Appendix G3

EEM Cycle 3 Study Design

ENVIRONMENTAL EFFECTS MONITORING:

AGNICO EAGLE MINES LTD.- MEADOWBANK DIVISION

CYCLE 3 STUDY DESIGN

Submitted to:

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EXECUTIVE SUMMARY

Agnico Eagle Mines Meadowbank Division is required to conduct the Cycle 3 Environmental Effects Monitoring (EEM) study for its Meadowbank Mine in 2017 pursuant to the companies' requirements under the Metal Mining Effluent Regulations (MMER). The mine (65°N, 96°W) is located approximately 75-km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut. Cycle 1 and Cycle 2 EEM Biological Monitoring Studies were conducted in 2011 and 2014, 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. Treated effluent was last discharged into Third Portage Lake on July 5, 2014, and will not resume.

Currently, the discharge point with the largest volume and that potentially has the most adverse impact on the environment, is in Wally Lake. Therefore this is the Cycle 3 EEM exposure area. 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. The Vault Attenuation Pond is where contact water, mainly from pit water pumping and local mine site drainage water, is currently stored prior to treatment. Discharge from the Vault Attenuation Pond into Wally Lake began in 2014 and has occurred annually since. In 2016, Phaser Lake was dewatered into Wally Lake via the Vault Attenuation Pond.

Beginning in 2014, water that seeps through the East Dike from Second Portage Lake is collected at two points, combined, and pumped back to Second Portage Lake, constituting 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.

During EEM Cycles 1 and 2 the exposure area was in Third Portage Lake North and there were two references areas, Inuggugayualik Lake (INUG) and Pipedream Lake (PDL). In Cycle 1 EEM, Lake Trout (*Salvelinus namaycush*) was the sentinel fish species for the fish study, being the only species captured in sufficient numbers at both the exposure and reference areas. The non-lethal study found no effects on Lake Trout. The benthic invertebrate study found no significant differences between the exposure area and the reference areas 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 reanalyzed 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 ($p \sim 0.27$).

In Cycle 2 EEM, as in Cycle 1, Lake Trout from the exposed area in Third Portage North Lake (TPN) were compared to those from two reference lakes, INUG and PDL. 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 Cycle 2 EEM survey of benthic invertebrates compared the exposure area in Third Portage North Lake with the INUG and PDL reference areas. This is the second invertebrate community survey for the Meadowbank Mine under the MMER. Effects assessment involved use of baseline period data, prior to TPN receiving effluent, used a before-after-control-impact (BACI) design. Benthic communities of the three study areas were similar in 2014, and similar to what had been described in previous years. The communities 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 results of Cycle 1 and Cycle 2 toxicity tests with fathead minnows and *Pseudokirchneriella subcapitata* were similar in that little or no inhibition was observed in any of the samples tested. Inhibition of *Ceriodaphnia dubia* survival and reproduction and of *Lemna minor* growth was often significant but was highly variable from sample to sample in both Cycle 1 and Cycle 2.

The Cycle 3 EEM study design utilizes the same overall design structure as the Cycle 1 and Cycle 2 EEM studies, but the exposure area is now in Wally Lake (WAL). The two reference areas, INUG and PDL, remain the same. Discharge in Wally Lake is from a single orifice diffuser, oriented to discharge vertically upward, located approximately 30 m from shore at a water depth of approximately 6 m. The 1% effluent dilution zone, based field investigations in 2016 and plume modeling includes all of the south basin of Wally Lake and extends approximately 2 km to north from the diffuser.

The proposed Cycle 3 adult fish survey is a lethal study of Lake Trout to be 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 are released.

The design for the Cycle 3 EEM benthic invertebrate community utilizes two reference areas (PDL and INUG) and one exposure area in Wally Lake and will use a before-after-control-impact (BACI) 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 Wally Lake.

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1.0 INTRODUCTION

The Meadowbank Mine is located approximately 75 km north of Baker Lake, Nunavut (Figure 1-1). The Metal Mining Effluent Regulations (MMER), under the Fisheries Act, imposes liquid effluent limits for pH, cyanide, radium, metals and total suspended solids, and prohibits the discharge of a liquid effluent that is acutely lethal to fish. The MMER 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. The primary receiver of effluent is now Wally Lake. Agnico began to discharge effluent from the Vault Attenuation Pond to Wally Lake on July 24, 2014, and has continues to do so. Seepage water is collected along the East Dike and discharged to Second Portage Lake but the volume of that effluent is much less. Based on its composition and volume, the discharge to Wally Lake has the most potential to adversely affect the environment. Therefore, under the MMER, the Cycle 3 EEM exposure area is in Wally Lake.

Schedule 5, Parts 1 and 2 of the MMER requires each operating mine to conduct an EEM program consisting of the following components:

- Effluent characterization and water quality monitoring studies including sublethal toxicity testing; and,
- Biological monitoring studies consisting of a study design, field studies, data assessment and reporting.

The focus of this report is to meet Agnico's obligation to submit an EEM Cycle 3 Study Design report for the Meadowbank Mine, six months prior to beginning field work. The change in effluent discharge location notwithstanding, this EEM Cycle 3 Study Design builds upon the results of the previous 2 EEM cycles (Azimuth, 2010a, 2012a; C. Portt and Associates and Kilgour & Associates Ltd., 2014, 2015). It is proposed that the same basic design, with one exposure area and two reference areas will be used in EEM Cycle 3. While the exposure area for Cycle 3 will be in Wally 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. Meadowbank and Vault general site plans are presented in Figure 1-2 and Figure 1-3, respectively.

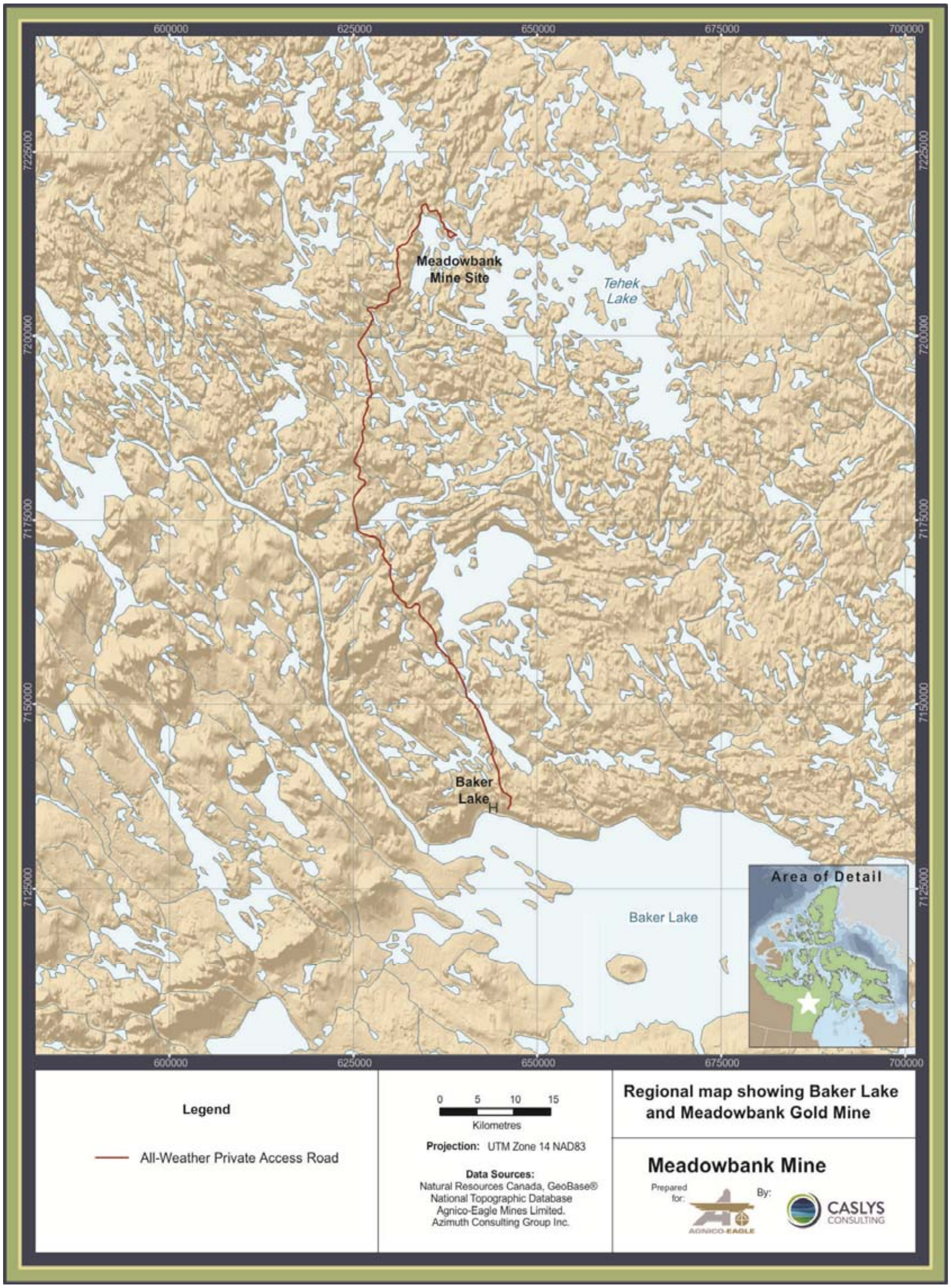

Figure 1-1. Regional map showing Baker Lake and Meadowbank Gold Mine.

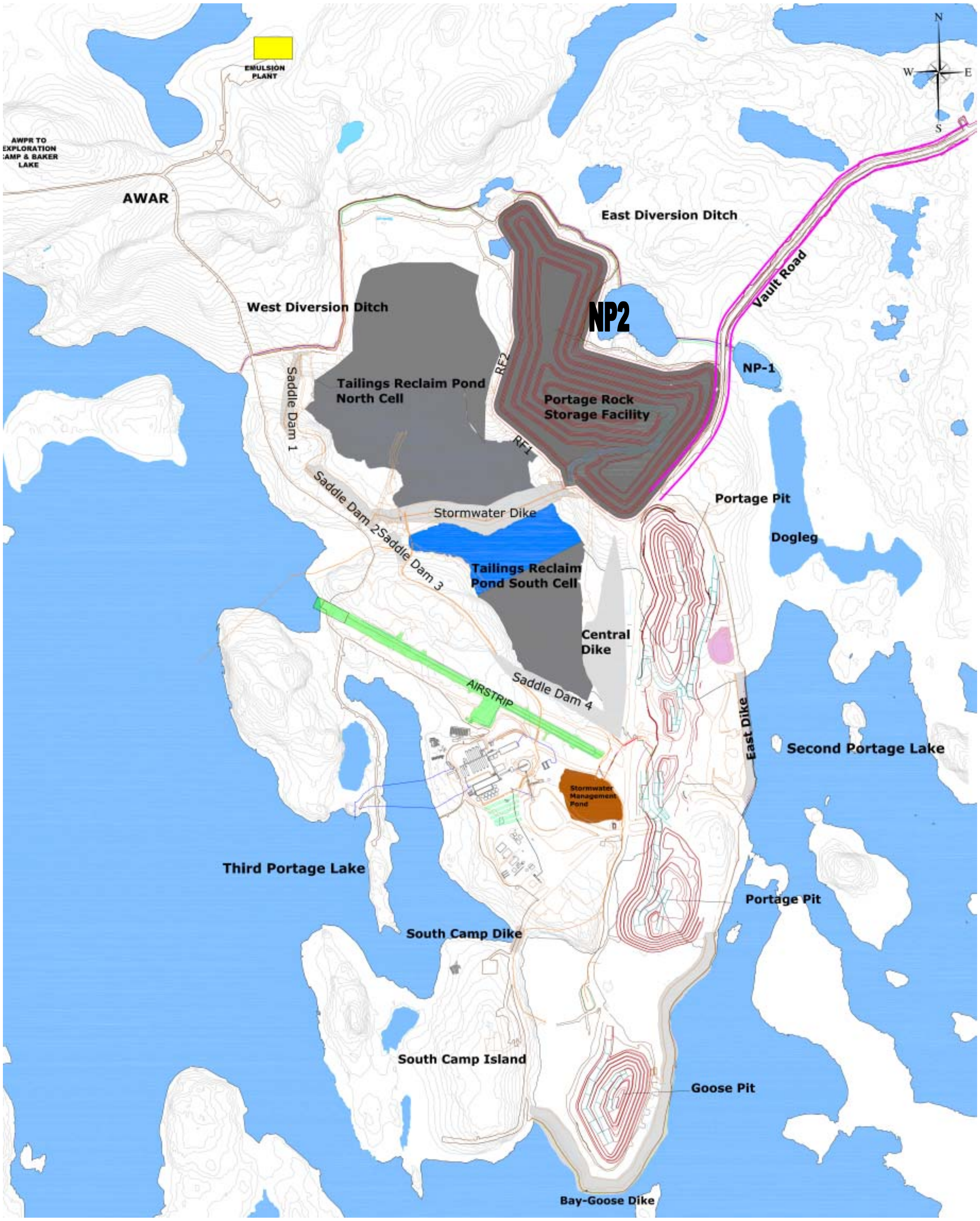

Figure 1-2. Meadowbank General site plan.

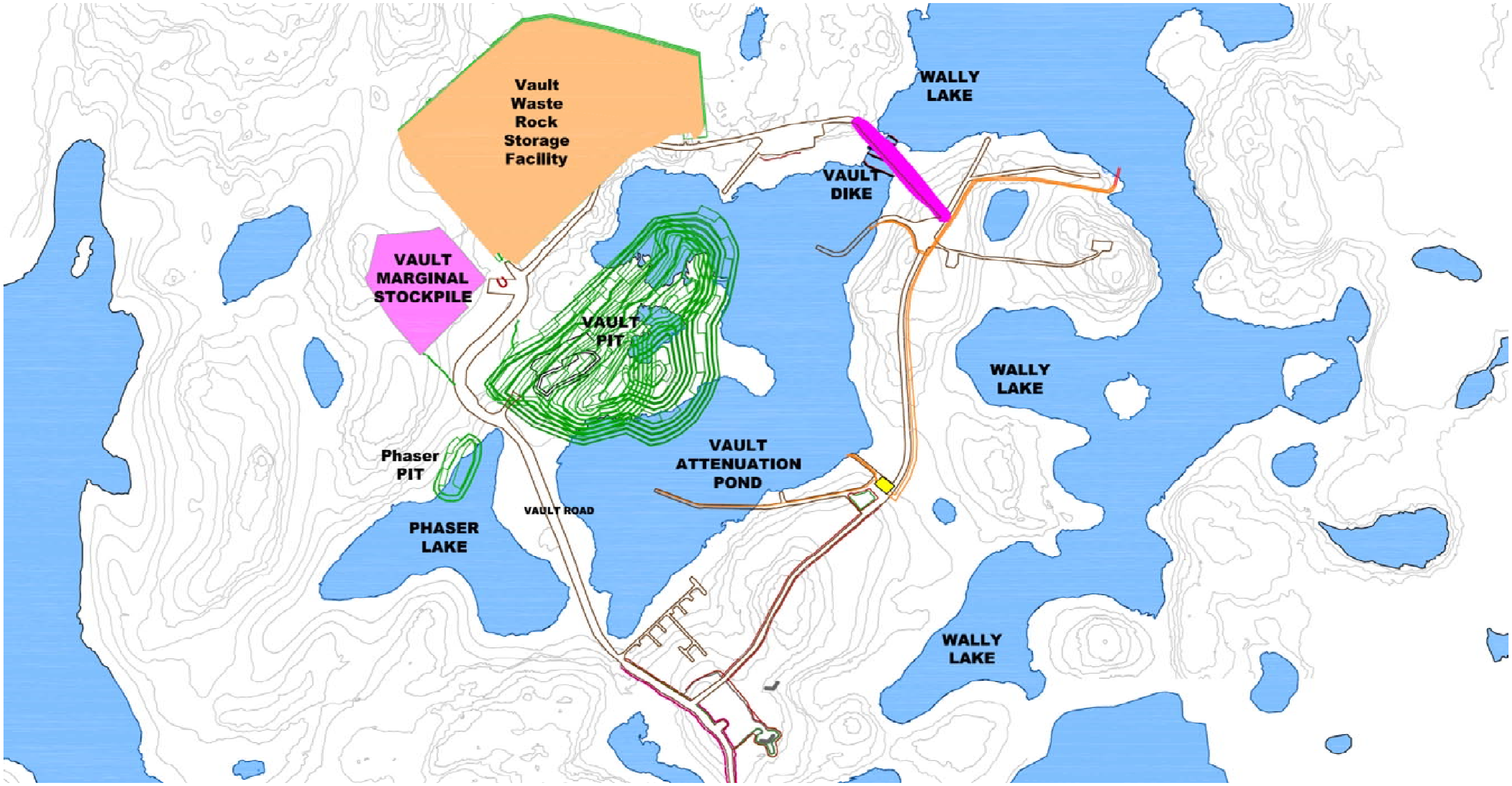

Figure 1-3. Vault general site plan.

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-MEA1525) and Fisheries and Oceans Canada Authorization for Works or Undertaking Affecting Fish Habitat NU-03-0191.3 and NU-03-0191.4. Meadowbank has been in operation since 2009, with mining activities formally underway since March 2010, and projected to continue until Q3 2018. Agnico Eagle has submitted an Environmental Assessment for Whale Tail Pit which is located approximately 65 km north of the Meadowbank site. The intent is to transport ore to Meadowbank for processing. Therefore, if approvals are granted to mine the Whale Tail Pit operations at the Meadowbank facilities will be extended.

A chronology of mine development and operational activities is presented in Table 1-1. Meadowbank and Vault general site plans are presented in Figure 1-2 and Figure 1-3, respectively.

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 Study Design 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. ● HCMP work completed for TP, SP and Dogleg lakes and at water crossing R02 along the all-weather access road. ● One incident of elevated TSS from Vault road culverts to NP-1, early june, during freshet.

Year	Major Mine-Related Activities at the Meadowbank site.
	Barriers installed. No impacts observed to Dogleg Lake.
2016	● No discharge to TPN in 2016. ● Vault discharge to Wally from June to September. No TSS treatment needed. ● East dike (North-South) discharge to Second Portage Lake all year. ● No seepage water from Rock Storage Facility to NP2. Monitoring ongoing. ● Phaser Lake dewatering - August 26th to September 10th and September 15th to October 4th. Water directed to Wally Lake via Vault Attenuation Pond. ● Phaser Lake fish-out from August 13th to 31st and September 10th to 25th. Fish transferred to Wally Lake. ● No Goose Pit re-flooding activities. ● Pit E and pushback assessment. ● Mining focused on Vault Pit and Pit A. ● Amaruq exploration road construction (km 25 at end of 2016).

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.

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 recently 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 (2009-10), dewatering of lakes and impoundments (2009-11, 2013, 2014, 2016), effluent discharge (2012 to present), and general site-related mining activities that mostly generate dust (e.g., rock crushing, blasting, ore and waste hauling; 2008 to present).

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

1.2 Approach

The Metal Mining Effluent Regulations stipulates that study designs subsequent to Cycle 1 should describe the following information:

- 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 description of how the fish survey will be conducted (if the concentration of effluent in the exposure area is greater than 1% in the area located 250 m of any final discharge point). Predicted for Meadowbank.
- A description of how the fish tissue analysis will be conducted (if during effluent characterization the concentration of total mercury in the effluent is equal to or greater than 0.1 µg/L). Not the case for Meadowbank.
- A description of how the benthic invertebrate community survey will be conducted.
- 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). Not applicable to Meadowbank at this time.

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 three 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 MMER.
- *Canadian Environmental Protection Act, 1999* and the Toxic Substances Lists (CEPA, 1999).
- *Nunavut Waters and Nunavut Surface Rights Tribunal Act* (NWNSRTA, 2002) (including the 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 the Aboriginal Affairs and Northern Development of Canada (AANDC). As per NWB Type A License, Part I Section 1, the AEMP (Azimuth 2012b) integrates the results of all monitoring programs informing environmental management of the aquatic receiving environment, including the following relevant monitoring programs (among others):

- MMER/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 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 3 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**Error! Reference source not found.**, the Meadowbank Mine is located approximately 75-km north of the Hamlet of Baker Lake, Kivalliq District, Nunavut. Several lakes, including Second Portage and Third Portage Lake, Vault Lake, 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**Error! Reference source not found.**) 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 and Figure 1-3**Error! Reference source not found.Error! Reference source not found.**. 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 11,300-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. The Vault Attenuation Pond is where contact water, mainly from pit water pumping and local mine site drainage water, is stored and discharged to Wally Lake through a diffuser. Beginning in 2014, water that seeps through the East Dike from Second Portage Lake is collected at two points, combined, and pumped back to Second Portage Lake.

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 Wally Lake, which is a headwater lake just within the Chesterfield Inlet watershed that flows to Hudson Bay. Wally Lake is approximately 3 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 and Figure 1-3.

In general, the Meadowbank Gold project consists of 7 main areas: Portage Pit, Goose Pit, Vault Pit, North Cell tailings storage, South Cell tailings storage, waste rock storage and the mill area (Figure 1-2 and Figure 1-3). Several gold-bearing open-pit deposits have been and will continue to be mined until the end of the mine life. The Portage Pits are presently being mined and will continue to be mined until Q3 2018. Goose- Pit was completely depleted in 2014 so no more mining is planned there. Vault Pit is being mined presently and is expected to continue until 2018. Work at Phaser Pit will begin with stripping at both Phaser Pit and BB Phaser Pit commencing in Q2 2017. The mining of Phaser Pit and BB Phaser Pit will also start in Q2 2017. Much of the infrastructure is located in close proximity to the pits, with the exception of the Vault Pit which is approximately 10 km northeast of the site (Figure 1-3). The open pit mineral reserve is 2.2 million ounces of gold, with an annual production of 360,000 ounces of gold per year, and a mill throughput of approximately 11,300 tonnes/day.

The northwest arm of Second Portage Lake was isolated in 2008 after construction of the East Dike. 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 are disposed of in the South Cell. The Central Dike, which has not reached its final elevation, contains, to the East, the South Cell. Much of the area west of the Central Dike is currently being mined or was mined as part of the Portage Pit.

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 reflooding of Goose Pit.

Presently, mine effluent does not contain water that has come into contact with milled tailings. As previously described, Agnico has two (2) active effluents. Contact water from the Vault Attenuation Pond is discharged to Wally Lake and non-contact water originating from the seepage at the East Dike is discharged into Second Portage Lake. Neither of these discharges has required water treatment to date.

2.3.2 Effluent and Receiving Environment Monitoring

Effluent is presently discharged to the receiving waters at two locations. The largest effluent stream is via a diffuser into Wally Lake and based on its composition, this is the effluent that has the greatest potential to cause harm to the environment. Therefore it is the focus of the Cycle 3 EEM field study. In

2015 and 2016, Wally Lake received effluent from the Vault Attenuation Pond, as well as from the dewatering of Phaser Lake (which was routed through the Vault Attenuation Pond), with total volumes both years exceeding one million cubic metres. In 2017 it is expected that the total discharge will be about half as much as in 2015 and 2016, because the Phaser Lake dewatering is complete. The second and smaller discharge occurs at the East Dyke, where water that seeps through the dyke from Second Portage Lake is collected and pumped via a diffuser back into Second Portage Lake. This second discharge was approximately 180,000 m^3 in 2016.

Mean daily discharge to the Wally Lake receiving environment is provided in Appendix B (Tables B1 and B2). Effluent mixing in the Wally Lake receiving environment is discussed in **Section 2.5**.

MMER (Part 2; Division 2) requires effluent quality monitoring on a weekly basis to ensure that MMER discharge limits are met. Weekly monitoring results for the Wally Lake effluent, from June 10, 2014, to October 10, 2016, are provided in Appendix B (Table B-3). Effluent toxicity test results for acute lethality (MMER Part 2) for the Wally Lake effluent, from June 10, 2014, to October 10, 2016, are provided in Table B-3 in Appendix B. Wally Lake effluent sublethal endpoints for 2015 and 2016, along with associated chemical and physical parameters, are presented in Table 2-1.

Receiving environment water quality monitoring results (EEM Part 1), for Wally Lake, as well as the Third Portage South (TPS) reference area, are presented in Table 2-2**Error! Reference source not found.**. Sampling locations are presented in (Figure 2-1).

Mean daily discharge to Second Portage Lake via the East Dyke diffuser over 2015 and 2016 is provided in Appendix B (Tables B4 and B5), with the weekly effluent monitoring results, including for acute lethality (MMER Part 2), provided in Table B-6. Chemical and physical parameters for effluent from the East Dyke Diffuser are presented in Table 2-3.

Receiving environment water quality monitoring results (EEM Part 1), for Second Portage Lake (SP) are presented in Table 2-4. Sampling locations are presented in Figure 2-1.

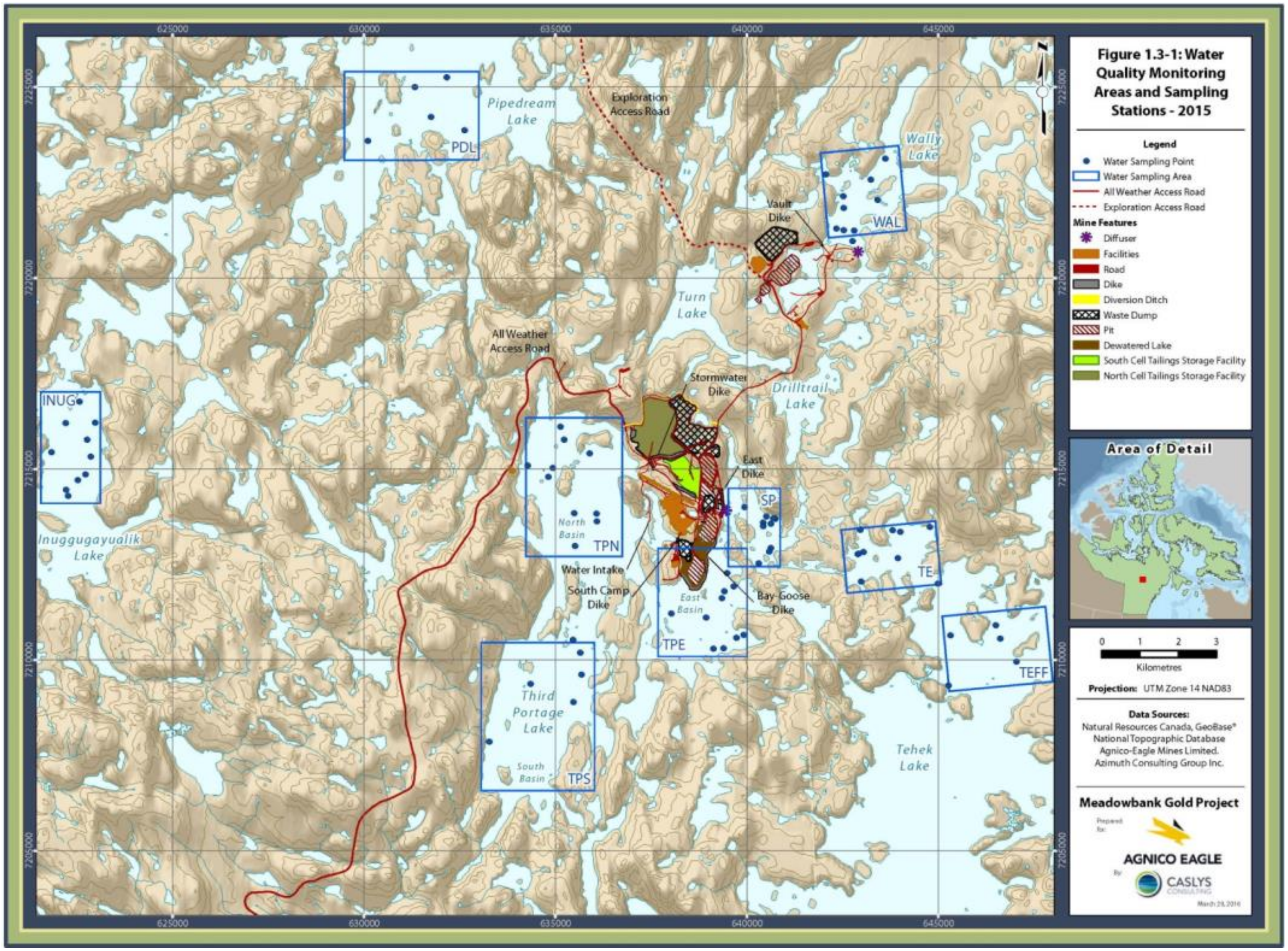

Figure 2-1. CREMP sampling locations. Map courtesy of Azimuth Consulting Group Partnership.

Table 2-1. Sub-lethal endpoints and associated chemical and physical parameters for final effluent (outfall MMER 2) to Wally Lake in 2015 and 2016.

Date **Parameter**	21/07/2015	24/08/2015	18/07/2016	22/08/2016	26/09/2016
Alkalinity (mg CaCO3/L)	34	34	23	28	15
Aluminium (mg/L)	0.018	0.008	0.046	0.161	0.01
Ammonia nitrogen (NH3-NH4) (mg N/L)	0.89	1.19	0.66	1.14	0.01
Cadmium (mg/L)	<0.00002	<0.00002	0.00007	<0.00002	<0.00002
Hardness (mg CaCO3/L)	53	72	67	113	20
Iron (mg/L)	0.08	0.13	0.07	0.45	0.01
Mercury (mg/L) (max allowance of 10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum (mg/L)	0.0031	0.0086	0.0054	0.0142	0.0005
Ammonia (mg N/L)	<0.01	<0.01	<0.01	0.01	<0.01
Nitrate (mg N/L)	1.82	3.97	3.36	6.6	0.24
Selenium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001
Conductivity (µs/cm)	172	178	170	261	179
Temperature (ºC)	4.21	13.4	14.1	15.7	12.52
Fathead Minnow IC25	<1	<1	58.3	64	-
Fathead Minnow LC50	>100	>100	82	>100	-
Ceriodaphnia dubia IC25	1.2	1.1	>100	>100	-
Ceriodaphnia dubia LC50	>100	>100	>100	>100	-
Pseudokirchneriella subcapitata IC25	*>90.91*	*>90.91*	*>90.91*	*>90.91*	-
Lemna minor IC25 dry weight %v/v	<1.03	<1.03	>97	>97	-
Lemna minor IC25 frond number %v/v	>97.09	>97.09	>97	>97	-

Table 2-2. EEM water quality results at Wally Lake (WAL) and TPS for 2015 and 2016 (2 pages; see notes at bottom of table).

Parameter	CCME (2007) Guideline[1]	2015		2016		
		27-Jul	2-Sep	19-Jul	22-Aug	27-Sep
WAL (Exposure Area)						
Alkalinity (mg CaCO$_3$/L)	NG	15	21	14	14	14
Aluminium-Total (mg/L)[2]	0.100 - 0.100	<0.006	<0.006	0.015	0.009	0.024
Ammonia-Total (mg N/L)[2,3]	0.832 - 2.6	<0.01	0.03	0.01	0.02	0.07
Arsenic-Total (mg/L)	0.0050	<0.005	<0.0005	<0.0005	0.002	<0.0005
Cadmium-Total (mg/L)[4]	0.0000065 - 0.0000087	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Copper-Total (mg/L)[4]	0.002 - 0.002	0.0009	0.0007	0.0007	0.0013	0.0007
Cyanide-Total (mg/L)	NG	<0.005	0.009	<0.001	<0.001	<0.001
Dissolved oxygen-Field (mg/L)	NG	8.62	14.63	-	-	-
Hardness (mg CaCO$_3$/L)	NG	17	20	15	21	21
Iron-Total (mg/L)	0.3	0.01	0.02	0.02	0.02	0.02
Lead-Total (mg/L)[4]	0.001 - 0.001	<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
Molybdenum-Total (mg/L)	0.073	<0.0005	0.0009	<0.0005	<0.0005	0.0006
Nickel-Total (mg/L)[4]	0.025 - 0.025	<0.0005	0.0006	<0.0005	0.0005	0.0007
Nitrate-Total (mg N/L)	2.9	0.14	0.44	0.12	0.18	0.17
pH-Field	6.5 - 9.0	7.27	6.84	7.58	7.62	7.42
Radium-226 (Bq/L)	NG	<0.002	<0.002	<0.002	-	-
Selenium-Total (mg/l)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Temperature-Field (°C)	NG	12.6	9.8	13.3	16.1	-
Total suspended solid (mg/L)	NG	2	5	2	6	3
Zinc-Total (mg/L)	0.030	<0.001	<0.001	<0.001	<0.001	0.001
Conductivity (µs/cm)	NG	41	85	34	49	102

	CCME (2007)	2015					2016			
Parameter	**Guideline[1]**	**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]	0.0000038 - 0.0000042	<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 2-3. Chemical and physical parameters for final effluent (outfall MMER 3) to Second Portage Lake in 2015 and 2016.

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 2-4. EEM water quality results at Second Portage Lake (SP) for 2015 and 2016 (see notes at bottom of table).

	CCME (2007)	2015				2016			
Parameter	Guideline[1]	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]	0.0000053 - 0.0000076	<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)

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 2017 that may confound the planned EEM biological monitoring studies. Furthermore, given the location of the final discharge point relative to the main mine site (i.e., to the NE of the main site) and the prevailing winds (i.e., from the NW), site-related dust inputs from the main site should not be significant. However, the Vault Pit is to the west of the southern portion of Wally Lake, and so the prevailing winds may deliver dust from the Vault Pit, most often to the portion of Wally Lake that is south of the outfall location. This may be the only confounding "mine-related" factor in the Cycle 3 study.

2.5 Effluent Mixing

The effluent discharge location has changed since EEM Cycle 2 – there is no more discharge from the South Cell Attenuation Pond to Third Portage Lake. Beginning on June 20, 2014, the effluent from Vault Attenuation Pond has been discharged to Wally Lake via a diffuser at the location shown in Figure 2-2.

Effluent mixing in Wally Lake was modeled by W.F. Baird & Associates Coastal Engineers Ltd. (Baird) in 2017 (Appendix C). Baird used the CORMIX model to predict plume mixing and dilution under combinations of four lake current conditions (near stagnant, low wind, average wind, and high wind) and three effluent buoyancy conditions (neutral, positive and negative) for a total of 12 different scenarios. Due to the vertical orientation of the diffuser, the direction of the current does not affect the mixing distance. Key results were as follows:

- Effluent dilution of 100:1 was generally not achieved within 250 m of the effluent discharge outfall for most scenarios, including the typical condition (this triggers the fish study).
- The typical scenario of median wind and positively buoyant effluent resulted in a distance of 800 m to attain 1% dilution, and a dilution of 18:1, or 5.6% dilution, at 250 m.
- The largest mixing zone to attain 1% dilution is predicted for a negatively buoyant discharge at stagnant to low wind conditions (approximately 2000 m).
- The smallest mixing zone to attain 1% dilution is predicted for a negatively buoyant discharge at high wind conditions (approximately 165 m).
- The plume will attach to the shoreline for all cases.

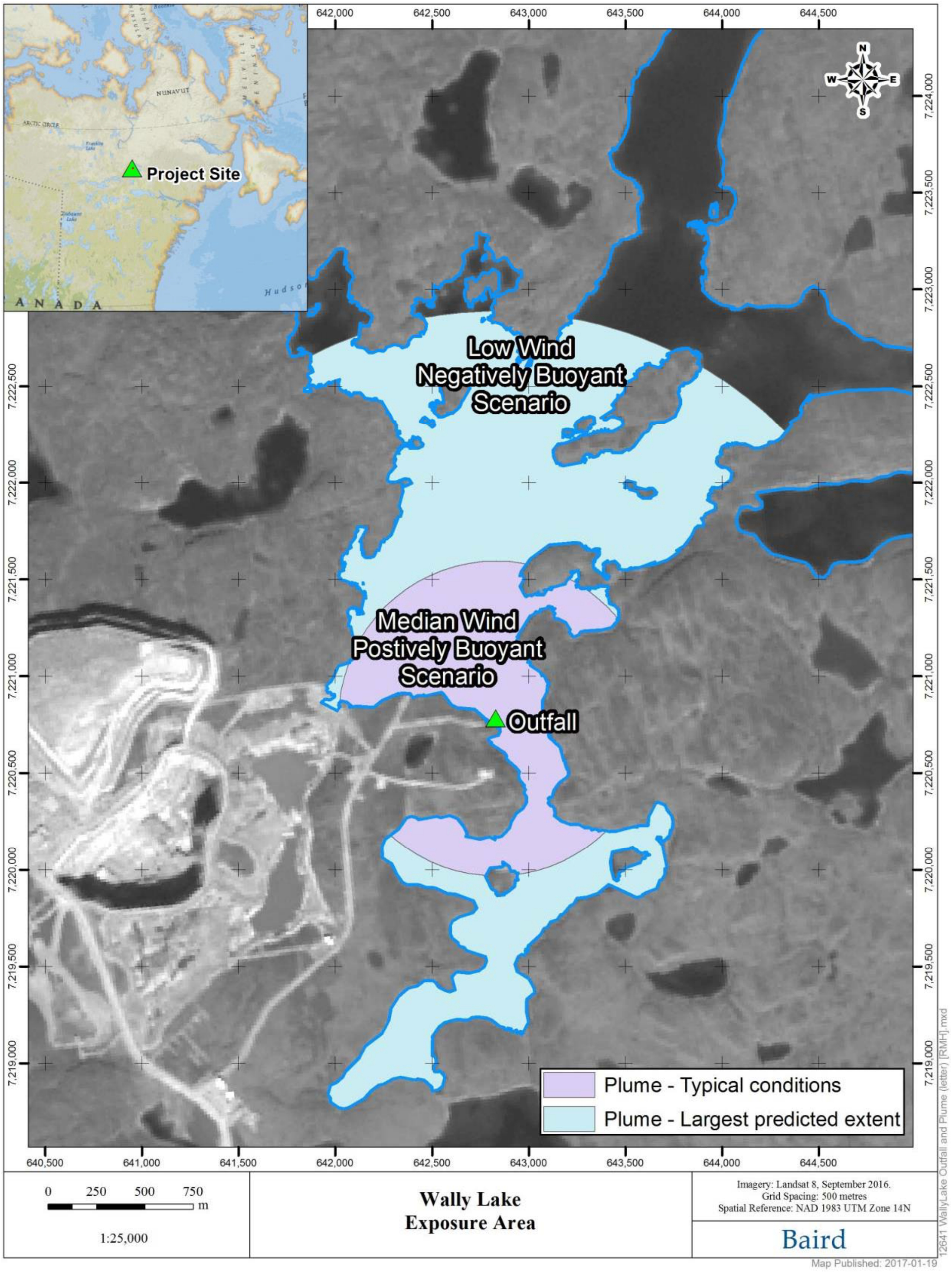

Figure 2-2. Diffuser (outfall) location and modeled plume extents. Source Baird Associates, 2017 (see Appendix C).

A field investigation of the Wally Lake effluent plume was conducted in 2016 by Agnico Eagle and C. Portt and Associates (Appendix D) using specific conductance as an effluent tracer. The effluent was generally completely or nearly completely mixed vertically and there was no thermal stratification. Effluent discharge commenced on July 16, 2016. On July 24, the effluent concentration was approximately 5% in the vicinity of the diffuser and on August 10 it was approximately 10% in the vicinity of the diffuser. On August 13 the effluent concentration exceeded 10% in the immediate vicinity of the diffuser and exceeded 1% at the farthest sampling station, 1.9 km from the diffuser.

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

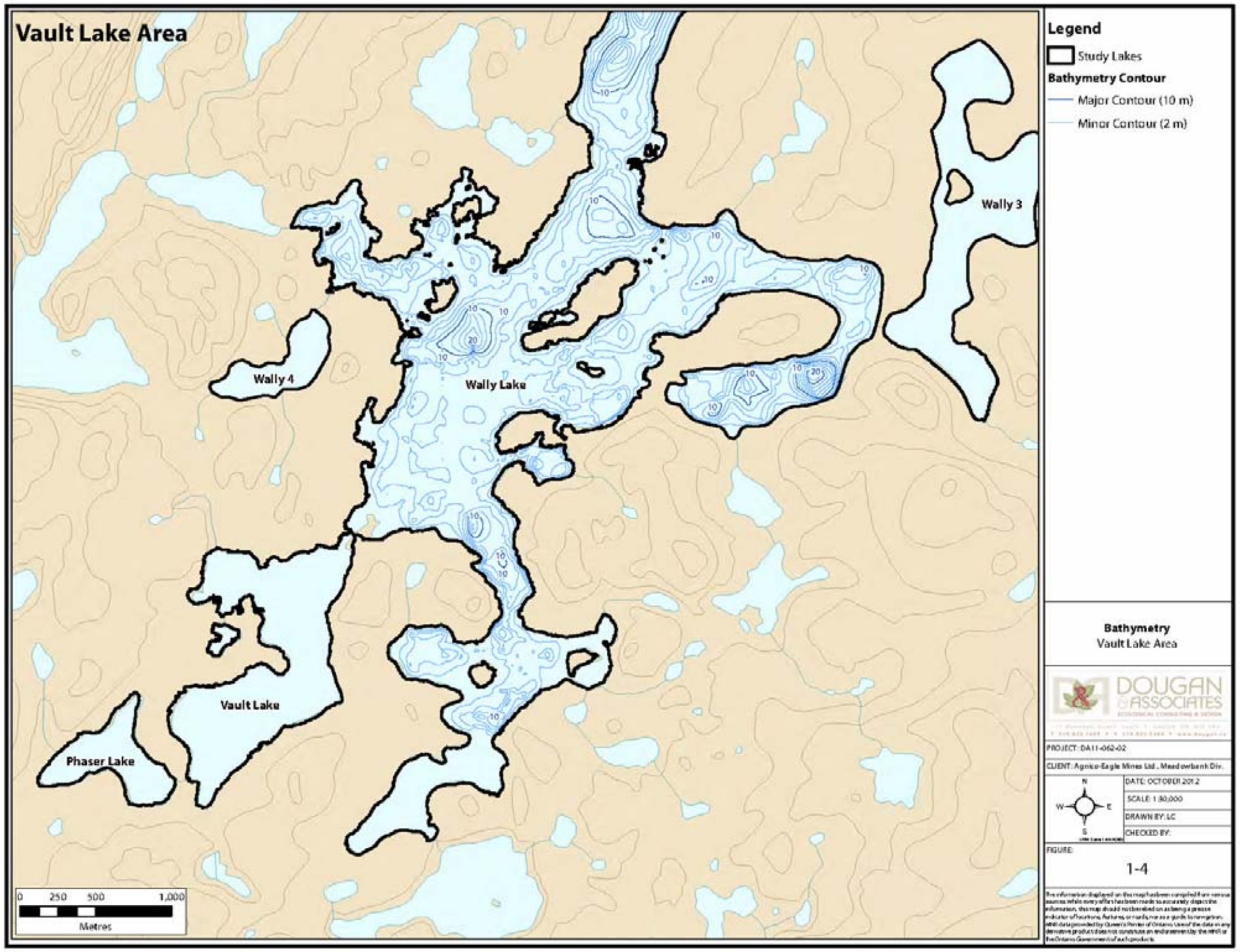

Figure 2-3. Wally Lake, illustrating the typical complex shorelines and bathymetric variability of study area lakes.

observed inter-basin and inter-lake differences in productivity (see Section 2.6.5.1 for further discussion).

2.6.2 Limnology

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

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, 2013).

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 at least 14°C by late July and early August (Azimuth, 2016).

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, 2013).

Monthly/annual profiles at control areas (INUG, PDL), up to 2015, 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 2015 were consistent with what has been observed in the past (Azimuth, 2016).

Additional detail regarding Limnology is provided in the Cycle 1 EEM study design report (Azimuth, 2010a) and the CREMP 2015 Annual Report (Azimuth, 2016).

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

- Metals –Mean total antimony, arsenic, cadmium, chromium, copper, mercury, and nickel concentrations from Third Portage, Second Portage, and the other project lakes were all below laboratory detection limits. With the exception of cadmium, the metals were well below CCME (2001) water quality guidelines for the protection of aquatic life. In the case of cadmium, the detection limit is greater than the CCME (2001) guideline, and therefore it is unknown if the actual cadmium concentration exceeds the guideline. The only metals to exceed detection limits were aluminum (0.006 to 0.014 mg/L), lead (up to 0.0012 mg/L), and zinc (0.001 to 0.019 mg/L). Overall, metals concentrations are typically low and the low frequency of detectable results makes it difficult to identify meaningful differences in baseline conditions among lakes, seasons or years.

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 is now 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. It is important to keep in mind that impact status does not necessarily meaning 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. Final dewatering of

Vault Lake into Wally Lake occurred in the latter half of June 2014. Upon completion of the dewatering, the former Vault Lake is referred to as the Vault Attenuation Pond. Discharge from the Vault Attenuation Pond into Wally Lake began in 2014 and has occurred annually since. Also, in 2016, Phaser Lake was dewatered into Wally Lake via the Vault Attenuation Pond.

The most recent CREMP results that have been reported are from 2015 (Azimuth, 2016). The 2015 CREMP identified statistically significant increases in Wally Lake, relative to baseline conditions, using a BACI statistical model, for conductivity, hardness, calcium, magnesium, and total Kjeldahl nitrogen (TKN). These increases appear to be related to mining activities. There are no CCME guidelines for these five parameters and the observed concentrations, while increasing relative to baseline/reference conditions, are not thought to pose a threat to aquatic life (Azimuth, 2016). 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.

Within CREMP, sediment coring is conducted on a three-year cycle to coincide with EEM field studies. Coring was last conducted in 2014 and will be conducted next in 2017. The 2014 core samples indicated a slight increase in lead and a moderate increase in zinc concentrations that were statistically significant based on the BACI statistical model. For both metals, the higher values were thought to be due to localized spatial heterogeneity and not to be mine-related (Azimuth, 2016). Grab samples submitted for analysis in 2015 showed similar concentrations to previous years based on visual comparison of the data (Azimuth, 2016).

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 2015 were within the range of reference/baseline conditions in each area (Azimuth, 2016). 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, 2011b, 2012c, 2013, 2014, 2015b, 2016).

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, 2011b, 2012c, 2013, 2014, 2015b, 2016) 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 Tehek Lake.

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).

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).

3.0 EEM CYCLE 3 STUDY DESIGN OVERVIEW

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

Discharge in Wally Lake is from a single orifice diffuser, oriented to discharge vertically upward, located approximately 30 m from shore at a water depth of approximately 6 m. The 1% effluent dilution zone, based field investigations in 2016 (Appendix D) and the plume delineation study (Appendix C) includes all of the south basin of Wally Lake and extends approximately 2 km to north from the diffuser (see Section 2.5).

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 (Third Portage North (TPN) during EEM Cycles 1 and 2, and WAL proposed for Cycle 3).
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 approaches for the fish study and benthic invertebrate study are discussed in greater detail in **Sections 4 and 5,** respectively.

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

EEM Sampling Area		UTM location (14NAD83)*	
Type	Name	Latitude (E)	Longitude (N)
Exposure	Wally Lake (WAL)	642893	7220883
Reference	Inuggugayualik Lake (INUG)	622797	7216811
Reference	Pipedream Lake (PDL)	630451	7223331

* UTM indicates the approximate centre of the sampling area.

4.0 FISH SURVEY

Third Portage North (TPN) was the exposure area for the EEM Cycle 1 and Cycle 2 studies. There has been no discharge to TPN since July 5, 2014, and Wally Lake (WAL) is the exposure area for the Cycle 3 EEM study. The results of the previous two EEM cycles are relevant to the Cycle 3 study design and are summarized in Sections 4.1 and 4.2. The Cycle 3 study design is described in Section 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). 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. 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 as a consequence of handling after their release.

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 4-1), 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, there were only six females that contained eggs that were developed to the stage that they would be expected to spawn that year and 20 males with 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 Study Design

4.3.1 Sentinel Species and Study Type

The exposure area for the Cycle 3 EEM study is in Wally Lake (WAL) and no previous EEM or similar fish studies have 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 ().

Table 4-5). The transferred Lake Trout were tagged with Floy tags but, inevitably, some of those tags will be shed meaning that the origin of Lake Trout captured in Wally Lake cannot be known with absolute certainty. The transfer of fish to Wally Lake has the potential to affect each of the EEM fish survey endpoints of Wally Lake fish. Therefore, the fish transfers will confound attempts to determine the cause if fish surveys in Cycle 3 and future EEM cycles demonstrate differences between Wally Lake and the reference lake(s).

Table 4-5. Number of fish transferred to Wally Lake during fish-outs of Vault and Phaser Lakes in 2014 and 2016.

	Source		
Species	**Vault Lake (2014)**	**Phaser Lake (2016)**	**Total**
Lake Trout	1086	334	1420
Round Whitefish	569	538	1107
Burbot	59	103	162
Arctic Char	54	0	54
Total	1768	975	2743

Although the EEM exposure area will be Wally Lake instead of Third Portage North (Figure 4-1), 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) remains valid. Environment Canada supported this study design for future EEM studies following their review of the Cycle 2 EEM interpretive report (letter from Suzanne Forbrich, Environment Canada, to Stephane Robert, Agnico Eagle, dated January 20, 2017). Following that 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. This recommendation has been incorporated into this 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 have been collected. Although the additional data are not required in order to achieve adequate sample sizes, measurement of length and weight of released individuals has been incorporated into this proposed study design. The removal of pectoral fin rays from fish prior to release is not proposed, 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. We are of the opinion that subjecting released fish to this discomfort, and possible post-release complications, is not justified by benefits to the study.

The Cycle 2 interpretive report recommended that if Third Portage Lake was the exposure area for future EEM cycles only Pipedream Lake be sampled as a reference area, as it is more similar to Third Portage North than INUG in nearly all of the effect and supporting endpoints that were examined for fish. Given that the exposure area for the Cycle 3 EEM study is Wally Lake, for which there are no previous EEM fish survey data, this recommendation is not relevant. It is proposed that two reference areas, Pipedream and INUG Lakes, be used for the study, as was done in Cycles 1 and 2.

In summary, the proposed Cycle 3 adult fish survey is a lethal study of Lake Trout to be 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 are released.

4.3.2 Study Methods

4.3.2.1 Fish Collection

Timing

Sampling will be conducted in the latter half of August, 2017, which is consistent with the Cycle 1 and Cycle 2 EEM sampling.

Gear

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

Net deployment and retrieval

Gill nets will be set within each sampling area, with the specific locations determined based on local habitat conditions. The UTM coordinates of each end of each net will be recorded, as will depth and the date and time of deployment and retrieval. Set duration will be determined in the field based on local conditions, with the objective of capturing 20 Lake Trout and minimizing the mortality of additional Lake Trout and incidental catch. The number of individuals of each species captured in each net will be recorded.

Supporting Environmental Variables

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

4.3.2.2 Lake Trout Measurements

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

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

Otoliths and first pectoral fin rays will be collected from fish that are lethally sampled and placed in envelopes labeled with the sampling area, date, species, and specimen number. Otoliths will be mounted whole on a glass slide, ground to the core on one side, flipped to adhere the core area to the glass, and then ground to a thin section on the other side. The proximal end of each fin ray will be ground flat and then cut away from the rest of the ray. The flat proximal end will be mounted on a glass slide and the remaining fin ray ground away to leave a thin section. Age will be estimated based on the number of annuli counted using transmitted light and stereo microscope. The number of annuli on fin rays and otoliths will be determined independently (i.e. without reference to each other) when both were available for a fish. As a QA/QC measure, annuli will be counted by a second person for at least 10% of the otoliths and fin rays.

4.3.2.3 Statistical Analysis

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

Initial Data QA/QC

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

Calculated Indices

Condition (K) will be calculated using the formula:

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

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

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

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

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

Summary statistics and comparisons of size

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

ANCOVA analyses

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

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

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

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

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

$$\%\text{Difference} = \frac{\overline{x}_{\text{exposure}} - \overline{x}_{\text{reference}}}{\overline{x}_{\text{reference}}}$$

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

Power analysis

Post-hoc power analysis will be conducted to determine the ability of the Cycle 3 EEM to detect the specified critical effect size for each of the parameters examined.

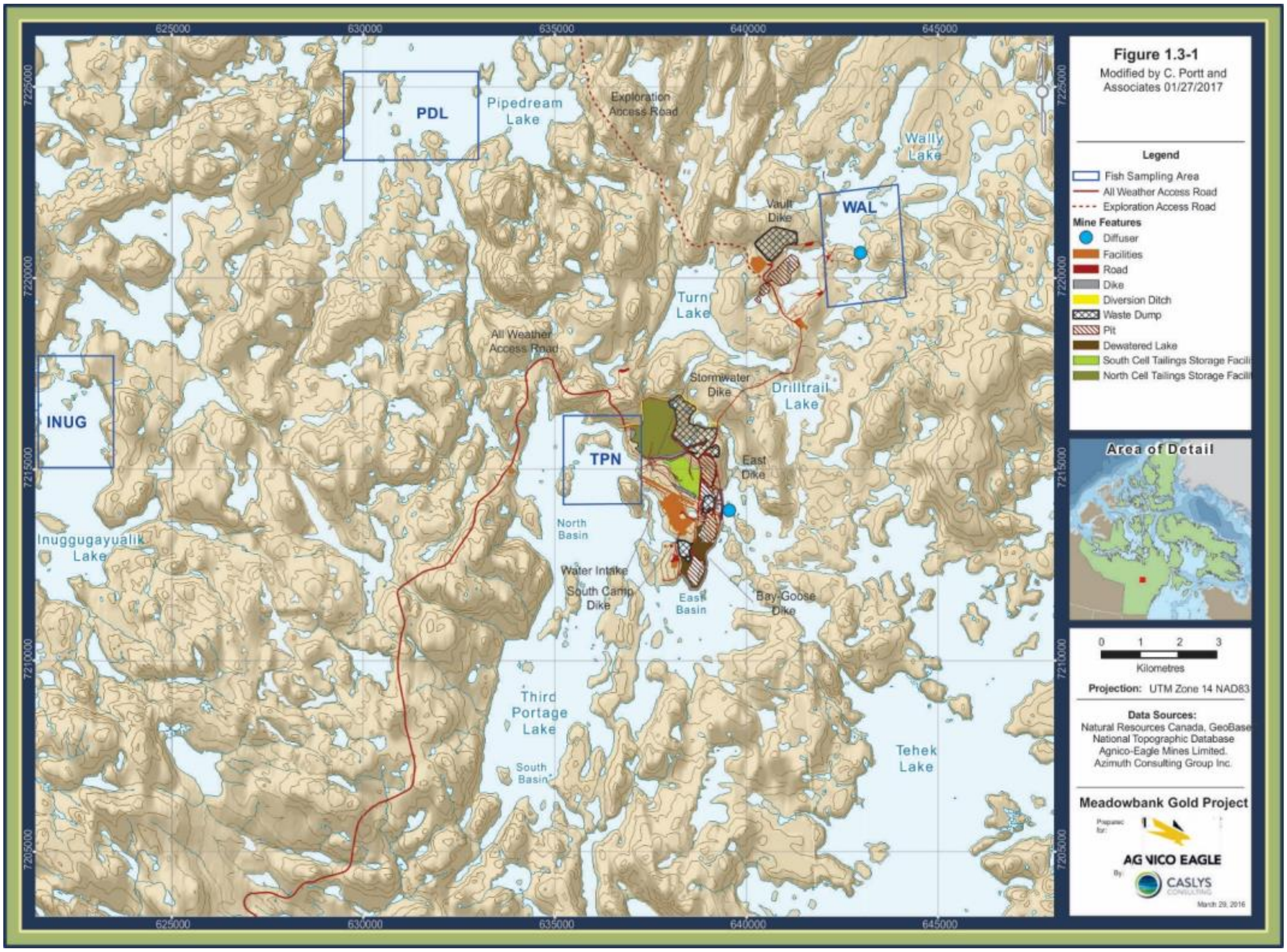

Figure 4-1. Fish reference areas PDL and INUG (Cycles 1, 2 and 3), and exposure areas TPN (Cycles 1 and 2) and WAL (Cycle 3). Map courtesy of Azimuth Consulting Group Partnership, modified by C. Portt and Associates.

5.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

5.1 Pre-Design Information

Agnico Eagle has been sampling benthic macroinvertebrates annually from various reference and exposed lakes in the general study area since 2006 (Table 5-1). The sampling area in Wally Lake (WAL) was in a 'control' or baseline condition from 2006 to 2012, and has been considered to be in an 'impact' or 'exposed' condition since July 2013 when construction activities for the Vault deposit were initiated. There are two reference areas proposed for this EEM program; one in Inuggugayualik Lake (INUG) and the other in Pipedream Lake (PDL). These two reference areas were used in the two EEM studies completed for the Meadowbank Mine when the mine was discharging to Third Portage Lake North (TPN). INUG and WAL have 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 (Table 5-1).

The benthos in WAL, INUG and PDL 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 ~ 8% in WAL, ~4% in INUG, and ~ 3% in PDL) based on 2015 data (Azimuth, 2016).

The benthic communities have been most recently documented in the 2015 CREMP report (Azimuth 2016). 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 2,000 organisms per m^2 (Figure 5-2), and with ~10 to 15 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), Ostracods and larval caddisflies (Trichoptera) (Figure 5-4, and see Azimuth 2016). Chironomids in INUG, PDL and WAL have generally included many common forms. *Procladius*, *Stichtochironomus* and *Psectrocladius* (all common) were each found in relatively high abundances in each of the lakes in August 2015. *Tanytarsus* (common) was abundant in INUG and WAL, but not abundant in PDL in 2015). *Microtendipes* (common) was abundant in INUG but not PDL or WAL in 2015. *Monodiamesa* (a classic indicator of oligotrophic conditions) was present in all three lakes, but in low numbers (in 2015). All of the chironomids occurring in WAL, INUG and PDL are relatively commonly distributed across the north and south of Canada (Thorp and Covich, 2001). The limnelphilid caddisfly *Grensia praeterita*, was found in low numbers in each sampling area (WAL, INUG, PDL) in 2016). The fingernail clams were represented by *Pisidium nitidum* and *Sphaerium nitidum* (Arctic fingernail clam), two relatively common forms (Clarke, 1981). Ostracods were relatively common, as were lumbriculid worms, and nematodes.

Table 5-1. CREMP benthic invertebrate community monitoring.

Year	Reference		Near-Field				Mid-Field		Far-Field
	INUG	PDL	TPN	SP	TPE	WAL	TPS	TE	TEFF
2006	C		C	C	C	C	C	C	
2007	C		C	C	C	C	C	C	
2008	C		C	I	C	C	C	I	
2009	C	C	I	I	I	C	C	I	C
2010	C	C	I	I	I	C	C	I	C
2011	C	C	I	I	I	C	C	I	C
2012	C	C	I	I	I	C	C	I	C
2013	C	C	I	I	I	I	C	I	C
2014	C	C	I	I	I	I	C	I	C
2015	C	C	I	I	I	I	C	I	C
2016	C	C	I	I	I	I	C	I	C
2017	C	C	I	I	I	I	C	I	C
Total C Years	12	9	3	2	3	7	12	2	9

Table Note: the letter "C" denotes a control, or baseline, year. The letter "I" denotes an 'impact' year. A blank indicates data were not collected.

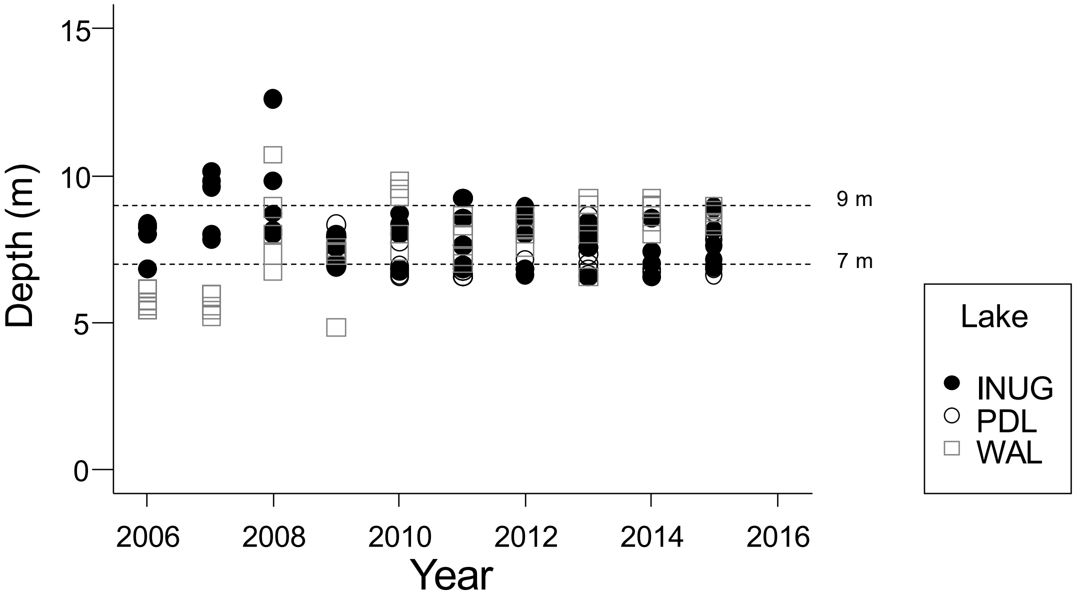

Figure 5-1. Variations in depths of sampled benthic macroinvertebrate communities between 2006 and 2015 in INUG, PDL and WAL, at the proposed sampling areas. (Source: Azimuth, 2016)

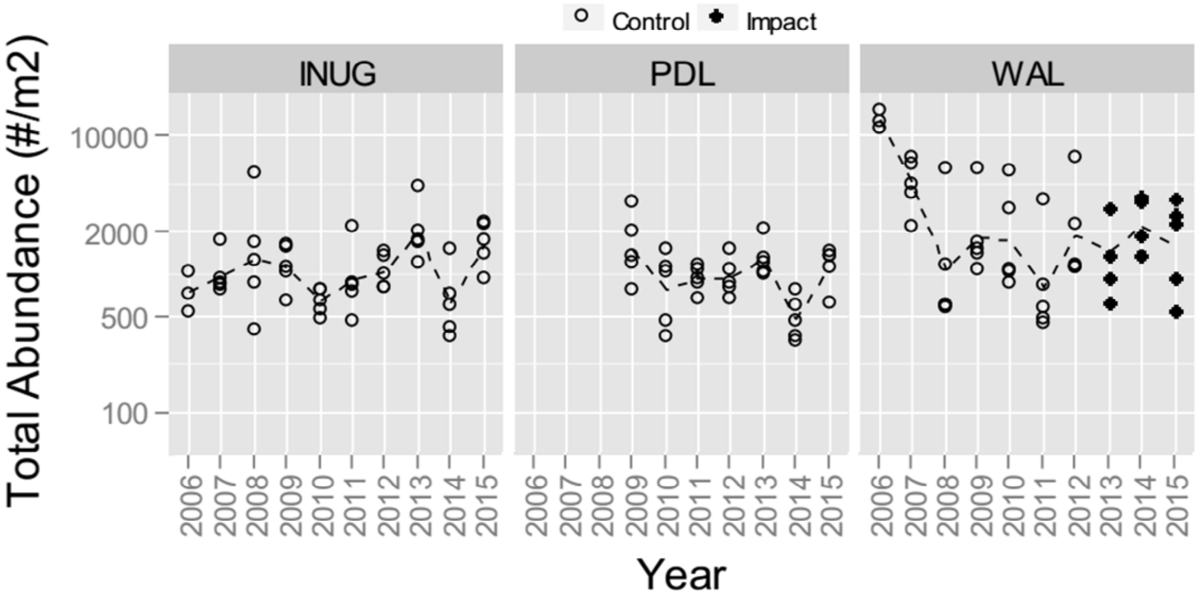

Figure 5-2. Variations in total abundances of benthic macroinvertebrates in INUG, PDL and WAL from 2006 to 2015. (Source: Azimuth, 2016)

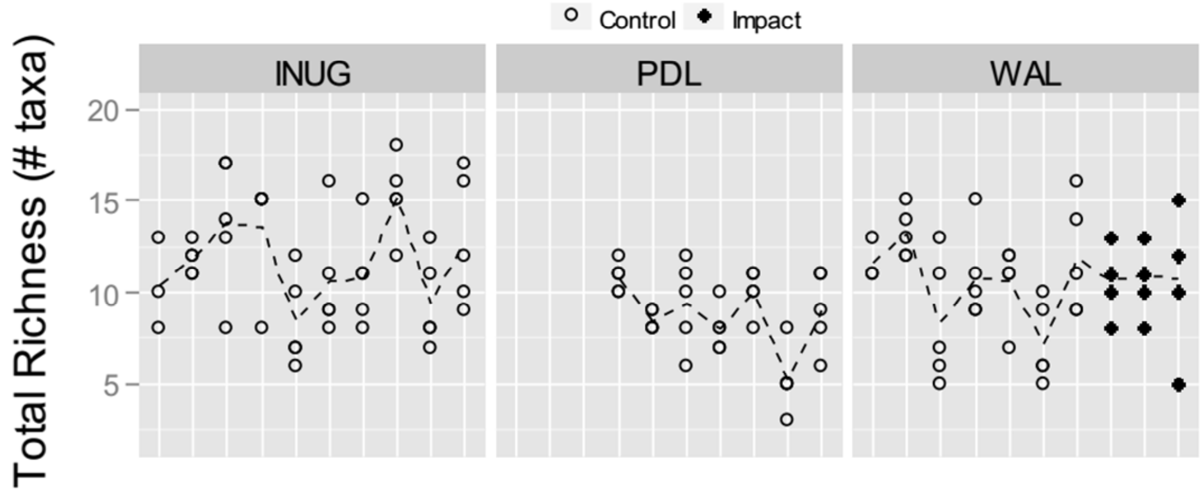

Figure 5-3. Variations in taxa richness of benthic macroinvertebrates in INUG, PDL and WAL from 2006 to 2015. Note that taxa richness in this figure is based on identification to lowest practical taxonomic level, and is higher than will be reported in the EEM report (which will report Family richness). (Source: Azimuth, 2016)

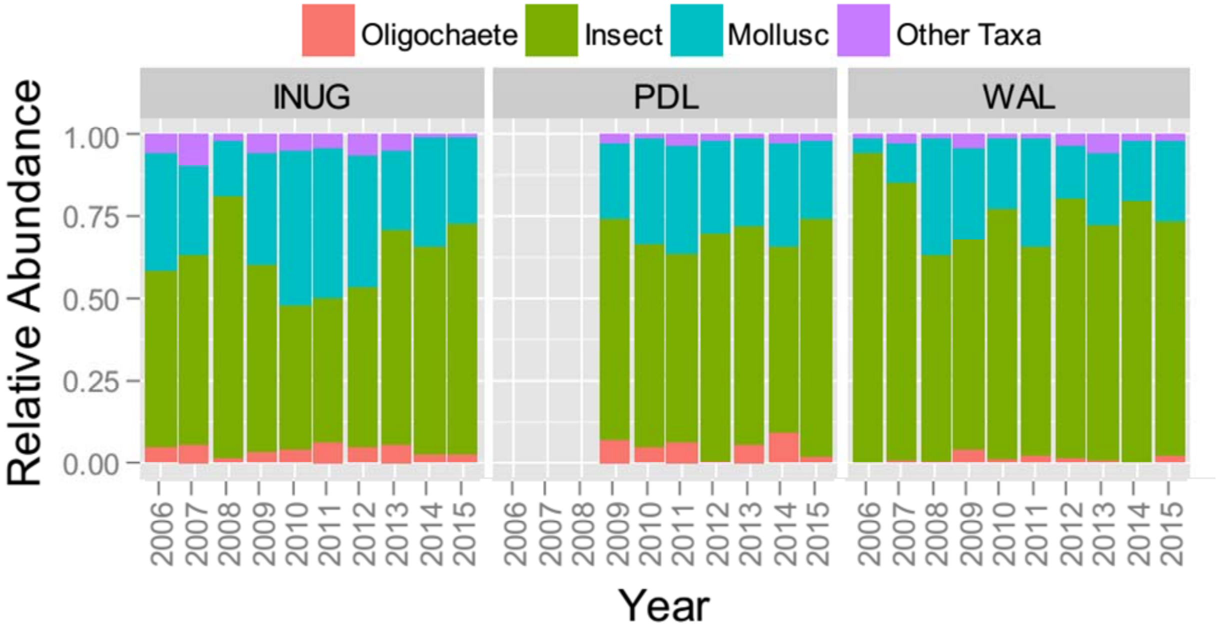

Figure 5-4. Variations in composition of benthic macroinvertebrate communities in INUG, PDL and WAL from 2006 to 2015. (Source: Azimuth, 2016)

5.2 Benthic Invertebrate Community Survey

5.2.1 Statistical Design

The design for the first EEM benthic invertebrate community survey for Wally Lake is proposed to be an extension of the annual monitoring that has already been undertaken by the CREMP and, except for the change in exposure area, similar to the Cycle 2 EEM study. There will be two reference areas (one each in Pipedream Lake (PDL) and INUG), and one exposure area in Wally Lake (WAL) (Figure 5-5). Five stations will be nested within each reference 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. Sampling stations will be a minimum of 20 m apart to ensure independence of stations.

Variability among stations will be used to judge the significance of variations among areas. Stations are therefore the unit of replication. Stations have been randomly selected each year that the sampling has been carried out under CREMP; that is, stations are a random assortment each year. Sampling this year in WAL, INUG and PDL will be similarly undertaken, with five sampling stations somewhat 'randomly' selected by the field crew, but given the constraints of depth and spatial separation per the previous paragraph. Sampling areas are defined by the circles in Figure 5-5.

5.2.2 Sampling Method

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

The rationale for collecting duplicate samples per station, and compositing them, is based on the following: Benthos sampling at Meadowbank under the CREMP has always involved the compositing of duplicate samples (see Azimuth, 2016). The collection and compositing of duplicate samples will thus allow the 2017 EEM program to use and compare observations for WAL to historical data for WAL, and to historical data for INUG, PDL and, potentially, other lakes that are or were in a reference condition (Table 5-1). Further, the study design for the last 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 EEM Cycle 2.

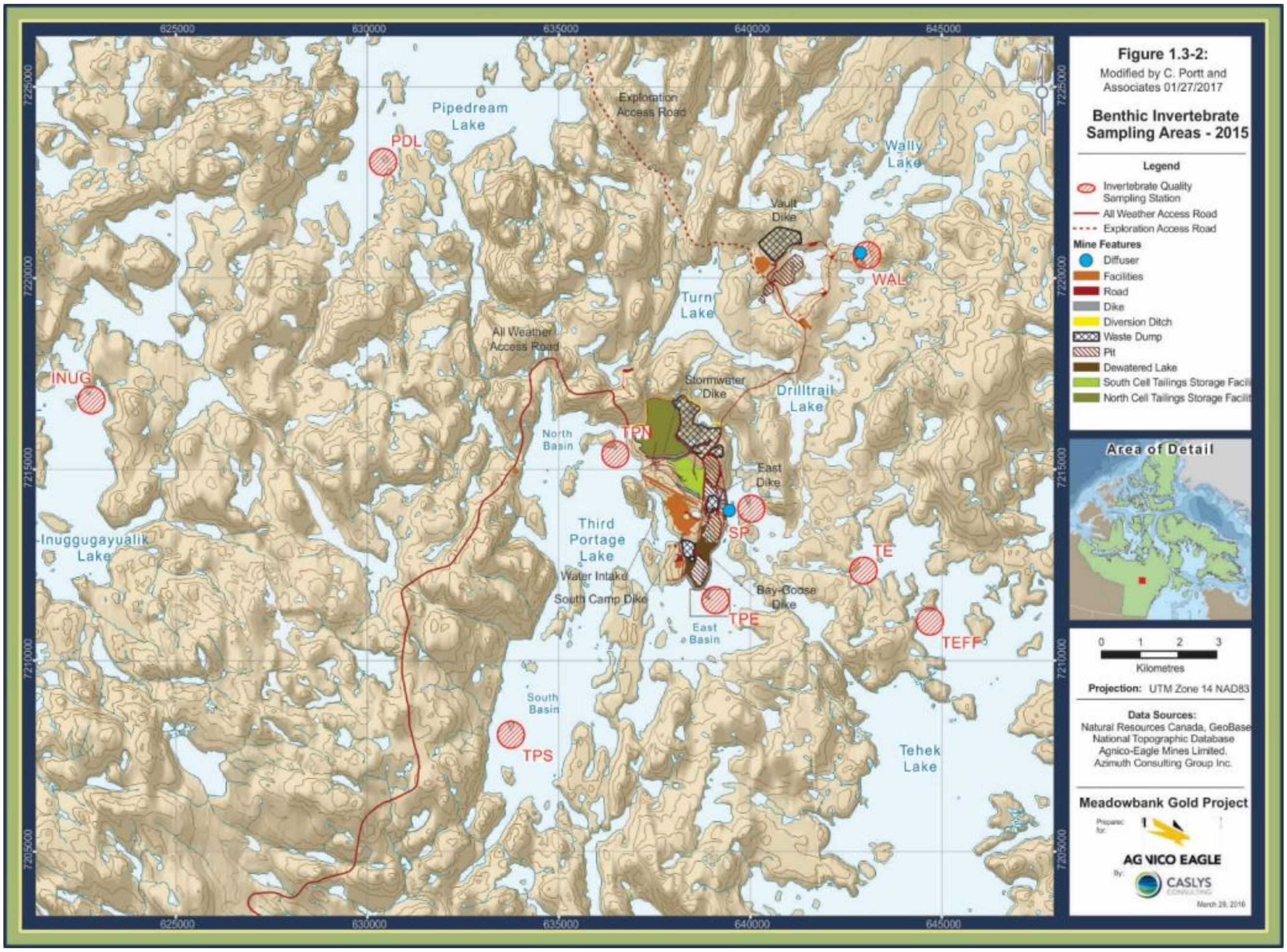

Figure 5-5. EEM Sediment and Benthos Sampling Areas. Map courtesy of Azimuth Consulting Group Partnership, modified by C. Portt and Associates.

6.0 SUPPORTING ENVIRONMENTAL VARIABLES

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

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 E). Water will be collected from two randomly selected locations (stations) within each sampling area. If the water at a station is NOT thermally or chemically (determined by conductivity) stratified, water will be collected from 3 m below surface. If the water at a station IS thermally or chemically stratified, water will be collected from three depths: (1) surface (2) = 3 m below surface; (2) deep (D) = 3 m above the bottom; and (3) integrated (INT) = integrated from just below surface (0.5 to 8 m).

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 (Table 6-1).

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 Table 6-2. 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	%

6.4 Timing

Benthic invertebrate sample collection (and collection of ancillary supporting data) is expected to begin on or about August 22, 2017, similar to the time period for the CREMP sampling. The specific timing of sampling for individual lakes in 2017 will be determined through coordination with staff at the Meadowbank Mine.

6.5 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

6.6 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.

We propose using the full complement of baseline and exposure period data (see Table 5-1) in an analysis of variance with Planned Linear Orthogonal Contrasts (or PLOC; see Hoke *et al*., 1990; Department of Fisheries and Oceans and Environment Canada, 1995). PLOC can test very specific hypotheses that are likely to be of interest. We propose, specifically, to test the hypotheses (1, 2, 3, 4) using the contrasts illustrated in Table 6-3 below.

In the ANOVAs, the 'before' period refers to the baseline period (years) before WAL received water from dewatered lakes or effluent, and the 'after' period refers to the exposure period (years) when WAL did received water from dewatered lakes or effluent. ANOVA 1 tests for a change in the average difference (in mean benthic indices) from before (2006 to 2012) to after. This first ANOVA will use only INUG as a reference, and encompasses the longest time period available. There were no baseline data collected from PDL between 2006 and 2008.

ANOVA 2 tests for a change in the average difference (in mean benthic indices) between WAL and (the mean of) INUG and PDL, from before (2010 to 2012) to after. This second ANOVA is designed to use the common baseline period data from WAL, INUG and PDL.

ANOVA 3 tests for a difference in time trends in the exposure period between WAL and what is observed in INUG and PDL. This ANOVA will use the average time trend in INUG and PDL as a contrast to what is observed in WAL.

We anticipate that Environment Canada will require ANOVA 4, which will test for a difference in mean index values between WAL and the average of INUG and PDL using only the 2017 data. This ANOVA is the classic ANOVA tested in EEM based on the current year of data. The challenge with this ANOVA is that it can demonstrate the natural differences in community composition that frequently occur (Underwood, 1994). The ANOVA will be presented for completeness of the Interpretive Report, but will not be relied upon as determining whether exposure to effluent has caused a change in benthic community composition (ANOVA’s 1, 2 and 3 will be used preferentially, because they are more sound; Green, 1979).

For these ANOVA’s, the variation among stations will be used to judge the significance of the contrasts, as per Table 6-4. The mean squared error term will be estimated through an omnibus ANOVA that incorporates data from all sample areas and years. Doing that ensures the most robust estimate of among station variability (i.e., among station SD), and therefore the most robust evaluation of the hypotheses.

Table 6-3. Potential linear contrasts that could be used to analyze the 2017 benthic community data from WAL, INUG and PDL (Meadowbank Mine)

Year	Exposure Period	Change in Difference WAL vs INUG (ANOVA 1)			Change in Difference WAL vs PDL (ANOVA 2)			Different Time Trend WAL vs INUG and PDL (ANOVA 3)			Difference between WAL and (INUG and PDL) in 2017 (ANOVA 4)		
		Reference		Exp	Reference		Exp	Reference		Exp	Reference		Exp
		INUG	PDL	WAL	INUG	PDL	WAL	INUG	PDL	WAL	INUG	PDL	WAL
2006	Baseline Period (Before)	5	no data	-5	0	no data	0	0	no data	0	0	no data	0
2007		5		-5	0		0	0		0	0		0
2008		5		-5	0		0	0		0	0		0
2009		5		-5	0		0	0		0	0		0
2010		5	0	-5	5	5	-10	0	0	0	0	0	0
2011		5	0	-5	5	5	-10	0	0	0	0	0	0
2012		5	0	-5	5	5	-10	0	0	0	0	0	0
2013	Exposure Period (After)	-7	0	7	-3	-3	6	-2	-2	4	-2	-2	4
2014		-7	0	7	-3	-3	6	-1	-1	2	-1	-1	2
2015		-7	0	7	-3	-3	6	0	0	0	0	0	0
2016		-7	0	7	-3	-3	6	1	1	-2	1	1	-2
2017		-7	0	7	-3	-3	6	2	2	-4	2	2	-4

Table 6-4. ANOVA table to analyze linear contrasts in Table 6-3.

Source	df	MS	F
Year x Lake Combinations (Y x L)	(Y x L) -1	MS (YxL)	
HO1: no change in difference (WAL vs INUG, 2006 to 2017 data) (BACI 1)	1	MS (BACI 1)	MS (BACI 1) / MS (E)
HO2: no change in difference (WAL vs INUG and PDL, 2010 to 2017 data) (BACI 2)	1	MS (BACI 2)	MS (BACI 2) / MS (E)
HO3: no difference in time trends in exposure period (TT)	1	MS (TT)	MS (TT) / MS (E)
HO4: no difference between WAL vs INUG and PDL, in 2017 (CI)	1	MS (CI)	MS (CI) / MS (E)
Error	(Y x L x n)-1	MS (E)	

Assessment of Covariable Effects

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

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;

We will use partial Mantel tests or simple Mantel tests to test the hypotheses listed in Table 6-4, and using the methods described by Borcard and Legendre (2013). Mantel tests will be completed in R.

Presentation of Basic Statistics

We will provide mean, median, standard deviation, standard error, minimum and maximum values for abundance, family richness, and equitability for each sample area using 2017 data. We will provide mean, median, SD, SE, and minimum and maximum Bray Curtis distances within WAL, INUG and PDL, and between WAL and INUG and PDL, again using only the 2017 data.

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

For Hypotheses 1, 2 and 4, to test the difference between reference and exposure in 2017, we will use:

$$ES = \frac{|\bar{x}_r - \bar{x}_e|}{SD_{pooled}}$$

Where

- ES is the effect size
- $\bar{x}_r$ is the average benthic community index value in the reference area
- $\bar{x}_e$is the average benthic community index value in the exposure area (grand mean of INUG and PDL, and potentially separate calculations for INUG and PDL separately),
- SD_{pooled} is the within-area standard deviation based on all available data from WAL, INUG and PDL.

For hypothesis 3, we will compute the mean differences at the beginning of the exposure period (2013) and at the end of the exposure period (2017), and express the change in difference relative to the within-area standard deviation:

$$ES = \frac{|\Delta_{2013} - \Delta_{2017}|}{SD_{pooled}}$$

Where, Δ_{2013} is the difference between WAL and INUG and PDL in 2013, and Δ_{2017} is the difference in 2017.

7.0 GENERAL QA/QC PROGRAM

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

Highly trained and experienced personnel will carry out the field sampling program for the biological components. It is expected that Cameron Portt (M.Sc., 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.

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.

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 E.

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

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

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

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

For measurements on fish and fish tissues, the following procedures and controls will be put in place: Measurements and weights will be obtained on site. Electronic balances will be calibrated daily. Weights and lengths will be recorded in hard copy and later entered into a digital spreadsheet. Plots of lengths and weights will be undertaken while the crew is still on site, to identify data outliers, and determine if any additional samples are required, prior to leaving the site. 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 and Cycle 2 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.

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

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APPENDIX A
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, 2012d) 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) to Wally Lake from Vault Attenuation Pond via outfall MMER 2 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	0	0	0	0	0	0	0	17,453	17,303	0	0	0
2	0	0	0	0	0	0	0	18,054	17,301	0	0	0
3	0	0	0	0	0	0	0	22,136	6,323	0	0	0
4	0	0	0	0	0	0	0	22,136	5,249	0	0	0
5	0	0	0	0	0	0	0	11,754	6,815	0	0	0
6	0	0	0	0	0	0	0	17,579	11,097	0	0	0
7	0	0	0	0	0	0	15,110	19,349	14,566	0	0	0
8	0	0	0	0	0	0	17,269	17,752	14,093	0	0	0
9	0	0	0	0	0	0	17,269	10,632	13,804	0	0	0
10	0	0	0	0	0	0	17,269	18,415	12,406	0	0	0
11	0	0	0	0	0	0	17,269	17,777	0	0	0	0
12	0	0	0	0	0	0	14,459	16,752	0	0	0	0
13	0	0	0	0	0	0	17,246	16,764	0	0	0	0
14	0	0	0	0	0	0	17,246	18,931	0	0	0	0
15	0	0	0	0	0	0	14,339	14,649	0	0	0	0
16	0	0	0	0	0	0	16,286	24,822	0	0	0	0
17	0	0	0	0	0	0	16,855	18,415	0	0	0	0
18	0	0	0	0	0	0	16,449	21,363	0	0	0	0
19	0	0	0	0	0	0	19,123	16,347	0	0	0	0
20	0	0	0	0	0	0	15,785	19,298	0	0	0	0
21	0	0	0	0	0	0	16,464	19,120	0	0	0	0
22	0	0	0	0	0	0	16,636	18,552	0	0	0	0
23	0	0	0	0	0	0	17,089	18,668	0	0	0	0
24	0	0	0	0	0	0	17,093	19,346	0	0	0	0
25	0	0	0	0	0	0	16,992	18,086	0	0	0	0
26	0	0	0	0	0	0	16,258	18,558	0	0	0	0
27	0	0	0	0	0	0	17,125	23,868	0	0	0	0
28	0	0	0	0	0	0	17,125	0	0	0	0	0
29	0		0	0	0	0	15,570	15,550	0	0	0	0
30	0		0	0	0	0	16,163	18,166	0	0	0	0
31	0		0		0		0	17,694		0		0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**398,490**	**547,986**	**118,957**	**0**	**0**	**0**

Table B-2. Meadowbank Division effluent volume (m^3) to Wally Lake from Vault Attenuation Pond via outfall MMER 2 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	0	0	0	0	0	0	0	12,306	4,393	20,394	0	0
2	0	0	0	0	0	0	0	12,306	14,951	15,228	0	0
3	0	0	0	0	0	0	0	12,306	17,681	8,482	0	0
4	0	0	0	0	0	0	0	12,306	17,510	9,427	0	0
5	0	0	0	0	0	0	0	12,306	17,270	12,211	0	0
6	0	0	0	0	0	0	0	12,306	10,591	14,381	0	0
7	0	0	0	0	0	0	0	12,306	17,094	10,666	0	0
8	0	0	0	0	0	0	0	12,306	18,204	14,646	0	0
9	0	0	0	0	0	0	0	12,306	18,216	13,667	0	0
10	0	0	0	0	0	0	0	12,306	18,210	13,697	0	0
11	0	0	0	0	0	0	0	12,306	16,304	4,586	0	0
12	0	0	0	0	0	0	0	12,306	17,959	0	0	0
13	0	0	0	0	0	0	0	12,306	9,736	0	0	0
14	0	0	0	0	0	0	0	12,306	15,107	0	0	0
15	0	0	0	0	0	0	0	12,306	8,805	0	0	0
16	0	0	0	0	0	0	0	10,777	21,797	0	0	0
17	0	0	0	0	0	0	14,400	15,241	8,903	0	0	0
18	0	0	0	0	0	0	16,077	8,643	22,733	0	0	0
19	0	0	0	0	0	0	14,117	0	11,287	0	0	0
20	0	0	0	0	0	0	13,068	0	16,232	0	0	0
21	0	0	0	0	0	0	14,252	0	17,044	0	0	0
22	0	0	0	0	0	0	13,385	4,270	16,694	0	0	0
23	0	0	0	0	0	0	17,131	0	16,574	0	0	0
24	0	0	0	0	0	0	17,131	0	15,501	0	0	0
25	0	0	0	0	0	0	17,131	0	7,275	0	0	0
26	0	0	0	0	0	0	17,131	0	5,144	0	0	0
27	0	0	0	0	0	0	17,424	0	0	0	0	0
28	0	0	0	0	0	0	17,760	0	0	0	0	0
29	0	0	0	0	0	0	15,768	0	12,687	0	0	0
30	0		0	0	0	0	17,088	0	15,061	0	0	0
31	0		0		0		16,728	0		0		0
Total	**0**	**0**	**0**	**0**	**0**	**0**	**238,588**	**223,521**	**408,963**	**137,385**	**0**	**0**

Table B-3. Final effluent analytical results discharged to Wally Lake from Vault Attenuation Pond via outfall MMER 2 (2 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											
10-Jun-14	0.0013	0.0046	0.331	<0.0003	0.0421	0.004	7	0.035	6.64	>100	>100
16-Jun-14	NMR	NMR	0.269	NMR	0.0297	NMR	11	NMR	6.60	NMR	NMR
24-Jun-14	NMR	NMR	0.358	NMR	0.0381	NMR	6	NMR	7.32	NMR	NMR
30-Jun-14	NMR	NMR	0.312	NMR	0.0362	NMR	9	NMR	NA	NMR	NMR
5-Jul-14	0.0029	0.006	0.45	0.0011	<0.0005	0.003	9	0.04	7.21	91.6	>100
8-Jul-15	<0.0005	0.003	<0.005	<0.0003	0.0044	<0.001	6	0.005	7.1	NMR	NMR
15-Jul-13	<0.0005	0.0013	<0.005	<0.0003	0.0033	<0.001	2	0.005	6.58	NMR	NMR
15-Jul-21	<0.0005	0.0023	<0.005	<0.0003	0.0033	0.001	6	0.002	6.98	>100	>100
15-Jul-29	<0.0005	0.0016	<0.005	<0.0003	0.0032	<0.001	1	0.006	7.66	NMR	NMR
4-Aug-15	<0.0005	<0.0005	<0.005	<0.0003	0.0038	<0.001	2	0.003	7.08	NMR	NMR
10-Aug-15	0.004	0.0033	<0.005	<0.0003	0.003	0.004	1	0.002	7.96	>100	>100
17-Aug-15	<0.0005	0.0015	<0.005	0.014	0.0034	0.001	3	0.021	6.92	NMR	NMR
24-Aug-15	0.0088	0.0028	<0.005	0.0031	0.0032	<0.001	1	0.008	7.73	NMR	NMR
1-Sep-15	<0.0005	0.0028	<0.005	0.0095	0.0029	<0.001	10	0.002	7.37	NMR	NMR
8-Sep-15	<0.0005	0.0025	<0.005	<0.0003	0.0019	<0.001	1	0.006	7.67	>100	>100
18-Jul-16	<0.0005	0.0025	<0.005	<0.0003	0.0046	<0.001	2	0.010	7.63	NMR	NMR
20-Jul-16	-	-	-	-	-	-	-	-	-	>100	>100
25-Jul-16	<0.0005	0.0020	<0.005	<0.0003	0.0035	<0.001	6	-	7.50	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 %**
1-Aug-16	<0.0005	0.0022	<0.005	<0.0003	0.0034	<0.001	3	-	7.52	NMR	NMR
8-Aug-16	0.0010	0.0057	<0.005	<0.0003	0.0055	<0.001	6	-	7.35	NMR	NMR
15-Aug-16	<0.0005	0.0029	<0.005	<0.0003	0.0048	0.002	<1	-	7.46	NMR	NMR
22-Aug-16	0.0041	0.0030	0.011	<0.0003	0.0039	0.001	5	-	7.36	>100	>100
1-Sep-16	-	-	-	-	-	-	4	-	7.55	NMR	NMR
5-Sep-16	<0.0005	0.0018	0.039	<0.0003	<0.0005	<0.001	4	-	7.49	NMR	NMR
12-Sep-16	<0.0005	0.0022	0.001	0.0058	0.0226	<0.001	3	-	6.99	NMR	NMR
20-Sep-16	<0.0005	0.0023	0.001	<0.0003	0.0037	0.004	14	0.005	6.71	NMR	NMR
26-Sep-16	<0.0005	0.0020	0.001	<0.0003	0.0039	0.002	11	0.010	6.68	>100	>100
3-Oct-16	<0.0005	0.0026	0.008	0.0008	0.0045	0.002	10	-	7.71	NMR	NMR
10-Oct-16	<0.0005	0.0029	0.005	<0.0003	0.0041	0.003	2	0.004	7.34	>100	>100

NMR = No measurement required.

Table B-4. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MMER 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-5. Meadowbank Division effluent volume (m^3) from East Dike seepage to Second Portage Lake via outfall MMER 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-6. Final effluent analytical results for East Dike seepage discharged to Second Portage Lake via outfall MMER 3 (5 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											
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

	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 %**
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
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

	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 %**
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
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

	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 %**
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
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

	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 %**
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
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

NMR = No measurement required.

APPENDIX C

PLUME MODELLING STUDY

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Wally Lake Effluent Plume Modelling Study

Meadowbank Gold Project, Nunavut

February 16, 2017
12641.101

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Wally Lake Effluent Plume Modelling Study

Prepared for
C. Portt & Associates

Prepared by

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12641.101

Revision	Date	Status	Comments	Reviewed by	Approved by
0	19 Jan 2017	Draft	Client review	EL/JDW	DMF
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2	16 Feb 2017	Final	Final report	JDW	DMF

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TABLE OF CONTENTS

1.0 INTRODUCTION

This report describes the results of an effluent plume modelling study for the Wally Lake outfall at the Meadowbank Gold Project, Nunavut. The outfall system conveys surface water from the Vault Attenuation Pond to Wally Lake during the ice-free season. 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 Wally 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 current and relative buoyancy conditions. The results of the study may be used to assist in the selection of sampling locations for the environmental effects monitoring (EEM) study.

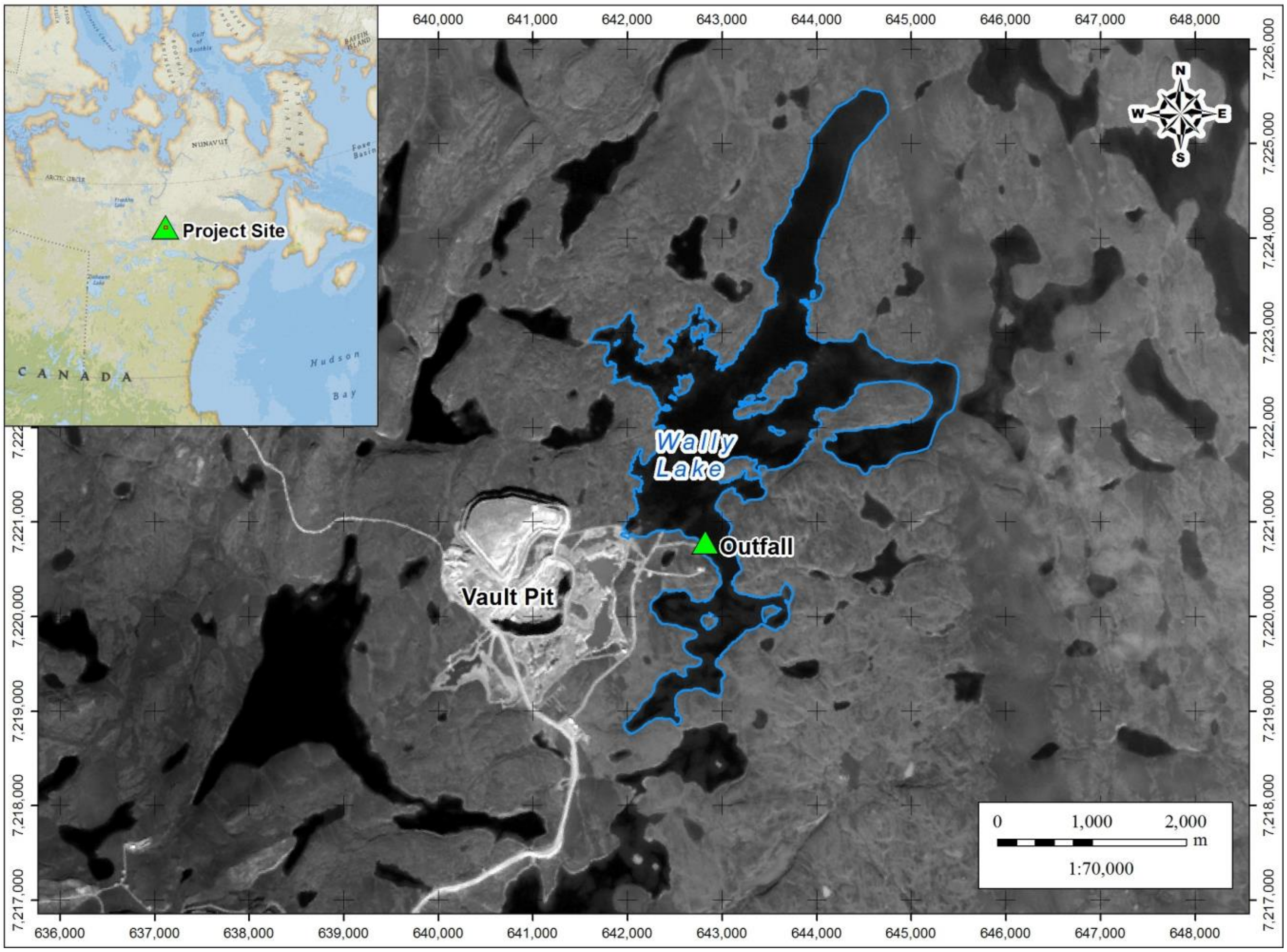

Figure 1.1 – Location of the Wally Lake Outfall.

2.0 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). Wind-induced currents in Wally Lake were estimated from long-term wind data from the Baker Lake Airport.

2.1 Wally Lake ambient water characteristics

Wally Lake is relatively shallow and contains several arms and small islands. The lake is 7.6 km long and has an average depth of 3.6 m (Golder, 2006). While most of the lake is less than 6 m deep, isolated depressions of up to 22 m deep exist in some of the arms. Lake levels measured in 2016 indicate that the seasonal water level range is relatively small (approximately 25 cm). The peak lake level occurred during the first week of July and the lowest lake level occurred during the third week of October.

Measurements of conductivity, temperature, and depth (CTD) were acquired by Portt and Agnico in 2016 using a Sontek CastAway®-CTD instrument. Measurements were taken on July 10 (before the outfall system began operating this season), and on July 25, August 10, and August 13, 2016 (while the outfall was discharging). The measured and derived parameters recorded by the instrument include: conductivity, temperature, pressure, salinity, sound speed, density, depth, and specific conductance. The unit has an internal GPS that records the coordinates of locations where measurements are taken.

Conductivity measurements taken on July 10, 2016 indicate a background specific conductance of approximately 32 microsiemens per centimeter (µS/cm) in Wally Lake. Specific conductance measurements taken while effluent was being discharged ranged between 35 and 68 µS/cm.

Water temperatures measured on July 10 were warmer on the surface and colder at increasing depths. Water temperatures measured in late July and August were relatively consistent throughout the water column, which suggests that winds are capable of mixing the surface and bottom waters.

The locations of the CTD measurements taken when the outfall was discharging are shown in Figure 2.1.

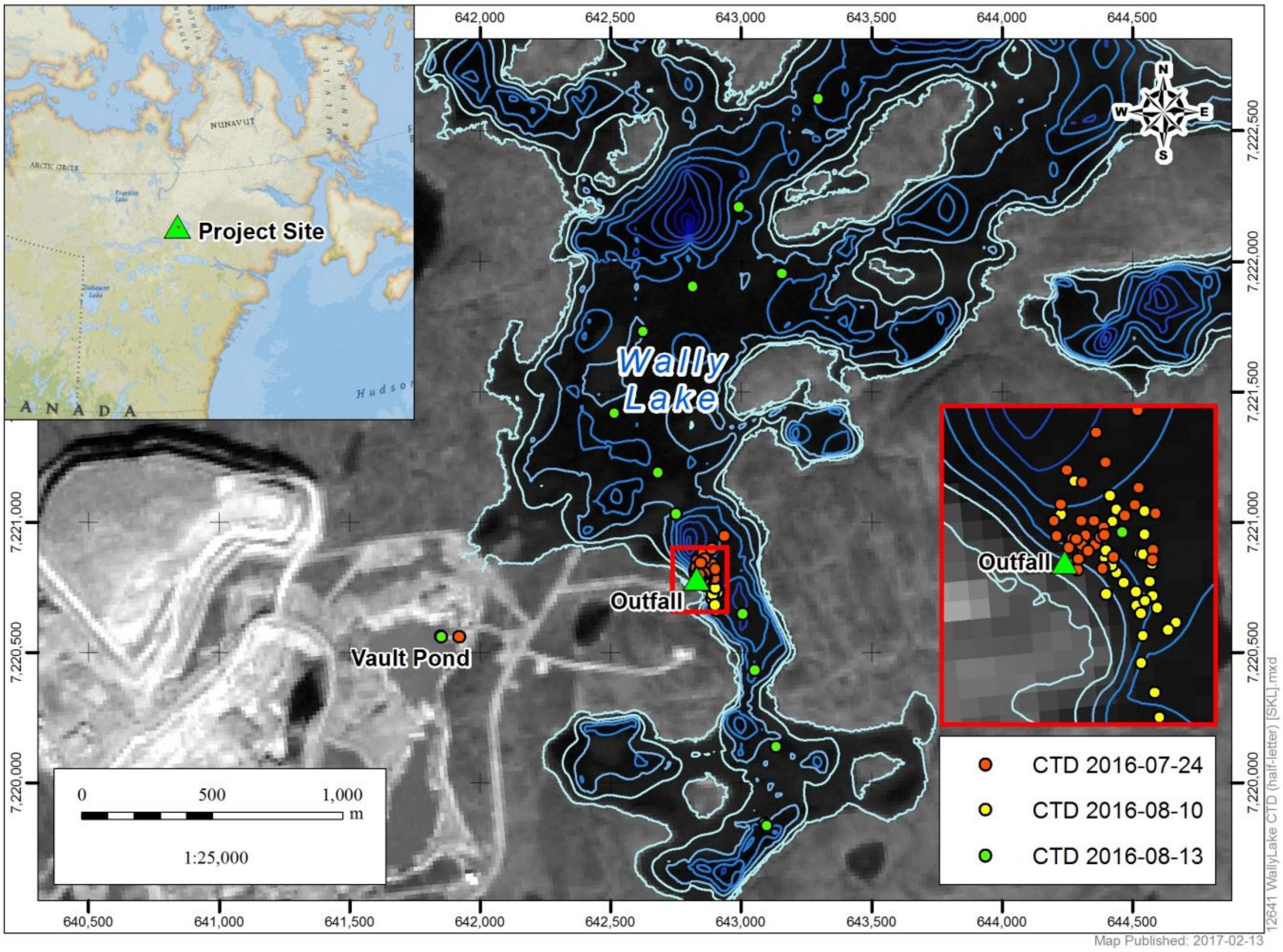

Figure 2.1 – Location of CTD measurements when outfall was discharging effluent.

2.2 Effluent water characteristics

Effluent water from the Vault Attenuation Pond is discharged into Wally Lake during the ice-free season. In 2015 and 2016, the average daily volume was approximately 15,000 m^3 per day and the total annual volume, which included water from dewatering of Phaser Lake, was approximately 1,000,000 m^3. The 2016 field measurements that are referred to in this report were taken prior to the 2016 dewatering, which began on August 23.

Effluent samples collected by Agnico in 2016 had a median and maximum Total Dissolved Solids (TDS) concentration of 133 and 182 mg/L, respectively. The median and maximum Total Suspended Solids (TSS) concentrations over this same period were 3 mg/L and 14 mg/L, respectively.

The specific conductance and temperature of the effluent was measured on July 25 and August 14 by placing the CastAway instrument in a bucket of effluent water. The specific conductance and temperature of the effluent increased over this period, which was likely due to the drawdown of the attenuation pond and solar heat transfer. On July 25, the effluent had a specific conductance of 193 μS/cm and a temperature of 13°C (0.6°C warmer than Wally Lake). On August 14, the effluent had a specific conductance of 230 μS/cm and a temperature of 16°C (2.2°C warmer than Wally Lake).

2.3 Diffuser configuration

The Wally Lake outfall is a vertically-oriented port with a diameter of 200 mm. The outfall is located approximately 30 m from the shoreline in a water depth of approximately 6 m. The outlet of the pipe is located 2.5 m above the lake bed (i.e. 3.5 m below the water surface).

The dewatering system operates at a flow rate of 600-650 m^3/hr (180 L/s), which results in an exit velocity of approximately 5.7 m/s. The effluent jet is believed to impinge the water surface due to its vertical orientation and relative depth. Agnico staff noted that the CastAway instrument could not be deployed above the outfall as the effluent jet would push the CastAway to the water surface.

2.4 Wind data

Hourly wind speed data from the Baker Lake Airport (1953-2016) was acquired from Environment Canada to estimate the wind-induced currents in Wally 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 north west.

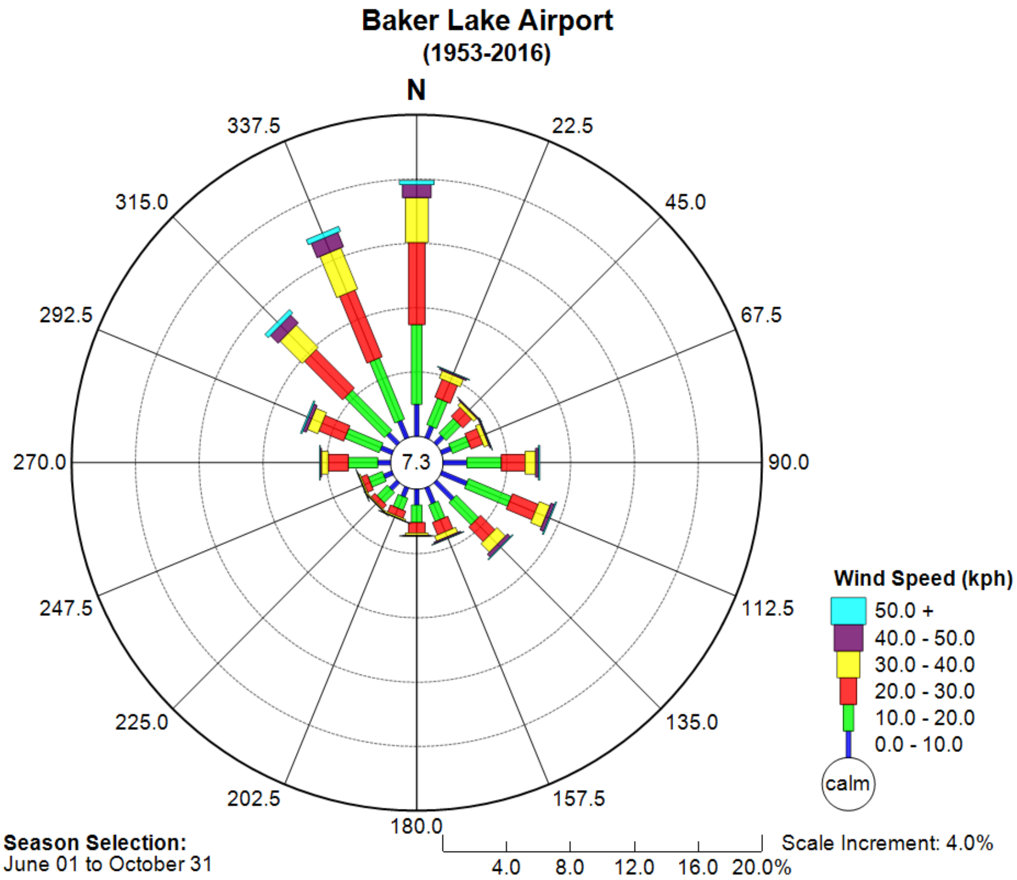

Figure 2.2 – Wind speed rose for Baker Lake, Nunavut (June 1 to October 31).

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%	14%
40-50	0.6%	0.5%	0.6%	0.9%	1.5%	4%
>50	0.1%	0.1%	0.1%	0.3%	0.6%	1%

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 north to northwest direction are between about 1 km to 2 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.

3.0 PLUME MODELLING

The plume modelling was carried out using the Cornell Mixing Zone Expert System (CORMIX). The model system is based on a number of semi-empirical and physically-based formulations which are selected automatically based on the classification of the ambient and effluent flow conditions (Doneker and Jirka, 1990). 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 dewatering system:

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

The ambient lake currents selected for modelling are based on the exceedance probability of seasonal wind speed data from the Baker Lake Airport. These selections (see 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	Percent exceedance	Wind speed (kph)	Estimated surface current speed (m/s)*
Near stagnant†	93%	1	0.01
Low wind	90%	3	0.03
Median wind	50%	17	0.15
High wind	1%	50	0.47

*Estimated per Wu (1983)

†Calm wind conditions 7% of occurrences

The relative densities of the effluent and receiving waters selected for modelling are based on the CTD measurements and water quality samples from the Vault Attenuation Pond in 2016. Relations between the physical water characteristics (temperature, salinity, TDS, and TSS) and density were drawn from Ji (2008). Given the limited data available for analysis, total dissolved solids, 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 3.2 provides a summary of the effluent and ambient density conditions used in the CORMIX model.

Table 3.2 – Summary of the ambient and effluent density

Description	Scenario	Ambient water		Effluent water			
		Temp (°C)	Density (kg/m^3)	Temp (°C)	TDS (mg/L)	TSS (mg/L)	Density (kg/m^3)
Negatively buoyant (i.e. sinking)	Effluent is more dense than receiving water due to higher concentration of suspended and dissolved solids.	13	999.4	13	450*	35*	999.8
Neutrally buoyant	Effluent has similar density to receiving water.	13	999.4	13.5	133†	3†	999.4
Positively buoyant (i.e. floating)	Effluent is less dense than receiving water due to differential warming of attenuation pond and lake.	13	999.4	17‡	133†	3†	998.9

*Selected as 2.5 times the maximum TDS and TSS concentrations from Vault Attenuation Pond in 2016.

†Median TDS and TSS concentrations from Vault Attenuation Pond in 2016.

‡ Selected to have a larger temperature differential than August 10-14, 2016 CTD measurements.

3.2 Model results

Four lake current conditions and three relative buoyancy conditions were simulated in the model for a total of twelve scenarios. 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 250 m from the outfall are summarized in Table 3.3. The extents of the 1% mixing zone under typical conditions and conditions which produce the largest mixing zone are presented in Appendix A. 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 3.3 do not follow a linear relationship with the wind speed.

Table 3.3 – Summary of the CORMIX model results

Scenario #	Wind condition	Relative buoyancy	Distance (m) to 1% effluent concentration	Dilution ratio 250 m from outfall
1	Near stagnant	negative	1425	15:1
2*	Low wind	negative	2105	9:1
3	Median wind	negative	800	18:1
4	High wind	negative	165	156:1
5	Near stagnant	neutral	235	108:1
6	Low wind	neutral	285	90:1
7	Median wind	neutral	390	57:1
8	High wind	neutral	545	39:1
9	Near stagnant	positive	1130	18:1
10	Low wind	positive	1670	10:1
11†	Median wind	positive	815	19:1
12	High wind	positive	630	33:1

*Largest predicted extent: low wind, negatively buoyant plume (i.e. sinking)

†Typical conditions: median wind, positively buoyant plume (i.e. floating)

A profile view demonstrating the different behaviours of positively and negatively buoyant plumes is shown in Figure 3.1. 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.

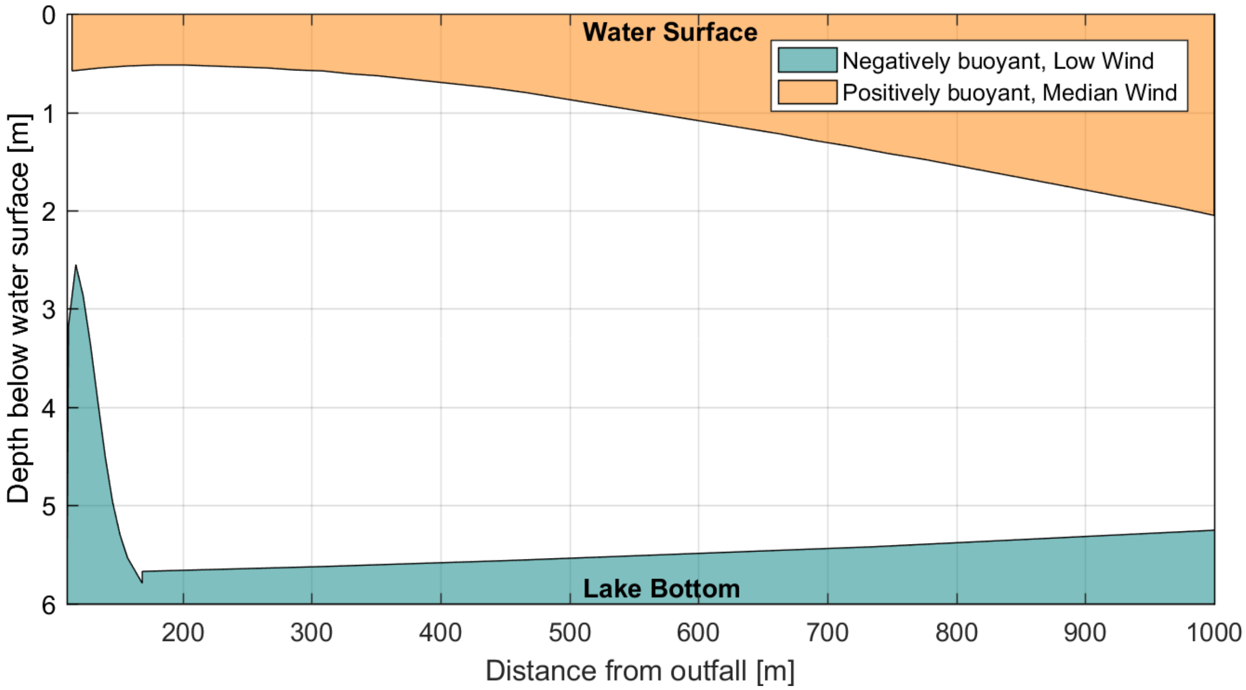

Figure 3.1 – Profile views of the predicted behaviour of positively and negatively buoyant plumes.

3.3 Discussion

The following observations were noted from the CORMIX simulations:

- For most scenarios, the effluent concentration 250 metres from the outfall is greater than 1%; that is, predicted dilution ratios are less than 100:1 at a distance 250 m from the outfall.

- The largest mixing zone is predicted for a negatively buoyant discharge at stagnant to low wind conditions. Generally, larger mixing zones are predicted for discharges with a greater buoyancy differential and lower wind speeds.

- 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.

3.4 Model sensitivity

The sensitivity of the model results to the effluent flow rate, water depth, and relative density were assessed by varying the input variables in the CORMIX model. The sensitivity tests were conducted for the median wind, positively buoyant scenario (e.g. typical conditions).

Near-field mixing is strongly dependent on the exit velocity and momentum of the effluent jet. It was found that increasing the effluent flow rate by 50% resulted in a 40% increase in the required distance to reach the 1% mixing zone and decreasing the flow rate by 50% resulted in a 40% decrease of the mixing zone extent. Mixing distances were not sensitive to a 50% increase or decrease in depth for positively or negatively buoyant plumes. The water depth was found to have an influence on the mixing distance for neutrally buoyant plumes, as these plumes tend to be re-entrained by the diffuser jet.

The relative density of the effluent affects whether the plume will rise to the water surface, remain suspended in the water column, or sink to the lake bottom. Mixing distances were not sensitive to a 0.2 kg/m^3 increase or decrease in the effluent density.

Overall, the model is most sensitive to the outfall’s flow rate and least sensitive to the water depth; this is in part due to the orientation of the outlet and the range of depths considered. Changes to the model’s input parameters may result in a different flow classification and the selection of different equations by the model system.

3.5 Comparison to CTD measurements

The CORMIX results were compared to the CTD measurements to assess the general accuracy of the model. This should not be considered a detailed validation but rather an assessment of general trends in the measured and modelled results. Note that the field data is based on a limited sample dataset and wind speeds on these dates (July 25, August 10 and 13, 2016) were representative of the median wind condition.

The CTD measurements indicate a background concentration of approximately 32 μS/cm in Wally Lake and an effluent concentration of approximately 210 μS/cm. CTD measurements taken near the outfall while the system was operating indicate a conductivity of 40 to 50 μS/cm. Assuming the increase in conductivity represents the influence from the effluent, a dilution ratio of approximately 10:1 to 22:1 occurs within about 100 m of the outfall.

CORMIX indicates dilution ratios between 10:1 and 40:1 at a distance 100 m from the outfall for a positively buoyant plume for low to median wind speeds. The average wind speed at the Baker Lake Airport during the sampling dates was 14 km/hr which is similar to the median wind speed scenario.

4.0 CONCLUSION

A total of twelve lake current and relative buoyancy scenarios were simulated for the Wally Lake outfall using the CORMIX model (Doneker and Jirka 1990). Under most conditions, the effluent from the Vault Attenuation Pond is anticipated to be the same temperature or warmer than Wally Lake, resulting in a neutral or positively buoyant plume.

The 100:1 dilution criteria at 250 metres from the outfall was only met in two scenarios. The largest exposure areas were predicted for negatively and positively buoyant plumes under low or stagnant wind conditions. These conditions result in an exposure area extending 1,000 to 2,100 metres from the outfall. The typical extent of the plume, occurring during long-term average wind conditions, is predicted to extend 800 metres from the outfall. The highest model uncertainties occur when the effluent is neutrally buoyant. A sensitivity analysis of the input parameters indicates that the model is most sensitive to the flow rate for all effluent densities and the dilution of a neutrally buoyant plume is most sensitive to the water depth.

A general comparison of the model results to CTD measurements gathered this summer in Wally Lake showed a good agreement providing a level of confidence in the modelled plume extents.

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Doneker, R., & Jirka, G. (1990). "Expert system for hydrodynamic mixing zone analysis of conventional and toxic submerged single port discharged (CORMIX1)." Cornell University, Ithaca, New York.

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APPENDIX A

EXTENTS OF PREDICTED EFFLUENT PLUMES

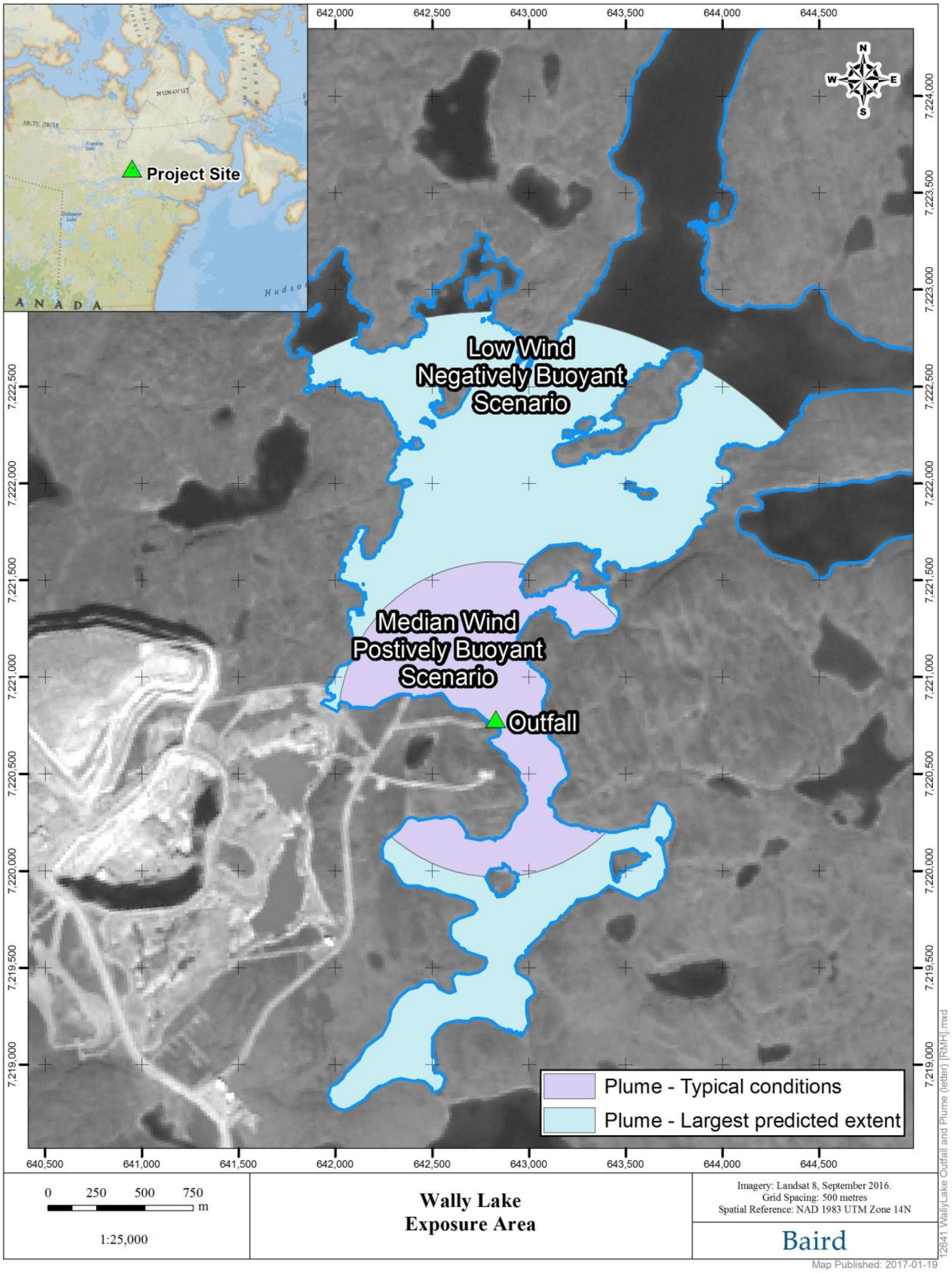


Figure A.1 – Region of Wally Lake where the predicted effluent concentration is greater than 1%. Plume extents shown for typical conditions and for conditions producing the largest plume extent.

APPENDIX D

2016 FIELD ASSESSMENT OF EFFLUENT MIXING AND DISPERSAL IN WALLY LAKE

2016 Field Assessment of Effluent Mixing and Dispersal In Wally Lake

Methods

Profiles of conductivity and temperature versus depth were used to assess the vertical mixing of the effluent and estimate effluent concentrations in Wally Lake. Depth, temperature, conductivity and specific conductance were collected from lake surface to lake bottom using a SonTek Castaway©-CTD (Xylem Inc.; refer to Table 1 for specifications). Data were collected by C. Portt and Associates and Agnico staff at six locations (Figure 1) in Wally Lake on July 10, 2016 (prior to any effluent discharge in 2016). Data were collected by Agnico staff using the same instrument at multiple locations while effluent was discharging on July 24 (Figure 2), August 10 (Figure 2) and August 13, 2016 (Figure 1). The coordinates of the sampling locations were determined by the instrument's internal GPS. The temperature, conductivity and specific conductance of effluent from the Vault Attenuation Pond, collected at the effluent pump, was determined using the same instrument on July 25 and August 14, 2016. The 2016 field measurements that are referred to in this report were taken prior to the 2016 dewatering of Phaser Lake, which began on August 23.

Table 1. Castaway© specifications. Source: http://www.sontek.com/productsdetail.php?CastAway-CTD-11 accessed January 25, 2017.

Parameter	Range	Resolution	Accuracy
Temperature	-5 to +45°C	0.01°C	±0.05°C
Conductivity	0 to 100,000 µS/cm	1 µS/cm	0.25% ±5 µS/cm
Depth	0 to 100 m	0.01 m	±0.25% FS

The field data were exported from the instrument to a computer using the Castaway software and these were exported to Excel which was used to plot specific conductance profiles (specific conductance versus depth). These plots were examined visually to assess the vertical mixing of the plume and the specific conductance values were used to calculate effluent concentrations using the mass balance equation:

$$K_X=(K_L*((100-X))+(K_e*X))/100$$

where K_X=specific conductance of solution containing X% effluent,

K_L= base line specific conductance of Wally Lake (32.6 µS/cm) , and

K_e= specific conductance of the effluent.

Temperature profiles were also examined to inform the interpretations. The profile coordinates were imported into GIS which was used to calculate the straight-line distance between each profile and the diffuser.

Results

July 10, 2016, was a very warm, calm day just after ice-out. Surface temperatures were between 16.9°C and 17.5°C, and the temperatures were between 5.5 C° and 9.3 C° colder at the bottom. This was an unusual situation, based on Agnico staff experience and temperature profiles taken for the CREMP in multiple lakes in multiple years. During the open water period, the water column is usually completely or nearly completely mixed, as it was on the three other dates when data were collected as part of this study. The temperature difference between surface and the bottom was less than 0.1 C° at 34 of 35 locations on July 24 and it was 0.13 C° at the other location. The temperature difference between surface and bottom was less than 0.1 C° at all locations on August 10 (n=28). On August 13 the temperature difference between the surface and the bottom was less than 0.1 C° at 9 of 13 locations and the maximum difference was 0.9 C°.

The specific conductance profiles are provided in Appendix A. Specific conductance varied somewhat with depth on July 10. The total range (all site, all depths) was from 31.3 µS/cm to 34.2 µS/cm and the overall mean was 32.6 µS/cm. This was considered to be the baseline specific conductance in calculations of effluent concentrations. On July 25, the specific conductance of the effluent was 193.9 µS/cm and on August 14 the specific conductance of the effluent was 229.6 µS/cm. The specific conductance of mixtures of lake water and effluent at effluent concentrations of 10%, 5% and 1% for each of these effluent specific conductance values is presented in Table 2.

Table 2. Specific conductance µS/cm of mixtures of Wally Lake water and effluent at effluent concentrations of 10%, 5%, and 1%.

Specific conductance of effluent (µSiemens/cm)	Effluent concentration		
	10%	5%	1%
194	48.7	43.0	34.2
230	52.3	44.8	34.6

On July 24, the sampling locations were clustered north of the diffuser at distances ranging from 83 m to 257 m. The specific conductance was between 40 and 45 µS/cm, indicating approximately 5% effluent, at all depths at most locations. There were a few locations (1, 2, 7, 9) where specific conductance exceeded 45 µS/cm at or near the surface, but overall the effluent was well mixed.

On August 10, the sampling locations were again clustered north of the diffuser. The furthest location was 152 m from the diffuser and one measurement was taken directly over the diffuser where the upward flow prevented the instrument from sinking. Specific conductance had increased since July 24 and was between 50 µS/cm and 55 µS/cm at all depths at most locations. This is indicative of approximately 10% effluent. Once again, there were a few locations where the concentration of effluent was higher at or just below the surface (11, 12, 15, 24, 25, 26). The specific conductance at the surface directly over the diffuser, where the upward flow from the diffuser suspended the CTD device, was 52.8 µS/cm, indicating that significant mixing had occurred between the diffuser port and the surface.

On August 13, a series of profiles were acquired over a wider area, from 1.9 km north of the diffuser to 0.855 km south of the diffuser. The mean specific conductance and calculated effluent concentration at each location, as well as the straight-line distance from the diffuser, are provided in Table 3. The calculated effluent concentrations are not exact because the specific conductance of the effluent increased during the period when it was discharged but they are considered reasonable approximations. At the locations closest to the diffuser, effluent concentration exceeded 10%. South of the diffuser the effluent concentration was 8% - 10% at distances of approximately 550 m and 850 m. North of the diffuser the effluent concentration decreased more quickly with distance, but even at the furthest location the effluent concentration exceeded 1%.

Table 3. Straight-line distance from the diffuser and effluent concentrations (%) at each August 13, 2016, profile location. Effluent concentration was calculated using the mean specific conductance for each profile and using both the July 25, 2016, and August 14, 2016, effluent specific conductance. Refer to Figure 1 for locations.

August 13, 2016, profile location	distance from diffuser (m)	mean specific conductance (µS/cm)	effluent concentration (%) calculated using each effluent specific conductance value	
			194 µS/cm (July 25, 2016)	230 µS/cm (August 14, 2016)
1	1932	35.0	1.5	1.2
2	1517	36.0	2.1	1.7
3	1260	36.6	2.5	2.0
4	1212	36.3	2.3	1.9
5	1038	35.8	2.0	1.6
6	725	37.3	2.9	2.4
7	498	38.8	3.8	3.1
8	339	45.7	8.1	6.6
9	113	51.9	12.0	9.8
10	44	53.1	12.7	10.4
11	259	52.5	12.3	10.1
12	554	49.6	10.5	8.6
13	856	49.0	10.2	8.3
14	847	48.9	10.1	8.3

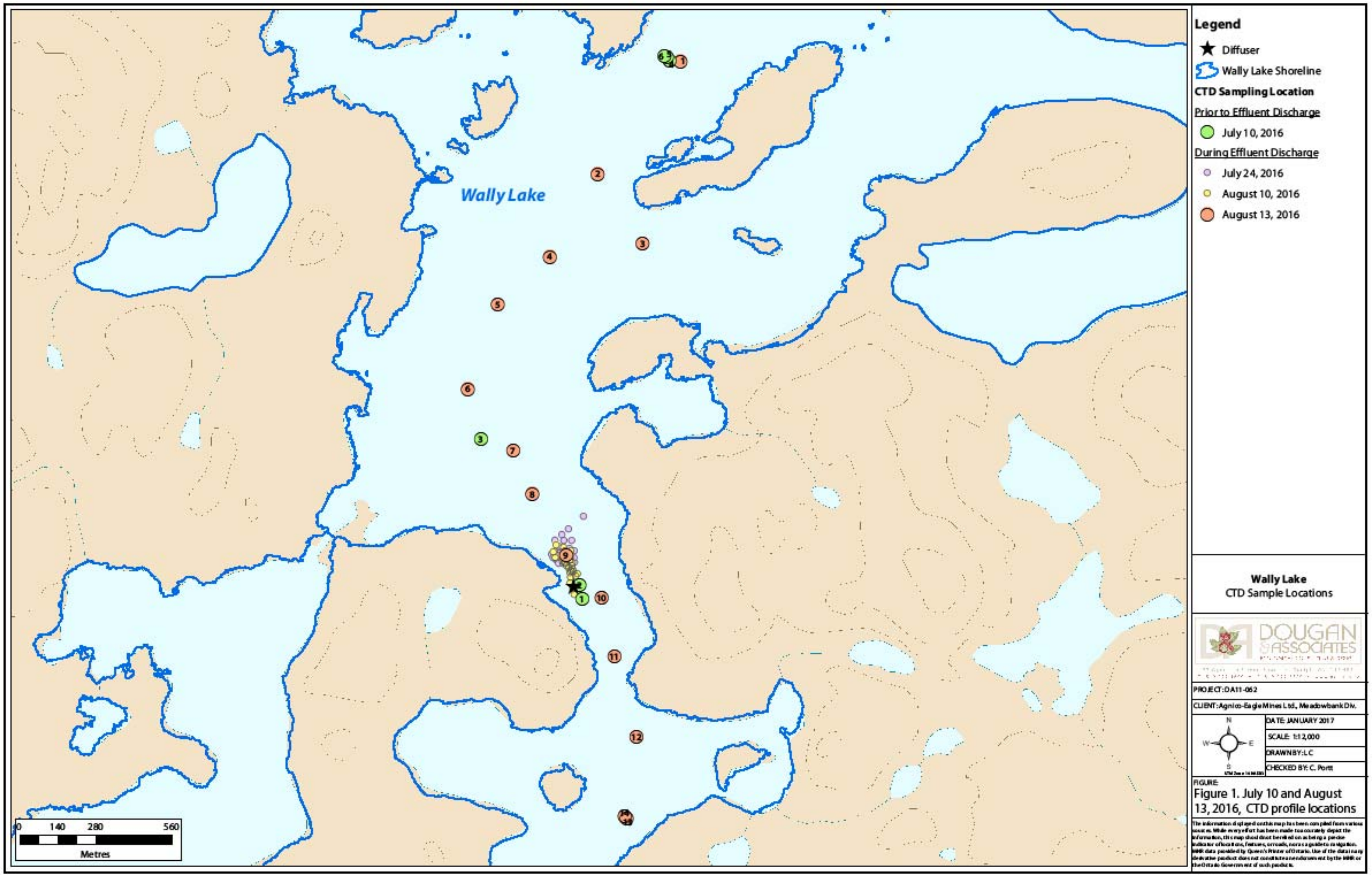


Figure 1. July 10 and August 13, 2016, CTD profile locations

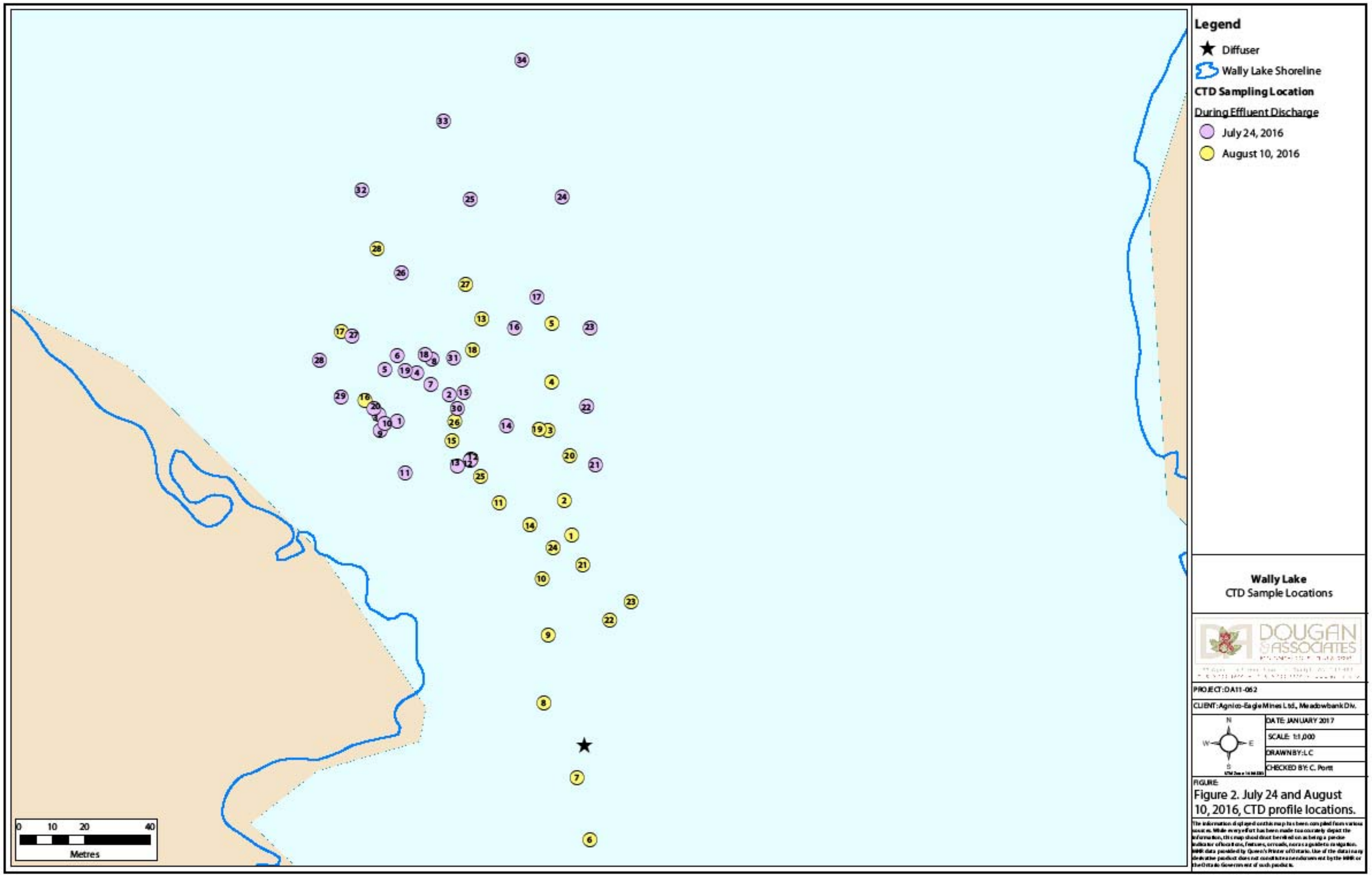
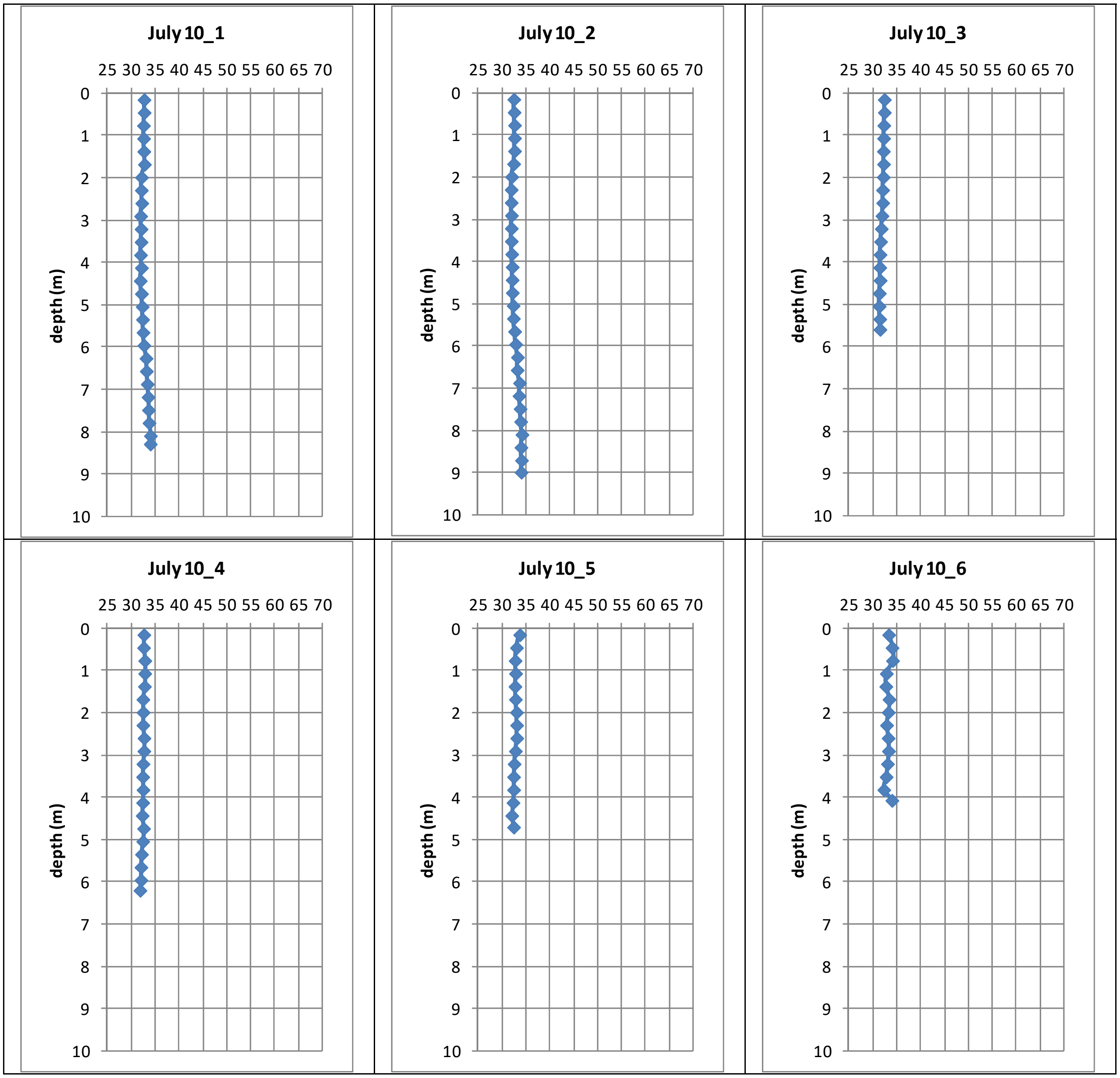


Figure 2. July 24 and August 10, 2016, CTD profile locations.

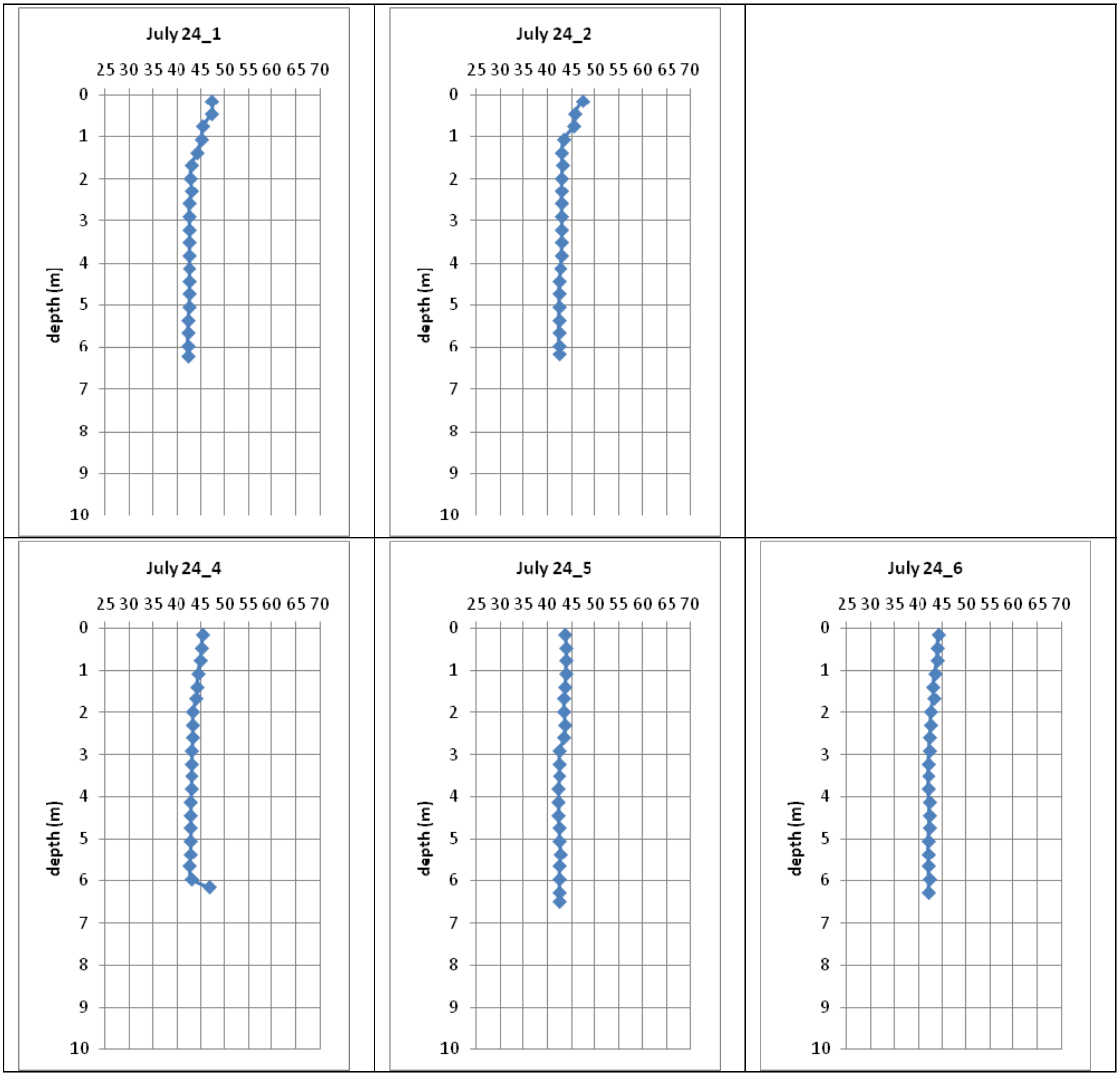
APPENDIX A

Specific Conductance Profiles

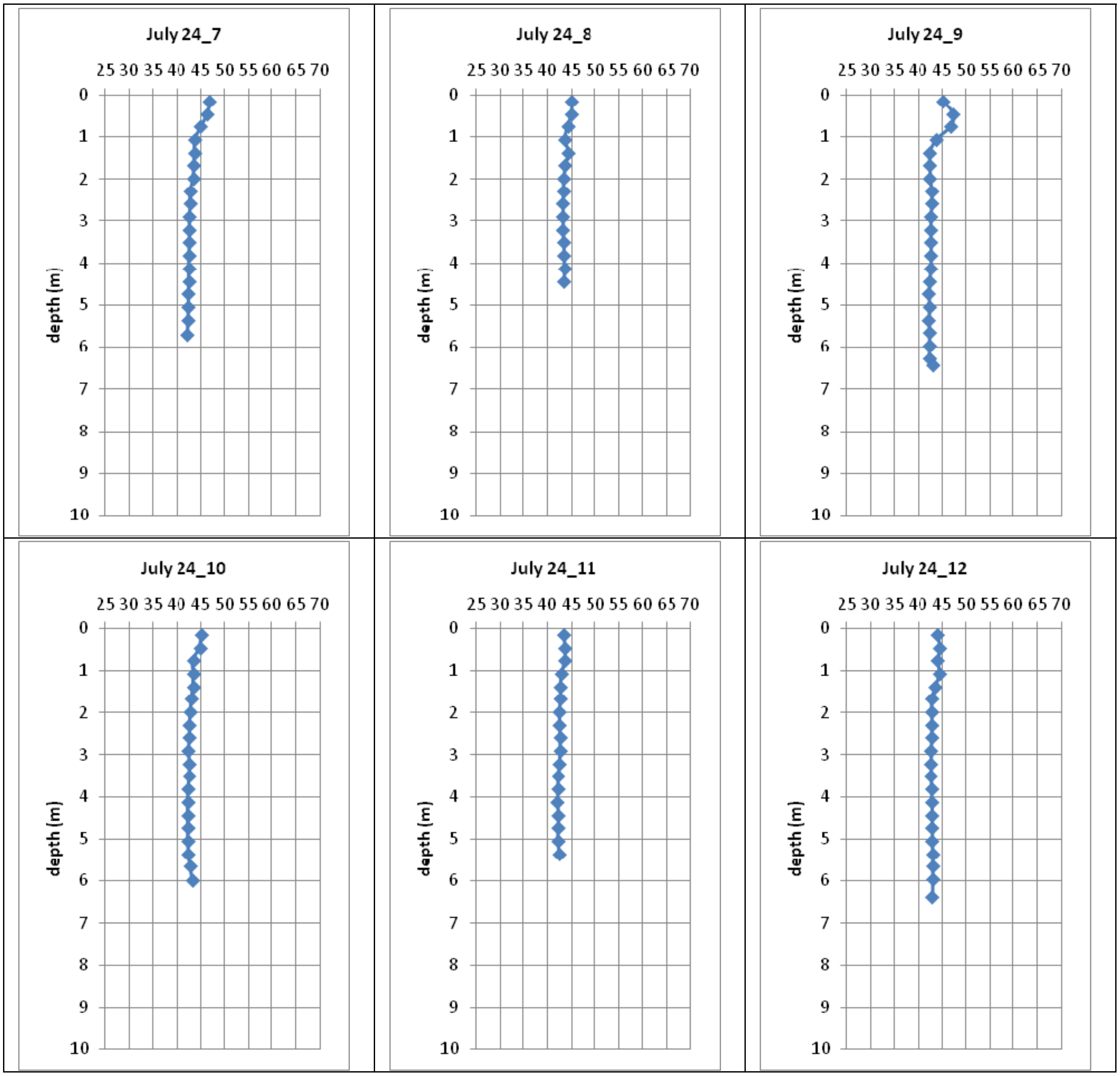
July 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 1.



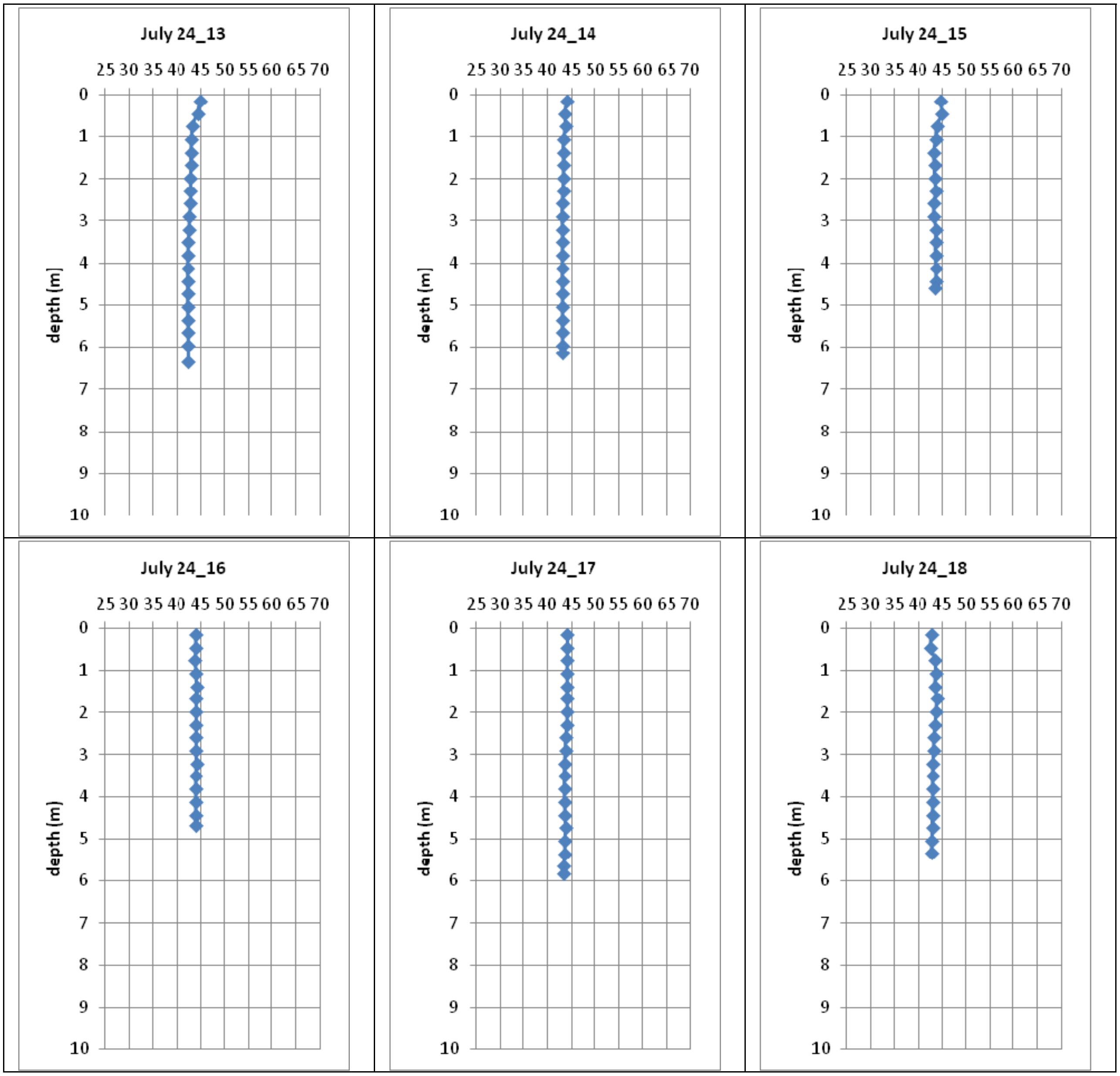
July 24, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



July 24, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



July 24, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



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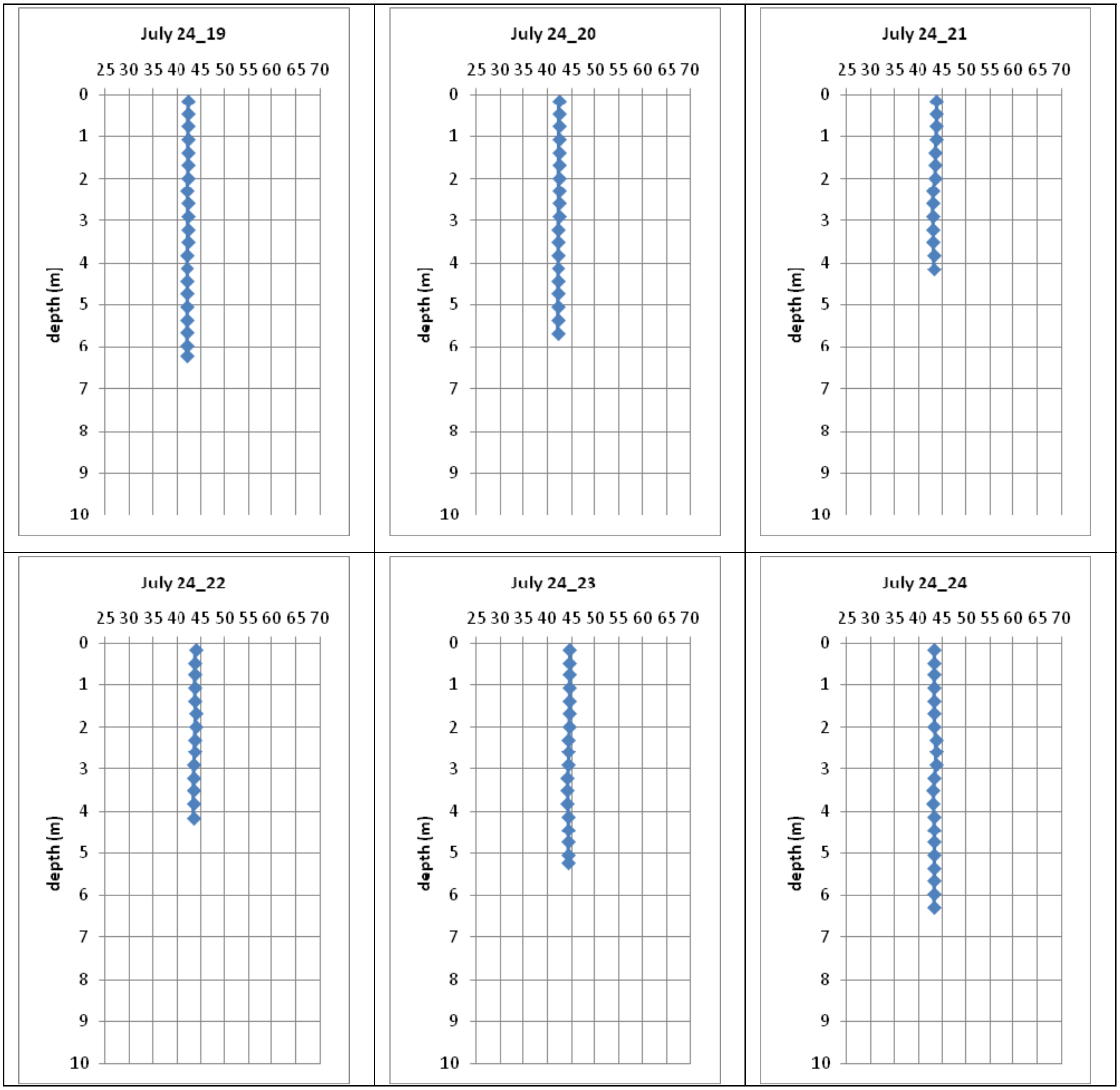

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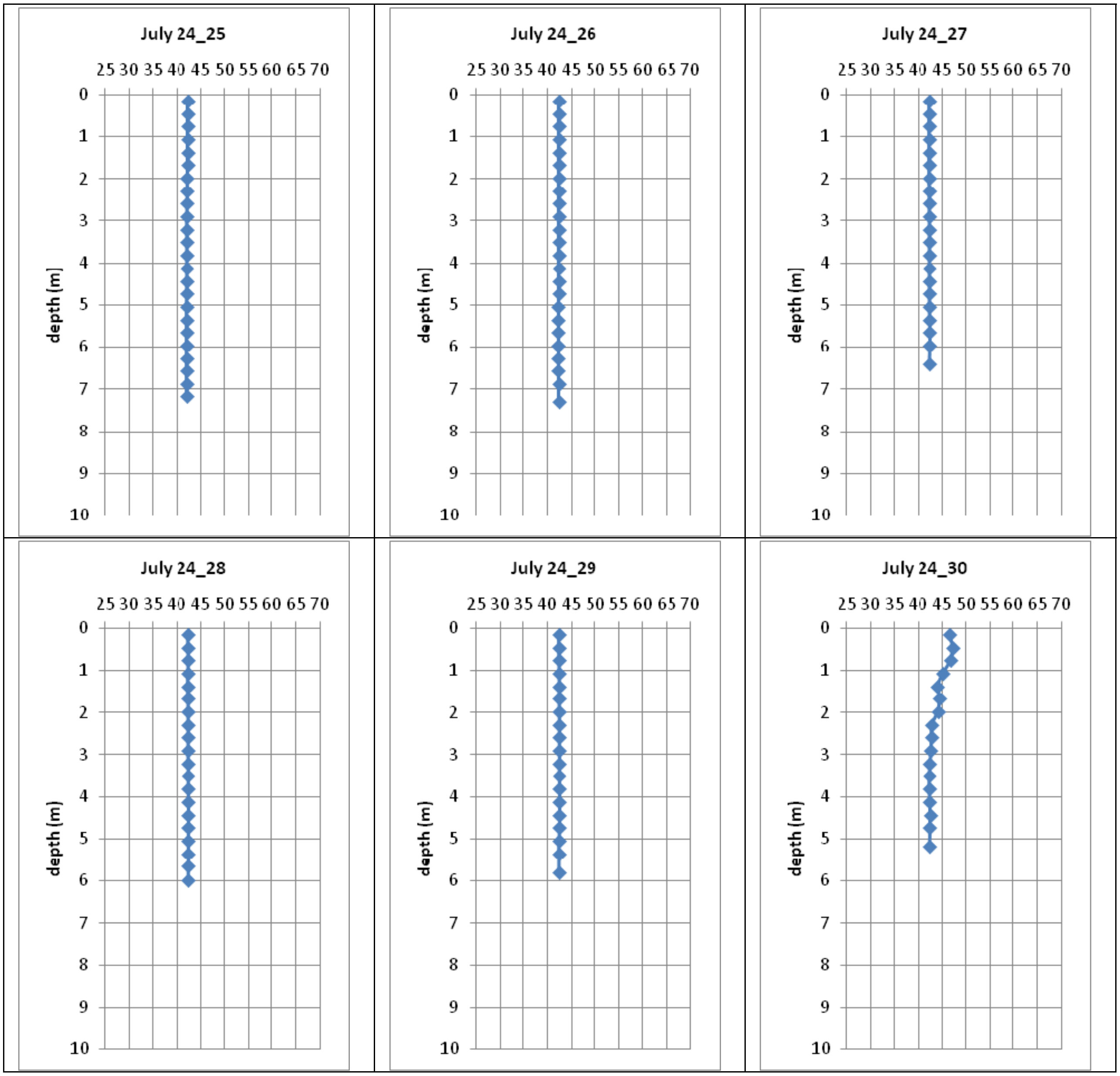

July 24_25

July 24_26

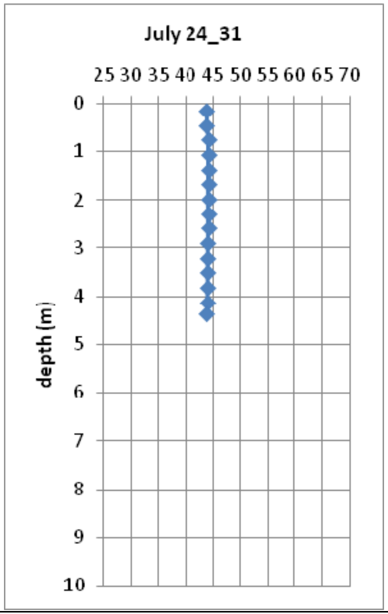
July 24_27

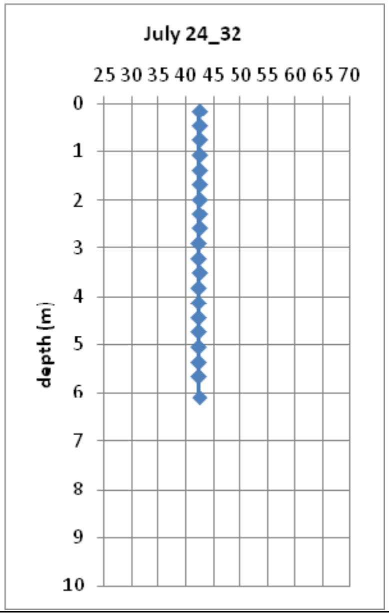
July 24_28

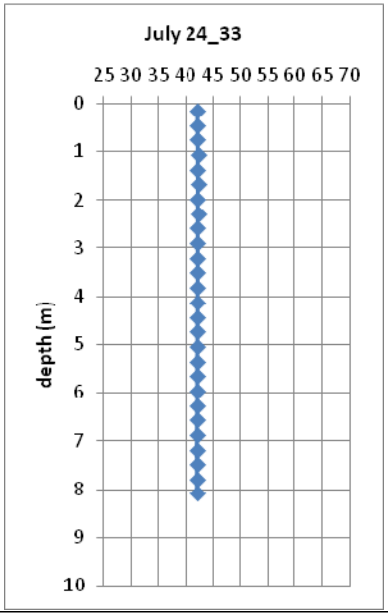
July 24_29

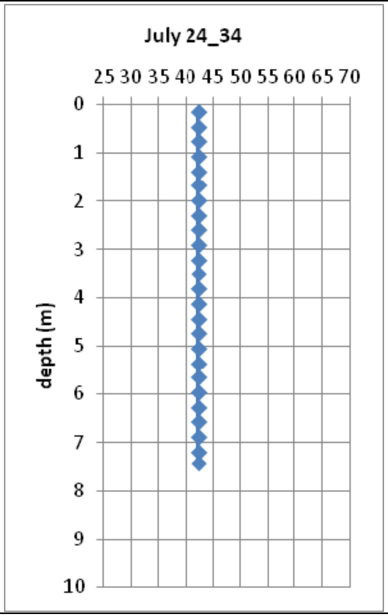
July 24_30

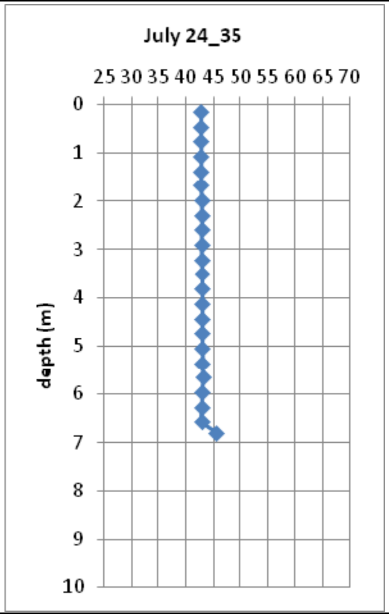
July 24, 2016, specific conductance (horizontal axis, μ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



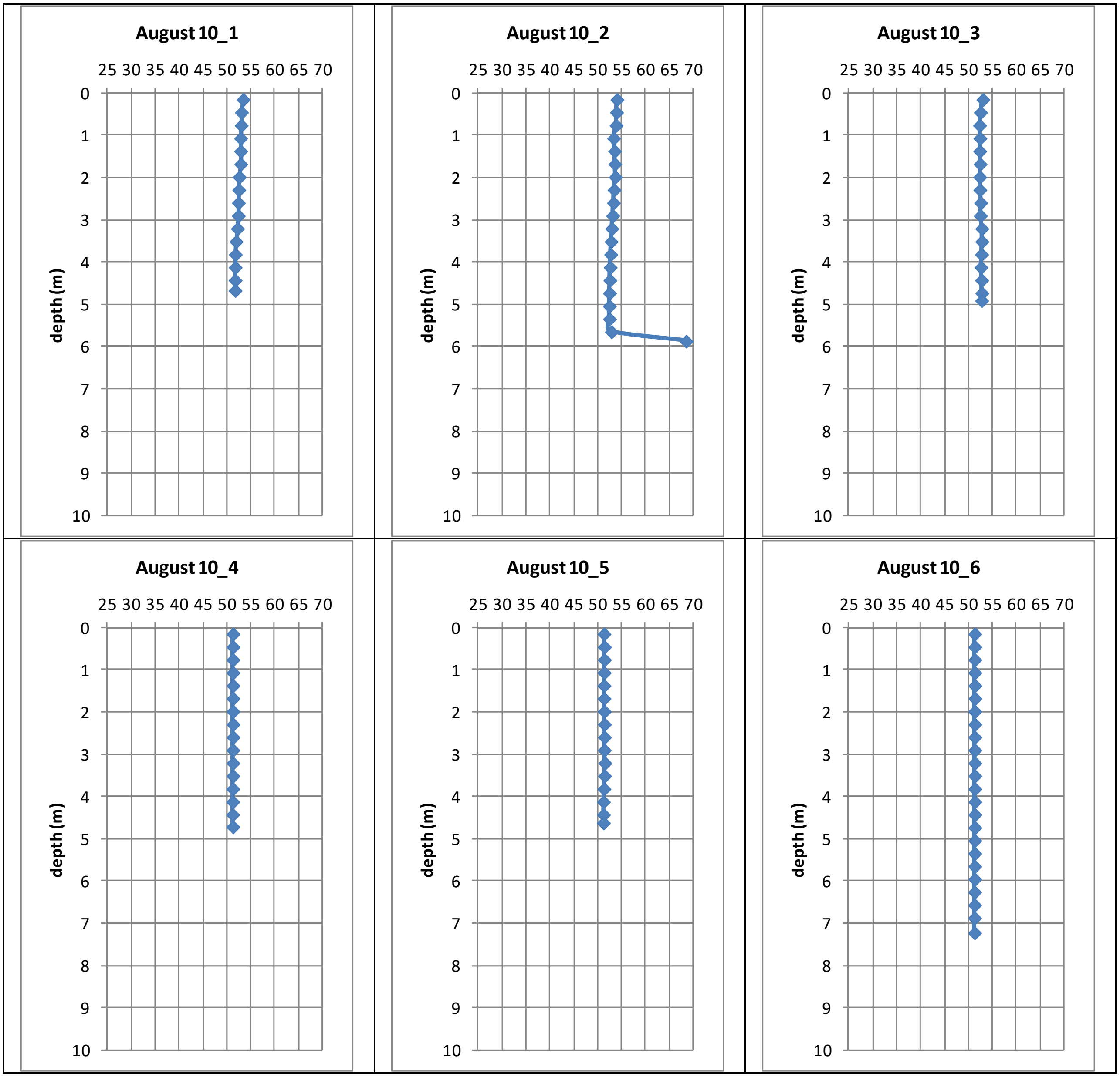




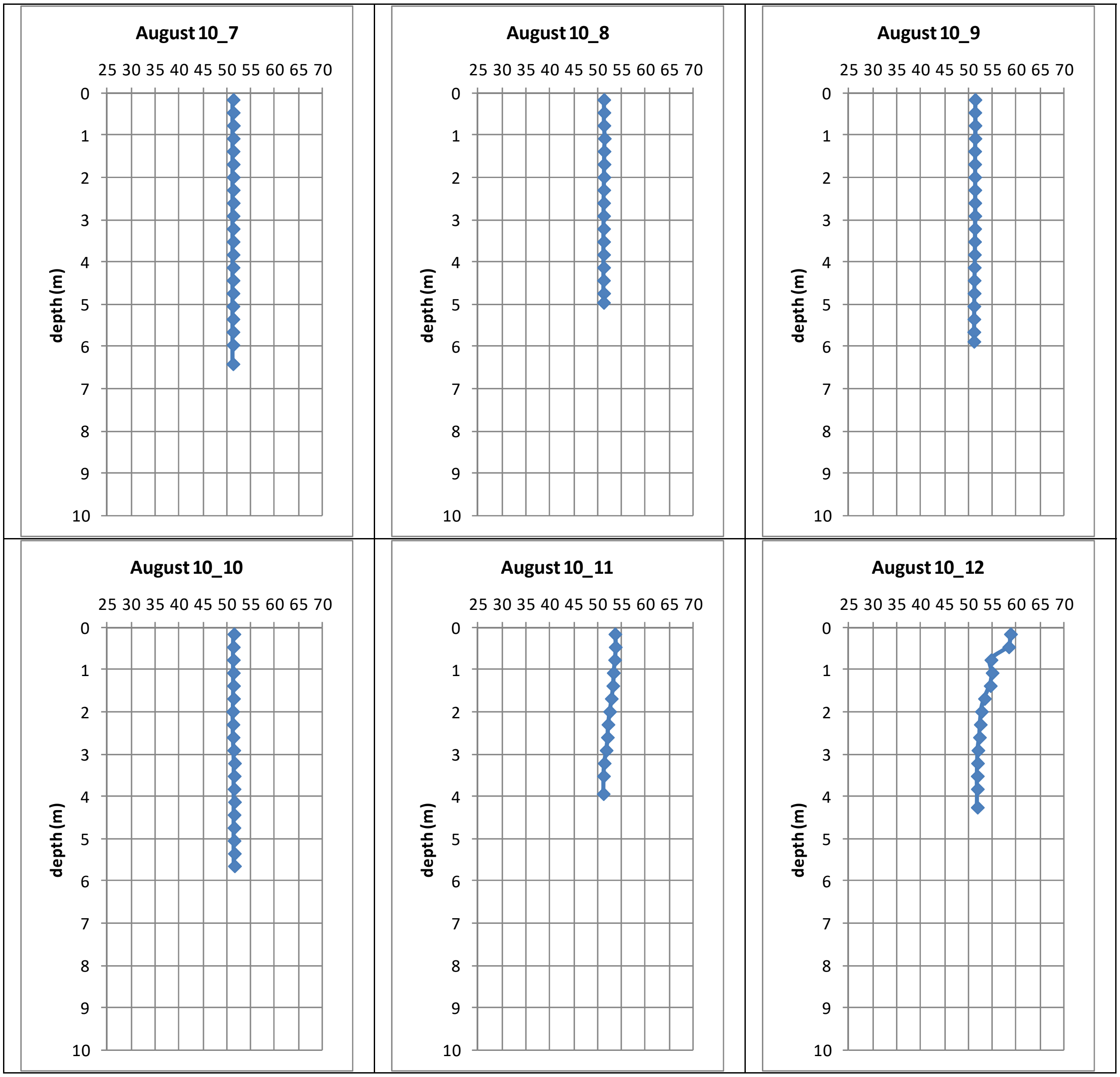




August 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



August 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



August 10_7

August 10_8

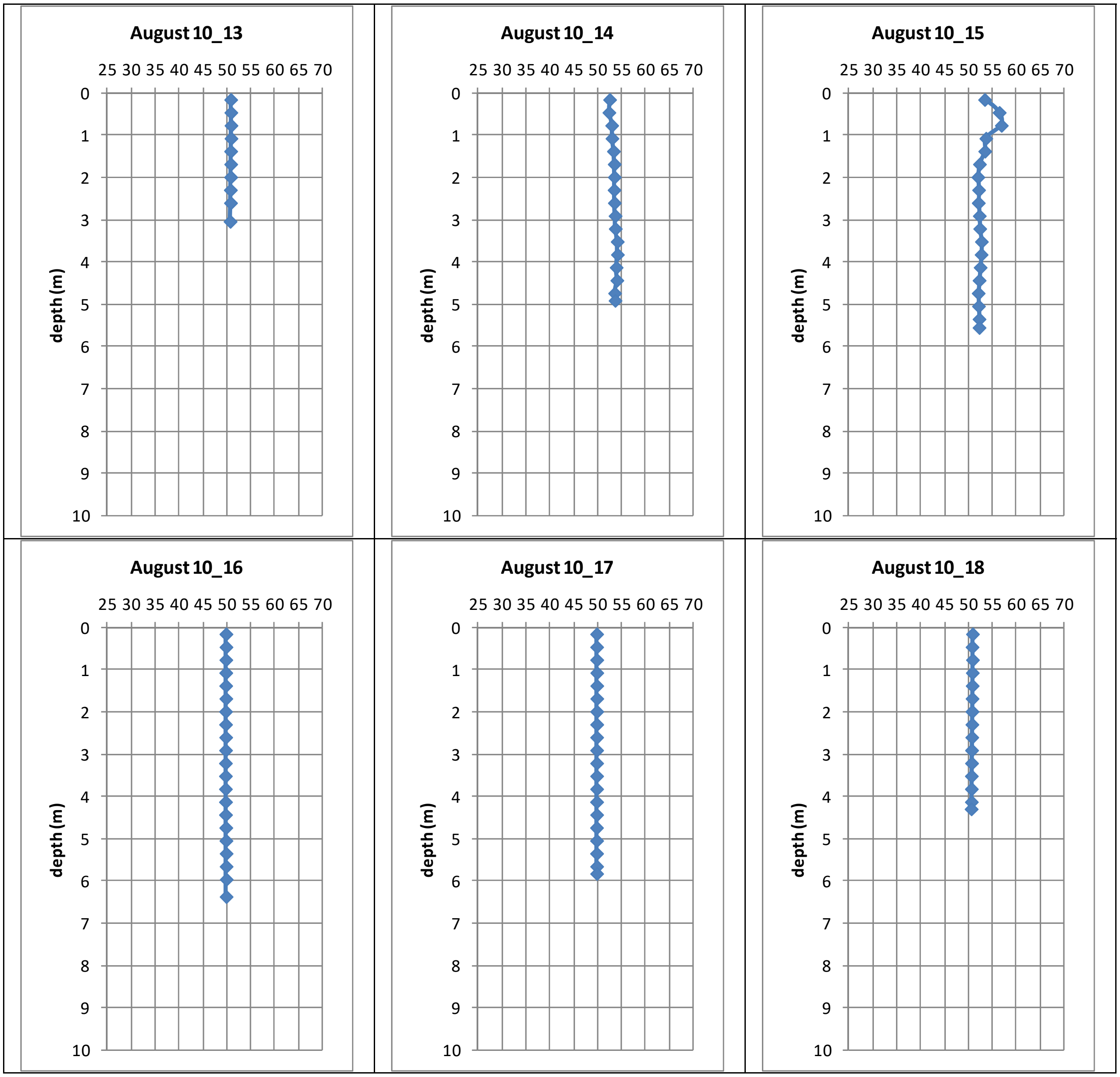
August 10_9

August 10_10

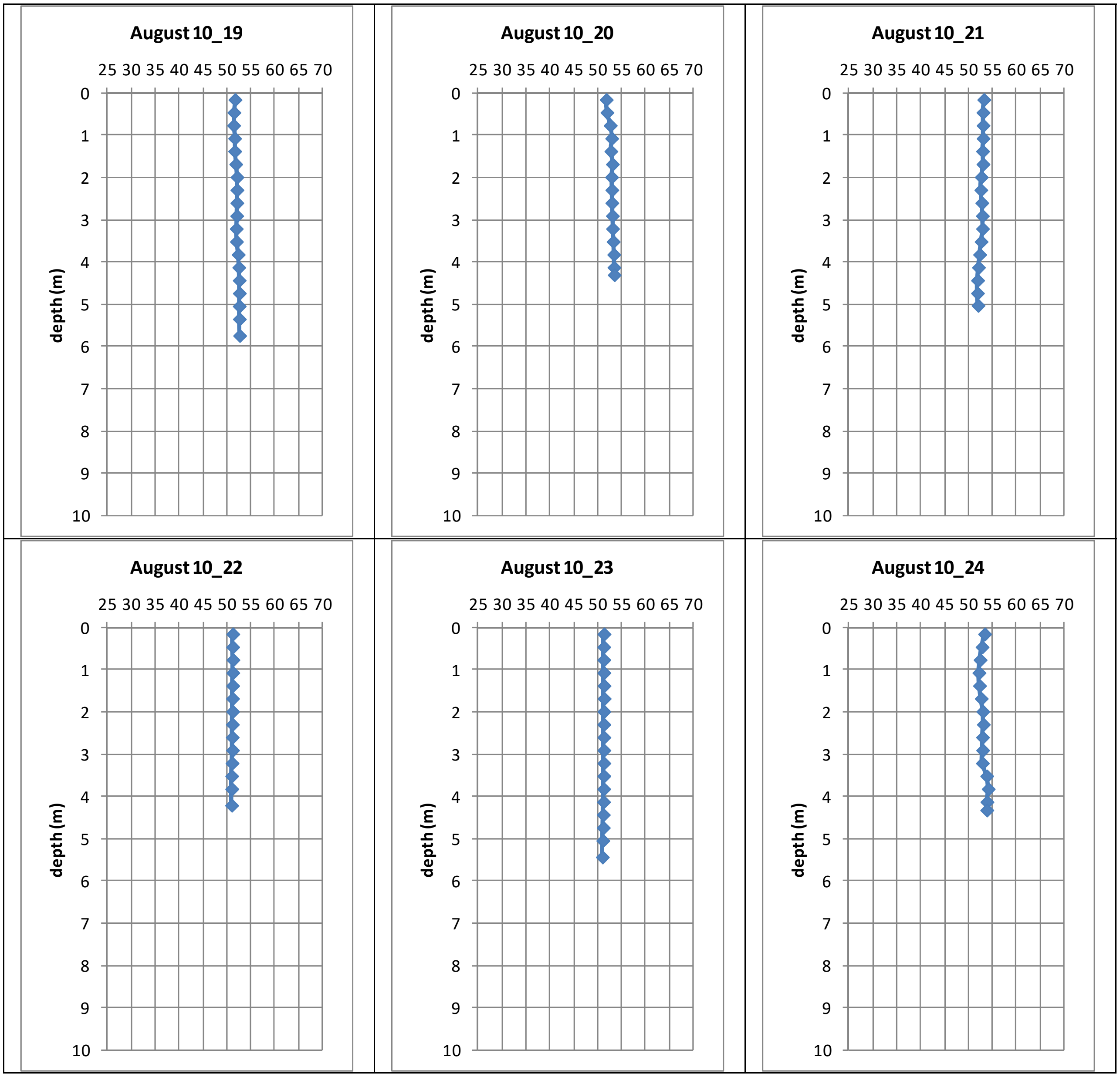
August 10_11

August 10_12

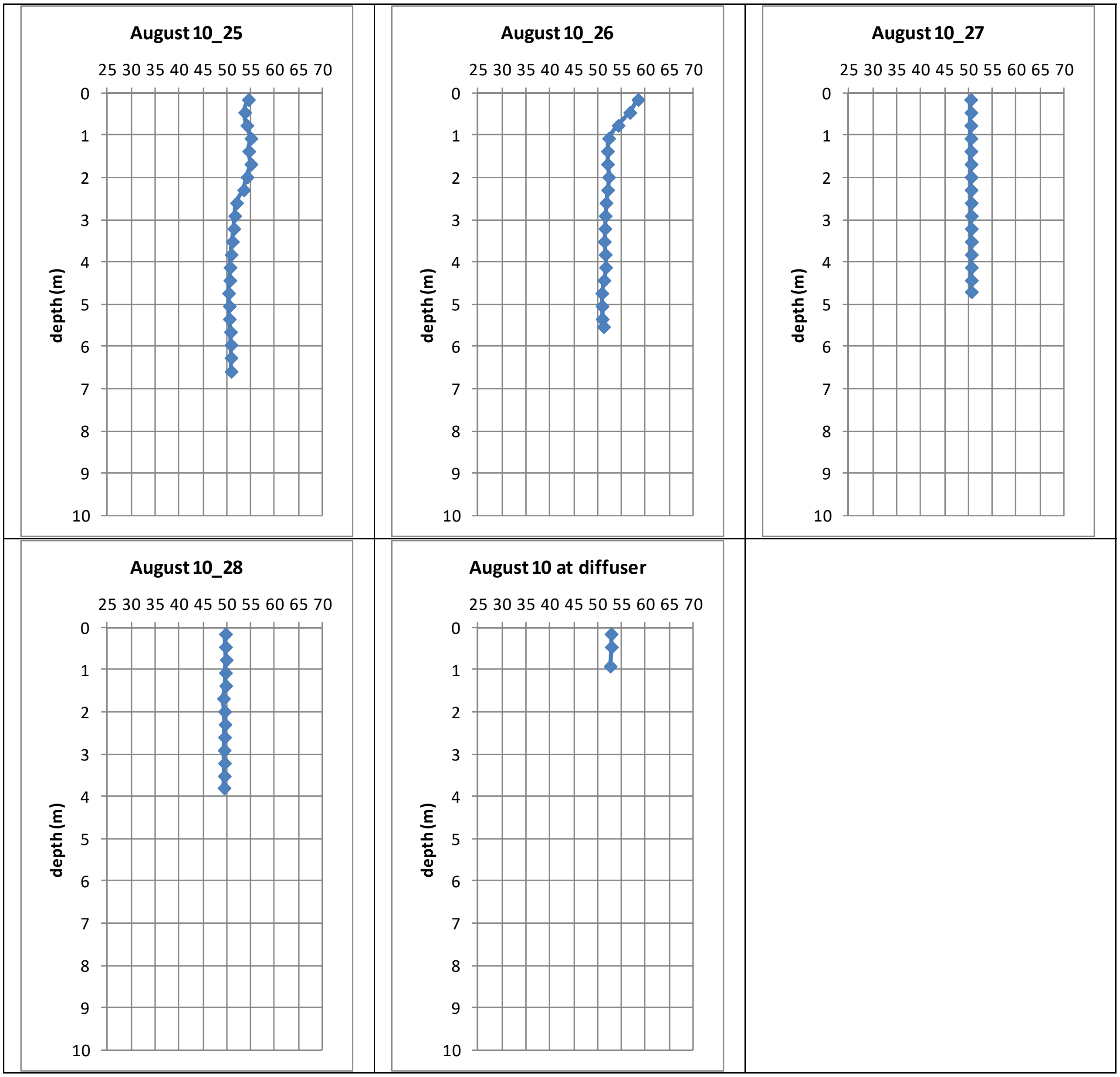
August 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



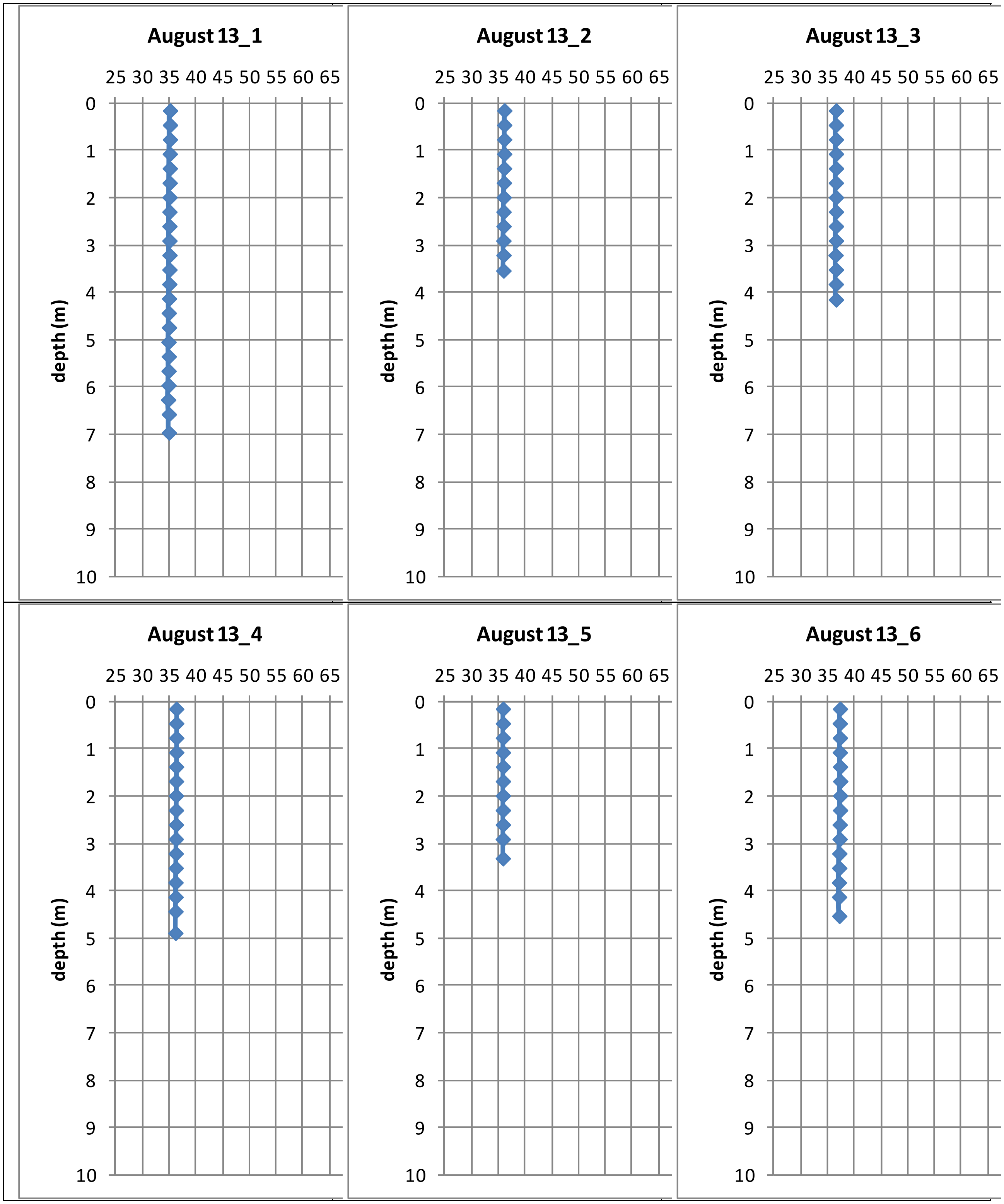
August 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



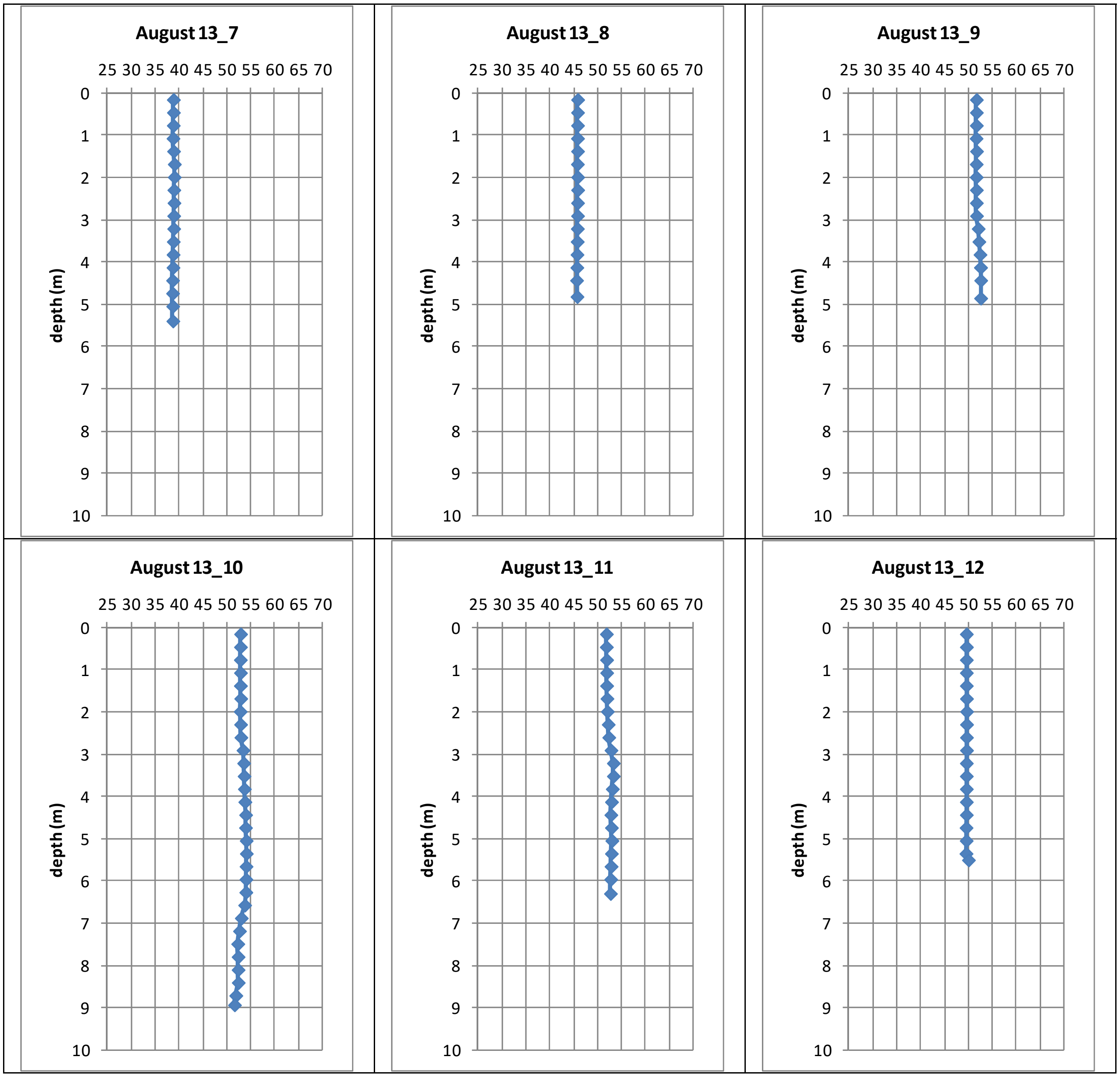
August 10, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 2.



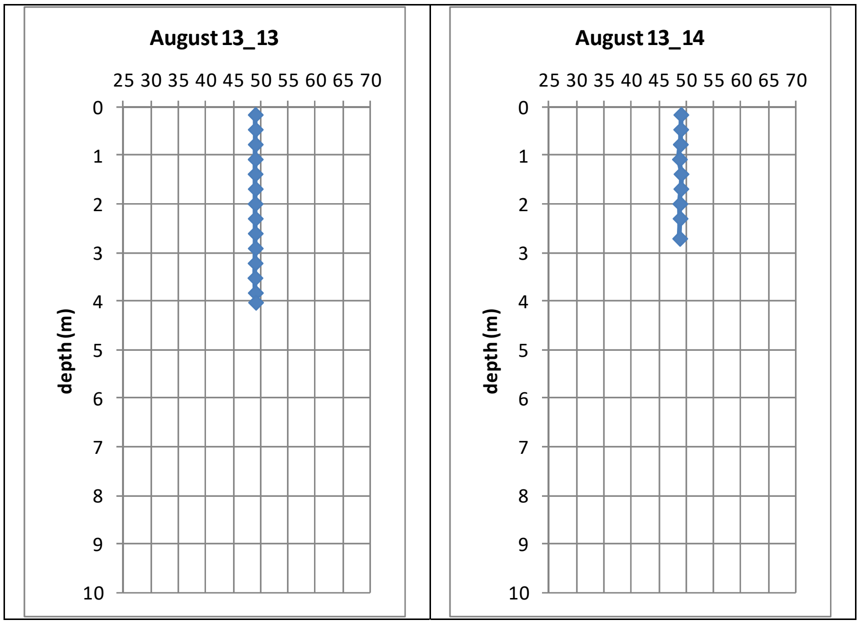
August 13, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 1.



August 13, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 1.



August 13, 2016, specific conductance (horizontal axis, µ-siemens per cm) profiles. The plot title format is Month Day_location. Locations are shown in Figure 1.



APPENDIX E

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:

- Wally Lake (TPN)
- 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, TPN)
    - Date of sample collection
    - Parameters to be measured from individual bottle (TOC, total metals, etc.)

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

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

In camp:

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

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

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

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

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

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

Field duplicate: All parameters measured in the original sample are measured in the field duplicate. The sampling station is selected at random and labeled as station CREMP [month] DUP-1, -2, -3, -4, etc. Prepare the QAQC labels and affix to the sampling containers, as described in step 2.

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

Equipment blank:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Packaging and shipping samples:

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

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

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

Standard Operating Procedure
Benthos & Sediment Sampling

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

1. Gather field collection materials:

In the boat:

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

In camp:

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

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

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

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

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

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

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

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

Transport Canada allows the free transport of formalin at concentrations less than 25% formaldehyde. Consequently, the formalin transported up to Meadowbank will be diluted in half (18.5% formaldehyde / 50% formalin solution). To prepare the neutral buffered formalin, add a small amount of calcium carbonate powder or pellets to the 50% formalin solution, seal the container and shake until mixed.
Check the pH of the solution using the pH pen. Continue adding the powder/pellets until the pH of the solution reaches approximately 7.0. Store at room temperature until ready to use. Only prepare the required volume of neutral buffered formalin for that sampling event. Buffered formalin will not store for long periods of time. Follow all safety precautions when preparing the formalin solution. Formalin is a carcinogen and irritant. Wear sampling gloves and safety glasses when mixing the solution and prepare the solution in a well ventilated area.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

PACKAGING &SHIPPING SAMPLES:

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

2. Ensure the COC form is enclosed and then seal the cooler(s). Label the cooler(s) with the following address (example):
ALS Environmental
101-8081 Lougheed Hwy.
Burnaby, BC, Canada
V5A 1W9
Tel: 604-253-4188
Attention: Natasha Marcovic-Mirovic

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

4. Ensure the COC form is enclosed and then seal the cooler(s). Label the cooler(s) with the following address:
Zaranko Environmental Assessment Services
36 McCutcheon Avenue
P.O. Box 1045

Nobleton, ON
L0G 1N0 Tel: _____________

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

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