Appendix 33

Meadowbank EEM Cycle 3 Interpretative report

ENVIRONMENTAL EFFECTS MONITORING: CYCLE 3, MEADOWBANK MINE INTERPRETIVE REPORT

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Submitted To:

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

Attention: Nancy Duquet-Harvey

C. PORTT and ASSOCIATES
56 Waterloo Avenue
Guelph, Ontario
N1H 3H5
519-824-8227
cportt@sentex.net

KILGOUR & ASSOCIATES LTD.
16-2285C St. Laurent Boulevard
Ottawa, Ontario,
K1G 4Z6
613-260-5555

EXECUTIVE SUMMARY

Introduction

Agnico Eagle Mines Ltd: Meadowbank Division began discharging treated effluent during 2009, and was subsequently required under the Metal Mining Effluent Regulations (MMER) to monitor effects of that effluent on fish and fish habitat. This is the mine's Third EEM Interpretive Report, and it is submitted to Environment Canada on behalf of Agnico Eagle Mines Limited, Val-d'Or, Québec. Although this is the Cycle 3 EEM study at the Meadowbank site, it is the first study for which Wally Lake has been the exposure site; during the previous EEM cycles the main discharge was to Third Portage North. This report documents the results of the adult fish population survey and the benthic invertebrate community survey completed for the mine's Cycle 3 EEM biological monitoring studies, as well as the sub-lethal toxicity testing carried out on the Meadowbank Division effluent since the drafting of the Cycle 2 Interpretive Report.

Fish Population Survey

Lake Trout was the sentinel fish species used in the 2017 Cycle 3 EEM survey; other species are not present in sufficient numbers. Lake Trout from the exposed area in Wally Lake (WAL) were compared to those from two reference lakes, Innuguguayalik Lake (INUG) and Pipedream Lake (PDL). The lethal study examined weight adjusted for length, liver weight adjusted for weight and length, weight at age and length at age, as well as size distribution and age distribution,. There were no significant differences ($P \leq 0.05$) in the slopes for any of the relationships examined using ANCOVA. There were no significant differences in the length or age distributions between lakes either. In other words, no effects were observed on Lake Trout in Wally Lake.

Benthic Invertebrate Community Survey

This 2017 survey of benthic invertebrates compared the exposure area in Wally Lake (WAL), with INUG and PDL as reference areas. This is the third invertebrate community survey for the Meadowbank Mine under the MMER, but the first undertaken in WAL (under MMER) because discharge to the previous exposure area (Third Portage North Lake) has ceased. Benthos have been sampled from WAL and INUG since 2006, while PDL has been sampled since 2009 as part of the mines Core Receiving Environment Monitoring Program (CREMP). The Cycle 3 EEM benthic invertebrate survey employed the same sampling methods as the CREMP program so that a before-after-control-impact (BACI) design could be used. Benthic invertebrates were collected on August 24 (PDL), 25 (INUG) and 26 (WAL), 2017. Effects assessment involved use of baseline period data dating back to 2006, and testing of before-after-control-impact (BACI) and trend over time variations.

The benthic community of WAL, in 2017, largely consisted of chironomids and sphaeriid fingernail clams, similar to what the community consisted of in all other surveys, including those from the baseline period 2006 to 2012. The community of WAL was, further, very similar to what has been described from INUG and from PDL. Some of the observed variations in core indices of composition (abundance, family richness, equitability, scores on NMDS axes 1 and 2) were related to variations in substrate total organic carbon and grain size, and sample depth. Testing for spatio-temporal variations, therefore, was carried out on residuals of the core indices, after taking into account the variations related to underlying physical variables.

When only the 2017 data were compared (H05) there was a significant difference between Reference (INUG, PDL) and Exposure (WAL) for the residuals of abundance and richness, but the effect sizes only exceeded 2 standard deviations for abundance. Abundances in WAL were high relative to INUG and PDL, however, even before the discharge of effluent into WAL. When all of the years of data were included (H01), which is arguably the most robust analysis, there was no significant difference between WAL and the average of INUG and PDL for any of the indices of composition. Residuals were significantly different between WAL and the average of INUG and PDL for equitability and both NMDS axes for H02, which included only the three most recent pre-exposure years (2010-2012), but the associated effect sizes were small (< 2SD). The time trend for the period 2013-2017 differed between WAL and the average of INUG and PDL for abundance (with ES>2 SD), and for NMDS1 (ES < 2 SD). For H04, which examined the step change in 2017 between Reference and Exposure, there were significant differences in the residuals of abundance, equitability and NMDS Axis 1, but again the difference were less than 2 SD.

Generally, and despite some of the statistically significant variations observed, the composition of benthic community of WAL was very similar to what is observed in the reference lakes, and in WAL during baseline periods, and further contained fauna indicative of high water quality. The benthic community of WAL did not indicate a degraded condition relative to the baseline period in WAL, and contained an assemblage of organisms that are typical for these Arctic systems.

There were a number of temporal variations that were significant and that were consistent with operational influences (Table 39). Most of the significant variations were small with effect sizes < 2 SDs. The most obvious significant variations that exceeded background variability were those associated with total abundances (higher in 2016 and 2017 relative to reference data), and scores on NMDS Axis 2 (lower in 2017, reflecting higher relative abundances of ostracods).

The benthic community of WAL, however, was very similar to what is observed in the reference lakes, and in WAL during baseline periods. The lake contained 10 genera of chironomid in 2017, similar to what has been observed in the other lakes. Further, the dominant chironomids in WAL are similar to what are dominant in the other lakes (i.e. *Cladotanytarsus*, *Constempellina* and *Sergentia*). Less-abundant chironomids in WAL indicated oligotrophic conditions (e.g., *Monodiamesa*). There were no oligochaete worms in the benthos of WAL in 2017, a group that typically increases in numbers when conditions degrade. The benthos of WAL also contained the caddisfly *Grensia*, which has been historically observed (in low relative abundances), and a species that is generally restricted to the cold, clear waters of the far north (Harris and Lawrence, 1978).

Sediments in WAL have around 5 to 13% TOC, whereas INUG and PDL have around 2 to 6% TOC. That difference alone would be sufficient to result in the benthos of WAL being different from what is observed in the reference lakes. Reference-condition models were used here to 'adjust' indices to a more common set of conditions in terms of substrate.

Each of the three sampling areas has relatively low hardness with concentrations of metals and nutrients that are well below CCME water quality guidelines, and near detection limits. There has been some elevation of cations (Ca, Mg, K) in WAL, reflecting the higher hardness in WAL which is associated with effluent treatment, but the changes are trivial relative to the concentrations that would be required in order to elicit a toxicity response (Mount *et al*., 1997).

Mercury in Fish Flesh

Agnico Eagle Mines Ltd. has monitored mercury concentrations in the Meadowbank Division effluent since August 2009. Concentrations have remained below or near the detection limit of 0.01 µg/L. There was, therefore, no requirement to conduct a fish tissue survey during Cycle 3.

Sub-Lethal Toxicity

Cycle 3 effluent samples produced little or no effect on survival of exposed fathead minnows. Measurable growth impairment in fathead minnows was observed in two of the samples provided, with IC25 estimates of 58.3% and 64%. Tests measured no effect on survival of *Ceriodaphnia dubia* while two tests resulted in IC25 estimates of 86.1% and 59.3%. Final effluent samples did not impair growth in any of the *Pseudokirchneriella subcapitata* or *Lenna minor* tests during Cycle 3.

Future EEM Schedule

This Cycle 3 EEM study was the first EEM study for which Wally Lake was the exposure area. The next EEM cycle should, therefore, be completed within 36 months of this submission. In 2017, 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 and, therefore, was the focus of this Cycle 3 EEM field study. Agnico will continue to monitor the volume and quality of the mine effluents. These data will be used to determine the effluent stream that will be the focus of the Cycle 4 EEM field study.

C. PORTT AND ASSOCIATES

Cam Portt, M.Sc.

KILGOUR & ASSOCIATES LTD.

Bruce Kilgour, PhD

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1.0 INTRODUCTION

1.1 Meadowbank Mine

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 (Figure 1). Mine construction began in 2008 under Nunavut Water Board Type A License 2AM-MEA0815 (now 2AM-MEA1525) and Fisheries and Oceans Canada Authorization for Works or Undertaking Affecting Fish Habitat NU-03-0191.3 and NU-03-0191.4. Mine construction activities for the Goose Pit and Portage Pit included the isolation of portions of two lakes using dikes, with the dewatering of these impoundments into adjacent lakes starting in 2009. On December 31, 2009, Environment Canada notified AEM that the Meadowbank Mine is subject to the Metal Mining Effluent Regulations (MMER). Mining activities have been formally underway since March 2010, and are projected to occur until Q3, 2018. Mining at Meadowbank has occurred in four open pits (Goose Pit, Portage Pit, Vault Pit and Phaser Pit), though only two are currently operational, with Goose Pit completely depleted. Much of the pit development is located in close proximity to the mill, office and lodging infrastructure, with the exception of the Vault and Phaser Pits which are approximately 10 km northeast of the main mine site (Figure 2).

1.2 Regulatory Background

The MMER, under the Fisheries Act, imposes liquid effluent limits for pH, cyanide, metals and 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. Under the MMER, Agnico Eagle Mines Limited (Agnico) is required to conduct aquatic monitoring studies on the potential effects of the Meadowbank Division Mine's final liquid effluent on 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.

Agnico conducted its Cycle 1 Biological Monitoring Study in August 2011, collecting fish and benthos from the exposure area in Third Portage Lake North (TPN) (Figure 2) and from two reference areas, one each in Innuguguayalik Lake (INUG) and Pipedream Lake (PDL)(Figure 2). The results of that first study were reported to Environment Canada in June 2012 (Azimuth, 2012). The Cycle 2 Biological Monitoring Study was conducted in August 2014, using the same exposure and reference areas. The results of the second study were reported to Environment Canada in June 2015 (C. Portt and Associates, and Kilgour & Associates Ltd., 2015). A study design for a proposed Cycle 3 EEM Study, with the exposure area in Wally Lake, was submitted to Environment Canada on February 17, 2017 (C. Portt and Associates, and Kilgour

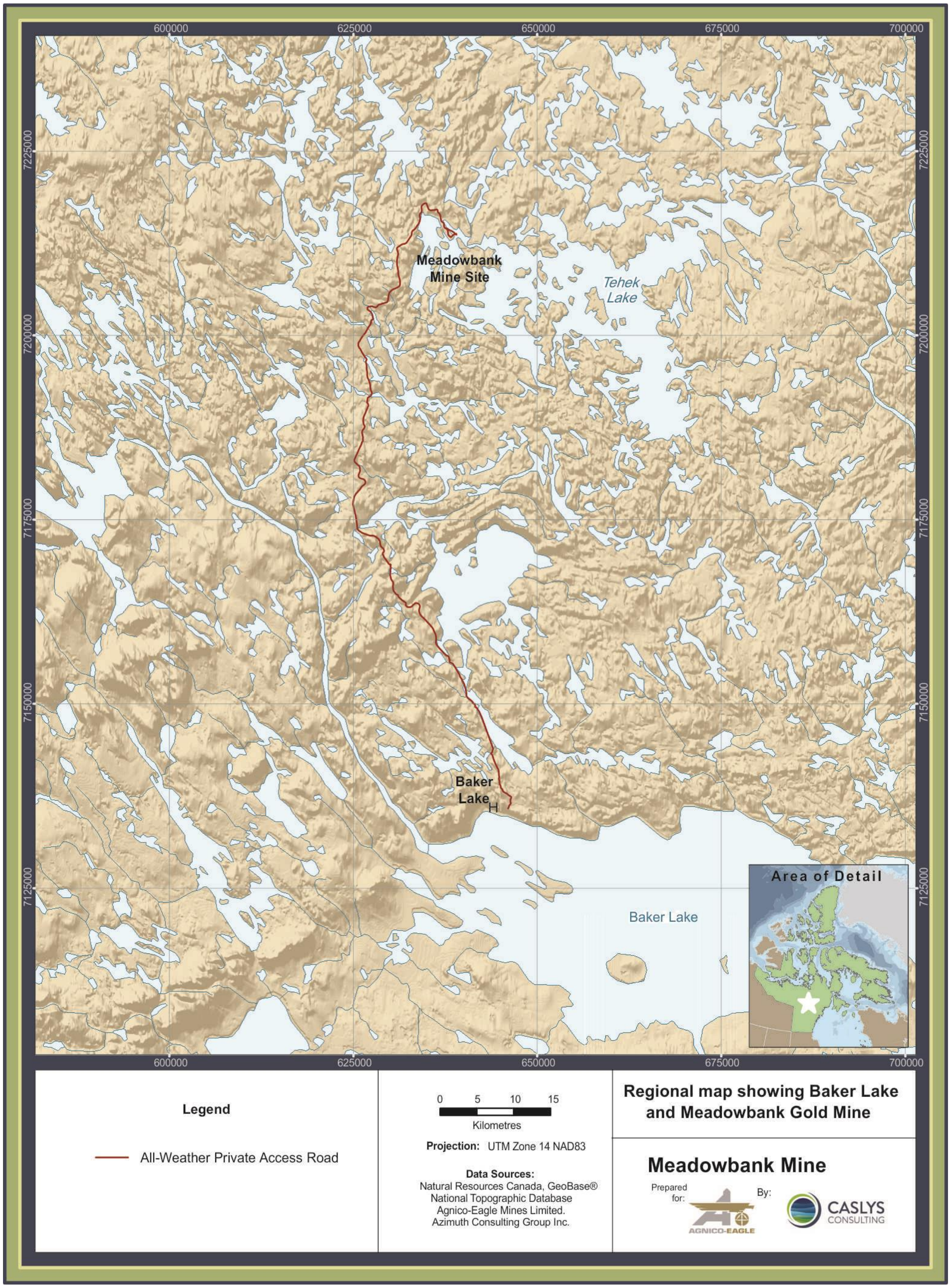


Figure 1. Location of Meadowbank Mine.

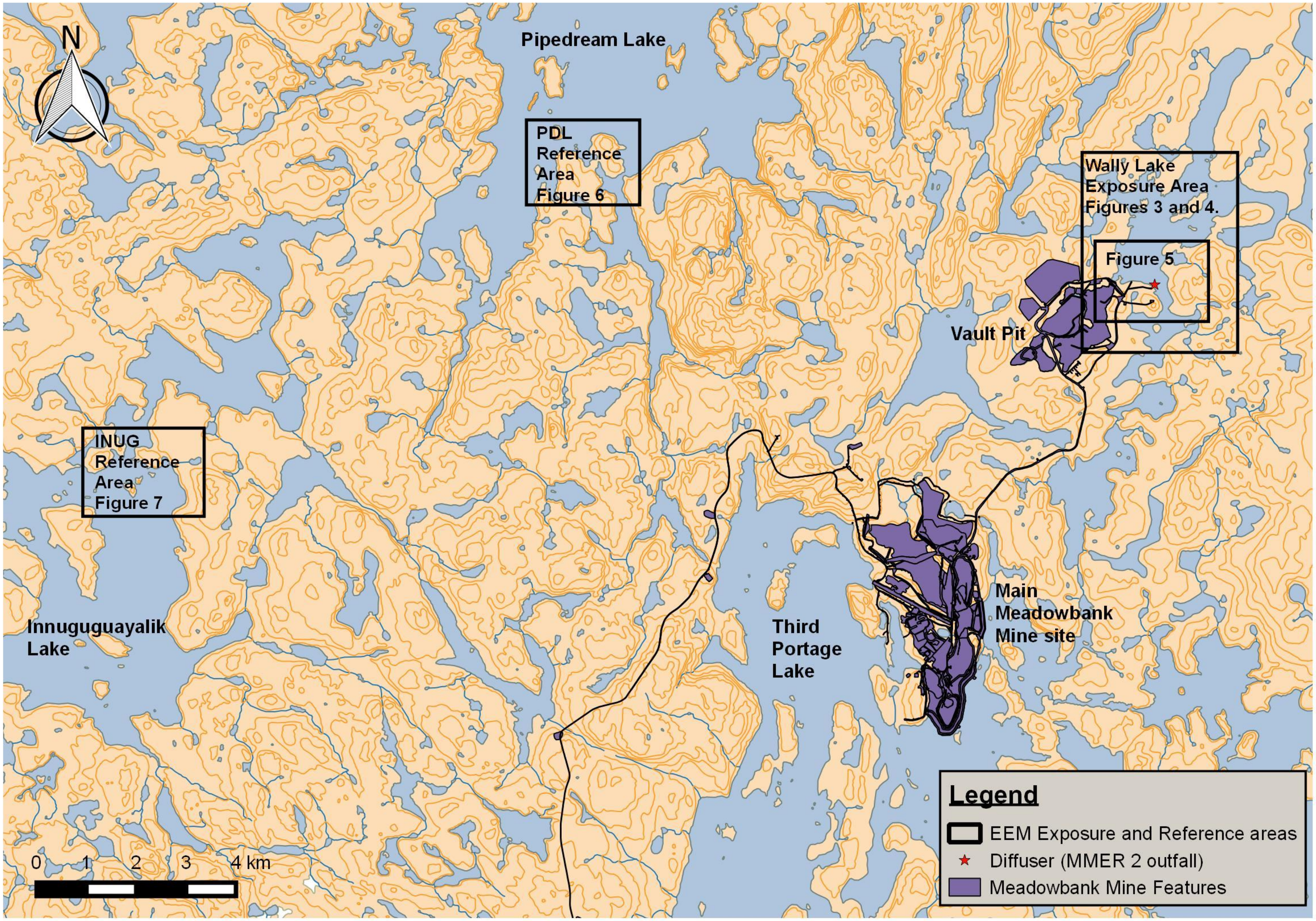


Figure 2. Map of the study area.

& Associates Ltd., 2017). The Technical Advisory Panel (TAP) reviewed the study design and provided comments to Agnico Meadowbank Division. These comments were addressed by Agnico, and the Meadowbank Cycle 3 EEM study design was apparently accepted by Environment Canada on July 26, 2017 (Appendix 1). This report describes the results of the Third Biological Study undertaken August 23-27, 2017, pursuant to Agnico's requirement under the MMER.

1.3 Concordance with Requirements

The Concordance Table (Table 1) provides a list of the MMER Interpretative Report requirements, and identifies where in this document the required information can be found.

Table 1. Concordance table identifying the sections of this report that address specific MMER reporting requirements.

MMER Requirement	Where Found in the Document
16. The data collected during the biological monitoring studies shall be used to: Calculate the arithmetic mean, the median, the standard deviation, the standard error and the minimum and maximum values in the sampling areas.	Raw data and summaries can be found in Section 3 and Appendix 2 and 3 for fish, and Section 4 and Appendix 5 for invertebrates. The raw data have also been submitted to the Environment Canada digital database.
17(a) Description of any deviation from the study design that occurred while the biological monitoring studies were being conducted and any impact that the deviation had on the studies.	Section 2.3
17(b) The latitude and longitude of sampling areas in degrees, minutes and seconds and a description of the sampling areas sufficient to identify the location of the sampling areas.	Digital data submission, Sections 3 and 4 and Appendix 2.
17(c) The dates and times when the samples were collected.	Sections 3 and 4
17(d) The sample sizes.	Sections 3 and 4
17(e) The results of the data assessment made under Section 16 and any supporting raw data	Section 3 for fish Section 4 for invertebrates
17(f) Based on (e), summary of effects on fish, fish tissues, invertebrates	Section 3 for fish A fish tissue study was not required (Section 5) Section 4 for invertebrates
17(g) Comparison of effects observed in (f) to results of sublethal toxicity testing.	Sections 6 and 7
17(h) conclusions of the biological monitoring studies taking into account: results of previous studies submitted under the study design; the presence of anthropogenic, natural or other factors that are not related to the effluent under study and that may reasonably be expected to contribute to any observed effect; the results of the statistical analysis conducted under paragraph 16(c) a description of the quality assurance/quality control measures that were implemented and the data related to the implementation of those measures.	Sections 3, 4, and 6 Appendices 3, 4 and 6
17(i) A description of how the results will impact the study design for subsequent biological monitoring studies	Section 3.4.1 for fish Section 4.4.1 for invertebrates
17(j) the date when the next biological monitoring study will be conducted.	Executive Summary Section 7

2.0 STUDY DESIGN UPDATE

2.1 Mining and Wastewater Management Overview

A detailed description of the Meadowbank Mine wastewater treatment system is provided in the EEM Cycle 3 Study Design (C. Portt and Associates, Kilgour & Associates Ltd., 2017). No changes in the wastewater treatment system occurred between the submission of the Study Design and the Cycle 3 field work in August 2017.

It is important to distinguish between the two major water-related "processes" that were in operation at the Meadowbank Mine prior to and during the EEM field work:

- *Reclaim Water* – All mining-related water (e.g., from the mill and/ or stormwater management pond, is segregated, and stored or actively pumped into the reclaim pond as make-up water. Presently, the reclaim pond is located within the South Cell of the TSF. **This water is not currently being discharged.**
- *Contact Water* – contains residual localized mine site drainage that may have been in contact with PAG material (i.e. from the Portage Waste Rock facility drainage which is directed to south cell) and water that is collected and actively pumped from the mine pits, either from groundwater sources, from dike water seepage to the South Cell or from the natural re-flooding of Goose Pit.

Relevant to this EEM, mine effluent did not contain water that had come into contact with milled tailings. The Meadowbank Mine has two (2) active effluents. Contact water from the Vault Attenuation Pond is discharged to Wally Lake via outfall MMER 2, and non-contact water originating from the seepage at the East Dike is discharged into Second Portage Lake via outfall MMER 3. Neither of these discharges has required water treatment to date. The largest effluent stream is via a diffuser into Wally Lake and, based on its composition, has the greatest potential to cause harm to the environment and, therefore, is the focus of this 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 the total discharge was significantly reduced from what occurred in 2015 and 2016, because the Phaser Lake dewatering was complete, with a total discharge of 715,605 m^3. 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 83,928 m^3 in 2017.

To date, the Meadowbank mine has not and, in the future, does not expect to discharge any reclaim water to the receiving environment; rather, it will be combined with freshwater from Third Portage Lake and used to re-flood the pits as part of mine reclamation. Effluent is only discharged to the environment periodically (Table 2, Table 3, and Table 4), and during 2017 it was discharged periodically from June 19 to October 9, including during the Cycle 3 EEM field studies conducted from August 23 to 27, 2017 (Table 4).

Effluent from the Meadowbank Mine was generally not acutely toxic during 2017 (Table 5). Toxicity test results for sublethal endpoints for 2017 are presented in Table 6.

There have been no exceedances of the MMER effluent discharge limits for deleterious substances at the Meadowbank Mine up to October 2017.

Table 2. 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 3. 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 4. Meadowbank Division effluent volume (m^3) to Wally Lake from Vault Attenuation Pond via outfall MMER 2 for 2017.

Date	Jan-17	Feb-17	Mar-17	Apr-17	May-17	Jun-17	Jul-17	Aug-17	Sep-17	Oct-17	Nov-17	Dec-17
1	0	0	0	0	0	0	16622	3465	0	0	0	0
2	0	0	0	0	0	0	17143	15840	0	0	0	0
3	0	0	0	0	0	0	16980	0	0	0	0	0
4	0	0	0	0	0	0	16320	0	0	0	0	0
5	0	0	0	0	0	0	16528	0	0	1655	0	0
6	0	0	0	0	0	0	0	0	0	16125	0	0
7	0	0	0	0	0	0	0	2602	0	14417	0	0
8	0	0	0	0	0	0	15787	0	0	13055	0	0
9	0	0	0	0	0	0	11076	0	0	11695	0	0
10	0	0	0	0	0	0	22559	0	0	0	0	0
11	0	0	0	0	0	0	779	0	139	0	0	0
12	0	0	0	0	0	0	21029	0	12,535	0	0	0
13	0	0	0	0	0	0	16733	0	10,794	0	0	0
14	0	0	0	0	0	0	11633	0	13,170	0	0	0
15	0	0	0	0	0	0	15771	0	6,279	0	0	0
16	0	0	0	0	0	0	16855	4095	0	0	0	0
17	0	0	0	0	0	0	10035	12000	0	0	0	0
18	0	0	0	0	0	0	0	11424	0	0	0	0
19	0	0	0	0	0	12165	0	11424	0	0	0	0
20	0	0	0	0	0	18504	0	3639	0	0	0	0
21	0	0	0	0	0	18960	16301	9312	0	0	0	0
22	0	0	0	0	0	18665	15169	9480	0	0	0	0
23	0	0	0	0	0	16767	9652	9480	0	0	0	0
24	0	0	0	0	0	17758	10093	9000	0	0	0	0
25	0	0	0	0	0	14290	0	8640	0	0	0	0
26	0	0	0	0	0	17528	0	7920	0	0	0	0
27	0	0	0	0	0	17012	0	6792	0	0	0	0
28	0	0	0	0	0	11760	0	7368	0	0	0	0
29	0		0	0	0	16258	0	6720	0	0	0	0
30	0		0	0	0	17897	0	1912	0	0	0	0
31	0		0		0		0	0		0		0
Total	**0**	**0**	**0**	**0**	**0**	**197,564**	**277,065**	**141,113**	**42,917**	**56,947**	**0**	**0**

Table 5. 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 month avg Conc	0.50	0.30	1	0.20	0.50	0.50	15	0.37	6-9.5		
Max grab Conc	1.00	0.60	2	0.40	1.00	1.00	30	1.11	6-9.5		
Date											
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
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

	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 %**
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
19-Jun-17	<0.0005	0.0025	0.0010	0.0009	0.0041	0.002	10.00	0.003	7.45	100	>100
26-Jun-17	<0.0005	0.0033	0.0030	0.0016	0.0043	0.0050	<1.00	-	-	NMR	NMR
3-Jul-17	<0.0005	0.0026	<0.001	0.0083	0.0045	0.0030	<1.00	0.0030	7.57	>100	>100
10-Jul-17	0.0043	0.0024	0.205	0.1225	0.0038	<0.001	4	-	8.05	NMR	NMR
17-Jul-17	<0.0005	0.0031	0.002	<0.0003	0.0048	<0.001	4	-	8.32	NMR	NMR
24-Jul-17	<0.0005	0.0028	0.001	<0.0003	0.0051	0.002	<1.00	0.003	7.73	NMR	NMR
1-Aug-17	<0.0005	0.0027	0.001	0.0004	0.0047	0.002	1.00	0.009	7.44	>100	>100
7-Aug-17	<0.0005	0.0023	<0.001	<0.0003	0.0041	0.006	10.00	0.008	7.95	NMR	NMR
21-Aug-17	<0.0005	0.0052	0.001	<0.0003	0.0056	<0.001	22.00	-	7.71	NMR	NMR
29-Aug-17	<0.0005	0.0030	0.014	<0.0003	0.0045	0.001	11.00	0.019	7.73	NMR	NMR
11-Sep-17	<0.0005	0.0032	0.019	<0.0003	0.0037	0.003	9.00	-	8.17	>100	>100
5-Oct-17	<0.0005	0.00	0.01	<0.0003	0.01	0.015	6.00	0.011	7.34	>100	>100
9-Oct-17	0.0022	0.0033	0.005	<0.0003	0.0076	0.001	10.00	-	7.80	NMR	NMR

NMR = No measurement required.

Table 6. Sublethal endpoints and associated chemical and physical parameters for final effluent (MMER 2) in 2016 and 2017.

Date	18/07/2016	22/08/2016	26/09/2016	19/06/2017	24/07/2017	07/08/2017	29/08/2017	11/09/2017
Parameter								
Alkalinity (mg $CaCO_3$/L)	23	28	15	30	53	53	54	63
Aluminium (mg/L)	0.046	0.161	0.01	0.23	0.101	0.202	0.389	0.283
Ammonia (mg N/L)	<0.01	0.01	<0.01	<0.01	0.01	<0.01	0.03	0.04
Ammonia nitrogen (NH3-NH4) (mg N/L)	0.66	1.14	0.01	0.54	0.98	0.63	1.82	3.1
Cadmium (mg/L)	0.00007	<0.00002	<0.00002	0.00003	<0.00002	0.00002	<0.00002	<0.00002
Hardness (mg $CaCO_3$/L)	67	113	20	38	77	85	151	148
Iron (mg/L)	0.07	0.45	0.01	0.39	0.21	0.32	0.47	0.47
Mercury (mg/L) (max allowance of 0.10µg/L)	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00004
Molybdenum (mg/L)	0.0054	0.0142	0.0005	0.0037	0.0081	0.0102	0.0198	0.0227
Nitrate (mg N/L)	3.36	6.6	0.24	0.68	2.90	2.97	6.34	7.48
Selenium (mg/L)	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002
Conductivity (µs/cm)	170	261	179	148.5	212.1	274	381	459
Temperature (^{0}C)	14.1	15.7	12.52	10.11	12.12	9	8.8	8.7
Fathead Minnow IC25	58.3	64	-	-	-	>100	-	>100
Fathead Minnow LC50	82	>100	-	-	>100	>100	-	>100
Ceriodaphnia dubia IC25	>100	>100	-	-	-	59.3	-	>100
Ceriodaphnia dubia LC50	>100	>100	-	-	>100	>100	-	>100
Freshwater Alga (*Pseudokirchneriella subcapitata* IC25	>90.91	>90.91	-	-	>90.9	>90.91	-	>90.91
Lemna minor IC25 dry weight %v/v	>97	>97	-	-	-	>97	-	>97
Lemna minor IC25 frond number %v/v	>97	>97	-	-	-	>97	-	>97

2.2 Effluent Mixing in the Receiving Environment

The effluent discharge location has changed since EEM Cycle 2, when effluent was discharged from the Portage 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. Effluent mixing in Wally Lake was modeled by W.F. Baird & Associates Coastal Engineers Ltd. (Baird) in 2017, and was provided in the Cycle 3 study design document (C. Portt and Associates, and Kilgour & Associates Ltd., 2017). 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.

A field investigation of the Wally Lake effluent plume was conducted in 2016 by Agnico Eagle and C. Portt and Associates (C. Portt and Associates, and Kilgour & Associates Ltd., 2017) 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 for 2016 commenced on July 16. 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, 2016, 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.

The plume was investigated in the field again on July 21, 2017, by Agnico Eagle staff, as well as during the Cycle 3 EEM field work on August 26, 2017, by C. Portt and Associates and Kilgour & Associates staff. Specific conductance was used as an effluent tracer. At multiple locations, depth, temperature, conductivity and specific conductance profiles, from lake surface to lake bottom, were collected using a SonTek Castaway©-CTD (Xylem Inc.; refer to Table 7 for specifications). Specific conductance of the effluent was determined from effluent collected at the effluent pump. The minimum specific conductance recorded for each profile was used in the calculation of effluent concentrations. The specific conductance at the profile located farthest from the diffuser was assumed to represent the background specific conductance of Wally Lake. Effluent concentration was calculated using the formula

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

where K_X=specific conductance of solution containing X% effluent,
K_L= base line specific conductance of Wally Lake, and
K_e= specific conductance of the effluent.

To solve for X, this equation is rearranged as

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

The results of the plume delineations are presented in Figure 3 and Figure 4. For the July 21 plume, the two sampling locations farthest north (ref. Figure 3) showed similarly low specific conductance (34.23 and 34.19 µS/cm), suggesting that the limit of the plume had been reached. The July 21 data indicate that the effluent concentration reached 1% approximately 1.6 km north of the diffuser, which is a slightly less extensive plume than the largest predicted extent calculated using CORMIX under a low wind, negatively buoyant, scenario (C. Portt and Associates, and Kilgour & Associates Ltd., 2017).

During the August 26, 2017, plume investigation, specific conductance continued to decrease slightly with increasing distance from the diffuser even at the locations of the farthest profiles (Figure 4), indicating that the limit of the plume may not have been reached. However, the similarity of these specific conductance readings farthest from the diffuser (ref. Figure 4) suggests that the specific conductance at the farthest location is a reasonable, and conservative, approximation of background. The August 26 data indicate that at its closest point from the diffuser the effluent concentration reached 1% approximately 711 m north of the diffuser, which is about the same as the extent of the "typical condition" plume calculated using CORMIX under a medium wind, positively buoyant, scenario (C. Portt and Associates, and Kilgour & Associates Ltd., 2017). As Figure 3 and Figure 4 illustrate, on both July 21 and August 26, the Cycle 3 EEM exposure sampling locations were all well within the >1% effluent plume.

Table 7. 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

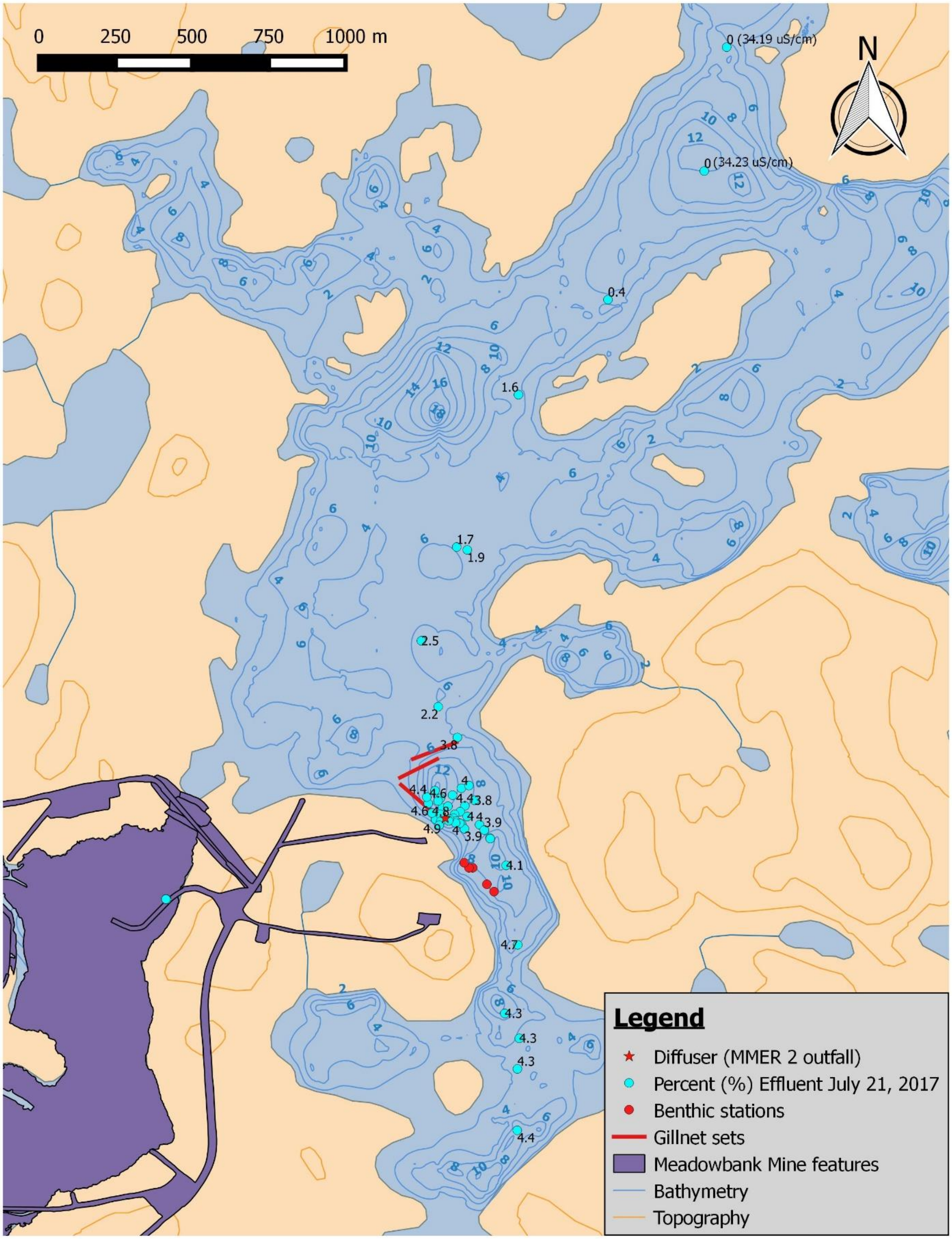


Figure 3. Effluent concentrations in Wally Lake on July 21, 2017.

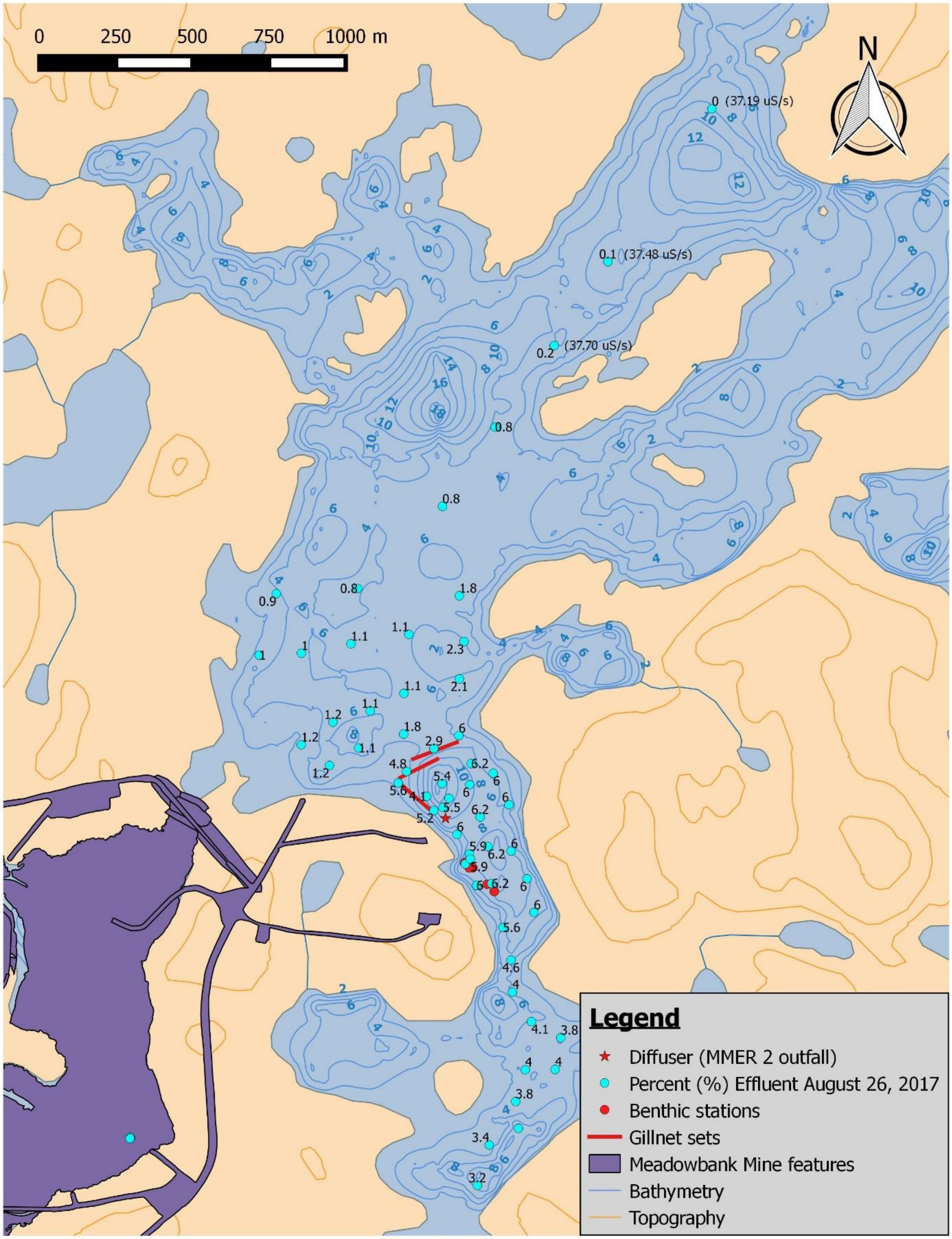


Figure 4. Effluent concentrations in Wally Lake on August 26, 2017.

2.3 Overview of Study Design and Changes

2.3.1 Adult Fish Survey

The Cycle 3 study design report (C. Portt and Associates, and Kilgour & Associates Ltd., 2017) proposed a lethal study of Lake Trout (*Salvelinus namaycush*) to be captured by gill netting in one exposure area (WAL; (Figure 5) and two reference areas (PDL and INUG; Figure 6 and Figure 7, respectively) with a target sample size of 20 fish per area, with length and weight determined for any additional Lake Trout that were released. The following information was to 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

Age would be determined from otoliths and the first pectoral fin rays collected from fish that are lethally sampled. The intent was that ages determined from otoliths would be used in the analyses and that the ages determined from fin rays would be provided to Environment Canada for possible use in developing a fin-ray-age to otolith-age correction factor.

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

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

Reproductive endpoints would not be examined because many of the fish would be immature and the proportion of mature fish that spawn in any given year is low; therefore meaningful comparisons involving gonad weight would not be possible.

It was also recognized that the sample size of 20 individuals would not achieve the desired power for comparisons involving fish weight versus age, and therefore the study design did not propose those comparisons. Those comparisons are provided in this report, although their power, as predicted, is low.

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

2.3.2 Benthic Invertebrate Community Survey

There were no changes to the design of the executed field program. The Cycle 3 EEM benthic invertebrate community study utilized two reference areas (PDL and INUG) and one exposure area in Wally Lake, and a before-after-control-impact (BACI) design. Sample collection and processing followed the methodology used by the Core Receiving Environment Monitoring Program (CREMP), which allowed the extensive data collected for that program, including data collected for Wally Lake prior to it becoming an exposure area, in the statistical analyses.

In this Cycle 3 EEM study there was one exposure area (Figure 5) and two reference areas (Figure 6 and Figure 7), with five sampling stations nested within each of these areas. Two sub-samples of the benthic community were collected from each sampling station and composited. However, at the request of Environment Canada, the two grabs composited from each station were processed separately and those data were used to assess if composites of 2 subsamples per benthic station properly characterize each station in Wally Lake. Locations and water depths in the two reference areas, and depth in the exposure area, were targeted to be approximately that of the Cycle 1 and Cycle 2 EEM studies, while ensuring that sampling stations were a minimum of 20 m apart to maintain some amount of independence of stations.

There were minor modifications to the analysis of benthic invertebrate community data relative to the submitted study design. The first change relates to the contrast coefficients used to test the four specified null hypotheses. The coefficients for the fourth hypothesis (no change in differences in benthic indices between exposure (WAL) and reference (INUG and PDL) from early in the exposure period (2013 to 2016) to the last year in the exposure period (i.e., 2017)) were incorrect in the study design and have been corrected here, and are provided in Table 27.

The second change made relates to the use of partial Mantel tests to test for association between Bray Curtis distances and hypothesis matrices. We had proposed to partial-out the effects of grain size, TOC and water depth, prior to carrying out the Mantel test. In a Reference Condition Approach, the ‘reference’ model would be developed with the reference data only, and then applied to the exposure data. In hindsight, there is no simple way in a Mantel test to partial-out the associations between benthos and natural underlying variables using just reference data, and then apply that model to exposure data. Therefore, instead, the Bray Curtis distances were used to compute NMDS axis scores (described in the methods section), and the NMDS axis scores were modeled in a fashion similar to what was done for the other core benthic invertebrate community metrics, i.e., models were developed with reference data, and those models were applied to the exposure data. This latter approach, i.e., use of an RCA statistical approach, was proposed in the study design for use on the core benthos indices (abundance, richness, evenness) in the original study design and is extended here to NMDS axis scores (i.e., an analysis of the Bray Curtis distances).

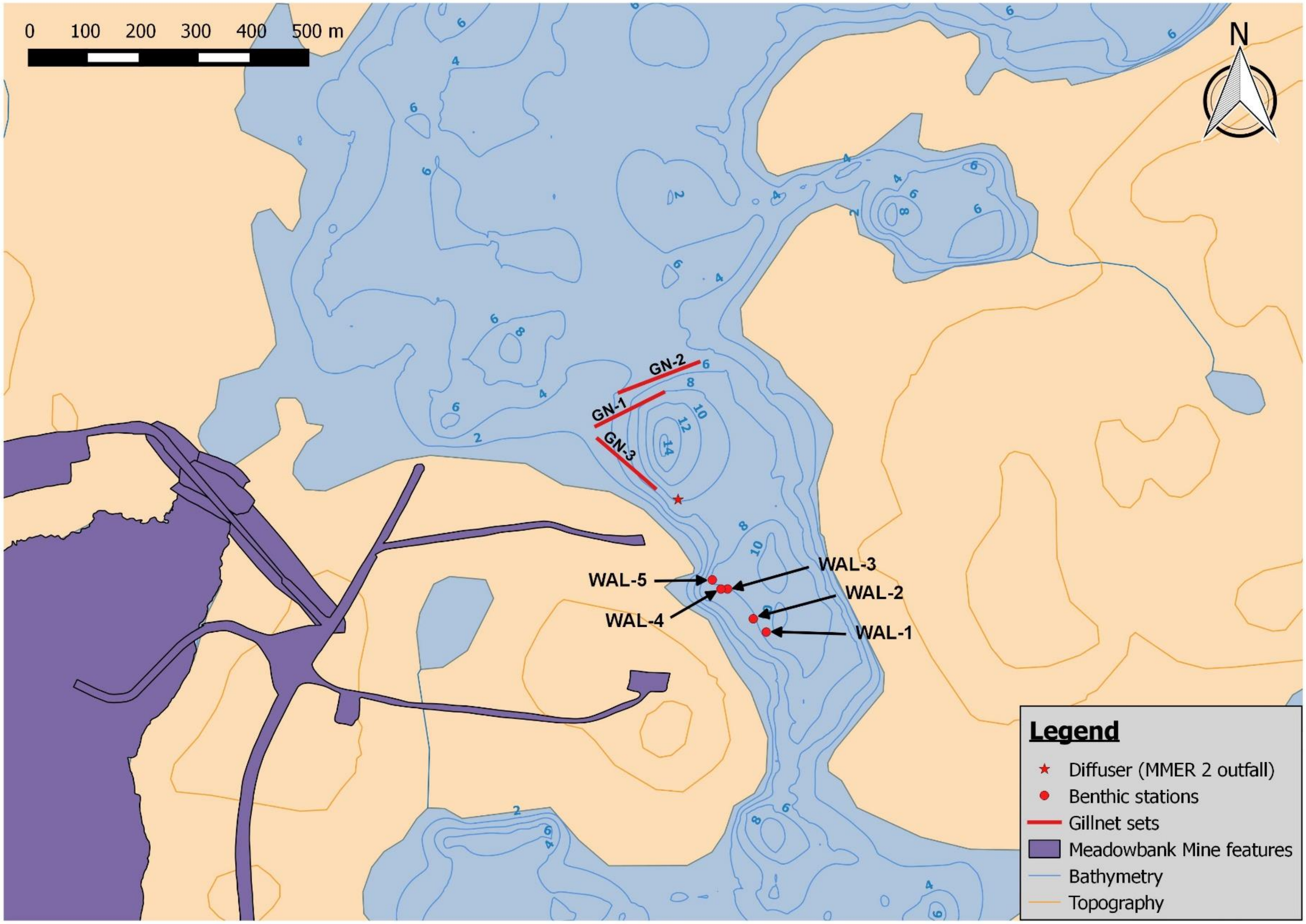


Figure 5. Wally Lake exposure area (WAL).

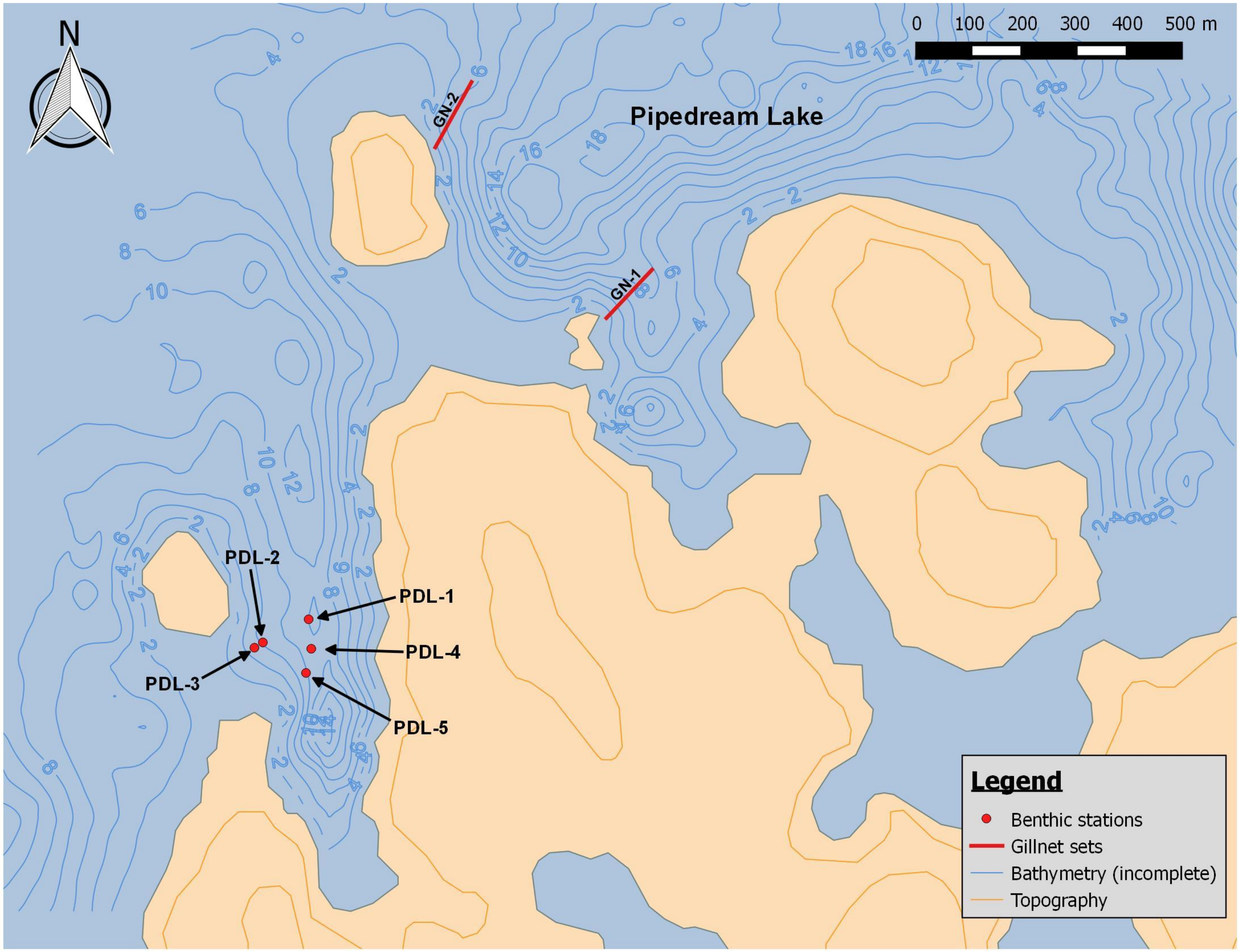


Figure 6. Pipedream Lake reference area (PDL).

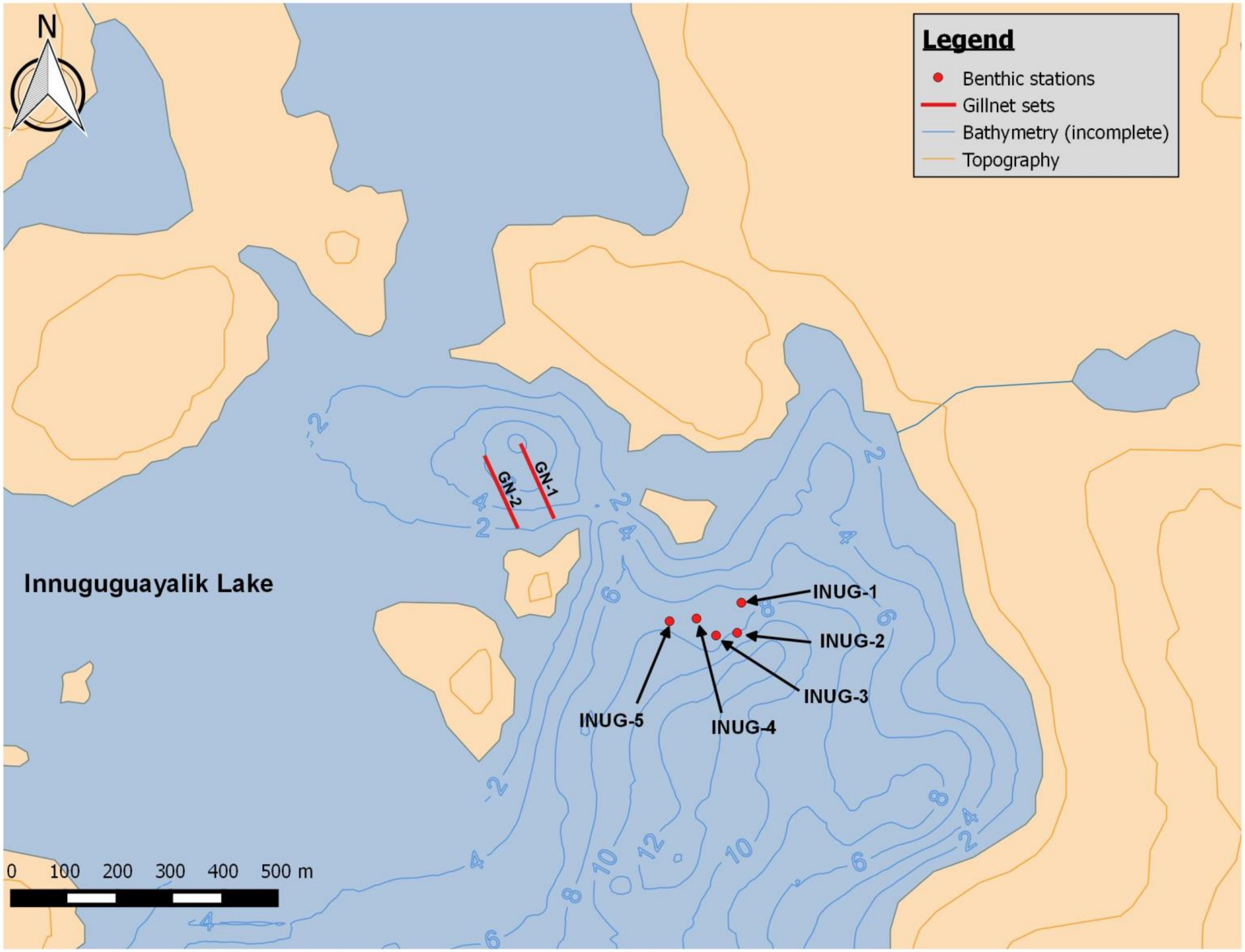


Figure 7. Innuguguayalik Lake reference area (INUG).

3.0 ADULT FISH SURVEY

3.1 Introduction

The adult fish survey was completed during the period August 23 – 26, 2017. There were no major deviations from the proposed study design. One minor deviation was that five Lake Trout that were released alive were not measured and weighed, due to high winds during net retrieval.

3.2 Materials and Methods

3.2.1 Field Work

3.2.1.1 Gill Net Fish Collections and Measurements

Fish were collected in the exposure area (WAL) in Wally Lake from August 23 to 26, from the PDL reference area in Pipedream Lake from August 24 to 25, and from the INUG reference area in Innuguguayalik Lake from August 25 to 27, 2017. The target species was Lake Trout, which dominated the catch. Index gill nets comprised of six panels of stretched mesh (sizes 126, 102, 76, 51, 38, and 25 mm) were the only means of fish capture for this study. Each panel of gill net was 1.8 m (6 feet) deep by 22.7 m (25 yards) long, so that the length of a six-panel gang was 136.4 m (150 yards). Gill nets were set within each sampling area, with the specific locations determined based on local habitat conditions and winds. During Cycle 2, shallow nearshore or shoal areas yielded the greatest number of fish and those areas were targeted in this study.

Most Lake Trout were collected using overnight gill net sets. The initial gill net set was overnight in Wally Lake, but in order to minimize unnecessary Lake Trout mortality and mortality of non-target species, shorter-duration daytime sets were used to collect the additional Lake Trout required to reach the target sample size of 20 for Wally Lake. The date and time of gill net deployments and lifts were recorded. The UTM coordinates of each end of each net were determined using a Garmin model GPSmap 76CSx, and the depth was determined using a portable Sonar unit. The number of individuals of each species captured that were dead, or killed and retained in the case of Lake Trout, and the number that were alive and released was recorded for each net set.

All dead Lake Trout were retained and Lake Trout captured alive were euthanized and retained until it was clear that the target sample size of 20 fish would be acquired for each lake. Once the target sample size was reached, or it was apparent that it would be, Lake Trout that were alive were released. The original intent was to measure and weigh the Lake Trout that were not required for the lethal sample prior to their release, but few Lake Trout were released and safety considerations, due to increasing winds, precluded this occurring in most cases. One Lake Trout captured in Wally Lake bore a tag, indicating that it had been captured during a fish-out and translocated to Wally Lake. This fish was released after the tag number was recorded and its fork length was determined to the nearest mm using a measuring tape and its weight was determined to the nearest 10 g using a Rapala digital hanging scale. Those data were not included in any analyses.

Dead Lake Trout were taken to the laboratory at the mine site for processing. Each fish was examined externally and any lesions of other anomalies that were not consistent with gillnet capture were recorded. Fork length was determined to the nearest mm using a standard fish measuring board. The weight of each fish was determined to the nearest 0.1 gram using an Ohaus Scout Pro Model SP6001 electronic balance.

The body cavity was opened and the viscera were examined for any anomalies. The gonads were examined to determine the sex, maturity, and gonad condition of the specimen. Females with opaque ovaries containing developing eggs visible with the naked eye were considered to be sexually mature. Females with translucent ovaries that did not contain eggs which were visible to the naked eye were considered to be immature. Females with opaque ovaries, and in some cases atretic eggs from the previous spawning season, but which did not appear to be developing eggs to spawn in the fall of 2017 are referred to as undeveloped females. Females with large eggs that appeared to be suitable to spawn in the current year were termed resting females. Males with opaque testes were considered to be mature, and males with small translucent testes were considered to be immature. The liver and gonads were removed and weighed to the nearest 0.01 g using an Ohaus Scout Pro Model SP202 electronic balance or, if they weighed more than 200 grams, to the nearest 0.1 g using an Ohaus Scout Pro Model SP6001 electronic balance. The calibration of the balances was confirmed each time they were set up, using the appropriate calibration weights.

3.2.1.2 Supporting Environmental Variables

Specific conductivity (µS/cm), pH, dissolved oxygen (mg/L) and temperature (°C) were determined at one metre intervals at each end of both of the gill nets set in PDL and one of the gill net(s) set in INUG and in WAL, using a YSI Professional Plus. Meter calibration was undertaken daily following the methods in the user manual. Parameter resolution and accuracy are as follows:

- Specific conductivity, resolution: 1 µS/cm, accuracy: the greater of ±1% of reading or 1 µS/cm.
- pH, resolution: 0.01 units, accuracy: ±0.2 units.
- Dissolved oxygen, resolution: 0.1 mg/L, accuracy: the greater of ±2% of reading or 0.2 mg/L.
- Temperature, resolution: 0.1°C, accuracy: ±0.2°C.

Depth, temperature, and specific conductance data were collected from lake surface to lake bottom when each gill net was either set or lifted, with one exception (WAL GN-2) using a SonTek Castaway©-CTD (Xylem Inc.; refer to Table 7 for specifications).

3.2.2 Age Determination

Aging of fish was completed by Louise Stanley, a fish aging expert who provides consulting services. Otoliths were mounted whole on a glass slide with CrystalBond thermoplastic adhesive. Otoliths which could not be aged whole were 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 was ground flat and then cut away from the rest of the ray with wire cutters. The flat proximal end was mounted on a glass slide with CrystalBond thermoplastic adhesive and the remaining fin ray ground away to leave a thin section. Age was estimated based on the number of annuli counted using transmitted light and a Leica GZ6 Stereo Zoom microscope. The number of annuli on fin rays and otoliths were determined independently (i.e. without reference to each other) when both were available for a fish. Age was independently estimated by C. Portt from otoliths and fin rays from 7 randomly selected fish.

3.2.3 Lake Trout Data Analysis

Data for individual fish were entered into an Excel spreadsheet, and the entered values were compared with the original data sheets. Data entry errors were corrected.

Condition (K) was calculated using the formula:

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

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

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

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

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

Box plots or scatterplots of the data were examined. Aberrant values were compared to the original data sheets to ensure they were not data entry errors. Fish with clearly aberrant values for one or more of the measured parameters that were not due to transcription errors were considered to be probable recording errors. Most were eliminated from the dataset but in cases where the nature of the error and the correct value was clear the value was corrected.

Statistical analyses were carried out using SYSTAT™ Version 13. Summary statistics (sample size, mean, minimum, maximum, standard deviation, standard error) were generated for each parameter, by lake. Comparisons were made between fish from the three lakes using the statistical techniques presented in Table 8. Analyses were conducted on all sexes combined as sex was not known for the individuals that were released and there were too few individuals for which sex was known to permit meaningful comparisons for either males or females.

Age distributions and length distribution were analyzed using the two-sample Kolmogorov-Smirnov test of raw data to compare each pair of sites. Analysis of covariance (ANCOVA) was performed on log-transformed data. Where ANCOVA was used, the data were analyzed using the complete model, which includes the interaction term (Area x independent variable) and the reduced model, which excludes the interaction term. Differences in slopes or intercepts were considered significant at the 5% level (i.e., $P \leq 0.05$). Significant interactions can be difficult to interpret, and complicate the computation of effect size. In cases where the interaction term accounted for < 2% of the total variation in the response variable the reduced model was considered to be appropriate and was used to assess significance and effect sizes, as per Barrett *et al*. (2010). When there were significant differences in intercepts, pair-wise comparisons were made using Tukey's honestly significant difference test.

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

The percent difference in least-square means between Wally Lake and each of the two reference lakes was calculated as:

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

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

Table 8. Statistical analyses conducted to compare fish populations between the Exposure and Reference Areas

Dependent variable	Independent variable	Statistical technique
Body weight	Length	ANCOVA
Liver weight	Body weight, length	ANCOVA
Length	Age	ANCOVA
Body weight	Age	ANCOVA
Length Distribution		Kolmogorov-Smirnov
Age Distribution		Kolmogorov-Smirnov

3.2.4 Power Analysis

Power analysis was used to determine, *a posteriori*, the probability of detecting a 10% (weight versus length) or 25% (length versus age, weight versus age, liver weight) increase in the parameters of interest, assuming a 10% probability of committing a Type I error, and given the sample sizes, mean values, and the unexplained variability (i.e. the population standard deviation) from this study. Power was calculated by re-arranging the following power equation (Green, 1989):

$$n = \frac{1.5(t_\alpha + t_\beta)^2 \sigma^2}{\delta^2}$$

where:

- n is the number of fish
- σ is the population standard deviation,
- δ is the specified effect size,

- t_α is the Students *t* statistic for a two-tailed test with significance level α,
- t_β is the Students *t* statistic for a one-tailed test with significance level β.

3.3 Results

3.3.1 Physico-Chemical Character of Capture Areas

The locations of the sampling Areas are shown in Figure 2, and the location of individual nets shown for each Area in Figure 5, Figure 6, and Figure 7. The range of temperature, dissolved oxygen concentration and specific conductance at each end of gill nets for which profiles were measured when the nets were set are provided in Table 9. The minimum and maximum temperature and specific conductance in profiles from just below the surface to the bottom, determined when gill nets were lifted are provided in Table 10. The lakes were essentially isothermal at the time of the fish collections and there was no indication of chemical stratification, although there were small differences in specific conductance with depth in Wally Lake when the nets were lifted, indicating that the effluent concentration was not homogenous from the surface to the bottom. The general limnology and water chemistry of the sampling areas is provided in Section 4 of this report.

Table 9. Minimum and maximum temperature, dissolved oxygen concentration and specific conductance for gill net sets where these parameters were measured at 1 m depth intervals when nets were set.

				Temperature (°c)		Dissolved Oxygen (ppm)		Specific conductance (µS/cm)	
Lake	**Set**	**Date**	**Depth (m)**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
INUG	GN-1	08/25/17	7	13.8	13.8	10.2	10.4	15.2	15.3
			2	13.7	13.9	10.3	10.4	15.3	15.3
PDL	GN-1	08/24/17	5	11.9	12.1	9.9	10.1	20.8	21
			3	12.0	12.1	10.0	10.1	20.9	21
	GN-2	08/24/17	7	12.0	12.0	9.8	10.1	21	21
			1	12.5	12.5	10.1	10.1	21	21.1
WAL	GN-3	08/26/17	6	13.2	13.2	10.0	10.1	53.4	53.6
			4	13.2	13.2	9.8	10.1	52.6	53

Table 10. Depth and the minimum and maximum temperature and specific conductance determined in surface to bottom profiles when gill nets were lifted.

Lake	Set	Date	Depth (m)	Temperature (°c) Min.	Temperature (°c) Max.	Specific conductance (µS/cm) Min.	Specific conductance (µS/cm) Max.
WAL	GN-1	08/23/17	3.6	12.4	12.5	58.7	61.7
WAL			6.9	12.2	12.5	49.7	55.8
WAL	GN-3	08/26/17	8.9	13.6	13.7	52.9	55.7
WAL			4.3	13.6	13.6	54.1	54.4
PDL	GN-1	08/25/17	1.6	12.1	12.1	19.7	19.7
PDL			6.9	12.1	12.1	19.6	19.7
PDL	GN-2	08/25/17	2.1	12.2	12.2	19.7	19.8
PDL			6.0	12.1	12.1	19.7	19.8
INUG	GN-1	08/26/17	1.8	13.6	13.6	13.8	13.8
INUG			7.5	13.6	13.7	13.7	13.8
INUG	GN-2	08/26/17	1.1	13.6	13.6	13.8	13.8
INUG			7.4	13.6	13.7	13.9	14.0

3.3.2 Sampling Effort and Catches

3.3.2.1 Gill Net Catches

Gill nets were set at two locations in INUG and PDL and at three locations in WAL (Figure 5, Figure 6 and Figure 7). Two nets were set overnight in INUG and in PDL. One overnight net set and two daytime sets were conducted in WAL. The mean soak time was 22.9 hours in INUG, 15.4 hours in PDL, and 10.3 hours in WAL (Table 11). The location, depth and set and lift dates and times for each gill net set are provided in Appendix 2.

Table 11. Number and mean soak time of daytime and overnight gill net lifts, by lake.

	Innuguguayalik (INUG)		Pipedream (PDL)		Wally (WAL)	
set type	number of lifts	mean soak time (hours)	number of lifts	mean soak time (hours)	number of lifts	mean soak time (hours)
daytime	0		0		2	7.8
overnight	2	22.9	2	15.4	1	15.4
total	2	22.9	2	15.4	3	10.3

The gill net catches are summarized in Table 12. Lake Trout were the most abundant species in the catches in all three lakes with a total of 76 captured. Round Whitefish (*Prosopium cylindraceum*) were captured in INUG and WAL, and Arctic Char (*Salvelinus alpinus*) were captured in PDL and WAL. Lake Trout CPUE was similar in overnight sets in PDL and WAL, and higher in those two lakes than in INUG (Table 13).

Table 12. Numbers of fish that were released alive or were dead in gill net catches, by lake and species.

	Lake Trout		Arctic Char		Round Whitefish	
waterbody	**alive**	**dead**	**alive**	**dead**	**alive**	**dead**
INUG	1	21	0	0	4	4
PDL	4	27	3	0	0	0
WAL	1	22	1	5	5	13
total	6	70	4	5	9	17

Table 13. Mean catch-per-unit-effort (CPUE; number of Lake Trout captured per hour of soak time) for daytime and overnight gill net sets, by lake.

	set type		
waterbody	**daytime**	**overnight**	**overall**
INUG		0.5	0.5
PDL		1.0	1.0
WAL	0.6	0.9	0.7

3.3.3 Lake Trout Characteristics

3.3.3.1 Overview

The numbers of Lake Trout processed by lake, sex, and maturity are presented in Table 14. A total of 21 Lake Trout from INUG, 27 Lake Trout from PDL and 22 Lake Trout from WAL were processed. Of the individuals for which sex could be determined, the majority of the female Lake Trout from each lake were immature, and the proportion of males that were mature ranged from 50% in INUG to 100% in WAL.

Table 14. Number of Lake Trout examined from each waterbody, by sex and maturity.

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

Half of the mature females were developing eggs that would be spawned in the current year (Table 15). All of the mature males captured in INUG and WAL appeared to be developing testes in preparation for spawning in the current year (Table 15) but the majority of mature males captured in PDL were not. The numbers of mature individuals that were developing gonads in preparation to spawn in the current year were too low to permit meaningful comparisons of gonad weights among lakes.

Table 15. Number of mature individuals that were developing gonads to spawn in the current year and that were not sufficiently developed to spawn in the current year (undeveloped).

	female		**male**	
waterbody	**developing**	**undeveloped**	**developing**	**undeveloped**
INUG	1	0	4	0
PDL	2	3	2	5
WAL	1	1	10	0
total	4	4	16	5

The summary statistics for each parameter measured or calculated are presented in Table 16. The gonads could not be discerned in some immature individuals; consequently there are no weights for these. The data for each specimen are provided in the digital submission to Environment Canada.

Table 16. Lake Trout summary statistics.

Lake	statistic	fork length (mm)	weight (g)	liver weight (g)	gonad weight (g)	condition	LSI	GSI	fin ray age (years)	otolith age (years)
WAL	N	22	22	22	22	22	22	22	22	22
	Minimum	207	87.7	0.98	0.08	0.86	0.62	0.03	5	5
	Maximum	839	6315.7	69.71	499.4	1.22	1.29	9.21	48	48
	Mean	549	2592.45	20.74	75.87	1.06	0.83	1.83	23	23
	Standard error	46.4	499.74	4.207	24.093	0.022	0.038	0.436	3.1	46.4
	Standard deviation	217.5	2344.00	19.730	113.007	0.102	0.178	2.044	14.7	217.5
PDL	N	27	27	27	26	27	27	27	27	27
	Minimum	136	27.8	0.22	0.03	0.87	0.61	0.00	2	0
	Maximum	1010	13410.0	257.70	2359.8	1.50	1.92	17.60	44	40
	Mean	492	2293.96	26.22	131.50	1.09	0.94	1.94	19	6
	Standard error	42.8	603.56	9.982	90.053	0.028	0.051	0.714	2.3	1.8
	Standard deviation	222.4	3136.18	51.867	459.183	0.143	0.267	3.710	11.7	9.1
INUG	N	21	21	21	20	21	21	21	21	21
	Minimum	130	21.4	0.27	0.02	0.84	0.63	0.00	2	0
	Maximum	806	5196.9	117.57	656.3	1.67	2.26	12.63	33	40
	Mean	454	1362.31	15.53	48.63	1.05	0.98	1.51	17	11
	Standard error	38.0	277.80	5.368	32.347	0.038	0.073	0.598	2.0	2.8
	Standard deviation	174.3	1273.04	24.601	144.661	0.173	0.336	2.742	9.1	12.8

3.3.3.2 Ageing QA/QC

The differences between the ages estimated by the primary aging expert (L. Stanley) and those estimated by C Portt are summarized in Table 17. The resulting otolith ages were identical for 3 of the 7 fish that were checked. The QA/QC ages were one less than assigned by the primary aging expert for 3 of the 7 fish that were checked. Only 1 of the 7 fish checked differed by more than 1 year. The ages for all fish are provided in Appendix 3.

Table 17. Magnitude of differences between age estimations by two different investigators (age-QA/QC age).

Fish #	Otolith age (years)	QA/QC otolith age (years)	Difference (years)
3	38	37	-1
8	15	14	-1
9	13	13	0
14	5	5	0
19	20	25	+5
38	8	8	0
67	17	16	-1

3.3.3.3 Lesions, Deformities and Parasites

No lesions were observed that were not consistent with having occurred while the fish was entangled in a gill net. Encysted cestodes were observed in the livers of 16 (76%) of the Lake Trout from INUG, 15 (55%) of the Lake Trout from PDL and 7 (32%) of the Lake Trout from WAL.

3.3.3.4 Stomach Contents

The stomachs of 44 (63%) of the Lake Trout examined were empty. Fourteen Lake Trout stomachs contained fish remains, included one containing two Slimy Sculpin, three containing Round Whitefish, and one from Wally Lake that contained the skeleton and tag of a Lake Trout transferred to Wally Lake from Phaser Lake in 2016 during the Phaser Lake fishout. At the time of transfer, its fork length was 380 mm and it weighed 600 g. The remaining stomachs contained aquatic insects and/or zooplankton which were also present in several of the stomachs that contained fish.

3.3.3.5 Recaptures of Previously Tagged Fish

One Lake Trout captured in WAL and released during this study was tagged on July 24, 2013, when it was transferred to WAL from Vault Lake during the Vault Lake fish-out. When that fish was tagged, in 2013, its fork length was 843 mm and its weight was 6500 g. On August 24, 2017, its fork length was 902 mm and it weighed 7360 g.

One Lake Trout captured in PDL and processed during this study was tagged in PDL on Aug 18, 2011, when its fork length was 818 mm and its weight was 6300 g. On August 25, 2017, the fork length of this fish was 824 mm and it weighed 6243 g. Its age was determined to be 32 years.

3.3.3.6 Between lake comparisons

The results of between-lake comparisons are summarized in Table 18 and each is discussed below.

Condition

Fish weight is plotted against fork length in Figure 8. There was no significant difference in the slopes or intercepts of the log of weight versus log of fork length relationship between lakes when all fish were included in the analysis. Repeating these analyses following the removal of two outliers and of three outliers did not alter this result. The analyses conducted following removal of the first identified outlier indicated that there was a significant difference in slopes, but the difference in the r-square values between the full and reduced ANCOVAs was very small, so the reduced model is considered appropriate for comparisons and there was no significant difference in the intercepts between lakes. The adjusted least-square means for WAL lay between those for INUG and those for PDL.

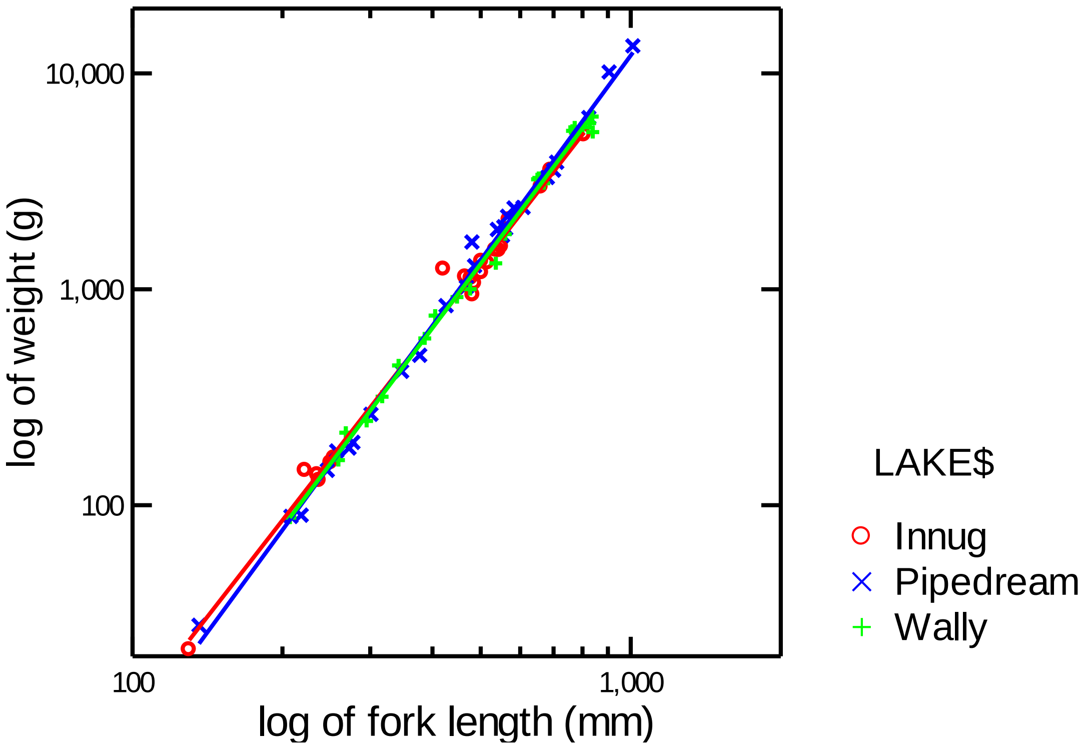


Figure 8. Plot of fish weight versus fork length (log scales).

Table 18. Summary of between-lake comparisons using ANCOVA. P-values ≤0.05 are in bold.

Depend-ent variable	Independ-ent variable	Data excluded	ANCOVA Procedure	Error MS	Interaction *p*-Value	Area *p*-value	r^2	LS Mean INUG	LS Mean PDL	LS Mean WAL	% Difference INUG	% Difference PDL
log of body weight	log of length	none	Full	0.0025	0.0532		0.994					
			Reduced	0.0027		0.528	0.994	956	997	961	0.5	-3.6
		fish 50	Full	0.0019	**0.0189**		0.996					
			Reduced	0.002		0.1938	0.995	945	998	964	2.0	-3.4
		fish 50, 25	Full	0.0016	0.0532		0.996					
			Reduced	0.0018		0.3376	0.996	942	983	961	2.0	-2.2
		fish 50, 25, 53	Full	0.0014	0.0550		0.997					
			Reduced	0.0015		0.0981	0.997	958	1016	992	3.5	-2.4
log of liver weight	log of body weight	none	Full	0.011	0.1350		0.976					
			Reduced	0.011		0.1247	0.974	9.2	8.87	7.94	-13.7	-10.5
		fish 62	Full	0.0085	0.0691		0.98					
			Reduced	0.009		0.2083	0.978	8.57	8.65	7.78	-9.2	-10.1
		fish 62,27	Full	0.0072	0.2723		0.982					
			Reduced	0.0073		0.3325	0.981	8.2	8.07	7.53	-8.2	-6.7
	log of length	none	Full	0.013	0.0647		0.971					
			Reduced	0.014		0.1123	0.968	9.11	9.05	7.82	-14.2	-13.6
		fish 62	Full	0.0108	**0.0150**		0.975					
			Reduced	0.012		0.1502	0.971	8.51	8.81	7.65	-10.1	-13.2
		fish 62,27	Full	0.0092	0.0852		0.977					
			Reduced	0.0097		0.2799	0.975	8.16	8.2	7.43	-8.9	-9.4
		fish 62,27, 5	Full	0.008	**0.0259**		0.980					
			Reduced	0.0087		0.1152	0.977	7.95	8	7.06	-11.2	-11.8
log of length	log of otolith age	none	Full	0.0027	0.1284		0.941					
			Reduced	0.0028		0.7424	0.937	448	448	459	2.5	2.5
log of weight	log of otolith age	none	Full	0.0251	0.057		0.942					
			Reduced	0.0266		0.8351	0.936	943	971	1010	7.2	4.0

Liver weight

A plot of liver weight versus body weight is presented in Figure 9. When all of the data were included in the analyses, there were no significant differences in the slopes or the intercepts of the log of liver weight versus the log of body weight relationship. Successive removal of two outliers did not alter this result.

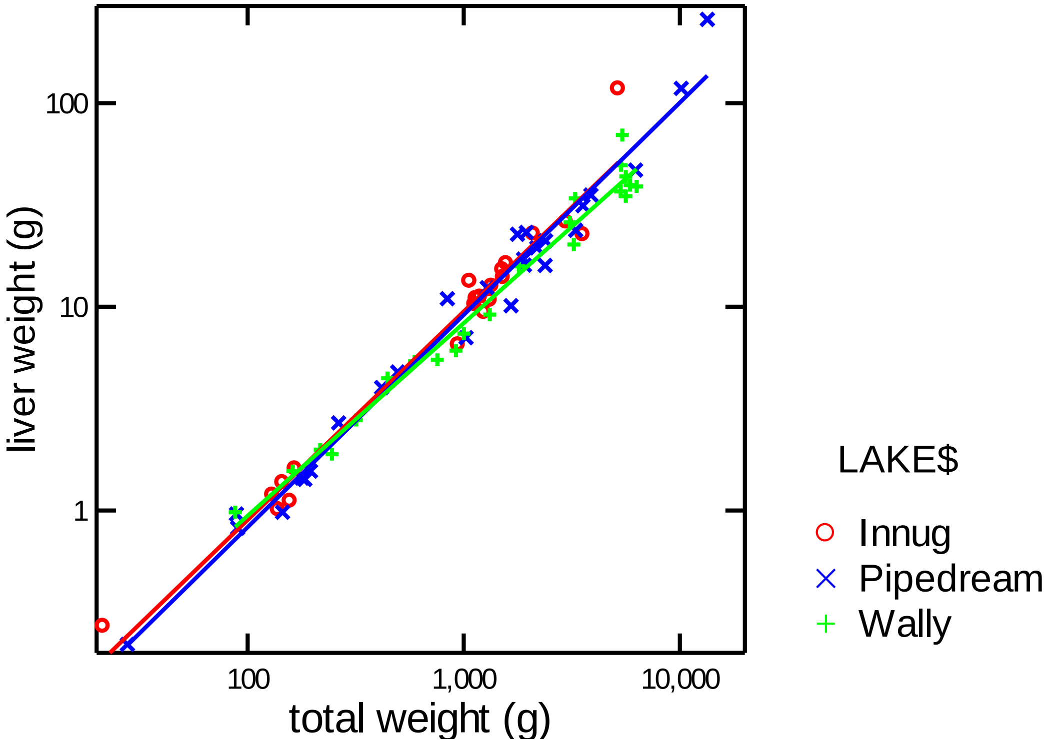


Figure 9. Plot of liver weight versus weight (log scales).

A plot of liver weight versus fork length is presented in Figure 10. When all of the data were included in the analyses, there were no significant differences in the slopes or the intercepts of the log of liver weight versus log of fork length relationships. This was also the case after the removal of two identified outliers. Following the removal of one and of three outliers there was a significant difference in the slopes of the relationship, however, the r^2 value was only reduced by 0.003 (one outlier removed) or 0.002 (three outliers removed) when the interaction term was removed (Table 18). Therefore, comparison of least square means using the reduced ANCOVA was considered appropriate and the intercepts of the log of liver weight versus log of fork length relationships were not significantly different.

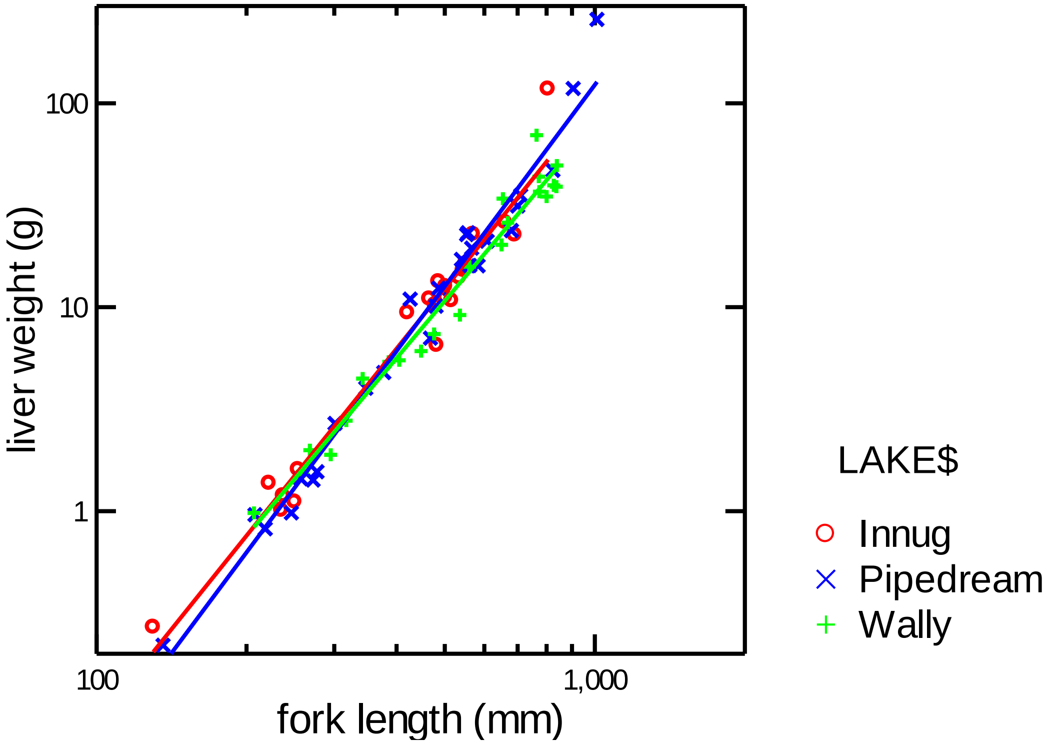


Figure 10. Plot of liver weight versus fork length (log scales).

Growth

Fork Length Versus Age

A plot of fork length versus age, determined from otoliths, is presented in Figure 11. There was no significant difference in the slopes or the intercepts of the log of length versus log of age relationship among lakes (Table 18).

Weight Versus Age

The study design did not propose to examine this relationship because it was expected that the statistical power would be low, given the proposed sample size, and it was (refer to Section 3.3.4). For information, a plot of weight versus age is presented in Figure 12, and the ANCOVA analyses were conducted (Table 18). There was no significant difference in the slopes or the intercepts of the log of length versus log of age relationship among lakes.

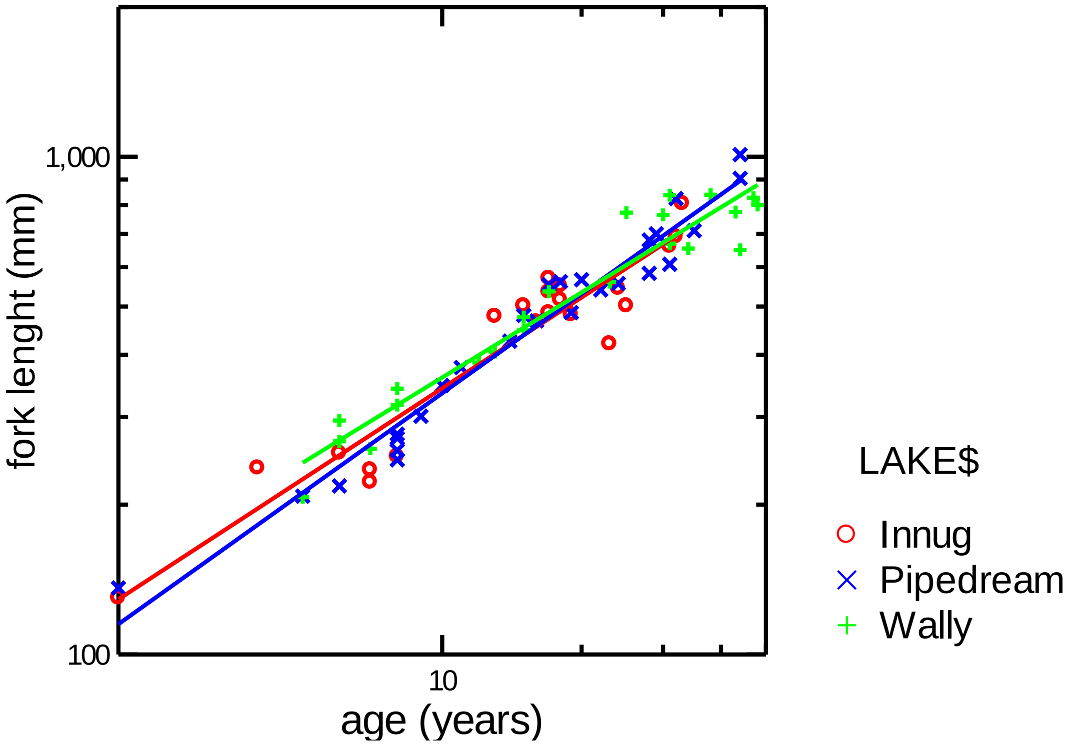


Figure 11. Plot of fork length versus otolith age (log scales).

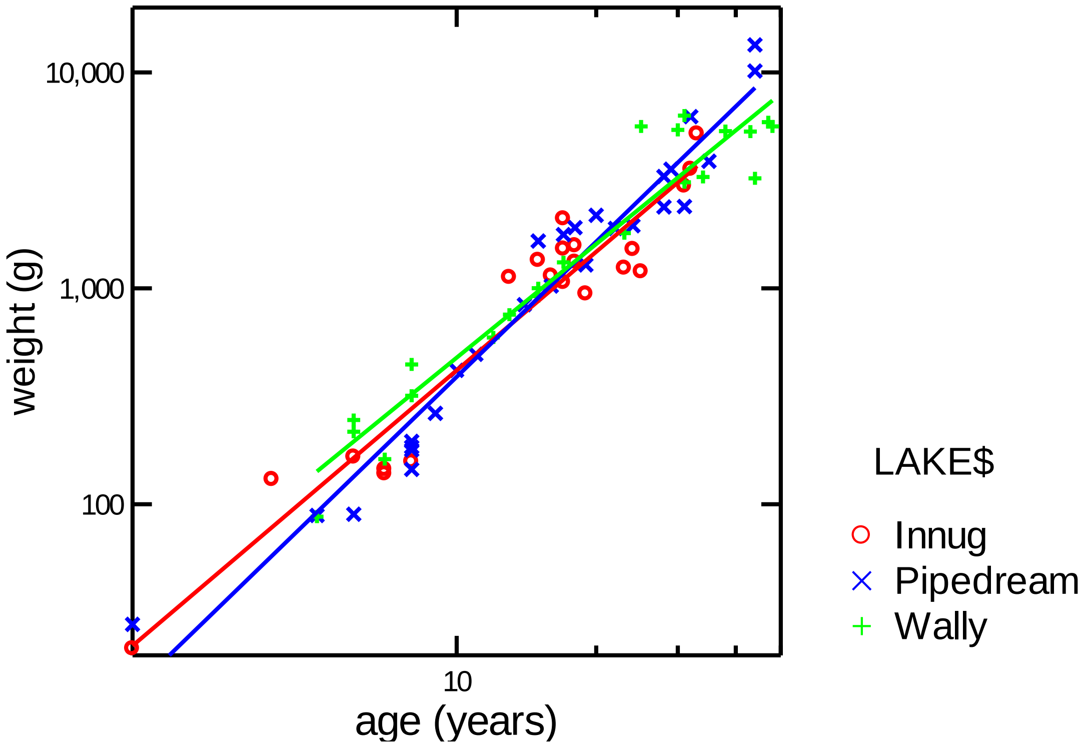


Figure 12. Plot of weight versus otolith age (log scales).

Length Distribution

The fork length-frequency distributions for each lake are shown in Figure 13. The distributions were compared between pairs of lakes using the two-sample Kolmogrov-Smirnov test, which indicated that was no significant difference in length distributions between any of the three lakes (Table 19).

Table 19. Kolmogorov-Smirnov two-sided probabilities of differences in the fork length distributions between each pair of lakes.

	INUG	PDL	TPN
INUG	1.000		
PDL	0.479	1.000	
WAL	0.282	0.566	1.000

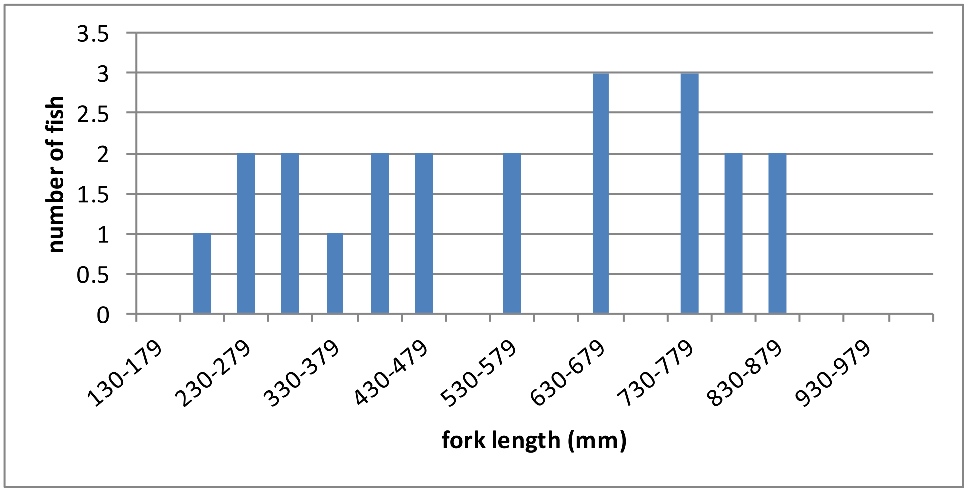
Age Distribution

The age-frequency distributions for each lake are shown in Figure 14. The distributions were compared between pairs of lakes using the two-sample Kolmogorov-Smirnov test, which indicated that there was no significant difference in age distributions between any of the three lakes (Table 20).

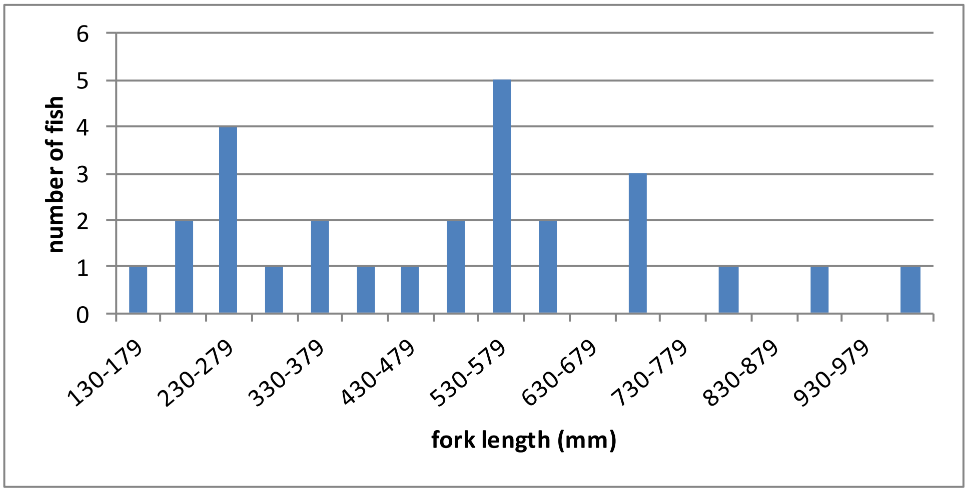
Table 20. Kolmogorov-Smirnov two-sided probabilities of differences in the age distributions between each pair of lakes.

	INUG	PDL	TPN
INUG	1.000		
PDL	0.926	1.000	
WAL	0.377	0.606	1.000

a) WAL



b) PDL



c) INUG

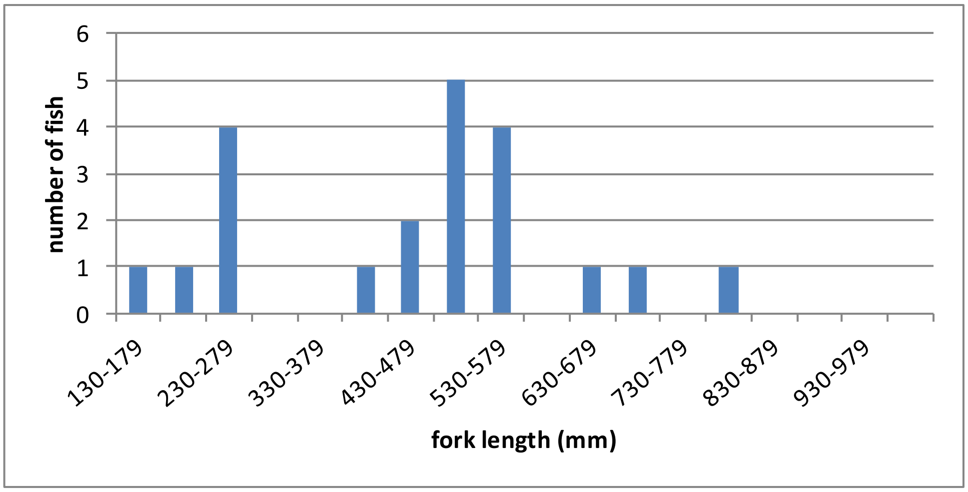
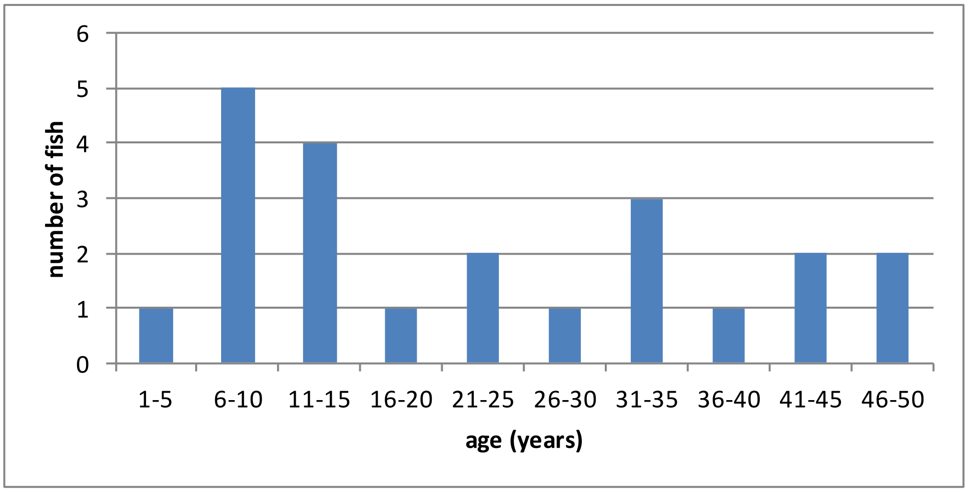
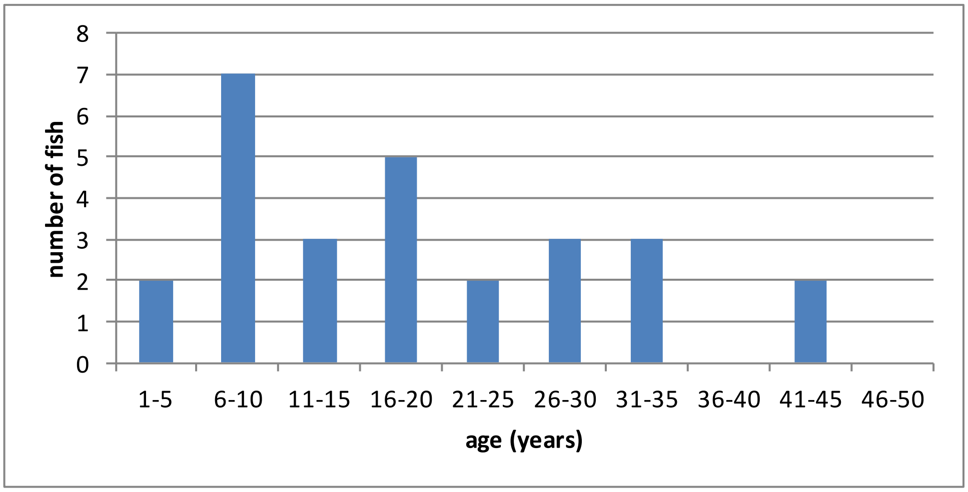


Figure 13. Length-frequency distributions.

a) WAL



b) PDL



c) INUG

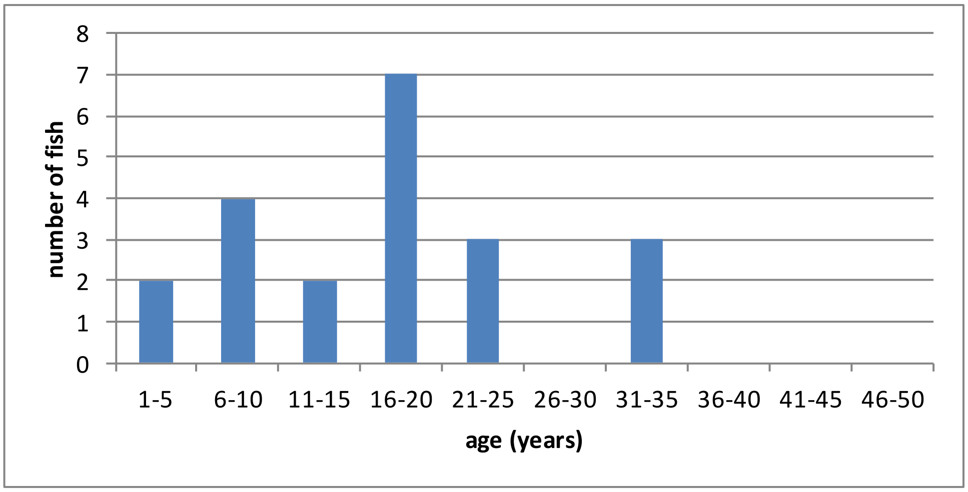


Figure 14. Age-frequency distributions.

3.3.4 Power Analysis

The probability of detecting effects as large as or larger than the critical effect sizes, for each of the calculated fish endpoints examined with ANCOVA, based on the variance and sample sizes in this study, is provided in Table 21, as is the number of fish required to detect a difference equal to the critical effect size based on the error mean square from this study. Power was greater than 90% except, as predicted in the study design, for the weight versus age relationship. The sample size required per site to detect the critical effect size, based on the error mean squares from this study, ranges from 5 for the length versus age relationship to 20 for the body weight versus length relationship.

Table 21. Power analysis results. P is the probability that the effect size, from Environment Canada (2012), could be detected with the sample sizes and variance observed in the present study, and assuming a 10% Type-II error rate. N is the number of samples per site required to detect a difference equal to the critical effect size assuming the variance observed in this study and a 10% Type II error rate.

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

The age versus length relationships would require the fewest fish (5) to detect the critical effect size followed by, in order of increasing sample size requirements, liver weight versus weight (16), liver weight versus length (19), weight versus length (21), and age versus weight (36).

3.4 Summary and Discussion

The results of the ANCOVA analyses comparing slopes of the relationships for the EEM endpoints examined in this study are summarized in Table 22. There were no significant differences ($P \leq 0.05$) in the slopes for any of the relationships. There were no significant differences in the length or age distributions between lakes either. In other words, no effects were observed on Lake Trout in Wally Lake. Although this is the Cycle 3 EEM study at Meadowbank site, it is the first study for which Wally Lake has been the exposure site; during the previous EEM cycles the main discharge was to Third Portage North.

Table 22. Summary of between-lake comparisons calculated with reduced ANCOVA (i.e. comparison of intercepts), with no outliers removed. Critical effect sizes are from Environment Canada (2012).

dependent variable	independent variable	p-value	WAL vs INUG % difference	WAL vs PDL % difference	critical effect size
log of body weight	log of length	0.528	0.5	-3.6	10%
log of liver weight	log of body weight	0.125	-13.7	-10.5	25%
log of liver weight	log of length	0.112	-14.2	-13.6	25%
log of weight	log of age	0.835	7.2	4.0	25%
log of length	log of age	0.742	2.5	2.5	25%

3.4.1 Recommendations for Future Fish Surveys, If Required

Based on the low catch-per-unit effort of other fish species in this cycle and previous cycles, Lake Trout are the only feasible sentinel fish species. A large number of lethally-sampled Lake Trout would be required in order to assess reproductive investment because only a portion of the Lake Trout captured are mature and only a portion of mature individuals spawn each year. Therefore the adult fish survey for this study was limited to examining relationships based on length, weight, liver weight and age. Power analysis based on the results of this study indicate that a sample size of 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. Nearly twice as many fish per site would be required to achieve this power for the weight versus age relationships (Table 21). This is consistent with the sample size requirements that were calculated based on the Cycle 2 data. It is recommended that the Cycle 3 study design, that is a lethal study using Lake Trout as the sentinel fish species with a sample size of 20 individuals per sampling area, be used in any future EEM adult fish surveys that are required at the Meadowbank Mine.

4.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

4.1 Introduction

The Cycle 3 EEM benthic invertebrate community study utilized one exposure area (WAL; Figure 5) and two reference areas, PDL (Figure 6) and INUG (Figure 7), and a before-after-control-impact (BACI) design utilizing data collected in 2017 and in previous years as part of the Core Receiving Environment Monitoring Program (CREMP). Benthos have been sampled from WAL and INUG since 2006, and PDL has been sampled since 2010. WAL was in a baseline condition from 2006 to 2012, and has been in an 'exposed' condition since 2013. Five sampling stations were nested within each sampling area. Sampling depths were targeted to be 7 to 8 m, with sampling stations minimally 20 m apart to ensure some amount of independence of stations.

Sample collection and processing followed the methodology used by the CREMP, which allowed use of the extensive data collected for that program, including data collected for Wally Lake prior to it becoming an exposure area, in the statistical analyses. Two sub-samples of the benthic community were collected from each sampling station and composited. However, at the request of Environment Canada, the two grabs composited from each station were processed separately and those data were used to assess if composites of 2 subsamples per benthic station properly characterize each station in Wally Lake.

Variability among stations was used to judge the significance of variations among areas. Stations were therefore the unit of replication.

4.2 Materials and Methods

4.2.1 Benthic Sample Collection

Benthic invertebrates were collected on August 24 (PDL; reference area), 25 (INUG; reference area) and 26 (WAL; exposure area), 2017, with five sampling stations nested within each of these areas (Table 23). Samples were collected from a boat using cleaned, stainless steel petite Ponar grabs (0.023 m^2). Samples were washed on site using a 500-µm nytex bag, transferred to a 1 L plastic bottle, and preserved with 10% buffered formalin. Sample sediments always sieved down such that the residue (sediments and animals) amounted to less than around 100 ml of material. Duplicate samples (< ~200 ml), per station, were processed separately (data were combined later). Sample containers were packed in coolers/plastic totes and transported to Zaranko Environmental Assessment Services (ZEAS), who provided taxonomic services for these and all previous CREMP samples collected since 2006.

Table 23. Benthos collection sample location waypoints.

Area	Station	Latitude (deg min sec)	Longitude (deg min sec)	Zone	Easting (m)	Northing (m)
INUG	1	65 03 09.3	96 23 23.4	14W	622818	7216852
	2	65 03 07.5	96 23 24.1	14W	622810	7216795
	3	65 03 07.4	96 23 27.2	14W	622770	7216790
	4	65 03 08.4	96 23 29.9	14W	622733	7216822
	5	65 03 08.4	96 23 33.9	14W	622682	7216817
PDL	1	65 06 18.9	96 13 01.2	14W	630687	7223063
	2	65 06 17.6	96 13 08.0	14W	630600	7223019
	3	65 06 17.3	96 13 09.3	14W	630584	7223009
	4	65 06 17.0	96 13 01.0	14W	630692	7223007
	5	65 06 15.6	96 13 01.9	14W	630682	7222961
WAL	1	65 04 40.7	95 57 29.3	15W	360951	7220401
	2	65 04 41.5	95 57 31.0	15W	360930	7220427
	3	65 04 43.3	95 57 34.3	15W	360889	7220485
	4	65 04 43.3	95 57 35.2	15W	360877	7220486
	5	65 04 43.9	95 57 36.4	15W	360863	7220504

4.2.2 Supporting Environmental Variables

4.2.2.1 Water

Specific conductance (µS/cm), pH, dissolved oxygen (mg/L) and temperature (°C) were determined at the time of benthic invertebrate sample collection with an YSI Professional Plus. Meter calibration was undertaken daily following the methods in the user manual. Parameter resolution and accuracy are as follows:

- Specific conductance; resolution: 1 µS/cm, accuracy: the greater of ±1% of reading or 1 µS/cm.
- pH; resolution: 0.01 units, accuracy: ±0.2 units.
- Dissolved oxygen; resolution: 0.1 mg/L, accuracy: the greater of ±2% of reading or 0.2 mg/L.
- Temperature; resolution: 0.1°C, accuracy: ±0.2°C.

These parameters were measured at 1 m intervals from surface to 1 m off bottom, at each sampling station, to document the level of stratification at the time of benthic invertebrate sampling.

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

Water samples were collected the same day that benthos were collected. Water was collected from two randomly selected locations within each benthos sampling area. The lakes were not thermally or chemically (determined by specific conductance) stratified, so water was collected from 3 m below surface. Samples in the past have all similarly been collected from 3 m below surface. The analytes and their detection limits, determined in water by ALS Environmental Ltd., Burnaby, British Columbia, are provided in Table 24.

Table 24. Water Quality Parameters and associated Detection Limits.

Parameter	Detection Limit	Units
Conductivity	2	µS/cm
Hardness	0.5	mg/L
pH	0.1	-
Total Suspended Solids	1	mg/L
Total Dissolved Solids	3	mg/L
Turbidity	0.1	NTU
Alkalinity	1	mg/L
Ammonia	0.005	mg/L
Bromide	0.05	mg/L
Chloride	0.1	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	0.5	mg/L
Sulfate	0.3	mg/L
Total Cyanide	0.001	mg/L
Free Cyanide	0.001	mg/L
Dissolved Organic Carbon	0.5	mg/L
Total Organic Carbon	0.5	mg/L
Aluminum	0.003	mg/L
Antimony	0.0001	mg/L
Arsenic	0.0001	mg/L
Barium	0.00005	mg/L
Beryllium	0.00002	mg/L
Bismuth	0.00005	mg/L
Boron	0.01	mg/L
Cadmium	0.000005	mg/L
Calcium	0.05	mg/L
Chromium	0.0001	mg/L
Cobalt	0.0001	mg/L
Copper	0.0005	mg/L
Iron	0.01	mg/L
Lead	0.00005	mg/L
Lithium	0.001	mg/L
Magnesium	0.1	mg/L
Manganese	0.0001	mg/L
Mercury	0.000005	mg/L
Molybdenum	0.00005	mg/L
Nickel	0.0005	mg/L
Phosphorus	0.05	mg/L
Potassium	0.1	mg/L
Selenium	0.00005	mg/L
Silicon	0.1	mg/L
Silver	0.00001	mg/L
Sodium	0.05	mg/L
Strontium	0.0002	mg/L
Sulfur	0.5	mg/L
Thallium	0.00001	mg/L
Tin	0.0001	mg/L

Parameter	Detection Limit	Units
Titanium	0.0003	mg/L
Uranium	0.00001	mg/L
Vanadium	0.0005	mg/L
Zinc	0.003	mg/L

4.2.2.2 Sediment

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

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

Detection limits for sediment quality measures are provided in Table 25 below.

Table 25. 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	%

Grain size data were used to compute an overall summary variable describing mean particle size (GMP).

$$GMP = \left[{d_g}^{w_g}\right] * [{d_{sa}}^{w_{sa}}] * [{d_{si}}^{w_{si}}] * [{d_c}^{w_c}]$$

where, d is the midpoint diameter of particles retained by a given sieve for gravel (g), sand (sa), silt (si) and clay (c), and w is the decimal fraction by weight of particles retained by a given sieve.

4.2.3 Data Analysis

4.2.3.1 Data

The data in this interpretive report included all prior annually collected benthic community samples from 2006 to 2014 for WAL, INUG and PDL. There were always five sample stations per area per year as per Agnico's CREMP sampling design, with the exception of 2006 when only three stations were sampled in WAL and INUG. PDL was not sampled in 2006, 2007 or 2008. In total, there were 161 two-grab benthos samples in the data set per Table 26.

Table 26. Summary of number of benthos stations per sample area, by year.

Area	Year												Grand Total
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
INUG	3	5	5	5	5	5	5	5	5	5	5	5	58
PDL				5	5	5	5	5	5	5	5	5	45
WAL	3	5	5	5	5	5	5	5	5	5	5	5	58
Grand Total	6	10	10	15	15	15	15	15	15	15	15	15	161

4.2.3.2 Descriptors of Benthic Community Composition

Benthos counts were provided in an Excel spreadsheet. Organisms were identified to lowest practical level. The data were ‘rolled up’ to the level of Family for the purpose of the analysis in this EEM Interpretive Report. Acarina were identified to genus only in 2017, and not in other years (only identified to Acarina in previous years). The 2017 genera were rolled up to Acarina to be consistent with the level of identification in previous years.

For each sample, the following descriptors of community composition and indices were calculated, as per the federal guidance for metal mining EEM (Environment Canada, 2012):

- Abundance (total number of animals per m^2);
- Taxon Richness (number of Families),
- Evenness (E), where,

$$E = 1/\sum(p_i)^2/S;$$

- Bray-Curtis (BC) Distance Index, where,

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

Where, y_{i1} = abundance of family *i* in sample 1, y_{i2} = abundance of family *i* in sample 2.

Bray-Curtis distances were computed between all pairs of the n=161 samples. Relative percent abundances were used as raw values and other transformations (e.g. log) did not provide reasonable NMDS scores.

The Bray-Curtis distance matrix was used as the input distance matrix for an NMDS-based ordination carried out in SYSTAT. Two NMDS axes were produced by the ordination. Pearson correlations between raw taxa (family) abundances and sample scores on each of the NMDS axes were computed. A scatterplot of taxa correlations was produced in order to illustrate the relationship between taxa abundances and NMDS axis scores. Scatterplots of NMDS sample scores, by year, were produced in order to illustrate variations in benthic community composition among sample areas, over time.

4.2.3.3 Testing for Effluent Related Effects

If mine effluent releases abruptly altered the benthic community of WAL, the effect on the community should be manifest as a change in the natural difference between Reference and Exposure areas, from before to during exposure. This effect pattern is termed here the before-after-control-impact (BACI) hypothesis. If, in contrast, mine effluent releases are gradually altering benthic communities in WAL, the effect on the community should be manifest as a change in the trend over time. This effect pattern is termed here the Time Trend hypothesis.

The full complement of baseline and exposure period data (see Table 26) were used in an analysis of variance with Planned Linear Orthogonal Contrasts (or PLOC; see Hoke *et al*., 1990; Environment Canada and Department of Fisheries and Oceans, 1995). PLOC can test very specific hypotheses that are likely to be of interest. Hypotheses 1, 2, 3 and 4 were tested the contrasts illustrated in Table 27 below.

In the ANOVA's, 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 receive 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.

ANOVA 4 tested for a significant change in differences between WAL and the two reference lakes (INUG, PDL) from early in the exposure period (2013 to 2016) to the last year in the exposure period (2017). This ANOVA then tested for a step change in differences in 2017.

We anticipated that Environment Canada would be interested in carrying out a more conventional EEM analysis of just the 2017 data. Therefore a fifth ANOVA was carried out which included only the data from 2017, and which tested (HO5) that there was no difference in mean index values between WAL and the average of the two reference area (INUG, PDL). Contrast coefficients were -1, -1, 2 for INUG, PDL and WAL respectively.

For these ANOVA's, the variation among stations was used to judge the significance of the contrasts per Table 28. The mean squared error term was estimated through an omnibus ANOVA that incorporated data from all sample areas and years. Doing that ensured the most robust estimate of among station variability (i.e., among station SD), and therefore the most robust evaluation of the hypotheses.

Table 27. Linear contrasts that were used to analyze the 2017 benthic community data from WAL, INUG and PDL (Meadowbank Mine).

Year	Exposure Period	Change from Baseline (2006 to 2012) to Exposure (2013 to 2017) Periods in Difference between Reference (INUG) and Exposure (WAL) (ANOVA 1)			Change from Baseline (2010 to 2012) to Exposure (2013 to 2017) Periods in Difference between Reference (INUG, PDL) and Exposure (WAL) (ANOVA 2)			Different Time Trend in Exposure Period (2013 to 2017) between Reference (INUG, PDL) and Exposure (WAL) (ANOVA 3)			Step change in 2017 in Difference between Reference (INUG, PDL) and Exposure (WAL) (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	1	1	-2
2014		-7	0	7	-3	-3	6	-1	-1	2	1	1	-2
2015		-7	0	7	-3	-3	6	0	0	0	1	1	-2
2016		-7	0	7	-3	-3	6	1	1	-2	1	1	-2
2017		-7	0	7	-3	-3	6	2	2	-4	-4	-4	8

Table 28. ANOVA table to analyze linear contrasts in Table 27.

Source	df	MS	F
Year x Lake Combinations (Y x L)	(Y x L) -1	MS (YxL)	
HO1:	1	MS (BACI 1)	MS (BACI 1) / MS (E)
HO2:	1	MS (BACI 2)	MS (BACI 2) / MS (E)
HO3:	1	MS (TT)	MS (TT) / MS (E)
HO4:	1	MS (CI)	MS (CI) / MS (E)
Error	(Y x L x n)-1	MS (E)	

Table Note: see hypothesis statements in Table 27.

4.2.3.4 Assessment of Covariable Effects

Prior to ‘running’ ANOVA’s on core indices of benthic community composition, we examined the associations between indices and potential modifying factors (e.g., depth, substrate texture [logarithm of geometric mean particle size], logarithm of sediment total organic carbon). Multiple regression (backwards stepwise) was used to determine models that best explained variations in indices of composition.

4.2.3.5 Presentation of Basic Statistics

Sample area means, medians, standard deviations, standard errors, minimum and maximum values for abundance, family richness, and equitability were computed for 2017 data. The mean, median, SD, SE, minimum and maximum BC distances within WAL, INUG and PDL, and between WAL and INUG and PDL, were also calculated using only the 2017 data.

Effect sizes for the various hypotheses, for abundance, richness, equitability, and scores on NMDS axes 1 and 2 were computed per the following:

For Hypotheses 1, 2 and 4, the difference between Reference and Exposure in 2017, we used:

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

Where

- $\bar{x}_r$ 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 computed 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.

We did not compute an effect size for the Mantel tests on Bray-Curtis distances since there is no guidance on how to do so (Environment Canada, 2012; Borcard and Legendre, 2013).

In addition to the conventional calculation of effect sizes described above, we also computed the normal range of variation for core indices of composition. Normal ranges were computed as the mean of the reference observations (all data from INUG and PDL, and reference period data from WAL), ± 2 SD_{ref}, where SD_{ref} is the standard deviation of those reference observations. This range of values is an estimate of the normal range of future values, and is a simplification of more complicated estimates based on tolerance ranges (Kilgour et al., 1998; 2017). The simplified calculation here is considered warranted given that there were > 130 reference observations used in the calculation, and the approximate values were very similar to what was produced by the more detailed calculations. The calculations of normal ranges were applied to 'residuals' of the core indices of composition, since (and as is shown later) variations in the core indices varied significantly with underlying co-variables (total organic carbon, water depth, grain size).

4.2.3.6 Statistical Power

The ability to detect an effect depends on sample size; where the study relies on a contrast of Reference versus Exposure locations, sample sizes refer to the number of replicate stations within both Reference and Exposure Areas. Environment Canada (2012) has deemed that effects that exceed two times the standard deviation of observations (i.e., ±2SDs) among stations will require further investigation. Therefore, it is necessary to calculate the probability that a difference of ± 2 SDs could be detected with a certain number of stations in both control and impact sampling Areas.

In this study, power was assessed using the conventional power equation given by Green (1989):

$$n = \frac{\left(\sum C_i^{2}\right)\left(t_\alpha + t_\beta\right)^2 \sigma^2}{\delta^2}$$

where,

n is the number of samples, C^2_i is the contrast coefficients squared, σ is the population standard deviation, δ is the specified effect size, t_α is the Students t statistic for a two-tailed test with significance level α, and t_β is the Students t statistic for a one-tailed test with significance level β. The $\sum C^2_i$ is normally 2 (i.e., $1^2 - 1^2 = 2$) for a two-sample contrast of Reference and Exposure Areas.

By re-arrangement, and by setting α, t_β can be solved iteratively. Alternatively, the detectable effect size δ, can be solved if both α and β are set. Here, with n=5, and $\alpha = \beta = 0.05$, this study had the ability to detect an effect size for BACI contrasts of about 0.9σ, and an effect size for time trend contrasts of about 1.1σ. Those detectable effect sizes are approximately ½ the effect size that is deemed important to detect in EEM (Environment Canada, 2012).

4.2.3.7 Precision

Statistical power is a function of the underlying true effect size (or correlation) and number of replicate samples. In this EEM study, stations were considered the unit of replication, so it was the number of replicate stations within each Area that was of critical importance in determining the power of the study. An additional factor indirectly influencing the power of a study is the degree of precision with which descriptors of community composition have been estimated. In benthic ecology, it is generally recommended that descriptors of community composition be estimated to within ± 20% of the actual (true) value (Elliott, 1977), which is what is stated in Environment Canada's (2012) guidance document.

The precision (*P*) of within-station estimates can be estimated as:

$$\mathrm{P} = \frac{\mathrm{S}}{\sqrt{\mathrm{n}}\,\bar{\mathrm{x}}}$$

where *s* is the within-station standard deviation, n is the number of replicate (field) sub-samples, and $\bar{x}$ is the estimated mean of the community descriptor. This equation can be re-arranged to solve for the number of replicate samples required to achieve the desired precision (*P*) of 0.2 (i.e., 20%):

$$n = \frac{S^2}{P^2 \bar{x}^2}$$

The standard deviation can be estimated for each station separately, resulting in an estimated number of samples required to achieve the desired precision for the next study. A more practical approach uses the pooled estimate of the standard deviation within stations based on an analysis of variance testing for differences between stations. This pooled estimator can be used in the second equation immediately above to estimate required sub-sample per station, and assuming the mean value. This was the approach taken here. Duplicate samples in 2017 from WAL, INUG and PDL were all kept separate and the individual samples were sorted and organisms identified separately. Abundance, family richness, and family-level equitability were computed for each grab.

An analysis of variance was completed with the following model (for example here for ‘abundance’):

Abundance = constant + Lake + STN(Lake)+Error;

Where stations are ‘nested’ within lakes. The error term (i.e., the MSE term) in this model is the estimator for the among-grab variation, within-station variation. The square root of the MSE for this model is the estimate of s, required for the equations above.

4.3 Results

4.3.1 Supporting Environmental Variables

4.3.1.1 General Limnology

The three benthos sampling areas were similar in terms of general character. The sampling areas in INUG and PDL were just over 8 m deep, while the sampling area in WAL was just over 9 m deep. Temperature profiles in all three areas were similar in that temperatures were homogeneous from surface to bottom. Temperatures were lower, however, in PDL at roughly 10°C compared to between 12 and 13°C in both WAL and INUG (Figure 15). Dissolved oxygen profiles were similar, with about 10 mg/L from surface to 1 m off bottom. There was no indication of a DO depression near the sediments in any of the three lakes, and in WAL there is a slight increase in DO near the sediment water interface. Water depths for stations in 2014 were similar to what was surveyed in previous years (Figure 16).

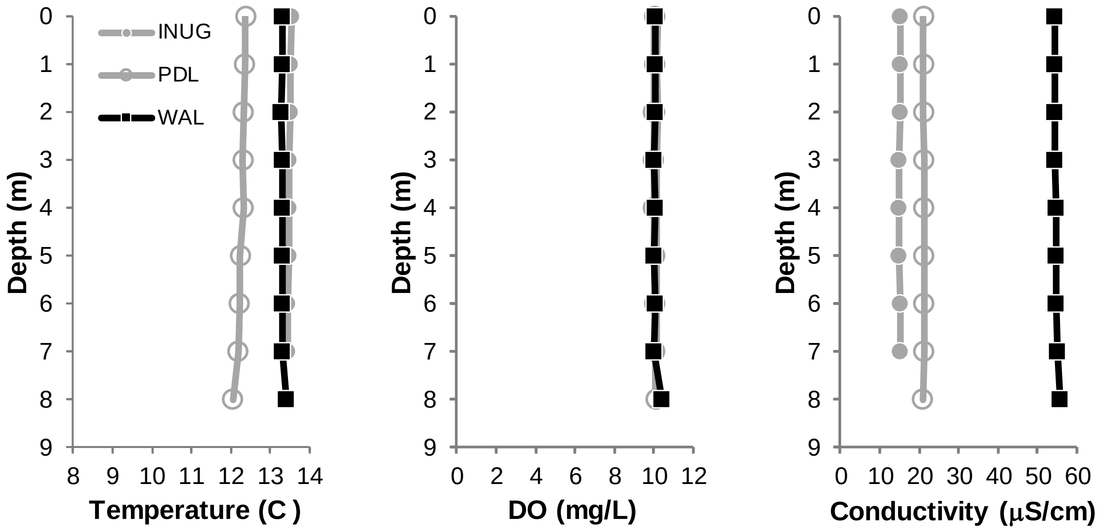


Figure 15. Depth profiles for water temperature, dissolved oxygen (DO) and conductivity, in each of the three benthos sampling areas, INUG, PDL and WAL. Values at each 1 m interval are the average from five sampling stations.

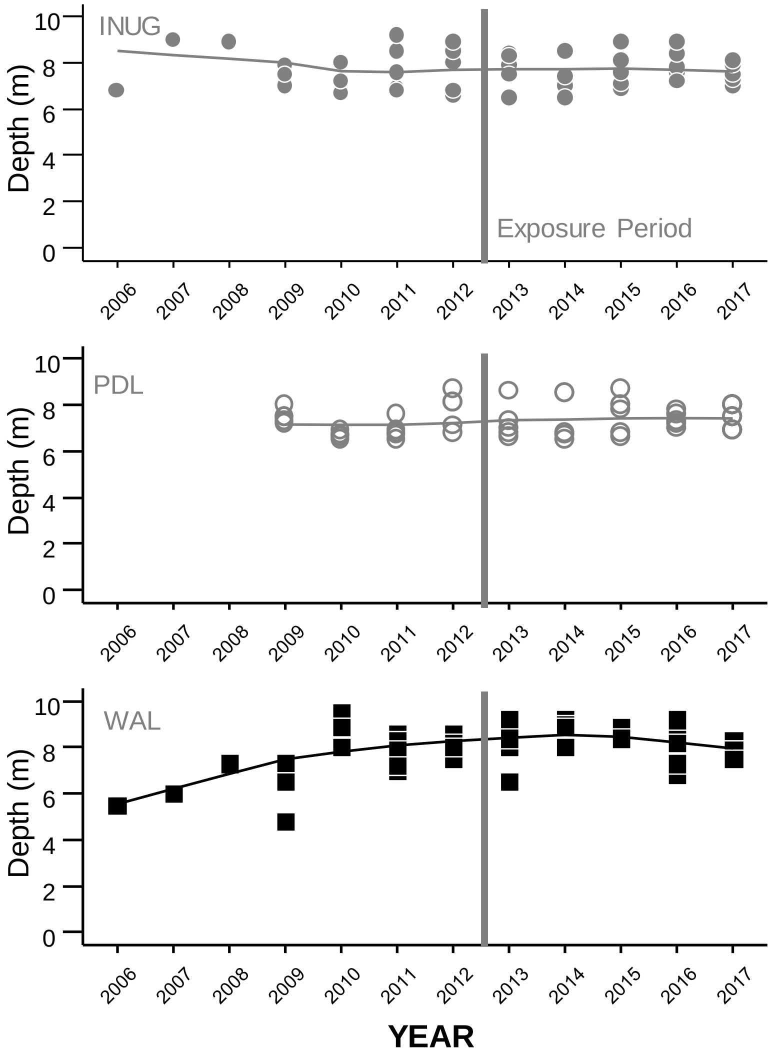


Figure 16. Water depth among years for INUG, PDL and WAL.

Figure Note: the line illustrates Locally Weighted Scatterplot Smoothing (LOWESS)-smoothed variations in annual averages.

4.3.1.2 Laboratory Water Chemistry

Detailed chemistry results for the benthos sampling areas is provided in Table 29 below. QA/QC for analytical chemistry is provided in Appendix 4. All RPD values were ≤ 20%, except for turbidity (27%) and total Kjeldahl nitrogen (31%), such that the quality of the water chemistry data is deemed sufficient.

The waters from the two control lakes were very ‘soft’, with hardness values of around 5.8 and 8.8 mg/L at INUG and PDL, respectively. Hardness at WAL was higher, at around 22.7 mg/L. Total ammonia was at non-detectable concentrations in INUG and PDL (i.e. < 0.005 mg/L), whereas concentrations in WAL were detectable but near 0.05 mg/L. Chloride concentrations in WAL were around 1.26 mg/L, higher than what was measured in INUG (0.7 mg/L) and PDL (0.6 mg/L), but very low relative to the water quality guideline of 120 mg/L. Orthophosphate and total phosphorus were at non-detectable concentrations in all three lakes. Sulphate concentrations were ~ 0.9 mg/L in INUG, ~ 1.7 mg/L in PDL, and about 8 mg/L in WAL. Sulphate concentrations were therefore elevated in WAL relative to the control lakes.

Measured concentrations of total metals never exceeded CCME guidelines for the protection of aquatic life (Table 29). Many of the metals were at or near non-detectable concentrations in all three lakes, including Sb, Be, Bi, B, Cd, Cr, Co, Cu, Fe, Pb, Li, Hg, Mo, Ni, P, Se, Ag, Tl, Sn, Ti, V and Zn. Consistent with historical data reported in Agnico CREMP annual reports (Azimuth, 2015), concentrations of the metals Ba, and Mn were modestly higher in WAL than in the reference lakes.

Concentrations of the cations Ca, K and Na were higher in WAL than the two reference lakes, reflecting the higher hardness in WAL. Sulfur was at non-detectable concentration in INUG (i.e. < 0.5 mg/L), was just above the detection limit in PDL (~ 0.63 mg/L) and was about 6x the detection limit in WAL (~ 3.12 mg/L). Silicon concentrations exceeded the detection limit of 0.05 mg/L in all lakes.

Table 29. Detailed water quality for the benthos monitoring areas.

Variable	Units	CCME	INUG-1	INUG-2	PDL-1	PDL-2	WAL-1	WAL-2
Physical Tests								
Conductivity	µS/cm		15.4	15.1	19.9	22.1	55.7	54.7
Hardness (as $CaCO_3$)	mg/L		5.7	5.8	8.8	8.8	22.9	22.4
pH (Laboratory)			6.84	6.86	7.06	7.02	7.37	7.38
Total Suspended Solids	mg/L		<1.0	<1.0	1	<1.0	2	1
Total Dissolved Solids	mg/L		15	15	18	16	46	39
Turbidity	NTU		0.36	0.41	0.23	0.28	0.44	0.52
Anions and Nutrients								
Alkalinity, Total	mg/L		4.9	4.5	7.4	7.3	14.8	15.0
Ammonia, Total (as N)	mg/L	*equation*[1]	<0.0050	<0.0050	<0.0050	<0.0050	0.048	0.047
Bromide (Br)	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Chloride (Cl)	mg/L	120	0.74	0.75	0.61	0.60	1.27	1.25
Fluoride (F)	mg/L	0.120	0.06	0.06	0.03	0.04	0.05	0.05
Nitrate (as N)	mg/L	3.0	<0.0050	<0.0050	<0.0050	<0.0050	0.2680	0.2530
Nitrite (as N)	mg/L	0.06	<0.0010	<0.0010	<0.0010	<0.0010	0.005	0.003
Total Kjeldahl Nitrogen			0.15	0.11	0.09	0.10	0.19	0.23
Orthophosphate-Dissolved (as P)	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Phosphorus (P)-Total Dissolved	mg/L		<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Phosphorus (P)-Total	mg/L	0.0040	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Silicate (as SiO_2)	mg/L		<0.50	<0.50	<0.50	<0.50	0.51	0.51
Sulfate (SO_4)	mg/L		0.86	0.87	1.65	1.65	8.29	8.09
Cyanides								
Cyanide, Total	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Cyanide, Free	mg/L	0.005	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Organic / Inorganic Carbon								
Dissolved Organic Carbon	mg/L		1.75	1.88	1.67	1.62	2.30	2.31
Total Organic Carbon	mg/L		2.11	1.96	1.74	1.80	2.73	2.33
Plant Pigments								
Chlorophyll-*a*	µg/L		0.26	0.31	0.22	0.26	0.89	0.88
Total Metals								
Aluminum (Al)-Total	mg/L	*equation*	0.0075	0.0072	0.0047	0.0044	0.0101	0.0117
Antimony (Sb)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	0.00	0.00

Variable	Units	CCME	INUG-1	INUG-2	PDL-1	PDL-2	WAL-1	WAL-2
Arsenic (As)-Total	mg/L	0.005	0.0002	0.0002	0.0002	0.0002	0.0004	0.0004
Barium (Ba)-Total	mg/L		0.0017	0.0018	0.0019	0.0019	0.0038	0.0038
Beryllium (Be)-Total	mg/L		<0.000020	<0.000020	<0.000020	<0.000020	<0.000020	<0.000020
Bismuth (Bi)-Total	mg/L		<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Boron (B)-Total	mg/L	1.5	<0.010	<0.010	<0.010	<0.010	<0.010	<0.010
Cadmium (Cd)-Total	mg/L	*equation*	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Calcium (Ca)-Total	mg/L		1.13	1.13	2.25	2.22	6.52	6.40
Chromium (Cr)-Total	mg/L	0.001	<0.00015	<0.00015	<0.00010	~~0.0046~~[2]	<0.00010	<0.00010
Cobalt (Co)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Copper (Cu)-Total	mg/L	*equation*	<0.00050	<0.00050	<0.00050	0.0006	0.0013	0.0013
Iron (Fe)-Total	mg/L	0.3	0.014	0.017	<0.010	0.037	0.028	0.030
Lead (Pb)-Total	mg/L	*equation*	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Lithium (Li)-Total	mg/L		<0.0010	<0.0010	<0.0010	<0.0010	<0.0010	<0.0010
Magnesium (Mg)-Total	mg/L		0.70	0.71	0.80	0.78	1.77	1.77
Manganese (Mn)-Total	mg/L		0.0020	0.0020	0.0014	0.0017	0.0045	0.0044
Mercury (Hg)-Total	mg/L	0.000026	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050	<0.0000050
Molybdenum (Mo)-Total	mg/L	0.073	<0.000050	<0.000050	<0.000050	0.0001	0.0013	0.0013
Nickel (Ni)-Total	mg/L	*equation*	<0.00050	0.0006	0.0007	0.0007	0.0006	0.0006
Phosphorus (P)-Total	mg/L		<0.050	<0.050	<0.050	<0.050	<0.050	<0.050
Potassium (K)-Total	mg/L		0.40	0.40	0.37	0.37	0.81	0.81
Selenium (Se)-Total	mg/L	0.001	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050	<0.000050
Silicon (Si)-Total	mg/L		0.18	0.18	0.17	0.15	0.26	0.25
Silver (Ag)-Total	mg/L	0.0001	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Sodium (Na)-Total	mg/L		0.60	0.60	0.53	0.53	0.97	0.94
Strontium (Sr)-Total	mg/L		0.0061	0.0062	0.0090	0.0089	0.0354	0.0353
Sulfur (S)-Total	mg/L		<0.50	<0.50	0.57	0.68	3.12	3.12
Thallium (Tl)-Total	mg/L	0.0008	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010	<0.000010
Tin (Sn)-Total	mg/L		<0.00010	<0.00010	<0.00010	<0.00010	<0.00010	<0.00010
Titanium (Ti)-Total	mg/L		<0.00030	<0.00030	<0.00030	<0.00030	<0.00030	<0.00030
Uranium (U)-Total	mg/L	0.015	0.000040	0.000039	0.000022	0.000021	0.000292	0.000275
Vanadium (V)-Total	mg/L		<0.00050	<0.00050	<0.00050	<0.00050	<0.00050	<0.00050
Zinc (Zn)-Total	mg/L	0.03	<0.0030	0.0038	<0.0030	<0.0030	<0.0030	<0.0030

[1] "equation" means that CCME guidelines (or thresholds) are calculated based on an equation which is either pH or hardness dependent. The ammonia and aluminum guidelines vary with pH; the cadmium, copper, lead, manganese, nickel and zinc guidelines vary with hardness.

[2] ~~strikethrough~~ = results flagged as unreliable in the QC assessment.

< indicates below detection limits.

4.3.1.3 Sediment Character

Sediments were largely fines with silt and clay comprising collectively > 90% of the sediment material (Table 30). TOC in sediments were generally higher in the two reference lakes (INUG, PDL) than had been previously reported from those lakes (typically < 5%), with percentages of between about 5.6 and 6.3% in 2017. WAL sediments have always had relatively high TOC with percentages ranging between 5 and 13 (Figure 17), and values in 2017 of between 7.15 and 8.10% (Table 30).

Table 30. Variations in sample depth, TOC, sand, silt and clay, 2017.

Area	Station	Depth (m)	TOC (%)	Sand (%)	Silt (%)	Clay (%)
INUG	1	7.0	6.02	4.0	74.1	22.0
	2	7.3	6.34	6.9	68.6	24.5
	3	7.5	6.08	4.3	69.8	25.9
	4	7.9	5.93	3.5	67.8	28.8
	5	8.1	5.70	2.8	68.5	28.7
PDL	1	8.0	6.21	2.8	77.2	20.0
	2	6.9	5.94	9.0	72.3	18.8
	3	6.9	5.62	7.7	74.0	18.3
	4	8.0	6.21	6.6	73.4	20.0
	5	7.5	6.29	7.1	75.1	17.7
WAL	1	8.0	7.48	4.7	78.5	16.8
	2	8.3	7.52	<1.0	79.3	19.8
	3	7.9	8.10	1.1	76.6	22.3
	4	7.9	7.15	2.1	76.1	21.8
	5	7.5	7.86	3.2	80.8	16.1

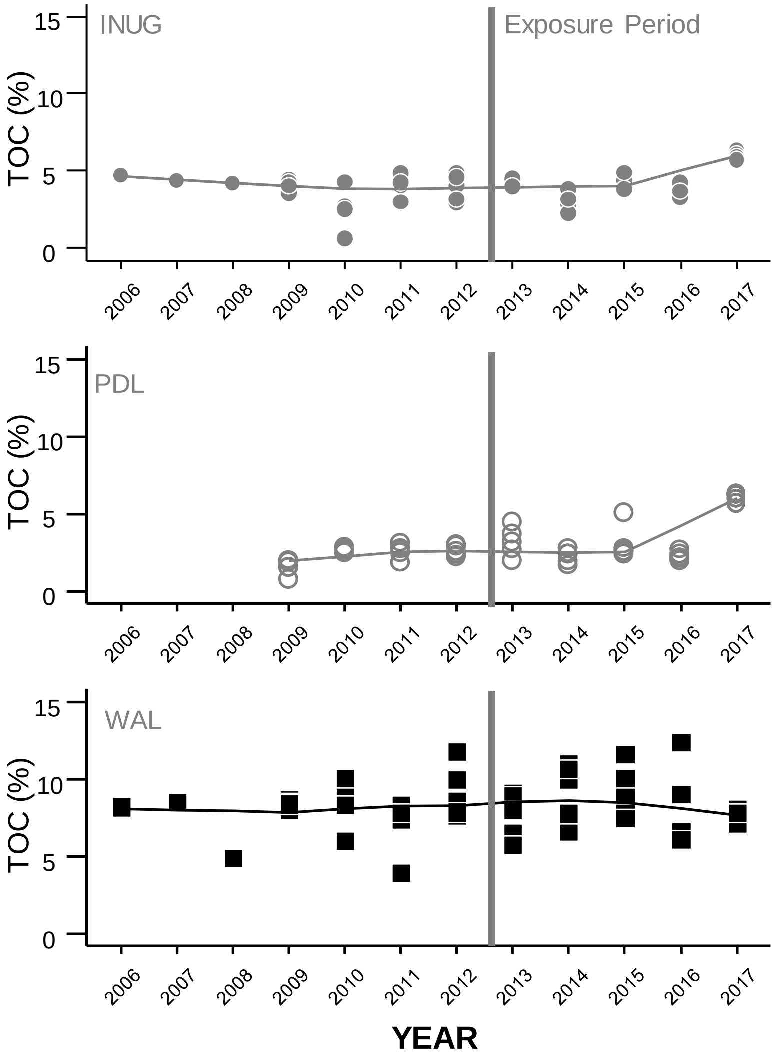


Figure 17. Total organic carbon (TOC) in sediment among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

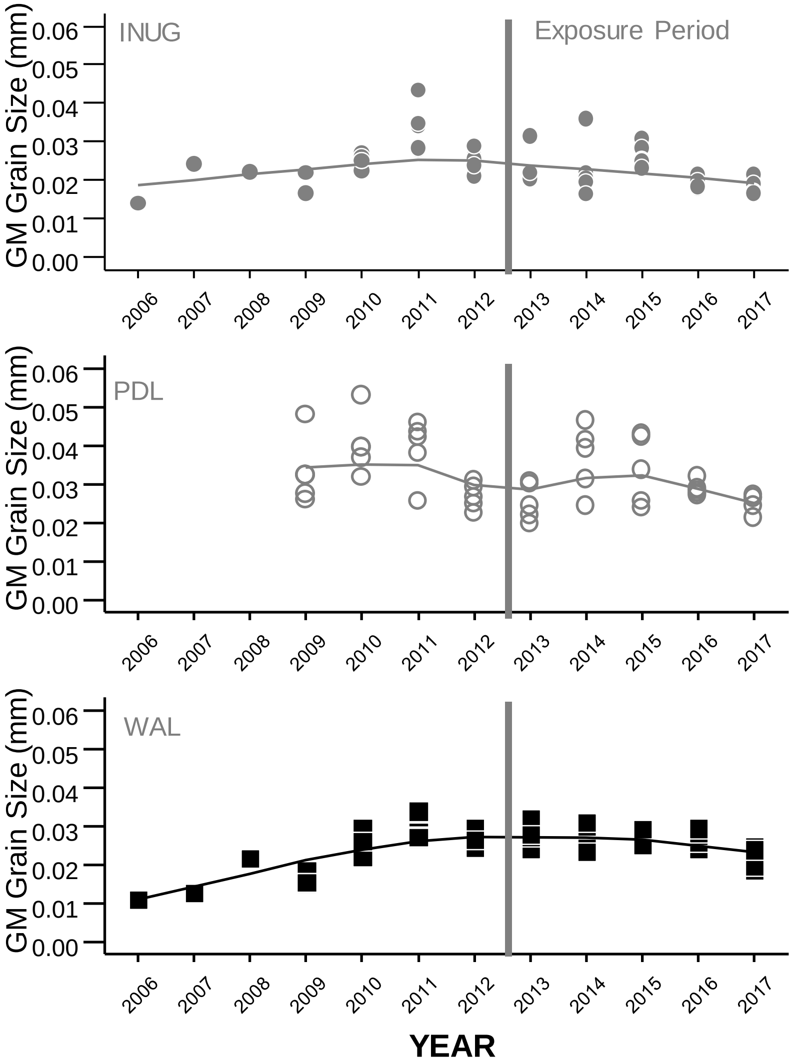


Figure 18. Geometric mean (GM) grain size of sediment among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

4.3.2 Invertebrate Community Composition

4.3.2.1 General Description

Relative abundances of benthos families in each of the lakes from the start of CREMP monitoring through to and including this 2017 survey are presented in Table 31. Required statistics for each of the core indices of composition are provided in Table 32 (Abundance, Family Richness, Equitability) and Table 33 (Bray-Curtis distances).

Benthic communities of the three study areas were generally similar in 2017, and similar to what had been described in previous years. The benthos of Wally Lake were dominated numerically by chironomids (79%) and Pisidiidae fingernail clams (14%, Table 31), in 2017, with sub-dominant taxa including Ostracoda (5%) and mites (Acari 1%). Nemata, Platyhelminthes and Limnephilidae caddisflies each accounted for < 1% of total numbers of benthos collected from Wally Lake in 2017. There were no oligochaete worms in the benthos of Wally Lake sediments in 2017. Two individual Limnephilidae caddisflies (*Grensia praeterita,* see Appendix 5 – benthos detailed taxonomic data) were present in WAL in 2017, whereas there were two in PDL and one in INUG in 2017. Quality assurance for the laboratory sorting of invertebrate samples is provided in Appendix 6. Sorting always produced > 95% of individuals in the samples, and was therefore acceptable.

There were 10 chironomid genera in the WAL stations in 2017. The following chironomid genera were numerically dominant not only in WAL, but also in INUG and PDL: *Micropsectra*, *Paratanytarsus*, *Stichtochironomus*, *Tanytarsus*, and *Procladius*. All of these genera are commonly distributed in the Holarctic.

The Pisidiidae clams in Wally Lake have always been of the genus *Pisidium*, like they have been in PDL. Pisidiidae in INUG have included both Pisidium and *Sphaerium nitidum*.

Variations in total abundance and indices of composition (richness, equitability) over time and within sample areas are illustrated in Figure 19 through Figure 21. Total abundances in Wally Lake have been generally higher and more variable than abundances in INUG or PDL. Abundances in Wally Lake in 2017 varied between about 3000 and 8000 individuals per m^2, whereas abundances in INUG varied between about 1000 and 3000 individuals per m^2, and abundances in PDL varied between about 500 and 1500 individuals per m^2. Abundances in Wally Lake have typically ranged up to about 5000 individuals per m^2, with the exception of samples collected in 2016 when abundances varied between 13000 and 32000 individuals per m^2.

In 2017, benthic samples from Wally Lake produced between 4 and 6 families per sample (i.e. per pair of Ponar grabs; see Figure 20). Those family richness values were similar to what had been reported previously, with the minimum number of families being 4 in a sample, and the maximum being 8. Family richness was higher in 2016, with values of between 6 and 8. Family richness values in 2017 were similar to what has been previously observed in INUG (3 to 9 families) and PDL (3 to 8 families).

Equitability values in Wally Lake varied between 0.23 and 0.38 in 2017, a range of values that was well within the range of values that was historically reported for that lake. Values have typically been between about 0.2 and 0.7, and therefore similar to the ranges of values reported from INUG and PDL (Figure 21).

The results of the NMDS ordination are illustrated in Figure 22 (taxa correlations with axis scores) and Figure 23 (sample scores). Chironomid abundances were most strongly and positively associated with Axis 1 scores, whereas ostracod abundances were most strongly associated with Axis 2 scores. Variations in Axis 1 scores therefore reflects (generally) variations in abundances of chironomids, while variations in Axis 2 scores reflects variations in ostracod abundances. Figure 23 illustrates the variations over time in axis scores. Benthic community data from Wally Lake produced larger positive Axis 1 scores than INUG in the baseline period years 2006 and 2007, and then again in the exposure period years

2016 and 2017. Wally Lake scores were somewhat more similar to scores produced by benthos from PDL than from INUG across all years. In 2017, the Wally Lake benthos produced scores that were generally similar to scores produced by PDL, but there were two samples that produced lower Axis 2 scores relative to all other samples, and one sample was an apparent outlier relative to other samples (see sample with most negative Axis 2 score, bottom right hand graph of Figure 23).

Table 31. Relative abundances (%) of benthos taxa (families or higher level) by year for INUG, PDL and WAL. Averages of total abundance, family richness and equitability are also provided.

Taxon	INUG											
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nemata	3	2	5	2	1	3	2	5	3	6	2	2
Platyhelminthes		3	<1	1	1		2	3			1	1
Naididae	1	2	1	1	1	<1	1	2	1	<1	1	<1
Lumbriculidae	3	3	<1	3	3	5	3	2	1	2	<1	1
Acarina	5	5	2	3	4	2	4	1	1	1	1	2
Ostracoda	7		6	9	9	4	5	6	1	4	1	2
Notostraca		1	<1	<1		2	1				1	
Limnephilidae				<1	2			<1	1	<1	<1	<1
Chironomidae	47	57	71	50	37	41	45	57	60	63	70	66
Empididae	1		<1									
Pisidiidae	33	27	15	31	43	42	37	22	32	24	23	26
Indices												
Abundance	841	1,043	2,143	1,339	704	1,096	1,152	2,470	752	1,917	2,335	1,904
Family Richness	5.33	5.80	6.40	6.20	5.00	5.80	6.20	8.00	3.80	5.40	6.40	5.27
Family Diversity	0.63	0.56	0.54	0.63	0.61	0.64	0.64	0.58	0.53	0.54	0.45	0.51
Family Evenness	0.57	0.43	0.38	0.46	0.53	0.48	0.50	0.31	0.58	0.41	0.32	0.42

Taxon	PDL								
	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nemata	1	3	2	3	5	9	4	3	4
Platyhelminthes	<1								1
Naididae	5	3	4		4	6	1	1	2
Lumbriculidae	1	1	2	1	1	2	1	1	3
Acarina	2	1	4	2	1	2	1	1	1
Ostracoda	9	8	3	2	7		11	3	13
Notostraca							<1		
Limnephilidae	1	1	1	2	2		2	1	1
Chironomidae	60	54	54	64	57	52	59	65	52
Empididae									
Pisidiidae	20	28	31	26	23	29	20	26	24
Indices									
Abundance	1,930	1,013	991	1,026	1,513	548	1,391	1,530	970
Family Richness	6.20	5.20	5.20	4.40	6.20	4.40	6.00	5.40	5.33
Family Diversity	0.60	0.59	0.58	0.48	0.61	0.57	0.59	0.51	0.61
Family Evenness	0.42	0.49	0.48	0.46	0.42	0.57	0.41	0.42	0.53

Taxon	WAL											
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Nemata	<1	<1	5	1	1	2	1	1	<1	2	1	<1
Platyhelminthes		2		1			2	1		<1	<1	<1
Naididae	<1	<1	<1	2							<1	
Lumbriculidae	<1	1	<1	1	1	2	1	<1		2	<1	
Acarina	1	1	1	2	1	1	1	4	2	1	1	1
Ostracoda	1	<1	7	15	7	11	14	14	16	19	2	5
Notostraca												
Limnephilidae		<1	<1	1	<1	<1	<1	1	<1	<1	<1	<1
Chironomidae	93	83	54	53	70	55	67	60	66	56	92	79
Empididae						<1						
Pisidiidae	4	12	32	24	20	28	14	19	15	20	4	14
Indices												
Abundance	13,167	4,739	1,309	2,683	2,470	1,313	2,930	2,052	2,857	2,443	16,343	5,570
Family Richness	4.67	6.00	5.20	6.80	5.20	5.60	6.20	6.00	4.40	6.00	6.80	4.80
Family Diversity	0.13	0.30	0.60	0.65	0.51	0.60	0.57	0.59	0.51	0.63	0.18	0.36
Family Evenness	0.25	0.25	0.52	0.46	0.45	0.49	0.41	0.43	0.48	0.49	0.18	0.34

Table 32. Mean, median, minimum, maximum, standard deviation (SD) and standard error (SE) for core indices of benthic community composition for INUG, PDL and WAL in 2017.

Area	Metric	Total Abundance	Family Richness	Family Equitability
INUG (2017)	Mean	1904	6.4	0.33
	Median	1891	6.0	0.30
	Min	1152	6.0	0.29
	Max	3087	7.0	0.40
	SD	768	0.5	0.05
	SE	343	0.2	0.02
PDL (2017)	Mean	970	6.4	0.44
	Median	913	7.0	0.44
	Min	543	5.0	0.31
	Max	1522	8.0	0.57
	SD	389	1.3	0.10
	SE	174	0.6	0.04
WAL (2017)	Mean	5570	5.0	0.32
	Median	6130	5.0	0.30
	Min	3261	4.0	0.27
	Max	8239	6.0	0.38
	SD	2127	0.7	0.04
	SE	951	0.3	0.02

Table 33. Mean, median, minimum, maximum, standard deviation (SD) and standard error (SE) for Bray-Curtis distances for INUG, PDL and WAL in 2017.

Metric	Within Reference	Within Exposure	Between Reference and Exposure	Between WAL and PDL	Between WAL and INUG
Mean	0.27	0.36	0.32	0.32	0.32
Median	0.24	0.33	0.28	0.29	0.25
Min	0.04	0.15	0.04	0.04	0.14
Max	0.50	0.55	0.63	0.59	0.63
SD	0.12	0.13	0.16	0.16	0.16
SE	0.02	0.04	0.02	0.03	0.03

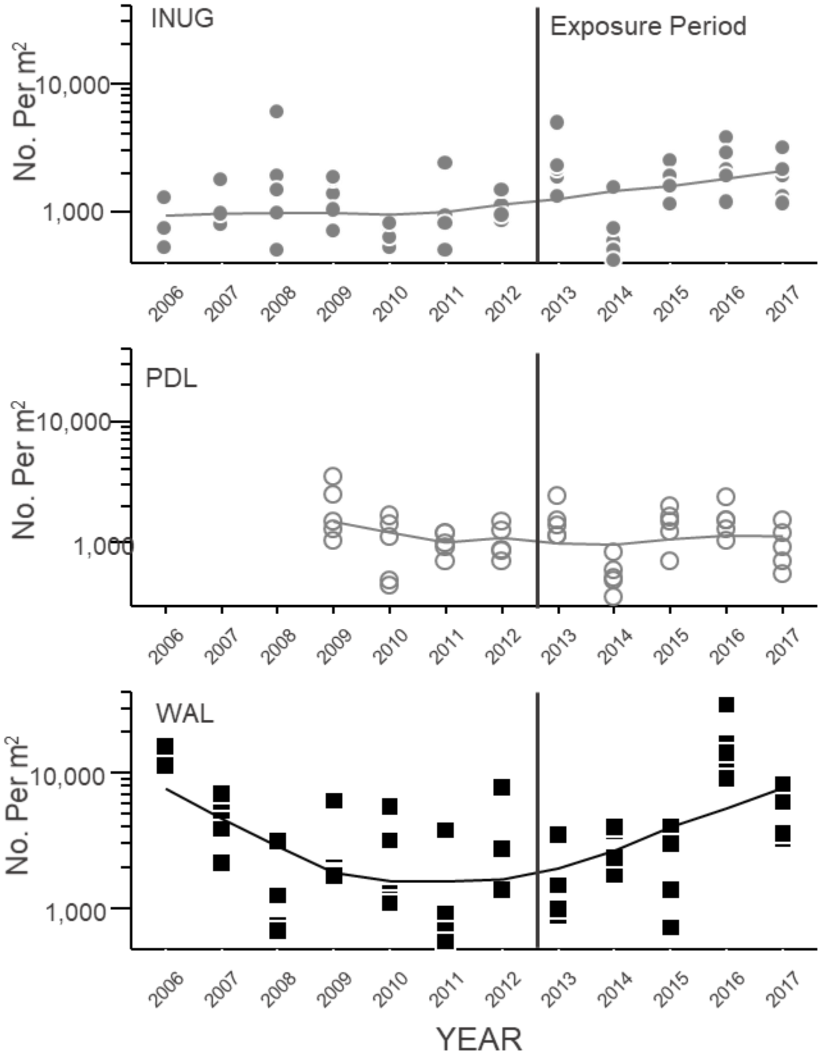


Figure 19. Number of organisms per m^2 among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed annual averages.

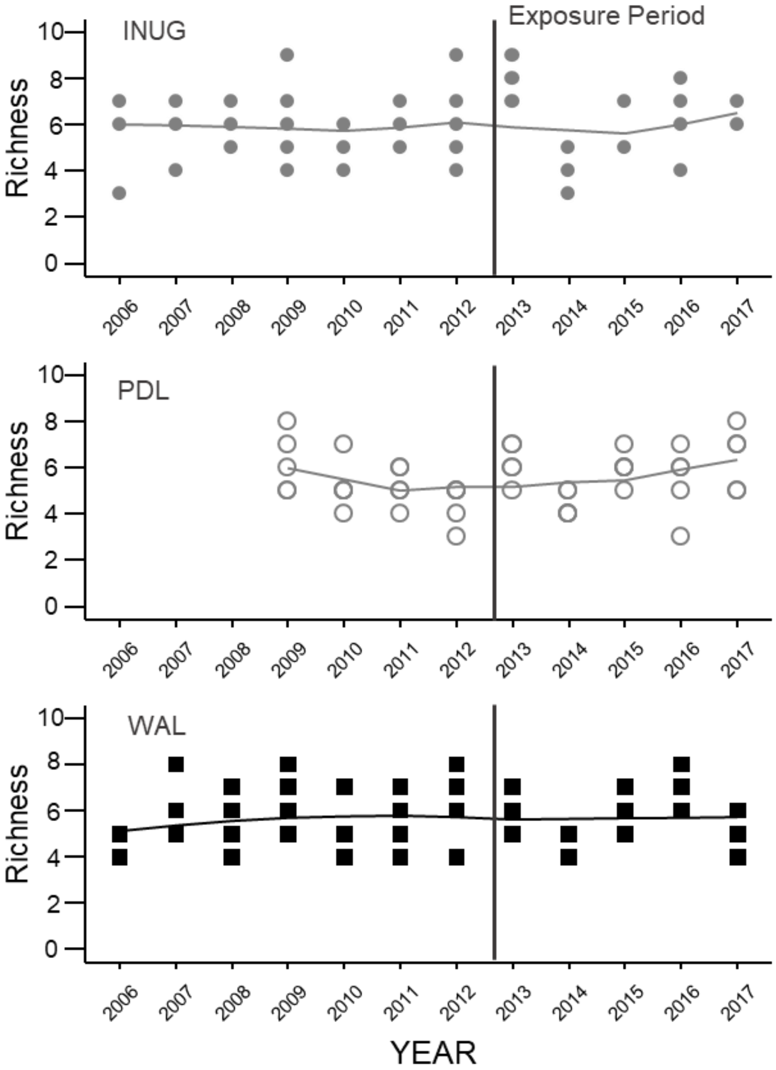


Figure 20. Taxa richness (number of families) among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed annual averages.

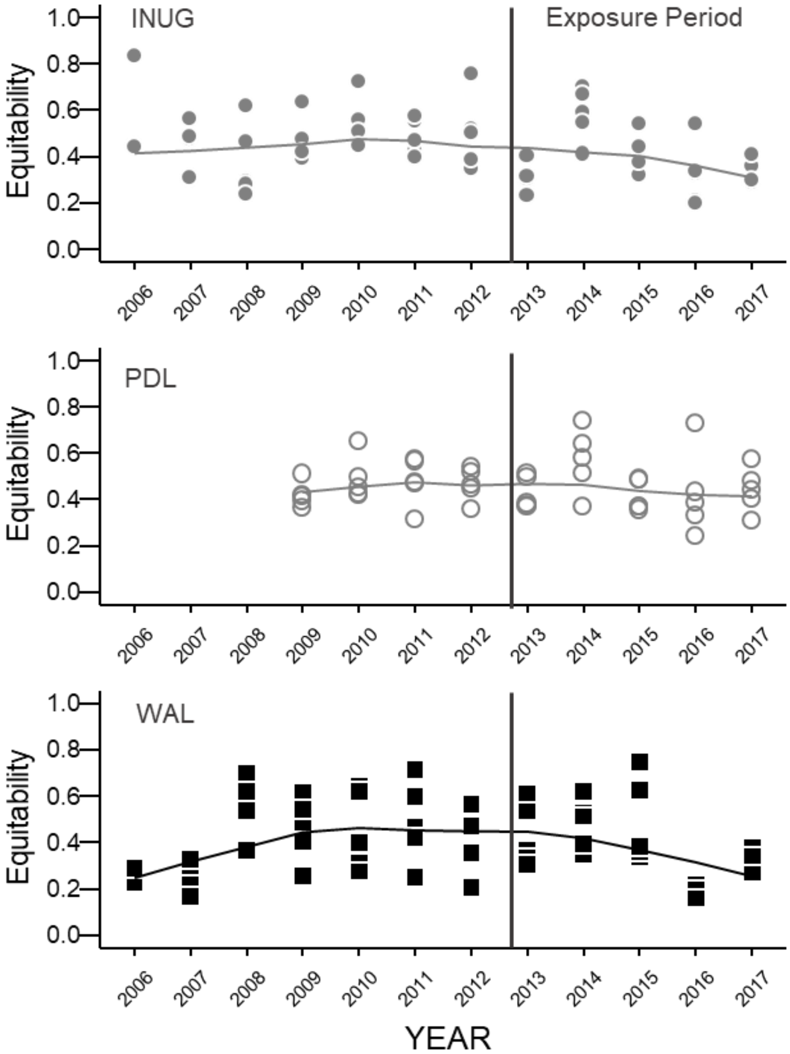


Figure 21. Equitability among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

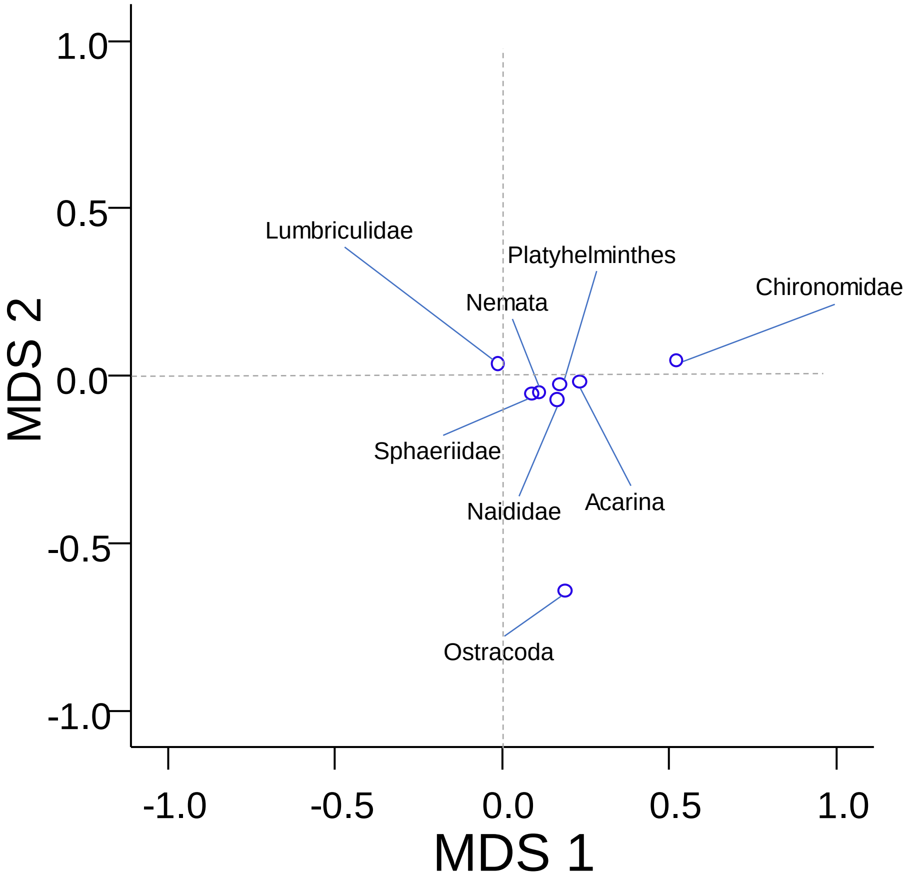


Figure 22. Scatterplot of Pearson correlation coefficients between taxa abundances and MDS axis scores.

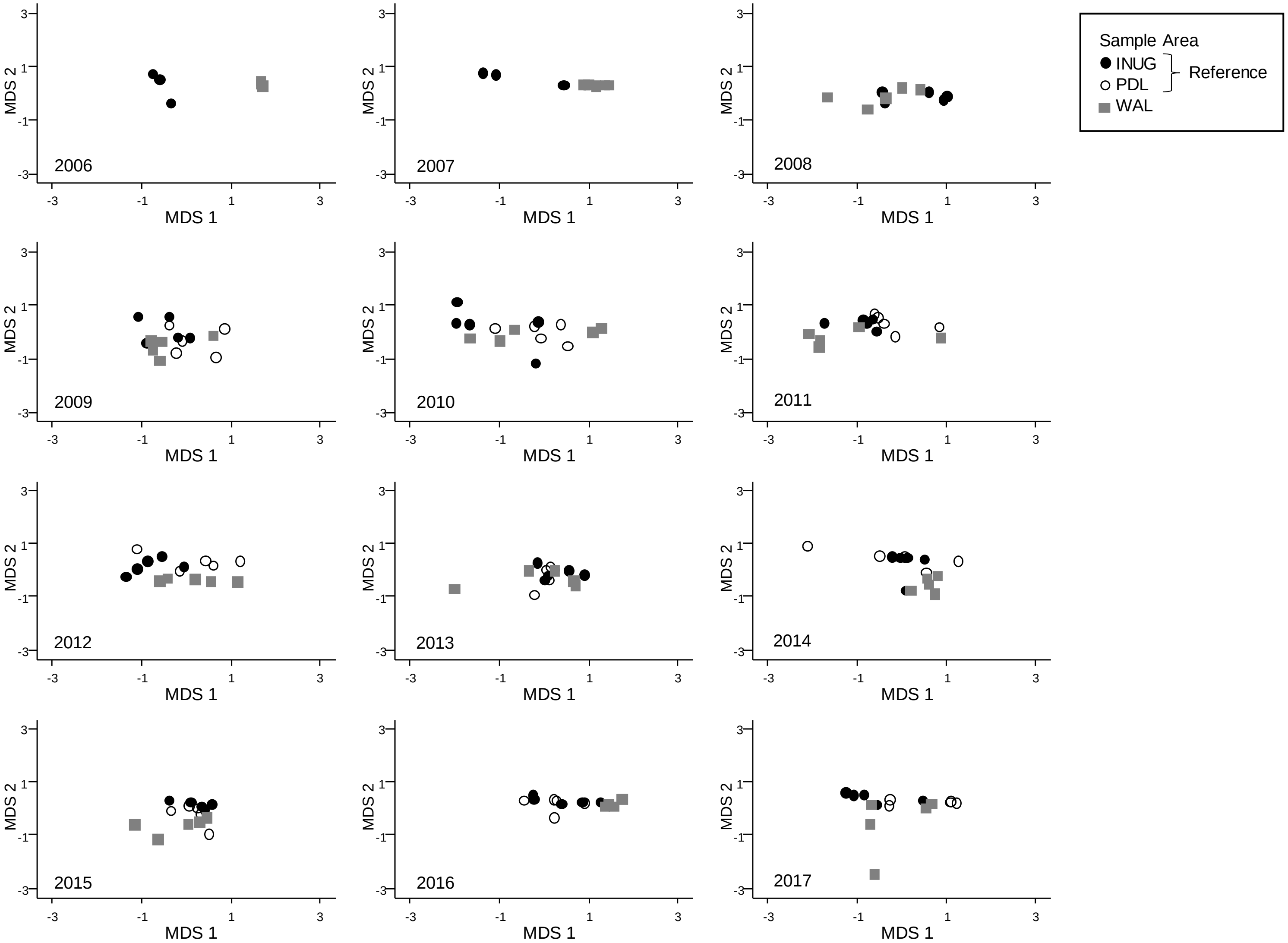


Figure 23. Scatterplots of NMDS axis scores for benthos community samples from INUG, PDL and WAL by year.

4.3.2.2 Controlling Variation in Benthic Indices

Backward, stepwise multiple regression was used to identify variables that explained variation indices of benthic community composition in INUG, PDL and in WAL (baseline period). The results of the stepwise regressions are provided in Table 34 (ANOVA table) and Table 35 (reference models) below. Total organic carbon and geometric mean particle size explained significant amounts of variation in all of the core indices of benthic community composition, in addition to diversity. The coefficients in Table 35 can be used to infer the nature of the association between indices and predictors. Total organic carbon had a positive coefficient (slope) for total abundances, family richness and NMDS axis 1 scores, indicating that the response variables increased in relation to TOC. TOC had a 'negative' association with equitability, diversity and NMDS axis 2 scores. Particle size had larger (and negative) coefficients for abundances and NMDS axis 2 scores, indicating that those indices decreased when sediment particle size increased.

Table 34. ANOVA table for multiple regression models developed for each of the core indices of benthic community composition, in addition to NMDS axes

Index of Composition	Source	Type III SS	df	Mean Squares	F-Ratio	p-Value
			Core Variables			
Log of Abundance	Regression	3.453	2	1.727	23.23	<0.001
	Residual	9.885	133	0.074		
Log of Family Richness	Regression	0.064	1	0.064	5.81	0.017
	Residual	1.476	134	0.011		
Equitability	Regression	0.192	1	0.192	11.21	0.001
	Residual	2.297	134	0.017		
NMDS Axis 1	Regression	1.128	1	1.128	1.51	0.221
	Residual	100.08	134	0.747		
NMDS Axis 2	Regression	0.946	2	0.473	2.88	0.060
	Residual	21.83	133	0.164		
			Supporting Variable			
Diversity	Regression	0.101	1	0.101	13.97	<0.001
	Residual	2.298	318	0.007		

Table 35. Multiple regression model parameter estimates and percent of variation explained for each of the core indices of benthic community composition, in addition to NMDS axes

Index of Composition	Model Parameter Estimates				
	Constant	Log of Depth	Log of TOC	Log of Geo Mean	Model R^2
Core Variables					
Log of Abundance	1.73		0.349	-0.741	0.26
Log of Family Richness	0.688		0.095	0.03	0.04
Equitability	0.538		-0.164	0.04	0.08
NMDS Axis 1	-0.303		0.398	0.07	0.01
NMDS Axis 2	-0.861		-0.272	-0.677	0.04
Supporting Variable					
Diversity	0.711	0.357	-0.046	0.273	0.16

4.3.2.3 Hypothesis Tests

This analysis focuses on the assessment of temporal variations in residuals of the core indices of benthic community composition. The resulting ANOVA table is provided below (Table 36), with computed effect sizes for each core index. Scatterplots of variations in 'residuals' of core indices of composition are illustrated in the figures below. In addition to illustrating the individual residuals, the graphs also illustrate the normal range of variation for residuals based on the range observed for the reference data (i.e., data from INUG, PDL and the baseline period for WAL).

HO1 tested for differences in indices between reference (INUG) and exposure (WAL) from before effluent discharge occurred in WAL (1996 to 2012) to after the start of effluent discharge into WAL (2013 to 2017). HO1 was not significant for any of the five core indices. These observed variations were all 'small' relative to Environment Canada's (2012) critical effect size of 2 SD, all being < 1.5 SD (Table 36).

HO2 tested for no changes from before exposure (2010 to 2012) to during exposure (2013 to 2017) between exposure (WAL) and reference lake (INUG, PDL) benthos. HO2 was significant for all indices except richness (Table 36). Scatterplots of residuals (and effect sizes) show that abundances increased, equitability decreased, scores on NMDS axis 1 increased and scores on NMDS axis 2 decreased more than expected during the exposure period in WAL, relative to what occurred in INUG and PDL.

HO3 tested for a difference in time trends during the exposure period (2013 to 2017) between exposure (WAL) and reference (INUG, PDL) lakes. HO3 was significant for residuals of abundance, and scores on NMDS axes 1 and 2 (Table 36). The scatterplots of residuals and computed effect sizes show that abundances tended to increase more in WAL than INUG and PDL during the exposure period (Figure 24). NMDS axis 1 scores also tended to get higher during the exposure period reflecting a general increase in relative abundances of several taxa, but particularly chironomids (Figure 27). Scores on NMDS axis 2 tended to decrease more in WAL during the exposure period than in INGU and PDL, reflecting an increasing abundance of ostracods (Figure 28). The effect size for abundance was 3.0 SD's suggesting a large variation.

HO4 tested for a change in the difference between exposure (WAL) and reference (INUG and PDL) from early in the exposure period (2013 to 2016) to the last/current year (2017). That hypothesized effect was significant for abundance, equitability, and scores on NMDS axes 1 and 2 (Table 36). Abundances tended to increase more in 2017 in WAL than was predicted by the reference lake data (Figure 24). Equitability, and scores on NDMS axes 1 and 2 tended to decrease more in 2017 relative to the reference lakes. All effect sizes related to HO4 were < 2 SD, indicating small variations.

HO5 tested for a difference in mean index values (residuals) between reference (INUG, PDL) and exposure (WAL) in 2017, using only the 2017 data (Table 37). There were statistically significant differences between reference and exposure in residuals of log of abundance (higher in WAL), family richness (lower in WAL), equitability (lower in WAL), and NMDS axis 1 scores (lower in WAL). Of those significant differences, only the difference in residuals of log abundance differed by > 2 SD's from the average of the reference data. The observed effect size for residuals of abundance, were 3.0 SD for the comparison of WAL to INUG and 4.3 SD's for the comparison of WAL to PDL. All of the other indices (residuals) produced differences between WAL and the average of the two reference lakes that were < 2 SD's.

The ANOVAs are one way to examine the variations in core indices. Normal ranges of reference data (station-level observations) provide another means of examining the significance of variations. Abundances have historically been between about 500 and 2000 individuals per m^2 in INUG and PDL. Abundances in WAL have generally been higher than that, ranging between about 500 and 10000 individuals per m^2, but abundances in 2016 were upwards of 30,000 individuals per m^2, which is considerably higher than what has been observed historically. The average of residuals of abundance in WAL in 2017 was within the range of values for reference-period data (see Figure 19). The ranges in family richness, and equitability in WAL in 2017 were within normal ranges of reference data (Figure 25 and Figure 26). Scores on NMDS Axis 1 in WAL in 2017 all fell within normal ranges for reference data (Figure 27). Average scores on NMDS Axis 2 in WAL in 2017 fell within normal ranges, but one sample fell outside the limits of normal ranges, indicating high abundances of ostracods (Figure 28).

Table 36. Results of analysis of variance (ANOVA) for the four specified hypotheses, for core indices of benthic community composition.

Index of Composition	Test	*SS*	*df*	*MSE*	*F* ratio	*P* value	Effect Size (SD's)
Log of Abundance Residuals	Omnibus	150.5	32	4.703	7.26	<0.001	
	HO1	0.576	1	0.576	0.89	0.348	0.43
	HO2	4.222	1	4.222	6.51	0.012	1.42
	HO3	11.52	1	11.52	17.78	<0.001	3.05
	HO4	25.72	1	25.72	39.68	<0.001	1.28
	Error	82.96	128	0.648			
Log of Richness Residuals	Omnibus	62.76	32	1.961	2.67	<0.001	
	HO1	0.009	1	0.009	0.01	0.912	-0.08
	HO2	0.251	1	0.251	0.34	0.560	-0.20
	HO3	0.008	1	0.008	0.01	0.919	-0.85
	HO4	1.019	1	1.019	1.39	0.241	-1.01
	Error	93.97	128	0.734			
Family Equitability Residuals	Omnibus	69.12	32	2.16	2.62	<0.001	
	HO1	3.149	1	3.149	3.83	0.053	0.60
	HO2	12.79	1	12.79	15.54	<0.001	-0.46
	HO3	1.392	1	1.392	1.69	0.196	-0.01
	HO4	8.033	1	8.033	9.76	0.002	-0.82
	Error	105.35	128	0.823			
NMDS Axis 1 Residuals	Omnibus	81.98	32	2.562	3.78	<0.001	
	HO1	1.369	1	1.369	2.02	0.158	-0.64
	HO2	34.40	1	34.40	50.81	<0.001	0.28
	HO3	5.65	1	5.65	8.35	0.005	0.50
	HO4	12.92	1	12.92	19.08	<0.001	-0.49
	Error	86.66	128	0.677			
NMDS Axis 2 Residuals	Omnibus	91.06	32	2.846	2.74	<0.001	
	HO1	2.13	1	2.13	2.05	0.154	-0.51
	HO2	7.285	1	7.285	7.02	0.009	0.63
	HO3	0.457	1	0.457	0.44	0.508	-2.11
	HO4	4.382	1	4.382	4.22	0.042	-1.54
	Error	132.9	128	1.038			

Table Notes: shading indicates contrasts that were significant and had effect sizes > 2 SD’s

Table 37. Results of analysis of variance (ANOVA) for the four specified hypotheses, for core indices of benthic community composition. 2017 data only.

Index of Composition	Test	*SS*	*df*	*MS*	*F* ratio	*P* value	Area	LS mean	Diff	ES
Log of Abundance Residuals	Omnibus	16.65	2	8.325	24.15	<0.001	Ref	-0.48		
	HO5	15.20	1	15.20	44.1	<0.001	Exp	1.66	2.14	3.64
	Error	4.137	12	0.345						
Log of Richness Residuals	Omnibus	4.144	2	2.072	4.87	0.028	Ref	0.38		
	HO5	4.134	1	4.134	9.71	0.009	Exp	-0.74	-1.11	1.71
	Error	5.107	12	0.426						
Family Equitability Residuals	Omnibus	2.437	2	1.218	4.31	0.039	Ref	-0.20		
	HO5	17.78	1	17.78	5.09	0.044	Exp	-0.60	-0.40	0.75
	Error	3.394	12	0.283						
NMDS Axis 1 Residuals	Omnibus	5.226	2	2.613	3.73	0.055	Ref	-0.04		
	HO5	0.123	1	0.123	0.18	0.683	Exp	-0.23	-0.19	0.23
	Error	8.408	12	0.701						
NMDS Axis 2 Residuals	Omnibus	17.94	2	8.971	2.57	0.118	Ref	0.65		
	HO5	17.78	1	17.78	5.09	0.044	Exp	-1.66	-2.31	1.24
	Error	41.97	12	3.497						

Table Notes: ES = effect size, expressed as standard deviations (based on square root of the MSE); shading indicates contrasts that were significant and with effect sizes > 2 SD's

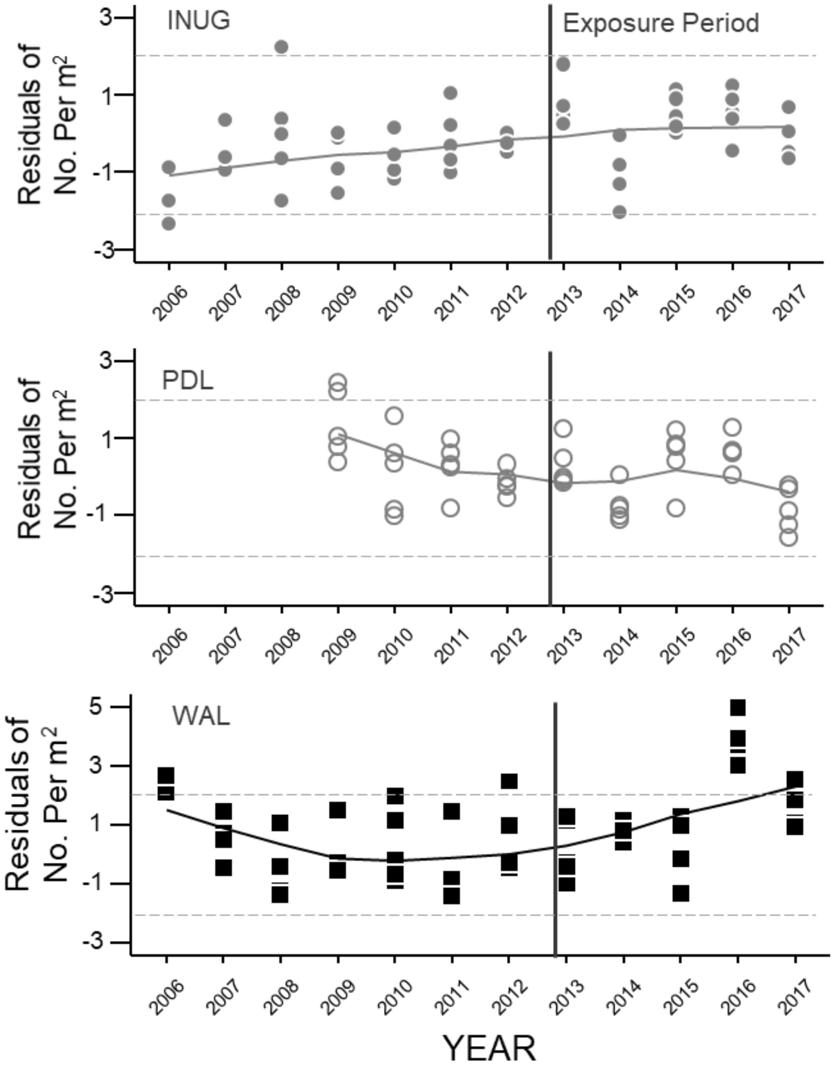


Figure 24. Residuals of total abundance, among years for INUG, PDL and WAL.

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

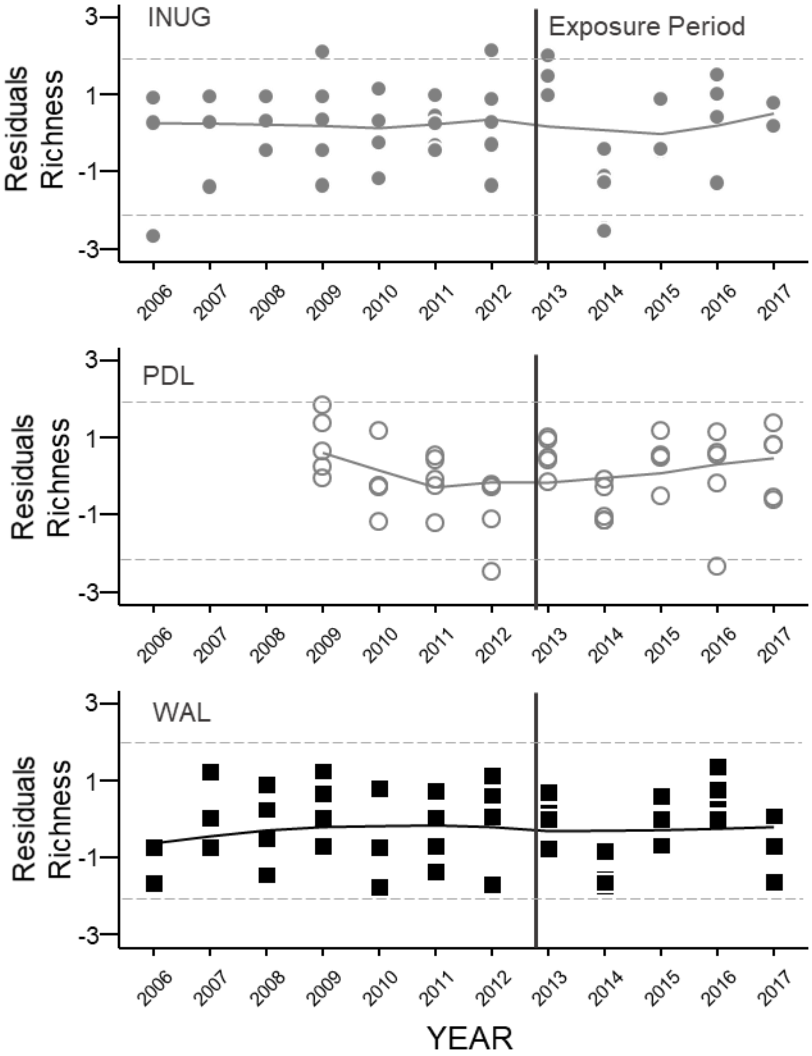


Figure 25. Residuals of family richness, among years for INUG, PDL and WAL

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

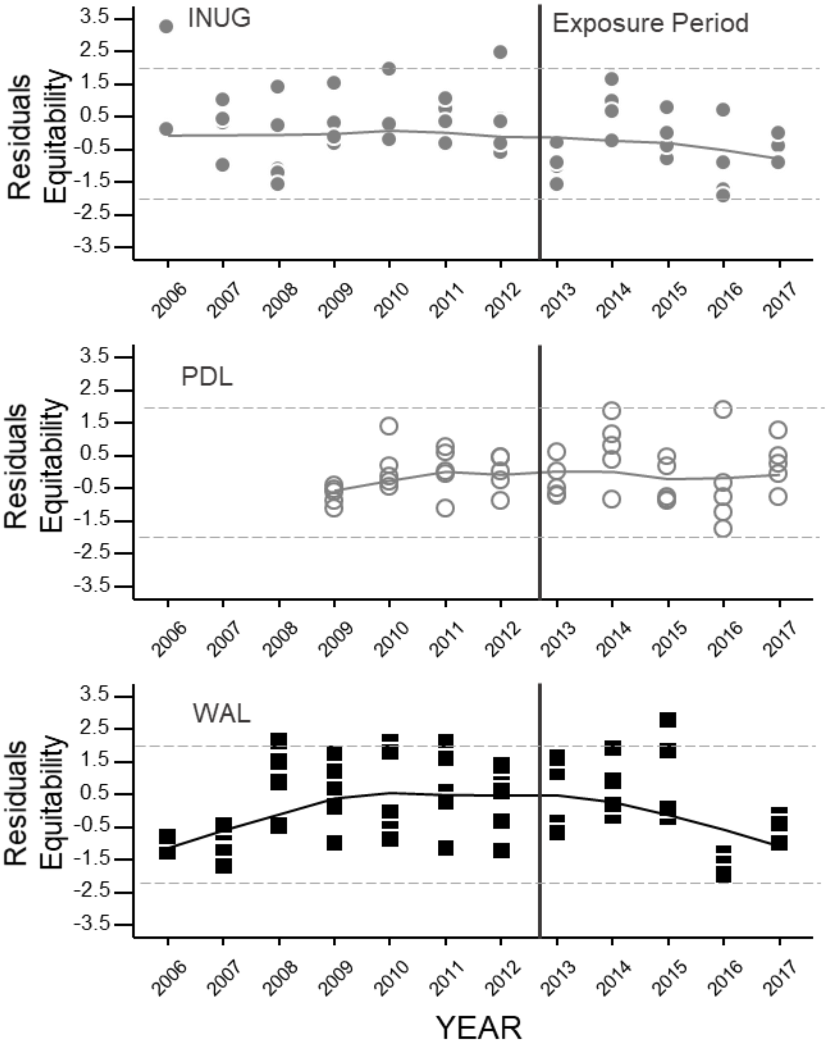


Figure 26. Residuals of equitability, among years for INUG, PDL and WAL

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

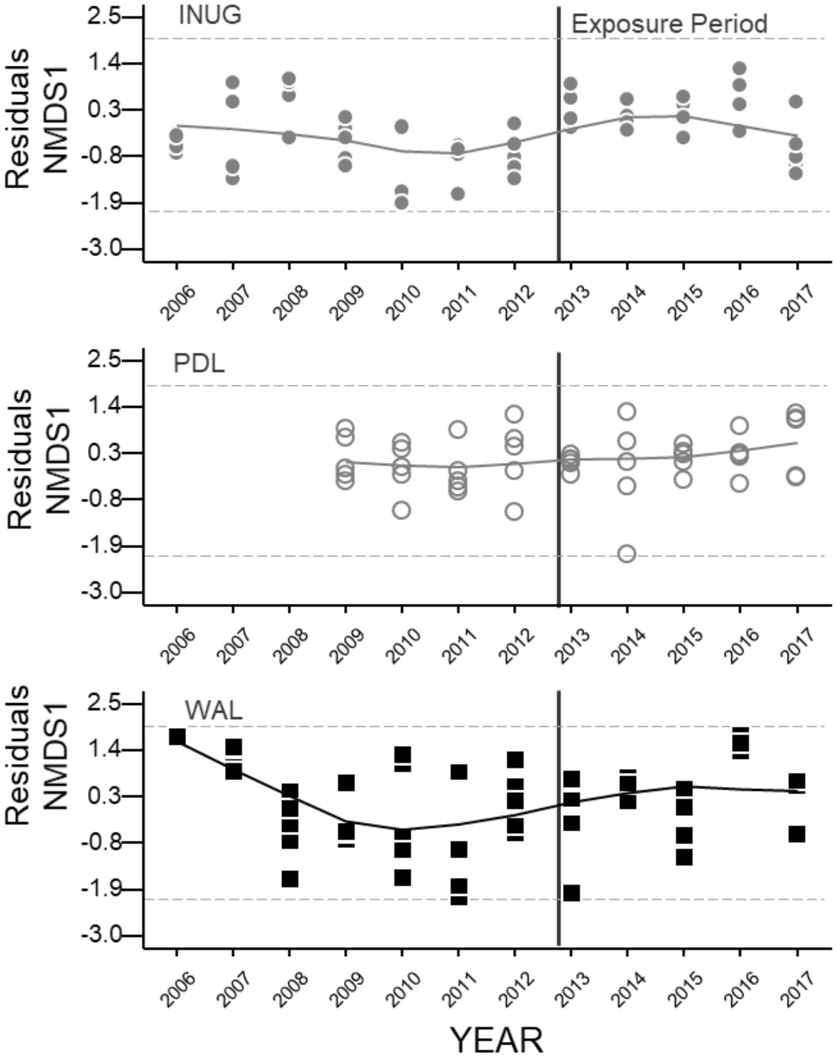


Figure 27. Residuals of NMDS Axis 1 Scores, among years for INUG, PDL and WAL

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

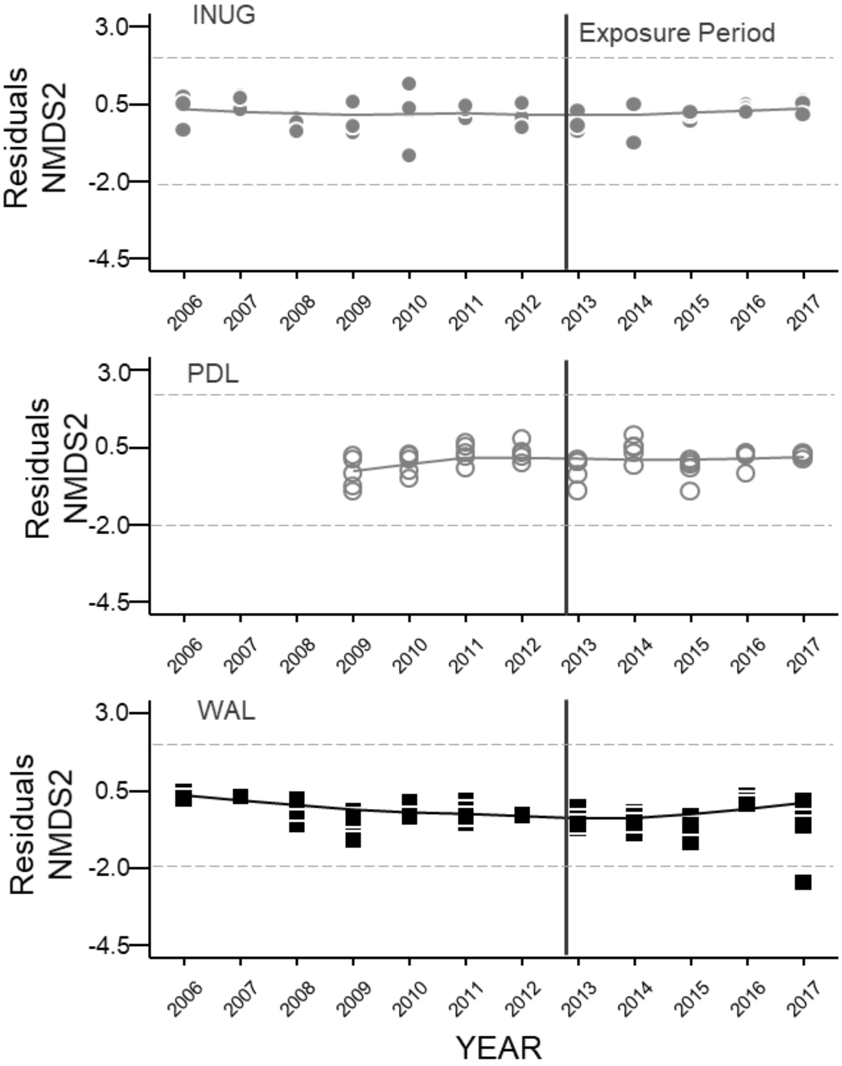


Figure 28. Residuals of NMDS Axis 2 Scores, among years for INUG, PDL and WAL

Figure Note: the line illustrates LOWESS-smoothed variations in annual averages.

4.3.2.4 Precision

Estimated sample sizes required to obtain a precision of 0.2 (station values estimated to within ± 20% of their true values) are provided in Table 38 below. Precision estimates vary depending on the mean, with smaller means generally requiring a larger number of samples to get the estimates within 20% of the mean value. That said, abundance and family richness can be estimated to within 20% of the observed true means in WAL, PDL and INUG with single Ponar grabs. Having two grabs from those lakes will produce estimates for those variables that are even more precise than required.

Equitability is a core variable, and in INUG and PDL, 2 Ponar grabs was sufficient to produce estimates within 20% of the true values. Equitability values were lower in WAL than the other lakes, such that the analysis suggested that four Ponar grabs would be necessary to estimate equitability to within 20% of the true values in Wally Lake.

Table 38. Sample sizes required to produce estimates of core and supporting indices of benthic invertebrate community composition that are within ±20% of the true values at a 'station' level

Core or Supporting	Variable	Lake	S	S^2	$\bar{x}$	Sample Size	
						$\hat{n}$	Rounded Up
Core	Log Abundance	INUG	0.23	0.053	1.59	0.53	1
		PDL	0.23	0.053	1.32	0.77	1
		WAL	0.23	0.053	2.02	0.33	1
	Log Richness	INUG	0.08	0.007	0.67	0.37	1
		PDL	0.08	0.007	0.67	0.38	1
		WAL	0.08	0.007	0.69	0.35	1
	Equitability	INUG	0.12	0.014	0.47	1.65	2
		PDL	0.12	0.014	0.58	1.08	1
		WAL	0.12	0.014	0.33	3.26	4
Supporting	Diversity	INUG	0.14	0.020	0.51	1.88	2
		PDL	0.14	0.020	0.60	1.37	2
		WAL	0.14	0.020	0.36	3.68	4

Table Notes: S = standard deviation; S^2 = variance; $\bar{x}$ = station mean; $\hat{n}$=estimated number of samples required.

4.4 Discussion

The benthic community of WAL, in 2017, largely consisted of chironomids and sphaeriid fingernail clams, similar to what the community consisted of in all other surveys, including those from the baseline period 2006 to 2012. In terms of family compositions, the community of WAL was, further, very similar to what has been described from INUG and from PDL. The benthos of WAL is therefore consistent with what is observed in reference lakes in the area, or for reference periods for WAL. Sediments in WAL have a higher organic carbon content than in either of the reference lakes. Sediments in WAL have around 5 to 13% TOC, whereas INUG and PDL have around 2 to 6% TOC. Some of the observed variations in core indices of composition were related to variations in substrate total organic carbon and grain size, and sample depth. Testing for spatio-temporal variations, therefore, was carried out on residuals of the core indices, after taking into account the variations related to underlying physical variables.

The results of the tests on residuals are summarized in Table 39. When only the 2017 data were compared (H05) there was a significant difference between Reference (INUG, PDL) and Exposure (WAL) for the residuals of abundance and richness, but the effect sizes only exceeded 2 standard deviations for abundance. Abundances in WAL were high relative to INUG and PDL however even before the discharge of effluent into WAL. When all of the years of data were included (H01), which is arguably the most robust analysis, there was no significant difference between WAL and the average of INUG and PDL for any of the indices of composition. Residuals were significantly different between WAL and the average of INUG and PDL for equitability and both NMDS axes for H02 which included only the three most recent pre-exposure years (2010-2012), but the associated effect sizes were small (< 2SD). The time trend for the period 2013-2017 differed between WAL and the average of INUG and PDL for abundance (with ES>2 SD), and for NMDS1 (ES < 2 SD). For H04, which examined the step change in 2017 between

Reference and Exposure, there were significant differences in the residuals of abundance, equitability and NMDS Axis 1, but again the difference were less than 2 SD.

Generally, and despite some of the statistically significant variations observed, the composition of benthic community of WAL was very similar to what is observed in the reference lakes, and in WAL during baseline periods, and further contained fauna indicative of high water quality. WAL benthos contained 10 genera of chironomid in 2017, similar to what had been observed in the other lakes. Further, the dominant chironomids in WAL were similar to what were also dominant in the other lakes (i.e. *Cladotanytarsus*, *Constempellina* and *Sergentia*). Less-abundant chironomids in WAL indicated oligotrophic conditions (e.g., *Monodiamesa*). There were no oligochaete worms in the benthos of WAL in 2017, a group that typically increases in numbers when conditions degrade. The benthos of WAL also contained the caddisfly *Grensia*, which has been historically observed (in low relative abundances), and a species that is generally restricted to the cold, clear waters of the far north (Harris and Lawrence, 1978). In summary, the benthic community in WAL does not indicate degraded conditions.

The surface waters in each of the three sampling areas has relatively low hardness with concentrations of metals and nutrients that are well below CCME water quality guidelines, and near detection limits. There was some elevation of cations (Ca, Mg, K) in WAL, reflecting the higher hardness in WAL which is associated with effluent treatment, but the changes were trivial relative to the concentrations that would be required in order to elicit a toxicity response (Mount *et al*., 1997).

Overall, the benthic community of WAL did not indicate a degraded condition relative to the baseline period in WAL, and contained an assemblage of organisms that are typical for these Arctic systems.

4.4.1 Recommendations for Next Cycle

Agnico-Eagle will continue to carry out the same benthos survey annually as part of its commitment to the government of Nunavut. In the event that Agnico is required to undertake another EEM benthos sampling program at Wally Lake, it is recommended that Agnico repeat the survey that has just been completed and described in this report, and that is part of their routine sampling program for CREMP.

Table 39. Summary of results of analysis of variance (ANOVA) for the five hypotheses tested for core indices of benthic community composition

Hypothesis	Description	Index of Composition	*P* value	Effect Size
HO1	Change from Baseline (2006 to 2012) to Exposure (2013 to 2017) Periods in Difference between Reference (INUG) and Exposure (WAL)	Log of Abundance Residuals	0.348	0.43
		Log of Richness Residuals	0.912	-0.08
		Family Equitability Residuals	0.053	0.6
		NMDS Axis 1 Residuals	0.158	-0.64
		NMDS Axis 2 Residuals	0.154	-0.51
HO2	Change from Baseline (2010 to 2012) to Exposure (2013 to 2017) Periods in Difference between Reference (INUG, PDL) and Exposure (WAL)	Log of Abundance Residuals	0.012	1.42
		Log of Richness Residuals	0.56	-0.2
		Family Equitability Residuals	<0.001	-0.46
		NMDS Axis 1 Residuals	<0.001	0.28
		NMDS Axis 2 Residuals	0.009	0.63
HO3	Different Time Trend in Exposure Period (2013 to 2017) between Reference (INUG, PDL) and Exposure (WAL)	Log of Abundance Residuals	<0.001	3.05
		Log of Richness Residuals	0.919	-0.85
		Family Equitability Residuals	0.196	-0.01
		NMDS Axis 1 Residuals	0.005	0.5
		NMDS Axis 2 Residuals	0.508	-2.11
HO4	Step change in 2017 in Difference between Reference (INUG, PDL) and Exposure (WAL)	Log of Abundance Residuals	<0.001	1.28
		Log of Richness Residuals	0.241	-1.01
		Family Equitability Residuals	0.002	-0.82
		NMDS Axis 1 Residuals	<0.001	-0.49
		NMDS Axis 2 Residuals	0.042	-1.54
HO5	Difference in 2017 between Reference (INUG, PDL) and Exposure (WAL)	Log of Abundance Residuals	<0.001	3.64
		Log of Richness Residuals	0.009	1.71
		Family Equitability Residuals	0.044	0.75
		NMDS Axis 1 Residuals	0.683	0.23
		NMDS Axis 2 Residuals	0.044	1.24

Table Notes: shading indicates contrasts that were significant and with effect sizes > 2 SD’s

5.0 FISH TISSUE SURVEY

Mines are required to carry out a study of mercury concentrations in fish tissue if mercury has been detected at concentrations ≥0.10 µg/L in effluent (Environment Canada, 2012). Agnico Eagle Mines Ltd. has monitored mercury concentrations in the Meadowbank Division effluent since August 2009. Concentrations have remained below or near the detection limit of 0.01 µg/L. There was, therefore, no requirement to conduct a fish tissue survey during Cycle 3.

6.0 SUBLETHAL TOXICITY TESTING

6.1 Introduction

Sub-lethal toxicity testing must be carried out two times per year for the first three years and once a year after the third year of the MMER EEM program on effluent discharged from regulated facilities. A summary of the results of the toxicological tests carried out on Meadowbank Mine effluent are presented here.

6.2 Materials and Methods

Laboratory testing of Meadowbank Mine final effluent was undertaken using four different tests: Fathead Minnow (*Pimephales promelas*) 7-Day Survival and Growth Test (EPS 1/RM/22, 2nd ed., Environment Canada, 2011), *Ceriodaphnia dubia* Survival and Reproduction Test (EPS 1/RM/21, Environment Canada, 2007a), the *Pseudokirchneriella subcapitata* 72-hour Growth Inhibition Test (EPS 1/RM/25, Environment Canada, 2007b), and the growth inhibition test with *Lemna minor* (EPS 1/RM/37, Environment Canada, 2007c). All four test protocols were run on final effluent samples at times of normal mine operation.

6.3 Results

Two samples of final effluent were submitted in each year during Cycle 3 for the suite of four sublethal tests as outlined above.

Final effluent was not lethal to Fathead Minnows in five of six laboratory tests conducted between 2015 and 2017. A small number of mortalities were observed in testing conducted on an effluent sample collected in July, 2015 and an LC50 of 86.1% effluent was estimated. Fathead growth inhibition was observed in two tests conducted in 2016. IC25 estimates for these tests were 58.3% and 64%.

There was no mortality among any of the organisms exposed in tests conducted with *Ceriodaphnia dubia* during Cycle 3, however measurable reproductive inhibition was observed in two samples tested and IC25 estimates for these were 86.1% and 59.3%.

No inhibitory effects were observed for either of the plant species, *Pseudokirchneriella subcapitata* or *Lemna minor,* exposed to any of the effluent samples during Cycle 3.

Table 40. Sublethal toxicity data for 2015, 2016 and 2017.

Sample Collection Date	Test Species and Endpoint						
	Pimephales promelas		*Ceriodaphnia dubia*		*Pseudokirchneriella subcapitata*	*Lemna minor*	
	LC50	Growth IC25	LC50	Reproduction IC25	Growth IC25	Frond growth (dry wt.) IC25	Frond No. IC25
21-07-2015	>100%	<100%	>100%	86.12%	>90.9%	>97%	>97%
24-08-2015	>100%	<100%	>100%	100%	>90.9%	>97%	>97%
18-07-2016	82%	58.3%	>100%	>100%	>90.9%	>97%	97%
22-08-2016	>100%	64%	>100%	>100%	>90.9%	>97%	97%
07-08-2017	>100%	>100%	>100%	59.3%	>90.9%	>97%	>97%
11-09-2017	>100%	>100%	>100%	>100%	>90.9%	>97%	>97%

Table Notes: Values represent percent effluent required to cause the effect; LC50 = concentration causing 50% mortality; IC25 = concentration causing 25% reduction in the sub-lethal endpoint, either growth, reproduction, frond number or frond weight.

6.4 Discussion

Cycle 3 effluent samples generally produced little or no effect on survival of exposed Fathead Minnows. Measurable growth impairment in Fathead Minnows was observed in two of the samples provided, with IC25 estimates of 58.3% and 64%. Tests measured no effect on survival of *Ceriodaphnia dubia* while two tests resulted in IC25 estimates of 86.1% and 59.3%. Final effluent samples did not impair growth in any of the *Pseudokirchneriella subcapitata* or *Lenna minor* tests during Cycle 3.

The EEM guidance document suggests that mines estimate the potential extent of the 25% effects zone in the receiving environment where the IC25 is less than 30% effluent concentration. No estimates were made because no test exceeded the 30% IC25 toxicity threshold. It should be noted that test results for which the IC25 was less than 30% that were reported in the Cycle 3 study design (C. Portt and Associates and Kilgour & Associates, 2017) were incorrect due to a transcription error.

7.0 SUMMARY AND CONCLUSIONS

Lake Trout was the sentinel fish species used in the 2017 Cycle 3 EEM survey; other species are not present in sufficient numbers. Lake Trout from the Exposure area in Wally Lake (WAL) were compared to Lake Trout from two reference lakes – Innuguguayalik Lake (INUG) and Pipedream Lake (PDL) in late August of 2017. The lethal study examined weight adjusted for length, liver weight adjusted for weight and length, weight at age and length at age, as well as size distribution and age distribution. Only a portion of the mature Lake Trout spawn in any given year, so reproductive endpoints could not be examined. There were no significant differences ($P \leq 0.05$) in the slopes for any of the relationships examined using ANCOVA. There were no significant differences in the length or age distributions between lakes either. In other words, no effects were observed on Lake Trout in Wally Lake.

This 2017 survey of benthic invertebrates compared the exposure area in Wally Lake (WAL), with INUG and PDL as local reference areas. This is the third invertebrate community survey for the Meadowbank Mine under the MMER, but the first undertaken in WAL (under MMER) because discharge to the previous exposure area (Third Portage North Lake) has ceased. Benthos have been sampled from WAL and INUG since 2006, while PDL has been sampled since 2009 as part of the mines Comprehensive Environmental Monitoring Program (CREMP). The Cycle 3 EEM benthic invertebrate survey employed the same sampling methods as the CREMP program so that a before-after-control-impact (BACI) design could be used. Benthic invertebrates were collected on August 24 (PDL), 25 (INUG) and 26 (WAL), 2017. Effects assessment involved use of baseline period data dating back to 2006, and testing of before-after-control-impact (BACI) and trend over time variations. There were significant spatio-temporal variations in total abundances, equitability, and scores on NMD axes 1 and 2. Those variations tended to be small relative to the normal range of variation of reference data including data from the two referenced lakes (INUG, PDL) and from the baseline period for WAL.

Cycle 3 effluent samples generally produced little or no effect on survival of exposed fathead minnows. Measurable growth impairment in fathead minnows was observed in two of the samples provided, with IC25 estimates of 58.3% and 64%. Tests measured no effect on survival of *Ceriodaphnia dubia* while two tests resulted in IC25 estimates of 86.1% and 59.3%. Final effluent samples did not impair growth in any of the *Pseudokirchneriella subcapitata* or *Lenna minor* tests during Cycle 3.

This Cycle 3 EEM study was the first EEM study for which Wally Lake was the exposure area. The next EEM cycle should, therefore, be completed within 36 months of this submission. The Meadowbank mine has not discharged reclaim water to date and does not intend to discharge any reclaim water in the future. As stated previously, the Meadowbank Mine has two (2) active effluents. Contact water from the Vault Attenuation Pond is discharged to Wally Lake via outfall MMER 2, and non-contact water originating from the seepage at the East Dike is discharged into Second Portage Lake via outfall MMER 3. Neither of these discharges has required water treatment to date. 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 and, therefore, was the focus of this Cycle 3 EEM field study. Agnico will continue to monitor the volume and quality of the mine effluents. These data will be used to determine the effluent that will be the focus of the Cycle 4 EEM field study.

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Appendix 1 Correspondence with Environment Canada

Environment and Climate Change Canada
Environnement et Changement climatique Canada

Prairie & Northern Region
Environmental Protection Operations Directorate
9250 – 49th Street NW
Edmonton, AB T6B 1K5

April 10, 2017

File: 7834-3-37/A350-2

Marie-Pier Marcil via email to: marie-pier.marcil@agnicoeagle.com
Agnico Eagle Mines Ltd. Meadowbank Division
10 200, route de preissac
Rouyn-Noranda, Québec, Canada
J0Y 1C0

Dear Mme Marcil:

Subject: ***Metal Mining Phase 3 Biological Study Design Report Meadowbank Mine***

This letter is to advise you that Environment and Climate Change Canada has reviewed your Environmental Effects Monitoring (EEM) biological study design report entitled, "Environmental Effects Monitoring: Agnico Eagle Mines Ltd. – Meadowbank Division Cycle 3 Study Design". The review of the study design report takes into account information requirements in the *Metal Mining Effluent Regulations (MMER)* of the *Fisheries Act* , and offers comments on the design based on the EEM Technical Guidance Document and on generally accepted standards of good scientific practice.

The compiled comments are attached.

Please send to my attention a final schedule relating to the biological monitoring at least two weeks prior to the commencement of field activities.

Although not required by the *MMER*, submitting an electronic version of documents in addition to paper copies would help the Department in managing all the received regulatory information. Please send the electronic copies to Susanne.Forbrich@canada.ca..

Environment and Climate Change Canada looks forward to receiving your interpretive report no later than July 1, 2018. Should you have any questions or concerns regarding the EEM program, or should you wish to discuss any major changes to the study design, please do not hesitate to contact Paula Siwik at 780-951-8824 or at paula.siwik@canada.ca..

Sincerely,

for
Susanne Forbrich
Regional Director
Regional Authorization Officer

cc:

Cristina Ruiu	Environment and Climate Change Canada, Regina
Paula Siwik	Environment and Climate Change Canada, Edmonton
Craig Broome	Environment and Climate Change Canada, Yellowknife
Karen Kharatyan	Nunavut Water Board, Gjoa Haven
Amanda Winegardner	Indigenous and Northern Affairs Canada, Iqaluit

Attachments : Technical Advisory Panel Review of "Agnico Eagle Mines Ltd – Meadowbank Division Cycle 3 Study Design"

Technical Advisory Panel Review of "Agnico Eagle Mines Ltd – Meadowbank Division Cycle 3 Study Design"

The following comments and recommendations are based on the review of the report by a Technical Advisory Panel (TAP) consisting of representatives from Environment and Climate Change Canada (ECCC), Nunavut Water Board (NWB) and Indigenous and Northern Affairs Canada (INAC).

1. As required under the *Metal Mining Effluent Regulations*, your biological monitoring studies must be conducted in accordance with your study design. If it is impossible to follow the study design because of unusual circumstances, then you may deviate from the study design but you must inform the Regional Authorization Officer without delay of those circumstances and how the study will be conducted.

2. P. 26 and 51: It appears that the detection for Cd sampled in water has been lowered and will more closely align with license detection limit of 0.000010 mg/L in 2017. The TAP supports this approach.

3. P. 38: Wally Lake is considered an exposure area as of 2013. Are there data collected prior to 2013 that could be used for baseline purposes?

4. P. 38: Fish from Vault and Phaser Lakes were transferred to Wally Lake in 2014 and 2016, and AEM recognizes that this is confounding factor in assessing fish endpoints in Wally Lake. While the change in fish community as a result of the transfer will likely confound the current study, its influence on future studies remains to be seen. There is no further discussion in the Cycle 3 Study Design as to how to deal with this issue for the present cycle or in future cycles. Are there studies from other sites that could give an indication of how long it may take the population of Wally Lake to regain a steady ecological state? Are there population estimates of the fish community or species specific age class estimates from Wally prior to the fish transfer for comparison?

5. P. 38: Please note, the proposed design of 20 lethal lake trout is supported provided that power analyses continue to indicate that it is suitable.

6. P. 40: Cycle 1 and Cycle 2 studies both encountered higher than expected fish mortality. The Cycle 3 study design has indicated that fish sampling will not include sampling of pectoral fin rays for non-lethally sampled fish, in order to prevent after- sampling mortality due to the procedure. Fish mortality from Cycle 1 and Cycle 2 is reported as the result of gill-netting. The TAP suggests that CPUE data from previous phases be reviewed to determine whether timing and/or duration of net deployment can be adjusted to minimize by-catch.

7. P. 40: Please clarify whether the supporting *in situ* variables will be collected at each net deployment location or at one location in the lake. The TAP suggests that *in situ* information be recorded at each net deployment location.

8. P. 46: The 2006 and 2007 total abundance number for Wally appear to be different from the pattern in subsequent years. Did this correspond with a change in collection location or depth?

9. P. 48: Are there within station precision estimates for Wally Lake? A visual comparison of abundance and richness suggests that there is more variation in the samples collected from Wally contrasted to Third Portage. Will 2 subsamples adequately characterize a station?

AGNICO EAGLE

April 26th, 2017

Susanne Forbrich
A/ MMER Authorization Officer
Prairie and Northern Region
Environment Canada
9250, 49 St. NW
Edmonton, AB
T6B 1K5

<u>Re: Environmental Effects Monitoring (EEM): Cycle 3 Meadowbank Mine Study Design</u>

Dear Ms. Susanne Forbrich,

On April 10th, 2017, Agnico Eagle received TAP comments regarding study design entitled "Agnico Eagle Mines Ltd. – Meadowbank Division Cycle 3 Study Design" submitted on February 17th, 2017. You will find, attached with this letter, responses to these comments.

Should you require any further information or questions please contact the below via email or by telephone.

Regards,

Erika Voyer
Environment General Supervisor Nunavut
Erika.Voyer@agnicoeagle.com
819-759-3555 ext.6980

Robin Allard
Senior Environmental Coordinator
Robin.Allard@agnicoeagle.com
819-759-3555 ext. 6744

CC: Paula Siwik, ECCC
Cam Portt, C. Portt and Associates
Jamie Quesnel, Agnico Eagle Nunavut

1. **As required under the Metal Mining Effluent Regulations, your biological monitoring studies must be conducted in accordance with your study design. If it is impossible to follow the study design because of unusual circumstances, then you may deviate from the study design but you must inform the Regional Authorization Officer without delay of those circumstances and how the study will be conducted.**

   <u>Agnico Eagle's response:</u>
   Agnico Eagle take note of TAP comments and will advise without any delay the Regional Authorization Officer if the study design, because of unusual circumstances, will deviate from the original approved study design.

2. **P. 26 and 51: It appears that the detection for Cd sampled in water has been lowered and will more closely align with license detection limit of 0.000010 mg/L in 2017. The TAP supports this approach.**

   <u>Agnico Eagle's response:</u>
   Agnico Eagle acknowledges TAP comments.

3. **P. 38: Wally Lake is considered an exposure area as of 2013. Are there data collected prior to 2013 that could be used for baseline purposes?**

   <u>Agnico Eagle's response:</u>
   There are no fish data for Wally Lake prior to 2013 that can be used for baseline purposes.

4. **P. 38: Fish from Vault and Phaser Lakes were transferred to Wally Lake in 2014 and 2016, and AEM recognizes that this is confounding factor in assessing fish endpoints in Wally Lake. While the change in fish community as a result of the transfer will likely confound the current study, its influence on future studies remains to be seen. There is no further discussion in the Cycle 3 Study Design as to how to deal with this issue for the present cycle or in future cycles. Are there studies from other sites that could give an indication of how long it may take the population of Wally Lake to regain a steady ecological state? Are there population estimates of the fish community or species specific age class estimates from Wally prior to the fish transfer for comparison?**

   <u>Agnico Eagle's response:</u>
   To the best of our knowledge there are no studies from other sites at similar latitudes that could provide an indication of how long it may take the population of Wally Lake to return to a steady ecological state. There are no population estimated or species-specific age class estimates from Wally Lake prior to the fish transfers.

5. **P. 38: Please note, the proposed design of 20 lethal lake trout is supported provided that power analyses continue to indicate that it is suitable.**

   Agnico Eagle's response:
   Agnico Eagle acknowledges TAP comments.

6. **P. 40: Cycle 1 and Cycle 2 studies both encountered higher than expected fish mortality. The Cycle 3 study design has indicated that fish sampling will not include sampling of pectoral fin rays for non-lethally sampled fish, in order to prevent after-sampling mortality due to the procedure. Fish mortality from Cycle 1 and Cycle 2 is reported as the result of gill-netting. The TAP suggests that CPUE data from previous phases be reviewed to determine whether timing and/or duration of net deployment can be adjusted to minimize by-catch.**

   Agnico Eagle's response:
   Agnico Eagle proposed not to remove pectoral fin rays from fish that are not lethally sampled due to the limited utility of those data, the discomfort that the removal imposes on the fish, and the possible post-release complications (which could include mortality). Agnico Eagle will use the data from previous cycles to determine the appropriate amount of netting effort to collect the desired 20 fish per area, in order to minimize by-catch.

7. **P. 40: Please clarify whether the supporting in situ variables will be collected at each net deployment location or at one location in the lake. The TAP suggests that in situ information be recorded at each net deployment location.**

   Agnico Eagle's response:
   The lakes that will be sampled are not thermally stratified in the summer and, based on the CREMP data, there is no indication that there is significant spatial variation in dissolved oxygen, temperature or pH. There was spatial variation in specific conductance in Wally Lake while effluent was being discharged in 2016. Agnico Eagle proposes to measure temperature and specific conductance at each of net deployment location in Wally Lake and will therefore do the same at each net deployment location in the other lakes.

8. **P. 46: The 2006 and 2007 total abundance number for Wally appears to be different from the pattern in subsequent years. Did this correspond with a change in collection location or depth?**

   Agnico Eagle's response:
   Sample depths did vary across years in Wally Lake suggesting modest movement in sample locations. Samples in 2006 and 2007 were collected from 5 to 6 m of water

depth, whereas in subsequent years samples were collected from typically 7 to 9 m of water depth (see Figure 5-1 in the Study Design). The observation by ECCC is noted. Agnico will need to consider 2006 and 2007 when we carry out the analysis of changes over time. We will determine if we can adjust data to depth so that we can retain 2006 and 2007 in the analysis, or perhaps leave 2006 and 2007 out of the analysis.

9. **P. 48: Are there within station precision estimates for Wally Lake? A visual comparison of abundance and richness suggests that there is more variation in the samples collected from Wally contrasted to Third Portage. Will 2 subsamples adequately characterize a station?**

Agnico Eagle's response:
There are no within-station samples from Wally Lake. The observation by ECCC is noted. In order to assess whether the observation is correct, we looked at within-year variability using abundance data for Wally (WAL), Inuggugayualik (INUG) and Pipedream Lake (PDL). For log of numbers per m^2*, the within-year residual variance was estimated by the mean-squared error (MSE) term from an analysis of variances among years. The MSE's were 0.0802 for Wally, 0.0439 for INUG and 0.0304 for PDL. An F ratio of largest over smallest variances (WAL/INUG) was 0.0802/0.0439 = 1.83, which with 38 and 38 degrees of freedom was significant at* $p = 0.03$*. Within-year variances of abundance have therefore been significantly higher in Wally Lake than in both INUG and PDL, per Environment Canada's observation. Within-station variance could be reduced by additional sampling, but among station variance would not be reduced by the collection of additional within-station grabs. The differences in variability between lakes will persist. Agnico and its consultants will ensure that sampling within Wally Lake is carried out to minimize variability related to depth in the upcoming 2017 survey. Agnico and its consultants will also examine the influence of water depth on variability in EEM endpoints, and remove the effects of depth on endpoint variance, prior to testing effects-related hypotheses.*

AGNICO EAGLE

August 11, 2017

Susanne Forbrich
Prairie and Northern Region
Environment Canada
9250, 49 St. NW
Edmonton, AB
T6B 1K5

Re: Metal Mining Phase 3 Biological Study Design Report Meadowbank Mine

Dear Ms. Forbrich,

Following your letter dated April 10, 2017 *Metal Mining Phase 3 Biological Study Design Report Meadowbank Mine*, Agnico Eagle Ltd. Meadowbank Mine is providing the final schedule for the EEM Cycle 3. The field work will be conduct as per the study design approved by Environment Canada and the TAP, and will be conducted from August 23 to August 30.

Should you have any questions, please do not hesitate to contact me.

Regards,

Mhaly

Mhaly Bois-Charlebois
Environmental Compliance Counselor
mhaly.charlebois@agnicoeagle.com
819.759.3700 x 5479

CC: Paula Siwik, ECCC
Cam Portt, C. Portt and Associates
Jamie Quesnel, Agnico Eagle Nunavut
Erika Voyer, Agnico Eagle Nunavut

Appendix 2 Gill Net Set and Catch Data

Appendix 2. Gill net set data and catch. Fish captured alive were released at the point of capture.

waterbody	net set ID	start latitude/ longitude	start depth	end depth	end latitude/ longitude	set date Aug. 2017	Set time	lift date Aug. 2017	Lift time	soak time (hours)	Lake Trout dead	Lake Trout alive	Arctic Char dead	Arctic Char alive	Round Whitefish dead	Round Whitefish alive
Wally Lake (WAL)	1	65° 04' 53.2" -95° 57' 51.4"	3.6	7.5	65° 04' 54.9" -95° 57' 41.9"	23	17:35	24	9:00	15.42	14	0	5	0	13	3
	2	65° 04' 55.1" -95° 57' 47.9"	7	3	65° 04' 56.6" -95° 57' 36.8"	24	9:15	24	15:45	6.5	2	1	0	1	0	1
	3	65° 04' 49.4" -95° 57' 43.7"	4.5	6	65° 04' 52.4" -95° 57' 51.2"	26	8:30	26	17:35	9.08	6	0	0	0	0	1
Pipedream Lake (PDL)	1	65° 06' 36.5" -96° 12' 16.0"	5	4	65° 06' 39.4" -96° 12' 09.0"	24	17:00	25	8:54	15.9	17	4	0	3	0	0
	2	65° 06' 47.5" -96° 12' 39.8"	2	8	65° 06' 51.4" -96° 12' 34.1"	24	17:30	25	8:18	14.8	10	0	0	0	0	0
Innugu-guayalik Lake (INUG)	1	65° 03' 19.5" -96° 23' 54.2"	8	1.5	65° 03' 15.0" -96° 23' 50.0"	25	15:00	26	8:45	17.75	12	0	0	0	0	1
	2	65° 03' 14.5" -96° 23' 55.3"	1.5	8	65° 03' 18.8" -96° 23' 59.5"	26	9:30	27	13:30	28	9	1	0	0	4	3

Appendix 3 Individual Fish Data

Water body	Fish ID	Net ID	fork length (mm)	weight (g)	otolith age (years)	fin ray age (years)	liver wt.(g)	gonad wt. (g)	sex	maturity	gonad condition	# of encysted cestodes	stomach contents
WAL	1	1	827	5887.5	47	35+	39.57	145	M	M	R	0	empty
WAL	2	1	669	3102	31	31+	25.96	80.33	M	M	R	0	empty
WAL	3	1	839	5350.9	38	34+	49.52	68.64	F	M	RST	0	empty
WAL	4	1	774	5322	43	36+	36.85	126.23	M	M	R	0	empty
WAL	5	1	764	5421.6	30	30+	69.71	499.4	F	M	R	0	whitefish
WAL	6	1	772	5623.9	25	25+	43.64	192.72	M	M	R	0	empty
WAL	7	1	650	3234.7	44	NA	20.21	105.4	M	M	R	0	empty
WAL	8	1	448	920.9	15	15+	6.09	0.33	F	I		0	whitefish
WAL	9	1	405	755.6	13	15+	5.49	20.11	M	M	R	0	empty
WAL	10	1	342	444.4	8	9+	4.47	1.62	F	I		0	zooplankton
WAL	11	1	295	245.7	6	6+	1.89	0.08	U	I		0	empty
WAL	12	1	268	216.8	6	6+	1.99	0.31	F	I		0	empty
WAL	13	1	259	161.9	7	7+	1.56	0.18	F	I		3	empty
WAL	14	1	207	87.7	5	5+	0.98	0.13	F	I		5	Diptera
WAL	15	2	837	6315.7	31	32+	38.99	160.36	M	M	R	0	empty
WAL	16	2	654	3281.3	34	NA	34.05	101.44	M	M	R	3	tag 0244 and skeleton - lake trout relocated from Phaser Lake in 2016
WAL	56	3	800	5626.1	48	41+	34.89	102.87	M	M	R	0	empty
WAL	57	3	560	1802.1	23	23+	15.8	43.68	M	M	R	7	empty
WAL	58	3	476	1002	15	15+	7.39	7.63	F	I		0	empty
WAL	59	3	536	1320.3	17	15+	9.15	8.07	F	I		3	empty
WAL	60	3	386	592.6	12	12+	5.4	4.11	F	I		4	zooplankton, Diptera
WAL	61	3	317	318.3	8	8+	2.78	0.48	F	I		1	2 sculpin, Diptera
PDL	17	2	905	10160	44	35+	118.11	271.2	F	M	RST	0	empty

Water body	Fish ID	Net ID	fork length (mm)	weight (g)	otolith age (years)	fin ray age (years)	liver wt.(g)	gonad wt. (g)	sex	maturity	gonad condition	# of encysted cestodes	stomach contents
PDL	18	2	824	6243.1	32	32+	46.88	145.75	M	M	RST	0	empty
PDL	19	2	566	2180.9	20	25+	19.47	53.08	M	M	RST	2	1 small fish
PDL	20	2	710	3879.6	35	31+	35.36	68.37	M	M	RST	1	empty
PDL	21	2	608	2394.6	31	30+	21.07	29.33	F	M	RST	1	packed with inverts
PDL	22	2	553	1773.4	17	16+	22.7	176.12	F	M	G	0	empty
PDL	23	2	486	1285.4	19	18+	12.4	9.04	F	I		0	full of inverts
PDL	24	2	556	1951.1	24	22+	23.17	33.7	F	I		0	empty
PDL	25	2	480	1656.4	15	15+	10.12	24.61	M	M	RST	0	empty
PDL	26	2	272	184.1	8	8+	1.42	0.11	U	I		6	empty
PDL	27	1	1010	13410	44	36+	257.7	2359.8	F	M	G	0	empty
PDL	28	1	583	2382.1	28	28+	15.95	4.75	M	I		3	inverts
PDL	29	1	426	840.7	14	13+	10.96	2.7	F	I		9	1 unidentified fish
PDL	30	1	540	1893.8	22	24+	17.14	55.71	M	M	G	0	empty
PDL	31	1	561	1911.8	18	18+	16.02	30.95	M	M	RST	0	empty
PDL	32	1	700	3564.9	29	28+	31.34	55.05	F	M	RST	2	empty
PDL	33	1	680	3297.7	28	25+	23.75	95.2	M	M	G	0	empty
PDL	34	1	468	1025.2	16	16+	7.05	0.87	F	I		11	empty
PDL	35	1	377	495.1	11	11+	4.78	0.99	F	I		0	empty
PDL	36	1	347	417.2	10	9+	4.01	0.95	F	I		21	empty
PDL	37	1	301	263.9	9	7+	2.69	0.17	U	I		10	inverts
PDL	38	1	246	145.2	8	7+	0.98	0.04	U	I		5	empty
PDL	39	1	277	195.6	8	8+	1.56	0.36	F	I		40	zooplankton, insects
PDL	40	1	257	178.5	8	8+	1.44	0.12	U	I		20	empty

Water body	Fish ID	Net ID	fork length (mm)	weight (g)	otolith age (years)	fin ray age (years)	liver wt.(g)	gonad wt. (g)	sex	maturity	gonad condition	# of encysted cestodes	stomach contents
PDL	41	1	208	88.8	5	5+	0.96	0.04	U	I		11	empty
PDL	42	1	218	90	6	6++	0.82	0.03	U	I		8	empty
PDL	43	1	136	27.8	2	3+	0.22		U	I		0	empty
Innug	44	1	550	1577.9	18	17+	16.3	20.15	F	I		4	empty
Innug	45	1	516	1325	18	18+	10.76	17.31	F	I		0	small fish and insects
Innug	46	1	502	1350	15	15+	12.63	45.93	M	M	R	6	insect larvae
Innug	47	1	570	2101.1	17	17+	22.79	2.61	M	I		0	insect larvae
Innug	48	1	535	1523.1	17	17+	13.95	12.35	F	I		7	empty
Innug	49	1	466	1141.8	16	16+	10.98	24	M	M	G	40	empty
Innug	50	1	421	1242.5	23	22+	9.39	2.95	F	I		23	small fish and insects
Innug	51	1	478	1124.8	13	12+	10.28	25.3	M	M	G	31	small fish and insects
Innug	52	1	254	165.6	6	6+	1.6	0.29	F	I		0	fish
Innug	53	1	222	145.2	7	7+	1.37	0.12	M	I		6	insect larvae
Innug	54	1	235	138.5	7	6+	1.01	0.02	U	I		6	small fish and inverts
Innug	55	1	130	21.4	2	2+	0.27		U	I		7	empty
Innug	62	2	806	5196.9	33	32+	117.57	656.3	F	M	R	0	empty
Innug	63	2	691	3565.4	32	31+	22.62	87.25	M	M	R	0	empty
Innug	64	2	661	2981.9	31	30+	26.08	38.98	F	I		2	whitefish 180 mm and insects
Innug	65	2	544	1515.3	24	23+	15.19	2.42	M	I		14	insect larvae
Innug	66	2	502	1194	25	21+	11.16	27.97	F	I		20	empty
Innug	67	2	486	1066.3	17	15+	13.34	7.63	F	I		40	empty
Innug	68	2	482	944	19	18+	6.51	0.62	M	I		17	empty
Innug	69	2	250	157.3	8	6+	1.11	0.2	F	I		5	small fish and insects

Water body	Fish ID	Net ID	fork length (mm)	weight (g)	otolith age (years)	fin ray age (years)	liver wt.(g)	gonad wt. (g)	sex	maturity	gonad condition	# of encysted cestodes	stomach contents
Innug	70	2	237	130.4	4	5+	1.19	0.23	F	I		6	small fish and insects

Appendix 4 Water Chemistry Quality Assurance

Table 4-1. Field duplicates, equipment blanks, and travel blanks for the 2017 CREMP water quality program.

		Duplicates				**Blanks**	
		Second Portage Lake				**AUG DI-1**	**AUG EB-1**
Analyte		**SP-107**	**AUG DUP-2**	**RPD**		**28-Aug-17**	**28-Aug-17**
Physical Tests							
Conductivity (µS/cm)		35.1	33.1	5.9		*<2.0*	*<2.0*
Hardness (mg/L)		14.30	14.3	0.0		*<0.50*	*<0.50*
pH (Laboratory)		7.23	7.17	0.8		5.19	5.27
Total Suspended Solids (mg/L)		*<1.0*	*<1.0*			*<1.0*	*<1.0*
Total Dissolved Solids (mg/L)		25.7	25.0	2.8		*<3.0*	*<3.0*
Turbidity (NTU)		0.34	0.26	27		*<0.10*	*<0.10*
Anions and Nutrients (mg/L)							
Alkalinity, Bicarbonate (as CaCO$_3$)		10	10	0.0		*<1.0*	*<1.0*
Alkalinity, Carbonate (as CaCO$_3$)		*<1.0*	*<1.0*			*<1.0*	*<1.0*
Alkalinity, Hydroxide (as CaCO3)		*<1.0*	*<1.0*			*<1.0*	*<1.0*
Alkalinity, Total (as CaCO$_3$)		10	10	0.0		*<1.0*	*<1.0*
Ammonia, Total (as N)		*<0.0050*	*<0.0050*			*<0.0050*	*<0.0050*
Bromide (Br)		*<0.050*	*<0.050*			*<0.050*	*<0.050*
Chloride (Cl)		0.84	0.84	0		*<0.10*	*<0.10*
Fluoride (F)		0.065	0.064	1.6		*<0.020*	*<0.020*
Nitrate (as N)		*<0.0050*	*<0.0050*			*<0.0050*	*<0.0050*
Nitrite (as N)		*<0.0010*	*<0.0010*			*<0.0010*	*<0.0010*
Total Kjeldahl Nitrogen		0.11	0.08	31		*<0.050*	*<0.050*
Orthophosphate-Dissolved (as P)		*<0.0010*	*<0.0010*			*<0.0010*	*<0.0010*
Phosphorus (P)-Total Dissolved		*<0.0020*	*<0.0020*			*<0.0020*	*<0.0020*
Phosphorus (P)-Total		*<0.020*	*<0.0020*			*<0.0020*	*<0.0020*
Silicate (as SiO$_2$)		*<0.50*	*<0.50*			*<0.50*	*<0.50*
Sulfate (SO$_4$)		4.90	4.91	-0.2		*<0.30*	*<0.30*
Cyanides (mg/L)							
Total Cyanide		*<0.0010*	*<0.0010*			*<0.0010*	*<0.0010*
Free Cyanide		*<0.0010*	*<0.0010*			*<0.0010*	*<0.0010*
Organic/Inorganic Carbon (mg/L)							
Dissolved Organic Carbon		1.76	1.93	-9.2		*<0.50*	*<0.50*
Total Organic Carbon		1.89	1.97	-4.1		*<0.50*	*<0.50*
Plant Pigments (µg/L)							
Chlorophyll-a		0.535	0.426	22.7		-	-
Total Metals (mg/L)							
Aluminum		0.0065	0.0064	2		*<0.0030*	*<0.0030*
Antimony		*<0.00010*	*<0.00010*			*<0.00010*	*<0.00010*
Arsenic		0.00034	0.00032	6		*<0.00010*	*<0.00010*
Barium		0.00271	0.00265	2.2		*<0.000050*	0.000095
Beryllium		*<0.000020*	*<0.000020*			*<0.000020*	*<0.000020*
Bismuth		*<0.000050*	*<0.000050*			*<0.000050*	*<0.000050*
Boron		*<0.010*	*<0.010*			*<0.010*	*<0.010*
Cadmium		*<0.0000050*	*<0.0000050*			*<0.0000050*	*<0.0000050*
Calcium		3.78	3.82	-1.1		*<0.050*	*<0.050*
Chromium		*<0.00010*	*<0.00010*			*<0.00010*	*<0.00010*
Cobalt		*<0.00010*	*<0.00010*			*<0.00010*	*<0.00010*
Copper		0.00061	0.00071	-15.2		*<0.00050*	*<0.00050*
Iron		0.021	0.02	4.9		*<0.010*	*<0.010*
Lead		*<0.000050*	*<0.000050*			*<0.000050*	0.000231
Lithium		*<0.0010*	*<0.0010*			*<0.0010*	*<0.0010*
Magnesium		1.22	1.20	1.7		*<0.10*	*<0.10*
Manganese		0.00206	0.00208	-1.0		*<0.00010*	*<0.00010*
Mercury		*<0.0000050*	*<0.0000050*			*<0.0000050*	*<0.0000050*
Molybdenum		0.000201	0.000187	7.2		*<0.000050*	*<0.000050*
Nickel		*<0.00050*	*<0.00050*			*<0.00050*	*<0.00050*

		Duplicates				**Blanks**	
		Second Portage Lake				**AUG DI-1**	**AUG EB-1**
Analyte		**SP-107**	**AUG DUP-2**	**RPD**		**28-Aug-17**	**28-Aug-17**
Phosphorus		*<0.050*	*<0.050*			*<0.050*	*<0.050*
Potassium		0.55	0.56	-2		*<0.10*	*<0.10*
Selenium		*<0.000050*	*<0.000050*			*<0.000050*	*<0.000050*
Silicon		0.170	0.170	0.0		*<0.10*	*<0.10*
Silver		*<0.000010*	*<0.000010*			*<0.000010*	*<0.000010*
Sodium		0.93	0.92	1.3		*<0.050*	*<0.050*
Strontium		0.0173	0.0173	0.0		*<0.00020*	*<0.00020*
Sulfur		1.79	1.93	-7.5		*<0.50*	*<0.50*
Thallium		*<0.000010*	*<0.000010*			*<0.000010*	*<0.000010*
Tin		*<0.00010*	*<0.00010*			*<0.00010*	*<0.00010*
Titanium		*<0.00030*	*<0.00030*			*<0.00030*	*<0.00030*
Uranium		0.000047	0.000043	9		*<0.000010*	*<0.000010*
Vanadium		*<0.00050*	*<0.00050*			*<0.00050*	*<0.00050*
Zinc		*<0.0030*	*<0.0030*			*<0.0030*	*<0.0030*

Appendix 5 Benthic Community Data

Appendix 5. Benthic community data. August 09 to 27, 2017.

Station	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
ROUNDWORMS										
P. Nemata (exclude from N and R)	1	1		2	1		1	2		
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate		2					2			
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae										
S.F. Naidinae										
Nais										
S.F. Tubificinae										
Limnodrilus hoffmeisteri										
Tasserkidrilus americanus										
immatures with hair chaetae										
immatures without hair chaetae										
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus									2	
Rhyacodrilus montana										
F. Lumbriculidae										
Lumbriculus				1		1		1	1	2
Stylodrilus										
indeterminate										
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										

Station	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
F. Acalyptonotidae										
Acalyptonotus										
F. Hygrobatidae										
Hygrobates										
F. Lebertiidae										
Lebertia										
F. Oxidae										
Oxus	1		4		1					1
F. Pionidae										
indeterminate										
HARPACTICOIDS										
O. Harpacticoida										
SEED SHRIMPS										
Cl. Ostracoda (exclude from N and R)		1	1		2	1		1	2	1
FAIRY SHRIMP (TADPOLE SHRIMP)										
O. Notostraca										
Lepidurus arcticus										
INSECTS										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae										
Apatania			1							
F. Limnephilidae										
Grensia praeterita	1									
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae		**1**			**1**	**2**	**1**		**1**	**2**
S.F. Chironominae										

Station	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Cladotanytarsus										
Constempellina										
Corynocera ambigua		1						1		
Corynocera ?oliveri										
Dicrotendipes										
Micropsectra	3	1		4	3	31	28	7	8	29
Microtendipes					1	3	6		2	6
Paracladopelma										
Paratanytarsus			2	1	1	1	2	1	2	6
Polypedilum										
Sergentia										
Stempellinella										
Stictochironomus	3	4	1	3	6	8	4	1	5	12
Tanytarsus		1					4		4	9
S.F. Diamesinae										
Potthastia										
Protanypus		1				1	2			
S.F. Orthocladiinae										
Abiskomyia										2
Cricotopus/Orthocladius										
Heterotrissocladius	1	1					1			
Hydrobaenus										
Mesocricotopus										
Nanocladius										
Paracladius	1									
Parakiefferiella										
Psectrocladius										
Zalutschia	1					1	6		1	4
Orthocladiinae *Genus "Greenland"*										
S.F. Prodiamesinae										

Station	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**	**INUG**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Monodiamesa	1	2	2		2	1	2	1	1	2
S.F. Tanypodinae										
Ablabesmyia										
Procladius	5	3	5	3		1	3	1	3	3
Thienemannimyia complex										
F. Empididae										
Neoplasta										
Wiedemannia										
pupae										
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata										
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae										
Cyclocalyx/Neopisidium	5	14	12	10	11	4	10	5	12	7
Cyclocalyx						2	1	1	3	3
Sphaerium nitidum		4		1		1		1	3	3
Totals	29	44	37	35	41	71	88	39	68	111

**Bold entries excluded from taxa count*

Station	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
ROUNDWORMS										
P. Nemata (exclude from N and R)	1	2	1	2	1				1	
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	1						1			
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae										
S.F. Naidinae										
Nais										
S.F. Tubificinae										
Limnodrilus hoffmeisteri										
Tasserkidrilus americanus										
immatures with hair chaetae			2		2	1				
immatures without hair chaetae										
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus										
Rhyacodrilus montana										
F. Lumbriculidae										
Lumbriculus	2		2					1		1
Stylodrilus										
indeterminate										
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										

Station	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
F. Acalyptonotidae										
Acalyptonotus										
F. Hygrobatidae							1			
Hygrobates										
F. Lebertiidae										
Lebertia										
F. Oxidae										
Oxus										
F. Pionidae										
indeterminate										
HARPACTICOIDS	7	2	1		4	1	3	4	1	5
O. Harpacticoida										
SEED SHRIMPS										
Cl. Ostracoda (exclude from N and R)										
FAIRY SHRIMP (TADPOLE SHRIMP)										
O. Notostraca										
Lepidurus arcticus										
INSECTS										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae	1			1			1			
Apatania										
F. Limnephilidae										
Grensia praeterita										
TRUE FLIES										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae										
S.F. Chironominae										

Station	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Cladotanytarsus										
Constempellina										
Corynocera ambigua										
Corynocera ?oliveri			4	5	1	1				
Dicrotendipes										
Micropsectra										
Microtendipes				1						
Paracladopelma										
Paratanytarsus				1						
Polypedilum						2				
Sergentia	8	2	5	2		3	5		4	1
Stempellinella			3	2		1		1		
Stictochironomus										
Tanytarsus										
S.F. Diamesinae									1	
Potthastia										
Protanypus									1	1
S.F. Orthocladiinae										
Abiskomyia	1									
Cricotopus/Orthocladius										
Heterotrissocladius										
Hydrobaenus										
Mesocricotopus										
Nanocladius										
Paracladius	1		3	1	2	1	1	2	1	
Parakiefferiella										
Psectrocladius										
Zalutschia										
Orthocladiinae *Genus "Greenland"*										1
S.F. Prodiamesinae										

Station	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Monodiamesa										
S.F. Tanypodinae	6	11	6	2		4	5	6	4	2
Ablabesmyia		1								
Procladius										
Thienemannimyia complex										
F. Empididae										
Neoplasta										
Wiedemannia										
pupae										
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata										
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae	11	9	2	1	1		4	6	4	4
Cyclocalyx/Neopisidium		3	4	3			1			
Cyclocalyx										
Sphaerium nitidum										
Totals	45	37	42	31	23	27	37	36	35	34

**Bold entries excluded from taxa count*

Station	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
ROUNDWORMS										
P. Nemata (exclude from N and R)					1	1	1	1		1
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
indeterminate	1			1						
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae										
S.F. Naidinae										
Nais										
S.F. Tubificinae										
Limnodrilus hoffmeisteri										
Tasserkidrilus americanus										
immatures with hair chaetae										
immatures without hair chaetae										
S.F. Rhyacodrilinae										
Rhyacodrilus coccineus										
Rhyacodrilus montana										
F. Lumbriculidae										
Lumbriculus										
Stylodrilus										
indeterminate										
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Acarina										

Station	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
F. Acalyptonotidae										
Acalyptonotus										
F. Hygrobatidae	1					3		2	1	2
Hygrobates										
F. Lebertiidae		1			1		1		2	1
Lebertia										
F. Oxidae										
Oxus										
F. Pionidae										
indeterminate										
HARPACTICOIDS	4	5	5	1	8	4	3	8	12	18
O. Harpacticoida										
SEED SHRIMPS										
Cl. Ostracoda (exclude from N and R)										
FAIRY SHRIMP (TADPOLE SHRIMP)										
O. Notostraca										
Lepidurus arcticus										
<u>INSECTS</u>										
CADDISFLIES										
O. Trichoptera										
F. Apataniidae	1	1								
Apatania										
F. Limnephilidae										
Grensia praeterita										
<u>TRUE FLIES</u>										
O. Diptera										
MIDGES										
F. Chironomidae										
chironomid pupae			5	1	25	4	10	7	14	20
S.F. Chironominae										

Station	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Cladotanytarsus	18	15	42	2	50	16	57	33	19	83
Constempellina	3	7	24	5	60	8	47	22	4	34
Corynocera ambigua					9		2			2
Corynocera ?oliveri	7				4	8		4		10
Dicrotendipes										
Micropsectra										
Microtendipes			10		3				4	
Paracladopelma										
Paratanytarsus										
Polypedilum										
Sergentia	20	17	11	8	14	10	18	12	27	31
Stempellinella	7	7	14	1	18	4	10	7	5	15
Stictochironomus										
Tanytarsus										
S.F. Diamesinae								1		
Potthastia										
Protanypus										
S.F. Orthocladiinae										
Abiskomyia										
Cricotopus/Orthocladius										
Heterotrissocladius										
Hydrobaenus										
Mesocricotopus										
Nanocladius										
Paracladius										
Parakiefferiella										
Psectrocladius										
Zalutschia										
Orthocladiinae *Genus "Greenland"*		1		1			1			
S.F. Prodiamesinae										

Station	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**
Replicate	**1.1**	**1.2**	**2.1**	**2.2**	**3.1**	**3.2**	**4.1**	**4.2**	**5.1**	**5.2**
# Grabs/sample	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
Monodiamesa										
S.F. Tanypodinae	3	6	6		10	2	7	3	5	10
Ablabesmyia						1				
Procladius										
Thienemannimyia complex										
F. Empididae										
Neoplasta										
Wiedemannia										
pupae										
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Valvatidae										
Valvata										
CLAMS										
Cl. Bivalvia										
F. Sphaeriidae	2	5	8	1	3	1	5	4	6	17
Cyclocalyx/Neopisidium	9	9	15	2	32	7	13	3	17	18
Cyclocalyx										
Sphaerium nitidum										
Totals	82	81	149	33	250	82	190	123	134	281

**Bold entries excluded from taxa count*

Appendix 6 Benthic Community Data Quality Assurance

Table 1. Percent recovery of benthic Macroinvertebrates from samples collected from AZIMUTH CREMP (2017).

Station	Number of Organisms Recovered (initial sort)	Number of Organisms in Re-sort	Percent Recovery
BAP-1	280	305	91.8%
INUG-4.2	23	23	100.0%
PDL-2.1	32	33	97.0%
SP-2	109	109	100.0%
TPE-3	218	222	98.2%
TPN-1	132	132	100.0%
WAL-1.2	71	74	95.9%
		Average % Recovery	97.6%

QA/QC notes

Pupae were not counted toward total number of taxa unless they were the sole representative of their taxa group.

Immatures were not counted toward total number of taxa unless they were the sole representative of their taxa group.