AECOM

OZ Minerals Canada Resources Inc.

Lupin Gold Mine Environmental Effects Monitoring Cycle 2 Interpretative Report

Prepared by:

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Project Number:

108154

Date:

May 28, 2009

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28 May 2009

Ms. Margaret Fairbairn
MMER Authorization Officer
Prairie and Northern Region
Environment Canada
Room 200, 4999-98 Ave. NW
Edmonton Alberta T6B 2X3

Dear Ms Siwik

Lupin Gold Mine Environmental Effects Monitoring Cycle 2 Interpretative Report

We are pleased to submit nine paper copies and 1 electronic copy of the attached Cycle 2 Interpretative report. The report provides the required information and biological details as per Environment Canada's accepted Study Design for the mine.

Should you have any questions regarding this report, please call myself, Andrew Mitchell (OZ Minerals, 807-346-1692) or Colleen Prather (AECOM, 780-486-7041).

Yours truly

Andrew Mitchell

Andrew Mitchell
Development Manager

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May 28, 2009 Project Number: 108154

Andrew Mitchell
Development Manager – Canadian Operations
OZ Minerals Canada Resources Inc.
200-1159 Alloy Drive
Thunder Bay, Ontario P7B 6M8

Dear Mr. Mitchell :

Re: Lupin Gold Mine Cycle 2 EEM Final Report

AECOM is pleased to submit the Lupin Gold Mine Environmental Effects Monitoring Cycle 2 Interpretative Report for OZ Minerals Canada Resources Inc., Lupin Mine.

The report provides the required information and biological details as per Environment Canada's accepted Study Design for the mine. If you have any questions or concerns please fee free to contact Colleen Prather at 780-486-7041.

Sincerely,
AECOM Canada Ltd.

Colleen Prather, PhD., P.Biol.
Colleen.Prather@aecom.com

CP:cs
Encl.
cc: File

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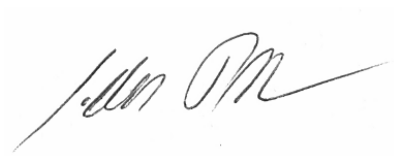
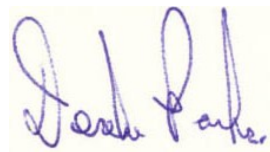
Signature Page

Report Prepared By:



Colleen Prather, Ph.D., P.Biol.

Report Reviewed By:



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Report Reviewed By:

Richard Carson, P.Biol.

Executive Summary

1. Overview

OZ Minerals Canada Resources Inc. (OZ) owns the Lupin Gold Mine in Nunavut. Under the Metal Mining Effluent Regulations (MMER), OZ was required to complete a Cycle 2 Environmental Effects Monitoring (EEM) biological study. The purpose of an EEM biological study is to collect data for assessment of effluent release on the receiving environment. Data for the Cycle 2 program was collected in 2008 and are discussed within this Interpretative Report.

The goal of this study was to investigate the effects, if any, of mine effluent on the benthic invertebrate community and/or the fish community. The monitoring program used a control/impact study design with samples collected from the direct effluent receiving environment and equivalent samples collected from a reference area. The effluent receiving environment, exposure area, is the Seep Creek system composed of small ponds and tributaries eventually discharging to Outer Sun Bay in the West Arm area of Contwoyto Lake. The reference area is the Fingers Creek system also composed of small ponds and tributaries. The reference area is located east of the tailings area and drains into the central region of Contwoyto Lake.

2. Biological Field Program

Benthic invertebrate samples were collected from the effluent receiving environment for analysis of community composition. Results of these analyses were compared to samples collected from a reference area. Various methodologies were used to collect target fish species (Arctic grayling and ninespine stickleback) from both the exposure and reference areas. A select number of fish from the exposure area were submitted to the lab for analysis of copper concentration in the muscle tissue. Finally, supporting environmental data including field chemistry, sampling area physical measurements, lab water quality and lab sediment quality were collected from each area to aid interpretations of data. The field program was designed to collect these samples during discharge of mine effluent. Effluent was scheduled to be released in 2008 but due to malfunctioning equipment at the outfall and low pH of the effluent it was not released in 2008. Based on the requirements of MMER and the first biological EEM report, the second EEM report is due 36 months after the first report (due June 2009). The field study and report were a requirement even if the mine did not discharge effluent.

Field and lab water quality differed between the exposure and reference areas for some parameters. In the exposure area, pH was lower and conductivity, hardness, magnesium, sodium, TOC, DOC, aluminum, boron, cadmium, chromium, cobalt, copper, iron, manganese and zinc were higher than in the reference area. Other measured parameters including ammonia, nitrate, total phosphorus, and other total metals were similar between areas. Field conductivity sampling was done to distinguish effluent plume, or residual plume, within the receiving environment. Field conductivity decreased from the point of effluent discharge through to Outer Sun Bay.

Sediment grain size was similar between areas except for clay; there was more clay in exposure sediments as compared to reference sediments (3% and 1.8%, respectively). Sediment quality was significantly different for some parameters including arsenic, cobalt, copper, nickel and zinc which were higher in exposure as compared to reference sediments.

Mean invertebrate density was higher in the exposure area as compared to the reference area; the mean difference was not statistically significant. Likewise, there was no significant difference by area for taxon richness, diversity and evenness. The dissimilarity index (Bray-Curtis) was significantly higher in the exposure area as compared to the reference area but statistical power was less than 0.9.

Backpack electrofishing was the most successful sampling method used. Based on all fish sampling methods, catch-per-unit-effort (CPUE) differed significantly by area: densities were lower in the reference area, when compared to the exposure area. Young of the Year (YoY) Arctic grayling were lighter and shorter within the exposure area as compared to the reference area. The ratio of liver weight to fork length differed significantly by area (for a given fork length, livers were lighter in the exposure area as compared to the reference area). There was no statistically significant difference in copper concentration of muscle tissue by area.

Body weight and length of ninespine stickleback in the exposure area were significantly heavier and longer, respectively, than reference area individuals. The ratio of liver weight to total length was statistically significantly different by area (for a given length, livers were heavier from exposure area versus individuals from the reference area).

3. Comparison of Cycle 1 and Cycle 2 Results

Water quality results were compared qualitatively to results from Cycle 1. In the exposure area, some parameters (pH, conductivity, hardness, nitrate and arsenic) were lower in Cycle 2 than Cycle 1, while others (aluminum and nickel) were higher in Cycle 2 as contrasted to Cycle 1. Water quality parameters in the reference area were below CCME guidelines for surface water.

Sediment quality differences between areas were similar to those results recorded from the Cycle 1 study. As compared to Cycle 1, some sediment quality parameter concentrations decreased, while others increased. Since there has been no effluent release since before the Cycle 1 program, these variations in sediment and water quality parameters of the receiving environment suggest that the environment could be recovering but historical impacts may influence ecological recovery for some time.

In Cycle 1, there were more benthic invertebrates within the reference area as compared to the exposure area. In Cycle 2 the opposite was observed. In Cycle 2, the average density of benthic invertebrates in the exposure area was higher than observed in Cycle 1 while the average density in the reference area was similar between the cycles. There is some evidence that the benthic invertebrate community within the exposure area is recovering as a result of no effluent discharge, but without existing data on pre-disturbance conditions in the exposure area, interpretations remain uncertain.

Arctic grayling in the exposure area were smaller than in the reference area. This may indicate that liver function has been impaired due to historical mine effluent contamination. For ninespine stickleback, condition (weight to length) was lower and liver weight higher in the exposure area indicating possible response to historical contamination. Total weight and total length in ninespine stickleback were higher in fish from the exposure as compared to the reference area. Livers from stickleback may be affected by historical effluent loading in the exposure area but other factors such as size class, predation pressure and resource availability may have also influenced stickleback populations and development in each area.

4. Conclusion

The Cycle 2 field program was conducted more than three years after the last mine effluent discharge period. Results of the Cycle 2 EEM study indicate that benthic invertebrates and fish may be influenced by historical mine contamination. Results of the Cycle 1 EEM study indicated that benthic invertebrates and fish were impacted by mine effluent. Based on the MMER guidelines, the Cycle 1 study was classed as a periodic monitoring study with the requirement to complete Cycle 2 within 36 months of the proceeding study. Based on the results of both Cycle 1 and 2, and that effluent has not been released it is recommended to continue with the 36 month cycle of studies.

Table of Acronyms and Units

ANCOVA	Analysis of covariance
ANOVA	Analysis of variance
AO	Authorizing Officer
BCI	Bray-Curtis Index
BIC	Benthic Invertebrate Community
CPUE	Catch-per-unit-effort
CWQG	Canadian Water Quality Guidelines
DO	Dissolved oxygen
EBM	Echo Bay Mines
EC	Environment Canada
EEM	Environmental Effects Monitoring
ALS	ALS Laboratory Group
FDP	Final Discharge Point
GPS	Global Positioning System
ISQG	Interim Sediment Quality Guidelines
Kinross	Kinross Gold Corporation
MDL	Method Detection Limit
MMER	Metal mining effluent regulations
QA/QC	Quality assurance / quality control
NWB	Nunavut water board
SD	Standard deviation
SDI	Simpson's diversity index
SE	Standard error
SNP	Surveillance Network Point
TAP	Technical Advisory Panel
TCA	Tailings containment area
TGD	Technical guidance document
TOC	Total organic carbon
TSS	Total suspended solids
UTM	Universal Transverse Mercator

α	Alpha
β	Beta
µg/L	micrograms per litre
µm	micrometres
µS/cm	microSeimens per centimetre
°C	degrees Celsius
Bq/L	Becquerels per litre
cm	centimetres
g	grams
h	hours
ha	hectares
Hz	hertz
km	kilometres
km^2	square kilometres
L	litre
m/s	metres per second
m^2	square metres
m^3	cubic metres
m^3/d	cubic metres/day
mg/kg	milligrams per kilogram
mg/L	milligrams per litre
mm	millimetres
ms	milliseconds
NTU	Nephelometric Turbidity Units
s	seconds
V	volts

Table of Contents

List of Figures

List of Tables

Appendices

1. Introduction

The Metal Mining Effluent Regulations (MMER) came into effect June 6, 2002 under the authority of the *Federal Fisheries Act*. The MMER require metal mines in Canada to conduct environmental effects monitoring (EEM) programs. Under this regulation, metal mines may deposit or discharge effluent containing cyanide, metals, radium-226 and suspended solids to the aquatic environment but at concentrations that are not acutely lethal to fish. EEM programs are carried out to provide information on the biological community of the receiving environment. The EEM program was designed as a series of 3-year monitoring and interpretation cycles. The requirements of the current cycle are dependent upon the findings of the previous cycle.

The EEM programs must be implemented in accordance with the MMER, and the generic and specific requirements of the studies are outlined in the documents listed below:

- Metal Mining Effluent Regulations (SOR/2002-222) of the *Fisheries Act*
- Metal Mining Guidance Document for Aquatic Environmental Effects (EEM/2002)
- Guidance for Determining Follow-up Actions when Effects Have Been Identified in Environmental Effects Monitoring (EEM) (Environment Canada, 2000)
- Revised Technical Guidance on How to Conduct Effluent Plume Delineation Studies (Environment Canada, 2003)

EEM programs are the responsibility of both industry and government. Industry is responsible for completing the pre-design study and to propose subsequent cycles of the EEM program. The government is responsible for providing guidance, review and acceptance of study designs, review of reports and review of recommendations for further action.

Environment Canada is responsible for administering certain aspects of the *Fisheries Act* and is responsible for ensuring that EEM programs are undertaken as required. Environment Canada is one member of the technical advisory panel (TAP). The study design and reports are reviewed by the TAP and communication between the mining company and the TAP is managed through Environment Canada.

Lupin Gold Mine, owned by OZ Minerals Canada Resources Inc. (OZ), is subject to MMER. In March 2008, the Cycle 2 EEM study design was submitted to Environment Canada (EC) as required under MMER. The study design was reviewed by the TAP and comments were provided back to OZ. OZ contracted AECOM (then Gartner Lee Limited) to provide technical guidance, complete the field program and complete the Cycle 2 Interpretative EEM reporting.

This report provides results of the Cycle 2 EEM program and completes the requirements for the biological monitoring study for Lupin Gold Mine in Nunavut (Figure 1). The Cycle 2 work was completed in accordance with the above-noted legislated requirements and Environment Canada's approval of the Cycle 2 EEM Study Design for the Lupin Mine. With the Cycle 1 program completion, conclusions and recommendations for the pending Cycle 2 are discussed.

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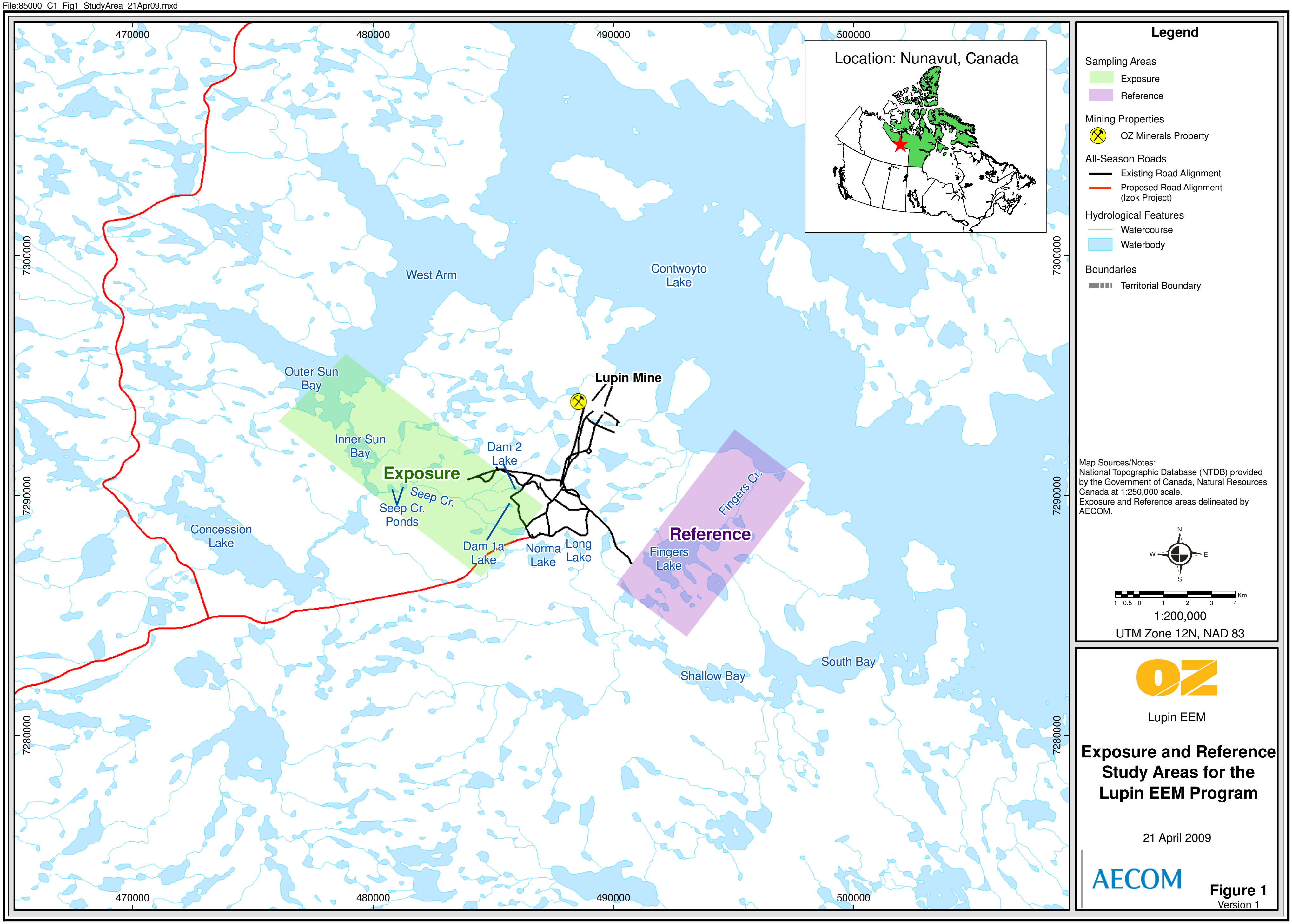

1.1 Purpose

The submission of this interpretative report, which includes data assessment and interpretation, will fulfill the requirements of Metal Mining Effluent Regulations (MMER) (SOR/2002-222) under the *Federal Fisheries Act*, specifically the requirements stipulated within the MMER in Part 2, Section 7 and in Schedule 5 of the MMER.

This report includes a description of field methods used during the biological monitoring study, and also provides data assessment and interpretation for the following EEM components:

- Water Quality
- Effluent Plume Dispersion
- Benthic Macro Invertebrate Survey
- Supporting Environmental Variables
- Fish Survey

1.2 Approach

There are three phases which comprise the Cycle 2 EEM studies:

- Study Design Phase
- Study Design Implementation Phase
- Interpretation and Report Preparation Phase

This report provides the data and interpretation of the Cycle 2 EEM program to complete the third phase in the above outline. The first phase was completed with the approval of the Cycle 2 EEM study design, as per the letter from Mr. David Noseworthy dated August 20th, 2008. Documents related to this approval are provided in Appendix A.

The second phase was completed with the implementation of the adult fish survey, benthic invertebrate community survey, sediment quality survey and water quality survey. Key dates in this implementation are:

- Water Quality Survey (including supporting environmental data)
    - Field Program and Data Collection: August 28 to September 8, 2008
    - Water Quality Lab Analysis: September 12 to 30, 2008

- Sublethal Toxicity Testing Field Sample Collection
    - This was planned to occur during the field program but samples were not collected because there was no release from the tailings containment area

- Benthic Invertebrate Community Survey
  - Field Program and Data Collection: September 1 to 4, 2008
  - Sediment Analysis: September 9 to 23, 2008
  - Benthic Invertebrate Community Sample Processing and Analysis: December 1, 2008 to January 26, 2009

- Fish Survey
  - Field Program and Data Collection: August 27 to September 8, 2008
  - Copper Analysis: September 9 to October 28, 2008
  - Fish Aging Estimates: January 1 to March 23, 2009

Various people contributed to the execution and completion of this EEM program. The Project Team is provided in Table 1.

Table 1. Cycle 2 EEM Project Team Personnel

Team Member	Affiliation	Role	Qualification
Mr. Andrew Mitchell	OZ Minerals Canada Resources Inc.	Client Representative and Project Manager	P. Geo.
Dr. Colleen Prather	AECOM	Project Lead	Ph.D. (Aquatic Ecology)
Mr. Derek Parks	AECOM	Senior Review	M.Sc. (Fisheries Biology)
Mr. Richard Carson	AECOM	Senior Review	B.Sc.
Mr. Jaroslaw Szczot	AECOM	Field Crew and Technical Support	B.Sc.
Mr. Scott Seward	AECOM	Field Crew and Technical Support	
Ms. Tiffany Hnatiuk	AECOM	Technical Support	B.Sc.
Ms. Alyson Marjerrison	AECOM	GIS Mapping	B.A., M.GIS

1.3 Previous Studies

The Cycle 1 EEM study was conducted in August 2005 and the report was submitted to EC in 2006 (Golder 2006a, b). The exposure and reference areas were determined through a literature and study design submitted to EC. The study design was based on a control/impact study design. The Cycle 1 study investigated the defined exposure and reference areas and completed a plume delineation model. Plume delineation modelling indicated that, under worst-case scenarios, 1% plume concentrations can extend for approximately 1,600 m into Outer Sun Bay. Based on the Benthic Invertebrate Community (BIC) survey data, mine effluent significantly affected patterns of benthic community diversity and evenness within the aquatic receiving environment The mine effluent did not significantly affect invertebrate density, family richness or the Bray-Curtis Index (BCI). The fish study focused on juvenile (age 1) Arctic grayling as the target species. Arctic grayling are common to both the exposure and reference areas of the Lupin Mine EEM biological monitoring studies. This species also is commonly fished and consumed by local residents and mine personnel. The state of general health of Arctic grayling was similar between the reference and the exposure areas. Based on information collected in the fish survey, Arctic grayling in the exposure area have been negatively impacted by mine effluent. Arctic grayling were heavier, longer and in better condition in the reference area. Laboratory assessments determined that mine effluent did not have sublethal or acute effects on test species. The results of the Cycle 1 EEM monitoring program indicated that the BIC and fish population have been impacted by mine effluent.

1.4 Report Structure

Following the introduction, this report is separated into five main sections (Sections 2 to 6). A description of the sections and report structure is as follows:

Section 2 reviews the Mine History

Section 3 presents the program design and results of the water quality study.

Section 4 presents the program design and results of the benthic invertebrate community surveys and sediment survey.

Section 5 presents the program design and results of the fish surveys.

Section 6 discusses Cycle 2 EEM program conclusions and provides recommendations.

2. Study Area and Setting

2.1 Mine History

2.1.1 Mine Setting

The Lupin Mine is located on the west shore of Contwoyto Lake, Nunavut, approximately 300 km south-east of Kugluktuk and 80 km south of the Arctic Circle (65°46' N, 111°15' W) (Figure 1).

Mine construction started in August 1980 and was completed in March 1982. The mine was operated continuously from 1982 to 1998 when operations were suspended and the mine went into care and maintenance status. Production resumed in April 2000 but in 2003 the mine went back into care and maintenance following a merger between Echo Bay Mine and Kinross. Operations were started again in 2004 but the mine once again went into care and maintenance in February 2005. The Lupin property was sold to Wolfden Resources Inc. in 2006, and in turn, is now owned by Lupin Mines Inc., a wholly owned subsidiary of OZ Minerals Canada Resources Inc..

Lupin mine included underground mining and production systems and an ore handling system. Mining and processing equipment was designed to manage up to 2,300 tonnes per day. Materials and supplies were brought into Lupin by air transport and winter road transport while labour was brought in by air transport. Lupin is a self-contained facility with power generation and sewage facilities. The tailings containment area (TCA) is located approximately 7 km south of the mine (Figure 2)

2.1.2 Tailings

As reported by Golder (2006a), effluent discharge began in September 1985. Discharge from the TCA was scheduled to occur between July and September. Effluent is discharged from the TCA into Dam Lake and eventually reaches Contwoyto Lake via Seep Creek, Seep Creek Lake, unnamed creek, unnamed lake and Inner Sun Bay of Contwoyto Lake (Figure 1).

2.1.3 Activities since Cycle 1 Interpretive Report

An overview of mine operations, including management of mine water and tailings was provided in the Cycle 1 report (Golder 2006). Some changes to the site have occurred since 2006.

Reclamation activities in the TCA during 2005 saw a major portion of Cell 5 and another portion of Cell 3 covered by a minimum of 1.0 m of esker gravel. The work was carried out between June 23 and September 28, 2005, with a total area covered of approximately 383,001 m^2.

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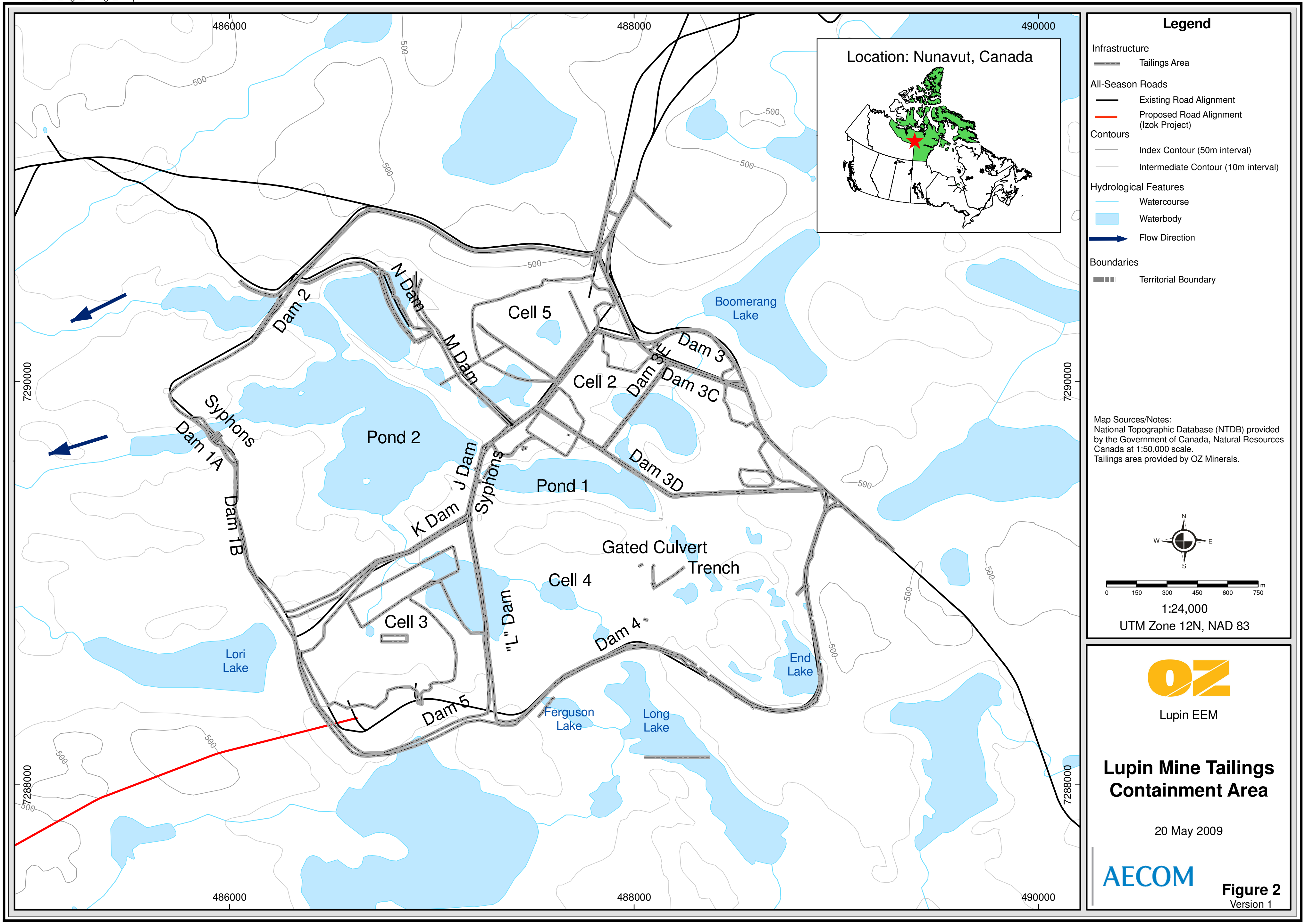

Approximately 250,000 m^2 of exposed tailings remain to be covered. This work was scheduled to be completed during the summer of 2006; however, due to the premature shutdown of the 2006 winter road, Lupin did not receive enough fuel to carry out the program as scheduled.

In 2008, as part of the preparation for discharge from the TCA, 76,000 kg of lime was spread on Pond 2. The lime was dispersed over the ice surface and then covered with snow to prevent wind from blowing it around.

No further activities have been carried out to date as the mine site remains in care and maintenance.

2.2 Environmental Setting

2.2.1 Climate

Climate in this region is semi-arid subarctic with a mean daily temperature of -11.1°C and average annual precipitation of 299 mm (Canadian Climate Normals 1961-2000). Average temperature in May through September is 4.6°C and the heaviest precipitation occurs in June through September (Canadian Climate Normals 1961-2000). Snowfall can occur in any month but the heaviest snowfalls generally occur in October with an average annual snowfall of 138.1 cm (Canadian Climate Normals 1961-2000). The study area is subject to frequent strong winds from the northwest (Beak Consultants Ltd. and Mary Collins Consultants Ltd. 1980; Geocon Ltd. 1980).

2.2.2 Geology and Topography

The bedrock in the vicinity of the Lupin Mine is archean in age including supracrustal rocks of the Yellowknife supergroup of the Slave province of the Canadian shield. Rock types occurring in the vicinity of the mine include ultramafic, mafic, intermediate and felsic volcanic rocks, intrusive rocks and siliciclastic rocks and ironstones. The gold mineralization at the mine is hosted primarily by the ironstones. This region contains intrusive igneous material such as granite (Natural Resources Canada 2003). In the vicinity of the mine, terrain is low and undulating ranging between 450 and 530 m elevation. There are numerous shallow lakes and streams throughout the area (Gartner Lee Limited 2008a, b).

2.2.3 Vegetation

Lupin Mine is located in the subarctic tundra vegetation zone. This is an area characterized by continuous permafrost and “barren ground” vegetation including moss, lichens, heather and dwarf shrub communities in the well-drained areas and grasses and sedges in the wet areas adjacent to waterbodies. Dwarf shrubs, up to 1 m high, occur adjacent to some waterbodies (RCPL and RL&L 1985).

2.2.4 Hydrology

Contwoyto Lake is the major waterbody in the study area with a surface area of approximately 959 km^2 and a drainage area of approximately 8,000 km^2 (Roberge *et al.* 1986). Contwoyto Lake has two outflows. The main outflow to the north, drains to the Burnside River and ultimately to Bathurst Inlet; the smaller outflow to the south, drains to the Contwoyto River and into Back River (Rescan 2002). The main basin of Contwoyto Lake is to the east and south of the mine (Figure 1). To the north of the mine, West Arm extends to the west terminating in a narrow bay (Outer and Inner Sun Bay). This area is west of the mine and ultimately receives mine waste after it has travelled through small lakes and streams.

Seep Creek, a small stream approximately 6.5 km in length, flows westerly from the mine area into Inner Sun Bay (Figure 1). Seep Creek watershed contains three lakes (Dam 2 Lake, Dam 1A Lake and Unnamed Lake), three headwater streams, two ponds (Seep Creek Ponds 1 and 2) and two embayment areas (Inner and Outer Sun Bay).

- Dam 2 Lake is a small lake, 7 m maximum depth, bordered to the north by a gravel pit and on the east by the TCA
- Dam 1A Lake is a shallow lake (< 1 m) south of Dam 2 Lake; water from the TCA discharges into this lake
- Dam 2 Lake and Dam 1A Lake are drained by tributaries that join to form Seep Creek
- Unnamed Lake is south of Dam 1A Lake
- A tributary from Unnamed Lake joins Seep Creek approximately 400 m downstream of the Dam 2 Lake and Dam 1A Lake tributary confluence

2.3 Historical Water Quality Monitoring and Effluent Plume Study

2.3.1 Historical Water Quality

There was one final effluent discharge monitoring point identified by Kinross to Environment Canada. This station is identified as Surveillance Network Point (SNP) 925-10. In the Cycle 1 report, water quality results collected from this location were summarized (Golder 2006a). There were no samples collected from this location as part of the EEM program so the table has not been reproduced. To summarize, several metals and other parameters were routinely measured. Routine parameters including pH, conductivity, total suspended solids (TSS) and metals including arsenic remained at consistent concentrations and less than the maximum concentrations for MMER deleterious substances.

Conductivity has historically been measured at various sampling points in the exposure area. Field conductivity at the mouth of Seep Creek was recorded at 519 µS/cm (SNP 925-20) while at the mouth of Concession Creek (creek that drains Concession Lake before it enters Seep Creek watershed) it was recorded at 11 µS/cm.

For the 2008 Cycle 2 program, only one water quality sample was collected from SNP 925-20. These results are compared qualitatively to the historical records. The historical records were provided in the Cycle 1 report and are reproduced here for comparison to the 2008 results (Table 2). Conductivity, hardness and pH were lower in 2008 as compared to 2000 to 2005. TSS and alkalinity, total cyanide, ammonia-nitrogen and total lead were non-detectable in the 2008 sample. Total arsenic, cadmium, nickel and zinc were lower in 2008 than other years. Concentration of total copper in 2008 was similar to previous years even though there was no effluent discharge in 2008.

Table 2. Summary of Water Quality Monitoring Downstream of Lupin Mine Effluent Discharge Location (SNP 925-20)

			2000	2002	2005	2008
Parameter	Units	CCME Aquatic Life[a]	Mean SD[b]	Mean SD[b]	Mean SD[b]	Sept
pH (units)	pH unit	6.5-9.0	6.03	6.48	5.7	*5.6*
			0.25	*0.15*	*0.45*	
Conductivity (µS/cm)	uS/cm		887	748	519	65.8
			37	*114*	*279*	
Hardness (as CaCO3)	mg/L		231	199	135	24
			9.1	*34.3*	*75.4*	
Total Suspended Solids	mg/L		0.53	0.93	<2	<3
			0.17	*0.73*	*0*	
Total Alkalinity (as $CaCO_3$)	mg/L		<5	7.4	<5	<5
			0	*9.2*	*0*	
Total Cyanide	mg/L	0.005	0.007	0.015	0.016	<0.002
			0.004	*0.014*	*0.008*	
Ammonia-Nitrogen	mg/L	0.019	2.72	0.72	0.64	<0.005
			0.48	*0.31*	*0.47*	
Total Arsenic	mg/L	0.005	0.0024	0.0036	0.0032	0.00186
			0.0006	*0.0006*	*0.0013*	
Total Cadmium	mg/L	0.000017	<0.0006	0.00017	0.00017	*0.00006*
			0	*0.00003*	*0.00010*	
Total Copper	mg/L	0.002-0.004	0.005	0.004	0.005	*0.0052*
			0.002	*0.002*	*0.002*	
Total Lead	mg/L	0.001-0.00[d]	<0.002	0.0002	0.0001	<0.00005
			0	*0.0002*	*0.0001*	
Total Nickel	mg/L	0.025-0.15	0.115	0.0755	0.0762	*0.0426*
			0.009	*0.0084*	*0.0411*	
Total Zinc	mg/L	0.03	0.228	0.146	0.159	0.0392
			0.026	*0.017*	*0.091*	

Note: a – Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007; b – Golder, 2006a

2.3.2 Historical Effluent Plume Study

The MMER requires an estimate of effluent concentration at 250 m downstream from the final discharge point (FDP) and a description of effluent mixing within the environment to a concentration of 1%. When effluent is being released, it is common to use field conductivity measurements as a way to measure effluent concentration.

At Lupin Mine, 250 m downstream of the FDP is within Dam 1A Lake. In 2005, field conductivity measured from the effluent was 847 µS/cm and the lab measured conductivity from the sample in Dam 1A Lake was 738 µS/cm. Base flows in Seep Creek are very low and it has been estimated that up to 90% of the flow is due to effluent discharge (RL&L and DFO 1991). Based on the conductivity of the sample from 250 m downstream of the FDP, the water in the receiving system was comprised of 87% effluent.

A mixing and dispersion model was developed by Golder (2004) to describe the movement and concentration of effluent from the FDP to Outer Sun Bay. The model predicted that the 1% effluent limit would extend 850 to 1200 m from the mouth of the narrows in Outer Sun Bay.

The dispersion model was initially developed using data from 2000 and 2002 but results were updated with data from 2005 (Golder 2006b). Runoff conditions were lower in 2005 than originally modelled. When these conditions were included and the model was re-analyzed, the 1% dispersion limit extended to 1630 m beyond station SNP 925-25. The 2005 results from the sample at SNP 925-25 were considered consistent with the model.

2.4 Exposure and Reference Areas

2.4.1 Exposure Area

Seep Creek, Seep Creek Ponds and Sun Bay were designated as the exposure area (Golder 2006a). Best attempts were made to use the same sampling stations in the exposure area in the Cycle 2 study as were used in the Cycle 1 study based on data provided in the Cycle 1 report. The aquatic habitat in the exposure area, downstream of the TCA, is referenced as the Seep Creek watershed. Lakes Dam 2, Dam 1A and unnamed are west of the TCA. Dam 1A Lake receives effluent from the FDP. Dam 1A Lake is drained by Seep Creek. The creek that drains Dam 1A Lake joins with the creek that drains Dam 2 Lake (Seep Creek). Seep Creek flows for approximately 2.5 km before it enters two ponds (Seep Creek Pond 2 and Seep Creek Pond 1). Seep Creek is a well defined channel, 1 to 4 m wide with substrate dominated by boulders (RCPL and RL&L 1985). Seep Creek Ponds 1 and 2 are shallow (less than 1.5 m).

Historically, Lake trout, Arctic grayling, Arctic cisco, round whitefish, ninespine stickleback and slimy sculpin have been documented in Seep Creek (RCPL and RL&L 1985). Fish use this stream for spawning, feeding and juvenile rearing in the early part of the open water season (RL&L and DFO 1991).

2.4.2 Reference Area

Fingers Lake and Fingers Creek was designated as the reference area. The Fingers Lake watershed is located east of the mine. Like the Seep Creek watershed, the Fingers Lake watershed also has a connection to Contwoyto Lake. Fingers Creek flows for approximately 3 km between Fingers Lake and Contwoyto Lake. Fingers Creek is between 1 to 3 m wide with substrate dominated by silt, boulders and cobble in the upper reaches, cobble gravel and silt in the middle reaches and cobble and boulders in the lower reaches. Habitat varied between shallow flat in the upper reaches and shallow run in the lower reaches.

Fingers Lake has a maximum depth of 6 m and a surface area of 3.7 km^2. Lake trout and Arctic char have been captured in Fingers Lake (Moore 1978) and prior to the Cycle 1 EEM study, fish capture data for Fingers Creek had not been previously collected.

3. Effluent and Water Quality

The following section provides a brief description of the effluent and water quality monitoring programs initiated as a result of the MMER.

3.1 Effluent Characteristics

Samples for effluent characterization have been collected in the TCA at station SNP 925-10. Effluent was released from the TCA at various periods from 1994 to 2005 (Table 3). Effluent has not been released since 2005.

Table 3. Total Annual Discharge Volumes from Lupin Mine TCA (SNP 925-10), 1994 to 2008

Year	Annual Total (m^3)	Discharge Period
1994	863,868	July 15 - 29
1995	938,715	July 15 – August 2
1996	1,139,233	July 15 – August 7
1997	2,892,289	July 15 – September 1
1998	0	n/a
1999	0	n/a
2000	2,701,360	July 15 – September 2
2001	0	n/a
2002	3,102,895	July 15 – September 7
2003	0	n/a
2004	0	n/a
2005	1,682,135	July 15 – August 11
2006	0	n/a
2007	0	n/a
2008	0	n/a

Samples for effluent characterization were collected in 2000, 2002 and 2005. Constituents listed in Schedule 4 of MMER have been sampled. Up to 2005, none of the constituents exceeded the authorized limits. Samples for effluent characterization were not collected in 2008, as there was no effluent discharge (Table 3).

3.2 Water Quality

Water quality samples were collected in the exposure and reference areas as part of the Cycle 1 (2005) and Cycle 2 (2008) field programs (Figure 3, 4 and 5). Sample collection and results are presented below. The field program was completed between August 28 and September 9, 2008. Field chemistry measurements were taken between August 28 through September 8 and samples for lab analysis were collected on September 8 and submitted.

3.2.1 Study Design

Sampling locations were based on those locations selected from the Cycle 1 study. For the Cycle 2 study, grab water samples for laboratory analyses were collected from three locations in the exposure area (SCD1, SCP1, SCP5) (Figure 3). The intent of these samples was to characterize water quality in the exposure area. In addition, one sample for lab analysis was collected from station SNP 925-20 while field conductivity was measured from another six locations (Figure 4). The intent of sample SNP 925-20 and field conductivity readings was to delineate effluent plume during discharge. In addition, samples for lab water analyses were collected from three locations in the reference area (FC2, FL1, FL5) (Figure 5). The intent of these samples was to characterize water quality in the reference area. It was decided to have samples analyzed separately rather than as a composite sample to represent the study areas. Sampling locations, sampling dates and field chemistry are in Appendix B Table B-1.

3.2.2 Methods

At each station *in situ* measurements were collected for pH, temperature (°C), conductivity (µS/cm) and turbidity (NTU). The meters were calibrated each day. Sampling coordinates were recorded with a hand-held GPS unit. Site conditions were noted and all information was recorded in a field log book.

Water samples for lab analysis were collected directly into the lab supplied bottles. Sampling followed recognized sampling protocol, including methods outlined in MMER technical guidance document (TGD) (Environment Canada 2002) and appropriate measures were taken to avoid sample contamination. Bottles were placed approximately 0.2 – 0.5 m below the water surface at each sampling location and allowing the bottle to fill. Pre-measured preservatives provided by the laboratory were used for the appropriate samples. Samples collected for total organic carbon were preserved with hydrochloric acid, and samples collected for metals (total and dissolved) were preserved with nitric acid, and samples collected for nutrients (ammonia, nitrite, etc.) were preserved with sulphuric acid.

After sampling was completed, a chain of custody form was filled out. The samples were packed into coolers and shipped to the ALS Laboratory in Yellowknife, on the next available plane leaving camp. Samples were analyzed for:

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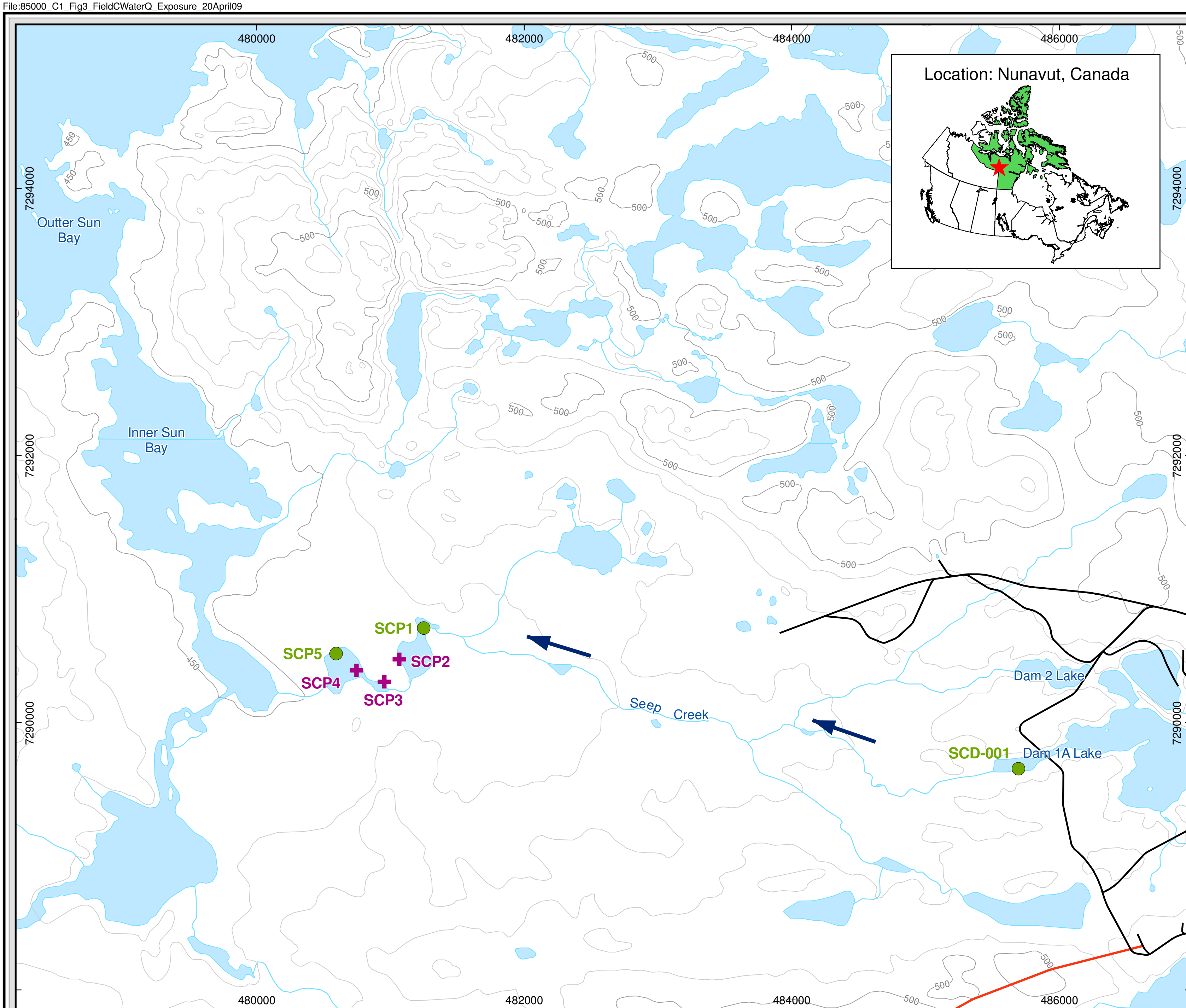

Lupin EEM

Field Chemistry and Water Quality Stations in the Exposure Area

20 May 2009

AECOM

Figure 3
Version 1

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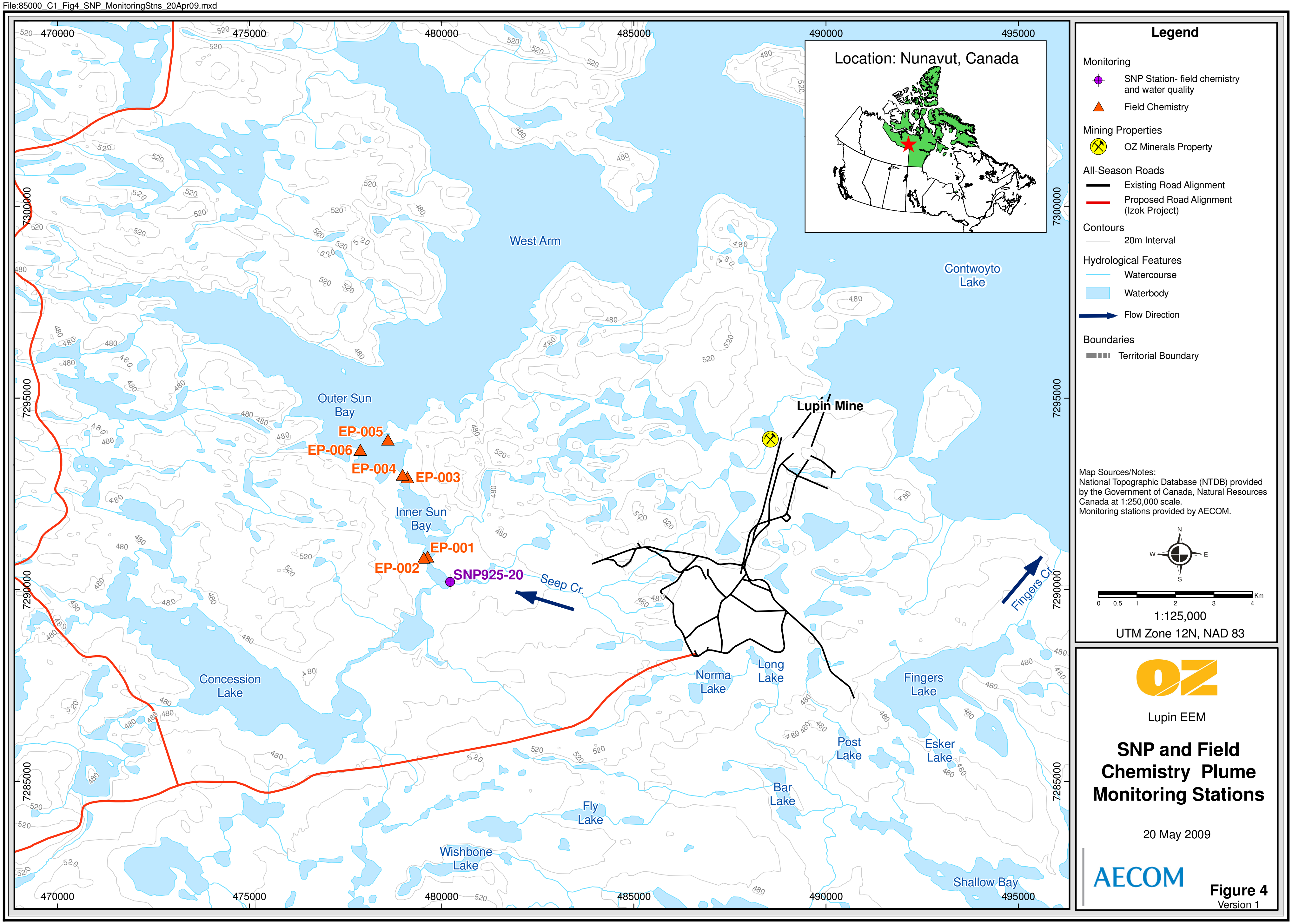
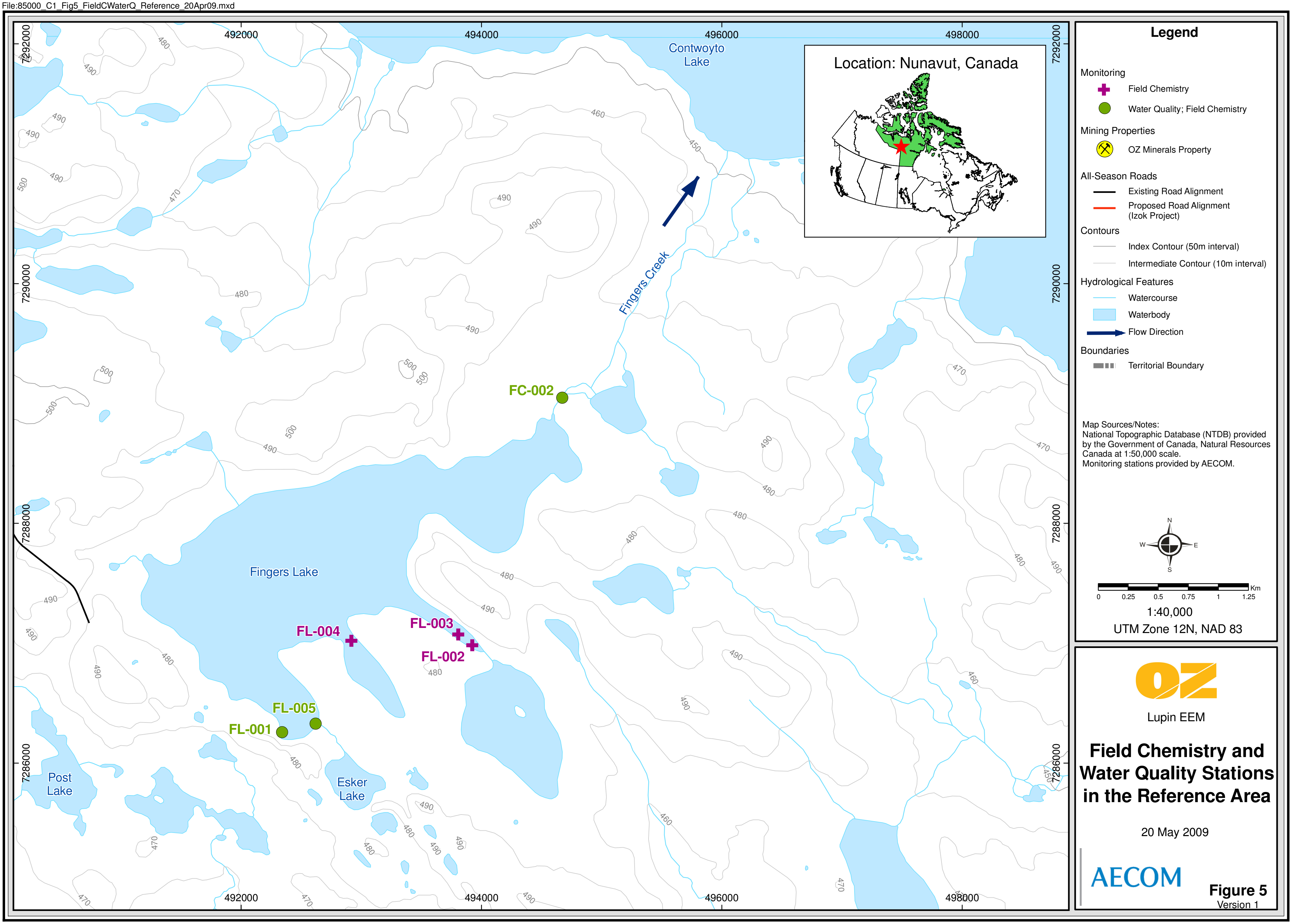


File:85000_C1_Fig5_FieldCWaterQ_Reference_20Apr09.mxd



- General chemistry including total suspended solids, alkalinity and major ions
- Cyanide
- Radium-226
- Total and dissolved metals including arsenic, copper, lead, nickel and zinc
- Total and dissolved organic carbon
- Nutrients including ammonia and total phosphorus

Results from the laboratory are provided in Appendix B Table B-2.

3.2.2.1 QA/QC

Quality assurance/quality control protocols are a necessary component to any environmental sampling program. For this study, field and trip blanks were used. The blanks are used to detect potential sample contamination during collection, shipping and analysis. Travel and field blanks are sample bottles filled with distilled water and analyzed for the same suite of parameters as the test samples. These are used to test for possible contamination of water samples. The travel blank bottles are filled at the lab with distilled water, and travel with all the sample bottles to the field and back again. The travel blank is used to test if any contamination is introduced into the samples through handling and transportation. Field blank bottles are filled with distilled water at one of the sampling stations following the same protocols as sample collection. The field blank is used to assess contamination introduced to the sample as a result of handling and processing samples in the field. The field blank sample was submitted blind to the lab. When a parameter in either the field or trip blank is detectable, further consideration is given, whereby the concentration is compared to the analytical detection limit of the particular parameter. When the value is less than the practical quantification limit (PQL), it is not considered further. The PQL is five times the Method Detection Limit (MDL) and is defined as the minimum concentration that can be measured within specified limits of precision and accuracy. Constituents with results below the PQL mean that the constituent being analyzed is not present in a sufficient amount to be reliably quantified.

3.2.3 Results

Water temperature, pH and conductivity was measured at every station when biological samples were collected (Appendix B Table B-1). Dissolved oxygen and water depth were measured at almost every station. Summary statistics for these five parameters were calculated by study area and are presented in the Table 4. Water temperature, dissolved oxygen and pH were statistically significantly lower in the exposure as compared to the reference area ($p \leq 0.05$). Conductivity was statistically significantly higher in the exposure as compared to the reference area ($p \leq 0.05$).

Table 4. Summary Statistics of Measured Field Parameters by Area

Area	Statistic	Water Depth (m)	Water Temperature (°C)	Dissolved Oxygen (mg/L)	pH (Field)	Conductivity (µS/cm)
Exposure	n	19	29	21	29	29
	Mean	0.49	5.10	12.38	6.26	68.97
	Min	0.10	2.20	11.40	4.60	10.00
	Max	1.50	7.00	13.40	7.30	250.00
Reference	n	27	30	17	30	30
	Mean	0.49	5.98	13.07	8.18	10.83
	Min	0.10	2.00	10.80	5.80	10.00
	Max	1.20	7.30	13.70	10.00	20.00

Field conductivity sampling was done to define the effluent plume, or residual plume, within the receiving environment. Field conductivity was highest in Dam 1A Lake and decreased through Seep Creek and into Inner and Outer Sun Bay (Appendix B Table B-1).

Samples for lab water quality analysis were also collected from three stations in the exposure area (SCD1, SCP1 and SCP5) and from three stations in the reference area (FC2, FL1 and FL5). Complete results are in Appendix B Table B-2. Results were compared to the CCME guidelines for protection of aquatic life (CCME 2007). For the reference area, none of the results exceeded the CCME guidelines. In the exposure area, pH, aluminum, cadmium, copper, nickel and zinc exceeded the guidelines.

Mann-Whitney tests were used to compare results from the exposure area to results from the reference area. For analytical data reported as less than the detection limit, half of the detection limit was substituted for these statistical tests. It is noted that the comparison is based on one set of results from 2008 and results from four exposure area samples are compared to results from three reference area samples. Based on these samples, pH was significantly lower in the exposure area compared to the reference area ($p \leq 0.05$) (Table 5). Hardness, magnesium, sodium, TOC, DOC, aluminum, boron, cadmium, chromium, cobalt, copper, iron, manganese and zinc were statistically significantly higher in the exposure area as compared to the reference area ($p \leq 0.05$).

Table 5. Significant Mann-Whitney results for Water Quality Comparison between Areas

Parameters	Units	Exposure			Reference			M-W Results (p-level)
		# Samples	Mean	Median	# Samples	Mean	Median	
pH (Lab)		4	5.4	5.6	3	6.6	6.6	0.042
Hardness (as CaCO3)	mg/L	4	35.0	26.5	3	5.3	5.0	0.050
Magnesium (Mg)	mg/L	4	4.0	3.0	3	0.6	0.6	0.050
Sodium (Na)	mg/L	4	2.0	1.5	3	0.5	0.5	0.042
TOC	mg/L	4	5.0	5.0	3	3.0	3.0	0.040
DOC	mg/L	4	5.0	5.0	3	3.0	3.0	0.040
Aluminum (Al)	mg/L	4	0.229	0.151	3	0.017	0.016	0.044
Boron (B)	mg/L	4	0.0035	0.0025	3	0.0005	0.0005	0.042
Cadmium (Cd)	mg/L	4	0.0001	0.0001	3	0.0000	0.0000	0.044
Chromium (Cr)	mg/L	4	0.00019	0.00020	3	0.00003	0.00003	0.044
Cobalt (Co)	mg/L	4	0.0260	0.0144	3	0.00007	0.00005	0.050
Copper (Cu)	mg/L	4	0.0081	0.0045	3	0.00030	0.00030	0.044
Iron (Fe)	mg/L	4	0.1	0.1	3	0.0	0.0	0.048
Manganese (Mn)	mg/L	4	0.250	0.103	3	0.003	0.003	0.050
Zinc (Zn)	mg/L	4	0.0788	0.0430	3	0.0004	0.0004	0.044

3.2.4 Discussion and Comparison to Cycle 1

The Seep Creek drainage system is the direct receiving environment of Lupin mine effluent. The ponds and channels that make up the exposure area are shallow. The Fingers Creek drainage system was selected as an appropriate reference monitoring area. The ponds and creeks that make up this system are slightly deeper than the exposure area. This was observed in Cycle 1 and Cycle 2. Based on the data collected in Cycle 2, average depth in the exposure area versus the reference area are similar but the pond depth in the exposure area is significantly shallower than pond depths within the reference area.

Field chemistry was measured in both the exposure and reference areas in 2008. Conductivity was measured to delineate the extent of the effluent plume. Since effluent discharge was not occurring during the field program, the measurement of field conductivity may only provide evidence of past contamination or other site-specific influences. Field conductivity was very low in the reference area and variable in the exposure area (Table 4). Conductivity was highest in Dam 1A Lake and decreased through Seep Creek and into Inner and Outer Sun Bay (Appendix B Table B-1). Conductivity values were much lower in 2008 as compared to 2005 but this is likely a reflection of timing of effluent discharge (3 weeks prior to Cycle 1 field study versus 3 years prior to Cycle 2 field study).

Water quality results from Cycle 2 are compared to results from Cycle 1 qualitatively. In samples collected from Dam1A Lake in 2008, pH, aluminum, cadmium, copper and nickel and zinc exceeded the CCME water quality guidelines for protection of aquatic life (Table 6). These same parameters plus arsenic exceeded the guidelines in 2005. In comparison to results from 2005, the concentrations of parameters from 2008 were lower for pH, cadmium and zinc but higher for aluminum, copper and nickel. In samples collected from Seep Creek Ponds in 2008, pH, aluminum, cadmium, copper, nickel and zinc exceeded the CCME water quality guidelines (Table 6). In comparison to 2005 results, pH, cadmium and copper were lower in 2008 while aluminum, nickel and zinc were higher. Measured conductivity in 2008, as compared to 2005 was much lower in Dam1A Lake and moderately lower in Seep Creek Ponds. Likewise, for 2008 compared to 2005, water hardness in Dam 1A Lake was much lower and it was slightly lower in Seep Creek Ponds. Nutrients (ammonia, nitrate and TP) were lower in the 2008 results as compared to the 2005 results.

Table 6. Summary of Water Quality Results from Cycle 2 compared to Cycle 1 for the Exposure Area

Parameter	Units	DL (Sep08)	CCME Aquatic Life[a]	SCD1 (2008)	Dam 1A (2005)	SCP1 (2008)	SCP5 (2008)	Seep Creek Ponds 1&2 (2005)
Physical Tests								
pH	pH unit	0.1	6.5-9.0	*4.9*	*5.8*	*5.5*	*5.6*	*6.1*
Conductivity	uS/cm	0.2		175	738	76.8	65.4	141
Hardness (as CaCO3)	mg/L	-		63	186	29	24	37
Major Ions								
Total Alkalinity (as CaCO3)	mg/L	5		<5	<5	<5	<5	<5
Nutrients								
Ammonia-Nitrogen	mg/L	0.005	0.019	0.014	0.51	<0.005	<0.005	<0.05
Nitrate-Nitrogen	mg/L	0.006	13	0.150	5.7	0.016	<0.006	0.4
Phosphorus, Total	mg/L	0.001		0.005	<0.02	0.004	0.004	<0.02
Total Organic Carbon	mg/L	1		4	2	4	6	6
Total Metals								
Aluminum (Al)	mg/L	0.0003	0.1	*0.461*	*0.11*	*0.151*	*0.151*	*0.0724*
Arsenic (As)	mg/L	0.00003	0.005	0.00377	0.0068	0.00165	0.00194	0.00293
Cadmium (Cd)	mg/L	0.000017	0.000017	*0.000336*	*0.000411*	*0.000082*	*0.000066*	*0.0000913*
Copper (Cu)	mg/L	0.0006	0.002-	*0.0197*	*0.0131*	*0.0037*	*0.0038*	*0.00653*
Lead (Pb)	mg/L	0.00005	0.001	0.00013	0.00115	<0.00005	<0.00005	0.00139
Nickel (Ni)	mg/L	0.00006	0.025	*0.170*	*0.133*	*0.0537*	*0.0433*	*0.0284*
Zinc (Zn)	mg/L	0.0008	0.03	0.190	0.314	0.0455	0.0405	0.0404

Note: a- Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007. Highlighted sections indicate parameters that exceeded guidelines.

Water quality parameters from the reference area (Fingers Creek and Fingers Lake) in 2008 were below the CCME guidelines (Table 7). Likewise, all water quality parameters in 2005, except for pH from Fingers Creek, were below the CCME guidelines. Results from the 2008 samples were very similar to the results from the 2005 samples.

Table 7. Summary of Water Quality Results from Cycle 2 compared to Cycle 1 for the Reference Area

Parameter	Units	DL (Sep08)	CCME Aquatic Life[a]	FC2 (2008)	Fingers Creek (2005)	FL1 (2008)	FL5 (2008)	Fingers Lake (2005)
Physical Tests								
pH	pH unit	0.1	6.5-9.0	6.6	6.3	6.6	6.6	6.5
Conductivity	uS/cm	0.2		13.2	15.3	12.2	13.1	14.8
Hardness (as CaCO3)	mg/L	-		7	7	4	5	5
Major Ions								
Total Alkalinity (as CaCO3)	mg/L	5		<5	<5	<5	<5	<5
Nutrients								
Ammonia-Nitrogen	mg/L	0.005	0.019	<0.005	<0.05	<0.005	<0.005	<0.05
Nitrate-Nitrogen	mg/L	0.006	13	<0.006	0.1	<0.006	0.007	0.1
Phosphorus, Total	mg/L	0.001		0.005	<0.02	0.008	0.008	0.02
Total Organic Carbon	mg/L	1		3	3	3	3	3
Total Metals								
Aluminum (Al)	mg/L	0.0003	0.1	0.0192	0.0103	0.0162	0.0158	0.0164
Arsenic (As)	mg/L	0.00003	0.005	0.00121	0.00121	0.00133	0.00143	0.00207
Cadmium (Cd)	mg/L	0.000017	0.000017	<0.000017	<0.000002	<0.000017	<0.000017	0.0000089
Copper (Cu)	mg/L	0.0006	0.002-	<0.0006	0.00039	<0.0006	<0.0006	0.000562
Lead (Pb)	mg/L	0.00005	0.001	<0.00005	0.000013	<0.00005	<0.00005	0.000279
Nickel (Ni)	mg/L	0.00006	0.025	0.00065	0.000339	0.00044	0.00059	0.000394
Zinc (Zn)	mg/L	0.0008	0.03	<0.0008	0.00167	<0.0008	<0.0008	0.00216

Note: a- Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007
Highlighted sections indicate parameters that exceeded guidelines.

3.3 Sublethal Toxicity Testing

Under the MMER, sublethal toxicity testing on final effluent must be conducted. The purpose of conducting sublethal testing is to determine if mine effluent may have an effect on fish, invertebrates and aquatic plants (EC 2002). MMER also requires sublethal toxicity testing to be conducted on four test organisms:

- Fish (fathead minnow)
- Invertebrates (*Ceriodaphnia*)
- Algae (*Pseudokirchneriella*)
- Plants (*Lemna*)

MMER requires sublethal toxicity testing to be conducted twice each calendar year for the first three years. Samples for toxicity testing can come from a portion of the samples collected for effluent characterization. In addition, these effluent samples for toxicity testing should be collected when released effluent poses the greatest potential for adverse effect, when biological monitoring is being conducted and in consideration of season.

In 2008, OZ Minerals planned to release effluent in late August. The biological field program was scheduled to occur when the mine was planning this release. Due to technical complications at site, including a release valve that was not working and effluent that did not meet discharge criteria for pH, effluent was not released in 2008. Thus effluent samples were not collected in Cycle 2 for the purposes of toxicity testing.

Results of the 2005 toxicity testing program (Golder 2006a) are summarized:

- Undiluted effluent was not acutely toxic to fish; sublethal effects on growth were not observed
- Undiluted effluent was not acutely toxic to invertebrates; reproductive impairment was observed at 4.1% to 15% effluent concentration range
- Undiluted effluent affected the growth of algae; 17% to 27% of diluted effluent inhibited algae growth
- Undiluted effluent was toxic to plants; growth was inhibited at 10% to 51% effluent and reproductive impairment was observed at <6.1% to 7.8% effluent

Based on the effluent plume modeling and the toxicity test results, biological effects due to effluent may be detected at effluent concentrations as low as 6.1%. The potential zone of effects from effluent may extend from the narrows between Inner and Outer Sun Bay or under worst case conditions, the zone of effects may extend to Outer Sun Bay.

4. Benthic Invertebrate Community and Sediment Surveys

4.1 Study Design

4.1.1 Benthic Invertebrate Community (BIC)

The objective of the BIC survey is to collect sufficient data to determine if the release of mine effluent has an ecological effect on the aquatic environment. Samples for this portion of the study were collected concurrently with the sediment quality samples. There were five sampling stations established in the exposure area (Figure 6) and five in the reference area (Figure 7). This is a control/impact study design to detect differences between exposure and reference areas (Golder 2004). At each sampling station, five replicate samples were collected and combined to form one composite sample (Appendix B Table B-1). The field program was completed between August 28 and September 9, 2008. Samples were collected on September 1 from the reference area and September 2 to 4 from the exposure area.

4.1.2 Sediment and Supporting Environmental Survey

Supporting environmental data and sediments were collected along with invertebrate samples. Measurements were collected for water depth, water temperature, dissolved oxygen, pH and conductivity (Appendix B Table B-1) to aid interpretations of BIC results.

4.2 Field Methods

4.2.1 Benthic Invertebrate Community

At each station, five replicate samples were collected and combined into a composite sample for the site. Replicate samples from each station were collected from water depth between 0.5 to 1.2 m. Sediment and BIC samples were collected using a Petit Ponar dredge (6” x 6” x 6”). The five replicate samples from each sampling area were combined into a single composite sample for a total sample area of 0.116 m^2. Samples were sieved (sieve size 243 μm), replicates were combined and the samples were preserved with buffered formalin.

Samples were stored in lab grade glass jars. After sampling was completed, a chain of custody form was filled out. In total, five BIC samples from the exposure area and five BIC samples from the reference area were submitted for laboratory analysis. The samples were packed into coolers and shipped to Cordillera Consulting Inc in Summerland, British Columbia.

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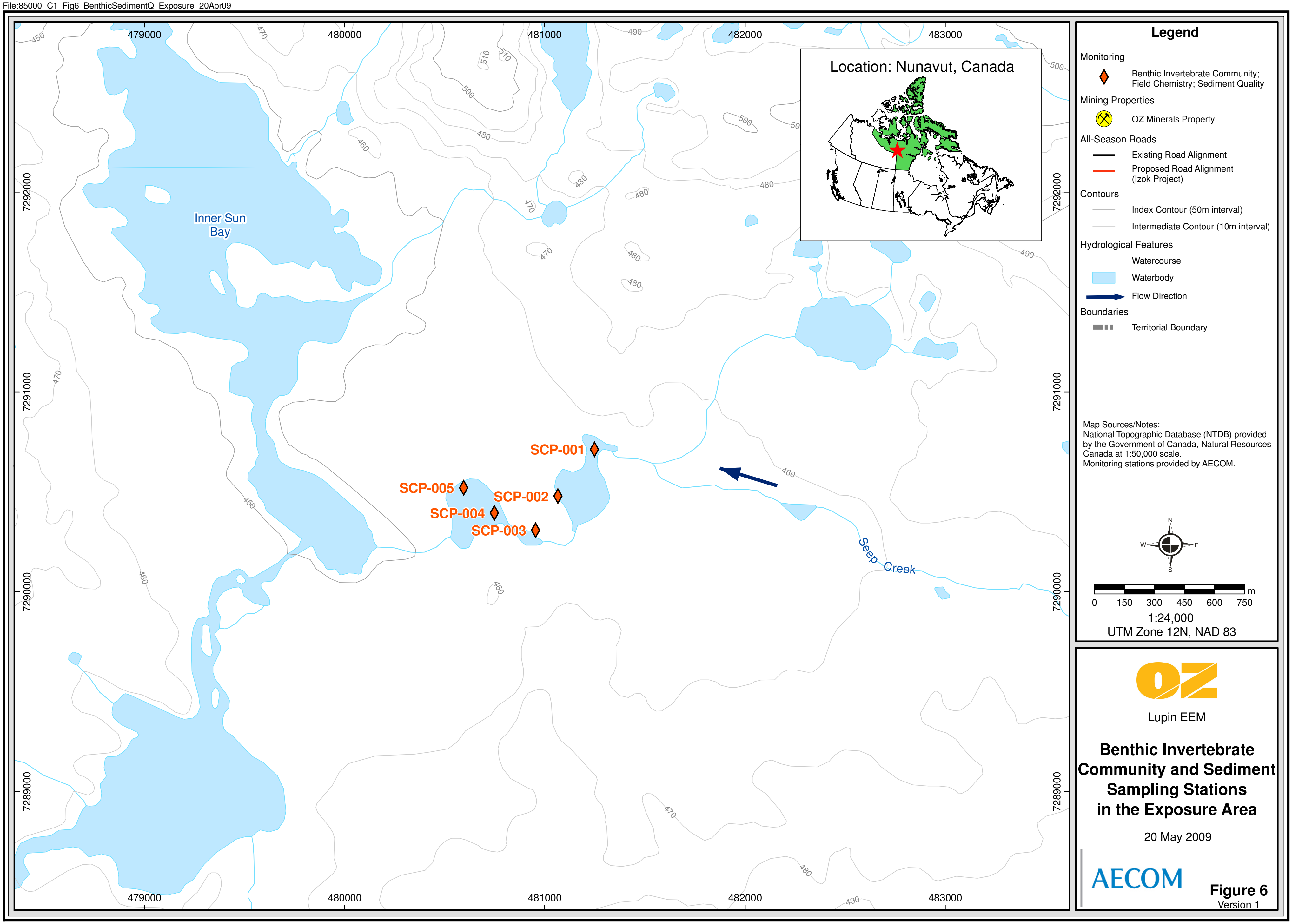

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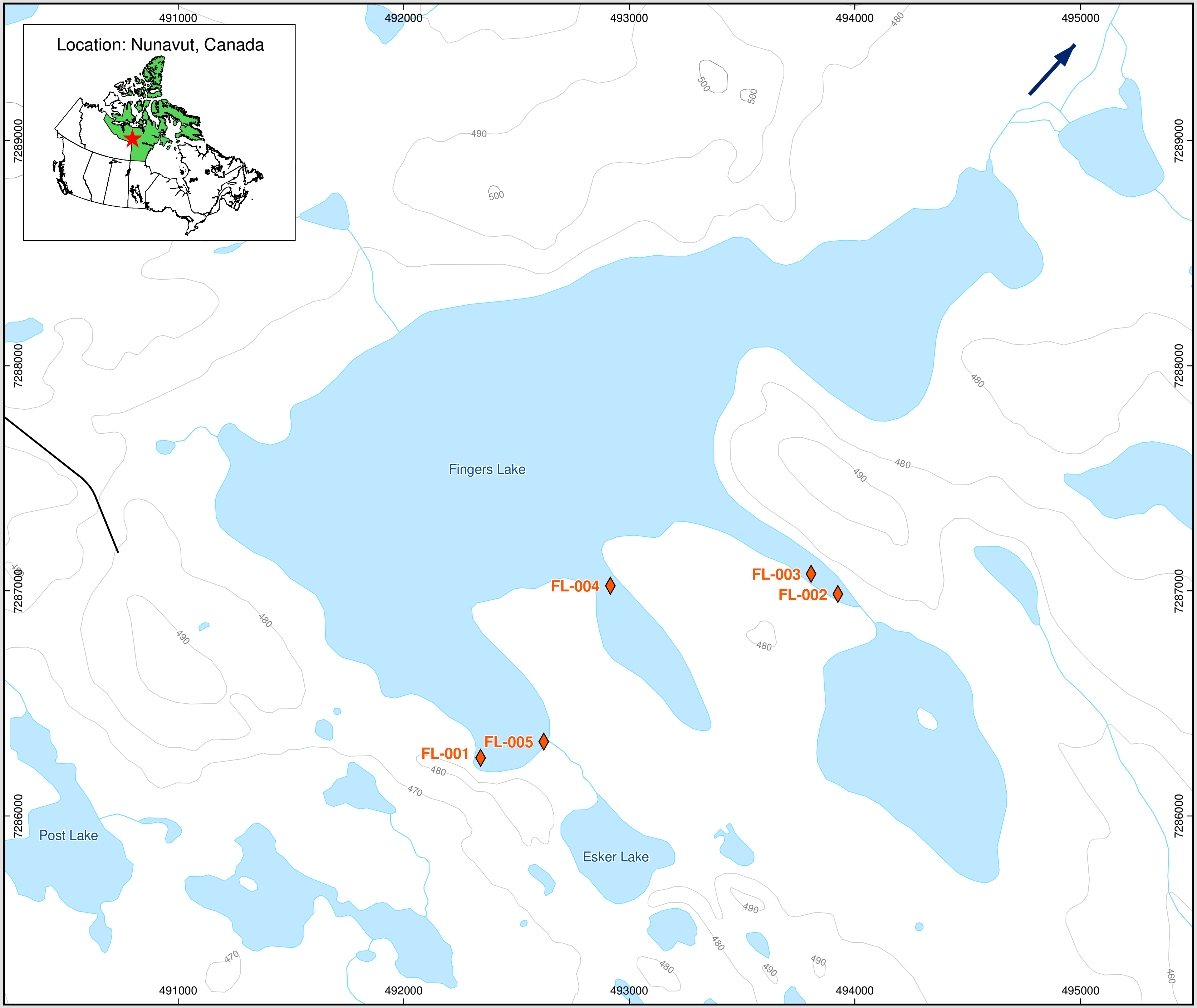


Legend

Monitoring
- Benthic Invertebrate Community; Field Chemistry; Sediment Quality

Mining Properties
- OZ Minerals Property

All-Season Roads
- Existing Road Alignment
- Proposed Road Alignment (Izok Project)

Contours
- Index Contour (50m interval)
- Intermediate Contour (10m interval)

Hydrological Features
- Watercourse
- Waterbody
- Flow Direction

Boundaries
- Territorial Boundary

Map Sources/Notes:
National Topographic Database (NTDB) provided by the Government of Canada, Natural Resources Canada at 1:50,000 scale.
Monitoring stations provided by AECOM.

N E S W

0 150 300 450 600 750 m

1:24,000

UTM Zone 12N, NAD 83

OZ

Lupin EEM

Benthic Invertebrate Community and Sediment Quality Sampling Stations in the Reference Area

20 May 2009

AECOM

Figure 7

Version 1

Upon arrival at the lab, the sand and gravel in each sample was separated from the organic matter by elutriation. The elutriate was examined under low power microscope for molluscs and Trichoptera, before it was discarded. The remaining part of the sample was sieved through a set of nested sieves: 250 μ, 500 μ, 1 mm and 2 mm. Formalin and clay particles were removed in the sieving process. The sample fractions were all transferred to an 80% ethanol solution. Each fraction was assessed for total numbers. Where total numbers were estimated to be greater than 200, fractions were sub-sampled in order to achieve a number of organisms more than 100. Sub-sampling was also performed on some fractions where the volume of the fraction was greater than 200 mL although the number of organisms removed from the fraction were less than 100. The sub-sampling record is provided in Appendix C. The sub-sampling method used was to divide by area using guidelines provided in the EEM protocol (Schedule 5.22.2).

Sorting and identification was done using a Nikon SMZ645 and a SMZ800 binocular microscope with help of various keys (Appendix C). Benthic raw data are in Appendix C Tables C-1 and C-2.

4.2.2 Sediment and Supporting Environmental Survey

Sediment quality samples were collected concurrently with the benthic invertebrate samples. There were five BIC sampling stations in the exposure area and five in the reference area. At each BIC sampling station, five sub-samples were collected and combined to form one composite sample for sediment quality analysis.

Supporting environmental data including water depth, water temperature, field water chemistry, were measured before samples were collected. Sediment samples were collected in water depth between 0.5 to 1.0 m. It was proposed to collect the sediments using a 63 mm core sampler. The substrate composition was too sandy and the samples would not stay in the tube. Sediment samples were collected using the same Petit Ponar sampler used to collect the BIC samples.

Samples were collected in laboratory supplied sampling containers. After sampling was completed, a chain of custody form was filled out. In total, five sediments samples from the exposure area and five samples from the reference area were submitted for laboratory analysis. Samples were packed into coolers and shipped to the ALS Laboratory in Yellowknife. Samples were analyzed for:

- Particle size (Wentworth Classification)
  - Course sand and gravel (> 2mm)
  - Sand (0.2 mm to 2mm)
  - Silt (0.2 to 0.063mm)
  - Clay (< 0.004mm)
- Total organic carbon
- Total metals

Analytical results are in Appendix C Table C-3.

4.3 Statistical Methods

4.3.1 Benthic Invertebrate Community Descriptors

Taxonomic data were received in electronic format. Raw count data was converted to organisms per square metre. Converted results were used for the calculation of the following community descriptors and biotic indices at the family level:

- Total invertebrate density
- Family richness
- Simpson's Diversity Index (SDI)
- Simpson's Evenness Index
- Bray-Curtis Index (BCI)

Calculations of community descriptors and biotic indices were based on the formulae provided in the MMER TGD (Environment Canada 2002).

Total invertebrate density was calculated as the total number of individuals in each sample per square meter. The mean (standard deviation and stand error), minimum and maximum are reported for each area. A two sample *t*-test was used to determine if there was a significant difference in density between exposure and reference area (α=0.1).

Richness was calculated as the total number of taxa in each sample. The mean (standard deviation and stand error), minimum and maximum are reported for each area. A two sample *t*-test was used to determine if there was a significant difference in richness between exposure and reference area (α=0.1).

Simpson's Diversity Index (SDI) gives the probability that two individuals chosen at random and independently will belong to the same taxonomic group. A lower probability indicates a more diverse community. SDI is defined as:

$$D = \sum_{i=1}^{s} \frac{n_i(n_i-1)}{N(N-1)}$$

where: D = Simpson's index
n_i = the number individual of the i^{th} taxon
N = the total number of individuals

$$SDI = 1-D$$

where: SDI = Simpson's Diversity Index

SDI was calculated for each sample. The mean (standard deviation and stand error), minimum and maximum are reported for each area. A Mann-Whitney *U* test was used to determine if there was a statistically significant difference in SDI between areas.

Simpson's Evenness Index (SEI) is the relative abundance of the different taxa, higher values indicate equitability. SEI is defined as:

$$E = \frac{(1/D)}{S}$$

Where: E = Simpson's index of evenness
D = Simpson's index of diversity
S = total number of taxa at the sampling station (richness)

SEI was calculated for each sample. The mean (standard deviation and stand error), minimum and maximum are reported for each area. A Mann-Whitney *U* test was used to determine if there was a statistically significant difference in SEI between areas.

Bray-Curtis Index (BCI) measures the degree of difference in community composition between reference area and the study area and is defined as:

$$D_{Bray\text{-}Curtis}(X_1, X_2) = \frac{\sum \lfloor X_{i1} - X_{i2} \rfloor}{\sum (X_{i1} + X_{i2})}$$

Where: $D_{Bray\text{-}Curtis}$ = the difference between sites 1 and 2
X_{i1} = number of individuals of i^{th} taxon at site 1
X_{i2} = number of individuals of i^{th} taxon at site 2

BCI calculates a value between 0 and 1 where 1 indicates that the sites possess completely different set of descriptors and 0 indicates that the sites posses an identical set of descriptors. The mean (standard deviation and stand error), minimum and maximum are reported for each area. A Mann-Whitney *U* test was used to determine if there was a statistically significant difference in BCI between areas.

4.3.2 Sediment and Supporting Environmental Survey

4.3.2.1 Statistical Power

When comparing Exposure and Reference stations, a t-test is the appropriate statistical test to detect differences between Areas. If any of the key descriptors (total invertebrate density, family richness, Simpson's diversity index and Simpson's Evenness index) demonstrate a statistical difference between Exposure and Reference Areas, or if there is a difference between the Reference and Exposure stations through the Bray-Curtis Index, then the conclusion is that there is an effect on the benthic invertebrate community. If no effect is seen, but there was insufficient power, than this is to be considered an effect on the benthic invertebrate community and we would proceed with the monitoring frequencies that would be necessary, based on the results of fish monitoring.

The ability to detect an effect largely depends on sample size. For control-impact study designs, Environment Canada (1998) has deemed that effects that exceed two times the standard deviation of observations (i.e., ± 2 SDs) among stations is unacceptable and reflects an ecological effect rather than natural variability. Therefore, it is necessary to calculate the probability that a difference of ± 2 SDs could be detected with a certain number of stations in both control and impact.

Statistical power is a function of underlying true effect size (or correlation) observed variability and number of replicate samples. In this EEM study, 5 samples per area were collected and analyzed. Using the benthic community descriptors that are calculated to determine a mill effluent effect, the mean, sample size (n) and standard deviation for both the reference and exposure areas were utilized with a statistical power analysis (SYSTAT version 10.2) to determine the power of the statistical tests completed.

4.3.2.2 Quality Assurance / Quality Control

QA/QC for lab work consisted of verifying invertebrate sorting efficiency. Two of the ten samples were resorted and the efficiency was greater than 10%. Identification was verified by another taxonomist on four out of 10 samples.

The QA/QC program applied to both field and laboratory activities and includes, but was not limited to, the following items:

- involvement, in all phases of the study, of employees having the appropriate training with methods to be applied as well as a strong knowledge of the Project and its objectives
- implementation of well understood sampling methodologies and equipment in good working condition which is relevant to the survey area and selected sentinel species
- use of detailed data record sheets
- preservation, storage, and shipment methods relevant to sample type
- maintenance of reference files (digital and hard copy) or original data and results
- document review by qualified personnel

4.4 Results

4.4.1 Benthic Invertebrate Community Descriptors

4.4.1.1 Total Invertebrate Density

Mean total invertebrate density was slightly higher in the exposure area as compared to the reference area but the difference was not statistically significant ($p>0.05$) (Table 8; Figure 8 and 9). The variability of density in the exposure area was greater than the variability in the reference area.

Table 8. Summary Statistics for Invertebrate Community Endpoint Parameters by Sampling Area

Effect Endpoint	Location	Mean	Median	SD	SE	(n)	Min	Max
Invertebrate Density (number/m2)	Exposure	10,812.1	13,724.1	6,901.4	3,086.4	5	2,724.1	18,879.3
	Reference	4,498.3	4,586.2	2,050.6	917.1	5	1,517.2	7,120.7
Taxon Richness (number)	Exposure	7.8	7.0	3.8	1.7	5	4.0	14.0
	Reference	6.6	6.0	0.9	0.4	5	6.0	8.0
Simpson's Diversity Index	Exposure	0.26	0.22	0.14	0.06	5	0.14	0.50
	Reference	0.32	0.27	0.16	0.07	5	0.21	0.60
Simpson's Evenness Value	Exposure	0.02	0.02	0.02	0.01	5	0.01	0.06
	Reference	0.03	0.02	0.02	0.01	5	0.01	0.06
Bray-Curtis Index	Exposure	0.87	0.90	0.11	0.05	5	0.73	1.03
	Reference	0.58	0.56	0.16	0.07	5	0.41	0.80
Ceratopogonidae Density (number/m^2)	Exposure	189.7	103.4	251.6	112.5	5	17.2	629.3
	Reference	Not Present in Samples						
Chironomidae Density (number/m^2)	Exposure	8,763.8	8,956.9	6,844.2	3,060.8	5	2,120.7	18,569.0
	Reference	3,451.7	3,681.0	1,406.3	628.9	5	1,396.6	5,224.1
Enchytraeidae Density (number/m^2)	Exposure	Not Present in Samples						
	Reference	Not Present in Samples						
Lumbriculidae Density (number/m^2)	Exposure	67.2	69.0	45.0	20.1	5	17.2	137.9
	Reference	71.8	69.0	5.0	2.9	3	69.0	77.6

Figure 8. Boxplots of Benthic Invertebrate Effect Endpoints

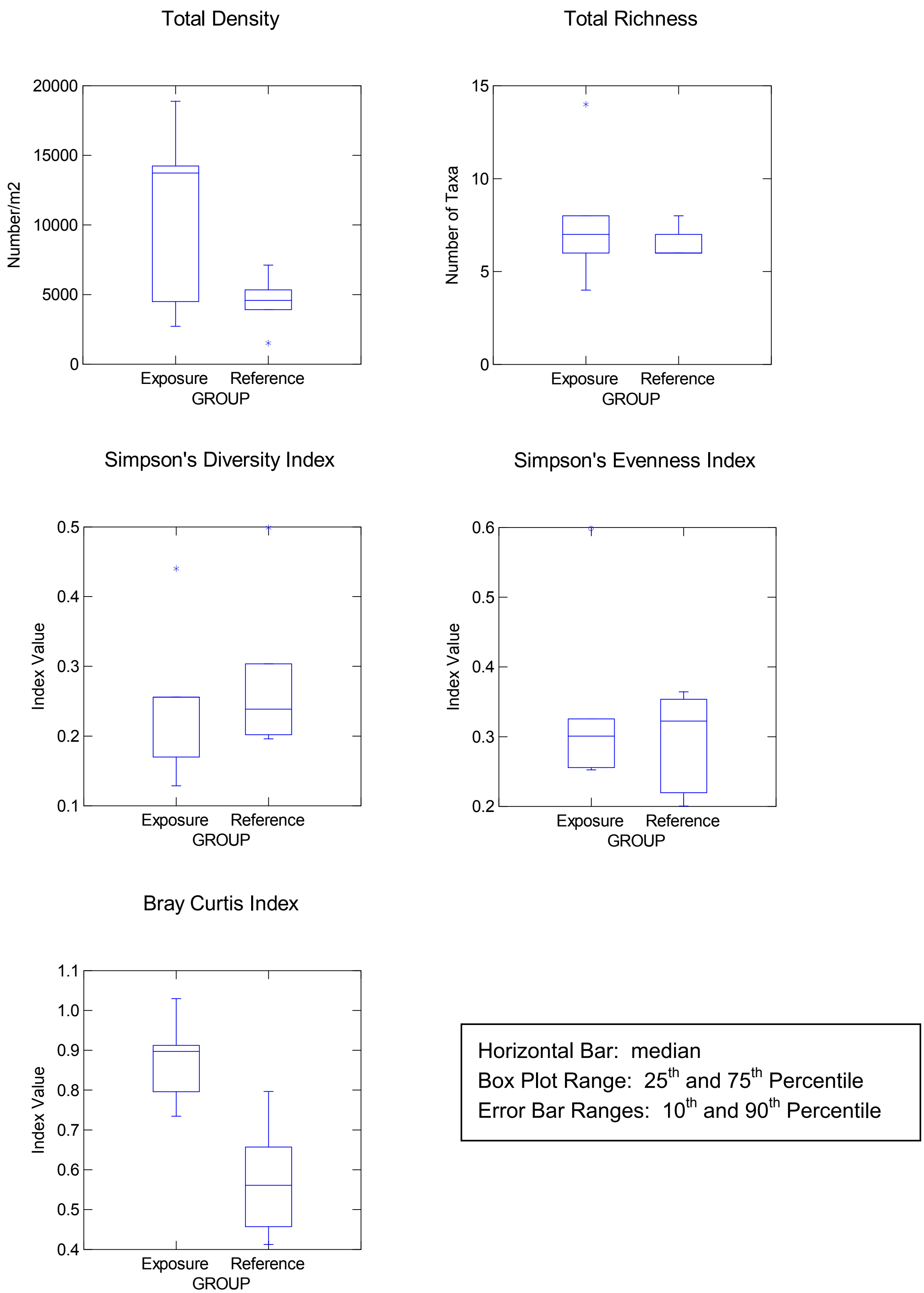
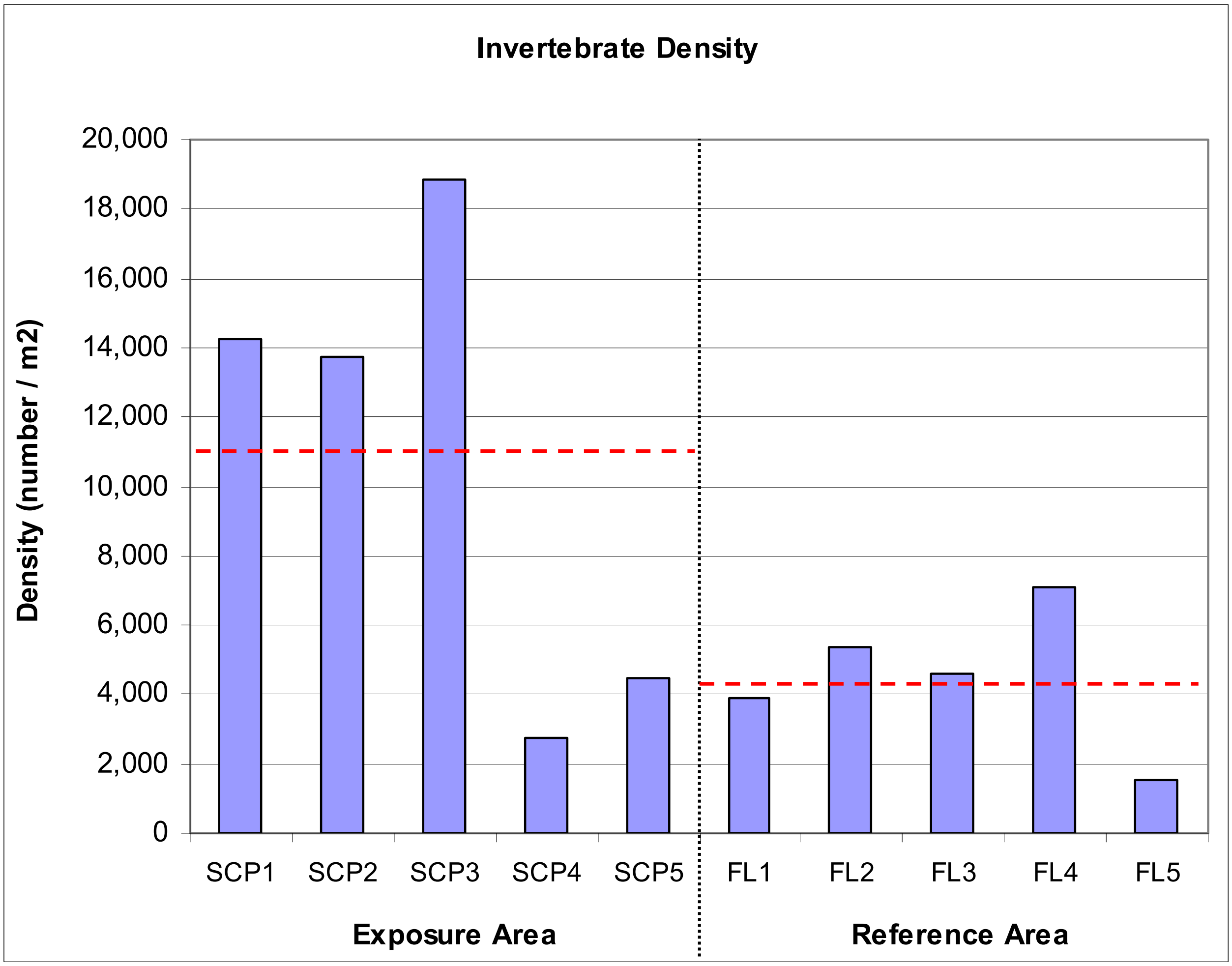


Figure 9. Benthic Invertebrate Density at Each Station



Note: Red line indicates mean for the area

Chironomids were the most common invertebrate group in all samples representing 45% or more of the total organisms (Figure 10). In the exposure area, the sub-dominant invertebrate groups were Nemata (SCP1 and SCP2) and "other" at SCP5. The dominant "other" taxa at SCP5 included Lumbrididae (Oligochaeta) and Ceratopogonidae (Diptera). This latter taxon was only recorded from the exposure samples and had the highest occurrence at SCP5 (Table 9). In the reference area, Chironomids represented at least 50% of the community in the samples. The taxon Empididae (Diptera) was recorded from 7 out of 10 samples but was excessively abundant in sample FL4. "Other" taxon present in the reference area samples included Tubificidae (Oligochaeta) and Pisidiidae (Mollusca). Both of these taxa were only recorded in the sample from FL1.

Figure 10. Relative Percent Composition of Major Invertebrate Taxa by Station

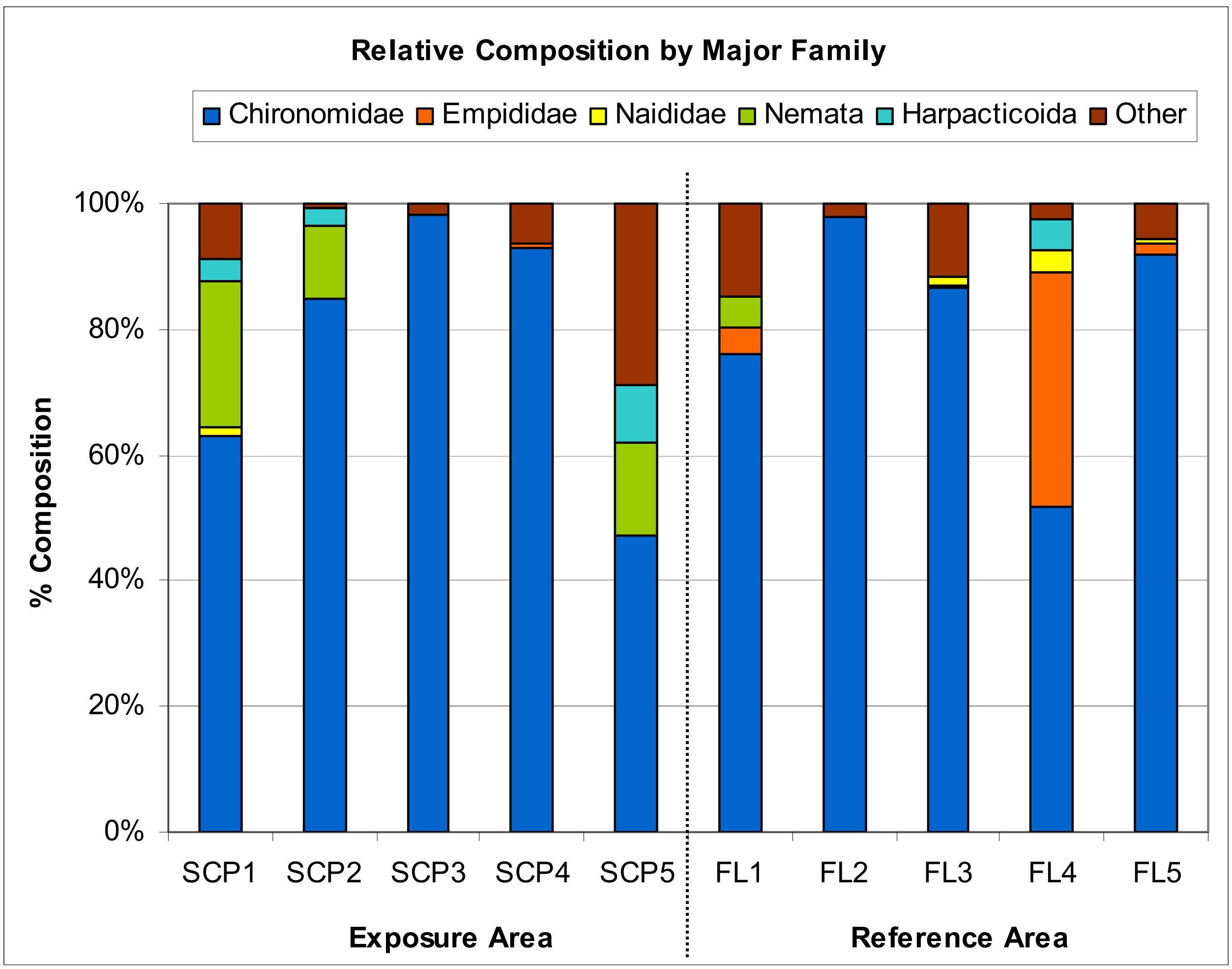
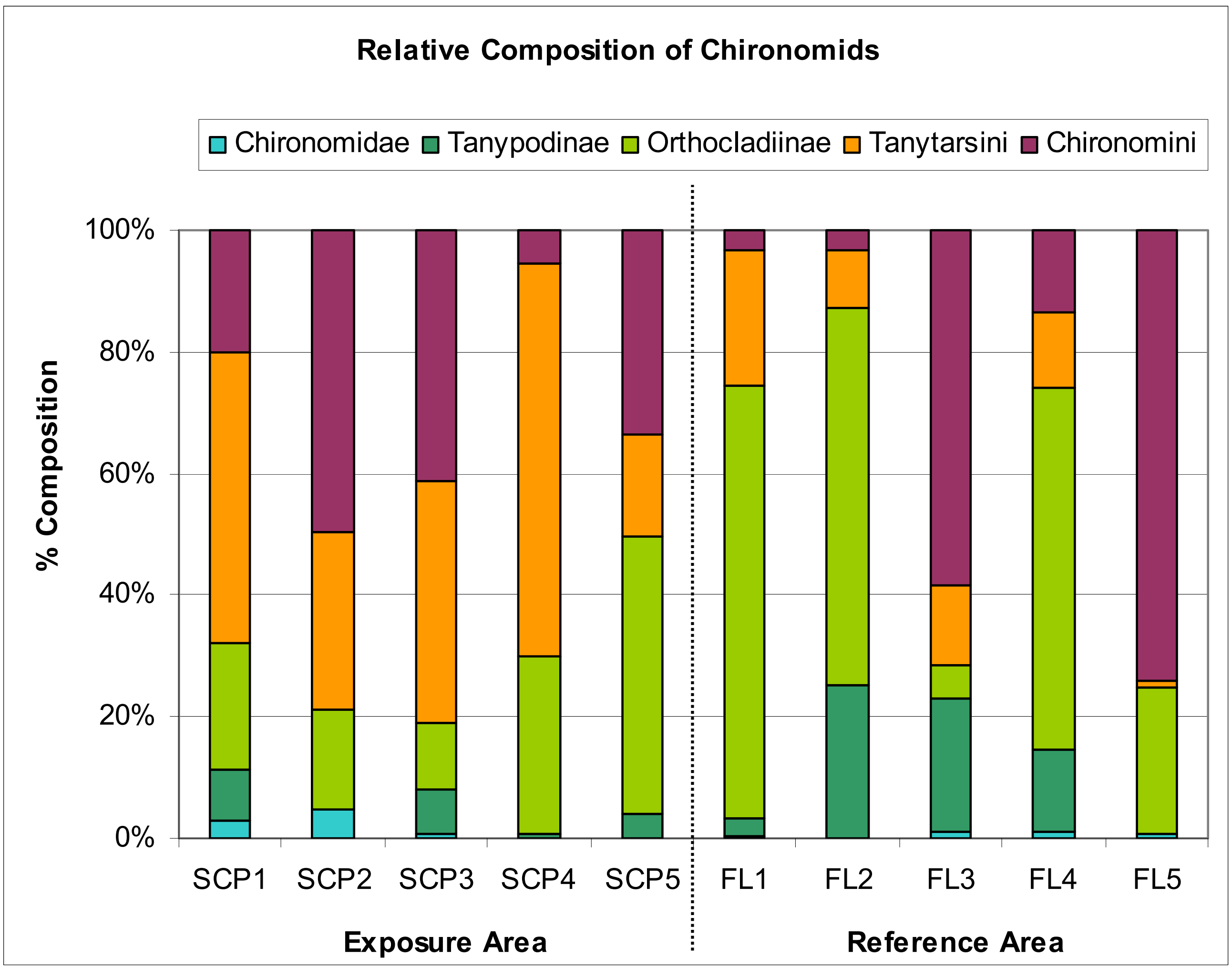


Table 9. Presence of Major Invertebrate Taxa in Exposure and Reference Areas

Major Taxon	Family	Subfamily	Tribe	Exposure	Reference
Diptera	Chironomidae	Orthocladiinae		yes	yes
		Chironominae	Tanytarsini	yes	yes
			Chironomini	yes	yes
			Tanypodinae	yes	yes
		Diamesinae		yes	yes
		Prodiamesinae			yes
	Tipulidae			yes	
	Ceratopogonidae			yes	
	Empididae			yes	yes
	Muscidae			yes	yes
Trichoptera	Limniphilidae				yes
	Leptoceridae			yes	
Ephemeroptera	Heptageniidae				yes
	Baetidae			yes	
Coleoptera	Dytiscidae				yes
Mollusca	Pisidiidae				yes
Oligochaeta	Naididae			yes	yes
	Tubificidae				yes
	Lumbiculiidae			yes	yes
	Lumbrididae			yes	yes
Tricladida					yes
Prostigmata	Lebertiidae			yes	yes
	Pionidae			yes	
Crustacea	Ostracoda			yes	yes
	Calanoida				yes
	Cyclopoida			yes	yes
	Harpacticoida			yes	yes
Nemata				yes	yes

Since Chrionomids represent the majority of the invertebrate composition, relative composition by major Chironomid taxa is also presented (Figure 11). There were five major Chironomid taxa (Chironomidae [Diamesinae and Prodiamesinae], Tanypodinae, Orthocladiinae, Tanytarsini and Chironomini). There were two stations in the exposure area (SCP1 and SCP3) and three in the reference area (FL1, FL3 and FL4) with individuals from all five of these taxa. In the exposure area, Tanytarsini and Chironomini were the dominant taxa even though the total invertebrate density differed between these samples. In the reference area, Orthocladiinae (FL1, FL2, FL4) and Chironomini (FL3 and FL5) were the dominant taxa. Tanytarsini was significantly more abundant in the exposure area than in the reference area ($p \leq 0.05$).

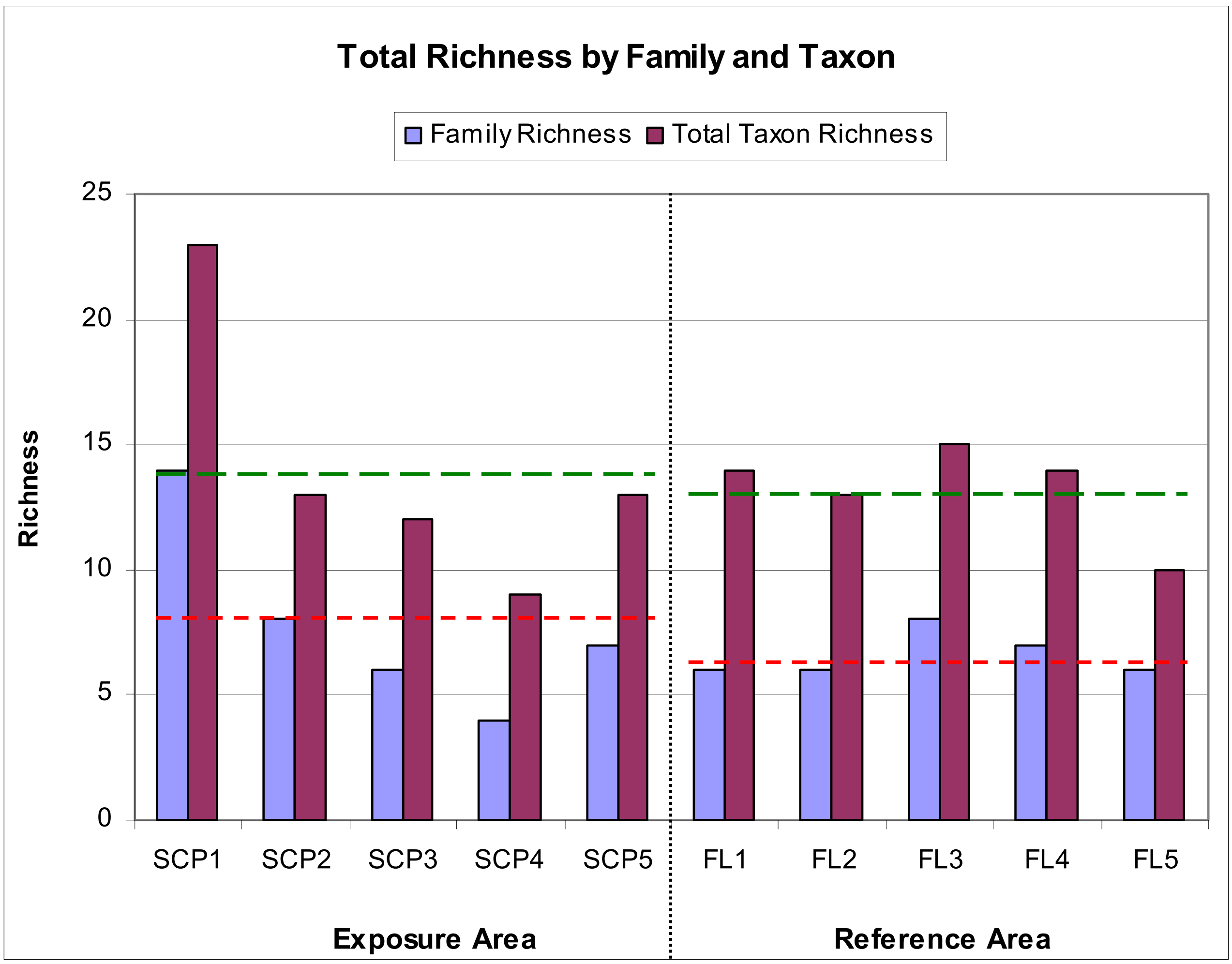
Figure 11. Relative Percent Composition of Chironomid Taxa by Station



4.4.1.2 Taxon Richness

Total taxon richness and family taxon richness was similar between areas (Table 8; Figure 8 and 12). Station SCP1 had the highest total taxon and family taxon richness in the exposure area while station SCP4 had the lowest richness. Stations within the reference area had similar richness with numbers between 10 and 15 for total richness and 6 and 8 for family richness.

Figure 12. Invertebrate Major Taxa and Family Richness by Station

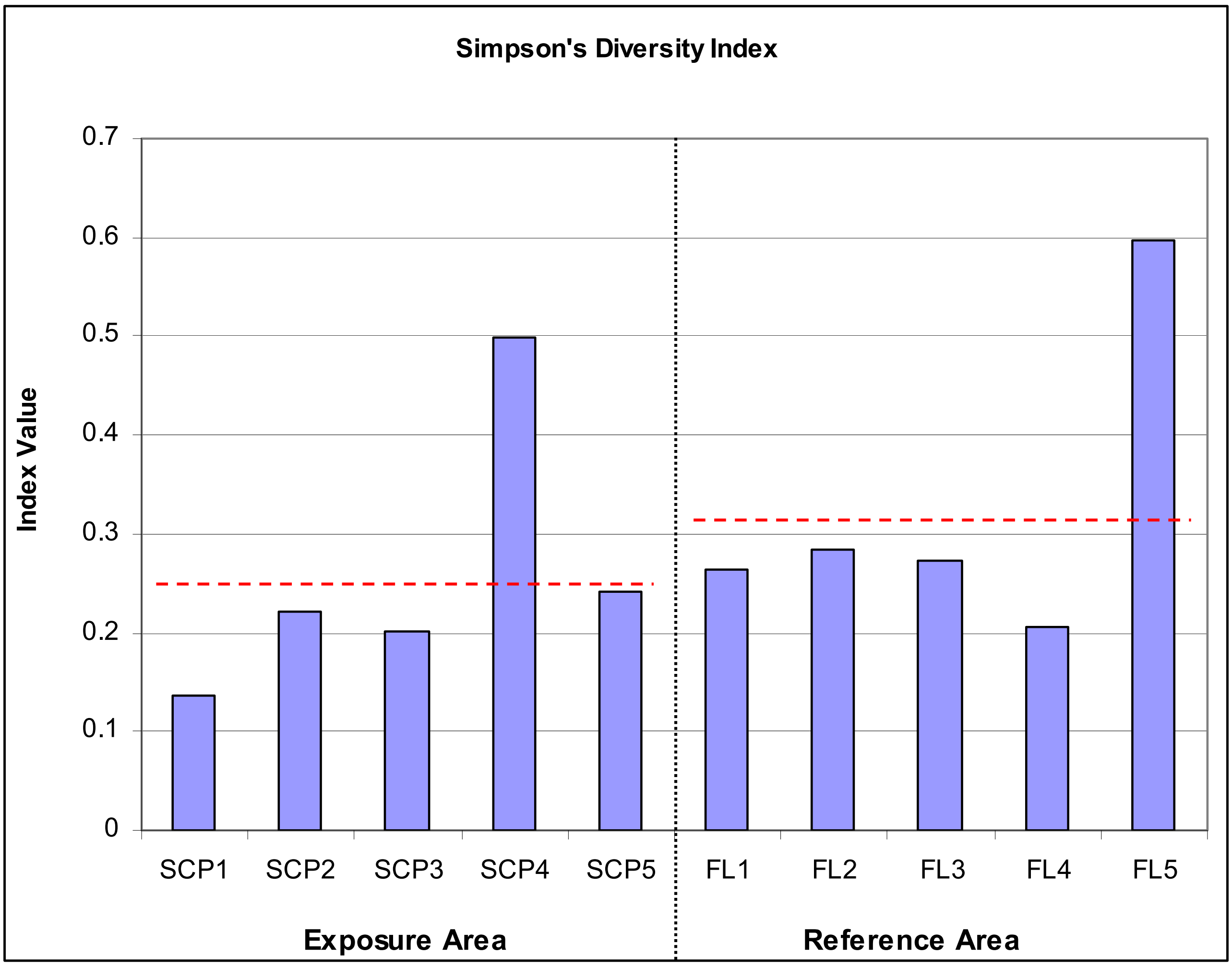


Note: Red line indicates mean family richness for the area; green line indicates mean total taxon richness for the area

4.4.1.3 Simpson's Diversity Index

Diversity was higher overall higher in the reference area as compared to the exposure area but the difference was not significant (Table 8; Figure 8 and 13). In both areas one station had noticeably higher diversity than the other four stations. Station SCP4 in the exposure area and FL5 in the reference area had more diverse invertebrate communities than the other samples.

Figure 13. Simpson's Diversity Index by Station

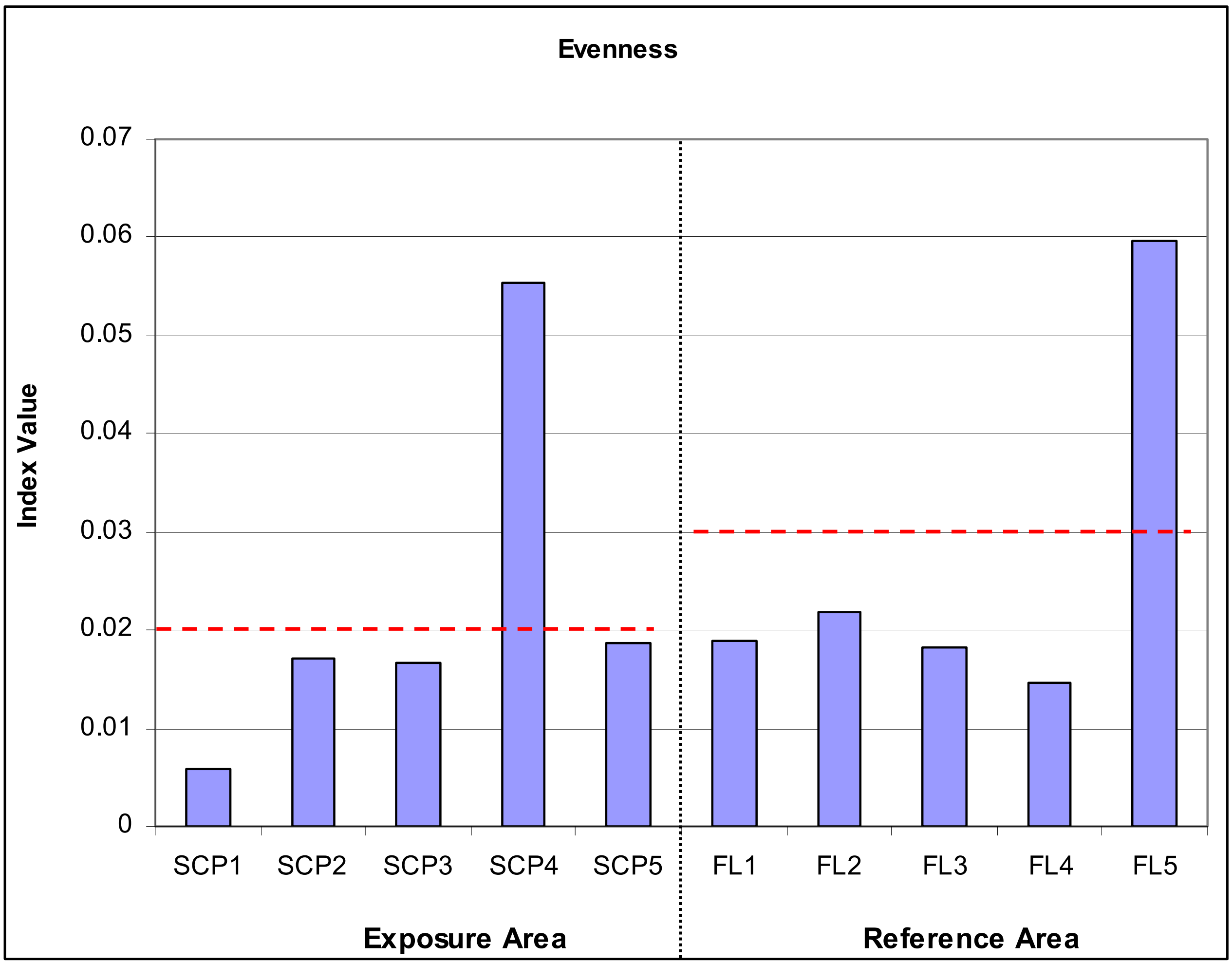


Note: Red line indicates mean for the area

4.4.1.4 Simpson's Evenness

Simpson's Evenness is a measure of the abundance of different species in the community. Evenness was higher in the reference area as compared to the exposure area but the difference was not statistically significant (Table 8; Figure 8 and 14).

Figure 14. Simpson's Evenness Index by Station

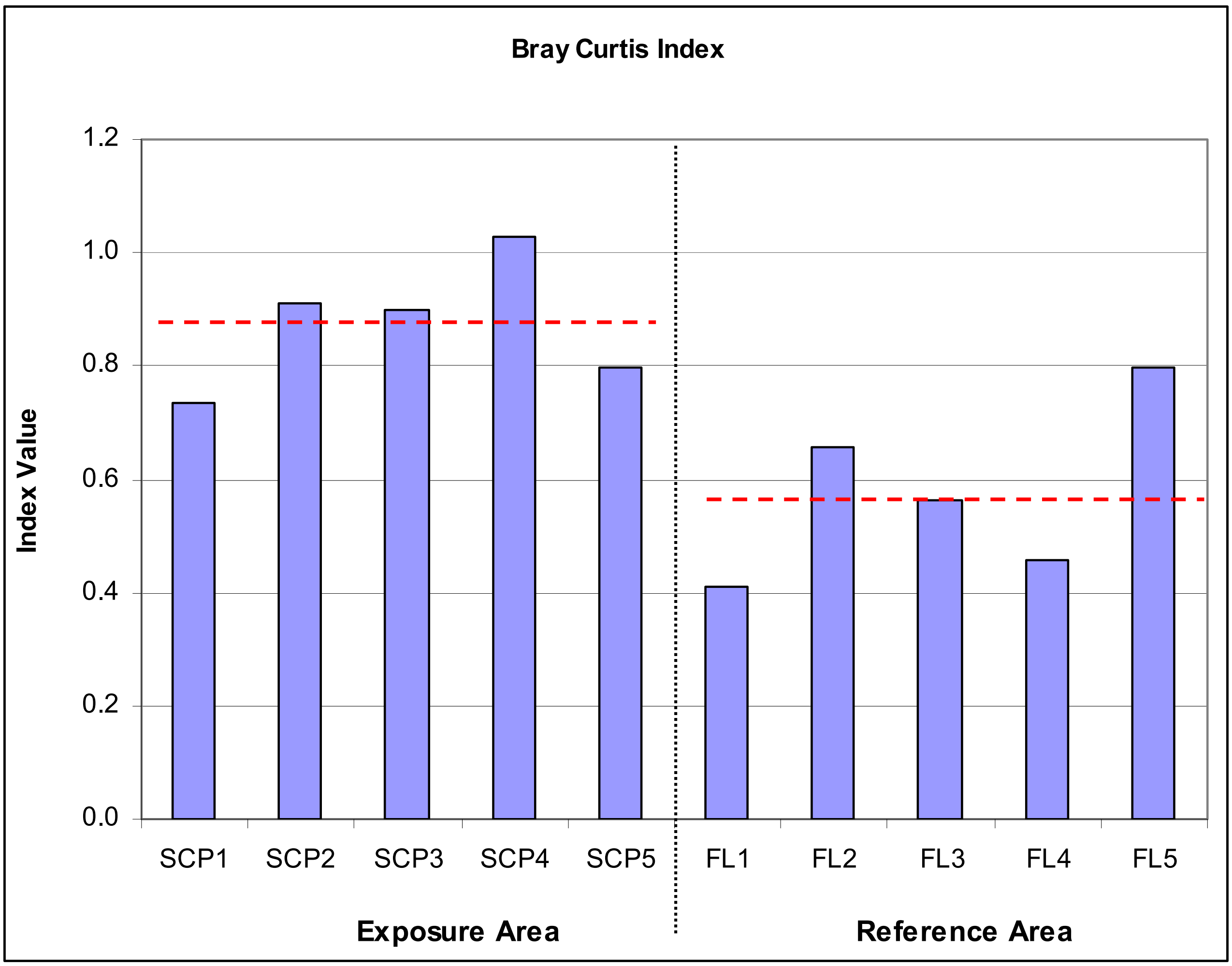


Note: Red line indicates mean for the area

4.4.1.5 Bray-Curtis Index

BCI is a measure of the dissimilarity of the invertebrate community between two areas. BCI was significant between the areas (Table 8; Figure 8 and 15). BCI was calculated by comparing the community composition at each station to the median community composition in the reference area. As expected the difference of the community composition in the reference area are compared to the reference median is lower than the difference of the community composition in the exposure area as compared to the reference median. BCI was significantly higher in the exposure area as compared to the reference area (p=0.039).

Figure 15. Bray-Curtis Index by Station



Note: Red line indicates mean for the area

4.4.1.6 Statistical Power

Power analyses for benthic endpoints are summarized in Table 10. The benthic endpoints with the most statistical power were density and BCI (Table 10). The lowest powered test was the number of Taxon (Richness) and Simpson's Evenness. The variability in the data was extremely high for the endpoints tested, and is the likely causal factor in the low test power observed.

The closer statistical power is to 1, the more sensitive the test. Generally, it is desirable to achieve a power of 0.80, which means that there is an 80% chance of detecting a specified effect with 1– α confidence (i.e., a 90% confidence when α = 0.10). Statistical power was determined for each of the comparison between Reference and Exposure stations. Statistical power ranged from 0.103 to 0.673 for the five comparisons. None of the comparisons had a power greater than 0.8 (Table 10). In order to raise statistical power greater than 0.8 it would be necessary to either raise the risk of a false positive (alpha>0.10), or increase the number of samples. For example, sample abundance was the lowest recorded power for all tests. Using the difference in means and standard deviation noted in the present dataset, a sample size of 32, 16 Reference and 16 Exposure, would be required to increase power over 0.9 with alpha remained at 0.1. For the present assessment, 5 separate samples were combined in the field for each sample identified in the lab. Therefore, essentially 25 samples were collected in each the Reference and Exposure locations, which would have likely resulted in statistical power greater than 0.8. It is therefore recommended that samples should be identified individually by the taxonomist to increase statistical power. Mean BCI differed between areas but statistical power was lower than 0.9 indicating that a larger sample size is required to determine if the difference is significant. From the Cycle 1 study, power analysis suggested that to increase the power to 95% seven replicates per area would be required (Golder 2006a).

Table 10. Statistical Summary for Invertebrate Community Analysis

Endpoint	p-Value	Power α=β=0.1	Effect	Magnitude	Sample Size to Attain Power of 0.9
Total Invertebrate Density	0.085	0.468	No	140%	n=16+16
Family Richness	0.508	0.172	No	18%	n=85+85
Simpson's Diversity Index	0.640	0.188	No	-19%	n=70+70
Simpson's Evenness Index	0.477	0.103	No	-33%	n=2,080+2,080
Bray Curtis Index	0.009	0.673	No	50%	n=9+9

4.4.2 Sediment and Supporting Environmental Survey

Samples for sediment quality were collected from all of the invertebrate sampling stations along with physical measurements of the habitat.

4.4.2.1 Sediment Quality

Sediment samples were silty to sandy in texture. Texture was variable in both areas and was not significantly different between areas except for clay (Table 11). On average, there was more clay in the exposure area samples than in the reference area samples although the relative percent composition of clay particles in either area was less than 5% of the entire sample. Sediment concentration of arsenic, cobalt, copper, nickel and zinc were significantly higher in the exposure area as compared to the reference area. The other metal parameters did not differ significantly between the areas but concentrations were higher in the exposure area as compared to the reference area. Lab water quality for cobalt, copper, nickel and zinc also differed significantly between the areas.

Table 11. Mean Sediment Quality by Area and Statistical Difference between Means

Parameter	Units	Exposure Area (Mean)	Reference Area (Mean)	p-value
Sand	%	57.60	76.20	*n.s.*
Silt	%	39.40	22.00	*n.s.*
Clay	%	3.00	1.80	**0.04**
TOC	mg/kg	1.16	0.64	*n.s.*
Al	mg/kg	7,548.00	4,822.00	*n.s.*
Arsenic	mg/kg	37.46	10.74	**0.005**
Barium	mg/kg	37.80	33.20	*n.s.*
Chromium	mg/kg	27.36	18.22	*n.s.*
Cobalt	mg/kg	15.60	4.20	**0.004**
Copper	mg/kg	16.60	6.80	**0.02**
Iron	mg/kg	12,980.00	7,660.00	*n.s.*
Nickel	mg/kg	30.80	11.40	**0.01**
Strontium	mg/kg	7.00	5.00	*n.s.*
Vanadium	mg/kg	21.20	14.80	*n.s.*
Zinc	mg/kg	64.00	24.00	**0.004**

4.4.2.2 Supporting Environmental Survey

The supporting environmental variables were described in section 3. Water temperature, pH and conductivity were measured at every station when biological samples were collected (Appendix B Table B-1). Water temperature, dissolved oxygen and pH were significantly lower in the exposure as compared to the reference area ($p \leq 0.05$) (Table 4 and 5). Conductivity was significantly higher in the exposure as compared to the reference area ($p \leq 0.05$).

4.5 Discussion and Comparison to Cycle 1

4.5.1 Supporting Environmental Variables

Supporting environmental variables included field measured water quality, water depth and lab measured water quality and sediment quality. For field measured water quality, water temperature, pH and dissolved oxygen were significantly lower in the exposure area as compared to the reference area. Water depth at the BIC sampling stations was significantly shallower in the exposure area as compared to the reference area.

Based on the lab water quality analyses, pH was significantly lower in the exposure area compared to the reference area ($p \leq 0.05$) (Table 5). Hardness, magnesium, sodium, TOC, DOC, aluminum, boron, cadmium, chromium, cobalt, copper, iron, manganese and zinc were significantly higher in the exposure area as compared to the reference area ($p \leq 0.05$). These results were similar to the differences reported in the Cycle 1 study. Water quality in the reference area from Cycle 1 and 2 were similar. Water quality in the exposure area from Cycle 1 and 2 were more variable. Some parameters (pH, cadmium and copper) were lower in Cycle 2 as compared to Cycle 1 while aluminum, nickel and zinc were higher in Cycle 2. Since effluent has not been released since prior to the Cycle 1 study, the decreased concentration of certain parameters indicate that the exposure area may be starting to recover but there may still be residual contamination of the water from the sediments.

Sediment quality in Cycle 2 was similar between the exposure and reference area for most variables. Grain size, other than clay, was similar between the areas. There was significantly more clay in the exposure area samples although on average 3% of sediments from the exposure area and 1.8% of sediments from the reference area were comprised of clay. TOC was low in these sediments but slightly higher in the exposure area (1.2%) as compared to the reference area (0.6%). This was similar to Cycle 1. Sediment concentration of arsenic, cobalt, copper, nickel and zinc were significantly higher in the exposure area as compared to the reference area. Concentrations of other parameters were higher, but not significantly higher, in the exposure area as compared to the reference area. Arsenic was above the sediment quality guideline in all five exposure samples and four of the reference area samples. One exposure area sample for chromium exceeded the guideline. These results were similar to results from Cycle 1.

4.5.2 Benthic Invertebrate Community

Density of benthic invertebrates and taxon richness was higher in the exposure area as compared to the reference area. In the Cycle 1 study, benthic density was higher in the reference area as compared to the exposure area. This difference was not statistically significant. Family taxon richness was also similar between areas in Cycle 1. The Cycle 2 study was conducted in August to September 2008, three years after the last effluent discharge. The Cycle 1 study was conducted after and not during effluent discharge. These results suggest that density and richness are variable by area and may not be influenced by historical contamination.

In Cycle 2 species diversity and evenness were higher in the reference area as compared to the exposure area. These differences were not statistically significant at the 0.05 level. In Cycle 1, diversity and evenness were significantly higher in the reference area. These results also suggest that the benthic community in the exposure area is recovering from lack of effluent discharge.

Results of the Cycle 1 study suggested that mine effluent had a low impact on the benthic community. Results from Cycle 2 also suggest the historical mine effluent had a low impact on the benthic community.

5. Fish Survey

5.1 Study Design

The purpose of the survey was to investigate the potential effects of the mine discharge on fish population structure, energy utilization and condition as well as to determine whether significant amounts of copper were accumulating in fish tissues in the area affected by effluent. The field program was completed between August 28 and September 7, 2009. Fish were collected from the exposure (Seep Creek system) and reference (Fingers Creek system) areas at similar locations as the Cycle 1 study (Golder 2006a). Based on Environment Canada (EC) recommendations, juvenile Arctic grayling (*Thymallus arcticus*) and ninespine stickleback (*Pungitius pungitius*) were selected as primary sentinel target species for a lethal sampling program. The preliminary study design was focused on capturing a minimum of 52 juvenile (age 1) Arctic grayling and 52 adult ninespine stickleback in each of the study areas, according to the recommendations of the Cycle 1 study (Golder 2006b). However, a preliminary catch analysis at the beginning of the field program indicated that the number of individuals captured from that specific age was low, so the study was modified to target one hundred individuals of each sentinel target species in both areas, regardless of age. The study also attempted to analyze the significance of copper accumulation in Arctic grayling livers, however due to the small fish size an insufficient mass of liver tissue was collected for laboratory analysis. As an alternative, muscle tissue samples taken from Arctic grayling in both areas were submitted for lab analysis of copper concentration, Fish survey sampling locations for the exposure and reference areas a listed in Appendix D Tables D-1, D-2 and D-3 and mapped in Figures 16 and 17.

5.2 Field Methods

5.2.1 Fish Capture

A variety of equipment was used to maximize collection of both target species at a variety of sizes (Appendix D, Tables D-1, D-2, D-3). Similar types of gear and fishing effort were used in both exposure and reference areas to eliminate the bias associated with gear selectivity identified during Cycle 1 study (Golder 2006b). Electrofishing (EF), with a Smith-Root LR-24 Backpack Electrofisher, was the primary method used in creeks and around the edges of ponds. Start and end coordinates were recorded for each survey section along with total effort in seconds, voltage, frequency and duty cycle settings. Baited minnow traps (MT) were used around edges of ponds and within creeks. The number of traps, set duration and effort (trap hours) were recorded. Gill net (GN) panes were 46 m long and 1.8 m high and were used in the deeper sections of ponds and lakes. Three mesh sizes were used (19, 25 and 36 mm) either singly or in combination. Number of individual lifts, mesh size and effort (panel hours) were recorded.

Sacrificed specimens of target species were kept on ice in collection containers, while all other species were counted and released into the waters where they were captured. Supporting environmental data including

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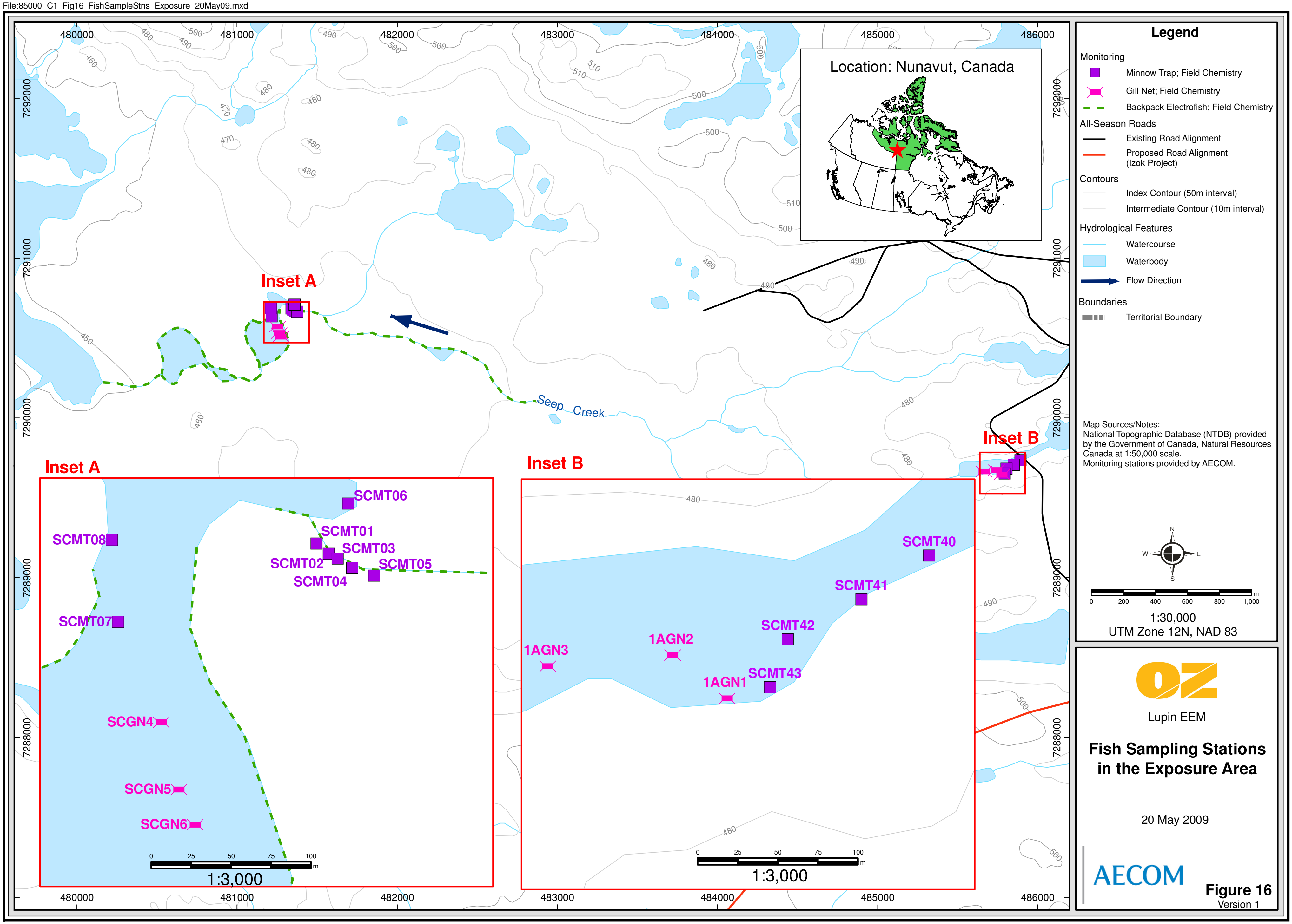
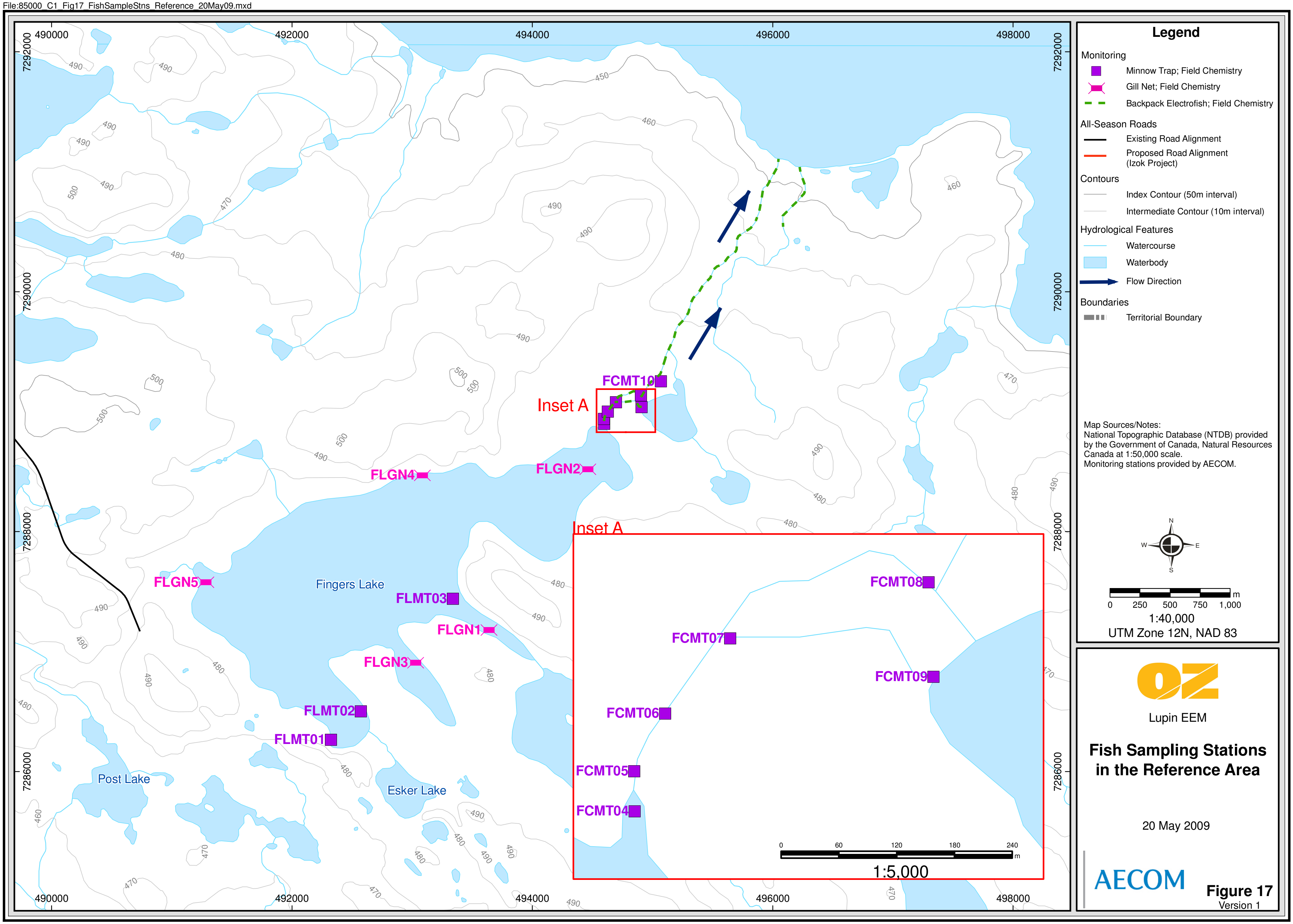


File:85000_C1_Fig17_FishSampleStns_Reference_20May09.mxd



water depth, water and air temperature and field water chemistry (pH, conductivity, dissolved oxygen and turbidity) were measured when the minnow traps and gill nets were set and at the start of each electrofishing run (Appendix B Table B-1). All measurements were recorded on waterproof paper forms.

5.2.2 Field Laboratory Analyses

Upon arrival in the field lab, the fish were dissected and the following measurements were taken: total length, standard length, fork length (Arctic grayling only), liver weight and carcass weight (Appendix D Tables D-4, D-5). Aging structures (scales and otoliths) were collected from Arctic grayling with stomach content and gonad weights recorded whenever possible. Notes were made on fish condition and any observed abnormalities were recorded. Fish troughs were used for length measurements to within 1 mm, while carcass weights were measured with an Acculab VI-200 balance (accuracy 0.01 g). Liver weights were measured with an Ohaus Adventurer Pro AV-53 balance (accuracy 0.001g). All measurements were recorded in standardized data forms.

The Arctic grayling aging structures (scales and otoliths) were placed into individual sealed envelopes with specimen identification. At the completion of the field program, they were sent to North Shore Environmental Ltd. in Thunder Bay, Ontario, for age determination (Appendix D Table D-7). All aging structures were returned and archived.

Due to the small sizes of Arctic grayling, insufficient amounts of liver tissue for copper analysis were collected, therefore the whole carcasses (head removed) were kept frozen and then submitted for analysis of copper concentrations in muscle tissues (Appendix D Table D-6). After sampling was completed, a chain of custody form was filled out. Eight composite muscle tissue samples from each area were submitted to ALS Laboratory Group in Edmonton, Alberta for copper analysis. The samples were prepared using EPA 200.3 method and the analysis was performed using EPA 6020 standards.

5.3 Statistical Methods

All the fish collection data from the reference and exposure areas was entered into summary tables based on the capture method employed. Catch-per-unit-effort (CUPE) was calculated to reflect the effectiveness of the various types of gear in capturing individuals of different species and sizes.

Summary statistics were calculated for Arctic grayling and ninespine stickleback for total length (NSSB), fork length (AG), weight, liver weight and carcass weight. Statistics including sample size, arithmetic mean, median, standard deviation, standard error, minimum and maximum were calculated. The results of Arctic grayling age determinations, based on aging structures, were analyzed and summarized in a frequency histogram. Length distribution data for ninespine stickleback were summarized in length-frequency histogram which included all specimens captured. Correlations were analyzed between length-weight, carcass weight-liver weight and length-liver weight individually for Arctic grayling and ninespine stickleback.

Since a statistical analysis of the effect such as energy storage and use require fish to be of same size and age, only grayling of the same age (young of year) were used in subsequent analyses (n=54 and 30, exposure and reference, respectively). Insufficient numbers of individuals were present in other age classes to perform a statistically significant analysis of the effects. Due to the small size of ninespine stickleback, and the difficulty in accurate age determination, all immature fish captured were used in the statistical analyses, and this should be taken into consideration when interpreting the results.

According to the MMER guidelines, survival, energy use and energy storage are the types of responses that can be used to assess the presence of effects (EC 2002). Due to the small fish size and limited number of age classes captured during field surveys, the effect endpoints of survival and size-at-age were not achievable during this study. Similarly, relative fecundity effect endpoints could not be determined due to a lack of adults of either target species captured in the study area. The selected endpoints were separated into two groups - effect and supporting variables. Effect endpoints were used for determining statistically significant differences between exposure and reference areas and included condition (body weight vs. length) and relative liver weight (liver weight vs. carcass weight). Supporting variable endpoints were used to substantiate the findings and were not necessarily used in determination of the effect. These included total body weight, length and relative liver weight (liver weight vs. length). In addition to these parameters, a statistical analysis was conducted on copper concentrations in Arctic grayling muscle tissue between exposure and reference areas.

Statistical methods were consistent with the procedures outlined in the current EEM Technical Guidance Document (EC 2002) and were completed using STATISTICA 8.0 software. For body weight and length (Energy Use) a *t*-test (P<0.1) was used to detect statistical differences between study areas, while for condition and relative liver weights (Energy Storage) – Linear regression and ANCOVA was applied. The statistical analysis comparing the copper concentrations in fish tissues from the exposure and reference areas was performed using a t-test. The summary of the statistical endpoints and analysis methods is presented in Table 12.

Table 12. Endpoints and Statistical Methods used for Fish Survey Data Analysis

Type of Response	Endpoint	Dependent Variable (y)	Independent Variable (x)	Statistical Procedure
Effect Endpoints				
Energy Storage	Condition	Body Weight	Length	ANCOVA
	Relative Liver Weight	Liver Weight	Carcass Weight	ANCOVA
Supporting Variables				
Energy Use	Body weight	n/a	n/a	t-test
	Length	n/a	n/a	t-test
Energy Storage	Relative Liver Weight	Liver Weight	Length	ANCOVA
Copper in Fish Tissue				
Metal Accumulation	Copper Concentration	n/a	n/a	t-test

For energy use endpoints a simple t-test was conducted comparing lengths and weights of sentinel species between the exposure and reference areas. Prior to conducting the analyses on the remaining endpoints, data was inspected to determine whether it satisfies the assumptions of ANCOVA and whether the parameters have a homogeneous distribution (EC 2002). To accomplish this, scatter plots were analyzed to identify any outliers and other erroneous data. The data log transformations were not necessary out since it was determined that the data are normally distributed and have a homogeneous variance. The plots were then examined to determine if sufficient overlap exists between exposure and reference data points and if there is a linear relationship between the variables. To verify that there is linearity of data, each relationship was tested using linear regression analysis at α=0.10. ANCOVA was applied only when it was determined that there is a significant linear regression between variables in the exposure and reference areas.

Following the application of ANCOVA, the magnitude of effect was calculated for each endpoint where a significant difference was detected using adjusted least square means. For slopes which were homogeneous the magnitude of effect was calculated as:

(Exposure mean-Reference mean)/Reference mean x 100

The results of the analyses were summarized in a table listing endpoint type, interaction statistic, statistically significant difference between exposure and reference areas as well as the direction and if a difference was significant, the magnitude of the difference.

5.3.1 Statistical Power Analysis

Following the Cycle 1 study (Golder 2006a) a retrospective power analysis was conducted to determine the estimated power at α=β=0.1 (Table 13). Since the characteristics of the fish populations were assumed to be unchanged from Cycle 1 study, results of the power analysis were also applied for power analysis during this study.

Table 13. Power Analysis as used in the Cycle 1 EEM (Golder 2006a)

Endpoint	Critical Effect Size	Estimated Power (α=β=0.1)	Required N for Desired Power 1-β=0.9
Length	5%	0.728	52
	10%	0.9941	14
	15%	1	7
Weight	5%	0.1971	446
	10%	0.4539	112
	15%	0.7408	51
	20%	0.9206	29
	25%	0.9851	19
	30%	0.9983	14
	35%	1	10
Condition	5%	1	11
Liver/Carcass Weight	5%	0.645	58
	10%	0.995	15
	15%	1	7

5.3.2 Quality Assurance / Quality Control

All field and lab personnel involved in the collection and laboratory preparation of specimens, were briefed on the proper procedures and techniques required to conduct the study under the supervision of experienced field leads. Water chemistry measuring equipment was calibrated at the end of each field day, and all field gear was cleaned and in proper working condition. All of the field forms were checked for consistency at the end of every field day. Laboratory data was entered by a separate recorder to ensure that there are no errors or inconsistencies. Following the completion of the field study, 10% of the field and lab forms were independently checked for consistency and data reliability by an individual not involved in the original data input. All aging structures were aged twice. The structure was aged first without length, weight, and sex known for the fish. During the second aging event, fish length, weight, and sex were known. The ages of the first and second reading were then compared. Results of the fish tissue analysis were confirmed by completing replicate analyses. Tables and data sets were also checked for accuracy during the preparation of the final report.

5.4 Results

5.4.1 Fish Habitat Characteristics

The fish habitats found in the study area include permanent and intermittent streams which connected larger bodies of water ranging in size from medium-sized lakes over 2 m deep (Fingers Lake), small shallow ponds less than 1 m deep (Seep Creek Ponds) to a very large lake (Contwoyto Lake). The substrate types ranged from sand to cobble and large boulders, which provided instream cover for adults. Algal growth was present in shallower areas, however during observed high water levels, most of the vegetation growing along lake and creek margins was flooded which provided cover for juveniles. Qualitatively, different types of habitat were observed in the exposure and reference areas, with the reference area containing more lake type habitats while the exposure area encompassed shallower pond and stream habitat areas.

The exposure area consisted of Seep Creek and its tributaries, which originated in Dam 1A Lake immediately below the tailings pond discharge area and terminated at the Inner Sun Bay. The drainage consisted of a number of shallow lakes and ponds that drain into Seep Creek. Sections of overland flow and flooded vegetated banks were present throughout the drainage.

The reference area consisted of Fingers Lake which drains by the way of Fingers Creek into Contwoyto Lake. Two shallow ponds were also emptying into Fingers Creek via three intermittent creeks, along with significant amounts of overland flow. A prominent sandbar was observed at the mouth of the main creek, which may inhibit fish movement between the two lakes.

5.4.2 Fish Capture Data

Sampling of the creeks and ponds was conducted primarily by backpack electrofishing, while gill nets were set across wider and deeper sections of lakes. Minnow traps were used primarily around creek margins, in flooded vegetated areas and near boulders.

In total, 247 fish representing seven species were captured in the exposure area (Appendix D Table D-4), and 282 fish representing six species were captured in the reference area (Appendix D Table D-5). Backpack electrofishing was the most successful method for fish capture in the both areas followed by gill nets and minnow traps (Table 14). CPUE rates indicated that it was much more difficult to capture the required numbers of fish in the reference area, and that the catch rates of non-target species were also higher, especially when using gill nets and minnow traps.

As for the sentinel target species in the exposure area, 112 Arctic grayling and 130 ninespine stickleback were captured while in the reference area the numbers of fish caught were 40 and 96, respectively. CPUE and the number of fish captured were significantly different for both areas, indicating that their densities were lower in the reference area. Raw data are in Appendix D Tables D-1, D-2 and D-3 and the CPUE are summarized in Table 14. The success of the different fishing methods for Arctic grayling and stickleback is summarized:

- Backpack Electrofishing
  - Capture both target species
  - Most successful fishing method
  - The only method that resulted in the capture of stickleback
- Gill Nets
  - Only captured Arctic grayling
  - Only captured in the shallow ponds in the exposure area
  - No Arctic grayling captured by this method in the reference area
- Baited Minnow Traps
  - Unsuccessful fishing method for this study
  - Only four Arctic grayling from the exposure area and one from the reference area were captured with this method

Table 14. Fish Catch Summary 2008 Lupin EEM

Capture Method	Location	Effort (hours)	Species	Number of Fish	CPUE (fish/hour)
Gill Nets	Exposure	819	Arctic Grayling	39	0.048
			Lake Trout	1	0.001
			Arctic Char	1	0.001
			Total	**41**	**0.050**
	Reference	1031	Lake Trout	13	0.013
			Round Whitefish	15	0.015
			Total	**28**	**0.027**
Minnow Traps	Exposure	681	Arctic Grayling	4	0.006
			Burbot	1	0.001
			Total	**5**	**0.007**
	Reference	2140	Arctic Grayling	1	0.000
			Slimy Sculpin	2	0.001
			Burbot	18	0.008
			Total	**21**	**0.010**
Electrofishing	Exposure	7.96	Arctic Grayling	69	8.673
			Ninespine Stickleback	130	16.341
			Slimy Sculpin	1	0.126
			Round Whitefish	1	0.126
			Total	**201**	**25.266**
	Reference	11.77	Arctic Grayling	39	3.312
			Ninespine Stickleback	96	8.153
			Slimy Sculpin	39	3.312
			Burbot	42	3.567
			Lake Trout	17	1.444
			Total	**233**	**19.789**
			Total Exposure	**247**	**0.164**
			Total Reference	**282**	**0.089**

5.4.3 Supporting Environmental Variables

Field pH values in the exposure area (4.6 to 7.3) were lower than in the reference area (5.8 to 10). Most of the values in both areas were compliant with CWQG, however, lower values were typical of the values reported by RCPL and RL&L (1985) in this area. Field conductivities were lower in the Fingers Creek system (10 to 20 μS/cm) than in the Seep Creek System (30 to 250 μS/cm).

The amount of total dissolved solids was higher in the exposure area, as was hardness, calcium, magnesium and sulphate ion concentrations. Nitrate and ammonia concentrations were slightly elevated in the Seep Creek system, while total phosphorus was higher in Fingers Lake. Concentrations of organic carbon were slightly elevated in the exposure area.

Generally, metal concentrations were higher in the Seep Creek system, and were decreasing further away from the tailings ponds. In the exposure area, the concentrations of aluminum, cadmium, copper, and nickel exceeded the CWQG. Concentrations of arsenic, barium, chromium, cobalt, iron, manganese, strontium, vanadium and zinc were also elevated in the Seep Creek system. More detailed comparison of water quality parameters is discussed in Section 3. Summary tables for field chemistry and water quality parameters are listed in Appendix B.

5.4.4 Fish Health – Arctic Grayling

5.4.4.1 General Health

In total, 109 fish from the exposure area and 39 fish from the reference area were used during the lethal sampling program. External and internal examinations revealed no major abnormalities however two specimens from the exposure and three from the reference areas had slightly pale livers. Analysis of stomach content from larger specimens of Arctic grayling indicated that a primary component of their diet were insects and to a lesser extent juvenile ninespine stickleback.

5.4.4.2 Summary Statistics (All Ages)

All of the fish captured were immature and length-frequency distribution for Arctic grayling indicated that three distinct size classes were captured during the survey (Figure 18 and 19). The subsequent age determination indicated that 50% of juvenile Arctic grayling captured in the exposure area were young-of-year (YoY) (0+), 17% were age 1+ fish, 31% were age 2+ fish and 2% were age 3+ fish. In the reference area, 77% of juveniles were young-of-year, 10% were age 1+, 17 % were age 2+ fish and there were no age 3+ fish captured (Figure 19). Since the majority of fish (54 in the exposure area and 30 in the reference area) were young-of-year, only they were included in the statistical analyses of energy use and storage. However, summary statistics for all age classes were calculated for fork length, weight, liver weight and carcass weight for both the exposure and reference areas (Table 15). Summary statistics were also calculated for the YoY fish included in the statistical analyses of energy use and storage (Table 16). The detailed results of the age determinations for Arctic grayling are listed in Appendix D Table D-7.

Table 15. Summary Statistics for Arctic Grayling (all ages)

Location	Variable	n	Median	Mean	SD	SE	Minimum	Maximum
Exposure	Fork Length(mm)	109	72.00	105.75	48.92	4.69	42.00	220.00
	Total weight (g)	108	6.06	22.38	25.95	2.50	1.07	131.73
	Liver weight (g)	108	0.10	0.27	0.30	0.03	0.01	1.30
	Carcass weight (g)	109	2.11	17.02	20.53	1.97	0.50	104.35
Reference	Fork Length(mm)	39	76.00	90.95	34.48	5.52	64.00	190.00
	Total weight (g)	39	3.94	12.03	19.16	3.07	2.61	90.17
	Liver weight (g)	39	0.06	0.14	0.21	0.03	0.03	1.09
	Carcass weight (g)	39	2.66	8.93	15.18	2.43	1.70	71.57

Note:SD-Standard Deviation, SE-Standard Error

Figure 18. Fork Length Frequency Distribution for Arctic Grayling (all ages) from Each Area

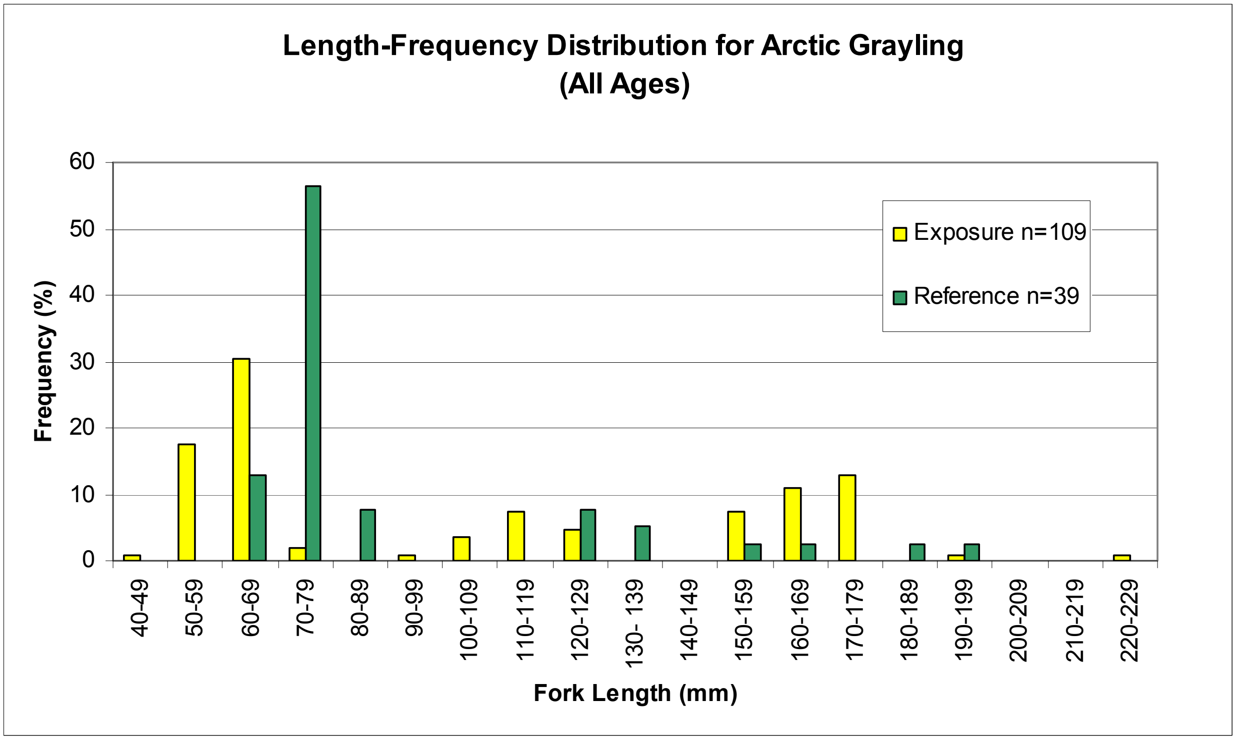
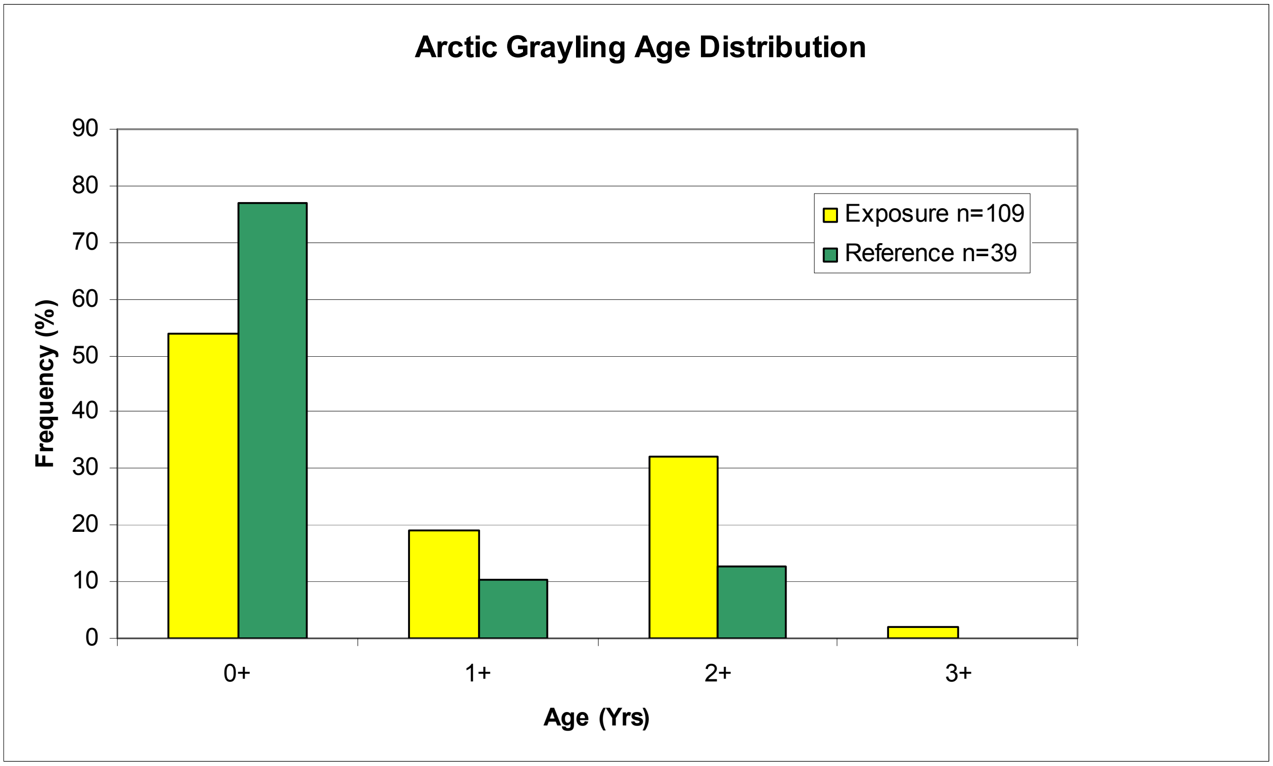


Figure 19. Frequency distribution of Arctic Grayling Age Categories



5.4.4.3 Summary Statistics (Young-of-Year)

Summary statistics for young-of-year (YoY) Arctic grayling which were used in the subsequent analyses are listed in Table 16. The results of the statistical analysis of the effect and supporting variables for YoY Arctic grayling are summarized in Table 17, along with the results of the tissue copper analysis for all grayling age classes.

Table 16. Summary Statistics for Arctic Grayling (YoY)

Location	Variable	n	Median	Mean	SD	SE	Minimum	Maximum
Exposure	Fork Length(mm)	54	63.00	61.48	5.68	0.77	42.00	72.00
	Total weight (g)	53	2.03	2.11	0.55	0.08	1.07	3.22
	Liver weight (g)	53	0.03	0.03	0.01	0.00	0.01	0.07
	Carcass weight (g)	54	1.21	1.28	0.40	0.05	0.50	2.11
Reference	Fork Length(mm)	30	73.00	73.50	4.55	0.83	64.00	83.00
	Total weight (g)	30	3.70	3.75	0.57	0.10	2.61	4.83
	Liver weight (g)	30	0.05	0.05	0.02	0.00	0.03	0.08
	Carcass weight (g)	30	2.38	2.46	0.43	0.08	1.70	3.26

Note:SD-Standard Deviation, SE-Standard Error

Table 17. Results of the Statistical Analyses for Arctic Grayling

Type of Response	Endpoint	Interaction Statistic P	Intercept Statistic P	Statistically Significant Difference	Direction of Difference	Magnitude of Difference (%)
Effect Endpoints						
Energy Storage	Condition	<0.0001	<0.0001	Yes	Ref>Exp	18
	Relative Liver Weight	<0.0001	0.659	No	none	-
Supporting Variables						
Energy Use	Body weight	n/a	<0.0001	Yes	Ref>Exp	44
	Length	n/a	<0.0001	Yes	Ref>Exp	16
Energy Storage	Relative Liver Weight	<0.0001	0.0004	Yes	Ref>Exp	4
Fish Tissue Analysis						
Metal Accumulation	Copper Concentration	n/a	0.931397	No	none	-

5.4.4.4 Energy Use

The fork length-frequency and total weight-frequency distributions for YoY fish are presented in Figures 20 and 21. The supporting variables of total body weight and length of young-of-year Arctic grayling were statistically different between exposure and exposure areas (t-test, P<0.1). The YoY fish in the reference area weighed 44% more and were 16% longer than individuals in the exposure area.

Figure 20. Fork Length-Frequency Distribution for Arctic Grayling (YoY) by Area

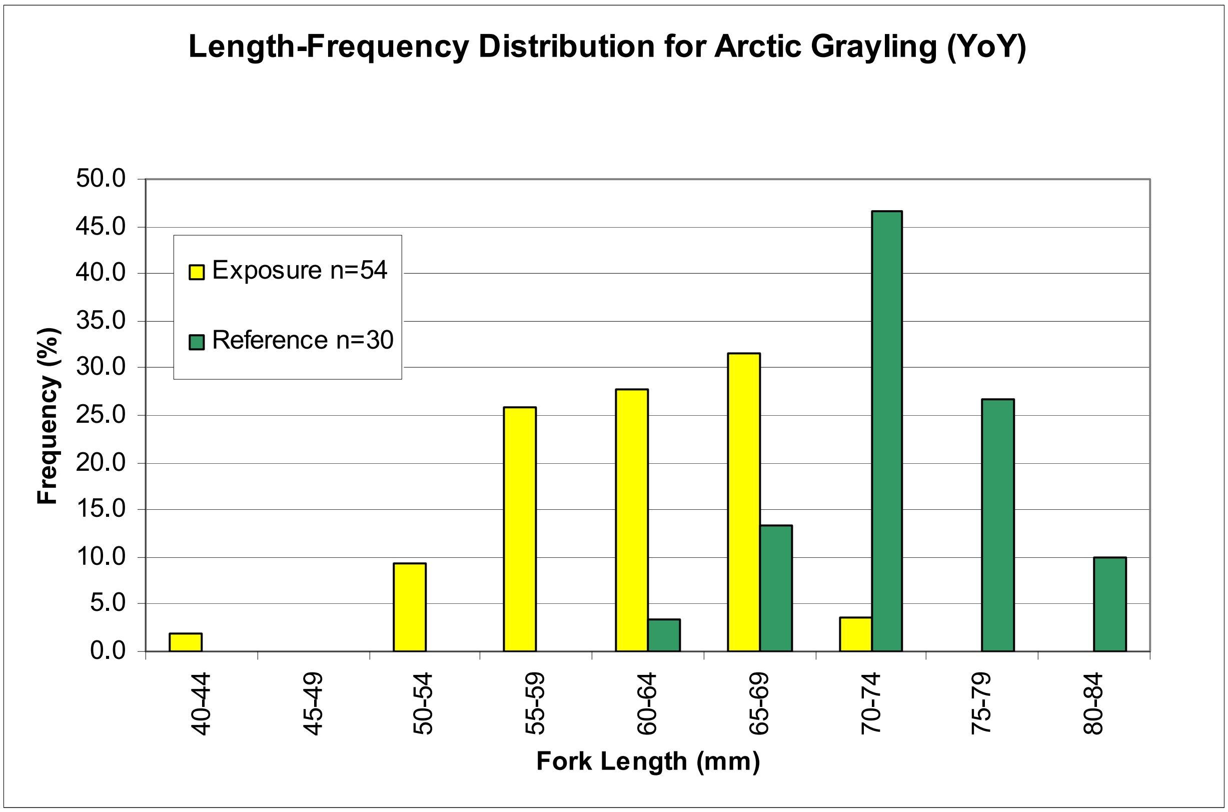
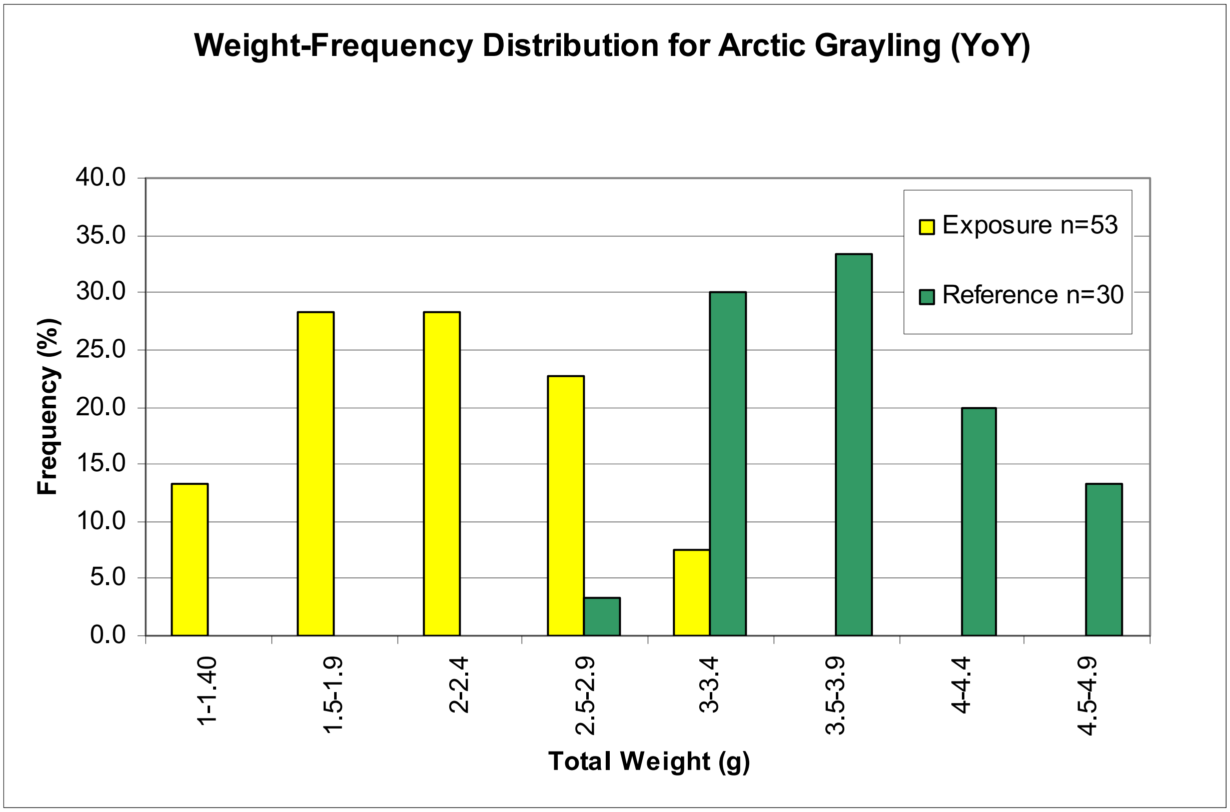


Figure 21. Total Weight-Frequency Distribution for Arctic Grayling (YoY) by Area



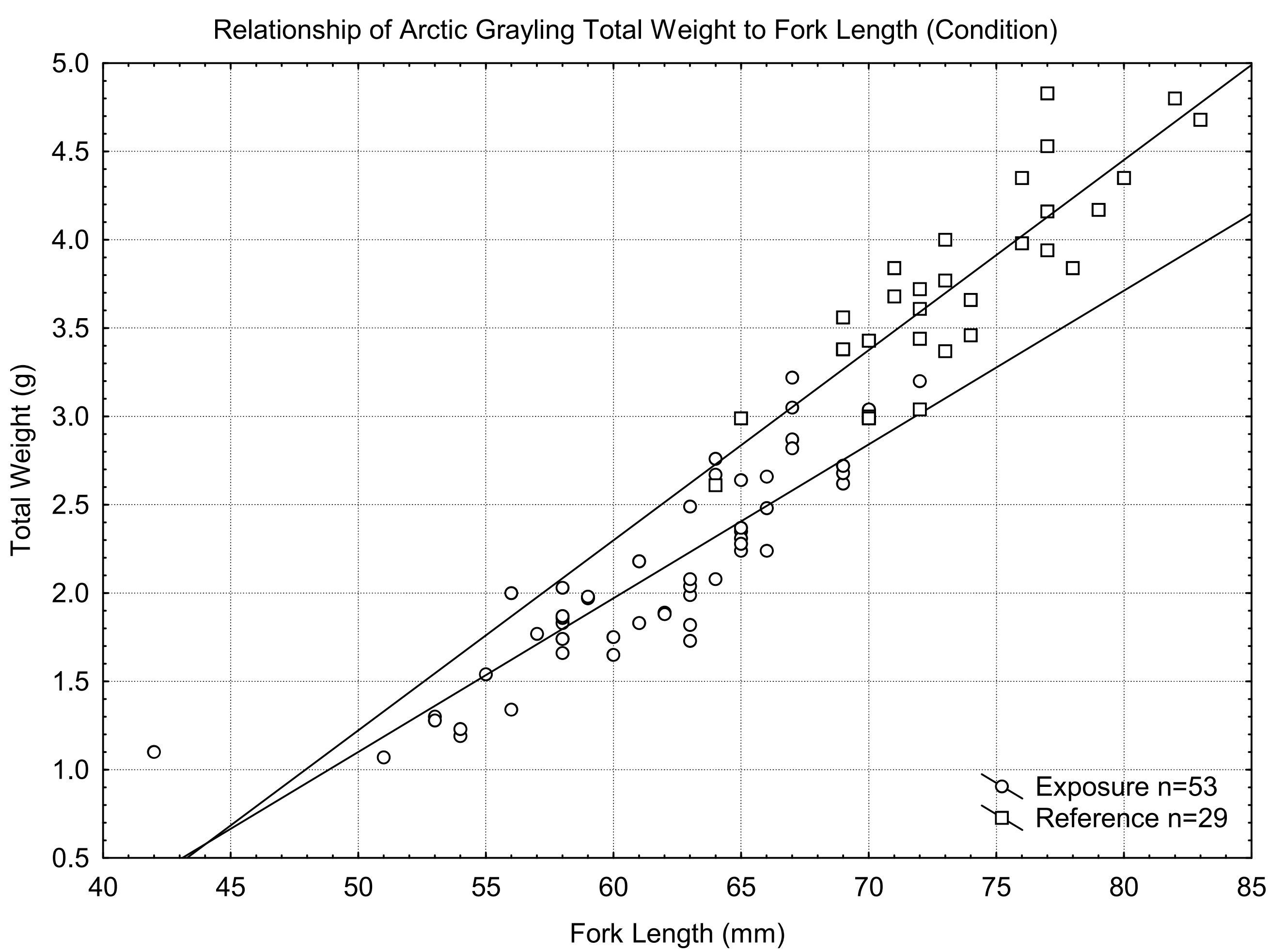
5.4.4.5 Energy Storage

The effect endpoint of condition for young-of-year Arctic grayling as determined by comparing the fork length-total weight relationships was significantly different between the exposure and reference areas (Figure 22). The interaction term was not significant indicating that the slopes were similar between the two areas, however the intercept was significantly higher in the reference area. The condition of the YoY fish in the reference area was 18% higher than in the exposure area, which indicated that for a given length, the fish weighed less in the exposure area. The linear length-weight relationships were described by the following equations:

Exposure Area: Total weight (g) = 0.0871 x Fork length (mm) – 3.2529, r^2=0.79

Reference Area: Total weight (g) = 0.1077 x Fork length (mm) – 4.1607, r^2=0.75

Figure 22. Relationship of Arctic Grayling Total Weight to Fork Length (condition)

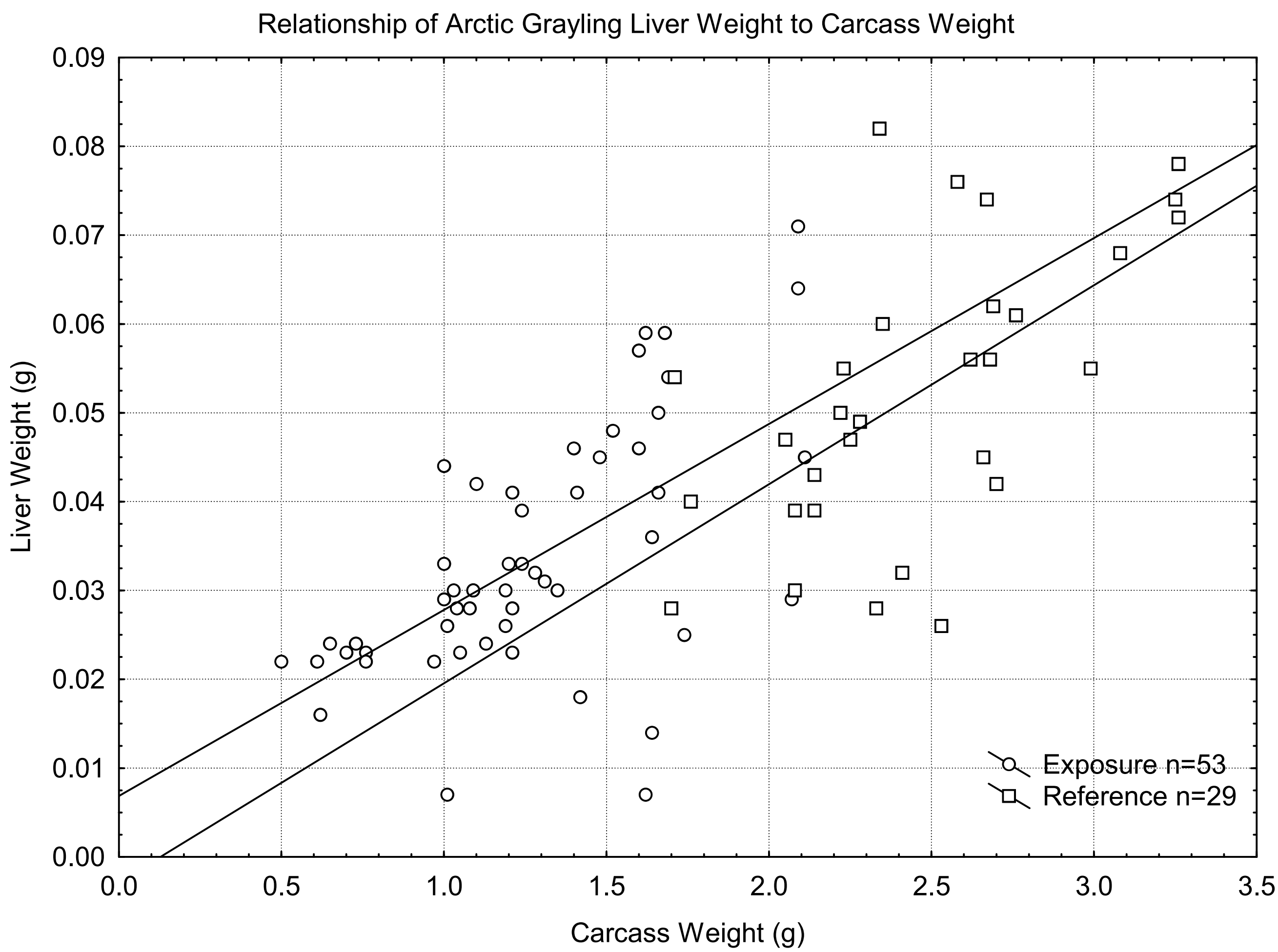


There was no significant difference in the relationship of liver weight to carcass weight for young-of-year Arctic grayling by area. This was determined by comparing the slopes and intercepts of the distributions by area (Figure 23). The linear liver to carcass weight relationships were described by the following equations:

Exposure Area: Liver weight (g) = 0.0209 x Carcass weight (g) + 0.0069, r^2=0.36

Reference Area: Liver weight (g) = 0.0224 x Carcass weight (g) – 0.0029, r^2=0.36

Figure 23. Relationship of Arctic Grayling Liver Weight to Carcass Weight by Area

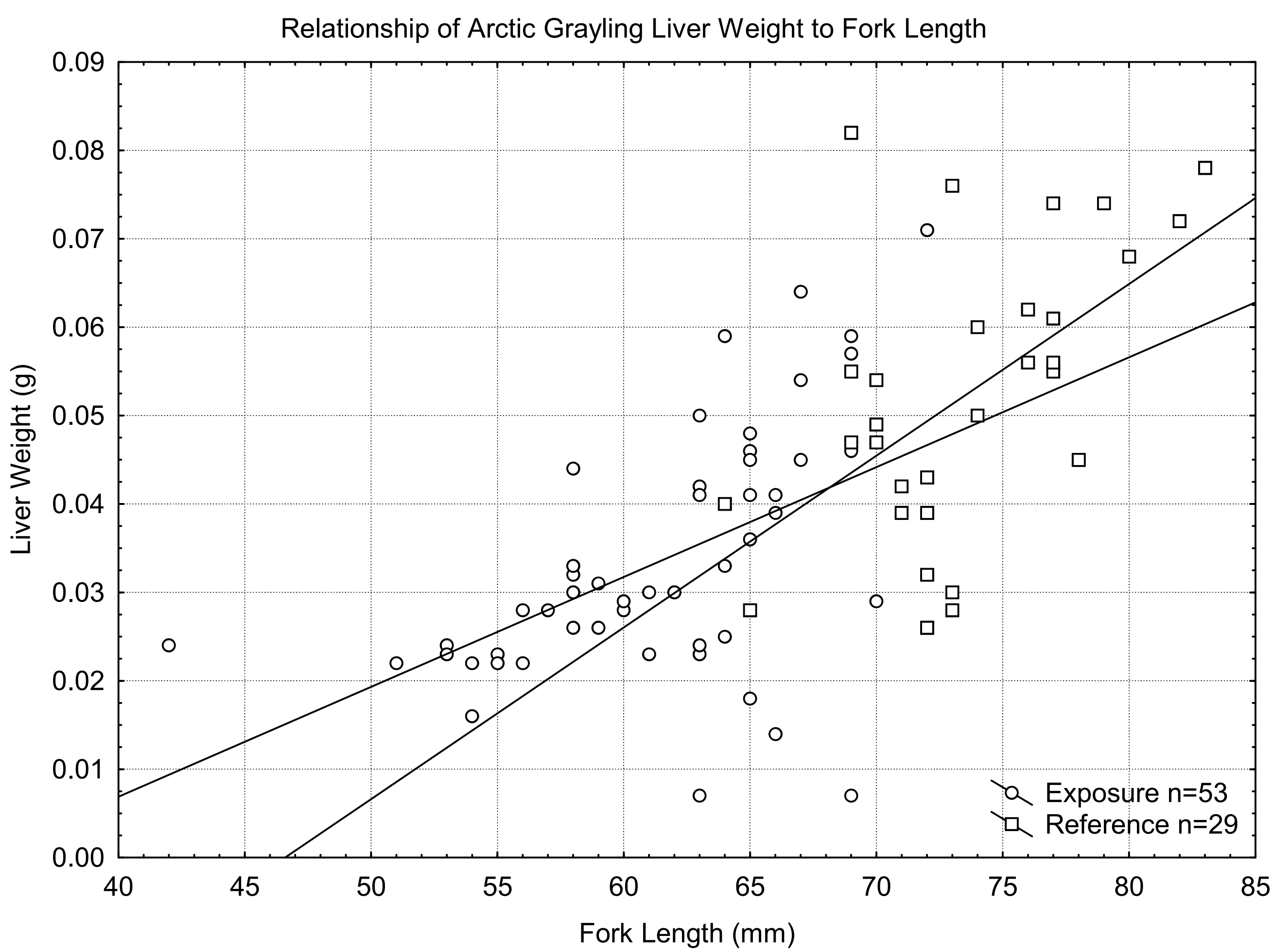


There was a significant difference in the relationship of relative liver weight to fork length by area for Arctic grayling (Figure 24). The supporting variable endpoint of relative liver weight to fork length for young-of-year Arctic grayling as determined by comparing the liver weight-fork length relationships was significantly different between the exposure and reference areas (Figure 24). The interaction term was not significant indicating that the slopes were similar between the two areas, however the intercept was significantly higher in the reference area. The relative liver weight of the fish in the reference area was 4% higher than in the exposure area, which indicated that for a given fork length the livers weighed less in the exposure area. The linear length-weight relationships were described by the following equations:

Exposure Area: Liver weight (g) = 0.0012 x Fork length (mm) – 0.0428, r^2=0.26

Reference Area: Liver weight (g) = 0.0019 x Fork length (mm) – 0.0906, r^2=0.30

Figure 24. Relationship of Arctic Grayling Liver Weight to Fork Length by Area



5.4.4.6 Tissue Analysis

The laboratory results of the muscle tissue analysis for copper concentration are provided in Appendix D Table D-6 and the statistical summary is provided in Table 18. A statistical t-test ($P<0.1$) has indicated that there is no significant difference in copper concentrations from Arctic grayling muscle tissue between the exposure and reference areas.

Table 18. Summary Statistics for Copper in Arctic Grayling Tissue (in mg/kg)

Location	n	Median	Mean	SD	Minimum	Maximum
Exposure	8	0.53	0.55	0.11	0.440	0.810
Reference	8	0.55	0.55	0.04	0.500	0.610

5.4.4.7 Power Analysis

Based on Cycle 1 power analysis results (Table 13), the data in this study had power greater than 90% to detect a change in 10% of length of young-of-year grayling, 20% in weight, 5% in condition and 10% in relative liver weight.

5.4.5 Fish Health – Ninespine Stickleback

5.4.5.1 General Health

In total, 104 ninespine stickleback from the exposure area and 95 from the reference area were used in the lethal sampling program. External and internal examinations revealed no major abnormalities present however five specimens in the exposure area had slightly pale livers.

5.4.5.2 Summary Statistics

All of the captured ninespine stickleback were immature, and length-frequency distribution indicated that no distinct size classes were captured during the survey (Figure 25). Due to the small size of specimens, it was not possible to collect aging structures from immature individuals, so for statistical analyses it was assumed that all the fish were of the same age. Summary statistics for ninespine stickleback were calculated for total length, weight, liver weight and carcass weight for both the exposure and reference areas (Table 19). The results of the statistical analysis of the effect and supporting variables for ninespine stickleback are summarized in Table 20.

Table 19. Summary Statistics for Ninespine Stickleback

Location	Variable	n	Median	Mean	SD	SE	Minimum	Maximum
Exposure	Total Length(mm)	104	37.00	36.70	5.54	0.54	25.00	51.00
	Total weight (g)	103	0.25	0.26	0.12	0.01	0.09	0.65
	Liver weight (g)	104	0.00	0.01	0.00	0.00	0.00	0.02
	Carcass weight (g)	103	0.13	0.14	0.07	0.01	0.05	0.36
Reference	Total Length(mm)	95	25.00	26.25	5.20	0.53	17.00	51.00
	Total weight (g)	94	0.09	0.11	0.08	0.01	0.05	0.74
	Liver weight (g)	94	0.00	0.00	0.00	0.00	0.00	0.01
	Carcass weight (g)	95	0.04	0.01	0.06	0.01	0.02	0.48

Note: SD-Standard Deviation, SE-Standard Error

Table 20. Results of the Statistical Analyses for Ninespine Stickleback

Type of Response	Endpoint	Interaction Statistic P	Intercept Statistic P	Statistically Significant Difference	Direction of Difference	Magnitude of Difference (%)
Effect Endpoints						
Energy Storage	Condition	<0.0001	<0.0001	Yes	Ref>Exp	15
	Relative Liver Weight	<0.0001	0.177	No		
Supporting Variables						
Energy Use	Body weight	n/a	<0.0001	Yes	Exp>Ref	138
	Length	n/a	<0.0001	Yes	Exp>Ref	40
Energy Storage	Relative Liver Weight	<0.0001	<0.0001	Yes	Exp>Ref	9

5.4.5.3 Energy Use

The total length-frequency and total weight-frequency distributions for ninespine stickleback are presented in Figures 25 and 26 .The supporting variables of total body weight and length of ninespine stickleback were statistically different between exposure and reference areas (t-test, P<0.1). The fish in the exposure area weighted 138% more and were 40% longer than individuals in the reference area.

Figure 25. Total Length-Frequency Distribution for Ninespine Stickleback by Area

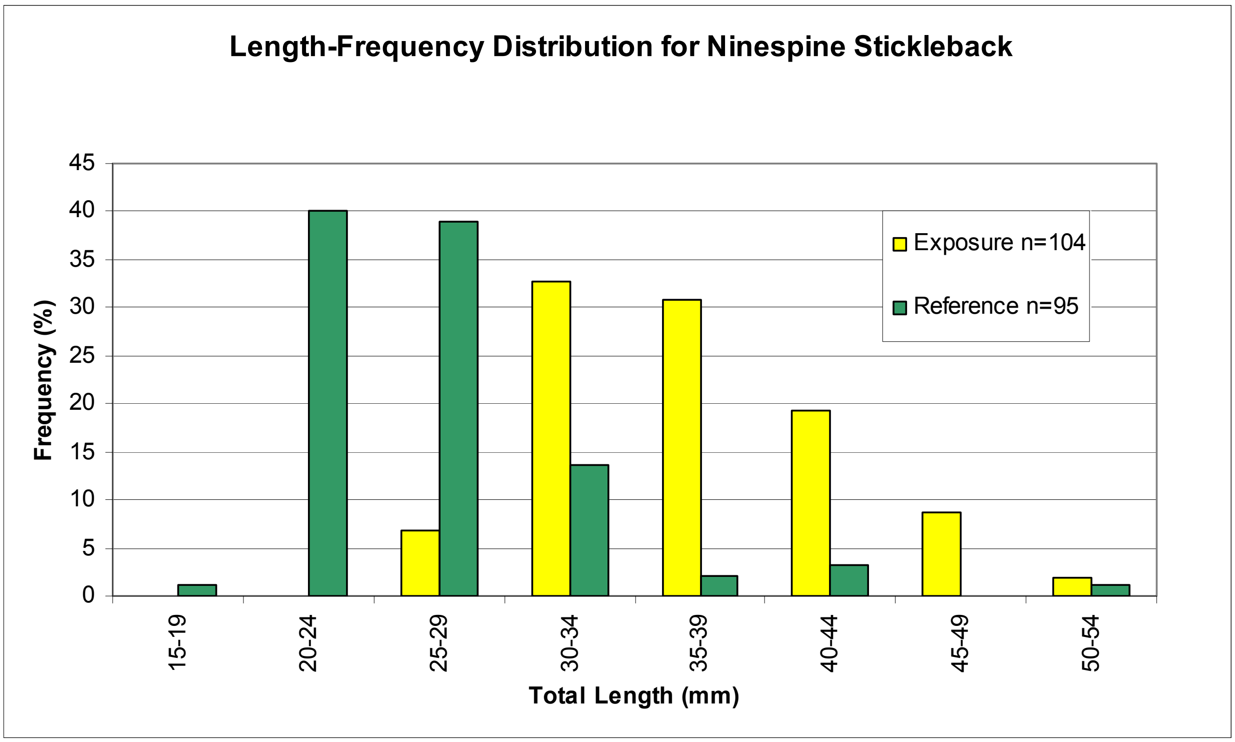
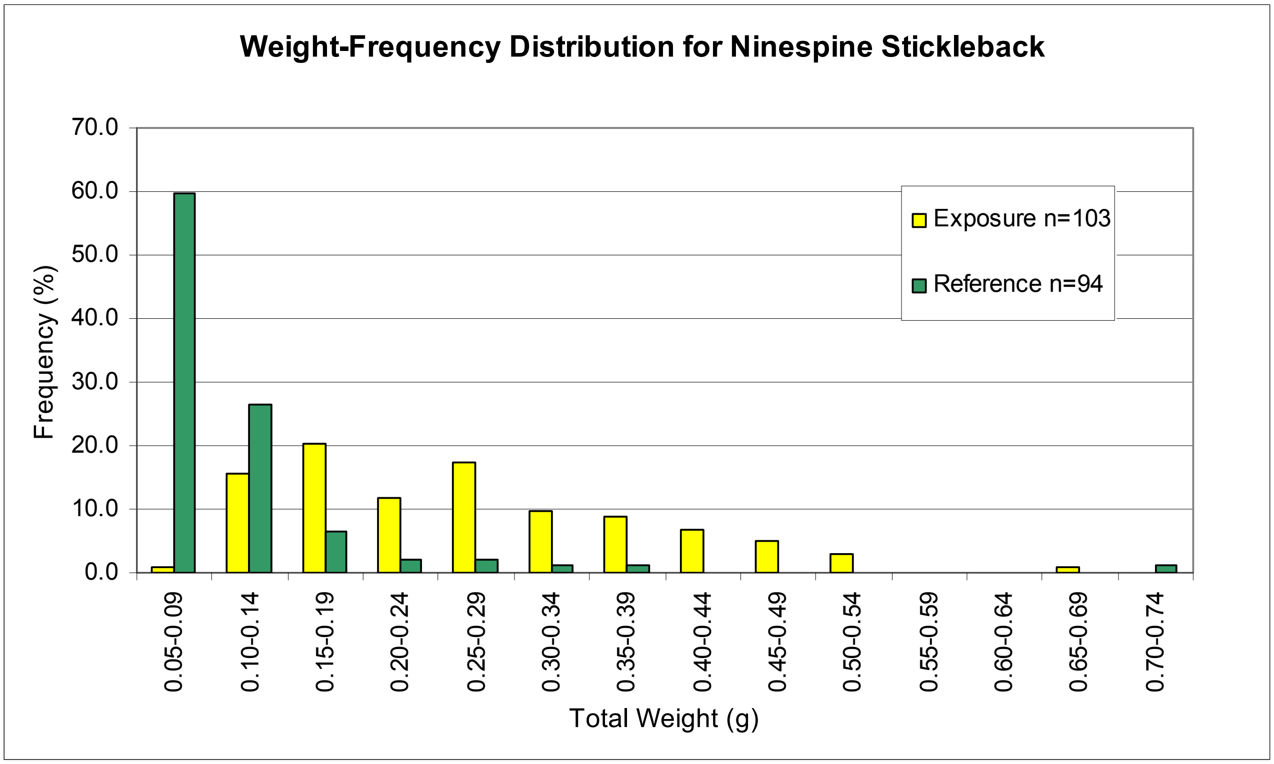


Figure 26. Total Weight-Frequency Distribution for Ninespine Stickleback



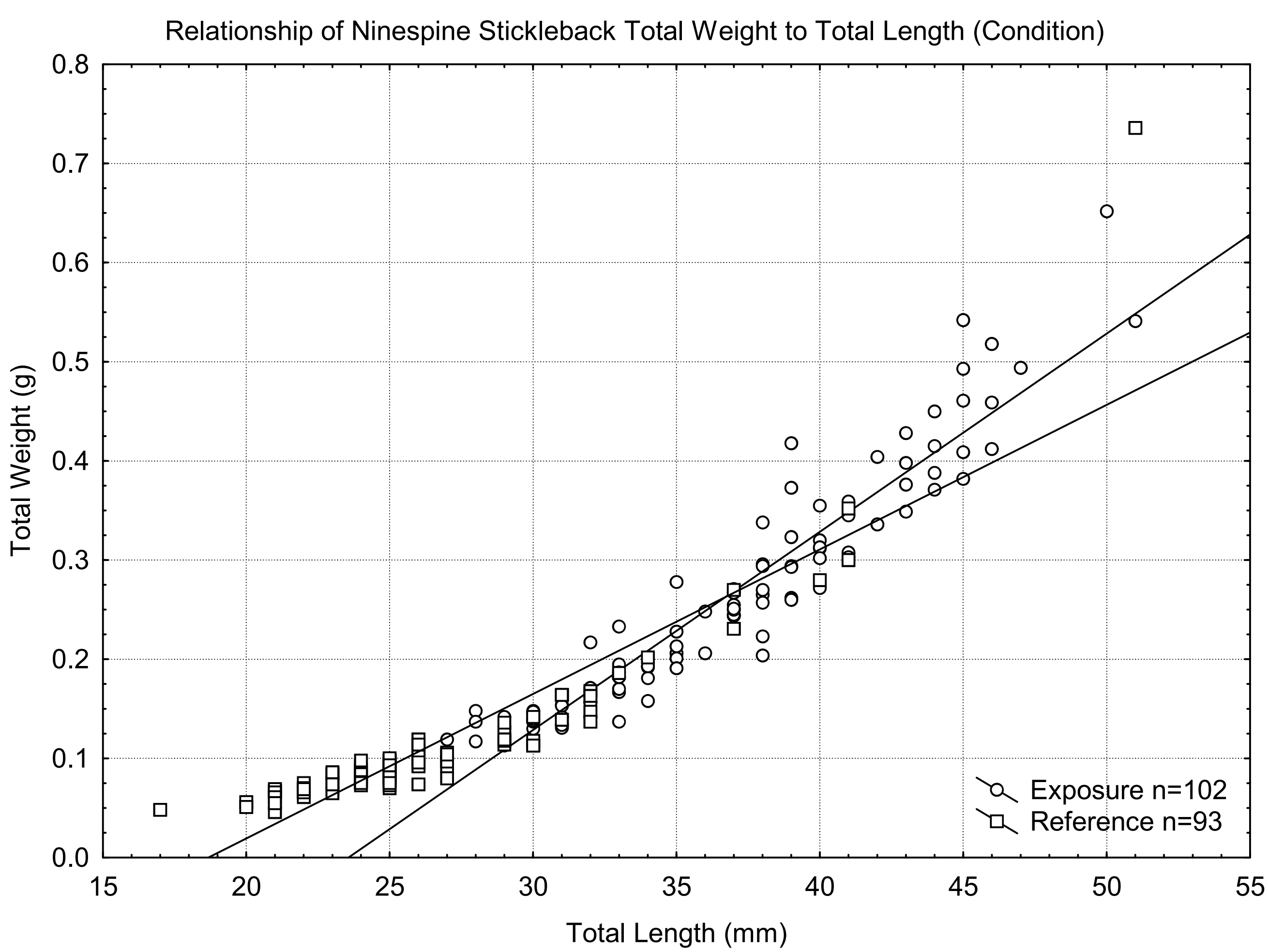
5.4.5.4 Energy Storage

The effect endpoint of condition for ninespine stickleback as determined by comparing the length-weight relationships was significantly different between the exposure and reference areas (Figure 27). The interaction term was not significant indicating that the slopes were similar between the two areas, however the intercept was higher in the reference area. The condition of the ninespine stickleback in the reference area was 15% higher than in the exposure area, which indicated that for a given length, fish weighed less in the exposure area. The linear length-weight relationships were described by the following equations:

Exposure Area: Total weight (g) = 0.02 x Fork length (mm) – 0.471, r^2=0.90

Reference Area: Total weight (g) = 0.0146 x Fork length (mm) – 0.2723, r^2=0.81

Figure 27. Relationship of Ninespine Stickleback Total Weight to Total Length (condition)

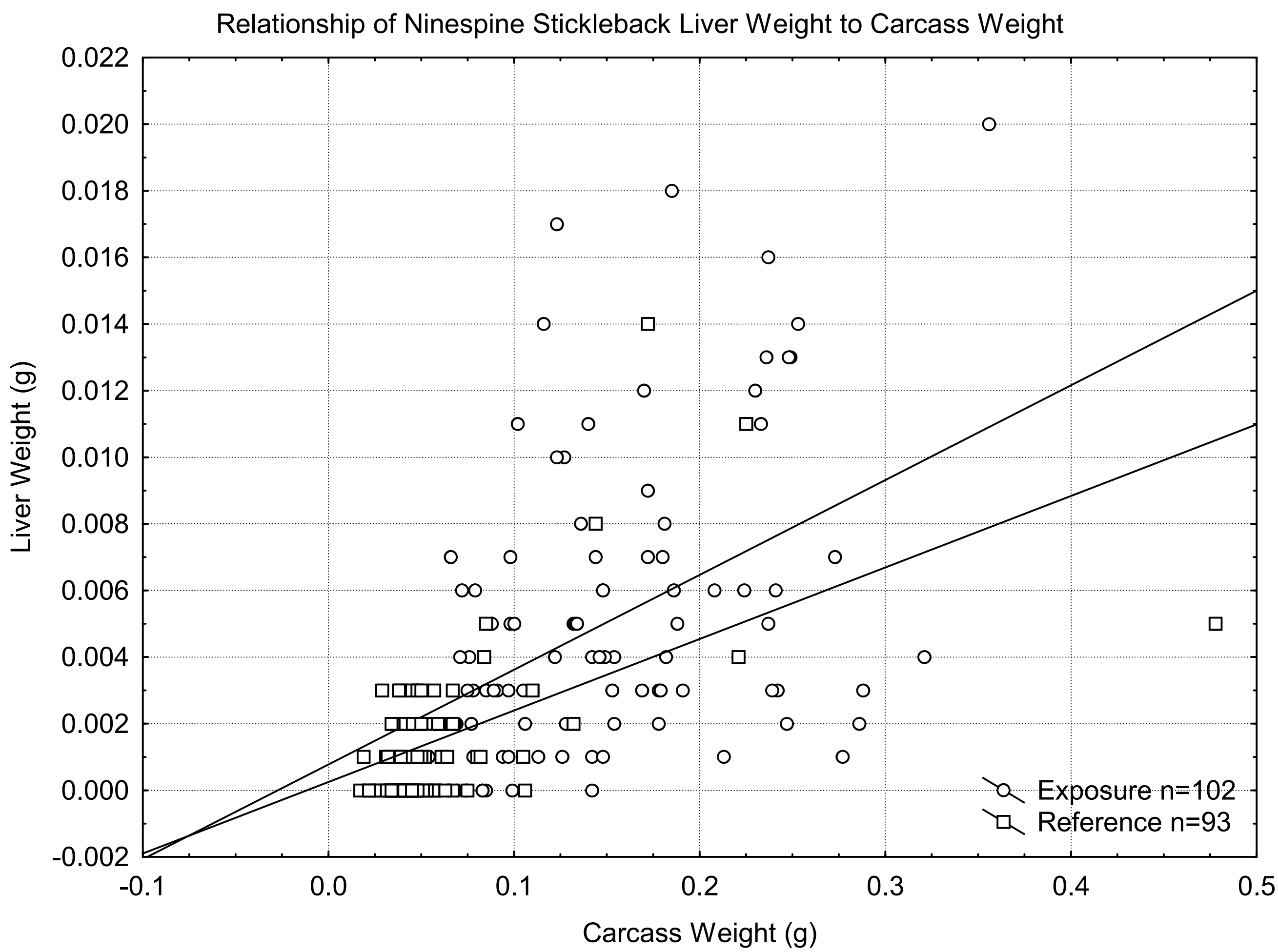


The effect endpoint of liver weight to carcass weight for ninespine stickleback was not significantly different between the exposure and reference areas (Figure 28). The linear liver to carcass weight relationships were described by the following equations:

Exposure Area: Liver weight (g) = 0.0285 x Carcass weight (g) + 0.0008, r^2=0.20

Reference Area: Liver weight (g) = 0.0215 x Carcass weight (g) + 0.0002, r^2=0.31

Figure 28. Relationship of Ninespine Stickleback Liver Weight to Carcass Weight by Area

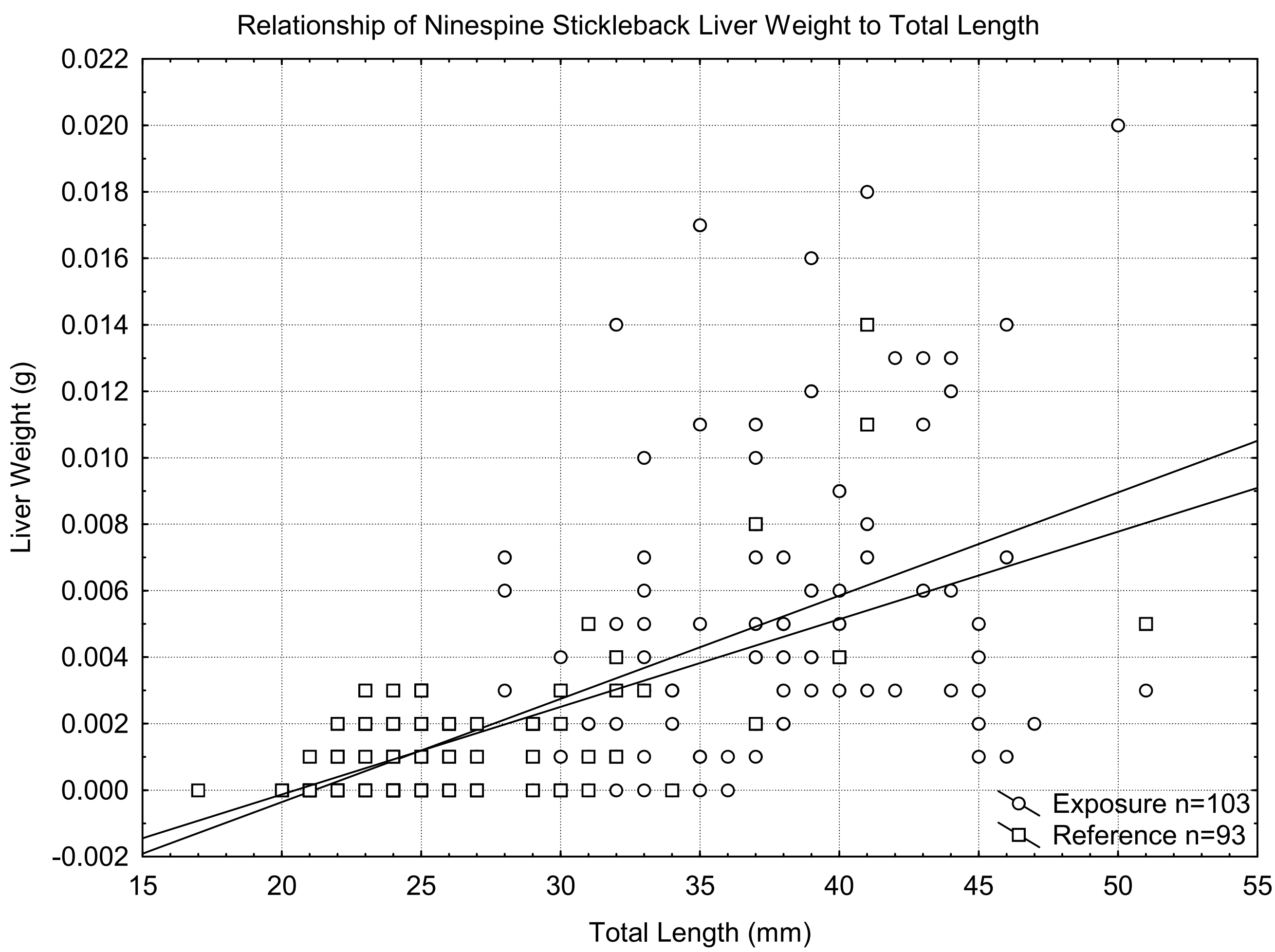


The supporting variable endpoint of relative liver weight to total length for ninespine stickleback was significantly different between the exposure and reference areas (Figure 29). The interaction term was not significant indicating that the slopes were similar between the two areas, however the intercept was higher in the exposure area. The relative liver weight of the fish in the exposure area was 9% higher than in the reference area, which indicated that for a given length the livers weighed more in the exposure area. The linear length-weight relationships were described by the following equations:

Exposure Area: Liver weight (g) = 0.0003 x Fork length (mm) – 0.0066, r^2=0.15

Reference Area: Liver weight (g) = 0.0003 x Fork length (mm) – 0.0054, r^2=0.40

Figure 29. Relationship of Ninespine Stickleback Liver Weight to Total Length by Area



5.4.5.5 Power Analysis

Based on Cycle 1 power analysis results (Table 13) the data in this study had power greater than 90% to detect a change in 5% of length of ninespine stickleback, 15% in weight, 5% in condition and 5% in relative liver weight.

5.5 Discussion and Comparison to Cycle 1

5.5.1 Summary of Results

Sampling location details provided in the Cycle 1 study (Golder 2006a,b) were used to locate sampling areas for the current study. Recommendations from the Cycle 1 study were used to enhance the current study design. Arctic grayling and ninespine stickleback were selected as the target fish species for the study since there were very few slimy sculpin captured. Fish collection for Cycle 1 was conducted between August 19 and September 4, 2005 and involved the use of a variety of gear including gill nets, fyke nets, hoop nets, baited minnow traps and a backpack electrofisher.

In the Cycle 2 study, the field program was conducted between August 28 and September 9, 2008. Similar sampling methods and effort were applied in the exposure and reference areas. Fish collection was completed by using backpack electrofishing, baited minnow traps and gill nets. Backpack electrofishing was the most successful method.

Supplementary field observations indicate that different types of fish habitat were present in the two areas, with the exposure area containing more pond and creek type habitats and the reference area containing more lake habitat and less creek habitat. The presence of a large sandbar at the mouth of Fingers Creek and the close proximity to Contwoyto Lake may influence the species assemblages and population densities of Arctic grayling in the reference area.

5.5.2 Fish Capture Data

In the Cycle 1 study, electrofishing, fyke nets, minnow traps and gill nets were used and 188 fish were captured in the exposure area while 71 fish were captured in the reference area (Table 21). In total, 86 Arctic grayling and 99 ninespine stickleback were captured in the exposure area while 52 grayling and one stickleback were captured in the reference area. Most of the grayling in the exposure area were captured using a backpack electrofisher (36 fish) and gill nets (45 fish) while the majority of fish in the reference area were captured with a backpack electrofisher (49 fish). Most of the ninespine stickleback in the exposure area were captured using baited minnow traps (90 fish). The total catch-per-unit-effort was 0.23 fish/hour for the exposure area and 0.074 fish/hour for the reference area.

Table 21. Summary of Fishing Effort between Cycle 1 and Cycle 2

		Cycle 1 (2005)			Cycle 2 (2008)		
Capture Method	Location	Effort (hours)	Number of Fish	CPUE (fish/hour)	Effort (hours)	Number of Fish	CPUE (fish/hour)
Gill nets	Exposure	102.4	48	0.47	819	41	0.05
	Reference	4	11	2.75	1031	28	0.027
Minnow Traps	Exposure	588.6	90	0.15	681	5	0.007
	Reference	759.7	2	0.003	2140	21	0.01
Electrofishing	Exposure	0.82			7.96	201	25.266
	Reference	1.4	54	1.07	11.77	233	19.789
Fyke Net	Exposure	90.9	13	0.14	Method not used		
	Reference	Method not used					
Hoop Net	Exposure	Method not used					
	Reference	189.4	4	0.02	Method not used		
	Total Exposure		188	0.23		247	0.164
	Total Reference		71	0.074		282	0.089

In the Cycle 2 study, fish were captured in a variety of habitats in the exposure (Seep Creek) and reference (Fingers Creek) areas at similar locations as in Cycle 1 study (Golder, 2006a). Overall catch-per-unit-effort (CPUE) rates were higher in the exposure area in Cycle 1 as compared to Cycle 2 but higher in the reference area in Cycle 2 as compared to Cycle 1. In Cycle 2 the majority of fish were captured by backpack electrofishing and lesser amounts were captured with gill nets (Table 21). Compared to Cycle 1 study, the CPUE rates were significantly lower for all species which indicates that the fish densities were considerably lower in both areas.

The overall age/size distribution of Arctic grayling and ninespine stickleback were significantly different between the two studies with a significant portion of the Arctic grayling belonging to young-of–year age class in 2008 while age 1 fish were more numerous in 2005. Similarly, ninespine stickleback were significantly smaller in 2008, and no adults were caught in either the exposure or reference areas.

5.5.3 Supporting Environmental Variables

At the time of Cycle 1 study, effluent was not being discharged from the tailings ponds but it had been discharged up to August 11, 2005. Water was slightly acidic in the Seep Creek drainage (5.3 to 5.6) and in the Fingers Creek drainage (5.3 to 5.9). Field conductivity was higher in the exposure area (90-240 µS/cm) than in the reference area (10 to 120 µS/cm).

For Cycle 1, nitrate and ammonia concentrations were slightly elevated within the exposure area relative to the reference area, while nitrite and phosphorus concentrations were below detection limits in both areas. Metal concentrations were elevated in the exposure area compared to the reference area and were higher in the areas closer to the discharge location. In the exposure area aluminum, arsenic, cadmium, copper, lead, nickel and zinc concentrations were above CWQG for protection of aquatic life.

During 2008, no effluent was released however field conductivities were still higher in the exposure area, and decreased with increasing distance from the tailings ponds. Concentrations of most metals were elevated in the exposure area, however compared to Cycle 1 study arsenic, lead and zinc levels were below the CWQG levels. Detailed comparison of water quality parameters is discussed in Section 3.

5.5.4 Fish Health

5.5.4.1 Arctic Grayling

The majority of the fish from both areas in Cycle 1 did not have any recordable abnormalities; however, one fish from the exposure area had severe fin erosion and one fish had abnormal liver texture. Ageing of Arctic grayling indicated that 34 fish were young-of-year, 51 were age 1 and one was age 2 in the exposure area. In the reference area 8 fish were young-of-year, 31 were age 1 and 6 were age 2. Due to the limited number of specimens captured in the young-of year and age 2 categories, only age 1 Arctic grayling was used in the statistical analyses. The summary statistics for age 1 Arctic grayling including fork length, total weight, carcass weight and liver weight are listed in Table 22.

Table 22. Cycle 1 Summary Statistics for Age 1 Arctic Grayling (Golder 2006a)

Location	Variable	n	Median	Mean	SD	SE	Minimum	Maximum
Exposure	Fork Length(mm)	51	101	103	9.3	1.3	86	122
	Total weight (g)	47	10.4	11.3	3.3	0.5	7.1	19.6
	Carcass weight (g)	37	7.34	8.2	2.5	0.4	4.9	13.4
	Liver weight (g)	37	0.1	0.1	0.04	0.01	0.1	0.2
Reference	Fork Length(mm)	31	111	110	3.3	0.5	92	123
	Total weight (g)	31	17.3	16.4	3.5	0.6	8.2	22.9
	Carcass weight (g)	29	13.2	13.1	3.2	0.6	6.7	18.9
	Liver weight (g)	29	0.2	0.2	0.04	0.01	0.1	0.2

The major findings on Arctic grayling health from the Cycle 1 study included:

- Age 1 Arctic grayling were 31% heavier and 7% longer, on average, in the reference area than in the exposure area.
- Condition was 7.5% greater in the reference fish than in the exposure fish.
- Liver weight to carcass weight was not statistically different between the two areas.
- The supporting variable of liver weight to fork length was 9.5% lower in the exposure area than in the reference area fish.

For the Cycle 2 study, the statistical comparisons of the two populations of young-of-year Arctic grayling indicated that the mine effluent significantly affected the parameters of energy use and storage in the exposure area. The major findings on Arctic grayling health from the Cycle 2 study include:

- The effect endpoint of condition (weight-length) was significantly lower in the exposure area; however, the relative liver weight (liver weight-carcass weight) was not statistically different between the two areas.
- The supporting variables of relative liver weight (liver weight-fork length) and total weight and length were also significantly lower in the exposure area compared to the reference area.

These results may indicate that liver function may be impaired in the presence of the mine effluent in the exposure area. Decreased liver weight may be related to the elevated concentrations of specific metals such as cadmium (Norris *et al.* 2000; Ricard *et al.*. 1998). However, it could also be attributed to other factors such as water temperature, food availability, competition, and predation (Schlenk *et al.* 2008).
The results of the analysis of copper concentrations in muscle tissue indicate that there are no statistically significant differences in copper concentration in the exposure and reference areas. However, since metals tend to bioaccumulate in livers, and insufficient numbers of livers were available for analysis, it may be possible that there may be more copper accumulating in liver tissues than is evident from muscle tissue analysis (Buckley *et al.* 1982). The results of the previous study indicate that there was a significant difference in the concentration of copper in liver tissue in the exposure and reference areas (Golder 2006a) but this relationship could not be confirmed during this study.

5.5.4.2 Ninespine Stickleback

In the Cycle 1 study, 99 stickleback were captured in the exposure area and 30 fish were examined for abnormalities and parasites. From these fish, 13% had recordable abnormalities and 20% had parasites. Since only one stickleback was caught in the reference area, a statistical comparison between the exposure and reference areas could not be made. Summary statistics from the Cycle 1 study for length, total weight, carcass weight and liver weight for ninespine stickleback in the exposure area are listed in Table 23.

Table 23. Cycle 1 Summary Statistics for Ninespine Stickleback (Golder 2006a)

Location	Variable	n	Median	Mean	SD	SE	Minimum	Maximum
Exposure	Total Length(mm)	99	55	56	5.184	0.521	43	74
	Total weight (g)	99	1.02	1.08	0.326	0.033	0.65	2.72
	Liver weight (g)	17	0.04	0.04	0.043	0.011	0.02	0.2
	Carcass weight (g)	17	0.52	0.60	0.238	0.060	0.34	1.23

The mean total length for ninespine stickleback in the exposure area was 56 mm (range 43 to 74 mm) and the mean weight was 1.08 g (range 0.65 to 2.72 g). Condition was assessed using linear regression analysis (r^2=0.80). Relative liver weight was assessed using linear regression analysis. No relationship was found between liver weight and carcass weight (r^2=0.003) or liver weight and total length (r^2=0.003).

The results of the statistical comparisons of the two populations of ninespine stickleback in Cycle 2 indicated that the presence of mine effluent significantly affected the parameters of energy use and storage in the exposure area. The major findings on stickleback health from the Cycle 2 study include:

- Condition (weight-length) was significantly higher in the reference area.
- Relative liver weight (liver weight-carcass weight) was not statistically different between the two areas.
- The supporting variables of relative liver weight (liver weight-fork length) and total weight and length were significantly higher in the exposure area compared to the reference area.

These results indicate that even though the fish in the exposure area are longer and heavier than in the reference area, their condition is poorer. Although the liver weight-length endpoint is not considered an effect endpoint, it is significantly higher in the exposure area, which may signify that liver weight is increased in the area exposed to the effluent, which was observed in other studies examining the effects of metal pollution of fish (Lowell *et al.*2005). This contradicts the findings for Arctic grayling in which liver weight-fork length ratio was lower in the exposure area. Based on the different growth rates, ages and habitat preferences the two species may have different adaptive responses to metals with sticklebacks having higher rates of liver metabolic activity as a result of closer association with metal exposed sediments (Paris-Palacios *et al.*2005). Another finding that supports this is the observation that six of the livers taken from the exposure area were depigmented, which may indicate liver function impairment (Moiseenko and Kudryavtseva, 2001).

Several factors other than the presence or absence of mine effluent (and historical contamination) may have influenced the stickleback size in the reference area. One of these factors could be the underlying assumption that both populations consist of individuals belong to the same age class. It may not always be the case since ninespine stickleback generally spawn once in the summer but they may also spawn more than once in a season (Scott and Crossman, 1998). Hence fish which may be in the same age class may in fact hatch at different times which would influence their growth characteristics. Also, due to the difficulty in accurately analyzing ageing structures of small bodied fish, separate age classes may be present in the exposure and reference areas which would make statistical comparisons difficult. Other potential factors that could have a strong influence on energy use but were not evaluated in detail include increased predation pressure and decreased resource availability in the reference area. This may be supported by the fish capture results which indicated that a significant number of lake trout, slimy sculpin and immature burbot were caught in the reference area stickleback habitat, while relatively low numbers of these predators were caught in the exposure area. Another factor, which may influence the size of stickleback in the reference area, is the amount of suitable habitat, which was not as abundant as in the exposure area.

5.5.5 Summary

In summary, the monitoring program has determined that the historical presence of mine effluent has had a negative impact on the population of Arctic grayling and ninespine stickleback in the exposure area as compared to the reference area. The grayling in the reference area were longer, heavier and in generally in better condition than grayling in the exposure area. This was similar to the results obtained during Cycle 1 study (Golder 2006a). The livers of the fish in the exposure area were smaller which may indicate hepatic function impairment and reduced fish condition caused by the mine effluent.

Ninespine stickleback in the reference area were in a better condition than in the exposure area, however the size and weight of the fish in the reference area were significantly lower than in the exposure area. This was most likely caused by presence of different age classes in the two areas. It is also likely that other environmental factors such as predation and habitat availability play key roles in the responses of ninespine stickleback population in the reference area however the influence of these factors was not quantitatively measured in this study.

6. Recommendations

6.1 Benthic Survey

Subsequent monitoring studies for benthic invertebrate community composition should follow the same study design used for Cycle 1 and Cycle 2. Timing for future studies and similar methods should be used to ensure that results from Cycle 1 and 2 can be comparable to future studies. The Cycle 1 study completed sub-lethal toxicity testing and concluded that effluent was not acutely lethal to fathead minnows or *Ceriodaphnia* dubia but effects on growth and reproduction were noted in *Ceriodaphnia dubia, Pseudokirchneriella subcapitata* and *Lemna minor*. In addition, the effluent plume modelling suggested that the potential zone of biological effects from effluent release could extend as far as Outer Sun Bay. Both the Cycle 1 and 2 field studies were conducted when effluent was not being released to the environment and as such actual effects of effluent release on the invertebrate community have not yet been observed. Future studies should be conducted when effluent is being release or immediately after release.

6.2 Supporting Environmental Variables

Supporting environmental variables include field chemistry, sampling area physical measurements, lab water quality analysis and sediment quality analysis. These data are very useful in the interpretation of effects and response by indicator organisms. Any future studies should include the collection of these data.

6.3 Fish Survey

In any future fish surveys it is recommended that a secondary reference area should be chosen in order to provide Arctic grayling and ninespine stickleback habitats that would more closely approximate the conditions found in the exposure area i.e. more stream habitats with shallow ponds. This would allow for a capture of more Arctic grayling and would limit the influence of factors such as habitat availability and predation pressure on ninespine stickleback. The area should also be located further away from the mine area, which would limit the possibility of fish migration between the exposure and reference area, and would eliminate any contamination via subsurface flow from the tailings area. The capture of more grayling and larger stickleback in the exposure and reference areas would also allow for a statistical comparison of metal concentrations in liver tissue which would provide a more accurate estimate of the extent of metal accumulation resulting from effluent discharge.

6.4 Future Studies

Results of the Cycle 2 study indicated that the benthic invertebrate community and fish community have been influenced by mine effluent. Results of the Cycle 1 and 2 studies have indicated that invertebrates and fish have been influenced by mine effluent in at least one measured effect endpoint. Based on the MMER guidance document, the mine is required to continue with subsequent Periodic Monitoring – Surveillance Study. Under MMER, if the mine's rate of production is less than 25% of design capacity, then the mine operator can apply for "closed mine" status. The steps to obtained closed status are summarized:

- Obtain records to verify that the mine has operated at 25% of design capacity for a period of three years
- Provide written notice to Authorization Officer (AO) at Environment Canada
- Submit to the AO a biological monitoring study within six months of providing notice
- Conduct study
- Submit interpretative report

The schedule to complete another monitoring study or to apply for closed status is outlined in Table 24.

Table 24. Schedule for Future EEM Program Study

Study Type	Phase	Execution/Submission Date
Periodic Monitoring – Surveillance	EEM Study Design	6 months prior to field program in 2011
	Field Program	Late Summer 2011
	Interpretative Report	June 2012
Application for Closure	Notice for closure status	After 3 years of operating at 10% design capacity
	Study Design	6 months after submitting notice
	Field Program	Late Summer after study design approved
	Interpretative Report	36 months after submitting written notice

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Appendix A

Study Design Approval and Supporting Documentation

Environmental Protection Operations
Prairie & Northern
Environment Canada
Room 200, 4999-98th Avenue NW
Edmonton, AB T6B 2X3

File: 7834-3-37/E77-1

August 20, 2008

Mr. Aaron MacDonell
Health Safety and Environment Coordinator
Lupin Mine
Oz Minerals Ltd.
401 – 1113 Jade Court
Thunder Bay, ON
P7B 6M7

Dear Mr. MacDonell

Re: Evaluation of Phase 2 Environmental Effects Monitoring (EEM) Study Design – Lupin Gold Mine, Nunavut

This letter is to advise you that the Phase 2 EEM Study Design for Lupin Mine has been evaluated and meets the requirements specified in Schedule 5 of the Metal Mining Effluent Regulations (MMER) for environmental effects monitoring studies. The evaluation of this proposed study is based on the Technical Advisory Panel's (TAP) review of the Zinifex Canada Inc. submission entitled '*Environmental Effects Monitoring Study Design, Lupin Gold Mine, Nunavut, Canada'*, received March 13, 2008, the June 24, 2008 addendum to the Study Design sent by Gartner Lee Limited entitled, '*GLL 80436- Lupin Gold Mine 2008 EEM Study Design – Addendum*', the meeting minutes produced from the July 31, 2008 discussion between Gartner Lee Limited, Environment Canada and Oz Minerals Ltd., and subsequent email correspondence (from Paula Siwik to Colleen Prather; August 13, 2008; forwarded to Mike Johns, Adrian Andreacchi and Aaron MacDonell, August 18, 2008).

It is my understanding that the facility will remain in contact with the TAP during field work, and that the TAP will be consulted on field decisions such as sentinel species selection, sample sizes, and EEM endpoints.

If you have any questions please do not hesitate to contact the EEM Coordinator for this facility, Paula Siwik (Email:Paula.Siwik@ec.gc.ca, Tel: 780-951-8824, Fax: 780-495-2758, Cell Phone (field season only): 780-887-0281).

Sincerely,

David Noseworthy
MMER Authorization Officer

cc:
Paula Siwik — Environment Canada, Edmonton

Barry Munson	Environment Canada, Edmonton
Jenny-Marie Ferone	Environment Canada, Edmonton
Craig Broome	Environment Canada, Yellowknife
Adrian Andreacchi	Oz Minerals Ltd., Thunder Bay
Andrew Mitchell	Oz Minerals Ltd., Thunder Bay

Appendix B

Field Chemistry and Water Quality Data

Table B-1. Field Chemistry Data Lupin EEM 2008

Survey Type	Area	Site	Date	Time	Zone	Easting	Northing	Depth (m)	Air Temp (Celcius)	Temp (Celcius)	D.O (mg/L)	pH	Conductivity (µS/cm)	Turbidity (NTU)
Water Quality	Exposure	SCD1	08-Sep-08	11:50	12W	485695	7289659			2.2	13.4	5.6	150	0
		SCP1	08-Sep-08	12:50	12W	481289	7290694			2.4	13.4	6.2	70	0
		SCP5	08-Sep-08	13:40	12W	480594	7290534			3.5	13.0	6.4	60	0
		SNP925-20	08-Sep-08	14:10	12W	480216	7290212			3.5	12.9	6.2	60	0.01
	Reference	FC2	08-Sep-08	8:40	12W	494671	7289051			3.5	13.0	7.6	10	0
		FL5	08-Sep-08	9:50	12W	492618	7286327			4.0	13.0	8.0	10	0.28
		FL1	08-Sep-08	10:50	12W	494145	7287789			3.1	10.8	8.0	10	0.42
Sediment Quality and Benthic Invertebrate Community	Exposure	SCP1	04-Sep-08	10:35	12W	481248	7290713	0.60	6.2	4.5	12.7	6.2	50	0.03
		SCP2	02-Sep-08	15:09	12W	481065	7290479	0.90	4.0	6.8	12.2	5.7	50	12.2
		SCP3	02-Sep-08	15:56	12W	480953	7290309	0.50	4.0	6.5	12.4	5.6	50	0.43
		SCP4	04-Sep-08	12:40	12W	480747	7290395	0.50	8.9	6.7	12.4	6.0	50	0.01
		SCP5	04-Sep-08	13:35	12W	480594	7290521	0.50	7.0	7.0	11.5	6.6	50	1.2
	Reference	FL1	01-Sep-08	10:55	12W	492340	7286260	1.10	3.0	6.0	13.1	5.8	10	
		FL2	01-Sep-08	14:40	12W	493924	7286987	0.70	4.0	6.0	13.0	6.4	10	
		FL3	01-Sep-08	13:47	12W	493806	7287077	1.00	2.0	6.0	13.0	6.0	10	
		FL4	01-Sep-08	13:20	12W	492915	7287024	0.90	3.0	5.0	13.1	6.1	10	
		FL5	01-Sep-08	12:28	12W	492620	7286332	1.20	3.0	6.0	13.1	6.5	10	
Fish Population	Exposure	SCMT1	04-Sep-08	15:00	12W	481340	7290686	0.65		5.0		7.3	50	
		SCMT2	04-Sep-08	15:15	12W	481339	7290672	0.50		5.0		7.3	50	
		SCMT3	04-Sep-08	15:15	12W	481342	7290668	0.48		5.0		7.3	50	
		SCMT4	04-Sep-08	15:00	12W	481357	7290657	0.45		5.0		7.3	50	
		SCMT5	04-Sep-08	15:00	12W	481376	7290666	0.35		5.0		7.3	50	
		SCMT40	04-Sep-08	8:50	12W	485914	7289722	0.10		5.7	11.4	4.6	250	0.11
		SCMT41	04-Sep-08	8:50	12W	485850	7289709	0.10		6.0	11.6	4.9	210	0.07
		SCMT42	04-Sep-08	8:55	12W	485809	7289684	0.10		6.0	11.6	5.1	180	0.07
		SCMT43	04-Sep-08	8:55	12W	485793	7289654	0.10		6.9	11.4	5.1	170	0.07
		SCMT7	05-Sep-08	11:20	12W	481216	7290637	0.10		6.6	12.8	6	50	0.1
		SCMT8	05-Sep-08	11:15	12W	481207	7290690	0.10		6.1	12.9	5.8	60	0.45
		SCEF1	02-Sep-08	15:30	12W	481316	7290688	1.50		6.0		6.4	70	
		SCEF2	04-Sep-08	15:30	12W	480172	7290236	0.75	5.0	4.0		6.5	40	
		SCEF3	05-Sep-08	16:05	12W	480783	7290417	1.00	5.0	6.0		6.4	50	
	Reference	FLGN1	28-Aug-08	19:45	12W	493625	7287128	0.10		6.0	13.7	9.2	10	
		FLGN2	28-Aug-08	20:00	12W	494447	7288523	0.10		7.0	13.1	9.2	10	
		FLGN3	28-Aug-08	20:15	12W	493015	7286911	0.10		6.4	13.3	8.8	10	
		FLMT1	01-Sep-08	16:00	12W	492326	7286267	0.10		7.1	13.2	10.0	20	
		FLMT3	01-Sep-08	13:30	12W	493399	7287444	0.10		6.0	13.7	9.2	10	
		FLMT4	02-Sep-08	9:25	12W	492375	7286244	0.10		6.0	12.7	9.1	20	
		FCMT1	01-Sep-08	14:30	12W	494621	7288861	0.40		7.2		8.5	10	
		FCMT2	01-Sep-08	14:35	12W	494591	7288874	0.50		7.2		8.5	10	
		FCMT3	01-Sep-08	14:40	12W	494600	7288875	0.40		7.2		8.5	10	
		FCMT4	01-Sep-08	14:35	12W	494632	7288899	0.45		7.1		8.6	15	
		FCMT5	01-Sep-08	14:30	12W	494616	7288932	0.50		7.2		8.6	10	
		FCMT6	01-Sep-08	14:25	12W	494634	7288999	0.46		7.0		8.6	10	
		FCMT7	01-Sep-08	14:15	12W	494693	7289074	0.40		7.0		8.6	10	
		FCMT8	01-Sep-08	14:10	12W	494889	7289122	0.40		7.0		8.6	10	
		FCMT9	01-Sep-08	14:00	12W	494908	7289041	0.53		7.0		8.5	10	
		FCMT10	01-Sep-08	14:00	12W	495068	7289255	0.45		7.2		8.5	10	
		FCEF1	28-Aug-08	15:50	12W	495067	7289261	1.00	8.5	7.2		8.5	10	
		FCEF2	01-Sep-08	10:30	12W	496337	7291003	0.27	4.0	5.5	13.4	8.6	10	
		FCEF3	01-Sep-08	-	12W	495872	7290588	0.45	4.0	5.2	13.3	8.6	10	
		FCEF4	01-Sep-08	15:35	12W	494751	7289153	0.43	9.0	7.3	13.7	7.8	10	
		FCEF5	06-Sep-08	16:00	12W	496046	7291098	0.60	-1.0	2.0		9.3	10	
		FCEF6	07-Sep-08	15:45	12W	495109	7289472	0.50	3.0	3.0		7.3	10	

Table B-1. Field Chemistry Data Lupin EEM 2008

Survey Type	Area	Site	Date	Time	Zone	Easting	Northing	Depth (m)	Air Temp (Celcius)	Temp (Celcius)	D.O (mg/L)	pH	Conductivity (µS/cm)	Turbidity (NTU)
Effluent Plume Delineation	Exposure	EP1	08-Sep-08	14:30	12W	479626	7290874			4.0	12.6	6.5	30	0
		EP2	08-Sep-08	14:36	12W	479525	7290844			4.0	12.6	6.6	10	0
		EP3	08-Sep-08	14:44	12W	479102	7292943			4.3	12.4	6.6	10	0
		EP4	08-Sep-08	14:55	12W	478977	7293007			4.2	12.4	6.6	10	0
		EP5	08-Sep-08	15:00	12W	478596	7293922			4.9	12.2	6.7	10	0
		EP6	08-Sep-08	15:05	12W	477875	7293659			5.2	12.1	6.7	10	0

Table B-2. Water Quality Data Lupin EEM 2008

AECOM

Date Reported	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08
ALS Sample ID	L681981-4	L681981-5	L681981-6	L681981-7	L681981-1	L681981-2	L681981-3
Date Sampled	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08
Sample Code	SCD1	SCP1	SCP5	SNP925-20	FC2	FL5	FL1

Parameter	Units	CCME Aquatic Life[a]	DL (Sep08)	SCD1 (EXPOSURE)	SCP1 (EXPOSURE)	SCP5 (EXPOSURE)	SNP925-20 (EXPOSURE)	FC2 (REFERENCE)	FL5 (REFERENCE)	FL1 (REFERENCE)
Physical Tests										
pH	pH unit	6.5-9.0	0.1	*4.9*	*5.5*	*5.6*	*5.6*	6.6	6.6	6.6
Conductivity (EC)	uS/cm		0.2	175	76.8	65.4	65.8	13.2	13.1	12.2
TDS (Calculated)	mg/L		-	98	42	35	34	5	7	4
Hardness (as CaCO3)	mg/L		-	63	29	24	24	7	5	4
Total Suspended Solids	mg/L		3	<3	8	<3	<3	<3	<3	<3
Major Ions										
Alkalinity, Total (as CaCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Bicarbonate (HCO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Carbonate (CO3)	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Hydroxide (OH)	mg/L		5	<5	<5	<5	<5	<5	<5	<5
Calcium (Ca)	mg/L		0.5	13.4	6.0	5.1	5.0	1.5	1.1	0.8
Magnesium (Mg)	mg/L		0.1	7.2	3.3	2.7	2.7	0.7	0.6	0.5
Potassium (K)	mg/L		0.1	1.0	0.5	0.4	0.4	0.4	0.5	0.4
Sodium (Na)	mg/L		1	4	2	1	1	<1	<1	<1
Chloride (Cl)	mg/L		1	3	1	2	1	<1	2	<1
Sulphate (SO4)	mg/L		0.05	68.4	29.0	24.2	24.3	2.54	2.67	2.36
Ion Balance	%		-	96.2	Low EC	Low EC	Low EC	Low EC	Low EC	Low EC
Cyanides										
Cyanide, Total	mg/L	0.005	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Nutrients										
Ammonia-Nirogen	mg/L	0.019	0.005	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Nitrate+Nitrite-N	mg/L		0.006	0.150	0.016	<0.006	<0.006	<0.006	0.007	<0.006
Nitrate-Nitrogen	mg/L	13	0.006	0.150	0.016	<0.006	<0.006	<0.006	0.007	<0.006
Nitrite-Nitrogen	mg/L	0.06	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002
Phosphorus, Total	mg/L		0.001	0.005	0.004	0.004	0.004	0.005	0.008	0.008
Total Organic Carbon	mg/L		1	4	4	6	6	3	3	3
Dissolved Organic Carbon	mg/L		1	4	4	6	6	3	3	3
Total Metals										
Aluminum (Al)	mg/L	0.005-0.1[b]	0.0003	*0.461*	*0.151*	*0.151*	*0.151*	0.0192	0.0158	0.0162
Antimony (Sb)	mg/L		0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Arsenic (As)	mg/L	0.005	0.00003	0.00377	0.00165	0.00194	0.00186	0.00121	0.00143	0.00133
Barium (Ba)	mg/L		0.00005	0.0240	0.0144	0.0130	0.0134	0.00186	0.00185	0.00172
Beryllium (Be)	mg/L		0.0002	0.0004	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Boron (B)	mg/L		0.001	0.007	0.003	0.002	0.002	<0.001	<0.001	<0.001
Cadmium (Cd)	mg/L	0.000017[c]	0.000017	*0.000336*	*0.000082*	*0.000066*	*0.000060*	<0.000017	<0.000017	<0.000017
Calcium (Ca)	mg/L		0.02	13.3	5.53	4.91	4.85	0.88	0.87	0.81
Chromium (Cr)	mg/L	0.001	0.00006	0.00017	0.00011	0.00023	0.00024	<0.00006	<0.00006	<0.00006
Cobalt (Co)	mg/L		0.0001	0.0629	0.0163	0.0123	0.0124	0.0001	<0.0001	<0.0001
Copper (Cu)	mg/L	0.002-0.004[d]	0.0006	*0.0197*	*0.0037*	*0.0038*	*0.0052*	<0.0006	<0.0006	<0.0006
Iron (Fe)	mg/L	0.3	0.005	0.085	0.099	0.099	0.109	0.034	0.028	0.028
Lead (Pb)	mg/L	0.001-0.007[e]	0.00005	0.00013	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Magnesium (Mg)	mg/L		0.004	6.81	2.95	2.49	2.48	0.521	0.517	0.506
Manganese (Mn)	mg/L		0.0001	0.705	0.115	0.0901	0.0903	0.0038	0.0025	0.0025
Mercury (Hg)-Total	mg/L	0.000026	0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum (Mo)	mg/L	0.073	0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006
Nickel (Ni)	mg/L	0.025-0.15[f]	0.00006	*0.170*	*0.0537*	*0.0433*	*0.0426*	0.00065	0.00059	0.00044
Potassium (K)	mg/L		0.02	1.05	0.49	0.44	0.41	0.35	0.37	0.36
Selenium (Se)	mg/L	0.001	0.0001	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silver (Ag)	mg/L	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	mg/L		0.005	3.84	1.41	1.34	1.31	0.441	0.427	0.434
Strontium (Sr)	mg/L		0.0001	0.0601	0.0277	0.0245	0.0244	0.0051	0.0048	0.0046
Uranium (U)	mg/L		0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Vanadium (V)	mg/L		0.00005	<0.00005	0.00006	0.00009	0.00010	<0.00005	<0.00005	<0.00005
Zinc (Zn)	mg/L	0.03	0.0008	0.190	0.0455	0.0405	0.0392	<0.0008	<0.0008	<0.0008

AECOM

Table B-2. Water Quality Data Lupin EEM 2008

Date Reported	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08	30-Sep-08
ALS Sample ID	L681981-4	L681981-5	L681981-6	L681981-7	L681981-1	L681981-2	L681981-3
Date Sampled	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08	08-Sep-08
Sample Code	SCD1	SCP1	SCP5	SNP925-20	FC2	FL5	FL1

Parameter	Units	CCME Aquatic Life[a]	DL (Sep08)	SCD1 (EXPOSURE)	SCP1 (EXPOSURE)	SCP5 (EXPOSURE)	SNP925-20 (EXPOSURE)	FC2 (REFERENCE)	FL5 (REFERENCE)	FL1 (REFERENCE)
Dissolved Metals										
Aluminum (Al)	mg/L		0.0003	0.441	0.146	0.146	0.146	0.0156	0.0110	0.0114
Antimony (Sb)	mg/L		0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003	<0.00003
Arsenic (As)	mg/L		0.00003	0.00353	0.00142	0.00183	0.00181	0.00107	0.00125	0.00114
Barium (Ba)	mg/L		0.00005	0.0240	0.0140	0.0127	0.0132	0.00187	0.00185	0.00168
Beryllium (Be)	mg/L		0.0002	0.0003	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002	<0.0002
Boron (B)	mg/L		0.001	0.007	0.003	0.002	0.003	<0.001	<0.001	<0.001
Cadmium (Cd)	mg/L		0.000017	0.000346	0.000082	0.000053	0.000057	<0.000017	<0.000017	<0.000017
Calcium (Ca)	mg/L		0.02	12.9	5.55	4.83	4.77	0.88	0.87	0.81
Chromium (Cr)	mg/L		0.00006	0.00015	0.00018	0.00020	0.00022	<0.00006	<0.00006	<0.00006
Cobalt (Co)	mg/L		0.0001	0.0599	0.0160	0.0121	0.0121	0.0001	<0.0001	<0.0001
Copper (Cu)	mg/L		0.0006	0.0186	0.0031	0.0036	0.0034	<0.0006	<0.0006	<0.0006
Iron (Fe)	mg/L		0.005	0.080	0.078	0.087	0.093	0.015	0.008	0.008
Lead (Pb)	mg/L		0.00005	0.00013	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Magnesium (Mg)	mg/L		0.004	6.50	2.96	2.45	2.46	0.524	0.516	0.494
Manganese (Mn)	mg/L		0.0001	0.675	0.113	0.0885	0.0888	0.0031	0.0013	0.0011
Mercury (Hg)	mg/L		0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002	<0.00002
Molybdenum (Mo)	mg/L		0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006	<0.00006
Nickel (Ni)	mg/L		0.00006	0.163	0.0528	0.0421	0.0418	0.00068	0.00063	0.00045
Potassium (K)	mg/L		0.02	1.04	0.49	0.42	0.40	0.37	0.37	0.36
Selenium (Se)	mg/L		0.0001	0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Silver (Ag)	mg/L		0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Sodium (Na)	mg/L		0.005	3.68	1.43	1.30	1.30	0.462	0.437	0.434
Strontium (Sr)	mg/L		0.0001	0.0602	0.0269	0.0240	0.0244	0.0051	0.0048	0.0046
Uranium (U)	mg/L		0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Vanadium (V)	mg/L		0.00005	<0.00005	0.00007	0.00007	0.00008	<0.00005	<0.00005	<0.00005
Zinc (Zn)	mg/L		0.0008	0.184	0.0466	0.0407	0.0395	0.0018	0.0019	0.0034
Radiological Parameters										
Radium-226	Bq/L		0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01

a) Canadian water quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2007

b) 0.005mg/L at pH < 6.5, [Ca2+] < 4 mg/L, DOC < 2 mg/L: 0.1 mg/L at pH $\geq$ 6.5, [Ca2+] $\geq$ 4 mg/L, DOC $\geq$ 2 mg/L

c) Hardness based guideline = $10^{\{0.86[\log(hardness)]-3.2\}}$

d) 0.002 mg/L at [CaCO3] = 0 - 120 mg/L; 0.003 mg/L at [CaCO3] =120 - 180 mg/L; 0.004 mg/L at [CaCO3] >180mg/L

e) 0.001 mg/L at [CaCO3] = 0 - 60 mg/L; 0.002 mg/L at [CaCO3] =60 - 120 mg/L; 0.004 mg/L at [CaCO3] =120 -180mg/L; 0.007 mg/L at [CaCO3] > 180mg/L

f) 0.025 mg/L at [CaCO3] = 0 - 60 mg/L; 0.065 mg/L at [CaCO3] =60 - 120 mg/L; 0.110 mg/L at [CaCO3] =120 -180mg/L; 0.150 mg/L at [CaCO3] > 180mg/L

italics *results exceed CCME Aquatic Life Guidelines*

Appendix C

Benthic and Sediment Data

AECOM

Table C-1. Raw Invertebrate Counts from Lupin September 2008
Analyzed by Cordillera Consulting Inc.

	GLL Code	SCP1	SCP2	SCP3	SCP4	SCP5	FL1	FL2	FL3	FL4	FL5
	CC#	080628	080629	080630	080631	080632	080633	080634	080635	080636	080637
Order : Diptera											
Family : Chironomidae											
Subfamily : Orthocladiinae				240			68	130	26	40	3
Cricotopus/Orthocladius sp.	Larvae	40					3				
Parakiefferiella sp.	Larvae	176	216		86	112	4	219		76	9
Psectrocladius sp.	Larvae							4			
Psuedosmittia c.f.	Larvae						172	23		138	
Rheocricotopus sp.	Larvae		8								
Subfamily Chironominae	Larvae										
Tribe : Tanytarsini	Larvae										
Micropsectra/Tanytarsus sp.	Larvae	497	393	280			44	49	35	8	
Rheotanytarsus sp.	Larvae					1	33	7	24	44	2
Stempellina sp.	Larvae			578	190	40					
Tribe : Chironomini	Larvae										
Cryptochironomius sp.	Larvae	16	32		6	33			2		
Dicrotendipes sp.	Larvae	90		30		34		21	268	58	12
Stictochironomus sp.	Larvae	103	637	856	10	16	11				
Subfamily : Tanypodinae	Larvae										
Procladius sp.	Larvae	85		154	2	10	10	153	101	58	
Subfamily : Diamesinae	Larvae										
Potthastia gaedii group	Larvae	32	64	16			1		3	5	1
Subfamily : Prodiamesinae	Larvae										
Monodiamesa sp.	Larvae								2		
Family Tipulidae											
Tipula (Arctotipula)	Larvae	12		12							
Family : Ceratopogonidae											
Bezzia/Palpomyia sp.	Larvae	5	2	12	18	73					
Family : Empididae											
Chelifera/Metachela sp.	Larvae	1			2		19	1	2	31	3
Culicoides sp.	Larvae	1									
Family : Muscidae	Larvae		1	2		1					1
Order : Trichoptera											
Family : Limniphilidae											
Grensia sp.	Larvae						2		1		
Family : Leptoceridae											
Mystacides sp.		2	1								
Oecetis sp.	larvae	27									
Order : Ephemeroptera											
Family : Heptageniidae											
Epeorus sp.	nymph							1			
Family : Baetidae	nymph	1									
Order : Coleoptera											
Family : Dytiscidae											
Oreodytes sp.	adult									1	
Class : Mollusca											
Order : Bivalvia											
Family : Pisidiidae											
Pisidium sp.							7				
Sphaerium sp.											
Class : Oligochaeta											
Family : Naididae		24							8	28	1
Family : Tubificidae							59				
Family : Lumbiculiidae		16	5	8	2	8		8		9	8
Family : Lumbricidae						68			9		
Order : Tricladida									1		
Order : Prostigmata											
Family : Lebertiidae											
Lebertia sp.		2	1	2						2	
Family : Pionidae											
Piona sp.		1									
Phylum : Nemata		384	184			77	22				
Class : Crustacea											
Family : Ostracoda		16						1	2		
Order : Copepoda											
Family : Calanoida									3		1
Family : Cyclopoida		64						3			
Family : Harpacticoida		56	48			49				40	
TOTAL		**1651**	**1592**	**2190**	**316**	**522**	**455**	**620**	**487**	**538**	**41**

AECOM

Table C-2 Sub-sampling Record Lupin Mine 2008

SCP1			SCP2			SCP3				SCP4		SCP5			
80628			80629			80630				80631		80632			
212 microns	1 mm	total	212 microns	1 mm	total	212 microns	1 mm	2 mm	212	212	total	212 microns	1 mm	2 mm	total
1/8th	all		1/8th	all		1/16th	half	half	all	half		1/8th	all	1/32nd	
197	74	1649	188	88	1592	87	211	188	2190	158	316	37	34	6	522

FL1				FL2			FL3			FL4				FL5
80633				80634			80635			80636				80637
212 microns	500 microns	2+1 mm	total	+2+500 micror	212 microns	total	+2+500 micror	212 microns	total	1+2 mm	500 microns	212 microns	total	total
quarter	quarter	all		all	1/16th		all	1/8th		all	quarter	1/8th		all
16	83	59	455	188	27	620	207	35	487	50	74	24	538	41

Report of Analysis of Benthic Invertebrate Samples from Lupin Mine Nunavut

January 27, 2009

Dates Collected: August 27 – September 5, 2008.
Location: Small ponds, southern Nunavut
Invertebrate analysis by: Cordillera Consulting

Sorting and identification was done using a Nikon SMZ645 and a SMZ800 binocular microscope with help of the following keys:

Brown HP & White DS (1978) Notes on Separation and Identification of North American Riffle Beetles (Coleoptera: Dryopidea: Elmidae).Entomological News 89 (1&2): 1-13
Clifford, Hugh F. 1991. Aquatic Invertebrates of Alberta. University of Alberta Press Edmonton, Alberta.
Epler, John. 2001 The Larval Chironomids of North and South Carolina. http://home.earthlink.net/~johnepler/
Kathman,R.D., R.O. Brinkhurst. 1999. Guide to the Freshwater Oligochaetes of North America. Aquatic Resources Center, College Grove, Tennessee.
Merritt, R.W., K.W. Cummins and Berg,M. (eds.). 2007. An introduction to the aquatic insects of North America, 4th. Kendall/Hunt, Dubuque, IA.
Oliver, Donald R. and Mary E. Roussel. 1983. The Insects and Arachnids of Canada Part 11. The Genera of larval midges of Canada. Biosystematics Research Institute. Ottawa, Ontario. Research Branch, Agriculture Canada. Publication 1746.
Proctor, H. The 'Top 18' Water Mite Families in Alberta. Zoology 351. University of Alberta, Edmonton, Alberta.
Thorpe, J. H. and A. P. Covich [Eds.] 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, San Diego.
Wiggins, Glenn B. 1998. Larvae of the North American Caddisfly Genera (Tricoptera) 2nd ed. University of Toronto Press. Toronto Ontario.

The invertebrates were further separated into groups of orders and stored in vials in 80% ethanol and the debris is stored in the original containers. An individual from each taxa reported is stored in a separate vial for reference purposes.

QA/QC

Sorting efficiency: 2 samples were resorted and the efficiency was found to be greater than 95%.

Taxonomic QA/QC: 4 of these samples will be reidentified by a different taxonomist. If there are any changes in identification the client will be notified.

Table C-3: Sediment Quality Data Lupin EEM 2008

Parameter	Units	ISQG[a]	PEL[b]	DL (Sep08)	SCP1 (EXPOSURE)	SCP-2 (EXPOSURE)	SCP3 (EXPOSURE)	SCP4 (EXPOSURE)	SCP5 (EXPOSURE)	FL1 (REFERENCE)	FL2 (REFERENCE)	FL3 (REFERENCE)	FL4 (REFERENCE)	FL5 (REFERENCE)
Date Reported					23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08	23-Sep-08
ALS Sample ID					L680152-6	L680152-7	L680152-8	L680152-9	L680152-10	L680152-1	L680152-2	L680152-3	L680152-4	L680152-5
Date Sampled					29-Aug-08	29-Aug-08	02-Sep-08	02-Sep-08	02-Sep-08	28-Aug-08	28-Aug-08	29-Aug-08	29-Aug-08	29-Aug-08
Sample Code					SCP1	SCP2	SCP3	SCP4	SCP5	FL 1	FL 2	FL 3	FL 4	FL 5
Physical Parameters														
Sand (2.00 - 0.63 mm)	%			1	71	90	96	25	6	87	32	80	96	86
Silt (0.063 mm - 4 mm)	%			1	26	8	2	71	90	11	66	18	3	12
Clay (< 4 um)	%			1	3	2	2	4	4	2	2	2	1	2
Fragments > 2mm	%			-	<1	69	7	<1	<1	4	2	2	2	28
Texture	-				Sandy loam	Sand	Sand	Silt loam	Silt	Sand	Silt loam	Loamy sand	Sand	Sand / Loamy sand
Carbon Content														
Total Organic Carbon	%			0.1	2.2	0.7	0.2	0.9	1.8	0.8	1.2	0.6	0.3	0.3
Total Metals														
Aluminum (Al)	mg/kg			50	4640	4170	3850	9880	15200	3890	6340	4770	3770	5340
Antimony (Sb)	mg/kg			0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Arsenic (As)	mg/kg	5.9	17.0	0.2	***45.5***	***39.6***	*15.8*	***35.7***	***50.7***	***22.3***	*14.7*	4.4	*6.0*	*6.3*
Barium (Ba)	mg/kg			5	31	24	19	47	68	25	45	33	25	38
Beryllium (Be)	mg/kg			1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Cadmium (Cd)	mg/kg	0.6	3.5	0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Chromium (Cr)	mg/kg	37.3	90.0	0.5	13.9	12.9	11.8	37.0	61.2	15.5	23.2	16.5	13.0	22.9
Cobalt (Co)	mg/kg			1	21	19	6	13	19	4	6	4	3	4
Copper (Cu)	mg/kg	35.7	197.0	2	20	14	6	17	26	6	10	7	4	7
Iron (Fe)	mg/kg			200	8400	8400	6600	16200	25300	7100	9300	6600	6400	8900
Lead (Pb)	mg/kg	35.0	91.3	5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Mercury (Hg)	mg/kg	0.17	0.486	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Molybdenum (Mo)	mg/kg			1	<1	<1	<1	<1	1	<1	<1	<1	<1	<1
Nickel (Ni)	mg/kg			2	36	26	13	32	47	11	14	12	8	12
Selenium (Se)	mg/kg			0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Silver (Ag)	mg/kg			1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Strontium (Sr)	mg/kg			1	6	5	4	9	11	4	8	4	4	5
Thallium (Tl)	mg/kg			1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Tin (Sn)	mg/kg			5	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Uranium (U)	mg/kg			2	<2	<2	<2	<2	<2	<2	<2	<2	<2	<2
Vanadium (V)	mg/kg			1	13	12	10	29	42	11	20	15	11	17
Zinc (Zn)	mg/kg	123	315	10	70	60	30	70	90	20	30	30	20	20

a) Interim Sediment Quality Guidelines, Canadian sediment quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2002
a) Probable Effects Levels, Canadian sediment quality guidelines for the protection of aquatic life, Council of Ministers of the Environment, 2002

italics	*results exceed ISQG*
italics	***results exceed PEL***

Appendix D

Fish Survey Data

Table D-1. Lupin 2008 Catch and Effort Summary Data for Gill Nets by area

Sampling Area	Water Body	UTM Easting	UTM Northing	Site Name	Lift Number	Set Time	Lift Time	Mesh Size (inches)	Duration (hours)	Effort (panel hours)	Arctic Grayling	Ninespine Stickleback	Slimy Sculpin	Burbot	Lake Trout	Round Whitefish	Arctic Char
Exposure	Dam1A Lake	485765	7289647	1AGN1	1	9/2/08 12:18	9/2/08 19:45	0.75	7.45	22.35	0	0	0	0	0	0	0
		485731	7289674	1AGN2	1	9/2/08 12:25	9/2/08 20:00	1.00	7.58	22.75	0	0	0	0	0	0	0
		485653	7289667	1AGN3	1	9/2/08 12:35	9/2/08 20:15	1.50	7.67	23.00	0	0	0	0	0	0	0
		485765	7289647	1AGN1	2	9/2/08 19:45	9/3/08 7:45	0.75	12.00	36.00	0	0	0	0	0	0	0
		485731	7289674	1AGN2	2	9/2/08 20:00	9/3/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		485653	7289667	1AGN3	2	9/2/08 20:15	9/3/08 8:15	1.50	12.00	36.00	0	0	0	0	0	0	0
		485765	7289647	1AGN1	3	9/3/08 7:45	9/3/08 19:45	0.75	12.00	36.00	0	0	0	0	0	0	0
		485731	7289674	1AGN2	3	9/3/08 8:00	9/3/08 20:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		485653	7289667	1AGN3	3	9/3/08 8:15	9/3/08 20:15	1.50	12.00	36.00	0	0	0	0	0	0	0
		485765	7289647	1AGN1	4	9/3/08 19:45	9/4/08 7:45	0.75	12.00	36.00	0	0	0	0	0	0	0
		485731	7289674	1AGN2	4	9/3/08 20:00	9/4/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		485653	7289667	1AGN3	4	9/3/08 20:15	9/4/08 8:15	1.50	12.00	36.00	0	0	0	0	0	0	0
	Seep Creep Pond	481242	7290574	SCGN4	1	9/4/08 9:45	9/4/08 19:45	0.75	10.00	30.00	0	0	0	0	0	0	0
		481253	7290532	SCGN5	1	9/4/08 10:00	9/4/08 20:00	1.00	10.00	30.00	0	0	0	0	0	0	0
		481263	7290510	SCGN6	1	9/4/08 10:05	9/4/08 20:15	1.50	10.17	30.50	11	0	0	0	0	0	1
		481242	7290574	SCGN4	2	9/4/08 19:45	9/5/08 7:45	0.75	12.00	36.00	0	0	0	0	0	0	0
		481253	7290532	SCGN5	2	9/4/08 20:00	9/5/08 8:00	1.00	12.00	36.00	1	0	0	0	0	0	0
		481263	7290510	SCGN6	2	9/4/08 20:15	9/5/08 8:15	1.50	12.00	36.00	14	0	0	0	0	0	0
		481242	7290574	SCGN4	3	9/5/08 7:45	9/5/08 19:45	0.75	12.00	36.00	0	0	0	0	0	0	0
		481253	7290532	SCGN5	3	9/5/08 8:00	9/5/08 20:00	1.00	12.00	36.00	2	0	0	0	0	0	0
		481263	7290510	SCGN6	3	9/5/08 8:15	9/5/08 20:15	1.50	12.00	36.00	3	0	0	0	0	0	0
		481242	7290574	SCGN4	4	9/5/08 19:45	9/6/08 9:30	0.75	13.75	41.25	0	0	0	0	0	0	0
		481253	7290532	SCGN5	4	9/5/08 20:00	9/6/08 9:25	1.00	13.42	40.25	2	0	0	0	0	0	0
		481263	7290510	SCGN6	4	9/5/08 20:15	9/6/08 9:20	1.50	13.08	39.25	6	0	0	0	1	0	0
Reference	Fingers Lake	493625	7287182	FLGN1	1	8/28/08 13:35	8/28/08 19:45	1.50	6.17	18.50	0	0	0	0	2	1	0
		494447	7288523	FLGN2	1	8/28/08 12:50	8/28/08 20:00	1.00	7.17	21.50	0	0	0	0	0	0	0
		493015	7286911	FLGN3	1	8/28/08 13:55	8/28/08 20:15	0.75	6.33	19.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	2	8/28/08 19:45	8/29/08 7:45	1.50	12.00	36.00	0	0	0	0	0	3	0
		494447	7288523	FLGN2	2	8/28/08 20:00	8/29/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		493015	7286911	FLGN3	2	8/28/08 20:15	8/29/08 8:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	3	8/29/08 7:45	8/29/08 19:45	1.50	12.00	36.00	0	0	0	0	2	0	0
		494447	7288523	FLGN2	3	8/29/08 8:00	8/29/08 20:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		493015	7286911	FLGN3	3	8/29/08 8:15	8/29/08 20:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	4	8/29/08 19:45	8/30/08 7:45	1.50	12.00	36.00	0	0	0	0	0	1	0
		494447	7288523	FLGN2	4	8/29/08 20:00	8/30/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		493015	7286911	FLGN3	4	8/29/08 20:15	8/30/08 8:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	5	8/30/08 7:45	8/30/08 19:45	1.50	12.00	36.00	0	0	0	0	2	0	0
		493070	7288472	FLGN4	1	8/30/08 8:00	8/30/08 20:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		491268	7287580	FLGN5	1	8/30/08 8:15	8/30/08 20:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	6	8/30/08 19:45	8/31/08 7:45	1.50	12.00	36.00	0	0	0	0	0	1	0
		493070	7288472	FLGN4	2	8/30/08 20:00	8/31/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		491268	7287580	FLGN5	2	8/30/08 20:15	8/31/08 8:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	7	8/31/08 7:45	8/31/08 19:45	1.50	12.00	36.00	0	0	0	0	0	2	0
		493070	7288472	FLGN4	3	8/31/08 8:00	8/31/08 20:00	1.00	12.00	36.00	0	0	0	0	1	2	0

AECOM

Table D-1. Lupin 2008 Catch and Effort Summary Data for Gill Nets by area

Sampling Area	Water Body	UTM Easting	UTM Northing	Site Name	Lift Number	Set Time	Lift Time	Mesh Size (inches)	Duration (hours)	Effort (panel hours)	Arctic Grayling	Ninespine Stickleback	Slimy Sculpin	Burbot	Lake Trout	Round Whitefish	Arctic Char
Reference	Fingers Lake	491268	7287580	FLGN5	3	8/31/08 8:15	8/31/08 20:15	0.75	12.00	36.00	0	0	0	0	1	0	0
		493625	7287182	FLGN1	8	8/31/08 19:45	9/1/08 7:45	1.50	12.00	36.00	0	0	0	0	3	1	0
		493070	7288472	FLGN4	4	8/31/08 20:00	9/1/08 8:00	1.00	12.00	36.00	0	0	0	0	1	1	0
		491268	7287580	FLGN5	4	8/31/08 20:15	9/1/08 8:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	9	9/1/08 7:45	9/1/08 19:45	1.50	12.00	36.00	0	0	0	0	1	0	0
		493070	7288472	FLGN4	5	9/1/08 8:00	9/1/08 20:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		491268	7287580	FLGN5	5	9/1/08 8:15	9/1/08 20:15	0.75	12.00	36.00	0	0	0	0	0	0	0
		493625	7287182	FLGN1	10	9/1/08 19:45	9/2/08 7:45	1.50	12.00	36.00	0	0	0	0	0	1	0
		493070	7288472	FLGN4	6	9/1/08 20:00	9/2/08 8:00	1.00	12.00	36.00	0	0	0	0	0	0	0
		491268	7287580	FLGN5	6	9/1/08 20:15	9/2/08 8:15	0.75	12.00	36.00	0	0	0	0	0	2	0
EXPOSURE TOTALS										**819.35**	**39**	**0**	**0**	**0**	**1**	**0**	**1**
REFERENCE TOTALS										**1031.00**	**0**	**0**	**0**	**0**	**13**	**15**	**0**

Note:
Lift and set times are approximate on days when helicopter could not acess site due to weather.
Nets were generally lifted twice daily between 7:30 and 8:30 AM and between 7:30 and 8:30 PM.

Table D-2. Lupin 2008 Catch and Effort Summary Data for Minnow Traps by Area

Sampling Area	Water Body	UTM Easting	UTM Northing	Site Name	Lift Number	Set Time	Lift Time	Duration (hours)	# of Traps	Effort (trap hours)	Arctic Grayling	Ninespine Stickleback	Slimy Sculpin	Burbot	Lake Trout	Round Whitefish	Arctic Char
Exposure	Seep Creek	481340	7290686	SCMT01	1	9/2/08 9:00	9/4/08 15:00	54.0	1	54.00	0	0	0	0	0	0	0
		481339	7290672	SCMT02	1	9/2/08 9:15	9/4/08 15:15	54.0	1	54.00	0	0	0	0	0	0	0
		481342	2290668	SCMT03	1	9/2/08 9:15	9/4/08 15:15	54.0	1	54.00	0	0	0	0	0	0	0
		481357	7290657	SCMT04	1	9/2/08 9:20	9/4/08 15:00	53.7	1	53.67	1	0	0	1	0	0	0
		481376	7290666	SCMT05	1	9/2/08 9:30	9/4/08 15:00	53.5	1	53.50	1	0	0	0	0	0	0
		485914	7289722	SCMT40	1	9/2/08 10:20	9/4/08 8:50	46.5	2	93.00	0	0	0	0	0	0	0
		485850	7289709	SCMT41	1	9/2/08 10:25	9/4/08 8:50	46.4	1	46.42	0	0	0	0	0	0	0
		485804	7289684	SCMT42	1	9/2/08 10:30	9/4/08 8:55	46.4	1	46.42	0	0	0	0	0	0	0
		485793	7289654	SCMT43	1	9/2/08 10:35	9/4/08 8:55	46.3	1	46.33	0	0	0	0	0	0	0
		481376	7290666	SCMT05	2	9/4/08 15:10	9/5/08 11:05	19.9	3	59.75	1	0	0	0	0	0	0
		481370	7290705	SCMT06	1	9/4/08 15:10	9/5/08 11:10	20.0	2	40.00	0	0	0	0	0	0	0
		481216	7290637	SCMT07	1	9/4/08 15:15	9/5/08 11:05	19.8	2	39.67	0	0	0	0	0	0	0
		481207	7290690	SCMT08	1	9/4/08 15:20	9/5/08 11:15	19.9	2	39.83	1	0	0	0	0	0	0
Reference	Fingers Lake	492326	7286267	FLMT01	1	8/28/08 11:30	9/1/08 16:00	100.5	3	301.50	0	0	1	0	0	0	0
		492573	7286504	FLMT02	1	8/28/08 11:35	9/1/08 13:00	97.4	1	97.42	0	0	0	0	0	0	0
		493339	7287444	FLMT03	1	8/28/08 12:15	9/1/08 13:30	97.3	2	194.50	0	0	0	0	0	0	0
		494621	7288861	FCMT01	1	8/28/08 11:50	9/1/08 14:30	98.7	1	98.67	0	0	0	0	0	0	0
		494591	7288874	FCMT02	1	8/28/08 12:00	9/1/08 14:35	98.6	1	98.58	0	0	0	9	0	0	0
		494600	7288875	FCMT03	1	8/28/08 17:10	9/1/08 14:40	93.5	1	93.50	0	0	0	0	0	0	0
		494632	7288899	FCMT04	1	8/28/08 12:15	9/1/08 14:35	98.3	1	98.33	0	0	0	0	0	0	0
		494616	7288932	FCMT05	1	8/28/08 12:20	9/1/08 14:30	98.2	1	98.17	0	0	0	3	0	0	0
		494621	7288861	FCMT01	2	9/1/08 14:30	9/2/08 8:45	18.3	1	18.25	0	0	0	0	0	0	0
		494591	7288874	FCMT02	2	9/1/08 14:35	9/2/08 8:30	17.9	1	17.92	0	0	0	1	0	0	0
		494600	7288875	FCMT03	2	9/1/08 14:40	9/2/08 8:35	17.9	1	17.92	0	0	0	0	0	0	0
		494632	7288899	FCMT04	2	9/1/08 14:35	9/2/08 8:35	18.0	1	18.00	0	0	0	0	0	0	0
		494616	7288932	FCMT05	2	9/1/08 14:30	9/2/08 8:35	18.1	1	18.08	0	0	0	0	0	0	0
		492375	7286244	FLMT04	1	9/1/08 4:10	9/2/08 9:25	29.3	3	87.75	0	0	0	0	0	0	0
		494634	7288999	FCMT06	1	8/28/08 12:30	9/1/08 14:25	97.9	1	97.92	0	0	0	0	0	0	0
		494634	7288999	FCMT06	2	9/1/08 14:25	9/4/08 16:15	73.8	1	73.83	0	0	0	0	0	0	0
		494693	7289074	FCMT07	1	8/28/08 12:45	9/1/08 14:15	97.5	1	97.50	0	0	0	0	0	0	0
		494693	7289074	FCMT07	2	9/1/08 14:15	9/4/08 16:20	74.1	1	74.08	0	0	0	0	0	0	0
		494889	7289122	FCMT08	1	8/28/08 13:00	9/1/08 14:10	97.2	1	97.17	0	0	0	1	0	0	0
		494889	7289122	FCMT08	2	9/1/08 14:10	9/4/08 16:25	74.3	1	74.25	1	0	0	2	0	0	0
		494908	7289041	FCMT09	1	8/28/08 13:10	9/1/08 14:00	96.8	1	96.83	0	0	1	1	0	0	0
		494908	7289041	FCMT09	2	9/1/08 2:00	9/4/08 16:25	86.4	1	86.42	0	0	0	0	0	0	0
		495068	7289255	FCMT10	1	8/28/08 1:30	9/1/08 14:00	108.5	1	108.50	0	0	0	0	0	0	0
		495068	7289255	FCMT10	2	9/1/08 14:00	9/4/08 16:35	74.6	1	74.58	0	0	0	1	0	0	0
EXPOSURE TOTALS										**680.58**	**4**	**0**	**0**	**1**	**0**	**0**	**0**
REFERENCE TOTALS										**2139.67**	**1**	**0**	**2**	**18**	**0**	**0**	**0**

Table D-3. Lupin 2008 Catch and Effort Summary Data for Electrofishing by Area

Sampling Area	Water Body	Site Name	Start UTM Easting	Start UTM Northing	End UTM Easting	End UTM Northing	Site Length (m)	Start Time	End Time	Duration (hours)	Effort (seconds)	Arctic Grayling	Ninespine Stickleback	Slimy Sculpin	Burbot	Lake Trout	Round Whitefish	Arctic Char
Exposure	Seep Creek	SCEF01	481316	7290688	482899	7290103	-	9/2/08 9:35	9/2/08 15:30	5.9	7445	12	45	0	0	0	0	0
		SCEF02	480172	7290236	481147	7290665	-	9/4/08 8:20	9/4/08 15:30	7.2	11774	30	42	1	0	0	1	0
		SCEF03	480783	7290417	-	-	1500	9/5/08 9:45	9/5/08 16:05	6.3	9420	27	43	0	0	0	0	0
Reference	Fingers Creek	FCEF01	495067	7289261	494655	7289018	-	8/28/08 13:35	8/28/08 15:50	2.3	4019	10	75	4	19	4	0	0
		FCEF02	496337	7291003	-	-	500	9/1/08 10:30	9/1/08 12:00	1.5	1694	0	0	0	0	0	0	0
		FCEF03	495872	7290588	495113	7289447	-	9/1/08 12:40	9/1/08 14:30	1.8	3229	0	0	0	0	0	0	0
		FCEF04	494751	7289153	-	-	300	9/1/08 14:45	9/1/08 15:35	0.8	973	1	0	5	4	0	0	0
		FCEF05	496046	7291098	-	-	1250	9/6/08 9:30	9/6/08 16:00	6.5	9784	8	2	6	5	2	0	0
		FCEF06	495109	7289472	-	-	1000	9/7/08 8:30	9/7/08 15:45	7.3	10688	8	12	12	6	3	0	0
		FCEF07	494716	7289143	-	-	1500	9/8/08 8:45	9/8/08 15:20	6.6	12000	12	7	12	8	8	0	0
Exposure Totals											28639	69	130	1	0	0	1	0
Reference Totals											42387	39	96	39	42	17	0	0

Table D-4. Fish Morphometric Data from the Lupin 2008 EEM Exposure Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
JS	E001	ARGR	2.35	5.9	6.5	7.0	sc	I	-	0.046	1.40	ok
MJ	E002	ARGR	8.89	8.9	9.9	11.0	sc, ot	I	-	0.148	5.78	ok
JS	E003	ARGR	2.24	6.0	6.6	7.1	sc	I	-	0.039	1.24	ok
MJ	E004	ARGR	1.83	5.1	5.8	6.4	sc	I	-	0.033	1.00	ok
JS	E005	ARGR	1.99	5.8	6.3	6.9	sc	I	-	0.023	1.21	ok
MJ	E006	ARGR	1.30	4.7	5.3	5.8	sc	I	-	0.024	0.73	ok
JS	E007	ARGR	2.62	6.4	6.9	7.5	sc	I	-	0.046	1.60	ok
MJ	E008	ARGR	1.28	4.7	5.3	5.7	sc	I	-	0.023	0.70	ok
JS	E009	ARGR	1.83	5.5	6.1	6.9	sc	I	-	0.023	1.05	ok
MJ	E010	ARGR	-	4.9	5.5	6.0	sc	I	-	0.023	0.76	ok - total weight not taken before fish eviscerated
JS	E011	NSSB	0.541	4.5	-	5.1	-	I	-	0.003	0.288	ok
MJ	E012	NSSB	0.461	3.7	-	4.5	-	I	-	0.003	0.242	ok
MJ	E013	NSSB	0.388	3.7	-	4.4	-	I	-	0.006	0.241	ok
JS	E014	NSSB	0.248	3.0	-	3.6	-	I	-	0.001	0.142	ok
MJ	E015	NSSB	0.192	2.8	-	3.4	-	I	-	0.003	0.091	ok
JS	E016	NSSB	0.373	3.4	-	3.9	-	I	-	0.006	0.208	ok
MJ	E017	NSSB	0.308	3.3	-	4.1	-	I	-	0.008	0.181	ok
MJ	E018	NSSB	0.195	2.7	-	3.3	-	I	-	0.006	0.079	ok
JS	E019	NSSB	0.137	2.5	-	3.3	-	I	-	0.000	0.085	ok
MJ	E020	NSSB	0.206	2.9	-	3.5	-	I	-	0.005	0.098	ok
MJ	E021	NSSB	0.265	3.2	-	3.8	-	I	-	0.005	0.132	ok
JS	E022	NSSB	0.213	2.8	-	3.5	-	I	-	0.000	0.142	ok
MJ	E023	NSSB	0.158	2.8	-	3.4	-	I	-	0.000	0.075	ok
JS	E024	NSSB	0.201	2.8	-	3.5	-	I	-	0.001	0.113	ok
MJ	E025	NSSB	0.244	3.0	-	3.7	-	I	-	0.005	0.133	ok
JS	E026	NSSB	0.154	2.6	-	3.1	-	I	-	0.001	0.126	ok
MJ	E027	NSSB	0.113	2.3	-	2.9	-	I	-	0.002	0.057	ok
JS	E028	NSSB	0.142	2.5	-	3.1	-	I	-	0.000	0.083	ok
MJ	E029	NSSB	0.156	2.7	-	3.2	-	I	-	0.001	0.078	ok
JS	E030	NSSB	0.204	3.4	-	3.8	-	I	-	0.004	0.122	ok
MJ	E031	NSSB	0.181	2.7	-	3.4	-	I	-	0.003	0.097	ok
MJ	E032	NSSB	0.131	2.6	-	3.1	-	I	-	0.002	0.069	ok
JS	E033	NSSB	0.223	3.2	-	3.8	-	I	-	0.002	0.128	ok
MJ	E034	NSSB	0.167	2.7	-	3.3	-	I	-	0.003	0.085	ok
JS	E035	NSSB	0.244	3.0	-	3.7	-	I	-	0.004	0.146	ok
MJ	E036	NSSB	0.130	2.5	-	3.0	-	I	-	0.001	0.061	ok
MJ	E037	NSSB	0.157	2.7	-	3.2	-	I	-	0.000	0.074	ok
JS	E038	NSSB	0.182	2.8	-	3.3	-	I	-	0.005	0.100	ok
MJ	E039	NSSB	-	2.8	-	3.3	-	I	-	0.007	0.098	ok - total weight not taken before fish eviscerated
MJ	E040	NSSB	0.153	2.6	-	3.1	-	I	-	0.002	0.060	ok
JS	E041	NSSB	0.206	3.2	-	3.6	-	I	-	0.000	0.099	ok
MJ	E042	NSSB	0.170	2.8	-	3.3	-	I	-	0.004	0.076	ok
JS	E043	NSSB	0.191	3.0	-	3.5	-	I	-	0.001	0.094	ok
MJ	E044	NSSB	0.137	2.4	-	3.0	-	I	-	0.000	0.065	ok

Table D-4. Fish Morphometric Data from the Lupin 2008 EEM Exposure Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
MJ	E045	NSSB	0.156	2.7	-	3.2	-	I	-	0.003	0.078	ok
JS	E046	NSSB	0.193	2.6	-	3.4	-	I	-	0.002	0.106	ok
MJ	E047	NSSB	0.182	2.6	-	3.3	-	I	-	0.003	0.089	ok
JS	E048	NSSB	0.140	2.5	-	3.0	-	I	-	0.002	0.055	ok
MJ	E049	NSSB	0.134	2.5	-	3.1	-	I	-	0.002	0.068	ok
JS	E050	NSSB	0.187	2.9	-	3.3	-	I	-	0.001	0.097	ok
MJ	E051	NSSB	0.138	2.6	-	3.0	-	I	-	0.004	0.071	ok
MJ	E052	NSSB	0.140	2.5	-	3.0	-	I	-	0.001	0.063	ok
JS	E053	NSSB	0.148	2.7	-	3.0	-	I	-	0.000	0.083	ok
MJ	E054	NSSB	0.119	2.3	-	2.7	-	I	-	0.001	0.054	ok
JS	E055	NSSB	0.142	2.4	-	2.9	-	I	-	0.000	0.069	ok
SS	E056	ARGR	15.80	10.8	11.6	12.8	sc, ot	I	-	0.195	10.80	ok
SS	E057	ARGR	12.06	9.6	10.7	11.7	sc, ot	I	-	0.258	7.96	ok
MJ	E058	ARGR	16.65	10.9	11.7	12.7	sc, ot	I	-	0.194	11.26	ok, stomach content mass = 0.54g
SS	E059	ARGR	2.27	6.0	6.7	7.2	sc, ot	I	-	0.046	1.29	ok
SS	E060	ARGR	14.55	10.6	11.5	12.6	sc, ot	I	-	0.216	10.52	ok, stomach content mass = 0.150g
MJ	E061	ARGR	2.76	5.9	6.4	7.1	sc	I	-	0.059	1.68	ok, stomach content mass = 0.132g
MJ	E062	ARGR	2.87	6.0	6.7	7.4	sc, ot	I	-	0.054	1.69	ok, stomach content mass = 0.144g
SS	E063	ARGR	55.39	15.9	17.4	19.0	sc, ot	I	-	0.420	43.56	ok
MJ	E064	ARGR	1.77	5.0	5.7	6.1	sc	I	-	0.028	1.08	ok
MJ	E065	ARGR	2.49	5.6	6.3	6.9	sc	I	-	0.050	1.66	ok
SS	E066	ARGR	131.73	20.1	22.0	24.0	sc, ot	F	0.498	1.303	104.35	ok, immature female
MJ	E067	ARGR	11.23	9.3	10.4	11.2	sc, ot	I	-	0.162	7.95	ok, stomach content mass = 0.264g
MJ	E068	ARGR	3.05	5.9	6.7	7.3	sc	I	-	0.045	2.11	ok
SS	E069	ARGR	22.02	11.3	12.5	13.8	sc, ot	I	-	0.136	15.92	ok
MJ	E070	ARGR	2.48	5.9	6.6	7.2	sc	I	-	0.014	1.64	ok
SS	E071	ARGR	2.68	6.2	6.9	7.5	sc	I	-	0.007	1.62	ok
MJ	E072	ARGR	2.66	5.9	6.6	7.2	sc	I	-	0.041	1.66	ok
SS	E073	ARGR	2.31	5.7	6.5	7.1	sc, ot	I	-	0.018	1.42	ok
SS	E074	ARGR	2.08	5.7	6.4	7.0	sc	I	-	0.033	1.24	ok
SS	E075	ARGR	1.19	4.8	5.4	5.8	sc	I	-	0.022	0.61	ok
MJ	E076	ARGR	1.66	5.3	5.8	6.4	sc	I	-	0.044	1.00	ok
SS	E077	ARGR	2.24	5.8	6.5	7.0	sc	I	-	0.041	1.41	ok
MJ	E078	ARGR	1.89	5.4	6.2	6.7	sc	I	-	0.030	1.09	ok
MJ	E079	ARGR	1.75	5.4	6.0	6.6	sc	I	-	0.028	1.04	ok
SS	E080	ARGR	1.07	4.5	5.1	5.6	sc	I	-	0.022	0.50	ok
MJ	E081	ARGR	1.86	5.3	5.8	6.3	sc	I	-	0.030	1.09	ok
SS	E082	ARGR	1.74	5.1	5.8	6.2	sc	I	-	0.026	1.01	ok
MJ	E083	ARGR	1.10	4.7	4.2	5.7	sc	I	-	0.024	0.65	ok
SS	E084	ARGR	2.04	5.6	6.3	6.7	sc	I	-	0.042	1.10	ok
MJ	E085	ARGR	1.34	4.9	5.6	6.0	sc	I	-	0.022	0.76	ok
SS	E086	ARGR	2.72	6.1	6.9	7.5	sc	I	-	0.059	1.62	ok
MJ	E087	ARGR	2.37	5.8	6.5	7.0	sc	I	-	0.048	1.52	ok
MJ	E088	NSSB	0.652	4.3	-	5.0	-	I	-	0.020	0.356	ok

Table D-4. Fish Morphometric Data from the Lupin 2008 EEM Exposure Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
SS	E089	NSSB	0.415	3.6	-	4.4	-	I	-	0.012	0.230	pale liver
MJ	E090	NSSB	0.255	3.2	-	3.7	-	I	-	0.010	0.127	ok
SS	E091	NSSB	0.494	4.0	-	4.7	-	I	-	0.002	0.286	ok
MJ	E092	NSSB	0.398	3.6	-	4.3	-	I	-	0.011	0.233	ok
SS	E093	NSSB	0.320	3.3	-	4.0	-	I	-	0.006	0.148	ok
MJ	E094	NSSB	0.257	3.2	-	3.8	-	I	-	0.005	0.134	ok
MJ	E095	NSSB	0.428	3.7	-	4.3	-	I	-	0.013	0.249	ok
SS	E096	NSSB	0.262	3.2	-	3.9	-	I	-	0.003	0.169	ok
MJ	E097	NSSB	0.296	3.2	-	3.8	-	I	-	0.003	0.153	ok
MJ	E098	NSSB	0.245	3.1	-	3.7	-	I	-	0.008	0.136	ok
SS	E099	NSSB	0.371	3.8	-	4.4	-	I	-	0.003	0.239	ok
MJ	E100	NSSB	0.459	3.9	-	4.6	-	I	-	0.014	0.253	ok
MJ	E101	NSSB	0.349	3.7	-	4.3	-	I	-	0.006	0.186	ok
SS	E102	NSSB	0.294	3.2	-	3.8	-	I	-	0.002	0.178	ok
MJ	E103	NSSB	0.312	3.5	-	4.0	-	I	-	0.004	0.182	ok
SS	E104	NSSB	0.376	3.6	-	4.3	-	I	-	0.006	0.224	ok
MJ	E105	NSSB	0.145	2.6	-	3.0	-	I	-	0.000	0.074	ok
MJ	E106	NSSB	0.323	3.3	-	3.9	-	I	-	0.012	0.170	ok
SS	E107	NSSB	0.272	3.4	-	4.0	-	I	-	0.004	0.154	ok
MJ	E108	NSSB	0.359	3.5	-	4.1	-	I	-	0.018	0.185	pale liver
MJ	E109	NSSB	0.233	2.8	-	3.3	-	I	-	0.010	0.123	pale liver
SS	E110	NSSB	0.260	3.2	-	3.9	-	I	-	0.004	0.149	ok
MJ	E111	NSSB	0.270	3.3	-	3.8	-	I	-	0.004	-	carcass accidentally discarded before obtaining weight
SS	E112	NSSB	0.355	3.3	-	4.0	-	I	-	0.005	0.188	pale liver
MJ	E113	NSSB	0.250	3.3	-	3.7	-	I	-	0.004	0.142	ok
SS	E114	NSSB	0.336	3.4	-	4.2	-	I	-	0.003	0.178	ok
MJ	E115	NSSB	0.142	2.7	-	3.2	-	I	-	0.002	0.077	ok
MJ	E116	NSSB	0.418	3.4	-	3.9	-	I	-	0.016	0.237	ok
SS	E117	NSSB	0.338	3.2	-	3.8	-	I	-	0.007	0.172	ok
MJ	E118	NSSB	0.094	2.1	-	2.5	-	I	-	0.002	0.046	ok
SS	E119	NSSB	0.294	3.3	-	3.9	-	I	-	0.004	0.146	ok
MJ	E120	NSSB	0.278	3.0	-	3.5	-	I	-	0.017	0.123	ok
MJ	E121	NSSB	0.271	3.2	-	3.7	-	I	-	0.007	0.144	ok
SS	E122	NSSB	0.228	2.9	-	3.5	-	I	-	0.011	0.102	ok
MJ	E123	NSSB	0.217	2.7	-	3.2	-	I	-	0.014	0.116	ok
MJ	E124	NSSB	0.171	2.7	-	3.2	-	I	-	0.005	0.088	ok
SS	E125	NSSB	0.143	2.6	-	3.0	-	I	-	0.002	0.067	ok
MJ	E126	NSSB	0.148	2.3	-	2.8	-	I	-	0.006	0.072	ok
SS	E127	NSSB	0.117	2.4	-	2.8	-	I	-	0.003	0.048	pale liver
MJ	E128	NSSB	0.147	2.5	-	3.0	-	I	-	0.003	0.075	ok
SS	E129	NSSB	0.137	2.3	-	2.8	-	I	-	0.007	0.066	ok
JS	E130	ARGR	60.35	16.3	17.5	19.4	sc, ot	I	-	0.530	46.90	ok
JS	E131	ARGR	51.18	15.6	16.7	18.5	sc, ot	I	-	0.566	40.09	ok
MJ	E132	ARGR	44.31	14.8	16.6	17.7	sc, ot	I	-	0.485	34.85	ok, immature female

Table D-4. Fish Morphometric Data from the Lupin 2008 EEM Exposure Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
JS	E133	ARGR	54.91	16.1	17.1	18.8	sc, ot	I	-	0.669	43.77	ok
MJ	E134	ARGR	1.88	5.5	6.2	6.6	sc	I	-	0.030	1.19	ok
JS	E135	ARGR	44.36	14.3	15.8	17.4	sc, ot	I	-	0.469	34.11	ok
MJ	E136	ARGR	2.00	5.0	5.6	6.2	sc, ot	I	-	0.028	1.21	ok
MJ	E137	ARGR	49.00	15.0	16.3	18.0	sc, ot	I	-	0.302	39.97	ok
JS	E138	ARGR	56.04	15.6	16.7	18.3	sc, ot	I	-	0.610	42.23	ok
MJ	E139	ARGR	13.20	9.8	10.7	11.7	sc	I	-	0.237	9.09	ok
JS	E140	ARGR	45.68	15.0	15.9	17.8	sc, ot	I	-	0.485	34.09	ok
MJ	E141	ARGR	57.75	15.7	17.0	19.0	sc, ot	I	-	0.809	46.98	ok
JS	E142	ARGR	44.99	14.3	15.6	17.2	sc, ot	I	-	0.562	34.39	ok
MJ	E143	ARGR	60.45	16.0	17.1	19.0	sc, ot	I	0.178	0.775	48.82	ok, immature female
JS	E144	ARGR	44.58	14.8	15.7	17.2	sc, ot	I	-	0.619	33.53	ok
MJ	E145	ARGR	49.96	15.1	16.3	17.9	sc, ot	I	-	0.686	40.20	ok
MJ	E146	ARGR	45.23	14.9	16.0	17.7	sc, ot	I	-	0.546	34.61	ok
JS	E147	ARGR	77.33	17.4	18.8	20.6	sc, ot	I	-	0.957	59.27	ok
MJ	E148	ARGR	19.06	11.3	12.3	13.5	sc, ot	I	-	0.314	14.27	ok
JS	E149	ARGR	45.04	14.5	15.4	17.3	sc, ot	I	-	0.574	34.41	ok
MJ	E150	ARGR	59.28	16.0	17.7	19.5	sc, ot	I	-	0.684	47.70	ok
JS	E151	ARGR	54.15	15.2	16.3	18.0	sc	I	-	0.793	41.73	ok
MJ	E152	ARGR	69.45	16.3	17.7	19.4	sc, ot	I	0.231	1.018	54.54	ok, immature female, stomach contents = 1.553g
JS	E153	ARGR	66.62	16.3	17.8	19.7	sc, ot	I	-	0.780	52.64	ok
MJ	E154	ARGR	61.38	16.1	17.5	19.1	sc, ot	I	-	0.909	47.32	ok, immature male
JS	E155	ARGR	47.65	15.2	15.9	17.7	sc, ot	I	-	0.559	37.25	ok
MJ	E156	ARGR	12.31	9.8	10.8	11.7	sc, ot	I	-	0.155	8.62	ok
MJ	E157	ARGR	19.65	11.4	12.5	13.6	sc, ot	I	-	0.258	14.65	ok
JS	E158	ARGR	58.45	15.9	17.0	18.7	sc, ot	I	-	0.880	45.48	ok
JS	E159	ARGR	2.72	6.4	6.9	7.4	sc	I	-	0.057	1.60	ok
JS	E160	ARGR	16.83	11.0	11.8	12.9	sc	I	-	0.245	11.67	ok
MJ	E161	ARGR	2.28	5.8	6.5	7.0	sc	I	-	0.045	1.48	ok
JS	E162	ARGR	15.30	10.5	11.7	12.8	sc, ot	I	-	0.171	11.56	slightly pale liver
MJ	E163	ARGR	20.12	11.7	12.9	14.1	sc, ot	I	-	0.304	15.17	ok
JS	E164	ARGR	59.02	16.2	17.5	19.3	sc	I	-	0.732	46.02	ok
MJ	E165	ARGR	3.22	6.2	6.7	7.5	sc	I	-	0.064	2.09	ok
MJ	E166	ARGR	3.20	6.4	7.2	7.8	sc	I	-	0.071	2.09	ok
JS	E167	ARGR	3.04	6.4	7.0	7.5	sc	I	-	0.029	2.07	ok
MJ	E168	ARGR	1.65	5.3	6.0	6.5	sc	I	-	0.029	1.00	ok
MJ	E169	ARGR	1.97	5.3	5.9	6.5	sc	I	-	0.031	1.31	ok
JS	E170	ARGR	1.73	5.8	6.3	6.8	sc	I	-	0.007	1.01	ok
JS	E171	ARGR	2.82	6.1	6.7	7.3	sc	I	-	-	1.76	liver accidentally discarded before obtaining weight
MJ	E172	ARGR	2.67	5.9	6.4	7.0	sc	I	-	0.025	1.74	ok
JS	E173	ARGR	1.82	5.8	6.3	6.8	sc	I	-	0.024	1.13	pale liver
MJ	E174	ARGR	2.03	5.2	5.8	6.3	sc	I	-	0.032	1.28	ok
MJ	E175	ARGR	2.18	5.4	6.1	6.6	sc	I	-	0.030	1.35	ok
JS	E176	ARGR	1.87	5.3	5.8	6.3	sc	I	-	0.033	1.20	ok

Table D-4. Fish Morphometric Data from the Lupin 2008 EEM Exposure Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
MJ	E177	ARGR	2.08	5.6	6.3	6.8	sc	I	-	0.041	1.21	ok
JS	E178	ARGR	2.64	5.9	6.5	7.1	sc	I	-	0.036	1.64	ok
MJ	E179	ARGR	1.98	5.3	5.9	6.6	sc	I	-	0.026	1.19	ok
JS	E180	ARGR	1.74	5.3	5.8	6.3	sc	I	-	0.030	1.03	ok
MJ	E181	ARGR	1.54	4.9	5.5	6.1	sc	I	-	0.022	0.97	ok
JS	E182	ARGR	1.23	5.0	5.4	6.0	sc	I	-	0.016	0.62	ok
JS	E183	NSSB	0.303	3.6	-	4.1	-	I	-	0.003	0.191	ok
JS	E184	NSSB	0.542	4.1	-	4.5	-	I	-	0.004	0.321	ok
JS	E185	NSSB	0.268	3.4	-	3.7	-	I	-	0.002	0.154	ok
MJ	E186	NSSB	0.404	3.6	-	4.2	-	I	-	0.013	0.236	ok
JS	E187	NSSB	0.518	4.0	-	4.6	-	I	-	0.007	0.273	ok
MJ	E188	NSSB	0.293	3.3	-	3.9	-	I	-	0.006	0.148	ok
MJ	E189	NSSB	0.450	3.8	-	4.4	-	I	-	0.013	0.248	ok
JS	E190	NSSB	0.382	4.0	-	4.5	-	I	-	0.002	0.247	ok
MJ	E191	NSSB	0.345	3.5	-	4.1	-	I	-	0.007	0.180	ok
JS	E192	NSSB	0.409	4.0	-	4.5	-	I	-	0.005	0.237	ok
MJ	E193	NSSB	0.267	3.2	-	3.7	-	I	-	0.011	0.140	ok
MJ	E194	NSSB	0.313	3.4	-	4.0	-	I	-	0.009	0.172	ok
JS	E195	NSSB	0.302	3.6	-	4.0	-	I	-	0.003	0.179	ok
JS	E196	NSSB	0.493	4.0	-	4.5	-	I	-	0.001	0.277	ok
JS	E197	NSSB	0.412	4.1	-	4.6	-	I	-	0.001	0.213	ok
MJ	E198	NSSB	0.193	2.9	-	3.4	-	I	-	0.003	0.105	ok
JS	E199	NSSB	0.251	3.3	-	3.7	-	I	-	0.001	0.148	ok
JS	E200	ARGR	51.47	15.3	15.8	17.7	sc, ot	I	-	0.551	39.34	ok, immature male, stomach contents = 0.656g
SS	E201	ARGR	62.11	16.1	17.1	19.0	sc, ot	I	-	0.674	49.37	ok, immature male
JS	E202	ARGR	50.07	15.5	16.6	18.3	sc, ot	I	-	0.453	39.23	ok, male, stomach contents = 0.375g
SS	E203	ARGR	55.48	15.9	17.0	18.9	sc, ot	I	-	0.679	43.71	ok
SS	E204	ARGR	54.27	15.7	17.0	18.7	sc, ot	I	0.178	0.661	42.84	ok, immature female
JS	E205	ARGR	50.87	15.4	16.8	18.5	sc, ot	I	-	0.651	40.92	ok, immature male
JS	E206	ARGR	44.19	14.8	15.8	17.5	sc, ot	I	-	0.609	34.19	ok, immature male
SS	E207	ARGR	53.67	15.5	16.5	18.2	sc, ot	I	0.156	0.606	41.81	ok, immature female
JS	E208	ARGR	53.40	15.5	16.8	18.4	sc, ot	I	-	0.558	42.29	ok, immature male, stomach contents = 0.820g
SS	E209	ARGR	20.24	11.4	12.5	13.6	sc, ot	I	-	0.313	15.47	ok
JS	E210	ARGR	49.64	15.0	16.1	17.7	sc, ot	I	-	0.571	38.59	ok, stomach contents = 0.092,g, abundant fatty tissue
SS	E211	ARGR	15.73	10.1	11.3	12.5	sc, ot	I	0.050	0.247	11.21	ok, immature female
SS	E212	ARGR	16.57	10.1	11.4	12.6	sc, ot	I	-	0.127	12.41	ok
JS	E213	ARGR	13.72	10.3	11.0		sc, ot	I	-	0.166	9.83	ok

AECOM

Table D-5. Fish Morphometric Data from the Lupin 2008 EEM Reference Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
SS	R001	NSSB	0.270	3.1	-	3.7	-	I	-	0.008	0.144	ok
SS	R002	NSSB	0.300	3.5	-	4.1	-	I	-	0.014	0.172	ok
MJ	R003	NSSB	-	1.9	-	2.4	-	I	-	0.002	0.039	ok, weight not recorded
SS	R004	NSSB	0.280	3.4	-	4.0	-	I	-	0.004	0.221	ok
MJ	R005	NSSB	0.089	2.0	-	2.5	-	I	-	0.002	0.049	ok
SS	R006	NSSB	0.168	2.7	-	3.2	-	I	-	0.001	0.080	ok
MJ	R007	NSSB	0.078	2.1	-	2.5	-	I	-	0.003	0.039	ok
SS	R008	NSSB	0.163	2.7	-	3.2	-	I	-	0.001	0.082	ok
MJ	R009	NSSB	0.073	2.0	-	2.4	-	I	-	0.001	0.041	ok
SS	R010	NSSB	0.139	2.7	-	3.1	-	I	-	0.000	0.067	ok
MJ	R011	NSSB	0.142	2.5	-	3.0	-	I	-	0.000	0.075	ok
SS	R012	NSSB	0.202	2.9	-	3.4	-	I	-	0.000	0.106	ok
SS	R013	NSSB	0.114	2.5	-	2.9	-	I	-	0.000	0.057	ok
MJ	R014	NSSB	0.094	2.0	-	2.5	-	I	-	0.002	0.044	ok
SS	R015	NSSB	0.127	2.5	-	2.9	-	I	-	0.002	0.062	ok
MJ	R016	NSSB	0.087	1.9	-	2.4	-	I	-	0.003	0.045	ok
SS	R017	NSSB	0.113	2.5	-	3.0	-	I	-	0.002	0.061	ok
MJ	R018	NSSB	0.069	1.8	-	2.3	-	I	-	0.003	0.038	ok
MJ	R019	NSSB	0.106	2.2	-	2.7	-	I	-	0.002	0.060	ok
SS	R020	NSSB	0.118	2.4	-	2.9	-	I	-	0.002	0.067	ok
MJ	R021	NSSB	0.092	2.2	-	2.6	-	I	-	0.002	0.050	ok
SS	R022	NSSB	0.119	2.5	-	2.9	-	I	-	0.002	0.060	ok
MJ	R023	NSSB	0.119	2.2	-	2.6	-	I	-	0.001	0.061	ok
SS	R024	NSSB	0.092	2.3	-	2.7	-	I	-	0.000	0.043	ok
MJ	R025	NSSB	0.084	2.0	-	2.5	-	I	-	0.000	0.046	ok
MJ	R026	NSSB	0.066	1.8	-	2.2	-	I	-	0.000	0.035	ok
SS	R027	NSSB	0.096	2.2	-	2.5	-	I	-	0.000	0.050	ok
MJ	R028	NSSB	0.070	1.9	-	2.2	-	I	-	0.002	0.035	ok
MJ	R029	NSSB	0.098	2.0	-	2.5	-	I	-	0.003	0.048	ok
SS	R030	NSSB	0.136	2.5	-	2.9	-	I	-	0.001	0.064	ok
MJ	R031	NSSB	0.109	2.2	-	2.6	-	I	-	0.002	0.059	ok
SS	R032	NSSB	0.118	2.5	-	3.0	-	I	-	0.000	0.058	ok
MJ	R033	NSSB	0.097	2.1	-	2.5	-	I	-	0.002	0.043	ok
SS	R034	NSSB	0.082	2.2	-	2.5	-	I	-	0.001	0.039	ok
MJ	R035	NSSB	0.099	2.0	-	2.5	-	I	-	0.003	0.050	ok
MJ	R036	NSSB	0.066	1.8	-	2.2	-	I	-	0.000	0.039	ok
SS	R037	NSSB	0.097	2.3	-	2.7	-	I	-	0.001	0.052	ok
MJ	R038	NSSB	0.084	1.9	-	2.3	-	I	-	0.002	0.043	ok
SS	R039	NSSB	0.103	2.2	-	2.6	-	I	-	0.001	0.050	ok
MJ	R040	NSSB	0.114	2.2	-	2.6	-	I	-	0.000	0.057	ok
MJ	R041	NSSB	0.089	2.0	-	2.5	-	I	-	0.002	0.047	ok
SS	R042	NSSB	0.082	2.1	-	2.5	-	I	-	0.002	0.039	ok
MJ	R043	NSSB	0.083	1.9	-	2.3	-	I	-	0.001	0.043	ok
SS	R044	NSSB	0.076	2.0	-	2.4	-	I	-	0.000	0.038	ok
MJ	R045	NSSB	0.076	1.8	-	2.3	-	I	-	0.000	0.037	ok
SS	R046	NSSB	0.094	2.2	-	2.5	-	I	-	0.000	0.044	ok
MJ	R047	NSSB	0.085	1.9	-	2.3	-	I	-	0.002	0.042	ok

Table D-5. Fish Morphometric Data from the Lupin 2008 EEM Reference Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
SS	R048	NSSB	0.075	2.0	-	2.2	-	I	-	0.000	0.034	ok
MJ	R049	NSSB	0.056	1.6	-	2.0	-	I	-	0.000	0.022	ok
SS	R050	NSSB	0.086	2.2	-	2.5	-	I	-	-	0.040	ok
MJ	R051	NSSB	0.067	1.7	-	2.1	-	I	-	0.000	0.034	ok
MJ	R052	NSSB	0.093	2.0	-	2.4	-	I	-	0.000	0.053	ok
SS	R053	NSSB	0.078	2.1	-	2.5	-	I	-	0.002	0.038	ok
MJ	R054	NSSB	0.068	1.9	-	2.2	-	I	-	0.000	0.039	ok
SS	R055	NSSB	0.089	2.1	-	2.4	-	I	-	0.000	0.045	ok
MJ	R056	NSSB	0.098	1.9	-	2.4	-	I	-	0.000	0.051	ok
SS	R057	NSSB	0.096	2.2	-	2.6	-	I	-	0.000	0.046	ok
MJ	R058	NSSB	0.070	1.8	-	2.2	-	I	-	0.001	0.034	ok
SS	R059	NSSB	0.065	1.9	-	2.3	-	I	-	0.000	0.033	ok
MJ	R060	NSSB	0.086	1.9	-	2.3	-	I	-	0.002	0.044	ok
SS	R061	NSSB	0.082	2.0	-	2.5	-	I	-	0.002	0.039	ok
MJ	R062	NSSB	0.074	1.9	-	2.3	-	I	-	0.000	0.040	ok
SS	R063	NSSB	0.081	2.0	-	2.4	-	I	-	0.000	0.040	ok
MJ	R064	NSSB	0.069	1.7	-	2.1	-	I	-	0.000	0.033	ok
SS	R065	NSSB	0.061	1.8	-	2.2	-	I	-	0.000	0.028	ok
MJ	R066	NSSB	0.066	1.8	-	2.2	-	I	-	0.001	0.031	ok
MJ	R067	NSSB	0.069	1.7	-	2.2	-	I	-	0.001	0.035	ok
SS	R068	NSSB	0.100	2.1	-	2.5	-	I	-	0.000	0.048	ok
MJ	R069	NSSB	0.085	1.9	-	2.4	-	I	-	0.001	0.048	ok
SS	R070	NSSB	0.077	2.1	-	2.4	-	I	-	0.000	0.043	ok
MJ	R071	NSSB	0.048	1.5	-	1.7	-	I	-	0.000	0.017	ok
MJ	R072	NSSB	0.084	1.9	-	2.4	-	I	-	0.001	0.039	ok
SS	R073	NSSB	0.076	2.0	-	2.4	-	I	-	0.000	0.041	ok
MJ	R074	NSSB	0.066	1.7	-	2.1	-	I	-	0.000	0.031	ok
SS	R075	NSSB	0.051	1.7	-	2.0	-	I	-	0.000	0.025	ok
MJ	R076	ARGR	50.37	14.8	16.1	17.6	sc, ot	I	-	0.481	37.20	ok
SS	R077	ARGR	23.92	12.1	13.3	14.4	sc, ot	I	-	0.307	16.75	ok
MJ	R078	ARGR	19.37	11.5	12.5	13.5	sc	I	-	0.195	15.23	ok
MJ	R079	ARGR	3.66	6.5	7.4	7.9	sc, ot	I	-	0.050	2.22	ok
SS	R080	ARGR	3.61	6.4	7.2	7.9	sc, ot	I	-	0.043	2.14	ok
MJ	R081	ARGR	4.16	6.9	7.7	8.3	sc, ot	I	-	0.061	2.76	ok
SS	R082	ARGR	4.00	6.5	7.3	7.9	sc, ot	I	-	0.028	2.33	ok
MJ	R083	ARGR	3.43	6.2	7.0	7.5	sc, ot	I	-	0.049	2.28	ok
SS	R084	ARGR	3.72	7.0	7.2	8.2	sc	I	-	0.032	2.41	ok
SS	R089	ARGR	3.00	6.3	7.0	7.6	sc,ot	I	-	0.054	1.71	ok
MJ	R090	ARGR	3.98	7.0	7.6	8.2	sc, ot	I	-	0.056	2.62	ok
JS	R091	ARGR	40.88	15.1	15.8	17.1	sc	I	-	0.311	30.10	ok, stomach contents = 0.581 g
SS	R092	ARGR	4.83	6.8	7.7	8.5	sc	I	-	0.074	3.25	ok
SS	R093	ARGR	4.53	6.8	7.7	8.4	sc	I	-	0.055	2.99	ok
JS	R094	ARGR	90.17	18.5	19.0	20.8	sc, ot	I	-	1.093	71.57	ok, stomach contents = 0.559 g
SS	R095	ARGR	3.56	6.1	6.9	7.6	sc	I	-	0.082	2.34	ok
SS	R096	ARGR	3.44	6.5	7.2	7.9	sc	I	-	0.026	2.53	pale liver
JS	R097	ARGR	3.68	6.5	7.1	7.7	sc	I	-	0.039	2.14	ok
JS	R098	ARGR	3.37	6.7	7.3	8.0	sc	I	-	0.030	2.08	pale liver

Table D-5. Fish Morphometric Data from the Lupin 2008 EEM Reference Area

Dissected by	Fish ID	Species	Total Weight (g)	Standard Length (cm)	Fork Length(cm)	Total Length(cm)	Aging Structure[a]	Sex[b]	Gonad Weight	Liver Weight (g)	Carcass Weight (g)	Condition/Comments
SS	R099	NSSB	0.113	2.5	-	3.0	-	I	-	0.003	0.057	ok
MJ	R100	ARGR	19.13	11.6	12.8	14.0	sc	I	-	0.247	14.67	ok
JS	R101	ARGR	3.84	7.1	7.8	8.5	sc	I	-	0.045	2.66	ok
JS	R102	ARGR	4.35	6.7	7.6	8.8	sc	I	-	0.062	2.69	ok
MJ	R103	ARGR	3.38	6.1	6.9	7.5	sc	I	-	0.055	2.23	ok
JS	R104	ARGR	4.80	7.5	8.2	8.8	sc	I	-	0.072	3.26	ok
MJ	R105	ARGR	4.68	7.5	8.3	8.8	sc	I	-	0.078	3.26	ok, stomach content mass = 0.107g
MJ	R106	ARGR	2.99	6.4	7.0	7.6	sc	I	-	0.047	2.05	ok
JS	R107	ARGR	4.35	7.7	8.0	8.6	sc	I	-	0.068	3.08	ok
MJ	R108	NSSB	0.352	3.5	-	4.1	-	I	-	0.011	0.225	ok
JS	R109	NSSB	0.164	2.6	-	3.1	-	I	-	0.001	0.105	ok
MJ	R110	NSSB	0.070	2.2	-	2.5	-	I	-	0.002	0.035	ok
MJ	R111	NSSB	0.147	2.7	-	3.2	-	I	-	0.004	0.084	ok
JS	R112	NSSB	0.104	2.3	-	2.7	-	I	-	0.000	0.063	ok
MJ	R113	NSSB	0.074	2.2	-	2.6	-	I	-	0.002	0.035	ok
JS	R114	NSSB	0.093	2.2	-	2.5	-	I	-	0.002	0.050	ok
MJ	R115	NSSB	0.073	2.1	-	2.5	-	I	-	0.003	0.029	ok
MJ	R116	NSSB	0.075	2.2	-	2.5	-	I	-	0.001	0.032	ok
JS	R117	NSSB	0.061	1.7	-	2.1	-	I	-	0.000	0.034	ok
MJ	R118	NSSB	0.046	1.8	-	2.1	-	I	-	0.001	0.019	ok
MJ	R119	NSSB	0.055	1.8	-	2.1	-	I	-	0.000	0.022	ok
JS	R120	ARGR	66.24	17.2	18.3	20.0	sc,ot	M	-	0.600	53.83	ok, immature male
SS	R121	ARGR	27.78	12.5	13.9	15.2	sc,ot	I	-	0.369	21.12	ok
SS	R122	ARGR	3.94	7.1	7.7	8.3	sc,ot	I	-	0.056	2.68	ok
JS	R123	ARGR	18.87	11.6	12.5	13.7	sc,ot	I	-	0.299	13.99	ok
SS	R124	ARGR	3.84	6.3	7.1	7.8	sc,ot	I	-	0.042	2.70	ok
JS	R125	ARGR	4.17	7.2	7.9	8.5	sc	I	-	0.074	2.67	ok
JS	R126	ARGR	3.46	7.0	7.4	8.0	sc	I	-	0.060	2.35	ok
SS	R127	ARGR	3.04	6.4	7.2	8.0	sc,ot	I	-	0.039	2.08	pale liver
JS	R128	ARGR	3.77	6.6	7.3	7.8	sc	I	-	0.076	2.58	ok
SS	R129	ARGR	3.38	6.2	6.9	7.5	sc	I	-	0.047	2.25	ok
JS	R130	ARGR	2.99	5.9	6.5	7.1	sc	I	-	0.028	1.70	ok
SS	R131	ARGR	2.61	5.6	6.4	6.9	sc	I	-	0.040	1.76	ok
JS	R132	NSSB	0.736	4.3	-	5.1	-	I	-	0.005	0.478	ok
SS	R133	NSSB	0.186	2.7	-	3.3	-	I	-	0.003	0.110	ok
JS	R134	NSSB	0.231	3.1	-	3.7	-	I	-	0.002	0.132	ok
SS	R135	NSSB	0.164	2.5	-	3.1	-	I	-	0.005	0.085	ok
JS	R136	NSSB	0.080	2.2	-	2.7	-	I	-	0.000	0.045	ok
SS	R137	NSSB	0.137	2.6	-	3.2	-	I	-	0.003	0.067	ok
SS	R138	NSSB	0.075	1.9	-	2.4	-	I	-	0.002	0.034	ok

Table D-6. Results of Copper Analysis from Fish Tissue Samples Lupin EEM 2008 (units in mg/kg)

Date Reported	ALS Sample ID	Date Sampled		Parameter	Copper (Cu)[a]
28-OCT-08	L680195-1	09-SEP-08	Reference	RT1	0.44
28-OCT-08	L680195-2	09-SEP-08		RT2	0.53
28-OCT-08	L680195-3	09-SEP-08		RT3	0.50
28-OCT-08	L680195-4	09-SEP-08		RT4	0.49
28-OCT-08	L680195-5	09-SEP-08		RT5	0.52
28-OCT-08	L680195-6	09-SEP-08		RT6	0.54
28-OCT-08	L680195-7	09-SEP-08		RT7	0.53
28-OCT-08	L680195-8	09-SEP-08		RT8	0.81
28-OCT-08	L680195-9	09-SEP-08	Exposure	ET1	0.50
28-OCT-08	L680195-10	09-SEP-08		ET2	0.58
28-OCT-08	L680195-11	09-SEP-08		ET3	0.51
28-OCT-08	L680195-12	09-SEP-08		ET4	0.52
28-OCT-08	L680195-13	09-SEP-08		ET5	0.57
28-OCT-08	L680195-14	09-SEP-08		ET6	0.51
28-OCT-08	L680195-15	09-SEP-08		ET7	0.59
28-OCT-08	L680195-16	09-SEP-08		ET8	0.61

Note: a-detection limit 0.05 mg/kg

AECOM

Table D-7. Arctic Grayling Age Determination (Performed by Northshore Environmental)

Fish ID	Species	Fork Length (cm)	Aging Structure	Age (>yrs)	Confidence[a]
E001	ARGR	6.5	sc	0	7
E002	ARGR	9.9	sc, ot	1	7
E003	ARGR	6.6	sc	0	7
E004	ARGR	5.8	sc	0	7
E005	ARGR	6.3	sc	0	7
E006	ARGR	5.3	sc	0	7
E007	ARGR	6.9	sc	0	7
E008	ARGR	5.3	sc	0	7
E009	ARGR	6.1	sc	0	7
E010	ARGR	5.5	sc	0	7
E056	ARGR	11.6	sc, ot	1	6 to 7
E057	ARGR	10.7	sc, ot	1	7
E058	ARGR	11.7	sc, ot	1	7
E059	ARGR	6.7	sc, ot	1	5 to 6
E060	ARGR	11.5	sc, ot	1	6
E061	ARGR	6.4	sc	0	6 to 7
E062	ARGR	6.7	sc, ot	0	7
E063	ARGR	17.4	sc, ot	2	7
E064	ARGR	5.7	sc	0	7
E065	ARGR	6.3	sc	0	7
E066	ARGR	22.0	sc, ot	3	7
E067	ARGR	10.4	sc, ot	1	7
E068	ARGR	6.7	sc	0	7
E069	ARGR	12.5	sc, ot	1	7
E070	ARGR	6.6	sc	0	7
E071	ARGR	6.9	sc	0	7
E072	ARGR	6.6	sc	0	7
E073	ARGR	6.5	sc, ot	0	7
E074	ARGR	6.4	sc	0	7
E075	ARGR	5.4	sc	0	7
E076	ARGR	5.8	sc	0	6 to 7
E077	ARGR	6.5	sc	0	7

AECOM

Table D-7. Arctic Grayling Age Determination (Performed by Northshore Environmental)

Fish ID	Species	Fork Length (cm)	Aging Structure	Age (>yrs)	Confidence[a]
E078	ARGR	6.2	sc	0	7
E079	ARGR	6.0	sc	0	7
E080	ARGR	5.1	sc	0	6 to 7
E081	ARGR	5.8	sc	0	7
E082	ARGR	5.8	sc	0	6 to 7
E083	ARGR	4.2	sc	0	7
E084	ARGR	6.3	sc	0	7
E085	ARGR	5.6	sc	0	7
E086	ARGR	6.9	sc	0	7
E087	ARGR	6.5	sc	0	7
E130	ARGR	17.5	sc, ot	2	7
E131	ARGR	16.7	sc, ot	2	7
E132	ARGR	16.6	sc, ot	2	7
E133	ARGR	17.1	sc, ot	2	7
E134	ARGR	6.2	sc	0	7
E135	ARGR	15.8	sc, ot	2	7
E136	ARGR	5.6	sc, ot	0	7
E137	ARGR	16.3	sc, ot	2	7
E138	ARGR	16.7	sc, ot	2	7
E139	ARGR	10.7	sc	1	7
E140	ARGR	15.9	sc, ot	2	7
E141	ARGR	17.0	sc, ot	2	7
E142	ARGR	15.6	sc, ot	2	7
E143	ARGR	17.1	sc, ot	2	7
E144	ARGR	15.7	sc, ot	2	7
E145	ARGR	16.3	sc, ot	2	7
E146	ARGR	16.0	sc, ot	2	7
E147	ARGR	18.8	sc, ot	3	6 to 7
E148	ARGR	12.3	sc, ot	1	7
E149	ARGR	15.4	sc, ot	2	7
E150	ARGR	17.7	sc, ot	2	7
E151	ARGR	16.3	sc	2	7

AECOM

Table D-7. Arctic Grayling Age Determination (Performed by Northshore Environmental)

Fish ID	Species	Fork Length (cm)	Aging Structure	Age (>yrs)	Confidence[a]
E152	ARGR	17.7	sc, ot	2	7
E153	ARGR	17.8	sc, ot	2	7
E154	ARGR	17.5	sc, ot	2	7
E155	ARGR	15.9	sc, ot	2	7
E156	ARGR	10.8	sc, ot	1	7
E157	ARGR	12.5	sc, ot	1	7
E158	ARGR	17.0	sc, ot	2	7
E159	ARGR	6.9	sc	0	7
E160	ARGR	11.8	sc	1	7
E161	ARGR	6.5	sc	0	7
E162	ARGR	11.7	sc, ot	1	7
E163	ARGR	12.9	sc, ot	1	7
E164	ARGR	17.5	sc	2	6 to 7
E165	ARGR	6.7	sc	0	7
E166	ARGR	7.2	sc	0	7
E167	ARGR	7.0	sc	0	7
E168	ARGR	6.0	sc	0	7
E169	ARGR	5.9	sc	0	7
E170	ARGR	6.3	sc	0	7
E171	ARGR	6.7	sc	0	7
E172	ARGR	6.4	sc	0	7
E173	ARGR	6.3	sc	0	7
E174	ARGR	5.8	sc	0	7
E175	ARGR	6.1	sc	0	7
E176	ARGR	5.8	sc	0	7
E177	ARGR	6.3	sc	0	7
E178	ARGR	6.5	sc	0	6
E179	ARGR	5.9	sc	0	7
E180	ARGR	5.8	sc	0	6 to 7
E181	ARGR	5.5	sc	0	7
E182	ARGR	5.4	sc	0	7
E200	ARGR	15.8	sc, ot	2	7

AECOM

Table D-7. Arctic Grayling Age Determination (Performed by Northshore Environmental)

Fish ID	Species	Fork Length (cm)	Aging Structure	Age (>yrs)	Confidence[a]
E201	ARGR	17.1	sc, ot	2	7
E202	ARGR	16.6	sc, ot	2	7
E203	ARGR	17.0	sc, ot	2	7
E204	ARGR	17.0	sc, ot	2	7
E205	ARGR	16.8	sc, ot	2	7
E206	ARGR	15.8	sc, ot	2	7
E207	ARGR	16.5	sc, ot	2	7
E208	ARGR	16.8	sc, ot	2	7
E209	ARGR	12.5	sc, ot	1	7
E210	ARGR	16.1	sc, ot	2	7
E211	ARGR	11.3	sc, ot	1	6
E212	ARGR	11.4	sc, ot	1	6 to 7
E213	ARGR	11.0	sc, ot	1	7
R076	ARGR	16.1	sc, ot	2	7
R077	ARGR	13.3	sc, ot	1	7
R078	ARGR	12.5	sc	1	7
R079	ARGR	7.4	sc, ot	0	7
R080	ARGR	7.2	sc, ot	0	7
R081	ARGR	7.7	sc, ot	0	7
R082	ARGR	7.3	sc, ot	0	7
R083	ARGR	7.0	sc, ot	0	7
R084	ARGR	7.2	sc	0	6 to 7
R089	ARGR	7.0	sc,ot	0	7
R090	ARGR	7.6	sc, ot	0	7
R091	ARGR	15.8	sc	2	7
R092	ARGR	7.7	sc	0	7
R093	ARGR	7.7	sc	0	6 to 7
R094	ARGR	19.0	sc, ot	2	6 to 7
R095	ARGR	6.9	sc	0	6 to 7
R096	ARGR	7.2	sc	0	7
R097	ARGR	7.1	sc	0	6 to 7
R098	ARGR	7.3	sc	0	6 to 7

AECOM

Table D-7. Arctic Grayling Age Determination (Performed by Northshore Environmental)

Fish ID	Species	Fork Length (cm)	Aging Structure	Age (>yrs)	Confidence[a]
R100	ARGR	12.8	sc	1	7
R101	ARGR	7.8	sc	0	7
R102	ARGR	7.6	sc	0	6 to 7
R103	ARGR	6.9	sc	0	7
R104	ARGR	8.2	sc	0	6
R105	ARGR	8.3	sc	0	7
R106	ARGR	7.0	sc	0	7
R107	ARGR	8.0	sc	0	7
R120	ARGR	18.3	sc,ot	2	7
R121	ARGR	13.9	sc,ot	2	7
R122	ARGR	7.7	sc,ot	0	7
R123	ARGR	12.5	sc,ot	1	7
R124	ARGR	7.1	sc,ot	0	7
R125	ARGR	7.9	sc	0	6
R126	ARGR	7.4	sc	0	6 to 7
R127	ARGR	7.2	sc,ot	0	7
R128	ARGR	7.3	sc	0	7
R129	ARGR	6.9	sc	0	7
R130	ARGR	6.5	sc	0	7
R131	ARGR	6.4	sc	0	7

a) Confidence levels indicate how good the age assessment is based on the condition of the aging structure provided, 7 - good confidence, 6 - fair confidence, 5 - low confidence