Starfield Resources Inc.

Ferguson Lake Project

Nunuvut, CANADA

Preliminary Baseline Study Ferguson Lake Project Area, 1999

January 2003

Prepared by:
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Vancouver/Yellowknife

EXECUTIVE SUMMARY

Executive Summary

Starfield Resources Inc. is currently exploring a mineral deposit containing significant quantities of palladium, platinum, nickel, copper and cobalt on its property at Ferguson Lake in the Kivalliq region of Nunavut Territory, Canada. At the request of Starfield Resources Inc., scientists from Rescan™ Environmental Services Ltd. conducted a preliminary baseline study of the aquatic environment of the property in the summer and autumn of 1999.

The objective of the study was to collect baseline data that would guide planning for a more comprehensive environmental impact assessment. The study focused on the area immediately affected by the mineralised zone, and it included water quality and sediment quality of Ferguson Lake and of six streams tributary to the lake, hydrology of four of those streams, and fish communities and fish habitat in three of the streams.

The water quality of Ferguson Lake is typical of a northern, clear-water, nutrient-poor lake. With two exceptions, all water quality variables were well below Canadian federal guidelines, and some variables were below analytical detection limits. The exceptions were some low values of pH and high concentrations of total aluminum. However, those characteristics are not unusual for pristine, northern waterbodies. The transparency of lake water ranged from 3.2 to 5.2 m, and the water remains cool and well-oxygenated throughout the summer. The lack of stratification is most likely due to strong winds that continuously mix the water column.

The sediments of Ferguson Lake are composed of sand, silt and clay with very little gravel. Particle size distributions are similar among the deep samples (>10 m), and among the shallow and middle depth samples (<10 m). All concentrations of total metals were well below federal guidelines for the protection of freshwater aquatic life.

Flows of four streams tributary to Ferguson Lake (W1, W2, E3 and R1) were measured between July 28 and 31, 1999. Flows of two other streams (E1 and E2) were too low to be accurately measured. Flow ranged from a low of 0.006 m^3/s in stream E3 to a high of 0.513 m^3/s in stream W1. Watershed areas ranged from 0.3 km^2 for stream E3 to 27.8 km^2 for stream W1. Therefore, dividing flow by watershed area gave the unit yield of each watershed, which ranged from 1.9 $L/s/km^2$ for stream R1 to 29.7 $L/s/km^2$ for stream W2.

Streams W1, E1 and R1 are typical northern streams with low to near-neutral pH, low total suspended sediment and turbidity, very low nutrient concentrations and generally low metal concentrations. In contrast, streams W2, E2 and E3 have much lower pH and higher metal concentrations, indicating the presence of natural acid rock drainage into these streams from local surface sulphide deposits. The sediments of the streams were mainly sand with varying degrees of gravel, silt and clay. The concentrations of metals were well below federal guidelines for the protection of freshwater aquatic life with the exception of total copper at station W2.

A total of 55 fish from four species (slimy sculpin, ninespine stickleback, Arctic grayling and longnose sucker) were captured by electrofishing in streams W1, W2 and R2. Between one and

four species were captured in each stream, and the density of fish was low – an average of only 0.048 fish/m^2. This reflects the low biological productivity of the three streams. The common characteristic of the fish was their small size – length ranged from 10 to 153 mm and 93% had lengths below 100 mm.

The three streams are narrow (1 to 3 m), shallow (0.15 to 0.60 m) and have low gradients (1 to 2%). They are composed mainly of riffles (20 to 60% of surface area) and runs (35 to 65%) with a few shallow pools (0 to 15%). There are no cascades or deep pools. Their substrates are a mixture of cobble and boulders (25 to 85%), silt, sand and organic matter (20 to 65%) and gravel (5 to 10%). There is no bedrock. The total surface area with cover for fish ranges from 40 to 80%. Of that cover, 85 to 95% is provided by boulders and the rest by macrophytes, pools, cutbanks and overhanging vegetation.

Most features of the three fish communities can be explained by differences in habitat among streams. The most obvious feature was the almost complete absence of fish in stream W2 due to low water quality. W1 had the highest percentage of cover habitat and the highest percentage of cover made up of boulders – two features that support relatively high densities of slimy sculpin. R2 was the shallowest of the three streams, which tends to encourage colonisation by very small fish such as ninespine stickleback.

None of the three streams are suitable for overwintering because they all freeze to the bottom in winter. Instead, all fish migrate downstream to Ferguson Lake to overwinter. W1 provides medium-quality spawning suitability, high-quality rearing and migration habitat and low-quality adult feeding. W2 is suitable only as low-quality rearing and migration habitat, and is unsuitable for spawning and adult feeding. R2 provides medium-quality rearing habitat, low-quality spawning and migration habitat and is unsuitable for adult feeding.

In summary, this study showed, first, that Ferguson Lake has the high-quality water and sediment expected of a pristine, undisturbed lake of the Southern Arctic Ecozone. Second, the streams entering Ferguson Lake are typically narrow and shallow, have low flows, provide average- to low-quality fish habitat and support low densities of small-bodied fish. Therefore, the fish community of the Ferguson Lake system is highly dependent on spawning, rearing, feeding and overwintering habitat contained within the lake. Third, at least three of the streams entering Ferguson Lake near the mineralised zone have very low water quality and almost no fish habitat because of natural acid rock drainage from the mineralised zone.

ACKNOWLEDGEMENTS

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Cover page photograph: stream W1 near Ferguson Lake, Nunavut Territory, late July 1999, showing cascades upstream of the survey distance.

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GLOSSARY AND ABBREVIATIONS

Glossary and Abbreviations

Glossary

Anoxic	Without oxygen. Term commonly used to refer to water with extremely low dissolved oxygen concentrations, and sediment with no oxygen present.
Benthic	Pertaining to the bottom region of a water body, on or near bottom sediments or rocks.
Benthos	Benthos communities are a group of organisms that live associated with the bottom of lakes or streams. These communities contain a diverse assortment of organisms, which have different mechanisms of feeding. Common benthos organisms include larval caddisflies, mayflies and stoneflies. Lake benthos are important prey for fish.
Biomass	The amount of living matter as measured on a weight or concentration basis. Biomass is an indication of the amount of food available for higher trophic levels.
Chlorophyll	Chlorophyll is a molecule contained in photosynthetic organisms which is required to carry out photosynthesis. It is an easily detected molecule, and is used as an indicator of phytoplankton biomass in this report.
Ecosystem	A community of interacting organisms considered together with the chemical and physical factors that make up their environment.
Freshet	Freshet refers to a high water flow event within a stream. In northern Canada, freshet occurs during the spring snowmelt in which the majority of annual water volume passes through streams in a short period of time.
Hydrology	The study of the properties of water and its movement in relation to land.
Invertebrates	Collective term for all animals without a backbone or spinal column.
ISQG	Interim Sediment Quality Guidelines established by the Canadian Council of Ministers of the Environment.
Limnology	The study of lakes, including their physical, chemical and biological processes.
Macrophyte	Macrophytes are plants that live submerged in lakes and rivers. Unlike algae, they are large and multi-cellular organisms.
Oligotrophic	Lakes with clear water, low concentrations of nutrients and low biological productivity.
Periphyton	Periphyton are aquatic plants attached to substrates such as rocks, debris or other plants in lakes and streams. They are single-celled organisms that can photosynthesise. Other non-photosynthetic organisms (*e.g.* bacteria, fungi) can be associated with periphyton. In this report, the term periphyton is used to refer only to the photosynthetic organisms.
Phleger Tube	Weighted, hollow tube used to collect sediment cores.
Photosynthesis	The metabolic process by which carbon dioxide and sunlight are converted to simple sugars and oxygen. Organisms that photosynthesise contain the molecule chlorophyll.
Phytoplankton	Phytoplankton are microscopic, single-celled plants that live free-floating in water. Some common types include diatoms and cyanobacteria.

Pool	Areas with 0% gradient, reduced stream velocity at low flow and deeper than surrounding areas. Often associated with Run habitat.
Primary Producers	In this report, primary producers refer to organisms which convert sunlight into food through the process of photosynthesis. Aquatic primary producers include phytoplankton, periphyton, macrophytes and submerged vegetation.
PEL	Probable Effects Level. The minimum concentration of a metal or compound in sediment that will probably cause some toxic effects on plants and animals
Riffle	Shallow area in a stream or river section where the water flows swiftly over completely or partially submerged obstructions to produce surface agitation, but standing waves are absent. Associated with increased habitat heterogeneity, sediment size, stream velocity and slope and sometimes oxygen content.
Run	Area of swiftly flowing water without surface agitation that approximates uniform flow, and in which the slope of the water surface is roughly equivalent to the overall gradient of the stream reach.
Runoff Coefficient	A ratio of the precipitation contributing to overland flow compared to the total precipitation occurring over a given area.
Secchi Depth	Secchi depth is the depth at which a Secchi disc, a standardised white and black disc, can no longer be seen when it is lowered into a lake. Secchi depth is used to calculate the depth of the euphotic zone.
SQG	Sediment Quality Guidelines established by the Canadian Council of Ministers of the Environment (CCME). There are two types: TEL (Threshold Effects Level) and PEL (Probable Effects level).
Stratification	A condition in which a lake is divided into horizontal layers with distinct differences in temperature and dissolved oxygen between layers, often with a sharp gradient between the layers.
Submerged Vegetation	Submerged vegetation are plants living submerged in water within lakes and streams. They are vascular plants rather than non-vascular algae.
TEL	Threshold Effects Level. The concentration of a metal or compound in sediments below which toxic effects are rarely expected to occur to aquatic life. Between TEL and PEL is a range of concentrations that may cause some toxic effects. Above PEL the toxic effects are probable.
Trophic Levels	Classification of organisms in an ecosystem according to feeding relationships. Primary producers (plants) constitute the first trophic level, and convert energy from the sun into food. All other trophic levels depend upon primary producers for their food. Secondary producers (herbivores and detrivores) are the second trophic level, and tertiary producers (carnivores) are the third trophic level. In a lake, phytoplankton constitute the first trophic level, zooplankton and some benthic organisms the second level, and fish the third.
Turbidity	A condition of reduced transparency in water caused by suspended colloidal or particulate material.
YOY	Young-of-Year fish that hatched from eggs laid in the same calendar year as the fish were sampled.
Zooplankton	Zooplankton are small animals which live free-floating in the water. They are secondary producers and feed mainly on phytoplankton.

Abbreviations

Centimetre	cm
Degree	°
Degrees Celsius	°C
Gram	g
Grams per litre	g/L
Greater than	>
Kilogram	kg
Kilometre	km
Less than	<
Litre	L
Metre	m
Micrometer (micron)	µm
microSiemens	µS
microSiemens per centimetre	µS/cm
Milligrams per litre	mg/L
Millimetre	Mm
Percent	%
Plus or minus	±
Second	s
Square kilometre	Km^2
Water gauge	w.g.

1. INTRODUCTION

1. Introduction

1.1 Background

Starfield Resources Inc. (Starfield) is currently exploring a mineral deposit containing significant quantities of palladium, platinum, nickel, copper and cobalt on its property at Ferguson Lake in the Kivalliq region of Nunavut Territory, Canada. The property is 240 km west of Rankin Inlet, 160 km south-southwest of Baker Lake and 765 km north of Thompson, Manitoba.

The property was initially discovered by Canadian Nickel Company Ltd. (now Inco Ltd.) in 1950 and was held in its mineral inventory for over 40 years. Exploration in 1953 defined a major copper-nickel resource, but did not recognise the palladium, platinum and cobalt resources. In 1987, the Homestake Mineral Development Company (now owned by Barrick Gold Corporation) explored the property for those three metals (with Inco Ltd.'s permission) and found significant quantities. In 1998, the property was acquired by Starfield, which confirmed the value of those metals and continued to explore and define the resource.

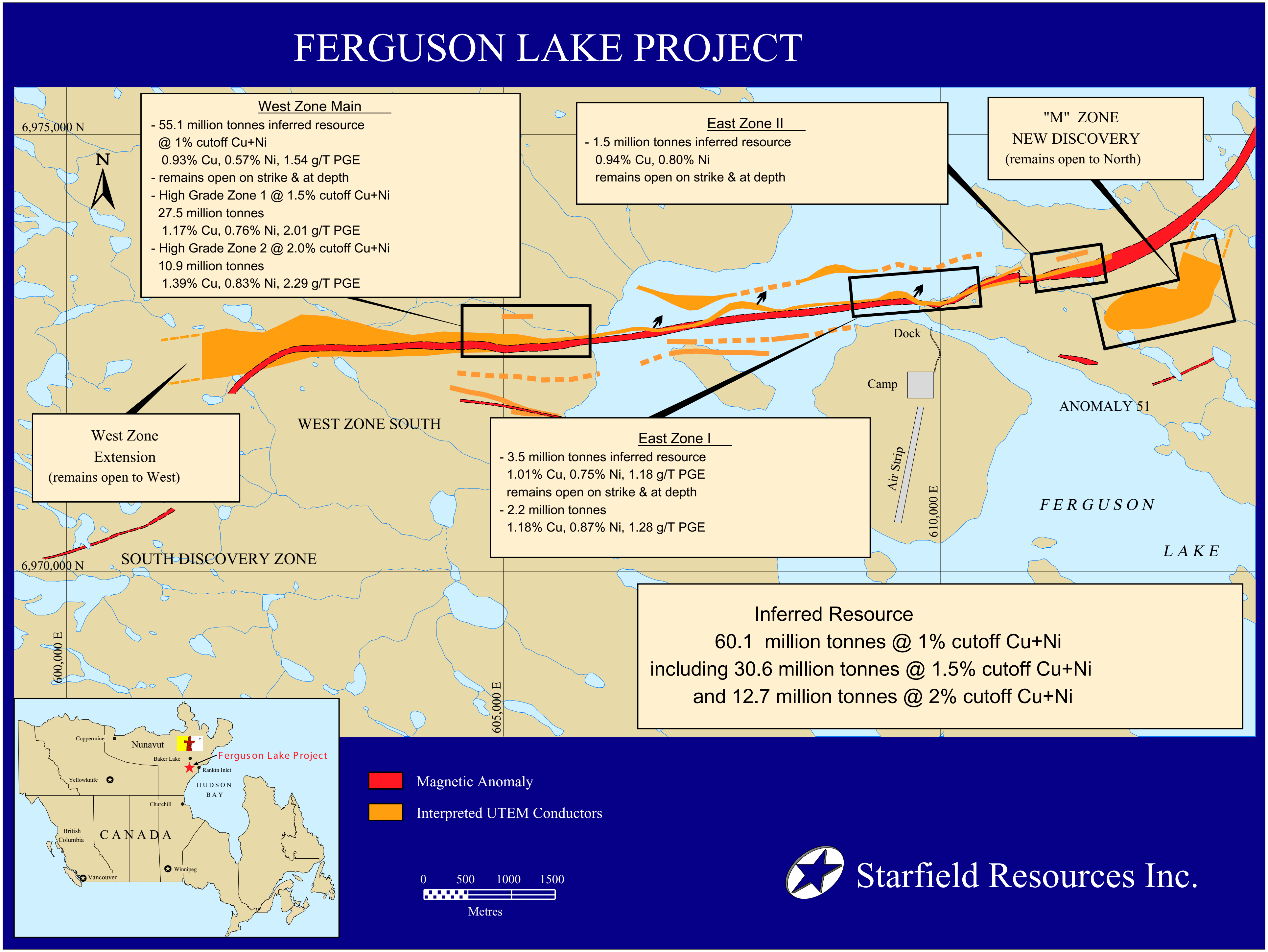
The mineralised zone is a massive sulphide deposit located in a long, narrow band that crosses underneath the middle of Ferguson Lake (Starfield, 2003) (Figures 1.1-1 and 2.1-1). The deposit is currently divided into four zones: the West Zone Main (underlying the western shore of the lake), East Zone I (underlying the eastern shore of the lake), East Zone II (on the east shore of the lake) and "M" Zone (south-east of East Zone II). Therefore, development of the Ferguson Lake property will likely have its greatest environmental impact on the central part of Ferguson Lake and on the streams leading into the western and eastern shores of that part of the lake.

1.2 Objectives

As part of its planning process, Starfield required an assessment of the pre-development (or baseline) status of the environment near the property. Rescan™ Environmental Services Ltd. (Rescan) proposed a preliminary baseline study that focused on the aquatic habitat of the area immediately surrounding the mineralised zone. The specific issues identified were: stream hydrology, stream and lake water quality and sediment quality, stream fish communities and stream fish habitat. The study was designed as a reconnaissance-level survey. Its objective was to collect baseline information that would guide planning for a more comprehensive environmental impact assessment.

1.3 Study Plan

The baseline study was carried out during the open-water period of 1999 in two phases in order to sample during two different hydrological periods: immediately post-freshet (July 28 to 31) and during the driest part of the year (September 11 to 13). Three Rescan scientists: a hydrologist (Frank Weber, B.Sc.), a fisheries biologist (David Tyson, M.Sc., R.P.Bio) and a water quality specialist (Deborah Muggli, Ph.D., R.P.Bio.), conducted the work.


FERGUSON LAKE PROJECT
West Zone Main
- 55.1 million tonnes inferred resource
@ 1% cutoff Cu+Ni
0.93% Cu, 0.57% Ni, 1.54 g/T PGE
- remains open on strike & at depth
- High Grade Zone 1 @ 1.5% cutoff Cu+Ni
27.5 million tonnes
1.17% Cu, 0.76% Ni, 2.01 g/T PGE
- High Grade Zone 2 @ 2.0% cutoff Cu+Ni
10.9 million tonnes
1.39% Cu, 0.83% Ni, 2.29 g/T PGE
East Zone II
- 1.5 million tonnes inferred resource
0.94% Cu, 0.80% Ni
remains open on strike & at depth
"M" ZONE
NEW DISCOVERY
(remains open to North)
6,975,000 N
N
West Zone
Extension
(remains open to West)
WEST ZONE SOUTH
Dock
Camp
ANOMALY 51
East Zone I
- 3.5 million tonnes inferred resource
1.01% Cu, 0.75% Ni, 1.18 g/T PGE
remains open on strike & at depth
- 2.2 million tonnes
1.18% Cu, 0.87% Ni, 1.28 g/T PGE
Air Strip
610,000 E
FERGUSON
LAKE
6,970,000 N
SOUTH DISCOVERY ZONE
600,000 E
605,000 E
Inferred Resource
60.1 million tonnes @ 1% cutoff Cu+Ni
including 30.6 million tonnes @ 1.5% cutoff Cu+Ni
and 12.7 million tonnes @ 2% cutoff Cu+Ni
Coppermine
Nunavut
Baker Lake
Ferguson Lake Project
Rankin Inlet
Yellowknife
HUDSON BAY
Churchill
British Columbia
CANADA
Winnipeg
Vancouver
Magnetic Anomaly
Interpreted UTEM Conductors
0 500 1000 1500
Metres
Starfield Resources Inc.

The focus of the study was on three streams that drain the eastern mineralised zone (E1, E2 and E3), two streams that drain the western mineralised zone (W1 and W2), and the area of the lake that is between those streams and that lies above the mineralised zone (stations L1, L2, L3 and L4) (Figure 2.1-1). Two reference streams (R1 and R2) and one reference site in Ferguson Lake (L5), all north of the mineralised zone, were also sampled. These reference sampling sites are assumed to be unaffected by the mineralised zones, hence they provide contrast with the sites from the mineralised zone.

This report describes the methods that were used during the field and laboratory components of the study (Section 2), and describes and discusses the results (Section 3). All original data are shown in the attached Appendices 3.1-1 to 3.7-2.

1.4 Site Description

Ferguson Lake lies within the Hudson Bay Seaboard drainage area. It has an area of 14,930 ha and one outlet, the Ferguson River, that flows south-east into Kaminuriak Lake. Water from Kaminuriak Lake flows south-east through a series of lakes and rivers into Hudson Bay south of Rankin Inlet.

Ferguson Lake lies within the Southern Arctic Terrestrial Ecozone (Natural Resources Canada, 2003). The physiography of that ecozone consists of flat plains (also called the Barrenlands) with a few interior hills. The vegetation type is shrub-herb-heath Arctic tundra, the soil type is cryosolic (*i.e*., permafrost-affected) with moraines and exposed bedrock, and the climate is cold and dry. Summers are short (about 4 months), cool and moist, and winters are long and extremely cold. Total annual precipitation is rarely more than 500 mm.

Permafrost occurs continuously through the ecozone, lying sometimes just a few centimetres beneath the surface. It acts as a barrier to downward movement of water and plant roots, hence even though precipitation is low the soil is often waterlogged or frozen. Repeated freezing and thawing of the soils has created hummocks and frost heaves that force angular boulders to the surface. The shallow surface layer and short growing season means that trees are almost entirely absent and the plant cover is dominated by shrubs, herbs, grasses, mosses and lichens.

These plants provide grazing for herbivores such as Barrenland caribou (*Rangifer tarandus groenlandicus*), muskox (*Ovibos moschatos*) and Arctic hare (*Lepus arcticus*) which are, in turn, prey for wolf (*Canis lupus*), grizzly bear (*Ursus arctos horribilis*), wolverine (*Gulo gulo*) and Arctic fox (*Alopex lagopus*). Caribou of the Kaminuriak herd are the most common species of large vertebrate in the area of Ferguson Lake. They calve around Kaminuriak Lake east of Ferguson Lake.

The principal hydrological processes in the Southern Arctic Ecozone are snow accumulation, snowmelt, surface runoff, stream flow and lake hydrology with a free-water evaporation component. Groundwater is absent because of permafrost. Snowfall accumulates over a 6 to 9 month period before melting quickly during spring freshet. Freshet occurs at the end of May or beginning of June and is usually the most severe flood of the year. However, intense rainstorms in late August and September can produce significant flooding in small watersheds.

Streams are shallow because of the permafrost barrier and increasing discharge results in a widening of a stream rather than a deepening. Pools are rare and only occur where the permafrost barrier is locally deep. Lakes typically consist of two types of habitat – a deep central basin with a substrate of silt surrounded by a narrow ring of shallow, sunlit littoral habitat with a substrate that ranges from silt to boulders. Most biological production occurs in the littoral zone. For example, the density and biomass of benthic invertebrates typically decreases with increasing lake depth.

Lakes and rivers in this ecozone typically have low concentrations of nutrients and metals. Combined with low temperatures and a short growing season, this means that species diversity, biological productivity and the density of plants and animals are low compared to southern Canada. Fish grow slowly, hence their populations are vulnerable to overharvesting. All streams freeze solid during winter, thus all stream-dwelling fish must migrate into nearby lakes in autumn in search of overwintering habitat. In spring, fish re-colonise the streams. This means there is no long-term stream fish community succession of the kind seen in southern Canada. Since the winter ice cover is at least 2 m thick, only lakes with depths greater than 2 m can support self-sustaining fish populations, and only streams with unobstructed access to deep lakes can support fish during spring and summer. Since Ferguson Lake is a large, deep lake, it provides the primary overwintering habitat for fish that use its tributary streams during spring and summer.

The shallow nature of streams in this ecozone means that they are mainly used as spawning and juvenile rearing habitat for small-bodied species of fish such as Arctic grayling (*Thymallus arcticus*), slimy sculpin (*Cottus cognatus*) and ninespine stickleback (*Pungitius pungitius*). Larger-bodied species such as lake trout (*Salvelinus namaycush*) and longnose sucker (*Catostomus catostomus*) are restricted almost entirely to lakes, although their juveniles will occasionally enter the mouths of streams in search of prey and refuge from predators. The main type of cover habitat in streams is boulders (fish use the crevices underneath boulders as refuges), followed by overhanging vegetation and cutbanks.

1.5 Previous Research

There is no published scientific information available on the aquatic ecosystem of Ferguson Lake, but there is some information available for other systems in the area. For example, Bond (1975) sampled the commercial fishery for lake whitefish (*Coregonus clupeaformis*) and lake trout of Kaminuriak Lake (downstream of Ferguson Lake) in August of 1972 and 1973.

2. METHODS

2. Methods

2.1 Monitoring Locations

The study focused on five watersheds that cross the main mineralised zones east and west of Ferguson Lake (Table 2.1-1 and Figure 2.1-1). For comparison, two reference watersheds located approximately 7 km to the northeast of Ferguson Lake Lodge were sampled. All monitored streams discharge into Ferguson Lake, which drains in an easterly direction into Hudson's Bay near Dawson Inlet.

Table 2.1-1
Location of Monitoring Stations, Ferguson Lake Project Area, 1999

Station	Type	UTM Co-ordinates (WGS 84)		Description
		Northing	Easting	
L1	Lake	6970663	614219	South of camp (outflow) – deepest spot
L2	Lake	6972735	606451	In front of west deposit
L3	Lake	6973845	610706	In front of east deposit
L4	Lake	6969464	608745	Southwest of camp (inflow)
L5	Lake	6977480	607261	Reference; North of camp
W1	Stream	6971235	605659	Western mineralised zone – south
W2	Stream	6972855	605901	Western mineralised zone – north
E1	Stream	6971757	612617	Eastern mineralised zone – south
E2	Stream	6973795	610870	Eastern mineralised zone – north-west
E3	Stream	6973868	610989	Eastern mineralised zone – north-east
R1	Stream	6977677	614267	Reference; northeast of camp
R2	Stream	n/a	n/a	Reference; northeast of camp

n/a = not available.

2.2 Sampling Program

Table 2.2-1 summarizes the environmental variables measured during the study and the frequency of sampling.

2.3 Hydrology

Stream flow was monitored at six stations within the Project area, and the lower reaches of the streams were visited to describe the channel characteristics. Table 2.3-1 summarises the locations and sampling dates for each of the monitoring stations, and Figure 2.3-1 shows the locations of the stations in relation to the watershed boundaries.

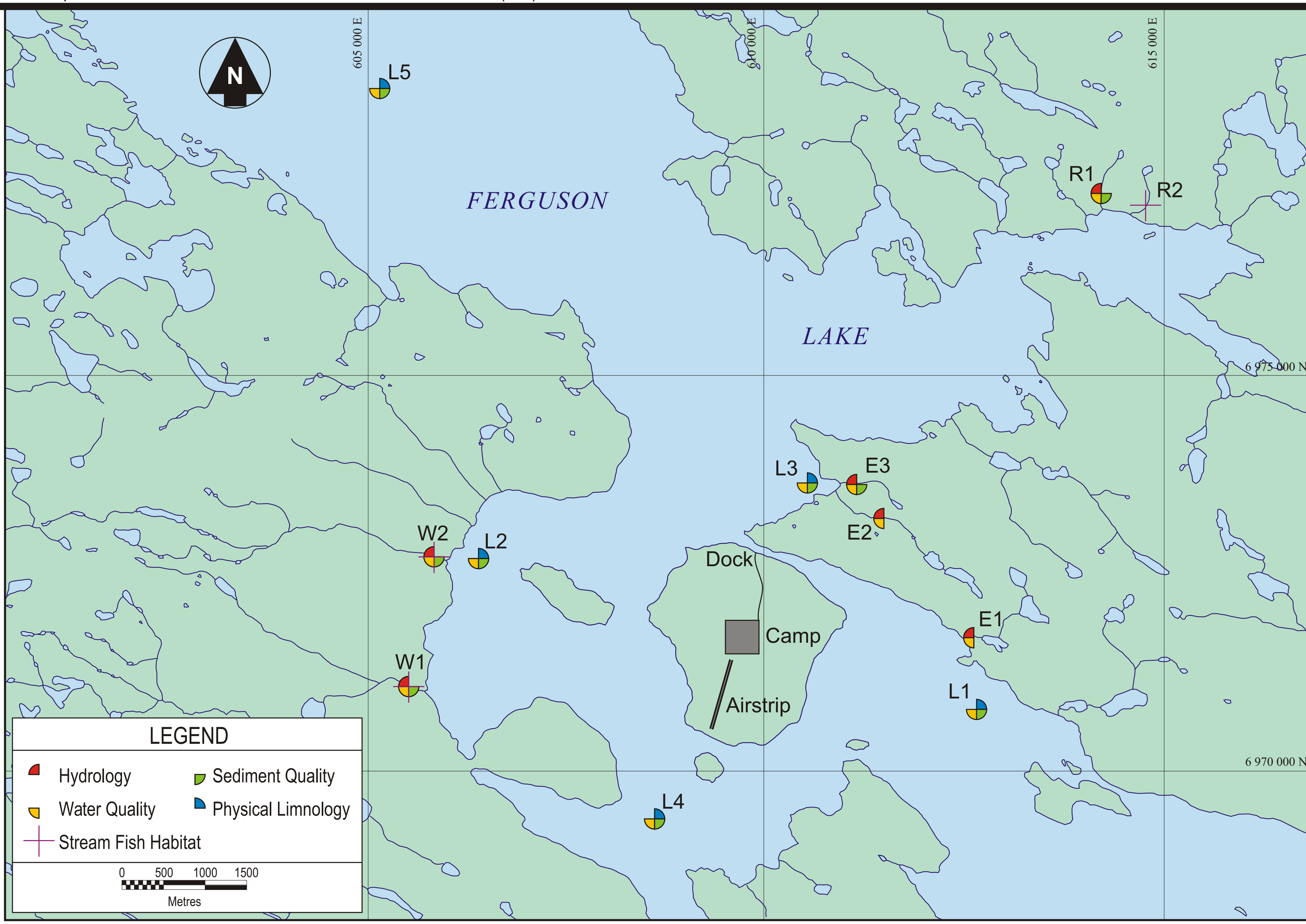


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FIGURE 2.1-1

Rescan

Baseline Sampling Locations, Ferguson Lake Project Area, 1999

Table 2.2-1
Variables Measured During the 1999 Ferguson Lake Baseline Sampling Program

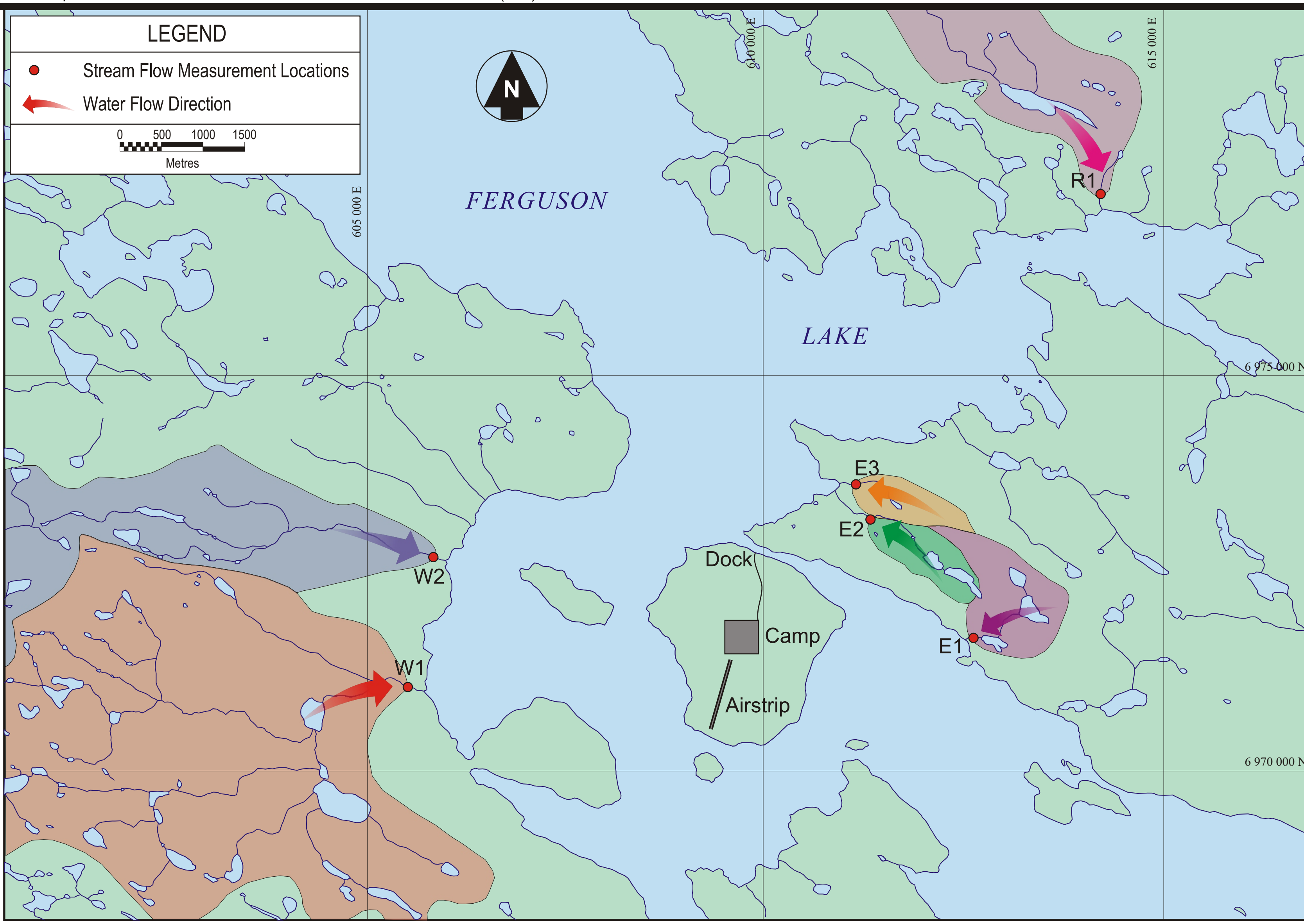
Variable	Sampling Frequency	Dates
Ferguson Lake		
Water Quality	2 times	July and September
Sediment Quality	1 time	September
Physical Limnology	2 times	July and September
Streams		
Flow and Unit Yield	2 times	July and September
Water Quality	2 times	July and September
Sediment Quality	1 time	September
Fish and Fish Habitat	1 time	September

Table 2.3-1
Sampling Locations for Hydrology Monitoring Stations, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Dates
W1	Stream flow	July 31 and September 12
W2	Stream flow	July 28 and September 12
E1	Stream flow	July 29 and September 13
E2	Stream flow	July 29 and September 13
E3	Stream flow	July 29 and September 13
R1	Stream flow	July 31 and September 13

Streamflow measurements were conducted during site visits in late July and early September, 1999. Water velocities were measured with a Swoffler Model 2100 velocity meter (Plate 2.3-1). Stream flows were calculated by multiplying water velocities by the cross-sectional area of the stream at the point of measurement. Flows of streams E1 and E2 could not be measured in July because the Swoffler meter was obstructed by grass at station E1 and because E2 had an extremely braided channel and diffuse drainage pattern. Flows were too low to be measured accurately in all six streams in September.

Drainage areas for each of the six watersheds were estimated from topographic maps of the Project area using a digitizer pad and SigmaScan software (SPSS Inc., 2003). Unit yield of each watershed was estimated by dividing its total stream flow by its drainage area.



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Stream Flow Monitoring Locations and Watershed Boundaries, Ferguson Lake Project Area, 1999

FIGURE 2.3-1

Rescan™

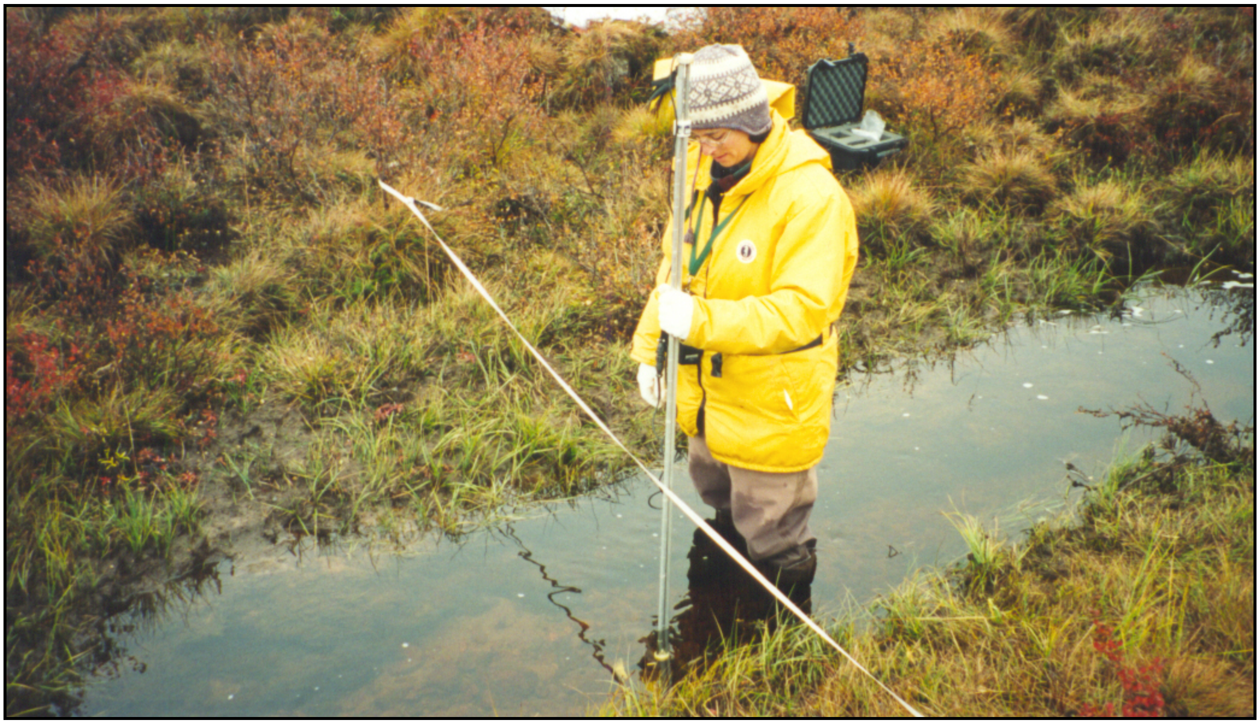


Plate 2.3-1 Rescan water quality scientist measuring stream flow with a Swoffler meter at the Ferguson Lake Project area in September, 1999

2.4 Lake Water Quality

Lake water quality samples were collected from five locations near the mineralised zones and around the Project camp, including one reference location (station L5) north of the mineralised zone. Table 2.4-1 lists the locations and dates of the lake water sampling, and Figure 2.1-1 shows the locations of the stations.

Table 2.4-1
Sampling Locations and Dates for Lake Water Quality, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Dates
L1	Physical, nutrients and total metals	July 30, September 12
L2	Physical, nutrients and total metals	July 30, September 12
L3	Physical, nutrients and total metals	July 30, September 11
L4	Physical, nutrients and total metals	July 30, September 12
L5	Physical, nutrients and total metals	July 30, September 11

Water samples were collected by hand from the lake at near-surface depths (Plate 2.4-1). Well-labelled, pre-rinsed plastic sampling bottles were rinsed three times and then filled with water.

Plate 2.4-1 Rescan fisheries biologist collecting water samples from the surface of Ferguson Lake in July, 1999

No replicate samples were taken. Samples for total metals were preserved with ultra-pure nitric acid, but physical and nutrient samples were not preserved. All samples were stored in a cool, dark place before being shipped to ALS Environmental Inc. in Vancouver for analysis. Table 2.4-2 lists the variables that were analyzed and their detection limits.

Table 2.4-2
Water Quality Variables and Detection Limits, Ferguson Lake and Project Streams, 1999

Variables	Units	Detection Limits
Physical		
pH	Log units	0.01
Conductivity	µmhos/cm	2
Total Suspended Solids (TSS)	mg/L	3
Hardness (as $CaCO_3$)	mg/L	0.05
Turbidity	NTU	0.1
Acidity (to pH 8.3)	mg/L	1
Alkalinity-Total	mg/L	1
Sulphate	mg/L	1

(continued)

Table 2.4-2
Water Quality Variables and Detection Limits, Ferguson Lake and Project Streams, 1999 (completed)

Variables	Units	Detection Limits
Nutrients		
Ammonia	mg/L	0.005
Nitrate	mg/L	0.005
Orthophosphate	mg/L	0.001
Total Phosphorus	mg/L	0.002
Total Metals		
Aluminum	mg/L	0.001
Antimony	mg/L	0.00005
Arsenic	mg/L	0.0001
Barium	mg/L	0.00005
Beryllium	mg/L	0.0005
Boron	mg/L	0.001
Cadmium	mg/L	0.00005
Calcium	mg/L	0.05
Chromium	mg/L	0.0005
Cobalt	mg/L	0.0001
Copper	mg/L	0.0001
Iron	mg/L	0.03
Lead	mg/L	0.000005
Magnesium	mg/L	0.1
Manganese	mg/L	0.00005
Mercury	mg/L	0.00001
Molybdenum	mg/L	0.00005
Nickel	mg/L	0.0001
Selenium	mg/L	0.001
Silver	mg/L	0.00001
Uranium	mg/L	0.00001
Vanadium	mg/L	0.001
Zinc	mg/L	0.001

A single field and travel blank were collected in September. Field and travel blanks were filled with distilled, de-ionised water by ALS Environmental Inc The field blank was treated the same way as the field-collected samples (*i.e.*, exposed to air for the same amount of time as the collected samples and preserved if necessary). This allowed an assessment of potential contamination from field conditions (none was found). The travel blank remained with the collected samples at all times but was never opened. This allowed an assessment of potential contamination from the laboratory (none was found). All bottles and preservatives were prepared by ALS Environmental Inc.

2.5 Stream Water Quality

Water quality samples were collected from five streams that pass through the mineralised zones or are adjacent to the zones. Samples were also collected at one reference station (R1) on a stream north of the mineralised zone. Table 2.5-1 summarises the sampling locations and dates and Figure 2.1-1 shows the station locations.

Table 2.5-1
Sampling Locations and Dates for Stream Water Quality, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Dates
W1	Physical, nutrient, total metals	July 31, September 12
W2	Physical, nutrient, total metals	July 28, September 12
E1	Physical, nutrient, total metals	July 29, September 13
E2	Physical, nutrient, total metals	July 29, September 13
E3	Physical, nutrient, total metals	July 29, September 13
R1	Physical, nutrient, total metals	July 31, September 13

All stream water samples were collected by hand from the stream surface and processed as described above, including the use of field and travel blanks (Plate 2.5-1). The one exception was that two replicate samples were taken at stations W1, W2, E2 and R1 in July and August, but not in September. Samples were preserved, if necessary, and shipped to ALS Environmental Inc. for analysis. The variables that were analyzed were identical to those analyzed for lake water samples. The field and travel blanks showed no contamination of water samples from field or laboratory procedures.

2.6 Lake Sediment Quality

Lake sediment samples were collected at the five lake stations. Samples were collected from each of three depth strata: shallow (0.0 to 5.0 m), middle (5.1 to 10.0 m) and deep (>10.1 m). Table 2.6-1 summarizes the sampling locations and variables measured and Figure 2.1-1 shows the sampling locations.

Table 2.6-1
Sampling Locations and Dates for Lake Sediment Quality, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Date	Depth Strata Sampled[1]
L1	Physical, nutrients, total metals, TOC, grain size	September 12	Deep
L2	Physical, nutrients, total metals, TOC, grain size	September 12	Shallow
L3	Physical, nutrients, total metals, TOC, grain size	September 11	Middle
L4	Physical, nutrients, total metals, TOC, grain size	September 12	Deep
L5	Physical, nutrients, total metals, TOC, grain size	September 11	Deep

1: Shallow = 0.0 to 5.0 m, Middle = 5.1 to 10.0 m and Deep > 10.1 m.

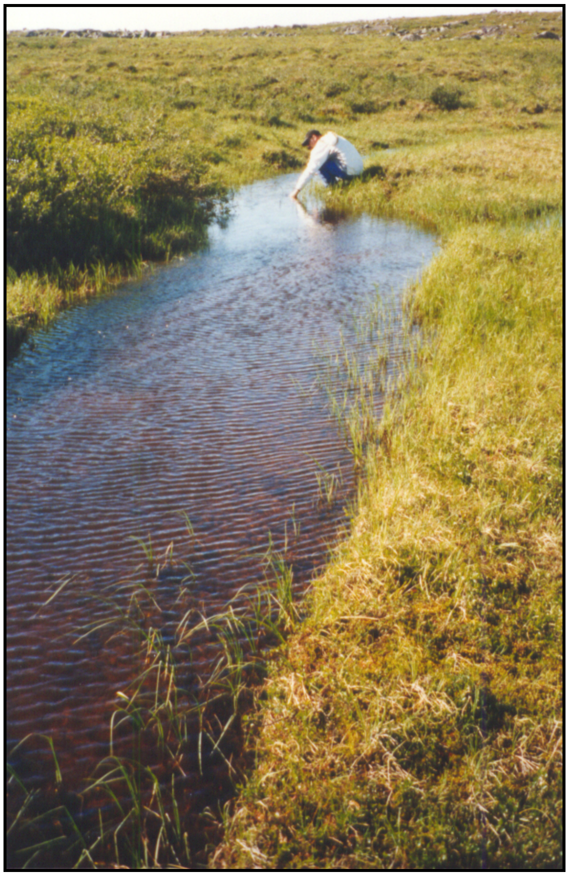


Plate 2.5-1 Rescan fisheries biologist collecting water samples from the surface of stream R1 in July, 1999

All samples were collected with a weighted Ekman grab sampler with a sampling area of 0.0225 m^2. The Ekman was lowered into the sediments using a metered line. The total water column depth was recorded from the line, and a Teflon-covered brass messenger was sent down the line to close the Ekman. The sample was then carefully brought up and inspected to ensure that minimal disturbance to the sample had occurred during collection. Satisfactory samples were placed on a clean white tray and photographed with a label identifying the location, depth and date of collection (Plate 2.6-1). A sediment description sheet was then completed using a Munsell colour chart to describe the colour of the sediment.

For measurement of sediment chemistry (*i.e.*, moisture, nutrients, total metals, and total organic carbon), 300 mL from the top 2 cm of the sediment sample were removed and placed in a clean, labelled Whirl-Pak bag. This was placed in another Whirl-Pak bag and stored in a cool, dark place until further processing. Another sample for particle size analysis was collected from the remaining Ekman grab sample. All samples were shipped to ALS in Vancouver for analysis. Table 2.6-2 shows the sediment quality variables that were analyzed along with their detection limits.

Plate 2.6-1 Sediment sample collected at station L3 in Ferguson Lake on September 11, 1999

Table 2.6-2
Sediment Quality Variables and Detection Limits, Ferguson Lake and Project Streams, 1999

Variables	Units	Detection Limits
Physical		
Moisture Content	%	0.1
Nutrients		
Available Phosphorus	mg/kg	1
Total Nitrogen	%	0.01
Total Metals		
Aluminum	mg/kg	50
Arsenic	mg/kg	0.4
Cadmium	mg/kg	0.1
Chromium	mg/kg	2
Cobalt	mg/kg	2
Copper	mg/kg	1
Iron	mg/kg	50
Lead	mg/kg	2

(continued)

Table 2.6-2
Sediment Quality Variables and Detection Limits, Ferguson Lake and Project Streams, 1999 (completed)

Variables	Units	Detection Limits
Manganese	mg/kg	1
Mercury	mg/kg	0.005
Nickel	mg/kg	5
Phosphorus	mg/kg	0.3
Selenium	mg/kg	0.1
Silver	mg/kg	0.1
Zinc	mg/kg	1
Organic Parameters		
Total Organic Carbon	%	0.05
Particle Size		
Gravel (>2.00 mm)	%	0.1
Sand (2.00 mm – 0.063 mm)	%	0.1
Silt (0.063 mm – 4µm)	%	0.1
Clay (<4 µm)	%	0.1

2.7 Stream Sediment Quality

Stream sediment samples were collected at the four stations that were established for water quality sampling, including one sample from the R1 reference station. Table 2.7-1 shows the sampling details and Figure 2.1-1 shows the station locations.

Table 2.7-1
Sampling Locations and Dates for Stream Sediment Quality, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Date
W1	Physical, nutrients, total metals, TOC, grain size	September 12
W2	Physical, nutrients, total metals, TOC, grain size	September 12
E3	Physical, nutrients, total metals, TOC, grain size	September 13
R1	Physical, nutrients, total metals, TOC, grain size	September 13

A phleger tube was used to collect all samples. The tube was inserted approximately 5 cm into the stream sediment and the sample was carefully extracted. Samples were inspected to ensure minimal disturbance had occurred during the collection. Satisfactory samples were placed on a clean white tray and photographed with a label identifying the location, depth and date of sampling. A sediment description sheet was then completed using a Munsell colour chart to describe the colour of the sediment.

Stream sediment samples were processed the same way as lake sediment samples. All stream sediment samples were sent to ALS Environmental Inc. for analysis. The same variables were analyzed as for the stream sediment samples (Table 2.6-2).

2.8 Physical Limnology of Ferguson Lake

Secchi depths and vertical profiles of dissolved oxygen and temperature were collected during both the July and September field trips at the five water quality stations in Ferguson Lake. Table 2.8-1 shows the sampling stations and dates and Figure 2.1-1 shows the locations of the sampling stations.

Table 2.8-1
Sampling Locations and Dates for Physical Limnology, Ferguson Lake Project Area, 1999

Station	Variables Measured	Sampling Dates
L1	Secchi depth, dissolved oxygen/temperature	July 30, September 12
L2	Secchi depth, dissolved oxygen/temperature	July 30, September 12
L3	Secchi depth, dissolved oxygen/temperature	July 30, September 11
L4	Secchi depth, dissolved oxygen/temperature	July 30, September 12
L5	Secchi depth, dissolved oxygen/temperature	July 30, September 11

Secchi depth was measured using a standard 20 cm-diameter black and white Secchi disk. Using a metered line, the Secchi disk was lowered over the shaded side of the boat until it was no longer visible in the water column. The disk was then slowly raised until it once again became visible, and the depth-at-visibility was recorded from the metered line to the nearest 0.1 m.

Profiles of temperature and dissolved oxygen were measured using a YSI Model 54 dissolved oxygen/temperature probe with a 50 m-long cable (Plate 2.8-1). The membrane of the probe was checked for air bubbles both before and after conducting a profile. If air bubbles were present, then the membrane was replaced and the profile was repeated. After initial calibration, the probe was lowered into the water to a depth of 1 m above the sediment-water interface (as indicated by depth sounder) and allowed to equilibrate. Depth, temperature, dissolved oxygen (in mg/L) and percent oxygen saturation were recorded at 0.5 m intervals in July and at 1.0 m intervals in September.

2.9 Stream Fish Communities and Habitats

Reconnaissance-level electrofishing and habitat surveys were conducted in streams W1, W2 and R2 on September 14, 1999. The three streams on the eastern shore of the lake (E1, E2 and E3) were not surveyed because of very low flows and braided and diffuse channels. R1, the reference stream for water and sediment quality, was also not surveyed for the same reason. However, the fish community and fish habitat of stream R2 (immediately adjacent to R1) was surveyed. The objectives were to identify the species composition of the fish communities in each stream and to assess the quality of fish habitat.

Plate 2.8-1 Rescan hydrologist preparing to lower an *in situ* water quality probe into Ferguson Lake in July 1999

Accessible portions of the streams were selected and, beginning at the downstream end of each stream, single-pass electrofishing was conducted in an upstream direction using a Smith-Root model 15C backpack electrofisher. All captured fish were identified to species, measured for fork length or total length (depending on whether or not a fish species had a forked caudal fin) and then released live back into the stream. Handling time was minimised to reduce mortality.

After an electrofishing survey was completed, measurements of habitat variables were made of the survey section using the same format previously employed by Rescan scientists for other Arctic streams (Table 2.9-1). Based on these variables, the suitability of the stream section for supporting fish was assessed using a simple numerical scale: 0 (not suitable), 1 (low), 2 (medium) and 3 (high). Each of five life-history stages (spawning, rearing, adult feeding, overwintering and migration) was assigned a habitat suitability number. Finally, a sketch was made of the surveyed section of stream and photographs were taken.

The definitions of stream habitat units were:

Riffle – shallow rapids where water flows swiftly over completely or partially submerged materials to produce surface agitation. Usually less than 0.2 m in depth and with a gradient less than 4%;

Run – areas of swiftly flowing water without surface agitation that approximates uniform flow, and in which the slope of the water surface is roughly equivalent to the overall gradient of the

Table 2.9-1
Stream Habitat Variables Measured in the Ferguson Lake Project Area, September 14, 1999

Variable	Units
Physical	
Survey length	m
Stream gradient	%
Mean channel width	m
Mean depth	m
Maximum pool depth (average over all pools)	m
Maximum riffle depth (average over all riffles)	m
Stage (dry, low, medium, high and flood)	-
Water Quality	
Temperature	°C
Conductivity	μS/cm
pH	log units
Colour	-
redox potential	mV
Substrate Composition[1]	
Organic matter	%
Silt	%
Sand	%
Small gravel	%
Large gravel	%
Cobble	%
Boulder	%
Bedrock	%
Habitat Composition[1]	
Riffle	%
Run (R1, R2 or R3, in order of decreasing quality)	%
Pool (P1, P2 or P3, in order of decreasing quality)	%
Total Cover[2]	%
Cover[1]	
Pool	%
Boulder	%
Cutbank	%
Macrophytes	%
Overhanging vegetation	%

Dashes indicate no units.
1: Must add up to 100% summed over all categories.
2: Percent of total surface area of stream with fish cover.

stream reach. ***R1*** is the best-quality run habitat with a depth greater than 0.75 m, ***R2*** is intermediate quality run habitat with a depth between 0.3 and 0.75 m, and ***R3*** is the poorest quality run habitat with a depth less than 0.3 m; and

Pool – areas with 0% gradient, reduced stream velocity and deeper than surrounding areas. Often associated with Run habitat. ***P1*** is the best-quality pool habitat with a depth greater than 0.75 m, ***P2*** is intermediate quality pool habitat with a depth between 0.3 and 0.75 m, and ***P3*** is the poorest quality run habitat with a depth less than 0.3.

3. RESULTS AND DISCUSSION

3. Results and Discussion

3.1 Stream Hydrology

Flows of the streams of the Ferguson Lake Project area were surveyed between July 28 and 31, 1999 (flows on September 12, 1999, were too low to be measured in any of the streams). The July survey was after freshet, hence the stream flows reported here fall within the low range of flows expected for these streams.

3.1.1 Stream Description

Streams W1 and W2 drain the main western mineralised zone of the Project area. They have the two largest drainage areas of the six monitored streams (Table 3.1-1). The streams flow in an easterly direction and discharge into Ferguson Lake. In the lower reaches of the streams, the channel pattern is straight to sinuous and the channels are moderately entrenched. With the exception of stream W1, the stream channels are characterised by riffle-pool sequences, and in the steeper reaches by rapids and cascades. A floodplain and oxbows are found within 1 km of the mouth of stream W1. Photographs of streams W1 and W2 are shown in Plates 3.7-6 to 3.7-8 of Section 3.7.2, as are detailed descriptions of the physical characteristics of the lower reaches of the two streams.

Table 3.1-1
Stream Flows, Drainage Areas and Unit Yields,
Ferguson Lake Project Area, July 28 to 31, 1999

Station/Stream	Flow (m^3/s)	Drainage Area (km^2)	Unit Yield ($L/s/km^2$)
W1	0.513	27.813	18.4
W2	0.294	9.901	29.7
E1	-	1.156	-
E2	-	1.157	-
E3	0.006	0.342	18.0
R1	0.010	5.361	1.9

Dashes indicate no data were available

Streams E1, E2 and E3 drain the main eastern mineralized zone. Their drainage areas are an order of magnitude lower than those of streams W1 and W2 (Table 3.1-1). Stream E1 discharges in a westerly direction into Ferguson Lake. Sections of the southern anticline of the main eastern mineralised zone are located within the watershed of stream E1. Streams E2 and E3 follow the general southeasterly-northwesterly drainage pattern of the Ferguson Lake area that was created by the movement of the Laurentide ice shield. The two streams discharge in a north-westerly direction, thereby crossing the main eastern mineralised zone.

Streams E1, E2 and E3 follow a low to moderate relief. The channels are straight to sinuous and are characterised by alternating units of riffles and pools. The outflow of E1 into Ferguson Lake deviates from this pattern – the lower and middle reaches of the stream run through intermittently flooded wetlands. Photographs of streams E1, E2 and E3 are shown in Plates 3.7-1 to 3.7-4 of Section 3.7.2.

A reference stream (R1) that is unaffected by the mineralized zones was selected to compare water quality and quantity parameters with streams that cross the mineralised zones. It is located approximately 7 km northeast of Ferguson Lake Lodge, and drains in a southerly direction into Ferguson Lake. Close to its mouth, the channel characteristics are similar to the ones of the streams crossing or adjacent to the deposits, *i.e.* straight to sinuous channel, riffle-pool sequences and few rapids and cascades. A photograph of stream R1 is shown in Plate 3.7-5 of Section 3.7.2, as are detailed descriptions of the physical characteristics of the lower reaches of the stream.

3.1.2 Stream Flow and Watershed Unit Yield

Appendix 3.1-1 shows the hydrological data collected at the gauging stations of streams W1, W2, E3 and R1 in July 28 to 31, 1999. Flows of streams E1 and E2 were too low to be accurately measured. Flow ranged over three orders of magnitude – from a low of 0.006 m^3/s in stream E3 to a high of 0.513 m^3/s in stream W1 (Table 3.1-1). Dividing flow by watershed area gave the unit yield of each watershed, which ranged over two orders of magnitude – from 1.9 $L/s/km^2$ for stream R1 to 29.7 $L/s/km^2$ for stream W2 (Table 3.1-1).

3.2 Lake Water Quality

Appendix 3.2-1 shows the results of the July and September surveys of Ferguson Lake water quality, Table 3.2-1 summarises that data, and Figures 3.2-1 to 3.2-8 graphically show how selected variables varied among sampling stations and how they compared to analytical detection limits and to the Canadian Council of Ministers of the Environment (CCME) water quality guidelines for the protection of freshwater life (CCME, 1999). The guidelines are not legally binding limits, but they are used to assess the potential environmental impacts of mine developments. To show values that were below detection limits, they were replaced with one-half the detection limit, a common procedure in water quality analysis.

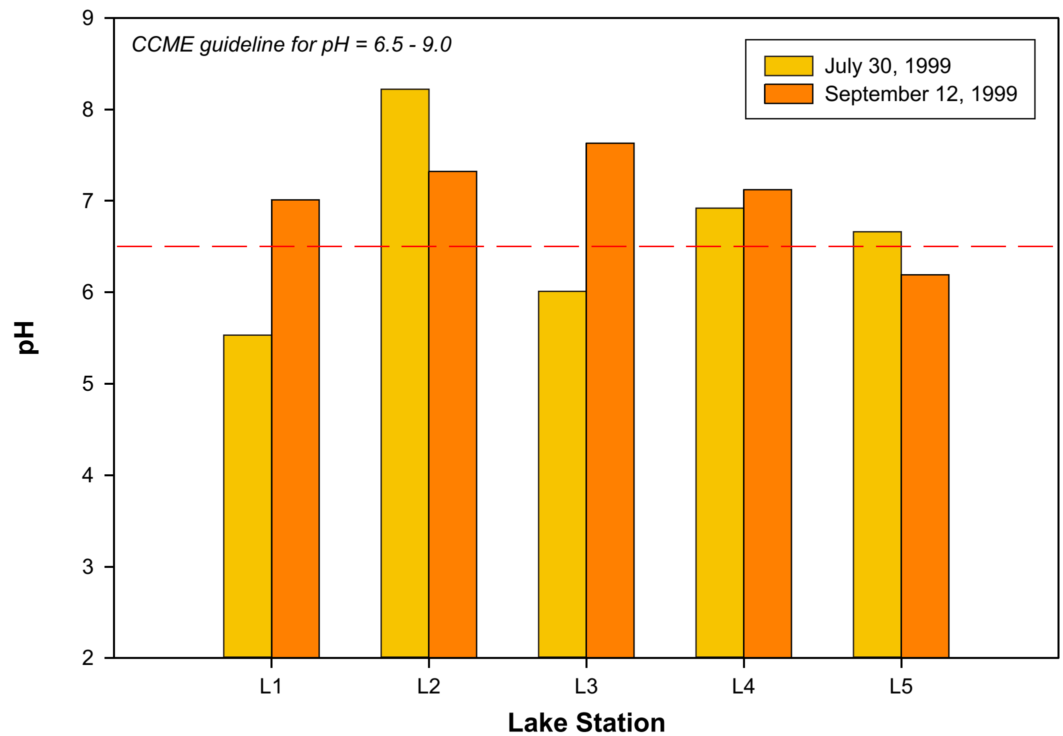
3.2.1 pH and Total Suspended Solids

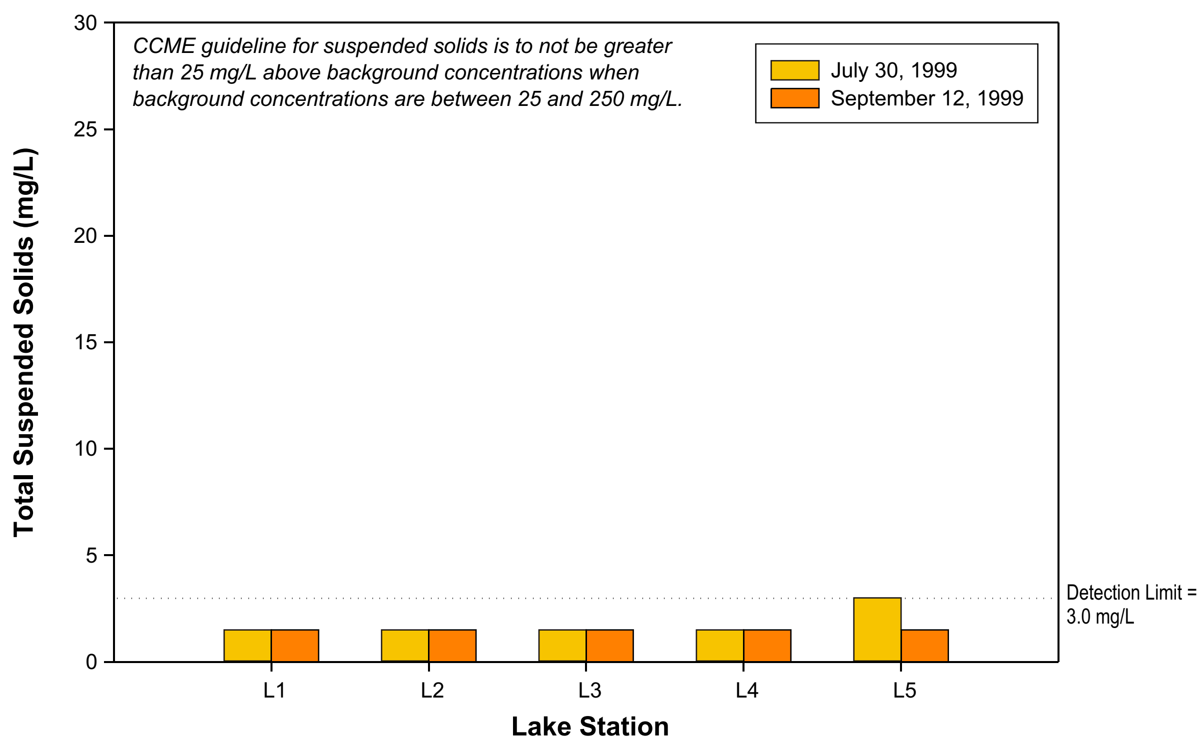
pH was lower in July than in September at stations L1, L3 and L4, and higher in July than in September at stations L2 and L5 (Figure 3.2-1). pH was below the lower limit (6.5) of the CCME guideline range at stations L1 and L3 in July, and at station L5 in September. Low pH is a typical characteristic of northern Canadian waterbodies, and is caused by a combination of factors, the most important of which may be the poor drainage of the tundra. The presence of standing water produces fens, peatlands and bogs in which acid-forming mosses thrive. The low pH then allows increased dissolution of some metals from soil and rock (*e.g.*, aluminum, see Section 3.2.4).

Table 3.2-1
Concentrations of Select Lake Water Quality Variables, Ferguson Lake Project Area, 1999

Station	Date	pH	Total Suspended Solids (mg/L)	Turbidity (NTU)	Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphate (mg/L)	Total Aluminum (mg/L)	Total Arsenic (mg/L)	Total Cadmium (mg/L)	Total Chromium (mg/L)	Total Cobalt (mg/L)	Total Copper (mg/L)	Total Lead (mg/L)	Total Manganese (mg/L)	Total Nickel (mg/L)	Total Zinc (mg/L)
	CCME Guideline[1]	*6.5-9.0*	*Stated*[2]	*Stated*[3]	*Stated*[4]	*Stated*[5]	*n/a*	*Stated*[6]	*0.005*	*0.000017*	*Stated*[7]	*n/a*	*0.002*	*0.001*	*n/a*	*0.025*	*0.03*
L1	30-Jul-99	5.53	<3	0.7	0.04	<0.005	0.005	0.021	<0.0001	<0.00005	<0.0005	<0.0001	0.0011	<0.00005	0.00245	0.0010	<0.001
	12-Sep-99	7.01	<3	0.5	<0.02	<0.005	0.008	0.018	<0.0001	<0.00005	<0.0005	<0.0001	0.0011	0.00014	0.00282	0.0011	<0.001
L2	30-Jul-99	8.22	<3	0.6	<0.02	<0.005	0.005	0.022	<0.0001	<0.00005	<0.0005	<0.0001	0.0012	<0.00005	0.00364	0.0012	<0.001
	11-Sep-99	7.32	<3	0.7	0.02	<0.005	0.006	0.020	<0.0001	<0.00005	<0.0005	0.0001	0.0014	0.00014	0.00530	0.0021	<0.001
L3	30-Jul-99	6.01	<3	0.8	0.02	<0.005	0.004	0.026	<0.0001	<0.00005	<0.0005	0.0002	0.0017	<0.00005	0.00408	0.0025	<0.001
	11-Sep-99	7.63	<3	1.1	0.03	<0.005	0.006	0.020	0.0001	<0.00005	<0.0005	0.0001	0.0013	0.00016	0.00476	0.0019	<0.001
L4	30-Jul-99	6.92	<3	0.6	0.05	<0.005	0.005	0.021	<0.0001	<0.00005	<0.0005	<0.0001	0.0013	<0.00005	0.00293	0.0011	<0.001
	12-Sep-99	7.12	<3	0.7	<0.02	<0.005	0.006	0.023	0.0001	<0.00005	<0.0005	0.0001	0.0014	0.00023	0.00387	0.0020	0.001
L5	30-Jul-99	6.66	3	1.0	<0.02	<0.005	0.006	0.024	<0.0001	<0.00005	<0.0005	<0.0001	0.0010	0.00007	0.00420	0.0009	<0.001
	11-Sep-99	6.19	<3	0.6	0.04	<0.005	0.008	0.020	0.0001	<0.00005	<0.0005	<0.0001	0.0013	0.00015	0.00441	0.0011	<0.001
Travel Blank	12-Sep-99	5.50	<3	<0.1	-	<0.005	<0.002	<0.001	<0.0001	<0.00005	<0.0005	<0.0001	<0.0001	<0.00005	<0.00005	<0.0001	<0.001

1: Guidelines presented are for the protection of freshwater aquatic life. Bolded values exceed CCME guidelines for that variable.
2: TSS is not to be greater than 25 mg/L above background concentrations.
3: Turbidity is not to be greater than 8 NTUs above background concentrations.
4: Guideline for total ammonia is pH and temperature dependent.
5: Nitrate concentrations that stimulate prolific weed growth should be avoided.
6: Guideline is pH dependent: 0.005 mg/L (pH<6.5) or 0.10 mg/L (pH>6.5).
7: Dependent upon species of chromium: 0.0010 mg/L for Cr (VI) and 0.0089 mg/L for Cr (III).
< = Less than the detection limit indicated.
n/a = guideline not available
Dashes indicate no data were available





Note: Dashed line indicates pH relevant to CCME guideline for aluminum.

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pH and Total Suspended Solids in Ferguson Lake, Ferguson Lake Project Area, 1999

FIGURE 3.2-1

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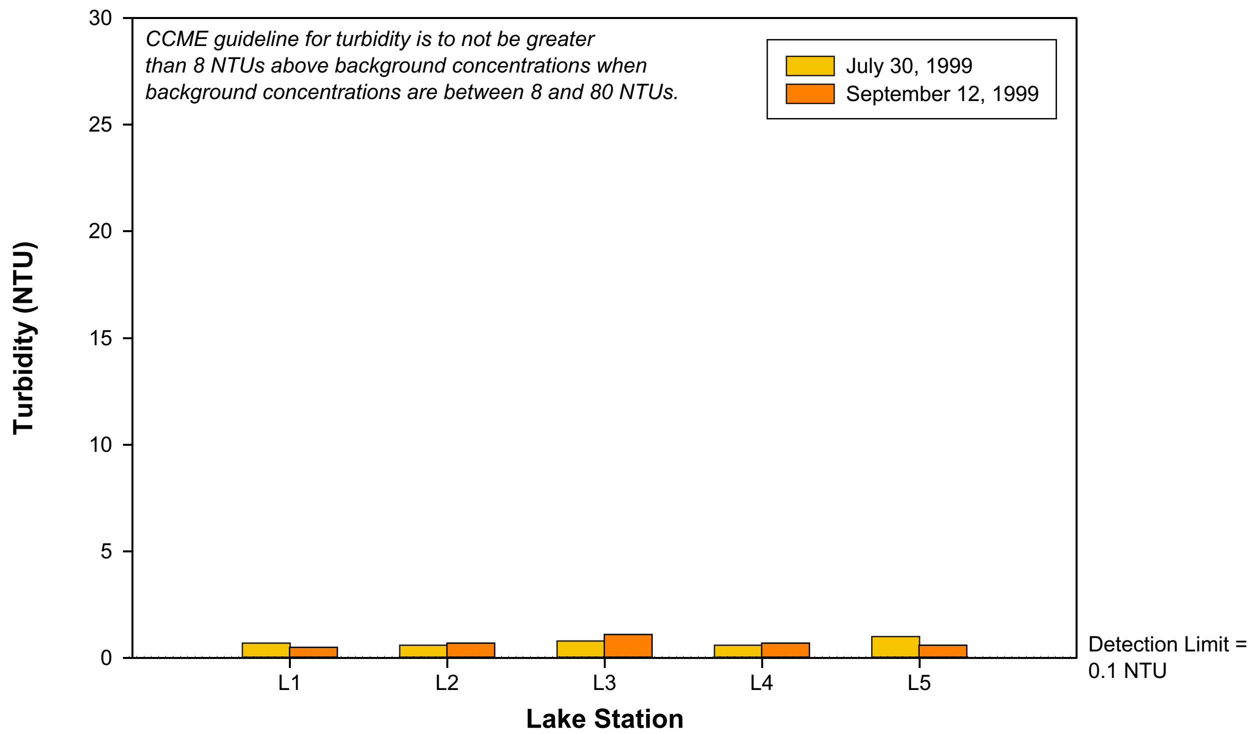

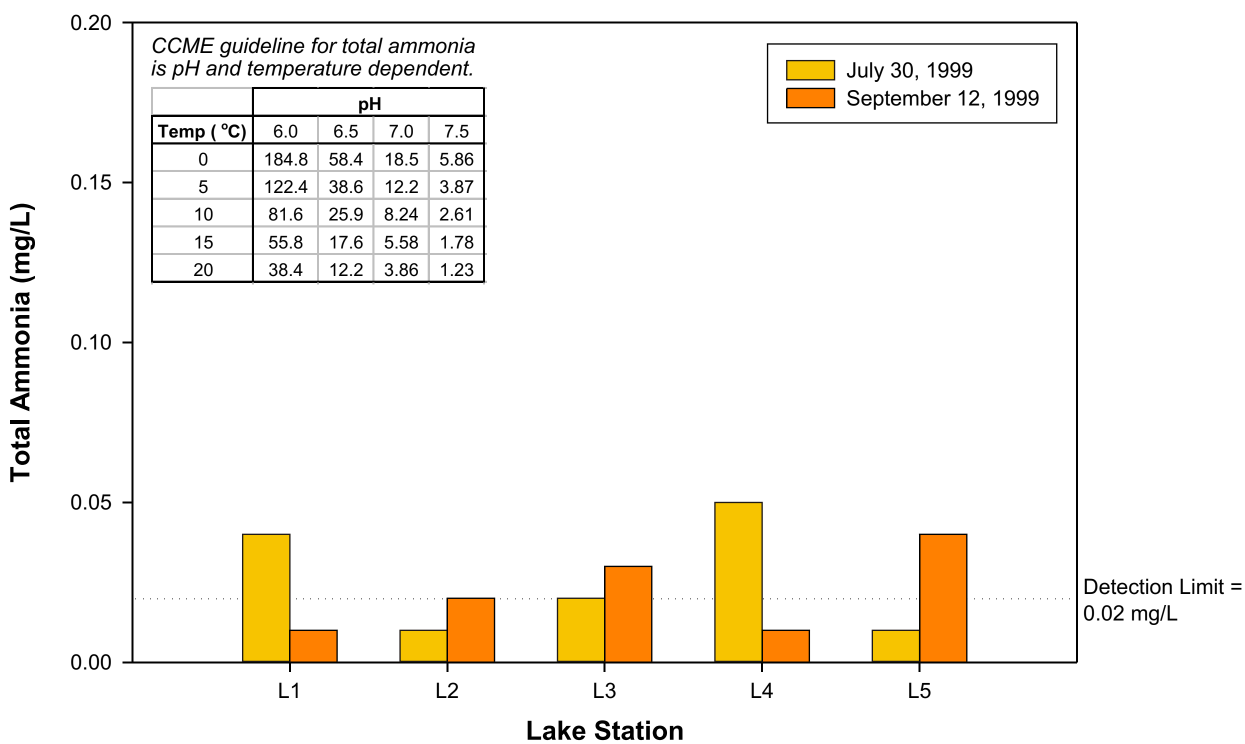

	pH			
Temp (°C)	6.0	6.5	7.0	7.5
0	184.8	58.4	18.5	5.86
5	122.4	38.6	12.2	3.87
10	81.6	25.9	8.24	2.61
15	55.8	17.6	5.58	1.78
20	38.4	12.2	3.86	1.23

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FIGURE 3.2-2

Turbidity and Total Ammonia in Ferguson Lake, Ferguson Lake Project Area, 1999

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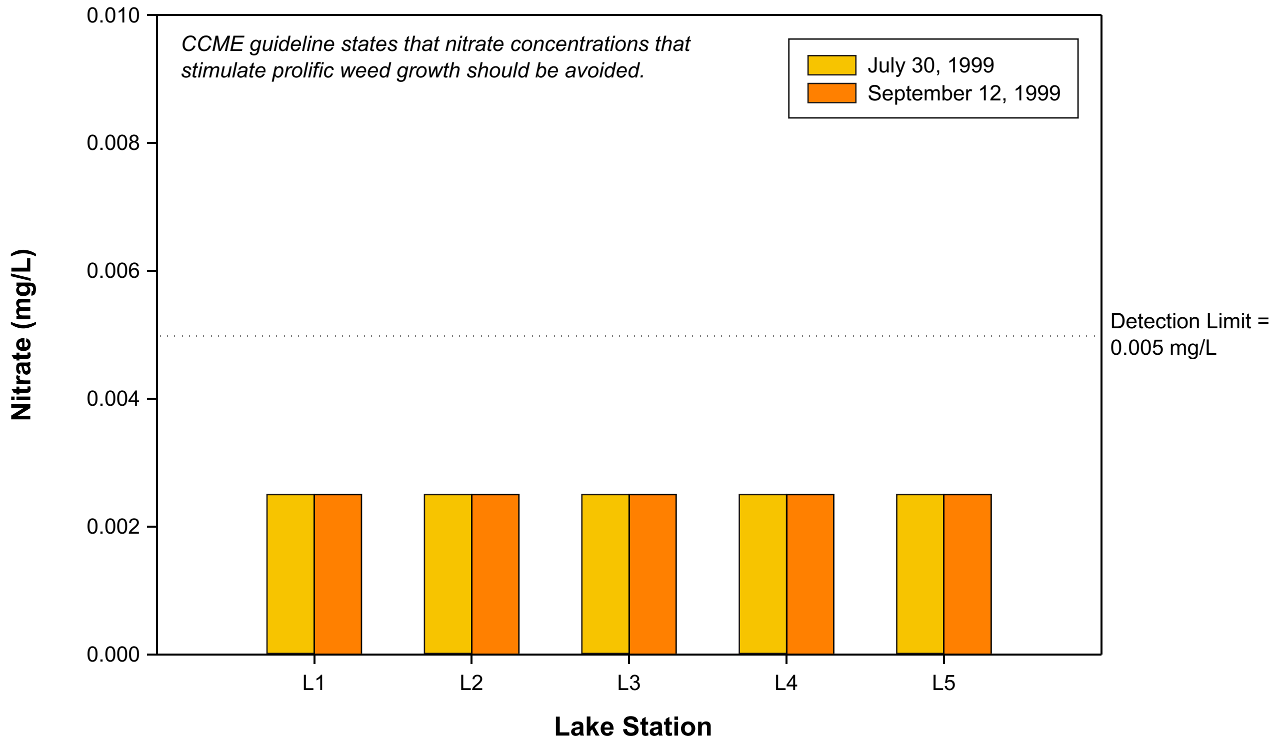

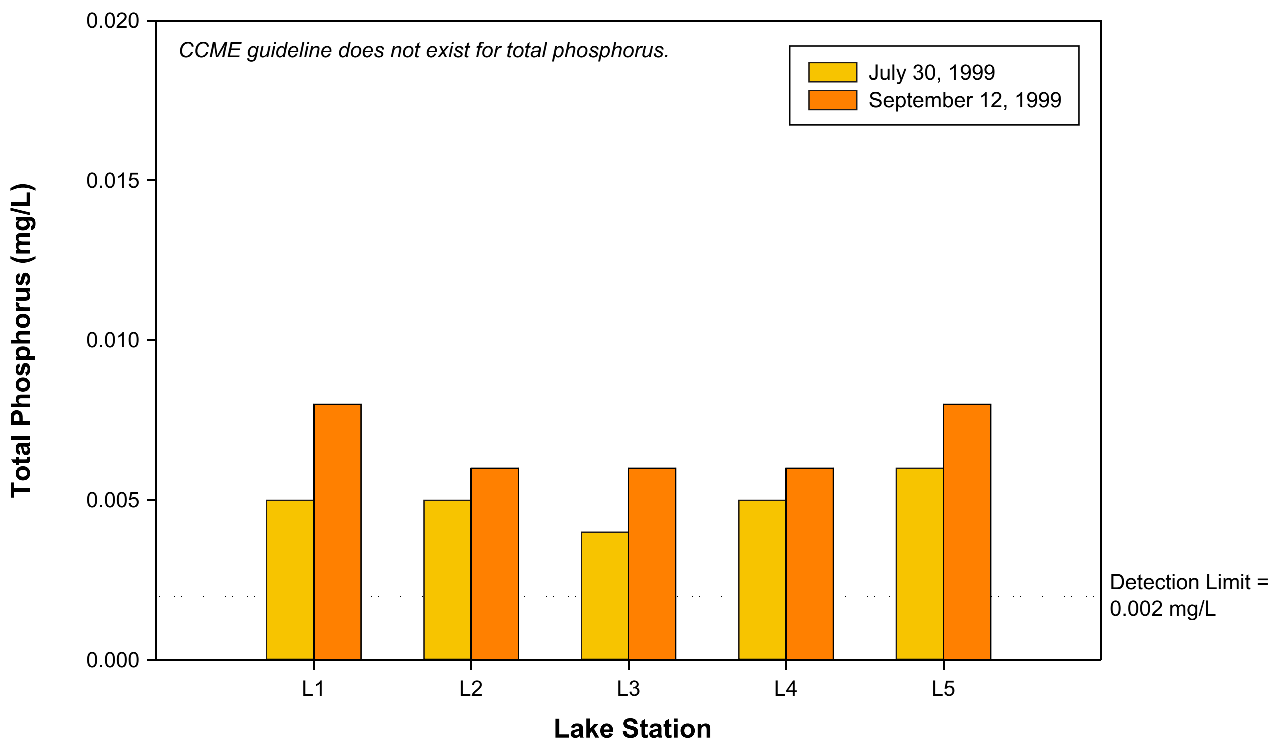

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FIGURE 3.2-3

Nitrate and Total Phosphorus in Ferguson Lake, Ferguson Lake Project Area, 1999

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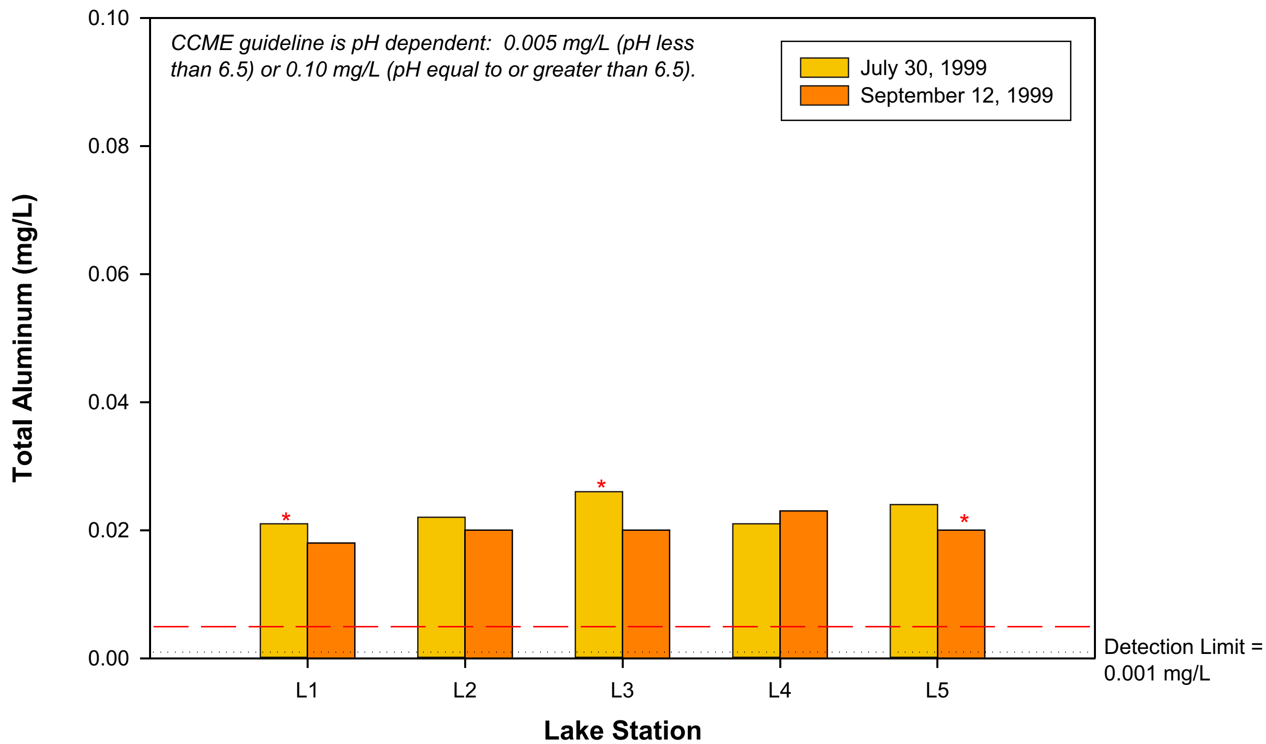

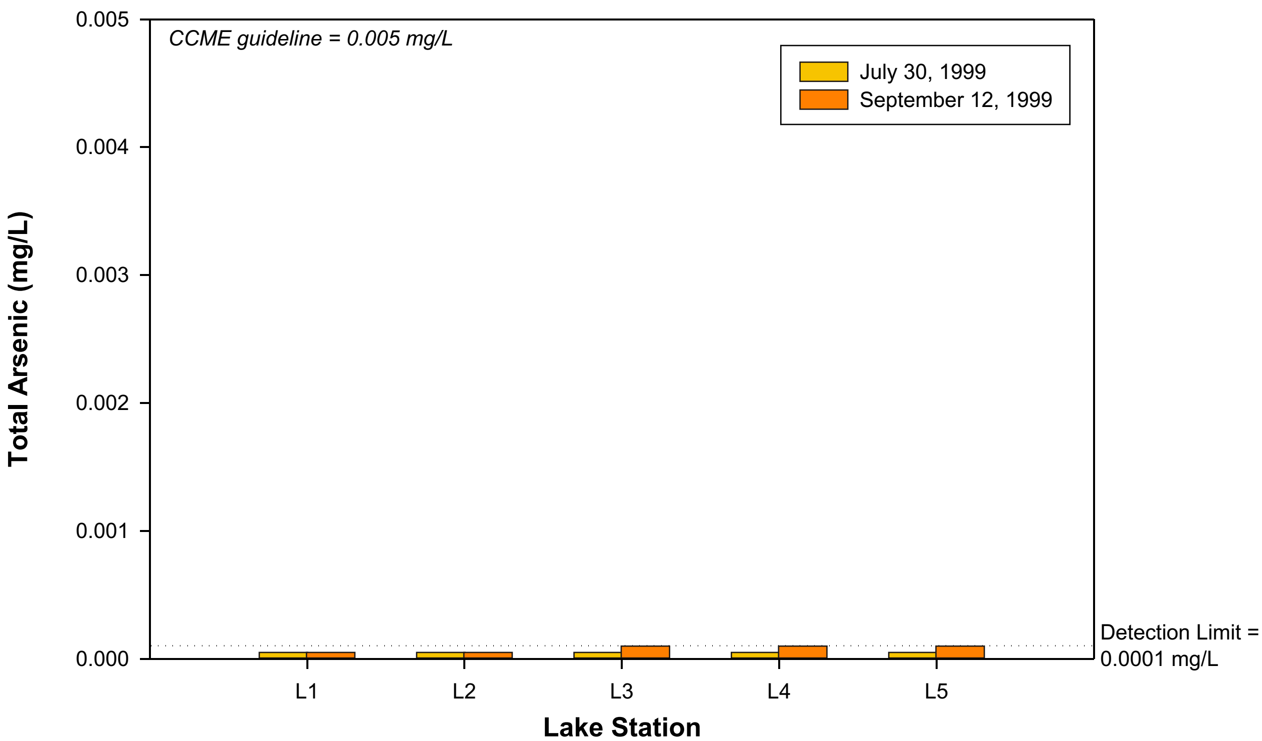

Note: Dashed line indicates lower CCME guideline.
* *Indicates when average pH was below 6.5.*

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FIGURE 3.2-4

Total Aluminum and Total Arsenic in Ferguson Lake, Ferguson Lake Project Area, 1999

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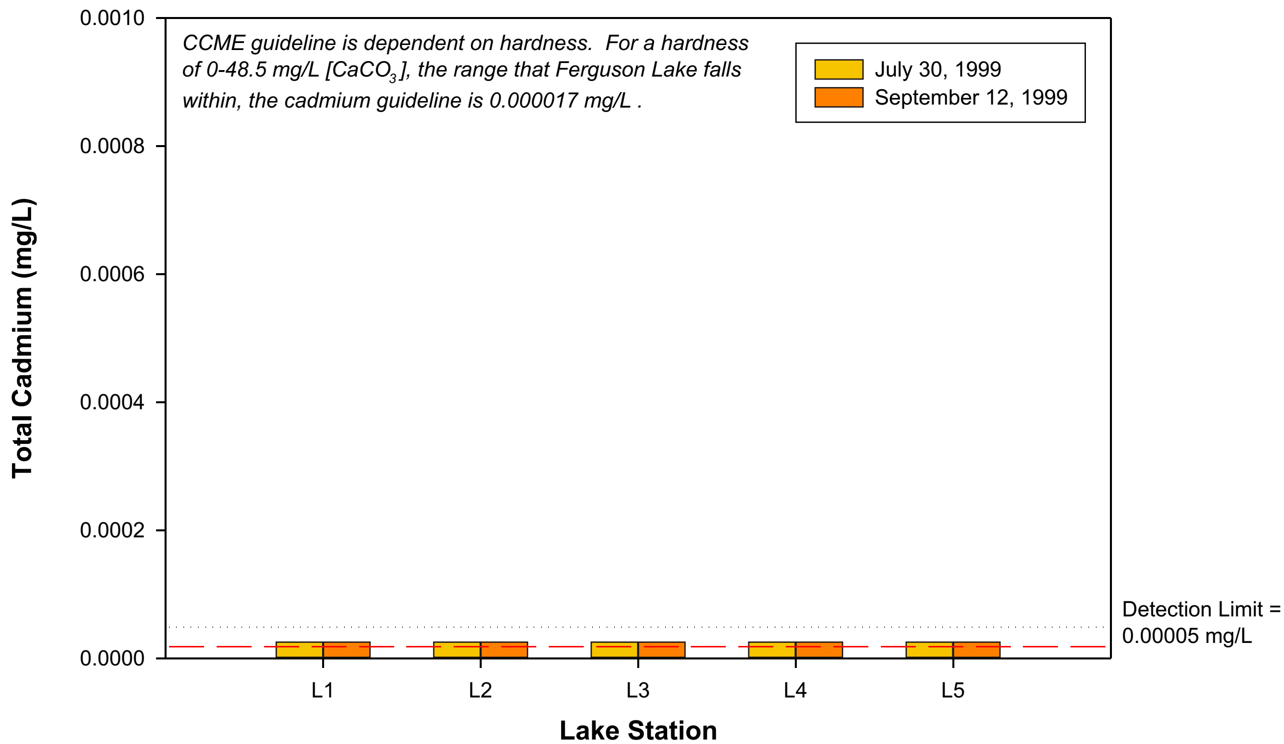

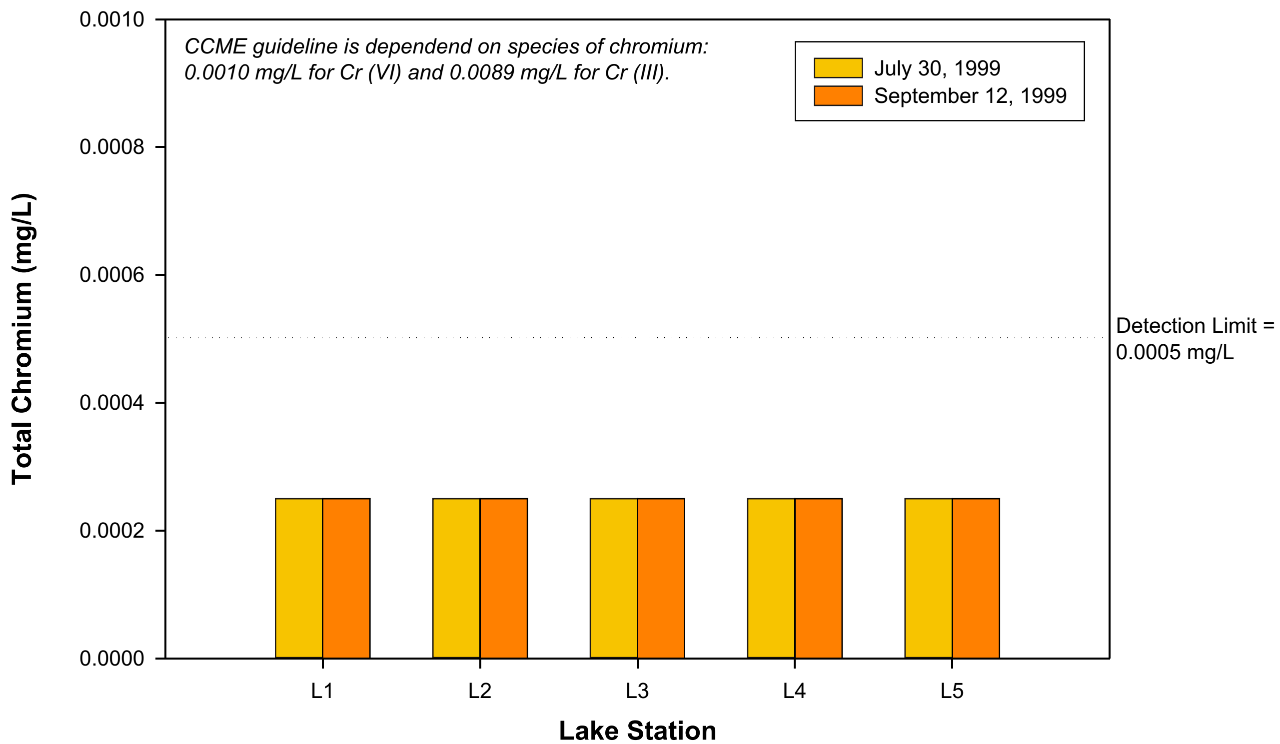

Note: Dashed line indicates CCME guideline.

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FIGURE 3.2-5

Total Cadmium and Total Chromium in Ferguson Lake, Ferguson Lake Project Area, 1999

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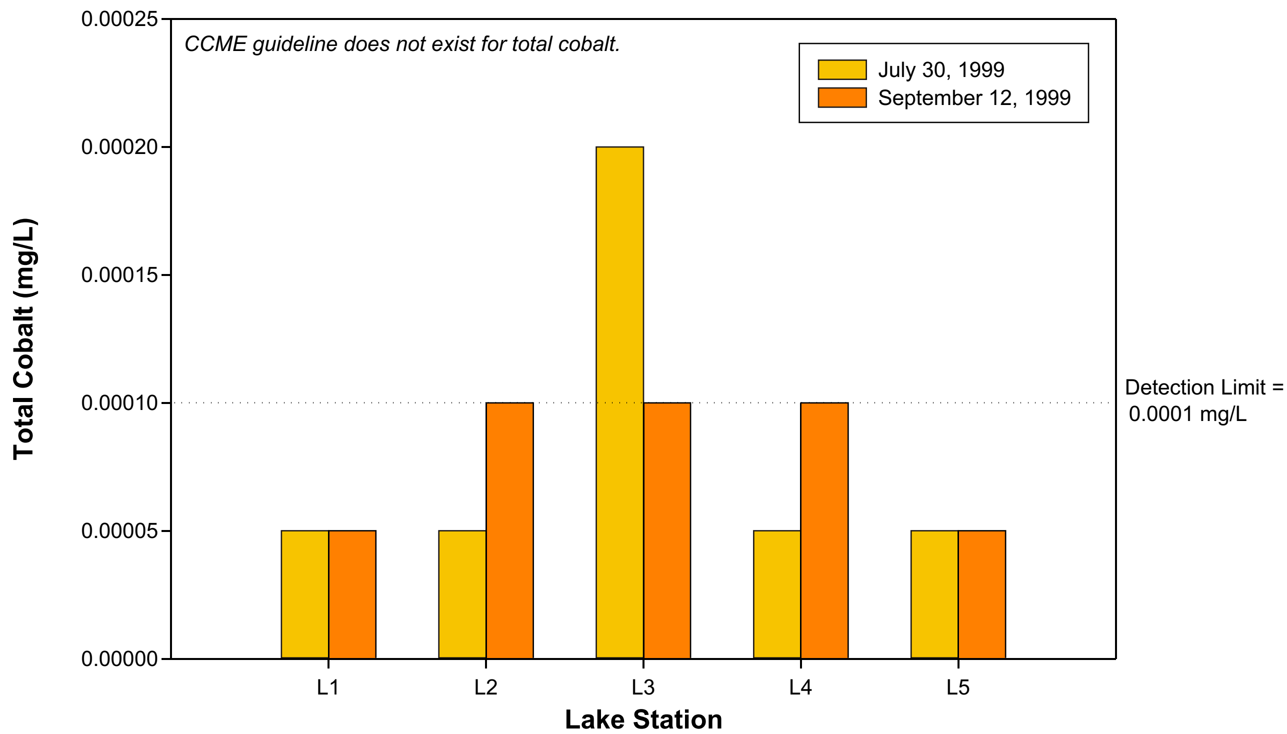

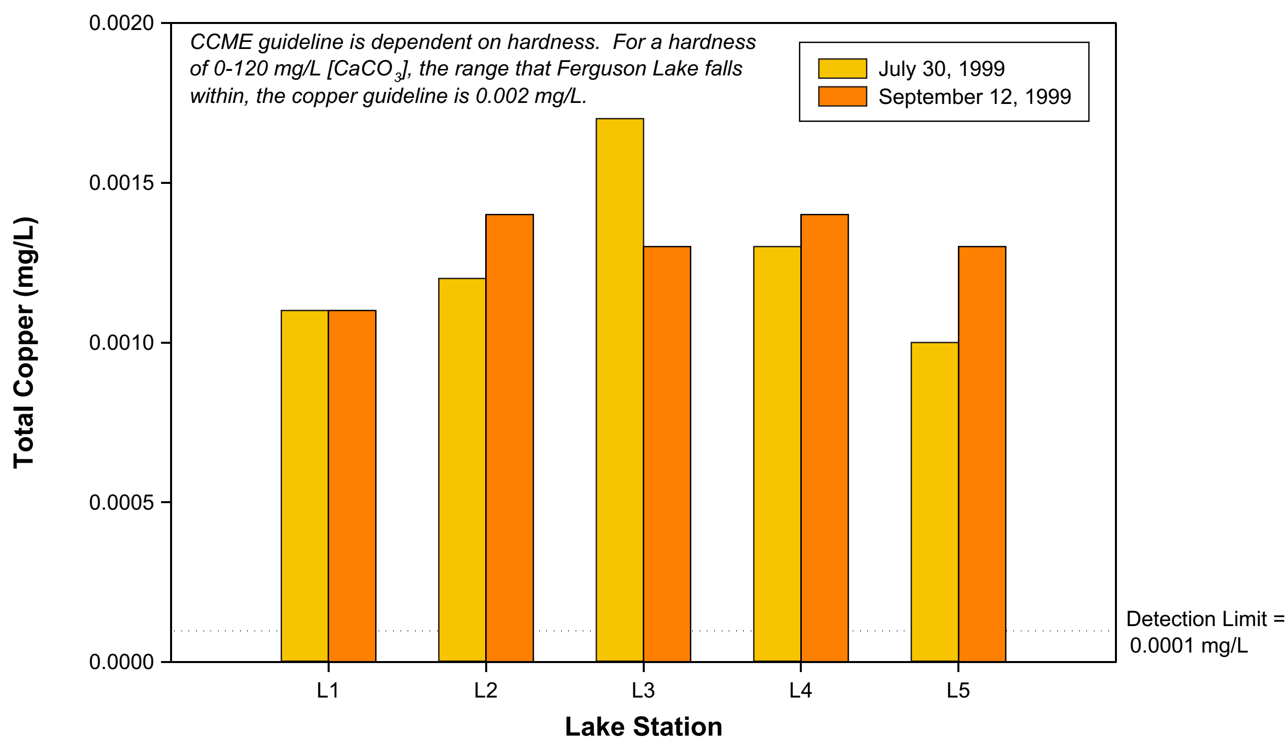

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FIGURE 3.2-6

Total Cobalt and Total Copper in Ferguson Lake, Ferguson Lake Project Area, 1999

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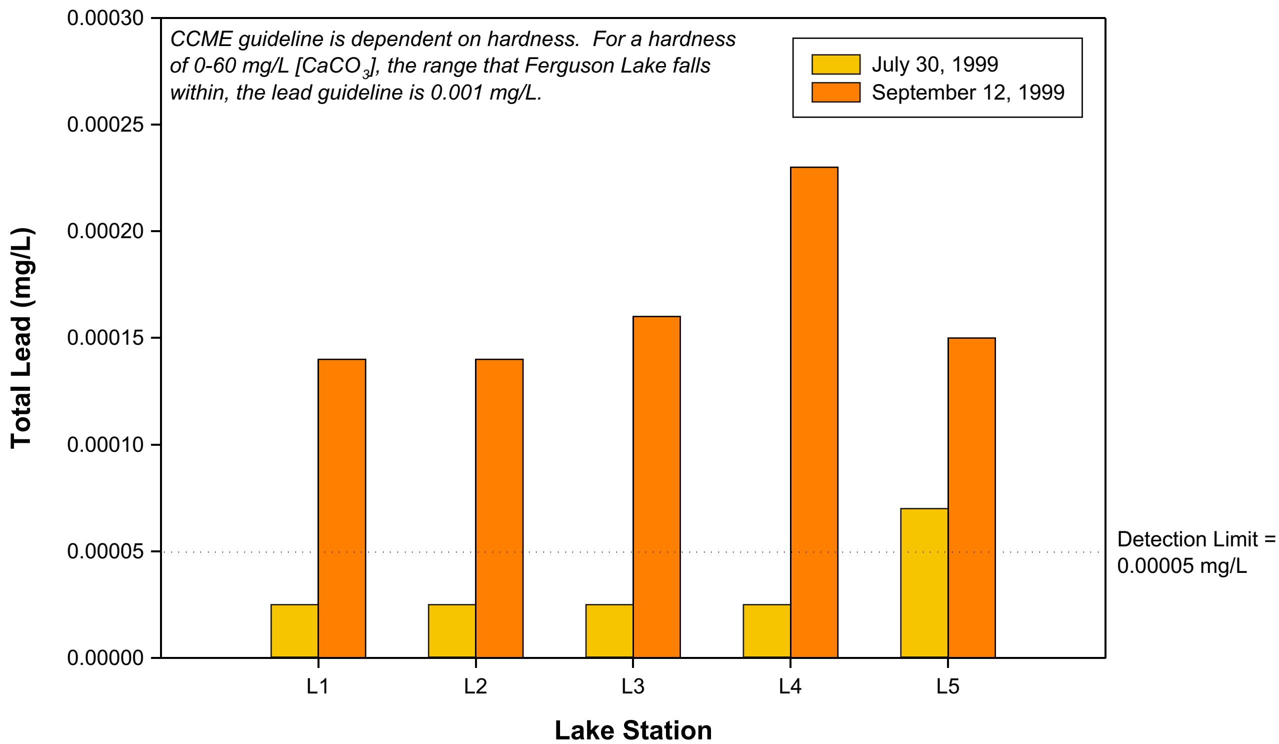

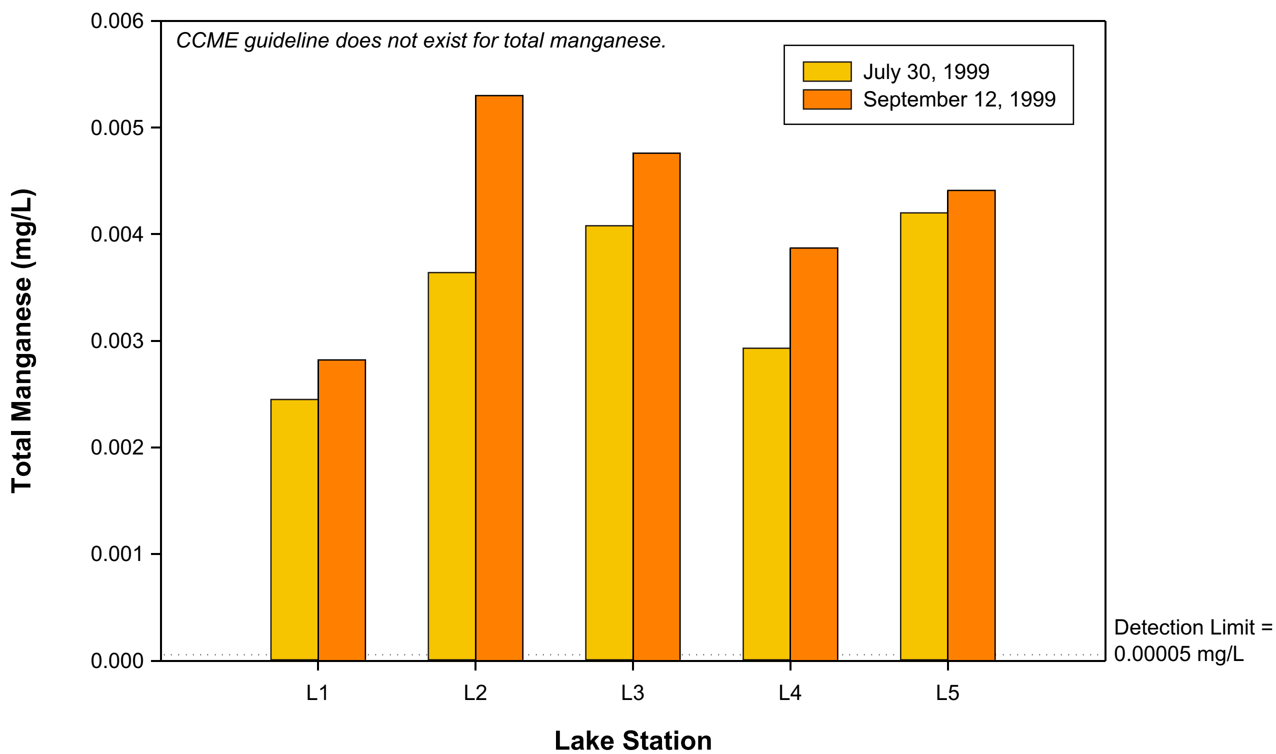

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FIGURE 3.2-7

Total Lead and Total Manganese in Ferguson Lake, Ferguson Lake Project Area, 1999

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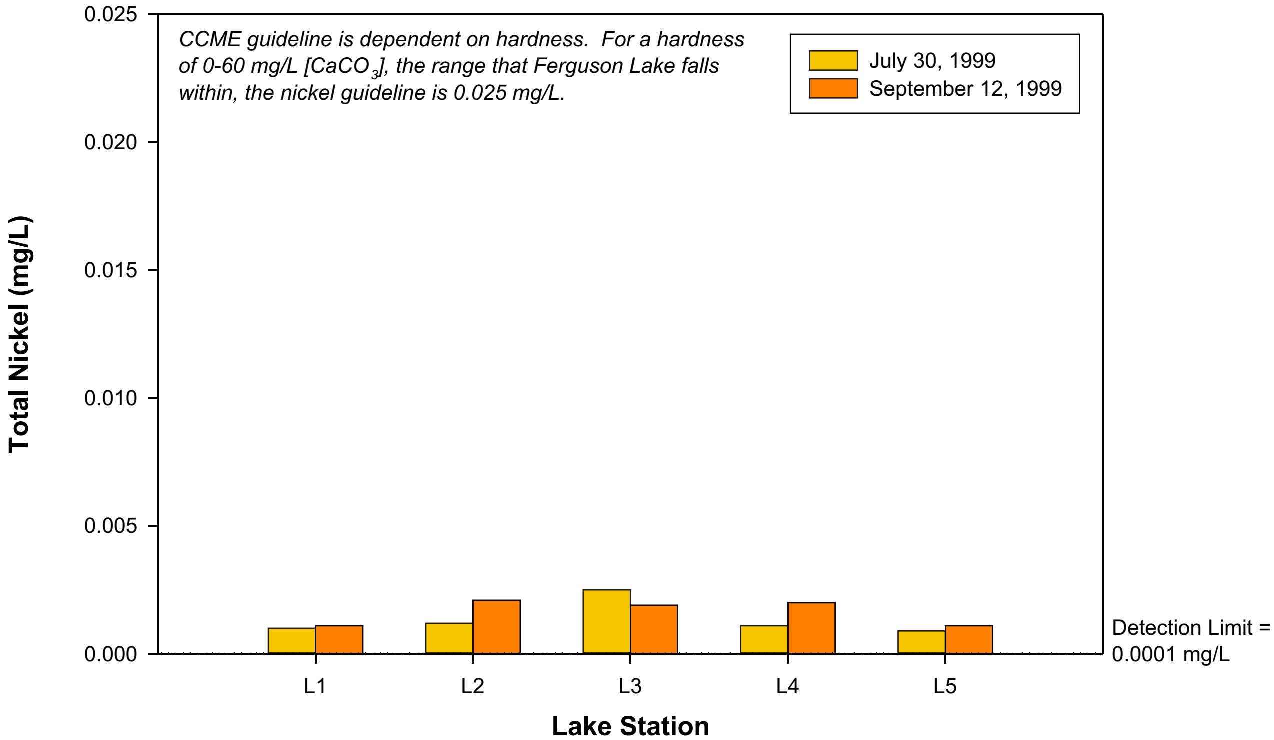

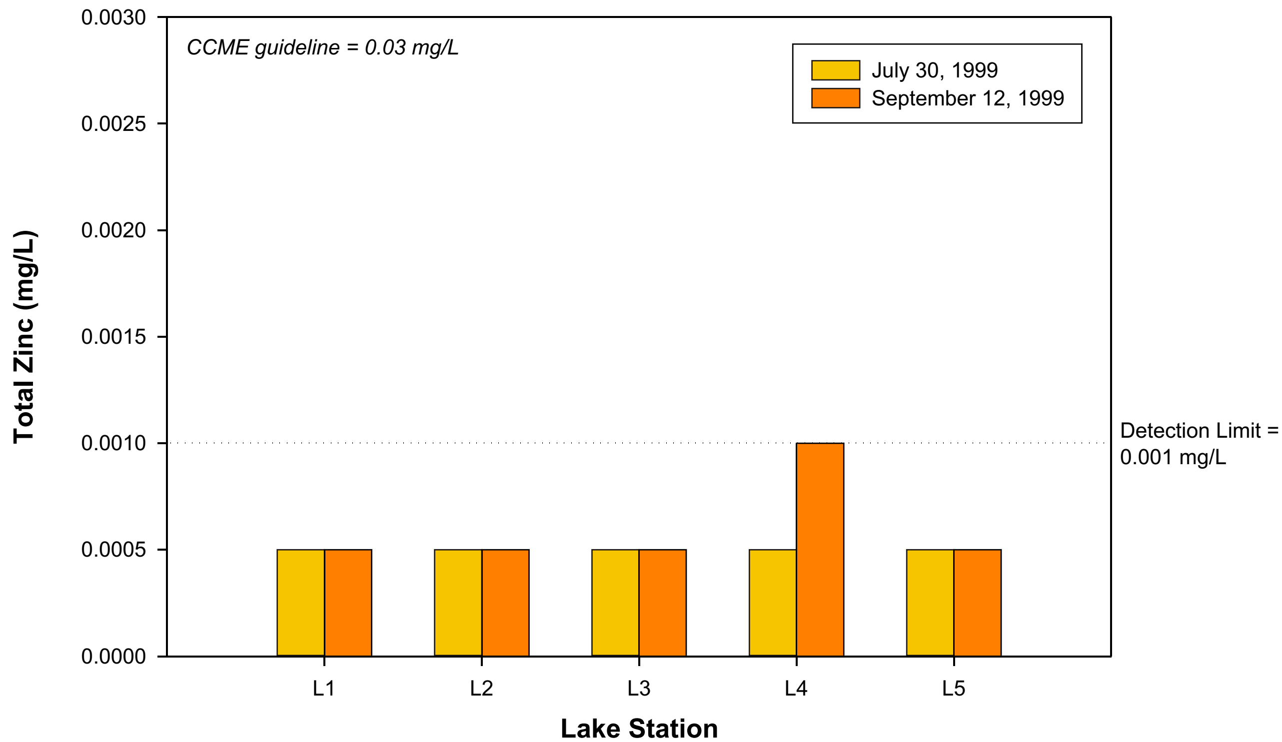

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FIGURE 3.2-8

Total Nickel and Total Zinc in Ferguson Lake, Ferguson Lake Project Area, 1999

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The concentrations of total suspended solids (TSS) were below detection limits at all stations and on all dates with the exception of L5 in July when TSS was 3 mg/L (Figure 3.2-1). These values were well below the CCME guideline and most were below the detection limit. These low TSS concentrations are typical of pristine, undisturbed northern waters.

3.2.2 Turbidity and Ammonia

As expected from the low TSS concentrations, turbidity was generally low at all stations on all dates, with values rarely exceeding 1.0 NTU (Figure 3.2-2). Ammonia was also low, often being at or below the detection limit of 0.02 mg/L. All values of turbidity and ammonia were well below their respective CCME guidelines.

3.2.3 Nitrate and Total Phosphorus

Nitrate was below the detection limit of 0.005 mg/L at all stations on all dates (Figure 3.2-3). Total phosphorus was also low, ranging from 0.004 mg/L for station L3 in July to 0.008 mg/L for stations L1 and L5 in September. Total phosphorus concentrations at all stations were slightly higher in September than in July. These data, when combined with those for ammonia, show that Ferguson Lake is a typical, nutrient-poor (*i.e.*, oligotrophic), pristine northern lake.

3.2.4 Total Aluminum and Total Arsenic

All concentrations of total aluminum were above the detection limit of 0.001 mg/L and ranged from 0.018 mg/L at station L1 in September to 0.024 mg/L at station L5 in July (Figure 3.2-4). Due to low pH (which influences the amount of total aluminum in water), several sites exceeded the CCME guideline of 0.005 mg/L when pH was less than 6.5, including stations L1 and L3 in July and station L5 in September. The occurrence of low pH and elevated concentrations of total aluminum is common for northern waterbodies, and reflects natural processes.

Total arsenic concentrations were below the detection limit of 0.0001 mg/L at all stations and on all dates (Figure 3.2-4). All arsenic concentrations were well below the CCME guideline of 0.005 mg/L.

3.2.5 Total Cadmium and Total Chromium

Total cadmium concentrations were below the analytical detection limit of 0.00005 mg/L at all stations and all dates (Figure 3.2-5). However, the CCME guideline for cadmium at the known hardness of Ferguson Lake water is 0.000017 mg/L, which is below the analytical detection limit. Therefore, it is not possible to state whether or not total cadmium concentrations in Ferguson Lake were above this guideline.

All total chromium values were also below the detection limit of 0.0005 mg/L, and these values were well below the lowest CCME guideline for chromium of 0.0010 mg/L for the Cr (VI) species (Figure 3.2-5).

3.2.6 Total Cobalt and Total Copper

Total cobalt was below the detection limit of 0.0001 mg/L at all stations and dates except for station L3 in July (Figure 3.2-6). Total copper concentrations ranged from 0.0010 mg/L at station L5 in July to 0.0017 mg/L at station L3 in July and were all below the CCME guideline of 0.002 mg/L. In general, copper concentrations were similar among all stations and both dates.

3.2.7 Total Lead and Total Manganese

Total lead concentrations in July were below the detection limit of 0.00005 mg/L for four of the five stations, but all September concentrations were above the detection limit (Figure 3.2-7). All values were well below the CCME guideline of 0.001 mg/L for total lead. Concentrations of total manganese ranged from 0.00245 mg/L for station L1 in July to 0.00530 mg/L for station L2 in September. Values were slightly higher in September than in July. There is no CCME guideline for total manganese.

3.2.8 Total Nickel and Total Zinc

Total nickel ranged from 0.0009 mg/L at station L5 in July to 0.0025 mg/L at station L3 in July and were well below the CCME guideline of 0.025 mg/L (Figure 3.2-8). Total zinc concentrations were all below the detection limit of 0.001 mg/L except for station L4 in September (0.0010 mg/L). Zinc concentrations were well below the CCME guideline of 0.03 mg/L.

3.2.9 Lake Water Quality Summary

The water quality of Ferguson Lake is typical of a northern, clear-water, nutrient-poor (*i.e.*, oligotrophic) waterbody. With two exceptions, all water quality variables were well below CCME guidelines, and many variables were below analytical detection limits (*e.g.*, TSS, nitrate, total arsenic, total cadmium, total chromium and total zinc). The exceptions were some low values of pH and high total aluminum that exceeded CCME guidelines. However, low pH and high aluminum concentrations are not unusual for pristine, northern waterbodies.

3.3 Stream Water Quality

Appendix 3.3-1 shows the results of the July and September surveys of stream water quality, Table 3.3-1 summarises the results, and Figures 3.3-1 to 3.3-9 show those results graphically in comparison with analytical detection limits and CCME guidelines for the protection of freshwater aquatic life. For stations and dates where two replicate samples were taken, an average value (with its standard error or SE) is shown. For data that included values below detection limits, averages were calculated by replacing all values that were below their respective detection limits with one-half of the appropriate detection limit.

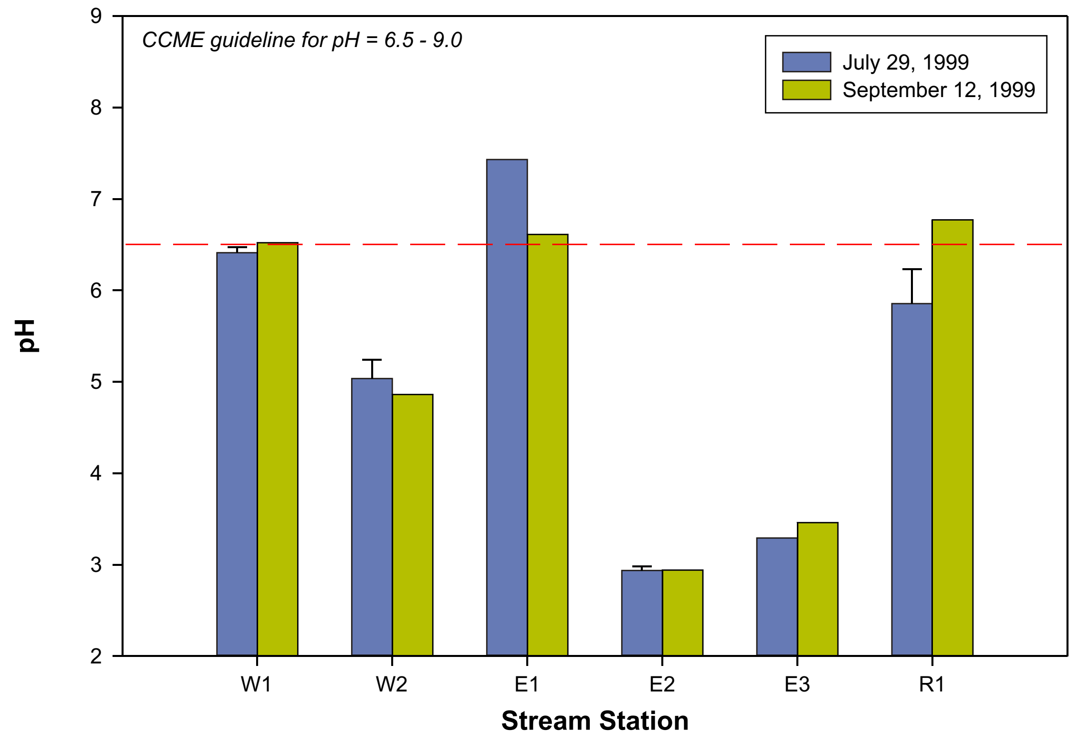
3.3.1 pH and Total Suspended Solids

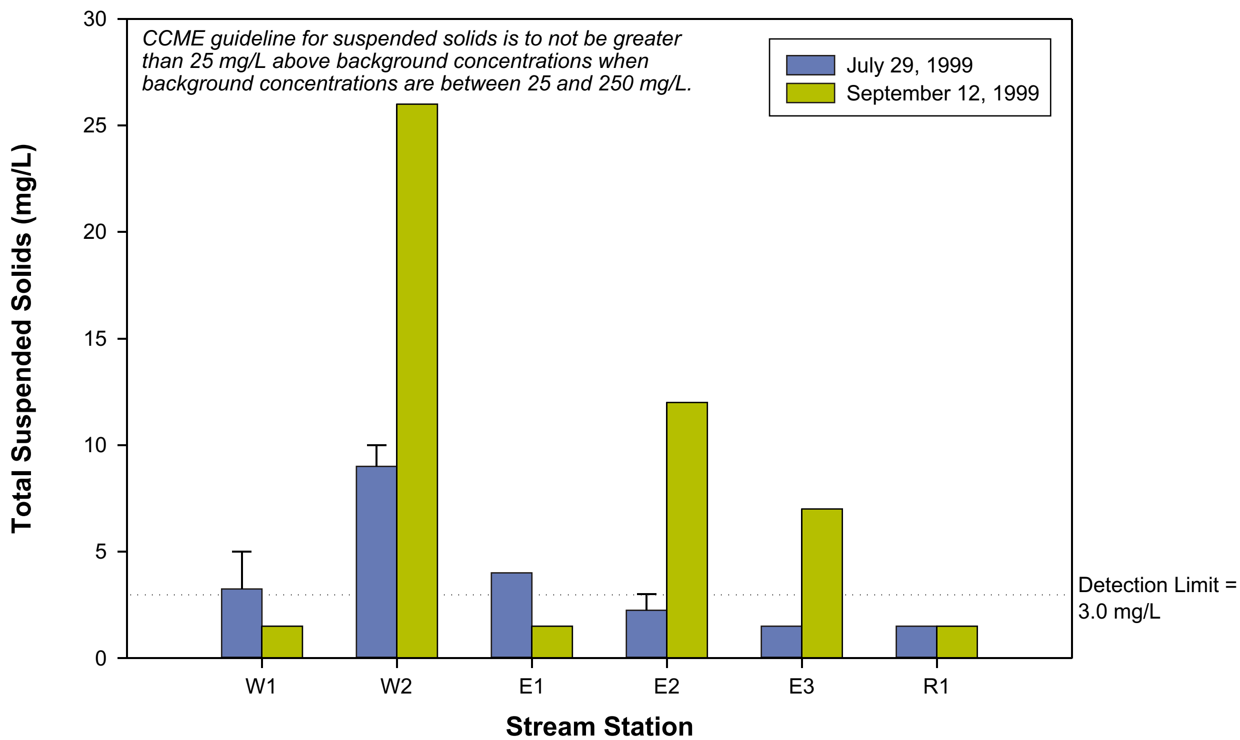
pH of stream water ranged from a low of 2.94 at station E2 in July and September to a high of 7.43 at station E1 in July (Figure 3.3-1). The values at stations W1, E1 and R1 are at or slightly below neutrality (pH = 7.0) and are typical of most pristine, northern streams. However, the low pH at station W2 and the extremely low pH of stations E2 and E3 (all values below 3.5) indicated the presence of nearby acid-generating sources. The concentrations of sulphate (SO_4)

Table 3.3-1
Concentrations for Select Stream Water Quality Parameters, Ferguson Lake Project Area, 1999

Station	Date	Hardness (as CaCO3) (mg/L)	pH	Total Suspended Solids (mg/L)	Turbidity (NTU)	Ammonia Nitrogen (mg/L)	Nitrate Nitrogen (mg/L)	Total Phosphate (mg/L)	Total Aluminum (mg/L)	Total Arsenic (mg/L)	Total Cadmium (mg/L)	Total Chromium (mg/L)	Total Cobalt (mg/L)	Total Copper (mg/L)	Total Iron (mg/L)	Total Lead (mg/L)	Total Manganese (mg/L)	Total Nickel (mg/L)	Total Zinc (mg/L)
Station	**CCME Guideline[1]**	***n/a***	***6.5-9.0***	***Stated[2]***	***Stated[3]***	***Stated[4]***	***Stated[5]***	***n/a***	***Stated[6]***	***0.005***	***0.000017***	***Stated[7]***	***n/a***	***0.002***	***0.3***	***0.001[a]***	***n/a***	***0.025***	***0.03***
W1 (Rep1)	28-Jul-99	10.1	6.35	<3	2.0	0.03	<0.005	0.012	0.111	0.0001	<0.00005	<0.0005	0.0001	0.0020	0.24	0.00008	0.00531	0.0018	<0.001
W1 (Rep 2)	28-Jul-99	10	6.47	5	2.1	0.02	<0.005	0.011	0.106	0.0001	<0.00005	<0.0005	0.0001	0.0019	0.21	0.00008	0.00521	0.0017	<0.001
W1 (Average)	28-Jul-99	10.05	6.41	3	2.1	0.02	<0.005	0.012	0.109	0.0001	<0.00005	<0.0005	0.0001	0.0020	0.23	0.00008	0.00526	0.0018	<0.001
W1	12-Sep-99	11.8	6.52	<3	2.2	0.03	0.005	0.010	0.115	0.0001	<0.00005	<0.0005	0.0001	0.0018	0.29	0.00011	0.00725	0.0018	0.001
W2 (Rep 1)	28-Jul-99	15.1	4.83	8	5.1	0.13	-	-	0.742	0.0001	<0.00005	0.0008	0.0310	0.1850	2.07	0.00007	0.02260	0.2470	0.006
W2 (Rep 2)	28-Jul-99	14	5.24	10	5.1	0.06	-	-	0.676	0.0001	<0.00005	0.0009	0.0322	0.1960	1.99	0.00010	0.02330	0.2590	0.006
W2 (Average)	28-Jul-99	14.55	5.04	9	5.1	0.10	-	-	0.709	0.0001	<0.00005	0.0009	0.0316	0.1905	2.03	0.00009	0.02295	0.2530	0.006
W2	12-Sep-99	26.4	4.86	26	24.8	0.04	<0.005	0.010	1.350	0.0002	<0.00005	0.0012	0.0551	0.1500	4.88	0.00014	0.05420	0.4810	0.007
E1	29-Jul-99	16.2	7.43	4	4.5	0.03	-	-	0.098	0.0002	<0.00005	<0.0005	0.0003	0.0024	1.02	0.00015	0.01610	0.0013	<0.001
E1	13-Sep-99	18.4	6.61	<3	5.4	0.03	0.006	0.015	0.064	0.0002	<0.00005	<0.0005	0.0003	0.0020	0.98	0.00009	0.01500	0.0017	<0.001
E2 (Rep 1)	29-Jul-99	95.1	2.89	3	0.4	0.07	<0.005	0.005	14.700	0.0004	0.00040	0.0156	0.8250	3.7400	22.30	0.00177	0.48900	6.1900	0.081
E2 (Rep 2)	29-Jul-99	101	2.98	<3	0.3	<0.08	<0.005	0.008	14.800	0.0005	0.00043	0.0159	0.8450	3.8000	23.80	0.00175	0.49600	6.3400	0.085
E2 (Average)	29-Jul-99	98.05	2.94	2	0.4	0.07	<0.005	0.007	14.750	0.0005	0.00042	0.0158	0.8350	3.7700	23.05	0.00176	0.49250	6.2650	0.083
E2	13-Sep-99	268	2.94	12	1.1	0.06	0.009	0.008	35.300	0.0012	0.00080	0.0300	2.3500	4.7700	144.00	0.00460	1.13000	18.2000	0.181
E3	29-Jul-99	56	3.29	<3	0.9	0.01	<0.005	0.007	8.600	0.0003	0.00016	0.0112	0.4170	1.5000	7.83	0.00055	0.30400	3.2400	0.043
E3	13-Sep-99	74.8	3.46	7	2.5	0.11	<0.005	0.004	9.090	0.0003	0.00014	0.0063	0.4290	0.7970	8.39	0.00054	0.38100	3.2500	0.041
R1 (Rep 1)	01-Aug-99	10.6	5.48	<3	6.3	0.01	<0.005	0.009	0.093	0.0001	<0.00005	<0.0005	0.0002	0.0025	0.29	0.00005	0.01110	0.0014	0.002
R1 (Rep 2)	01-Aug-99	10.4	6.23	<3	0.9	0.01	<0.005	0.009	0.091	0.0001	<0.00005	<0.0005	0.0001	0.0019	0.29	<0.00005	0.01070	0.0012	0.002
R1 (Average)	01-Aug-99	10.5	5.86	<3	3.6	0.01	<0.005	0.009	0.092	0.0001	<0.00005	<0.0005	0.0002	0.0022	0.29	0.00005	0.01090	0.0013	0.002
R1	13-Sep-99	12.9	6.77	<3	2.4	<0.02	0.005	0.012	0.093	0.0001	<0.00005	<0.0005	0.0002	0.0018	0.49	0.00007	0.02590	0.0014	0.001
Travel Blank	12-Sep-99	<0.05	5.50	<3	<0.1	-	<0.005	<0.002	<0.001	<0.0001	<0.00005	<0.0005	<0.0001	<0.0001	<0.03	<0.00005	<0.00005	<0.0001	<0.001

1: Guidelines are for the protection of freshwater aquatic life. Bolded values exceed CCME guidelines for that variable.
2: TSS is not to be greater than 25 mg/L above background concentrations.
3: Turbidity is not to be greater than 8 NTUs above background concentrations.
4: Guideline for total ammonia is pH and temperature dependent.
5: Nitrate concentrations that stimulate prolific weed growth should be avoided.
6: Guideline is pH dependent: 0.005 mg/L (pH<6.5) or 0.10 mg/L (pH>6.5).
7: Dependent upon species of chromium: 0.0010 mg/L for Cr (VI) and 0.0089 mg/L for Cr (III).
a: CCME guideline for lead increases with an increase in hardness. For E2 (July) and E3 (September) the lead guideline is 0.002 mg/L. For E2 (September) the lead guideline is 0.007 mg/L.
< = Less than the detection limit indicated.
n/a = guideline not available for that variable. Dashes indicate no data were available.
If a value was below the detection limit for one sampling period, one-half the detection limit was used for calculating the average.





Notes: Dashed line indicates pH relevant to CCME guideline for aluminum.
Error bars represent standard error of the mean.

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FIGURE 3.3-1

pH and Total Suspended Solids in Streams, Ferguson Lake Project Area, 1999

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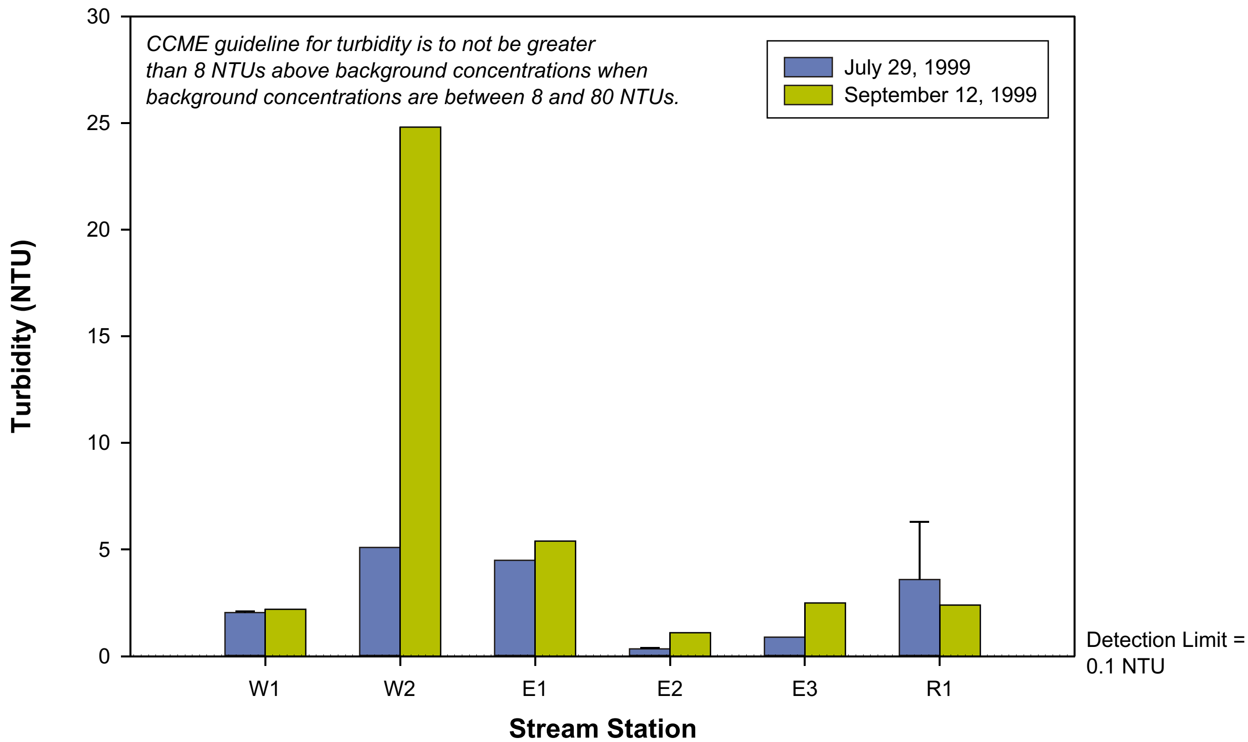

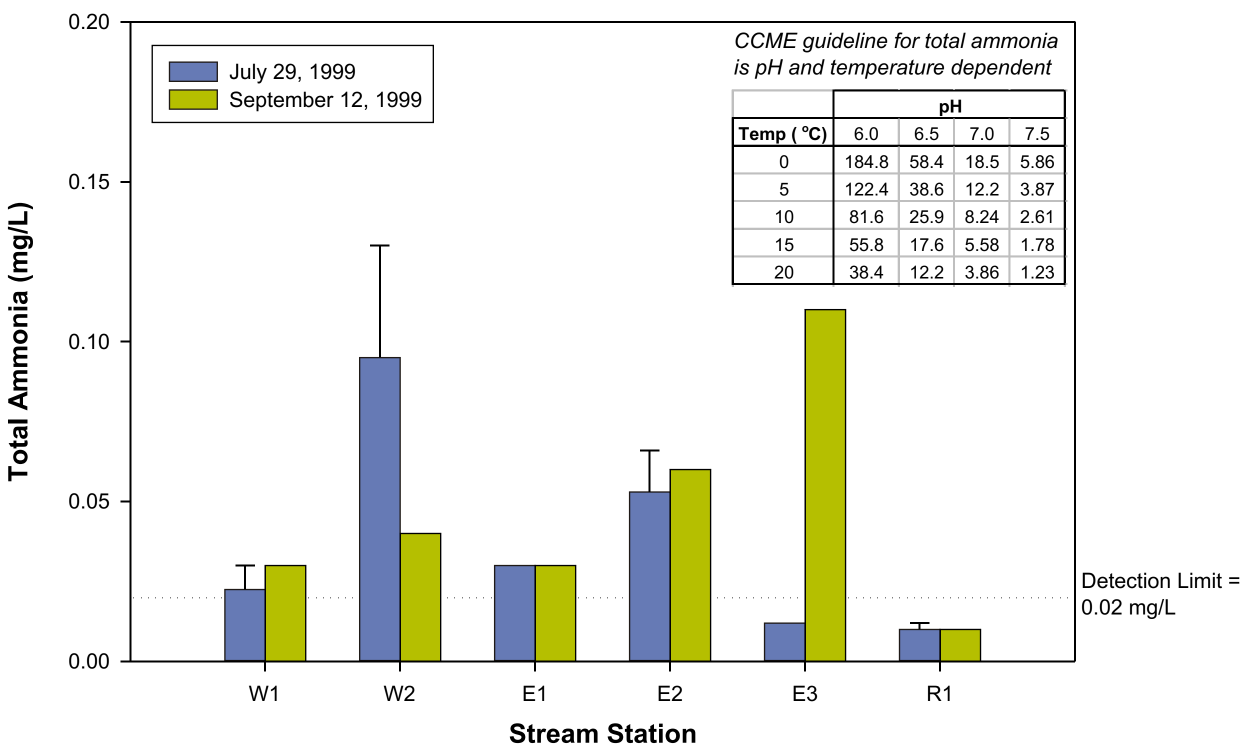

	pH			
Temp (°C)	6.0	6.5	7.0	7.5
0	184.8	58.4	18.5	5.86
5	122.4	38.6	12.2	3.87
10	81.6	25.9	8.24	2.61
15	55.8	17.6	5.58	1.78
20	38.4	12.2	3.86	1.23

Note: Error bars represent standard error of the mean.

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FIGURE 3.3-2

Turbidity and Total Ammonia in Streams, Ferguson Lake Project Area, 1999

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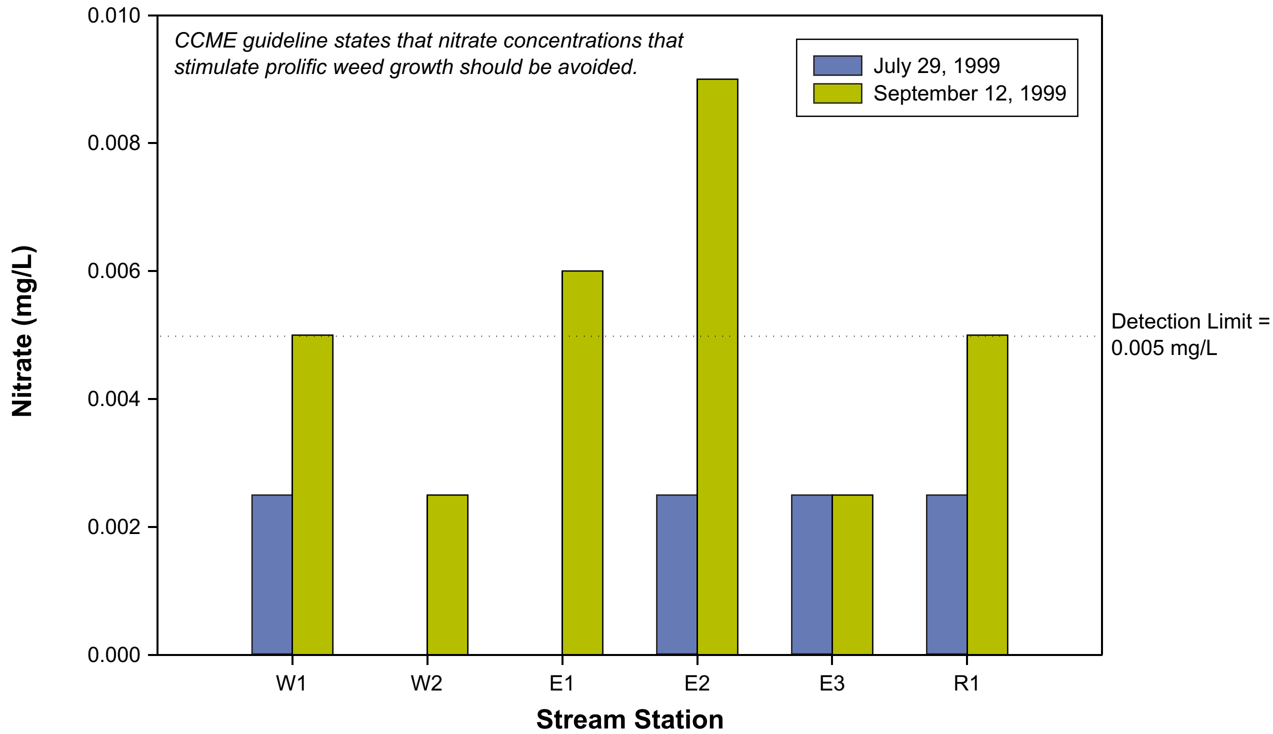

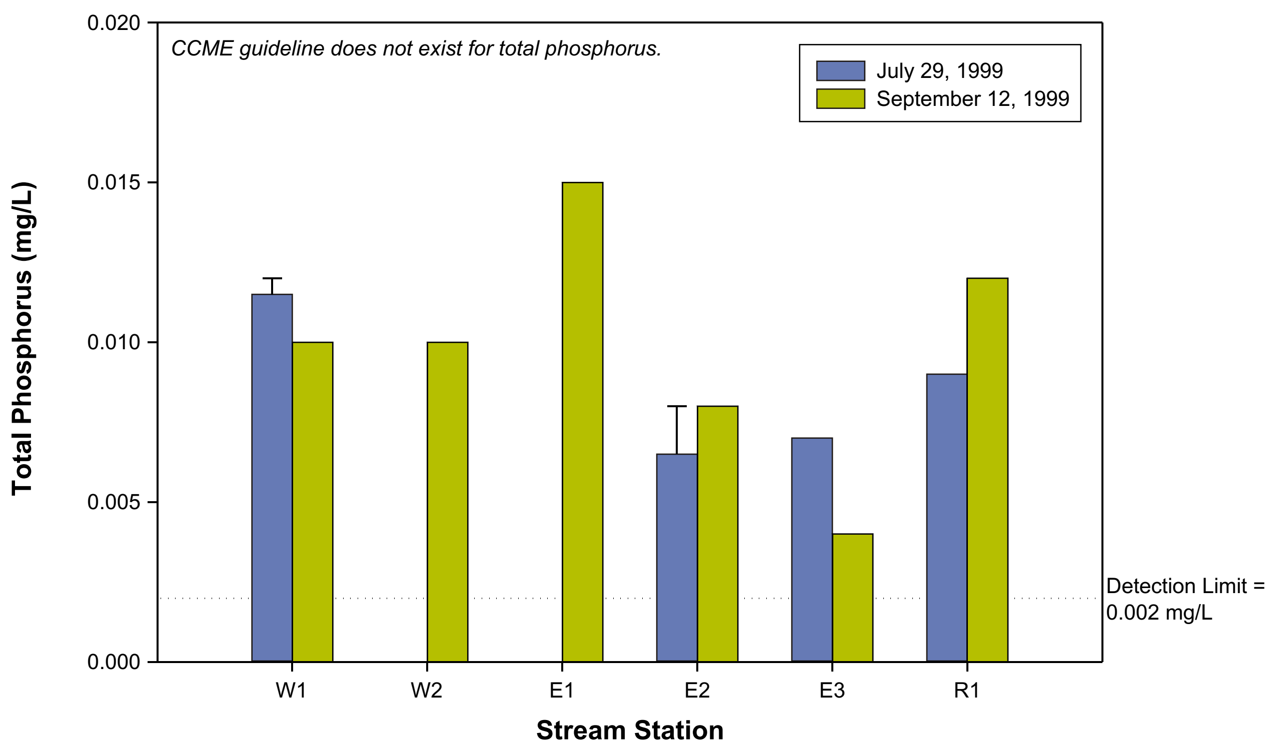

Note: Error bars represent standard error of the mean.

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FIGURE 3.3-3

Nitrate and Total Phosphorus in Streams, Ferguson Lake Project Area, 1999

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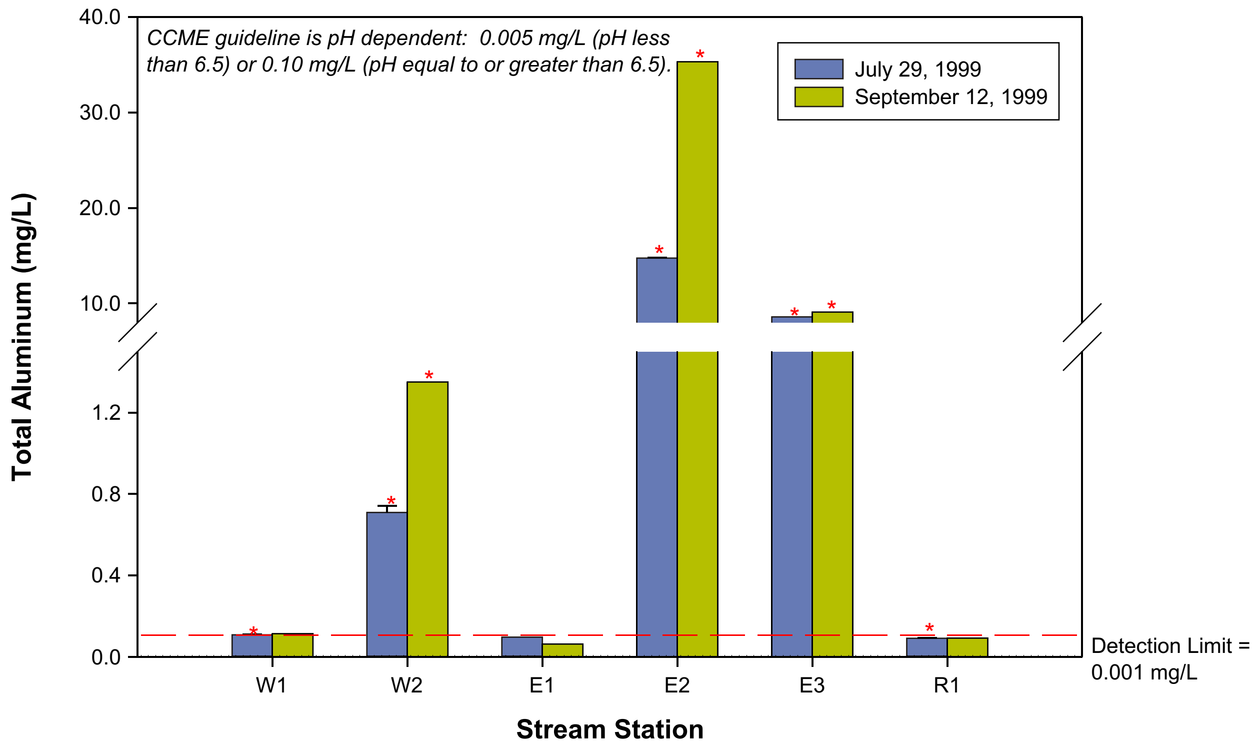

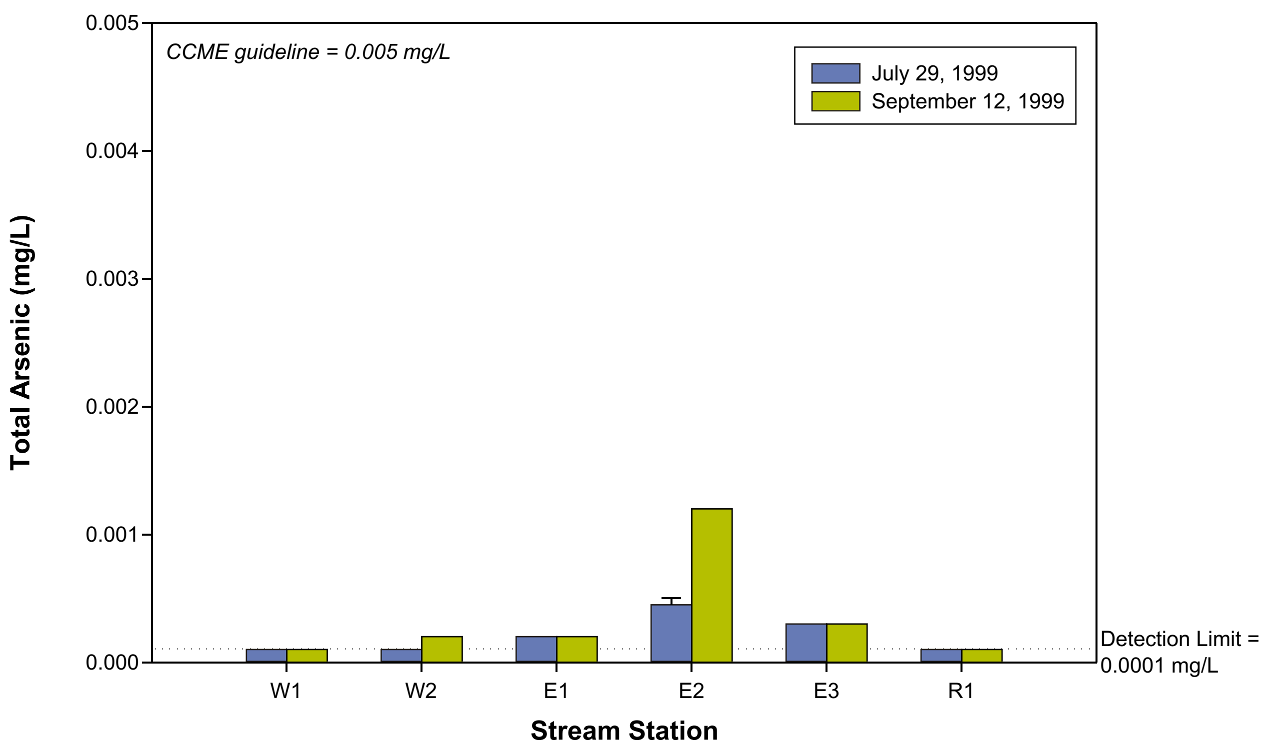

Notes: Dashed line indicates upper CCME guideline.
* *Indicates when average pH was below 6.5.*
Error bars represent standard error of the mean.

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FIGURE 3.3-4

Total Aluminum and Total Arsenic in Streams, Ferguson Lake Project Area, 1999

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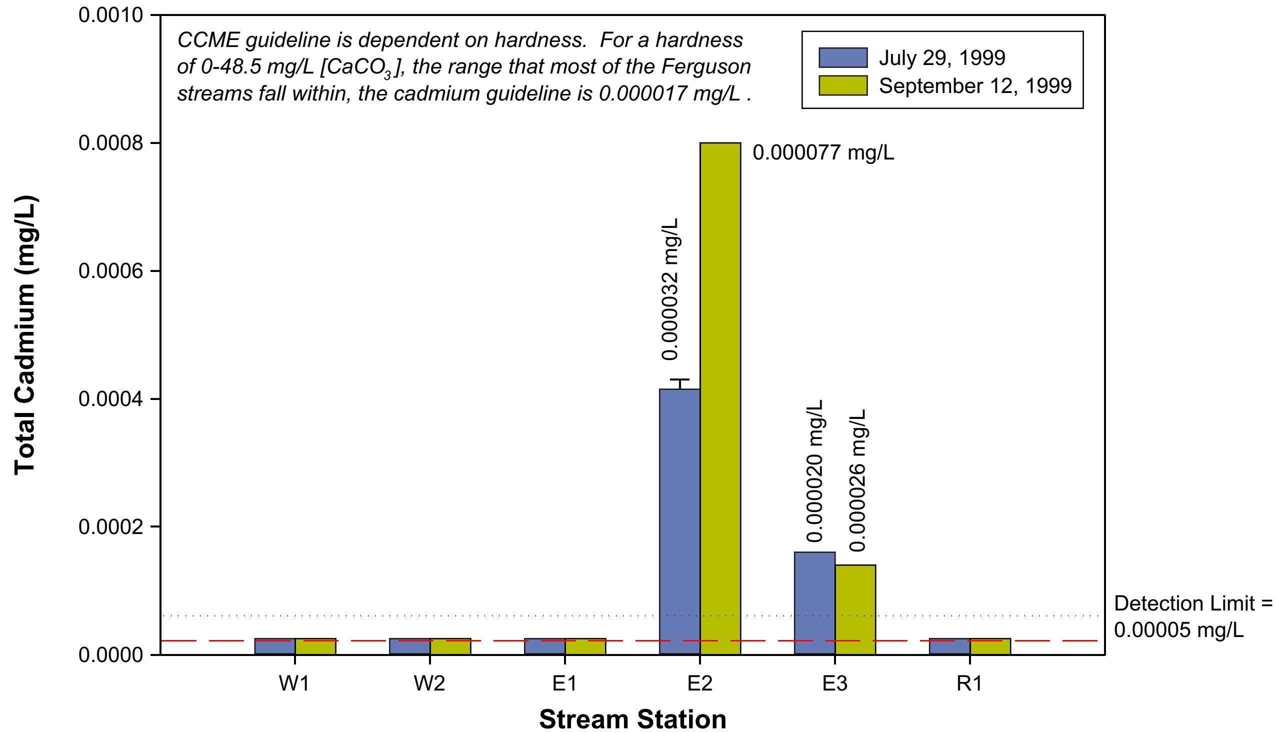
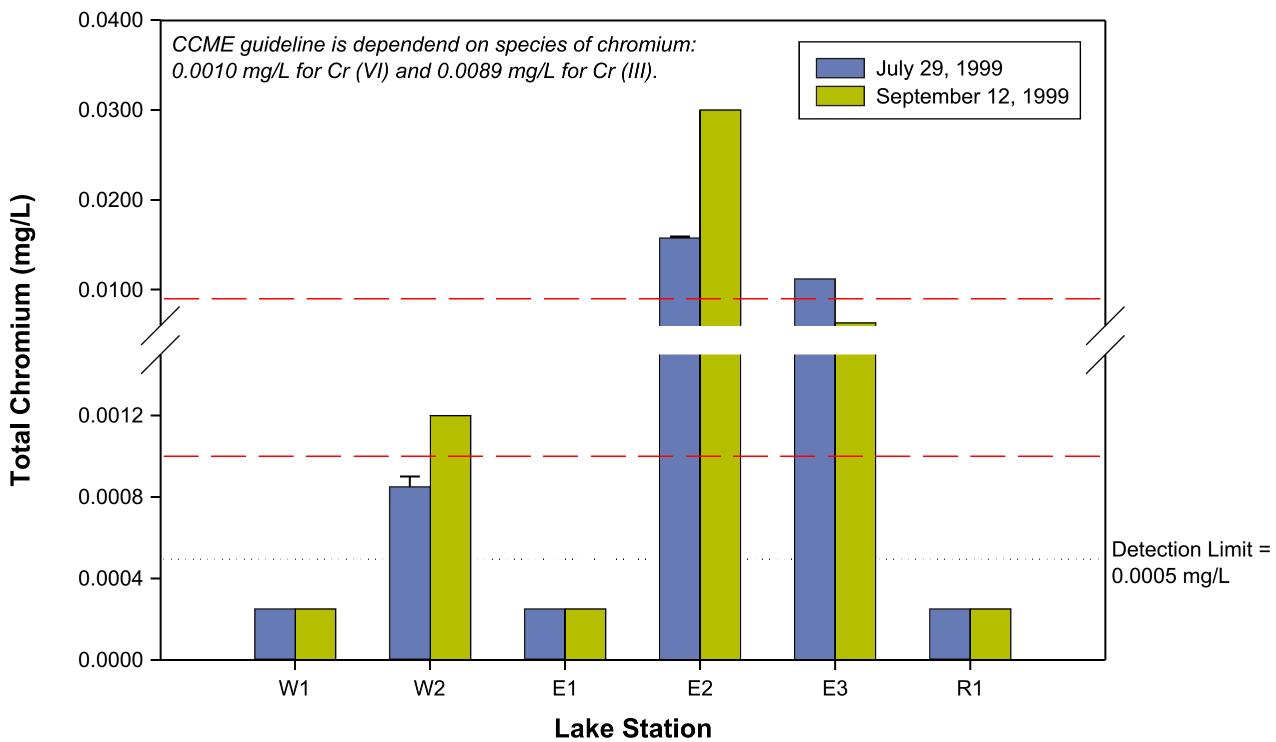


Note: Numbers above each bar indicate CCME guideline for cadmium with hardness > 48.5 mg/L.



Notes: Dashed line indicates CCME guideline.
Error bars represent standard error of the mean.

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FIGURE 3.3-5

Total Cadmium and Total Chromium in Streams, Ferguson Lake Project Area, 1999

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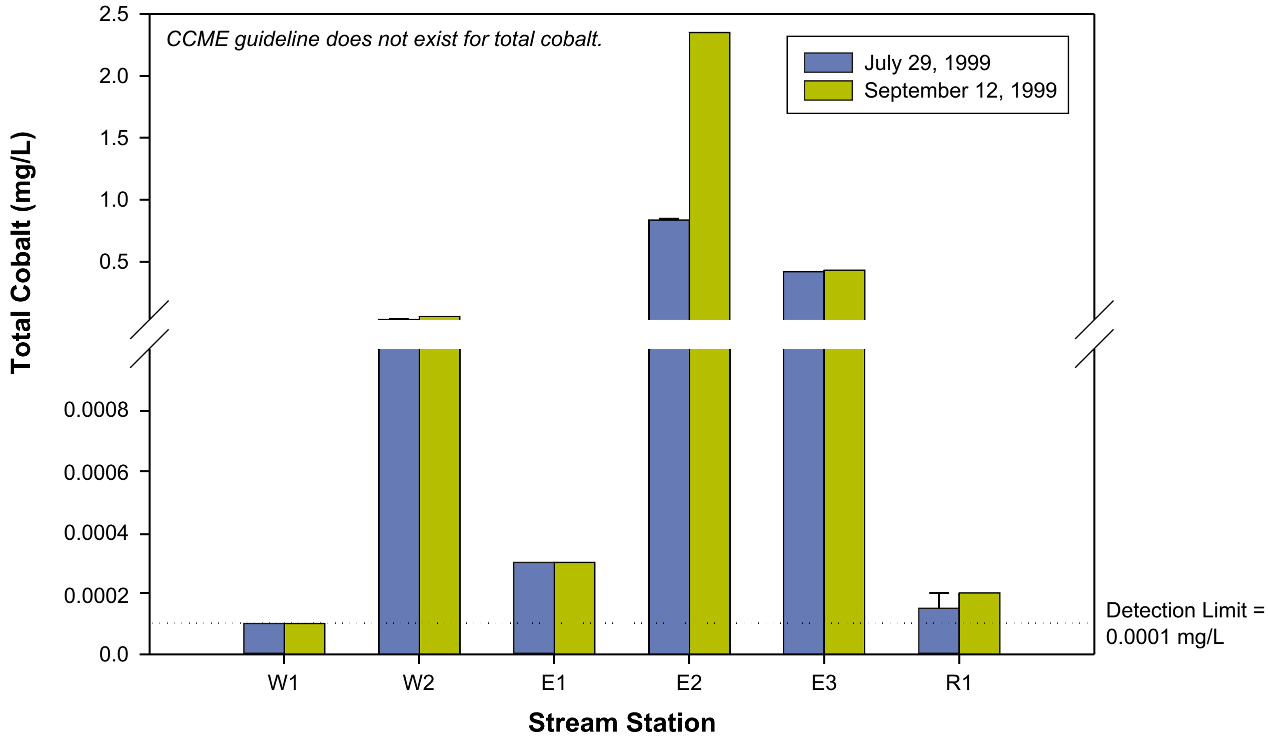

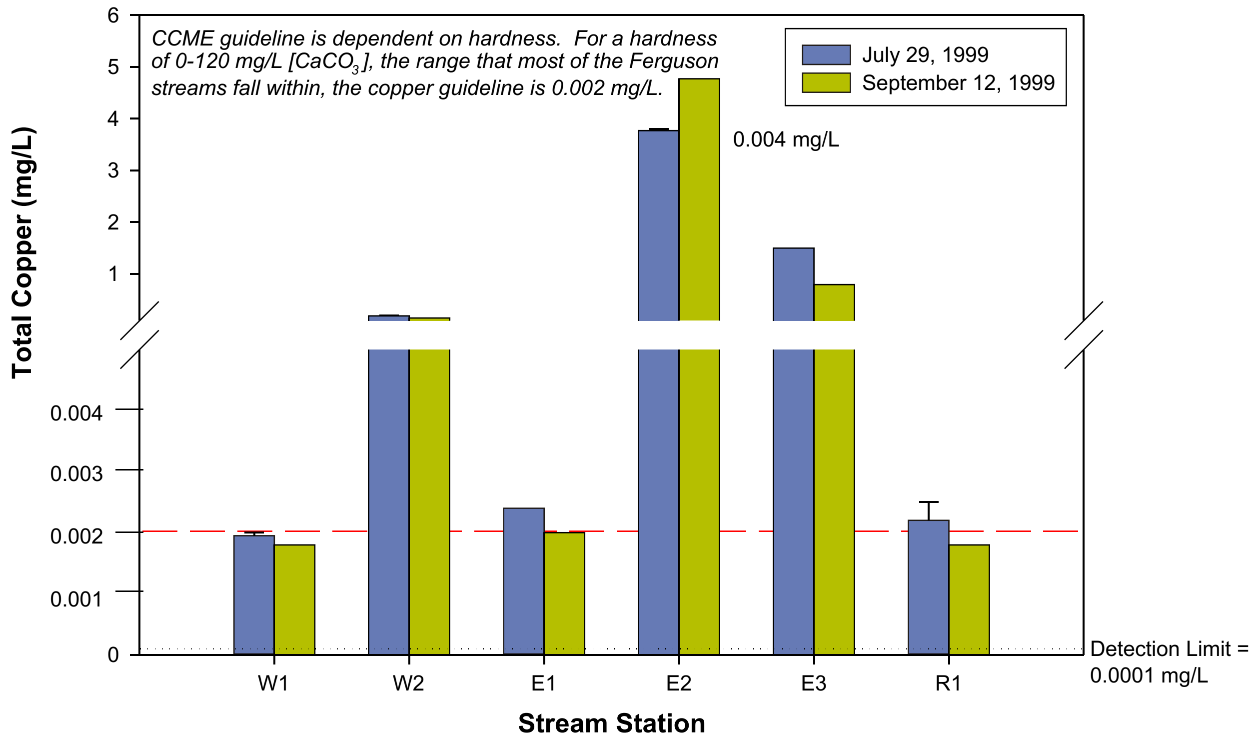

Notes: Dashed line indicates CCME guideline.
Error bars represent standard error of the mean.
Numbers above each bar indicate CCME guideline for copper with hardness > 120 mg/L.

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FIGURE 3.3-6

Total Cobalt and Total Copper in Streams, Ferguson Lake Project Area, 1999

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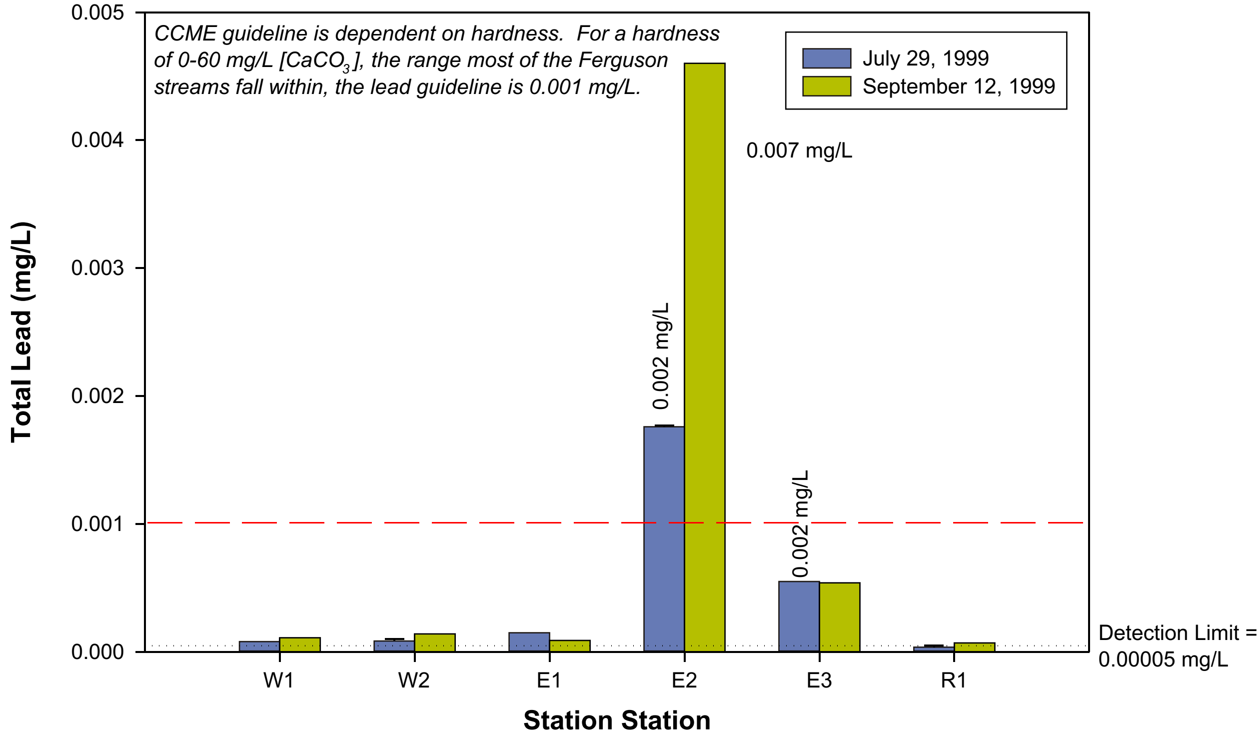
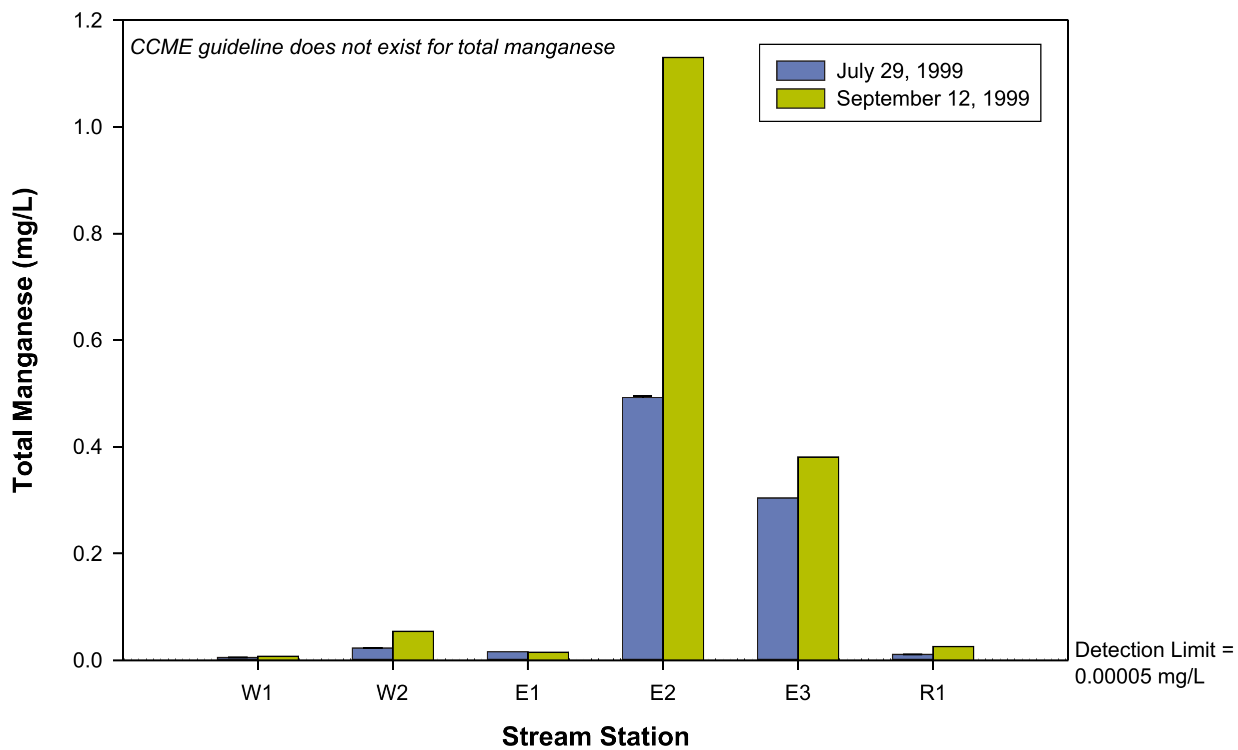


Note: Numbers above each bar indicate CCME guideline for lead with hardness > 60 mg/L.



Notes: Dashed line indicates CCME guideline.
Error bars represent standard error of the mean.

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FIGURE 3.3-7

Total Lead and Total Manganese in Streams, Ferguson Lake Project Area, 1999

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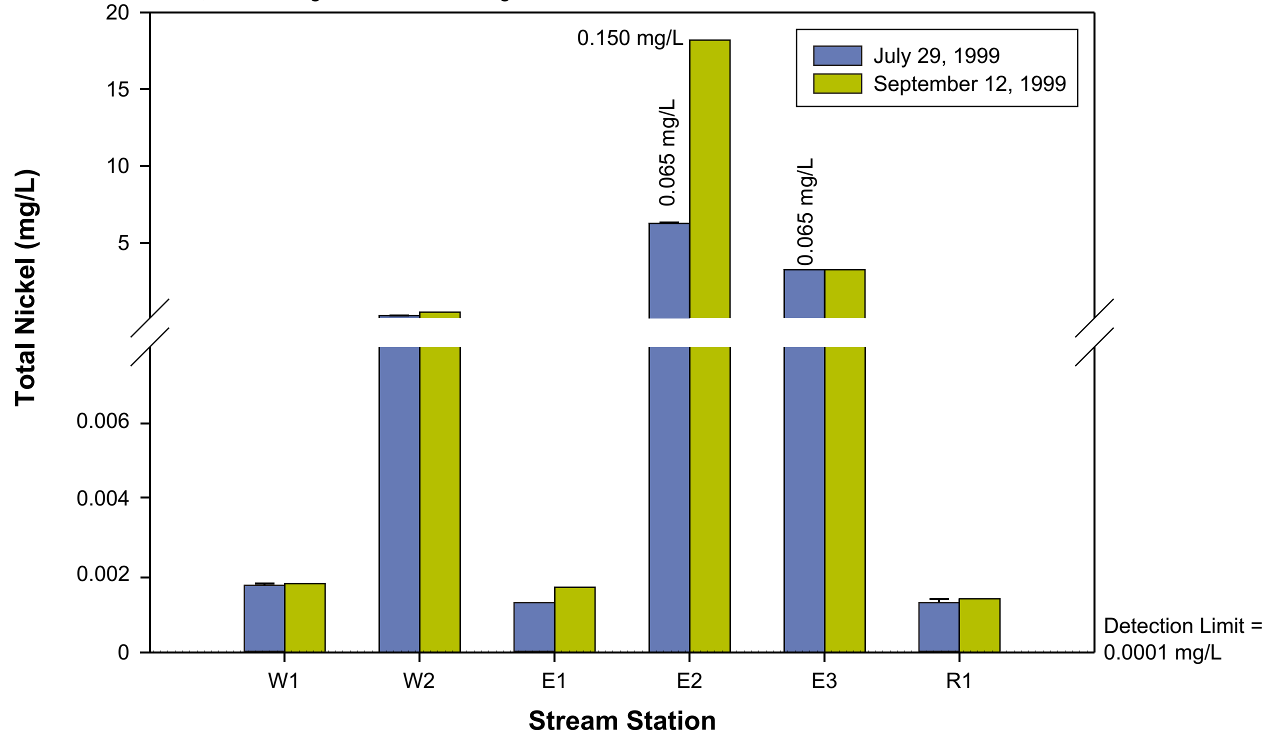
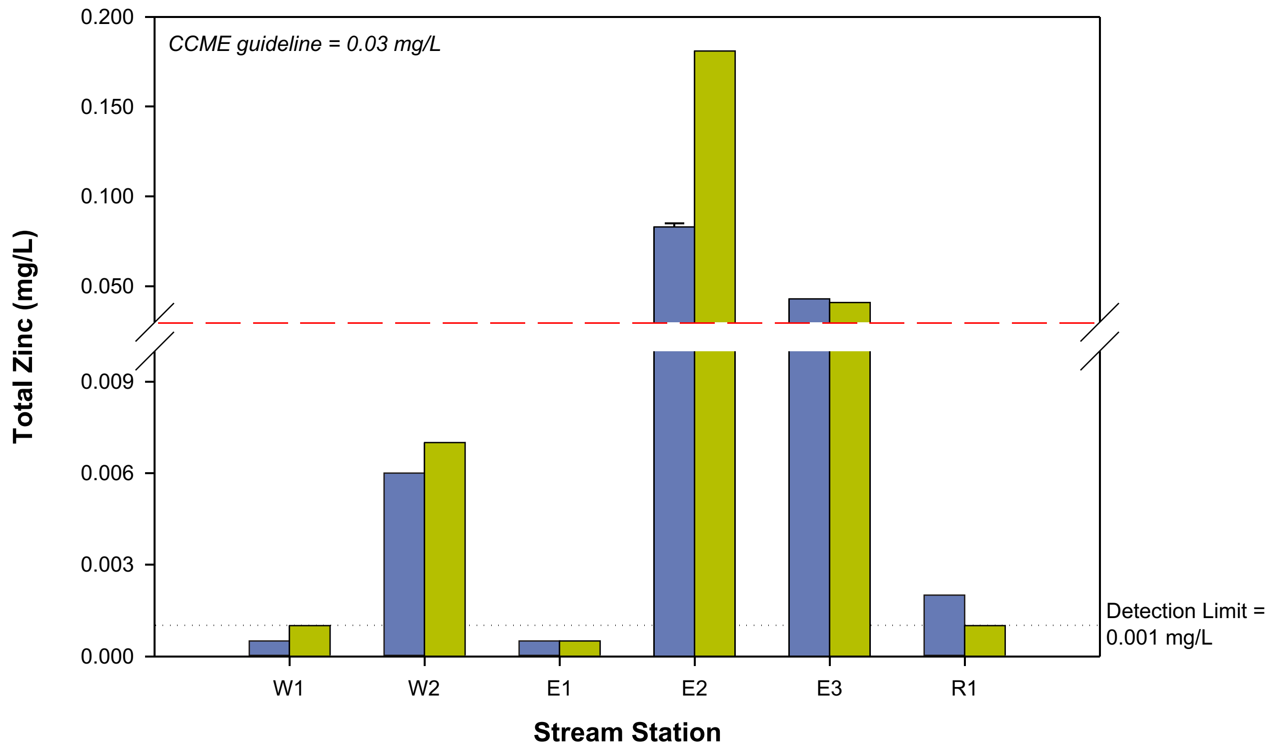
CCME guideline is dependent on hardness. For a hardness of 0-60 mg/L [$CaCO_3$], the range that Ferguson streams fall within, the nickel guideline is 0.025 mg/L.



Note: Numbers above each bar indicate CCME guideline for nickel with hardness > 60 mg/L.



Notes: Dashed line indicates CCME guideline.
Error bars represent standard error of the mean.

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FIGURE 3.3-8

Total Nickel and Total Zinc in Streams, Ferguson Lake Project Area, 1999

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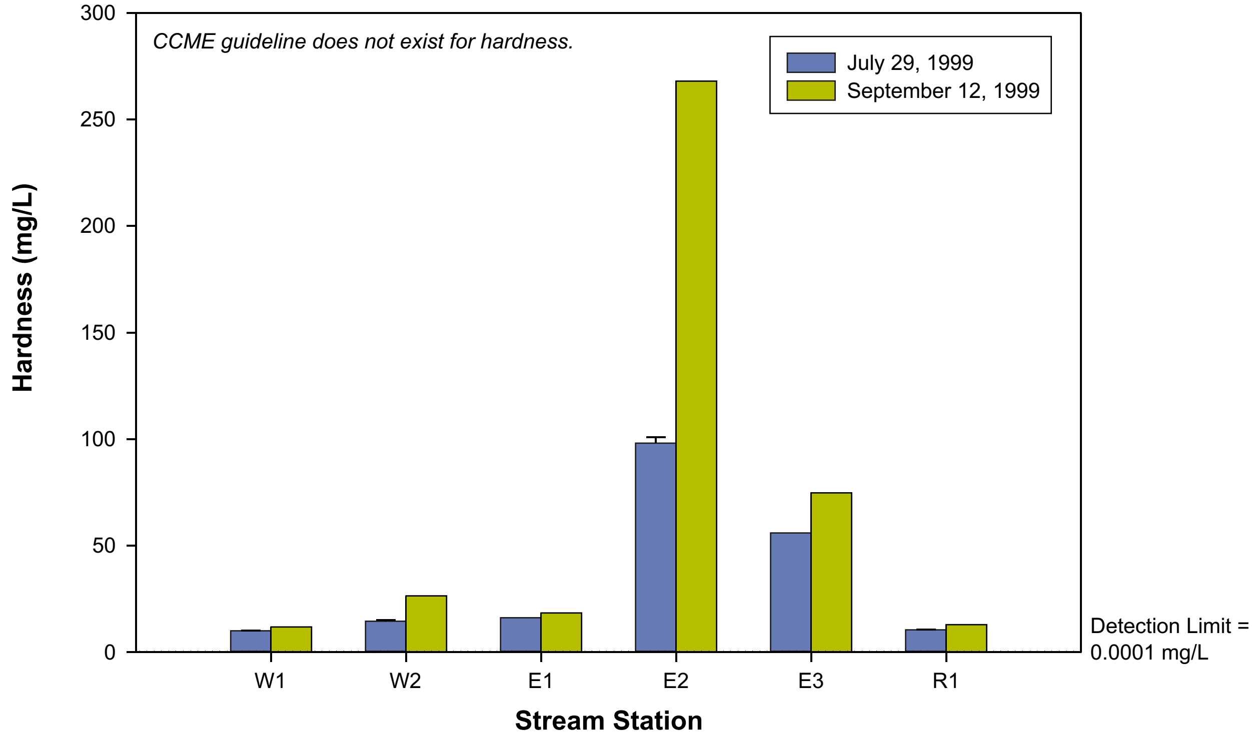

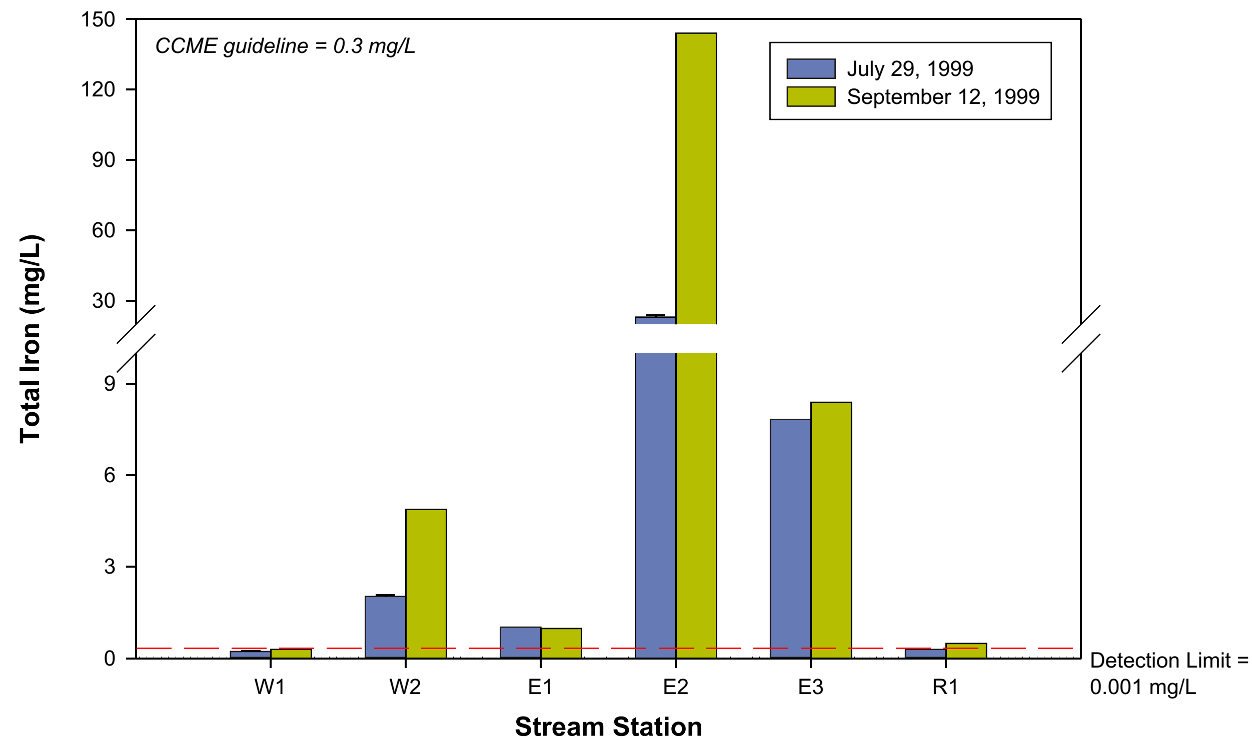

Notes: Dashed line indicates CCME guideline.
Error bars represent standard error of the mean.

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FIGURE 3.3-9

Hardness and Total Iron in Streams, Ferguson Lake Project Area, 1999

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measured in September, 1999 (see Appendix 3.3-1), were two orders of magnitude higher at stations E2 and E3 (170 to 636 mg/L) than at the other four stations (range = 2 to 27 mg/l), further indicating the presence of acid-generating rock in the watersheds of streams E2 and E3.

The acid-generating source is the massive sulphide deposit that contains the Platinum Group Metals targeted by Starfield's exploration efforts. Plate 3.3-1 shows acid-generating surface rock near stream E2, and Plates 3.3-2 and 3.3-3 show acid-generating surface rock of the western mineralised zone close to stream W2.

Plate 3.3-1 Acid-generating surface rock near stream E2, photographed in July 1999

TSS was low at most stream stations, ranging from below the analytical detection limit of 3 mg/L to a high of 26 mg/L at station W2 in September (Figure 3.3-1). TSS was elevated at W2 in both July and September, indicating that this is a natural condition for that stream and was not the result of disturbance by the sampler. All TSS values were

3.3.2 Turbidity and Ammonia

As expected from the TSS concentrations, turbidity ranged from 0.4 NTU at stream E2 in July to 24.8 NTU at W2 in September (Figure 3.3-2). All values were above the detection limit, and only the September W2 turbidity value exceeded the CCME guideline of 8 NTUs above background concentration.

Plate 3.3-2 Acid-generating surface rock of the western mineralised zone near stream W2, photographed in July 1999

Plate 3.3-3 Acid-generating surface rock of the western mineralised zone (UTM co-ordinates: 72700 Northing and 604200 Easting). The disturbed surface was caused by bulk sampling in the 1950s

Concentrations of total ammonia ranged from below the detection limit of 0.02 mg/L at several sites to a high of 0.11 mg/L at stream E3 in September (Figure 3.3-2). Values were slightly elevated at W2 in July and at E3 in September, but were otherwise similar among stations. All values were well below the CCME guideline.

3.3.3 Nitrate and Total Phosphorus

Nitrate concentrations in streams ranged from below the detection limit of 0.005 mg/L at several stations to 0.009 mg/L at station E2 in September (Figure 3.3-3). Nitrate concentrations were generally low at all sites and dates. Total phosphorus concentrations ranged from 0.004 mg/L at station E3 in September to 0.015 mg/L at station E1 in September, and were similar among stations and between dates. As with the lake stations, nutrient concentrations in the streams were low, which is typical of northern, oligotrophic waterbodies.

3.3.4 Total Aluminum and Total Arsenic

Aluminum concentrations varied over three orders of magnitude from a low of 0.064 mg/L in stream E1 in September to a high of 35.300 mg/L in stream E2 in September (Figure 3.3-4). The July and September aluminum concentrations at stations W2, E2 and E3 were significantly higher than those of all other stations. The majority of stations had aluminum concentrations in July and September that exceeded the CCME guideline of 0.005 mg/L at pH less than 6.5, or even the higher guideline of 0.10 mg/L at pH greater than 6.5.

These results are similar to those for the lake stations. Since the streams were undisturbed at the time of sampling, these elevated concentrations of aluminum are natural occurrences for these streams. High concentrations of aluminum are linked to low pH and are not unusual for pristine northern waterbodies.

Total arsenic concentrations ranged from 0.0001 mg/L at several stations to 0.0012 mg/L at E2 in September (Figure 3.3-4). With the exception of E2, arsenic concentrations were similar among all streams sampled. All total arsenic values were well below the CCME guideline of 0.005 mg/L.

3.3.5 Total Cadmium and Total Chromium

Total cadmium concentrations were below the detection limit of 0.00005 mg/L at all stations except for E2 and E3, where concentrations ranged from 0.00014 to 0.00080 mg/L, well above the CCME guideline of 0.000017 mg/L (Figure 3.3-5). Total chromium concentrations were also below the detection limit of 0.0005 mg/L at most stations except W2, E2 and E3. Concentrations at these stations ranged from a low of 0.0009 mg/L at W2 in July to a high of 0.0300 mg/L at E2 in September. Only the values for E2 in July and September and E3 in July exceeded the CCME guideline of 0.0089 mg/L for the Cr (III) species.

3.3.6 Total Cobalt and Total Copper

As with other water quality variables, total cobalt was low at stations W1, E1 and R1, but substantially higher at stations W2, E2 and E3 (Figure 3.3-6). No CCME guideline exists for cobalt. Similarly, concentrations of total copper were lower at stations W1, E1 and R1, but elevated at W2, E2 and E3. A large number of total copper concentrations were above the CCME guideline of 0.002 mg/L, including July values at stations E1 and R1.

3.3.7 Total Lead and Total Manganese

Total lead concentrations ranged from below the detection limit of 0.00005 mg/L at station R1 in August to 0.00460 mg/L at station E2 in September (Figure 3.3-7). All lead concentrations were well below the CCME guideline. Total manganese concentrations ranged from 0.00521 mg/L at station W1 in July to 1.13000 mg/L at station E2 in September. As with the Ferguson Lake samples, total manganese concentrations were slightly higher in September than in July.

3.3.8 Total Nickel and Total Zinc

Total nickel concentrations ranged from 0.0012 mg/L at station R1 in August to 18.2000 mg/L at station E2 in September (Figure 3.3-8). All values were below the CCME guideline for nickel except for those from stations W2, E2 and E3.

Total zinc concentrations ranged from below the detection limit of 0.001 mg/L at several stations to 0.181 mg/L at station E2 in September (Figure 3.3-8). With the exception of E2 and E3 stations, all zinc values were below the CCME guideline of 0.03 mg/L.

3.3.9 Hardness and Total Iron

Stations E2 and E3 showed elevated water hardness compared to the other four stream stations (Figure 3.3-9). There are no CCME guidelines for water hardness. Stations E2 and E3 also showed elevated concentrations of total iron compared to the other stations. All stations except W1 in both July and September and R1 in August had total iron concentrations that were above the CCME guideline of 0.3 mg/L.

3.3.10 Stream Water Quality Summary

Streams W1, E1 and R1 are typical northern streams with low pH, low TSS, low turbidity, very low nutrient concentrations and generally low metal concentrations. In contrast, streams W2, E2 and E3 have much lower pH and higher metal concentrations, indicating the presence of natural acid rock drainage into these streams from local surface sulphide deposits.

3.4 Lake Sediment Quality

Appendix 3.4-1 describes the lake sediments collected in the September survey, and Appendix 3.4-2 shows the chemical composition (nutrients and metals) and particle size distribution (clay, silt, sand and gravel) of the sediments. Figures 3.4-1 to 3.4-9 compare the nutrient and metals concentrations of Ferguson Lake sediments with analytical detection limits and the Canadian sediment quality guidelines (SQG) (CCME, 1999). The SQG are guidelines only and are not legal limits. They can only be interpreted when placed into context with other, supporting information.

3.4.1 Lake Sediment Description

In general, the Ferguson Lake sediments consisted of a brown organic layer 0.5 to 1.0 cm deep overlying a silt or clay layer. The colour of the top layer was light brown (5YR 6/4), while the colours of lower layers were predominantly moderate brown (10YR 5/4). Insect casings were observed in all sediment samples, but no other patterns were observed.

3.4.2 Nutrients

The percent of sediments made of total organic carbon (TOC) ranged from 0.19% at station L5 to 3.34% at station L1 (Table 3.4-1 and Figure 3.4-1). Stations L1 and L4 had the highest TOC values compared to the other stations. Available phosphorus concentrations ranged from 15 mg/kg at stations L2 and L4 to 180 mg/kg at station L1 (Table 3.4-1 and Figure 3.4-2). Although the highest concentration occurred at the deepest station, no clear trend with lake depth was apparent. Total nitrogen values in the lake stations ranged from 0.04% at station L5 to 0.36% at station L1. No clear differences in percent total nitrogen were observed among station depths.

Table 3.4-1
Nutrient Concentrations for Lake Sediment Quality, Ferguson Lake Project Area, 1999

Sample ID:		L1	L2	L3	L4	L5
Date Sampled:		12-Sep-99	12-Sep-99	11-Sep-99	12-Sep-99	11-Sep-99
Depth:		34.5 m	3.9 m	7.5 m	11.4 m	24.4 m
Variable	Units					
Total Organic Carbon	%	3.34	0.9	1.15	2.38	0.19
Available Phosphorus	mg/kg	180	15	46	15	22
Total Nitrogen	%	0.36	0.07	0.11	0.31	0.04

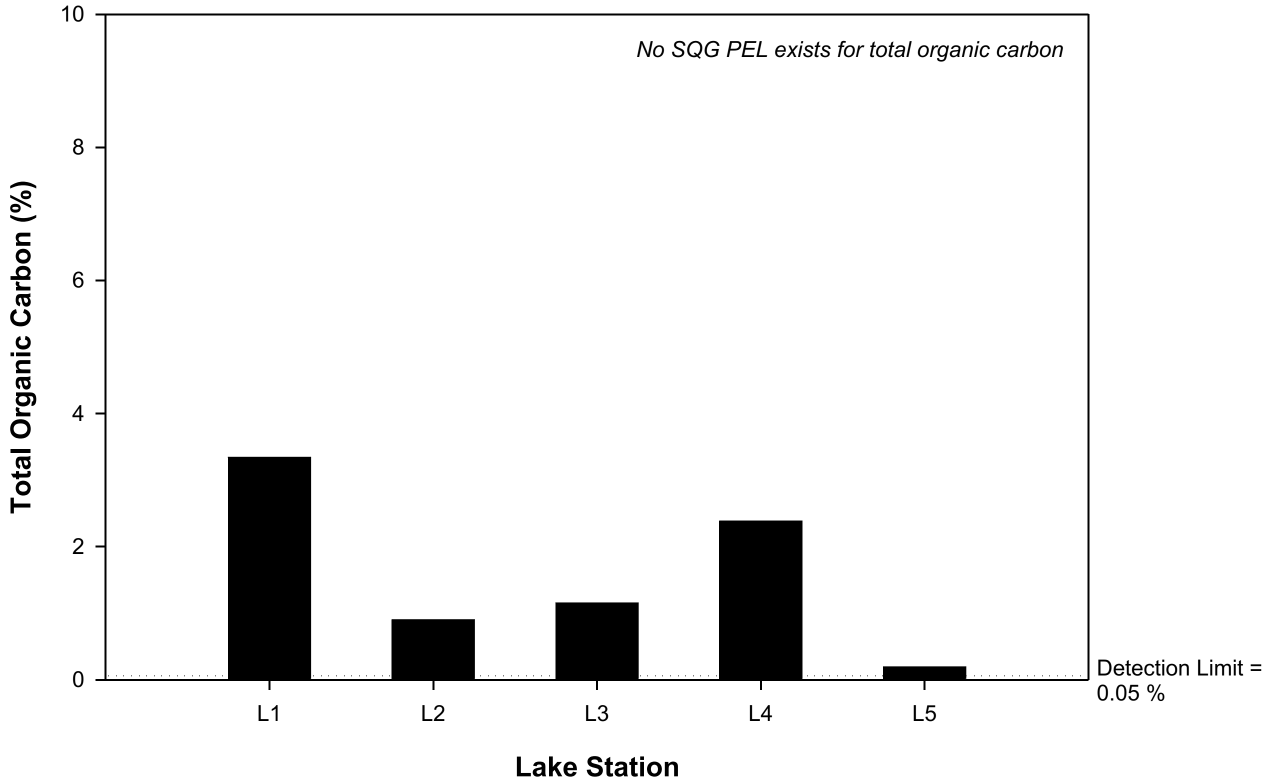
Notes: Results are expressed on a dry weight basis.
< = Less than the detection limit indicated.

3.4.3 Total Metals

The metals discussed in Sections 3.4.3.1 to 3.4.3.5 below were selected because they have known toxic biological effects, are known to be naturally elevated in the Arctic environment or they exhibited distinct variation among stations or depths in Ferguson Lake.

3.4.3.1 Aluminum and Arsenic

Aluminum concentrations in lake sediments ranged from 8,580 mg/kg at station L2 to 25,800 mg/kg at station L1 (Table 3.4-2 and Figure 3.4-3). Aluminum concentrations were higher at deep depths (>10.0 m) compared to both shallow (0.0 to 5.0 m) and middle (5.1-10.0 m) depths. There is no SQG Probable Effects Level (PEL) for aluminum. Arsenic concentrations ranged from 1.4 mg/kg at station L3 to 5.1 mg/kg at station L4. All arsenic values were well below the SQG PEL of 17.0 mg/kg.



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Total Organic Carbon (TOC) in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-1

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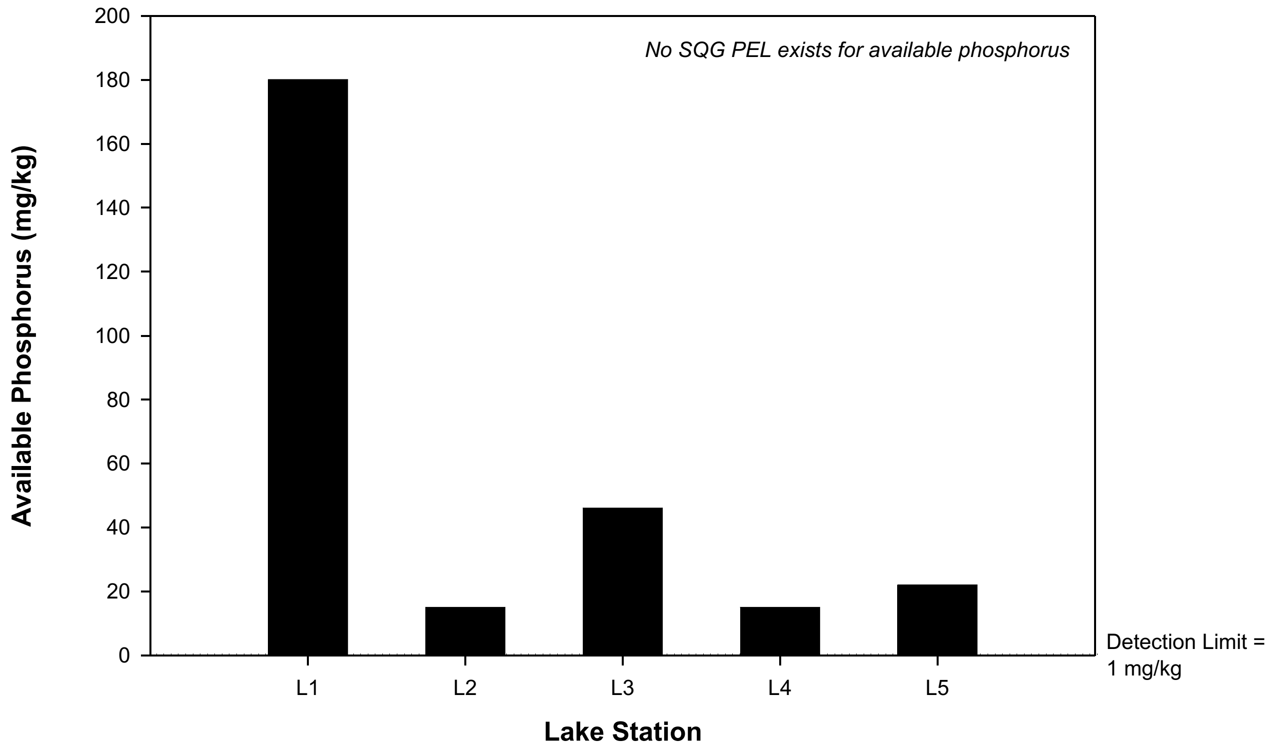

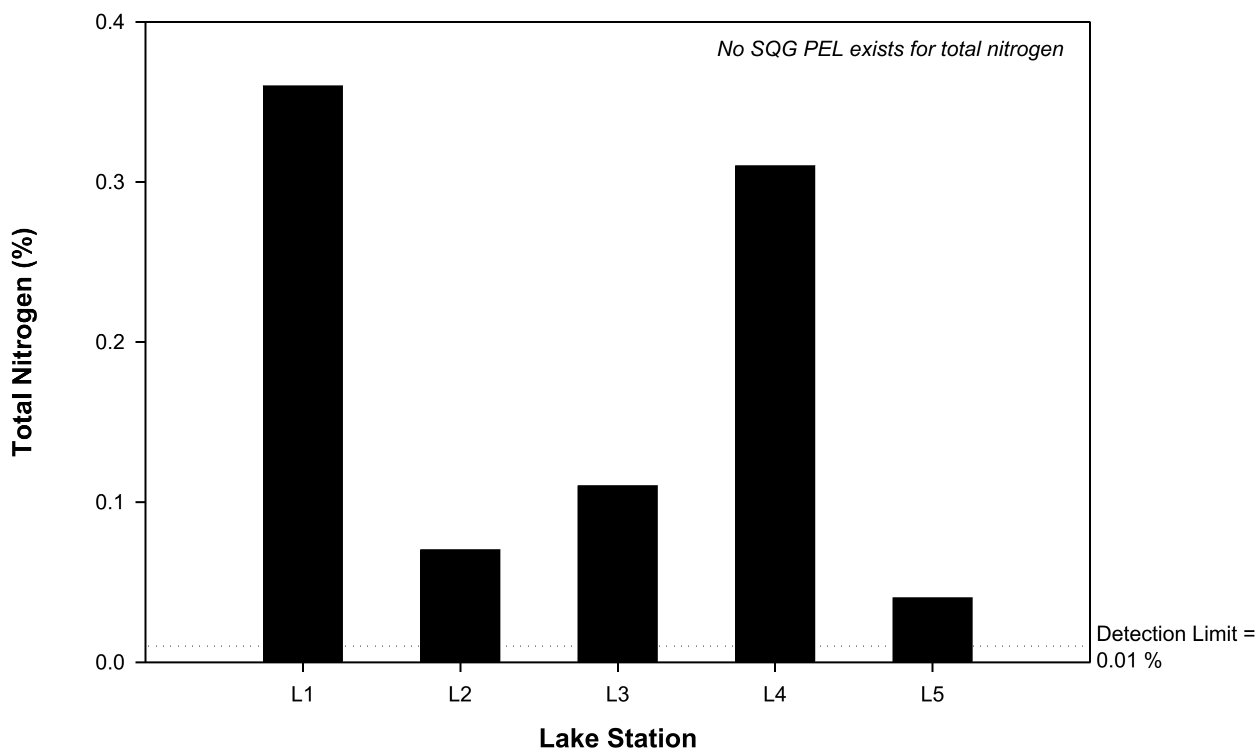

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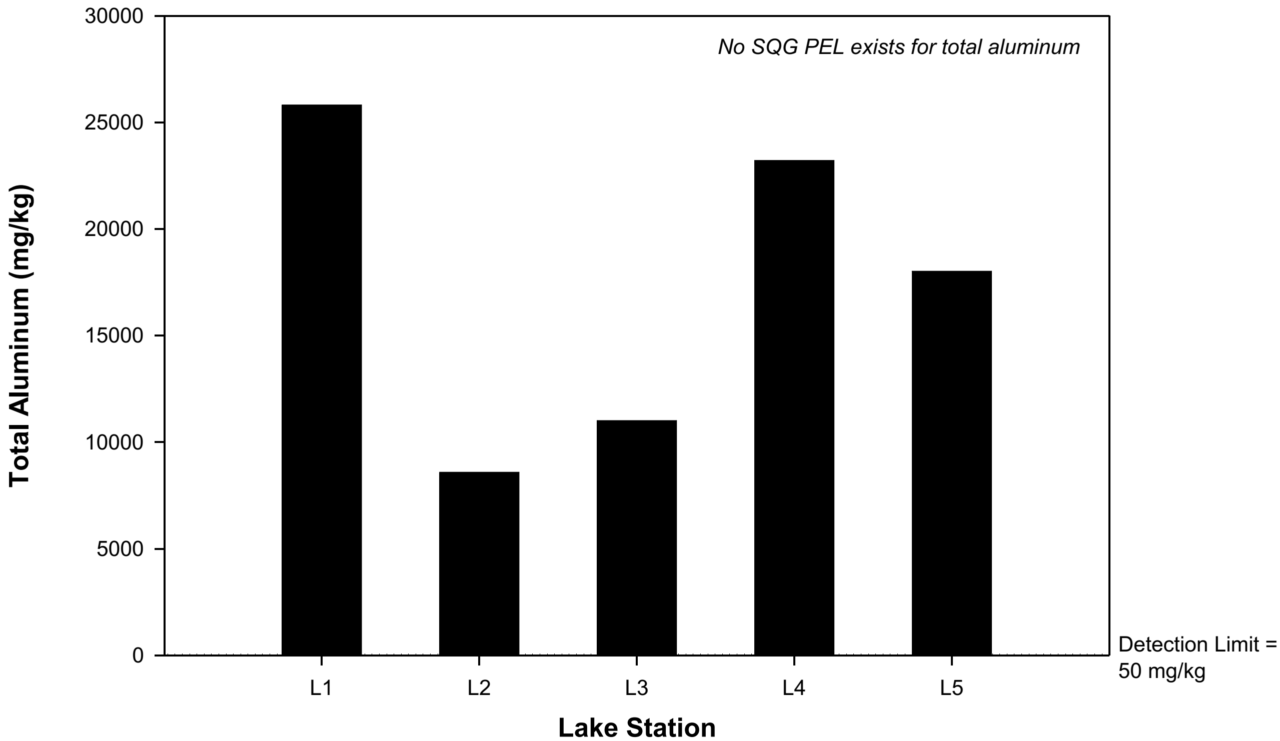
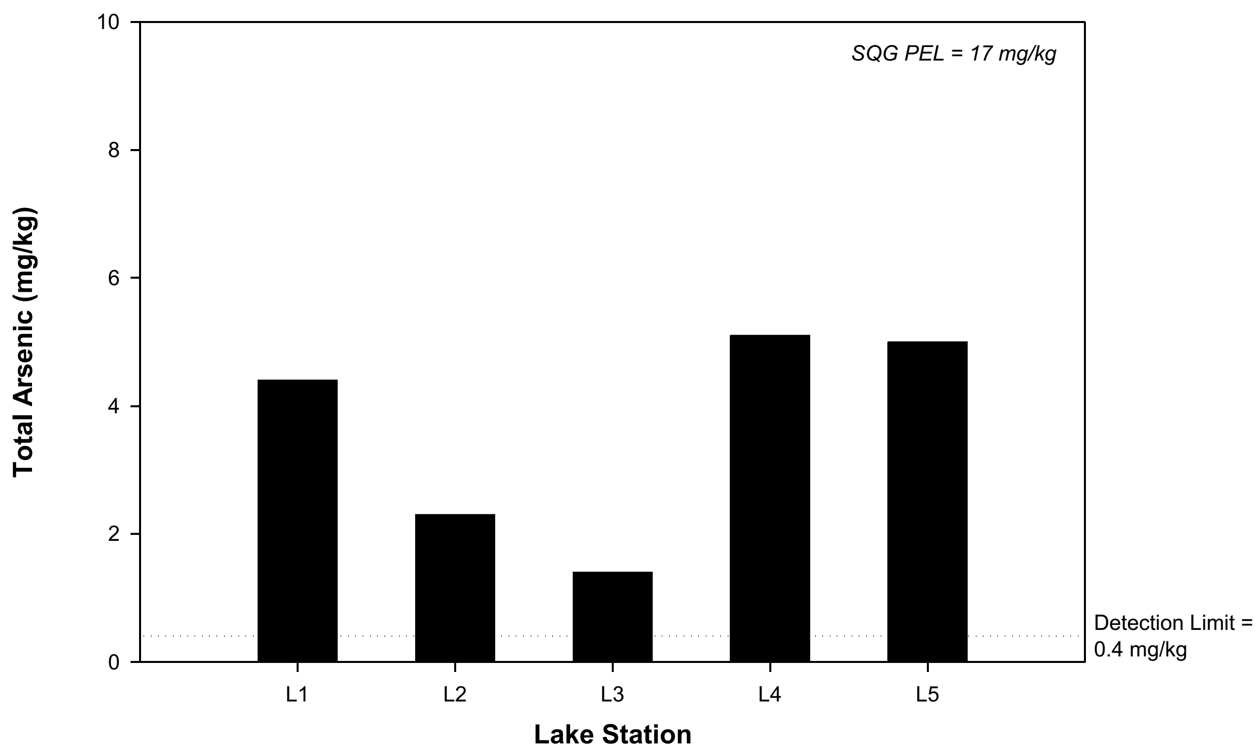
Available Phosphorus and Total Nitrogen in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-2

Rescan™





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Total Aluminum and Total Arsenic in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-3

Rescan™

Table 3.4-2
Total Metal Lake Sediment Concentrations with Canadian Sediment Quality Guidelines, Ferguson Lake Project Area, 1999

Station:		**L1**	**L2**	**L3**	**L4**	**L5**		
Date:		**12-Sep-99**	**12-Sep-99**	**11-Sep-99**	**12-Sep-99**	**11-Sep-99**	***SQG***	
Depth:		**34.5 m**	**3.9 m**	**7.5 m**	**11.4 m**	**24.4 m**	***ISQG***	***PEL***
Metal	Units							
Aluminum	Mg/kg	25,800	8,580	11,000	23,200	18,000	-	-
Arsenic	Mg/kg	4.4	2.3	1.4	5.1	5.0	*5.9*	*17*
Cadmium	Mg/kg	0.2	<0.1	<0.1	0.5	<0.1	*0.6*	*3.5*
Chromium	Mg/kg	56	19	25	46	36	*37.3*	*90*
Cobalt	Mg/kg	12	11	8	29	7	-	-
Copper	Mg/kg	35	12	31	29	11	*35.7*	*197*
Iron	Mg/kg	33,500	18,200	12,700	40,200	21,100	-	-
Manganese	Mg/kg	671	1,590	214	7,020	424	-	-
Nickel	Mg/kg	33	25	26	68	18	-	-
Zinc	Mg/kg	97	38	43	101	44	*12.3*	*315*

Notes: All values are expressed on a dry weight basis.
SQG = sediment quality guidelines; ISQG = interim sediment quality guidelines; PEL = probable effect level.
Dashes indicate SQG are not available for that metal.
< = Less than the detection limit.

3.4.3.2 Cadmium and Chromium

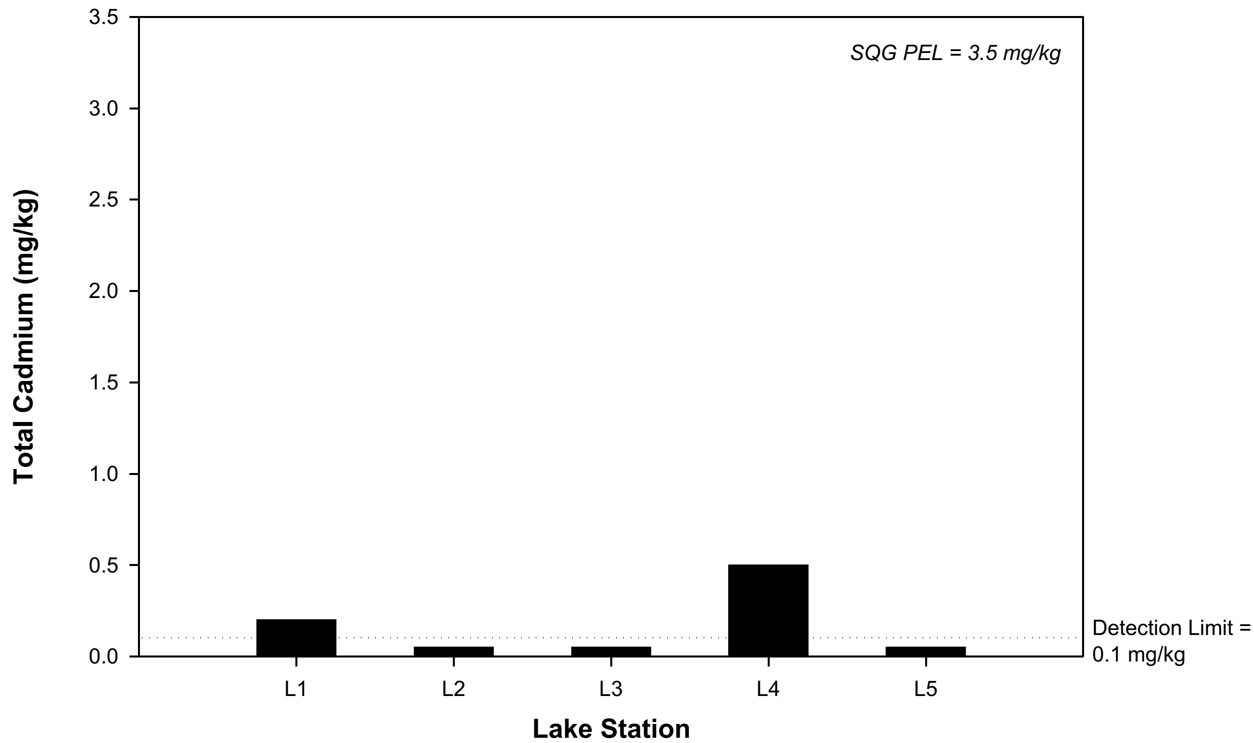
Cadmium concentrations ranged from less than 0.1 mg/kg at several stations to 0.5 mg/kg at station L4 (Table 3.4-2 and Figure 3.4-4). All cadmium concentrations were below the SQG PEL of 3.5 mg/kg. Chromium concentrations ranged from 19 mg/kg at station L2 to 56 mg/kg at station L1. All chromium concentrations were well below the SQG PEL of 90 mg/kg.

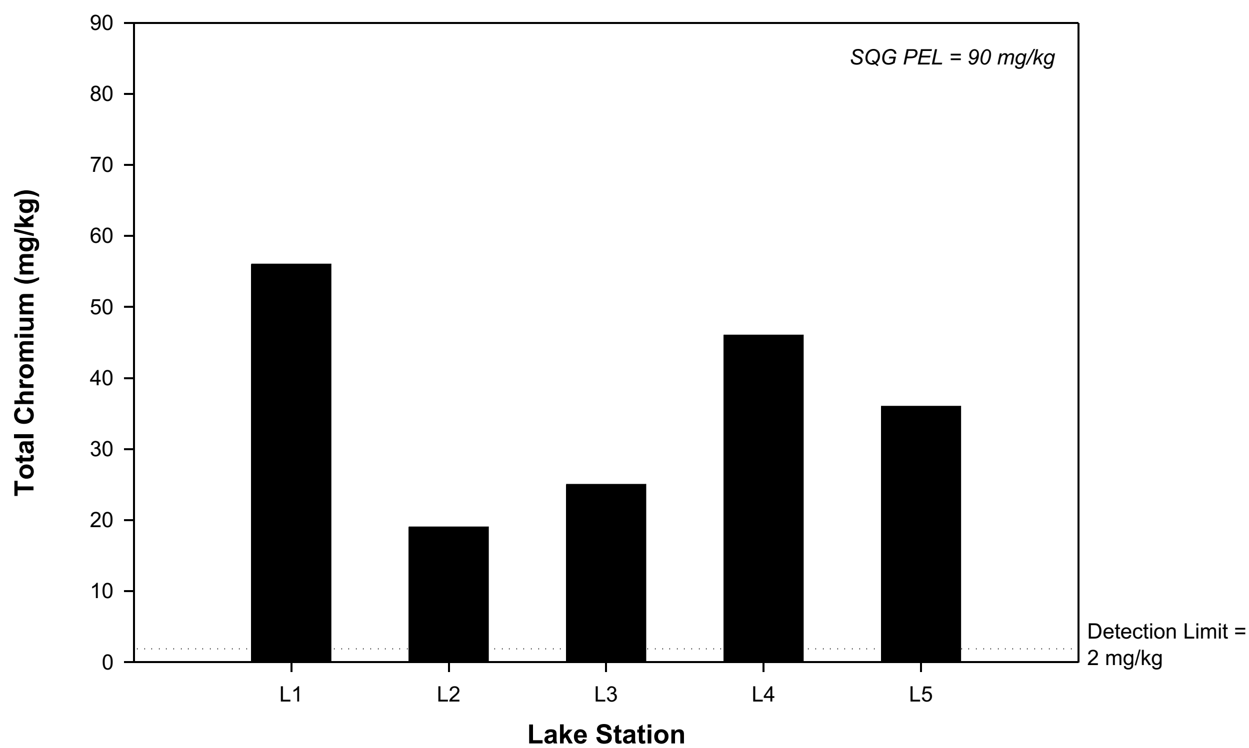
3.4.3.3 Cobalt and Copper

Cobalt concentrations ranged from 7 mg/kg at station L5 to 29 mg/kg at station L4 (Table 3.4-2 and Figure 3.4-5). No trend was observed among depths. There are currently no SQGs for cobalt. Copper concentrations ranged from 11 mg/kg at station L5 to 35 mg/kg at station L1. No trend was observed among depths in the lake. All copper concentrations were well below the SQG PEL guideline of 197 mg/kg.

3.4.3.4 Iron and Manganese

Iron concentrations in lake sediments ranged from 12,700 mg/kg at station L3 to 40,200 mg/kg at station L4 (Table 3.4-2 and Figure 3.4-6). No trend was observed among depths. There are currently no SQGs for iron. Manganese concentrations ranged from 214 mg/kg at station L3 to 7,020 mg/kg at station L4. Manganese concentrations were approximately 5 to 30 times higher at station L4 compared to the other four stations. No SQG PEL currently exists for manganese.





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Total Cadmium and Total Chromium in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-4

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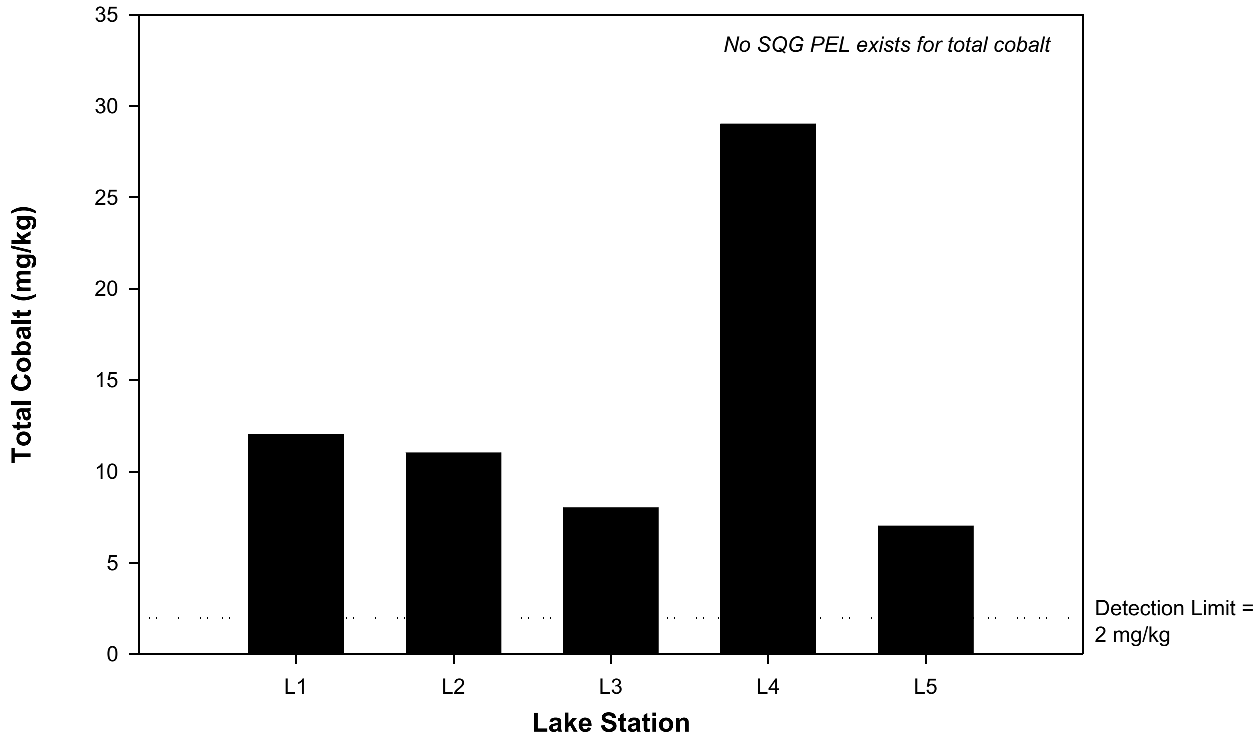

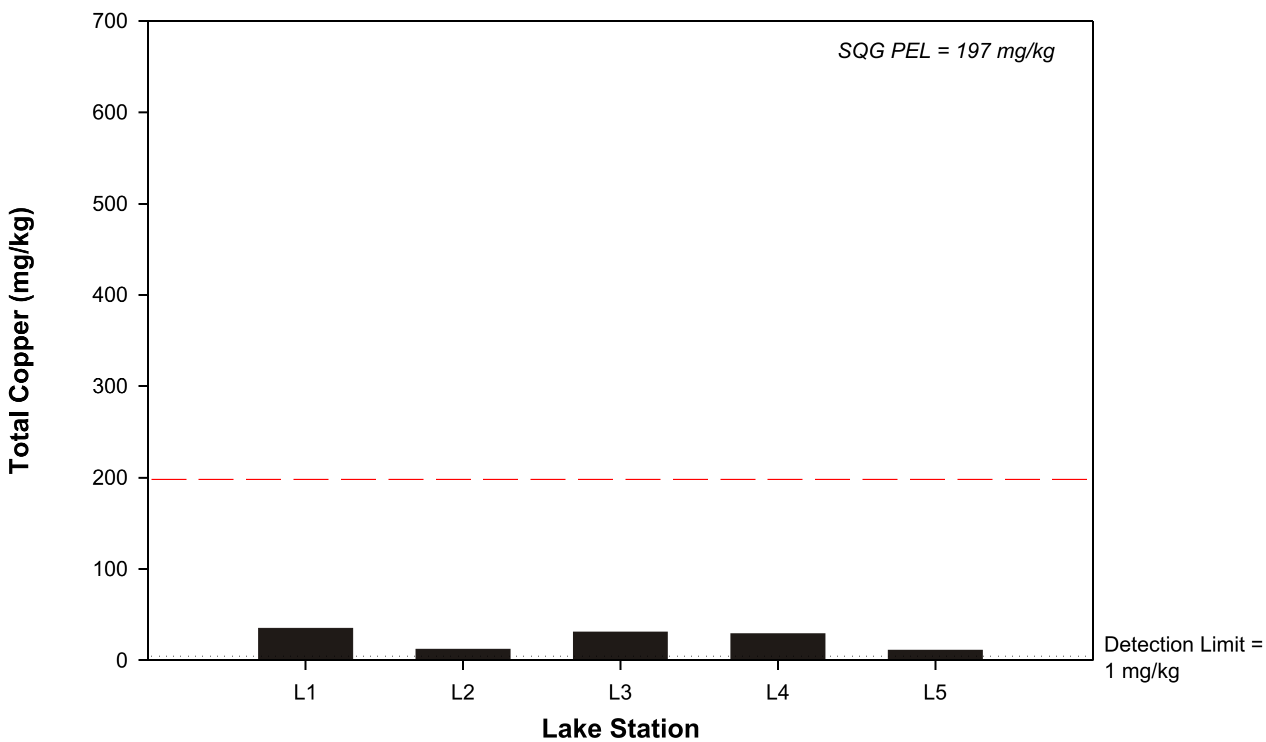

Note: Dashed line indicates SQG PEL guideline

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FIGURE 3.4-5

Total Cobalt and Total Copper in Lake Sediments, Ferguson Lake Project Area, 1999

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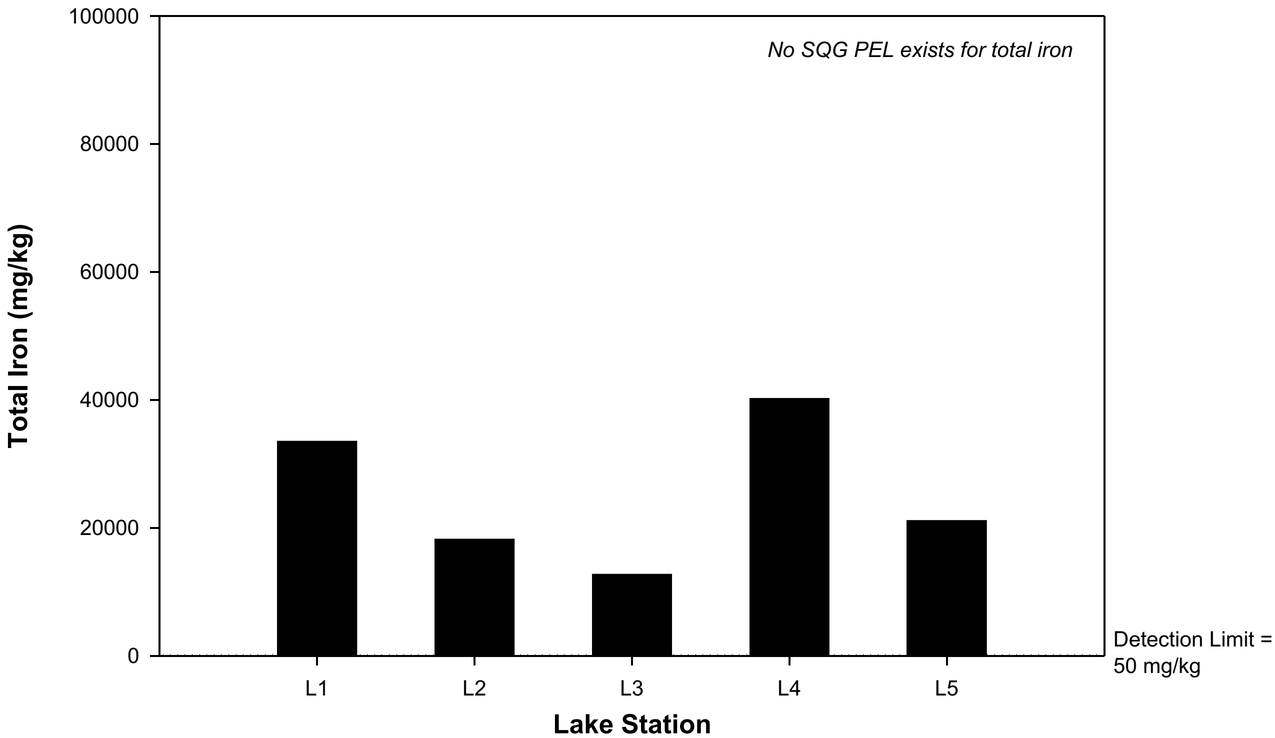

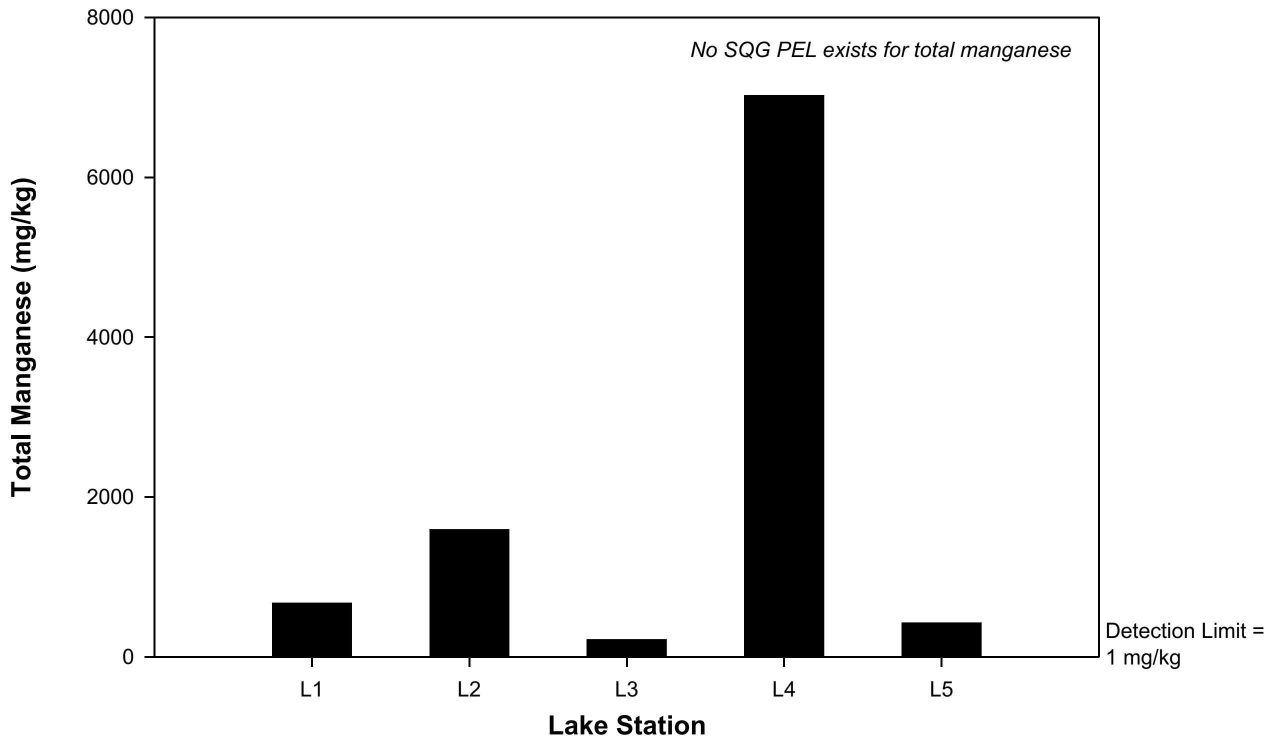

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Total Iron and Total Manganese in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-6

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3.4.3.5 Nickel and Zinc

Nickel concentrations ranged from 18 mg/kg at station L5 to 68 mg/kg at station L4 (Figure 3.4-7). No SQG PEL currently exists for nickel and no trend was observed among the different depths. Total zinc concentrations ranged from 38 mg/kg at station L2 to 101 mg/kg at station L4. None exceeded the zinc SQG PEL 315 mg/kg, but stations L1 and L4 had significantly higher zinc concentrations compared to the other stations.

3.4.4 Lake Sediment Particle Size Distribution

Sediment particle size was separated into four categories: clay (<4 µm), silt (4 µm to 0.063 mm), sand (0.063 m to 2.00 mm) and gravel (>2.00 mm). Sediments from Ferguson Lake consist mainly of sand (4.5 to 78.4%), silt (11.7 to 42.9%) and clay (9.0 to 55.1%) with very little gravel (<0.1%) (Table 3.4-3 and Figures 3.4-8 and 3.4-9). Silt and clay percentages are similar among deep depths (L1, L4 and L5), and sand, silt and clay percentages are similar among shallow and middle depths (L2 and L3). Stations L2 and L3 has higher sand percentages (70.5 and 78.4%) compared to the other stations.

Table 3.4-3
Particle Size Distribution of Lake Sediments,
Ferguson Lake Project Area, 1999

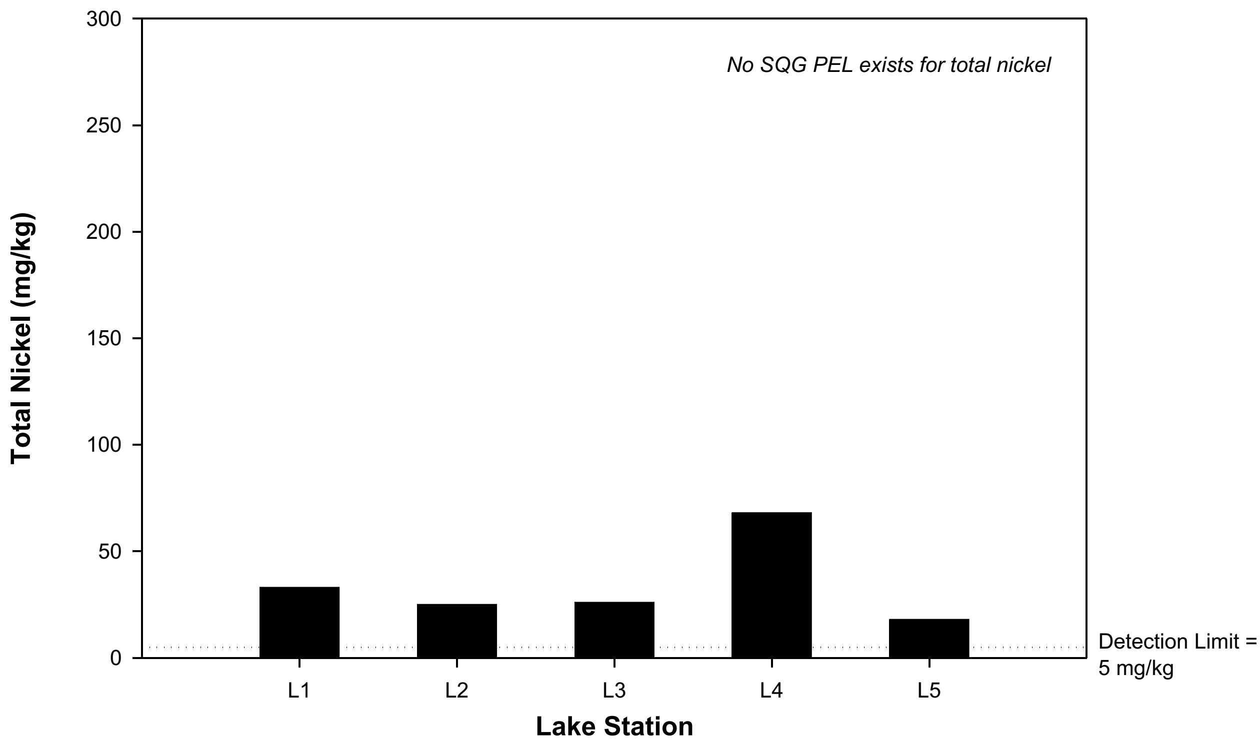
Sample ID:		**L1**	**L2**	**L3**	**L4**	**L5**
Date Sampled:		**12-Sep-99**	**12-Sep-99**	**11-Sep-99**	**12-Sep-99**	**11-Sep-99**
Depth:		**34.5 m**	**3.9 m**	**7.5 m**	**11.4 m**	**24.4 m**
Particle Size	**Units**					
Gravel (>2.00 mm)	%	<0.1	<0.1	<0.1	<0.1	<0.1
Sand (2.00 mm – 0.063 mm)	%	4.5	70.5	78.4	21.3	29.8
Silt (0.063 mm – 4 µm)	%	40.4	20.5	11.7	42.9	38.5
Clay (<4 µm)	%	55.1	9.0	9.9	35.8	31.7

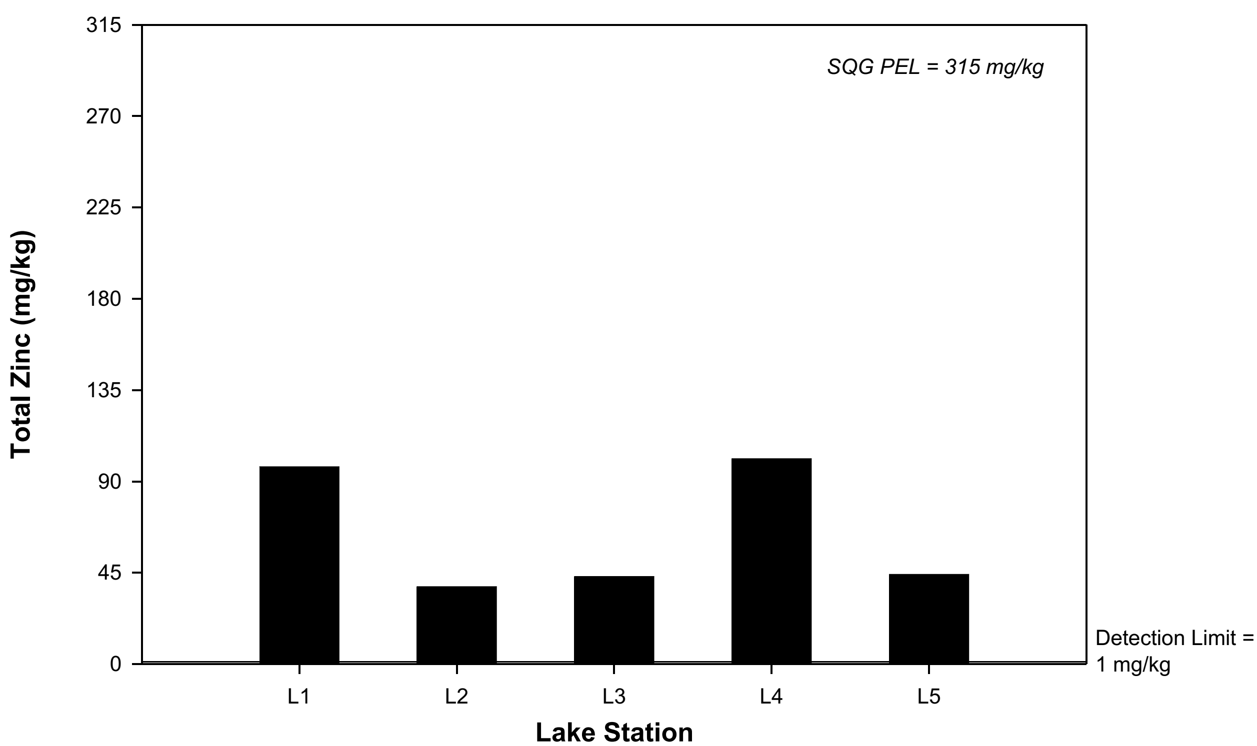
Notes: All values are expressed on a dry weight basis.
< = Less than the detection limit.

3.4.5 Lake Sediment Summary

Station L1 had the highest concentrations of nutrients compared to the other five stations, and station L5 had the lowest concentrations of total organic carbon and total nitrogen.

All concentrations of total metals were well below CCME guidelines for the protection of freshwater aquatic life. Station L4 generally had higher metal concentrations as compared to the other stations. Lake sediment samples were composed primarily of sand, silt and clay with very little gravel. Stations L2 and L3 had the highest sand values as compared to the other sediment samples. The particle size distributions were similar among the deep depth samples (>10 m), and among the shallow and mid depth samples (<10 m).





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Total Nickel and Total Zinc in Lake Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.4-7

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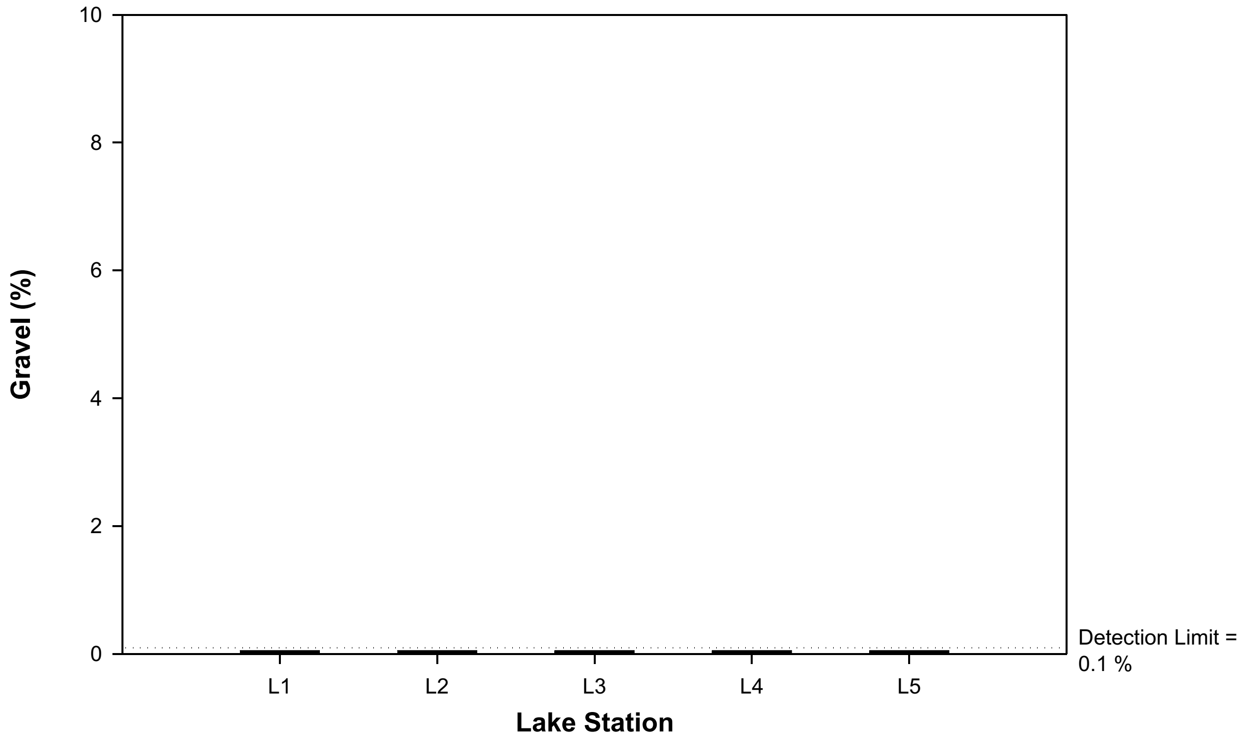

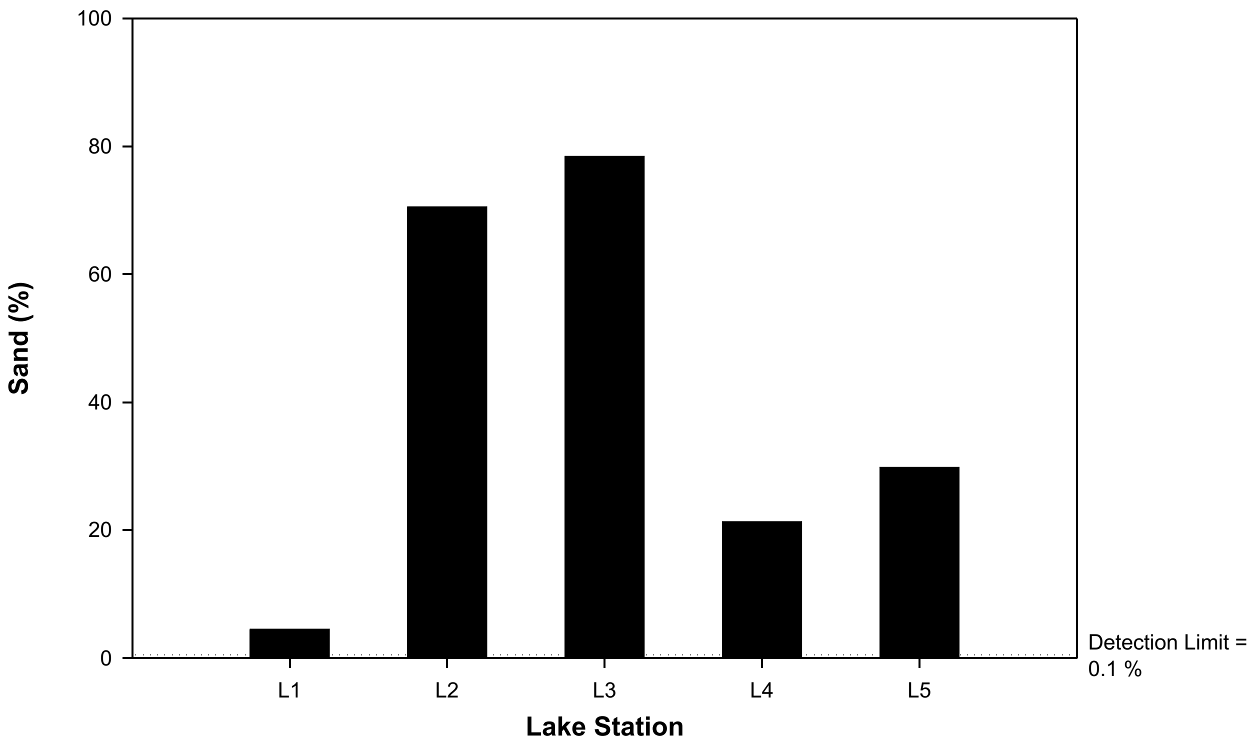

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FIGURE 3.4-8

Gravel and Sand Content in Lake Sediments, Ferguson Lake Project Area, 1999

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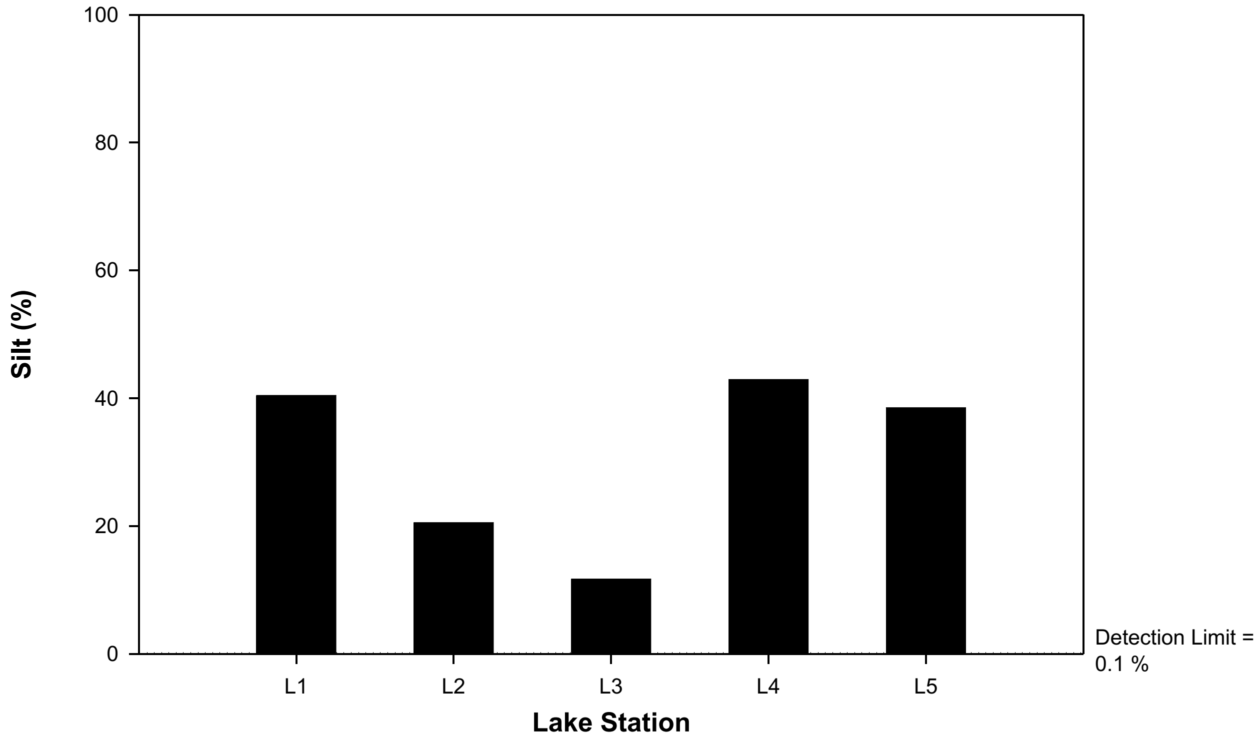

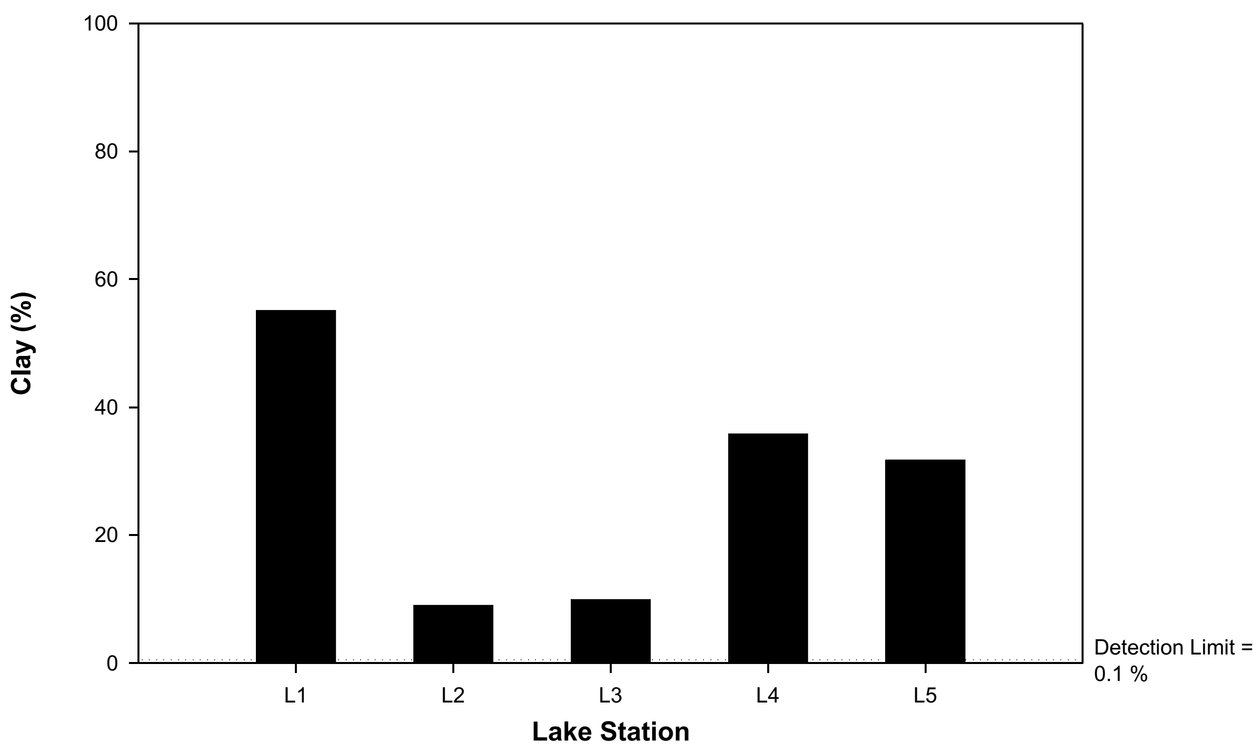

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FIGURE 3.4-9

Silt and Clay Content in Lake Sediments, Ferguson Lake Project Area, 1999

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3.5 Stream Sediment Quality

Appendix 3.4-1 describes the stream sediment samples collected from the Project area, and Appendix 3.4-2 shows the chemical composition (nutrients and metals) and particle size distributions (clay, silt, sand and gravel) of the stream sediments.

3.5.1 Stream Sediment Description

Stream sediments were mainly composed of silt and gravel with roots and grasses growing on the top layer (Plate 3.5-1). The colour of the sediments ranged from a gravel colour to a moderate brown colour. No other patterns were observed in the sediments.

Plate 3.5-1 Sediment sample collected from stream W1 in September, 1999

3.5.2 Nutrients

Total organic carbon (TOC) percentages in stream sediments ranged from less than 0.05% for station R1 to 8.15% for station W2 (Table 3.5-1 and Figure 3.5-1). All stream stations had much higher TOC percentages than the reference station R1. Concentrations of available phosphorus in the stream sediments ranged from 1 mg/kg at stations W2 and R1 to 11 mg/kg at station W1, and total nitrogen percentages ranged from 0.01% at station R1 to 0.33% at station E3 (Figure 3.5-2). Total nitrogen values were much lower at station R1 (at the detection limit) compared to the other stations.

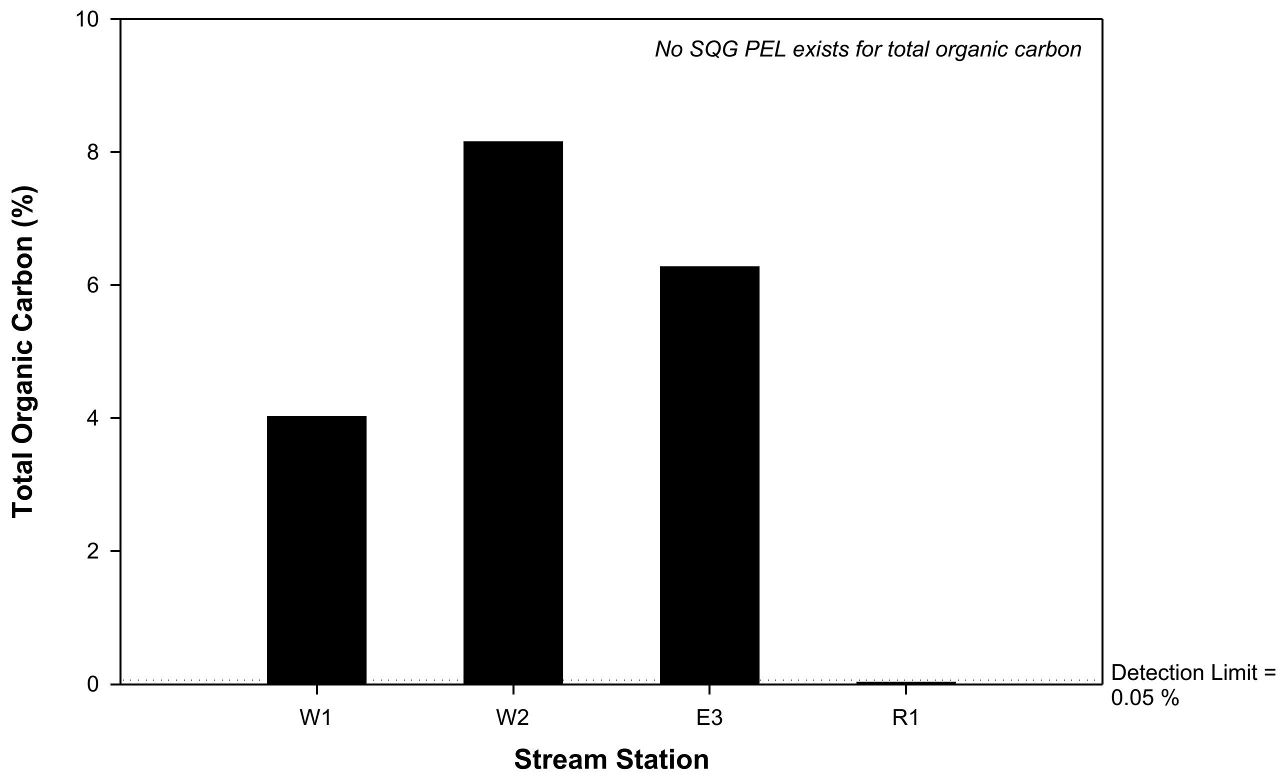

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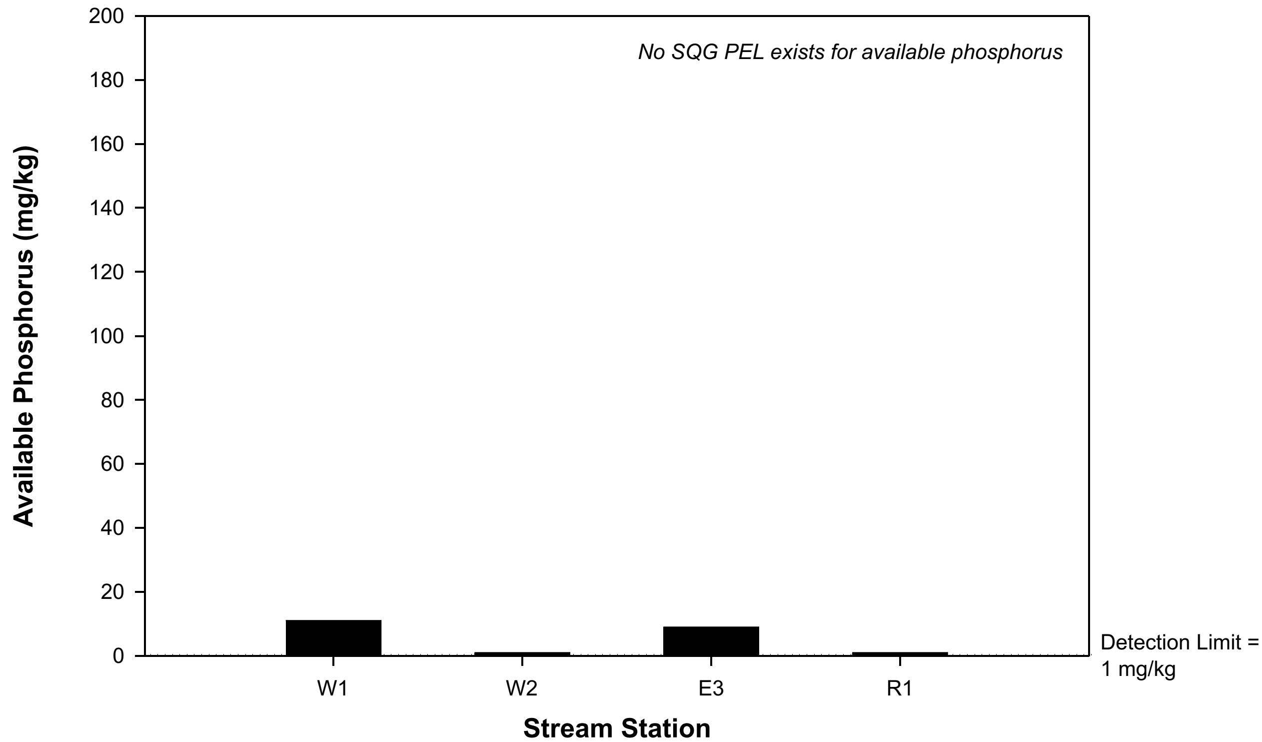
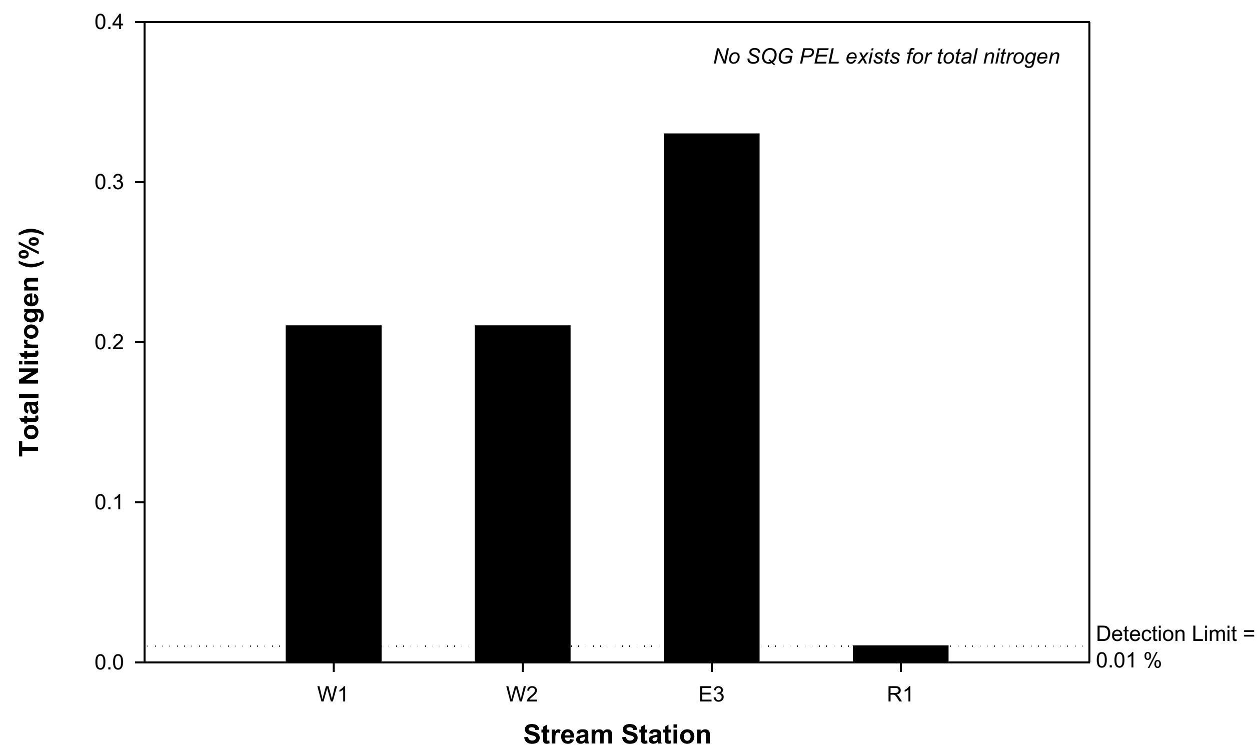
FIGURE 3.5-1

Total Organic Carbon (TOC) in Stream Sediments, Ferguson Lake Project Area, 1999

Rescan™





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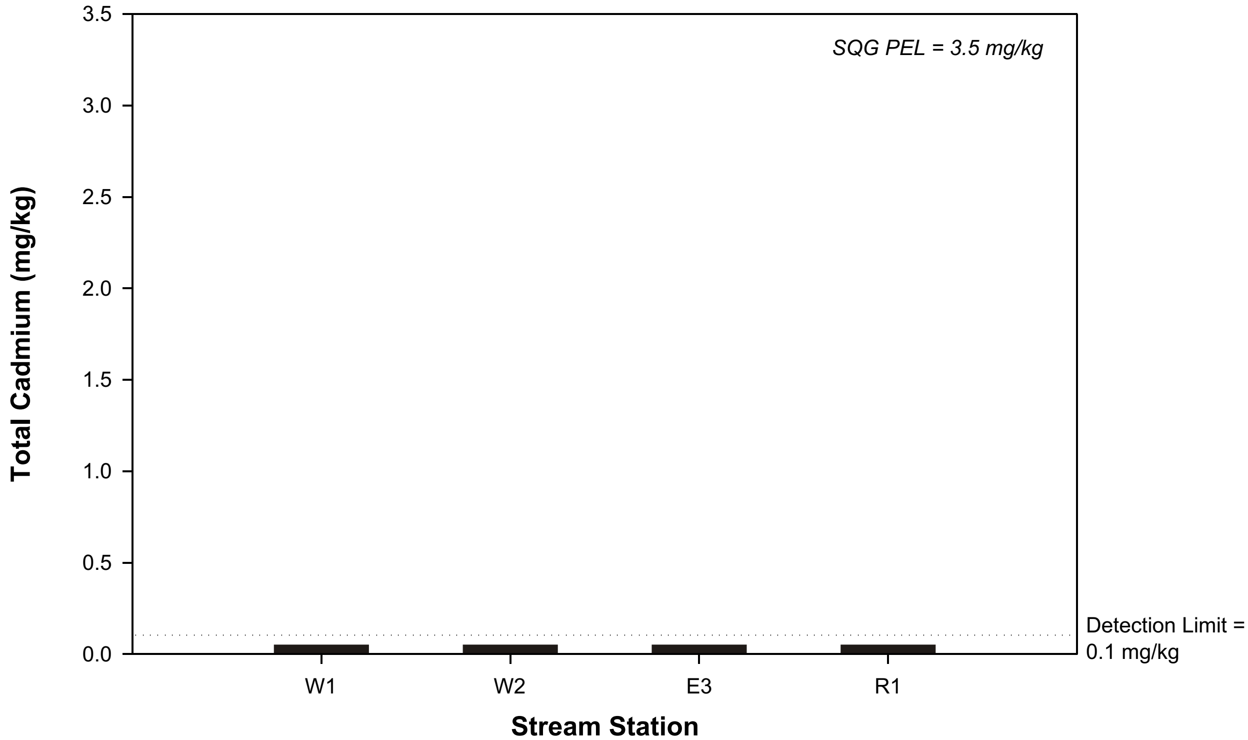
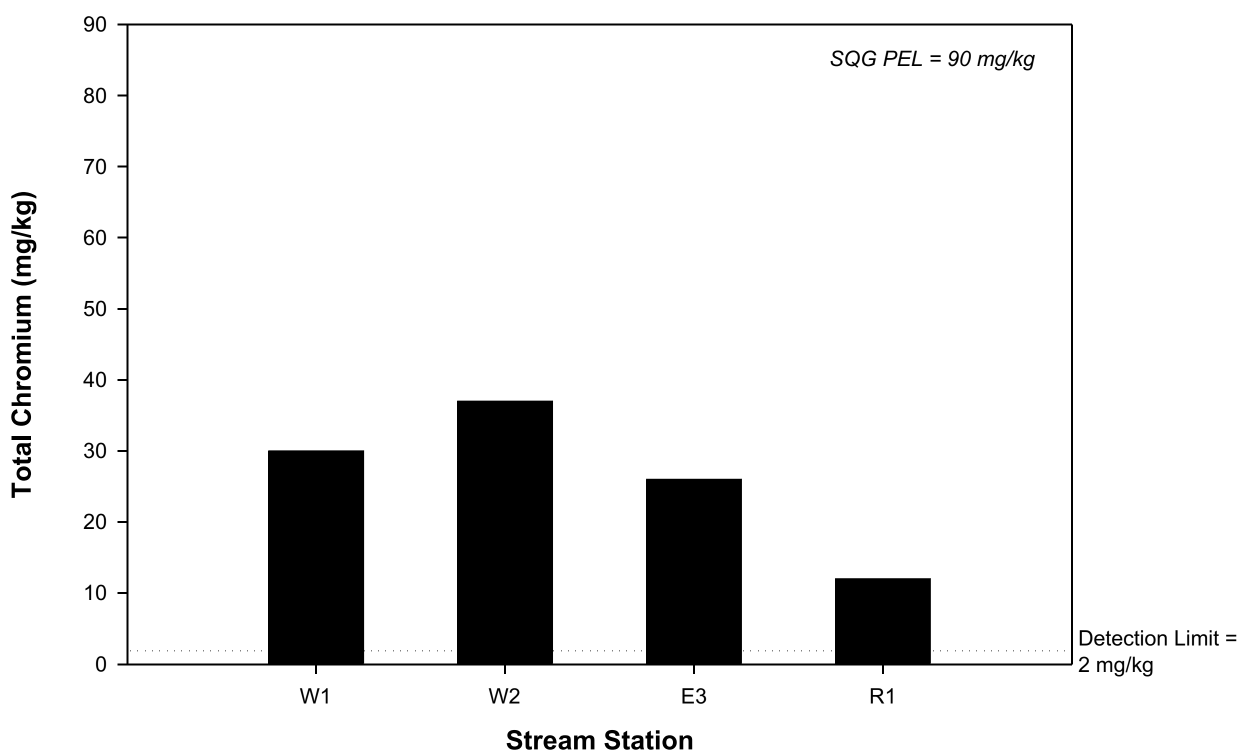
Available Phosphorus and Total Nitrogen in Stream Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.5-2

Rescan™





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Total Cadmium and Total Chromium in Stream Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.5-4

Rescan™

Table 3.5-1
Nutrients of Stream Sediments,
Ferguson Lake Project Area, 1999

Sample ID:		W1	W2	E3	R1
Date Sampled:		12-Sep-99	12-Sep-99	13-Sep-99	13-Sep-99
Depth:		0.5 m	0.45 m	0.01 m	0.4 m
Variable	**Units**				
Total Organic Carbon	%	4.02	8.15	6.27	<0.05
Available Phosphorus	mg/kg	11	1	9	1
Total Nitrogen	%	0.21	0.21	0.33	0.01

Notes: Results are expressed as mg/kg dry weight.
< = Less than the detection limit indicated.

3.5.3 Total Metals

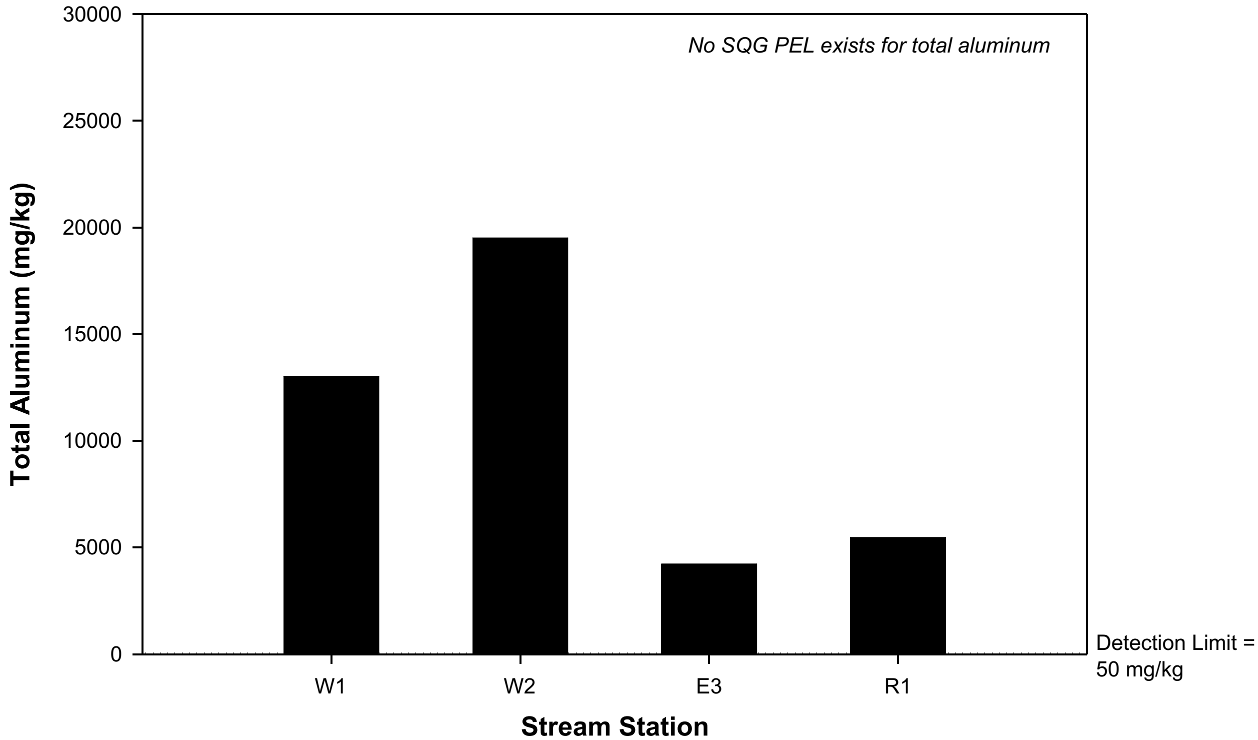
3.5.3.1 Aluminum and Arsenic

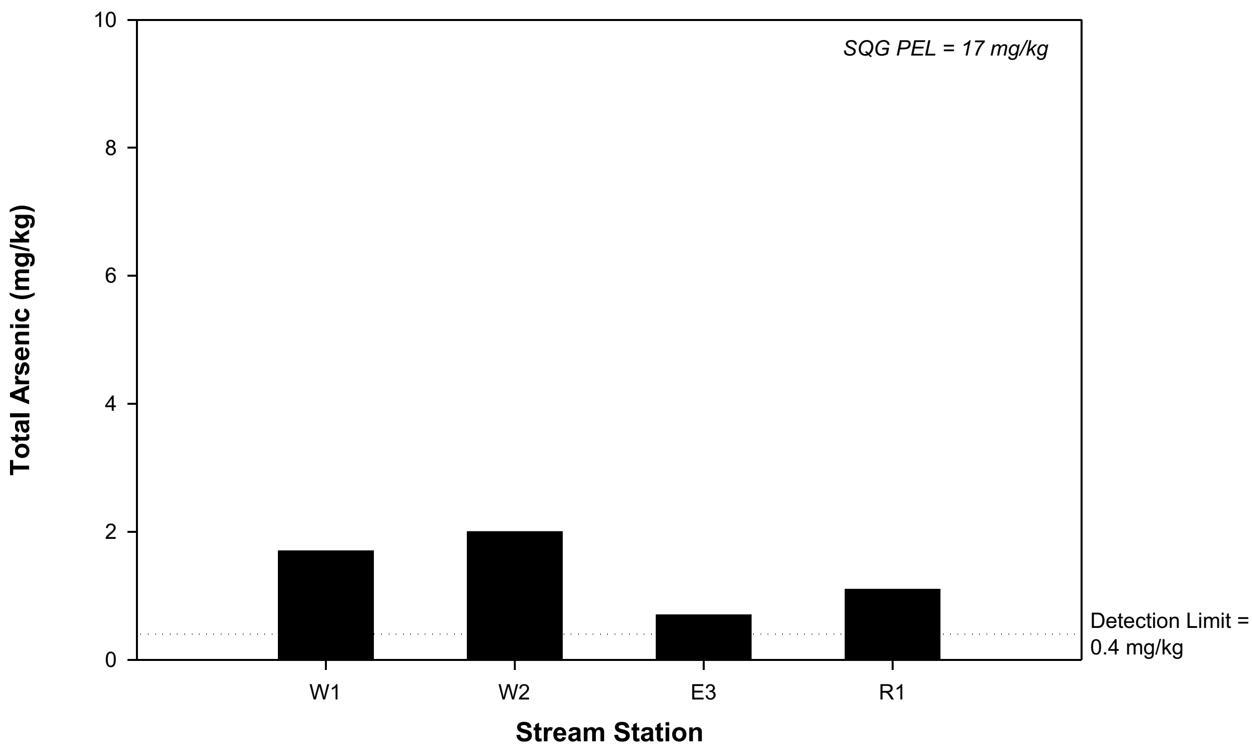
Aluminum concentrations in stream sediments ranged from 4,220 mg/kg at station E3 to 19,500 mg/kg at station W2 (Table 3.5-2 and Figure 3.5-3). There is no SQG PEL for aluminum. Arsenic concentrations ranged from 0.7 mg/kg at station E3 to 2.0 mg/kg at station W2. All arsenic concentrations were well below the SQG PEL of 17.0 mg/kg.

Table 3.5-2
Total Metal Stream Sediment Concentrations with Canadian Sediment Quality Guidelines, Ferguson Lake Project Area, 1999

Station:		W1	W2	E3	R1		
Date:		12-Sep-99	12-Sep-99	13-Sep-99	13-Sep-99	SQG	
Depth:		0.5 m	0.45 m	0.01 m	0.4 m	ISQG	PEL
Metal	**Units**						
Aluminum	mg/kg	13,000	19,500	4,220	5,460	-	-
Arsenic	mg/kg	1.7	2.0	0.7	1.1	*5.9*	*17*
Cadmium	mg/kg	<0.1	<0.1	<0.1	<0.1	*0.6*	*3.5*
Chromium	mg/kg	30	37	26	12	*37.3*	*90*
Cobalt	mg/kg	6	25	4	3	-	-
Copper	mg/kg	13	600	93	5	*35.7*	*197*
Iron	mg/kg	17,500	88,500	16,600	10,900	-	-
Manganese	mg/kg	191	145	52	115	-	-
Nickel	mg/kg	18	283	32	7	-	-
Zinc	mg/kg	38	41	8	22	*12.3*	*315*

Notes: All values are expressed on a dry weight basis.
SQG = sediment quality guidelines; ISQG = interim sediment quality guidelines; PEL = probable effect level.
Dashes indicate that guidelines are not available for that metal.
< = Less than the detection limit.





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Total Aluminum and Total Arsenic in Stream Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.5-3

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3.5.3.2 Cadmium and Chromium

All cadmium concentrations were below the detection limit of 0.1 mg/kg (Figure 3.5-4). Chromium concentrations ranged from 12 mg/kg at station R1 to 37 mg/kg at station W2. All chromium values were well below the SQG PEL of 90.0 mg/kg.

3.5.3.3 Cobalt and Copper

Cobalt concentrations ranged from 3 mg/kg at station R1 to 25 mg/kg at station W2 (Figure 3.5-5). There are currently no SQGs for cobalt. Copper concentrations in the stream sediments ranged from 5 mg/kg at station R1 to 600 mg/kg at station W2. With the exception of station W2, all copper concentrations were well below the SQG PEL of 197 mg/kg. Sediment copper concentration at station W2 was approximately three times higher then the recommended SQG PEL.

3.5.3.4 Iron and Manganese

Iron concentrations in stream sediments ranged from 10,900 mg/kg at station R1 to 88,500 mg/kg at station W2 (Figure 3.5-6). Total iron concentrations at station W2 were five to eight times higher than concentrations of the other stream sediment stations. There are currently no SQGs for iron. Manganese concentrations ranged from 52 mg/kg at station E3 to 191 mg/kg at station W1. There is no SQG PEL for manganese.

3.5.3.5 Nickel and Zinc

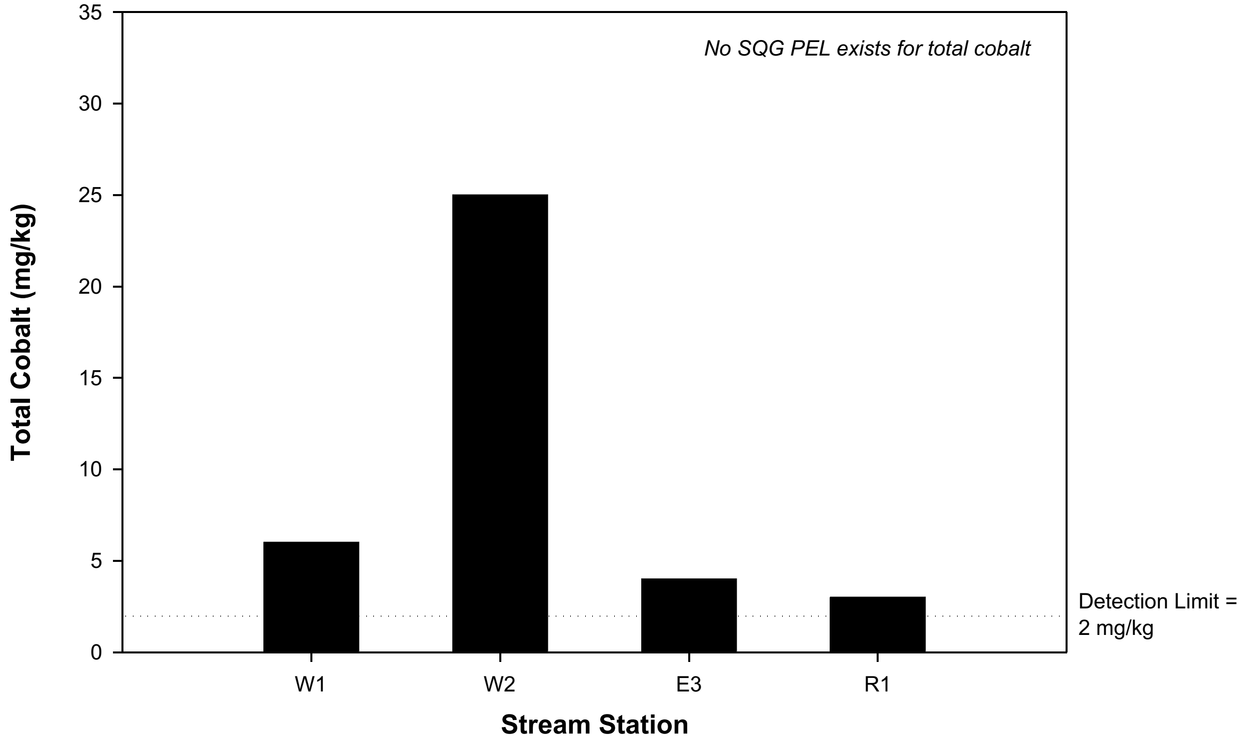
Total nickel concentrations in stream sediments ranged from 7 mg/kg at station R1 to 283 mg/kg at station W4 (Figure 3.5-7). Total nickel concentrations at station W4 were 9 to 40 times higher than at the other three stations. No SQG PEL currently exists for nickel. Total zinc concentrations ranged from 8 mg/kg at station E3 to 41 mg/kg at station W2. The zinc SQG PEL of 315 mg/kg was not exceeded at any of the stream sites.

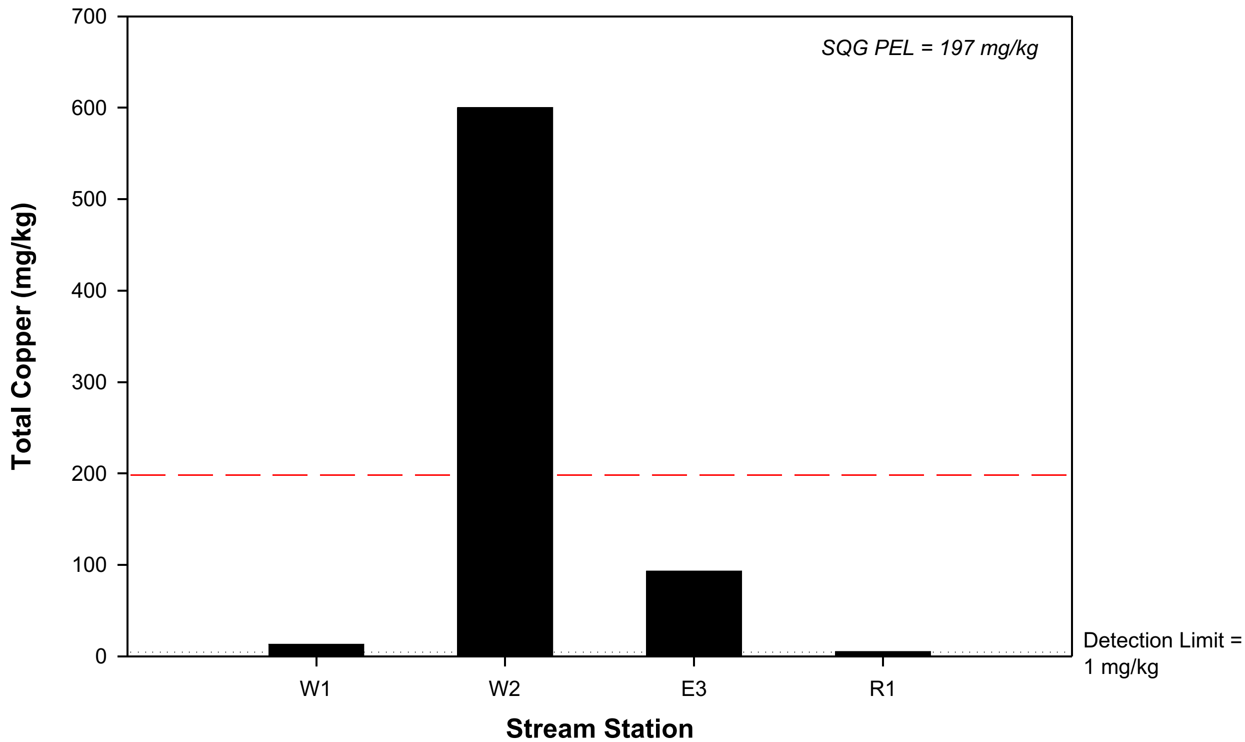
3.5.4 Particle Size Distributions

Sediments from the stream stations consisted mainly of sand (28.9 to 84.8%), followed by gravel (0.7 to 40.8%), silt (0.6 to 25.2%) and clay (0.5 to 13.7%) (Table 3.5-3 and Figures 3.5-8 and 3.5-9). Stations W1, E3 and R1 had more sand (60.4% to 84.8%) than station W2, and station W2 had more gravel than the other three stations.

3.5.5 Stream Sediment Summary

Station W2 had a higher percent TOC compared to the other three stream stations, and station R1 had the lowest TOC and nutrient concentrations. All total metals were well below federal guidelines for the protection of freshwater aquatic life with the exception of total copper at station W2. In general, station W2 had higher metal concentrations compared to the other stations, which may reflect its relatively low pH. Stream sediment samples were composed primarily of sand, with varying degrees of gravel, silt and clay. Station E3 had the highest sand content and station R1 had the lowest clay content.





Note: Dashed line indicates SQG PEL guideline

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FIGURE 3.5-5

Total Cobalt and Total Copper in Stream Sediments, Ferguson Lake Project Area, 1999

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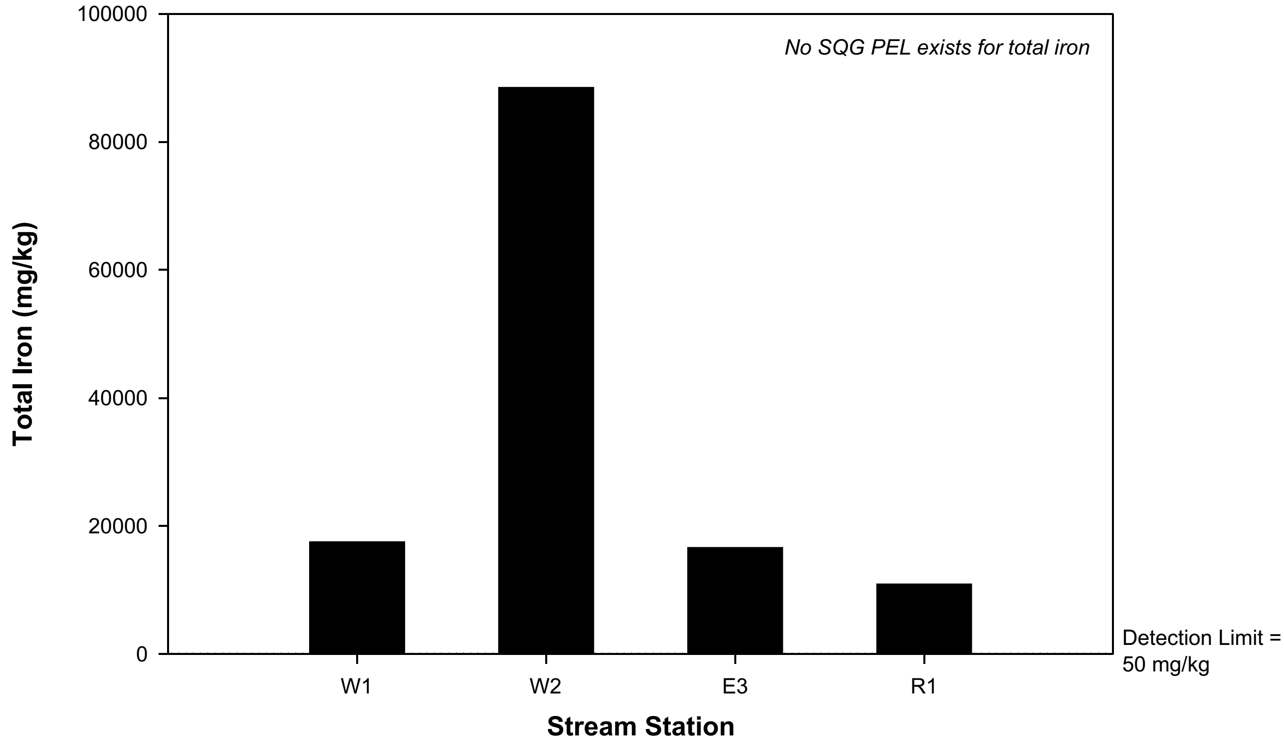

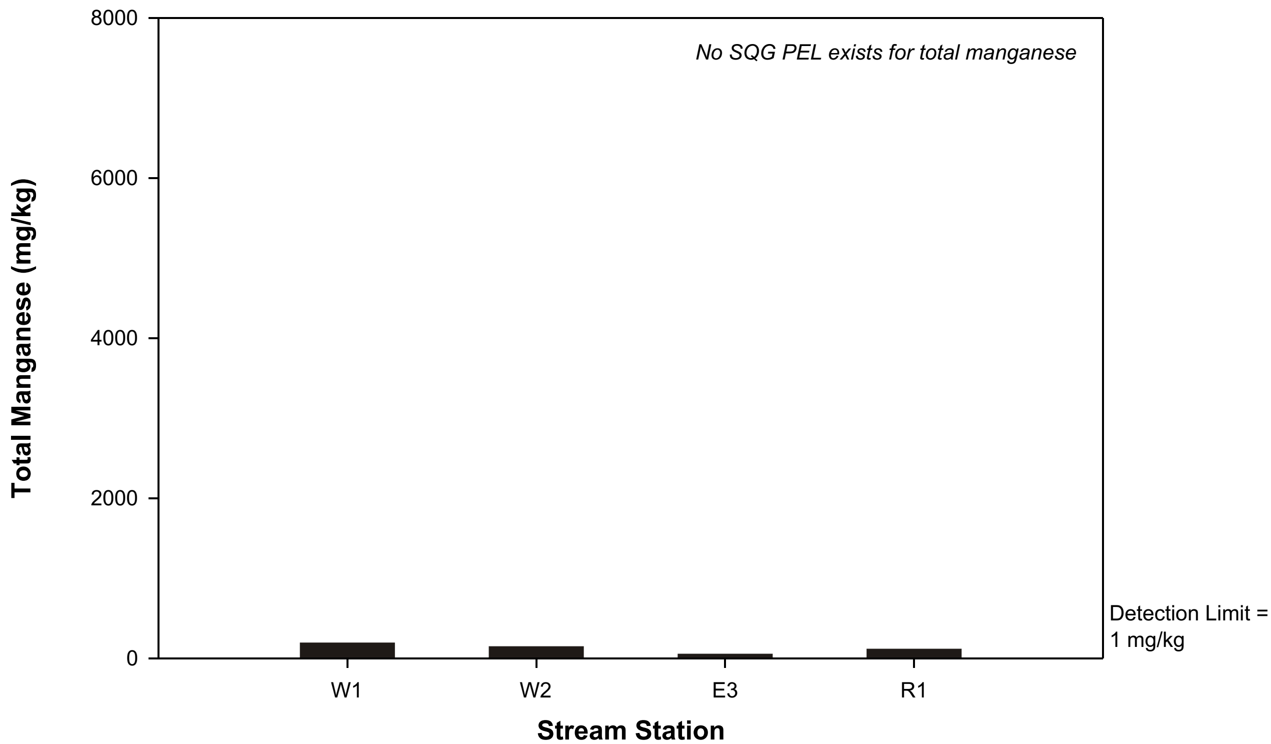

Note: Dashed line indicates SQG PEL guideline

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FIGURE 3.5-6

Total Iron and Total Manganese in Stream Sediments, Ferguson Lake Project Area, 1999

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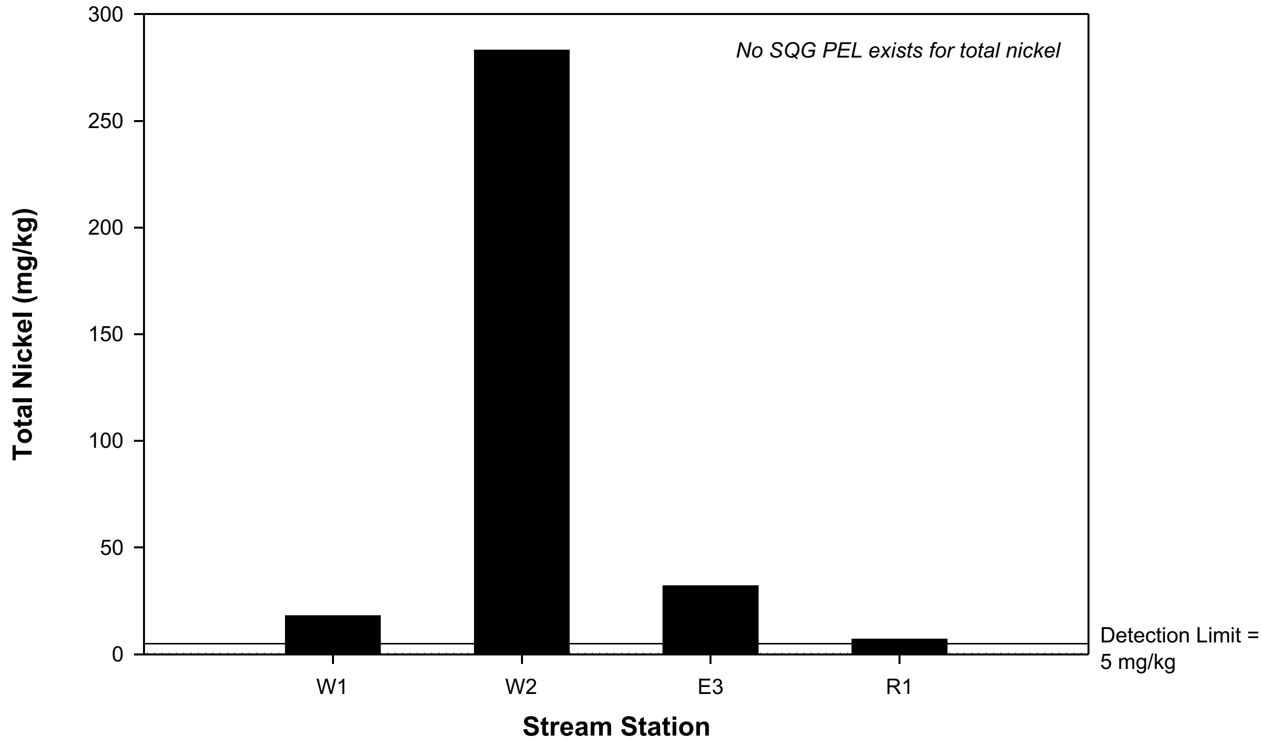

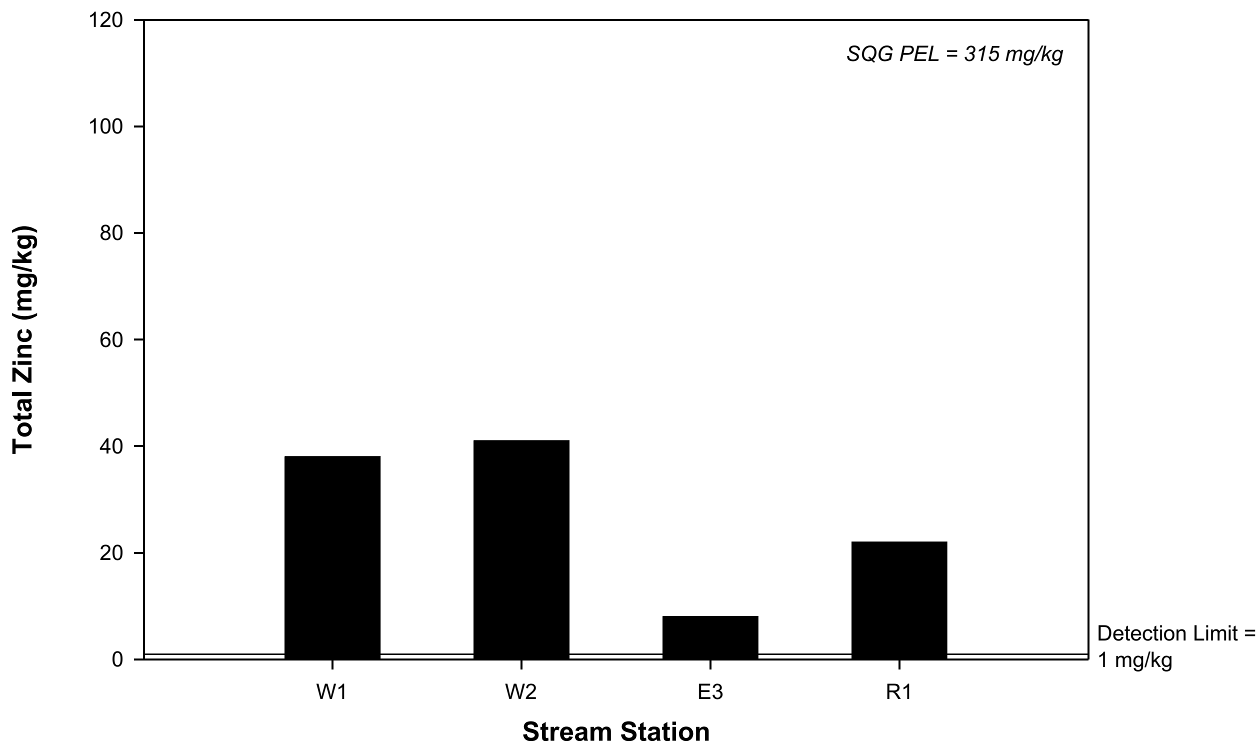

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Total Nickel and Total Zinc in Stream Sediments, Ferguson Lake Project Area, 1999

FIGURE 3.5-7

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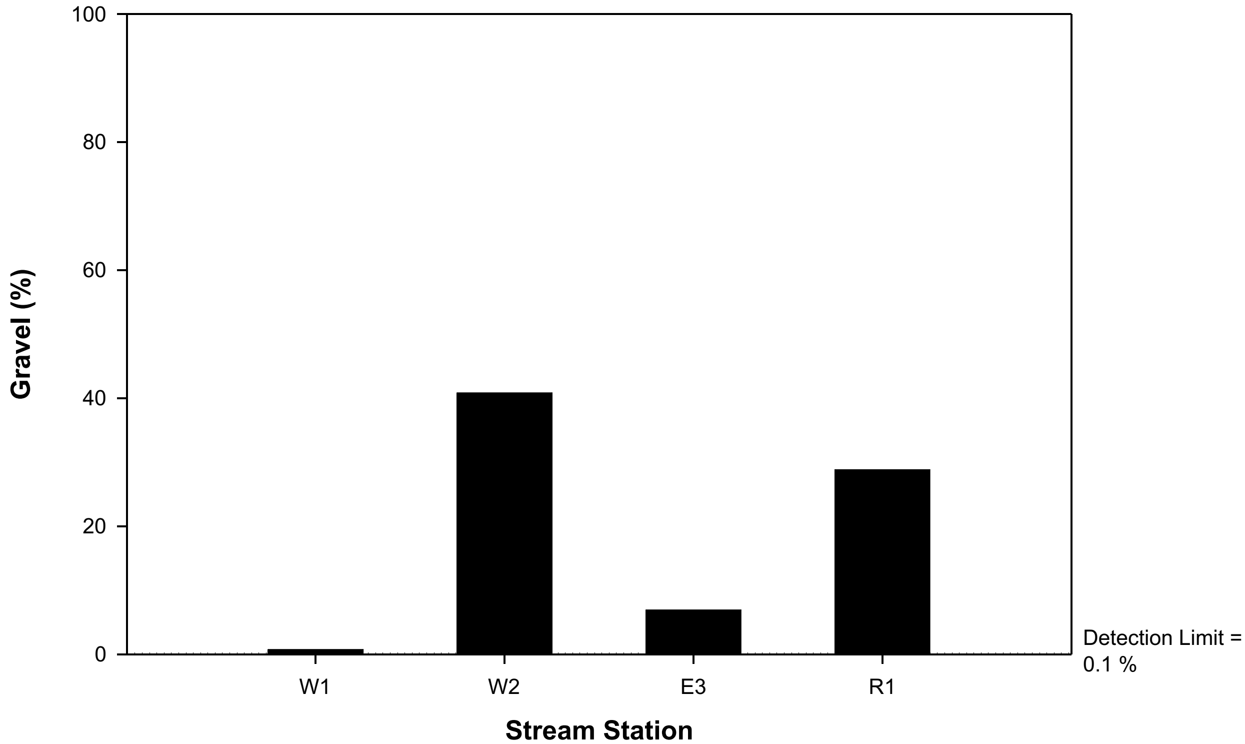

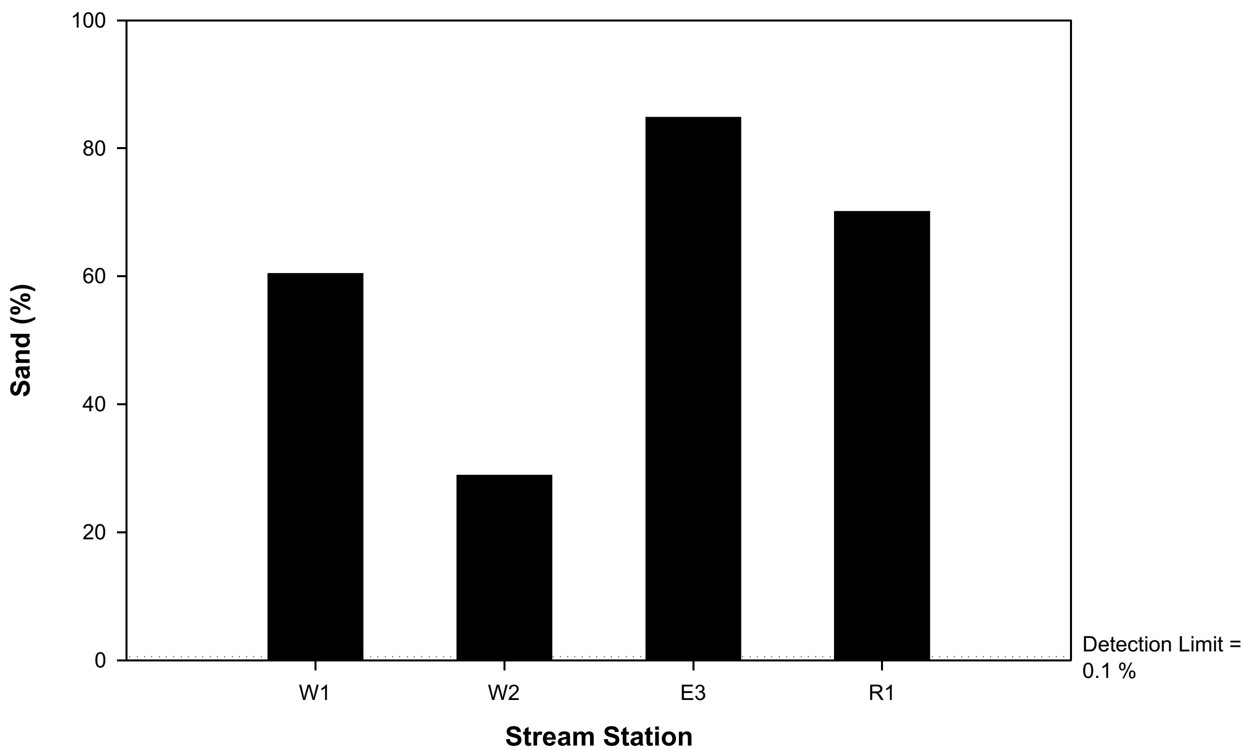

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FIGURE 3.5-8

Gravel and Sand Content in Stream Sediments, Ferguson Lake Project Area, 1999

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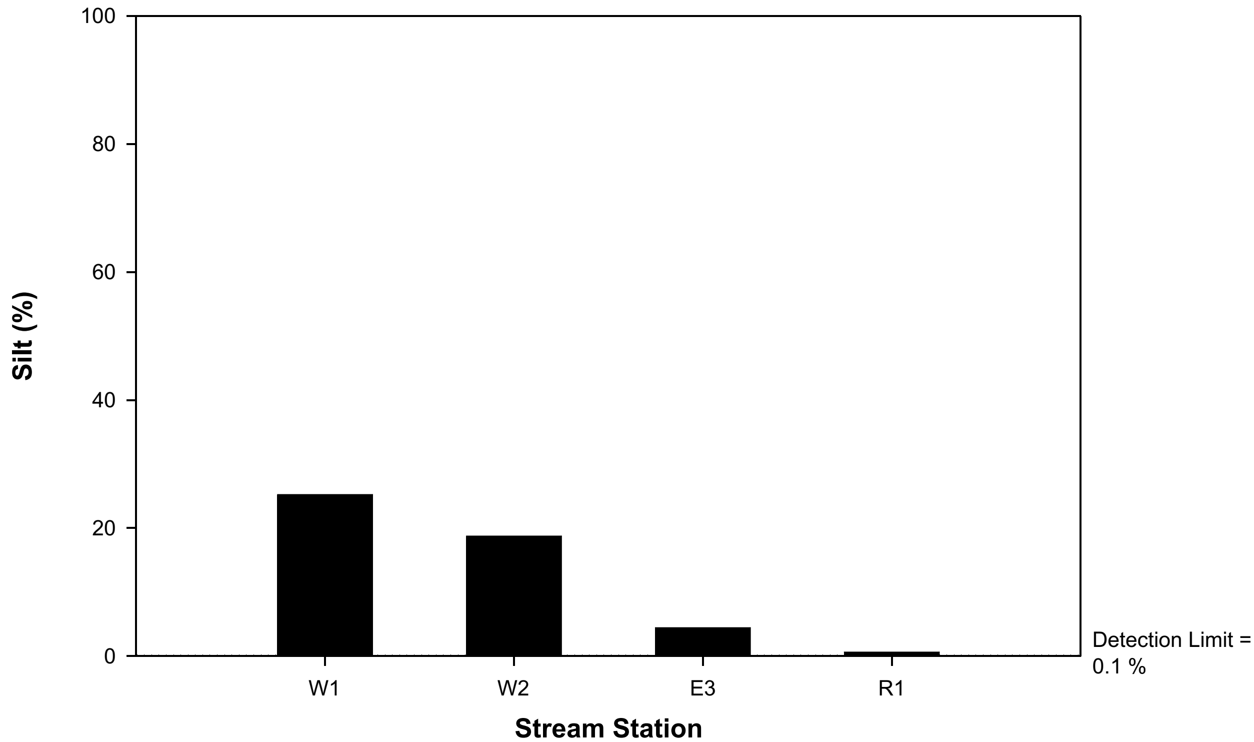

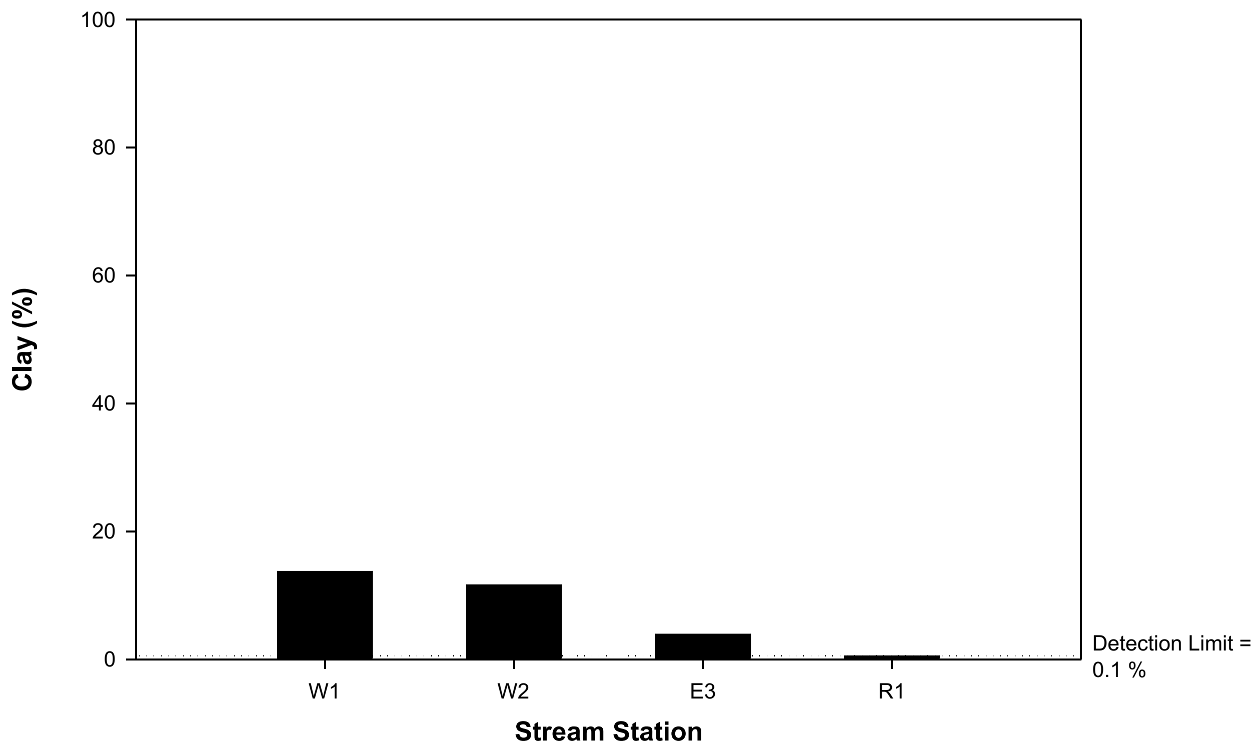

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FIGURE 3.5-9

Silt and Clay Content in Stream Sediments, Ferguson Lake Project Area, 1999

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Table 3.5-3
Particle Size Distribution of Stream Sediments, Ferguson Lake Project Area, 1999

Sample ID:		W1	W2	E3	R1
Date Sampled:		12-Sep-99	12-Sep-99	13-Sep-99	13-Sep-99
Depth:		0.5 m	0.45 m	0.01 m	0.4 m
Particle Size	Units				
Gravel (>2.00 mm)	%	0.7	40.8	6.9	28.8
Sand (2.00 mm – 0.063 mm)	%	60.4	28.9	84.8	70.1
Silt (0.063 mm – 4 µm)	%	25.2	18.7	4.4	0.6
Clay (<4 µm)	%	13.7	11.6	3.9	0.5

Notes: All values are expressed as percent dry weight.

3.6 Physical Limnology of Ferguson Lake

Appendix 3.6-1 shows the Secchi depths (a measure of water clarity) and vertical profiles of temperature and dissolved oxygen for the five lake stations for July and September sampling periods.

Secchi depth was greater in September than in July at all stations, but was generally similar among stations within a sampling period (Figure 3.6-1). July Secchi depths ranged from 3.2 to 4.1 m while September Secchi depths ranged from 3.9 to 5.2 m. The seasonal difference in Secchi depth was due to higher densities of light-absorbing phytoplankton in July than in September.

Profiles of dissolved oxygen and temperature in July were similar at all stations (Figure 3.6-2). Dissolved oxygen was typically around 10 mg/L at all stations, and temperature around 11˚C. Stratification was not present at any of the stations in July.

In contrast, profiles of dissolved oxygen and temperature in September differed among stations with stations L3 and L5 showing weak stratification. Temperature was near 9˚C at all stations, with L3 and L5 having slightly warmer surface waters (approximately 9.5˚C in the upper 2 m). Oxygen concentrations were approximately 9 mg/L at L2 which was low relative to the other stations. Stations L3, L4 and L5 had surface oxygen concentrations of approximately 11 mg/L. At station L3, oxygen concentrations decreased to 7 mg/L at 6 m depth, while in L5 they dropped to 9.5 mg/L at 10 m depth. In L4, oxygen concentrations stayed around 11 mg/L through the entire water column. No profile was available at L1 due to a probe malfunction.

In summary, the Secchi depths and profiles of temperature and dissolved oxygen of Ferguson Lake are typical of large lakes in this region. The water remains cool and well-oxygenated throughout the summer. The lack of strong stratification at most stations is most likely due to strong winds that continuously mix the water column.

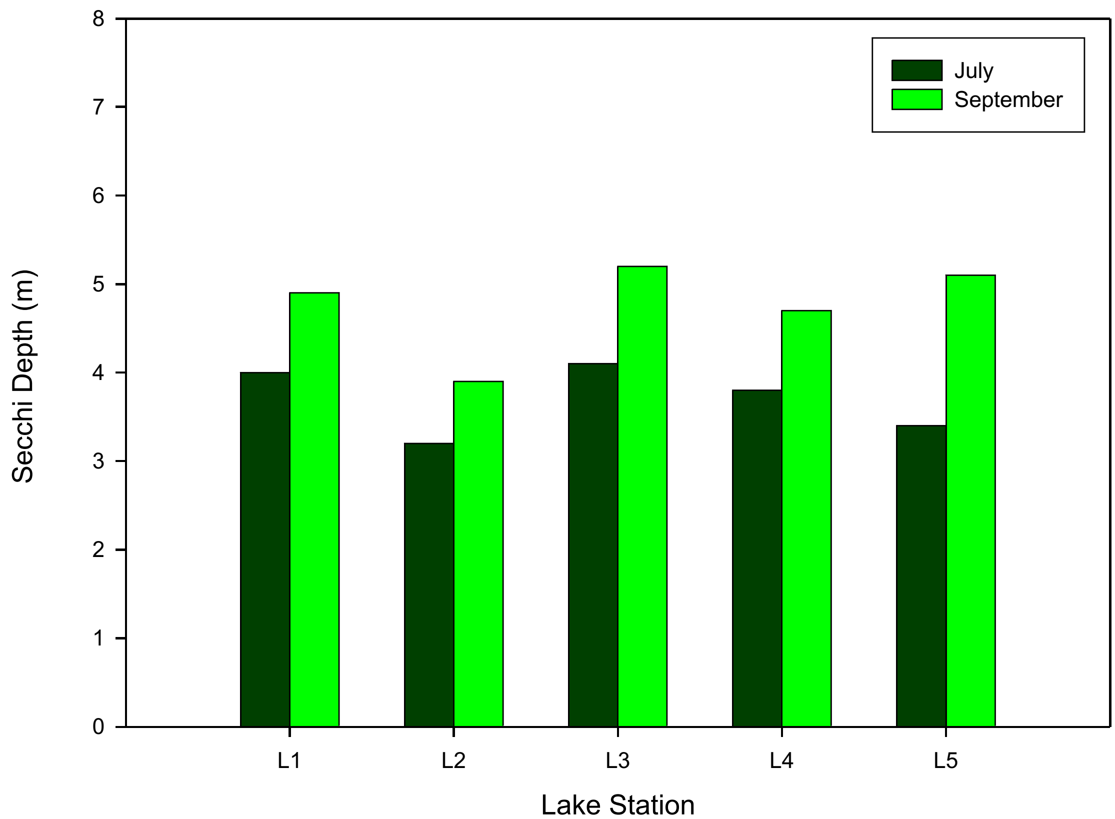

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FIGURE 3.6-1

Secchi Depths, Ferguson Lake Project Area, 1999

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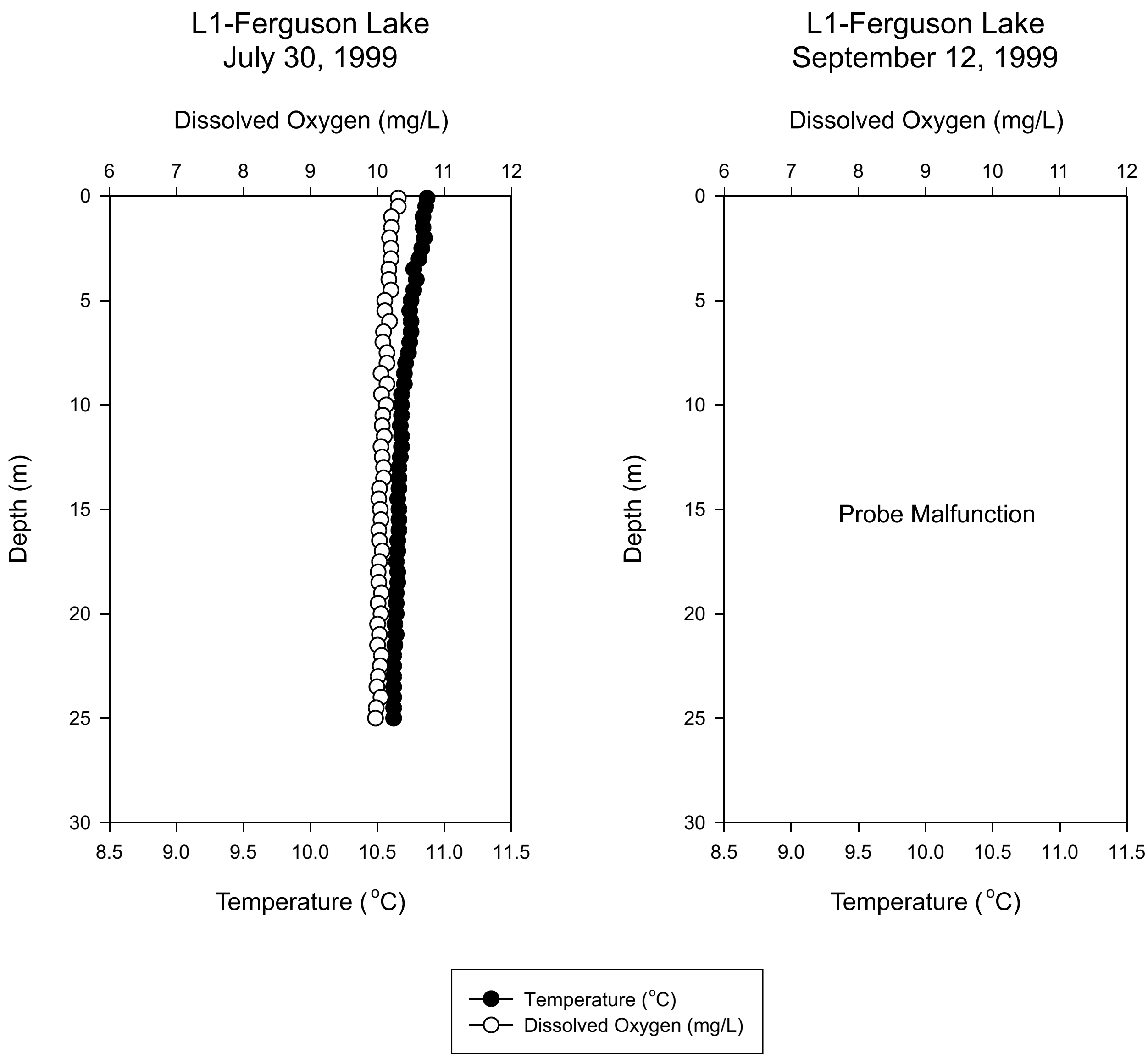

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Figure 3.6-2a

Temperature and Dissolved Oxygen Profiles, Ferguson Lake Project Area, 1999

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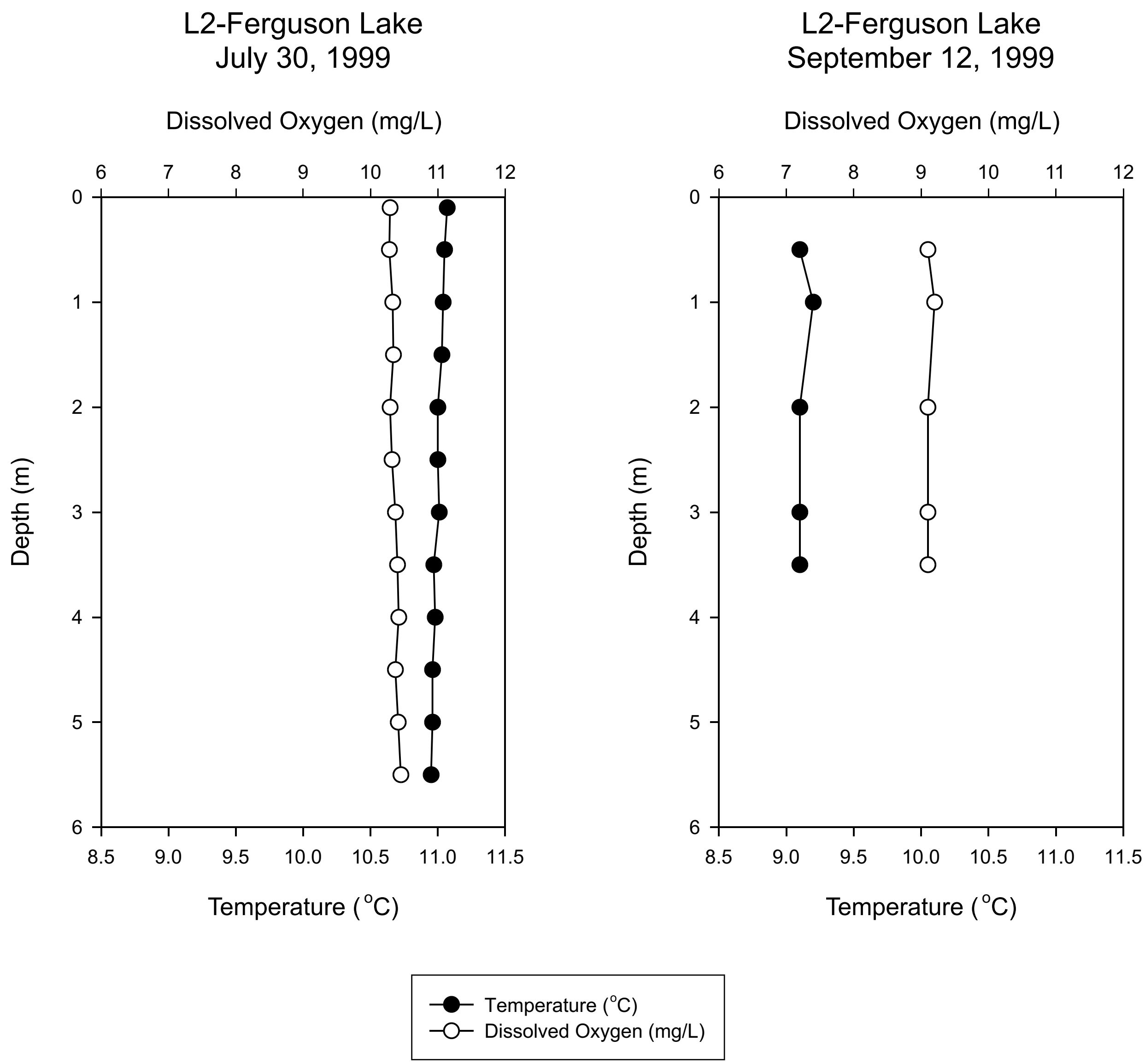

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Figure 3.6-2b

Temperature and Dissolved Oxygen Profiles, Ferguson Lake Project Area, 1999

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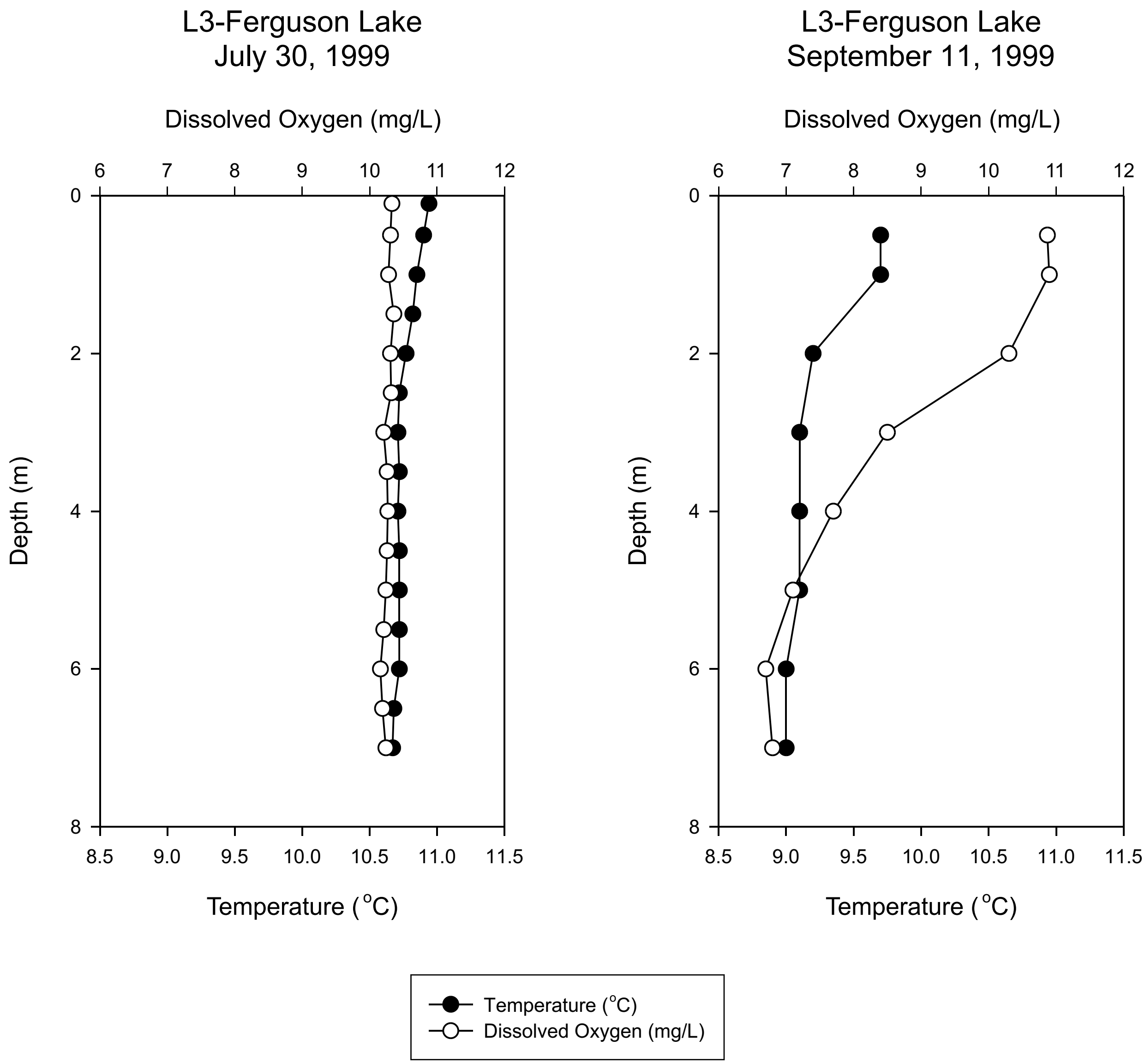

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Figure 3.6-2c

Temperature and Dissolved Oxygen Profiles, Ferguson Lake Project Area, 1999

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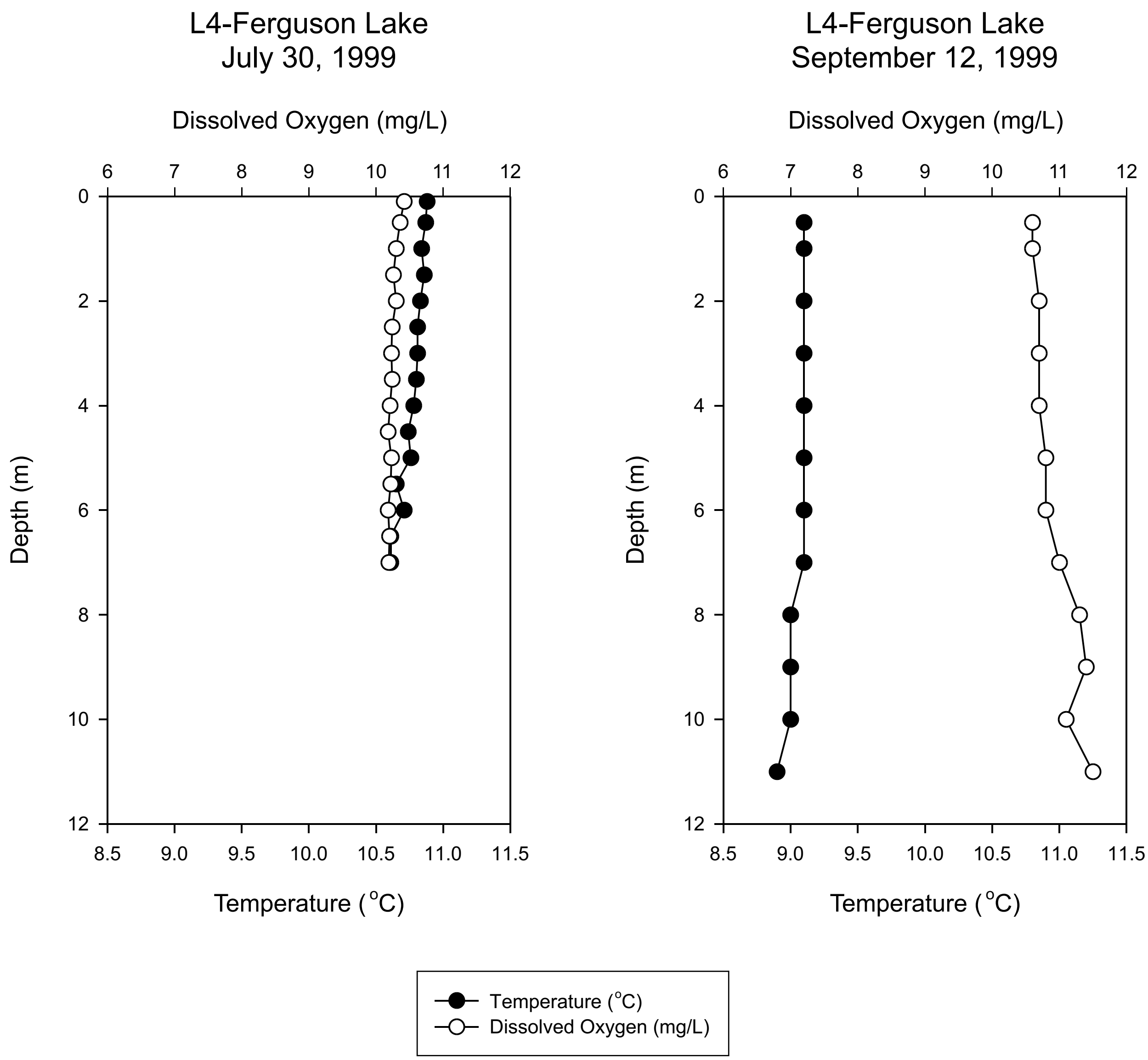

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Temperature and Dissolved Oxygen Profiles, Ferguson Lake Project Area, 1999

Figure 3.6-2d

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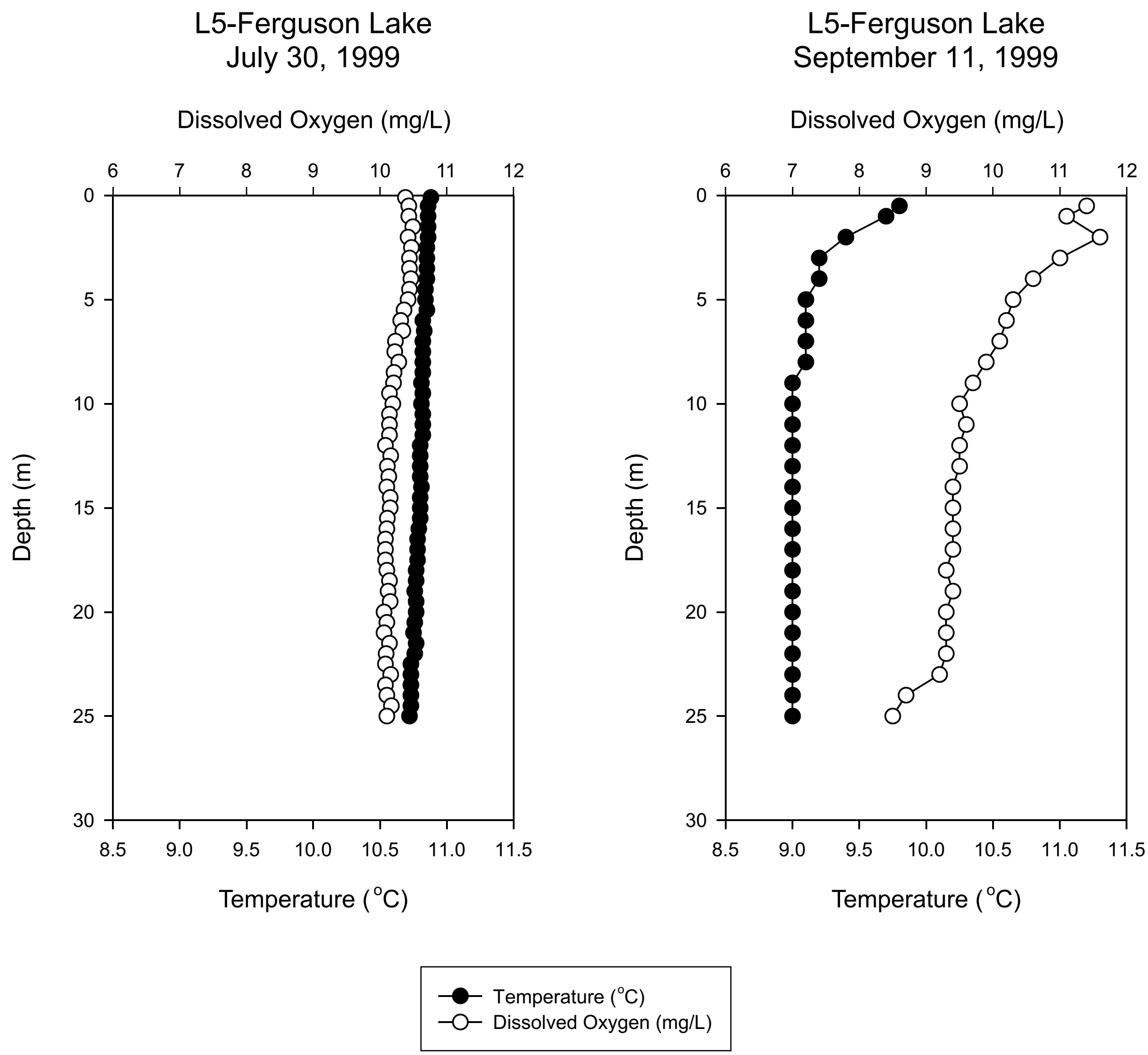

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Figure 3.6-2e

Temperature and Dissolved Oxygen Profiles,
Ferguson Lake Project Area, 1999

3.7 Stream Fish Communities and Habitats

3.7.1 Fish Community

3.7.1.1 Catch by Species and Stream

Appendix 3.7-1 shows the number of fish by species and their body lengths for each of the three streams that were electrofished in 1999, and Table 3.7-1 summarises the number of fish caught – it shows that a total of 55 fish from four species were captured, and that fish were found in all three streams.

Table 3.7-1
Number of Fish Caught by Species and Stream, Ferguson Lake Project Area, 1999

	Stream			
Species	**W1**	**W2**	**R2**	**Total**
	Number captured in stream			
Slimy sculpin	20	0	2	22
Ninespine stickleback	7	1	11	19
Arctic grayling	2	0	9	11
Longnose sucker	3	0	0	3
Total number	32	1	22	55
	Surveyed Area (m^2)			
	375	450	325	1150
	Catch/Surveyed Area (number/m^2)			
Slimy sculpin	0.053	0.000	0.006	0.019
Ninespine stickleback	0.019	0.002	0.034	0.017
Arctic grayling	0.005	0.000	0.028	0.010
Longnose sucker	0.008	0.000	0.000	0.003
Total catch/area	0.085	0.002	0.068	0.048

Stream W1 had the greatest number of fish species (four) and the greatest number of fish (32 or 58% of total catch). Stream R2, a second reference stream that is close to reference stream R1, had the second-greatest number of species (three) and the second-greatest number of fish (22 or 40% of total catch). Stream W2 had the lowest number of species (one) and the lowest number of fish (1 or 2% of total catch).

The most common species (at 22 fish or 40% of the total catch) was slimy sculpin (*Cottus cognatus*), a small, compact, bottom-dwelling fish that is found in streams and lakes throughout northern Canada with the exception of the Arctic islands of Nunavut and the northern tip of

Québec (Scott and Crossman, 1973). Slimy sculpins feed mainly on benthic invertebrates, particularly insect larvae, but a wide range of other insects are also eaten. Adults spawn in spring. The male builds a nest under a boulder in which the female lays eggs, and then the male fertilises the eggs and guards them until they hatch. The larvae and juveniles rear in streams until autumn, at which time they (as well as the adults) migrate to nearby lakes to overwinter. In the Project area, they migrate downstream to Ferguson Lake. Most of the slimy sculpin of this study were caught in stream W1 (20 or 91% of all slimy sculpin). Only two slimy sculpin were caught in stream R2, and none were caught in stream W2.

The second most common species (at 19 fish or 35% of the total catch) was the ninespine stickleback (*Pungitius pungitius*), a small, slender fish that is found in shallow water of streams and lakes throughout northern Canada with the exception of the Yukon Territory and the high Arctic islands (Scott and Crossman, 1973). It feeds on aquatic insects and small crustaceans. It spawns in summer. The male builds a nest among weeds or stones in shallow water using fragments of vegetation bound together with a secretion. The female deposits her eggs in the nest and the male fertilises them and guards them until they hatch. These fish also overwinter in Ferguson Lake. Most of the sticklebacks were caught in streams R2 (11 or 58% of all stickleback) and W1 (7 or 37% of all stickleback). Only one stickleback was caught in stream W2, and that was the only fish caught in that stream. That fish was found dead instead of being stunned by the electrofisher, suggesting that it may have been killed by habitat-related factors (see Section 3.7-2).

The third most common species (at 11 fish or 20% of the total catch) was Arctic grayling (*Thymallus arcticus*), a mid-sized, salmonid fish found throughout northern Canada with the exception of the Arctic islands and northern Québec (Scott and Crossman, 1973). They feed mainly on plankton such as insects and zooplankton and occasionally on small fish. They spawn in early spring in streams and rivers just before or after break-up of the ice cover. No nest or redd is constructed, instead eggs are broadcast over rocky substrate. Adults immediately return to lake habitat, in this case Ferguson Lake, but larvae and juveniles remain in their natal streams for the rest of the summer and only leave to overwinter in Ferguson Lake. Most of the Arctic grayling of this study were found in stream R2 (9 or 82% of all grayling), two were found in stream W1 and none in stream W2.

The least common of the four species (at 3 fish or 5%) was longnose sucker (*Catostomus catostomus*), a large, torpedo-shaped member of the sucker family that is found in streams and lakes throughout northern Canada with the exception of the Arctic coastline, the Arctic islands and the northern tip of Québec (Scott and Crossman, 1973). They feed entirely on benthic invertebrates such as amphipods and chironomid larvae. Spawning occurs in streams during spring. No nest are constructed, instead the fertilised eggs are broadcast over a gravel substrate. Adults leave the spawning stream for lake habitat, in this case Ferguson Lake, but larvae and juveniles remain in streams to rear. Some begin to migrate downstream to lake habitat within 1 month of hatch. Longnose sucker were only captured in stream W1.

3.7.1.2 Fish Density

The numbers of fish caught in each stream section were divided by the surface area of the stream section that was fished to obtain an estimate of fish density. Area was calculated by multiplying the length of the stream section by its average width (see Appendix 3.7-2). Area ranged from 325 m^2 for stream R2 to 450 m^2 for stream W2 and fish density ranged from 0.002 fish/m^2 for W2 to 0.085 fish/m^2 for W1 (Table 3.7-1). These are low densities compared to streams of southern Canada, which reflects the oligotrophic status of Ferguson Lake and its tributaries. Standardising fish numbers by area did not change the rank order of streams or of species within streams, indicating that fishing effort was distributed evenly over all three streams.

3.7.1.3 Length Frequency Distributions

Figure 3.7-1 shows the length frequency distributions for each of the four species. Lengths were pooled over all three streams because there were too few fish to show distributions for each species for each stream. The length frequency distributions were divided into 50 mm-wide intervals in order to minimise the number of intervals with zero counts.

Arctic grayling had the largest average size (87 mm) and the widest range of sizes. The Arctic grayling between 50 and 99 mm in length were most likely dominated by young-of-the-year (YOY) fish – those that hatched in the spring of 1999 and spent the summer growing in their natal streams. Growth rates of Arctic grayling are highly variable among watersheds, but the limited data from the Northwest Territories, Alaska and northern Saskatchewan and Alberta reported by Scott and Crossman (1973) indicate that 1-year-old grayling (*i.e.*, grayling that had spent one winter in lake habitat) have average lengths between 90 to 112 mm, and 2 year-olds have average lengths between 135 and 191 mm. Hence, the grayling between 150 and 199 mm in length that were caught in tributaries of Ferguson Lake were most likely 1 and 2 year-old juveniles that had overwintered in Ferguson Lake and then had entered streams during spring and summer of 1999 to feed on stream insects and avoid lake-resident predators. Grayling between 100 and 149 mm in length were most likely a mixture of YOY and 1 and 2 year-old juveniles.

Longnose suckers were the second largest fish in the streams of the study area (mean = 64 mm), but had the narrowest range length range. Growth of this species is also highly variable among watersheds, but data reported from Scott and Crossman (1973) indicate that these fish were probably mostly YOY.

Slimy sculpin were the third largest fish in the streams of the study area (mean = 56 mm). Sculpin between 39 and 49 mm in length were probably a mixture of YOY and juveniles whereas sculpins between 50 and 99 mm in length were a mixture of juveniles and adults because adult slimy sculpin rarely exceed 120 mm in total length (Scott and Crossman, 1973). Hence, the slimy sculpin captured in this study probably spanned the entire length range of the population(s) in the Ferguson Lake drainage.

Ninespine stickleback were the smallest fish in the study streams (mean = 41 mm). Sticklebacks from 10 to 49 mm in total length were a mixture of YOY and juveniles, and those 50 to 99 mm

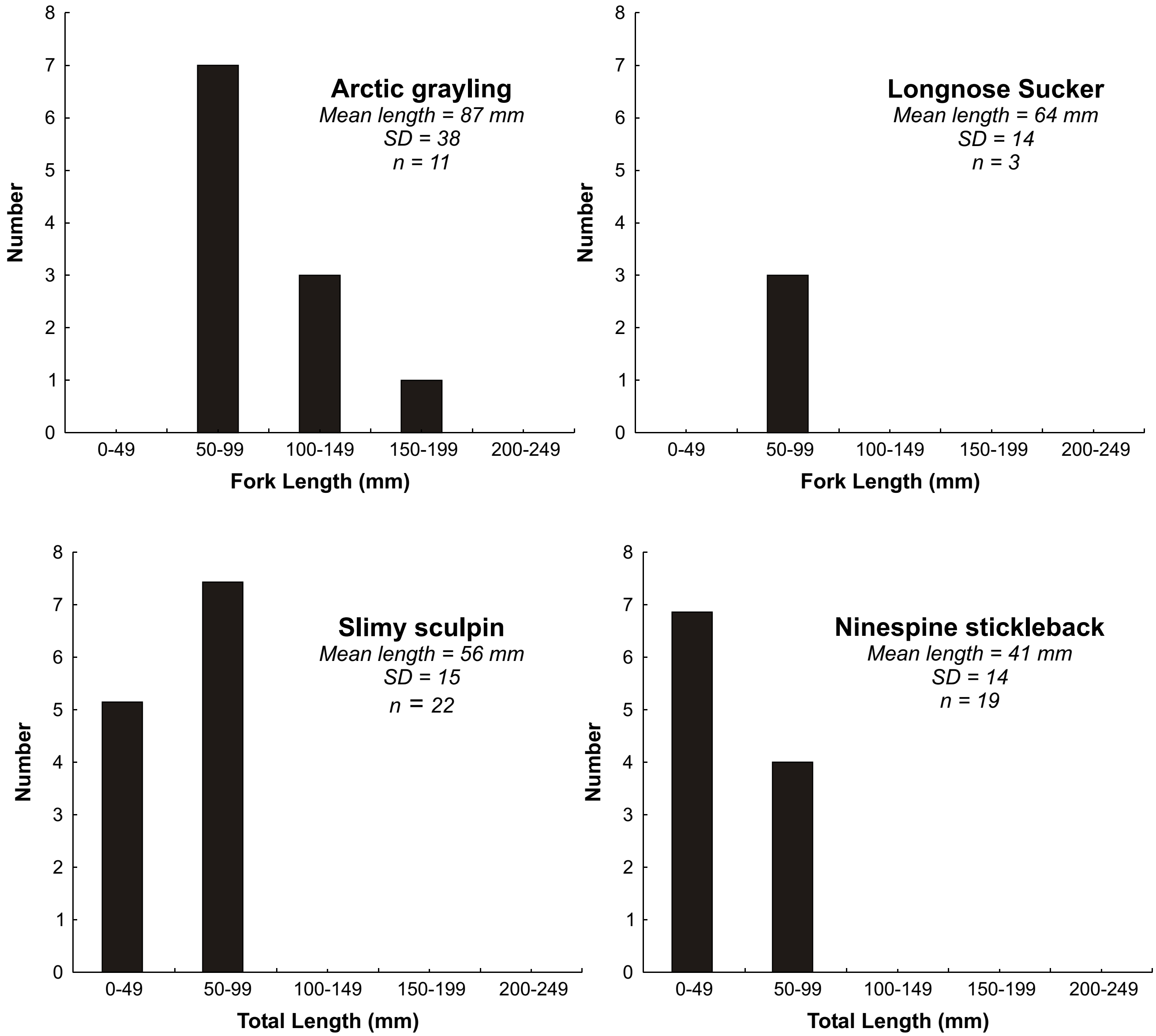

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FIGURE 3.7-1

Length Frequency Distribution of Stream Fish, Ferguson Lake, 1999

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in total length were adults (Scott and Crossman, 1973). Hence, the specimens captured in this study probably spanned the entire length range of the population(s) of the Ferguson Lake drainage.

3.7.2 Fish Habitat

Appendix 3.7-2 shows the habitat characteristics for the surveyed reaches of each of the three streams (W1, W2 and R2), and Figures 3.7-2 to 3.7-4 are sketches of the surveyed sections of the streams showing the distribution of habitat types along the sections. The essential features of each stream are described in Sections 3.7.2.1 to 3.7.2.3 below.

3.7.2.1 Streams E1, R2, E3 and R1

Streams E1, E2 and E3 were not surveyed for fish and fish habitat because they were too small in size and have too poor water quality to provide habitat for fish. Hence there was little purpose in sampling them for fish. Plate 3.7-1 is a photograph of stream E1 taken in July, 1999. The stream is small in width and depth with an unconfined, diffuse channel and a substrate composed of tundra grasses. Flows were low in July and even lower in September.

Plate 3.7-1 Photograph of stream E1 in July, 1999, showing the unconfined channel and low flows

Plate 3.7-2 is a photograph of the mouth of stream E2 as it enters Ferguson Lake that was taken in July 1999. The stream has a diffuse channel with some subterranean flow. Flows were low in

Plate 3.7-2 Photograph of the mouth of stream E2 as it enters Ferguson Lake (in background) showing the diffuse drainage pattern

July and even lower in September. Plate 3.7-3 is a close-up of the mouth of E2 showing some run/pool habitat. It may be the only part of the stream that could support fish. However, stream E2 has unusually low pH and unusually high elevated metals concentrations, hence it is unlikely that any fish would reside there.

Plate 3.7-3 Close-up photograph of the mouth of stream E2 as it enters Ferguson Lake showing pool/run habitat

Plate 3.7-4 is a photograph taken in July, 1999, showing the gauging station on stream E3. Although the stream has a confined channel, it also has unusually low pH and unusually high elevated metals concentrations, hence it is unlikely that any fish would reside there.

Plate 3.7-4 The gauging station on stream E3 showing the confined channel and low flows. Flows in September were lower than in July, making it difficult to conduct an electrofishing survey

Plate 3.7-5 is a photograph of the water and sediment reference stream R1 taken just upstream of the gauging station in July 1999. Although the stream appears large enough to support fish and the water quality is known to be moderate, the adjacent reference stream R2 was fished instead because it had even higher quality fish habitat.

3.7.2.2 Stream W1

Stream W1 was surveyed for a distance of 125 m upstream from its mouth with Ferguson Lake to the water gauge (Figure 3.7-2). This distance consisted of a mixture of runs (60% of surface area) and riffles (40% of surface area) with an average width of 3.0 m and an average depth of 0.60 m. Hence, the surface area that was fished was 375 m^2. Gradient was only 1% and the stream stage in September was Medium, as would be expected for that time of year. The substrate was dominated by boulders (50%), followed by cobble (35%), silt (10%) and sand (5%). Eighty percent of the surface area provided some kind of cover for fish. Boulders provided almost all of the cover (95%) with small contributions from pools (2.5%) and cutbanks (2.5%). The water was clear with a temperature of 7.0°C, very low conductivity (5 µS/cm) and a near-neutral pH (7.7).

Plate 3.7-5 The gauging station on reference stream R1. Ferguson Lake is in the background

Plates 3.7-6 and 3.7-7 (and the cover photograph of this report) show the type of fish habitat present in stream W1.

Plate 3.7-6 Photograph of the mouth of stream W1 looking upstream showing the low gradient, the riffle-run habitat and cobble-boulder substrate

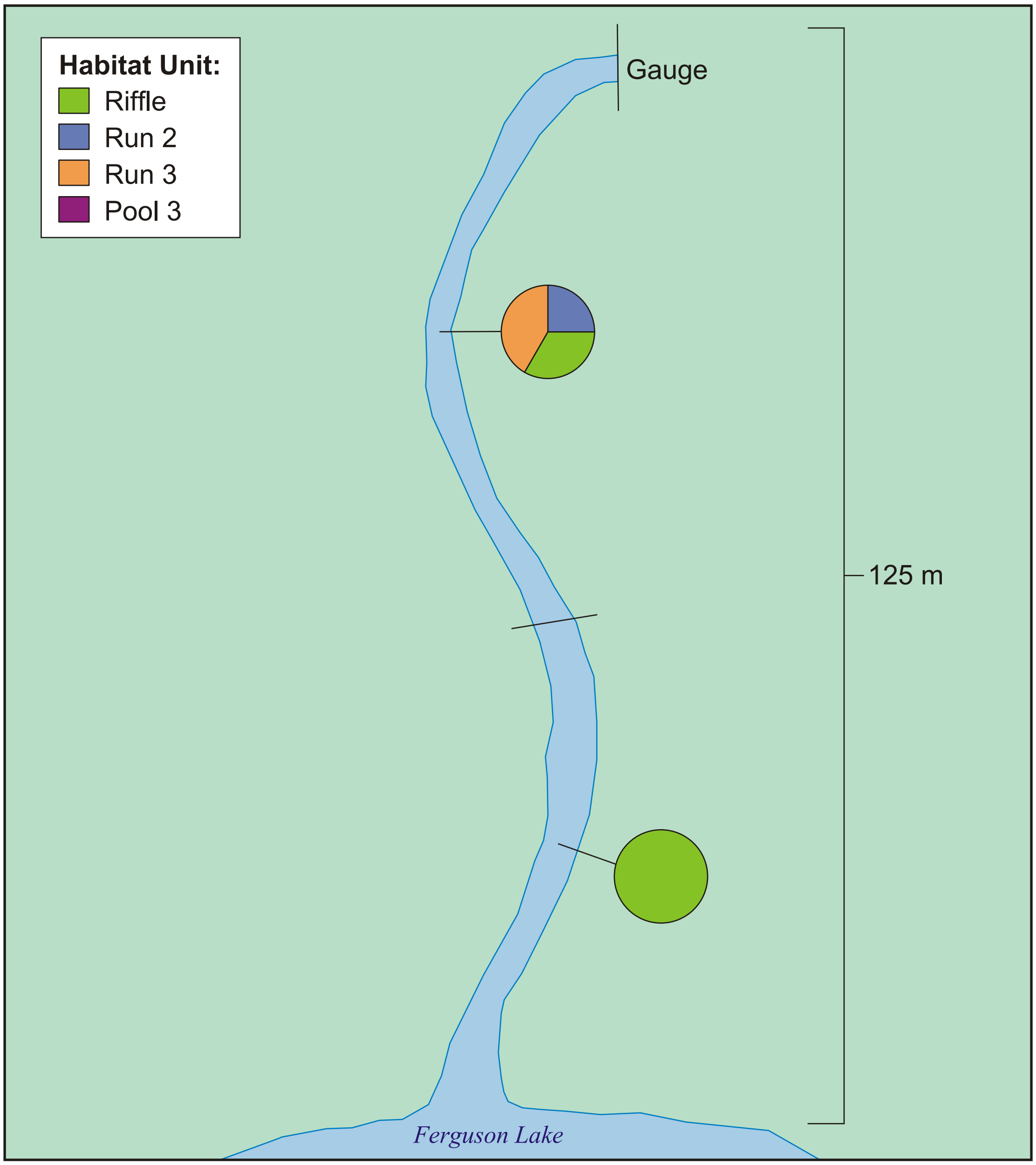

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FIGURE 3.7-2

Sketch of the Habitat of Stream W1, Ferguson Lake Project, 1999

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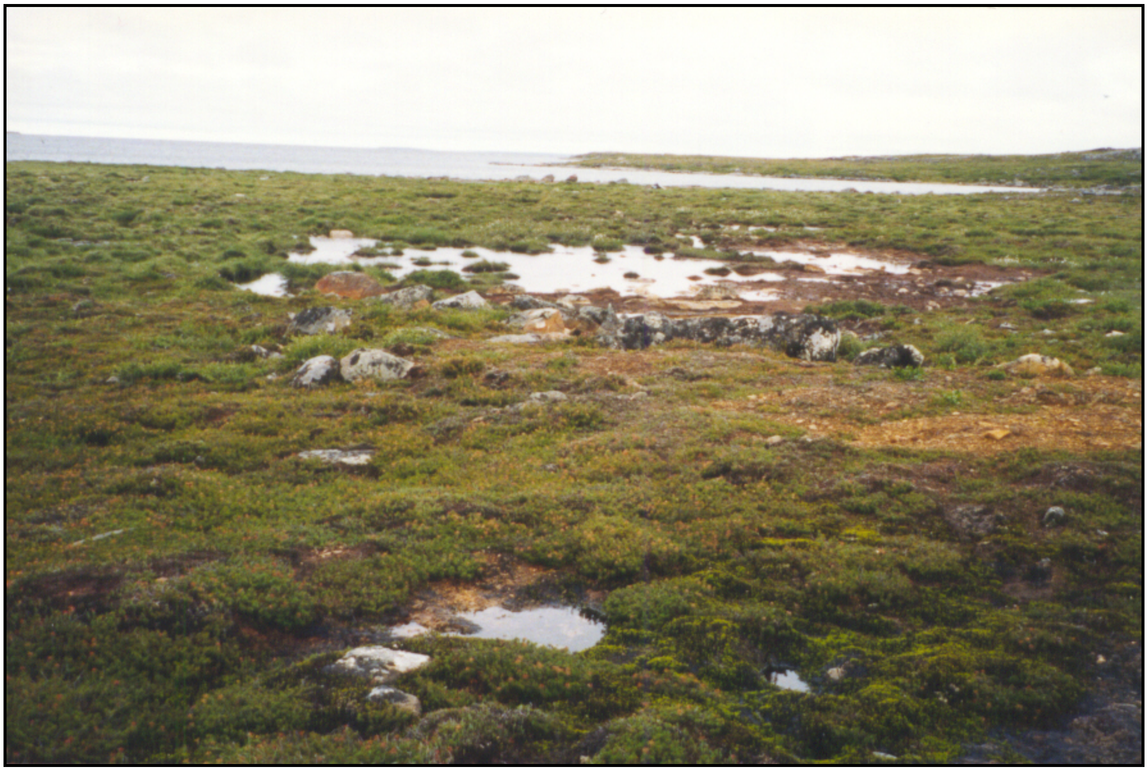


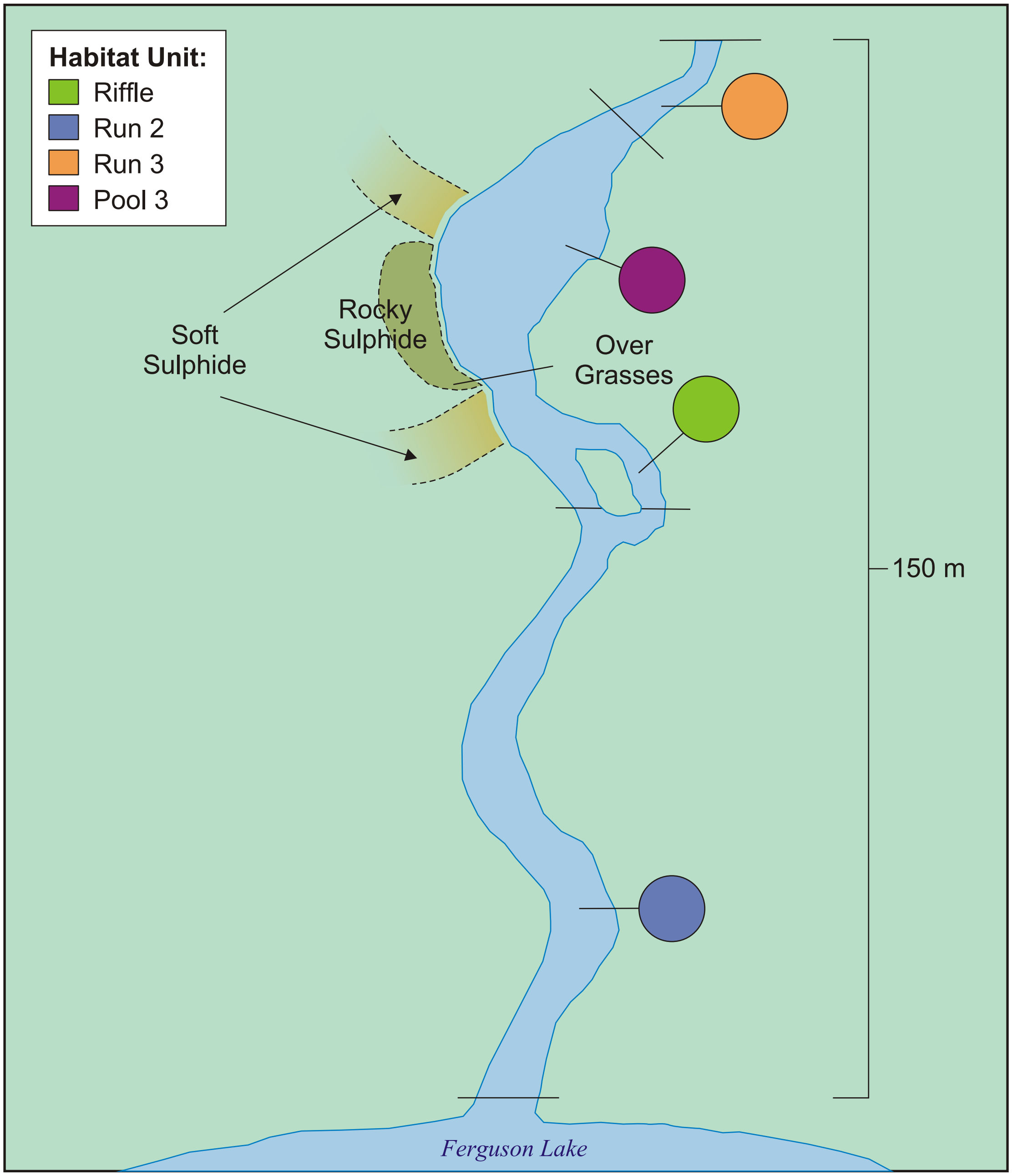
Plate 3.7-7 Photograph of stream W1 further upstream than in Plate 3.7-6 showing the narrowing of the channel, the riffle-run habitat and the banks with overhanging vegetation

The stream was ranked high for rearing and migration (rank = 3) because of its clear water and lots of boulder cover. It was ranked less favourably for spawning (rank = 2), mainly because of the lack of gravel – the preferred substrate for Arctic grayling and longnose sucker – and the presence of sand and silt, which tends to kill fish eggs due to poor oxygen permeability. Adult feeding was ranked even lower (rank = 1) because of the absence of cover for large fish – boulder habitat is only useful for juveniles and small adults because adults cannot fit inside the crevices. The stream was not suitable for overwintering (rank = 0) because its relatively shallow depth and lack of significant pool habitat meant that it would freeze to the bottom during winter. A stream has to be deeper than 2 m to allow liquid water to persist during winter in Nunavut.

Based on those habitat characteristics, it was not surprising to find that W1 contained the greatest number of fish and the highest fish density of the three streams. The large amount of boulder habitat provided excellent spawning and rearing cover for slimy sculpin, the dominant fish species of that stream.

3.7.2.3 Stream W2

Stream W2 was surveyed for a distance of 159 m upstream from its mouth at Ferguson Lake (Figure 3.7-3). That distance consisted of a mixture of runs (65% of surface area), riffles (20% of surface area) and pools (15%) with an average width of 3.0 m and an



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Sketch of the Habitat of Stream W2, Ferguson Lake Project, 1999

FIGURE 3.7-3

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average depth of 0.50 m. Hence, the surface area that was fished was 450 m^2. Gradient was 2% and the stream stage was Medium. The substrate was dominated by silt (60%), followed by cobble (15%), boulder (10%), large and small gravel (10%) and organic matter (5%). The boulders and cobble were embedded in the silt. The silt appeared to come from a sulphide deposit on the right bank of the stream (as looking downstream).

Only 40% of the surface area provided cover for fish. Boulders provided almost all of the cover (85%) with small contributions from macrophytes (10%) and cutbanks (5%). The water was red in colour and turbid with a temperature of 8.9°C, low conductivity (17 µS/cm – although two to three times higher than in either of the other two streams), and a relatively low pH (5.0). This poor water quality, compared to W1 and R2, was undoubtedly related to the silt and acid generated by the sulphide deposit.

Plate 3.7-8 shows a photograph of stream W2 as it flows into Ferguson Lake.

Plate 3.7-8 Photograph of stream W2 entering Ferguson Lake (in the background) with the gauging station in the foreground, taken in July 1999

The stream was ranked as unsuitable for spawning (rank = 0) and adult feeding (rank = 0), mainly because of the silt, the poor water quality and the absence of gravel. The stream was also unsuitable for overwintering (rank = 0) because it was too shallow to prevent freezing to the bottom during winter. The stream had only marginal suitability for rearing (rank = 1) and migration (rank = 1) because of the large quantities of silt, the poor water quality and the low amount of cover.

Based on this poor fish habitat, it was not surprising to find that only one fish was captured in stream W2, and that the fish was a ninespine stickleback. Sticklebacks are often found in streams and ponds with poor water quality. It was also not surprising to find that the fish was found dead instead of being stunned by electrofishing. Water quality results suggest that low pH and elevated metals concentrations make this stream inhospitable to fish.

3.7.2.4 Stream R2

Stream R2 was surveyed for a distance of 325 m upstream from its mouth with Ferguson Lake (Figure 3.7-4). It consisted mainly of riffles (60%), followed by shallow runs (35%) and few, shallow pools (5%) with an average width of 2.0 m and an average depth of 0.15 m. Hence, the surface area that was fished was 325 m^2. There was heavy braiding of the channel near Ferguson Lake and in the middle of the reach. Gradient was 2% and the stream stage was Medium. The substrate was a mixture of boulders (35%), organic matter (25%), sand (15%), silt (10%), cobble (10%) and small gravel (5%). Only 40% of the surface area provided cover for fish. Boulders provided most of the cover (90%) with small contributions from pools (5%) and overhanging vegetation (5%). The water was clear with a temperature of 12.4°C, very low conductivity (7 μS/cm), and a near-neutral pH (6.8). The higher temperature of R2 compared to W1 and W2 was probably a result of its shallower depth which would result in faster daytime heating.

The stream was ranked moderately high for rearing (rank = 2) because of the presence of boulder habitat, the high water quality and the relatively high percentage of riffle habitat.

It ranked low for spawning (rank = 1) because of the presence of silt, sand and organic matter and the lack of spawning gravel. It also ranked low for migration (rank = 1) due to its shallow depth. It was unsuitable for adult feeding (rank = 0) due to the shallow depth and the organic/silty/sandy substrate, and it was too shallow to provide any overwintering habitat (rank = 0).

These habitat characteristics place stream R2 intermediate in overall habitat quality between streams W1 and W2. It was not surprising, therefore, to find that the number of fish and the fish density of R2 was intermediate between W1 and W2. Fewer slimy sculpin were found in R2 than in W1 because there was less boulder cover in R2 than in W1. However, more Arctic grayling and ninespine stickleback were present in R2 than in W1, perhaps because R2 was shallower than W1. The higher numbers of stickleback may also be related to the higher percentages of organic matter and silt in R2 compared to W1, although that difference would not explain the greater numbers of Arctic grayling in R2 compared to W1.

3.7.3 Fish Summary

A total of 55 fish from four species (slimy sculpin, ninespine stickleback, Arctic grayling and longnose sucker) were captured by electrofishing in three tributaries of Ferguson Lake on September 14, 1999. The fish communities are very simple – between one and four species were captured in each stream. The density of fish was also low – an average of only 0.048 fish/m^2 over all three streams and species combined (range: 0.002 to 0.085 fish/m^2 for the three streams). The low numbers and densities reflect the generally low biological productivity of the three

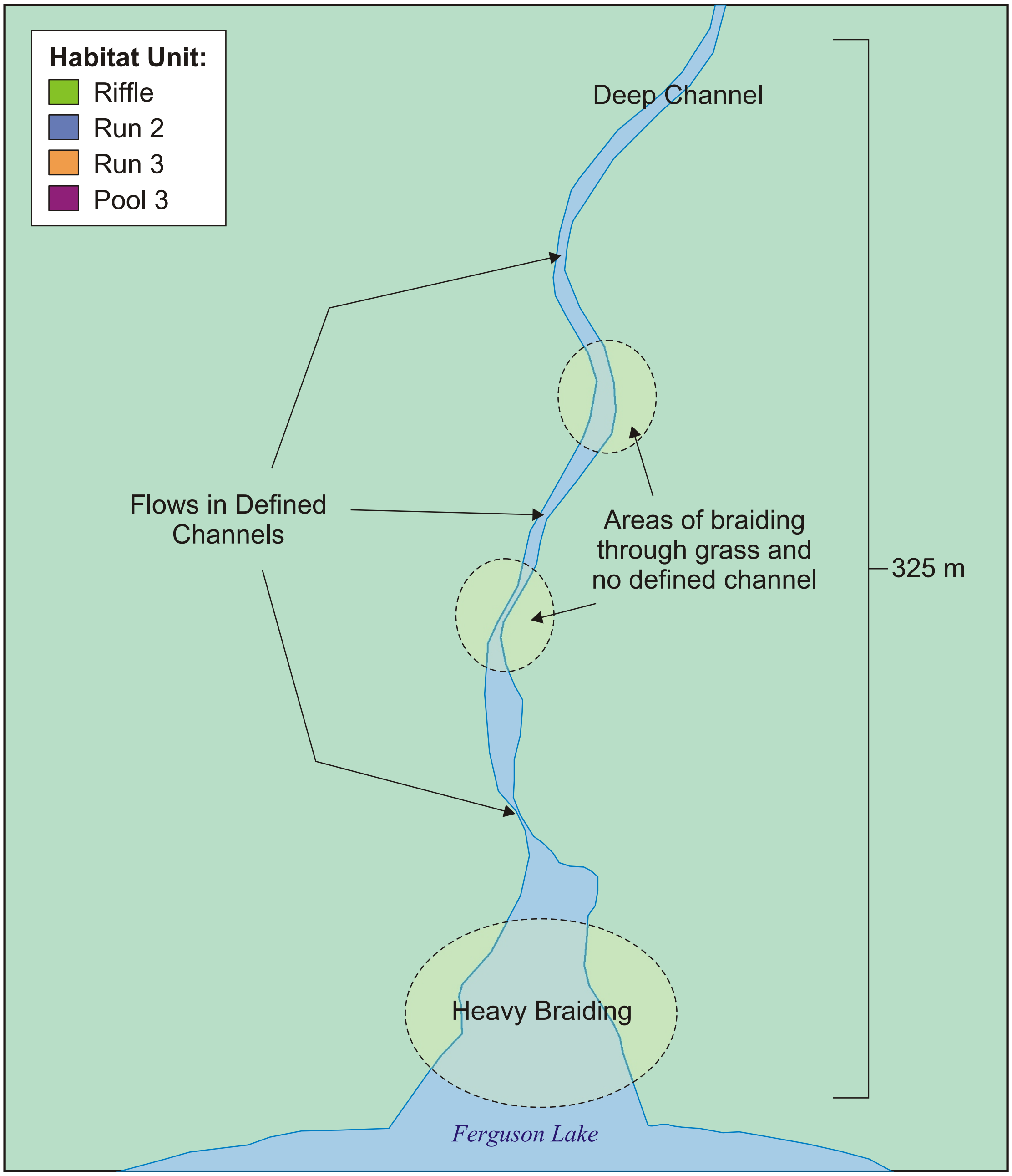

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FIGURE 3.7-4

Sketch of the Habitat of Stream R2, Ferguson Lake Project, 1999

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streams, as indexed by the low nutrient concentrations and very low conductivities of stream water. For example, the conductivities of streams W1 and R2, at 5 and 7 µS/cm, respectively, are only slightly high than that of distilled water.

The four species are either obligate stream residents (juvenile and adult slimy sculpin and juvenile Arctic grayling) or lake-resident species with juvenile stages that occasionally seek rearing habitat in streams (longnose sucker) or species that seek either stream or lake habitat for all life stages (ninespine stickleback). The common characteristic of the fish caught in the three streams was their small size – length ranged from 10 to 153 mm and 93% had lengths below 100 mm. The Arctic grayling, slimy sculpin and ninespine stickleback represented several age classes (although only slimy sculpin and ninespine stickleback included adults), but the longnose suckers were probably young-of-the-year.

The three streams were narrow (1-3 m), shallow (0.15-0.60 m) and had low gradients (1-2%). They were composed mainly of riffles (20-60% of surface area) and runs (35-65%) with a few shallow pools (0-15%). There were no cascades or deep pools. Their substrates were a mixture of cobble and boulders (25-85%), silt, sand and organic matter (20-65%) and gravel (5-10%). There was no bedrock in the substrate. The total surface area with cover for fish ranged from 40 to 80%. Of that cover, 85 to 95% was provided by boulders and the rest by macrophytes, pools, cutbanks and overhanging vegetation. Water quality varied substantially between streams. W1 and R2 had clear water, low conductivities (5-7 µS/cm) and near-neutral pH (6.8-7.7), while stream W2 had red, turbid water with higher conductivity (17 µS/cm) and a much lower pH (5.0). The difference in water quality was due to drainage into W2 of acid water from a sulphide deposit. As discussed above, W2 also has high concentrations of several potentially toxic metals.

Most features of the three fish communities can be explained by differences in habitat among streams. The most obvious feature was the almost complete absence of fish in stream W2 compared to the other two streams. That was most likely due to the low water quality in stream W2. Other obvious features were the higher numbers and densities of fish in stream W1 compared to R2, the dominance of slimy sculpin in stream W1 compared to R2, and the dominance of ninespine stickleback in R2 compared to W1. W1 had the highest percentage of cover habitat and the highest percentage of cover made up of boulders. Those features support slimy sculpin because the crevices in the boulders are ideal hiding places for sculpin. R2 was the shallowest of the three streams, which tends to encourage colonisation by small fish such as ninespine stickleback.

The suitability of the streams to support fish life history stages followed directly from their habitat characteristics. None of the three streams are suitable for overwintering because they all freeze to the bottom in winter. Instead, all fish have to migrate downstream to Ferguson Lake to overwinter. W1 provides medium-quality spawning suitability, high-quality rearing and migration habitat and low-quality adult feeding. W2 is suitable only as low-quality rearing and migration habitat, and is unsuitable for spawning and adult feeding. R2 provides medium-quality rearing habitat, low-quality spawning and migration habitat and is unsuitable for adult feeding.

3.8 Wildlife Observations

Several species of wildlife were observed during the survey, including caribou (*Rangifer tarandus*), muskox (*Ovibos moschatos*), Arctic hare (*Lepus arcticus*) and willow ptarmigan (*Lagopus lagopus*) (Plates 3.8-1 to 3.8-4).

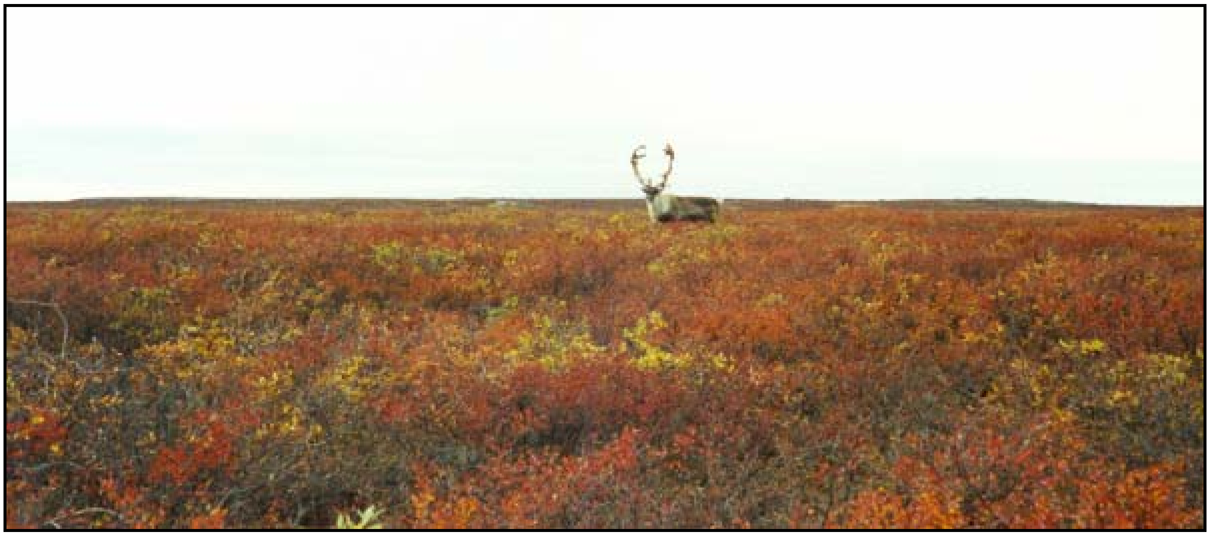

Plate 3.8-1 Male caribou observed near Ferguson Lake in mid-September 1999

Plate 3.8-2 Muskox observed near Ferguson Lake in mid-September 1999

Plate 3.8-3 Arctic hare observed near the camp at Ferguson Lake in mid-September 1999

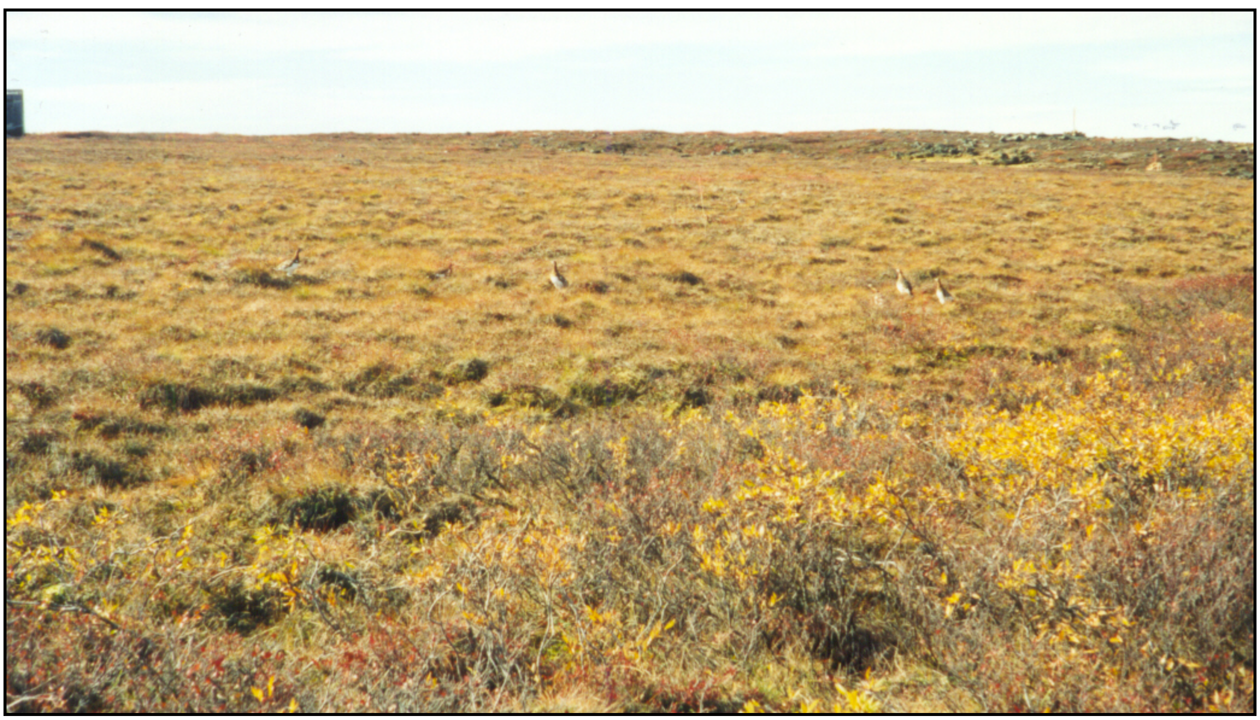

Plate 3.8-4 Ptarmigan observed near Ferguson Lake in mid-September 1999.

4. CONCLUSIONS

4. Conclusions

This study showed, first, that Ferguson Lake has the high-quality water and sediment expected of a pristine, undisturbed lake of the Southern Arctic Ecozone. It has near-neutral pH, low nutrient concentrations, very low metals concentrations and high concentrations of dissolved oxygen from the surface to the lake bottom.

Second, the streams entering Ferguson Lake are typically narrow and shallow, have low flows, provide average- to low-quality fish habitat and support low densities of small-bodied fish. This means the fish community of the Ferguson Lake system is highly dependent on spawning, rearing, feeding and overwintering habitat contained within Ferguson Lake rather than on tributary habitat.

Third, at least three of the streams entering Ferguson Lake near the mineralised zone have very low water quality and almost no fish habitat because of acid rock drainage from the mineralised zone. This acid rock drainage is a natural feature of the area.

This study was only a reconnaissance-level study of parts of the aquatic ecosystem. A comprehensive environmental impact assessment of the Ferguson Lake Project will require more detailed study of the aquatic ecosystem (as well as the atmospheric, geological, terrestrial and socio-economic aspects). A detailed study of the aquatic ecosystem would require descriptions of primary producers (the phytoplankton community in Ferguson Lake and the periphyton and macrophyte communities in streams), secondary producers (the zooplankton community of the lake and the benthic invertebrate communities in both the lake and its streams), the fish community of Ferguson Lake (species composition, relative abundance, size, age, growth and tissue metals concentrations), and fish habitat in those parts of Ferguson Lake that may be altered by development of the property.

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APPENDIX 3.1-1:
STREAM FLOW MONITORING, FERGUSON LAKE PROJECT AREA, 1999

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Appendix 3.1-1
Stream Flow Monitoring, Ferguson Lake Project Area, 1999

Location: E3
Drainage area (km^2): 0.342
Survey Date: 29-Jul-99
Total flow (m^3/s): 0.006
Unit Yield ($L/s/km^2$): 18.0

Notes	Stream station (m)	Stream depth (cm)	Average velocity[1] (cm/s)	Stream width (cm)	Flux[2] (cm^2/s)	Average flux[2] (cm^2/s)	Incremental flow[3] (m^3/s)	Percent of total flow
upstream left	0.50	0	0	0	0	0	0.000	0.0
	0.60	27	0	10	0	0	0.000	0.0
	0.70	29	-1	10	-29	-15	0.000	-2.4
	0.80	28	-2	10	-56	-43	0.000	-6.9
	0.90	23	-3	10	-69	-63	-0.001	-10.2
	1.00	30	-2	10	-60	-65	-0.001	-10.5
	1.10	29	3	10	87	14	0.000	2.2
	1.20	26	9	10	234	161	0.002	26.1
	1.30	25	13	10	325	280	0.003	45.5
	1.40	21	8	10	168	247	0.002	40.1
	1.50	14	1	10	14	91	0.001	14.8
	1.60	8	0	10	0	7	0.000	1.1
	1.70	3	0	10	0	0	0.000	0.0
	1.80	3	0	10	0	0	0.000	0.0
upstream right	1.90	0	0	10	0	0	0.000	0.0
	Total						0.006	100.0

[1]: Measured at a depth 60% of total depth.

[2]: Flux = depth x velocity.

[3]: Flow = average flux x width

APPENDIX 3.2-1: ANALYTICAL RESULTS FOR LAKE WATER QUALITY PARAMETERS, FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.2-1
Analytical Results for Lake Water Quality Parameters, Ferguson Lake Project Area, 1999

Station Number:		**L1**	**L1**	**L2**	**L2**	**L3**	**L3**	**L4**	**L4**	**L5**	**L5**
Date Sampled:		**30-Jul-99**	**12-Sep-99**	**30-Jul-99**	**11-Sep-99**	**30-Jul-99**	**11-Sep-99**	**30-Jul-99**	**12-Sep-99**	**30-Jul-99**	**11-Sep-99**
Parameters	**Units**										
Physical Tests											
Conductivity	µS/cm	23	21	24	23	25	24	26	22	23	26
Hardness ($CaCO_3$)	mg/L	-	6.74	6.59	7.02	7.01	6.91	-	7.08	-	6.89
pH	pH units	5.53	7.01	8.22	7.32	6.01	7.63	6.92	7.12	6.66	6.19
Total Suspended Solids	mg/L	<3	<3	<3	<3	<3	<3	<3	<3	3	<3
Turbidity	NTU	0.7	0.5	0.6	0.7	0.8	1.1	0.6	0.7	1	0.6
Dissolved Anions											
Acidity (to pH 8.3)	mg/L	-	<1	-	<1	-	<1	-	<1	-	4
Alkalinity-Total ($CaCO_3$)	mg/L	-	6	-	5	-	5	-	5	-	5
Sulphate (SO_4)	mg/L	-	<1	-	2	-	1	-	2	-	1
Nutrients											
Ammonia Nitrogen-N	mg/L	0.04	<0.02	<0.02	0.02	0.02	0.03	0.05	<0.02	<0.02	0.04
Total Kjeldahl Nitrogen-N	mg/L	0.24	-	0.23	-	0.28	-	0.25	-	0.22	-
Nitrate Nitrogen-N	mg/L	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Dissolved Ortho-Phosphate-P	mg/L	<0.001	0.002	0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001
Total Phosphate-P	mg/L	0.005	0.008	0.005	0.006	0.004	0.006	0.005	0.006	0.006	0.008
Total Metals											
Aluminum T-Al	mg/L	0.021	0.018	0.022	0.02	0.026	0.02	0.021	0.023	0.024	0.02
Antimony T-Sb	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Arsenic T-As	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.0001	<0.0001	0.0001
Barium T-Ba	mg/L	0.00683	0.00649	0.00645	0.00595	0.00629	0.00573	0.00659	0.00657	0.00619	0.00547
Beryllium T-Be	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Boron T-B	mg/L	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002
Cadmium T-Cd	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Calcium T-Ca	mg/L	1.45	1.47	1.41	1.47	1.46	1.47	1.44	1.53	1.46	1.46
Chromium T-Cr	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
Cobalt T-Co	mg/L	<0.0001	<0.0001	<0.0001	0.0001	0.0002	0.0001	<0.0001	0.0001	<0.0001	<0.0001
Copper T-Cu	mg/L	0.0011	0.0011	0.0012	0.0014	0.0017	0.0013	0.0013	0.0014	0.001	0.0013
Iron T-Fe	mg/L	<0.03	<0.03	<0.03	<0.03	0.03	<0.03	<0.03	0.03	0.03	<0.03
Lead T-Pb	mg/L	<0.00005	0.00014	<0.00005	0.00014	<0.00005	0.00016	<0.00005	0.00023	0.00007	0.00015
Magnesium T-Mg	mg/L	0.7	0.7	0.7	0.8	0.8	0.8	0.7	0.8	0.8	0.8
Manganese T-Mn	mg/L	0.00245	0.00282	0.00364	0.0053	0.00408	0.00476	0.00293	0.00387	0.0042	0.00441
Mercury T-Hg	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum T-Mo	mg/L	<0.00005	<0.00005	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Nickel T-Ni	mg/L	0.001	0.0011	0.0012	0.0021	0.0025	0.0019	0.0011	0.002	0.0009	0.0011
Selenium T-Se	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Silver T-Ag	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Uranium T-U	mg/L	0.00004	0.00004	0.00004	0.00003	0.00004	0.00003	0.00004	0.00004	0.00003	0.00003
Vanadium T-V	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc T-Zn	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001
Extractable Hydrocarbons[1]											
EPH10-19	mg/L	-	<0.3	-	<0.3	-	<0.3	-	<0.3	-	<0.3
EPH19-32	mg/L	-	<1	-	<1	-	<1	-	<1	-	<1
Organic Parameters											
Chemical Oxygen Demand-COI	mg/L	<20	-	<20	-	<20	-	<20	-	<20	-
Total Organic Carbon-C	mg/L	5	-	4.3	-	4.2	-	4.4	-	4.3	-

< = Less than the detection limit indicated.

1: EPH = Extractable Petroleum Hydrocarbons.

- Parameter not collected at this site.

APPENDIX 3.3-1: ANALYTICAL RESULTS FOR STREAM WATER QUALITY PARAMETERS, FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.3-1
Analytical Results for Stream Water Quality Parameters, Ferguson Lake Project Area, 1999

Station Number:		**W1 (Rep1)**	**W1 (Rep 2)**	**W1**	**W2 (Rep 1)**	**W2 (Rep 2)**	**W2**	**E1**	**E1**	**E2 (Rep 1)**	**E2 (Rep 2)**	**E2**	**E3**	**E3**	**R1 (Rep 1)**	**R1 (Rep 2)**	**R1**
Date Sampled:		**28-Jul-99**	**28-Jul-99**	**12-Sep-99**	**28-Jul-99**	**28-Jul-99**	**12-Sep-99**	**29-Jul-99**	**13-Sep-99**	**29-Jul-99**	**29-Jul-99**	**13-Sep-99**	**29-Jul-99**	**13-Sep-99**	**1-Aug-99**	**1-Aug-99**	**13-Sep-99**
Parameters	**Units**																
Physical Tests																	
Conductivity	µS/cm	22	22	33	51	52	99	77	65	813	741	1560	368	473	32	26	33
Hardness ($CaCO_3$)	mg/L	10.1	10	11.8	15.1	14	26.4	16.2	18.4	95.1	101	268	56	74.8	10.6	10.4	12.9
pH	pH units	6.35	6.47	6.52	4.83	5.24	4.86	7.43	6.61	2.89	2.98	2.94	3.29	3.46	5.48	6.23	6.77
Total Suspended Solids	mg/L	<3	5	<3	8	10	26	4	<3	3	<3	12	<3	7	<3	<3	<3
Turbidity	NTU	2	2.1	2.2	5.1	5.1	24.8	4.5	5.4	0.4	0.3	1.1	0.9	2.5	6.3	0.9	2.4
Dissolved Anions																	
Acidity (to pH 8.3)	mg/L	-	-	3	-	-	11	-	6	-	-	675	-	103	-	-	4
Alkalinity-Total ($CaCO_3$)	mg/L	-	-	9	-	-	<1	-	12	-	-	<1	-	<1	-	-	10
Sulphate (SO_4)	mg/L	-	-	3	-	-	27	-	2	-	-	636	-	170	-	-	2
Nutrients																	
Ammonia Nitrogen-N	mg/L	0.03	0.015	0.03	0.13	0.06	0.04	0.03	0.03	0.066	<0.08	0.06	0.012	0.11	0.008	0.012	<0.02
Total Kjeldahl Nitrogen-N	mg/L	0.37	0.43	-	0.46	0.45	-	0.59	-	0.3	0.24	-	0.25	-	0.43	0.41	-
Nitrate Nitrogen-N	mg/L	<0.005	<0.005	0.005	-	-	<0.005	-	0.006	<0.005	<0.005	0.009	<0.005	<0.005	<0.005	<0.005	0.005
Dissolved Ortho-Phosphate-P	mg/L	0.001	0.001	0.002	-	-	0.002	-	0.001	0.002	0.003	0.003	0.001	0.003	0.001	0.001	0.002
Total Phosphate-P	mg/L	0.012	0.011	0.01	-	-	0.01	-	0.015	0.005	0.008	0.008	0.007	0.004	0.009	0.009	0.012
Total Metals																	
Aluminum T-Al	mg/L	0.111	0.106	0.115	0.742	0.676	1.35	0.098	0.064	14.7	14.8	35.3	8.6	9.09	0.093	0.091	0.093
Antimony T-Sb	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.0001	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
Arsenic T-As	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001	0.0002	0.0002	0.0002	0.0004	0.0005	0.0012	0.0003	0.0003	0.0001	0.0001	0.0001
Barium T-Ba	mg/L	0.014	0.0136	0.015	0.0178	0.0177	0.0254	0.0157	0.0173	0.0268	0.0277	0.0304	0.0361	0.0505	0.0146	0.0143	0.0134
Beryllium T-Be	mg/L	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	0.0006	0.0006	0.001	<0.0005	0.0006	<0.0005	<0.0005	<0.0005
Boron T-B	mg/L	0.001	0.001	0.002	0.001	0.002	0.002	0.003	0.002	0.005	0.006	0.008	0.003	0.003	0.002	0.002	0.002
Cadmium T-Cd	mg/L	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.0004	0.00043	0.0008	0.00016	0.00014	<0.00005	<0.00005	<0.00005
Calcium T-Ca	mg/L	2.3	2.34	2.67	3.55	3.42	6.55	3.41	4.06	19.2	20.4	50	11.3	15.8	2.4	2.37	2.93
Chromium T-Cr	mg/L	<0.0005	<0.0005	<0.0005	0.0008	0.0009	0.0012	<0.0005	<0.0005	0.0156	0.0159	0.03	0.0112	0.0063	<0.0005	<0.0005	<0.0005
Cobalt T-Co	mg/L	0.0001	0.0001	0.0001	0.031	0.0322	0.0551	0.0003	0.0003	0.825	0.845	2.35	0.417	0.429	0.0002	0.0001	0.0002
Copper T-Cu	mg/L	0.002	0.0019	0.0018	0.185	0.196	0.15	0.0024	0.002	3.74	3.8	4.77	1.5	0.797	0.0025	0.0019	0.0018
Iron T-Fe	mg/L	0.24	0.21	0.29	2.07	1.99	4.88	1.02	0.98	22.3	23.8	144	7.83	8.39	0.29	0.29	0.49
Lead T-Pb	mg/L	0.00008	0.00008	0.00011	0.00007	0.0001	0.00014	0.00015	0.00009	0.00177	0.00175	0.0046	0.00055	0.00054	0.00005	<0.00005	0.00007
Magnesium T-Mg	mg/L	1	1	1.2	1.4	1.3	2.4	1.9	2	11.4	12.1	34.7	6.4	8.6	1.1	1.1	1.4
Manganese T-Mn	mg/L	0.00531	0.00521	0.00725	0.0226	0.0233	0.0542	0.0161	0.015	0.489	0.496	1.13	0.304	0.381	0.0111	0.0107	0.0259
Mercury T-Hg	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum T-Mo	mg/L	0.00005	<0.00005	<0.00005	<0.00005	0.00009	0.00005	0.0001	0.00006	<0.00005	0.00056	<0.0001	0.00008	<0.00005	0.00007	0.00006	<0.00005
Nickel T-Ni	mg/L	0.0018	0.0017	0.0018	0.247	0.259	0.481	0.0013	0.0017	6.19	6.34	18.2	3.24	3.25	0.0014	0.0012	0.0014
Selenium T-Se	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Silver T-Ag	mg/L	<0.00001	<0.00001	<0.00001	<0.00001	<0.00001	0.00003	<0.00001	<0.00001	<0.00001	<0.00001	<0.00002	<0.00001	0.00001	<0.00001	<0.00001	<0.00001
Uranium T-U	mg/L	0.00011	0.00011	0.0001	0.00021	0.0002	0.00035	0.00016	0.00014	0.00344	0.00341	0.0107	0.00116	0.00101	0.00006	0.00006	0.00009
Vanadium T-V	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Zinc T-Zn	mg/L	<0.001	<0.001	0.001	0.006	0.006	0.007	<0.001	<0.001	0.081	0.085	0.181	0.043	0.041	0.002	0.002	0.001
Organic Parameters																	
Chemical Oxygen Demand-CC	mg/L	28	26	-	33	35	-	42	-	<20	<20	-	<20	-	34	35	-
Total Organic Carbon-C	mg/L	8.8	9.2	-	11.3	11.4	-	12.8	-	4.2	4.2	-	5.1	-	11.6	11.2	-

< = Less than the detection limit indicated.

- Parameter not collected at this site.

APPENDIX 3.4-1: LAKE AND STREAM SEDIMENT DESCRIPTION, FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.4-1
Lake and Stream Sediment Description, Ferguson Lake Project Area, 1999

Lake Sediment Samples

Sample ID:	L1	L2	L3	L4	L5
Date:	September 12, 1999	September 12, 1999	September 11, 1999	September 12, 1999	September 11, 1999
Position:	14 612052 E 6971012 N	14 606328 E 6972813 N	14 610780 E 6973944 N	14 608607 E 6969642 N	14 605228 E 6979184 N
Water Depth (m):	34.5	3.9	7.5	11.4	24.4
Grab Thickness (mm):	Full	Full	40	40	30
Structure Description:	Top organic brown layer (0.5 cm), bottom silt (no sand)	Top organic brown layer (1 cm), bottom silt with fine sand	Top organic brown layer (1 cm), bottom silt/clay with some gravel	Top organic brown layer (1 cm), bottom silt with some sand	Top organic brown layer (0.5 cm), bottom clay
Munsell Colour Classification:	Top: light brown (5YR 6/4) Bottom: light olive gray (5Y 6/1)	Top: light brown (5YR 6/4) Bottom: moderate yellowish brown (10YR 5/4)	Top: light brown (5YR 6/4) Bottom: dark yellowish brown (10YR 4/2)	Top: light brown (5YR 6/4) Bottom: moderate yellowish brown (10YR 5/4)	Top: light brown (5YR 6/4) Bottom: grayish brown (5YR 3/2)
Biological Material:	Top: Insect casings	Top: Insect casings/worms	Top: Insect casings	Top: Insect casings	Top: Insect casings and small worms
Debris Material:	None	None	None	None	None
Notes:					
Photographs (Y/N):	Y	Y	Y	Y	Y

Stream Sediment Samples

Sample ID:	W1	W2	E3	R1
Date:	September 12, 1999	September 12, 1999	September 12, 1999	September 13, 1999
Position:	100 m upstream of mouth	100 m upstream of mouth	50 m upstream of mouth	250 m upstream of mouth
Water Depth (m):	0.5	0.5	0.1	0.4
Grab Thickness (mm):	20	20	20	20
Structure Description:	Uniform grain size, silt	Top organic layer, bottom silt/sand	Uniform silt and sand, some gravel	Gravel and sand
Munsell Colour Classification:	Moderate brown (5YR 3/4)	Top: grayish brown (5YR 3/2) Bottom: grayish black (N2)	Dusky brown (5YR 2/2)	Gravel colour
Biological Material:	Roots and grassy vegetation	Roots and grassy vegetation, macrophytes	Some grass roots	None
Debris Material:	Small twigs	Leaf litter, roots and grass	None	None
Notes:				
Photographs (Y/N):	Y	Y	Y	Y

APPENDIX 3.4-2:
ANALYTICAL RESULTS FOR LAKE AND STREAM SEDIMENT QUALITY, FERGUSON LAKE PROJECT AREA, 1999

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Appendix 3.4-2
Analytical Results for Lake and Stream Sediment Quality, Ferguson Lake Project Area, 1999

	Lake Sediment Samples					Stream Sediment Samples			
Sample ID	**L1**	**L2**	**L3**	**L4**	**L5**	**W1**	**W2**	**E3**	**R1**
Date Sampled	**12-Sep-99**	**12-Sep-99**	**11-Sep-99**	**12-Sep-99**	**11-Sep-99**	**12-Sep-99**	**12-Sep-99**	**13-Sep-99**	**13-Sep-99**
Depth:	**34.5 m**	**3.9 m**	**7.5 m**	**11.4 m**	**24.4 m**	**0.5 m**	**0.45 m**	**0.01 m**	**0.4 m**
Physical Tests									
Moisture %	77.5	47.9	49	68.7	38.2	56.9	78.3	48.4	14.8
Nutrients									
Available Phosphorus P	180	15	46	15	22	11	1	9	1
Total Nitrogen N	0.36	0.07	0.11	0.31	0.04	0.21	0.21	0.33	0.01
Total Metals									
Aluminum T-Al	25800	8580	11000	23200	18000	13000	19500	4220	5460
Arsenic T-As	4.4	2.3	1.4	5.1	5	1.7	2	0.7	1.1
Cadmium T-Cd	0.2	<0.1	<0.1	0.5	<0.1	<0.1	<0.1	<0.1	<0.1
Chromium T-Cr	56	19	25	46	36	30	37	26	12
Cobalt T-Co	12	11	8	29	7	6	25	4	3
Copper T-Cu	35	12	31	29	11	13	600	93	5
Iron T-Fe	33500	18200	12700	40200	21100	17500	88500	16600	10900
Lead T-Pb	18	7	7	15	12	9	9	4	6
Manganese T-Mn	671	1590	214	7020	424	191	145	52	115
Mercury T-Hg	0.061	0.007	0.009	0.028	<0.005	0.016	0.041	0.018	0.006
Nickel T-Ni	33	25	26	68	18	18	283	32	7
Phosphorus T-P	2630	915	757	1370	872	804	1090	269	549
Selenium T-Se	0.5	<0.1	<0.1	0.4	<0.1	0.1	0.5	0.2	<0.1
Silver T-Ag	<0.2	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Zinc T-Zn	97	38	43	101	44	38	41	8	22
Organic Parameters									
Total Organic Carbon C	3.34	0.9	1.15	2.38	0.19	4.02	8.15	6.27	<0.05
Particle Size									
Gravel (>2.00mm) (%)	<0.1	<0.1	<0.1	<0.1	<0.1	0.7	40.8	6.9	28.8
Sand (2.00mm - 0.063mm) (%	4.5	70.5	78.4	21.3	29.8	60.4	28.9	84.8	70.1
Silt (0.063mm - 4um) (%)	40.4	20.5	11.7	42.9	38.5	25.2	18.7	4.4	0.6
Clay (<4um) (%)	55.1	9	9.9	35.8	31.7	13.7	11.6	3.9	0.5

Notes: Results are expressed as milligrams per dry kilogram except where noted.

Total Organic Carbon and Total Nitrogen results are expressed as percent, dry weight basis.

< = Less than the detection limit indicated.

APPENDIX 3.6-1: RESULTS FOR PHYSICAL LIMNOLOGY, FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.6-1
Results for Physical Limnology, Ferguson Lake Project Area, 1999

Station:	**L1**
Date Sampled:	**30-Jul-99**
Maximum Depth:	**38.4 m**
Secchi Depth:	**4.0 m**

Depth (m)	Temperature (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Conductivity µS/cm
0.1	10.87	10.31	94.3	6.41	18.40
0.5	10.86	10.31	93.6	6.45	18.40
1.0	10.84	10.21	93.1	6.43	18.40
1.5	10.84	10.21	92.1	6.54	18.60
2.0	10.85	10.18	92.3	6.45	18.40
2.5	10.83	10.20	92.2	6.45	18.70
3.0	10.81	10.20	92.5	6.50	18.40
3.5	10.77	10.17	91.9	6.46	18.60
4.0	10.79	10.17	91.9	6.47	18.60
4.5	10.77	10.20	92.0	6.56	18.60
5.0	10.75	10.11	92.0	6.48	18.60
5.5	10.74	10.11	91.4	6.52	18.60
6.0	10.75	10.18	91.9	6.55	18.40
6.5	10.75	10.09	91.3	6.53	18.60
7.0	10.74	10.08	91.2	6.49	18.40
7.5	10.73	10.14	91.2	6.56	18.70
8.0	10.71	10.14	91.2	6.52	18.60
8.5	10.70	10.05	91.0	6.57	18.60
9.0	10.70	10.14	91.6	6.53	18.60
9.5	10.68	10.06	90.9	6.53	18.70
10.0	10.68	10.13	91.0	6.55	18.60
10.5	10.68	10.08	91.5	6.53	18.70
11.0	10.67	10.07	90.9	6.51	18.60
11.5	10.68	10.10	91.3	6.56	18.60
12.0	10.68	10.05	91.3	6.52	18.60
12.5	10.67	10.07	91.0	6.54	18.70
13.0	10.66	10.09	91.0	6.52	18.70
13.5	10.66	10.09	91.1	6.51	18.60
14.0	10.66	10.03	91.1	6.56	18.60
14.5	10.65	10.02	90.9	6.52	18.60
15.0	10.66	10.04	91.2	6.58	18.60
15.5	10.66	10.05	91.2	6.53	18.40
16.0	10.66	10.02	90.7	6.52	18.70
16.5	10.65	10.03	90.5	6.57	18.40
17.0	10.65	10.07	90.4	6.57	18.70
17.5	10.64	10.03	90.6	6.56	18.70
18.0	10.65	10.01	90.4	6.54	18.70
18.5	10.65	10.02	90.8	6.57	18.60
19.0	10.64	10.06	90.9	6.56	18.70
19.5	10.64	10.01	90.9	6.57	18.70
20.0	10.64	10.05	90.7	6.34	18.60
20.5	10.63	10.00	90.7	6.55	18.60
21.0	10.64	10.03	90.8	6.53	18.70
21.5	10.63	10.00	90.6	6.55	18.60
22.0	10.62	10.06	90.5	6.57	18.60
22.5	10.62	10.04	90.5	6.57	18.60
23.0	10.62	10.01	90.7	6.56	18.60
23.5	10.62	9.99	90.2	6.57	18.60
24.0	10.62	10.05	90.5	6.59	18.70
24.5	10.62	9.98	90.2	6.55	18.70
25.0	10.62	9.97	90.0	6.54	18.70

(continued)

Appendix 3.6-1
Results for Physical Limnology, Ferguson Lake Project Area, 1999

Station: L2
Date Sampled: 30-Jul-99
Maximum Depth: 5.6 m
Secchi Depth: 3.2 m

Depth (m)	Temperature (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Conductivity µS/cm
0.1	11.07	10.29	93.9	6.49	19.80
0.5	11.05	10.28	93.8	6.61	19.90
1.0	11.04	10.33	94.2	6.57	19.90
1.5	11.03	10.34	94.2	6.57	19.90
2.0	11.00	10.29	93.8	6.60	19.80
2.5	11.00	10.32	93.9	6.58	19.90
3.0	11.01	10.37	94.2	6.63	19.90
3.5	10.97	10.40	94.5	6.55	19.90
4.0	10.98	10.42	94.5	6.63	20.10
4.5	10.96	10.37	94.4	6.62	19.90
5.0	10.96	10.41	94.1	6.65	19.90
5.5	10.95	10.45	95.6	6.52	20.60

Station: L3
Date Sampled: 30-Jul-99
Maximum Depth: 7.0 m
Secchi Depth: 4.1 m

Depth (m)	Temperature (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Conductivity µS/cm
0.1	10.94	10.33	93.7	6.47	20.90
0.5	10.90	10.31	93.8	6.51	21.10
1.0	10.85	10.28	92.9	6.53	21.20
1.5	10.82	10.36	93.2	6.55	21.10
2.0	10.77	10.31	92.8	6.62	21.00
2.5	10.72	10.32	93.0	6.58	21.20
3.0	10.71	10.21	92.8	6.58	21.30
3.5	10.72	10.26	92.8	6.61	21.10
4.0	10.71	10.27	93.2	6.52	21.30
4.5	10.72	10.26	92.8	6.59	21.30
5.0	10.72	10.24	92.4	6.56	21.50
5.5	10.72	10.21	91.9	6.54	21.50
6.0	10.72	10.16	92.3	6.61	21.50
6.5	10.68	10.19	92.1	6.57	21.30
7.0	10.67	10.24	91.8	6.58	21.50

Station: L4
Date Sampled: 30-Jul-99
Maximum Depth: 7.0 m
Secchi Depth: 3.8 m

Depth (m)	Temperature (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Conductivity µS/cm
0.1	10.88	10.42	95.2	6.48	19.10
0.5	10.87	10.36	93.9	6.51	19.10
1.0	10.84	10.30	93.4	6.48	19.10
1.5	10.86	10.26	93.3	6.53	19.20
2.0	10.83	10.30	93.4	6.50	19.20
2.5	10.81	10.24	92.9	6.57	19.30
3.0	10.81	10.23	92.7	6.59	19.20
3.5	10.80	10.24	92.9	6.52	19.20
4.0	10.78	10.21	92.4	6.53	19.20
4.5	10.74	10.18	92.3	6.67	19.20
5.0	10.76	10.23	92.6	6.54	19.40
5.5	10.65	10.22	92.4	6.61	19.30
6.0	10.71	10.18	92.0	6.57	19.30
6.5	10.61	10.20	91.5	6.54	19.10
7.0	10.61	10.19	91.9	6.58	19.20

(continued)

Appendix 3.6-1
Results for Physical Limnology, Ferguson Lake Project Area, 1999

Station:	**L5**
Date Sampled:	**30-Jul-99**
Maximum Depth:	**29.0 m**
Secchi Depth:	**3.4 m**

Depth (m)	Temperature (ºC)	Dissolved Oxygen (mg/L)	Dissolved Oxygen (% saturation)	pH	Conductivity µS/cm
0.1	10.88	10.38		6.37	20.90
0.5	10.86	10.43		6.48	21.10
1.0	10.86	10.43	96.9	6.49	21.10
1.5	10.86	10.49		6.50	21.10
2.0	10.86	10.42	96.9	6.51	21.10
2.5	10.85	10.47		6.55	21.20
3.0	10.85	10.44	97.1	6.51	21.20
3.5	10.85	10.44		6.49	21.10
4.0	10.85	10.46	96.9	6.58	20.90
4.5	10.84	10.44		6.56	21.10
5.0	10.84	10.42	96.7	6.61	20.90
5.5	10.85	10.36		6.60	21.20
6.0	10.82	10.31	96.7	6.54	21.10
6.5	10.83	10.34		6.56	21.20
7.0	10.82	10.23	96.4	6.61	21.00
7.5	10.82	10.22		6.56	21.10
8.0	10.82	10.28	95.8	6.61	21.10
8.5	10.82	10.21		6.62	21.00
9.0	10.81	10.20	96.0	6.63	21.10
9.5	10.82	10.14		6.62	21.10
10.0	10.81	10.19	95.4	6.64	21.20
10.5	10.82	10.14		6.62	21.10
11.0	10.82	10.14	95.3	6.59	21.20
11.5	10.82	10.14		6.62	21.10
12.0	10.80	10.08	94.5	6.60	21.10
12.5	10.80	10.16		6.61	21.00
13.0	10.80	10.11	94.7	6.63	21.20
13.5	10.80	10.13		6.64	21.20
14.0	10.81	10.10	94.3	6.64	21.10
14.5	10.80	10.15		6.65	21.20
15.0	10.80	10.15	93.9	6.63	21.10
15.5	10.80	10.11		6.64	21.00
16.0	10.79	10.10	91.7	6.65	21.20
16.5	10.78	10.08		6.65	21.20
17.0	10.78	10.08	92.0	6.63	21.10
17.5	10.78	10.08		6.65	21.10
18.0	10.77	10.10	91.3	6.62	21.00
18.5	10.77	10.14		6.59	21.20
19.0	10.76	10.12	91.7	6.61	21.00
19.5	10.77	10.15		6.65	21.10
20.0	10.77	10.06	91.9	6.68	21.10
20.5	10.76	10.10		6.69	21.20
21.0	10.75	10.06	91.1	6.65	21.20
21.5	10.77	10.14		6.61	21.00
22.0	10.76	10.09	91.8	6.64	21.20
22.5	10.73	10.08		6.65	21.10
23.0	10.73	10.16	91.2	6.67	21.10
23.5	10.73	10.08		6.63	21.20
24.0	10.73	10.10	91.8	6.62	21.20
24.5	10.73	10.17		6.70	21.10
25.0	10.72	10.10	91.0	6.68	21.10

(completed)

APPENDIX 3.7-1:
STREAM FISH CAPTURED IN THE FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.7-1
Stream Fish Captured in the Ferguson Lake Project Area, 1999

Stream	Sample number	Species	Length (mm): fork	total	Comments
W1	1	Arctic grayling	134	-	
W1	2	Arctic grayling	61	-	
W1	3	Longnose sucker	80	-	
W1	4	Longnose sucker	58	-	
W1	5	Longnose sucker	54	-	
W1	6	Slimy sculpin	-	56	
W1	7	Slimy sculpin	-	67	
W1	8	Slimy sculpin	-	57	
W1	9	Slimy sculpin	-	57	
W1	10	Slimy sculpin	-	60	
W1	11	Slimy sculpin	-	65	
W1	12	Slimy sculpin	-	41	
W1	13	Slimy sculpin	-	49	
W1	14	Slimy sculpin	-	79	
W1	15	Slimy sculpin	-	69	
W1	16	Slimy sculpin	-	40	
W1	17	Slimy sculpin	-	40	
W1	18	Slimy sculpin	-	42	
W1	19	Slimy sculpin	-	44	
W1	20	Slimy sculpin	-	42	
W1	21	Slimy sculpin	-	41	
W1	22	Slimy sculpin	-	50	
W1	23	Slimy sculpin	-	56	
W1	24	Slimy sculpin	-	39	
W1	25	Slimy sculpin	-	92	
W1	26	Ninespine stickleback	-	10	
W1	27	Ninespine stickleback	-	63	
W1	28	Ninespine stickleback	-	45	
W1	29	Ninespine stickleback	-	45	
W1	30	Ninespine stickleback	-	30	
W1	31	Ninespine stickleback	-	34	
W1	32	Ninespine stickleback	-	38	
W2	1	Ninespine stickleback	-	39	not killed by EF
R2	1	Arctic grayling	153	-	
R2	2	Arctic grayling	128	-	
R2	3	Arctic grayling	116	-	
R2	4	Arctic grayling	64	-	
R2	5	Arctic grayling	65	-	
R2	6	Arctic grayling	68	-	
R2	7	Arctic grayling	59	-	
R2	8	Arctic grayling	53	-	
R2	9	Arctic grayling	52	-	
R2	10	Slimy sculpin	-	67	
R2	11	Slimy sculpin	-	72	
R2	12	Ninespine stickleback	-	53	
R2	13	Ninespine stickleback	-	55	
R2	14	Ninespine stickleback	-	54	
R2	15	Ninespine stickleback	-	54	
R2	16	Ninespine stickleback	-	60	
R2	17	Ninespine stickleback	-	50	
R2	18	Ninespine stickleback	-	32	
R2	19	Ninespine stickleback	-	32	
R2	20	Ninespine stickleback	-	29	
R2	21	Ninespine stickleback	-	25	
R2	22	Ninespine stickleback	-	22	

Note: All fish captured by electrofishing (EF)

Dashes indicate type of length not appropriate for a species

APPENDIX 3.7-2: STREAM HABITAT DATA, FERGUSON LAKE PROJECT AREA, 1999

Appendix 3.7-2
Stream Habitat Data, Ferguson Lake Project Area, 1999

Habitat variable	Units	Stream: W1	Stream: W2	Stream: R2
Physical				
Survey length	m	125	150	325
Stream gradient	%	1.0	2.0	2.0
Mean channel width	m	3.0	3.0	1.0
Mean depth	m	0.60	0.50	0.15
Maximum pool depth (average over all pools)	m	0.65	0.70	0.50
Maximum riffle depth (average over all riffles)	m	0.30	0.10	0.20
Stage (dry, low, medium, high and flood)	-	M	M	M
Water quality				
Temperature	°C	7.0	8.9	12.4
Conductivity	µS/cm	5	17	7
pH	log units	7.7	5.0	6.8
colour	-	clear	red, turbid	clear
redox potential	mV	120	183	90
Substrate composition				
Organic matter	%	0	5	25
Silt	%	10	60	10
Sand	%	5	0	15
Small gravel	%	0	5	5
Large gravel	%	0	5	0
Cobble	%	35	15	10
Boulder	%	50	10	35
Bedrock	%	0	0	0
Habitat composition				
Riffle	%	40	20	60
Run 1 (best quality)	%	0	0	0
Run 2 (intermediate quality)	%	20	60	0
Run 3 (lowest quality)	%	40	5	35
Pool 1 (best quality)	%	0	0	<1
Pool 2 (intermediate quality)	%	0	0	0
Pool 3 (lowest quality)	%	0	15	5
Total Cover	%	80	40	40
Cover				
Pool	%	2.5	<1	5
Boulder	%	95.0	85	90
Cutbank	%	2.5	5	<1
Macrophytes	%	<1	10	<1
Overhanging vegetation	%	<1	<1	5
Habitat suitability				
Spawning	-	2	0	1
Rearing	-	3	1	2
Adult feeding	-	1	0	0
Overwintering	-	0	0	0
Migration	-	3	1	1