FINAL REPORT ON

EFFLUENT AND AQUATIC MONITORING STUDY DESIGN FOR DORIS NORTH PROJECT, NUNAVUT, CANADA

Submitted To
Miramar Hope Bay Ltd.

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1. INTRODUCTION

Miramar Hope Bay Ltd. (MHBL) proposes to construct and operate a new underground gold mine ("the Doris North Project") in the West Kitikmeot Region of Nunavut. The project is located 685 km northeast of Yellowknife and 160 km southwest of Cambridge Bay. The mine is on Inuit owned land, approximately 5 km south of the Arctic Ocean. The nearest communities are Umingmaktok, located 65 km to the west and Bathurst Inlet located 110 km to the southwest. Following approval, and upon commencing discharge of >50 m^3/d of effluent to the receiving environment, the mine will be subject to the Metal Mining Effluent Regulations (MMER), which include requirements for an aquatic Environmental Effects Monitoring (EEM) program.

The MMER were developed under the federal *Fisheries Act*, with the intent of protecting fish, fish habitat, and the use of fisheries resources in waterbodies adjacent to metal mines. These regulations require metal mines that discharge effluent into an aquatic receiving environment to monitor the effluent for deleterious substances, pH and acute lethality, to prepare an emergency response plan, and to undertake EEM studies.

The EEM program is intended to achieve national uniformity in the monitoring of aquatic effects, while taking site specific factors into consideration. The program includes requirements for monitoring fish populations, mercury levels in fish tissue, benthic invertebrate communities, and the quality of effluent and water. Aquatic EEM consists of a series of monitoring and interpretation cycles, with the requirements of each cycle dependent upon the findings of the previous cycle. Specific requirements for the EEM program are outlined in the "Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring" (Environment Canada 2002; hereafter referred to as the guidance document).

In preparation for monitoring the aquatic effects of the Doris North Project, Miramar Hope Bay Ltd. (MHBL) retained Golder Associates to evaluate available baseline data and to design a monitoring program in accordance with EEM requirements. MHBL has also requested that other effluent monitoring requirements that fall under the MMER be included in this document. The MMER and, hence, EEM requirements are not yet applicable to the Doris North Project. The project will be bound by these regulations once effluent is discharged at a rate exceeding

50 m^3/day. In addition to the foregoing, the mine will also be bound by the conditions of a Water License issued by the Nunavut Land and Water Board.

1.1 Metal Mining Effluent Regulations (MMER)

The MMER were promulgated in June 2002 to give effect to several provisions of the *Fisheries Act*. The MMER stipulate the conditions under which deleterious substances may be discharged to the aquatic environment by metal mines. MMER stipulations include the following:

- classes of mine and associated operations that are authorized to discharge deleterious substances;
- persons who may authorize the deposit of deleterious substances, and the conditions or circumstances under which those persons may grant the authorization;
- nature and classes of deleterious substances that may be discharged;
- nature of waters or places into which such substances may be discharged;
- quantities or concentrations of deleterious substances that may be discharged;
- conditions or circumstances under which such discharges may be made; and,
- requirements for monitoring of discharges and their effects (i.e., EEM).

The MMER, which were registered in the Canada Gazette Part II (Vol. 136, No. 13) on June 6, 2002, supersede the Metal Mining Liquid Effluent Regulations (MMLER), which previously regulated the discharge of deleterious substances. Under the new MMER, the MMLER were repealed. The majority of MMER provisions, including the EEM program, came into force six months after registration of the MMER (i.e., by December 6, 2002). The regulations apply to all "mines", "mines under development" or "recognized closed mines" that:

- discharge an effluent containing deleterious substances with a flow rate that exceeds 50 m^3/day, based on effluent deposited from all the final discharge points (including seeps) of the mine; and,
- deposit a deleterious substance in such a way that it enters or can enter any water that is frequented by fish.

Requirements of the Metal Mining Effluent Regulations

The MMER require mine operators to undertake three distinct programs:

1. effluent monitoring;
2. emergency preparedness; and,
3. environmental effects monitoring.

Effluent monitoring requires the mine to undertake the following activities:

- weekly testing of effluent for the deleterious substances and pH as specified in Schedule 3 - Analytical Requirements for Metal Mining Effluent of the MMER;
- weekly or continuous measurement of flow rates; and,
- monthly testing of acute lethality of effluent to rainbow trout and *Daphnia magna*.

Each mine is required to develop, and update annually, an emergency response plan that identifies environmental risks, together with the measures that have been put in place to mitigate the effects of an unplanned deposit of a deleterious substance. The emergency response plan, which must be completed within 60 days of the mine becoming subject to the MMER, shall include the following:

- a site risk analysis;
- an organizational scheme for emergency responses;
- alerting and notification procedures;
- an inventory of spill-response equipment; and,
- a training plan for mine personnel.

Under EEM, mines are required to undertake a series of monitoring studies to assess the potential effects of effluent on water quality, fish populations, fish tissue concentrations of mercury, and on the benthic invertebrate community. Monitoring requirements under the EEM program are outlined in the following section.

1.2 Metal Mining Environmental Effects Monitoring (EEM) Program

1.2.1 Summary of Environmental Effects Monitoring

Environmental effects monitoring is a requirement of the MMER under the authority of the *Fisheries Act*. The objective of EEM, as defined in the guidance document, is to evaluate the effects of mine effluent on fish, fish habitat, and the use of fisheries resources. The guiding principles of the EEM program are that it be scientifically defensible, cost-effective, and flexible around site-specific requirements, without subjecting field crews to unsafe sampling conditions. The program is designed to allow for the incorporation of new or improved monitoring techniques and to build on findings of relevant research programs or pilot studies.

The MMER require that all metal mines in Canada to which the regulations apply undertake EEM studies in accordance with the requirements and within the periods set out in Schedule 5 - Environmental Effects Monitoring Studies of the MMER. Environmental effects monitoring requirements have been divided into two parts:

- Part 1: Effluent and Water Quality Monitoring Studies; and,
- Part 2: Biological Monitoring Studies.

Part 1: Effluent and Water Quality Monitoring Studies

The purpose of effluent and water quality monitoring is to assess, and track changes in, the quality of the effluent and the receiving water, and to provide background supporting information for the assessment and interpretation of the results of biological monitoring. Effluent and water quality monitoring consists of effluent characterization, sublethal toxicity testing of effluent and receiving water quality monitoring. Mines are to begin effluent and water quality monitoring six months after they are subject to the MMER, and results are be submitted in a report to the authorization officer annually, by March 31.

Table 1-1
Effluent and Water Quality Studies

Studies	Parameters Test	Frequency/Period
Effluent Characterization	Hardness, alkalinity, aluminium, cadmium, iron, mercury, molybdenum, ammonia, nitrate	Four times per year
Sublethal Toxicity Testing	Fish test (fathead minnow or rainbow trout) Invertebrate test (the Cladoceran *Ceriodaphnia dubia*) Plant test (the macrophyte *Lemna minor*) Algal test (*Selenastrum capricornutum*)	Two times per year for the first three years and once per year after the third year
Water Quality Monitoring	Temperature, dissolved oxygen, pH, hardness, alkalinity, aluminium, cadmium, iron, mercury, molybdenum, ammonia, nitrate, arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids, radium 226	Four times per year from an area surrounding the discharge and a reference area and at the same time and at the same locations as samples collected for the Biological Monitoring Studies

Part 2: Biological Monitoring Studies

The first biological monitoring study for a new mine is an ***Initial Monitoring*** study**.** The study design for the biological monitoring study must be submitted within 12 months of the mine being subject to the MMER (i.e., once effluent is discharged at a rate exceeding 50 m^3/day). The Interpretative Report of the study will then be submitted within 30 months of the mine being subject to the MMER. The Initial Monitoring studies will be designed to determine if the effluent is causing an effect by conducting biological monitoring studies on:

- fish;
- fish tissue; and,
- the benthic invertebrate community.

1.2.2 Implementation of Environmental Effects Monitoring

Each EEM study is carried out in a sequence of activities:

- submission of the study design for biological monitoring;
- conducting biological monitoring in the field (EEM Part 2);
- data assessment and interpretation, including submission of the interpretative report; and,
- effluent and water quality monitoring and reporting (EEM Part 1).

Study Design

The objective of a study design is to outline the field work and associated laboratory work that will be undertaken to complete the Biological Monitoring Studies of the EEM program. Achieving an appropriate study design will be an iterative process. Prior to conducting Biological Monitoring Studies, a study design will be submitted to the Authorization Officer at least six months prior to the commencement of biological monitoring in the field. This will allow reasonable time for the Authorization Officer to review and provide comments to the mine regarding the study design. The study design must include the following items:

- a detailed timetable for conducting each of the biological monitoring study requirements;
- a description of site characterization information;
- a description of how the fish survey will be conducted;
- a description of how the benthic invertebrate community survey will be conducted;
- identification of the quality assurance and quality control measures that will be taken; and,
- a summary of any previous biological monitoring conducted for EEM.

Site Characterization

Each Biological Monitoring Study design must contain site characterization information, which is information that is needed to prepare an EEM study design. Site characterization information must be updated (if necessary) and used in designing each study at different phases of the EEM program. A variety of information about mine operations and sampling (exposure and reference) areas will be essential for the preparation of an EEM study design. Such information should include: mine operation information; a description of the study area, including geological, oceanographical, limnological, hydrological, chemical and biological features of the area; a description of how the effluent mixes within the exposure area; and a description of confounding factors, which refers to any anthropogenic, natural or other factors, that are not related to the effluent under study but may reasonably be expected to contribute to an observed effect.

Fish Survey

The fish survey consists of a study of up to two fish populations to determine if mine effluent is having an effect on the fish. This is accomplished by examining specific indicators of fish population health. The fish survey also includes a study of fish tissue to determine if effluent is having an effect on fish usability. A mine is not required to conduct a fish survey if the concentration of effluent in the exposure area is less than 1% within 250m of each final discharge point. A fish tissue study is only required if the mine has measured concentrations of mercury greater than or equal to 0.10 µg/L in the effluent, as determined during effluent characterization (under EEM Part 1: Effluent And Water Quality Monitoring).

The fish survey is conducted to determine if there have been changes in fish growth, reproduction, condition, and survival. The scientifically-defensible method recommended to determine if there are changes in these parameters is to collect fish found in the exposure and reference areas, and to compare measurements of length, weight, gonad size, liver size, fecundity, and egg size. Results for fish collected in the exposure area will be compared statistically with those from fish collected in the reference area.

Tissue sampling is required if during effluent characterization, a concentration of total mercury in the effluent is identified that is equal to or greater than 0.10 µg/L. If this is the case, the fish tissue study is conducted by collecting tissue samples from a fish species that is locally consumed, from a minimum of eight fish per sampling area. Mercury concentrations in tissue samples from the exposure area will be compared to both mercury concentrations in samples from the reference area and to the Schedule 5 (EEM Monitoring Studies) guideline of 0.45 µg/g (wet weight) of mercury in fish tissue.

Benthic Invertebrate Community Survey

The benthic invertebrate community survey is conducted to determine if mine effluent is having an effect on fish habitat. This is accomplished by collecting benthic invertebrates in the exposure and reference areas, and comparing measurements of benthic invertebrate density, taxa richness, the Simpson's Diversity Index, and the Bray-Curtis Index between areas. To ensure site-specific flexibility, mines can choose from any of several scientifically-defensible sampling designs, including: control/impact; gradient; and the reference condition approach. Sample sizes (i.e., number of sampling stations) are determined site-specifically using statistical power analysis. Samples from both the exposure and reference areas must be collected in the most "ecologically-relevant" area (i.e., considering habitat type with the highest benthic invertebrate diversity and the dominant habitat in the exposure area) and season (i.e., the time of year when the benthic invertebrate diversity is highest and benthic invertebrates are most exposed to effluent). Mines must also report the total organic carbon content and particle size distribution of the sediments collected at each benthic invertebrate sampling station.

Data Assessment, Data Interpretation and Interpretative Reports

Following biological monitoring, data assessment and interpretation will be conducted to determine if mine effluent is causing an effect and what future monitoring requirements will be. Interpretative reports for the first and for subsequent biological monitoring studies completed as part of the EEM program will include the following information:

- a description of any deviations from the study design that occurred;
- description of the location of sampling areas;
- dates and times when the samples were collected;
- sample sizes;
- summary of the results, including summary statistics;
- an appendix outlining all measurements recorded;
- the results and statistical power of the statistical analyses conducted on data;
- identification, based on the scientific statistical analyses, of the presence or absence of an effect;
- results of the sublethal toxicity testing;

- the conclusions to the EEM study, and identification of how the conclusions will impact the study design for the subsequent EEM study;
- a schedule outlining: when the next study design will be submitted; when the next monitoring will be conducted; and when the next interpretative report will be submitted; and,
- any recommendations for improvements or changes to the study design for the subsequent EEM study.

1.3 Scope

The objectives of this document were to provide a study design for biological monitoring conforming to requirements described in the EEM guidance document and to evaluate available aquatic baseline data in terms of suitability for designing an EEM program. Aquatic environmental baseline studies were carried out in the Doris Lake area from 1995 to 1998, 2000 and 2002 (RL&L/Golder 2002 and 2003a). These studies collected valuable baseline data but were not intended to function as baseline studies for aquatic EEM. Thus, an EEM fisheries reconnaissance survey was conducted in 2003 (Golder 2003b) to aid in finalizing the design of the Doris North Project EEM study. The finalized design will be required for submission once the mine becomes operational and is subject to the MMER. In preparation for the application of the MMER, Section 2 of this report summarizes the effluent monitoring conditions that will be required of the Doris North Project under the MMER. The sections that follow are organized according to the structure of the EEM guidance document. They include a brief description of the study area (Section 3) and study designs for monitoring fish (Section 4), benthic invertebrate communities (Section 5), water quality (Section 6), and sediment quality (Section7).

The monitoring program design outlined in this document is consistent with the principles of the study design adopted by the metal mining EEM program (Environment Canada 2002); however, it should be noted that an official EEM study design document, including site characterization information, will not be required for submission until 12 months after the Doris North Project is subject to the MMER. Since EEM study designs for biological surveys are subject to regulatory approval, the actual design approved by the EEM authorization officer that will be used in the Doris North Project EEM program may differ from that proposed here.

2. EFFLUENT AND RECEIVING WATER MONITORING

2.1 Summary of Effluent Monitoring Requirements

Under the MMER, the Doris North Project mine will be required to monitor its effluent as follows:

- weekly testing of effluent for the deleterious substances and pH as specified in Schedule 3 of the MMER (summarized in Table 2-1, Suite 1);
- weekly or continuous measurement of flow rates;
- monthly testing for acute lethality of effluent to rainbow trout and *Daphnia magna*; and,
- effluent characterization conducted four times per year under EEM (Table 2-1, Suite 2).

The specific chemicals and parameters to be measured in effluent under the MMER are summarized in Table 2-1. A schedule for completing the effluent monitoring is presented in Table 2-2.

Table 2-1
Chemicals and Parameters to be Measured[a] in Effluent Under the MMER

Effluent Monitoring Required under MMER (Suite 1)		Effluent Characterization Compulsory under EEM (Suite 2)		Effluent Characterization Recommended under EEM (Suite 3)	
Arsenic	As	Aluminium	Al	Fluoride	F
Copper	Cu	Cadmium	Cd	Manganese	Mn
Cyanide[b]	CN	Iron	Fe	Selenium	Se
Lead	Pb	Mercury	Hg	Uranium	U
Nickel	Ni	Molybdenum	Mo	Total phosphorus	P
Zinc	Zn	Ammonia	NH_3	Conductivity	
Total suspended solids	TSS	Nitrate	NO_3	Calcium	Ca
Radium 226	Ra	Hardness		Chloride	Cl
pH		Alkalinity		Magnesium	Mg
				Potassium	K
				Sodium	Na
				Sulphate	SO_4
				Temperature	

a Total concentrations only.
b Only required if the mine utilises cyanide as a process reagent.

Table 2-2
Sampling Schedule for Effluent Monitoring and Characterization Under the MMER

Weekly	Effluent chemistry monitoring (Suite 1)
	Effluent flow rate monitoring (unless utilizing continuous flow monitoring)
Monthly	Testing of acute lethality of effluent to rainbow trout
	Testing of acute lethality of effluent to *Daphnia magna*
	Calculation of mean monthly effluent flow volume
	Calculation of mean monthly load of (Suite 1) chemicals
Four Times Yearly	Effluent characterization testing (Suite 2, plus Suite 3 if required)
	Report with results of Effluent Monitoring for each calendar quarter
Twice Yearly	Sub-lethal toxicity testing of effluent
Yearly	Report summarizing Effluent Monitoring results for the year
	Report summarizing effluent and water quality monitoring results (under EEM) for the year

2.2 Effluent Monitoring Under the MMER

2.2.1 Deleterious Substance and pH Testing

The Doris North Project will, on a weekly basis during the discharge period, collect a sample of final effluent from Tail Lake discharge, and analyze for pH and total concentrations of the substances listed in Table 2-1 (Suite 1) through a commercial laboratory. The chemical analyses will comply with the analytical requirements set out in Schedule 3 of the MMER.

2.2.2 Acute Lethality Testing

The Doris North Project mine will, on a monthly basis during the period of discharge, collect a grab sample of final effluent from Tail Lake, and conduct an acute lethality test of effluent on rainbow trout in accordance with the requirements and procedures specified in Reference Method EPS 1/RM/13. Concurrently with the rainbow trout tests, the Doris North Project mine will also conduct an acute lethality test of effluent on *Daphnia magna* in accordance with the procedures specified in Reference Method EPS 1/RM/14. The *Daphnia magna* tests will be conducted on aliquots of each effluent sample collected for the rainbow trout tests.

2.2.3 Volume of Effluent, Flow Rate and Loading

The Doris North Project mine will record the total monthly volume of effluent released from Tail Lake. The total monthly volume will be based on the average of the flow rates that are measured either concurrently with the other samples collected for effluent monitoring or with the use of a continuous measurement system. The mass loading of the substances listed in Table 2-1 (Suite 1) discharged from Tail Lake will be calculated for each day on which the sample is collected for analysis. The mass loading will be determined by multiplying the concentration of the substance by the total volume of effluent discharged for each day sampled. The mass loading for each calendar month will be determined by multiplying the average of all mass loadings determined for that month by the number of days in that calendar month during which effluent was discharged.

2.2.4 Reporting Monitoring Results

An effluent monitoring report for all tests and monitoring conducted during each calendar quarter will be submitted to the authorization officer within 45 days following the end of the quarter. The report will include the following items:

- results of the acute lethality test of effluent on rainbow trout and *Daphnia magna*;
- concentration and monthly mean concentration of each substance listed in Table 2-1 (Suite 1);
- pH of effluent samples;
- whether a composite or grab sample collection method was used;
- total volume of effluent discharged during each month of the reporting quarter; and
- mass loading of the substances set out in Table 2-1 (Suite 1).

An additional report summarizing the effluent monitoring results for the previous calendar year will be prepared according to the format set out in Schedule 6 – Information to be Included in Annual Summary Report of the MMER. This report will be submitted to the authorization officer before March 31 in each year. All reports will be submitted in writing and in electronic format.

2.3 Effluent and Water Quality Monitoring Under EEM

2.3.1 Effluent Characterization

The Doris North Project mine will characterize Tail Lake effluent by analyzing a sample of effluent for the chemicals and parameters listed in Table 2-1 (Suite 2). Although MMER Section 2.2 states that effluent characterization will be conducted four times per year on aliquots of effluent sample collected for the effluent monitoring program, the proposed project will only be discharging effluent during the months of June and July, thus the frequency of effluent characterization will be negotiated with the authorization officer. Appropriate quality assurance and quality control (QA/QC) measures will be implemented. In addition to the QA/QC measures outlined in Section 6.6 of this document, the analytical requirements outlined in Schedule 3 of the MMER will be adhered to in order to ensure the accuracy of the effluent characterization data.

2.3.2 Sublethal Toxicity Testing

In accordance with the toxicological testing requirements as outlined in the MMER, aliquots of effluent samples collected for the effluent monitoring program (Section 2.2) will be tested for sublethal toxicity using a suite of tests. These will include: a fish early life stage development test, an invertebrate reproduction test, a freshwater plant growth inhibition test and a freshwater alga growth inhibition toxicity test. The species of test organisms that will be used for this study are the fathead minnow (*Pimephales promelas*), the water flea *Ceriodaphnia dubia,* the macrophyte *Lemna minor*, and the alga *Selenastrum capricornutum*. These biological tests estimate the sublethal (i.e., chronic) toxicity of effluents to the test organisms. As required, testing will be conducted twice per year for three year and once per year after the third year.

2.3.3 Water Quality Monitoring

Water samples from an exposure area and a related reference area will be analyzed for the same parameters as required for effluent characterization (Table 2-1, Suite 2), as well as for the deleterious substances and pH (Table 2-1, Suite 1), temperature and dissolved oxygen. Similar to the effluent characterization (Section 2.3.1), the frequency of sampling will be negotiated with the authorization officer since discharges will only be conducted during the months of June and July.

Samples will be collected at the same time as samples for effluent characterization are collected. The exposure and reference areas for water quality monitoring will not necessarily be the same as the sampling areas chosen for biological monitoring. If they are different, samples for water quality monitoring will also be collected in the sampling areas for biological monitoring, at the same time that biological monitoring is conducted. The exposure area for water quality monitoring will be the area immediately downstream of the discharge location in Doris Lake Outflow.

2.3.4 Reporting Effluent and Water Quality Monitoring Results

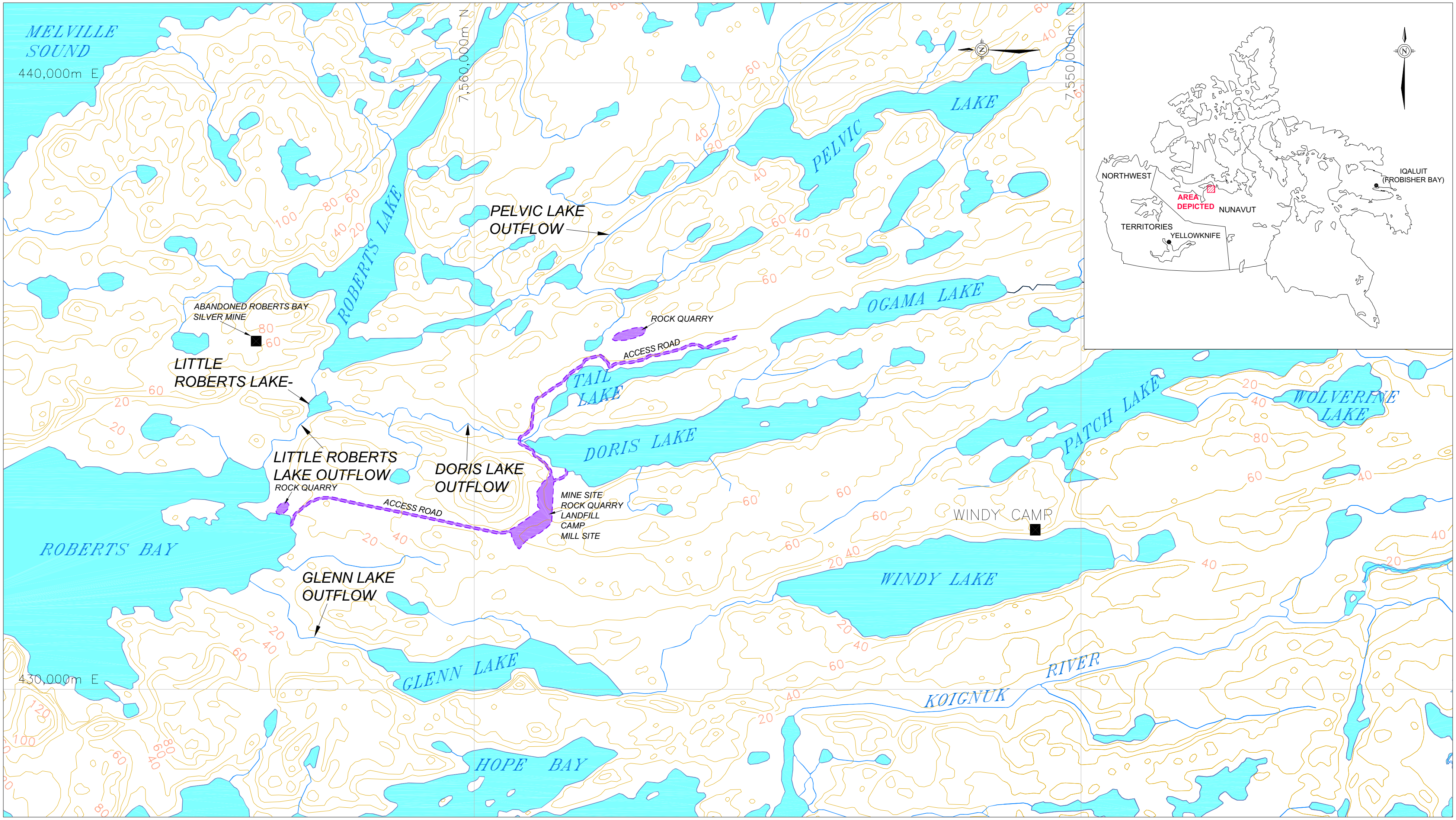
The Doris North Project will submit to the authorization officer an Effluent and Water Quality Monitoring Report no later than March 31 each year, which will include the following information with respect to effluent and water monitoring completed in the previous calendar year:

- dates when all samples were collected for sublethal toxicity testing, effluent characterization and water quality monitoring;
- latitude and longitude (in degrees, minutes and seconds) of sampling areas for water quality monitoring and written descriptions that can identify the location of the sampling areas;
- results of effluent characterization, water quality monitoring and sublethal toxicity testing;
- methodologies used to conduct the analyses and the related detection limits;
- description of QA/QC measures that were implemented and the data related to the implementation of these measures; and,
- comparison of water quality data in exposure and reference areas.

3. SITE DESCRIPTION

The Doris North Project is located 685 km northeast of Yellowknife and 160 km southwest of Cambridge Bay within the West Kitikmeot Region of Nunavut (Figure 3-1). Climate in this region can be characterized as a low arctic ecoclimate, with a mean annual temperature of approximately -13°C and an estimated mean annual precipitation of 220 mm (AMEC 2003a). The topography of this area is coastal lowland (sea level to 158 m), with numerous lakes, ponds, and streams separated by glacial landforms. The area surrounding the Doris North Project is largely undeveloped, with the exception of an existing exploration camp on the east shore of Windy Lake and an abandoned silver mine about 1 km north of the west basin of Roberts Lake.

The Doris North Project will consist of an underground gold mine, and an associated camp and supporting infrastructure. After the ore is processed, tailings will be pumped to Tail Lake. Effluent from Tail Lake will be released annually (if necessary), primarily during June and July, to the Doris Lake outflow and will ultimately reach Roberts Bay in the Arctic Ocean. The discharge point from Tail Lake to Doris Lake outflow will be located approximately 400 m downstream of Doris Lake. Maximum discharge rate of the effluent is estimated as 220,900 m^3/yr.



LEGEND

DORIS NORTH PROJECT - PLANNED ACCESS ROAD AND FACILITIES

Miramar MINING CORPORATION

1.5 0 1.5

SCALE KILOMETRES

NOTE : CONTOUR INTERVAL 20 m

REFERENCE

BASE MAP PROVIDED BY RESCAN, JANUARY 22, 2001

TITLE

MAP OF THE AREA SURROUNDING THE DORIS NORTH PROJECT

Golder Associates
Edmonton, Alberta

PROJECT: 03-1370-009.5000			FILE No.	sampling areas
DESIGN	DJ	13/05/03	SCALE 1:60,000	REV. 3
CADD	PSR	30/10/03		
CHECK	AL	30/10/03	**FIGURE: 3-1**	
REVIEW				

R:\CAD\2003\1370\03-1370-009\5000\ Drawing file: Fig 1-Sampling Areas.dwg Nov 17, 2003 - 11:30am

4. FISH SURVEY

4.1 Introduction

The EEM fish survey consists of (a) monitoring fish to determine if there are differences in the growth, reproduction, survival or condition of fish populations exposed to effluent and (b) monitoring levels of mercury in fish tissue (as an indicator of fish usability) in order to determine whether or not the mine effluent is having an effect on fish. The objective of the fish survey (FS) is to compare fish parameters in reference areas with those in exposure areas in order to determine whether there are any differences between these areas.

4.2 Historical Data Review

Prior to designing the EEM FS, a review of historical information was undertaken. Aquatic baseline data for the Doris North Project was collected between 1995 and 2002 (RL&L/Golder 2002 and 2003a). These studies provide information on fish populations, fish habitat, and contaminants in fish tissues in lakes and streams in the area surrounding the Doris North Project. In 2003, baseline studies were continued and initial scoping of fish collection sites for the design of the EEM program were conducted. Available baseline data are summarized in the following sections.

4.2.1 Fish Species Summary

4.2.1.1 Lake Communities

Several lakes were sampled during baseline studies including Doris, Tail, Ogama, Patch, Windy, Little Roberts, Roberts, and Pelvic lakes. Field surveys were conducted from late July to early September. A summary of the lakes surveyed and the results obtained are presented in Table 4-1.

Fish capture methods employed in the lake surveys consisted primarily of gill net sampling, although beach seining was conducted in Windy, Doris, and Roberts lakes, and fyke net sampling was used in Roberts, Little Roberts, and Doris lakes. Fish species present in the lakes during the previous studies included lake trout (*Salvelinus namaycush*), Arctic char (*Salvelinus alpinus*), cisco (*Coregonus artedii*), least cisco (*Coregonus sardinella*), lake whitefish (*Coregonus clupeaformis*), broad whitefish (*Coregonus nasus*), and ninespine stickleback (*Pungitius pungitius*). The most common large-bodied species found were lake trout, lake whitefish, and cisco. These species were observed with varying abundance in all of the lakes surveyed (Table 4-1).

4.2.1.2 Stream Communities

Several streams in the Doris Lake area were surveyed during the 1996 to 2000 studies. Sampling was conducted by backpack electrofishing, angling, and visual observations (RL&L/Golder 2002). Additional sampling was conducted in Roberts Lake outflow during the months of July and August 2002 using a fish fence and fyke net (RL&L/Golder 2003a). During 2003, as part of the initial scoping assessment for EEM, numerous stream sections within the study area were sampled (refer to Table 4-2). Several types of fishing equipment were used during the 2003 survey, including a fish fence, backpack electrofishing, and fyke nets (RL&L/Golder 2003b).

Eight confirmed fish species were captured in the streams; these included lake trout, Arctic char, cisco, least cisco, lake whitefish, broad whitefish, fourhorn sculpin (*Myoxocephalus quadricornis*), and ninespine stickleback (Table 4-2). The most frequently captured fish were Arctic char (n=358), ninespine stickleback (n=336), and lake trout (n=127). Slimy sculpin (*Cottus cognatus*) were also reported in Glen Outflow, although it is likely that this species was misidentified for fourhorn sculpin due to the close proximity of the capture location to the ocean and no other slimy sculpins were captured in previous baseline sampling.

Table 4-1
Summary of Baseline Fish Studies and Fish Tissue Monitoring in Lakes in the Doris Lake Area

Lake	Year Sampled[a]	Fishing Method	Species Captured	Number of Fish Captured	Tissue Analysis: Number of Fish Sampled	Tissue Analysis: Tissues Analyzed	Tissue Analysis: Metals Analyzed[b]
Doris Lake	1995 & 1996	gill net	lake trout	5			
			lake whitefish	27			
			cisco	21			
	1997	gill net	lake trout	56	22	muscle, liver	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn
			lake whitefish	126	29		
			cisco	338			
	2003	gill net	lake trout	2			
			lake whitefish	3			
			least cisco	1			
		fyke net	lake trout	2			
			lake whitefish	1			
			cisco	5			
		beach seine	cisco	1			
			lake whitefish	1			
		backpack electrofishing	ninespine stickleback	11			
			lake trout	1			
Tail Lake	1995 & 1996	gill net	lake trout	29			
	2000	gill net	lake trout	134			
	2002	gill net	lake trout	98			
		angling	lake trout	109			
Ogama Lake	1996	gill net	lake trout	4			
			lake whitefish	29			
			cisco	5			
Patch Lake	1995 & 1996	gill net	lake trout	16			
			lake whitefish	3			
			cisco	5			
	1997	gill net	lake trout	54	25	muscle, liver	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn

Lake	Year Sampled[a]	Fishing Method	Species Captured	Number of Fish Captured	Tissue Analysis: Number of Fish Sampled	Tissue Analysis: Tissues Analyzed	Tissue Analysis: Metals Analyzed[b]
Patch Lake	1997	gill net	lake whitefish	78	26	muscle, liver	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn
			cisco	31			
Windy Lake	1996	gill net	lake trout	19			
			lake whitefish	2			
		beach seine	lake whitefish	53			
	1997	gill net	lake trout	58	25	muscle, liver	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn
			cisco	5			
Little Roberts Lake	2000	gill net	Arctic char	29			
			lake trout	21			
			lake whitefish	7			
			broad whitefish	1			
			least cisco	6			
	2002	gill net	Arctic char	6			
			lake trout	3			
			least cisco	1			
	2003	gill net	Arctic char	3			
			lake trout	4			
			cisco	1			
			least cisco	3			
		fyke net	Arctic char	4			
			lake trout	2			
			ninespine stickleback	20			
Roberts Lake	2002	gill net	Arctic char	1			
			lake trout	33			
			lake whitefish	72			
			cisco	14			
			least cisco	4			

Lake	Year Sampled[a]	Fishing Method	Species Captured	Number of Fish Captured	Tissue Analysis		
					Number of Fish Sampled	Tissues Analyzed	Metals Analyzed[b]
Roberts Lake	2002	fyke net	Arctic char	2			
			lake trout	1	30	Muscle, Liver, Kidney	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn
			lake whitefish	7			
			cisco	1			
			least cisco	2			
		angling	lake trout	6			
	2003	gill net	Arctic char	1			
			lake trout	1			
		fyke net	Arctic char	3			
			lake trout	1			
			ninespine stickleback	1			
		backpack electrofishing	Arctic char	1			
Pelvic Lake	1998	gill net	lake trout	32	21	muscle, liver	Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn
			lake whitefish	198	22		
			cisco	160			
	2002	gill net	lake trout	33			
			lake whitefish	92			
			cisco	14			
			least cisco	161			

Note: na = CPUE, or raw data to calculate CPUE, were not provided.
[a] Source: RL&L/Golder (2002) for 1995 to 2000 studies, RL&L/Golder (2003a) for 2002 studies, and RL&L/Golder (2003b) for 2003 studies.
[b] Metals analyzed: Al = aluminum, As = arsenic, Cd = cadmium, Cu = copper, Pb = lead, Hg = mercury, Ni = nickel, Se = selenium and Zn = zinc.

Table 4-2
Summary of Fish Captured in Streams in the Doris Lake Area

Stream	Years Sampled[a]	Fishing Method	Species Captured	Number of Fish Captured
Doris Lake outflow	July 1996; August 1995, 1997, 2000	angling, backpack electrofishing	Arctic char	12
			lake trout	12
			lake whitefish	2
			cisco	10
			ninespine stickleback	35
	August 2003	backpack electrofishing	Arctic char	5
			lake trout	12
			ninespine stickleback	11
Doris Lake inflow	June 1997	backpack electrofishing	ninespine stickleback	3
Tail Lake outflow	June 1997, 2000	backpack electrofishing	ninespine stickleback	1
	August 2003	backpack electrofishing	ninespine stickleback	10
Ogama Lake outflow	July 1996; August 1995, 1997	angling, backpack electrofishing	lake trout	6
			lake whitefish	2
			ninespine stickleback	25
Ogama Lake inflow	June 1997; July 1996; August 1995, 1997	backpack electrofishing	lake trout	16
			lake whitefish	1
			cisco	1
			ninespine stickleback	33
Patch Lake inflow	June 1997	backpack electrofishing	lake trout	4
			ninespine stickleback	68
Windy Lake outflow	June 1997	backpack electrofishing	Arctic char	1
			lake trout	11
	August 2003	backpack electrofishing	ninespine stickleback	5
Windy Lake inflow	June 1997	backpack electrofishing	ninespine stickleback	8
Glenn Lake outflow	June 1997, 2000; August 1997, 2000	backpack electrofishing	Arctic char	18
			lake trout	6
			slimy sculpin[b]	3
			ninespine stickleback	4
	August 2003	backpack electrofishing	Arctic char	8
			lake trout	7
Little Roberts Lake outflow	August 1997 2000	backpack electrofishing	Arctic char	10
			lake trout	3
			ninespine stickleback	11
	August 2003	backpack electrofishing	Arctic char	1
			fourhorn sculpin	1
			ninespine stickleback	11
Roberts Lake outflow	August 2002	fish fence, dip net, hand grab, fyke net	Arctic char	204
			lake trout	21
			ninespine stickleback	1

Stream	Years Sampled[a]	Fishing Method	Species Captured	Number of Fish Captured
Roberts Lake outflow	August 2003	fish fence, fyke net, backpack electrofishing	Arctic char[c]	479
			lake trout	43
			cisco	3
			least cisco	8
			broad whitefish	2
			ninespine stickleback	8
Roberts Lake Tributaries	August 2003	backpack electrofishing	Arctic char	34
			lake trout	8
			ninespine stickleback	17
Pelvic Outflow Drainage	August 2003	backpack electrofishing	Arctic char	13
			lake trout	15
			lake whitefish	6
			Cisco	2
			least cisco	13
			ninespine stickleback	31
Pelvic Inflow	August 2003	backpack electrofishing	ninespine stickleback	11

[a] Source: RL&L/Golder (2002) for 1995 to 2000 studies, RL&L/Golder (2003a) for 2002 studies, and RL&L/Golder (2003b) for 2003 studies.

[b] Slimy sculpin were likely misidentified for fourhorn sculpin due to the close proximity of the capture location to the ocean and no other slimy sculpins were captured in previous baseline sampling.

[c] tissues from 30 Arctic char in Roberts Outflow were analyzed for metal concentrations; tissues included muscle, liver, and kidney; 34 metals were analyzed of which some included Al, As, Cd, Cu, Pb, Hg, Ni, Se, Zn (RL&L/Golder 2002).

4.2.2 Fish Habitat Summary

4.2.2.1 Lakes

Lake habitat assessments were performed at an overview level for Doris, Tail, Ogama, Patch, and Windy lakes in August 1995. The overview-level assessments consisted of aerial surveys of habitat along the littoral zone of lakes (via helicopter). With the exception of Little Roberts Lake, detailed ground work was not conducted. Substrate was classified using five substrate categories: silt, sand, cobble, boulder, and bedrock. Habitat quality was rated using a classification system based on habitat requirements for various life stages of lake trout and coregonids (RL&L/Golder 2002).

Habitat surveys in Little Roberts Lake were conducted in 1997, 2000, and 2003. Little Roberts Lake is approximately 0.10 km^2 in area (Figure 3-1). The lake receives inflows from Doris Lake and Roberts Lake. The substrate in the littoral zone is predominantly silt and sand, with the occasional patches of gravel, cobble and boulder; therefore, habitat quality in Little Roberts Lake was rated as fair for salmonids (RL&L/Golder 2002). A detailed bathymetry survey was carried out in August 2003. The mean depth of Little Roberts Lake was 2.0 m and the maximum depth was 4.1 m (RL&L/Golder 2003b).

4.2.2.2 Streams

Aerial and detailed stream habitat surveys were conducted in 1995, 1996, 1997, and 2000 in various streams in the Doris Lake area. Habitat summaries were compiled from these data and are provided in Appendix E - RL&L/Golder (2002). A summary of habitat information for streams targeted for sampling under the EEM FS (Section 3.4.2) is presented below.

Little Roberts Lake Outflow

In 1997, a 150-m length of stream was assessed near the mouth. The entire stream (1250 m) was assessed in 2000. The mean bankfull width of this stream was approximately 18 m, with bank heights of approximately 3.5 m. Banks of the stream were stable and vegetated. Instream habitat types consisted of pools, runs, and flats with interspersed riffles and chutes. Substrate was dominated by cobble. The habitat quality of Little Roberts Lake outflow was rated as excellent for spawning, rearing, and adult feeding for salmonids. Overwintering habitat potential was considered poor for salmonids.

Doris Lake Outflow

Habitat surveys in Doris Lake outflow were conducted in 1995, 1997, and 2000. Doris Lake outflow, which connects Doris Lake and Little Roberts Lake, is approximately 3700 m long. Approximately 750 m of the outflow was surveyed, starting at Doris Lake. A waterfall, which is 4.3 m in height, is located approximately 400 m downstream from Doris Lake, making the lake inaccessible to migrating fish originating from downstream. The mean width of the stream was approximately 2.5 to 3.0 m and mean depth at moderate flows was between 0.35 and 0.45 m. Instream habitat types consisted of a series of rapids, riffles, and runs. Substrate was dominated by sand and gravel. The habitat quality of Doris Lake outflow was rated as fair to good for spawning, rearing and as adult feeding habitat for salmonids. Overwintering habitat for salmonids was considered poor to fair as a result of an absence of deep pools.

Pelvic Lake Outflow

Pelvic Lake outflow is located downstream of Pelvic Lake and drains into Little Roberts Lake through a series of unnamed lakes and Roberts Lake. Habitat data for the Pelvic Lake outflow drainages were collected only during the EEM field reconnaissance in 2003. Maximum depths throughout the surveyed sections ranged from 0.3 m in riffle boulder gardens to 1.5 m in flat habitats. Other habitat types present were moderate depth pools (1 to 1.2 m depth) and shallow flat and runs habitat types (<0.5 m depth). Substrate was dominated by silt, with some gravel, cobble, and boulder. Instream cover was provided by vegetation and boulders.

Patch Inflow

This tributary drains Wolverine Lake through a low-lying, large marshy area. This small tributary was in flood when surveyed on 22 June 1997; it drained a series of small ponds and a marshy melt water area into the northwest side of Patch Lake. The stream flowed over terrestrial grass and organic matter, forming shallow runs and riffles. Ninespine stickleback were captured in the lowest reach of the stream and four lake trout were observed in the lake near the stream mouth.

4.2.3 Contaminants in Fish Tissue

Fish tissue samples were collected during several of the aquatic baseline studies for the Doris North Project (RL&L/Golder 2002 and 2003a). The objective of the fish-tissue sampling was to provide baseline data on metal concentrations in the lakes close to potential development activities. Fish tissue samples from lake trout, lake whitefish, and cisco were collected at Doris, Tail, Ogama, Patch, Windy, and Pelvic lakes between 1995 and 1998 (RL&L/Golder 2002). During the most recent baseline study in 2002, fish tissues samples were collected from Arctic char in Roberts Lake outflow and lake trout in Roberts Lake (RL&L/Golder 2003a).

The concentrations of metals in fish tissue indicated that the accumulation of most metals in fish is low in the lakes surveyed between 1995 and 1998 (RL&L/Golder 2002). The exceptions were for arsenic and mercury. Elevated concentrations of arsenic in lake trout were detected in Windy

Lake and in Roberts Lake, and elevated concentrations of mercury were recorded in lake trout sampled in Patch Lake. Additional baseline fish tissue data were also collected during 2002 for Roberts Lake. Tissue analyses in 2002 indicated generally low levels of metal concentrations; with the exception of arsenic in both lake trout and Arctic char tissues and for mercury in lake trout tissues only.

4.2.4 Summary of Historical Data

The information collected during the baseline studies provides an indication of the species available for an EEM program. The fish tissues collected during baseline studies provide an indication of existing metal concentrations in fish from several locations within close proximity to potential development activities; however, several of the waterbodies proposed as sampling sites for the Doris North Project EEM were not previously sampled for fish tissues; those waterbodies include Little Roberts Lake (exposure lake), Little Roberts Lake outflow (exposure stream), Patch Lake inflow (reference stream), and Pelvic lake outflow (reference stream) and the accompanying lakes (reference lakes).

Although previous studies prior to 2003 had collected valuable aquatic baseline data in the vicinity of the Doris North Project, they were not sufficient to meet design requirements of EEM programs. Consequently, an EEM reconnaissance survey was conducted in 2003 to acquire the required information. The reconnaissance survey was used to confirm the suitability of the study areas and the fish species proposed for the EEM program.

4.3 Study Design

The proposed EEM FS is based on recommendations provided in the guidance document for metal mining EEM (Environment Canada 2002). The following sections outline the EEM FS, including sentinel species selection, study locations, and proposed methods.

4.3.1 Study Overview

The recommended EEM FS will focus on monitoring whole-organism parameters for two sentinel fish species that are resident in the receiving environment (Doris Lake outflow, Little Roberts Lake, and Little Roberts Lake outflow) and in a reference area. For each fish captured, the following fish health parameters will be measured: length; total body weight; age; weight of liver; the external appearance including abnormalities, lesions, tumors and parasites, and, if the fish are sexually mature then, sex, egg size, fecundity, and gonad weight would also be recorded. Fish tissue analysis will be required from one species of fish if during effluent characterization, a concentration of total mercury in the effluent is identified that is equal to or greater than 0.10 µg/L. The species sampled does not necessarily need to be one of the sentinel species. Mercury concentrations found in tissue samples from fish captured in the exposure area will be compared with the mercury concentrations in fish tissue samples from the reference area and with human health consumption guidelines.

4.3.2 Sentinel Species Selection

The fish species known to be present in the Doris North Project area include lake trout, Arctic char, cisco, lake whitefish, and ninespine stickleback. The parameters considered during the determination of candidate sentinel species included species abundance, mobility, and sensitivity to environmental change. Of the species present in the area, potential sentinel species candidates include lake trout and ninespine stickleback. The reasons for the selection of the sentinel species candidates are outlined in Sections 4.3.3 and 4.3.4.

4.3.3 Lake Species

Large and small-bodied fish can be used as sentinel species in EEM programs; however, during baseline studies in the Doris North Project area, few small-bodied fish were captured in the lakes (RL&L/Golder 2003b) and are, therefore, not being considered as sentinel species for the lakes. Each of the large-bodied fish species present in the area (i.e., Arctic char, lake whitefish, and lake trout) were considered as candidates for use as sentinel species; however, lake trout is the preferred candidate sentinel species due to its presence/abundance in the lakes throughout the Doris North Project area. During preparation of the final design for the EEM program, consideration must be given, when determining sample sizes, to the robustness of the lake trout populations in the area to ensure that the population will not be depleted to non-sustainable levels as a result of sampling pressure.

4.3.4 Stream Species

Small-bodied fish species are being considered as sentinels for the study as they will likely be long-term residents in the streams from which they are captured. Large-bodied fish captured in the streams would likely be transient fish, which would not reflect the condition of the streams in which they were captured. Small-bodied fish identified in the area include ninespine stickleback and a few slimy sculpin (only three were captured in streams during previous studies). The ninespine stickleback is being proposed as a sentinel species based on potentially sufficient abundance and known limited migration behaviour in this species. Ninespine stickleback were captured in all reference and exposure streams during the 2003 EEM reconnaissance survey (Table 4-2; RL&L/Golder 2003b).

4.4 Study Areas

4.4.1 Habitat Selected for the Fish Survey

The proposed EEM FS will focus on both stream and lake habitat. Exposure areas will include fish habitat that will receive mine discharge in the future, and reference areas will be selected according to habitat features that are similar to those present in the exposure area. Additionally, reference areas must contain the same fish species found in the exposure areas.

4.4.2 Locations of Sampling Areas

Sampling area is defined as a relatively long (1 to 2 km) reach of river or an entire lake, which is either exposed to a defined concentration or dilution of effluent (exposure area) or which is in an area where exposure to effluent cannot occur (reference area). Exposure areas can be divided into near-field and far-field exposure areas, the distinction between the two being the distance from the discharge and effluent dilution. In the text that follows, sampling areas in streams are referred to as reference, near-field and far-field *areas*, and those in lakes are referred to as reference and exposure *lakes*.

The study design selected for the EEM baseline study is the Multiple Control/Impact design. This design consists of two or more reference areas and a series of downstream exposure areas representing near-field and far-field areas (Figure 4-1). This design was selected because there was no opportunity to select upstream reference streams or lakes that are similar to the streams and lakes that will be exposed to the effluent discharged from Tail Lake. Two reference areas (Reference areas A and B; Figure 4-1) and two reference lakes (Reference Lakes A and B) were selected to characterize natural variation in biological communities and to account for the potential confounding influence of an abandoned silver mine near Roberts Lake.

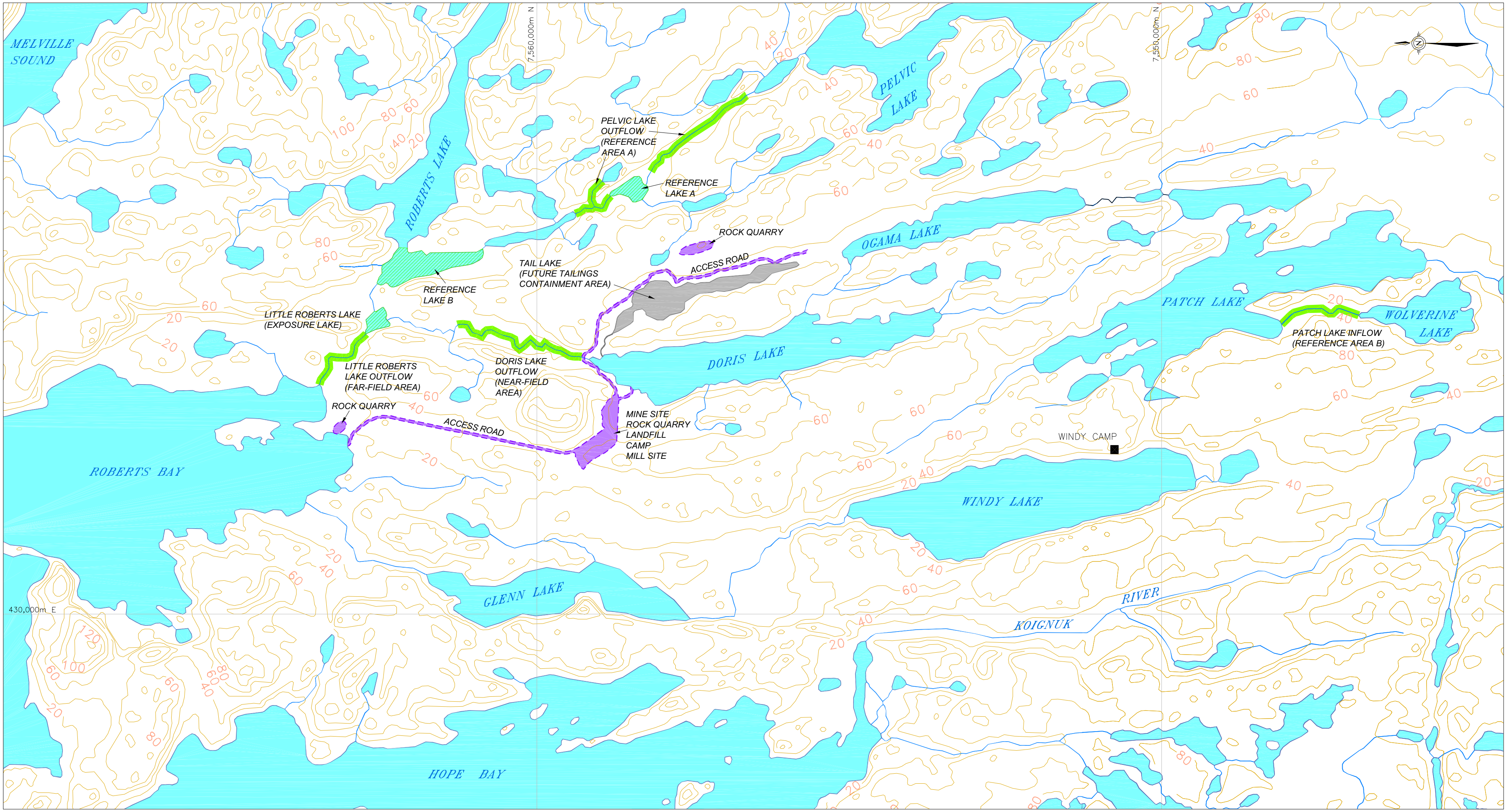
The anticipated dilution of effluent from Tail Lake, expressed as the percentage of effluent present in the receiving stream, is a useful measure of the level of exposure of aquatic life to the future effluent. The total annual decant volume is 220,900 m^3, where most (69%) of the decant occurs in June and July (Table 4-3). The percentage of effluent in stream water downstream of the discharge would be expected to range from 1.64 to 1.90%; however, during dry conditions (i.e., driest months and year between 1984 and 1997), the anticipated range is 2.97 to 6.30% (Table 4-3).

Table 4-3
Anticipated dilution of effluent from Tail Lake for the Doris North Project.

	Doris Lake Outlet Flow		Decant Volume	Total Downstream Volume	Dilution
	(m^3/s)	(m^3)	(m^3)	(m^3)	(%)
Mean Conditions					
June	1.805	4,679,592	90,600	4,770,192	1.90%
July	1.221	3,271,448	61,900	3,333,348	1.86%
August	0.541	1,450,251	26,500	1,476,751	1.79%
September	0.635	1,646,602	30,900	1,677,502	1.84%
October	0.246	660,060	11,000	671,060	1.64%
Annual	0.886	11,707,953	220,900	11,928,853	1.85%
Dry Conditions (Driest Months and Year of 1984-1997 Period)					
June	1.142	2,960,560	90,600	3,051,160	2.97%
July	0.477	1,277,176	61,900	1,339,076	4.62%
August	0.166	445,710	26,500	472,210	5.61%
September	0.208	538,777	30,900	569,677	5.42%
October	0.061	163,603	11,000	174,603	6.30%
Annual[a]	0.609	8,055,696	220,900	8,276,596	2.67%

[a] For dry conditions, monthly low values are based on modelling data for the driest month from June 1984 to July 1997 and annual conditions are based on modelling data for the driest whole year, which was 1995.

The Near-Field Area, representing the maximum exposure to the effluent, will be located in Doris Lake outflow, between the discharge from Tail Lake and an unnamed stream draining a small pond (Figure 4-1). Little Roberts Lake outflow will serve as the Far-Field Area. Reference Area A will be located in Pelvic Lake outflow and Reference Area B will be in Patch Lake inflow.



LEGEND

SAMPLING AREAS IN LAKES

SAMPLING AREAS IN STREAMS

DORIS NORTH PROJECT
PLANNED ACCESS ROAD AND FACILITIES

NOTE

CONTOUR INTERVAL 20 m.

Miramar
MINING CORPORATION

REFERENCE

BASE MAP PROVIDED BY RESCAN, JANUARY 22, 2001.

1.5 0 1.5
SCALE KILOMETRES

TITLE

SAMPLING AREAS SELECTED FOR THE AQUATIC BASELINE MONITORING PROGRAM

Golder Associates
Edmonton, Alberta

PROJECT 03-1370-009.5000			FILE No. sampling areas	
DESIGN	DJ	13/05/03	SCALE 1:40,000	REV. 2
CADD	AS	15/10/03		
CHECK	AL	15/10/03		
REVIEW				

FIGURE: 4-1

R:\CAD\2003\1370\03-1370-009\5000\ Drawing file: Fig 2-Sampling Areas.dwg Nov 17, 2003 – 11:37am

Sampling areas will be one to two kilometres long, as dictated by the length of the Near-Field Area. Fish sampling will occur throughout these reaches.

Little Roberts Lake, located between the Near-Field and Far-Field areas, will serve as the single Exposure Lake (Figure 4-1). This lake will be subject to effluent inputs from Tail Lake via Doris Lake outflow. Two reference lakes were selected for comparisons with Little Roberts Lake, including Reference Lake A, located about 3 km upstream of Roberts Lake, and the west basin of Roberts Lake (Reference Lake B). Reference Lake A appears similar in size and hydrology to Little Roberts Lake, although it receives drainage from a considerably smaller area than Little Roberts Lake. The west basin of Roberts Lake will be used as a reference lake to investigate the potential confounding influence of an abandoned silver mine in its drainage basin. Baseline surveys of fish tissue chemistry found elevated levels of arsenic in lake trout and Arctic char in Roberts Lake (RL&L/Golder 2003a), which may interfere with detecting potential future effects from the Tail Lake discharge. Sampling in Roberts Lake will afford an opportunity to assess potential existing effects on fish from disturbances other than the Doris North Project under baseline conditions. Fish sampling will occur at selected locations in each reference and exposure lake.

Because of the large dilution of the effluent by the time it will reach Roberts Bay, biological sampling is not planned in the marine environment. Rather, sediment sampling is proposed in Roberts Bay (Section 6.2) to characterize background sediment chemistry for future comparisons with sediment chemistry during and after mine operation.

4.5 EEM Fish Survey

4.5.1 EEM Field Reconnaissance

An EEM reconnaissance survey was conducted during August and early September 2003 to complete the final selection of the sentinel species and to verify the adequacy of the proposed reference streams for use in an EEM program. Backpack electrofishing was conducted in tributaries of the Pelvic, Roberts, Little Roberts, Doris, Tail, Glenn, and Windy drainages (Appendix Figure A1). Two small-bodied fish species have previously been documented in the Doris North area (slimy sculpin and ninespine stickleback); however, after considerable effort was expended during 2003 in an attempt to capture both species, only ninespine stickleback were captured. Catch-per-unit effort (CPUE) of ninespine stickleback ranged from 0 fish/s in Glenn Outflow to 8.9 fish/s in Tail Outflow (Appendix Table A2). Sampling in Doris Lake outflow (Near-Field Area) and Little Roberts Lake outflow (Far-Field Area) each yielded 11 ninespine stickleback over 600 m, with CPUEs of 0.59 and 0.62 fish/s, respectively. For the reference areas, sampling in the Pelvic Lake drainage system yielded 42 ninespine stickleback over a distance of 2.2 km (0.69 fish/s). Glenn Outflow, which was originally identified as Reference B Stream did not yield any ninespine stickleback. Roberts Lake tributaries were also sampled to determine the presence of ninespine stickleback; in total, 17 ninespine stickleback were captured, with a CPUE of 0.79 fish/s. Since no ninespine stickleback were captured in Glenn Outflow during 2003 and only three have previously been documented, Patch Inflow will be designated as the Reference Area B. In 1997, 68 ninespine sticklebacks were captured during backpack electrofishing in Patch Inflow.

The following sections outline the proposed design of the EEM FS.

4.5.2 Fish Sample Size

The minimum number of sampling units (i.e., individual fish) recommended in the guidance document for a mine with no background data for developing a program when conducting lethal sampling is 20 sexually mature males and 20 sexually mature females of the two selected sentinel species. The two potential sentinel species are lake trout and ninespine stickleback. Since ninespine stickleback are small-bodied fish, an additional 20 sexually-immature fish will be collected in accordance with the standards provided in the guidance document.

4.5.3 Field Program Timing

Ideally, fish should be collected during the period of maximum residency in the effluent plume. Since many species undergo spawning migrations that may take them away from, or temporarily into, the effluent plume, the FS should be conducted outside of the spawning season. Although the extent of gonadal development near the spawning season is ideal for determining reproductive parameters, the confounding potential movement of the fish during this period may negate the benefits of the late-stage in gonadal development. Since the sampling window in the area is very limited, sampling will occur in August, when most of these fish will still be residing in their summer habitat.

4.5.4 Field Methods

Field personnel will collect fish for the FS following the detailed methods set out in Golder Associates Technical Procedure (TP) TP 8.1-3 (Fish Inventory Methods; Golder 1997a) and TP 8.16-0 (Fish Health Assessment – Metals; Golder 1997b). Fish collections will be conducted primarily by angling and with gill nets in lakes, and by backpack electrofishing and minnow trapping in streams. Data recorded for each electrofishing section will include UTM (Universal Transverse Mercator) coordinates, length of stream sampled (m), sampling effort (s), electrofishing power settings, the bank surveyed, supporting environmental data (i.e., air and water temperatures, percent cloud cover, wind direction, and velocity, dissolved oxygen, conductivity, pH, and Secchi depth) and a general habitat description for the backpack electrofishing collections.

All captured individuals of the sentinel fish species will be labelled and enumerated, and the following measurements and observations will be recorded within the level of accuracy outlined in the guidance document:

- fork length;
- fresh weight (whole fish and carcass);
- age (laboratory);
- gonad weight;
- liver weight;
- internal/external pathology;
- stomach contents;
- life stage;
- sex;
- state-of-maturity;
- egg size; and
- number of eggs.

Ageing structures will be collected from all fish, and these will include otoliths and fin rays for lake trout and otoliths for ninespine stickleback. All abnormal tissues will be photographed and preserved in 10% buffered formalin for histopathological analysis. General biological parameters and tissue collection information for each fish examined will be recorded on Internal/External Autopsy forms and in the field logbooks.

4.6 Laboratory Methods

4.6.1 Fish Aging

Ages of the sentinel fish collected during the FS field collections will be determined following the methods outlined in Mackay et al. (1990). Independent confirmation of at least 10% of these will be provided by a fish aging expert external to the project.

4.6.2 Tissue Analyses

Fish tissue samples (fillets from lake trout are being proposed) for mercury analysis will be stored and shipped to the appropriate laboratories following the detailed storage and shipping procedures described in TP 8.16-0 (Golder 1997b).

4.7 Data Analysis

Analysis of data collected during the FS will include comparisons of population parameters, individual parameters, and tissue concentrations of metals among study areas to characterize existing differences between reference and exposure areas. Data interpretation will follow recommendations in the guidance document and will include the following analyses:

- Initially, visual screening techniques will be used to identify extreme values and to assess the data for normality and homogeneity of variances.
- CPUE will be used as a measure of relative abundance and will be compared among sampling areas using graphical means.
- Statistical comparisons between sampling areas and estimates of variability for power analysis will be conducted for the following parameters, using log-transformed data:

  - age structure (mean adult age);
  - growth (size at age);
  - energy stores (condition, relative liver size); and
  - reproductive investment (gonad weight and fecundity).
- With the exception of mean adult age, all parameters will be estimated by regressing one variable over another. The size variable used in these regressions will consist of either weight or length. Individual level parameters will be analyzed separately for males and females.
- Analysis of Covariance (ANCOVA; Sokal and Rohlf 1995) will be used to compare regressions between the sampling areas and to obtain estimates of variance for fish parameters. Analysis of Variance (ANOVA; Sokal and Rohlf 1995) will be used for comparisons of mean adult age.
- Baseline fish tissue data will be examined for potential spatial trends using graphical methods and will be compared with tissue data collected during the EEM FS.

5. INVERTEBRATE COMMUNITY SURVEY

5.1 Introduction

The major objective of the Invertebrate Community Survey (ICS) will be to assess the effects of mine effluent from Tail Lake on fish habitat. The ICS will also provide an estimate of the aquatic food resources available for fish selected as a sentinel species for the adult FS. Although some benthic invertebrate data are available for the Doris North Project area, the available data are of limited use for designing an ICS according to EEM requirements because spatial coverage is limited to single stations in streams and one or two stations in each depth category in lakes (RL&L/Golder 2002). In addition, benthic invertebrates were collected in streams using methods (artificial substrates) that are incompatible with those recommended for metal mining EEM in the habitats present in the study area.

5.2 Study Design

5.2.1 Definitions

Terms describing aspects of the study design are used in the manner defined in the guidance document. Brief definitions are provided below.

Sampling area (area) is defined as a relatively long reach of river, which is exposed to a defined level of discharge. Examples of sampling areas include reference, near-field, and far-field areas. For the ICS, sampling areas will represent about one to two kilometre reaches of river.

Replicate station (station) is defined as a specific, fixed sample location within a sampling area, within which a number of field subsamples are collected. For the ICS, replicate stations in streams will consist of individual riffles. In lakes, replicate stations will correspond to randomly chosen locations within a specified depth range.

Field subsample (sample) is defined as the material collected from a defined area (i.e., the area enclosed by the sampling device) at a randomly selected point within a replicate station.

5.2.2 Habitat Selected for the ICS

The proposed ICS will focus on one type of stream habitat, as recommended by the guidance document. Erosional (riffle) habitat will be sampled because available information suggests it is the dominant stream habitat in the study area. Erosional habitats in rivers and streams typically support diverse and pollution-sensitive benthic communities. Riffles are abundant in the streams in the Doris Lake area, which allows proper selection of replicate stations and ensures that the data generated by the ICS will be representative of a large proportion of the study reach.

Sampling in lakes will occur in depositional habitat free of aquatic macrophytes, within a limited depth range. The depth range to be sampled could be determined during a brief EEM reconnaissance survey prior to initiating the survey.

5.2.3 Locations of Sampling Areas

Locations of sampling areas for the ICS will be identical to those selected for the FS and are described in Section 4.4.2.

5.2.4 Number of Replicate Stations and Subsamples

Each sampling area will contain a number of replicate stations, as determined by power analysis. Based on Table 5-5 in the guidance document, five replicate stations will be sampled in each area, corresponding to a power ($1-\beta$) of 0.9, an effect size of two standard deviations, and a significance level (α) of 0.10.

Field subsamples within a station will be collected in a stratified random pattern, to ensure that each point within the area encompassed by a station has an equal probability of being sampled. The number of subsamples that should be taken at each station is dependent on the density and distribution of organisms, with the objective of ensuring that the sampling effort will produce an accurate reflection of all variables of interest (i.e., taxonomic richness, total abundance, and abundances of dominant taxa). Elliott (1977) suggests that an index of precision (D) of 20% (i.e., a standard error equal to 20% of the mean) is acceptable for most benthic surveys. Hence, the number of replicate stations with this amount of error (or less) provides sufficient confidence that a representative number of animals were collected at a station.

It was difficult to determine the required number of subsamples in streams based on the data collected during baseline studies because samples were collected using different methods than those proposed here. However, previous work has shown that, for abundances of invertebrates of the magnitude anticipated in the streams to be sampled, six subsamples will usually be sufficient to obtain the desired level of precision (Canton and Chadwick 1988; Voshell et al. 1989; Taylor 1997). Therefore, six subsamples will be collected at each replicate station in stream habitat.

Based on both baseline benthic invertebrate data summarized by RL&L/Golder (2002) and previous sampling of arctic lakes by Golder (1997c), six subsamples per station are also proposed for lake habitat. Using data for total invertebrate abundance and richness (total number of taxa) from summaries provided by RL&L/Golder (2002) for a number of lakes in the study area, the number of field subsamples required to reach the desired level of precision was calculated according to the formula provided by the guidance document (Table 5-1). The mean number of subsamples for lakes was close to six, although a considerably greater number of subsamples would be required from certain lakes. Analysis of benthic invertebrate data collected from Lac de Gras in the Northwest Territories by Golder (1997c) showed that precision did not improve substantially beyond six subsamples.

Table 5-1
Estimates of the Required Number of Field Subsamples for the ICS in Lake Habitat in the Doris North Project Area

Lake	Sample Date	Water Depth (m)	Total Abundance (No./m^2)		Subsamples Needed
			Mean	Standard Error	
Doris	Aug-96	16.5	2059	182	0.6
	Aug-97	0 - 5	3481	466	1.3
	Aug-97	10+	1126	286	4.8
Tail	Aug-96	4.5	4093	1554	10.8
Ogama	Aug-96	3.5	5629	360	0.3
Patch	Aug-96	11.5	1866	566	6.9
Windy	Aug-96	7.5	504	175	9.0
Little Roberts	Aug-96	3	37 492	19 954	21.2
Mean					**6.9**

Data source: RL&L/Golder (2002).

To maximize efficiency of sample processing, three of the six subsamples will initially be processed from each replicate station. The standard errors will be calculated for total abundance and total taxa based on three subsamples, and will be compared with the respective means. In the event that the standard error is generally close to 20% or lower for three subsamples, no additional subsamples will be processed. If the standard error is higher than 20% for most stations, additional subsamples will be processed to a maximum of six per replicate station.

5.2.5 Sample Timing

The ICS will be carried out in late August. This period was selected for logistical reasons (i.e., suitable weather for sampling in northern locations) and because late summer represents a period when benthic invertebrates are usually abundant and sufficiently large for taxonomic identification to genus.

5.3 Sampling Methods

Benthic invertebrate samples will be collected according to TP 8.6-1 (Benthic Invertebrate Sampling Methods; Golder 1997d). Stream benthic samples in erosional habitat will be collected using a Neill cylinder of 0.093-m^2 bottom area. The sampler mesh size will be 210 µm. If water depth is too shallow for use of the Neill cylinder, a Surber sampler of equal bottom area will be used. Lake benthic samples will be collected using an Ekman grab of 0.0232-m^2 bottom area. Lake samples will be field-sieved using a 500-µm mesh sieve bucket. All samples will be preserved immediately after collection in 10% buffered formalin.

Habitat attributes will be standardized among stations in the field to the extent possible. Key habitat features that will be standardized include water depth, current velocity, and substrate composition in streams, and water depth and macrophyte cover in lakes.

As part of routine quality assurance and quality control (QA/QC) for field operations, samples will be collected by appropriately trained personnel and will be labelled, preserved and shipped according to TP 8.6-1 (Golder 1997d). Detailed field notes will be recorded in perfect-bound, waterproof field books and on pre-printed waterproof field data sheets. Specific work instructions outlining each field task in detail will be provided in writing to the field crew by the task manager.

5.4 Sample Processing

Benthic invertebrate samples will be processed according to standard protocols provided in the guidance document. Briefly, samples will be washed through a 500-µm sieve to remove the preservative and fine sediments. Sand and gravel will be removed by elutriation, and the remaining organic material will be split into coarse and fine fractions using 1-mm and 500-µm sieves. The coarse and fine fractions will be sorted with the aid of a dissecting microscope by examining small amounts of detritus in a gridded Petri dish.

Subsampling will only be used for large samples and only for the fine size fraction. The proportion of the fine fraction sorted will depend on the number of organisms in the sample. All remaining sorted and unsorted material will be preserved for quality control checks of sorting efficiency (i.e., 10% of samples will be chosen at random and will be resorted). Invertebrates will be identified to the family level, as required for initial or periodic monitoring.

The QA/QC program for the laboratory work will include the following:

- complete sorting of the subsampled fine fractions for 10% of samples to verify the performance of the subsampling technique used;
- re-sorting 10% of samples to evaluate removal efficiency. Upon not achieving 90% removal efficiency, all sorted parts of samples within the group represented by the failed sample will be re-sorted; and,
- preparation of a reference collection, consisting of several representative specimens of each taxon; identifications of invertebrates in the reference collection will be verified by an external taxonomic expert.

5.5 Supporting Environmental Variables

As outlined in the guidance document, a number of key environmental variables are required to aid in the interpretation of benthic invertebrate data. In addition, there are certain site-specific variables that may be measured where applicable. Supporting environmental information that will be collected at each replicate station will include the following. The method of measurement is shown in parentheses.

- UTM coordinates (GPS unit);
- field water quality parameters (dissolved oxygen, pH, conductivity, water temperature) (field water quality meter);
- water depth at each subsample point (current velocity meter wading rod, or graduated rope on Ekman grab);
- current velocity (at each subsample point in streams only, using current velocity meter);
- stream order and drainage area (measurement from topographic map);
- wetted and bankfull channel width (measuring tape, in streams only);
- slope (survey equipment);
- riparian vegetation (field observation);
- substratum characteristics:
  - particle size distribution (visual assessment in streams using standard size categories; laboratory analysis of % sand/silt/clay in bottom sediments for lakes);
  - sediment total organic carbon (TOC; lakes only, composite samples for laboratory analysis); and,
  - embeddedness (streams only, visual assessment).

5.6 Data Analysis

Data analysis will utilize a variety of statistical and graphical methods and will follow recommendations in the guidance document. The general sequence of analysis will be as follows:

- Data quality will be verified by screening for potential data entry errors. Corrections will be made as necessary.
- The data will be converted to numbers of organisms/m^2 and averaged for each taxon and replicate station, yielding five replicate taxon lists for each sampling area.
- A number of graphical techniques will be used to compare the benthic faunas of the sampling areas and examine the variation in community composition among sampling areas. Variables examined will include at minimum those required by the guidance document.
- Before comparing sampling areas using statistical tests, the variation in physical habitat characteristics among replicate stations will be examined to screen for

potential confounding factors. The range in the value of each habitat variable will be assessed to determine whether it is sufficiently wide to be included in a formal analysis.

- Variables selected for analysis will be compared among sampling areas using statistical tests (ANOVA/ANCOVA) to evaluate whether there is significant variation in benthic community structure under baseline conditions. The raw abundance data will be transformed before statistical analysis, if necessary, to stabilize variances and satisfy the assumption of normal distribution. A power analysis will also be conducted to estimate the minimum detectable difference for each non-significant comparison.

Conclusions regarding the presence or absence, type, and magnitude of existing differences among reference and exposure areas will be formulated based on the weight of evidence provided by the analyses described above.

6. WATER QUALITY SURVEY

6.1 Introduction

The purpose of monitoring water quality in an EEM program is to evaluate mine-related changes in water chemistry in the exposure area. Water quality monitoring is part of the Effluent and Water Quality Monitoring Studies required under EEM and described in Section 2.3 of this document. Data generated from water quality monitoring are used to:

- monitor changes in mining operations and environmental conditions in the receiving environment;
- provide an indication of variability in effluent quality and temporal or seasonal trends; and,
- provide supporting environmental variables to help interpret results from the biological monitoring (fish and benthic invertebrate community survey) and the sublethal toxicity testing.

6.2 Sample Locations

Composite water quality samples will be collected at one location within each study stream (four samples) and lake (three to six samples, depending on water depth; Figure 4-1) in conjunction with the biological surveys (ICS and FS). In addition, one composite water sample will be collected in Doris Lake Outflow, in an area surrounding the point of entry of effluent.

6.3 Sampling Methods

Water quality samples will be collected using standard methods described in TP 8.3-1 (Golder 1997f). In streams, five grab samples will be collected at a representative station within each sampling area and will be mixed to form a composite sample for water chemistry analysis. In shallow Lakes (<2 m), a single composite sample consisting of five grabs will be collected. In deeper lakes, one subsurface and one near-bottom composite sample will be collected. Each lake composite sample will also consist of five grab samples. Water samples will be labelled, preserved, stored, and shipped according to methods described in TP 8.3-1 (Golder 1997f), and will be submitted to the analytical laboratory in the shortest time possible.

Field water quality parameters will be measured at the time of benthic invertebrate sampling (Section 4.5) and during water quality sampling. Field water quality parameters will include dissolved oxygen, pH, conductivity, and water temperature. In streams and shallow lakes (<2 m), these measurements will be made at mid depth. In deeper lakes, field parameters will be measured as vertical profiles, at 0.5 to 5 m intervals, depending on water depth. Secchi depth will also be measured in lakes at each of the five grab sample locations.

6.4 Water Quality Parameters

Water quality parameters (and their method detection limits in mg/L) to be measured by the analytical laboratory include the following:

- Conventional parameters
  - colour (3 T.C.U.)
  - conductivity (0.2 µS/cm)
  - dissolved organic carbon (1)
  - pH (0.1)
  - total alkalinity (5)
  - total cyanide (0.01)
  - total dissolved solids (1)
  - total hardness (1)
  - total organic carbon (0.2)
  - total suspended solids (0.5)
- Major ions:
  - calcium (0.004)
  - chloride (1)
  - fluoride (1)
  - magnesium (0.004)
  - potassium (0.005)
  - sodium (0.005)
  - sulphate (0.05)
  - sulphide (0.05)
- Nutrients
  - nitrate (0.006)
  - total ammonia (0.006)
  - total Kjeldahl nitrogen (0.006)
  - total phosphorus (0.006)

- Metals (total)
  - aluminum (0.0003)
  - antimony (0.0003)
  - arsenic (0.00003)
  - barium (0.00005)
  - beryllium (0.0002)
  - bismuth (0.0003)
  - boron (0.001)
  - cadmium (0.00005)
  - chromium (0.00006)
  - cobalt (0.0001)
  - copper (0.0006)
  - iron (0.005)
  - lead (0.00005)
  - manganese (0.0001)
  - mercury (0.00002)
  - molybdenum (0.00006)
  - nickel (0.00006)
  - radium 226 (0.01 Bq/L)
  - selenium (0.0001)
  - silver (0.0001)
  - strontium (0.0001)
  - thallium (0.0003)
  - tin (0.0003)
  - uranium (0.00005)
  - vanadium (0.00005)
  - zinc (0.0008)

6.5 Data Analysis

Water quality data will be presented in tabular format and concentrations of parameters will be compared with water quality guidelines for the protection of freshwater aquatic life, where applicable.

6.6 Quality Assurance and Quality Control

As part of routine QA/QC for field operations, water samples will be collected by appropriately trained personnel and will be labelled, preserved, stored, and shipped according to TP 8.3-1 (Golder 1997f). Detailed field notes will be recorded in perfect-bound, waterproof field books and on pre-printed waterproof field data sheets. Specific work instructions outlining each field task in detail will be provided to the field personnel by the task manager. Chain of custody forms will be used to track samples.

Field and trip blanks will be used to test for possible contamination of water samples, and duplicate samples will be collected to verify sampling variability and analytical precision. Blanks and duplicate samples will be collected at a frequency of 5 to 10% of the total number of samples.

7. SEDIMENT SURVEY

7.1 Introduction

A sediment quality survey will be conducted in conjunction with the ICS. The objective of the sediment quality component will be to collect sediment samples in each study area and lake to document background concentrations of sediment quality parameters that will be monitored during future EEM cycles. Sediment samples will also be collected from marine habitat in Roberts Bay, which will be the final receiving waterbody for the future mine effluent.

7.2 Sample Locations

Composite sediment samples will be collected at one replicate station within each freshwater study stream (four samples) and lake (three samples; Figure 4-1) in conjunction with the ICS. Marine sediment samples will be collected in Roberts Bay in a shallow area close to the mouth of Little Roberts Lake outflow and a reference area of similar depth near the mouth of Glenn Lake outflow. These samples will be analyzed for sediment particle size, TOC and metals.

Composite sediment samples will also be collected from the remaining four ICS replicate stations in each lake selected for the study, for analysis of sediment particle size and TOC. The particle size and TOC data are necessary as supporting data for analysis and interpretation of the ICS results for lake habitat.

7.3 Sampling Methods

Sediment samples will be collected at depositional locations within each stream sampling area and in close proximity to ICS sampling stations in lakes. Because of the predominance of erosional habitats in streams, sediment sample stations will be selected based on availability of depositional sediment. Sediment samples will be collected according to TP 8.2-3 (Golder 1997g). A composite sample consisting of 10 grab samples will be collected at one station within each stream sampling area and lake, and at three stations within each marine area selected for sampling. A Ponar or Ekman grab sampler with a bottom area of 0.0232 m^2 will be used to obtain samples. Field meters will be used to measure dissolved oxygen (freshwater) and redox potential (marine). Sediment samples will be labelled, stored and shipped according to methods described in TP 8.2-3 (Golder 1997g), and will be submitted to the analytical laboratory in the shortest time possible.

7.4 Sediment Quality Parameters

Sediment quality parameters measured by the analytical laboratory will include particle size, TOC and the following metals:

- Metals (total)
  - aluminum
  - antimony
  - arsenic
  - barium
  - beryllium
  - bismuth
  - boron
  - cadmium
  - chromium
  - cobalt
  - copper
  - iron
  - lead
  - manganese
  - mercury
  - molybdenum
  - nickel
  - potassium
  - selenium
  - silver
  - sodium
  - strontium
  - thallium
  - tin
  - uranium
  - vanadium
  - zinc

7.5 Data Analysis

Sediment quality data will be presented in tabular format and concentrations of parameters will be compared with the Canadian Sediment Quality Guidelines (CCME 1999) for the protection of freshwater or marine aquatic life, where applicable.

7.6 Quality Assurance and Quality Control

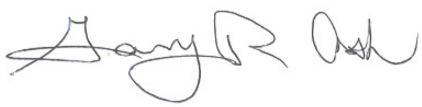
As part of routine quality assurance and quality control (QA/QC) for field operations, sediment samples will be collected by appropriately trained personnel and will be labelled, stored and shipped according to TP 8.2-3 (Golder 1997g). Sampling equipment will be maintained and cleaned according to procedures specified in the EEM guidance document. Detailed field notes will be recorded in waterproof field books and on pre-printed waterproof field data sheets. Specific work instructions outlining each field task in detail will be provided to the field personnel by the task manager. Chain of custody forms will be used to track samples.

As a quality control measure, a duplicate sediment sample will be collected at one station, and one composite sample will be split and submitted to the analytical laboratory as two separate samples.

8. CLOSURE

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

GOLDER ASSOCIATES LTD.



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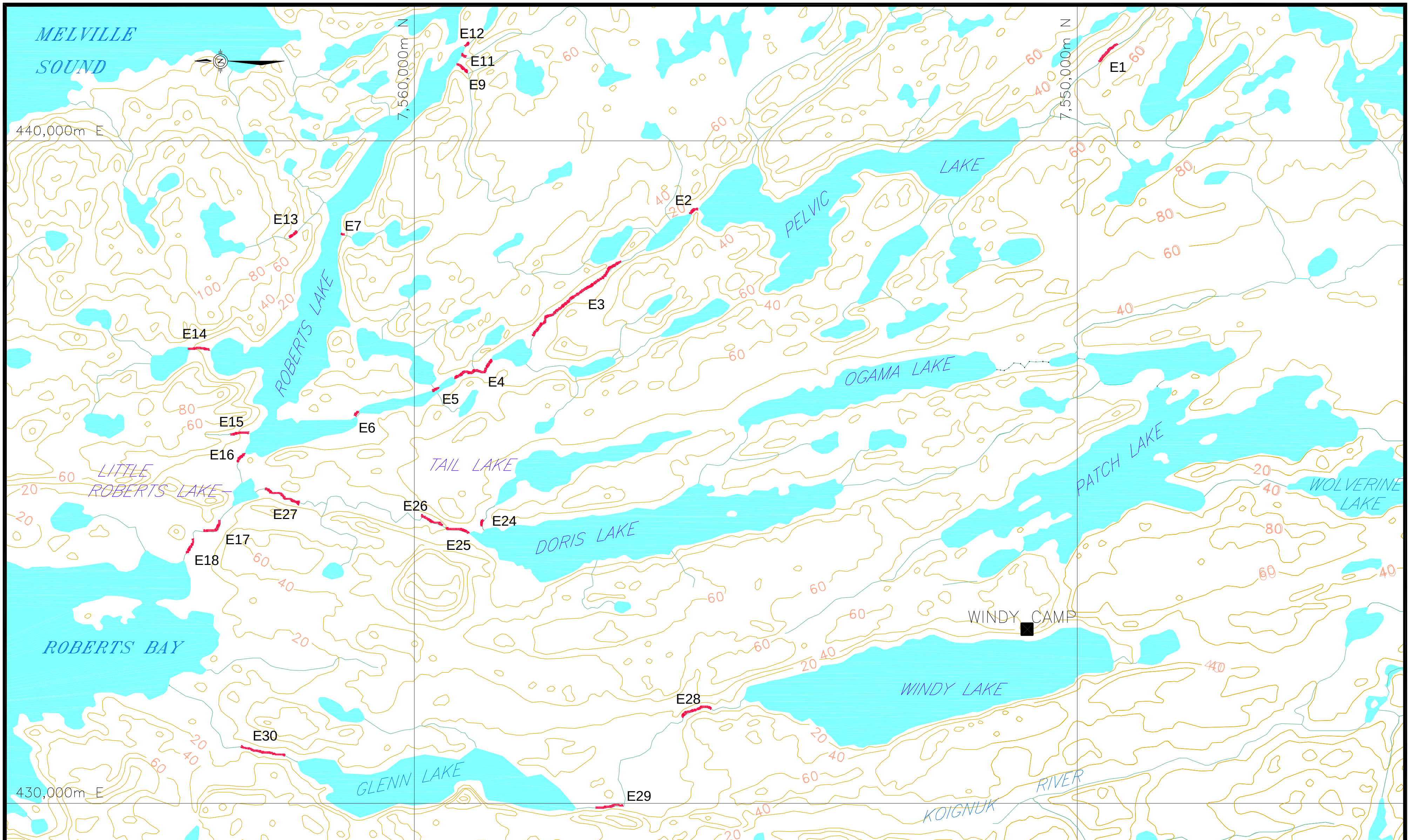
APPENDIX A

STREAM RECONNAISSANCE SURVEY DATA



LEGEND

E1 STREAM ELECTROFISHING SITE

NOTE

CONTOUR INTERVAL 20 m

REFERENCE

BASE MAP PROVIDED BY RESCAN, 22 JANUARY 2001

Miramar MINING CORPORATION

SCALE 2 0 2 KILOMETRES

TITLE

STREAM FISH SAMPLING SITES IN THE DORIS NORTH PROJECT AREA, 2003

Golder Associates Calgary, Alberta

PROJECT 03-1370-009.5000			FILE No. Fykenet-Fish-2003	
DESIGN	AL	03/10/03	SCALE AS SHOWN	REV. 0
CADD	PSR	15/10/03		
CHECK	AL	15/10/03	**Appendix: A1**	
REVIEW				

Appendix Table A2. Backpack electrofishing sampling locations, effort, fish catches and catch-per-unit-effort (CPUE) in streams of the Doris North Project, 2003.

Site	Effort		Number of Fish Captured[a]									CPUE (Number of Fish / 100 s)								
	(m)	(s)	ARCH	LKTR	LKWH	CISC	LSCS	BRWH	FRSC	NNST	Total	ARCH	LKTR	LKWH	CISC	LSCS	BRWH	FRSC	NNST	Total
Pelvic Inflow	50	272								11	11								4.04	4.04
Pelvic Outflow	2154	5859	13	15	6	2	13			31	80	0.22	0.26	0.10	0.03	0.22			0.53	1.37
Roberts Lake Tributaries	508	2148	34	8						17	59	1.58	0.37						0.79	2.75
Roberts Outflow	170	1476	48	2						8	58	3.25	0.14						0.54	3.93
Little Roberts Outflow	600	1781	1						1	11	13	0.06						0.06	0.62	0.73
Tail Outflow	50	113								10	10								8.85	8.85
Doris Outflow	600	2126	5	12						11	28	0.24	0.56						0.52	1.32
Windy Outflow	450	1741								5	5								0.29	0.29
Glen Outflow	600	1382	8	7							15	0.58	0.51							1.09
Total	**5182**	**16898**	**109**	**44**	**6**	**2**	**13**		**1**	**104**	**279**	**0.65**	**0.26**	**0.04**	**0.01**	**0.08**		**0.01**	**0.62**	**1.65**

[a] where ARCH=Arctic char; LKTR=lake trout; LKWH=lake whitefish; CISC=cisco; LSCS=least cisco; BRWH=broad whitefish; FRSC=fourhorn sculpin; NSST=ninespine stickleback.