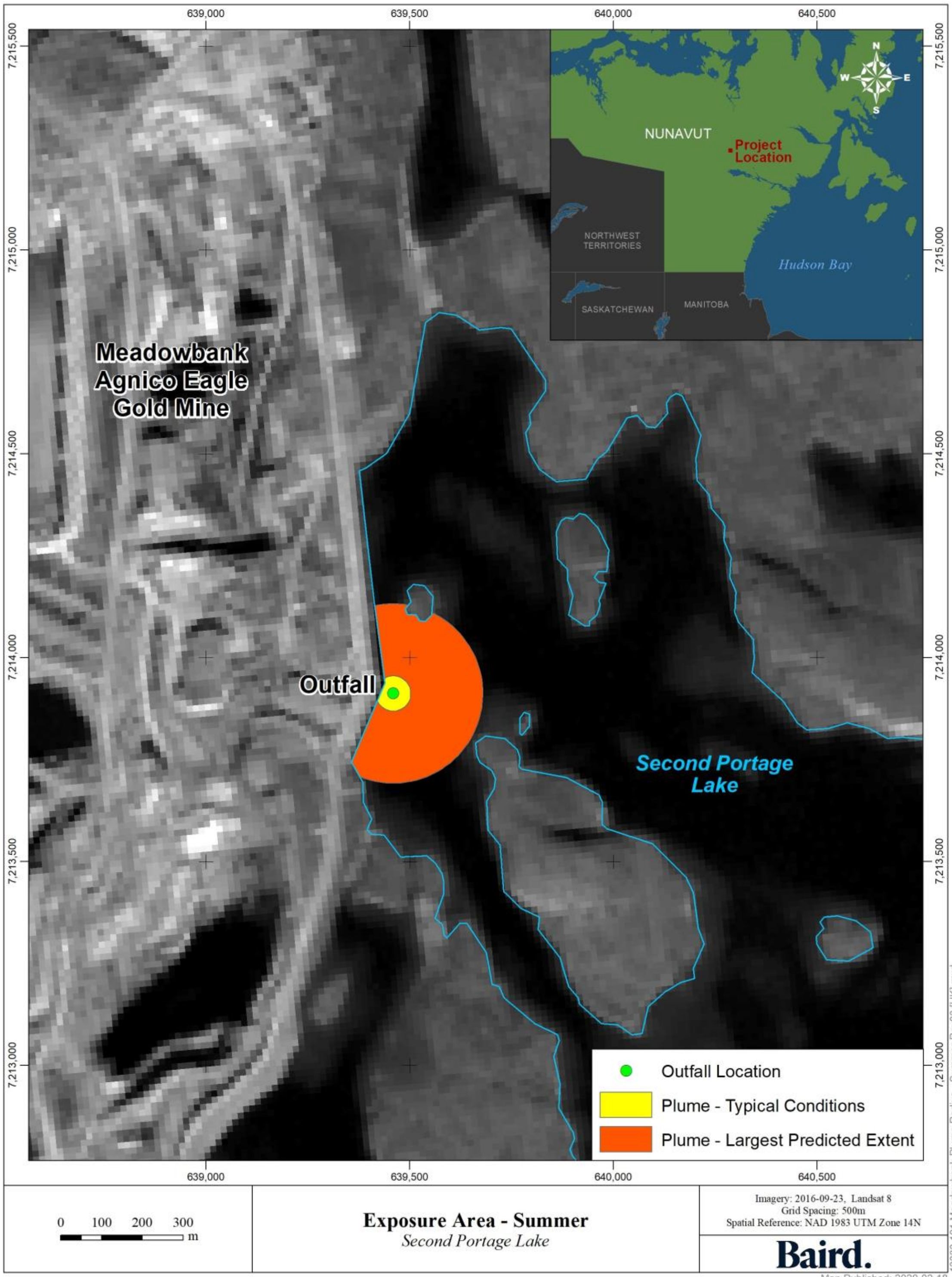

Figure A.1: Summer Conditions - Region of Second Portage Lake where the predicted effluent concentration is greater than 1%. Plume extents shown for typical conditions and for conditions producing the largest plume for flow of 10.8 L/s.

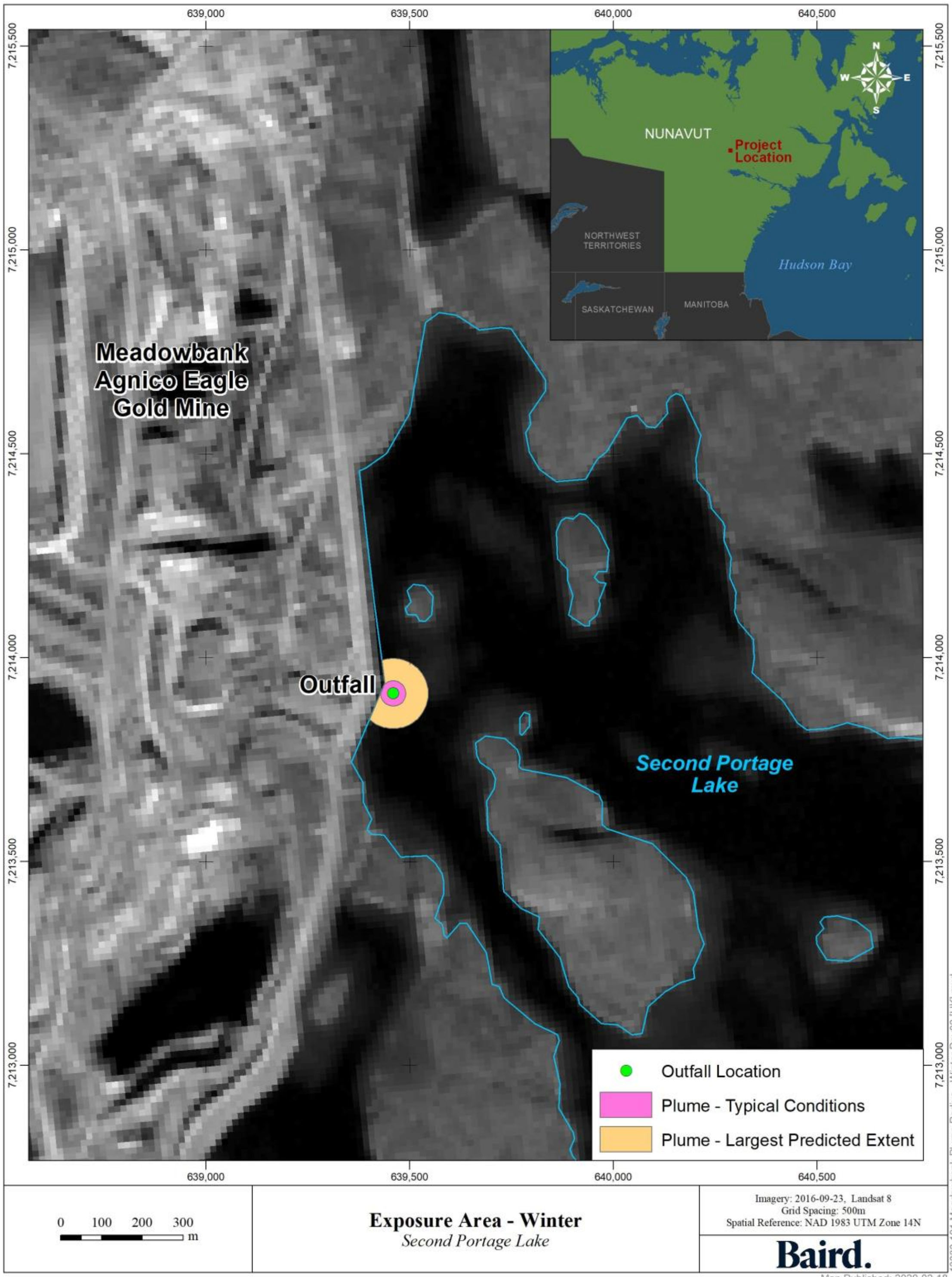

Figure A.2: Winter Conditions - Region of Second Portage Lake where the predicted effluent concentration is greater than 1%. Plume extents shown for typical conditions and for conditions producing the largest plume for flow of 7.9 L/s.

APPENDIX D

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 Meadowbank project lakes:

- Second Portage Lake (SP)
- Inuggugayualik Lake (INUG)
- Third Portage Lake – South Basin (TPS)

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. TPS, SP)
    - 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 (°C), 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. SP-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. SP-1, SP-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. SP-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