ZINIFEX

ENVIRONMENTAL EFFECTS MONITORING STUDY DESIGN

LUPIN GOLD MINE
NUNAVUT, CANADA

March, 2008

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TABLE OF ACRONYMS AND UNITS

AO	Authorizing Officer	TOC	Total organic carbon
ARC	Alberta Research Council	TSS	Total suspended solids
BCI	Bray-Curtis index	UTM	Universal Transverse Mercator
BIC	Benthic invertebrate community	%	percent
CPUE	Catch-per-unit-effort	µg/L	micrograms per litre
CWQG	Canadian water quality guidelines	µm	micrometres
DO	Dissolved oxygen	µS/cm	microSeimens per centimetre
EBM	Echo Bay Mines	°C	degrees Celsius
EC	Environment Canada	Bq/L	Becquerels per litre
EEM	Environmental effects monitoring	cm	centimetres
ETL	Enviro-Test Laboratories Ltd.	g	grams
FDP	Final discharge point	h	hours
Golder	Golder Associates Ltd.	ha	hectares
GLM	General linear model	Hz	hertz
GPS	Global positioning system	km	kilometres
ISQG	Interim sediment quality guidelines	km_2	square kilometres
Kinross	Kinross Gold Corporation	L	litre
MDL	Method detection limit	m/s	metres per second
MMER	Metal mining effluent regulations	m^2	square metres
QA/QC	Quality assurance/quality control	m^3	cubic metres
NWB	Nunavut Water Board	m_3/d	cubic metres per day
SD	Standard deviation	m_3/s	cubic metres per second
SDI	Simpson's diversity index	mg/kg	milligrams per kilogram
SE	Standard error	mg/L	milligrams per litre
SNP	Surveillance Network Point	mm	millimetres
SSD	Statistically significant difference	ms	milliseconds
TAP	Technical Advisory Panel	NTU	Nephelometric Turbidity Units
TCA	Tailings containment area	s	Seconds
TGD	Technical guidance document	V	volts

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1.0 INTRODUCTION

The Metal Mining Effluent Regulations (MMER) of the *Fisheries Act*, promulgated in June 2002, stipulates conditions under which owners/operators of metal mines may deposit or discharge effluent to the aquatic environment (GC 2002). The regulations apply to all operating metal mines in Canada, and impose limits on release of cyanide, metals, radium-226, suspended solids, and prohibit the discharge of effluent that is acutely lethal to fish. Schedule 5 of the MMER requires that all mines subject to the regulations develop and implement an environmental effects monitoring (EEM) program to assess the effects of metal mining effluent on fish, fish habitat, and the use of fisheries resources. Where there is no pre-existing biological data, the first study design must be submitted within 12 months of a mine becoming subject to the regulations. Where there is pre-existing biological data the first Study Design must be submitted with 24 months. In the latter scenario, the mine must prepare a report that summarizes the biological monitoring studies and supporting documentation within 12 months of becoming subject to the regulations.

The Lupin Mine, purchased by Zinifex Canada Inc. (Zinifex) from Kinross Gold Corporation (Kinross) in 2006, is subject to the MMER. Consequently, Zinifex is required to conduct biological monitoring studies in the aquatic receiving environment for its operations. Because numerous studies have been conducted since initial environmental assessments in the late 1970s and early 1980s, a summary of historical biological monitoring data was submitted by Kinross in December 2003 in compliance with the MMER.

In December 2004, the Fish Study Design for Lupin Mine's Cycle 1 EEM program was submitted to Environment Canada (EC), as required under the MMER. Recommended changes to the Cycle 1 study design were reviewed during a meeting with EC's Technical Advisory Panel (TAP), Kinross, and Golder Associates Ltd. (Golder) in April 2005, and a revised field survey and study design was approved by the TAP in August 2005. Following approval of the Cycle 1 study design by the TAP, Kinross contracted Golder to conduct a comprehensive aquatic monitoring program during the summer of 2005. Study components included a sentinel fish survey, a benthic invertebrate community survey, water quality and sediment quality monitoring, and sublethal toxicity testing. The 2006 (Golder) *Lupin Gold Mine Environmental Effects Monitoring Cycle 1 Interpretive Report*, recommended that, in addition to the information included in the First EEM Study Design, the second study design should include a summary of the results from the First EEM Biological Monitoring Program. The historical results of the 2005 Cycle 1 study, including the biological monitoring program, water quality monitoring, sediment quality monitoring and sublethal toxicity testing, which were carried out in fulfillment of the MMER requirements, are summarized below, followed by the proposed EEM study design to be applied during the summer of 2008.

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2.0 SITE CHARACTERIZATION

This section provides a summary of the site characterization that is provided in the Lupin gold mine EEM study design (Golder 2004).

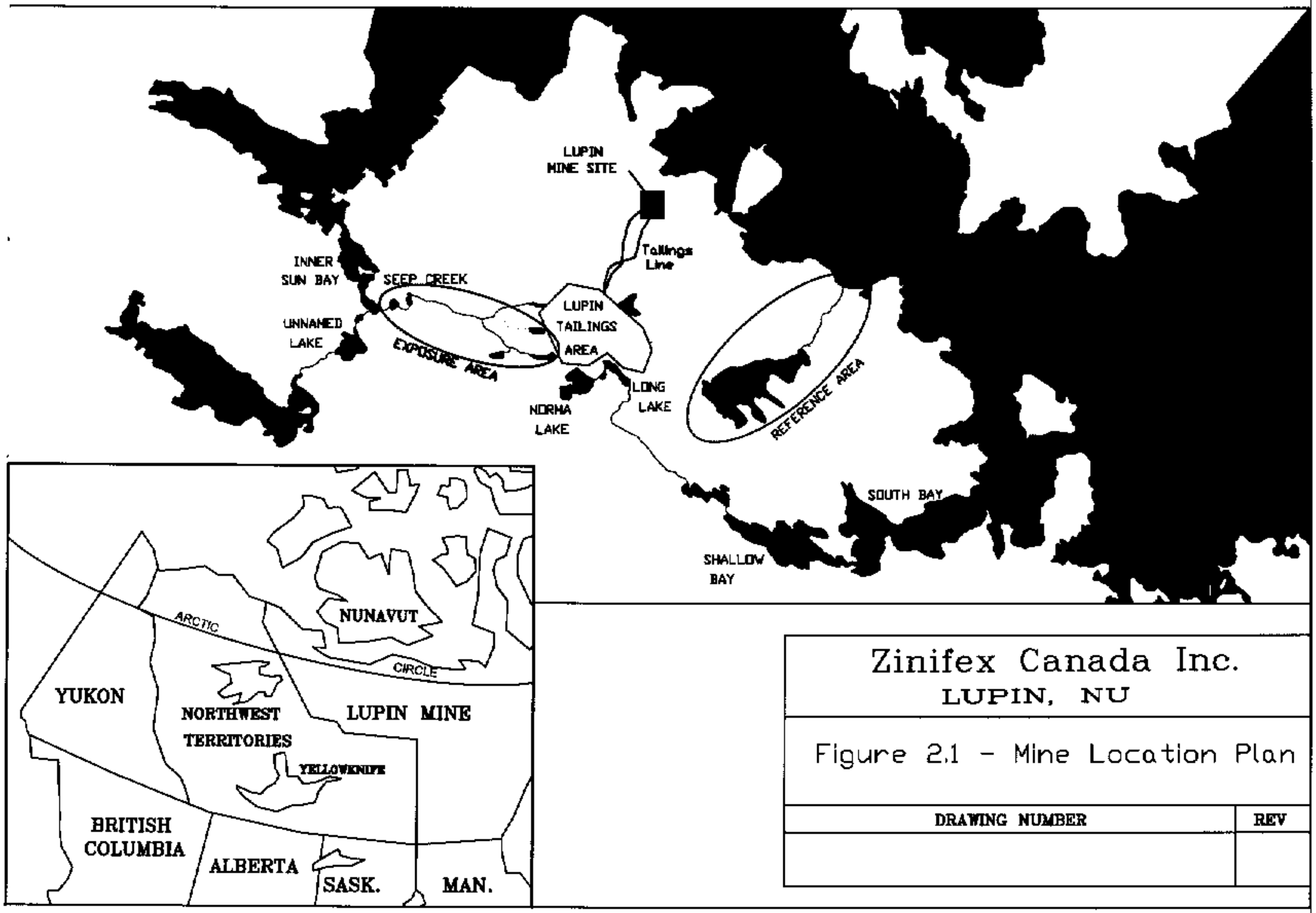
2.1. General Mine Site Description

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 2.1). Between April and late December each year, the only access to Lupin is by air, and from January to March the mine can also be accessed from Yellowknife via an ice road.

Mine site construction started in August 1980 and was completed in March 1982, when pre-production commissioning began. The mine operated continuously from 1982 to January 1998, when operations were suspended and the mine was placed in care and maintenance status due to low gold prices. Production resumed in April 2000. Following Echo Bay Mine's merger with Kinross in 2003, the mine was re-closed and placed under care and maintenance while undergoing feasibility studies to re-commence operations. Lupin Mine re-started operations during March 2004. In February 2005, the mine returned to care and maintenance.

The Lupin Mine included underground mining and production systems, as well as an ore handling system. Mining and processing equipment was designed to handle up to 2300 tonnes per day. During the mine's most recent operational period, processing rates were approximately 1200 tonnes of ore per day. Since the start of production in 1982, the Lupin Mine produced over 100 million grams of gold.

Other than transportation requirements for materials and supplies necessary to sustain the workforce and operations, the Lupin site is completely self-contained. It is comprised of two principal clusters of buildings: the residential complex, which consists of accommodations, a kitchen and recreation center; and the industrial complex, which houses the mine, mill, powerhouse, maintenance facility, warehouse and offices. Ancillary features include a sewage lagoon immediately to the south of the industrial complex, a 1.9 km long airstrip, and a tailings containment area (TCA) located approximately 7 km south of the mine (Figure 2.1).



Zinifex Canada Inc. LUPIN, NU	
Figure 2.1 - Mine Location Plan	
DRAWING NUMBER	REV

2.2. ENVIRONMENT LAWS AND REGULATIONS

The territorial and federal laws that apply to the operations of the Lupin Mine, and are applicable to effluent and environmental monitoring, are summarized below.

The Nunavut Water Board (NWB), which operates under regulations in the *Nunavut Land Claims Agreement,* governs the use of water and the deposition of waste in the Lupin Mine's area. Zinifex holds a water license with criteria for limiting the amount of water drawn from Contwoyto Lake, and discharge of deleterious substances and other water quality constituents under these regulations from the NWB. Zinifex also has an Emergency Spill Response and Contingency Plan developed under these regulations. Some of the conditions in the NWB license comply with the *Northwest Territories Waters Act.*

The federal *Territorial Lands Act,* and Land Use Regulations pertaining to the *Act,* applies to Crown lands in the Northwest Territories and Nunavut. The Lupin Mine received a Land Use Permit with conditions related to waste disposal under these regulations.

The federal *Fisheries Act* is applicable to effluent discharges from the Lupin Mine. The main objective of the *Fisheries Act* is to conserve and protect fish and fish habitat from harm caused by physical alteration or pollution. The MMER, administered within the *Fisheries Act,* restricts the release of deleterious substances to maximum discharge concentrations, regulates the requirements for release of non-acutely lethal effluent, and through the EEM program, assess the effectiveness of these limits with regards to environmental protection.

2.3. LOCAL ENVIRONMENT

2.3.1. CLIMATE

Climate in this region (Environment Canada Station 23026HN, Lupin A) is classified as semi-arid sub Arctic, with a mean daily temperature of -11.1°C and an average annual precipitation of 299 mm (Canadian Climate Normals 1961-2000). Average temperature for the months May through September is 4.6°C (Canadian Climate Normals 1961-2000). Precipitation is heaviest in the months of June through September. Snowfall can occur during any month, although heaviest snowfalls generally occur in October. The average total annual snowfall is 138.1 cm (Canadian Climate Normals 1961-2000). The project area is subject to frequent strong winds from the northwest (Beak Consultants Ltd. and Mary Collins Consultants Ltd. 1980; Geocon Ltd. 1980).Geology and Topography

The Lupin Mine is located in the tundra zone of the Canadian Shield, the geological core of the continent that occupies almost half of Canada's surface. The mine is located within the Slave province of the Shield, a province that features intrusive igneous material, such as granite (Natural Resources Canada 2003). Terrain in the vicinity of the mine is generally low and undulating, ranging between 450 and 530 m elevation. Numerous shallow lakes and streams occur in depressions throughout the area (Beak Consultants Ltd. and Mary Collins Consultants Ltd. 1980; Geocon Ltd. 1980).

2.4. VEGETATION

The Lupin Mine is located in the sub Arctic tundra vegetation zone, an area characterized by continuous permafrost and typical "barren ground" vegetation of moss, lichens, heather, and dwarf shrub communities. These types of vegetation are predominant on the more well-drained areas, whereas grasses and sedges are dominant in the wet ground adjacent to stream courses and around the perimeters of lakes. Dwarf willow shrubs up to 1 m high occur adjacent to some stream courses (RCPL and RL&L 1985).

2.5. HYDROLOGY

Contwoyto Lake is the major waterbody in the region, with a surface area of approximately 95 900 hectares (ha) and a drainage area of 8000 km^2 (Roberge et al. 1986). Contwoyto Lake has two outlets – the Burnside River, which flows from the northwest end of the lake towards Bathurst Inlet, and the Back River at the southeast end of the lake, which flows into Pellatt Lake (Roberge et al. 1986). The main body of Contwoyto Lake lies to the east and south of the mine site (Figure 2.1). To the north of the mine, a portion of the lake (known as the West Arm) extends to the west and south, terminating in a narrow bay (Sun Bay), which lies directly west of the mine site (Moore 1978; Roberge et al. 1986).

Seep Creek is a small stream (approximately 6.5 km in length) that flows in a westerly direction into Inner Sun Bay of Contwoyto Lake (Figure 2.1). The Seep Creek watershed includes three lakes (colloquially known as Dam 2 Lake, Dam 1a Lake and Unnamed Lake), three headwater streams, two ponds (Seep Creek Ponds 1&2), and two embayment areas (Inner and Outer Sun bays). Dam 2 Lake is a small lake (maximum depth of 7 m), bordered on the north by a gravel pit and on the east by the TCA. Dam 1 a Lake is a small lake (maximum depth of less than 1 m) that is located to the south of Dam 2 Lake. This waterbody freezes to the bottom in winter. A southern branch of Seep Creek, originating from Dam 1 a Lake, enters Seep Creek approximately 2 km downstream of Dam 2 Lake.A third branch of the creek arises to the south of Dam 1a Lake and joins the main stem about 400 m downstream of the confluence of Dam 2 Lake and Dam 1 a Lake branches.

2.6. Description of Production Processes

The ore body at the Lupin Mine extends from the surface to about 2000 m below the surface. Gold is found primarily within a sulphide rich iron formation. The gold is fine grained (generally less than 100 µm in diameter) and is associated mainly with pyrrhotite and arsenopyrite. The Lupin Mine has historically used cyanidation processing to leach gold into solution. A detailed description of the underground mining and milling techniques used at the Lupin Mine is provided in Golder (2003) and Echo Bay Mines Ltd. (2001).

2.7. Environmental Protection Practices

A waste management program for the handling, disposal and tracking of contaminated and non-contaminated waste generated by the Lupin Mine, previously established by Kinross, complies with applicable federal and territorial laws and regulations. While the storage and disposal of non-contaminated waste does occur at the Lupin Mine, the value of the 4Rs system (reduce, reuse, recycle, and recover) is recognized and actively promoted. Following is a summary of the waste management program as it relates to wastewater management.

2.7.1. Waste Rock

While the Lupin Mine was in operation, waste rock was used as roadbed material, in dams, in the airstrip, or as backfill. During the last few years of operation, very little development waste was produced in the underground operation; as a result, a surface waste stockpile no longer exists.

2.7.2. Management of Mine Water

Relative to most underground mining operations, Lupin is a dry mine, having an average water inflow of between 45 and 95 L per minute. Most of this water seeps into workings below the permafrost level (500 m below surface). The main de-watering system consists of four main sumps located at the 250, 650, 890, and 1105 m shaft stations. The discharge line is 15.24 cm diameter, and is located in the shaft. The mine discharge water is pumped to the TCA via the mill.

Both drill water and potable water is supplied to the mine via separate pipelines located in the shaft. A brine line services the upper levels, in permafrost. A 3% to 6% brine solution (by weight) is mixed in tanks on the surface and fed to upper level sumps when needed. Also located in the shaft is a 3.81 cm fuel line, which allows diesel fuel to be sent to a main storage facility on the 890 m level.

2.7.3. MANAGEMENT OF TAILINGS

Originally, all waste was to be contained within the TCA. As mine capacity increased, it became necessary to expand the TCA and discharge effluent. Effluent discharge commenced on 5 September 1985. Effluent was discharged in mid summer, generally beginning on 15 July and continued for periods that extended into early September. The maximum rate of effluent discharge, as per the Nunavut Water Board water license, has been 60 000 to 70 000 m^3/d (AQUAMIN 1996; EVS 1996). Since the initial discharge in 1985, effluent is discharged into Seep Creek, which empties into an unnamed lake. Unnamed Lake drains into Contwoyto Lake at the south end of Inner Sun Bay (Figure 2.1).

The tailings management process at Lupin is as follows:

- The tailings slurry is pumped from the mill to one of two solids retention cells (Cell 3 or Cell 5) in the TCA, where the solids settle. For the past six years, Cell 5 has been used for winter deposition and Cell 3 for summer deposition (Figure 2.2).

- Each spring, usually beginning in late June, the build-up of meltwater and tailings water is decanted from Cells 5 and 3 into Cell 4. Cell 4 has not been used for solids deposition, and functions as a primary polishing pond. Water is held in this cell for a one-year period, where cyanide undergoes natural degradation due to exposure to sunlight, air, and agitation by wind.

- The following year, water is released from Cell 4, through a gated culvert, into Pond 1, where it is held for a one-year period, before being siphoned into Pond 2 where it is held for another year. If necessary, the water can be treated with ferric-sulphate during the siphoning process to precipitate arsenic in Pond 2.

- Historically, water was retained only for a 2-year period, and arsenic levels were still high in Pond 1. An arsenic treatment plant was built between Pond 1 and Pond 2, so that the water could be injected with ferric sulphate solution as it was being siphoned between the two ponds. Since 2000, water has been retained for a three year period (one year in Cell 4, one year in Pond 1, and one year in Pond 2). The extra year of water retention before going into Pond 2 has resulted in naturally lowering the arsenic levels, thus negating the use of the treatment plant. Periodically, treatments of ferric sulphate (two tonne batches) are placed into Pond #1 to control arsenic concentrations.

- Depending on the water level and water quality in Pond 2, water can be released to the environment after 15 July of any year (as per Nunavut Water Board water license). Water quality is monitored on a daily basis during discharge to ensure that discharge criteria are not exceeded.

Reclamation activities have been ongoing at the Lupin Mine since 1988. Between 1988 and 2005, Cell 1, Cell 2, Cell 3 and Cell 5 have been covered with esker sand to prevent access to surface tailings by wildlife in the area. Water from Cell 3 was pumped into Cell 4 prior to covering with esker sand, and water from Cell 4 will be released to Pond 1 after a suitable retention period.

2.7.4. SEWAGE DISPOSAL

Sewage and domestic grey water is pumped to the Sewage Lake Disposal System for natural degradation. The system features two small unnamed lakes located to the south of the mine and empty via an unnamed creek into Contwoyto Lake (Echo Bay Mines Ltd. 1994).

2.7.5. HISTORICAL EFFLUENT AND WATER QUALITY MONITORING

Kinross identified one final discharge point to Environment Canada in 2003. Plans, specifications, operation, and maintenance information were provided in accordance with Section 9 of the MMER (GC 2002). The final discharge point is regularly monitored under licensing agreement with the Nunavut Water Board (SNP 925-10), along with downstream receiving environment sampling locations. Effluent is siphoned from TCA Pond 2 into Dam 1a Lake, a headwater tributary of Seep Creek (Figures 2.1 and 2.2). A brief description of the final discharge water quantity, quality, and plume delineation is provided below.

2.7.6. EFFLUENT MONITORING

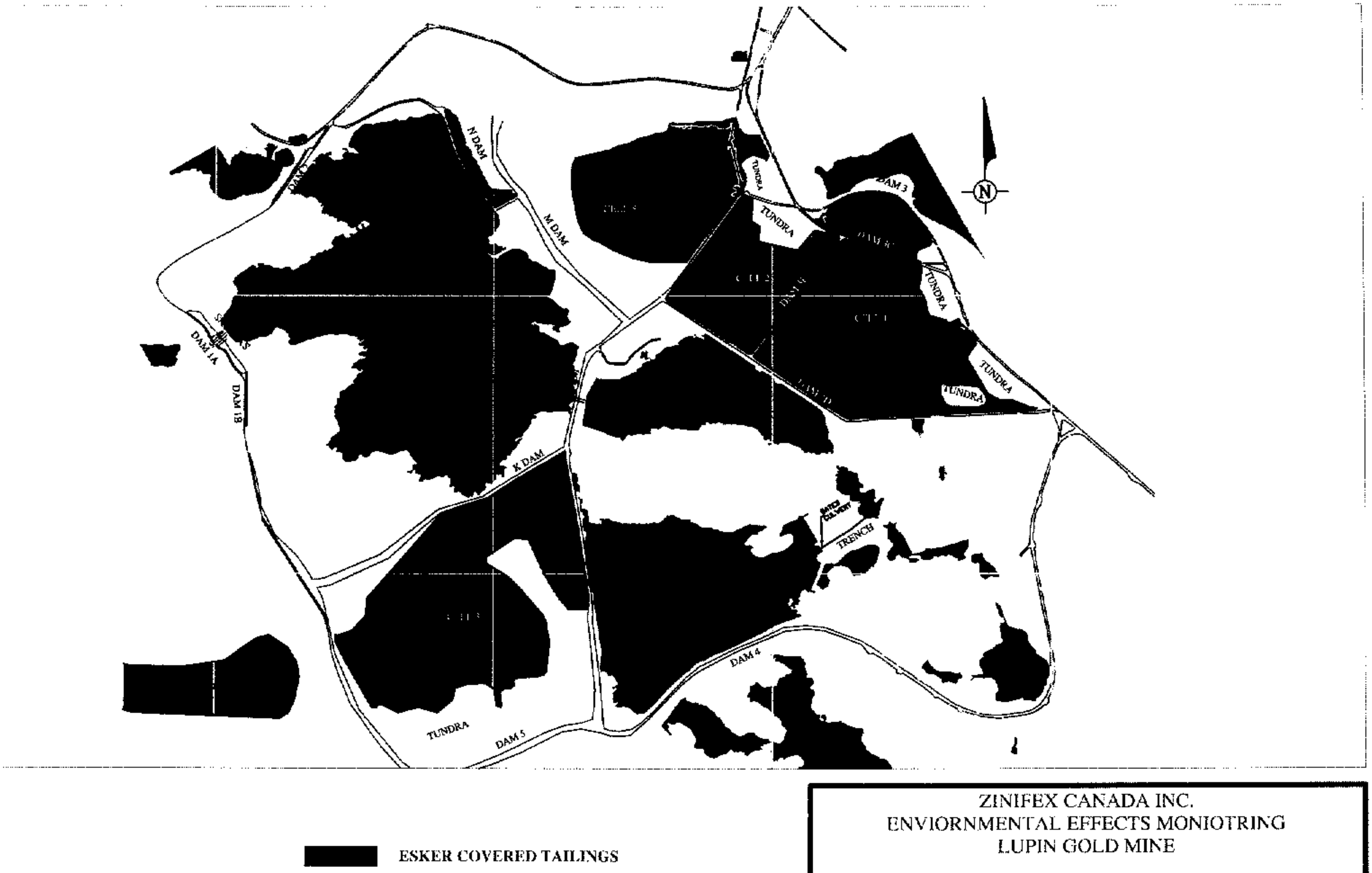
Discharge at SNP 925-10 is monitored regularly (65°43'43.8" N, 111°18'23.3" W), with annual quality reports submitted to the NWB. Total annual discharge between 1994 and 2005 ranged from 0 m^3 to 3 102 895 m^3 (Table 2.1).

Table 2.1. Total annual discharge volumes from Lupin Mine TCA (SNP 925-10), 1994 to 2005

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

Note: n/a = not applicable

Water quality at SNP 925-10 is monitored for a variety of constituents at varying frequencies (Table 2.2). Constituents listed in Schedule 4 of the MMER (GC 2002), with the exception of radium-226, are routinely measured at SNP 925-10. The maximum concentrations discharged from SNP 925-10 during 2000, 2002 and 2005 (Table 2.3) are below authorized limits (GC 2002).



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LUPIN TAILINGS CONTAINMENT AREA

ZINIFEX

FIGURE 2.2

Table 2.2. Monitoring and sampling frequencies of TCA effluent at SNP 925-10

Constituents	Frequency
pH, Conductivity, Temperature, Total Suspended Solids, Arsenic, Cyanide, Copper, Zinc, Volume	Daily (grab)
Cadmium, Lead, Nickel, Alkalinity, Ammonia, Hardness	Weekly (grab)
24 Metals (Total), ICPMS (inductive coupled plasma mass spectrometer)	First discharge day and monthly thereafter (grab)
Static Pass/Fail Bioassay for Both Rainbow Trout and *Daphnia* Species (per Environment Canada's Environmental Protection Series Biological Test Methods)	Twice per year (grab)

Table 2.3. Maximum concentrations of MMER deleterious substances at the Lupin Mine (SNP 925-10)

Constituent	Units	2000	2002	2005	Maximum Authorized Concentration in a Grab Sample
Arsenic	mg/L	0.0133	0.0800	0.0146	1.00
Copper	mg/L	0.011	0.034	0.015	0.60
Cyanide	mg/L	0.032	0.144	0.040	2.00
Lead	mg/L	<0.0020	0.0006	0.0050	0.40
Nickel	mg/L	0.1210	0.0893	0.0955	1.00
Zinc	mg/L	0.303	0.247	0.251	1.00
Radium-226	Bq/L	n/a	n/a	0.006	1.11
TSS	mg/L	2	5	<2	30.00

Note: [a] GC (2002) ; TSS = Total Suspended Solids; n/a = not available

Several metals and other constituents were measured as part of the routine water quality monitoring program at SNP 925-10 (Table 2.4). Metal concentrations and levels of conventional constituents, such as conductivity, pH and total suspended solids (TSS), have remained at consistent concentrations. Arsenic, for example, remained below 0.015 mg/L, and conductivity ranged between 847 and 906 µS/cm.

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Table 2.4. Water quality of Lupin Mine TCA effluent at SNP 925-1

Constituent	Units	2000				2002		2003
CONVENTIONAL								
Field Temperature	C	n/a	14	12	6	14.7	15	n/a
pH	Units	6.95	7.00	7.05	6.53	7.01	6.95	6.39
TSS	mg/L	1	1	1	1	<1	<1	<2
Conductivity	uS/cm	869	887	n/a	906	858	855	847
Total Alkalinity	mg/L	10	11	7	<5	20	10	<5
Total Hardness	mg/L	227	227	244	239	245	218	216
INORGANIC NON-METALLIC								
Ammonium-N	mg/L	4.57	4.00	3.91	3.07	1.08	1.36	1.88
Cyanide	mg/L	0.016	0.016	0.014	0.016	0.004	0.078	0.040
MAJOR IONS								
Calcium	mg/L	78.7	78.9	n/a	n/a	84.7	75.1	74.2
Magnesium	mg/L	7.49	7.37	n/a	n/a	8.03	7.41	7.50
Hydroxide	mg/L	<5	<5	n/a	n/a	<5	<5	<5
METALS TOTAL								
Aluminum	mg/L	0.063	0.56	0.090	0.096	0.055	0.080	0.128
Antimony	mg/L	<0.006	<0.006	<0.006	<0.006	<0.002	0.005	<0.002
Arsenic	mg/L	<0.01	<0.01	<0.01	0.01	0.0149	0.0108	0.0146
Barium	mg/L	0.0412	0.015	0.0158	0.0162	0.016	0.017	0.016
Berylium	mg/L	<0.006	<0.006	<0.006	<0.006	<0.001	<0.001	<0.001
Bismuth	mg/L	<0.006	<0.008	<0.008	<0.006	<0.0005	<0.0005	<0.0005
Boron	mg/L	0.126	0.134	0.116	0.099	0.098	0.106	0.087
Cadmium	mg/L	<0.0006	<0.0006	<0.0006	<0.0006	0.0002	0.0002	0.0001
Calcium	mg/L	78.1	82.1	77.6	81.0	71.6	76.8	n/a
Chromium	mg/L	<0.0009	<0.0009	<0.0009	<0.0009	0.0007	<0.0009	<0.0009
Cobalt	mg/L	0.0626	0.0658	0.0654	0.0684	0.0559	0.0566	0.0496
Copper	mg/L	0.003	0.005	0.007	0.011	0.012	0.006	0.015
Iron	mg/L	0.068	0.075	0.227	0.25	0.980	0.267	0.200
Lead	mg/L	<0.002	<0.002	<0.002	<0.002	0.0005	0.0004	0.0005
Lithium	mg/L	0.018	0.019	0.018	0.019	0.018	0.019	0.030
Manganese	mg/L	1.26	1.32	1.30	1.36	1.10	1.14	0.005
Molybdenum	mg/L	0.001	<0.001	<0.001	0.002	0.002	0.003	0.002
Nickel	mg/L	0.103	0.110	0.107	0.111	0.0807	0.0838	0.0955
Phosphorus	mg/L	0.04	<0.03	<0.03	<0.03	n/a	n/a	n/a

ZINIFEX

2.8. WATER QUALITY MONITORING

Water quality is routinely monitored at several locations in the exposure area downstream of the final discharge point (Figure 2.3). In the 2005, conductivity was reported to be 11 µS/cm at the mouth of Concession Creek (SNP 925-21), which does not receive effluent from Lupin Mine. Concentrations of several constituents were noted to decrease with increasing distance from the mouth of Seep Creek. In 2005, mean conductivity was 519 µS/cm at the mouth of Seep Creek (SNP 925-20), 240 µS/cm at the centre of Inner Sun Bay (SNP 925-22), 129 µS/cm at the Sun Bay narrows (SNP 925-24), and 76 µS/cm in Outer Sun Bay (SNP 925-25). Nickel, zinc, hardness, and ammonium exhibited similar data trends of decreasing concentrations with increasing distance from the final discharge point (FDP) (Table 2.5 to 2.7).

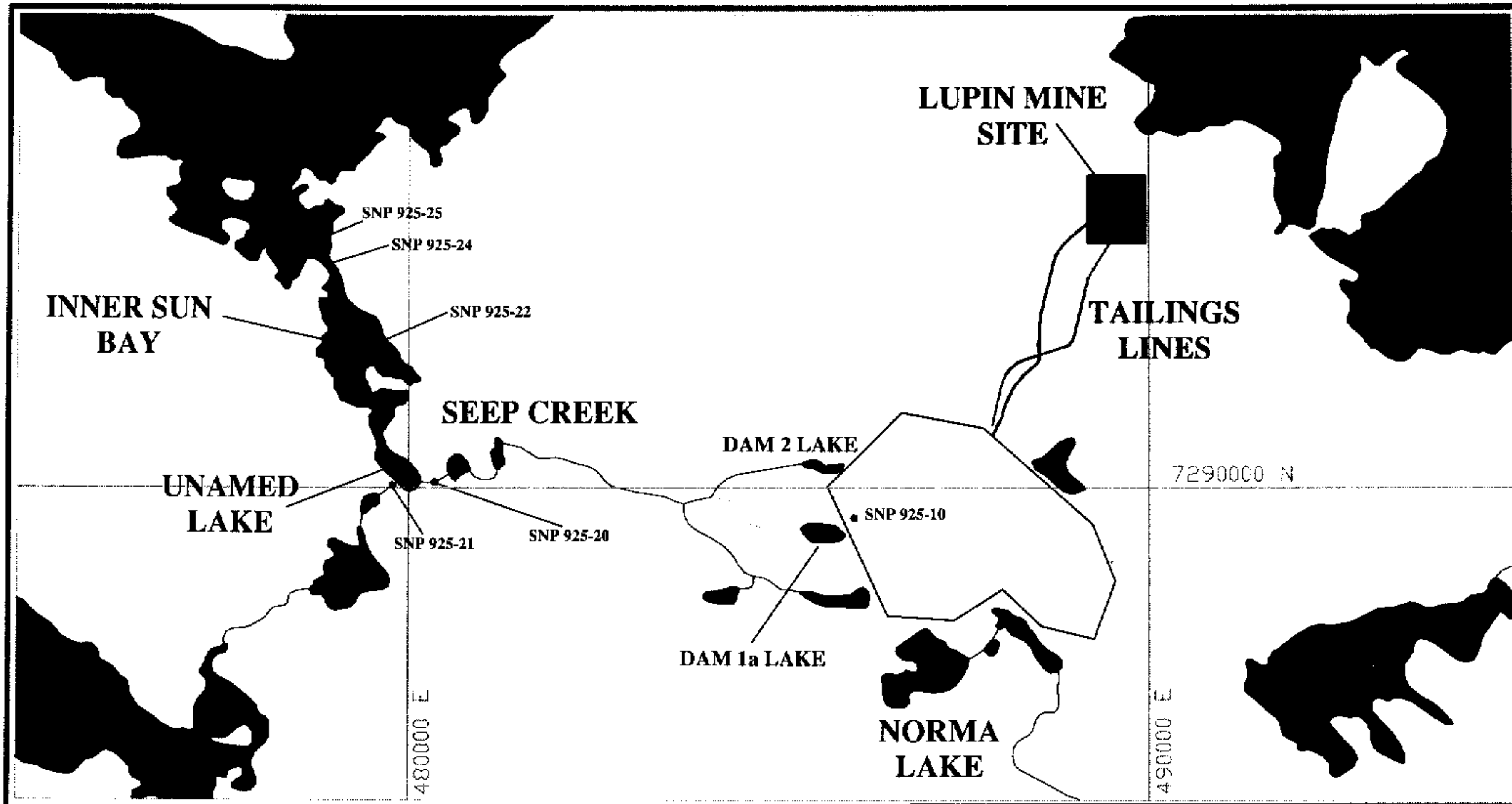
2.9. DELINEATION OF EFFLUENT PLUME

The MMER requires an estimate of the effluent concentration at 250 m downstream of the FDP. A description of the extent of effluent contact with the surrounding water environment, to a concentration level of 1% of discharged effluent, is also required.

The common method used to estimate the effluent concentration at 250 m from the FDP is to compare the effluent conductivity to the field conductivity at a point 250 m from the FDP while the Mine is discharging effluent. The mine terminated effluent discharge on 11 August 2005; therefore, effluent was not being discharged during the 2005 EEM sampling program. Although effluent was not being discharged, the laboratory conductivity measurement was 738 µS/cm 250 m from the FDP, in Dam 1a Lake, on 21 August 2005. The effluent conductivity on 27 July 2005 was 847 µS/cm. In 1985, RL&L and DFO (1991) estimated that up to 90% of the flow in Seep Creek was due to effluent discharge into the stream system. Mine effluent discharged from the TCA is the main source of water into Dam 1a Lake; therefore, we cautiously estimate the effluent concentration to be 87% in Dam 1 a Lake, 250 m from the FDP.

Effluent mixing in the exposure zone was described in Golder (2004) using dilution and dispersion modeling of the effluent stream into Outer Sun Bay. The model predicted that a 1% effluent concentration would extend 850 to 1200 m from the mouth of the narrows into Outer Sun Bay under average effluent discharge and ambient current velocity (average conditions). At maximum effluent discharge and high ambient current velocity (worst case conditions), the model predicted that the 1% effluent concentration would extend up to 1630 m from the mouth of the narrows into Outer Sun Bay (Figure 2.4).

Water quality is monitored in Outer Sun Bay (SNP 925-25), approximately 500 m from the mouth of the narrows. Based on monitoring data in 2000 and 2002, effluent concentrations of 1.3 to 3.4% were present in the bay. These values are consistent with the results of the dilution and dispersion analysis, and indicate that there is sufficient mixing in Outer Sun Bay.



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LUPIN GOLD MINE

EXPOSURE AREA WATER QUALITY MONITORING STATIONS

ZINIFEX

FIGURE 2.3

Table 2.5. Summary of water quality monitoring data downstream of the Lupin Mine effluent discharge location

Note: [a] Concentration units are mg/L, unless otherwise listed; [b] Total suspended solids; [c] where a portion of the results were below the method detection limits, half of this limit was used to calculate means; SD=standard deviation;

Constituent[a]	Mouth of Seep Cr. (SNP 925-20)									Mouth of Concession Cr. (SNP 925-21)								
	n	2000 Mean[c]	SD	n	2002 Mean	SD	n	2005 Mean	SD	n	2000 Mean	SD	n	2002 Mean	SD	n	2005 Mean	SD
pH (units)		6.03	0.25	7	6.48	0.15	6	5.70	0.45	7	6.43	0.32	7	6.28	0.41	6	6.67	0.14
Conductivity (S/cm)		887	37		748	114		519	279		1 4	6	7	1 2	1	6	1 1	1
TSS[b]		0.53	0.17	7	0.93	0.73	5	<2	0	7	0.96	1.35	7	<1	0	5	<2	0
Total Arsenic		0.0024	0.0006	7	0.0036	0.0006	6	0.0032	0.0013	7	0.0004	0.0003	7	0.0011	0.0017	6	0.0007	0.0002
Total Cyanide		0.007	0.004	7	0.015	0.014	6	0.016	0.008	7	<0.002	0	7	0.003	0.004	6	0.002	0
Total Cadmium		<0.0006	0	7	0.00017	0.00003	6	0.00017	0.00010	7	<0.000	0	7	<0.0000	0	6	<0.00001	0
Total Copper		0.005	0.002	7	0.004	0.002	6	0.005	0.002	7	0.001	0.001	7	0.001	0.001	6	<0.001	0
Total Lead		<0.002	0	7	0.0002	0.0002	6	0.0001	0.0001	7	0.001	0.001	7	0.0001	0.0001	6	0.0001	0
Total Nickel		0.115	0.009	7	0.0755	0.0084	6	0.0762	0.0411	7	0.008	0.018	7	0.0006	0.0003	6	0.0006	0.0001
Total Zinc		0.228	0.026	7	0.146	0.017	6	0.159	0.091	7	0.008	0.01	7	0.003	0.003	6	0.002	0.001
Total Alkalinity (as $CaCO_3$)		<5	0	7	7.4	9.2	6	<5	0	7	<5	0	7	<5	0	6	6	1
Hardness (as $CaCO_3$)		231	9.1	7	199	34.3	6	135	75.4	7	4	0.6	7	5	0.3	6	3	1.4
Ammonium		2.72	0.48	7	0.72	0.31	6	0.64	0.47	7	0.32	0.16	7	0.03	0.02	6	<0.05	0

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Table 2.6. Summary of water quality monitoring data downstream of the Lupin Mine effluent discharge location

Constituent[a]	Centre of Inner Sun Bay (SNP 925-22)									Sun Bay Narrows (SNP 925-24)								
	2000			2002			2005			2000			2002			2005		
	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD
pH (units)	7	6.33	0.33	7	6.37	0.09	17	6.36	0.27	7	6.47	0.29	7	6.36	0.29	7	6.47	0.18
Conductivity (S/cm)	3	296	130	7	336	88.5	17	240	155	3	78.4	48.5	7	267	114	7	129	101
TSS[b]	7	0.47	0.2	7	<1	0	17	<2	0	7	0.37	0.3	7	<1	0	6	<2	0
Total Arsenic	7	0.001	0.0004	7	0.014	0.0003	17	0.0017	0.0006	7	0.0007	0.0005	7	0.0011	0.0002	7	0.0012	0.0003
Total Cyanide	7	0.007	0.01	7	0.007	0.004	17	0.010	0.008	7	0.006	0.012	7	0.004	0.002	7	0.006	0.003
Total Cadmium	7	<0.0006	0	7	0.00006	0.00002	17	0.00017	0.00019	7	<0.0006	0	7	0.00003	0.00002	7	0.00005	0.00002
Total Copper	7	0.002	0.001	7	0.003	0.004	17	0.002	0.001	7	0.002	0.002	7	0.002	0.001	7	0.001	0.001
Total Lead	7	<0.002	0	7	0.0002	0.0002	17	0.0004	0.0003	7	<0.002	0	7	0.0002	0.0003	7	0.0005	0.0003
Total Nickel	7	0.041	0.016	7	0.027	0.007	17	0.029	0.020	7	0.012	0.011	7	0.0163	0.0073	7	0.0130	0.0108
Total Zinc	7	0.08	0.034	7	0.054	0.017	17	0.070	0.055	7	0.025	0.022	7	0.038	0.014	7	0.029	0.023
Total Alkalinity (as $CaCO_3$)	7	<5	0	7	<5	0	17	<5	0	7	<5	0	7	<5	0	7	<5	0
Hardness (as $CaCO_3$)	7	88	25	7	82.7	21.9	17	57.8	38.4	7	31.2	22.6	7	64.3	26.4	7	31.1	23.5
Ammonium	7	1.06	0.28	7	0.24	0.12	17	0.40	0.14	7	0.57	0.28	7	0.15	0.1	7	0.17	0.09

Note: [a] Concentration units are mg/L, unless otherwise listed; [b] Total suspended solids; [c] where a portion of the results were below the method detection limits, half of this limit was used to calculate means; SD=standard deviation

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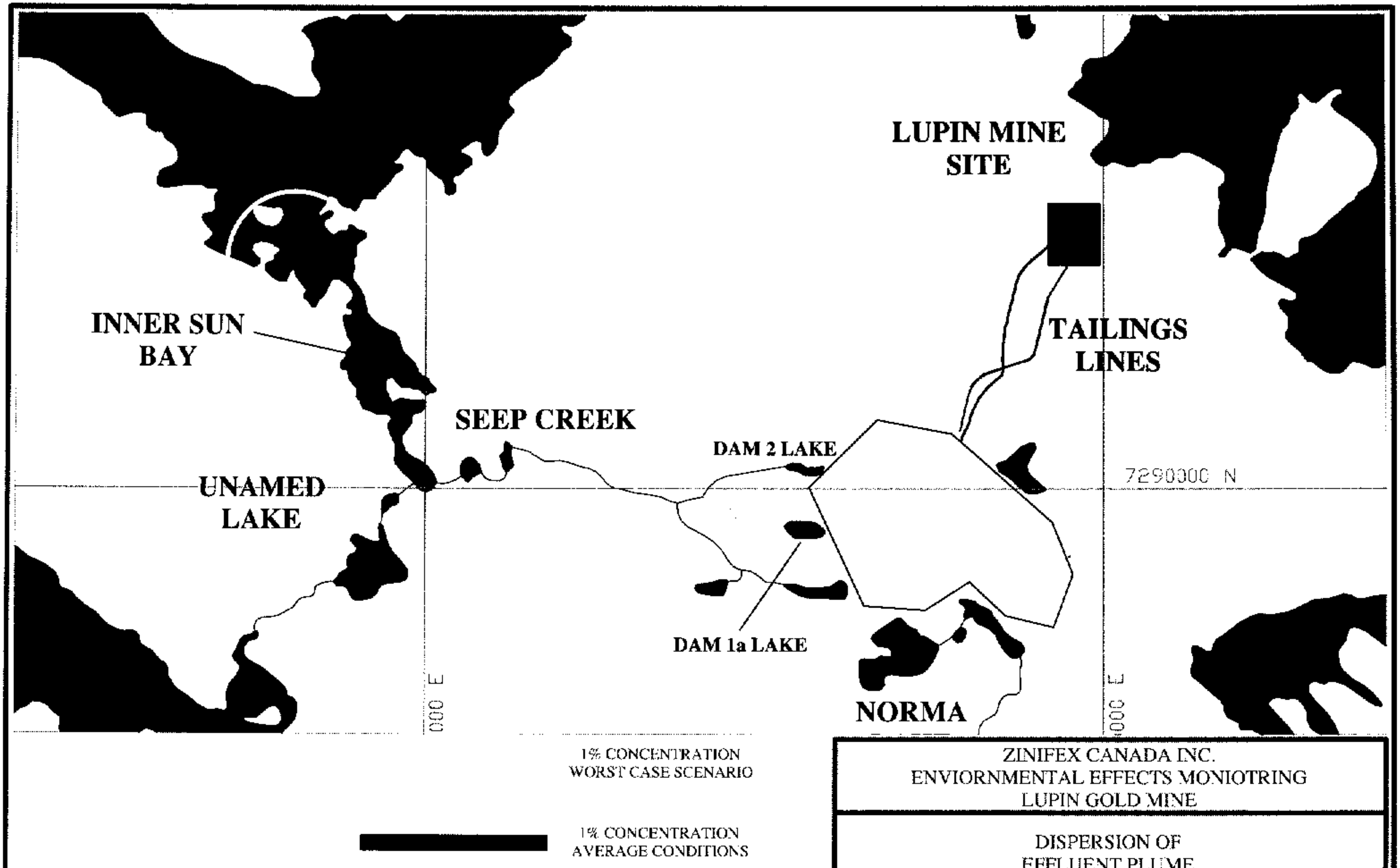
Table 2.7. Summary of water quality monitoring data downstream of the Lupin Mine effluent discharge location

Constituent[a]	Outer Sun Bay (SNP 925-25)								
	n	2000 Mean	SD	n	2002 Mean	SD	n	2005 Mean	SD
pH (units)	7	6.51	0.28	7	6.39	0.35	7	6.63	0.13
Conductivity (S/cm)	3	25.3	19.8	7	40.7	25.7	7	76	81
TSS[b]	7	0.46	0.27	7	0.8	0.6	6	<2	0
Total Arsenic	7	0.0012	0.0021	7	0.0006	0.0001	7	0.0013	0.0002
Total Cyanide	7	0.001	0.001	7	0.002	0.001	7	0.005	0.007
Total Cadmium	7	<0.0006	0	7	<0.00001	0	7	0.00003	0
Total Copper	7	0.001	0.001	7	0.002	0.002	7	0.001	0.001
Total Lead	7	<0.002	0	7	0.0002	0.0004	7	0.0007	0.0005
Total Nickel	7	0.002	0.001	7	0.0026	0.0016	7	0.0039	0.0036
Total Zinc	7	0.009	0.004	7	0.007	0.004	7	0.012	0.007
Total Alkalinity (as $CaCO_3$)	7	<5	0	7	<5	0	7	<5	0
Hardness (as $CaCO_3$)	7	6.63	3.86	7	9.97	5.52	7	20.6	25.2
Ammonium	7	0.28	0.16	7	0.04	0.02	7	<0.05	0

Note: [a] Concentration units are mg/L, unless otherwise listed; [b] Total suspended solids; [c] where a portion of the results were below the method detection limits, half of this limit was used to calculate means; SD=standard deviation;



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DISPERSION OF EFFLUENT PLUME

FIGURE 2.4

2.10. EXPOSURE AND REFERENCE AREA CHARACTERIZATION

2.10.1. SEEP CREEK AND SEEP CREEK PONDS – EXPOSURE AREA

Aquatic habitat in the receiving environment downstream of the tailings area (Figures 2.1 and 2.3) is comprised of three shallow lakes (Dam 2 Lake, Dam 1a Lake, and Unnamed Lake), two streams (Seep Creek and Concession Creek), two shallow ponds, and two embayment areas of Contwoyto Lake (Inner and Outer Sun bays). With the exception of Dam 2 Lake, all of the small lakes and ponds freeze to the bottom in winter. Much of Inner Sun Bay also freezes to the bottom. Due to low winter flows, both Seep Creek and Concession Creek freeze to the bottom in winter. As a consequence, over-wintering habitat for fish is limited primarily to Outer Sun Bay and the main body of Contwoyto Lake (RCPL and RL&L 1985).

Seep Creek is approximately 6.5 km in length, flowing from its source in Dam 2 Lake and Dam 1a Lake (via separate branches which join about 2 km downstream) to Unnamed Lake (Figures 2.1 and 2.3). The stream channel in upper Seep Creek is generally poorly defined, often flowing through marshy areas, or between large boulders or through bedrock fractures. This section of the creek generally was less than 0.5 m in depth and less than 2 m wide. The dominant substrate type is boulders, although localized areas of cobble and gravel are present. Lower Seep Creek (i.e., the 400 m section upstream of Unnamed Lake) is characterized by a well developed channel varying in width from 1 to 4 m, although during freshet, maximum wetted width was about 20 m. The dominant substrate type is boulder, with localized areas of cobble and gravel (RCPL and RL&L 1985).

Two ponds are located near the downstream end of Seep Creek. The maximum depths of these ponds are approximately 1.5 m; the surface area of the upstream-most pond (Pond 1) was 3 ha, and the surface area of the downstream-most pond (Pond 2) was 2 ha.

Lake trout, arctic grayling, cisco, round whitefish, ninespine stickleback and slimy sculpin have been documented in Seep Creek (RCPL and RL&L 1985). RL&L and DFO (1991) indicated that fish use the stream for spawning, feeding and juvenile rearing in the early part of the open water season. The majority of the fish were moving downstreamwhen captured in 1990. RL&L and DFO (1991) suggested that this was in response to decreasing water levels as snowmelt run-off subsided. RCPL and RL&L (1985) documented Arctic grayling spawning in Seep Creek in 1983 and 1984.

2.11. FINGERS CREEK AND FINGERS LAKE - REFERENCE AREA

Note that the 2006 Golder report identified that Fingers Creek has provided appropriate data for use as a reference comparison and should remain as the reference area for the second EEM program.

Fingers Creek flows for approximately 3 km between Fingers Lake and Contwoyto Lake (Figure 2.1). The upstream end of the channel was braided and contained substrate composed primarily of silt and boulders, with some cobble. The stream channel widened to approximately two to three metres in the mid-section of the stream. The substrate consisted of cobble, gravel, and silt, with limited boulders also present. The downstream end of the creek featured a narrow channel, approximately 1.0 m wide, with substrate dominated by cobble and boulders. The upstream section was primarily shallow flat habitat, whereas the midstream and downstream sections were primarily shallow run habitat. The average depth was 0.5 m through the upstream and midstream sections, and approximately 0.3 m in the downstream section. Approximately 20% of the entire creek, and 40% of the midstream section, contained aquatic vegetation and periphytic algae. The banks were vegetated and stable, and were composed primarily of fines.

Fingers Lake has a maximum depth of 6 m and a surface area of 370 ha (Moore 1978). Fingers Lake is a clearwater lake with little aquatic vegetation, except in the deposition areas. The lake is shallower toward the north-east end of the lake, and the substrate is primarily cobble and boulders extending from the north-east shore to approximately 400 m into the lake. There is a boat dock on the south-west end of the lake. The north, east and west shores had steep drop-offs and boulders near shore. The south shore of the lake has a gradual slope, and there are four narrow shallow bays on the south-east side of the lake that are primarily depositional habitat.

Moore (1978) encountered lake trout and Arctic char in Fingers Lake. Fish capture data has not been collected for Fingers Creek.

3.0 PREVIOUS EEM RESULTS SUMMARY

3.1. BENTHIC INVERTEBRATE COMMUNITY FIELD MEASUREMENTS SUMMARY

3.1.1. SUPPORTING ENVIRONMENTAL VARIABLES

Limnological field measurements (i.e., pH, conductivity, turbidity) were only recorded within the exposure area (Seep Creek Ponds 1 & 2). Due to the absence of the reference area field water quality, comparison betweens treatments were not possible; however, laboratory measured pH was lower in the exposure area than the reference area. Laboratory conductivity was higher in the exposure sample than in the reference sample.

Nitrate concentration was slightly higher in the BIC exposure area than in the reference area. With the exception of selenium and mercury, concentrations of total metals tended to be higher in the exposure area compared to the reference area. In the BIC exposure area, cadmium, copper, lead, nickel and zinc concentrations exceeded the CWQG for the protection of aquatic life.

The substrate of the exposure area was composed primarily of silt and sand, whereas the substrate of the reference area was composed primarily of sand. Relative to the reference station, substrate particle size was more variable within the exposure area, with higher silt contributions. The higher TOC observed in the exposure stations may be linked to differences in basin morphologies (i.e., fingers Lake is larger than the Seep Creek Ponds).

Sediments collected within the exposure area had elevated metal concentrations compared to the reference area. Arsenic concentrations were above the ISQG at all exposure stations, as well as at Station FL1 within the reference area. Chromium concentrations were above the ISQG sediment guidelines for two stations within the exposure area.

3.1.2. BENTHIC INVERTEBRATE COMMUNITY (BIC) DATA

Although BIC density was greater in the reference area than in the exposure area, differences were not statistically significant. Family richness was similar in both areas, and was not significantly different. BCI was more variable in the reference area, but was not significantly different from the exposure area. SDI and evenness were significantly lower in the exposure area than the reference area. The differences in SDI and evenness may be linked to the elevated arsenic and chromium concentrations in the exposure area sediments, and the elevated metal concentrations in the water column of the exposure area.

Based on the information collected during the BIC survey, mine effluent has had a low impact on the BIC within the aquatic receiving environment (Seep Creek Ponds 1 & 2) relative to the reference area (Fingers Lake). The mine did not significantly affect invertebrate density, family richness or BCI, but did significantly affect SDI and evenness.

3.2. FISHERIES FIELD MEASUREMENTS SUMMARY

3.2.1. SUPPORTING ENVIRONMENTAL VARIABLES

Water pH was slightly acidic in Fingers Creek (5.3 to 5.9) and the Seep Creek system (5.3 to 5.6; Table 4.3). These pH values were non-compliant with the CWQG, but were typical of the range of pH values in Nunavut barrenlands waterbodies reported by RCPL and RL&L (1985). Field conductivity was lower in Fingers Creek (10 to 120 µS/cm) than in the Seep Creek system (90 to 740 µS/cm).

Nitrate and ammonia concentrations were slightly elevated within the exposure area relative to the reference area. Nitrite and total phosphorus concentrations were at or below the MDL for both the reference and exposure areas. In general, metal concentrations were elevated in the exposure area compared to the reference area, and were higher in the stations nearest to the FDP than those farther downstream. In the exposure area, aluminum, arsenic, cadmium, copper, lead, nickel and zinc concentrations exceeded the CWQG for the protection of aquatic life.

3.2.2. FISH CATCH DATA

Fish sampling was conducted in a variety of habitat types in both the reference and exposure areas. Except for gill net locations at Inner Sun Bay of Contwoyto Lake (exposure area) and Fingers Lake (reference), which were in deeper water (3 m), the majority of sampling stations were in shallow water that could be waded (0.3-0.6 m).

In total, 71 fish, representing six species, were captured in the reference area, and 188 fish, representing four species, were captured in the exposure area. Within the reference area, backpack electrofishing was conducted for a total of 5044 s (1.4 h), the hoop net was set for 189.4 h, baited minnow traps were set for a total of 759.7 h, and gill nets were set for a total of 4.0 h. Within the exposure area, backpack electrofishing was conducted for 2935 s (0.82 h), fyke nets were set for a total of 90.9 h, baited minnow traps were set for a total of 588.6 h and gill nets were set for a total of 102.4 h.

The majority of the Arctic grayling in the reference area were captured by backpack electrofishing (49 fish). Despite considerable effort, only one ninespine stickleback and no slimy sculpin were captured in the reference area. In the exposure area, similar numbers of Arctic grayling were captured using backpack electrofishing (36 fish) and gill nets (45 fish). Most of the ninespine stickleback were captured in baited minnow traps.

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4.0 STUDY DESIGN

This section provides an overview of the proposed 2008 Lupin EEM Study Design, as well as the required components of the Biological Monitoring Study.

Based on the results obtained from the Initial EEM Biological Monitoring program, the MMGD (EC 2002) suggested that the appropriate subsequent EEM study should be a Periodic Monitoring – Surveillance study.

The schedule proposed to carry out the 2008 study includes the following key milestones.

- EEM Study design submitted 6 months prior to the 2008 biological monitoring field program.
- Field Program – Late Summer, 2008
- Second Interpretive Report – June, 2009

4.1. BIOLOGICAL MONITORING STUDY

The objective of a MMER EEM biological monitoring program is to determine whether mine effluent is having a significant impact on fish, fish habitat or the use of fisheries resources. Depending on effluent conditions, there are two possible components of an EEM Biological Monitoring Program:

- a benthic invertebrate community survey; and,
- a fisheries survey, consisting of a fish population study and a fish tissue study.

According to the MMER EEM requirements, Kinross was previously required to complete a benthic invertebrate study and a fish population study because the mine effluent concentration in the exposure area was greater than 1% within 250 m of the FDP.

Although adequate biological information was collected in the Initial EEM Biological Monitoring Program to determine if there was an effect, it was recommended that the following changes be made to the current study design:

- standardize fishing gear use between reference and exposure areas to eliminate the potential confounding influence of differential size-selectivity between gear types

- increase efforts to capture ninespine stickleback in the reference area
- sample fish when the Mine is discharging effluent into the exposure area if possible,
- sample the BIC when the Mine is discharging effluent into the aquatic receiving environment, if possible

Note that the 2006 report identified that Fingers Creek has provided appropriate data for use as a reference comparison and should remain as the reference area for the second EEM program.

Kinross was not previously required to complete a mercury study for fish tissues because the concentration of mercury in the TCA and discharged effluent was below the MMER limit of 0.10 µg/L. However, the TAP requested that liver and muscle tissues from Arctic grayling be collected for possible copper analysis, pending the results of the fish population survey.

4.1.1. Benthic Invertebrate Community Survey

The biological monitoring component of a MMER EEM program requires an evaluation of the effects of mine effluent on fish habitat, which is determined by examining the benthic invertebrate community (BIC) structure. The information collected as part of this study includes benthic invertebrate taxonomic enumeration, sediment particle size, water quality, and limnology.

During the last monitoring component, sampling was completed in the exposure (Seep Creek Ponds) and reference (Fingers Lake) areas. The 2006 EEM report indicated in the recommendations section that Fingers Creek has provided appropriate data for use as a reference comparison and should remain as the reference area for the second EEM program. As outlined in the previously approved study design, both the exposure and reference areas contain five replicate stations in depositional habitats (Table 5.1).

Zinifex proposes to complete monitoring and sampling as per the previous study design. Detailed methods of which are provided in section 5.0.

4.1.2. FISHERIES SURVEY

The fish survey is a requirement of the MMER EEM program. Fish will be collected from an exposure area (Seep Creek and Dam 1a Lake) and a reference area (Fingers Creek). The survey will investigate whether mine effluent is affecting the fish population, using several descriptors (age distribution, energy use and energy storage).

Historically, juvenile arctic grayling *(Thymalus arcticus)* and slimy sculpin *(Cottus cognatus)* were selected as the primary target sentinel species for a lethal sampling program. Ninespine stickleback *(Pungitius pungitius)* were to be a contingent target species under a non-lethal sampling program. However, in consultation between Kinross and the AO in 2005, the fish study design was modified during the field survey to focus on juvenile Arctic grayling due to the low numbers of slimy sculpin and ninespine stickleback in the catch. The AO requested that 100 ninespine stickleback from the exposure area be measured for length and weight, and a sub-sample of 30 fish be examined for parasites. Due to the small size of fish collected in the sampling program, liver tissues were small and difficult to collect. In consultation with the AO, liver tissues were composited into approximately 2.0 g samples, and whole carcasses were preserved for future copper analysis. As mentioned previously, several recommendations with regards to the fisheries study were made in the 2006 EEM report. One of the recommendations was to increase the efforts to capture ninespine stickleback in the reference area. This will be attempted in 2008 in an effort to diversify the study through the utilization of stickleback as contingent target species under a non-lethal sampling program, which was part of the original design. Detailed methods of the proposed fish study are provided in Section 6.0.

5.0 BENTHIC INVERTEBRATE COMMUNITY SURVEY

The BIC in Fingers Lake (reference area) and Seep Creek Ponds 1 & 2 (exposure areas) were surveyed in 2005 to meet MMER EEM requirements. The objective of the BIC survey will be to provide sufficient data to determine whether the Mine effluent has had a significant negative effect on the BIC within the aquatic receiving environment. Supporting environmental variables (limnology, water quality, and sediment) will be collected at each BIC replicate station.

5.1. *Field Methodologies*

5.1.1. *Benthic Invertebrate Community*

Benthic invertebrate sampling is planned concurrently with the sediment quality survey. The previous TAP approved study design identified that both the exposure and reference areas contain five replicate stations in depositional habitats (Table 5.1). Replicate stations will be spaced approximately 100 m apart (Figures 5.1 and 5.2). At each replicate station, five benthic sub-samples will be collected from within a 100 m^2 area. Benthic sub-samples are to be collected using an Ekman grab, or similar dredge sampler, with an area of 0.0232 m^2, following procedures outlined in the EEM guidance document (EC 2002). The five sub-samples will be combined into a single composite sample for a total sample area of 0.116 m^2. All benthic samples will be collected at a water depth ranging between 0.3 to 1.3 m. Benthic samples will be sieved in the field using a 243 μm mesh sieve bag (or equivalent) and preserved with 10% buffered formalin in one litre containers. Samples will be shipped in sealed coolers to a qualified laboratory for enumeration and taxonomic identification.

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Table 5.1. Benthic sampling station locations

Treatment	Sampling Station	UTM (Zone 12W NAD 83)		Latitude	Longitude
		Easting	Northing		
Exposure	Seep Creek Pond 1	480913	7290274	65°44'15.58" N	111°24'30.71" W
	Seep Creek Pond 1	480748	7290394	65°44'04.63" N	111°25'11.35" W
	Seep Creek Pond 1	480595	7290520	65°44'15.04" N	111°24'31.90" W
	Seep Creek Pond 2	481252	7290713	65°44'00.78" N	111°24'58.28" W
	Seep Creek Pond 2	481109	7290489	65°44'08.67" N	111°25'23.41" W
Reference	Fingers Lake (FL1)	492619	7286326	65°41'54.98" N	111°09'38.63" W
	Fingers Lake (FL2)	492927	7287021	65°42'17.46" N	111°09'14.62" W
	Fingers Lake (FL3)	493930	7286995	65°42'16.69" N	111°07'55.67" W
	Fingers Lake (FL4)	494157	7287794	65°42'42.51" N	111°07'38.29" W
	Fingers Lake (FL5)	493801	7287081	65°42'19.46" N	111°08'06.10" W

5.1.2. Supporting Environmental Variables

Limnology and Water Quality

Field water quality parameters will be measured within the exposure area (Seep Creek Ponds 1 & 2), and within the reference area (Fingers Lake and Creek). water samples in the reference and exposure areas will be collected according to the methods outlined in the MMER TGD (EC 2002), and will be analysed for metals, deleterious substances, major ions, and nutrients.

Sediment

Sediment samples will be collected concurrently with the BIC samples. One sediment sample, composed of five sub samples, will be collected at each replicate station using a core sampler for metal analysis, TOC content, and particle size determination.

5.1.3. FIELD QA/QC

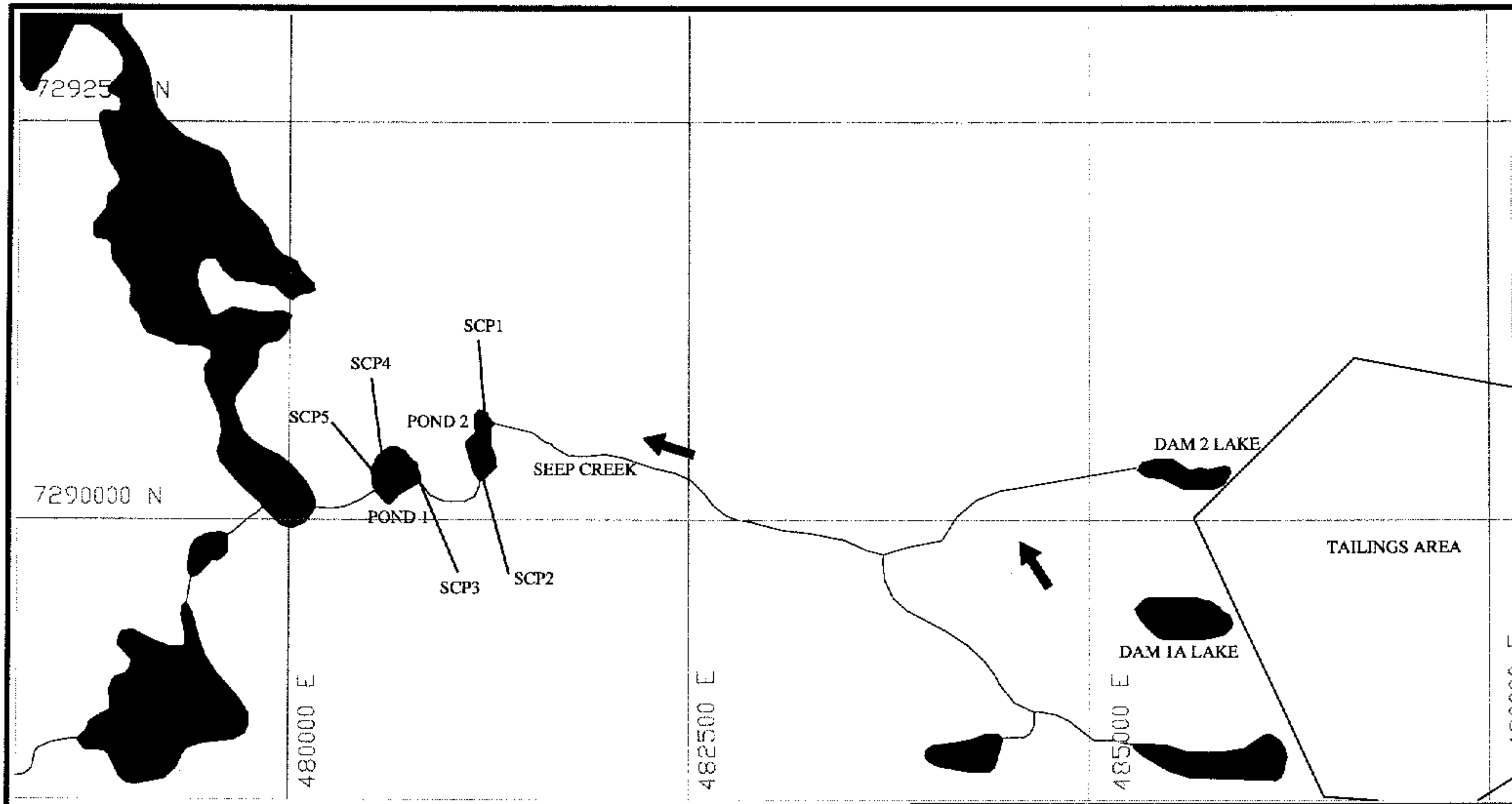
Specific work instructions outlining each field task in detail are to be provided to field personnel prior to the field program. Samples will be collected by experienced personnel, and will be collected, labeled, preserved, and shipped according to EC (2002). Detailed field notes will be recorded in field notebooks, and sample jars will be labeled in waterproof ink or pencil. Chain-of-Custody forms will be used to track sample shipments from the field to the laboratory/taxonomist.

5.2. LABORATORY ANALYSES

5.2.1. BENTHIC INVERTEBRATE COMMUNITY

Invertebrates are to be identified to the lowest practical taxonomic level (typically to the family level), using current literature and nomenclature. Organisms that may not be identified to the desired level (e.g., immature or damaged specimens) will be reported as a separate category, at the lowest level of taxonomic resolution possible, typically family. Organisms that may require detailed microscopic examination for identification (e.g., Chironomidae and Oligochaeta) may be mounted on microscope slides using an appropriate mounting medium (i.e., Hoyers'). The most common taxa will likely be distinguishable based on gross morphology, and required only a few mounts (5 to 10) as checks. All rare or less commonly occurring taxa may be mounted for identification. A reference collection will potentially be prepared, consisting of several representative specimens from each taxon.

In 2005, due to large sample size and large amounts of organic debris, two composite BIC samples (FL3 and SCP5) were divided into 1.0 mm, 500 μm and 250 μm fractions, which were all sub-sampled using standard taxonomic methods. The remaining composite BIC samples were divided into coarse (500 μm) and fine (250 μm) fractions. The coarse fraction was sorted and fine fractions were sub-sampled as outlined in the MMER TGD (EC 2002).



● BENTHIC INVERTEBRATE SAMPLING STATION

← DIRECTION OF FLOW

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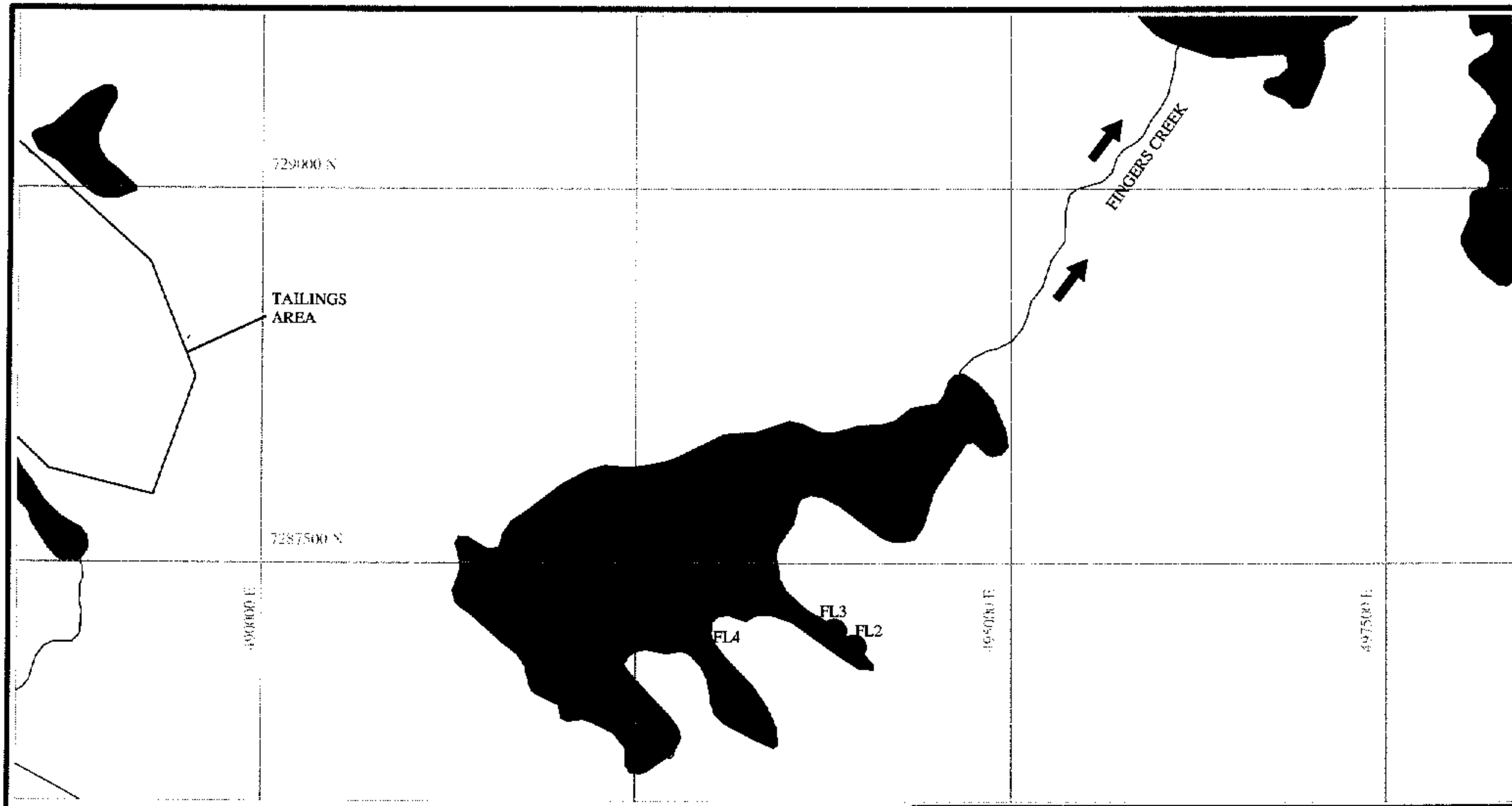
BENTHIC INVERTEBRATE SAMPLING
IN THE EXPOSURE AREA LOCATIONS

FIGURE 5.1



WATER QUALITY, FIELD LIMNOLOGY, SEDIMENT

DIRECTION OF FLOW

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LUPIN GOLD MINE

BENTHIC INVERTEBRATE
IN THE REFERENCE AREA

ZINIFEX

FIGURE 5.2

5.2.2. Benthic Invertebrate Taxonomist QA/QC

QA/QC for laboratory work has previously consisted of verifying invertebrate removal efficiency and taxonomic identification. Identification of specimens was conducted by one person, and as part of standard quality control measurements, one sample (10% of all samples) was re-sorted. A removal efficiency of greater than 90% was considered acceptable. This same QA/QC procedure is proposed in 2008.

5.2.3. Data Analysis

Data results will be used to determine calculations of the following community descriptors and biotic indices at the family level:

- total invertebrate density;
- taxon richness;
- Simpson's Diversity Index (SDI);
- Bray-Curtis Index (BCI);
- evenness;
- taxon density;
- taxon proportion; and,
- taxon presence/absence.

Calculations of the community descriptors and biotic indices will be based on the formulas provided in the MMER TGD (EC 2002).

5.2.4. Statistical Analyses

An effect on the BIC will be determined if there were statistical differences in any of the following endpoints:

- total invertebrate density;
- family richness;
- BCI;
- SDI; and
- evenness

If necessary, the following descriptors may be calculated included as supporting variables (i.e., they are not statistically analyzed to determine "effects"):

- major family density;
- family proportion; and,
- family presence/absence.

Summary statistics for each descriptor (i.e., arithmetic mean, median, minimum, maximum, standard deviation, standard error, and sample size) will be calculated and summarized by area.

Statistical analyses will be conducted on total density, richness, and index data calculated for each replicate station.

6.0 FISH SURVEY

The fish community in Fingers Creek and Fingers Lake (reference area) and the Seep Creek system (exposure area) were surveyed in 2005 to meet MMER EEM requirements. The objective of the 2008 EEM fish population survey will be to determine if mine effluent has had any significant effect the aquatic environment, such as on the growth, reproduction, survival, condition or usability of fish relative to fish populations in a reference area. Supporting environmental variables (limnology and water quality) will also be collected in each area.

6.1. FIELD METHODOLOGIES

As part of the revised TAP-approved study design, juvenile Arctic grayling *(Thymalus arcticus)* and slimy sculpin *(Cottus cognatus)* were selected as the primary target sentinel species for a lethal sampling program. Ninespine stickleback *(Pungitius pungitius)* was to be a contingent target species, under a non-lethal sampling program. Target sample sizes for each area were 40 juvenile Arctic grayling, and 60 slimy sculpin (20 adult males, 20 adult females, and 20 juveniles).

The field sampling schedule included a two-day reconnaissance survey in each of the reference and exposure areas to assess the presence of fish and spawning condition. However, seven days (including the two-day reconnaissance) of intensive fishing efforts in each of the study areas resulted in the capture of only two slimy sculpin from the reference area and none in the exposure area. Similarly, although several ninespine sticklebacks were captured in the exposure area, only one was captured in the reference area. Thus, due to the low numbers of slimy sculpin and ninespine stickleback, the fish study design was modified during the field survey, in consultation with the AO, to focus the EEM study on juvenile (age 1 or younger) Arctic grayling. Carcass and liver tissue from these juvenile Arctic grayling were frozen for copper analysis. In addition, ninespine stickleback from the exposure area were measured for length and weight, and a sub-sample was examined for parasites, as directed by the AO.

Fish sampling was conducted in the Fingers Creek system (reference) and (Seep Creek system (exposure) from 19 August to 4 September 2005, using a variety of gear types. (Tables 6.1 and 6.2; Figures 6.1 and 6.2). To maximize fish capture, fish sampling was conducted in different habitat types and at different times of the day.

Table 6.1. Gill net, hoop net and fyke net locations

			UTM (Zone 12W NAD 83)			
Method	**Treatment**	**Station**	**easting**	**northing**	**Latitude**	**Longitude**
Gill net	Exposure	C1	479104	7292537	65° 45' 13.45" N	111° 27' 21.64" W
		SCD1	485723	7289663	65° 43' 41.95" N	111 ° 18' 40.50" W
		SCD1	485903	7289729	65° 43' 44.08" N	111 ° 18' 26.42" W
		SCD1	485716	7289665	65° 43' 41.99" N	111 ° 18' 41.04" W
		SCD1	485632	7289683	65° 43' 42.56" N	111 ° 18' 47.66" W
		SCP2	481268	7290730	65° 44' 15.58" N	111° 24' 30.71" W
	Reference	FL1	494153	7288557	65° 43' 07.14" N	111° 07' 38.71" W
Fyke net	Exposure	SC3	484061	7289912	65° 43' 49.69" N	111 ° 20' 51.11" W
Hoop net	Reference	FC3	494622	7288989	65° 43' 21.14" N	111 ° 07' 01.92" W

The fishing gear consists of five minnow traps, two fyke nets, one hoop net, a set of six 1.8 × 15 m gill nets of different mesh sizes (19, 25, 38, 50, 64, and 76 mm stretch mesh), and a Smith-Root Type XII POW (Programmable Output Waveform) backpack electrofisher (settings of 400-500 V, 50 Hz, and 6 ms).

Gill nets will be set for 4 to 12 h periods, whereas minnow traps, hoop, and fyke nets will be set for a minimum of 24 h. The following information will be recorded for each sampling station:

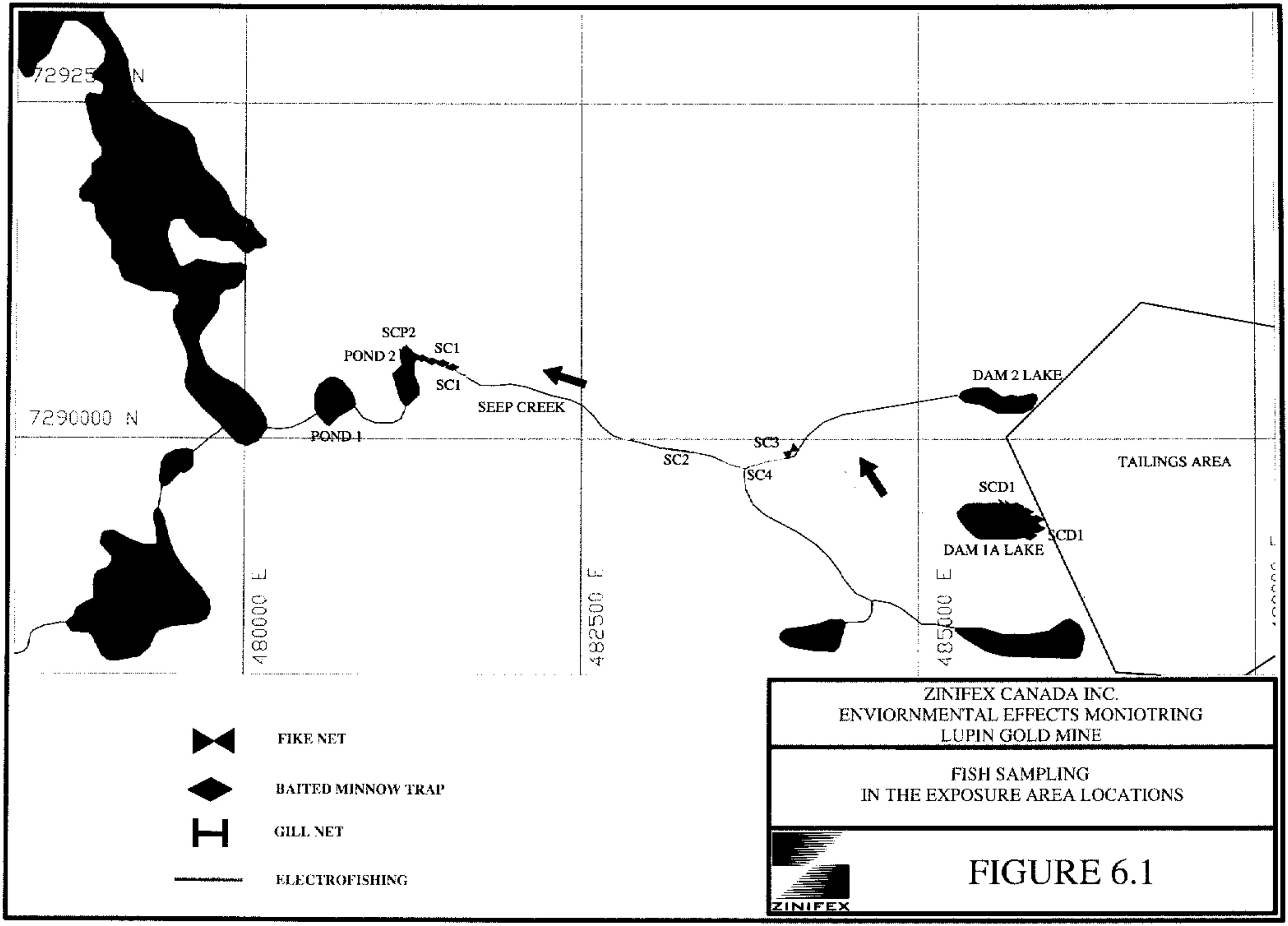
- date and time set and retrieved (traps and gill nets);
- whether the trap was baited or unbaited;
- mesh and panel size (gill nets);
- date and time started and ended (electrofishing);
- electrofisher setting;
- the number and species of fish captured;
- water depth; and,
- UTM coordinates.

Table 6.2. Backpack electrofishing and baited minnow trap locations

Method	Treatment	Station	UTM Zone (12W NAD 83)				Latitude and Longitude			
			Start Point		End Point		Start Point		End Point	
			East	North	East	North	Lat. (N)	Long. (W)	Lat. (N)	Long. (W)
Backpack	Exposure	SC1	481838	7290521	481654	7290539	65° 44' 08.95" N	111° 23' 45.82"	65° 44' 09.46"	111° 22' 00.70"
		SC2	483135	7289994	483325	7289999	65° 43' 52.18" N	111° 22' 03.83"	65° 43' 52.32"	111° 24' 00.32"
		SC4	483918	7289949	483592	7289894	65° 43' 50.84" N	111° 21' 02.34"	65° 43' 49.01"	111° 21' 27.86"
	Reference	FC3	494608	7288867	494617	7288953	65° 43' 17.22" N	111° 07' 03.00"	65° 43' 19.96"	111° 07' 02.42"
		FC3	494680	7289068	494681	7289068	65° 43' 23.70" N	111° 06' 57.42"	65° 43' 23.70"	111° 06' 57.35"
		FC3	496327	7290999	496123	7290579	65° 44' 12.59" N	111° 05' 04.31"	65° 44' 26.16"	111° 04' 48.36"
		FC3	495303	7289841	494619	7288840	65° 43' 16.36" N	111° 07' 02.17"	65° 43' 48.72"	111° 06' 08.64"
Baited Minnow Traps	Exposure	SCD1	485594	7289539	n/a	n/a	65° 43' 37.90" N	111° 18' 50.60"	n/a	n/a
		SCD1	485685	7289495	n/a	n/a	65° 43' 36.50" N	111° 18' 43.44"	n/a	n/a
		SCD1	485730	7289436	n/a	n/a	65° 43' 34.60" N	111° 18' 39.89"	n/a	n/a
		SCD1	485689	7289366	n/a	n/a	65° 43' 32.33" N	111° 18' 43.08"	n/a	n/a
		SCD1	485603	7289325	n/a	n/a	65° 43' 30.99" N	111° 18' 49.81"	n/a	n/a
		SC1	481432	7290659	n/a	n/a	65° 44' 13.31" N	111° 24' 11.66"	n/a	n/a
		SC1	481510	7290643	n/a	n/a	65° 44' 12.80" N	111° 24' 17.86"	n/a	n/a
		SC1	481570	7290632	n/a	n/a	65° 44' 12.48" N	111° 24' 06.95"	n/a	n/a
		SC1	481618	7290570	n/a	n/a	65° 44' 10.46" N	111° 24' 03.13"	n/a	n/a
		SC1	481704	7290530	n/a	n/a	65° 44' 09.17" N	111° 24' 03.13"	n/a	n/a

6.2. FIELD DATA COLLECTION

Length (fork length for Arctic grayling and total length for ninespine stickleback) and weight will be recorded for all sentinel and non-target fish. Length will be measured using a measuring board, marked by metric graduations with an accuracy of 1 mm. Total body weight is to be measured using an Acculab® VIC-123 electronic scale with an accuracy of 0.001 g. Scales were collected from Arctic grayling for fish ageing. Ageing structures from Arctic grayling were removed in the field and placed into individual sealed envelopes with the appropriate information for identification (i.e., fish number, area, length, weight).



7292500 N
7290000 N
480000 E
482500 E
485000 E
SCP2
POND 2
SC1
SC1
SEEP CREEK
POND 1
SC2
SC3
SC4
DAM 2 LAKE
TAILINGS AREA
SCD1
SCD1
DAM 1A LAKE
FIKE NET
BAITED MINNOW TRAP
GILL NET
ELECTROFISHING
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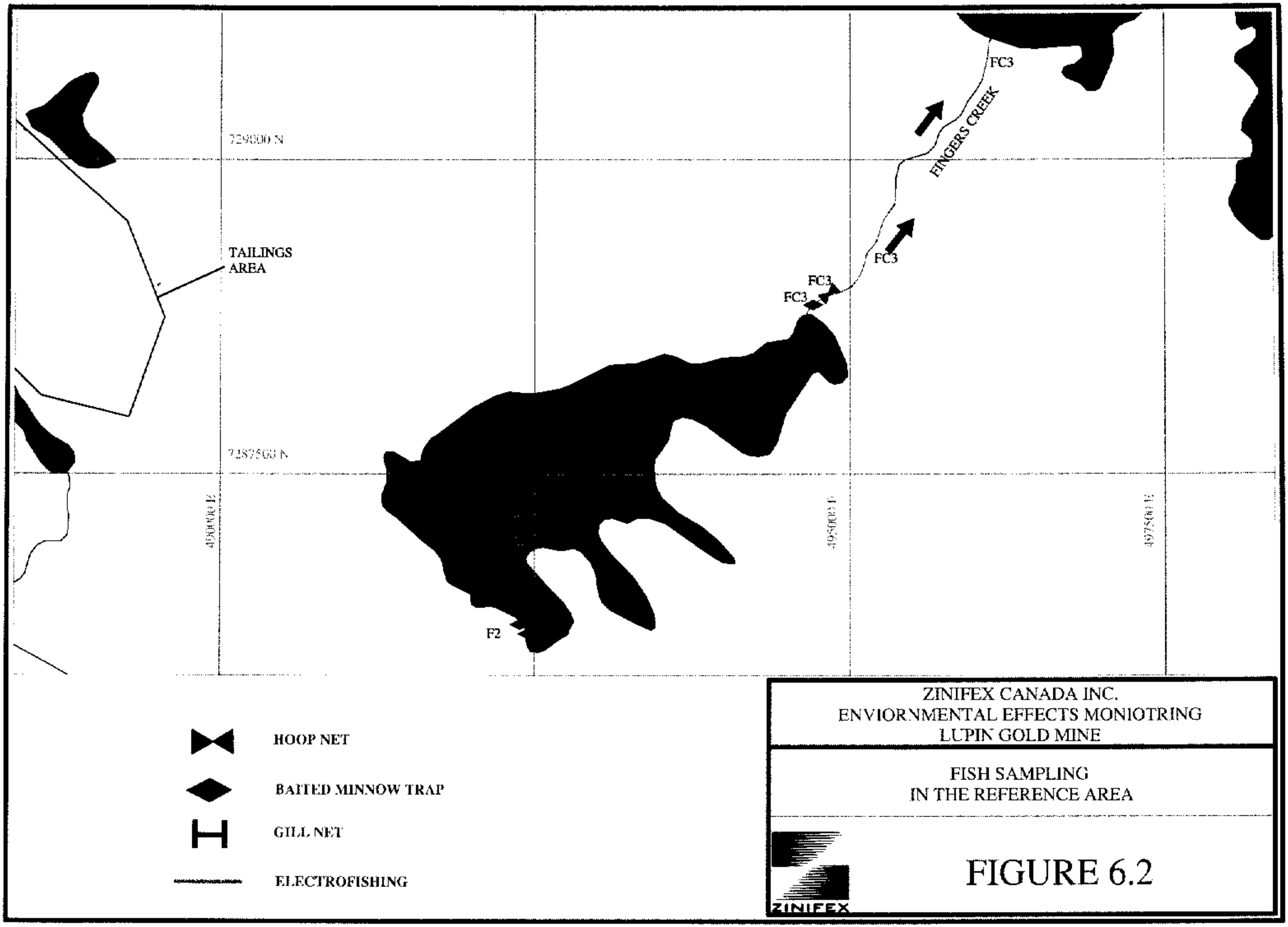
ENVIORNMENTAL EFFECTS MONIOTRING
LUPIN GOLD MINE
FISH SAMPLING
IN THE EXPOSURE AREA LOCATIONS
ZINIFEX

FIGURE 6.1



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LUPIN GOLD MINE

FISH SAMPLING
IN THE REFERENCE AREA

FIGURE 6.2

6.2.1. Supporting Environmental Variables

Field water quality parameters will be measured at each sampling station within the exposure area (Seep Creek and Dam 1a Lake) and the reference area (Fingers Creek and Fingers Lake). One water quality grab sample is to be collected from Fingers Creek and one in Dam 1 a Lake. A composite water quality sample is to be collected from Fingers Lake and one from the Seep Creek ponds.

water samples in the exposure and reference areas will be collected according to the methods outlined in the MMER TGD (EC 2002), and analysed for metals, deleterious substances, major ions and nutrients.

6.2.2. Laboratory Measurements

An external examination is to be conducted on all sentinel fish sampled during the fish survey. Detailed observations will be made on any features of the fish that do not appear normal (i.e., wounds, tumors, parasites, fin fraying, gill parasites or lesions). External examinations will be completed following the recommendations outlined in the MMER TGD (EC 2002).

A complete internal health examination will be conducted on all collected Arctic grayling, following the recommendations outlined in the MMER TGD (EC 2002). Ninespine stickleback will be examined for internal abnormalities and parasites. The internal examination will include the following:

- sex;
- life stage;
- internal pathology;
- liver weight;
- stomach contents; and,
- state-of-maturity.

In both sentinel species, all organ systems will be examined for the presence of any abnormalities, such as tumors, necrosis, or parasites. The livers will be carefully excised from the intestines, and liver weight will be determined using an electronic scale with an accuracy of 0.001g. Stomach fullness will be noted, along with a general description of gut contents. When possible, maturity and sex will be recorded for Arctic grayling.

6.2.3. FISH TISSUE COLLECTION

In the previous EEM study, the TAP requested that the Mine conduct copper analysis for muscle fillets and liver tissues as part of the fish survey if significant results were found in the effect endpoints. Due to the small size of the juvenile Arctic grayling captured in the fish survey, muscle fillets could not be removed without contamination of the sample. In consultation with the AO, whole carcasses (head removed) were preserved for copper analysis. In total, 35 carcasses were preserved from the reference area and 40 from the exposure area.

Fish tissue collection for the purpose of copper analysis will be carried out during the EEM study. A minimum 2.0 g sample is required for liver tissue analysis. To meet this requirement, liver tissues are to be combined into composite samples. The number of individual liver tissues required to meet the required 2.0 g sample weight will vary in each composite sample. Two composite samples will be collected in the exposure area, and three composite samples will be collected in the reference area. The results of the tissue analysis will be reported separately when the data are available.

6.2.4. QUALITY ASSURANCE/QUALITY CONTROL

Specific work instructions outlining the fish survey tasks in detail will be provided to field personnel by the task manager prior to the field program. Samples will be collected by experienced personnel and labeled, preserved, and shipped to the laboratory. Detailed field notes will be recorded.

6.3. LABORATORY

6.3.1. FISH AGEING

Ages of the Arctic grayling collected during the fish survey will be determined following the methods outlined in Mackay et al. (1990). Scales will be viewed using a compound microscope, and annuli counted on the distal side from the focus to the edge of the dorsal tip.

6.3.2. DATA ANALYSIS

Catch-per-unit-effort (CPUE) will be calculated for each species captured, and summarized by area and sampling method to document the effort expended in collecting the required number of fish. This calculation also provides a measure of relative abundance among sampling areas by standardizing the catch data for the exposure and reference areas.

The biological variables that can/will be analyzed in the summary and/or statistical analyses includes the following:

- physical abnormalities (e.g., tumors, lesions, obvious parasites);
- total body weight (g);
- fork length (mm);
- age (years); and,
- liver weight (g).

Summary statistics for each biological variable (i.e., sample size, arithmetic mean, median, minimum, maximum, standard deviation, and standard error) will be calculated for mature fish, and summarized by area, and species. The biological variables will be used to estimate energy storage and energy use in fish populations from the reference and exposure areas.

7.0 WATER QUALITY AND SEDIMENT QUALITY SURVEY

The goal of the EEM water quality and sediment quality survey is to generate supporting environmental data to aid in the interpretation of results of the biological monitoring survey, as well as provide a basis upon which chemical habitat within the study areas can be compared (EC 2002).

Water quality monitoring is to be conducted concurrently with fish and invertebrate surveys to monitor variables specified in Schedule 4 of the MMER (GC 2002). The Seep Creek and associated Dam 1a Lake and Ponds will serve as the exposure sites (Figure 7.1) whereas Fingers Lake and Fingers Creek will serve as the reference sites (Figure 7.2). *In situ* field measurements will be conducted at each sampling location in the exposure area, BIC stations and in Fingers Creek. One composite sample for laboratory analyses will be collected from each of the BIC survey reference and exposure areas. For the fish survey, one additional grab sample from Fingers Creek, and one grab sample from Dam 1a Lake are to be collected for laboratory analyses.

Physical and chemical information acquired from the sediment samples will also be used to help characterize the benthic invertebrate habitat and identify potential confounding factors. During the 2005 study, sampling was conducted at the benthic invertebrate sampling stations (Figures 7.1 and 7.2), concurrently with the BIC survey during the late summer.

7.1. WATER QUALITY METHODOLOGY

7.1.1. FIELD SAMPLING AND MEASUREMENTS

Water samples in the reference and exposure areas are to be collected according to the methods outlined in the MMER technical guidance document (TGD) (EC 2002).
Grab water samples will be collected at each BIC sampling site in the exposure and reference areas, approximately 0.2 – 0.5 m below the water surface. The grab samples will be combined to form composite samples for the Seep Creek Ponds, and for Fingers Lake. A single grab sample will be collected in each of the fish survey exposure (Dam 1a Lake, Site SCD1) and reference areas (Fingers Creek, Site FC2). Pre-washed and sterilized sample bottles, supplied from a CAEL accredited analytical laboratory, will be utilized for all water

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samples. When required, the appropriate preservatives will be added in the field, and all samples will be kept cool on ice until delivered to the analytical laboratory. The following variables will be measured in the field:

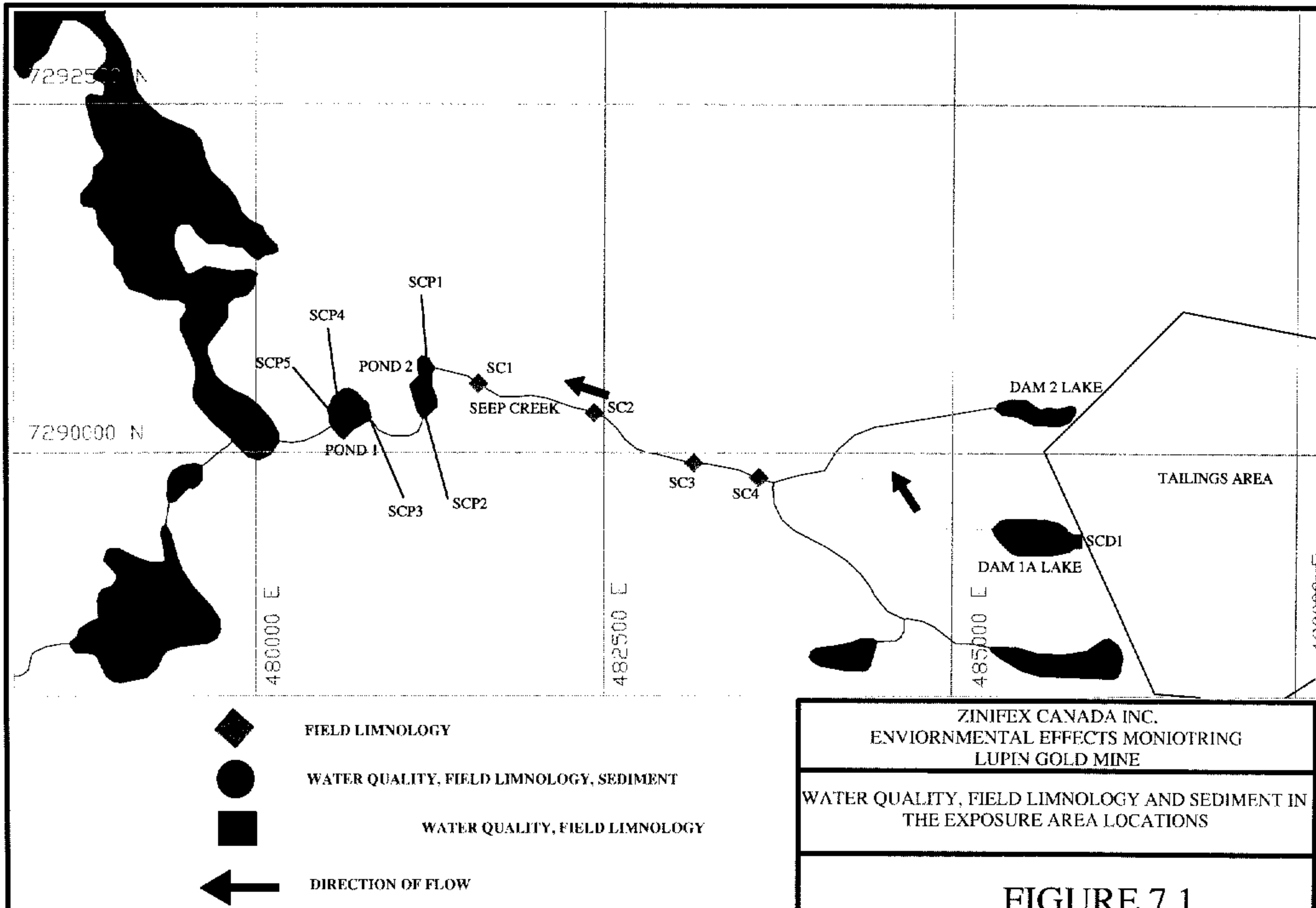
- water temperature;
- dissolved oxygen (DO);
- pH;
- conductivity;
- turbidity; and
- air temperature.

All sampling sites have been previously geo-referenced as Universal Transverse Mercator (UTM) and longitude-latitude coordinates with a hand-held GARMIN™ model 12 global positioning system (GPS) unit. This ensures long term continuity with regards to maintenance of monitoring and sampling locations over the course of the various EEM components required.

7.1.2. *Laboratory Analysis*

Water samples will be analysed for the following variables by a CAEL certified analytical laboratory:

- deleterious substances listed in Schedule 4 of the MMER (i.e., arsenic, copper, cyanide, lead, nickel, zinc, total suspended solids, and radium-226);
- nutrients and carbon (i.e., ammonia, nitrite and nitrate, total phosphorus, total organic carbon, and dissolved organic carbon);
- physical characteristics (i.e., pH, conductivity, alkalinity and total hardness, total and dissolved metals); and,
- major ions (i.e., chloride, calcium, magnesium, potassium, sodium, sulphate).



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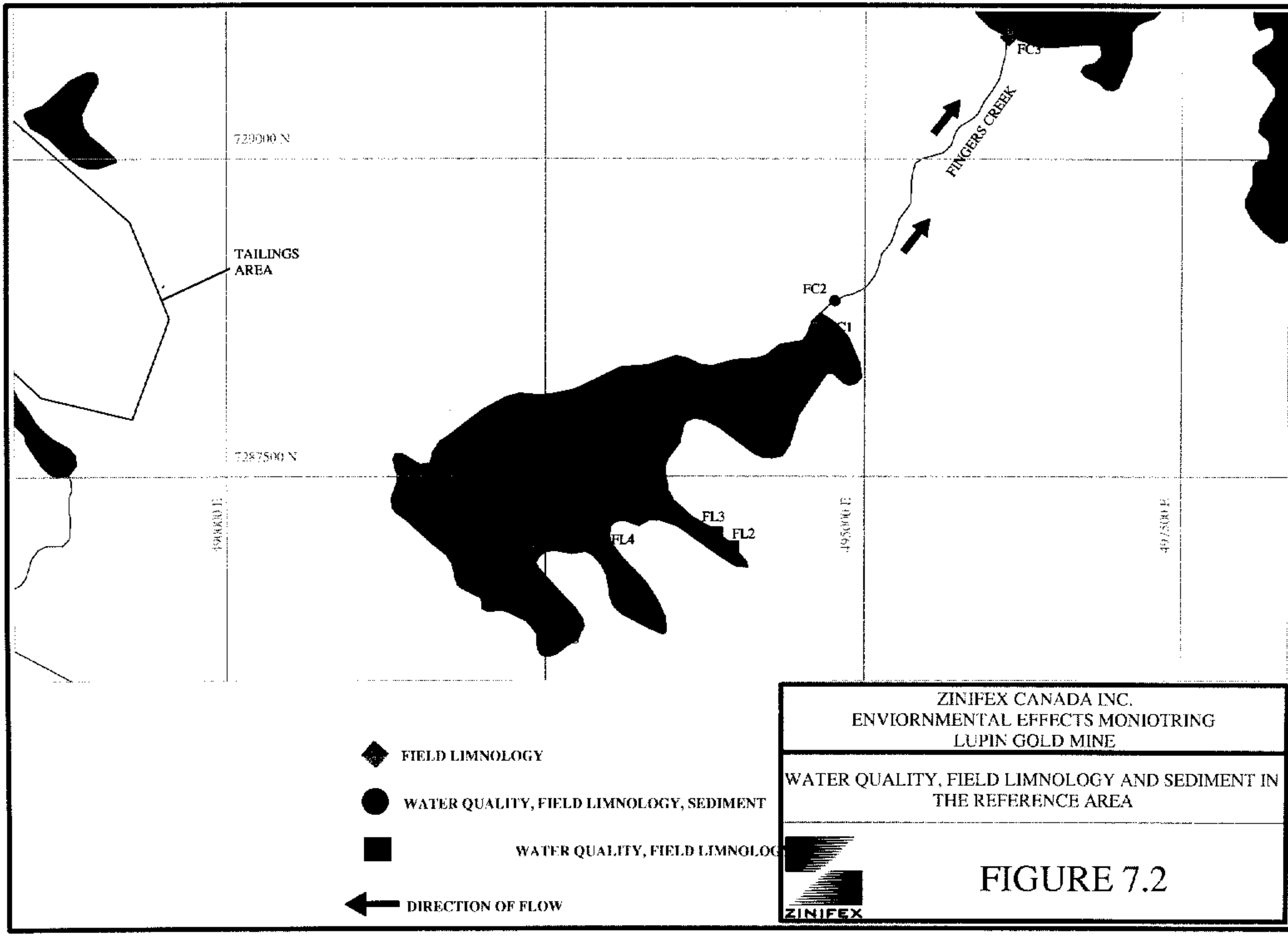
WATER QUALITY, FIELD LIMNOLOGY AND SEDIMENT IN THE EXPOSURE AREA LOCATIONS

FIGURE 7.1



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LUPIN GOLD MINE

WATER QUALITY, FIELD LIMNOLOGY AND SEDIMENT IN THE REFERENCE AREA

FIGURE 7.2

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8.0 SUBLETHAL TOXICITY TESTING

8.1. DATA ANALYSIS

Under the MMER regulations, sublethal toxicity tests on the final effluent must be conducted by the Mine twice each calendar year for the first three years; thereafter, the frequency may be reduced to once per calendar year. The purpose of sublethal toxicity testing is to determine if mine effluent may affect fish, invertebrates, and aquatic plants.

Sublethal toxicity test results can be used to estimate the potential for exposure area impacts (EC 2002). The regulations stipulate that if the sublethal toxicity results show an IC_{25} result of less than 30% concentration of effluent, the mine should calculate the geographic extent of the response in the exposure area and identify the zone where the concentration of effluent is comparable to the IC_{25} result. The IC_{25} is the effluent concentration where a 25% inhibition is observed in the exposed test organisms.

Sublethal toxicity test results can also be used to measure changes in effluent quality over time as a result of changes in water treatment, surface water management, acid rock drainage mitigation measures or mine process changes, etc.

8.1.1. FIELD METHODS

Grab samples will be collected from the final discharge point (SNP 925-10) during final discharge.. Samples will be shipped to a certified laboratory for toxicity testing.

8.1.2. LABORATORY

Toxicity testing will be performed on the effluent samples according to the following established protocols:

- 7 day *Ceriodaphnia dubia* survival and reproduction (EC 1992a).
- 7 day Fathead minnow *(Pimephales promelas)* survival and growth (EC 1992b).
- 72 hour algal growth inhibition *(Selenastrum capricornutum;* EC 1992c).
- 7 day *Lemna minor* growth (EC 1999).

Results of the toxicity testing will be included in the annual EEM report.

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