Appendix A3

Report: *Aquatic Effects Monitoring Program – Targeted Study: Dike Construction TSS Effects Assessment Study 2011*

FINAL

Aquatic Effects Monitoring Program – Targeted Study: Dike Construction TSS Effects Assessment Study 2011

Meadowbank Mine, Nunavut

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Gary Mann (Azimuth) – Gary provided overall management for this project. Gary was co-author of this report and conducted the statistical analyses for benthic invertebrates and periphyton.

Maggie McConnell (Azimuth) –Maggie conducted data compilation, analysis, interpretation, and report writing. Maggie also provided technical support in the field.

Ryan Hill (Azimuth) – Ryan reviewed the statistical analysis appendix.

Morgan Finley (Azimuth) – Morgan was monitoring crew leader in the field.

Ryan VanEngen (AEM) – Ryan participated in this project on many levels, from helping with the study design, to collecting sediment trap samples, to providing background literature, to reviewing the report for AEM. Ryan is also conducting his M.Sc. research at the University of Guelph on the effects of sedimentation on benthic invertebrate communities and suspended sediment on lake trout feeding behavior from the data collected at Meadowbank since 2008.

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This report has been prepared by Azimuth Consulting Group (Azimuth), for the use of Agnico-Eagle Mines Ltd. (AEM), who has been party to the development of the scope of work for this project and understands its limitations. The extent to which previous investigations were relied on is detailed in the report.

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ACRONYMS

AEM – Agnico-Eagle Mines Ltd.

AEMP – Aquatic Effects Monitoring Program

ANOVA – Analysis of Variance

BACI – Before/After Control/Impact

CCME – Canadian Council of Ministers of the Environment

CPUE – Catch Per Unit Effort

DQO – Data Quality Objective

EAS – Effects Assessment Study

ED – East Dike

GPS – Global Positioning System

HVH – High value habitat

INUG – Inuggugayualik Lake

ISQG – Interim Sediment Quality Guidelines

LOI – Loss-on-Ignition analysis

MDL – Method Detection Limit

MMER – Metal Mining Effluent Regulations

PDL – Pipedream Lake

PEL – Probable Effect Level

QA/QC – Quality Assurance / Quality Control

RPD – Relative Percent Difference

SEP – Sequential Extraction Procedure

SIA – Stable isotopes analysis

SIE – Severity of Ill Effects

SOP – Standard Operating Procedure

SP – Second Portage Lake

SQG – Sediment Quality Guidelines

TE – Tehek Lake

TEFF – Tehek Lake Far Field

TKN – Total Kjeldahl Nitrogen

TPE – Third Portage Lake – East Basin

TPN – Third Portage Lake – North Basin

TPS – Third Portage Lake – South Basin

TSS – Total suspended solids

UTM – Universal Transverse Mercator

WAL – Wally Lake

WOE – Weight of Evidence

EXECUTIVE SUMMARY

The East Dike TSS EAS (2008 – 2011) targeted the effects of total suspended solids (TSS) on Second Portage Lake. The Bay-Goose TSS EAS (2009 – 2011) targeted the effects of TSS from Bay-Goose construction on the east basin of Third Portage Lake.

Collectively, the results of these studies have improved our understanding of the potential short-term and long-term effects of elevated TSS on a broad range of ecosystem components in local receiving environments. Construction-related sediment inputs were initially found (lasting weeks to months) in the water column (pelagic zone), but settled over time (sedimentation) onto the lake bottom (benthic zone). In both cases, the primary concern was TSS, but nutrients and metals were also present.

From a water column (pelagic zone) perspective, both TSS EAS studies identified some short-term effects to primary productivity (e.g., phytoplankton biomass). However, these did not appear to affect zooplankton. Laboratory studies confirmed no adverse effects to zooplankton or fish. Thus, while some effects were seen initially in the water column, they were limited in time and were not shown to propagate up the food chain.

In the benthic zone, sediment trap results showed increased sedimentation closer to the dikes. A 2009 coring study confirmed elevated metals in Second Portage Lake relative to baseline conditions. However, in 2010 sediment toxicity tests and specialized chemical analyses confirmed that sediment metals were not toxic. Initial studies on periphyton biomass in 2009 showed reductions close to the East Dike; follow-up studies in 2010 confirmed that effects were limited to the area closest to the dike. A broader study in 2011 across both lakes confirmed the initial results for periphyton. Benthic invertebrates showed an initial drop in abundance in Second Portage Lake in 2008. However, the subsequent recover pattern to 2011 has been inconsistent due to high natural variability. Results of a graduate research project conducted in Second Portage Lake corroborated these findings. For the east basin of Third Portage Lake, changes since 2009 appear to be more consistent with natural variability than with TSS exposure patterns, suggesting that no impacts occurred there.

As for fish and fish habitat, the main concerns were effects due to sedimentation on high-value habitats. These concerns were based on the sediment trap results and on a trout embryo development test that suggested possible impairment. Underwater video surveys of high-value habitats in 2009 and 2011 showed conditions improving in Second Portage Lake; minimal impacts were observed in Third Portage Lake. Habitat compensation monitoring conducted in 2009 and 2011 had higher catch-per-unit-effort (CPUE) near the East Dike than in reference areas, suggesting that fish may prefer the dike habitat.

At this stage, we have no further recommendations for additional follow-up studies and welcome discussions with regulators.

1. INTRODUCTION

1.1. Background

Agnico-Eagle Mines (AEM) Ltd.'s Meadowbank Mine is situated approximately 75 km north of the hamlet of Baker Lake, Nunavut. Construction phase for the mine started in 2008 and the operations phase started in late February 2010. An important component of mine development was the construction of major dikes across Second Portage Lake (East Dike) and the northwestern portion of the east basin of Third Portage Lake (Bay-Goose Dike) to isolate the ore-body and tailings storage facility (**Figure 1-1**).

As described in detail elsewhere (Azimuth, 2009a and 2010b), East Dike (during 2008) and Bay-Goose Dike (during 2009 – 2010) construction activities resulted in increases in total suspended solids (TSS) in Second and Third Portage Lake East basin, respectively. The status of key local receiving environments since 2008 is provided in **Table 1-1** to help better characterize spatial and temporal patterns of TSS concentrations. In response to these situations, AEM commissioned studies in 2008 (Azimuth, 2009b), 2009 (Azimuth, 2010c), and 2010 (Azimuth, 2011a) to evaluate the potential for adverse ecological effects related to acute and chronic exposure to elevated TSS concentrations (the TSS Effects Assessment Study, or TSS EAS).

The 2011 TSS EAS program was conducted by Azimuth Consulting Group (Azimuth) to address outstanding issues identified in last year's 2010 EAS report, that are summarized in Azimuth (2011a). The information provided in the summary table in **Section 4** is a compilation of results to date for a suite of field and laboratory effects measurements.

1.2. Study Outline

This study was initiated in 2008 to assess the ecological significance of elevated TSS concentrations associated with construction of the East Dike (Azimuth, 2009b). The program was expanded in 2009 to address potential effects related to Bay-Goose Dike construction (Azimuth, 2010c).

An overview of the sampling components for 2011 included:

- **Sediment Traps** – This program has been conducted since 2008 to monitor sediment deposition rates and thickness (and, where possible, sediment chemistry) at key locations relative to dike construction activities. Select traps were deployed in September 2010 and retrieved in August 2011. Traps were not redeployed as in-lake dike construction activity has been completed in Second Portage Lake and Third Portage Lake.
- **Periphyton Mat Sediment Survey** – In 2009 and 2010, potential effects to the periphyton community in Second Portage Lake construction-related (2008 East Dike construction) sediment inputs were assessed by direct measurement and underwater video. Those studies identified likely effects in close proximity to the

East Dike due to sedimentation. Further direct sampling was recommended for 2011 to assess the spatial extent of adverse effects including effects related to Bay-Goose Dike construction (in Third Portage Lake). To that end, sampling was conducted in 4 areas in Second Portage Lake and at 16 areas in Third Portage Lake. Analyses were for total dry weight of the sample and loss on ignition analysis to determine sediment content in the periphyton mat.

- **Video Surveys of HVH areas –** In 2009, underwater video surveys were conducted at high-value habitat (HVH) areas in Second Portage Lake (i.e., following dike construction) and in the east basin of Third Portage Lake (i.e., prior to any sedimentation events from dike construction). Video surveys were repeated in 2011 to determine the status of HVH areas in both lakes.
- **Benthic Invertebrates** – In the past, inferences regarding potential TSS-related effects relied on analysis of both the broader CREMP data set (i.e., providing a better temporal [since 2006] and spatial [among all lakes/basins] context) and the higher resolution EAS data set (i.e., providing better spatial resolution within Second Portage Lake or the east basin of Third Portage Lake). For 2011, analysis focused only on the CREMP data set to determine the general trends in the community in Second Portage Lake and in the east basin of Third Portage Lake. Additional monthly benthic community data (for July, August and September) was also collected in 2009 and 2010 in areas located inside the turbidity curtains along the East Dike and at the Second Portage Lake CREMP sampling area (SP) as part of academic research (unpublished data, VanEngen, 2012). The results of these data are presented in a **text box** in **Section 3.5.2**.

1.3. Report Organization

To facilitate interpretation of results across the events and to reduce redundancy, this year's EAS report is organized by study component. The remainder of this report is organized into the following sections:

- **Section 2** Methods – describes the methods used to collect data, and quality assurance/quality control measures taken.
- **Section 3** Results – presents and discusses the results for each study component.
- **Section 4** Conclusions and Recommendations – provides a summary of key results to date for the TSS EAS.

Table 1-1. Status of key receiving environments related to TSS from 2008 – 2011.

	2008				2009				
	July	Aug	Sept	Oct - Dec	Jan - Jun	July	Aug	Sept	Oct - Dec
Third Portage Lake									
North Basin (TPN)	Background	Background	Background	Presumed background	Dewatering - no apparent TSS increase	Dewatering stopped; background	TSS > 2 mg/L	TSS ~2 mg/L	Background
South Basin (TPS)	Background	Background	Background	Presumed background	Presumed background	Background	TSS ~2 mg/L	TSS ~1.5 mg/L	Background
East Basin (TPE)	Background	Background	Background	Presumed background	Background	BG Dike construction starts; background	TSS concentrations gradually increase, but mostly at depth (>2 mg/L)	Strong winds mix TSS throughout water column and basin; TSS source finished (~5 mg/L)	TSS drops over time; still above HVH trigger by end of October (~2 mg/L)
Second Portage Lake									
Main Basin (SP)	Background	ED construction starts; TSS rises dramatically in third week (>10 mg/L)	TSS drops over time; meets targets by end of month (~4 mg/L)	Presumed settlement under ice	TSS drops initially, then dewatering starts in March	Background	Some TSS input from BG dike construction, but low concentrations (1 mg/L)	TSS increases slightly, but limited spatially (~1-1.5 mg/L)	TSS drops over time (~1 mg/L)
NW Arm	Background	TSS rises in parallel to main basin, but lower concentrations than main basin	TSS reduced, but rises again during WC Dike construction	TSS drops	TSS drops initially, then increases due to dewatering	TSS elevated due to dewatering activities; dewatering stops in early July	Isolated	Isolated	Isolated
Drilltrail Arm	Background	Background	Background	Background	Background	Background	Background	Background	Background
Tehek Lake									
Near-field Basin (TE)	Background	TSS rises during third week	TSS drops over time; meets targets by end of month (~3 mg/L)	Presumed settlement under ice	Background	Background	Very slight increase in TSS	TSS slightly above background (~1.5-2 mg/L)	Background; TSS ~3 mg/L in December only
Far-field Basin (TEFF)	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Background	Background	Background	Presumed background

	2010					2011				
	Jan - Jun	July	Aug	Sept	Oct - Dec	Jan - Jun	July	Aug	Sept	Oct - Dec
Third Portage Lake										
North Basin (TPN)	Dewatering; TSS ~2 mg/L in April only	Dewatering; background	Dewatering; background	Dewatering; background	Dewatering; presumed background	Dewatering; background	Dewatering; background	Dewatering; background	Dewatering; background	Dewatering; background
South Basin (TPS)	Background; TSS ~1.5 mg/L in April only	TSS ~1 mg/L	Background	Background	Presumed background	Presumed background	Background	Background	Background	Presumed background
East Basin (TPE)	TSS increases again during causeway construction (~1-1.5 mg/L)	TSS ~1-2 mg/L	TSS ~4 mg/L	TSS >1 mg/L	Presumed settlement under ice	Background	Background	Background	Background	Background
Second Portage Lake										
Main Basin (SP)	TSS generally < 1 mg/L; 2 mg/L in Apr/May	Background	Background	TSS ~1 mg/L	Presumed settlement under ice	Background	Background	Background	Background	Background
NW Arm	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated	Isolated
Drilltrail Arm	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background	Presumed background
Tehek Lake										
Near-field Basin (TE)	TSS ~1 mg/L	TSS ~2 mg/L	Background	TSS ~3 mg/L	Presumed settlement under ice	Background	Background	Background	Background	Background
Far-field Basin (TEFF)	Presumed background	Background	Background	Background	Presumed background	Presumed background	Background	Background	Background	Presumed background

Notes: Shaded months indicate ice cover on lakes; CREMP sampling areas are shown in (), where applicable; acronyms: ED = East Dike; BG = Bay-Goose Dike; TSS = total suspended solids; DCM = dike construction monitoring; “Background” = TSS < Detection Limit.

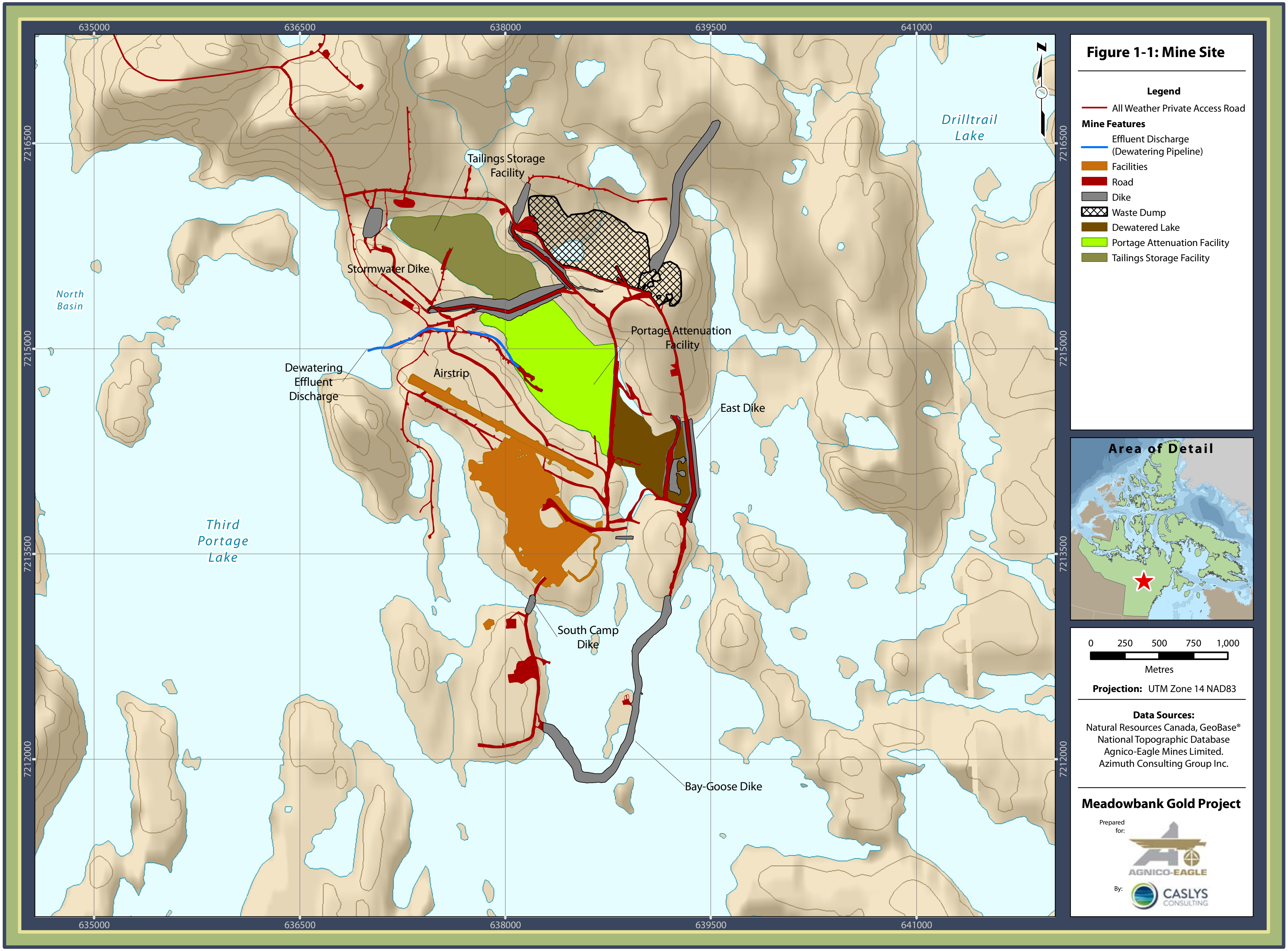


Figure 1-1: Mine Site
Legend
All Weather Private Access Road
Mine Features
Effluent Discharge (Dewatering Pipeline)
Facilities
Road
Dike
Waste Dump
Dewatered Lake
Portage Attenuation Facility
Tailings Storage Facility
Area of Detail
0 250 500 750 1,000
Metres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Meadowbank Gold Project
Prepared for:
AGNICO-EAGLE
By:
CASLYS CONSULTING
Drilltrail Lake
North Basin
Third Portage Lake
Tailings Storage Facility
Stormwater Dike
Portage Attenuation Facility
Dewatering Effluent Discharge
Airstrip
East Dike
South Camp Dike
Bay-Goose Dike
635000
636500
638000
639500
641000
7216500
7215000
7213500
7212000

2. METHODS

2.1. Sediment Traps

Sediment traps have been an integral part of dike construction monitoring and the TSS EAS since 2008. The initial network (focused on the East Dike) was expanded in 2009 to support monitoring efforts for the Bay-Goose Dike. Trap deployment throughout the year since 2008 provides us with a good understanding of spatial and temporal dynamics of sedimentation due to in-lake dike construction.

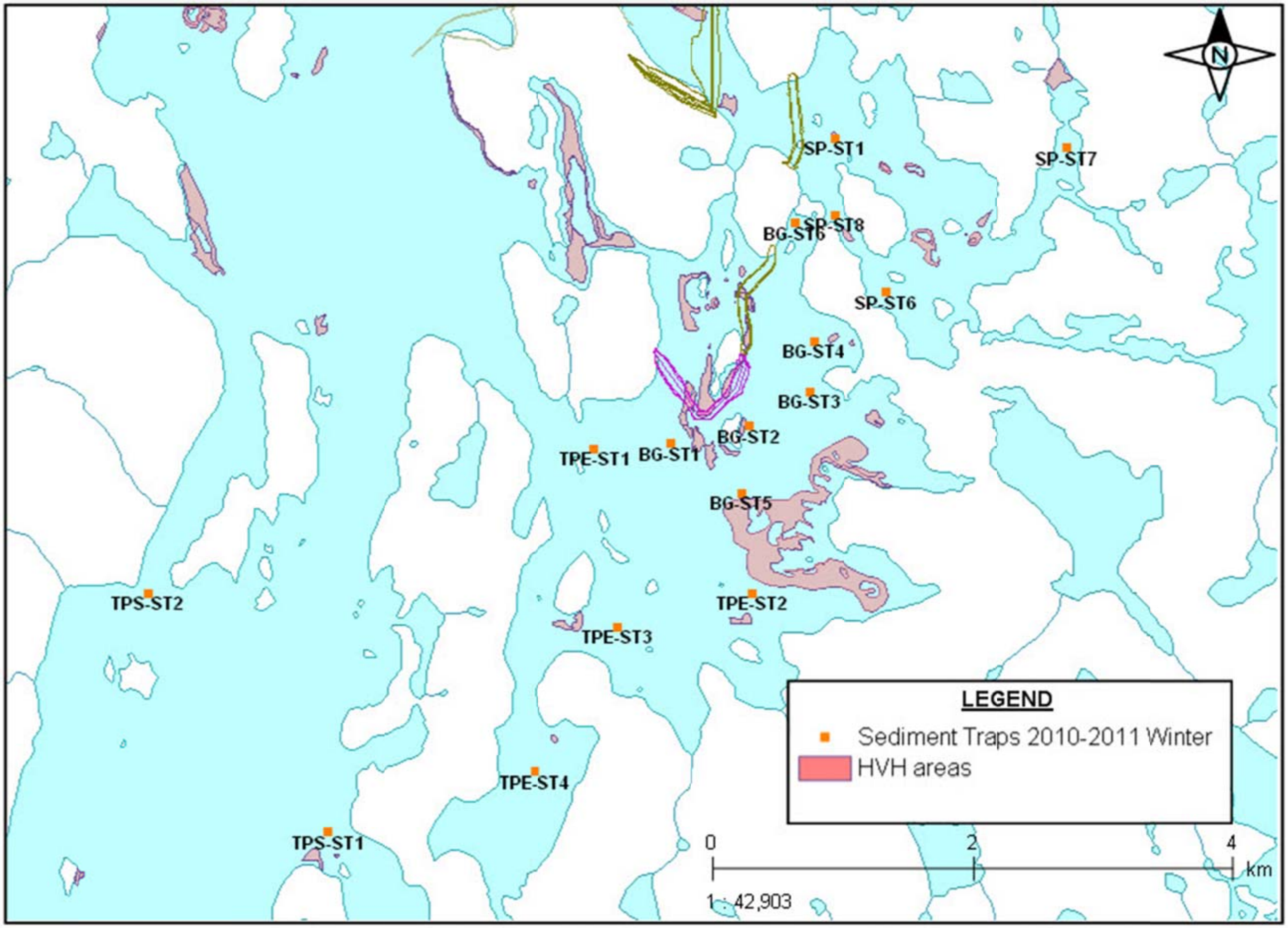
Sixteen sediment traps (each consisting of 4 replicate trap tubes) were deployed throughout the local receiving environments during Bay-Goose Dike construction activities. Traps were deployed in September 2010, retrieved in August 2011 (locations shown in **Figure 2-1**). The trap locations were primarily set near high value habitat to provide data on sediment deposition in proximity to important fish habitat. Sediment trap coordinates are presented in the results section in **Table 3-2**.

In 2009, the sediment trap frames were fully painted prior to deployment to remove any concern for rust formation. The same design was maintained in 2010 and 2011. Each installation consisted of four PVC sediment trap tubes, positioned vertically, open-end up, in a grid formation on a small metal frame. Two types of trap tubes were used in 2010/2011 with the following dimensions: (1) 7.7 cm inner diameter opening, 51.4 cm long, and (2) 10.1 cm inner diameter opening, 51.4 cm long. These differing diameters were accounted for when calculating accumulation thickness and deposition rates. Traps were deployed in the open water by looping sideline to all corners of the frame, gathering the line into a single loop and slowly lowering the trap to the lake bottom while keeping it level. Each trap was marked with a labeled surface buoy (winter traps were set up so that the buoy would be below the ice).

Sediment traps were retrieved by slowly pulling the line when the boat was directly above the buoy to keep the trap vertical. In a few cases, one of the four trap tubes was missing or was cracked and leaking when the trap was retrieved. Once removed from the lake, each trap tube was capped, removed from the frame and left to settle for at least one day. Overlying water was decanted from each trap tube until the onset of resuspension, at which point the remaining water was swirled vigorously to suspend all sediments and transferred to pre-labeled 1-L containers. The overlying water was collected into a squirt bottle and used to fully rinse the trap tubes and ensure all sediment was collected into the 1-L container.

Sampling containers were transported to ALS Environmental (Burnaby, BC) for analysis. A completed chain-of-custody form accompanied the samples during transport. In the laboratory, samples were filtered through pre-weighed glass fiber filters then dried at 105°C. The dry weight of the sample was determined by subtracting the weight of the filter from the total dry weight. A portion of the samples were ashed by further drying the sample at 550°C and subtracting the ash weight from the dry weight of the sample.

Figure 2-1. Sediment traps deployed in ***September 2010*** and retrieved in ***August 2011***.



2.2. Periphyton Mat Sediment Survey

In 2009 and 2010, potential effects to the periphyton community in Second Portage Lake construction-related (2008 East Dike construction) sediment inputs were assessed by direct measurement and underwater video. Those studies identified likely effects in close proximity to the East Dike due to sedimentation. A complementary study was also conducted in 2009 and 2010 that quantified the inorganic sediment content of the periphyton mat based on loss-on-ignition (LOI) analyses. Continuation of this complementary study was recommended for 2011 to assess the spatial extent of adverse effects with a focus on effects related to Bay-Goose Dike construction (in Third Portage Lake).

Sampling in 2011 was conducted in 4 areas in Second Portage Lake and at 16 areas in Third Portage Lake during August 24 – 28, 2011. In addition to dike face samples, for continuity, areas that had been sampled in previous years were selected again in 2011 (i.e., all –CREMP areas). Five replicate samples were collected from each area and analyzed independently. UTM coordinates for each replicate sample are presented in **Table 2-1** and locations are mapped in **Figure 2-2**. The sampling areas are listed below by lake (Second or Third Portage Lake), area type (impact or control) and substrate (natural or dike):

Second Portage Lake

- Impact Areas
    - SP-ED – East Dike
    - SP-BL – Natural
- Control Areas
    - SP-CREMP – Natural
    - SP-DT – Natural

Third Portage Lake

- Impact Areas
    - TPE-BGN – Bay-Goose Dike North section
    - TPE-BGS – Bay-Goose Dike South section
    - TPE-CREMP – Natural
    - TPE-A *through* TPE-I (9 individual areas) – Natural
- Control Areas
    - TPN-CREMP – Natural
    - TPN-A – Natural
    - TPS-CREMP – Natural
    - TPS-A – Natural

Sampling locations were chosen according to the following criteria: a sufficient number of large, flat rocks from a water depth of approximately 0.5 m with a flat surface facing upwards as much as possible, and with uniform algal coverage, not particularly dense or sparse. Periphyton growth is naturally variable due to differences in wave action, aspect to sun, water depth and clarity, nutrient availability, rock type, water temperature and other factors.

Periphyton samples were collected by using the periphyton “scrubber” to scribe a circle onto the chosen rock (one rock per replicate) to maintain a consistent surface area size (20 cm^2). Using two knifes (one thin filleting knife and one wider spatula shaped knife), the circle was carefully scraped. The scraped sample was placed into a 125-ml glass sampling jar which had been pre-labeled with the area and replicate ID. Samples were frozen until the time of shipping. The procedures for collecting the samples are outlined in detail in the SOP for periphyton sampling (**Appendix B**).

Sampling containers were packed frozen and transported to ALS Environmental (Burnaby, BC) for analysis. A completed chain-of-custody form accompanied the samples during transport. In the laboratory, samples were filtered through pre-weighed glass fiber filters then dried at 105°C, and dry weight recorded (total weight minus the filter weight). Samples were then further dried at 550°C. This procedure ‘ashes’ the sample which produces yields the inorganic (sediment) component of the sample. Subtracting the ash weight from the dry weight yields the organic component of the sample.

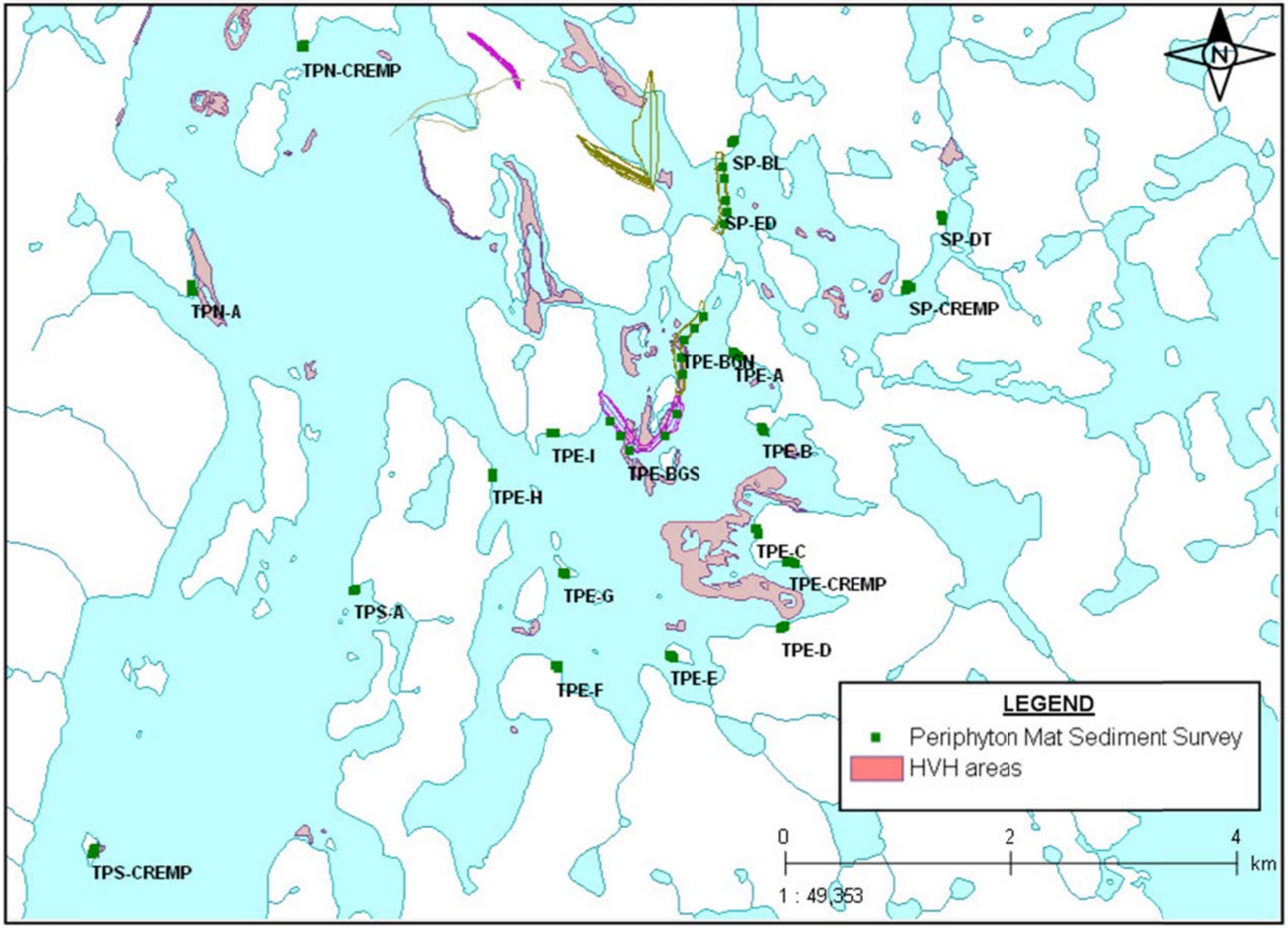
Table 2-1. Periphyton mat sediment survey sampling location coordinates (UTM, NAD 83).

Lake	Area ID	Date	Replicate #	Easting	Northing
Second Portage Lake	SP-ED	28-Aug-11	1	14 W 639366	7214361
			2	14 W 639380	7214257
			3	14 W 639400	7214057
			4	14 W 639413	7213948
			5	14 W 639378	7213846
	SP-CREMP	27-Aug-11	1	14 W 641010	7213319
			2	14 W 641023	7213295
			3	14 W 641038	7213293
			4	14 W 641008	7213267
			5	14 W 640996	7213258
	SP-DT	27-Aug-11	1	15 W 358677	7213877
			2	15 W 358680	7213891
			3	15 W 358683	7213901
			4	15 W 358683	7213917
			5	15 W 358696	7213925
	SP-BL	27-Aug-11	1	14 W 639475	7214597
			2	14 W 639471	7214594
			3	14 W 639465	7214584
			4	14 W 639456	7214581
			5	14 W 639449	7214565

Lake	Area ID	Date	Replicate #	Easting	Northing
Third Portage Lake - North & South Basins	TPN-CREMP	24-Aug-11	1	14 W 635637	7215444
			2	14 W 635634	7215433
			3	14 W 635638	7215412
			4	14 W 635622	7215416
			5	14 W 635612	7215431
	TPS-CREMP	24-Aug-11	1	14 W 633781	7208300
			2	14 W 633779	7208290
			3	14 W 633773	7208283
			4	14 W 633769	7208272
			5	14 W 633764	7208259
	TPN-A	24-Aug-11	1	14 W 634644	7213245
			2	14 W 634643	7213251
			3	14 W 634640	7213267
			4	14 W 634638	7213300
			5	14 W 634642	7213310
	TPS-A	24-Aug-11	1	14 W 636101	7210612
		25-Aug-11	2	14 W 636096	7210607
			3	14 W 636088	7210599
			4	14 W 636081	7210595
			5	14 W 636076	7210590

Lake	Area ID	Date	Replicate #	Easting	Northing
Third Portage Lake - East Basin	TPE-BGS	27-Aug-11	1	14 W 638950	7212166
			2	14 W 638845	7211965
			3	14 W 638529	7211831
			4	14 W 638453	7211967
			5	14 W 638361	7212098
	TPE-BGN	26-Aug-11	1	14 W 639195	7213027
			2	14 W 639110	7212917
			3	14 W 639012	7212819
			4	14 W 638985	7212664
			5	14 W 639006	7212520
	TPE-CREMP	25-Aug-11	1	14 W 639938	7210848
		25-Aug-11	2	14 W 639956	7210849
		26-Aug-11	3	14 W 639969	7210847
		26-Aug-11	4	14 W 639982	7210836
		26-Aug-11	5	14 W 640006	7210834
	TPE-A	26-Aug-11	1	14 W 639455	7212716
			2	14 W 639464	7212710
			3	14 W 639474	7212703
			4	14 W 639493	7212689
			5	14 W 639512	7212677
	TPE-B	26-Aug-11	1	14 W 639729	7212004
			2	14 W 639734	7212011
			3	14 W 639728	7212023
			4	14 W 639724	7212035
			5	14 W 639715	7212045
	TPE-C	25-Aug-11	1	14 W 639685	7211095
			2	14 W 639687	7211105
			3	14 W 639671	7211136
			4	14 W 639671	7211144
			5	14 W 639659	7211148
	TPE-D	26-Aug-11	1	14 W 639918	7210279
			2	14 W 639908	7210271
			3	14 W 639897	7210266
			4	14 W 639892	7210262
			5	14 W 639882	7210259
	TPE-E	25-Aug-11	1	14 W 638890	7210021
			2	14 W 638893	7210018
			3	14 W 638905	7210010
			4	14 W 638912	7210002
			5	14 W 638922	7209995
	TPE-F	25-Aug-11	1	14 W 637879	7209933
			2	14 W 637902	7209927
			3	14 W 637905	7209910
			4	14 W 637905	7209906
			5	14 W 637911	7209898
	TPE-G	25-Aug-11	1	14 W 637940	7210751
			2	14 W 637947	7210747
			3	14 W 637960	7210745
			4	14 W 637967	7210740
			5	14 W 637975	7210732
	TPE-H	26-Aug-11	1	14 W 637321	7211633
			2	14 W 637320	7211627
			3	14 W 637318	7211619
			4	14 W 637319	7211606
			5	14 W 637316	7211598
	TPE-I	26-Aug-11	1	14 W 637884	7211992
			2	14 W 637871	7211993
			3	14 W 637861	7211991
			4	14 W 637850	7211992
			5	14 W 637842	7211991

Figure 2-2. Periphyton mat sediment survey locations.



2.3. Video Surveys of HVH Areas

Underwater video surveys were conducted at high-value habitat (HVH) areas in Second Portage Lake and in the east basin Third Portage Lake. The intent of the survey was to document the status of high-value habitat relative to potential increased sediment deposition on rock surfaces related to East Dike and Bay-Goose Dike construction, which could decrease the value of habitat for spawning or food (e.g., through smothering). Secondary objectives included documenting and qualitatively describing substrate composition and periphyton coverage, with the aim to gather data on post-construction recovery and changes to periphyton growth in both lakes compared to baseline conditions, where available.

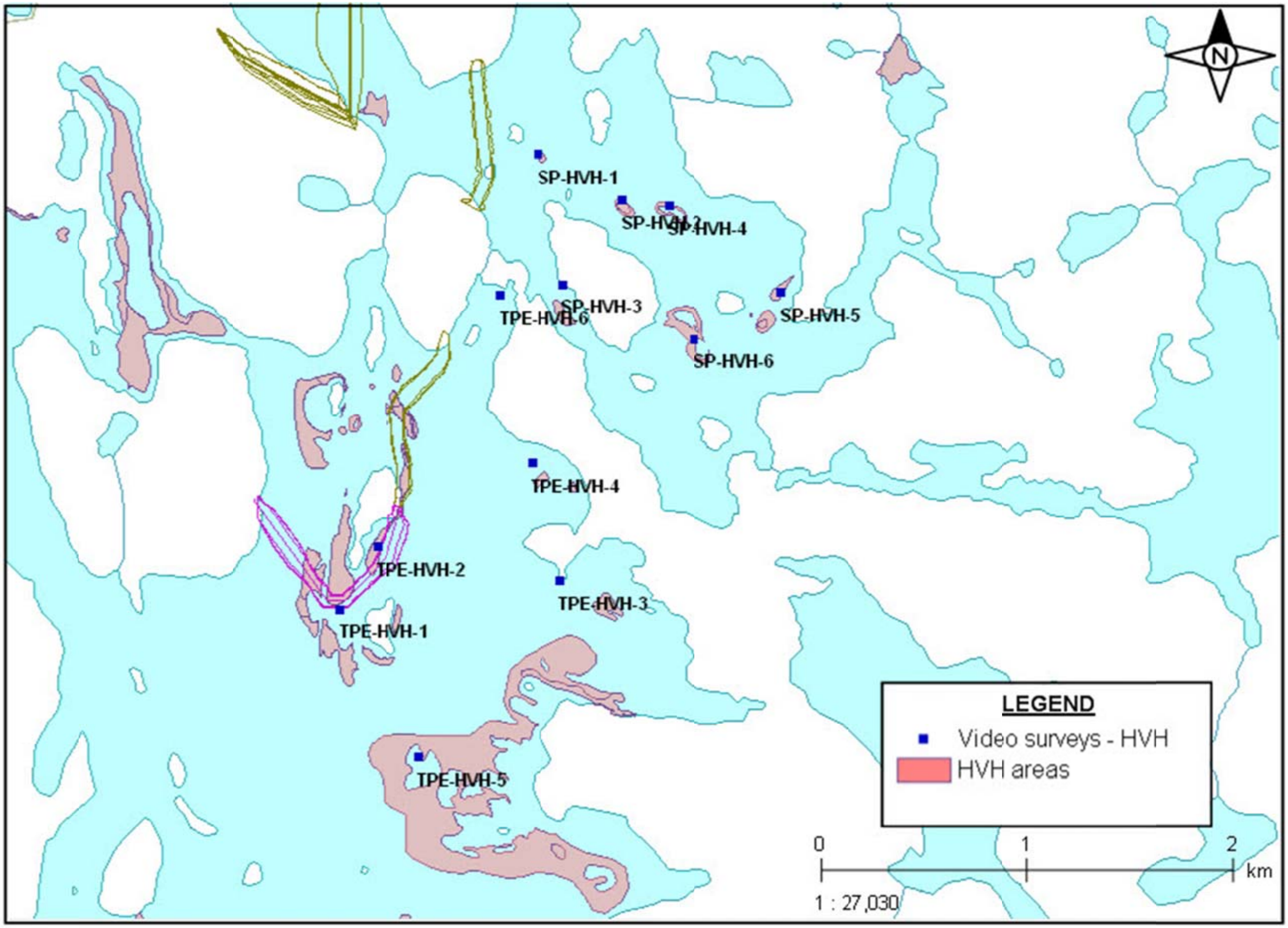
Video surveys were conducted in 2009 from 6 areas in both Second Portage Lake (post East Dike construction), and Third Portage Lake (pre Bay-Goose Dike construction). HVH areas in both lakes were re-surveyed in 2011, apart from 2 HVH areas in TPE which were lost due to Bay-Goose Dike construction. UTM coordinates for survey locations are presented in **Table 2-2** and locations are mapped in **Figure 2-3**.

Video imagery was acquired using a 'Deep Blue Pro' underwater camera system manufactured by Ocean Systems, Inc. (Everett, Washington). The camera was deployed from a boat at each HVH location. Five video segments were recorded from each HVH area; the boat was moved by approximately 3 m between each video segment. Video segments were about 30 seconds in length and slowly panned the substrate surrounding a reference gauge (to help determine rock size; a metal square with green tape denoting 10 inch increments). Target depth was anywhere between 1 – 4 m. The procedures for video work are outlined in detail in the SOP for underwater video survey (**Appendix C**).

Table 2-2. Video survey sampling location coordinates (UTM, NAD 83).

Lake	Area ID	Date	Depth (m)	Easting	Northing
Second Portage Lake	SP-HVH-1	29-Aug-11	3.2 to 3.7	14 W 639638	7214029
	SP-HVH-2	29-Aug-11	2.2 to 2.3	14 W 640045	7213806
	SP-HVH-3	29-Aug-11	1.3 to 3.7	14 W 639755	7213397
	SP-HVH-4	29-Aug-11	1.6 to 2.3	14 W 640269	7213780
	SP-HVH-5	29-Aug-11	2.4 to 3.8	14 W 640816	7213356
	SP-HVH-6	29-Aug-11	2.1 to 2.9	14 W 640395	7213130
East basin - Third Portage Lake	TPE-HVH-1	*Lost due to Bay-Goose Dike Construction*			
	TPE-HVH-2	*Lost due to Bay-Goose Dike Construction*			
	TPE-HVH-3	29-Aug-11	1.4 to 2.4	14 W 639741	7211954
	TPE-HVH-4	29-Aug-11	3.2 to 3.3	14 W 639604	7212527
	TPE-HVH-5	29-Aug-11	1.5 to 2.1	14 W 639053	7211097
	TPE-HVH-6	29-Aug-11	1.6 to 3.1	14 W 639451	7213341

Figure 2-3. Video survey locations of HVH areas.



2.4. Benthic Invertebrates

As described in **Section 1.2**, the assessment of TSS-related impacts to the benthic invertebrate community in 2011 relied on the CREMP data set, which covers all long-term monitoring locations since 2006. This data set provides a broad context within which to assess the presence of spatial patterns consistent with TSS-related effects. Methods for sample collection were consistent with previous years and are provided in detail in the CREMP report (Azimuth, 2012a); a synopsis is provided below.

General information regarding CREMP benthic invertebrate community sampling:

- CREMP areas are shown in **Figure 2-4**. Depths ranged from 6.5 to 10.0 m.
- Five replicates were sampled in each area. Two independent grabs (subsamples; Petite Ponar grab [0.023 m^2 per grab]) per replicate were composited to form a single sample to reduce sampling variation within areas and to increase the surface area sampled.
- Samples were sieved through a 500-µm sieve and preserved in the field with a 10% buffered formalin solution.
- Samples were sent to Zaranko Environmental Assessment Services (ZEAS) (Nobleton, ON) for taxonomic identification and analysis.
- Abundance of organisms/m^2 was determined from the total number of organisms enumerated. Nematodes and ostracods were not reported, nor were they included in abundance and richness calculations because they are too small to be reliably retained on a 500-µm sieve.

The following endpoints were used for assessing benthic community structure, based on sensitivity, objectivity, ease of interpretation and consistency:

- Taxa richness (i.e., corresponds to the number of species or taxa per sample and provides a measure of diversity).
- Total abundance (i.e., number of organisms per m^2).
- Abundance and richness of all major taxa (e.g., insects, molluscs, worms).
- Simpson's Diversity index (D), calculated as follows:

$$D = 1 - \sum \frac{n_i(n_i - 1)}{N(N - 1)}$$

  where: N is the total number of organisms/replicate sample; n_i is the total number of organisms of the *ith* taxa/replicate sample.

- Bray-Curtis index (B-C), calculated as follows:

$$\text{B-C} = \frac{\sum_{i=1}^{n} \left| y_{i1} - y_{i2} \right|}{\sum_{i=1}^{n} \left(y_{i1} + y_{i2} \right)}$$

where: Y_{i1} is the count for species i at site 1, Y_{i2} is the median of the count for species i at the references site(s), and n is the total number of species present at the two sites.

Details regarding methods for the statistical analyses of benthic invertebrates are provided in **Appendix A**.

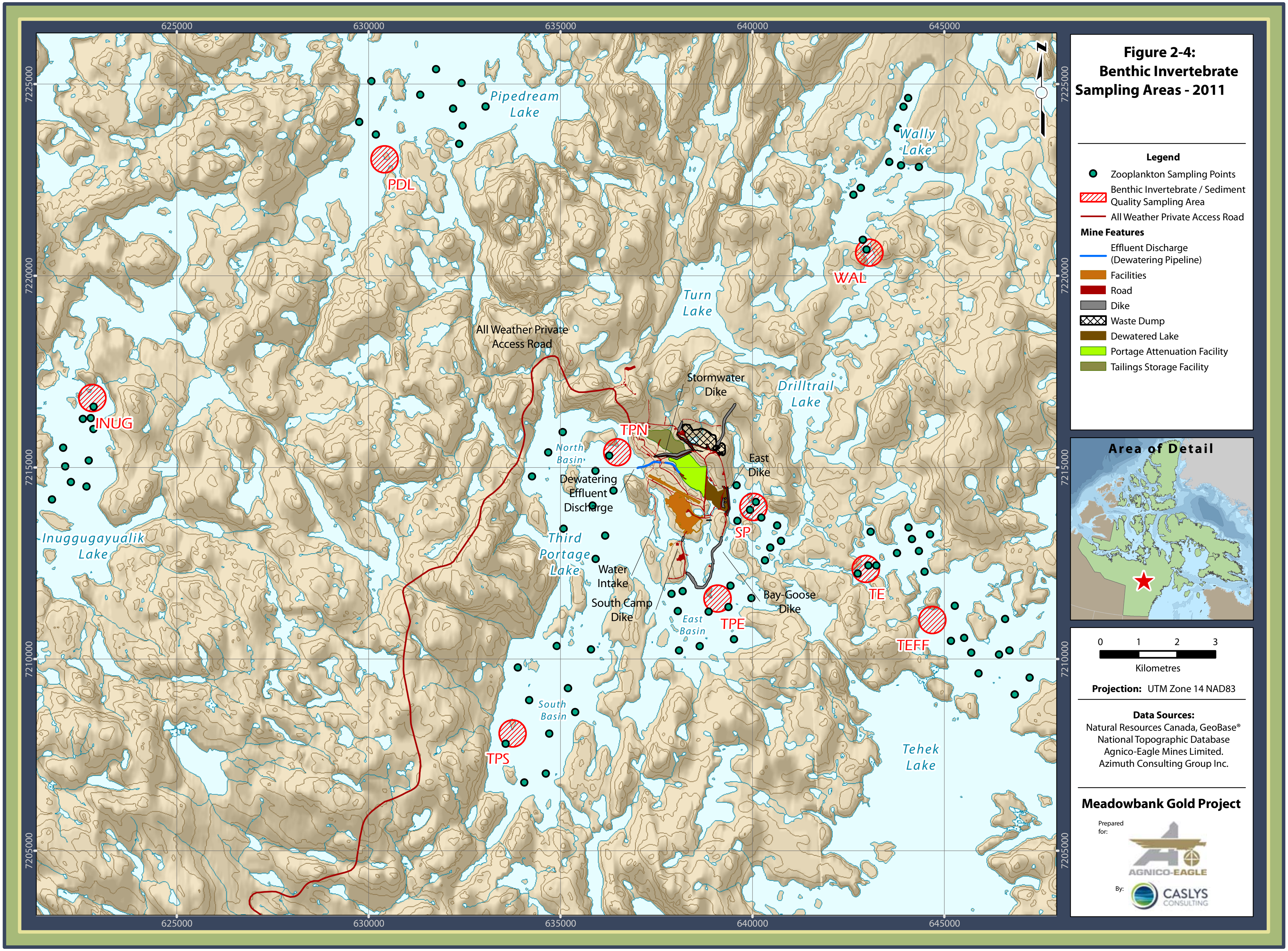


Figure 2-4:
Benthic Invertebrate Sampling Areas - 2011
Legend
Zooplankton Sampling Points
Benthic Invertebrate / Sediment Quality Sampling Area
All Weather Private Access Road
Mine Features
Effluent Discharge (Dewatering Pipeline)
Facilities
Road
Dike
Waste Dump
Dewatered Lake
Portage Attenuation Facility
Tailings Storage Facility
Area of Detail
0 1 2 3
Kilometres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Meadowbank Gold Project
Prepared for:
By:
Pipedream Lake
PDL
Wally Lake
WAL
Turn Lake
All Weather Private Access Road
Stormwater Dike
Drilltrail Lake
INUG
TPN
North Basin
East Dike
Dewatering Effluent Discharge
SP
Inuggugayualik Lake
Third Portage Lake
Water Intake
South Camp Dike
Bay-Goose Dike
TE
East Basin
TPE
TEFF
South Basin
TPS
Tehek Lake
625000
630000
635000
640000
645000
7225000
7220000
7215000
7210000
7205000

2.5. Quality Assurance / Quality Control

The objective of quality assurance and quality control (QA/QC) is to ensure that the chemical and biological data collected are representative of the material or populations being sampled, are of known quality, are properly documented, and are scientifically defensible. Data quality was assured throughout the collection and analysis of samples using specified standardized procedures, by the employment of laboratories that have been certified for all applicable methods, and by staffing the program with experienced technicians.

Field QA/QC: Periphyton Mat Sediment Sampling – In terms of field QA/QC, two field duplicates and field replicates (5 per area) were collected for periphyton LOI to test consistency in field methods and to determine natural variability and spatial heterogeneity within and among areas. Collection tools were thoroughly rinsed in lake water to ensure that no debris was carried between sample replicates or areas. We target a RPD of 50% for total dry weight, ash weight and ash-free dry weight.

Laboratory and Field QA/QC: Benthic Invertebrate Sampling – Standard procedures were used to collect benthic invertebrate samples. All sampling gear was thoroughly rinsed between sampling areas and replicates to ensure that there was no inadvertent introduction (i.e., cross-contamination) of biota from one replicate to another.

ZEAS incorporates the following set of QA/QC procedures in all benthic projects undertaken by the company to ensure the generation of high quality and reliable data:

- Samples were logged upon arrival, inspected, and enumerated;
- Samples were checked for proper preservation;
- Samples were stained to facilitate sorting;
- Taxonomic identifications were based on the most updated and widely used keys;
- 10% of the samples were re-sorted, and re-counted, targeting >90% recovery;
- Precision and accuracy estimates were calculated;
- A voucher collection was compiled;
- Sorted sediments and debris were re-preserved in 10% formalin and are retained for up to three months. For samples subject to subsampling, sorted and unsorted fractions were re-preserved separately.

Field replicates (5 per area) were collected for benthos to determine natural variability and heterogeneity. Replicates were collected at least 20 m apart from one another, within the defined sampling areas, as described in **Section 2.4**.

3. RESULTS

3.1. Quality Assurance / Quality Control

QA/QC procedures consisted of a combination of careful field collection and sample handling, the collection of field duplicate samples, field replicate samples and standard reference materials.

Periphyton Mat Sediment Sampling – Periphyton samples collected from prescribed areas of rock surface underwent drying and ashing procedures. Two randomly chosen samples were selected for field duplication. The quality of the data is evaluated based on total dry weight, ash weight and ash-free dry weight. Overall, these two samples showed a high level of consistency with the original samples. There was only one case where the RPD exceeded 50%; in this case, the original sample had more organic content than the duplicate (**Table 3-1**). The latter result is not uncommon given the natural variability of the periphyton community from rock to rock and should not affect data quality.

Benthic Invertebrate Sampling – Laboratory replicate counts were performed on 10% of all benthic samples. Replicate samples were chosen at random and processed at different times from the original analysis to reduce bias. Of the re-sorted samples, 9/269 (3.35%), 14/314 (4.46%), 1/42 (2.38%), 0/35 (0%), 2/44 (4.55%), 0/118 (0%), and 0/51 (0%) of organisms were missed, with an overall omission rate of less about 2%. These results suggest that the vast majority of animals observed in benthic samples by the taxonomist were recovered (see Azimuth, 2012a for more detail). A reference collection of benthic taxa has been compiled.

Table 3-1. QA/QC data for periphyton mat sediment sampling.

	Third Portage Lake			Second Portage Lake		
	TPE-G-5 25-Aug-11	**Field Duplicate-1**	**RPD (%)**	**SP-CREMP-3 27-Aug-11**	**Field Duplicate-2**	**RPD (%)**
Loss-on-Ignition Analysis (LOI)						
Dry Weight (g Total)	0.536	0.486	10	0.993	0.907	9.1
Ash Weight (g Sediment)	0.468	0.420	11	0.876	0.895	-2.1
Ash-Free Dry Weight (g Organic)	0.068	0.066	2.7	0.117	0.012	163

Notes:
RPD = Relative Percent Difference (%) = ((original-duplicate) / ((original+duplicate)/2)) x100.
Shaded RPDs exceed 50%.

3.2. Sediment Traps

Trap retrieval rates were very good this year as all 16 traps deployed over winter (2010–2011) were successfully recovered with minor disturbance. One replicate sample (i.e., one tube) from each of SP-ST6, SP-ST7, and SP-ST8 sediment traps was discarded due to incidental spillage. An overview of sediment trap set locations (all trap locations from 2008-2011) are shown in **Figure 3-1** and a close-up view is shown in **Figure 3-2**.

As noted in previous years, many traps contained more than just sediment (e.g., some biota and/or other organic matter). Consequently, rather than just drying and weighing trap contents (e.g., as was done in 2008), in 2009, 2010 and 2011 the samples were also ashed (see **Section 2.1** for methods) to remove organic matter. Sedimentation rates and accumulation estimates were made using the ash weights (i.e., inorganic content weight) in **Table 3-2**. We have also looked at accumulation in sediment traps across all years (2008-2011) using ash weights[1]. Using the mean ratio of ash weight to total weight (0.85) from the 2009-2011 data, we converted the summer 2008 total weights into ash weights, since LOI analysis was not done for this earlier dataset; this conversion allowed for comparisons with all other seasons/years. The sediment trap data from 2008-2011 are shown in **Figure 3-3**, which presents total accumulation (mm) based on ash weight. All data used in **Figure 3-3** are reported in a table in **Appendix D**.

Results for sediment deposition rates and estimated accumulation thickness from the 2010-2011 winter are presented in **Table 3-2** (lab reports in **Appendix E**). Sediment deposition and accumulation were estimated based on ash weight density relative to tube diameter in this table. Residual sediment from Bay-Goose Dike construction in the east basin of Third Portage Lake may have contributed to the accumulation of sediment in the BG-ST traps over winter 2010-2011. It is also possible that dust from site activities accumulated on the snow cover which when melted deposited sediment into the lake, particularly at BG-ST6 (closest to the Bay-Goose Dike and pit). This may also explain the accumulation at SP-ST1 (adjacent to the East Dike) over winter 2010-2011.

Sediment deposition in earlier seasons/years can be more clearly attributed to dike construction events. In the summer of 2008, up to 1.5 mm of material accumulated in SP sediment traps during East Dike construction (**Figure 3-3**) and there was a clear pattern related to proximity to the construction zone in Second Portage Lake receiving environment (which was also corroborated statistically using regression analysis [VanEngen, unpublished data, 2012]).

Similarly, in the summer of 2009, about 4 mm (at BG-ST6) but generally 1 – 1.5 mm (other BG-ST samples) of inorganic material accumulated in TPE sediment traps during

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[1] Note that an error was reported from the laboratory regarding the 2009 sediment trap LOI analysis data. The laboratory reversed reports for ash weights (inorganic content) and ash-free weights (organic content) thus these data were also wrongly reported in the 2009 EAS report (Azimuth, 2010c). We have re-calculated sediment deposition rates and accumulation for the 2009 data herein.

construction of the north section of Bay-Goose Dike (**Figure 3-3**). During that summer, some areas in SP were still receiving inputs, particularly in the output channel from TPE (SP-ST8 and SP-ST6; **Figure 3-1 and 3-2**), but also close to the East Dike at the north end (SP-STBL) which may be due to mine activities in proximity to the road along the dike.

Construction of the south section of the Bay-Goose Dike was started over the 2009-2010 winter (i.e., a narrow causeway was built through ice with no turbidity barriers), contributing to the accumulation measured in the BG-ST and other TPE sediment traps during this time period. From the summer of 2009 to the summer of 2010, accumulation in sediment traps increased somewhat in the TPE samples while decreasing in the BG-ST samples, as the turbidity plume moved out into the east basin of Third Portage Lake away from the Bay-Goose Dike. Note that the TPE-ST2 trap was set for an entire year (September 2009 – September 2010).

The accumulation in sediment traps from the drilltrail arm (DT) of Second Portage Lake (SP-ST7) and in the south basin of Third Portage Lake (TPS-ST1 and TPS-ST2) represent natural conditions and are always low (**Figure 3-3**). Apart from the ~1 mm accumulated over winter (2010-2011) in traps closest to mine activities (SP-ST1, SP-ST8 and BG-ST6), residual sedimentation now that dike construction has ended appears to be low and comparable to natural conditions as seen in SP-DT and TPS traps.

Table 3-2. Sediment deposition rates and estimated accumulation for sediment traps, Second Portage and Third Portage Lakes, winter 2010-2011.

Lake	Sediment Trap ID	UTM Location Easting	UTM Location Northing	Set date	Retrieval date	Ash Weight (g dry weight)	Ash Weight[1] (g wet weight)	Set length (days)	Deposition Rate[2] (g wet weight/cm²/day)	Accumulation[2,3] (mm)
Second Portage Lake	SP-ST1	14W 639659	7213989	23-Sep-10	7-Aug-11	1.8	12	318	8.0E-04	1.3
	SP-ST6	14W 640060	7212811	25-Sep-10	7-Aug-11	0.44	2.9	316	2.0E-04	0.32
	SP-ST7	15W 358774	7213913	23-Sep-10	7-Aug-11	0.24	1.6	318	6.4E-05	0.10
	SP-ST8	14W 639667	7213402	25-Sep-10	7-Aug-11	1.7	11	316	4.5E-04	0.70
Third Portage Lake	BG-ST1	14W 638391	7211633	24-Sep-10	6-Aug-11	0.54	3.6	316	1.42E-04	0.22
	BG-ST2	14W 639005	7211768	25-Sep-10	6-Aug-11	0.49	3.3	315	2.25E-04	0.35
	BG-ST3	14W 639469	7212038	25-Sep-10	5-Aug-11	0.67	4.5	314	3.06E-04	0.48
	BG-ST4	14W 639512	7212421	25-Sep-10	5-Aug-11	0.64	4.3	314	2.93E-04	0.46
	BG-ST5	14W 638947	7211254	24-Sep-10	6-Aug-11	0.38	2.5	316	1.72E-04	0.27
	BG-ST6	14W 639360	7213336	25-Sep-10	5-Aug-11	1.1	7.2	314	4.95E-04	0.78
	TPE-ST1	14W 637808	7211590	24-Sep-10	6-Aug-11	0.44	2.9	316	2.00E-04	0.32
	TPE-ST2	14W 639030	7210488	24-Sep-10	7-Aug-11	0.39	2.6	317	1.75E-04	0.28
	TPE-ST3	14W 637986	7210217	24-Sep-10	7-Aug-11	0.55	3.6	317	1.44E-04	0.23
	TPE-ST4	14W 637351	7209107	24-Sep-10	7-Aug-11	0.40	2.7	317	1.05E-04	0.17
	TPS-ST1	14W 635750	7208642	24-Sep-10	6-Aug-11	0.23	1.5	316	1.05E-04	0.17
	TPS-ST2	14W 634359	7210449	24-Sep-10	6-Aug-11	0.52	3.5	316	1.38E-04	0.22

Notes:
[1] Assumes 85% moisture content.
[2] Normalized for differences in trap tube size.
[3] Assumes mean material density of 2 g/cm3.

Figure 3-1. Sediment trap locations ***overview*** for traps sampled from 2008-2011.

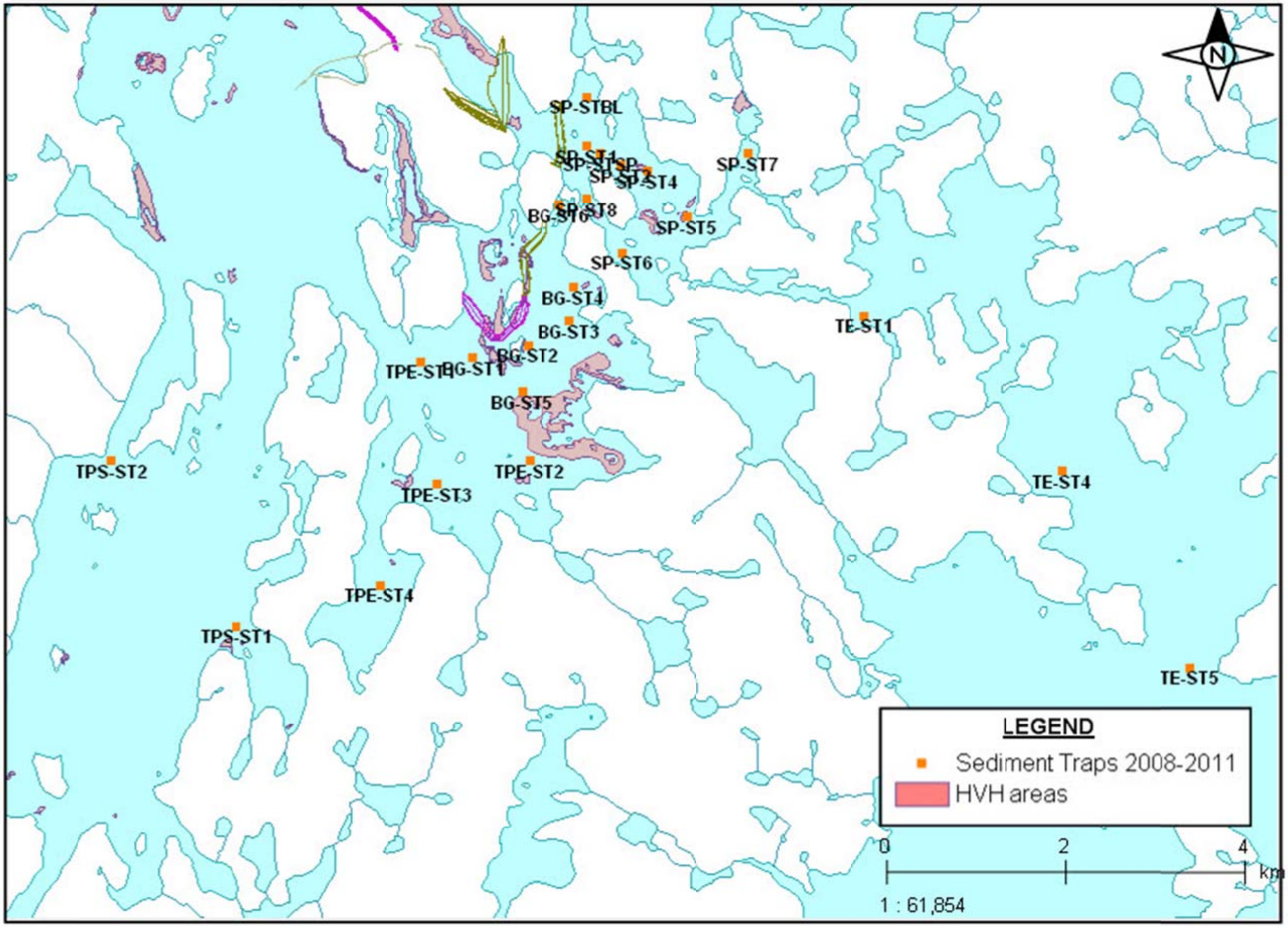


Figure 3-2. Sediment trap locations ***close-up view*** for traps sampled from 2008-2011.

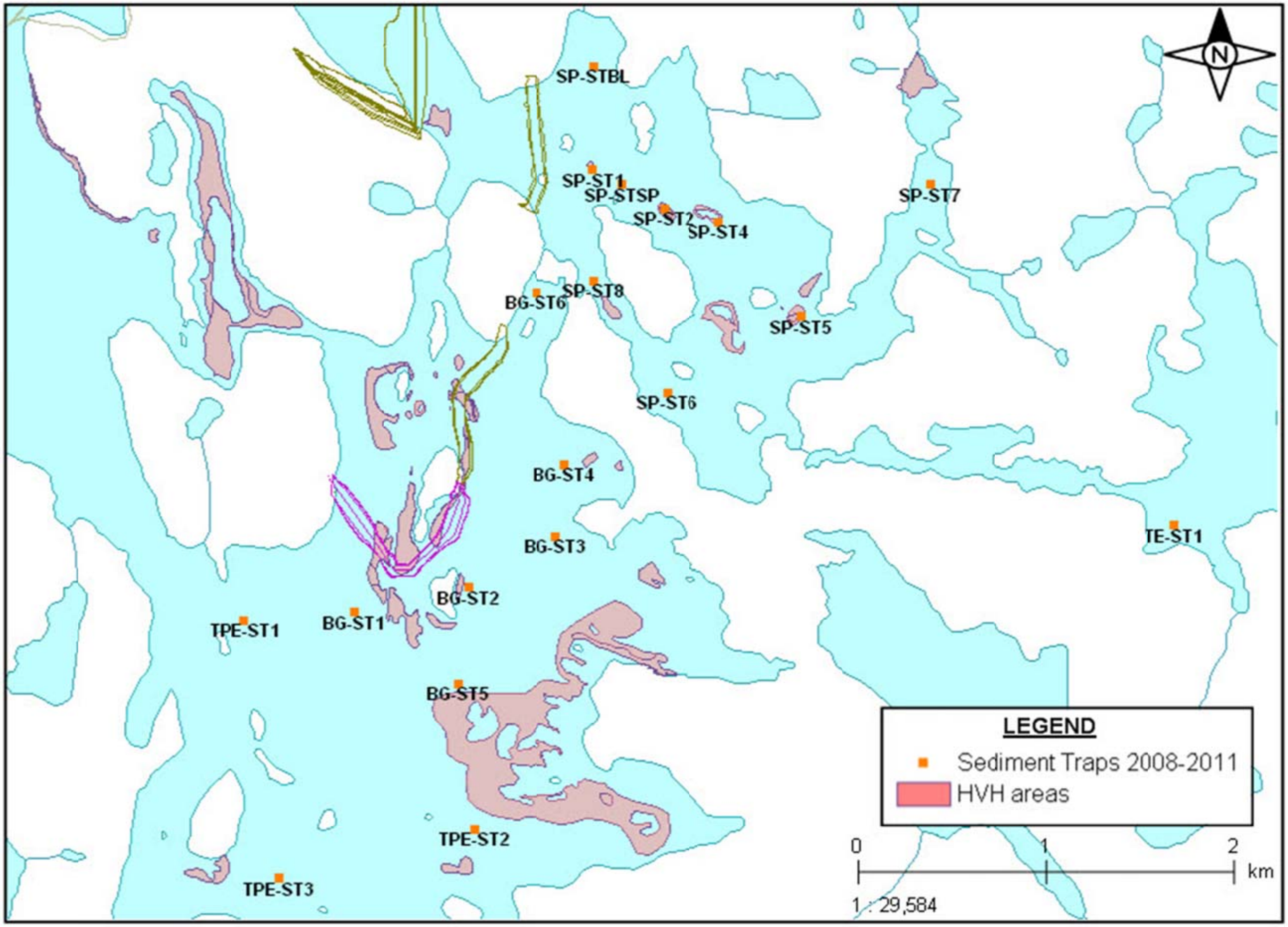
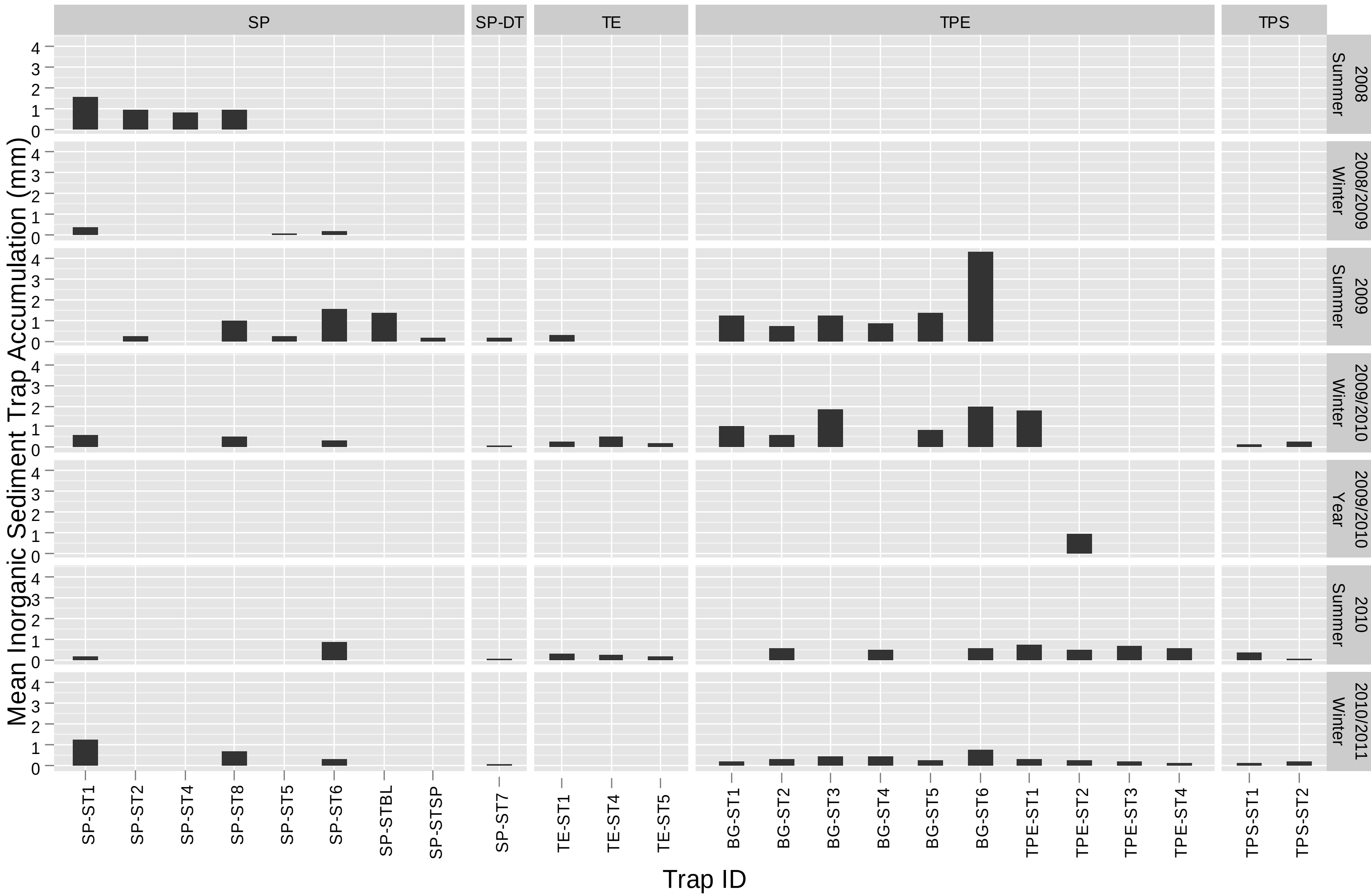


Figure 3-3. Mean inorganic sediment trap accumulation (mm) for traps sampled from 2008-2011.



Note: Summer 2008 data were converted to ash weights by applying the mean ratio of ash weight to total weight in data from 2009-2011.

3.3. Periphyton Mat Sediment Survey

Periphyton are unicellular and colonial aquatic algae species attached to and coating rocks and other hard substrates beneath the water surface (i.e. the epithelial layer). Periphyton provide an important food source for certain benthic invertebrate species and together with phytoplankton and benthic algae form the base of the aquatic food web. Periphyton are most abundant between the surface and several meters water depth, and typically increase in biomass during the course of the open water season, reaching maximum abundance during late summer, and decline during late fall and winter, as light diminishes.

Despite inherent high variability, direct measurements of species composition and biomass of periphyton are indicators of lake productivity, reflecting nutrient concentrations in the lake, and are sometimes indicators of the presence of physical or chemical stressors. Quantitative periphyton studies were conducted in Second Portage Lake in 2009 and 2010 to assess whether the 2008 sedimentation event that occurred during construction of the East Dike impacted benthic primary productivity. Those results are described in detail elsewhere (Azimuth, 2011a). Quantitative periphyton sampling was not conducted for the 2011 EAS.

A complementary study (that had also been conducted in 2009 and 2010) was conducted in 2011 that quantified the inorganic sediment content of the periphyton mat at each location (based on loss-on-ignition [LOI] analyses). The amount of inorganic material present (relative to organic matter) was assumed to be directly related to the magnitude of settling of suspended solids from the water column. As described in **Section 2.2**, a much broader periphyton mat LOI program (20 areas with 5 replicates in each) was conducted in 2011 than in previous years, with a more intense focus on the east basin of Third Portage Lake relative to Second Portage Lake. Results are presented in **Table 3-3** and lab reports can be viewed in **Appendix F.**

The intent of the LOI investigation is to assess whether construction-related sedimentation has (or is) adversely affecting periphyton mat biomass. An assumption inherent in this analysis is that the organic content from the LOI analyses is correlated to living periphyton biomass. This assumption was explored in some detail in the 2009 EAS (Azimuth, 2010c), where three types of periphyton mat samples were collected:

- Quantitative periphyton (i.e., biomass/density of various taxa scrubbed from a known area with a special tool);
- LOI analyses to estimate sediment content of the periphyton mat; and
- “Deal/Alive” analysis that looked specifically at the relative amounts of living versus dead periphyton cells based on the presence/absence of chloroplasts.

The results of the above studies essentially showed that: (1) Quantitative periphyton biomass was lowest where LOI sediment content was highest, (2) LOI organic content was proportional to quantitative periphyton biomass, and (3) there was no difference in the proportions of living versus dead periphyton among areas. Thus, the assumption that LOI organic content can be used as a surrogate for total periphyton biomass appears reasonable.

Figure 3-4 shows the relative amount of organic (i.e., periphyton mat material) and inorganic (i.e., sediment) material across a range of locations in each lake. As would be expected in early colonization, samples collected from the dike areas had the lowest organic content; however, these areas also had low sediment content, which suggests that mat thickness is apparently more important than proximity to the construction zone in determining residual sediment content after dike construction. There also does not appear to be any negative relationship between sediment mass and periphyton mat biomass (**Figure 3-4**), in fact the opposite may be true and warrants further assessment.

The relationship between organic content (periphyton) and inorganic content (sediment) in periphyton mat samples is shown in **Figure 3-5**. There was a significant positive correlation (statistical results presented on the plot) between organic and inorganic content of the mats, suggesting that, similar to the observation made above for the dike samples, mat thickness is important in determining sediment mass. Furthermore, an analysis of covariance (ANCOVA) with Area Type (i.e., control or impact) as a covariate was conducted to assess whether the relationship differed between control (i.e., reference areas) and impact (i.e., areas in closer proximity to the dikes) areas; the results were not statistically different ($p=0.313$ for the Area Type term in the ANCOVA model).

General results from the 2009 and 2010 studies (both quantitative periphyton community and LOI studies) found that sediment content decreased and periphyton biomass increased with distance from the East Dike, but that effects were limited in spatial extent to an area immediately adjacent to the construction zone (i.e., SP-BL, which was immediately outside the zone bounded by turbidity barriers during dike construction). To explore this further in the 2011 data, the organic content – sediment content relationship was used to identify samples (for natural substrates only) that fell well below the regression line (i.e., samples that had higher sediment content relative to organic content) (**Figure 3-6**). The following areas stand out (with two or more points or because they are control areas):

- SP-BL – three of the samples come from this area in Second Portage Lake, which is the same location where lower periphyton biomass was seen in 2009 and 2010 (i.e., as described above).
- TPE-D – three of the samples were from this area, located in the southeastern portion of the east basin of Third Portage Lake (**Figure 2-2**). Based on this location and the TSS patterns observed in the east basin during dike construction monitoring (i.e., the highest TSS concentrations were close to the dike in deeper

zones of the northwestern portion of the east basin [Azimuth, 2010b]), these results seem unlikely to be related to dike construction.

- TPE-I – two of the samples come from this area in Third Portage Lake, located just west of the southern portion of the Bay-Goose Dike (i.e., where construction activities occurred in 2010).
- SP-CR, TPN.A – both these areas are well away from mine-related activity. These results are apparently natural.

Thus, the 2011 LOI results suggest that periphyton mat sediment mass does not appear to have caused a general reduction in periphyton biomass (based on LOI organic content; see assumption rationale provided earlier) in shallow zones of the east basin of Third Portage Lake (the primary focus of the study). Further analysis did identify localized areas where construction-related sedimentation may have reduced periphyton biomass (e.g., TPE-I), although there were other locations where similar results were apparently natural.

Based on available literature, periphyton communities should be fairly resilient to disturbances such as the elevated TSS associated with dike construction. Sedimentation has been shown to affect the periphyton growth (Yamada and Nakamura, 2002). Izagirre et al. (2009) assessed the effects of pulse sediment deposition on periphyton, and found that within 2 weeks of the event, periphyton almost fully recovered in terms of chlorophyll-α content, but failed to regain community composition within the same time frame.

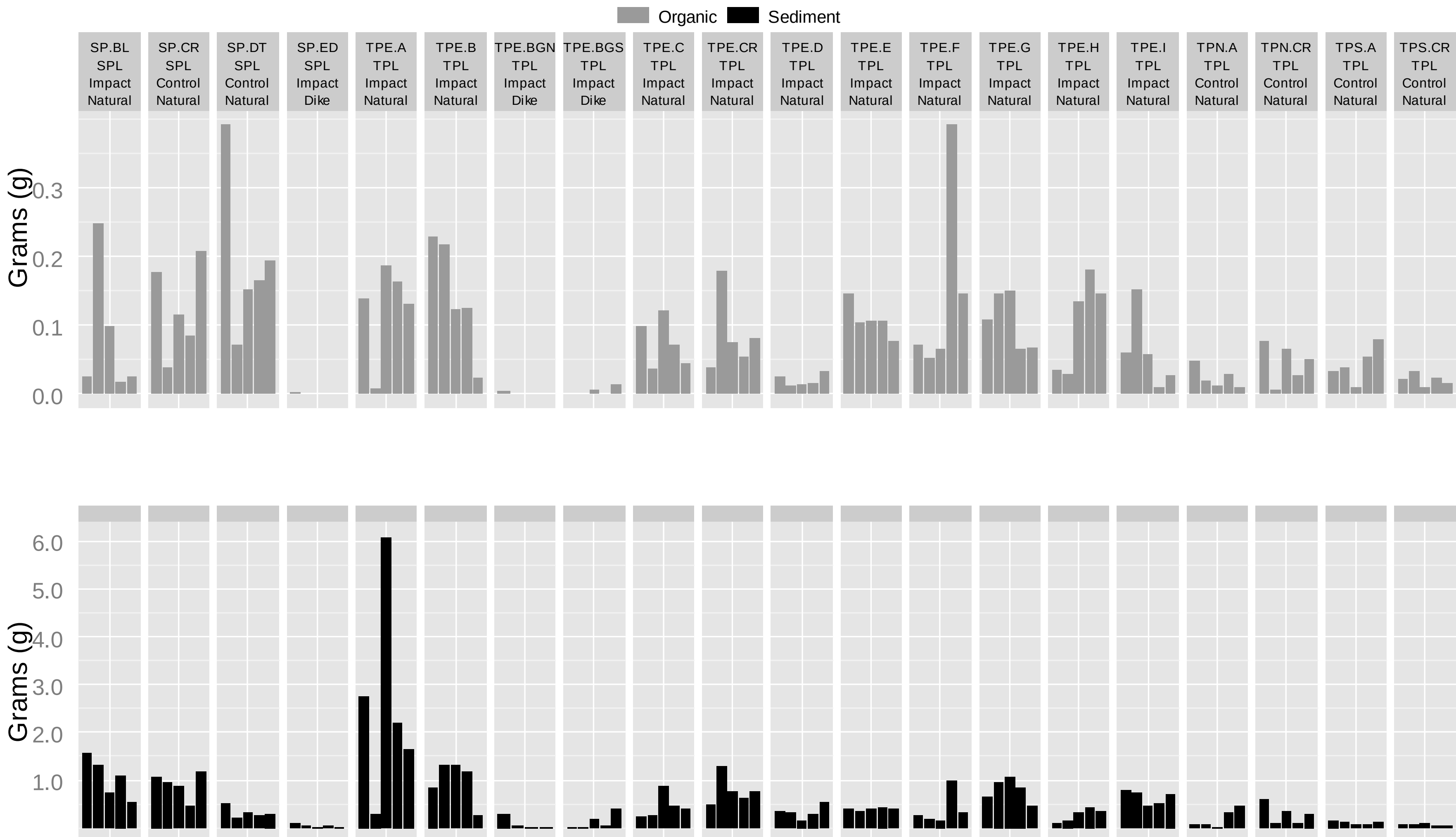
Overall, these results appear consistent with the findings of the 2009/2010 studies in Second Portage Lake; the specific identification of SP-BL, an area of known low periphyton biomass in Second Portage Lake, provides a good cross-validation of the methods used in 2011. These findings are limited to the shallow littoral zones; the assessment of the potential effects of TSS on the periphyton community in deeper water is conducted in **Section 3.4**.

Table 3-3. Weights and content ratio of periphyton samples collected for loss on ignition (LOI) analysis.

Lake	Area ID	n	Sample Weight (g)			Ratio (sediment:organic)
			Sediment	Organic	Total	
Second Portage Lake	SP-ED	5	0.037	0.002	0.039	22 : 1
	SP-BL*	5	1.058	0.084	1.143	13 : 1
	SP-CREMP	5	0.910	0.125	1.035	7.3 : 1
	SP-DT	5	0.320	0.196	0.516	1.6 : 1
Third Portage Lake	TPE-BGS	5	0.133	0.008	0.138	17 : 1
	TPE-BGN	5	0.091	0.004	0.093	22 : 1
	TPE-CREMP	5	0.783	0.086	0.870	9.1 : 1
	TPE-A	5	2.602	0.126	2.726	21 : 1
	TPE-B	5	0.988	0.144	1.131	6.8 : 1
	TPE-C	5	0.449	0.075	0.524	6.0 : 1
	TPE-D	5	0.333	0.021	0.354	16 : 1
	TPE-E	5	0.400	0.108	0.509	3.7 : 1
	TPE-F	5	0.385	0.146	0.532	2.6 : 1
	TPE-G	5	0.801	0.108	0.911	7.4 : 1
	TPE-H*	5	0.277	0.106	0.382	2.6 : 1
	TPE-I	5	0.646	0.062	0.708	10 : 1
	TPN-A	5	0.188	0.024	0.211	7.8 : 1
	TPN-CREMP	5	0.289	0.046	0.335	6.3 : 1
	TPS-A	5	0.121	0.044	0.165	2.8 : 1
	TPS-CREMP	5	0.074	0.021	0.095	3.4 : 1

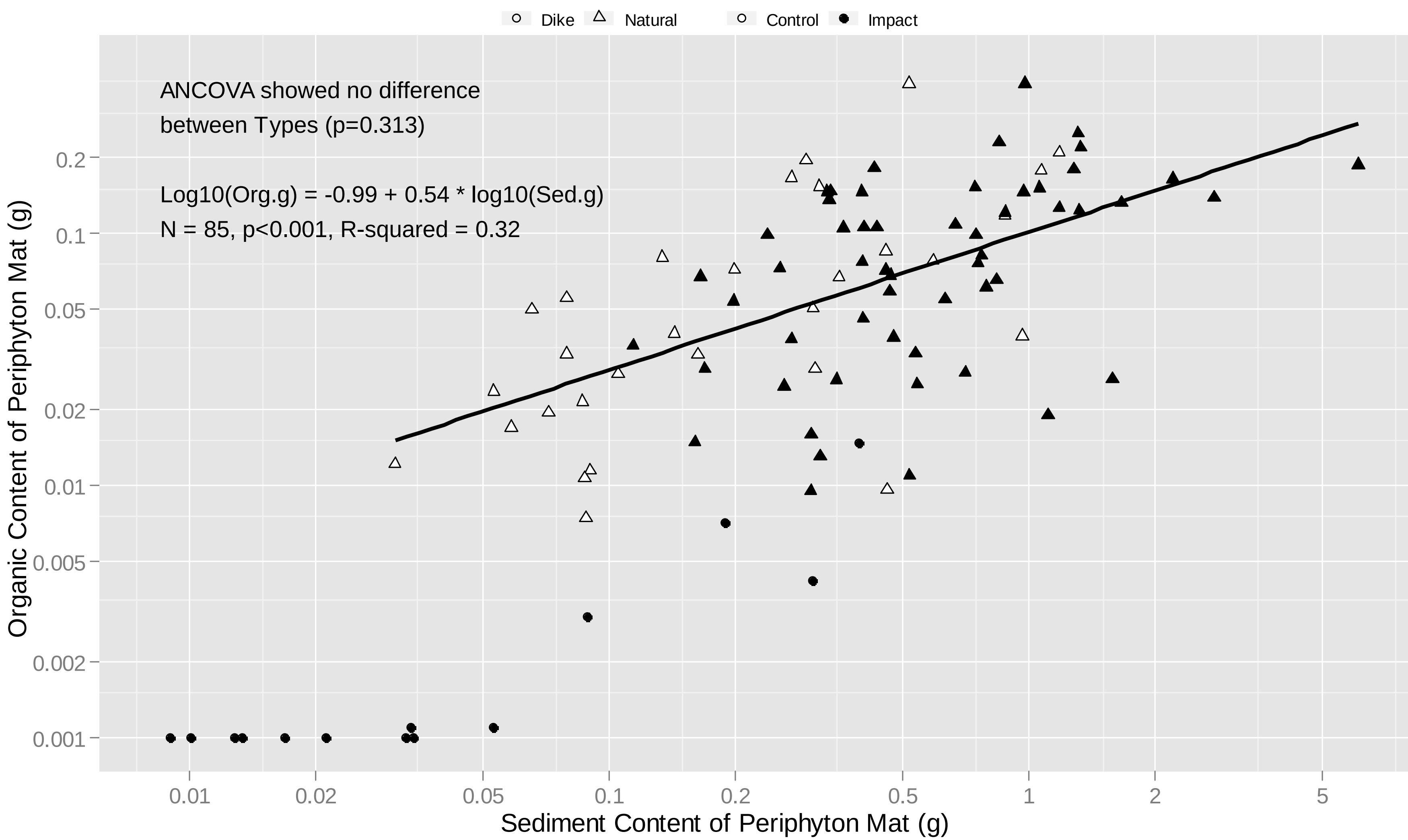
Notes:
***** Results of TPE-H-2, and SP-BL-1 are possibly slightly biased high due to glass contamination from the lab; the results of SP-BL-2 are possibly biased low due to a spill during the weighing process at the lab.

Figure 3-4. Relative amount of organic material (top) and sediment (bottom) in periphyton mats.



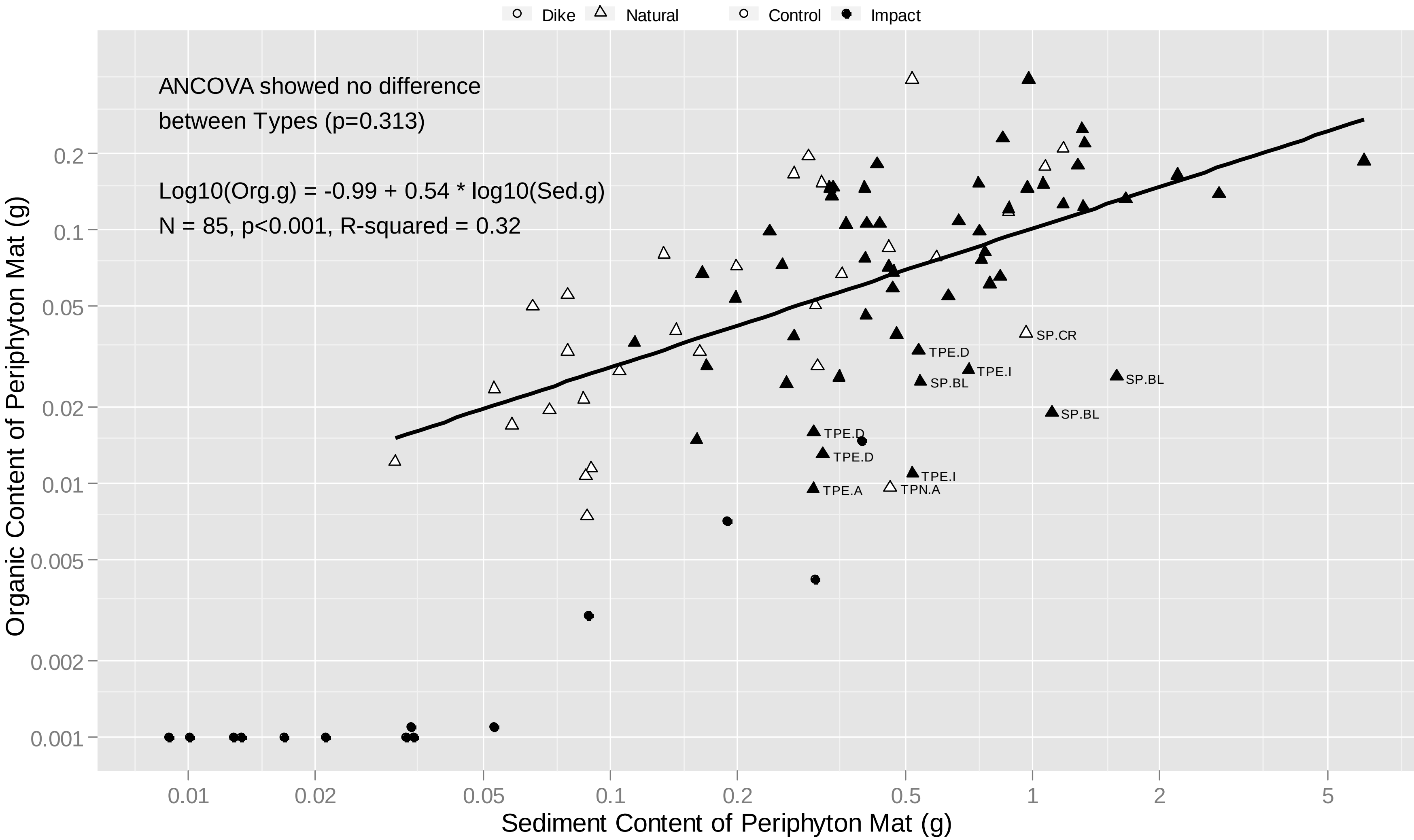
Notes: Scales different on above graphs. Weights are dry. Area = 20 cm^2/sample. Column names include the area ID, lake ID, area type (i.e., "impact" or "control" designation), and substrate type (i.e., natural or dike).

Figure 3-5. Relationship between organic and sediment content of periphyton mats on natural substrates.



Note: Dike points shown for reference only.

Figure 3-6. Relationship between organic and sediment content of periphyton mats on natural substrates, identifying points representing particularly low organic:sediment content.



Note: Dike points shown for reference only.

3.4. Video Surveys of HVH Areas

The results of underwater video surveys of high-value habitat areas conducted in 2009 and 2011 are presented in **Tables 3-4 and 3-5**. Video captures (i.e., still photos "captured" from the video) were used to identify features of the periphyton communities and are provided for reference in **Appendix G** (2009) and **Appendix H** (2011). Note that **Appendix I** is a key for interpreting sediment and periphyton coverage from video surveys. Key similarities and contrasts are provided below by lake and HVH area.

Second Portage Lake

The 2009 video survey was conducted after the 2008 sedimentation event associated with construction of the East Dike and the 2011 survey documents changes since then, as follows:

- **SP-HVH-1**: Proximal to East Dike (**Figure 2-3**), SP-HVH-1 had moderate sediment cover in 2009, with a dense periphyton mat covering the substrate. In 2011, periphyton coverage at SP-HVH-1 continues to be high, with thick periphyton mats present, and thin sediment coverage on the periphyton mats.
- **SP-HVH-2**: In 2009, SP-HVH-2 had less sediment evident than SP-HVH-1, but some smothering of periphyton was present. Where there was lighter sediment cover, periphyton mats were thick and dense. Two years later, sediment cover appeared lower and periphyton mats with raised fronds covered a high percentage of the substrate.
- **SP-HVH-3**: SP-HVH-3 is located in the channel within Second Portage Lake which flows from TPE (**Figure 2-3**), and experienced less sediment deposition in 2009 compared to the other HVH areas in Second Portage Lake. Dense mats of periphyton were present on most boulders. Similar results were found in 2011, as periphyton at SP-HVH-3 continued to be present on most substrates, with thick mats on the sides of boulders, and thinner mats on the surface.
- **SP-HVH-4**: The 2009 footage showed evidence of sediment deposition at SP-HVH-4, with some smothering of periphyton. After two years, sediment coverage was thin and sparse, and a high percentage of the substrate was covered with thick, dense periphyton.
- **SP-HVH-5 and SP-HVH-6**: Relatively far from the East Dike (**Figure 2-3**), these areas had very sparse sediment coverage and thick raised mats of periphyton with moderate to high coverage in both 2009 and 2011.

In general, the 2011 video survey results suggest that visible sediment accumulation has decreased at most Second Portage Lake HVH areas since 2009 and that periphyton coverage remains similar.

Third Portage Lake

Bay-Goose Dike construction in the east basin of Third Portage Lake began in August 2009. The 2009 video survey was conducted in late July, prior to the onset of dike construction to characterize baseline conditions. The 2011 survey was conducted to assess potential changes related to dike construction and the associated sedimentation. Survey results for both years are described below:

- **TPE-HVH-1 and TPE-HVH-2**: Dike construction occurred in the area of TPE-HVH-1 and -2, so while they were visited in 2009, there is no comparison to these sites in 2011.
- **TPE-HVH-3**: In 2009, TPE-HVH-3 showed some thin and sparse sediment cover, and had thin to moderate periphyton mats on substrate surfaces and dense mats with raised fronds on the sides of boulders. In 2011, both periphyton and sediment coverage were similar to that found in 2009.
- **TPE-HVH-4**: TPE-HVH-4 also showed little change from 2009 to 2011. This area had thin and sparse sediment coverage and continuous mats of periphyton with moderate to high density and thickness.
- **TPE-HVH-5**: TPE-HVH-5 was characterized by continuous mats of periphyton and light sediment coverage in 2009. Periphyton mats appeared thicker and denser in 2011, but slightly more sediment coverage was detected.
- **TPE-HVH-6**: Periphyton coverage at TPE-HVH-6 was variable in 2009, with thin flat periphyton mats in some areas, and dense mats with raised fronds in other areas. In 2011, periphyton coverage was moderate on substrate surfaces and high on sides. Sediment coverage was light in 2009 and more noticeable, but still thin and sparse, in 2011.

In general, the construction of the Bay-Goose Dike does not appear to have increased sediment coverage appreciably in HVH areas of TPE, and periphyton thickness and continuity was similar in 2009 and 2011.

Overall, periphyton in HVH areas of both lakes were thick and dense. Despite their healthy appearance, periphyton mats in the deeper zone were associated with some degree of sediment cover, typically light and sparse. This association between sediment and periphyton was also detected in the shallow zone – results from the periphyton mat sediment survey (see **Section 3.3**). This survey of periphyton mats in shallow areas found that there was a positive correlation between organic content and sediment content in periphyton mats across all exposure and reference areas (i.e., thicker mats retain more sediment, regardless of location).

Based on the literature, some studies have shown that an accumulation of fine sediment can result in lowered periphyton biomass and community composition (e.g., Izagirre et al., 2009; Yamada and Nakamura, 2002). However, Vadeboncoeur et al. (2006) studied periphyton chlorophyll content and productivity on various substrates and found the highest area-specific biomass and productivity on sediments (i.e., epipelon), relative to rocks (epilithon), wood (epixylon), macrophytes (epiphyton), or the water column (phytoplankton).

Periphyton mats in both the shallow and deep zones of Second and Third Portage Lakes seem to be quite resilient and do not appear to have been affected by the sedimentation events.

Table 3-4. Qualitative characteristics of the periphyton community from video surveys for SP-HVH areas, 2009 and 2011.

Site Info			Periphyton and Substrate Description			
Area ID	**Year**	**Depth (m)**	**Substrate Composition**	**Periphyton Cover**	**Description of Cover**	**Sediment Cover**
SP-HVH-1	2009	3.0 to 3.9	Boulder (20%), Cobble (30%), Fines (50%)	80%	Denser/more luxuriant periphyton mats in shallow areas. Periphyton coverage on fines is continuous.	Moderate sediment coverage
SP-HVH-2	2009	2.2 to 2.4	Boulder (50%), Cobble (40%), Fines (10%)	80-100%	Mats are thick and highly luxuriant on protected rock sides, but less so on surfaces where sediment may be flattening periphyton.	Some surfaces are more sparse due to thin sediment layer
SP-HVH-3	2009	1.0 to 3.0	Boulder (50%), Cobble (35%), Gravel (5%), Fines (10%)	80%	Denser/more luxuriant periphyton mats with raised fronds in shallow areas. Periphyton mats at depth are continuous but not thick.	Light dusting and very sparse sediment coverage
SP-HVH-4	2009	1.4 to 2.0	Boulder (70%), Cobble (30%)	95%	Patchy in places, very luxuriant in others, but generally all areas have raised fronds.	Some smothering due to thin sediment coverage
SP-HVH-5	2009	1.6 to 2.0	Boulder (60%), Cobble (35%), Fines (5%)	90%	Patchy in places, very luxuriant in others, but generally periphyton coverage appears thick and raised.	Very sparse sediment coverage
SP-HVH-6	2009	1.4 to 1.5	Boulder (100%)	70%	Mat is thick in places, but not continuous, highly patchy. In some areas sporadic long fronds are surrounded by bare rock.	Thin to moderate sediment coverage
SP-HVH-1	2011	3.2 to 3.7	Boulder (30%), Cobble (10%), Fines (60%)	High coverage on surface and sides	Thick periphyton mats with raised fronds on surface and sides; somewhat dense coverage	Thin sediment coverage
SP-HVH-2	2011	2.2 to 2.3	Boulder (45%), Cobble (45%), Pebble (5%), Fines (5%)	Moderate-high coverage on surface and sides	Thick periphyton mats with raised fronds on surface and sides; sparse coverage	Thin and sparse sediment coverage
SP-HVH-3	2011	1.3 to 3.7	Boulder (40%), Cobble & Pebble (30%), Fines (40%)	Moderate coverage on surface and high on sides	Thin, flat and somewhat patchy coverage on surface; thick, raised and dense coverage on sides	Thin and sparse sediment coverage
SP-HVH-4	2011	1.6 to 2.3	Boulder (48%), Cobble (48%), Fines (2%)	High coverage on surface and sides	Thick periphyton mats with raised fronds on surface and sides; somewhat dense coverage	Thin and sparse sediment coverage
SP-HVH-5	2011	2.4 to 3.8	Boulder (40%), Cobble & Pebble (30%), Fines (40%)	High coverage on surface and sides	Thick and raised periphyton with dense coverage on all surfaces	Thin sediment coverage
SP-HVH-6	2011	2.1 to 2.9	Boulder (5%), Cobble (45%), Fines (45%)	Moderate coverage on surface and high on sides	Thin, flat and somewhat patchy coverage on surface; thick, raised and dense coverage on sides	Thin sediment coverage

Notes: Periphyton Cover: Low (0-30%), Moderate (35-70%), High (75-100%); HCF = Habitat Compensation Feature.

Table 3-5. Qualitative characteristics of the periphyton community from video surveys for TPE-HVH areas, 2009 and 2011.

Site Info			Periphyton and Substrate Description			
Area ID	Year	Depth (m)	Substrate Composition	Periphyton Cover	Description of Cover	Sediment Cover
TPE-HVH-1	2009	1.5 to 1.9	Boulder (100%)	75%	Most surfaces covered with mats of high density and luxurious, raised fronds. However, some areas appear to have ice scour where periphyton is absent or very thin.	Thin and sparse sediment coverage
TPE-HVH-2	2009	2.2 to 2.6	Boulder (40%), Cobble (40%), Fines (20%)	90-100%	Highly dense and thick mats with well developed and raised fronds. Mats are continuous on all substrates.	Light sediment dusting
TPE-HVH-3	2009	1.6 to 2.2	Boulder (100%)	75%	Generally thin-moderate density and thickness. Some protected areas are thick and dense with well raised fronds (sides of rocks and in crevices).	Thin and sparse sediment coverage
TPE-HVH-4	2009	3.2 to 3.6	Boulder (65%), Cobble (15%), Fines (20%)	70-90%	Periphyton covers all substrate, mats are mostly continuous, and of medium density and thickness. Periphyton on fines is highly textured. No areas of highly luxurious periphyton, even in crevices.	Thin and sparse sediment coverage
TPE-HVH-5	2009	1.7 to 2.3	Boulder (80%), Cobble (20%)	70%, but higher at depth	Not as thick or dense as HVH-2 but highly continuous, especially at depth. At depth, thick and luxurious periphyton covers all substrate.	Very light sediment dusting
TPE-HVH-6	2009	1.6 to 2.9	Boulder (60%), Cobble (30%), Fines (10%)	60-80%	Highly variable periphyton mats. Some areas on boulders and cobble (especially on sides) are very luxurious and dense, while other boulders and cobble have thin or no periphyton. Mats, where present are continuous, especially on fines.	Light sediment dusting
TPE-HVH-1	2011		Lost due to Bay-Goose Dike Construction			
TPE-HVH-2	2011		Lost due to Bay-Goose Dike Construction			
TPE-HVH-3	2011	1.4 to 2.4	Boulder (100%)	Moderate coverage on surface and high on sides	Thin, flat and somewhat patchy coverage on surface; thick, raised and dense coverage on sides	Thin and sparse sediment coverage
TPE-HVH-4	2011	3.2 to 3.3	Boulder (25%), Cobble (25%), Pebble (25%), Fines (25%)	High coverage on surface and sides	Thick mats of periphyton with raised fronds; dense coverage on all surfaces	Thin and sparse sediment coverage
TPE-HVH-5	2011	1.5 to 2.1	Boulder (100%)	High coverage on surface and sides	Thick mats of periphyton with raised fronds; dense coverage on all surfaces	Thin and sparse sediment coverage
TPE-HVH-6	2011	1.6 to 3.1	Boulder (40%), Cobble & Pebble (30%), Fines (30%)	Moderate coverage on surface and high on sides	Thick, flat and somewhat dense coverage on surface; thick, raised and dense coverage on sides	Thin and sparse sediment coverage

Notes: Periphyton Cover: Low (0-30%), Moderate (35-70%), High (75-100%); HCF = Habitat Compensation Feature.

3.5. Benthic Invertebrates

This section summarizes results of the CREMP benthic invertebrate community studies to provide insights into the potential for adverse effects from TSS related to dike construction.

3.5.1. Results

CREMP monitoring has been conducted since 2006 at a number of lakes surrounding the Meadowbank Mine. As such, it includes pre-development baseline data and thus provides context regarding spatial and temporal variability in the benthic community. In past years, the data set has been used to complement the finer-resolution EAS data sets to aid in the interpretation of the EAS results; this year, sampling was only conducted at the CREMP areas. The CREMP areas are shown in **Figure 2-4**[2]. The potential for mining-related impacts in each sampling area has been tracked annually since the construction phase of the development started in 2008. The status of specific areas over time is shown in **Table 3-6**. This data set was used to test for specific area-year impacts relative to control area-years and for specific longer-term impacts by area (i.e., for areas where more subtle, but prolonged, effects may have occurred). Details on statistical analyses are provided in **Appendix A**.

Response variables for all benthic community analyses were selected to match the requirements of Environment Canada (2002), as follows (see **Section 2.4** for details regarding each variable):

- Total abundance (#/m^2; this is actually density) of all taxa
- Total species richness (# taxa/sample)
- Simpson's diversity (D)
- Bray Curtis Distance (BC)[3]

Detailed results are provided in **Appendix A**. The CREMP data set is summarized by each Area[4] and Year in **Appendix A** (see **Table A3-2** of **Appendix A** for the summary and **Appendix A1** for the raw data file). Results by Area and Year for each variable are

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[2] The Baker Lake areas and Wally Lake were not included. Baker Lake benthos and sediment chemistry is quite different from the Meadowbank project lakes. Wally, which is one of the Meadowbank project lakes, was not included as it is inherently different (e.g., shallow, high TOC and more productive) than the other project lakes.

[3] Bray-Curtis is essentially an index of dissimilarity and the distance is based on comparison to reference (control) areas. It should be noted that large distances can be based on compositional differences between areas that are not related to impairment of the community. Consequently, caution must be used in interpreting this metric.

[4] Note that variable names used in statistical analyses are capitalized.

shown in **Figure 3-7**, highlighting Area-Year combinations (dark points) potentially impacted by mining activities.

Statistical analyses focused on testing for single-year effects and for multi-year effects based on the following rationale for key areas:

- *SP and TE* – These areas were exposed to elevated TSS concentrations in 2008 (East Dike construction) and are the main focus of these analyses. While exposure concentrations were much lower in 2009 and 2010, they remain impact areas.
- *TPE* – In 2009, this area was sampled on August 13/14, which was during construction of the first phase of the Bay-Goose Dike. Monitoring showed TSS concentrations had increased slightly relative to background. Consequently, while TSS exposure was relatively low, this area was conservatively designated as "impact" starting in 2009. TSS concentrations went on to increase in the basin soon after the sampling event (Azimuth, 2010b), but were generally lower during the second year of Bay-Goose Dike construction (AEM, 2011).
- *TPN* – Dewatering discharges from the NW Arm of Second Portage Lake were directed into this basin from March through early July 2009. While CREMP water quality monitoring results for that basin showed negligible exposure conditions, the area was conservatively designated as an impact area for 2009. While not directly related to dike construction activities, TSS is the major constituent of interest in the dewatering effluent and therefore relevant to the EAS.

Results for short-term (i.e., testing for effects in each year since initial exposure to TSS) and long-term (i.e., testing for effects in all years since initial exposure to TSS) effects testing are reported in **Table 3-7** (2008 & 2009; single-year effects as reported in Azimuth, 2010c), **Table 3-8** (2010; single-year effects as reported in Azimuth, 2011a), **Table 3-9** (2011; single-year effects) and **Table 3-10** (2008-2011 or 2009-2011; multi-year effects) for each benthic community metric. Graphical representations of the analyses are shown in box-whisker plots for short-term (**Figure 3-8**) and long-term (**Figure 3-9**) effects. Key results for each area are as follows (followed by a brief discussion of uncertainty):

- *SP (2008, 2009, 2010, 2011 and 2008-2011)* – As reported for the past three years, the 2008 EAS (Azimuth, 2009b) reported a marginal trend ($0.05<P<0.15$) for decreased total abundance at SP that did not extend to TE (see **Table 3-7**). As shown in **Figures 3-7, 3-8 and 3-9**, abundance at SP rebounded in 2009 to slightly below "no-effect" predictions for that area and within the range of SP baseline results (i.e., 2006 – 2007), then dropped again in 2010 (>50% reduction in abundance compared to what was expected). Results for 2011 showed improvements for all endpoints. There were marginal (i.e., $0.05<p<0.15$) long-term trends for total abundance (negative) and Simpson's Diversity[5] (positive). See main report for more discussion.

- *TE (2008, 2009, 2010, 2011 and 2008-2011)* – As discussed above, the marginal trend in abundance observed in 2008 at SP did not extend into (for abundance or any other response variable; see **Tables 3-7 through 3-10**). The other single-year (2009 through 2011) and the multi-year (2008-2011) results confirm that finding and reaffirm that there does not appear to be any significant changes at TE related to mining activity (there was a marginal increase in Simpson's Diversity for the long-term effects). **Figure 3-7** shows this the best for all response variables. Most results for TE since 2008 are within the range of baseline results. The two low Simpson's Diversity results for TE in 2009 are due to replicate samples that contained relatively high numbers of sphaerid clams, which substantially reduced the diversity scores for those replicates (but not richness).
- *TPE (2009, 2010 and 2009-2010)* – Given that this area is up-gradient of the East Dike and in the same basin (i.e., East Basin of Third Portage Lake) as the Bay-Goose Dike, the results for this area are only relevant for the Bay-Goose EAS. The main trends seen at this area were a decrease in benthic invertebrate abundance (not significant for 2009, 2010 or 2011separately [**Tables 3-7 through 3-9**], but significant for the 2009-2011 multi-year effect [**Table 3-10**]) and an increase in Simpson's Diversity (marginal for 2010 [**Table 3-9**] and significant for 2009-2011 [**Table 3-10**]). The overall results for abundance are heavily influenced by the 2008 data, where abundance and richness were anomalously elevated relative to what would be expected in that basin (see **Figure A3-5 and A3-6** in **Appendix A**).
- *TPN (2009, 2010, 2011 and 2009-2011)* – As discussed above, this area was potentially exposed to elevated TSS during dewatering of the NW arm of Second Portage Lake starting in March 2009. During dewatering, AEM was required to discharge water that was lower than TSS thresholds to minimize the potential for adverse effects in Third Portage Lake north basin. Based on CREMP water quality (Azimuth, 2010a; 2011b; 2012a) and Bay-Goose dike construction monitoring (Azimuth, 2010b), TSS values in the north basin were very low (< 1 mg/L), suggesting that adverse effects to the benthic community would be unlikely. This was confirmed by the CREMP benthos results, which had no significant adverse effects. The only significant or marginal changes observed were increases for richness (2010; **Table 3-8**) and Simpson's Diversity (2009-2011; **Table 3-10**).

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[5] Simpson's diversity index is sensitive to how organisms are allocated across taxa, not to the number of taxa.

As discussed in **Appendix A**, effect sizes and associated confidence intervals help to place the observed results into perspective. As seen in **Tables 3-7 to 3-10**, the confidence intervals associated with reported effect sizes were quite large in a number of cases (i.e., reflective of high uncertainty in the estimated effect size). These confidence intervals are due to the fairly high degree of spatial and temporal variability that exists naturally in this region. The larger the confidence interval, the larger the effect size required for a statistically significant result (i.e., lower power). The degree to which the confidence interval extends above zero (or below for an adverse positive change, such as Bray Curtis distance) is a rough measure of how much larger an effect would have needed to be in order to be considered statistically significant.

The implication of this situation is that statistical significance should not be the only consideration when evaluating these results. As per previous year's EAS reports (Azimuth 2009a, 2010c, 2011a), which highlighted the decrease in abundance at SP in 2008, marginal trends have been highlighted when p-values range between $0.05 < p < 0.15$. A variety of graphical methods have also been used to help visualize what the statistical models are actually testing.

The observed changes in the CREMP data set will be discussed in a broader temporal and spatial context using a weight-of-evidence approach in the following section.

3.5.2. Benthos Weight of Evidence

Since the first EAS study was conducted in 2008 (Azimuth, 2009b), two main data sets have been used to assess the potential effects of dike-construction-related-TSS on benthic invertebrate communities: (1) the CREMP, which provides a broader spatial (all Meadowbank study lakes) and temporal (since 2006) context, and (2) the EAS, which provided a higher resolution spatial (focusing on Second Portage Lake and on the east basin of Third Portage Lake only) and more narrow temporal (2009 [Second Portage Lake only] and 2010 [both lakes] only) context. While each independently provides some insights into the potential for TSS related impacts, collectively they support making stronger inferences regarding the nature of observed changes. Ideally, consideration of broader spatial and temporal patterns in the data should help to better elucidate the relative importance of natural variability *versus* TSS in explaining observed changes.

Tables 3-11 and 3-12 present weight-of-evidence assessments for Second Portage Lake (i.e., targeting potential effects related to sediment releases from construction of the East Dike in 2008) and for the east basin of Third Portage Lake (i.e., targeting potential effects related to sediment releases from construction of the Bay-Goose Dike in 2009 and 2010). The 2010 EAS included sediment toxicity testing and sequential extraction analyses (i.e., to assess metals bioavailable) to assess the potential for contaminant-related effects; both components suggested that metals-related effects to biota were unlikely. Consequently, physical smothering is considered the most likely mechanism for TSS-related adverse effects to the benthic

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Second Portage Lake – East Dike
(unpublished data, 2012)

Additional monthly benthic community data (for July, August and September) were collected in 2009 and 2010 at the CREMP SP area and two locations situated inside the dike construction work zone (i.e., within the turbidity barrier enclosure), TRB-1 (north) and TRB-2 (south). During East Dike construction, TRB-2 had higher TSS exposure than TRB-1; both had much higher than SP (see TSS exposure plot in **Appendix J**). VanEngen's sampling methods and benthic taxonomy were consistent with the CREMP and EAS.

Pre-construction sampling was conducted in July 2008 at TRB-1 and TRB-2; historical CREMP results were used for SP.

VanEngen's results were generally consistent with those reported herein:

- An initial drop in abundance and richness after dike construction (larger response at TRB-2 than TRB-1, as expected from exposure differences) that showed some recovery by September 2009, then declined again by August 2010. The 2010 decline in abundance was most pronounced at SP and contradicted trends associated with TSS monitoring.
- While VanEngen's data collection ended in September 2010, there was a substantial increase in abundance and richness seen over that last month at all sampling areas. Abundance and diversity were generally equal to or exceeded pre-construction baseline levels.

Overall, VanEngen's data corroborate the initial response seen at SP in 2008. A significant reduction in abundance was still apparent at TRB-2 one year after dike construction. The recovery pattern after that, however, was also obscured by the August 2010 results, which appears related to natural variability rather than to construction of the East Dike). The large increase (i.e., larger than the initial effect) seen between August and September 2010 exemplify the just how variable the benthic community can be naturally (see abundance and richness plots in **Appendix J**).

community. The expected response, therefore, would be a fairly sharp decline associated with the period of highest exposure, then some sort of recovery after exposure stops (i.e., either rapid or prolonged, depending on exposure characteristics). Given these impact hypotheses, the lack of an observed "recovery" could suggest that there may not have been an adverse effect from which to recover.

3.5.2.1. Second Portage Lake

There is reasonable (but not conclusive) evidence (**Table 3-11**) to suggest that changes to the benthic community observed in the CREMP 2008 were due to construction-related sediment inputs (i.e., SP had the lowest abundance measured at that area compared to baseline data). Since then, however, patterns of abundance and richness have been variable and not consistent with either a rapid or prolonged recovery. The large drop in abundance and richness seen at the CREMP SP area in 2010 (a period of relatively low TSS in Second Portage Lake) was not seen in any of the five sampling areas of the EAS data set (despite a regional trend for lower abundance in 2010); consequently, this result was considered highly localized (i.e., not representative of general conditions in Second Portage Lake in 2010) and unlikely related to dike construction (consistent with the findings of VanEngen [unpublished data, 2012; see **text box**]). Indeed, this type of result obscures the detection of a consistent recovery, with the "signal" getting lost in the "noise" of natural variability.

Alternatively, it may be that the original "signal" of impact observed in 2008 was also part of the "noise" of natural variability (although that seems unlikely given the corroboration of initial response found by VanEngen [unpublished data, 2012; see **text box**]). There are examples from Meadowbank CREMP areas (i.e., either the reference areas or baseline [collectively the "control" data]):

- **Wally Lake (WAL)** – This lake was not featured in the EAS assessment as it is generally much shallower and more productive than either Second Portage Lake or the east basin of Third Portage Lake; the 2011 CREMP report (Azimuth, 2012a) contains time series plot for this area for key benthic community metrics. Benthos abundance dropped nearly two fold between 2006 and 2007, and then dropped over four fold the next year; 2011 numbers were an order of magnitude lower than they were in 2006. Taxa richness dropped by a third in 2008 and have an overall downward trend since 2006.
- **Inuggugayualik Lake (INUG)** – Abundance dropped nearly two fold between 2008 and 2010; taxa richness dropped by nearly a third over this same period.
- **East Basin of Third Portage Lake (TPE)** – Abundance increased approximately three-fold, and taxa richness by a quarter, between 2007 and 2008.

- **North Basin of Third Portage Lake (TPN)** – Between 2006 and 2008, abundance and taxa richness decreased by two times and approximately a third, respectively.

Another example is the large increase seen between August and September 2010 in VanEngen's results (unpublished data, 2012; see **Appendix J** abundance and richness plots and **text box**). These results demonstrate the magnitude of some of the natural changes in benthic community occurring in the Meadowbank study lakes. Some of the biggest shifts have not been consistent among lakes, making it particularly hard to determine whether changes at the near-field impact areas are due to natural or mine-related causes.

3.5.2.2. Third Portage Lake – East Basin

The results for the east basin of Third Portage Lake are also somewhat inconclusive (**Table 3-12**), again related to challenges discerning between natural variability and low level TSS exposure. In this case, the main cause is the high (but potentially anomalous) invertebrate abundance measured during baseline period at the CREMP area TPE (i.e., the change in 2008 noted above). Firstly, despite low exposure to TSS in 2009, a large (but not statistically significant) drop in benthos abundance was observed at the CREMP area TPE. Given the low exposure to TSS, this observed change was likely due to natural variability. Secondly, the further change in abundance observed at TPE in 2010 was also not statistically significant and was likely due to the regional trend in decreased abundance that occurred in 2010 (see **Table 3-12**). Thirdly, the 2010 EAS data (see **Table 3-12**) showed no significant difference in abundance between the east basin impact areas and the control areas. The 2011 CREMP results documented a modest increase in abundance and a slight decrease in taxa richness. Overall, trends in both abundance and taxa richness at CREMP TPE since 2009 have been slightly below the baseline range, but not by much relative to the large, natural swings discussed previously for the CREMP control data.

3.5.2.3. Conclusions

This component of the EAS study was initiated to assess the potential effects of TSS from sedimentation events associated with dike construction to the benthic community. Overall, after four years of study, the results based on annual data (i.e., CREMP and EAS August data) are inconclusive due to high natural variability. At SP, the recovery following the initial response in 2008 has not been consistent. A similar result was seen in the monthly data (unpublished data, VanEngen, 2012), where the initial drop was substantial but recovery variable, ending with a large increase over the last month of the study (see abundance and richness plot in **Appendix J**). At TPE, no pattern of impact-recovery has been seen at all due to the high natural variability.

As discussed previously, the magnitude of natural changes observed in the CREMP control data have been much higher than the changes observed in SP and TPE. There may have been an initial sedimentation-related drop in benthos abundance at SP in 2008, but a consistent response pattern has not been observed since; the alternating increases and decreases appear better explained by natural variability as the don't match the exposure pattern. The same holds true for the east basin of Third Portage Lake. A large "drop" (a reduction after a large peak in 2008) in abundance and taxa richness was observed at TPE in 2009, despite sampling taking place very early in the sedimentation event (i.e., when TSS concentrations in the water column were above background, but far below peak concentrations). TPE abundance dropped further in 2010 (i.e., the period after the highest TSS exposure), but so did many of the lakes and basins away from mining activity that year. Given this pattern, one could ask whether there has even been a TSS-related drop at TPE. While inconclusive, the prevailing patterns in the available data for both lakes do not support the presence of a TSS-related impact (i.e., the abundance reductions observed in the CREMP data do not appear related to TSS).

Table 3-6. Area “effect” status by year for CREMP data set.

Year	INUG	PDL	TPS	TEFF	SP	TE	TPE	TPN
2006	C		C		C		C	
2007	C		C		C	C	C	C
2008	C		C		I	I	C	C
2009	C	C	C	C	I	I	I	I
2010	C	C	C	C	I	I	I	I
2011	C	C	C	C	I	I	I	I

Note: 1. Area designations: C = control; I = impact.

Notes: Only CREMP areas relevant to 2011 EAS are shown.

Table 3-7. Results of statistical analyses of benthic invertebrate community descriptors for the 2008 and 2009 CREMP data set; short-term effect (from 2009 EAS report; Azimuth, 2010c).

	Total Abundance (#/m²)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x-120)	NA	NA	NA
Tests relative to controls				
C-SP2008 Differences?	No	No	No	No
p-value	0.08	0.27	0.12	0.95
Effect Size	-578	-2.4	0.11	-0.01
95% Upper CI[3]	-775	-7.1	-0.04	-0.24
95% Lower CI[3]	184	2.3	0.26	0.33
C-TE2008 Differences?	No	No	No	No
p-value	0.47	0.89	0.14	0.24
Effect Size	-396	0.3	0.12	-0.16
95% Upper CI[3]	-881	-5.0	-0.05	-0.36
95% Lower CI[3]	1824	5.6	0.28	0.16
C-SP2009 Differences?	No	No	No	No
p-value	0.68	0.26	0.60	0.75
Effect Size	-195	-2.6	0.04	-0.04
95% Upper CI[3]	-693	-7.7	-0.12	-0.24
95% Lower CI[3]	1948	2.5	0.20	0.27
C-TE2009 Differences?	No	No	No	No
p-value	0.51	0.37	0.80	0.77
Effect Size	-384	-2.3	-0.02	-0.04
95% Upper CI[3]	-893	-7.9	-0.20	-0.26
95% Lower CI[3]	2195	3.4	0.16	0.31
C-TPE2009 Differences?	No	No	No	No
p-value	0.19	0.68	0.24	0.65
Effect Size	-2047	-0.9	0.08	-0.04
95% Upper CI[3]	-3197	-5.7	-0.07	-0.21
95% Lower CI[3]	2512	3.9	0.23	0.21

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables &
3. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
4. Results are for model adjusted to account for unequal variances (see text for details).
5. Model assumptions not met, see text for details.

Table 3-8. Results of statistical analyses of benthic invertebrate community descriptors for the 2010 CREMP data set; short-term effect (from 2010 EAS report; Azimuth, 2011a).

	Total Abundance (#/m²)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x-70)	NA	NA	NA
Tests relative to controls				
C-SP2010 Differences?	Marginal	No	No	No
p-value	0.07	0.55	0.67	0.49
"No Effect" Mean[3]	599	5.7	0.67	0.67
Effect Size	-362	-1.3	0.03	0.08
95% Upper CI[4]	-483	-6.2	-0.11	-0.15
95% Lower CI[4]	83	3.6	0.16	0.43
C-TE2010 Differences?	No	No	No	No
p-value	0.57	0.74	0.29	0.94
"No Effect" Mean	697	5.6	0.64	0.66
Effect Size	-194	0.8	0.07	-0.01
95% Upper CI[4]	-524	-4.6	-0.07	-0.23
95% Lower CI[4]	1203	6.3	0.22	0.33
C-TPE2010 Differences?	No	No	Marginal	No
p-value	0.23	0.50	0.06	0.45
"No Effect" Mean	2160	8.4	0.67	0.60
Effect Size	-1035	1.4	0.12	-0.07
95% Upper CI[4]	-1780	-3.2	-0.01	-0.23
95% Lower CI[4]	1506	6.1	0.24	0.16
C-TPN2010 Differences?	No	Yes (incr.)	No	No
p-value	0.55	0.05	0.11	0.88
"No Effect" Mean	714	5.4	0.67	0.60
Effect Size	263	5.0	0.10	0.02
95% Upper CI[4]	-392	0.1	-0.03	-0.18
95% Lower CI[4]	2614	9.8	0.23	0.30

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

Table 3-9. Results of statistical analyses of benthic invertebrate community descriptors for the 2011 CREMP data set; short-term effect.

	Total Abundance (#/m^2)	Taxa Richness (# taxa/ sample)	Simpon's Diversity (unitless)[5]	Bray Curtis Distance (unitless)[5]
Data Transformation[1]	Log10	None	None	None
Advanced Transformation[2]	Log10(x-10)	NA	NA	NA
Tests relative to controls				
C-SP2011 Differences?	No	Marginal	No	No
p-value	0.78	0.14	0.17	0.46
"No Effect" Mean[3]	647	7.1	0.72	0.63
Effect Size	-85	3.1	0.08	0.18
95% Upper CI[4]	-458	-1.2	-0.04	-0.23
95% Lower CI[4]	1068	7.5	0.21	1.01
C-TE2011 Differences?	No	No	No	No
p-value	0.87	0.89	0.29	0.95
"No Effect" Mean	791	6.5	0.66	0.60
Effect Size	-68	-0.3	0.07	-0.01
95% Upper CI[4]	-559	-4.9	-0.07	-0.33
95% Lower CI[4]	1516	4.3	0.20	0.68
C-TPE2011 Differences?	No	No	No	No
p-value	0.42	0.87	0.62	0.41
"No Effect" Mean	2357	9.7	0.72	0.77
Effect Size	-774	-0.3	0.03	-0.19
95% Upper CI[4]	-1803	-4.4	-0.09	-0.49
95% Lower CI[4]	2205	3.8	0.15	0.44
C-TPN2011 Differences?	No	No	Marginal	No
p-value	0.38	0.52	0.09	0.48
"No Effect" Mean	779	6.7	0.72	0.69
Effect Size	-282	1.3	0.10	-0.15
95% Upper CI[4]	-608	-3.0	-0.02	-0.44
95% Lower CI[4]	703	5.5	0.23	0.46

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

Table 3-10. Results of statistical analyses of benthic invertebrate community descriptors for the 2006 to 2011 CREMP data set; long-term effect.

	Total Abundance (#/m²)	Taxa Richness (# taxa/ sample)	Simpon's Diversity (unitless)[5]	Bray Curtis Distance (unitless)[5]
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x+50)	NA	NA	NA
Tests relative to controls				
C-SP'08-'11 Differences?	Marginal	No	Marginal	No
p-value	0.10	0.61	0.10	0.87
"No Effect" Mean[3]	836	8.05	0.71	0.60
Effect Size	-379	-0.8	0.07	0.02
95% Upper CI[4]	-625	-4.3	-0.01	-0.17
95% Lower CI[4]	101	2.6	0.15	0.29
C-TE'08-'11 Differences?	No	No	Marginal	No
p-value	0.29	1.00	0.07	0.89
"No Effect" Mean[3]	1018	7.41	0.65	0.60
Effect Size	-335	-0.01	0.08	0.01
95% Upper CI[4]	-710	-3.70	-0.01	-0.18
95% Lower CI[4]	432	3.68	0.17	0.30
C-TPE'09-'11 Differences?	Yes	No	Yes	No
p-value	0.02	0.97	0.02	0.11
"No Effect" Mean[3]	2866	10.02	0.70	0.70
Effect Size	-1484	-0.06	0.10	-0.16
95% Upper CI[4]	-2139	-3.20	0.02	-0.32
95% Lower CI[4]	-277	3.09	0.17	0.05
C-TPN'09-'11 Differences?	No	No	Yes	No
p-value	0.67	0.24	0.01	0.33
"No Effect" Mean[3]	963	7.08	0.69	0.63
Effect Size	-130	1.96	0.11	-0.10
95% Upper CI[4]	-556	-1.43	0.03	-0.26
95% Lower CI[4]	692	5.34	0.19	0.13

Notes:
1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

Table 3-11. Weight-of-evidence assessment of potential TSS-related impacts to benthic invertebrates for Second Portage Lake from construction of the East Dike.

Lake (Basin)	Year(s)	CREMP	EAS	Weight-of-Evidence Interpretation
Second Portage Lake				
Elevated TSS primarily from East Dike construction in 2008, but also to a much lower degree from Bay-Goose Dike construction in 2009 and 2010.	2008	Marginally significant, but large drop in abundance was found at SP in 2008. This trend did not extent to TE.	No data.	Benthic community change (while statistically marginal) was substantial and affected both abundance and richness. Responses patterns at SP and TE consistent with TSS exposure gradient (i.e., much lower TSS in Tehek Lake).
	2009	Apparent recovery seen at area SP in 2009, particularly for abundance, which was within the range of baseline conditions.	EAS study initiated; Community abundance and richness about 30% lower at impact areas relative to controls in 2009. The impact area results were, however, within the range of baseline conditions for Second Portage Lake. These results are consisten with inherent differences between the EAS impact areas (largely in Second Portage Lake) and the EAS control areas (i.e., consisting of one within-lake reference and a number of other CREMP areas), but could be due (in part) to TSS-related effects.	The apparent recovery at SP (CREMP) suggests that the differences observed in the 2009 EAS data are likely due to inherent inter-lake differences rather than to TSS exposure (i.e., SP and TE communities were typically lower in abundance and richness than other lakes from baseline studies). This is supported by the EAS impact area data largely meeting or exceeding baseline conditions in Second Portage Lake. Some contribution from the residual TSS effects, however, cannot be ruled out (particularly given the 2010 results below).
	2010	A marginally significant, but large drop was seen again at area SP in 2010, for both abundance and richness. This was over and above the general decrease in abundance and richness observed at most CREMP areas in 2010 (regional trend).	Evidence of a "recovery" (see text) at impact areas in 2010 was observed relative to 2009 results. Similar to 2009, it is difficult to attribute this to a true recovery as the data (except for SP) were within or exceeded the range of baseline conditions for the lake. That said, it is also difficult to understand why the lake wouldn't respond to a regional trend like most of the control areas.	SP was the only impact station in the EAS data set to drop substantially in 2010, suggesting a highly local trend at SP (not expected to be related to TSS exposure). The overall "recovery" observed at EAS impact areas (despite the drop at SP) suggests an improvement in 2010 relative to control areas. However, it is difficult to attribute this to a true recovery (as opposed to inherent inter-lake differences).
	2011	Results showed improvements for all endpoints relative to 2010. While mean total abundance was slightly below the baseline means, mean total richness was the highest seen to date.	No data.	See main text for more discussion.
	2008 to 2011	When the above years are looked at together (i.e., asking whether there have been longer-term changes since the TSS event), there is a marginal trend for community abundance (reduction) and Simpson's Diversity (increase) compared to controls.	2010 data show relative improvements relative to 2009, with impact area means well within the historical range for SP. There were no data for 2011.	The marginal trend for reduced abundance at SP in the CREMP data was strongly influenced by the 2010 results, which were thought to be localized and unrelated to TSS exposure (see the 2010 discussion above). Overall, while the initial marginal response in 2008 may have been related to sedimentation, any "signal" of a recovery appears lost in the "noise" of natural variability. See main report for more discussion.

Table 3-12. Weight-of-evidence assessment of potential TSS-related impacts to benthic invertebrates for Third Portage Lake from construction of the Bay-Goose Dike.

Lake (Basin)	Year(s)	CREMP	EAS	Weight-of-Evidence Interpretation
Third Portage Lake - East Basin				
Elevated TSS primarily from Bay-Goose Dike in 2009 and 2010.	2009	Baseline conditions were variable with high abundance and diversity in 2006 and 2008. Despite a substantial drop in abundance and richness in 2009, none were statisitically significant. Exposure to TSS was also quite low, suggesting that the observed responses were likely due to natural fluctuations.	No data.	Results for TPE show a large drop that was not statistically significant, likely due to high variability at this station in baseline years and in the 2009 data.
	2010	Another drop in abundance and richness was observed in 2010, but of similar magnitude to the general regional trend of decreased abundance and diversity observed at most CREMP areas. None were statistically significant.	No significant differences identified between impact and control areas.	Both found no significant differences relative to controls, but variability was high (resulting in large confidence intervals) so there is uncertainty in this conclusion.
	2011	There were no statistically significant changes to the benthic community in 2011. Abundance increased relative to 2010 and was slightly below the 2007 baseline. Richness dropped slightly relative to 2010 and was more variable.	No data.	See main text for more discussion.
	2009 to 2011	Significantly reduced abundance at TPE from 2009 to 2011. This result is likely influenced by the anomalously high abundance observed in 2008.	Only 2010 data available; see above.	The CREMP results are strongly influenced by the very high abundance found at TPE during 2008. While the 2009 TPE results were within the baseline range, the 2010 results were the about a third lower than was measured at TPE in 2009. That said, there was a general trend of decreased abundance at most CREMP areas in 2010 (regional trend).

Figure 3-7. Benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) across CREMP areas for 2006 – 2011.

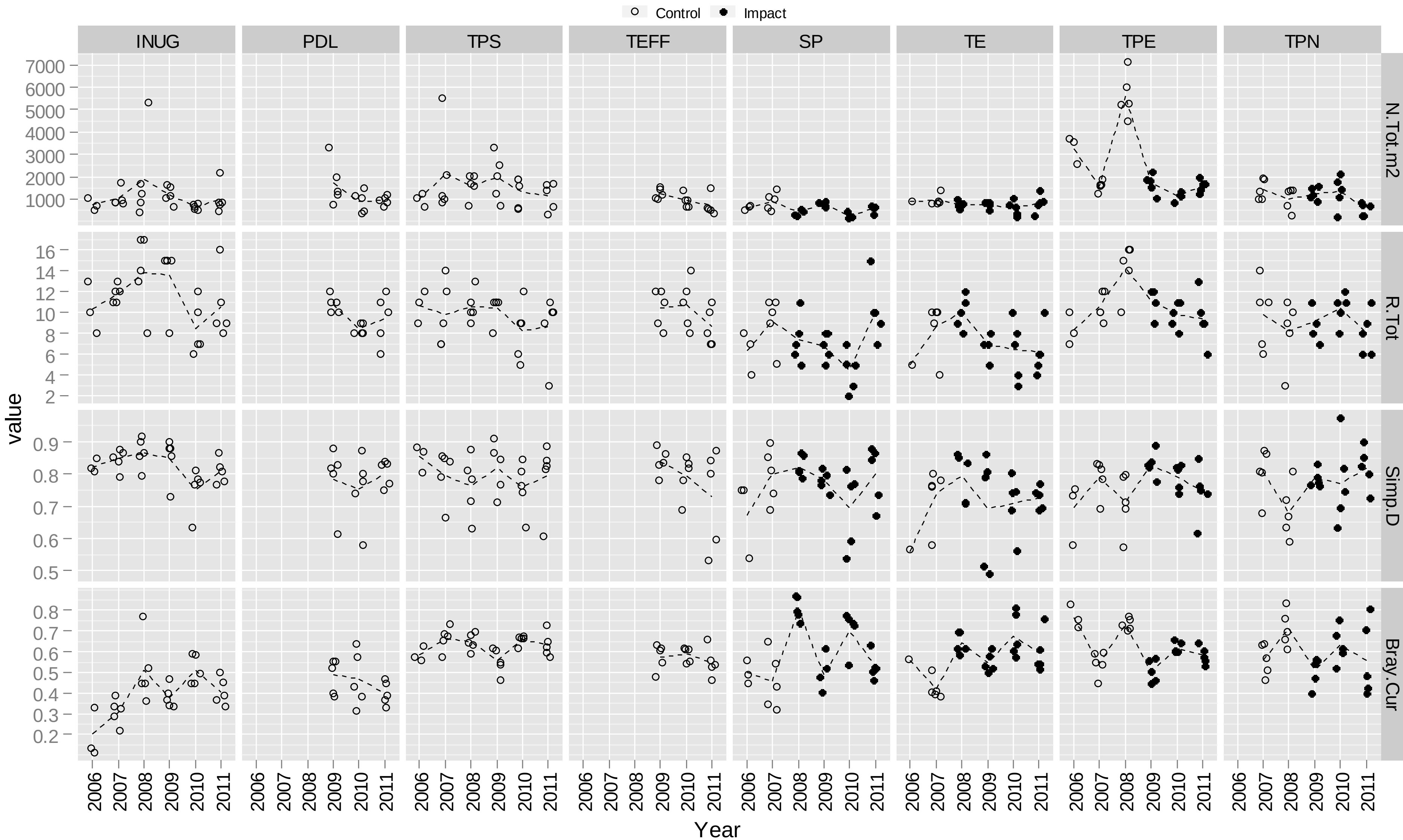


Figure 3-8. Boxplots of benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) by short-term effect grouping for CREMP data set.

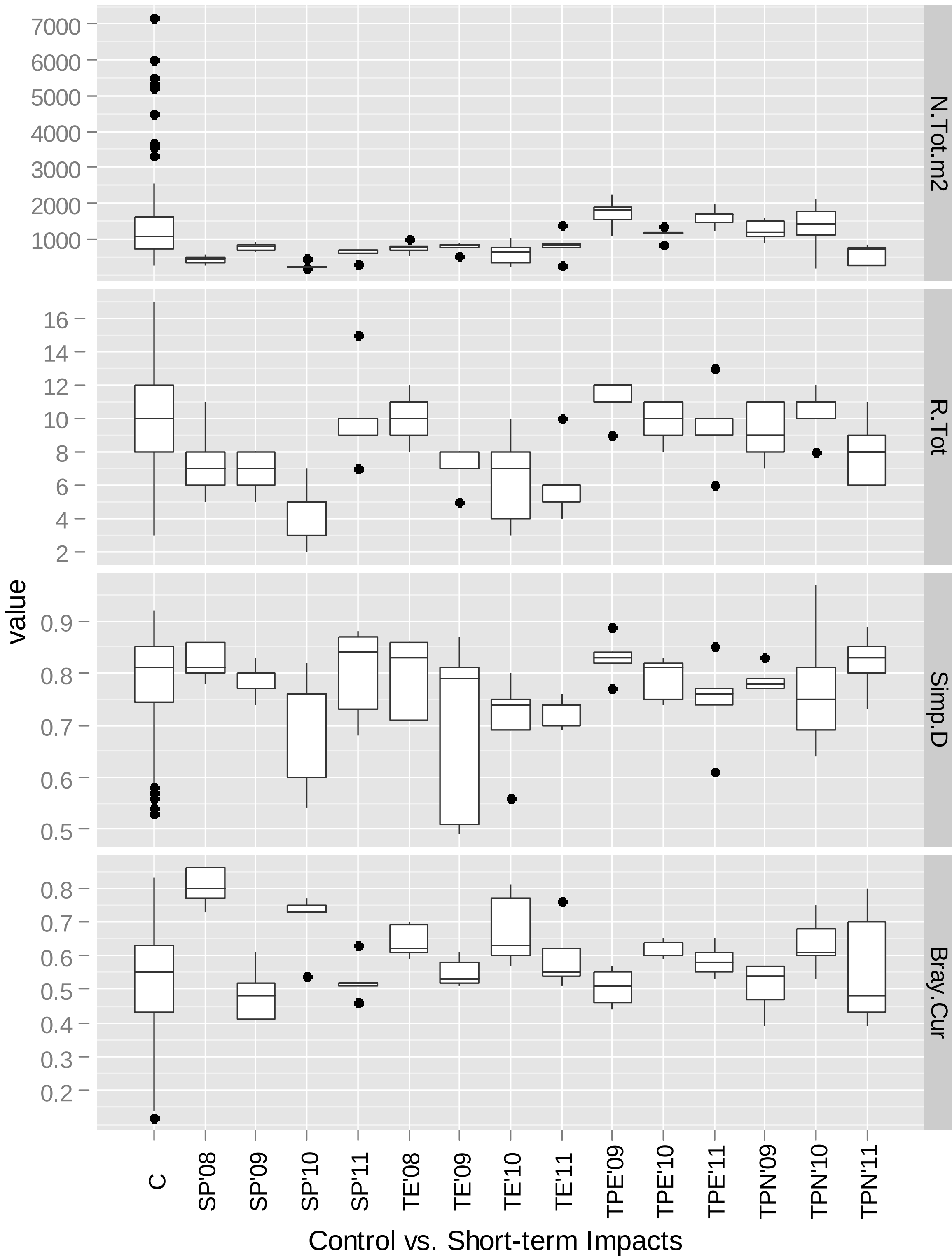
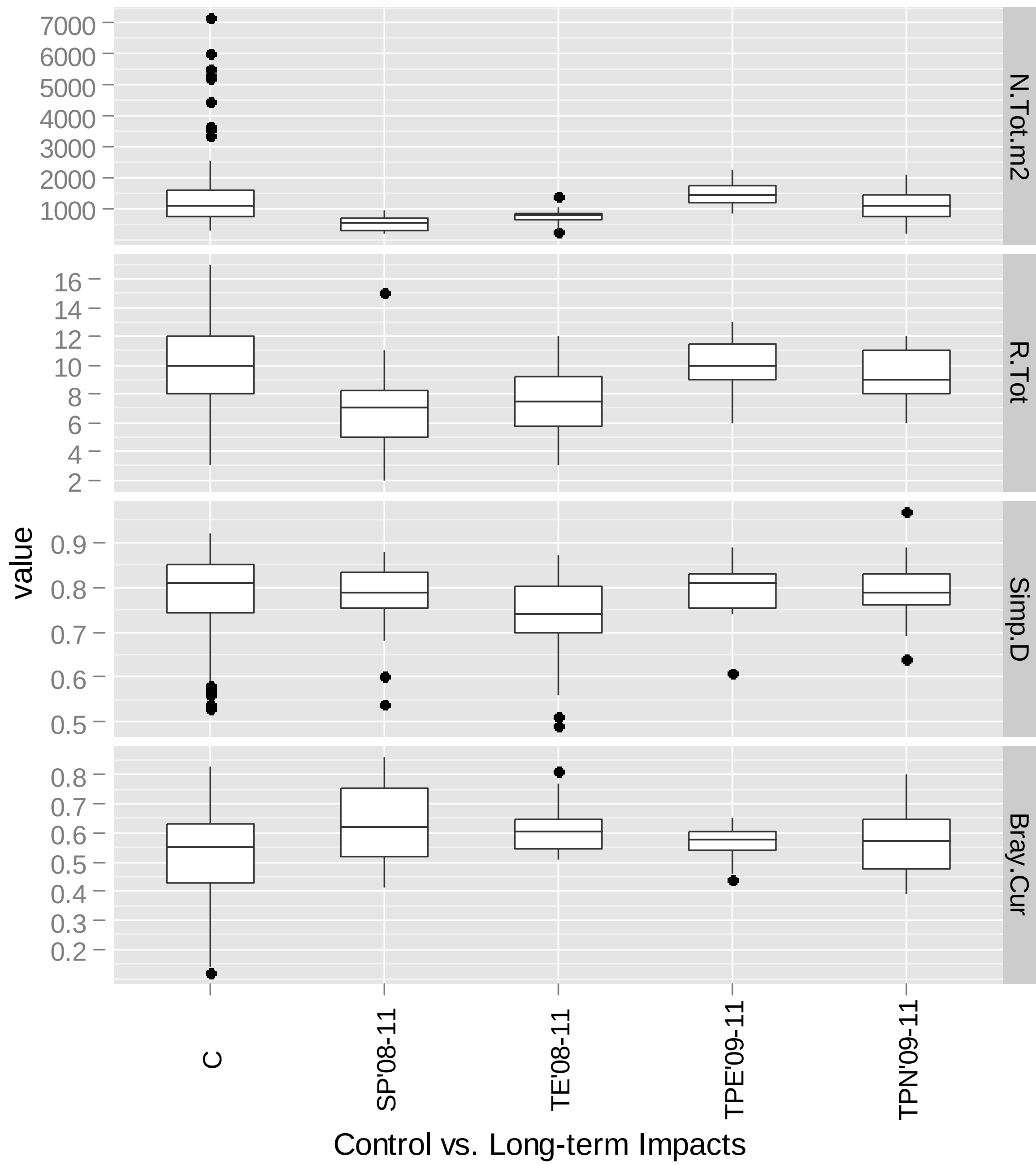


Figure 3-9. Boxplots of benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) by long-term effect grouping for CREMP data set.



4. CONCLUSIONS AND RECOMMENDATIONS

AEM commissioned studies[6] in each of the last four years (2008 - 2011) to address concerns regarding potential impacts on the local receiving environment of elevated TSS concentrations associated with dike construction. Based on the literature, elevated TSS concentrations can directly or indirectly affect the entire range of organisms in the aquatic environment, so these studies have addressed a broad array of ecosystem elements.

The East Dike TSS EAS was initiated in 2008 and targeted the effects of TSS from East Dike construction, primarily on Second Portage Lake, but also extending into Tehek Lake (Azimuth, 2009b). As planned, this study continued into 2009 (Azimuth, 2010c), 2010 (Azimuth, 2011a) and 2011 (this report), focusing more on characterizing potential deposition-related impacts, largely to periphyton and benthic invertebrate communities.

The Bay-Goose TSS EAS was initiated in 2009 and targeted the effects of TSS from Bay-Goose construction, primarily on the east basin of Third Portage Lake, but also downstream into Second Portage Lake and Tehek Lake. Due to the phased nature of construction of the Bay-Goose Dike (i.e., Phase 1 in 2009; Phase 2 in 2010), the timing of study components has been variable, with some conducted in 2009 (Azimuth, 2010c) and others conducted in 2010 (Azimuth, 2011a) and 2011 (this report).

Collectively, the results of these studies have improved our understanding of the potential short-term and long-term effects of elevated TSS on a broad range of ecosystem components in local receiving environments. Results to date for each major study component have been summarized in **Table 4-1** (2011 results highlighted in **bold**) for both TSS EAS studies to provide a more holistic perspective.

TSS EAS studies have targeted both the pelagic zone (i.e., water column) and benthic zone (i.e., lake bottom) of receiving environments. Elevated TSS concentrations over basin-wide spatial scales were well documented for both studies, lasting on the scale of weeks-to-months. While the TSS had obvious consequences for water clarity (and thus light penetration), no other substantial changes to local limnology were identified. From a water chemistry perspective, elevated metals and nutrients were largely found to be associated with particulates rather than in dissolved (and more bioavailable) form. From a water column (pelagic zone) perspective, both TSS EAS studies identified some short-term effects to primary productivity (e.g., phytoplankton biomass). However, these did not appear to cascade up the food chain to zooplankton. Consequently, based on available data, indirect effects to higher-level organisms through reduced prey biomass are considered unlikely. This was also corroborated in the laboratory with a larval trout test using live zooplankton as a food resource. With respect to potential direct effects in the

[6] In addition to the TSS EAS, AEM funded graduate research conducted by VanEngen (some of which is presented in the **text box** in **Section 3.5.2 and Appendix J**.

water column, no adverse effects to zooplankton or fish were seen in toxicity tests. Thus, the body of evidence collected to date suggests that while some effects have been seen in the water column, they were likely limited in time and were not shown to propagate up the food chain.

In contrast to the pelagic zone, where potential effects would be linked to suspended sediments in the water column and thus less likely to have prolonged consequences, the benthic zone is susceptible to the potential effects of sedimentation. Sediment traps have been used to document sedimentation rates, deposition thickness and chemistry of settled matter over the last four years, both during the open water season and under ice cover. The 2008 results suggested that between 1 to 1.5 mm of construction-related deposition occurred in Second Portage Lake, and identified possible changes to surface sediment chemistry (i.e., settled material in the traps contained elevated concentrations of several metals). Surface sediment chemistry results for 2009 did confirm that certain metals had increased in concentration in Second Portage Lake and in Tehek Lake relative to baseline. Thus, initial concerns in this zone related primarily to physical smothering and to metals toxicity.

The concerns regarding metals toxicity were directly tested in 2010 using sediment toxicity tests and sequential extraction analysis. Results of amphipod (*Hyalella azteca*) and midge (*Chironomus tentans*) survival and growth endpoints in bioassays showed that surface sediments collected from within or adjacent to the East Dike construction zone (i.e., the zone delineated by the turbidity barriers) were not toxic relative to local reference sediment. The sequential extraction results showed that the most of the metals in the sediment are associated with the residual matrix fraction, which is not considered bioavailable. Consequently, metals toxicity is not likely an issue.

From a physical effects perspective, initial studies on periphyton biomass and community structure in Second Portage Lake conducted in 2009 identified reduced biomass and altered community composition in close proximity to the East Dike (i.e., in an area that would have been exposed to high TSS concentrations in 2008); these differences were not observed in an area exposed to lower TSS concentrations in 2008 (Azimuth, 2010c). Follow-up studies conducted in 2010 provided greater spatial resolution, confirming that effects were limited to the area closest to the East Dike.

Given the correlation between periphyton mat sediment load and biomass, more extensive studies on periphyton mat sediment load were conducted throughout the east basin of Third Portage Lake and repeated in Second Portage Lake (to cross-validate the approach) in 2011. Both the organic and inorganic content of the periphyton mat was measured. The results were consistent with those reported above for Second Portage Lake; in general there were no apparent differences between reference and exposure areas, but potential localized impacts were identified near the Bay-Goose Dike (although there were also examples of similar natural results in reference areas).

For benthic invertebrates, the 2008 CREMP data indicated reduced benthic invertebrate abundance (a marginal trend) in Second Portage Lake (that did not extend to Tehek Lake); this was no longer observed in 2009 (i.e., abundance was similar to baseline), suggesting a short-term physical effect and subsequent recovery. The higher resolution EAS results in 2009 highlighted natural differences between Second Portage Lake (and Tehek) and the control areas (i.e., inherent inter-lake differences). Unfortunately, the 2010 results were contradictory, with the CREMP showing an even bigger drop in 2010 than that observed in 2008 (despite very low TSS exposure in 2010) and the EAS data suggesting further recovery relative to control areas. When considered together, the 2010 CREMP results are likely highly localized and unrelated to TSS. Results from 2011 CREMP data showed improvements for all endpoints relative to 2010. While mean total abundance was slightly below the baseline means, mean total richness was the highest seen to date. Overall, high natural variability has precluded the confident identification of impact-recovery patterns linked to TSS exposure in Second Portage Lake (i.e., neither a strong impact nor a consistent recovery pattern are evident). The VanEngen study (unpublished data 2012; see **text box** in **Section 3.5.2**) showed a stronger impact at two areas that were inside the turbidity barrier zone during dike construction (consistent with predicted effects from a model)[7], but a similarly inconsistent recovery trend obscured by natural variability. Both these studies, however, agree that there do not appear to be any lingering effects of dike construction in Second Portage Lake.

Available data for potential effects to benthic invertebrate communities in the east basin of Third Portage Lake are also inconclusive. While most results point to the lack of any TSS-related impacts to the community, there have been two successive drops in abundance that coincide with dike construction. However, these “drops” are likely due to natural variability (2009) or a regional trend of decreased abundance and richness (2010). The 2011 results are again in line with baseline levels for both metrics (abundance and richness). The overall response patterns observed in the east Basin of Third Portage Lake appear consistent with natural variability rather than with exposure to TSS.

As for fish and fish habitat, the 2008 results raised concerns regarding physical effects due to sedimentation on high-value habitats. These concerns were raised based on the sediment trap results (discussed above) and on the trout embryo development toxicity (no renewal) test, which suggested that physical settling of particles onto embryos could impair development. Habitat compensation monitoring conducted in 2009 and 2011

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[7] VanEngen (unpublished data, 2012) used available monitoring data for TSS concentration and duration) in a TSS impact model (Newcombe and Jensen, 1996) to predict effects in Second Portage Lake. The model predicted minor or moderate physical effects to salmonids and possible habitat degradation immediately adjacent to the turbidity curtains.

(AEM, 2012) had higher catch-per-unit-effort (CPUE) near the East Dike than in reference areas. Underwater video was used in 2009 to examine high-value fish habitat for evidence of increased sediment deposition; areas close to the East Dike were found to contain more obvious signs of sediment accumulation than areas further away. Despite having some continued sediment deposition (as measured from sediment traps), video footage in 2011 shows that the amount of sediment on periphyton has visibly decreased in most Second Portage Lake high-value habitat areas.

Underwater video was also used in 2009 to characterize baseline conditions in high-value fish habitat areas in the east basin of Third Portage Lake, prior to the onset of Bay-Goose Dike construction. These high-value habitat areas were re-surveyed in 2011 to assess potential changes related to dike construction and the associated sedimentation; periphyton thickness and continuity were similar in 2009 and 2011 and sediment coverage does not appear to have increased appreciably. Notwithstanding some minimal accumulation in Bay-Goose sediment traps, periphyton in high-value habitat areas in the east basin of Third Portage Lake do not appear to have been impacted from Bay-Goose Dike construction.

At this stage, we have no further recommendations for additional follow-up studies and welcome discussions with regulators.

Table 4-1. Conclusions from all TSS Effects Assessment Studies, 2008 - 2011.

TSS EAS Component	East Dike TSS EAS	Bay-Goose TSS EAS
Water Quality and Limnology (studies conducted during major TSS release events (2008 for East Dike; 2009 for Bay-Goose Dike).		
TSS Exposure	Prevailing TSS concentrations at exposure areas in 2008 were estimated to be about 10 mg/L (Sept 13/14, 2008) and 6 mg/L (Sept 24/25, 2008).	Prevailing TSS concentrations at exposure areas in 2009 were estimated to be about 10 mg/L (Sept 17-19, 2009) and 8 mg/L (Sept 24-27, 2009).
Limnology	Elevated TSS reduced water clarity, but did not lead to changes in temperature or dissolved oxygen profiles over depth.	Similar to East Dike TSS EAS.
Water Quality	While certain metals and nutrients were elevated, dissolved concentrations were low and these were associated with particulate matter and not expected to result in direct effects to pelagic aquatic life.	Similar to East Dike TSS EAS.
Field Effects Measurements		
Primary Production - Pelagic ● Chlorophyll- α ● Phytoplankton biomass/taxonomy	Phytoplankton biomass was reduced in exposure areas in 2008. Biomass differences were much less two weeks later, suggesting a short-term effect.	Both phytoplankton biomass and chlorophyll-α were reduced in exposure areas in 2009. However, based on CREMP data they had recovered by November relative to the north and south basins.
Primary Production - Benthic ● Periphyton Community ● Sediment accumulation in mats.	Impacts of sedimentation were observed in Second Portage Lake in close proximity to the East Dike in 2009. Periphyton biomass was reduced in proportion to observed sediment content of periphyton mats. The 2010 results confirmed these findings and provided better spatial resolution of affected areas.	**Organic and inorganic content of the periphyton mat was measured at 16 locations in the east basin of Third Portage Lake and at 4 locations in Second Portage Lake (to cross-validate the approach) in 2011. The results were consistent with those reported for Second Portage Lake (i.e., in general there were no apparent differences between reference and exposure areas, but potential localized impacts were identified near the Bay-Goose Dike [although there were also examples of similar natural results in reference areas]).**
Secondary Production - Pelagic ● Zooplankton biomass/taxonomy	No differences in zooplankton biomass at exposure areas relative to reference areas.	Higher zooplankton biomass in 2009 in the east basin than observed in 2008 despite TSS exposure.
Secondary Production - Benthic ● Benthic community - Total abundance - Species richness - Simpson's Diversity Index - Bray Curtis Distance ● Surface sediment chemistry (coring) ● Surface sediment geochemistry - Sequential extraction analysis	Based on CREMP data from 2006 to 2011, the only effect identified was a marginal reduction in benthic abundance in Second Portage Lake (SP) in 2008. Abundance at SP improved in 2009 to baseline levels, dropped again in 2010 (thought to be localized based on contrary EAS results...see below), **then increased again in 2011**. Higher resolution spatial sampling in 2009 did show specific areas in Second Portage Lake to differ from control areas. However, this may be due to inherently lower benthic abundance in Second Portage Lake and Tehek Lake (as seen in the CREMP) . The 2010 EAS results showed a modest "recovery" at impact areas relative to the 2009 control areas. Sediment coring conducted in 2009 did identify elevated metals in surface sediments (relative to 2008). Follow-up studies in 2010 showed no sediment toxicity (see below) and that metals were not bioavailable (based on sequential extraction analyses). **Overall: The overall response patterns observed in Second Portage Lake appear consistent with natural variability rather than with exposure to TSS.**	Based on CREMP data from 2006 to 2011, there has been a drop in benthic abundance and diversity coincident with dike construction. However, these results appear due to very high baseline (2007-2008) levels for both metrics. In 2009, the drop occurred despite low TSS exposure. In 2010, the drop was consistent with a general regional trend of reduced abundance and richness. **The 2011 results are again in line with baseline levels for both metrics.** Higher resolution spatial sampling in 2010 showed no differences between the east basin of Third Portage Lake and control areas. **Sampling was not repeated at BG EAS areas in 2011. Rather, the longer term CREMP results were relied on for inferences regarding potential effects related to dike construction.** **Overall: The overall response patterns observed in the East Basin of Third Portage Lake appear consistent with natural variability rather than with exposure to TSS.**
Fish/Fish Habitat ● Sediment Traps ● Underwater Video ● Food web (stable isotopes) ● Fish Population	Sediment trap data from open water 2008 and over winter 2008-2009 show increased sedimentation (1 - 1.5 mm), particularly in proximity to the East Dike. This was confirmed by the underwater video. HVH areas away from the dike were much less affected. 2010 results show some elevated accumulation due to BG Dike inputs. **Some accumulation was measured over winter (2010-2011) from traps (SP-ST1 and 8) in proximity to ongoing mine activities.** Stable isotope studies confirmed the importance of both benthic and pelagic food webs in 2008. Underwater video surveys were conducted in 2009 at HVH areas in SP post- dike construction. **HVH areas were resurveyed in 2011. The amount of sediment on periphyton has visibly decreased in most SP-HVH areas.**	Sediment trap data show some accumulation (up to 1.1 mm) in proximity of HVH areas in 2009. 2010 results showed similar to higher accumulations (to nearly 2 mm). **Minimal accumulation was measured over winter (2010-2011) from traps (BG-ST6) in proximity to ongoing mine activities. Generally, accumulation was low and comparable to natural conditions as seen in TPS traps.** Underwater video surveys conducted in 2009 at HVH areas in TPE pre- dike construction. **HVH areas were resurveyed in 2011. Most TPE-HVH areas showed little change from 2009 to 2011 and no appreciable amount of sediment was detected.**
Laboratory Effects Measurements		
<u>Zooplankton</u> ● Lethal - *Daphnia magna* 48-hr LC50 ● Sublethal - *Ceriodaphnia dubia* 7-day growth/survival/repro	No direct effects were observed in toxicity tests of surface waters.	No direct effects were observed in toxicity tests of surface waters.
<u>Fish</u> ● Lethal - Rainbow trout 96-hr LC50 ● Sublethal - Rainbow trout embryo 7-day (w/out renewal) ● Sublethal - Rainbow trout embryo 7-day (with renewal) ● Sublethal - Rainbow trout swim-up larvae 7-day surv/growth	No effects were found for juvenile and larval tests. No effects were also seen in the standard (with renewal) embryo development test. Impaired development was seen in test without renewal, which suggests that physical settling of sediments could harm developing embryos.	No direct effects were observed in toxicity tests of surface waters.
<u>Benthic Invertebrates (Sediment)</u> ● Lethal/sublethal - *Hyalella azteca* 14-d survival/growth ● Lethal/sub - *Chironomus tentans* 10-d survival/growth	No adverse effects in 2010 to survival or growth for amphipods (*Hyalella azteca*) or midges (*Chironomus tentans*) at impact areas relative to control areas. Sediments tested in Second Portage Lake are not toxic.	

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Appendix A – Statistical Analyses for TSS Effects Assessment Study 2011

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APPENDICES

Appendix A1. Raw data for benthic invertebrate analyses.

1. INTRODUCTION

This appendix documents the statistical analyses conducted to support the 2011 TSS Effects Assessment Study (EAS) for the Meadowbank Mine. The 2011 EAS included components targeting potential environmental effects of East Dike construction in 2008 and Bay-Goose Dike construction in 2009 and 2010. This appendix is organized as follows:

- **Section 2** – presents an overview of the general approach used for statistical analysis of the EAS data set.
- **Section 3** – presents the results of the 2011 benthic invertebrate studies related to construction of both the East Dike and the Bay-Goose Dike.

This appendix must be read along with the main report, because (1) raw data and basic descriptive statistics and graphs presented in the report are not generally repeated in the appendix, and (2) the main report provides an integrative assessment of these results.

2. GENERAL STATISTICAL APPROACH

2.1. Overview

All statistical analyses were conducted using R software (v. 2.13.0). Further information on all methods used in this appendix can be found in Dalgaard (2008), Pinheiro and Bates (2000), Venables and Ripley (2002), Gelman and Hill (2006), and Zar (1984).

The following process was generally followed for each response variable[1]:

(1) Individual replicates were plotted by area (and year if applicable). These plots were used to get a sense of the general response pattern and natural variability within and among areas (years). Plots were also used to identify potential outliers.

(2) Model assumptions of normality and homogeneity of variance were tested formally using Shapiro-Wilk's and Bartlett's tests, respectively. In cases where either failed, four transformation options were evaluated: square root, fourth root, $\log_{10}$, and $\log_{10}(y+1)$. The selected option is displayed in the results tables for each response variable.

(3) In cases where none of the basic transformation options were sufficient to meet model assumptions, the Box-Cox method (Pinheiro and Bates 2000) was used to determine an optimal transformation.

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[1] Note that names were generally capitalized when referring specifically to a variable and not capitalized when making general references to the factors they represent.

(4) Hypotheses regarding adverse changes to response variables were tested using one of the following two general models (each explained further in **Section 2.2**):

a. Spatial control-impact (CI) model

b. Spatial-temporal before-after, control-impact (BACI) model

(5) Statistical significance was based on $\alpha = 0.05$ (see **Section 2.3** for more information). In addition, p values between 0.05 and 0.15 were highlighted as "marginal trends." Note that effect sizes[2] and associated confidence intervals are typically provided to help interpret the results and put non-significant results into perspective.

(6) Model assumptions were retested using visual methods (e.g., examination of model residuals and quartile-quartile plots). Where model assumptions were not fully met, several model variations were explored to determine the implications of the situation for model output; these options are explained further in the text.

2.2. Statistical Models

This section presents the basic model structure for CI and BACI type statistical models. Variations on these themes used for specific analyses are documented in the results sections.

Spatial (CI-type) – Model 1

This model is used to test for differences between control (C) and impact (I) areas. This is used when there is no temporal component to the study design. The C and I aspects of the design are coded into a single effect variable (i.e., a dummy variable with levels for each type of station). At Meadowbank, the CI designs usually incorporate multiple C and/or I areas. Note that when multiple I areas occur in the design, the effect coding can be the same for both or different to reflect different exposure levels (e.g., a simple exposure gradient). Basic model format is a two-factor model (i.e., response is a function of area + effect + error), which is formally represented as follows:

(1) $$X_{jrs} = \mu + \beta_j + \gamma_{r(j)} + \varepsilon_{jrs}$$

where:

X_{jrs} is the response associated with subsample *s* at Area *j*, which has Effect level *m*

μ is an intercept term

β_j is the coefficient for Area *j*

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[2] Effects sizes are typically reported in absolute terms (e.g., a negative value means a drop in a value relative to what would have been expected in the absence of an effect).

$\gamma_{r(j)}$ is the coefficient for Effect level *r* associated with Area *j*

ε_{jrs} is the error term where *s* denotes the number of subsamples taken in each Area *j*

This model is coded in R as follows (where "y" is the response variable):

lm (y ~ Area + Effect)

Spatial-Temporal (BACI-type) - Model 2

This study design is an extension of the basic BACI approach (e.g., Underwood 1991, 1992, 1994). While the actual designs at Meadowbank are not necessarily the same across response variables, all have the same general factors: Area, Year, and an Effect variable coded to distinguish two or more TSS exposure levels (e.g., 0 = not exposed, 1 = exposed; or 0 = none, 1 = minor exposure and 2 = major exposure) across years. This results in a three-factor additive model (i.e., response is a function of Area + Year + Effect + error). In addition, we also include a random term for Area:Year interactions to properly characterize patterns of inter-annual variation that innately differ among areas (not just between the ones we are testing with the variable 'Effect'), therefore. The model then becomes:

(2) $$X_{kjrs} = \mu + \beta_j + \tau_k + \gamma_{r(kj)} + (\tau\beta)_{kj} + \varepsilon_{kjrs} \ .$$

where:

X_{kjrs} is the response associated with subsample *s* in Year *k* at Area *j*, which has Effect level *r*

μ is an intercept term

β_j is the coefficient for Area *j*

τ_k is the coefficient for Year *k*

$\gamma_{r(kj)}$ is the coefficient for effect level *r* associated with Year *k* and Area *j*

$(\tau\beta)_{kj}$ is the Area:Year interaction term

ε_{kjrs} is the error term where *s* denotes the number of subsamples taken for each Area-Year (*jk*) combination

This model can be coded in R in the following ways (depending on whether or not the design is balanced [i.e., same number of replicates in all Area-Year combinations]) (where "y" is the response variable):

- Balanced: lm (y ~ Area * Year + Effect)
- Unbalanced lmer (y ~ Area + Year + Effect + (1|Area:Year))

For balanced designs, both of these models yield the same coefficients for the fixed effects.

2.3. Determining Statistical Significance

As described above, the determination of statistical significance in these analyses relied on evaluating p values relative to $\alpha = 0.05$ ("marginal trends" were highlighted with $0.05 < p < 0.15$). It is important to note that estimation of p values is dependent on the interpretation of the study design and the primary inferences being made, which ultimately dictate the statistical degrees of freedom. Inappropriately defined experimental units can lead to pseudoreplication (Hurlbert, 1984), which is the use of inferential statistics to test impact effects when either treatments are not replicated or replicate samples are not temporally or spatially independent.

Hurlbert (1984) described several types of pseudoreplication: simple, sacrificial, temporal, and implicit. For the purposes of this discussion, we focus on the first two:

- *Simple pseudoreplication* – is the lack of independent replication of study treatments. Replication can be considered as the independent application (or occurrence) of the same treatment. As recognized by Stewart-Oaten et al. (1986, 1992), accidental environmental perturbations rarely occur in an independent, yet similar, manner. Thus, we are usually left with attempting to make inferences regarding the effects of the perturbation without proper replication. Statistical comparisons between control and impact areas are ultimately confounded by possible inherent differences between the areas that would exist in the absence of the perturbation. Consequently, inferences regarding impact-related differences between control and impact areas are only as strong as the evidence available to support the fundamental assumption that the areas were similar prior to the perturbation; this is particularly important for control-impact (CI) designs where no data were available prior to the perturbation.

- *Sacrificial pseudoreplication* – occurs when treatments are replicated, but where the subsample data for replicates are pooled (thus sacrificing information regarding true within-treatment variance) for analysis or where measurements taken within experimental units (i.e., subsamples) are treated as independent replicates (Hurlbert, 1984). The primary implication of sacrificial pseudoreplication is its effect on the estimation of error through the inflation of its degrees of freedom, which ultimately lowers the p value of the fixed effects being tested.

Although they are quite different in their nature, the end result of both types of pseudoreplication is the increased probability of Type 1 error (i.e., incorrectly concluding that a difference exists, a "false positive").

Due to the nature of the EAS (i.e., determining the potential effects of construction-related sediment inputs), the study designs used in the EAS are not immune to pseudoreplication. From a practical perspective, the assessment of unplanned impacts has to acknowledge the reality of some level of pseudoreplication associated with the lack of proper treatment replication and employ strategies to deal with the non-independence among samples (Wiens and Parker, 1995). The following are examples of the main strategies used to minimize the influence of pseudoreplication on EAS conclusions:

- *"Replication" of Treatments* – While true replication of the treatments was not possible, the extent of elevated TSS in the receiving environment often allowed multiple areas to be sampled within the zone of elevated TSS. Coupled with multiple control areas, this reduced (but did not eliminate) the potential for natural differences between control and impact treatments to drive conclusions.
- *Verifying Area Similarity Prior to Treatment* – For CI designs (i.e., no "before" data), information from other monitoring programs (where available) was used to assess the validity of the assumption that control and impact areas were similar prior to exposure to elevated TSS.
- *Scale of Inference and the Independence of Samples* – The scale of inference was matched to the study design. When inferences were made regarding differences between control and impact groups, then the degrees of freedom for the error term (see below for more information) was based on the Areas

<u>Basic EAS CI Study Designs</u>

The following represent the general hierarchy present in most of the EAS CI-type study designs. Design specifics are discussed later in the text for each study component.

Control – Impact Grouping
Sampling "Areas" (see below) were grouped according to whether or not they were exposed to elevated TSS concentrations.

Within C or I Groups
Multiple Areas were usually sampled within the above groupings.

Within Areas
Multiple measurements were randomly taken within areas.

<u>Basic EAS BACI-type Study Designs</u>

In addition to the sampling hierarchy used in the spatial CI designs (see previous text box), the BACI-type design also included the element of time, as follows:

Before – After Grouping
Sampling "Years" (see below) were grouped according to whether or not the impact treatment had occurred.

Within B or A Groups
Multiple Years (some or all Areas) were sometimes sampled within the above groupings.

> as the experimental unit (rather than on the number of subsamples taken in each Area). In contrast, where study design constraints prevented this scale of inference, conclusions were made regarding differences among areas (with degrees of freedom based on subsamples), with a qualitative discussion of the potential influence of TSS across the collective pool of impact areas.

In light of the previous discussion, careful consideration was given to how the statistical models were structured so that the p values were estimated in an appropriate manner for the intended scale of inference. Depending on the R package used to run the statistical model, the desired p values (and associated degrees of freedom) were either included directly as part of the model outputs (e.g., for lm or lme functions) or they were calculated in R (see below) based on the model outputs (for coefficient estimates and standard errors) and on our calculated degrees of freedom (e.g., for lmer function).

R's lme4 package for mixed-effects modeling does not include p values or degrees of freedom in model outputs[3]. Consequently, these were calculated in R after determining the appropriate degrees of freedom.

The following table shows the general formulations for the degrees of freedom and expected mean-squared error (E[MS]) for various model terms (note that CI designs would not include year as an element [or an interaction term] unless multiple "after" years were sampled; model terms as per **Section 2.2**):

Term	Levels	Df	E[MS]
Effect (γ)	$r = 1, 2, \ldots, R$	$R - 1$	$\sigma^2 + Q + SK\sigma_\beta^2 + S\sigma_{\tau\beta}^2$
Area (β)	$j = 1, 2, \ldots, J$	$J - R$	$\sigma^2 + SK\sigma_\beta^2 + S\sigma_{\tau\beta}^2$
Year (τ)	$k = 1, 2, \ldots, K$	$K - 1$	$\sigma^2 + SJ\sigma_\tau^2 + S\sigma_{\tau\beta}^2$
Interaction ($\beta\tau$)		$(J - 1)(K - 1)$	$\sigma^2 + S\sigma_{\tau\beta}^2$
Error (ε)	$s = 1, 2, \ldots, S$	$(S - 1)JK$	σ^2

For a mixed-effects CI model with Effect as the fixed effect and Area as the random effect, overall significance of the Effect term would be tested by defining the appropriate F ratio as MS[Effect]/MS[Area] with degrees of freedom = (R -1), (J - R). For R = 2 (e.g., only two levels of Effect, control and impact), this provides the same result as the t-test for the treatment coefficient γ with degrees of freedom = $J - R$. If R > 2 (e.g., when multiple impact areas were coded separately [0 for control areas and 1, 2, … for impact

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[3] The primary reason for omitting these results is to avoid errors in model output. Mixed effect models can be quite complex, making estimation of the degrees of freedom statistically challenging. While there are computational methods that work for most situations, they fail to produce appropriate results in certain cases. Methods for determining the appropriate degrees of freedom for the simple mixed-effects models documented in this report are well established.

areas) to allow estimation of impacts at specific areas, then each *t*-test comparing the specific impact level to controls would have df = $J - R$.

For a mixed-effects BACI model with Year and Effect as fixed effects and Area-Year as the random effect, overall significance of the Effect term would be tested by defining the appropriate F ratio as MS[Effect]/MS[Area*Year]. Numerator degrees of freedom are the same as discussed for the CI example, $R - 1$. The calculation of denominator degrees of freedom starts with $(J - 1) * (K - 1)$, then subtracts the Effect coefficients $(R - 1)$, then subtracts 1 for each Area-Year combination missing from the data set (e.g., for unbalanced designs). Again, for R = 2 (e.g., only two levels of Effect, control and impact, where the latter are specific Area-Year combinations exposed to elevated TSS), this provides the same result as the *t*-test for the treatment coefficient γ using the denominator degrees of freedom. Also, if R > 2, then the denominator degrees of freedom would be used in each *t*-test comparing the specific impact level (e.g., Area SP in 2008) to controls.

In R, p values for the overall *F*-test for the Effect term were determined as follows:

p.value = 1-pf(F.ratio, df1=df1, df2=df2))

where:

pf is an R function that gives the *F* distribution function

F.ratio is the *F* ratio from the model ouput

Df1 is the numerator degrees for freedom for the *F*-test (see text above)

Df2 is the denominator degrees of freedom for the *F*-test (see text above)

For *t*-tests of specific Effect levels relative to controls, the p values were determined using the following R code:

p.value = 2 * (1-pt(abs(t.stat), Df=df2))

where:

pt is an R function that gives the Student t distribution

t.stat is the t statistic from the model output

Df is the appropriate degrees of freedom

3. BENTHIC INVERTEBRATE COMMUNITY STUDIES - 2011

3.1. Study Design Overview

The following provides an overview of basic study design information for each component:

- *CREMP Benthic Invertebrates* – CREMP monitoring has been conducted since 2006 at a number of lakes surrounding the Meadowbank Mine. As such, it includes pre-development baseline data and thus provides context regarding spatial and temporal variability in the benthic community. In past years, the CREMP data set has been used to complement the finer-resolution EAS data sets to aid in the interpretation of the EAS results. This year, given that sampling was not conducted at the EAS areas, it is the only data set The CREMP areas relevant to this year's EAS are shown in **Figure A3-1**[4]. The potential for mining-related impacts in each sampling area has been tracked annually since the construction phase of the development started in 2008. The status of specific areas over time is shown in **Table A3-1**. This data set was used to test for specific area-year impacts relative to control area-years and for specific longer-term impacts by area (i.e., for areas where more subtle, but prolonged, effects may have occurred). Details on Effect coding are provided in the results in **Section 3.2.1**. The BACI (Model 2) model was used for the analysis to test for both types (i.e., single-year and multi-year) of effects.
- *East Dike EAS Benthic Invertebrates* – No further sampling was conducted in 2011.
- *Bay-Goose Dike EAS Benthic Invertebrates* – No further sampling was conducted in 2011.

[4] The Baker Lake areas and Wally Lake were not included. Baker Lake has a marine influence and is substantially different from the Meadowbank project lakes. Wally, which is one of the Meadowbank project lakes, was not included as it is inherently different (e.g., shallower and more productive) than the other project lakes.

3.2. Results

Response variables for all benthic community analyses were selected to match the guidance of Environment Canada (2002), as follows (see main EAS report for details regarding each variable):

- Total abundance (#/m^2; this is actually density) of all taxa
- Total species richness (# taxa/sample)
- Simpson's diversity (D)
- Bray Curtis Distance (BC)

Summary data for these variables are presented in **Table A3-2** for the CREMP dataset (the raw data file is provided in **Appendix A1**). Results by Area and Year for each variable are shown in **Figure A3-2**, highlighting Area-Year combinations (dark points) potentially impacted by mining activities.

Statistical analyses focused on testing specific Area-Year combinations against the rest of the data set (i.e., Area-Year combinations for which no effects were anticipated). Two "Effect" dummy variables were coded (for separate analysis) based on **Table A3-1**: one targeting single-year effects (**Table A3-3**) and the other multi-year effects (**Table A3-4**). Rationale for Effect codes were as follows:

- *TE and SP* – These areas were exposed to elevated TSS concentrations in 2008 and are the main focus of these analyses. While exposure concentrations were much lower in 2009 through 2011, they remain designated as impact areas.
- *TPE* – In 2009, this area was sampled on August 13/14, which was during construction of the first phase of the Bay-Goose Dike (monitoring results showed that TSS concentrations had increased relative to background). Consequently, while TSS exposure was relatively low, this area was designated as "impact" starting in 2009. TSS concentrations went on to increase in the basin soon after the sampling event (Azimuth, 2010b), but were generally lower during the second year of Bay-Goose Dike construction (AEM, 2011).
- *TPN* – Dewatering discharges from the NW Arm of Second Portage Lake were directed into this basin from March through early July 2009. While CREMP water quality monitoring results for that basin showed negligible exposure conditions, the area was conservatively designated as an impact area for 2009. While not directly related to dike construction activities, TSS is the major constituent of interest in the dewatering effluent and therefore relevant to the EAS.

Model 2 (unbalanced design) was used to identify statistically significant ($p<0.05$) differences between the base Effect levels (i.e., the control Area-Year[s] combinations; see **Tables A3-3 and A3-4**) and each subsequent Effect level (i.e., each impact Area-Year[s] combination) (note that PDL and TEFF, while shown in many graphs, were not included in the analyses as these areas were only added in 2009). In cases where key model assumptions (i.e., normality and equality of variance) were not fully met, between two and five model variations were tested to assess the potential implications on the robustness of the conclusions. These included various combinations of basic vs. advanced transformations (e.g., log10[x] vs Box-Cox results for abundance), with/without certain outliers (identified in plots of various model output diagnostics) removed and with explicit modeling of heterogeneous within-group variances (see Heteroscedasticity Modeling in **Section 3.2.2** for more information). In general, the analyses were robust to observed variations from key model assumptions; results of these secondary analyses were only reported when they would result in substantive changes to a conclusion regarding effects.

Results for short-term and long-term effects testing are reported in **Table A3-5** (2008 & 2009; single-year effects as reported in Azimuth, 2010c), **Table A3-6** (2010; single-year effects as reported in Azimuth, 2011b), **Table A3-7** (2010; single-year effects), and **Table A3-8** (2008-2011 or 2009-2011; multi-year effects) for each benthic community metric. Graphical representations of the analyses are shown in two ways: box-whisker plots for the Effect groupings (**Figures A3-3 and A3-4**) and Area-Year interaction plots for each response variable (**Figures A3-7 through A3-10**). Key results for each area are as follows (followed by a brief discussion of uncertainty):

- *SP (2008, 2009, 2010, 2011, and 2008-2011)* – As reported for the past three years, the 2008 EAS (Azimuth, 2009b) reported a marginal trend ($0.05<P<0.15$) for decreased total abundance at SP that did not extend to TE (see **Table A3-5**). As shown in **Figures A3-2, A3-3 and A3-5**, abundance at SP rebounded in 2009 to slightly below "no-effect" predictions for that area and within the range of SP baseline results (i.e., 2006 – 2007), then dropped again in 2010 (>50% reduction in abundance compared to what was expected). Results for 2011 showed improvements for all endpoints. There were marginal (i.e., $0.05<p<0.15$) long-term trends for total abundance (negative) and Simpson's Diversity[5] (positive). See main report for more discussion.
- *TE (2008, 2009, 2010,2011, and 2008-2011)* – As discussed above, the marginal trend in abundance observed in 2008 at SP did not extend to TE (for abundance or any other response variable; see **Tables A3-5 through A3-7**). The other single-year (2009 through 2011) and the multi-year (2008-2011) results confirm that finding and reaffirm that there does not appear to be any significant changes at TE related to mining activity (there was a marginal increase in Simpson's Diversity for the long-term effects). **Figure A3-2** probably shows this the best for all response variables. Most results for TE since 2008 are within the range of baseline results. The two low Simpson's Diversity results for TE in 2009 are due

[5] Simpson's diversity index is sensitive to how organisms are allocated across taxa, not to the number of taxa.

to replicate samples that contained relatively high numbers of sphaerid clams, which substantially reduced the diversity scores for those replicates (but not richness).

- *TPE (2009, 2010, 2011, and 2009-2011)* – Given that this area is up-gradient of the East Dike and in the same basin (i.e., East Basin of Third Portage Lake) as the Bay-Goose Dike, the results for this area are most relevant for the Bay-Goose EAS. The main trends seen at this area were a decrease in benthic invertebrate abundance (not significant for 2009, 2010 or 2011 separately [**Tables A3-5 through A3-7**], but significant for the 2009-2011 multi-year effect [**Table A3-8**]) and an increase in Simpson's Diversity (marginal for 2010 [**Table A3-6**] and significant for 2009-2011 [**Table A3-8**]). The overall results for abundance are heavily influenced by the 2008 data, where abundance and richness were anomalously elevated relative to what would be expected in that basin (see **Figures A3-5 and A3-6**). See main report for more discussion.
- *TPN (2009, 2010, 2011, and 2009-2011)* – As discussed above, this area was potentially exposed to elevated TSS during dewatering of the NW arm of Second Portage Lake starting in March 2009. Based on CREMP water quality (Azimuth, 2010a; 2011c; 2012) and Bay-Goose dike construction monitoring (Azimuth, 2010b), TSS exposure in the north basin was likely low, suggesting that adverse effects to the benthic community would be unlikely. This was confirmed by the CREMP benthos results, which showed no significant adverse effects. The only significant or marginal changes observed were increases for richness (2010; **Table A3-6**) and Simpson's Diversity (2009-2011; **Table A3-8**).

As discussed in **Section 2**, effect sizes and associated confidence intervals help to place the observed results in to perspective. As seen in **Tables A3-7 and A3-8**, the confidence intervals associated with reported effect sizes were quite large in a number of cases (i.e., reflective of high uncertainty in the estimated effect size). These confidence intervals are due to the fairly high degree of spatial and temporal variability that exists naturally in this region. The larger the confidence interval, the larger the effect size required for a statistically significant result (i.e., lower power). The degree to which the confidence interval extends above zero (or below for an adverse positive change, such as Bray Curtis distance) is a rough measure of how much larger an effect would have needed to be in order to be considered statistically significant.

The implication of this situation is that statistical significance should not be the only consideration when evaluating these results. As per previous year's EAS reports (Azimuth 2009b, 2010c), which highlighted the decrease in abundance at SP in 2008, marginal trends have been highlighted even when P values exceed 0.05. A variety of graphical methods have also been used to help visualize what the statistical models are actually testing.

The observed changes in the CREMP data set will be discussed in more detail in **Section 3.5.1** of the main EAS document using a weight-of-evidence approach.

Table A3-1. Area "effect" status by year for CREMP data set.

Year	INUG	PDL	TPS	TEFF	SP	TE	TPE	TPN
2006	C		C		C		C	
2007	C		C		C	C	C	C
2008	C		C		I	I	C	C
2009	C	C	C	C	I	I	I	I
2010	C	C	C	C	I	I	I	I
2011	C	C	C	C	I	I	I	I

Note: 1. Area designations: C = control; I = impact.

(Note: Only CREMP areas relevant to 2011 EAS are shown.)

Table A3-2. Benthic invertebrate descriptors by sampling area and year for the CREMP data set (page 1/2).

		Depth					Abundance					Richness					Simpson's Diversity Index					Bray Curtis Index				
Area	**Year**	**Mean**	**SD**	**Med**	**Min**	**Max**	**Mean**	**SD**	**Med**	**Min**	**Max**	**Mean**	**SD**	**Med**	**Min**	**Max**	**Mean**	**SD**	**Med**	**Min**	**Max**	**Mean**	**SD**	**Med**	**Min**	**Max**
INUG	2006	8.0	0.0	8.0	8.0	8.0	761	264	717	522	1043	10.3	2.5	10	8	13	0.82	0.02	0.82	0.81	0.84	0.20	0.12	0.14	0.12	0.34
INUG	2007	9.1	1.1	9.6	7.8	10.1	1022	393	848	783	1717	11.8	0.8	12	11	13	0.85	0.03	0.86	0.79	0.87	0.31	0.06	0.32	0.22	0.38
INUG	2008	9.4	1.9	8.7	8.0	12.6	1900	1975	1239	391	5326	13.8	3.7	14	8	17	0.87	0.05	0.86	0.79	0.92	0.51	0.16	0.45	0.36	0.77
INUG	2009	7.3	0.5	7.0	6.9	7.9	1191	407	1130	630	1630	13.6	3.1	15	8	15	0.85	0.06	0.88	0.74	0.9	0.38	0.06	0.36	0.33	0.47
INUG	2010	7.7	0.9	8.0	6.7	8.7	639	133	630	478	783	8.4	2.5	7	6	12	0.75	0.07	0.77	0.64	0.81	0.51	0.07	0.49	0.45	0.59
INUG	2011	7.8	1.0	7.6	6.8	9.2	1017	678	826	457	2196	10.6	3.2	9	8	16	0.81	0.04	0.81	0.77	0.86	0.41	0.07	0.38	0.34	0.49
PDL	2009	7.7	0.5	7.5	7.2	8.3	1726	999	1348	761	3326	10.8	0.8	11	10	12	0.78	0.10	0.81	0.61	0.88	0.49	0.09	0.53	0.39	0.56
PDL	2010	6.9	0.5	6.8	6.5	7.7	896	484	1043	348	1500	8.4	0.5	8	8	9	0.75	0.11	0.77	0.58	0.88	0.47	0.13	0.42	0.32	0.63
PDL	2011	6.9	0.4	6.8	6.5	7.6	943	191	935	674	1174	9.4	2.4	10	6	12	0.80	0.04	0.83	0.74	0.84	0.40	0.06	0.38	0.34	0.47
TPS	2006	8.7	0.0	8.7	8.7	8.7	971	305	1065	630	1217	10.7	1.5	11	9	12	0.86	0.04	0.87	0.81	0.89	0.58	0.04	0.58	0.55	0.62
TPS	2007	9.1	1.3	8.4	8.3	11.4	2100	1961	1130	826	5500	9.8	3.1	9	7	14	0.80	0.08	0.83	0.66	0.86	0.66	0.06	0.67	0.57	0.73
TPS	2008	10.1	1.0	9.9	9.1	11.7	1604	552	1674	696	2043	10.6	1.5	10	9	13	0.76	0.10	0.78	0.62	0.88	0.65	0.04	0.65	0.58	0.69
TPS	2009	7.8	1.1	7.3	6.8	9.7	1961	1035	2022	717	3326	10.4	1.3	11	8	11	0.82	0.08	0.84	0.72	0.92	0.56	0.06	0.55	0.47	0.62
TPS	2010	7.6	0.7	7.6	6.7	8.4	1296	667	1587	565	1870	8.2	2.8	9	5	12	0.76	0.08	0.77	0.63	0.84	0.66	0.02	0.66	0.62	0.68
TPS	2011	7.5	0.7	7.3	6.7	8.4	1122	614	1370	283	1674	8.6	3.2	10	3	11	0.80	0.11	0.83	0.6	0.88	0.63	0.06	0.61	0.58	0.73
TEFF	2009	7.1	0.5	6.9	6.6	7.8	1235	249	1196	978	1543	10.4	1.8	11	8	12	0.84	0.04	0.84	0.78	0.88	0.58	0.07	0.61	0.47	0.64
TEFF	2010	7.3	0.5	7.4	6.6	8.0	922	298	935	652	1391	10.8	2.4	11	8	14	0.80	0.06	0.81	0.69	0.85	0.59	0.03	0.61	0.55	0.62
TEFF	2011	7.2	0.6	7.0	6.9	8.2	700	456	543	370	1500	8.6	1.8	8	7	11	0.73	0.15	0.81	0.54	0.87	0.55	0.08	0.54	0.46	0.67

Abbreviations: SD = standard deviation (presented for interest only on raw data as variables may not be normally distributed) ; Med = median; Min = minimum; Max = maximum.

Table A3-2. Benthic invertebrate descriptors by sampling area and year for the CREMP data set (page 2/2).

		Depth					Abundance					Richness					Simpson's Diversity Index					Bray Curtis Index				
Area	Year	Mean	SD	Med	Min	Max	Mean	SD	Med	Min	Max	Mean	SD	Med	Min	Max	Mean	SD	Med	Min	Max	Mean	SD	Med	Min	Max
SP	2006	7.8	0.0	7.8	7.8	7.8	623	91	652	522	696	6.3	2.1	7	4	8	0.67	0.12	0.74	0.53	0.75	0.50	0.06	0.49	0.45	0.56
SP	2007	9.1	1.0	9.1	8.0	10.6	913	390	978	457	1435	9.2	2.5	10	5	11	0.80	0.08	0.82	0.69	0.9	0.46	0.14	0.42	0.32	0.65
SP	2008	9.6	2.4	9.9	7.0	13.2	413	130	457	239	565	7.4	2.3	7	5	11	0.82	0.04	0.81	0.78	0.86	0.80	0.06	0.8	0.73	0.86
SP	2009	7.4	0.5	7.5	6.8	8.1	778	114	804	630	913	6.8	1.3	7	5	8	0.78	0.03	0.77	0.74	0.83	0.49	0.08	0.48	0.41	0.61
SP	2010	8.0	0.9	8.0	6.8	8.9	257	113	217	174	457	4.4	1.9	5	2	7	0.70	0.12	0.76	0.54	0.82	0.70	0.09	0.73	0.54	0.77
SP	2011	7.7	0.8	7.8	6.5	8.8	587	163	674	304	696	10.2	2.9	10	7	15	0.80	0.09	0.84	0.68	0.88	0.53	0.06	0.52	0.46	0.63
TE	2006	8.0	NA	8.0	8.0	8.0	913	NA	913	913	913	5.0	NA	5	5	5	0.56	NA	0.56	0.56	0.56	0.56	NA	0.56	0.56	0.56
TE	2007	9.1	1.3	9.1	7.1	10.7	952	251	870	783	1391	8.6	2.6	10	4	10	0.74	0.09	0.77	0.58	0.81	0.42	0.06	0.4	0.38	0.52
TE	2008	10.9	2.4	11.7	7.5	13.1	757	159	761	543	978	10.0	1.6	10	8	12	0.79	0.08	0.83	0.71	0.86	0.64	0.05	0.62	0.59	0.7
TE	2009	7.5	0.6	7.4	6.9	8.2	770	145	848	522	870	7.0	1.2	7	5	8	0.69	0.18	0.79	0.49	0.87	0.55	0.04	0.53	0.51	0.61
TE	2010	8.0	1.0	7.7	6.9	9.6	596	322	630	217	1022	6.4	2.9	7	3	10	0.71	0.09	0.74	0.56	0.8	0.68	0.11	0.63	0.57	0.81
TE	2011	7.4	0.7	7.3	6.5	8.3	822	395	826	261	1370	6.2	2.3	6	4	10	0.73	0.03	0.74	0.69	0.76	0.60	0.10	0.55	0.51	0.76
TPE	2006	8.0	0.0	8.0	8.0	8.0	3261	606	3543	2565	3674	8.3	1.5	8	7	10	0.70	0.09	0.74	0.59	0.76	0.76	0.05	0.75	0.72	0.82
TPE	2007	8.5	0.8	8.7	7.6	9.5	1578	240	1609	1217	1891	10.6	1.3	10	9	12	0.79	0.06	0.81	0.7	0.84	0.54	0.06	0.55	0.45	0.6
TPE	2008	9.6	1.6	8.9	7.8	11.5	5626	1013	5261	4478	7152	14.2	2.5	15	10	16	0.71	0.09	0.72	0.57	0.8	0.73	0.03	0.73	0.7	0.77
TPE	2009	7.1	0.6	6.9	6.5	7.8	1713	439	1826	1065	2239	11.2	1.3	12	9	12	0.83	0.04	0.83	0.77	0.89	0.51	0.06	0.51	0.44	0.57
TPE	2010	7.5	0.9	7.5	6.5	8.4	1139	182	1152	848	1348	9.8	1.3	10	8	11	0.79	0.04	0.81	0.74	0.83	0.62	0.03	0.6	0.59	0.65
TPE	2011	8.3	0.7	8.2	7.7	9.5	1604	285	1674	1217	1978	9.4	2.5	9	6	13	0.75	0.09	0.76	0.61	0.85	0.58	0.05	0.58	0.53	0.65
TPN	2007	8.9	0.6	9.2	8.0	9.4	1422	471	1326	978	1935	9.8	3.3	11	6	14	0.81	0.08	0.81	0.68	0.88	0.56	0.07	0.56	0.47	0.63
TPN	2008	8.3	0.6	8.4	7.8	9.2	1017	509	1326	261	1391	8.2	3.1	9	3	11	0.68	0.08	0.66	0.59	0.81	0.71	0.08	0.7	0.62	0.83
TPN	2009	8.2	0.7	8.5	7.1	8.8	1239	279	1174	891	1565	9.2	1.8	9	7	11	0.79	0.02	0.78	0.77	0.83	0.51	0.08	0.54	0.39	0.57
TPN	2010	8.7	0.8	8.8	7.5	9.5	1322	731	1435	196	2109	10.4	1.5	11	8	12	0.77	0.13	0.75	0.64	0.97	0.63	0.08	0.61	0.53	0.75
TPN	2011	8.4	0.9	8.6	7.0	9.2	565	281	717	261	826	8.0	2.1	8	6	11	0.82	0.06	0.83	0.73	0.89	0.56	0.18	0.48	0.39	0.8

Abbreviations: SD = standard deviation (presented for interest only on raw data as variables may not be normally distributed) ; Med = median; Min = minimum; Max = maximum.

Table A3-3. Area-year “effects” coding for short-term effects, CREMP data set.

Year	INUG	PDL	TPS	TEFF	SP	TE	TPE	TPN
2006	0		0		0		0	
2007	0		0		0	0	0	0
2008	0		0		1	5	0	0
2009	0	0	0	0	2	6	9	12
2010	0	0	0	0	3	7	10	13
2011	0	0	0	0	4	8	11	14

Note: 1. Area designations: C = control; I = impact.

Table A3-4. Area-year "effect" coding for long-term effects, CREMP data set.

Year	INUG	PDL	TPS	TEFF	SP	TE	TPE	TPN
2006	0		0		0		0	0
2007	0		0		0	0	0	0
2008	0		0		1	2	0	0
2009	0	0	0	0	1	2	3	4
2010	0	0	0	0	1	2	3	4
2011	0	0	0	0	1	2	3	4

Note: 1. Area designations: C = control; I = impact.

Table A3-5. Results of statistical analyses of benthic invertebrate community descriptors for the 2008 and 2009 CREMP data sets; short-term effect (from 2009 EAS report; Azimuth, 2010c).

	Total Abundance (#/m²)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x-120)	NA	NA	NA
Tests relative to controls				
C-SP2008 Differences?	No	No	No	No
p-value	0.08	0.27	0.12	0.95
Effect Size	-578	-2.4	0.11	-0.01
95% Upper CI[3]	-775	-7.1	-0.04	-0.24
95% Lower CI[3]	184	2.3	0.26	0.33
C-TE2008 Differences?	No	No	No	No
p-value	0.47	0.89	0.14	0.24
Effect Size	-396	0.3	0.12	-0.16
95% Upper CI[3]	-881	-5.0	-0.05	-0.36
95% Lower CI[3]	1824	5.6	0.28	0.16
C-SP2009 Differences?	No	No	No	No
p-value	0.68	0.26	0.60	0.75
Effect Size	-195	-2.6	0.04	-0.04
95% Upper CI[3]	-693	-7.7	-0.12	-0.24
95% Lower CI[3]	1948	2.5	0.20	0.27
C-TE2009 Differences?	No	No	No	No
p-value	0.51	0.37	0.80	0.77
Effect Size	-384	-2.3	-0.02	-0.04
95% Upper CI[3]	-893	-7.9	-0.20	-0.26
95% Lower CI[3]	2195	3.4	0.16	0.31
C-TPE2009 Differences?	No	No	No	No
p-value	0.19	0.68	0.24	0.65
Effect Size	-2047	-0.9	0.08	-0.04
95% Upper CI[3]	-3197	-5.7	-0.07	-0.21
95% Lower CI[3]	2512	3.9	0.23	0.21

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables &
3. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
4. Results are for model adjusted to account for unequal variances (see text for details).
5. Model assumptions not met, see text for details.

Table A3-6. Results of statistical analyses of benthic invertebrate community descriptors for the 2010 CREMP data set; short-term effect (from 2010 EAS report; Azimuth, 2011b).

	Total Abundance (#/m^2)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x-70)	NA	NA	NA
Tests relative to controls				
C-SP2010 Differences?	Marginal	No	No	No
p-value	0.07	0.55	0.67	0.49
"No Effect" Mean[3]	599	5.7	0.67	0.67
Effect Size	-362	-1.3	0.03	0.08
95% Upper CI[4]	-483	-6.2	-0.11	-0.15
95% Lower CI[4]	83	3.6	0.16	0.43
C-TE2010 Differences?	No	No	No	No
p-value	0.57	0.74	0.29	0.94
"No Effect" Mean	697	5.6	0.64	0.66
Effect Size	-194	0.8	0.07	-0.01
95% Upper CI[4]	-524	-4.6	-0.07	-0.23
95% Lower CI[4]	1203	6.3	0.22	0.33
C-TPE2010 Differences?	No	No	Marginal	No
p-value	0.23	0.50	0.06	0.45
"No Effect" Mean	2160	8.4	0.67	0.60
Effect Size	-1035	1.4	0.12	-0.07
95% Upper CI[4]	-1780	-3.2	-0.01	-0.23
95% Lower CI[4]	1506	6.1	0.24	0.16
C-TPN2010 Differences?	No	Yes (incr.)	No	No
p-value	0.55	0.05	0.11	0.88
"No Effect" Mean	714	5.4	0.67	0.60
Effect Size	263	5.0	0.10	0.02
95% Upper CI[4]	-392	0.1	-0.03	-0.18
95% Lower CI[4]	2614	9.8	0.23	0.30

Notes:
1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

Table A3-7. Results of statistical analyses of benthic invertebrate community descriptors for the 2011 CREMP data set; short-term effect.

	Total Abundance (#/m²)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)[5]
Data Transformation[1]	Log10	None	None	None
Advanced Transformation[2]	Log10(x-10)	NA	NA	NA
Tests relative to controls				
C-SP2011 Differences?	No	Marginal	No	No
p-value	0.78	0.14	0.17	0.46
"No Effect" Mean[3]	647	7.1	0.72	0.63
Effect Size	-85	3.1	0.08	0.18
95% Upper CI[4]	-458	-1.2	-0.04	-0.23
95% Lower CI[4]	1068	7.5	0.21	1.01
C-TE2011 Differences?	No	No	No	No
p-value	0.87	0.89	0.29	0.95
"No Effect" Mean	791	6.5	0.66	0.60
Effect Size	-68	-0.3	0.07	-0.01
95% Upper CI[4]	-559	-4.9	-0.07	-0.33
95% Lower CI[4]	1516	4.3	0.20	0.68
C-TPE2011 Differences?	No	No	No	No
p-value	0.42	0.87	0.62	0.41
"No Effect" Mean	2357	9.7	0.72	0.77
Effect Size	-774	-0.3	0.03	-0.19
95% Upper CI[4]	-1803	-4.4	-0.09	-0.49
95% Lower CI[4]	2205	3.8	0.15	0.44
C-TPN2011 Differences?	No	No	Marginal	No
p-value	0.38	0.52	0.09	0.48
"No Effect" Mean	779	6.7	0.72	0.69
Effect Size	-282	1.3	0.10	-0.15
95% Upper CI[4]	-608	-3.0	-0.02	-0.44
95% Lower CI[4]	703	5.5	0.23	0.46

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

Table A3-8. Results of statistical analyses of benthic invertebrate community descriptors for the 2006 to 2011 CREMP data set; long-term effect.

	Total Abundance (#/m²)	**Taxa Richness** (# taxa/ sample)	**Simpon's Diversity** (unitless)[5]	**Bray Curtis Distance** (unitless)[5]
Data Transformation[1]	Log10	None	None	Log10
Advanced Transformation[2]	Log10(x+50)	NA	NA	NA
Tests relative to controls				
C-SP'08-'11 Differences?	Marginal	No	Marginal	No
p-value	0.10	0.61	0.10	0.87
"No Effect" Mean[3]	836	8.05	0.71	0.60
Effect Size	-379	-0.8	0.07	0.02
95% Upper CI[4]	-625	-4.3	-0.01	-0.17
95% Lower CI[4]	101	2.6	0.15	0.29
C-TE'08-'11 Differences?	No	No	Marginal	No
p-value	0.29	1.00	0.07	0.89
"No Effect" Mean[3]	1018	7.41	0.65	0.60
Effect Size	-335	-0.01	0.08	0.01
95% Upper CI[4]	-710	-3.70	-0.01	-0.18
95% Lower CI[4]	432	3.68	0.17	0.30
C-TPE'09-'11 Differences?	Yes	No	Yes	No
p-value	0.02	0.97	0.02	0.11
"No Effect" Mean[3]	2866	10.02	0.70	0.70
Effect Size	-1484	-0.06	0.10	-0.16
95% Upper CI[4]	-2139	-3.20	0.02	-0.32
95% Lower CI[4]	-277	3.09	0.17	0.05
C-TPN'09-'11 Differences?	No	No	Yes	No
p-value	0.67	0.24	0.01	0.33
"No Effect" Mean[3]	963	7.08	0.69	0.63
Effect Size	-130	1.96	0.11	-0.10
95% Upper CI[4]	-556	-1.43	0.03	-0.26
95% Lower CI[4]	692	5.34	0.19	0.13

Notes:

1. Initial transformation options discussed in **Section 2**.
2. Advanced transformations determined using Box-Cox method (Venables & Ripley 2002).
3. "No Effect" Mean estimated by not including the Effect coefficient when estimating Area-Year mean.
4. Confidence intervals estimated using 2 * Std. Error of Effect Size estimate.
5. Model assumptions not met, see text for details.

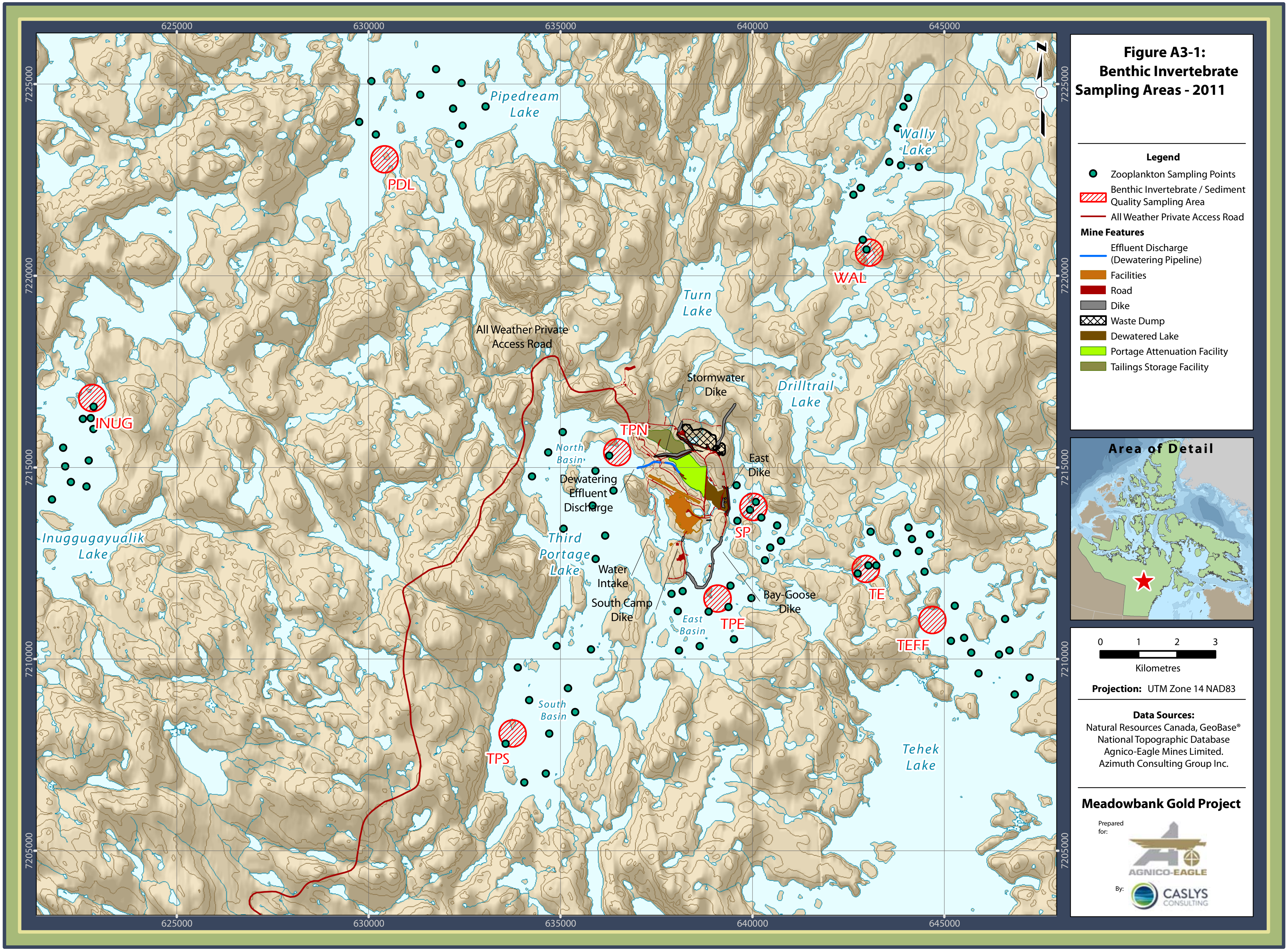


Figure A3-1: Benthic Invertebrate Sampling Areas - 2011
Legend
Zooplankton Sampling Points
Benthic Invertebrate / Sediment Quality Sampling Area
All Weather Private Access Road
Mine Features
Effluent Discharge (Dewatering Pipeline)
Facilities
Road
Dike
Waste Dump
Dewatered Lake
Portage Attenuation Facility
Tailings Storage Facility
Area of Detail
0 1 2 3
Kilometres
Projection: UTM Zone 14 NAD83
Data Sources:
Natural Resources Canada, GeoBase®
National Topographic Database
Agnico-Eagle Mines Limited.
Azimuth Consulting Group Inc.
Meadowbank Gold Project
Prepared for:
AGNICO-EAGLE
By:
CASLYS CONSULTING
625000
630000
635000
640000
645000
7225000
7220000
7215000
7210000
7205000
N
Pipedream Lake
PDL
Wally Lake
WAL
Turn Lake
All Weather Private Access Road
Stormwater Dike
Drilltrail Lake
INUG
TPN
North Basin
East Dike
Dewatering Effluent Discharge
SP
Inuggugayualik Lake
Third Portage Lake
Water Intake
South Camp Dike
Bay-Goose Dike
TE
East Basin
TPE
TEFF
South Basin
TPS
Tehek Lake

Figure A3-2. Benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) across CREMP areas for 2006 – 2011.

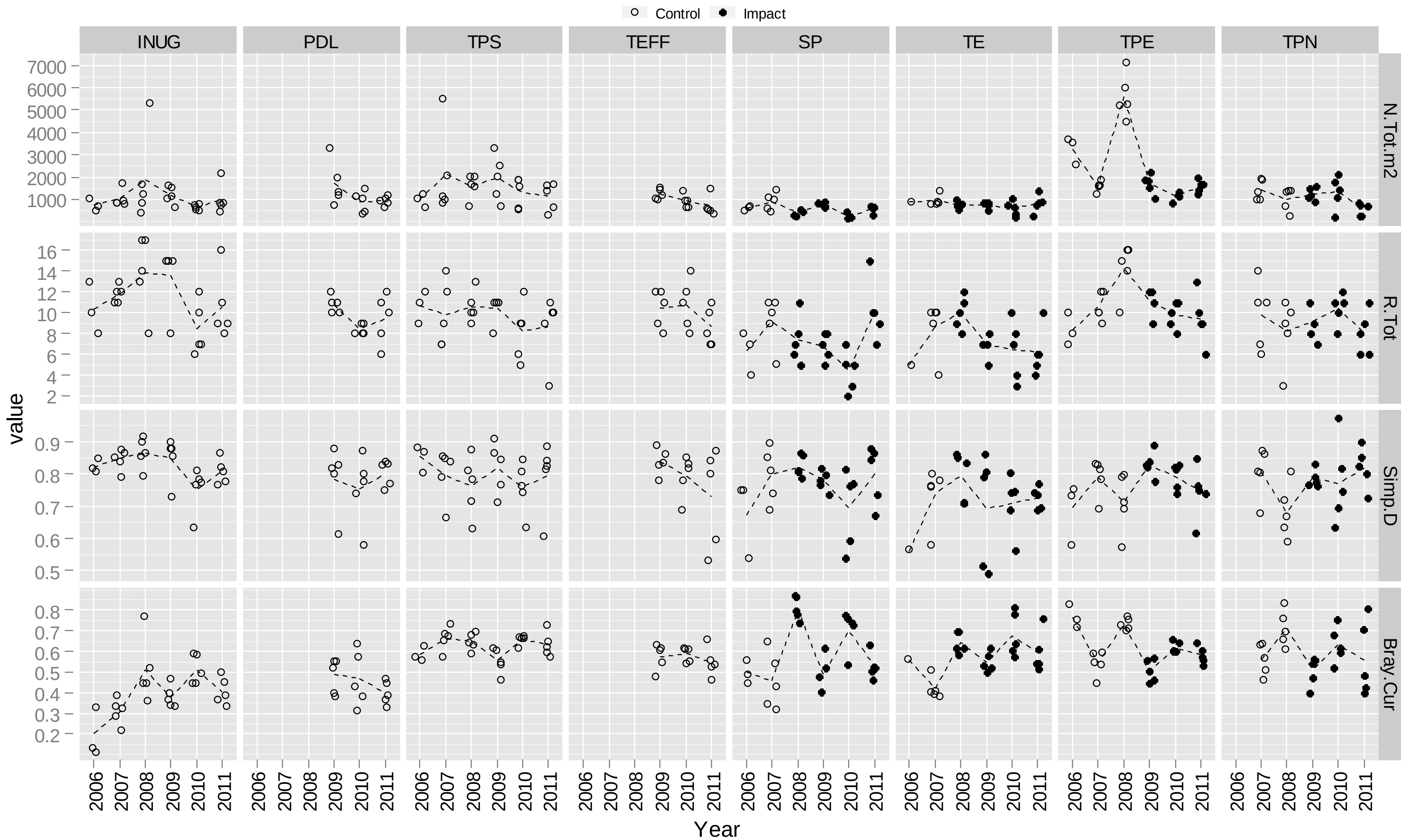


Figure A3-3. Boxplots of benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) by short-term effect grouping for CREMP data set.

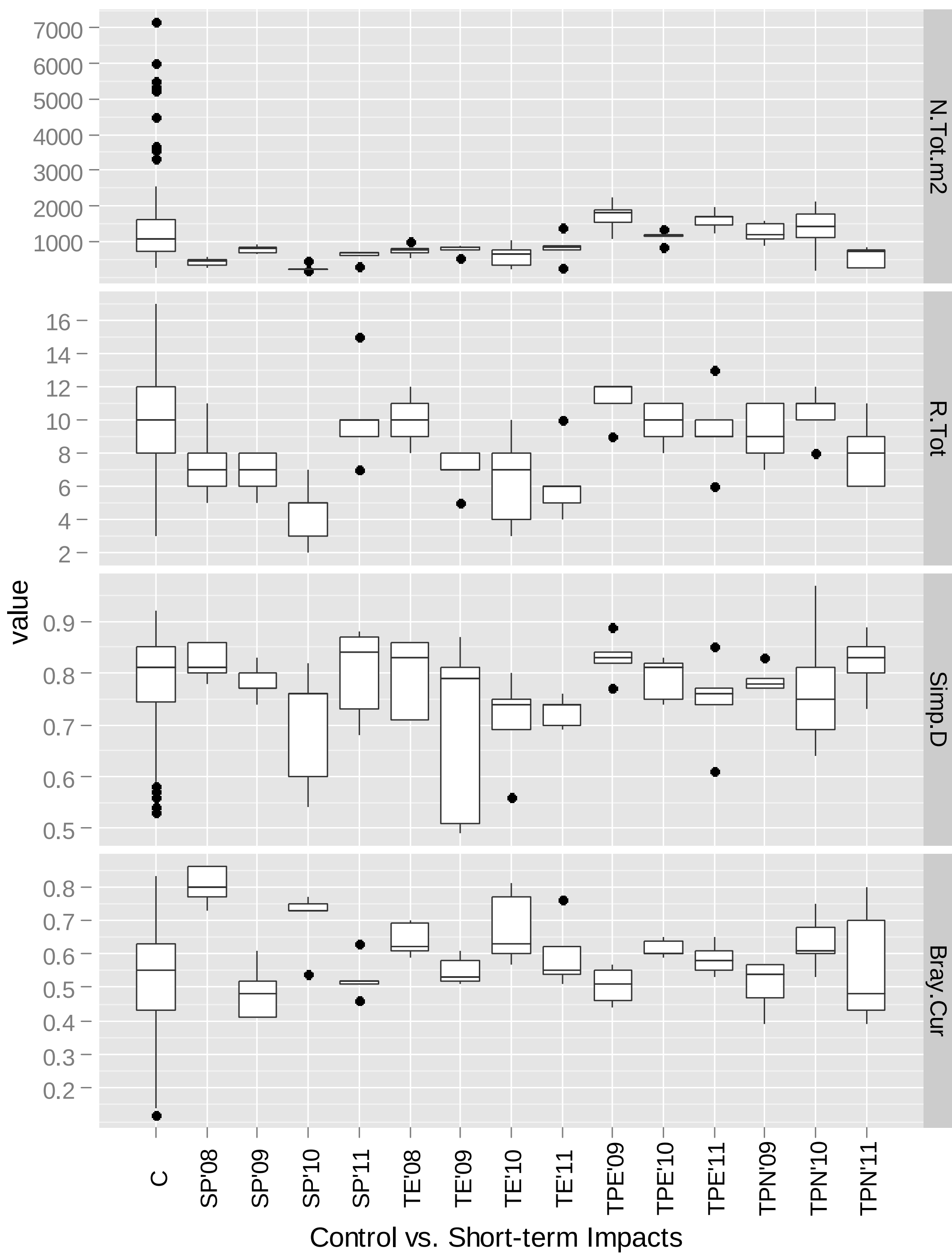


Figure A3-4. Boxplots of benthic community metrics (abundance, richness, Simpson's Diversity, and Bray Curtis distance) by long-term effect grouping for CREMP data set.

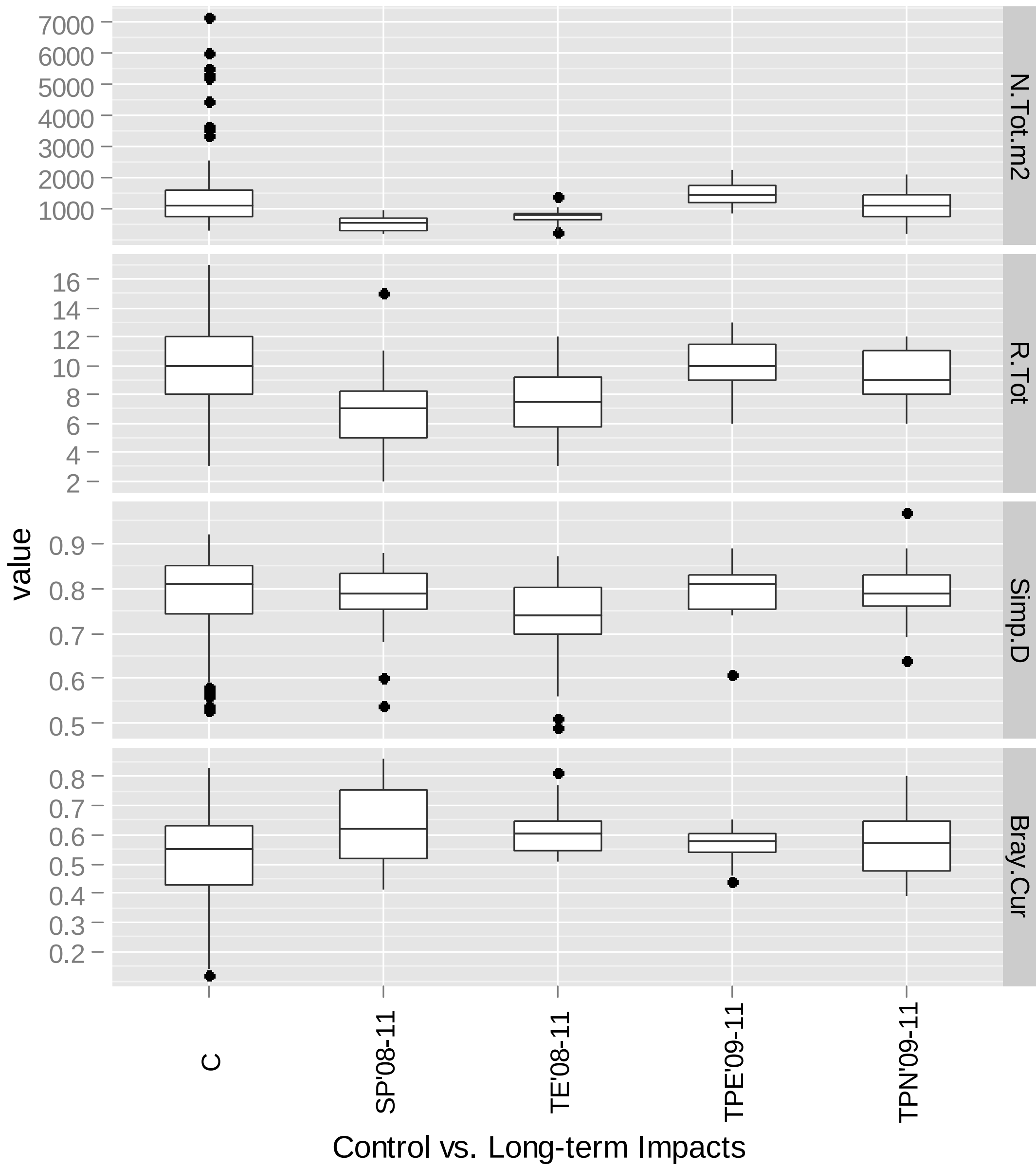


Figure A3-5. Interaction Plot for total benthic abundance by Area and Year for the CREMP data set.

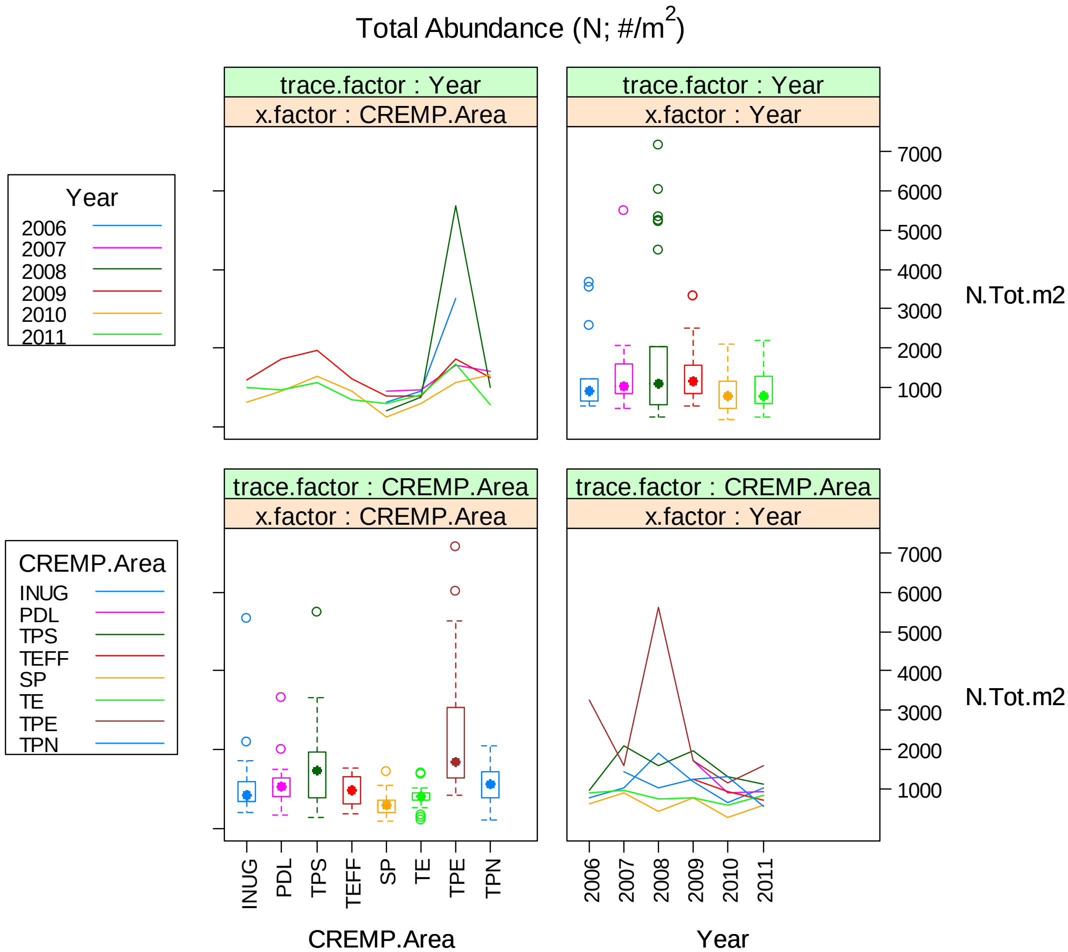


Figure A3-6. Interaction Plot for total benthic richness by Area and Year for the CREMP data set.

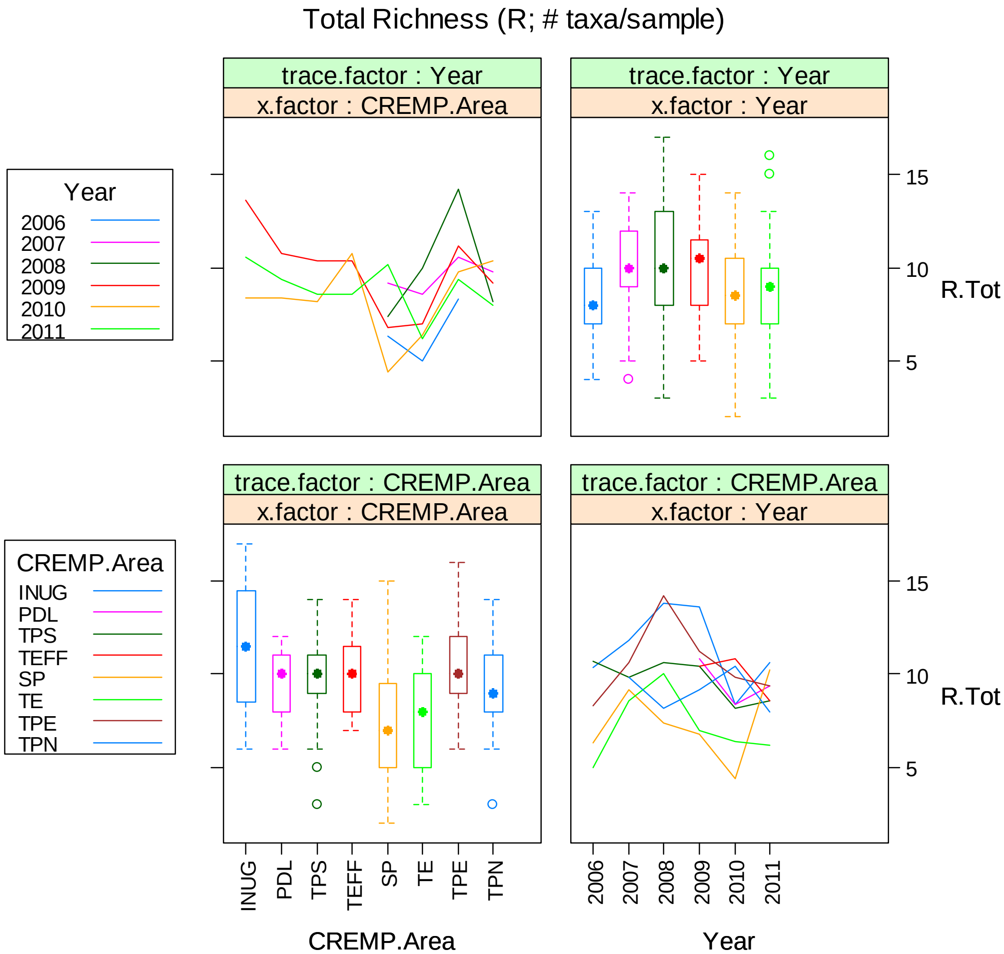


Figure A3-7. Interaction Plot for benthic Simpson's Diversity by Area and Year for the CREMP data set.

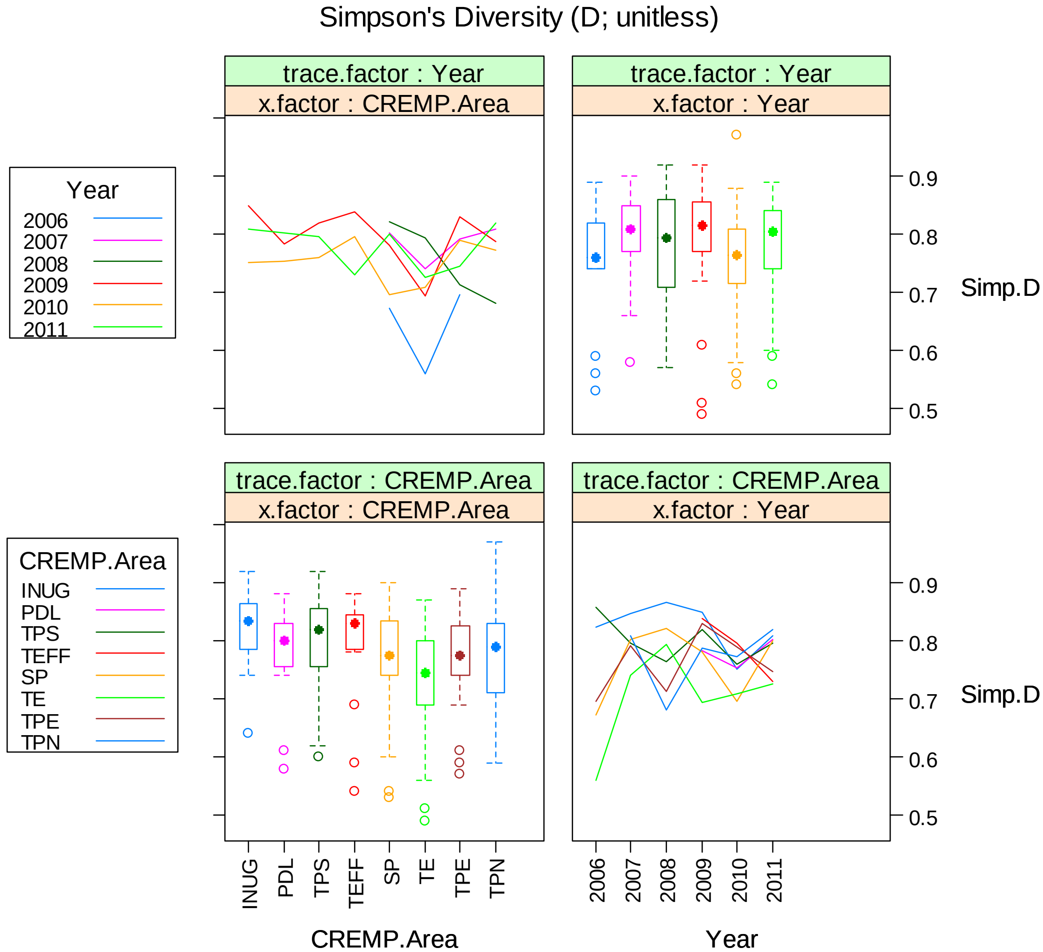
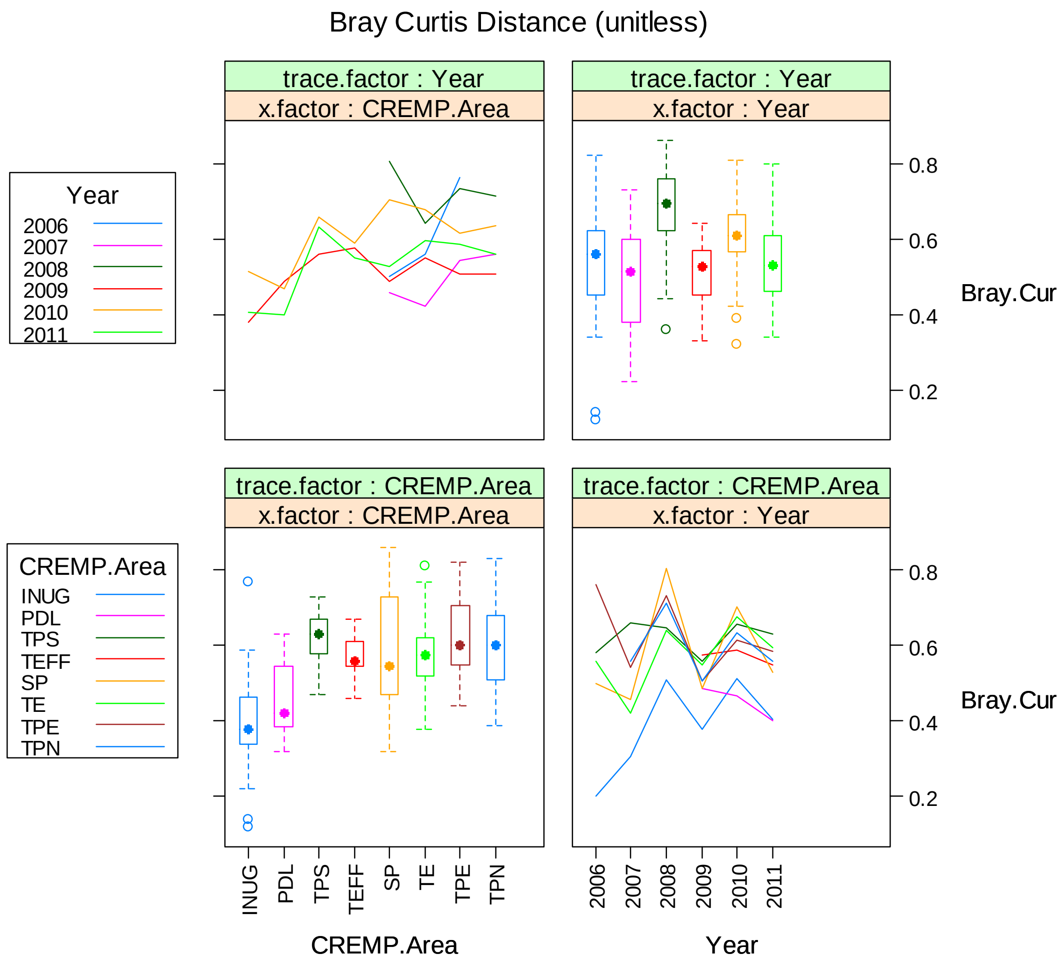


Figure A3-8. Interaction Plot for Bray Curtis distance by Area and Year for the CREMP data set.



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APPENDIX A1

RAW DATA FOR ANALYSIS OF BENTHIC INVERTEBRATES

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	**BAP**	**BAP**	**BAP**	**BAP**	**BAP**	**BBD**	**BBD**	**BBD**	**BBD**	**BBD**	**BES**	**BES**	**BES**	**BES**	**BES**	**BPJ**	**BPJ**	**BPJ**	**BPJ**	**BPJ**	**INUG**
Replicate	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1
Depth (m)	7.2	7.3	8.9	8.3	8.2	8.0	9.5	8.2	8.2	8.0	8.0	7.9	8.8	9.2	9.1	7.5	6.8	7.8	7.7	8.2	6.9
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	14-Aug-11
ROUNDWORMS																					
P. Nemata	13	16	25	732	5	5	5	1	3	6	11	27	12	11	13	19	23	1	3	10	
FLATWORMS																					
P. Platyhelminthes																					
Cl. Turbellaria																					
indeterminate																					
ANNELIDS																					
P. Annelida																					
WORMS																					
Cl. Oligochaeta																					
F. Enchytraeidae	14		5	8					1		4	14	2	2						2	
F. Naididae																					
Nais barbata																					
Nais communis																2				1	
Nais										1											
Slavina appendiculata																					
F. Tubificidae																					
Limnodrilus hoffmeisteri		5	5				1														
Rhyacodrilus coccineus		5	24																		
Rhyacodrilus montana	36	59	42	24	8	3	9	15		1	3	8	3	2	2	1	13	1	1	10	
Rhyacodrilus sodalis																					
Tasserkidrilus americanus						1															
immatures with hair chaetae	3	11		120		1	2	1								4				2	1
immatures without hair chaetae		5	14					2													
F. Lumbriculidae																					
Lumbriculus		5	5	8																	1
Stylodrilus	3	16																			
indeterminate																					
ARTHROPODS																					
P. Arthropoda																					
MITES																					
Cl. Arachnida																					
O. Acarina	12	8	10	11	10	2	4		1	3	3	9	5	2	3	6	2		1	1	
HARPACTICOIDS																					
O. Harpacticoida																					
SEED SHRIMPS																					
Cl. Ostracoda	1	26	5	18	10	4	10	3		9	2	3	10	1		26	15				2
FAIRY SHRIMP																					
O. Notostraca																					
Lepidurus arcticus																					
WATER SCUDS																					
O. Amphipoda																					
F. Gammaracanthidae																					
Gammaracanthus aestuariorum		1	1																		
F. Hyalellidae																					
Hyalella																					
INSECTS																					
Cl. Insecta																					
BEETLES																					
O. Coleoptera																					
F. Staphylinidae																					
MAYFLIES																					
O. Ephemeroptera																					
F. Baetidae																					
indeterminate																					
CADDISFLIES																					
O. Trichoptera																					
F. Limnephilidae																					
Grammotaulius																					
Grensia praeterita		3	2	3	1				1							2	5			1	
pupae																					
immature																					

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	**BAP**	**BAP**	**BAP**	**BAP**	**BAP**	**BBD**	**BBD**	**BBD**	**BBD**	**BBD**	**BES**	**BES**	**BES**	**BES**	**BES**	**BPJ**	**BPJ**	**BPJ**	**BPJ**	**BPJ**	**INUG**
Replicate	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1
Depth (m)	7.2	7.3	8.9	8.3	8.2	8.0	9.5	8.2	8.2	8.0	8.0	7.9	8.8	9.2	9.1	7.5	6.8	7.8	7.7	8.2	6.9
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	21-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	20-Aug-11	14-Aug-11
TRUE FLIES																					
O. Diptera																					
indeterminate				1																	
MIDGES																					
F. Chironomidae																					
chironomid pupae	3	10	7	14	3	10	3	6	1	18	2	9	7	5	12	7	4	2	7	5	
S.F. Chironominae																					
Chironomus				1																	
Cladotanytarsus																					
Constempellina	1	2	2				4	1		1											
Corynocera																					
Dicrotendipes																					
Micropsectra	20	7	10	3	34		25	5	2		1	13	4	41			31		4	19	
Microtendipes																					
Parachironomus																					
Paracladopelma					1						1		1					1	1		
Paratanytarsus	19	112	30	111	13	6					2	21	11	11	8	23					
Polypedilum																					
Sergentia		1				1				1						1					
Stempellinella																					
Stictochironomus	9	46	23	66			77	40		3		3				70	40		3	14	2
Tanytarsus	5	13		22	4	53	24	36	1	57	5	9	4		8	31	25		5	7	
indeterminate																					
S.F. Diamesinae																					
Potthastia	1	3	3	28						1		1			2						
Protanypus	7		6		3		3	2	4	3	2		2	1			1	1		2	1
Pseudodiamesa	7	3	9		2							1		2					2		
S.F. Orthocladiinae																					
Abiskomyia	3	2		1		7	39	103	1	31				1		51	38		12	27	2
Corynoneura																					
Cricotopus																					
Cricotopus/Orthocladius		3		3			1				1	2	3	1	1						
Heterotrissocladius	3	2	3	1	38	4	6	6	2	2	32	16	47	59	60	17	19	6	9	5	
Hydrobaenus																					
Mesocricotopus				1																	
Nanocladius																					
Paracladius	2	1			1						1	5	3	2	1	2	4			2	
Parakiefferiella				1						1		1			1						
Psectrocladius																					
Psectrocladius (Monopsectrocladius)																					
Psectrocladius		1		1																	1
Zalutschia										1											
indeterminate																					
S.F. Prodiamesinae																					
Monodiamesa	1		2			4	3	1		9	1		1	1		2	3				1
S.F. Tanypodinae																					
Ablabesmyia																					
Procladius	12	12	7	17	7	11	6	10	10	10	4	7		2	2	9	15	5	1	4	4
Thienemannimyia complex		2	1	1	2			1				2				3	2				
Trissopelopia																					
indeterminate																					
F. Empididae																					
Chelifera/Neoplasta																					
Chelifera	5		4		3		1			2		1			2	2	1			2	
Wiedemannia																		3			
pupae																					
MOLLUSCS																					
P. Mollusca																					
CLAMS																					
Cl. Bivalvia																					
F. Sphaeriidae																					
Cyclocalyx/Neopisidium	21	35	19		27	1	4	5		1	4	21	5	5	22	33	38		1	3	8
Cyclocalyx	2	3	5				1									3	2			2	
Cyclocalyx nitidium																					
Cyclocalyx (Pisidium)																					
Sphaerium nitidum																					
TOTAL NUMBER OF TAXA [1]	**20**	**25**	**22**	**19**	**15**	**11**	**16**	**12**	**9**	**17**	**14**	**17**	**13**	**14**	**12**	**17**	**16**	**6**	**11**	**16**	**8**
TOTAL NUMBER OF ORGANISMS [2]	**189**	**376**	**239**	**446**	**157**	**104**	**213**	**234**	**24**	**146**	**66**	**143**	**98**	**137**	**124**	**269**	**243**	**19**	**47**	**109**	**21**

Notes:

[1] Number of taxa totals exclude nematodes & ostracods, immatures & pupae (Tubificidae, Limnephilidae, Chironomidae, Empididae), and indeterminates (Lumbriculidae, Diptera, Chironominae, Orthocladiinae, Tanypodinae).

[2] Number of organisms totals exclude nematodes (P. Nemata) & ostracods (Cl. Ostracoda).

TPE,TPN,TPS=Third Portage Lake - East, North, South basins; SP=Second Portage Lake; TE,TEFF=Tehek Lake - Farfield;
INUG=Inuggugayualik Lake; WAL=Wally Lake; PDL=Pipedream Lake;
BBD,BPJ,BAP,BES=Baker Lake - Barge Dock, Proposed Jetty, Akilahaarjuk Point, East Shore.

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	**INUG**	**INUG**	**INUG**	**INUG**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**SP**	**SP**	**SP**	**SP**	**SP**	**TE**	**TE**	**TE**	**TE**	**TE**	**TEFF**	**TEFF**	**TEFF**
Replicate	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3
Depth (m)	6.8	7.6	8.5	9.2	6.5	6.8	6.9	7.6	6.7	8.8	7.5	7.8	8.0	6.5	7.2	8.3	7.7	7.3	6.5	6.9	8.2	6.9
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	15-Aug-11	15-Aug-11	15-Aug-11
ROUNDWORMS																						
P. Nemata	1	1	2	3	1			1	2	1	2		3		1	3	3	1	6	3	2	5
FLATWORMS																						
P. Platyhelminthes																						
Cl. Turbellaria																						
indeterminate																						
ANNELIDS																						
P. Annelida																						
WORMS																						
Cl. Oligochaeta																						
F. Enchytraeidae																						
F. Naididae																						
Nais barbata																						
Nais communis																						
Nais																						
Slavina appendiculata																						
F. Tubificidae																						
Limnodrilus hoffmeisteri																						
Rhyacodrilus coccineus													1							1		
Rhyacodrilus montana																						
Rhyacodrilus sodalis																						
Tasserkidrilus americanus							3		1													
immatures with hair chaetae					3				1			1										
immatures without hair chaetae																						
F. Lumbriculidae																						
Lumbriculus	2	3	4	3		1	4						1		2	1						
Stylodrilus																						
indeterminate																						
ARTHROPODS																						
P. Arthropoda																						
MITES																						
Cl. Arachnida																						
O. Acarina	1	2	1	1	3		3	1	1	5	2	2	2	1		3	1	4	2	2		5
HARPACTICOIDS																						
O. Harpacticoida																						
SEED SHRIMPS																						
Cl. Ostracoda	1	3	5		5	2				5	2		1	7	2	3		5		1	9	44
FAIRY SHRIMP																						
O. Notostraca																						
Lepidurus arcticus			5															1				
WATER SCUDS																						
O. Amphipoda																						
F. Gammaracanthidae																						
Gammaracanthus aestuariorum																						
F. Hyalellidae																						
Hyalella																						
INSECTS																						
Cl. Insecta																						
BEETLES																						
O. Coleoptera																						
F. Staphylinidae																						
MAYFLIES																						
O. Ephemeroptera																						
F. Baetidae																						
indeterminate																						
CADDISFLIES																						
O. Trichoptera																						
F. Limnephilidae																						
Grammotaulius																						
Grensia praeterita						1			1					1	1			1				
pupae																						
immature																						

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	**INUG**	**INUG**	**INUG**	**INUG**	**PDL**	**PDL**	**PDL**	**PDL**	**PDL**	**SP**	**SP**	**SP**	**SP**	**SP**	**TE**	**TE**	**TE**	**TE**	**TE**	**TEFF**	**TEFF**	**TEFF**
Replicate	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3
Depth (m)	6.8	7.6	8.5	9.2	6.5	6.8	6.9	7.6	6.7	8.8	7.5	7.8	8.0	6.5	7.2	8.3	7.7	7.3	6.5	6.9	8.2	6.9
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	13-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	17-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	16-Aug-11	15-Aug-11	15-Aug-11	15-Aug-11
TRUE FLIES																						
O. Diptera																						
indeterminate																						
MIDGES																						
F. Chironomidae																						
chironomid pupae				1		1		1	1						1	1				1		1
S.F. Chironominae																						
Chironomus																						
Cladotanytarsus																						
Constempellina																						
Corynocera																						
Dicrotendipes																						
Micropsectra	1	2	3	1	1						1									2		3
Microtendipes	1		3	1																		
Parachironomus																						
Paracladopelma																						
Paratanytarsus			2	2					2	1										1	1	5
Polypedilum																						
Sergentia																						
Stempellinella													2									
Stictochironomus	9	2	1	1	15	8	17	5	16		1							3			2	1
Tanytarsus		2	2			1			2	1			1	1								
indeterminate																						
S.F. Diamesinae																						
Potthastia																						
Protanypus					2	1	1			1		1	2							1		
Pseudodiamesa																						
S.F. Orthocladiinae																						
Abiskomyia					1			2			1		1	1				1				1
Corynoneura																						
Cricotopus					2																	
Cricotopus/Orthocladius																						
Heterotrissocladius			1	2		1	4	1	2	4	1	1	3	1						1	1	5
Hydrobaenus					1																	
Mesocricotopus													1									
Nanocladius																						
Paracladius										2			1								1	
Parakiefferiella																						
Psectrocladius																						
Psectrocladius (Monopsectrocladius																						
Psectrocladius			5		1	6			2	3	3	3	2		11	17	5	26	11		3	10
Zalutschia			1										1									4
indeterminate																						
S.F. Prodiamesinae																						
Monodiamesa			2		1					1	2	2	1	1	2	2		4	1	2	1	
S.F. Tanypodinae																						
Ablabesmyia																						
Procladius	7	5	26	9	5	4	3	7	7	3	2	2	1	2	4	7	1	7	8			6
Thienemannimyia complex																						4
Trissopelopia																						
indeterminate																						
F. Empididae																						
Chelifera/Neoplasta																						
Chelifera																		1				
Wiedemannia																						
pupae																						
MOLLUSCS																						
P. Mollusca																						
CLAMS																						
Cl. Bivalvia																						
F. Sphaeriidae																						
Cyclocalyx/Neopisidium	13	17	40	9	12	13	19	14	2	11	16	15	11	5	14	7	5	15	19	6	16	24
Cyclocalyx	5	1	1	2	2	3			5		2			1								
Cyclocalyx nitidium																						
Cyclocalyx (Pisidium)																						
Sphaerium nitidum	1	4	4	2																		
TOTAL NUMBER OF TAXA [1]	**9**	**9**	**16**	**11**	**12**	**10**	**8**	**6**	**11**	**10**	**10**	**7**	**15**	**9**	**6**	**6**	**4**	**10**	**5**	**8**	**7**	**11**
TOTAL NUMBER OF ORGANISMS [2]	**40**	**38**	**101**	**34**	**49**	**40**	**54**	**31**	**43**	**32**	**31**	**27**	**31**	**14**	**35**	**38**	**12**	**63**	**41**	**17**	**25**	**69**

Notes:

[1] Number of taxa totals exclude nematodes & ostracods, immatures & pupae (Tubificidae, Limnephilidae, Chironomidae, Empididae), and indeterminates (Lumbriculidae, Diptera, Chironominae, Orthocladiinae, Tanypodinae).

[2] Number of organisms totals exclude nematodes (P. Nemata) & ostracods (Cl. Ostracoda).

TPE,TPN,TPS=Third Portage Lake - East, North, South basins; SP=Second Portage Lake; TE,TEFF=Tehek Lake - Farfield;
INUG=Inuggugayualik Lake; WAL=Wally Lake; PDL=Pipedream Lake;
BBD,BPJ,BAP,BES=Baker Lake - Barge Dock, Proposed Jetty, Akilahaarjuk Point, East Shore.

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	**TEFF**	**TEFF**	**TPE**	**TPE**	**TPE**	**TPE**	**TPE**	**TPN**	**TPN**	**TPN**	**TPN**	**TPN**	**TPS**	**TPS**	**TPS**	**TPS**	**TPS**	**WAL**	**WAL**	**WAL**	**WAL**	**WAL**
Replicate	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Depth (m)	7.0	7.0	7.7	8.4	8.2	9.5	7.9	7.0	9.0	9.2	8.6	8.4	6.9	6.7	7.3	8.1	8.4	8.6	7.0	8.3	7.9	7.2
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	15-Aug-11	15-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11
ROUNDWORMS																						
P. Nemata	1	5	3	1	1		3	3		1			4	10	6	12	1		1	3	1	2
FLATWORMS																						
P. Platyhelminthes																						
Cl. Turbellaria																						
indeterminate																						
ANNELIDS																						
P. Annelida																						
WORMS																						
Cl. Oligochaeta																						
F. Enchytraeidae																						
F. Naididae																						
Nais barbata																						
Nais communis																						
Nais					1																	
Slavina appendiculata																						
F. Tubificidae																						
Limnodrilus hoffmeisteri																						
Rhyacodrilus coccineus			21	8	3		6						1	1								
Rhyacodrilus montana																						
Rhyacodrilus sodalis																						
Tasserkidrilus americanus									1													
immatures with hair chaetae						1			1				1	2								
immatures without hair chaetae																						
F. Lumbriculidae																						
Lumbriculus					1	1	2	1					1		1	2		1		2	1	1
Stylodrilus																						
indeterminate																						
ARTHROPODS																						
P. Arthropoda																						
MITES																						
Cl. Arachnida																						
O. Acarina	1			5	4	2	1			1	2								2	1	1	
HARPACTICOIDS																						
O. Harpacticoida																						
SEED SHRIMPS																						
Cl. Ostracoda	12	18	72	68	69	45	41	1	1	1	2	6	26	26	19	23	19	7	3	16	4	4
FAIRY SHRIMP																						
O. Notostraca																						
Lepidurus arcticus																						
WATER SCUDS																						
O. Amphipoda																						
F. Gammaracanthidae																						
Gammaracanthus aestuariorum																						
F. Hyalellidae																						
Hyalella																						
INSECTS																						
Cl. Insecta																						
BEETLES																						
O. Coleoptera																						
F. Staphylinidae																						
MAYFLIES																						
O. Ephemeroptera																						
F. Baetidae																						
indeterminate																						
CADDISFLIES																						
O. Trichoptera																						
F. Limnephilidae																						
Grammotaulius																						
Grensia praeterita	1	1										1										
pupae																						
immature																				1		

Appendix A1. Benthic invertebrate raw data (total number of organisms in two 0.023 m2 grabs), Meadowbank study lakes and Baker Lake, August 2011.

Area	TEFF	TEFF	TPE	TPE	TPE	TPE	TPE	TPN	TPN	TPN	TPN	TPN	TPS	TPS	TPS	TPS	TPS	WAL	WAL	WAL	WAL	WAL
Replicate	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Depth (m)	7.0	7.0	7.7	8.4	8.2	9.5	7.9	7.0	9.0	9.2	8.6	8.4	6.9	6.7	7.3	8.1	8.4	8.6	7.0	8.3	7.9	7.2
# Grabs/sample	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mesh Size (µm)	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500	500
Date	15-Aug-11	15-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	19-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	22-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11	14-Aug-11
TRUE FLIES																						
O. Diptera																						
indeterminate																						
MIDGES																						
F. Chironomidae																						
chironomid pupae		2	5						4	3		1	4	4	11	1	1			3		
S.F. Chironominae																						
Chironomus																						
Cladotanytarsus																				51		
Constempellina																						
Corynocera																						
Dicrotendipes																						
Micropsectra		1			11			2	2		1	2	2	8	6	6			1			
Microtendipes																						
Parachironomus																						
Paracladopelma																						
Paratanytarsus	2	2	22	13	10	4	10	1			1		14	13	18	1			1			
Polypedilum																						
Sergentia																						
Stempellinella																			1			
Stictochironomus			3	3	5	1	1	6	1		1		2			2		2	3		1	3
Tanytarsus		2		1	2	5	2	2	2		2		5	4	2	2				59		
indeterminate																						
S.F. Diamesinae																						
Potthastia					1																	
Protanypus					1						1								1			
Pseudodiamesa																						
S.F. Orthocladiinae																						
Abiskomyia																						
Corynoneura																						
Cricotopus																						
Cricotopus/Orthocladius																						
Heterotrissocladius		2	2	2		3		2	3	3	7	1	13	6	1	4	1					
Hydrobaenus																						
Mesocricotopus																						
Nanocladius																						
Paracladius															1							
Parakiefferiella																						
Psectrocladius																						
Psectrocladius (Monopsectrocladius																				1		
Psectrocladius	1	3									2	1	2	1	3					4		
Zalutschia									3	1				1		1						
indeterminate																						
S.F. Prodiamesinae																						
Monodiamesa	1	1				1	2											2				
S.F. Tanypodinae																						
Ablabesmyia																						
Procladius		1	6	10	3	9	6	4	6	2	1	1	1	1	2			3	10	11	5	3
Thienemannimyia complex	1	1		3	4	3			2	1	2		8	2	8	4	3					
Trissopelopia																						
indeterminate																						
F. Empididae																						
Chelifera/Neoplasta																						
Chelifera																				1		
Wiedemannia																						
pupae																						
MOLLUSCS																						
P. Mollusca																						
CLAMS																						
Cl. Bivalvia																						
F. Sphaeriidae																						
Cyclocalyx/Neopisidium	15	12	32	33	21	47	26	17	13	1	13	5	20	20	24	8	8	13	16	12	15	10
Cyclocalyx																		1	2	10	3	3
Cyclocalyx nitidium																						
Cyclocalyx (Pisidium)																						
Sphaerium nitidum																						
TOTAL NUMBER OF TAXA [1]	**7**	**10**	**6**	**9**	**13**	**10**	**9**	**8**	**9**	**6**	**11**	**6**	**11**	**10**	**10**	**9**	**3**	**6**	**9**	**10**	**6**	**5**
TOTAL NUMBER OF ORGANISMS [2]	**22**	**28**	**91**	**78**	**67**	**77**	**56**	**35**	**38**	**12**	**33**	**12**	**74**	**63**	**77**	**31**	**13**	**22**	**38**	**155**	**26**	**20**

Notes:

[1] Number of taxa totals exclude nematodes & ostracods, immatures & pupae (Tubificidae, Limnephilidae, Chironomidae, Empididae), and indeterminates (Lumbriculidae, Diptera, Chironominae, Orthocladiinae, Tanypodinae).

[2] Number of organisms totals exclude nematodes (P. Nemata) & ostracods (Cl. Ostracoda).

TPE,TPN,TPS=Third Portage Lake - East, North, South basins; SP=Second Portage Lake; TE,TEFF=Tehek Lake - Farfield;
INUG=Inuggugayualik Lake; WAL=Wally Lake; PDL=Pipedream Lake;
BBD,BPJ,BAP,BES=Baker Lake - Barge Dock, Proposed Jetty, Akilahaarjuk Point, East Shore.

Standard Operating Procedure
Meadowbank Project Lakes
EAS & HCM Periphyton Sampling

Equipment:

- Field collection data forms, pencils, waterproof markers & clipboard
- GPS unit, batteries
- Periphyton sampler, syringes & plastic tubes
- Binder clips (to pinch tubes on periphyton sampler)
- Shoulder gloves (with 5 cm increments marked from fingertip to shoulder)
- Scraping tools
- Large tote
- Field sample bottles & preservative (per replicate):
    - 1 – 500 mL plastic jar (if scrubbing)
    - 1 syringe & Lugol's solution
    - 1 – 125 mL glass jar (if scraping)
- Cooler(s) or action packer(s) (for storing and shipping samples)
- Address labels for cooler(s)/action packer(s)
- Chain-of-custody forms
- Large Ziploc bag (for sending chain-of-custody form in cooler)
- Packing tape (for sealing cooler)

General Procedures:

- Before going into the field, **label** all **sampling containers**. Using a permanent waterproof marker, print the following information directly onto both the jar and jar lid:
    - Azimuth company name
    - Station abbreviation (e.g. SP-CREMP) and replicate number (e.g. SP-CREMP -1, TPE-CREMP-2)
    - Date of sample collection

- Before and during sampling fill in the requested information on the **field data form**. Forms are made of waterproof paper; **print** all information on the form using a **lead pencil** or write-in-the-rain pen.

- Access to the area may be by boat or foot; in either event, ensure the sampling area is not impacted by boat (launch) or other anthropogenic activities. Record the **UTM coordinates** for each sampling station, measured using a GPS unit in NAD 83, on the field data form. In future sampling events, sample periphyton from the same locations.

Appendix B. SOP EAS & HCM periphyton sampling.

- **Select a rock** with a **flat surface**, no more than 0.5 meter below the water surface, with the following criteria:
  - Facing up as much as possible; if not, with a small slope
  - Uniform algal coverage, not uniformly dense or sparse

- The periphyton sampler is a specially designed **scrubber**, consisting of a plexiglass tube with a plunger that fits snugly inside and a distal wire brush that is in direct contact with the rock surface. Press the tube against the rock to form a tight seal. To **detach** the **periphyton colonies**, depress the plunger and twist for approximately 30 half turns. The periphyton mixture is suspended (i.e. by opening the plunger approximately ¼ of the device volume) and drawn into a syringe that is attached to the tube (pinch intake tube closed when drawing suspension into syringe). Empty the syringe (pinch output tube closed prior to detaching the syringe) into the pre-labeled replicate 1 sampling container (i.e. TPE-CREMP-1). Continue scraping and syringing (approximately 2 times: another 20 half turns of the sampler, then 10 half turns, then a final rinse of sampler) until all visible periphyton are completely removed from the rock surface. This procedure works well with two people; one to scrape the rocks and clamp the intake tube, the other to operate the syringe and clamp the output tube. The number of turns in this SOP errs on the side of caution and may be too many for the average sampling site. Use discretion and examine each sampled rock to ensure it has been fully cleaned where the scrubber was used.

- **Repeat** rock selection and scrubbing steps **two more times**, selecting undisturbed flat rocks in less than 0.5 meter of water. Put the collected periphyton samples from each rock into the same pre-labeled replicate 1 sampling container (i.e. TPE-1) as above. These 3 rocks are composited into one replicate sample; approximately 500 mL of water/periphyton are collected in total.

- **Repeat** above steps for each replicate required at the station. For every 125 mL of periphyton mixture in each sampling container, **add 1 mL of Lugol's solution** to preserve the sample (the sample should look the colour of weak tea). Seal the sampling containers and store in a cooler at **room temperature**.

- For **periphyton scraping** the periphyton sampler is used to scribe a circle onto the chosen rock. Any same diameter item could be used instead if that is easier. Using two spatulas the circle can be carefully scraped. The rock choice should match those outlined above, in fact if one of the rocks used in scrubbing has enough undisturbed space the same rock could be used for scraping. The sample is placed into a 125 mL glass sampling jar which had been pre-labeled with the station ID. The sample is placed in a **freezer** at the end of the sampling day. It is not preserved.

- Fill out a **chain-of-custody** form completely and place into a sealed ziploc plastic bag inside the shipping container. If using digital COC form, print 2 copies of the document in the field (one for the laboratory, one for Azimuth). Questions about COCs can be directed to Maggie McConnell.

Appendix B. SOP EAS & HCM periphyton sampling.

EAS Periphyton Scraping

- Collect periphyton scraping samples from up to **20 stations** within SP and TPE
- Stations in SP that will be revisited are: SP-CREMP, SP-DT, SP-BL and SP-ED
- Stations in Third Portage Lake will include: TPE-CREMP, TPN-CREMP, TPS-CREMP, TPE-BGN and TPE-BGS
- 11 additional stations in TPE will also be collected (rough locations are provided on a field map with the intent of getting adequate spatial representation)
- Each station consists of 5 replicate samples (these are close together for most stations but spread out for the 3 dike stations)
- Each replicate will be placed in 1 x 125mL jar and frozen until shipped
- Ship samples and COC to ALS Environmental

ALS Environmental
101-8081 Lougheed Hwy.
Burnaby, BC, Canada
V5A 1W9
Tel: 604-253-4188
Attn: Brent Mack

HCM Periphyton Scrubbing

- Collect periphyton scrubbing samples from **7 stations** within SP and TPE
- Stations in SP that will be revisited are: SP-CREMP, SP-DT and SP-ED
- Stations in TPE will include: TPE-CREMP, TPE-BGN, TPE-BGS and one other reference site (which will coincide with one of the 11 TPE stations chosen for scraping)
- Each station consists of 5 replicate samples (these are close together for 4 stations but spread out for the 3 dike stations)
- Each replicate will consist of scrubbings from 3 rocks and will be placed in 1 x 500mL jar and preserved with Lugol's solution
- Ship samples and COC to David Findlay at Plankton R Us

David Findlay
Plankton R Us Inc.
39 Alburg Drive
Winnipeg, MB
R2N 1M1
Tel: 204-254-7952

NOTE: Along the dike face it may be necessary to set up a tote to receive the rock. If the aspect of the dike face is too steep to safely or properly sample in-situ place the rock in the tote in the boat. It must hold enough water to cover the sampled rock so that the plunger works properly. Make sure the tote is clean after each sample.

Appendix C. SOP EAS & HCM underwater video survey.

Standard Operating Procedure
Meadowbank Project Lakes
EAS & HCM Underwater Video Survey

Equipment:

- Video Camera
- Lowrance depth sounder (Recording sonar with GPS is required for Bathymetry)
- Note book/clip board with data sheets
- Reference tool
- GPS/spare batteries
- Underwater Viewer
- Anchor with a good long line

General Procedures:

Underwater video sampling was completed in 2009 for both EAS high value habitat (HVH) and for Habitat Compensation Monitoring (HCM). Most of these operating procedures are based on the procedures that were in place for those sampling events, some changes have been made to accommodate changes in circumstance or due to 2009 experiences.

- To provide a frame of reference for the underwater video, a rebar frame can be fabricated (50 cm square, marked with electrical tape at desired intervals) and featured in each video clip. The frame will then be attached to a line so that it can be lowered with or before the video camera (care must be taken to avoid tangling or knocking the camera with this device).
- DVDs should not be left in the DVR when the machine is being moved because it is possible to scratch the disc and loss the data. At each site, and after all replicates are complete, the DVD should be removed, labeled and stored.
- This equipment should not be operated in rain or spray.
- Always closely follow the setup and dismantling instructions for the camera equipment (make sure all connections are solid; tape if necessary).
- Previously three people were recommended for completing video survey work, however, for 2011 two people should be sufficient (n.b. there may be students available who could help out).
- One person will be responsible for the DVR, viewscreen, and note taking. Note taking will include the station name and replicate, time stamp, coordinates, and notes on substrate size, features, and the impression of periphyton conditions. After each site has been visited, and all replicates have been completed, this person will remove the DVD from the DVR, record the station name on the DVD, then place the DVD into a protective case.
- The other person will operate the camera, reference tool, and underwater viewer.

Appendix C. SOP EAS & HCM underwater video survey.

EAS HVH Video Survey

- Follow the video survey general procedures and visit the HVH stations in TPE
- If time allows (strongly recommended) visit the HVH stations in SP
- All surveyed sites should match those from 2009 as closely as possible

Objectives

- The intent of the survey is to document the status of HVH relative to potential increased sediment loadings on rock surfaces related to East Dike & Bay-Goose Dike construction
- Document and qualitatively describe substrate composition and periphyton coverage at HVH sites in TPE and SP (revisit the sites from 2009)

These sites are spread throughout Second Portage (SP) and the east basin of Third Portage Lake (TPE). Initial video survey work was completed to assess HVH areas in Third Portage prior to dike construction also providing a reference to HVH areas that were potentially impacted by sedimentation from the East Dike construction. By revisiting these sites it may be possible to view the deposition of sediment in TPE that might have resulted from the construction of the Bay Goose Dike. In SP it may be possible to gather more data on post construction recovery/changes to the periphyton growth.
For both lakes, notes must be taken that include station name, depth, and substrate (see data sheets); and which *record* the %cover of periphyton including any noted sediment coverage, mat density, colour, any snap shots, distinctive features such as ice scour, and any other relevant notes.

Station Locations

There are six (6) stations in each lake; however, two of the TPE stations may have been lost due to BGD construction. Target locations are available in a Garmin file that can be uploaded onto the GPS before going into the field. Station naming is as follows:

- VID-2PL-HVH-1 through HVH-6 (for SP stations)
- VID-3PL-HVH-1 through HVH-6 (for TPE stations)

Each of the 12 stations has 5 replicates, with a target depth range of 1-4 meters. Replicates should be about 3 meters apart and will be determined by letting the anchor line out. Depths should be recorded for each replicate, but only one set of coordinates needs to be recorded for each station. The time stamp should be for start of first replicate to end of the last replicate. Each video segment should target 30 seconds in length.

HCM Video Survey and Bathymetry

- Following the video survey general procedures revisit ED video sites from 2009
- Complete a similar video survey at BGD stations
- Complete video transects at each of the replicates on each dike
- Video work would ideally be completed before periphyton work along dike faces
- Gather bathymetry information from Bay Goose Dike

(1) Video for Deeper Periphyton

Objective

- Make inferences regarding periphyton community development in deeper zones, close to where periphyton communities will be sampled (scrubbing)

Description & Station Locations

The focus will be on substrate, sedimentation, and periphyton standing crop (community). The area of focus will be the lake side faces of both dikes. The East Dike was studied in 2009 and will be revisited in this year (2011). The Bay Goose Dike will be separated into North and South portions; this makes a total of three 3 stations – East Dike, Bay-Goose Dike North and South. Each of the 3 stations has 5 replicates. Replicates should be evenly spaced to cover the entire station (i.e., the dike or portion of the dike). Station naming is as follows:

- VID-ED (for East Dike stations)
- VID-BGN (for Bay-Goose Dike N stations)
- VID-BGS (for Bay-Goose Dike S stations)

Target depth range is 1-4 meters. Depth and coordinates should be recorded for *each* replicate. The time stamp should be for start to end of *each* replicate. There is no target length for each video segment. The sample locations should match with periphyton scrubbing (both dikes) and porewater quality (BGD only). It is important to coordinate with these two other sample types to match locations.

(2) Video for Physical

Objective

- Inform physical monitoring aspects of habitat compensation plan

Description & Station Locations

A video record of habitat features particularly substrate size and composition will be conducted. Start the video in shallow water near the dike face at each of the dike station replicates (same as for "deeper periphyton"; if short on time, ED stations can be dropped). Move the video camera slowly into deeper water recording the physical structures on the dike face (i.e., make a transect perpendicular to the dike face). The camera will descend down the dike face to the lake bottom or the maximum length of the camera cable, whichever comes first. Notes should include a record of site name and replicate, date, and time stamp. It may be difficult to lower both the camera and reference object at the same time.

(3) Bathymetry

Objective

- Map out depth intervals encircling both portions of the BGD

Description & Station Locations

Bathymetry data will only be collected along the Bay-Goose Dike face because bathymetry data has already collected for the East Dike in 2009. The time stamps for both the sonar and video camera should be the same because the time information is received from the internal GPS units (double check this). Conduct slow transects parallel to each portion of the BGD. Conduct transects at 3 meter intervals out from the dike face (i.e., 3m, 6m, 9m, etc.) Be sure to record bathymetric data in the sonar's memory card.

Appendix D. Sediment trap data from 2008-2011.

Trap ID	Rep	UTM Coordinates (NAD 83)			Lake	Season	Year	Trap Contents: Total Weight	Trap Contents: Ash Weight	Trap Contents: Ash Weight	Accumulation Thickness	Set Length	Deposition Rate	Notes
		Zone	Easting	Northing				(g dry)	(g ash dry)	(g ash wet)	(mm)	(days)	(g ash wet/cm^2/d)	
SP-ST1	R1	14 W	639659	7213989	SP	Winter	2010/2011	1.72	1.69	11.27	1.21	318	0.000761	
SP-ST1	R2	14 W	639659	7213989	SP	Winter	2010/2011	1.86	1.84	12.27	1.32	318	0.000829	
SP-ST1	R3	14 W	639659	7213989	SP	Winter	2010/2011	1.75	1.73	11.53	1.24	318	0.000779	
SP-ST1	R4	14 W	639659	7213989	SP	Winter	2010/2011	1.85	1.82	12.13	1.30	318	0.000820	
SP-ST6	R1	14 W	640060	7212811	SP	Winter	2010/2011	0.49	0.44	2.90	0.31	316	0.000197	
SP-ST6	R2	14 W	640060	7212811	SP	Winter	2010/2011	0.48	0.44	2.92	0.31	316	0.000199	
SP-ST6	R3	14 W	640060	7212811	SP	Winter	2010/2011	0.52	0.45	3.01	0.32	316	0.000204	
SP-ST7	R1	15 W	358774	7213913	SP-DT	Winter	2010/2011	0.39	0.27	1.79	0.11	318	0.000070	
SP-ST7	R2	15 W	358774	7213913	SP-DT	Winter	2010/2011	0.37	0.26	1.75	0.11	318	0.000069	
SP-ST7	R3	15 W	358774	7213913	SP-DT	Winter	2010/2011	0.28	0.20	1.34	0.08	318	0.000053	
SP-ST8	R1	14 W	639667	7213402	SP	Winter	2010/2011	1.78	1.69	11.27	0.70	316	0.000445	
SP-ST8	R2	14 W	639667	7213402	SP	Winter	2010/2011	1.84	1.75	11.67	0.73	316	0.000461	
SP-ST8	R3	14 W	639667	7213402	SP	Winter	2010/2011	1.73	1.64	10.93	0.68	316	0.000432	
BG-ST1	R1	14 W	638392	7211631	TPE	Winter	2010/2011	0.56	0.51	3.40	0.21	316	0.000134	
BG-ST1	R2	14 W	638392	7211631	TPE	Winter	2010/2011	0.80	0.71	4.71	0.29	316	0.000186	
BG-ST1	R3	14 W	638392	7211631	TPE	Winter	2010/2011	0.47	0.43	2.86	0.18	316	0.000113	
BG-ST1	R4	14 W	638392	7211631	TPE	Winter	2010/2011	0.56	0.51	3.39	0.21	316	0.000134	
BG-ST2	R1	14 W	639003	7211765	TPE	Winter	2010/2011	0.55	0.49	3.28	0.35	315	0.000224	
BG-ST2	R2	14 W	639003	7211765	TPE	Winter	2010/2011	0.53	0.50	3.31	0.36	315	0.000226	
BG-ST2	R3	14 W	639003	7211765	TPE	Winter	2010/2011	0.52	0.48	3.19	0.34	315	0.000218	
BG-ST2	R4	14 W	639003	7211765	TPE	Winter	2010/2011	0.56	0.51	3.41	0.37	315	0.000232	
BG-ST3	R1	14 W	639466	7212031	TPE	Winter	2010/2011	0.71	0.68	4.51	0.48	314	0.000308	
BG-ST3	R2	14 W	639466	7212031	TPE	Winter	2010/2011	0.69	0.63	4.19	0.45	314	0.000287	
BG-ST3	R3	14 W	639466	7212031	TPE	Winter	2010/2011	0.78	0.70	4.68	0.50	314	0.000320	
BG-ST3	R4	14 W	639466	7212031	TPE	Winter	2010/2011	0.72	0.68	4.51	0.48	314	0.000309	
BG-ST4	R1	14 W	639514	7212423	TPE	Winter	2010/2011	0.75	0.66	4.38	0.47	314	0.000300	
BG-ST4	R2	14 W	639514	7212423	TPE	Winter	2010/2011	0.65	0.62	4.12	0.44	314	0.000282	
BG-ST4	R3	14 W	639514	7212423	TPE	Winter	2010/2011	0.66	0.62	4.15	0.45	314	0.000284	
BG-ST4	R4	14 W	639514	7212423	TPE	Winter	2010/2011	0.70	0.67	4.49	0.48	314	0.000307	
BG-ST5	R1	14 W	638946	7211250	TPE	Winter	2010/2011	0.44	0.41	2.74	0.29	316	0.000186	
BG-ST5	R2	14 W	638946	7211250	TPE	Winter	2010/2011	0.41	0.39	2.57	0.28	316	0.000175	
BG-ST5	R3	14 W	638946	7211250	TPE	Winter	2010/2011	0.37	0.35	2.33	0.25	316	0.000158	
BG-ST5	R4	14 W	638946	7211250	TPE	Winter	2010/2011	0.40	0.38	2.51	0.27	316	0.000170	
BG-ST6	R1	14 W	639356	7213340	TPE	Winter	2010/2011	1.19	1.06	7.07	0.76	314	0.000484	
BG-ST6	R2	14 W	639356	7213340	TPE	Winter	2010/2011	1.41	1.10	7.33	0.79	314	0.000502	
BG-ST6	R3	14 W	639356	7213340	TPE	Winter	2010/2011	1.26	1.07	7.13	0.77	314	0.000488	
BG-ST6	R4	14 W	639356	7213340	TPE	Winter	2010/2011	1.39	1.11	7.40	0.79	314	0.000506	
TPS-ST1	R1	14 W	635750	7208642	TPS	Winter	2010/2011	0.24	0.19	1.28	0.14	316	0.000087	
TPS-ST1	R2	14 W	635750	7208642	TPS	Winter	2010/2011	0.34	0.27	1.82	0.20	316	0.000124	
TPS-ST1	R3	14 W	635750	7208642	TPS	Winter	2010/2011	0.27	0.22	1.45	0.16	316	0.000098	
TPS-ST1	R4	14 W	635750	7208642	TPS	Winter	2010/2011	0.30	0.24	1.62	0.17	316	0.000110	
TPS-ST2	R1	14 W	634359	7210449	TPS	Winter	2010/2011	0.67	0.54	3.57	0.22	316	0.000141	
TPS-ST2	R2	14 W	634359	7210449	TPS	Winter	2010/2011	0.67	0.53	3.54	0.22	316	0.000140	
TPS-ST2	R3	14 W	634359	7210449	TPS	Winter	2010/2011	0.62	0.49	3.25	0.20	316	0.000128	
TPS-ST2	R4	14 W	634359	7210449	TPS	Winter	2010/2011	0.69	0.54	3.59	0.22	316	0.000142	
TPE-ST1	R1	14 W	637808	7211590	TPE	Winter	2010/2011	0.52	0.42	2.78	0.30	316	0.000189	
TPE-ST1	R2	14 W	637808	7211590	TPE	Winter	2010/2011	0.57	0.45	3.00	0.32	316	0.000204	
TPE-ST1	R3	14 W	637808	7211590	TPE	Winter	2010/2011	0.59	0.44	2.93	0.31	316	0.000199	
TPE-ST1	R4	14 W	637808	7211590	TPE	Winter	2010/2011	0.61	0.46	3.03	0.33	316	0.000206	
TPE-ST2	R1	14 W	639030	7210488	TPE	Winter	2010/2011	0.41	0.39	2.57	0.28	317	0.000174	
TPE-ST2	R2	14 W	639030	7210488	TPE	Winter	2010/2011	0.46	0.43	2.85	0.31	317	0.000193	
TPE-ST2	R3	14 W	639030	7210488	TPE	Winter	2010/2011	0.43	0.39	2.59	0.28	317	0.000175	
TPE-ST2	R4	14 W	639030	7210488	TPE	Winter	2010/2011	0.38	0.35	2.31	0.25	317	0.000156	
TPE-ST3	R1	14 W	637986	7210217	TPE	Winter	2010/2011	0.67	0.57	3.81	0.24	317	0.000150	
TPE-ST3	R2	14 W	637986	7210217	TPE	Winter	2010/2011	0.63	0.53	3.53	0.22	317	0.000139	
TPE-ST3	R3	14 W	637986	7210217	TPE	Winter	2010/2011	0.75	0.64	4.29	0.27	317	0.000169	
TPE-ST3	R4	14 W	637986	7210217	TPE	Winter	2010/2011	0.54	0.44	2.96	0.18	317	0.000117	
TPE-ST4	R1	14 W	637351	7209107	TPE	Winter	2010/2011	0.48	0.38	2.56	0.16	317	0.000101	
TPE-ST4	R2	14 W	637351	7209107	TPE	Winter	2010/2011	0.46	0.38	2.51	0.16	317	0.000099	
TPE-ST4	R3	14 W	637351	7209107	TPE	Winter	2010/2011	0.47	0.39	2.58	0.16	317	0.000102	
TPE-ST4	R4	14 W	637351	7209107	TPE	Winter	2010/2011	0.53	0.45	2.97	0.19	317	0.000117	

Appendix D. Sediment trap data from 2008-2011.

Trap ID	Rep	UTM Coordinates (NAD 83)			Lake	Season	Year	Trap Contents: Total Weight	Trap Contents: Ash Weight	Trap Contents: Ash Weight	Accumulation Thickness	Set Length	Deposition Rate	Notes
		Zone	Easting	Northing				(g dry)	(g ash dry)	(g ash wet)	(mm)	(days)	(g ash wet/cm^2/d)	
SP-ST1	R1	14 W	639651	7213991	SP	Summer	2010	0.29	0.24	1.61	0.17	62	0.000559	
SP-ST1	R2	14 W	639651	7213991	SP	Summer	2010	0.33	0.28	1.85	0.20	62	0.000642	
SP-ST1	R3	14 W	639651	7213991	SP	Summer	2010	0.27	0.23	1.50	0.16	62	0.000520	
SP-ST1	R4	14 W	639651	7213991	SP	Summer	2010	0.28	0.25	1.63	0.18	62	0.000566	
SP-ST6	R1	14 W	640077	7212803	SP	Summer	2010	1.25	1.02	6.80	0.73	62	0.002356	
SP-ST6	R3	14 W	640077	7212803	SP	Summer	2010	2.07	1.69	11.27	1.21	62	0.003904	
SP-ST6	R4	14 W	640077	7212803	SP	Summer	2010	1.21	0.99	6.61	0.71	62	0.002292	
SP-ST7	R1	15 W	358779	7213871	SP-DT	Summer	2010	0.19	0.11	0.73	0.05	62	0.000146	
SP-ST7	R2	15 W	358779	7213871	SP-DT	Summer	2010	0.21	0.11	0.76	0.05	62	0.000153	
SP-ST7	R3	15 W	358779	7213871	SP-DT	Summer	2010	0.18	0.11	0.73	0.05	62	0.000148	
BG-ST2	R1	14 W	639011	7211788	TPE	Summer	2010	0.85	0.78	5.18	0.56	61	0.001825	
BG-ST2	R2	14 W	639011	7211788	TPE	Summer	2010	0.75	0.68	4.53	0.49	61	0.001597	
BG-ST2	R3	14 W	639011	7211788	TPE	Summer	2010	0.78	0.70	4.67	0.50	61	0.001646	
BG-ST4	R1	14 W	639517	7212414	TPE	Summer	2010	0.73	0.66	4.37	0.47	63	0.001491	
BG-ST4	R2	14 W	639517	7212414	TPE	Summer	2010	0.75	0.68	4.56	0.49	63	0.001555	
BG-ST4	R4	14 W	639517	7212414	TPE	Summer	2010	0.75	0.68	4.50	0.48	63	0.001535	
BG-ST6	R1	14 W	639343	7213331	TPE	Summer	2010	0.81	0.74	4.94	0.53	63	0.001685	
BG-ST6	R2	14 W	639343	7213331	TPE	Summer	2010	0.74	0.66	4.43	0.48	63	0.001510	
BG-ST6	R4	14 W	639343	7213331	TPE	Summer	2010	0.81	0.75	4.99	0.54	63	0.001703	
TE-ST1	R2	15 W	359935	7212097	TE	Summer	2010	0.34	0.24	1.62	0.17	63	0.000552	
TE-ST1	R3	15 W	359935	7212097	TE	Summer	2010	0.49	0.34	2.26	0.24	63	0.000771	
TE-ST1	R4	15 W	359935	7212097	TE	Summer	2010	0.63	0.51	3.42	0.37	63	0.001166	
TE-ST4	R1	15 W	361998	7210374	TE	Summer	2010	0.41	0.33	2.23	0.14	63	0.000441	
TE-ST4	R2	15 W	361998	7210374	TE	Summer	2010	0.36	0.29	1.95	0.12	63	0.000386	
TE-ST4	R4	15 W	361998	7210374	TE	Summer	2010	1.04	0.91	6.06	0.38	63	0.001201	
TE-ST5	R3	15 W	363218	7208181	TE	Summer	2010	0.58	0.44	2.95	0.18	63	0.000585	
TE-ST5	R4	15 W	363218	7208181	TE	Summer	2010	0.61	0.49	3.24	0.20	63	0.000642	
TPS-ST1	R1	14 W	635726	7208651	TPS	Summer	2010	0.73	0.66	4.39	0.47	56	0.001686	
TPS-ST1	R3	14 W	635726	7208651	TPS	Summer	2010	0.30	0.25	1.69	0.18	56	0.000650	
TPS-ST1	R4	14 W	635726	7208651	TPS	Summer	2010	0.57	0.51	3.39	0.36	56	0.001302	
TPS-ST2	R1	14 W	634347	7201444	TPS	Summer	2010	0.24	0.18	1.21	0.08	56	0.000271	
TPS-ST2	R2	14 W	634347	7201444	TPS	Summer	2010	0.21	0.16	1.06	0.07	56	0.000236	
TPS-ST2	R3	14 W	634347	7201444	TPS	Summer	2010	0.23	0.18	1.21	0.08	56	0.000269	
TPS-ST2	R4	14 W	634347	7201444	TPS	Summer	2010	0.19	0.15	0.97	0.06	56	0.000217	
TPE-ST1	R1	14 W	637802	7211607	TPE	Summer	2010	0.92	0.81	5.41	0.58	63	0.001844	
TPE-ST1	R3	14 W	637802	7211607	TPE	Summer	2010	1.01	0.91	6.04	0.65	63	0.002060	
TPE-ST1	R4	14 W	637802	7211607	TPE	Summer	2010	1.53	1.35	9.00	0.97	63	0.003069	
TPE-ST2	R1	14 W	639043	7210495	TPE	Summer	2010	0.95	0.84	5.60	0.60	63	0.001910	
TPE-ST2	R2	14 W	639043	7210495	TPE	Summer	2010	0.68	0.60	4.02	0.43	63	0.001371	
TPE-ST2	R4	14 W	639043	7210495	TPE	Summer	2010	0.72	0.64	4.23	0.45	63	0.001444	
TPE-ST3	R1	14 W	637953	7210229	TPE	Summer	2010	1.44	1.32	8.80	0.55	63	0.001744	
TPE-ST3	R2	14 W	637953	7210229	TPE	Summer	2010	2.34	2.14	14.27	0.89	63	0.002828	
TPE-ST3	R3	14 W	637953	7210229	TPE	Summer	2010	1.41	1.26	8.40	0.52	63	0.001665	
TPE-ST4	R1	14 W	637344	7209104	TPE	Summer	2010	0.88	0.73	4.85	0.52	67	0.001556	
TPE-ST4	R2	14 W	637344	7209104	TPE	Summer	2010	1.34	1.15	7.67	0.82	67	0.002459	
TPE-ST4	R3	14 W	637344	7209104	TPE	Summer	2010	0.44	0.36	2.41	0.26	67	0.000772	
SP-ST1	R2	14 W	639661	7213999	SP	Winter	2009/2010	0.84	0.78	5.17	0.56	306	0.000363	
SP-ST1	R3	14 W	639661	7213999	SP	Winter	2009/2010	0.88	0.82	5.46	0.59	306	0.000383	
SP-ST1	R4	14 W	639661	7213999	SP	Winter	2009/2010	0.85	0.78	5.21	0.56	306	0.000366	
SP-ST6	R1	14 W	640072	7212805	SP	Winter	2009/2010	0.52	0.43	2.89	0.31	305	0.000203	
SP-ST6	R3	14 W	640072	7212805	SP	Winter	2009/2010	0.58	0.49	3.27	0.35	305	0.000230	
SP-ST6	R4	14 W	640072	7212805	SP	Winter	2009/2010	0.66	0.55	3.64	0.39	305	0.000256	
SP-ST7	R1	15 W	358781	7213838	SP-DT	Winter	2009/2010	0.26	0.17	1.12	0.12	309	0.000078	
SP-ST7	R2	15 W	358781	7213838	SP-DT	Winter	2009/2010	0.24	0.15	1.03	0.11	309	0.000071	
SP-ST7	R3	15 W	358781	7213838	SP-DT	Winter	2009/2010	0.23	0.15	0.99	0.11	309	0.000069	
SP-ST7	R4	15 W	358781	7213838	SP-DT	Winter	2009/2010	0.23	0.15	0.98	0.11	309	0.000068	
SP-ST8	R1	14 W	639687	7213350	SP	Winter	2009/2010	0.85	0.78	5.19	0.56	305	0.000366	
SP-ST8	R2	14 W	639687	7213350	SP	Winter	2009/2010	0.81	0.73	4.85	0.52	305	0.000342	
SP-ST8	R3	14 W	639687	7213350	SP	Winter	2009/2010	0.80	0.74	4.92	0.53	305	0.000347	
BG-ST1	R1	14 W	638706	7211757	TPE	Winter	2009/2010	1.71	1.52	10.13	1.09	306	0.000712	
BG-ST1	R2	14 W	638706	7211757	TPE	Winter	2009/2010	1.67	1.48	9.87	1.06	306	0.000693	
BG-ST1	R3	14 W	638706	7211757	TPE	Winter	2009/2010	1.58	1.41	9.40	1.01	306	0.000660	
BG-ST2	R1	14 W	638974	7211821	TPE	Winter	2009/2010	0.84	0.75	5.01	0.54	306	0.000352	
BG-ST2	R3	14 W	638974	7211821	TPE	Winter	2009/2010	0.80	0.72	4.79	0.51	306	0.000336	
BG-ST2	R4	14 W	638974	7211821	TPE	Winter	2009/2010	1.01	0.91	6.03	0.65	306	0.000424	
BG-ST3	R2	14 W	639538	7211819	TPE	Winter	2009/2010	2.38	2.19	14.60	1.79	317	0.001132	
BG-ST3	R3	14 W	639538	7211819	TPE	Winter	2009/2010	2.42	2.25	15.00	1.84	317	0.001163	
BG-ST3	R4	14 W	639538	7211819	TPE	Winter	2009/2010	2.45	2.27	15.13	1.86	317	0.001173	
BG-ST5	R1	14 W	639012	7211252	TPE	Winter	2009/2010	1.29	1.18	7.87	0.85	317	0.000533	
BG-ST5	R2	14 W	639012	7211252	TPE	Winter	2009/2010	1.18	1.07	7.13	0.77	317	0.000483	
BG-ST5	R4	14 W	639012	7211252	TPE	Winter	2009/2010	1.32	1.21	8.07	0.87	317	0.000547	
BG-ST6	R1	14 W	639343	7213331	TPE	Winter	2009/2010	3.07	2.81	18.73	2.01	310	0.001298	
BG-ST6	R2	14 W	639343	7213331	TPE	Winter	2009/2010	2.88	2.68	17.87	1.92	310	0.001238	
BG-ST6	R3	14 W	639343	7213331	TPE	Winter	2009/2010	2.91	2.66	17.73	1.91	310	0.001229	
TE-ST1	R1	15 W	359929	7212109	TE	Winter	2009/2010	0.52	0.41	2.72	0.29	306	0.000191	
TE-ST1	R2	15 W	359929	7212109	TE	Winter	2009/2010	0.51	0.44	2.95	0.32	306	0.000207	
TE-ST1	R4	15 W	359929	7212109	TE	Winter	2009/2010	0.50	0.39	2.60	0.28	306	0.000183	
TE-ST4	R1	15 W	362003	7210391	TE	Winter	2009/2010	0.99	0.75	4.97	0.53	306	0.000349	
TE-ST4	R3	15 W	362003	7210391	TE	Winter	2009/2010	0.96	0.73	4.87	0.52	306	0.000342	
TE-ST4	R4	15 W	362003	7210391	TE	Winter	2009/2010	0.91	0.69	4.63	0.50	306	0.000325	
TE-ST5	R1	15 W	363218	7208193	TE	Winter	2009/2010	0.42	0.29	1.92	0.21	306	0.000135	
TE-ST5	R2	15 W	363218	7208193	TE	Winter	2009/2010	0.40	0.27	1.79	0.19	306	0.000126	
TE-ST5	R3	15 W	363218	7208193	TE	Winter	2009/2010	0.41	0.27	1.82	0.20	306	0.000128	
TE-ST5	R4	15 W	363218	7208193	TE	Winter	2009/2010	0.39	0.27	1.78	0.19	306	0.000125	
TPS-ST1	R1	14 W	635729	7208657	TPS	Winter	2009/2010	0.32	0.23	1.56	0.19	308	0.000124	
TPS-ST1	R2	14 W	635729	7208657	TPS	Winter	2009/2010	0.28	0.21	1.41	0.17	308	0.000113	
TPS-ST1	R3	14 W	635729	7208657	TPS	Winter	2009/2010	0.33	0.24	1.62	0.20	308	0.000129	
TPS-ST1	R4	14 W	635729	7208657	TPS	Winter	2009/2010	0.28	0.21	1.39	0.17	308	0.000111	
TPS-ST2	R1	14 W	634334	7210449	TPS	Winter	2009/2010	0.55	0.41	2.75	0.34	313	0.000216	
TPS-ST2	R2	14 W	634334	7210449	TPS	Winter	2009/2010	0.47	0.36	2.38	0.29	313	0.000187	
TPS-ST2	R3	14 W	634334	7210449	TPS	Winter	2009/2010	0.49	0.37	2.44	0.30	313	0.000192	
TPE-ST1	R2	14 W	637796	7211593	TPE	Winter	2009/2010	2.96	2.66	17.73	1.91	303	0.001257	
TPE-ST1	R3	14 W	637796	7211593	TPE	Winter	2009/2010	2.50	2.25	15.00	1.61	303	0.001064	
TPE-ST1	R4	14 W	637796	7211593	TPE	Winter	2009/2010	2.77	2.48	16.53	1.78	303	0.001172	
TPE-ST2	R2	14 W	639014	7210490	TPE	Year	2009/2010	1.54	1.36	9.07	0.97	366	0.000532	This trap was in for entire year
TPE-ST2	R3	14 W	639014	7210490	TPE	Year	2009/2010	1.48	1.30	8.67	0.93	366	0.000509	This trap was in for entire year

Appendix D. Sediment trap data from 2008-2011.

Trap ID	Rep	UTM Coordinates (NAD 83)			Lake	Season	Year	Trap Contents: Total Weight	Trap Contents: Ash Weight	Trap Contents: Ash Weight	Accumulation Thickness	Set Length	Deposition Rate	Notes
		Zone	Easting	Northing				(g dry)	(g ash dry)	(g ash wet)	(mm)	(days)	(g ash wet/cm^2/d)	
SP-ST2	R1	14 W	640043	7213817	SP	Summer	2009	0.32	0.27	1.81	0.22	59	0.000755	
SP-ST2	R2	14 W	640043	7213817	SP	Summer	2009	0.42	0.36	2.39	0.29	59	0.000997	
SP-ST5	R1	14 W	640775	7213208	SP	Summer	2009	0.34	0.28	1.87	0.23	50	0.000921	Name change from SP-ST3
SP-ST5	R2	14 W	640775	7213208	SP	Summer	2009	0.42	0.35	2.33	0.29	50	0.001147	Name change from SP-ST3
SP-ST5	R4	14 W	640775	7213208	SP	Summer	2009	0.30	0.25	1.67	0.20	50	0.000819	Name change from SP-ST3
SP-STBL	R1	14 W	639668	7214544	SP	Summer	2009	2.78	2.14	14.27	1.75	50	0.007012	Name change from SP-ST4
SP-STBL	R3	14 W	639668	7214544	SP	Summer	2009	2.19	1.69	11.27	1.38	50	0.005537	Name change from SP-ST4
SP-STBL	R4	14 W	639668	7214544	SP	Summer	2009	1.96	1.12	7.47	0.92	50	0.003670	Name change from SP-ST4
SP-STSP	R1	14 W	639819	7213911	SP	Summer	2009	0.20	0.17	1.16	0.14	50	0.000570	Name change from SP-ST5
SP-STSP	R2	14 W	639819	7213911	SP	Summer	2009	0.25	0.22	1.46	0.18	50	0.000718	Name change from SP-ST5
SP-STSP	R3	14 W	639819	7213911	SP	Summer	2009	0.22	0.18	1.23	0.15	50	0.000603	Name change from SP-ST5
SP-STSP	R4	14 W	639819	7213911	SP	Summer	2009	0.23	0.20	1.32	0.16	50	0.000649	Name change from SP-ST5
SP-ST6	R2	14 W	640069	7212807	SP	Summer	2009	2.32	1.91	12.73	1.56	57	0.005489	
SP-ST6	R3	14 W	640069	7212807	SP	Summer	2009	2.11	1.69	11.27	1.38	57	0.004857	
SP-ST6	R4	14 W	640069	7212807	SP	Summer	2009	2.71	2.20	14.67	1.80	57	0.006323	
SP-ST7	R1	14 W	641452	7213873	SP-DT	Summer	2009	0.24	0.19	1.27	0.16	47	0.000666	
SP-ST7	R3	14 W	641452	7213873	SP-DT	Summer	2009	0.32	0.26	1.73	0.21	47	0.000903	
SP-ST7	R4	14 W	641452	7213873	SP-DT	Summer	2009	0.25	0.19	1.28	0.16	47	0.000669	
SP-ST8	R1	14 W	639684	7213356	SP	Summer	2009	0.75	0.64	4.27	0.53	57	0.001842	
SP-ST8	R3	14 W	639684	7213356	SP	Summer	2009	0.79	0.70	4.67	0.57	57	0.002012	
SP-ST8	R4	14 W	639684	7213356	SP	Summer	2009	2.55	2.24	14.93	1.83	57	0.006438	
BG-ST1	R1	14 W	638711	7211761	TPE	Summer	2009	1.70	1.51	10.07	1.24	57	0.004340	
BG-ST1	R2	14 W	638711	7211761	TPE	Summer	2009	2.16	1.90	12.67	1.56	57	0.005461	
BG-ST1	R3	14 W	638711	7211761	TPE	Summer	2009	1.40	1.24	8.27	1.02	57	0.003564	
BG-ST2	R1	14 W	639016	7211788	TPE	Summer	2009	0.95	0.89	5.92	0.73	57	0.002552	
BG-ST2	R2	14 W	639016	7211788	TPE	Summer	2009	0.86	0.78	5.22	0.64	57	0.002250	
BG-ST2	R4	14 W	639016	7211788	TPE	Summer	2009	1.20	1.11	7.40	0.91	57	0.003190	
BG-ST3	R1	14 W	639535	7211811	TPE	Summer	2009	1.38	1.30	8.67	1.06	57	0.003736	
BG-ST3	R2	14 W	639535	7211811	TPE	Summer	2009	1.71	1.61	10.73	1.32	57	0.004627	
BG-ST3	R3	14 W	639535	7211811	TPE	Summer	2009	1.72	1.63	10.87	1.34	57	0.004685	
BG-ST4	R1	14 W	639521	7212410	TPE	Summer	2009	1.13	1.04	6.93	0.85	57	0.002989	
BG-ST4	R2	14 W	639521	7212410	TPE	Summer	2009	1.07	1.00	6.65	0.82	57	0.002868	
BG-ST4	R3	14 W	639521	7212410	TPE	Summer	2009	1.29	1.21	8.07	0.99	57	0.003478	
BG-ST5	R2	14 W	639012	7211243	TPE	Summer	2009	1.26	1.14	7.60	0.93	57	0.003276	
BG-ST5	R3	14 W	639012	7211243	TPE	Summer	2009	2.79	2.68	17.87	2.20	57	0.007703	
BG-ST5	R4	14 W	639012	7211243	TPE	Summer	2009	1.21	1.09	7.27	0.89	57	0.003133	
BG-ST6	R2	14 W	639355	7213333	TPE	Summer	2009	15.00	12.00	80.00	9.83	60	0.032765	
BG-ST6	R3	14 W	639355	7213333	TPE	Summer	2009	2.53	2.09	13.93	1.71	60	0.005706	
BG-ST6	R4	14 W	639355	7213333	TPE	Summer	2009	2.06	1.67	11.13	1.37	60	0.004560	
TE-ST1	R1	15 W	359929	7212109	TE	Summer	2009	0.30	0.23	1.55	0.19	50	0.000760	
TE-ST1	R2	15 W	359929	7212109	TE	Summer	2009	0.61	0.50	3.31	0.41	50	0.001628	
SP-ST1	R2	14 W	639649	7214045	SP	Winter	2008/2009	0.53	0.49	3.27	0.40	309	0.000260	
SP-ST1	R3	14 W	639649	7214045	SP	Winter	2008/2009	0.47	0.43	2.88	0.35	309	0.000229	
SP-ST1	R4	14 W	639649	7214045	SP	Winter	2008/2009	0.43	0.40	2.68	0.33	309	0.000213	
SP-ST5	R1	14 W	640813	7213329	SP	Winter	2008/2009	0.08	0.07	0.47	0.06	307	0.000038	
SP-ST5	R2	14 W	640813	7213329	SP	Winter	2008/2009	0.12	0.10	0.67	0.08	307	0.000054	
SP-ST5	R3	14 W	640813	7213329	SP	Winter	2008/2009	0.07	0.05	0.36	0.04	307	0.000029	
SP-ST5	R4	14 W	640813	7213329	SP	Winter	2008/2009	0.12	0.11	0.73	0.09	307	0.000058	
SP-ST6	R1	14 W	640377	7213082	SP	Winter	2008/2009	0.12	0.10	0.68	0.08	309	0.000054	
SP-ST6	R2	14 W	640377	7213082	SP	Winter	2008/2009	0.41	0.34	2.29	0.28	309	0.000182	
SP-ST6	R3	14 W	640377	7213082	SP	Winter	2008/2009	0.34	0.30	1.97	0.24	309	0.000156	
SP-ST1	R1-R4	14 W	639641	7214019	SP	Summer	2008	9.30		**58.13**	**1.79**	50	**0.007142**	Name change from HV-1
SP-ST2	R1-R4	14 W	640043	7213782	SP	Summer	2008	5.60		**35.00**	**1.08**	28	**0.007679**	Name change from HV-2
SP-ST4	R1-R4	14 W	640333	7213713	SP	Summer	2008	5.04		**31.50**	**0.97**	54	**0.003584**	Name change from HV-4
SP-ST8	R1-R4	14 W	639716	7213372	SP	Summer	2008	5.62		**35.13**	**1.08**	57	**0.003786**	Name change from HV-5

Note: numbers in **red bold font** are calculated based on total weight of trap contents (inorganic + organic), not ash weights like the others.

AZIMUTH CONSULTING GROUP INC.
ATTN: MAGGIE McCONNELL
218 - 2902 WEST BROADWAY
VANCOUVER BC V6K 2G8

Date Received: 23-AUG-11
Report Date: 28-SEP-11 12:32 (MT)
Version: FINAL

Client Phone: 604-730-1220

Certificate of Analysis

Lab Work Order #: L1048820

Project P.O. #: NOT SUBMITTED
Job Reference: MEADOWBANK MINE EAS
C of C Numbers: 1, 2, 3, 4, 5, 6
Legal Site Desc:

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1048820-1	L1048820-2	L1048820-3	L1048820-4	L1048820-5
	Sample ID	L1048820-1	L1048820-2	L1048820-3	L1048820-4	L1048820-5
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	06-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11
	Sampled Time					
	Client ID	BG-ST1-1	BG-ST1-2	BG-ST1-3	BG-ST1-4	BG-ST2-1
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.560	0.797	0.469	0.558	0.551
	Ash Weight (g)	0.510	0.707	0.429	0.508	0.492
	Ash Free Dry Weight (g)	0.0499	0.900	0.0399	0.0498	0.0594

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1048820-6	L1048820-7	L1048820-8	L1048820-9	L1048820-10
		Description	OTHER	OTHER	OTHER	OTHER	OTHER
		Sampled Date	06-AUG-11	06-AUG-11	06-AUG-11	05-AUG-11	05-AUG-11
		Sampled Time					
		Client ID	BG-ST2-2	BG-ST2-3	BG-ST2-4	BG-ST3-1	BG-ST3-2
Grouping	**Analyte**						
TISSUE							
Physical Tests	Dry Weight (g)		0.531	0.515	0.562	0.711	0.694
	Ash Weight (g)		0.496	0.479	0.511	0.676	0.629
	Ash Free Dry Weight (g)		0.0348	0.0357	0.0511	0.0354	0.0648

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-11	L1048820-12	L1048820-13	L1048820-14	L1048820-15
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	05-AUG-11	05-AUG-11	05-AUG-11	05-AUG-11	05-AUG-11
	Sampled Time					
	Client ID	BG-ST3-3	BG-ST3-4	BG-ST4-1	BG-ST4-2	BG-ST4-3
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.781	0.715	0.745	0.645	0.657
	Ash Weight (g)	0.702	0.677	0.657	0.618	0.623
	Ash Free Dry Weight (g)	0.0796	0.0378	0.0884	0.0267	0.0344

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1048820-16	L1048820-17	L1048820-18	L1048820-19	L1048820-20
		Description	OTHER	OTHER	OTHER	OTHER	OTHER
		Sampled Date	05-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11
		Sampled Time					
		Client ID	BG-ST4-4	BG-ST5-1	BG-ST5-2	BG-ST5-3	BG-ST5-4
Grouping	**Analyte**						
TISSUE							
Physical Tests	Dry Weight (g)		0.704	0.436	0.409	0.373	0.403
	Ash Weight (g)		0.673	0.411	0.386	0.349	0.376
	Ash Free Dry Weight (g)		0.0308	0.0256	0.0235	0.0237	0.0264

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1048820-21	L1048820-22	L1048820-23	L1048820-24	L1048820-25
	Sample ID	L1048820-21	L1048820-22	L1048820-23	L1048820-24	L1048820-25
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	06-AUG-11	05-AUG-11	05-AUG-11	05-AUG-11	06-AUG-11
	Sampled Time					
	Client ID	BG-ST6-1	BG-ST6-2	BG-ST6-3	BG-ST6-4	TPE-ST1-1
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.19	1.41	1.26	1.39	0.519
	Ash Weight (g)	1.06	1.10	1.07	1.11	0.417
	Ash Free Dry Weight (g)	0.134	0.312	0.196	0.280	0.102

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1048820-26	L1048820-27	L1048820-28	L1048820-29	L1048820-30
	Sample ID	L1048820-26	L1048820-27	L1048820-28	L1048820-29	L1048820-30
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	06-AUG-11	06-AUG-11	06-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	TPE-ST1-2	TPE-ST1-3	TPE-ST1-4	TPE-ST2-1	TPE-ST2-2
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.571	0.594	0.613	0.413	0.461
	Ash Weight (g)	0.450	0.439	0.455	0.386	0.428
	Ash Free Dry Weight (g)	0.121	0.156	0.158	0.0267	0.0337

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-31	L1048820-32	L1048820-33	L1048820-34	L1048820-35
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	TPE-ST2-3	TPE-ST2-4	TPE-ST3-1	TPE-ST3-2	TPE-ST3-3
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.432	0.380	0.673	0.632	0.753
	Ash Weight (g)	0.388	0.346	0.571	0.530	0.644
	Ash Free Dry Weight (g)	0.0434	0.0337	0.102	0.102	0.109

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-36	L1048820-37	L1048820-38	L1048820-39	L1048820-40
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	TPE-ST3-4	TPE-ST4-1	TPE-ST4-2	TPE-ST4-3	TPE-ST4-4
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.543	0.478	0.461	0.469	0.532
	Ash Weight (g)	0.444	0.384	0.377	0.387	0.446
	Ash Free Dry Weight (g)	0.0993	0.0933	0.0836	0.0819	0.0861

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-41	L1048820-42	L1048820-43	L1048820-44	L1048820-45
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	06-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11	06-AUG-11
	Sampled Time					
	Client ID	TPS-ST1-1	TPS-ST1-2	TPS-ST1-3	TPS-ST1-4	TPS-ST2-1
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.241	0.338	0.274	0.300	0.669
	Ash Weight (g)	0.192	0.273	0.217	0.243	0.536
	Ash Free Dry Weight (g)	0.0490	0.0646	0.0570	0.0571	0.133

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-46	L1048820-47	L1048820-48	L1048820-49	L1048820-50
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	06-AUG-11	06-AUG-11	06-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	TPS-ST2-2	TPS-ST2-3	TPS-ST2-4	SP-ST1-1	SP-ST1-2
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.668	0.617	0.685	1.72	1.86
	Ash Weight (g)	0.531	0.487	0.538	1.69	1.84
	Ash Free Dry Weight (g)	0.137	0.129	0.147	0.0259	0.0238

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-51	L1048820-52	L1048820-53	L1048820-54	L1048820-55
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	SP-ST1-3	SP-ST1-4	SP-ST6-1	SP-ST6-2	SP-ST6-3
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.75	1.85	0.490	0.482	0.517
	Ash Weight (g)	1.73	1.82	0.435	0.438	0.451
	Ash Free Dry Weight (g)	0.0267	0.0282	0.0549	0.0439	0.0662

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-56	L1048820-57	L1048820-58	L1048820-59	L1048820-60
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11	07-AUG-11
	Sampled Time					
	Client ID	SP-ST7-1	SP-ST7-2	SP-ST7-3	SP-ST8-1	SP-ST8-2
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.387	0.370	0.283	1.78	1.84
	Ash Weight (g)	0.269	0.263	0.201	1.69	1.75
	Ash Free Dry Weight (g)	0.118	0.107	0.0815	0.0862	0.0914

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1048820-61				
	Description	OTHER				
	Sampled Date	07-AUG-11				
	Sampled Time					
	Client ID	SP-ST8-3				
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.73				
	Ash Weight (g)	1.64				
	Ash Free Dry Weight (g)	0.0819				

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ASHFREE-DRY-VA	Tissue	Ash Free Dry Weight	44.3 ASH CONTENT & ORG. MATTER CONTENT

This analysis is carried out using procedures adapted from the Canadian Society of Soil Science method "44.3 Ash Content and Organic Matter Content", (1993). Ash Free Dry Weight is determined by the difference between 'Dry Weight' and 'Ash Weight' which are both determined gravimetrically. Dry Weight is determined by drying the sample at 105 "C and the Ash Weight is subsequently determined by ashing the dried sample at 550 "C.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

1	2	3	4	5
6				

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

COC # ______

ALS Environmental

L1048820-COFC

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway
	Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To	Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1048820

Re	
☐ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	mmcconnell@azimuthgroup.ca
Email 2:	gmann@azimuthgroup.ca
Email 3:	
Client / Project Information	
Job #:	Meadowbank Mine **EAS**
PO / AFE:	
LSD:	
Quote #:	**Q29231**
ALS Contact:	Brent Mack
Sampler:	RV, MF

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
1	BG-ST1-1	06-Aug-11		**Other	X	X	1
2	BG-ST1-2	06-Aug-11		**Other	X	X	1
3	BG-ST1-3	06-Aug-11		**Other	X	X	1
4	BG-ST1-4	06-Aug-11		**Other	X	X	1
5	BG-ST2-1	06-Aug-11		**Other	X	X	1
6	BG-ST2-2	06-Aug-11		**Other	X	X	1
7	BG-ST2-3	06-Aug-11		**Other	X	X	1
8	BG-ST2-4	06-Aug-11		**Other	X	X	1
9	BG-ST3-1	05-Aug-11		**Other	X	X	1
10	BG-ST3-2	05-Aug-11		**Other	X	X	1
11	BG-ST3-3	05-Aug-11		**Other	X	X	1
12	BG-ST3-4	05-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" is a mixture of water and sediment; not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) ~~17-Aug-11~~	Time (hh-mm)	Received by: Mani	Date: Aug 23/11	Time: 12:45	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS Environmental

L1048820-COFC

COC # ____________

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To	Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1048820

Report Format / Distribution

☐ Standard ☐ Other
☑ PDF ☑ Excel ☐ Digital ☐ Fax

Email 1: mmcconnell@azimuthgroup.ca
Email 2: gmann@azimuthgroup.ca
Email 3:

Client / Project Information

Job #: Meadowbank Mine **EAS**
PO / AFE:
LSD:
Quote #: Q29231

ALS Contact: Brent Mack **Sampler:** RV, MF

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
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Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
13	BG-ST4-1	05-Aug-11		**Other	X	X	1
14	BG-ST4-2	05-Aug-11		**Other	X	X	1
15	BG-ST4-3	05-Aug-11		**Other	X	X	1
16	BG-ST4-4	05-Aug-11		**Other	X	X	1
17	BG-ST5-1	06-Aug-11		**Other	X	X	1
18	BG-ST5-2	06-Aug-11		**Other	X	X	1
19	BG-ST5-3	06-Aug-11		**Other	X	X	1
20	BG-ST5-4	06-Aug-11		**Other	X	X	1
21	BG-ST6-1	05-Aug-11		**Other	X	X	1
22	BG-ST6-2	05-Aug-11		**Other	X	X	1
23	BG-ST6-3	05-Aug-11		**Other	X	X	1
24	BG-ST6-4	05-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" is a mixture of water and sediment; not preserved; email Maggie McConnell if there are any questions.

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: ~~Morgan Finley~~ Maggie McConnell	Date (dd-mmm-yy) ~~17-Aug-11~~	Time (hh-mm)	Received by: Mani	Date: Aug 23/11	Time: 12:15	Temperature: 9.0 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

COC # ____________

ALS Environmental

L1048820-COFC

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway, Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To Same as Report ?	☑ Yes ☐ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1048820

Rep

☐ Standard ☐ Other

☑ PDF ☑ Excel ☐ Digital ☐ Fax

Email 1: mmcconnell@azimuthgroup.ca

Email 2: gmann@azimuthgroup.ca

Email 3:

Client / Project Information

Job #: Meadowbank Mine **EAS**

PO / AFE:

LSD:

Quote #: **Q29231**

ALS Contact: Brent Mack **Sampler:** RV, MF

Service Requested (Rush for routine analysis subject to availability)

◉ Regular (Standard Turnaround Times - Business Days)

○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT

○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT

○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
25	TPE-ST1-1	06-Aug-11		**Other	X	X	1
26	TPE-ST1-2	06-Aug-11		**Other	X	X	1
27	TPE-ST1-3	06-Aug-11		**Other	X	X	1
28	TPE-ST1-4	06-Aug-11		**Other	X	X	1
29	TPE-ST2-1	07-Aug-11		**Other	X	X	1
30	TPE-ST2-2	07-Aug-11		**Other	X	X	1
31	TPE-ST2-3	07-Aug-11		**Other	X	X	1
32	TPE-ST2-4	07-Aug-11		**Other	X	X	1
33	TPE-ST3-1	07-Aug-11		**Other	X	X	1
34	TPE-ST3-2	07-Aug-11		**Other	X	X	1
35	TPE-ST3-3	07-Aug-11		**Other	X	X	1
36	TPE-ST3-4	07-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" is a mixture of water and sediment; not preserved; email Maggie McConnell if there are any questions.

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SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley, Maggie McConnell	Date (dd-mmm-yy): ~~17-Aug-11~~	Time (hh-mm)	Received by: Mani	Date: Aug 18/11	Time: 12:15	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

COC # ______

ALS Environmental

L1048820-COFC

Report To
Company: Azimuth Consulting Group
Contact: Maggie McConnell / Gary Mann
Address: #218 - 2902 West Broadway, Vancouver, BC
Phone: 604-730-1220 Fax: 604-739-8511

☑ PDF ☑ Excel ☐ Digital ☐ Fax
Email 1: mmcconnell@azimuthgroup.ca
Email 2: gmann@azimuthgroup.ca
Email 3:

Invoice To Same as Report ? ☑ Yes ☐ No
Hardcopy of Invoice with Report? ☑ Yes ☐ No
Company:
Contact:
Address:
Phone: Fax:

Client / Project Information
Job #: Meadowbank Mine EAS
PO / AFE:
LSD:
Quote #: Q29231

ALS Contact: Brent Mack
Sampler: RV, MF

Lab Work Order # (lab use only): L1048820

Service Requested (Rush for routine analysis subject to availability)
◉ Regular (Standard Turnaround Times - Business Days)
○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request
Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
37	TPE-ST4-1	07-Aug-11		**Other	X	X	1
38	TPE-ST4-2	07-Aug-11		**Other	X	X	1
39	TPE-ST4-3	07-Aug-11		**Other	X	X	1
40	TPE-ST4-4	07-Aug-11		**Other	X	X	1
41	TPS-ST1-1	06-Aug-11		**Other	X	X	1
42	TPS-ST1-2	06-Aug-11		**Other	X	X	1
43	TPS-ST1-3	06-Aug-11		**Other	X	X	1
44	TPS-ST1-4	06-Aug-11		**Other	X	X	1
45	TPS-ST2-1	06-Aug-11		**Other	X	X	1
46	TPS-ST2-2	06-Aug-11		**Other	X	X	1
47	TPS-ST2-3	06-Aug-11		**Other	X	X	1
48	TPS-ST2-4	06-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley, Maggie McConnell	Date (dd-mmm-yy): 17-Aug-11	Time (hh-mm):	Received by: Mani	Date: Aug 23/11	Time: 12:15	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

COC # ____________

ALS Environmental

L1048820-COFC

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway
	Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To	Same as Report ? [x] Yes [ ] No
Hardcopy of Invoice with Report?	[x] Yes [ ] No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1048820

R.	
[ ] Standard [ ] Other	
[x] PDF [x] Excel [ ] Digital [ ] Fax	
Email 1:	mmcconnell@azimuthgroup.ca
Email 2:	gmann@azimuthgroup.ca
Email 3:	
Client / Project Information	
Job #:	Meadowbank Mine **EAS**
PO / AFE:	
LSD:	
Quote #:	**Q29231**
ALS Contact:	Brent Mack
Sampler:	RV, MF

Service Requested (Rush for routine analysis subject to availability)

- (●) Regular (Standard Turnaround Times - Business Days)
- ( ) Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ( ) Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ( ) Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
49	SP-ST1-1	07-Aug-11		**Other	X	X	1
50	SP-ST1-2	07-Aug-11		**Other	X	X	1
51	SP-ST1-3	07-Aug-11		**Other	X	X	1
52	SP-ST1-4	07-Aug-11		**Other	X	X	1
53	SP-ST6-1	07-Aug-11		**Other	X	X	1
54	SP-ST6-2	07-Aug-11		**Other	X	X	1
55	SP-ST6-3	07-Aug-11		**Other	X	X	1
56	SP-ST7-1	07-Aug-11		**Other	X	X	1
57	SP-ST7-2	07-Aug-11		**Other	X	X	1
58	SP-ST7-3	07-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" is a mixture of water and sediment; not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by:	Date (dd-mmm-yy)	Time (hh-mm)	Received by:	Date:	Time:	Temperature:	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF
~~Morgan Finley~~ Maggie McConnell	~~17-Aug-11~~		Mani	Aug 23/11	1215	7.0 °C				

COC #

ALS Environmental

L1048820-COFC

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway, Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To Same as Report ?	[x] Yes [ ] No
Hardcopy of Invoice with Report?	[x] Yes [ ] No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1048820.

Re	
[x] PDF [x] Excel [ ] Digital [ ] Fax	
Email 1:	mmcconnell@azimuthgroup.ca
Email 2:	gmann@azimuthgroup.ca
Email 3:	
Client / Project Information	
Job #:	Meadowbank Mine **EAS**
PO / AFE:	
LSD:	
Quote #:	**Q29231**
ALS Contact:	Brent Mack
Sampler:	RV, MF

Service Requested (Rush for routine analysis subject to availability)

- (●) Regular (Standard Turnaround Times - Business Days)
- ( ) Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ( ) Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ( ) Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
59	SP-ST8-1	07-Aug-11		**Other	X	X	1
60	SP-ST8-2	07-Aug-11		**Other	X	X	1
61	SP-ST8-3	07-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" is a mixture of water and sediment; not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: ~~Morgan Finley~~ Maggie McConnell	Date (dd-mmm-yy) ~~17-Aug-11~~	Time (hh-mm)	Received by: Mari	Date: Aug 25/11	Time: 12:25	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

AZIMUTH CONSULTING GROUP INC.
ATTN: MAGGIE McCONNELL
218 - 2902 WEST BROADWAY
VANCOUVER BC V6K 2G8

Date Received: 09-SEP-11
Report Date: 21-OCT-11 18:28 (MT)
Version: FINAL

Client Phone: 604-730-1220

Certificate of Analysis

Lab Work Order #: **L1056596**

Project P.O. #: NOT SUBMITTED
Job Reference: MEADOWBANK MINE EAS
C of C Numbers: 1, 2, 3, 4, 5, 6, 7, 8, 9
Legal Site Desc:

Comments: Please note that the results of TPE-H-2, SP-BL-1, and DUP-2 are possibly slightly biased high due to glass contamination. The results of SP-BL-2 are possibly biased low due to a spill during the weighing process.

Brent Mack
Account Manager

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-1	L1056596-2	L1056596-3	L1056596-4	L1056596-5
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11
	Sampled Time					
	Client ID	TPN-CREMP-1	TPN-CREMP-2	TPN-CREMP-3	TPN-CREMP-4	TPN-CREMP-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.669	0.0955	0.420	0.133	0.357
	Ash Weight (g)	0.591	0.0880	0.353	0.105	0.306
	Ash Free Dry Weight (g)	0.0776	0.0074	0.0668	0.0276	0.0504

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1056596-6	L1056596-7	L1056596-8	L1056596-9	L1056596-10
		Description	OTHER	OTHER	OTHER	OTHER	OTHER
		Sampled Date	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11
		Sampled Time					
		Client ID	TPN-A-1	TPN-A-2	TPN-A-3	TPN-A-4	TPN-A-5
Grouping	**Analyte**						
TISSUE							
Physical Tests	Dry Weight (g)		0.115	0.0912	0.0431	0.339	0.469
	Ash Weight (g)		0.0655	0.0717	0.0309	0.310	0.460
	Ash Free Dry Weight (g)		0.0496	0.0194	0.0121	0.0290	0.0096

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-11	L1056596-12	L1056596-13	L1056596-14	L1056596-15
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11
	Sampled Time					
	Client ID	TPS-CREMP-1	TPS-CREMP-2	TPS-CREMP-3	TPS-CREMP-4	TPS-CREMP-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.108	0.113	0.102	0.0768	0.0756
	Ash Weight (g)	0.0864	0.0793	0.0902	0.0531	0.0585
	Ash Free Dry Weight (g)	0.0215	0.0332	0.0114	0.0236	0.0170

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-16	L1056596-17	L1056596-18	L1056596-19	L1056596-20
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11
	Sampled Time					
	Client ID	TPE-C-1	TPE-C-2	TPE-C-3	TPE-C-4	TPE-C-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.336	0.310	0.998	0.527	0.449
	Ash Weight (g)	0.238	0.272	0.878	0.456	0.403
	Ash Free Dry Weight (g)	0.0985	0.0379	0.121	0.0712	0.0458

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-21	L1056596-22	L1056596-23	L1056596-24	L1056596-25
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11
	Sampled Time					
	Client ID	TPE-E-1	TPE-E-2	TPE-E-3	TPE-E-4	TPE-E-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.546	0.467	0.511	0.541	0.478
	Ash Weight (g)	0.400	0.362	0.405	0.434	0.401
	Ash Free Dry Weight (g)	0.146	0.105	0.106	0.106	0.0772

ALS ENVIRONMENTAL ANALYTICAL REPORT

		Sample ID	L1056596-26	L1056596-27	L1056596-28	L1056596-29	L1056596-30
		Description	OTHER	OTHER	OTHER	OTHER	OTHER
		Sampled Date	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11
		Sampled Time					
		Client ID	TPE-F-1	TPE-F-2	TPE-F-3	TPE-F-4	TPE-F-5
Grouping	**Analyte**						
TISSUE							
Physical Tests	Dry Weight (g)		0.327	0.252	0.232	1.37	0.477
	Ash Weight (g)		0.255	0.198	0.165	0.977	0.331
	Ash Free Dry Weight (g)		0.0723	0.0537	0.0671	0.392	0.146

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-31	L1056596-32	L1056596-33	L1056596-34	L1056596-35
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11
	Sampled Time					
	Client ID	TPE-G-1	TPE-G-2	TPE-G-3	TPE-G-4	TPE-G-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.775	1.12	1.22	0.902	0.536
	Ash Weight (g)	0.667	0.973	1.06	0.837	0.468
	Ash Free Dry Weight (g)	0.108	0.146	0.151	0.0653	0.0680

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1056596-36	L1056596-37	L1056596-38	L1056596-39	L1056596-40
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11
	Sampled Time					
	Client ID	TPE-BGS-1	TPE-BGS-2	TPE-BGS-3	TPE-BGS-4	TPE-BGS-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.0177	0.0108	0.196	0.0541	0.409
	Ash Weight (g)	0.0169	0.0101	0.189	0.0529	0.394
	Ash Free Dry Weight (g)	<0.0010	<0.0010	0.0071	0.0011	0.0147

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-41	L1056596-42	L1056596-43	L1056596-44	L1056596-45
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	
	Sampled Time					
	Client ID	TPE-BGN-1	TPE-BGN-2	TPE-BGN-3	TPE-BGN-5	DUP-1
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.311	0.0335	0.0128	0.0144	0.486
	Ash Weight (g)	0.306	0.0328	0.0128	0.0134	0.420
	Ash Free Dry Weight (g)	0.0042	<0.0010	<0.0010	<0.0010	0.0662

ALS ENVIRONMENTAL ANALYTICAL REPORT

Sample ID		L1056596-46	L1056596-47	L1056596-48	L1056596-49	L1056596-50
Description		OTHER	OTHER	OTHER	OTHER	OTHER
Sampled Date		26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11
Sampled Time						
Client ID		TPE-A-1	TPE-A-2	TPE-A-3	TPE-A-4	TPE-A-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	2.89	0.311	6.27	2.37	1.79
	Ash Weight (g)	2.76	0.302	6.09	2.20	1.66
	Ash Free Dry Weight (g)	0.139	0.0095	0.187	0.164	0.132

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-51	L1056596-52	L1056596-53	L1056596-54	L1056596-55
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11
	Sampled Time					
	Client ID	TPE-B-1	TPE-B-2	TPE-B-3	TPE-B-4	TPE-B-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.08	1.55	1.44	1.30	0.286
	Ash Weight (g)	0.851	1.33	1.32	1.18	0.261
	Ash Free Dry Weight (g)	0.230	0.218	0.123	0.126	0.0247

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-56	L1056596-57	L1056596-58	L1056596-59	L1056596-60
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11
	Sampled Time					
	Client ID	TPE-H-1	TPE-H-2	TPE-H-3	TPE-H-4	TPE-H-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.150	0.198	0.470	0.610	0.484
	Ash Weight (g)	0.114	0.169	0.335	0.429	0.337
	Ash Free Dry Weight (g)	0.0359	0.0289	0.136	0.181	0.147

ALS ENVIRONMENTAL ANALYTICAL REPORT

		L1056596-61	L1056596-62	L1056596-63	L1056596-64	L1056596-65
	Sample ID	L1056596-61	L1056596-62	L1056596-63	L1056596-64	L1056596-65
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11
	Sampled Time					
	Client ID	TPE-I-1	TPE-I-2	TPE-I-3	TPE-I-4	TPE-I-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.854	0.898	0.525	0.531	0.733
	Ash Weight (g)	0.793	0.745	0.467	0.520	0.705
	Ash Free Dry Weight (g)	0.0612	0.152	0.0588	0.0109	0.0280

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-66	L1056596-67	L1056596-68	L1056596-69	L1056596-70
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11	26-AUG-11
	Sampled Time					
	Client ID	TPE-D-1	TPE-D-2	TPE-D-3	TPE-D-4	TPE-D-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.374	0.332	0.174	0.319	0.569
	Ash Weight (g)	0.348	0.319	0.160	0.303	0.536
	Ash Free Dry Weight (g)	0.0262	0.0130	0.0148	0.0159	0.0334

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-71	L1056596-72	L1056596-73	L1056596-74	L1056596-75
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	28-AUG-11	28-AUG-11	28-AUG-11	28-AUG-11	28-AUG-11
	Sampled Time					
	Client ID	SP-ED-1	SP-ED-2	SP-ED-3	SP-ED-4	SP-ED-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.0915	0.0352	0.0218	0.0349	0.0091
	Ash Weight (g)	0.0884	0.0341	0.0211	0.0337	0.0090
	Ash Free Dry Weight (g)	0.0030	0.0010	<0.0010	0.0011	<0.0010

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-76	L1056596-77	L1056596-78	L1056596-79	L1056596-80
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11
	Sampled Time					
	Client ID	SP-CREMP-1	SP-CREMP-2	SP-CREMP-3	SP-CREMP-4	SP-CREMP-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.25	1.00	0.993	0.541	1.39
	Ash Weight (g)	1.07	0.965	0.876	0.457	1.18
	Ash Free Dry Weight (g)	0.177	0.0391	0.117	0.0849	0.208

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-81	L1056596-82	L1056596-83	L1056596-84	L1056596-85
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11
	Sampled Time					
	Client ID	SP-DT-1	SP-DT-2	SP-DT-3	SP-DT-4	SP-DT-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.910	0.271	0.470	0.438	0.491
	Ash Weight (g)	0.518	0.199	0.317	0.272	0.295
	Ash Free Dry Weight (g)	0.392	0.0715	0.153	0.166	0.195

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-86	L1056596-87	L1056596-88	L1056596-89	L1056596-90
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11	27-AUG-11
	Sampled Time					
	Client ID	SP-BL-1	SP-BL-2	SP-BL-3	SP-BL-4	SP-BL-5
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	1.61	1.56	0.846	1.13	0.567
	Ash Weight (g)	1.58	1.31	0.747	1.11	0.542
	Ash Free Dry Weight (g)	0.0263	0.249	0.0985	0.0190	0.0252

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-91	L1056596-92	L1056596-93	L1056596-94	L1056596-95
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date		24-AUG-11	24-AUG-11	24-AUG-11	24-AUG-11
	Sampled Time					
	Client ID	DUP-2	TPS-A-1	TPS-A-2	TPS-A-3	TPS-A-4
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.907	0.196	0.184	0.0982	0.135
	Ash Weight (g)	0.895	0.163	0.143	0.0874	0.0792
	Ash Free Dry Weight (g)	0.0120	0.0331	0.0401	0.0107	0.0553

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-96	L1056596-97	L1056596-98	L1056596-99	L1056596-100
	Description	OTHER	OTHER	OTHER	OTHER	OTHER
	Sampled Date	24-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11	25-AUG-11
	Sampled Time					
	Client ID	TPS-A-5	TPE-CREMP-1	TPE-CREMP-2	TPE-CREMP-3	TPE-CREMP-4
Grouping	**Analyte**					
TISSUE						
Physical Tests	Dry Weight (g)	0.214	0.516	1.46	0.833	0.686
	Ash Weight (g)	0.134	0.477	1.28	0.757	0.631
	Ash Free Dry Weight (g)	0.0802	0.0386	0.179	0.0758	0.0548

ALS ENVIRONMENTAL ANALYTICAL REPORT

	Sample ID	L1056596-101
	Description	OTHER
	Sampled Date	25-AUG-11
	Sampled Time	
	Client ID	TPE-CREMP-5
Grouping	**Analyte**	
TISSUE		
Physical Tests	Dry Weight (g)	0.854
	Ash Weight (g)	0.772
	Ash Free Dry Weight (g)	0.0819

Reference Information

Test Method References:

ALS Test Code	Matrix	Test Description	Method Reference**
ASHFREE-DRY-VA	Tissue	Ash Free Dry Weight	44.3 ASH CONTENT & ORG. MATTER CONTENT

This analysis is carried out using procedures adapted from the Canadian Society of Soil Science method "44.3 Ash Content and Organic Matter Content", (1993). Ash Free Dry Weight is determined by the difference between 'Dry Weight' and 'Ash Weight' which are both determined gravimetrically. Dry Weight is determined by drying the sample at 105 "C and the Ash Weight is subsequently determined by ashing the dried sample at 550 "C.

** ALS test methods may incorporate modifications from specified reference methods to improve performance.

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location
VA	ALS ENVIRONMENTAL - VANCOUVER, BC, CANADA

Chain of Custody Numbers:

1	2	3	4	5
6	7	8	9	

GLOSSARY OF REPORT TERMS

Surrogate - A compound that is similar in behaviour to target analyte(s), but that does not occur naturally in environmental samples. For applicable tests, surrogates are added to samples prior to analysis as a check on recovery.
mg/kg - milligrams per kilogram based on dry weight of sample.
mg/kg wwt - milligrams per kilogram based on wet weight of sample.
mg/kg lwt - milligrams per kilogram based on lipid-adjusted weight of sample.
mg/L - milligrams per litre.
< - Less than.
D.L. - The reported Detection Limit, also known as the Limit of Reporting (LOR).
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
Analytical results in unsigned test reports with the DRAFT watermark are subject to change, pending final QC review.

ALS [redacted]

Chain of Cust[illegible]
Canada

L1056596-COFC

COC # ______

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis ...)
Company:	Azimuth Consulting Group	☐ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business D...)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS ...
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		
Invoice To	Same as Report ? ☑ Yes ☐ No	**Client / Project Information**		
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine **EAS**	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	**Q29231**	
Lab Work Order # (lab use only)	L1056596	**ALS Contact:** Brent Mack	**Sampler:** MM, MF	

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)											Number of Containers
	TPN-CREMP-1	24-Aug-11		**Other	X	X											1
	TPN-CREMP-2	24-Aug-11		**Other	X	X											1
	TPN-CREMP-3	24-Aug-11		**Other	X	X											1
	TPN-CREMP-4	24-Aug-11		**Other	X	X											1
	TPN-CREMP-5	24-Aug-11		**Other	X	X											1
	TPN-A-1	24-Aug-11		**Other	X	X											1
	TPN-A-2	24-Aug-11		**Other	X	X											1
	TPN-A-3	24-Aug-11		**Other	X	X											1
	TPN-A-4	24-Aug-11		**Other	X	X											1
	TPN-A-5	24-Aug-11		**Other	X	X											1
	TPS-CREMP-1	24-Aug-11		**Other	X	X											1
	TPS-CREMP-2	24-Aug-11		**Other	X	X											1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: Ryan	Date: Sep 9	Time: 10:15	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS *L1056596-COFC*

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # ____

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway, Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To — Same as Report ?	[x] Yes [ ] No
Hardcopy of Invoice with Report?	[x] Yes [ ] No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1056596

Report Format / Distribution	
[ ] Standard [ ] Other	
[x] PDF [x] Excel [ ] Digital [ ] Fax	
Email 1:	mmcconnell@azimuthgroup.ca
Email 2:	gmann@azimuthgroup.ca
Email 3:	
Client / Project Information	
Job #:	Meadowbank Mine **EAS**
PO / AFE:	
LSD:	
Quote #:	**Q29231**
ALS Contact:	Brent Mack
Sampler:	MM, MF

Service Requested (Rush for routine analysis subject to availability)

- (●) Regular (Standard Turnaround Times - Business Days)
- ( ) Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ( ) Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ( ) Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request — Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
	TPS-CREMP-3	24-Aug-11		**Other	X	X	1
	TPS-CREMP-4	24-Aug-11		**Other	X	X	1
	TPS-CREMP-5	24-Aug-11		**Other	X	X	1
	TPS-A-1	24-Aug-11		**Other	X	X	1
	TPS-A-2	24-Aug-11		**Other	X	X	1
	TPS-A-3	24-Aug-11		**Other	X	X	1
	TPS-A-4	24-Aug-11		**Other	X	X	1
	TPS-A-5	24-Aug-11		**Other	X	X	1
	TPE-CREMP-1	25-Aug-11		**Other	X	X	1
	TPE-CREMP-2	25-Aug-11		**Other	X	X	1
	TPE-CREMP-3	26-Aug-11		**Other	X	X	1
	TPE-CREMP-4	26-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley, Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: RYAN	Date: Sept 9	Time: 10:15	Temperature: 22°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS

L1056596-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To

Company: Azimuth Consulting Group

Contact: Maggie McConnell / Gary Mann

Address: #218 - 2902 West Broadway, Vancouver, BC

Phone: 604-730-1220 Fax: 604-739-8511

Invoice To Same as Report ? [x] Yes [ ] No

Hardcopy of Invoice with Report? [x] Yes [ ] No

Company:

Contact:

Address:

Phone: Fax:

Lab Work Order # (lab use only) L1056596

Report Format / Distribution

[ ] Standard [ ] Other

[x] PDF [x] Excel [ ] Digital [ ] Fax

Email 1: mmcconnell@azimuthgroup.ca

Email 2: gmann@azimuthgroup.ca

Email 3:

Client / Project Information

Job #: Meadowbank Mine **EAS**

PO / AFE:

LSD:

Quote #: **Q29231**

ALS Contact: Brent Mack **Sampler:** MM, MF

Service Requested (Rush for routine analysis subject to availability)

(•) Regular (Standard Turnaround Times - Business Days)

( ) Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT

( ) Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT

( ) Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)											Number of Containers
	TPE-CREMP-5	26-Aug-11		**Other	X	X											1
	TPE-C-1	25-Aug-11		**Other	X	X											1
	TPE-C-2	25-Aug-11		**Other	X	X											1
	TPE-C-3	25-Aug-11		**Other	X	X											1
	TPE-C-4	25-Aug-11		**Other	X	X											1
	TPE-C-5	25-Aug-11		**Other	X	X											1
	TPE-E-1	25-Aug-11		**Other	X	X											1
	TPE-E-2	25-Aug-11		**Other	X	X											1
	TPE-E-3	25-Aug-11		**Other	X	X											1
	TPE-E-4	25-Aug-11		**Other	X	X											1
	TPE-E-5	25-Aug-11		**Other	X	X											1
	TPE-F-1	25-Aug-11		**Other	X	X											1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley, Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: RJAW	Date: SEPT 9	Time: 10:15	Temperature: 20°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

L1056596-COFC

Chain of Custody / Analytical Request Form

~~Canada Toll Free: 1 800 668 9878~~

www.alsglobal.com

COC # ______

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☐ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		Analysis Request
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine EAS	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	Q29231	
Lab Work Order # (lab use only)	L1056596	ALS Contact: Brent Mack	Sampler: MM, MF	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)											Number of Containers
	TPE-F-2	25-Aug-11		**Other	X	X											1
	TPE-F-3	25-Aug-11		**Other	X	X											1
	TPE-F-4	25-Aug-11		**Other	X	X											1
	TPE-F-5	25-Aug-11		**Other	X	X											1
	TPE-G-1	25-Aug-11		**Other	X	X											1
	TPE-G-2	25-Aug-11		**Other	X	X											1
	TPE-G-3	25-Aug-11		**Other	X	X											1
	TPE-G-4	25-Aug-11		**Other	X	X											1
	TPE-G-5	25-Aug-11		**Other	X	X											1
	TPE-BGS-1	27-Aug-11		**Other	X	X											1
	TPE-BGS-2	27-Aug-11		**Other	X	X											1
	TPE-BGS-3	27-Aug-11		**Other	X	X											1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: RYAN	Date: SEP 1	Time: 10:15	Temperature: 22°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

VLM

ALS Env... *L1056596-COFC*

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

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COC #

Report To	
Company:	Azimuth Consulting Group
Contact:	Maggie McConnell / Gary Mann
Address:	#218 - 2902 West Broadway
	Vancouver, BC
Phone:	604-730-1220 Fax: 604-739-8511
Invoice To Same as Report ?	☑ Yes ☐ No
Hardcopy of Invoice with Report?	☑ Yes ☐ No
Company:	
Contact:	
Address:	
Phone:	Fax:
Lab Work Order # (lab use only)	L1056596

Report Format / Distribution	
☐ Standard ☐ Other	
☑ PDF ☑ Excel ☐ Digital ☐ Fax	
Email 1:	mmcconnell@azimuthgroup.ca
Email 2:	gmann@azimuthgroup.ca
Email 3:	
Client / Project Information	
Job #:	Meadowbank Mine **EAS**
PO / AFE:	
LSD:	
Quote #:	Q29231
ALS Contact:	Brent Mack
Sampler:	MM, MF

Service Requested (Rush for routine analysis subject to availability)

- ◉ Regular (Standard Turnaround Times - Business Days)
- ○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
- ○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
- ○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT

Analysis Request

Please indicate below Filtered, Preserved or both (F, P, F/P)

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
	TPE-BGS-4	27-Aug-11		**Other	X	X	1
	TPE-BGS-5	27-Aug-11		**Other	X	X	1
	TPE-BGN-1	26-Aug-11		**Other	X	X	1
	TPE-BGN-2	26-Aug-11		**Other	X	X	1
	TPE-BGN-3	26-Aug-11		**Other	X	X	1
	TPE-BGN-5	26-Aug-11		**Other	X	X	1
	DUP-1	--		**Other	X	X	1
	TPE-A-1	26-Aug-11		**Other	X	X	1
	TPE-A-2	26-Aug-11		**Other	X	X	1
	TPE-A-3	26-Aug-11		**Other	X	X	1
	TPE-A-4	26-Aug-11		**Other	X	X	1
	TPE-A-5	26-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: Ryan	Date: Sep 9	Time: 10:15	Temperature: 2°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

L1056596-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC #

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☐ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		Analysis Request
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine **EAS**	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	**Q29231**	
Lab Work Order # (lab use only)	L1056596	ALS Contact:	Brent Mack	Sampler: MM, MF

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
	TPE-B-1	26-Aug-11		**Other	X	X	1
	TPE-B-2	26-Aug-11		**Other	X	X	1
	TPE-B-3	26-Aug-11		**Other	X	X	1
	TPE-B-4	26-Aug-11		**Other	X	X	1
	TPE-B-5	26-Aug-11		**Other	X	X	1
	TPE-H-1	26-Aug-11		**Other	X	X	1
	TPE-H-2	26-Aug-11		**Other	X	X	1
	TPE-H-3	26-Aug-11		**Other	X	X	1
	TPE-H-4	26-Aug-11		**Other	X	X	1
	TPE-H-5	26-Aug-11		**Other	X	X	1
	TPE-I-1	26-Aug-11		**Other	X	X	1
	TPE-I-2	26-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: RYAN	Date: 1/9/15	Time:	Temperature: 25°C SP19°C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS E *L1056596-COFC*

Chain of Custody / Analytical Request Form

~~Canada Toll Free: 1 800 668 9878~~

www.alsglobal.com

COC #

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☐ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		Analysis Request
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine EAS	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	Q29231	
Lab Work Order # (lab use only)	L1056596	ALS Contact: Brent Mack	Sampler: MM, MF	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)	Number of Containers
	TPE-I-3	26-Aug-11		**Other	X	X	1
	TPE-I-4	26-Aug-11		**Other	X	X	1
	TPE-I-5	26-Aug-11		**Other	X	X	1
	TPE-D-1	26-Aug-11		**Other	X	X	1
	TPE-D-2	26-Aug-11		**Other	X	X	1
	TPE-D-3	26-Aug-11		**Other	X	X	1
	TPE-D-4	26-Aug-11		**Other	X	X	1
	TPE-D-5	26-Aug-11		**Other	X	X	1
	SP-ED-1	28-Aug-11		**Other	X	X	1
	SP-ED-2	28-Aug-11		**Other	X	X	1
	SP-ED-3	28-Aug-11		**Other	X	X	1
	SP-ED-4	28-Aug-11		**Other	X	X	1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: [signature]	Date: Sep 9	Time: 1015	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

[signature]

ALS Env

L1056596-COFC

Chain of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # ____

Report To		Report Format / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☐ Standard ☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		Analysis Request
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine EAS	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	Q29231	
Lab Work Order # (lab use only)	L1056596	ALS Contact:	Brent Mack	Sampler: MM, MF

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)											Number of Containers
	SP-ED-5	28-Aug-11		**Other	X	X											1
	SP-CREMP-1	27-Aug-11		**Other	X	X											1
	SP-CREMP-2	27-Aug-11		**Other	X	X											1
	SP-CREMP-3	27-Aug-11		**Other	X	X											1
	SP-CREMP-4	27-Aug-11		**Other	X	X											1
	SP-CREMP-5	27-Aug-11		**Other	X	X											1
	SP-DT-1	27-Aug-11		**Other	X	X											1
	SP-DT-2	27-Aug-11		**Other	X	X											1
	SP-DT-3	27-Aug-11		**Other	X	X											1
	SP-DT-4	27-Aug-11		**Other	X	X											1
	SP-DT-5	27-Aug-11		**Other	X	X											1
	SP-BL-1	27-Aug-11		**Other	X	X											1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

By the use of this form the user acknowledges and agrees with the Terms and Conditions as provided on a separate Excel tab.

Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: Morgan Finley / Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: RYAN	Date: SEPT 9	Time: 10:15	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

ALS Environm[ental]

L1056596-COFC

of Custody / Analytical Request Form

Canada Toll Free: 1 800 668 9878

www.alsglobal.com

COC # ____________

Report To		[Report Fo]rmat / Distribution		Service Requested (Rush for routine analysis subject to availability)
Company:	Azimuth Consulting Group	☐ Other		◉ Regular (Standard Turnaround Times - Business Days)
Contact:	Maggie McConnell / Gary Mann	☑ PDF ☑ Excel ☐ Digital ☐ Fax		○ Priority (2-4 Business Days) - 50% Surcharge - Contact ALS to Confirm TAT
Address:	#218 - 2902 West Broadway	Email 1:	mmcconnell@azimuthgroup.ca	○ Emergency (1-2 Bus. Days) - 100% Surcharge - Contact ALS to Confirm TAT
	Vancouver, BC	Email 2:	gmann@azimuthgroup.ca	○ Same Day or Weekend Emergency - Contact ALS to Confirm TAT
Phone:	604-730-1220 Fax: 604-739-8511	Email 3:		Analysis Request
Invoice To	Same as Report ? ☑ Yes ☐ No	Client / Project Information		Please indicate below Filtered, Preserved or both (F, P, F/P)
Hardcopy of Invoice with Report?	☑ Yes ☐ No	Job #:	Meadowbank Mine EAS	
Company:		PO / AFE:		
Contact:		LSD:		
Address:				
Phone:	Fax:	Quote #:	Q29231	
Lab Work Order # (lab use only)	L1056596	ALS Contact: Brent Mack	Sampler: MM, MF	

Sample #	Sample Identification (This description will appear on the report)	Date (dd-mmm-yy)	Time (hh:mm)	Sample Type	Dry weight (in dw, not %)	Ash-Free DW (in dw, not %)											Number of Containers
	SP-BL-2	27-Aug-11		**Other	X	X											1
	SP-BL-3	27-Aug-11		**Other	X	X											1
	SP-BL-4	27-Aug-11		**Other	X	X											1
	SP-BL-5	27-Aug-11		**Other	X	X											1
	DUP-2	--		**Other	X	X											1

Special Instructions / Regulations with water or land use (CCME-Freshwater Aquatic Life/BC CSR - Commercial/AB Tier 1 - Natural, etc) / Hazardous Details

**Sample type "Other" represents a mix of periphyton and sediment; frozen but not preserved; email Maggie McConnell if there are any questions.

Failure to complete all portions of this form may delay analysis. Please fill in this form LEGIBLY.

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Also provided on another Excel tab are the ALS location addresses, phone numbers and sample container / preservation / holding time table for common analyses.

SHIPMENT RELEASE (client use)			SHIPMENT RECEPTION (lab use only)				SHIPMENT VERIFICATION (lab use only)			
Released by: ~~Morgan Finley~~ Maggie McConnell	Date (dd-mmm-yy) 31-AUG-11	Time (hh-mm)	Received by: Ryan	Date: Sept 9	Time: 10:15	Temperature: 20 °C	Verified by:	Date:	Time:	Observations: Yes / No ? If Yes add SIF

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

D.1. Second Portage Lake – High Value Habitat (HVH)

Photo D.1-1. SP-HVH-1. Periphyton coverage on fines and cobble. The green colour of the periphyton may be muted due to moderate sediment coverage.

Photo D.1-2. SP-HVH-2. Flat surface with periphyton mat that is considerably less green, dense and luxuriant as compared to that on the vertical sides of boulders; this may be due to the thin sediment layer.

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

Photo D.1-3. SP-HVH-3. Green, luxurious periphyton covering boulders as a dense, continuous mat. Light and sparse sediment dusting.

Photo D.1-4. SP-HVH-4. Patchy periphyton mat on boulder in shallow water; thin sediment coverage.

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

Photo D.1-5. SP-HVH-5. Periphyton coverage appears thick and raised; very sparse sediment coverage.

Photo D.1-6. SP-HVH-6. Mat is thick but patchy; thin to moderate sediment coverage.

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

D.2. Third Portage Lake East – High Value Habitat (HVH)

Photo D.2-1. TPE-HVH-1. Continuous mat of periphyton with thin and sparse sediment coverage.

Photo D.2-2. TPE-HVH-2. A boulder covered with a very dense, thick and raised mat of periphyton; light sediment dusting.

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

Photo D.2-3. TPE-HVH-3. The raised green fronds of a continuous mat of periphyton covering the side of a boulder.

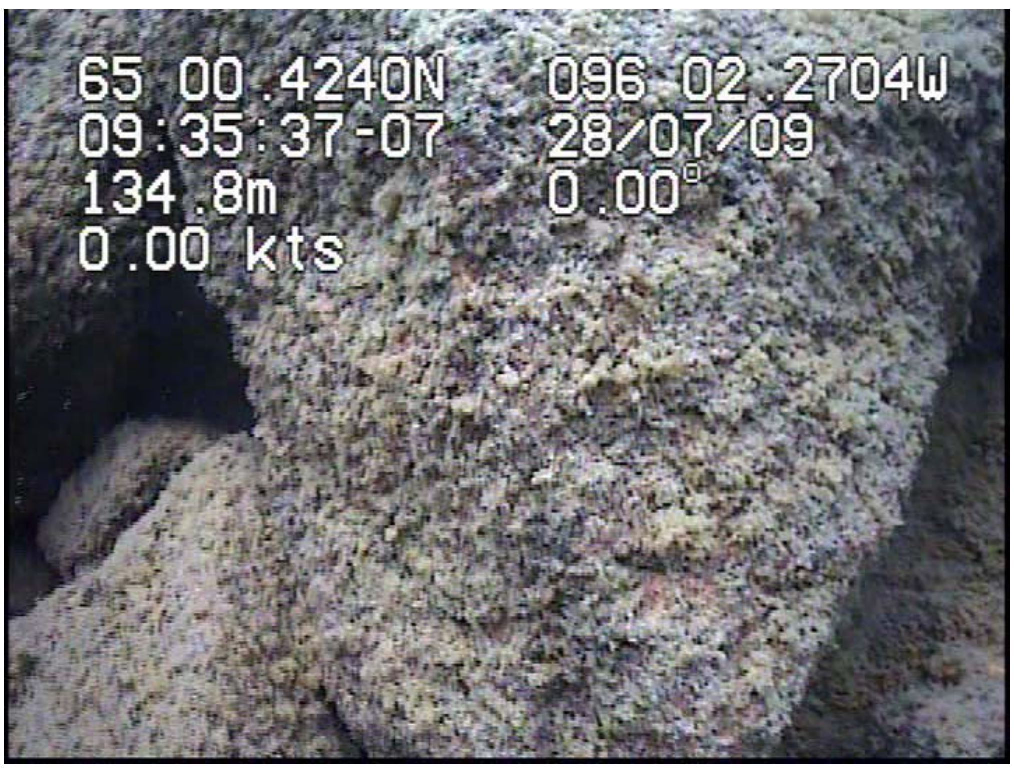

Photo D.2-4. TPE-HVH-4. Periphyton covers all substrates with a continuous mat; thin and sparse sediment coverage.

Appendix G. Photos of 2009 periphyton community at HVH areas from underwater video imagery.

Photo D.2-5. TPE-HVH-5. Thick, luxurious periphyton covers all surfaces. Very light sediment dusting.

Photo D.2-6. TPE-HVH-6. Mats are continuous, luxurious and dense, covering all surfaces. Light sediment dusting.

Appendix H. Photos of 2011 periphyton community at HVH areas from underwater video imagery.

D.1. Second Portage Lake – High Value Habitat (HVH)

Photo D.1-1. SP-HVH-1. Thick coverage of periphyton on all substrates.

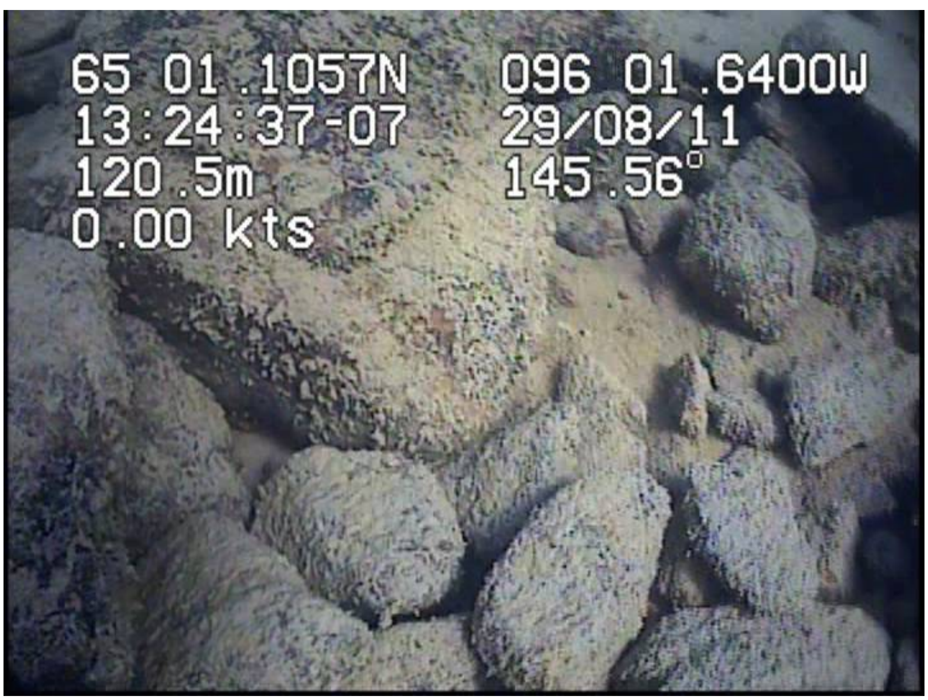

Photo D.1-2. SP-HVH-2. Thick coverage of periphyton on boulders and cobble; thin and sparse sediment coverage on surface of periphyton.

Appendix H. Photos of 2011 periphyton community at HVH areas from underwater video imagery.

Photo D.1-3. SP-HVH-3. Thin and flat periphyton on rock surfaces but thick and raised coverage on sides. Thin and sparse sediment coverage.

Photo D.1-4. SP-HVH-4. Thick layer of periphyton on all surfaces (including fines); some sediment on surfaces of boulders.

Appendix H. Photos of 2011 periphyton community at HVH areas from underwater video imagery.

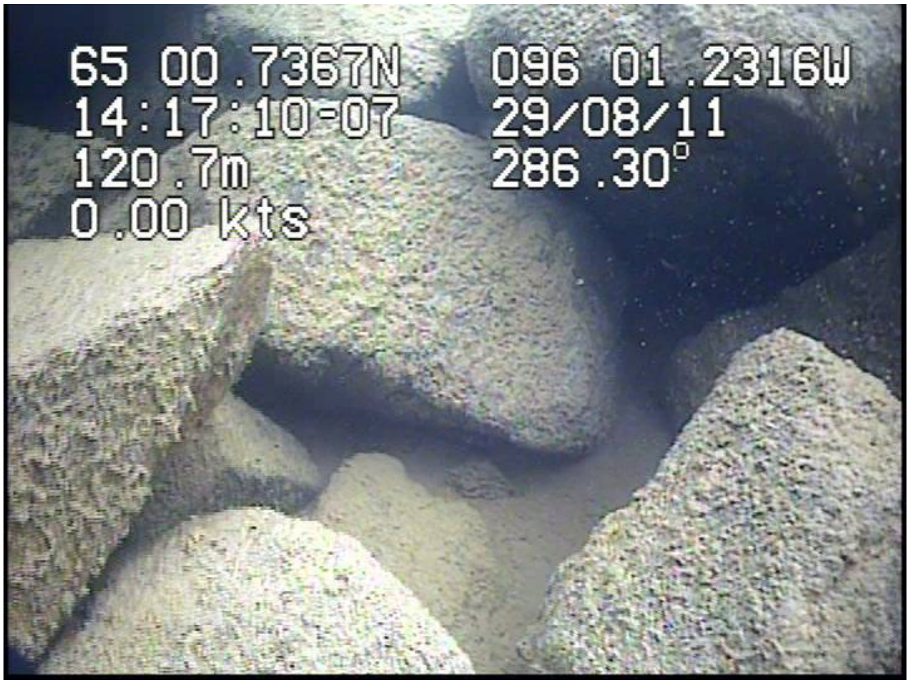

Photo D.1-5. SP-HVH-5. Thick and raised periphyton with dense coverage on all surfaces; thin sediment coverage.

Photo D.1-6. SP-HVH-6. Thin and somewhat patchy coverage on surfaces (including fines); thick and raised periphyton on sides. Thin layer of sediment.

Appendix H. Photos of 2011 periphyton community at HVH areas from underwater video imagery.

D.2. Third Portage Lake East – High Value Habitat (HVH)

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Photo D.2-1. TPE-HVH-3. Thin and flat on surface but thick and raised coverage on sides; thin and sparse sediment coverage.

Photo D.2-2. TPE-HVH-4. All surfaces are densely covered by thick and raised periphyton; thin and sparse sediment coverage.

Appendix H. Photos of 2011 periphyton community at HVH areas from underwater video imagery.

Photo D.2-3. TPE-HVH-5. Thick mats of periphyton with raised fronds.

Photo D.2-4. TPE-HVH-6. Thick but flat coverage on surface; thick, raised and dense coverage on sides.

Appendix I. Key for interpreting sediment and periphyton coverage from video surveys of the periphyton community. Includes 3 examples for each of 4 levels of sediment coverage.

Light Sediment Dusting

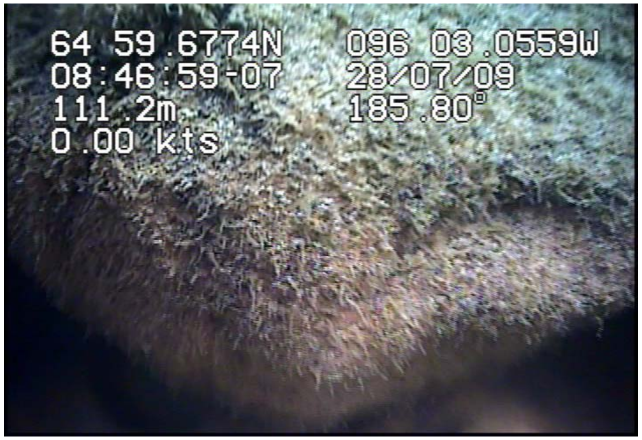


Photo 1. Light sediment dusting with moderate-high periphyton coverage on surfaces and sides (TPE-HVH-5, 2009).

Photo 2. Light and sparse sediment dusting with high periphyton coverage on surface and sides (SP-HVH-3, 2009).

Photo 3. Light sediment dusting on bare rock with no periphyton coverage (TPE-BGN-5, 2011).

Thin and Sparse Sediment Coverage

Photo 4. Thin and sparse sediment coverage with moderate-high periphyton coverage on surface and sides (SP-HVH-2, 2011).

Photo 5. Thin and sparse sediment coverage with moderate periphyton coverage on surface and high on sides (TPE-HVH-6, 2011).

Photo 6. Thin and sparse sediment coverage with low-moderate periphyton coverage on surface and sides (TPE-BGN-4, 2011).

Appendix I. Key for interpreting sediment and periphyton coverage from video surveys of the periphyton community. Includes 3 examples for each of 4 levels of sediment coverage.

Moderate Sediment Coverage

Photo 7. Moderate sediment coverage with high periphyton coverage on surface and sides (SP-HVH-1, 2009).

Photo 8. Moderate sediment coverage with low-moderate periphyton coverage on surface and sides (TPE-BGN-1, 2011).

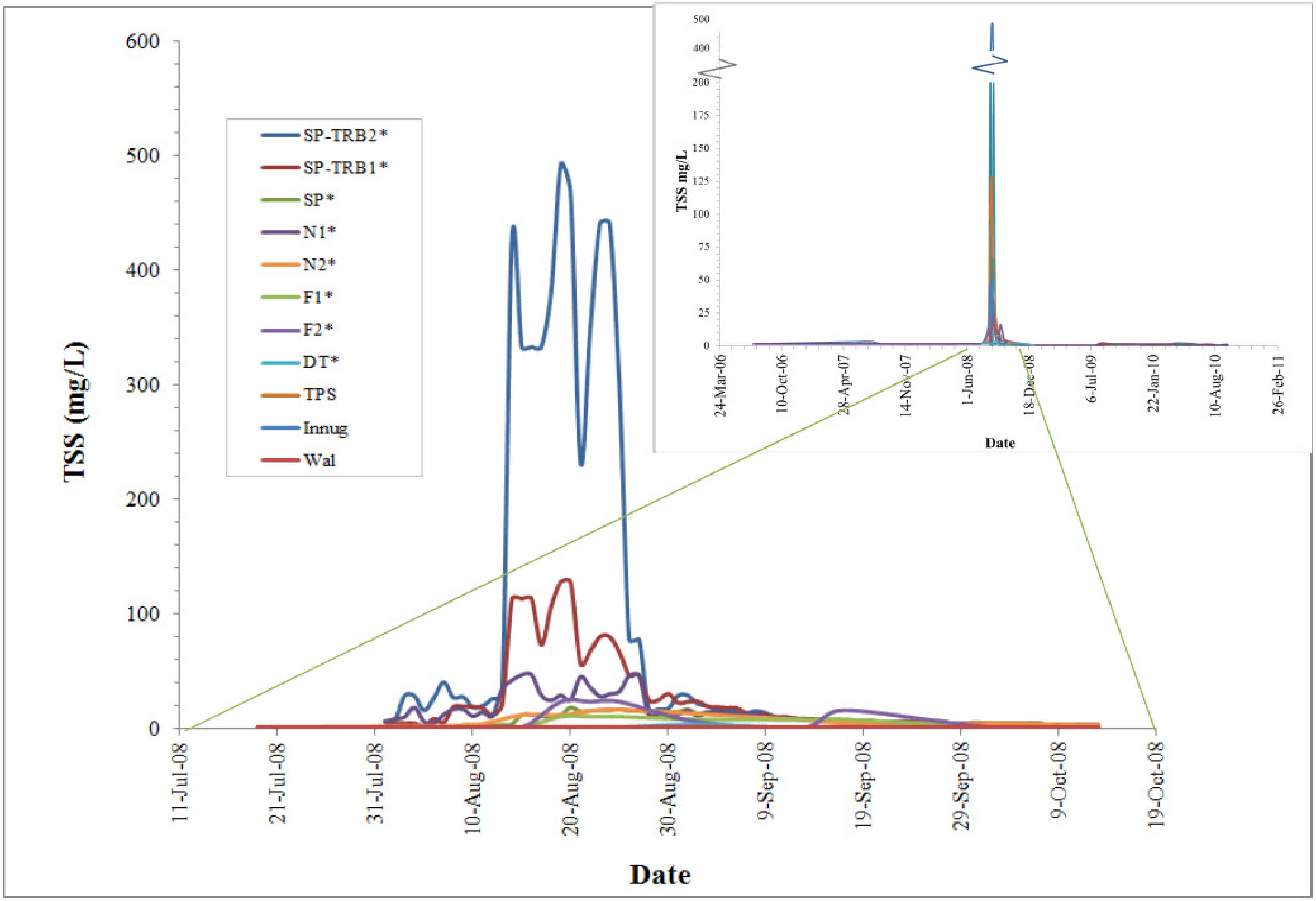
Photo 9. Moderate sediment coverage in some areas with low-moderate periphyton coverage on surface and sides (SP-ED-3, 2011).

Dense Sediment Coverage

Photo 10. Dense sediment coverage with low periphyton coverage on surface and high on sides (SP-ED-1, 2009).

Photo 11. Dense sediment coverage with low periphyton coverage on surface and moderate on sides (SP-ED-2, 2009).

Appendix J. VanEngen Unpublished Data Plots – Benthic Invertebrate Community in Second Portage Lake Before/After East Dike Construction.



Appendix J. VanEngen Unpublished Data Plots – Benthic Invertebrate Community in Second Portage Lake Before/After East Dike Construction.