5.0 WATER QUALITY

This section of the baseline report describes the baseline water quality for the study area. These data include water chemistry in lakes during open water and under ice conditions.

The specific objectives of the water quality baseline were as follows:

- to describe the baseline open water conditions in streams and open water and under ice conditions in lakes of the study area;
- to discuss seasonal and spatial variation of water quality parameters; and
- to compare baseline water quality data with applicable guidelines for the protection of aquatic life and human health.

The description of water quality is based on historical data (1994, 1995, and 1998 to 2000) and data collected from more recent field programs (2007 to 2009) within the study area. All data were compiled into a database that was used to describe the baseline water quality.

5.1 Methods

5.1.1 Data Sources

Water quality data in streams and lakes were collected during 9 studies performed between 1994 and 2009 (Table 5-1). Surface grab water quality samples were collected from 10 lake stations in August 1994 (Dillon 1994). These stations were located in lakes on the Peninsula draining into Meliadine Lake (specifically, from Basins A, B, C, D, and E); in Chickenhead Lake (part of the Atulik Lake drainage basin), and in DI2 Lake, which is part of a watershed that drains into the southeast basin of Meliadine Lake. Surface grab samples were also collected from 7 lake stations and 2 stream stations in the Meliadine Lake and Atulik Lake drainage basins in July 1995 (Dillon 1995).

RL&L performed 4 water quality baseline studies between 1997 and 2000. Most sampling occurred in 1997 and 1998. During these 2 studies, grab samples were collected from streams located on the Peninsula draining into Meliadine Lake (specifically, from Basins A, B, D, and G); from the 2 streams discharging from Meliadine Lake into Peter Lake and Meliadine River; from the stream discharging from Peter Lake to Diana Lake; and in the Meliadine River. Most stream stations were sampled both in the spring and summer/fall. Samples were also collected from stations in lakes on the Peninsula (specifically, from Basins A, B, D, and G); in Meliadine Lake (multiple stations); in Peter Lake; in Little Meliadine Lake; and in Hudson Bay. Lake samples were collected in summer, fall, and winter (under-ice).

Table 5-1: Water Quality Data Baseline Studies, 1994 to 2009

Report Author(s)	Publication Year	Report Title	Drainages Sampled – Streams	Drainages Sampled – Lakes
M.M. Dillon Ltd. (Dillon)	1994	Meliadine Project – Baseline Surface Water and Lake Sediment Sampling	None	Peninsula Basins A, B, C, D, E; Lake DI2; Atulik Lake
Dillon	1995	Discovery Project – Rankin Inlet Area 1995 Environmental Investigations	Atulik Lake	Meliadine Lake; Lake DI1; Atulik Lake
RL&L Environmental Services Ltd. (RL&L)	1998	Meliadine West Baseline Aquatic Studies: 1997 Data Report	Peninsula Basins A, B, D, G; Meliadine River; Peter Lake	Peninsula Basins A, B, D, G; Meliadine Lake; Peter Lake
RL&L	1999	Meliadine West Baseline Aquatic Studies: 1998 Data Report	Peninsula Basins A, B; Meliadine River; Peter Lake	Peninsula Basins A, B, D; Meliadine Lake; Peter Lake; Control Lake; Ocean
RL&L	2000	Meliadine West Baseline Aquatic Studies: 1999 Data Report	Peninsula Basins A, B; Meliadine River	Peninsula Basins A, B; Meliadine Lake; Control Lake
RL&L	2001	Meliadine West Baseline Aquatic Studies: 2000 Data Report	Peninsula Basins A, B; Meliadine River	Peninsula Basins A, B; Meliadine Lake; Control Lake
Comaplex Minerals Corporation (Comaplex)	2007	Not applicable; data collected under water licence	Peninsula Basin A	Peninsula Basin A, Control Lake
Golder Associates Ltd. (Golder)	2008	Meliadine West Gold Project: Water Quality Baseline Studies 2008	Peninsula Basins A, B; Meliadine River; Meliadine Lake; Atulik Lake	Peninsula Basins A, B; Meliadine Lake; Atulik Lake; Control Lake
Golder	2009	Not applicable – data are summarized in this report	None	Peninsula Basins A, B; Meliadine Lake; Atulik Lake; Control Lake

Two smaller baseline studies were performed by RL&L in 1999 and 2000. These studies focused on a few streams and lakes near the proposed mine site. Stations included 2 streams in Basins A and B, the outlet of Meliadine Lake to Meliadine River, 4 lakes in Basin A and B, and one station in Meliadine Lake. These stations were sampled during the summer only.

The 2008 and 2009 baseline studies were designed to update the existing water quality database. Most stream stations were sampled in spring and summer. Stations included streams in Basins A and B, streams in the Discovery Area, and the outlet of Meliadine Lake to Meliadine River. Lake stations were sampled in the summer and winter (under ice) and included lakes in Basins A and B, multiple stations in Meliadine Lake, one station in Chickenhead Lake (part of the Atulik Lake drainage basin), and one station in Control Lake.

In addition to the above studies, Comaplex Minerals Corporation (Comaplex) provided water quality data collected in 2007 for sampling locations mandated by the water licence issued by the Nunavut Water Board (S. Barham, Comaplex, 2008a, pers. comm.). Water quality data from stream and lake stations in Basin A and from one station in Control Lake were added to the baseline database.

5.1.2 Water Quality Parameters

Physical and chemical parameters are used to describe the water quality of the different waterbodies in the study area. Parameters can be classed into major categories that are used to describe different aspects of the water or sediment. The major categories of parameters used in the discussion are detailed below.

5.1.2.1 Field-Measured Parameters

This category includes parameters, such as pH, specific conductivity, temperature, and dissolved oxygen, that are measured in the field using hand-held instruments. These measurements are used to describe the physical limnology of the streams and lakes.

5.1.2.2 Conventional Parameters

These parameters are measured in the laboratory; this category includes pH, specific conductivity, total dissolved solids (TDS), total alkalinity, total hardness, organic carbon, total suspended solids (TSS), and turbidity. Most of these parameters can also be classified as indicator parameters because each indicates the general trend in a larger group of substances. An example of an indicator parameter is TDS, which is a measure of all the dissolved ions in a sample of water. Thus, rising and falling TDS indicates that some individual ions, such as calcium and magnesium, are also rising and falling but provides no information on proportions of individual ions.

Conductivity is an indicator parameter that is strongly correlated with TDS. Conductivity is a measure of water's ability to conduct electricity. The more ions that are dissolved in water, the better it conducts electricity, and therefore conductivity rises proportionally with TDS. Because the exact relationship between conductivity and TDS depends on the specific quantities of ions present, it varies among waterbodies.

The capacity of a water sample to neutralize acids is termed alkalinity. This buffering capacity is based on the presence of bicarbonate, carbonate, and hydroxide. Alkalinity is expressed as the equivalent of calcium carbonate ($CaCO_3$). Alkalinity provides an indication of a waterbody's sensitivity to acidification or its acid neutralizing capacity. Saffran and Trew (1996) presented a scale of lake surface water sensitivity to acidification based on alkalinity (Table 5-2).

Table 5-2: Scale of Acid Sensitivity for Lakes Based on Alkalinity

Acid Sensitivity in Lakes	Alkalinity (mg/L as $CaCO_3$)
High	0 to 10
Moderate	>10 to 20
Low	> 20 to 40
Least	>40

Notes: $CaCO_3$ = calcium carbonate; > = greater than.
Source: Saffran and Trew (1996).

Water hardness is primarily determined by the concentration of calcium and magnesium, although other ions can contribute. As with alkalinity, hardness is expressed as the equivalent of calcium carbonate ($CaCO_3$). Both hardness and alkalinity can affect the bioavailability of metals to aquatic life. For example, the toxicity of many metals declines with increasing hardness. Natural waters can range from very soft to very hard (Table 5-3; McNeely et al. 1979).

Table 5-3: Scale of Hardness in Fresh Waters

Degree of Hardness	Hardness (mg/L as $CaCO_3$)
Very soft	0 to 30
Soft	31 to 60
Moderately soft	61 to 120
Hard	121 to 180
Very hard	>180

Notes: CaCO3 = calcium carbonate; > = greater than.
Source: Thomas (1953) as cited in McNeely et al. (1979).

Organic carbon is the main chemical form of decaying plants and animals. Total organic carbon (TOC) includes dissolved organic carbon (DOC) and particulate organic carbon (POC). The dissolved organic carbon released from plants is responsible for most of the yellow to brown water colour in natural water systems. This is especially evident in muskeg and bog regions, which are naturally rich in organic matter. Total organic carbon is generally found in higher concentrations in lake sediments because it is partly associated with suspended particles, which settle out on the lake bed. Total organic carbon can vary from 1 to 30 mg/L, with higher levels generally being the result of anthropogenic (man-made) inputs or occurring naturally in brown waterbodies (McNeely et al. 1979).

Total suspended solids include all solid particles suspended in the water column. An increase in suspended solids usually results in a corresponding increase in stress to aquatic animals. Concentrations of TSS below 25 mg/L are usually not considered harmful to aquatic life (EIFAC 1965; US EPA 1973). However, the nature and extent of adverse effects attributable to TSS is a function of concentration and exposure. For example, aquatic organisms can withstand high levels of TSS for short periods of time and low levels of TSS for long periods of time (Newcombe and MacDonald 1991). Turbidity is a measure of how much light can transmit through a water sample and thus is a surrogate measure of total suspended solids.

5.1.2.3 Major Ions

Major ions can occur naturally at high concentrations in freshwater systems. These ions, which account for the majority of TDS, include bicarbonate, calcium, carbonate, chloride, fluoride, hydroxide, magnesium, potassium, sodium, and sulphate.

5.1.2.4 Nutrients

Nutrients include phosphorus and nitrogen compounds that are required in small quantities for plant growth. While some plant growth is required to maintain a healthy ecosystem, excess plant growth can lead to the undesirable condition of excess weed and algae growth called eutrophication. Biological productivity of fresh water is usually limited by phosphorus, meaning that phosphorus is the nutrient in the shortest supply. Total phosphorus concentrations can range from about a microgram per litre (1 µg/L) in unproductive waters to more than 100 µg/L in highly productive waters (Vollenweider and Kerekes 1982).

No drinking water guideline exists for phosphorus, although 0.10 mg/L is considered a maximum detectable concentration for streams (McNeely et al. 1979). In the Northwest Territories (NT) and Nunavut (NU), a total phosphorus guideline of 0.03 mg/L is used for both lotic and lentic waters (Statistics Canada 2008).

Nitrogen is another important nutrient that can affect the productivity of a waterbody. Nitrogen can be present in various forms in fresh waters, such as nitrate, nitrite, ammonia, and organic nitrogen. Total Kjeldahl nitrogen (TKN) is a common measure of ammonia and organic nitrogen that is used to assess the amount of nitrogen available for biological uptake and approximates the amount of total nitrogen available (total nitrogen includes both organic and inorganic forms). Concentrations of TKN in uncontaminated fresh waters range from 0.1 to 0.5 mg/L (McNeely et al. 1979).

Chlorophyll *a* is an indicator parameter used to classify the nutrient status and productivity of a waterbody. Chlorophyll *a* is pigment used by plants and green algae to convert sunlight to energy. Chlorophyll *a* concentrations range from less than 8 µg/L in unproductive waters to greater than 75 µg/L in highly productive waters (Mitchell and Prepas 1990). Total phosphorus, total nitrogen, and chlorophyll *a* concentrations can be used to classify the trophic level of lakes, which is an indicator of lake productivity based on nutrient and chlorophyll *a* concentrations (Table 5-4; Wetzel 1983).

Table 5-4: General Trophic Classification of Lakes in Relation to Total Phosphorus, Total Nitrogen, and Chlorophyll *a*

Trophic Status	Total Phosphorus (µg/L)		Total Nitrogen (µg/L)		Chlorophyll *a* (µg/L)	
	Mean	Range	Mean	Range	Mean	Range
Oligotrophic	8.0	3.0 to 17.7	661	307 to 1630	1.7	0.3 to 4.5
Mesotrophic	26.7	10.9 to 95.6	753	361 to 1387	4.7	3 to 11
Eutrophic	84.4	16 to 386	1875	393 to 6100	14.3	3 to 78

Source: Wetzel (1983).

5.1.2.5 Metals

Metals[1] are naturally present in surface waters in small quantities (i.e., typically less than 1 mg/L). Higher metal concentrations are usually associated with suspended sediments and tend to settle out. The level at which metals are toxic varies by metal and can be dependent on the hardness of the water. For example, iron and manganese enter waterways as a result of the weathering of naturally occurring minerals and generally cause no harm other than rust stains. Conversely, other metals, such as lead and mercury, can impair the health of aquatic organisms, wildlife, and humans in very small quantities. Therefore, metals are analyzed individually as part of a water quality program.

5.1.2.6 Organic Compounds

Organic compounds are defined as chemicals made up of mainly carbon and hydrogen; they include a vast number of natural and synthetic compounds. Phenols are one of the most frequently measured organic compounds in surface waters. Phenols are released by plants and decaying vegetation and can occur naturally in trace amounts in surface waters. Even at low concentrations, phenols can impart an undesirable taste and odour to water, and can be transported over long distances.

Total volatile hydrocarbons and total extractable hydrocarbons degrade over time and are usually present at lower levels than total recoverable hydrocarbons, which comprise total volatile hydrocarbons, total extractable hydrocarbons, and heavier carbon compounds. Total recoverable hydrocarbons are usually present at low levels, (i.e., less than the detection limit) in water not affected by natural or anthropogenic hydrocarbon inputs.

5.1.3 Water Quality Trends

In natural surface waters, trends over time or space are observed in most water quality parameters. These trends can be seasonal cycles or spatial differences. Understanding natural trends in baseline water quality is important because resource development might result in further changes that can only be characterized in the context of natural variation.

5.1.3.1 Seasonal

Seasonality is a very important feature in lakes of northern Canada, where long cold winters can cause ice build-up that can isolate lakes within a watershed by freezing channels to the bottom. The ice build-up itself causes pure water to form ice while dissolved substances are concentrated into the unfrozen water.

Oxygen depletion by sediments and organisms is also common in winter months. Because ice forms a barrier between the atmosphere and the water, oxygen is not replenished from the atmosphere until open water conditions return. Additionally, complete depletion of oxygen can lead to chemical reactions such as the conversion of the relatively benign sulphate ion to the potentially toxic sulphide ion. Oxygenation during open water conditions can replenish the decreasing oxygen supply of waterbodies due to turbulence caused by winds, which helps the dissolved oxygen concentration increase.

Winter water quality is also characterized by high TDS. Ice is formed from pure water and leaves the dissolved solids (i.e., salts) in solution. The water remaining under the ice becomes more highly concentrated as the salt freeze-out occurs.

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[1] For brevity, metals and metalloids are referred to as metals.

The open water season in the study area lasts usually from the end of May or mid June to early October; thus, during the majority of the year, the waterbodies are frozen and isolated from one another. For this reason, water quality in lakes was compared for open water (i.e., spring, summer, and fall) and under-ice (i.e., winter) conditions.

During open water conditions, runoff from snowmelt and precipitation, which is usually low in dissolved substances, decreases TDS. As the volume of inputs to a lake from surface runoff increases, the TDS tends to decrease. The large flows generated by spring melt can result in scouring of river beds and banks, which in turn leads to high levels of parameters such as TSS and aluminum.

Mid to late summer water quality is usually characterized by low flow in rivers and streams. Depending on nutrient levels, productivity can increase to eutrophic (nutrient rich) levels during the summer. Plants and algae grow faster in warmer water temperatures. Dissolved oxygen can also decline in the summer because its solubility decreases in increasing temperatures.

Fall water quality depends to a large extent on the level of productivity during the summer. If the water body was highly productive during the summer, the plants and algae can contribute substantial amounts of oxygen demand to the waterbody when they die-off in the fall.

5.1.3.2 Spatial

Spatial heterogeneity of typical water quality features originate from differences in lake morphometry, the intensity of surface water and groundwater interactions, the amount of surface inflow and outflow from tributaries, as well as other factors. Seasonal effects also contribute to spatial differences, particularly in vertical distribution of water quality parameters (e.g., stratification effects).

The major feature in spatial trends of water quality within northern regions is its relative homogeneity. Water quality of lakes in the study areas originates from direct precipitation to the surface in winter, which enters lakes during the snowmelt period. Spring runoff occurs mostly as flow on top of the frozen ground, thus limiting the amount of dissolved and particulate substances that can enter a waterbody. Very shallow and seasonal sub-soil flow can occur during the short summer season when some organics and nutrients from the soil can enter surface waterbodies. Thus, opportunities for heterogeneity are limited in the northern region, resulting in similarities in the natural water quality between the different waterbodies.

5.1.4 Sample Collection

Field sampling protocols were similar among the baseline studies. Dillon (1994, 1995) and Comaplex (S. Barham, 2009, pers. comm.) collected grab samples at the water surface in streams and lakes. In all other studies, stream and river samples were collected approximately 0.1 m below the water surface at 50 to 150 m downstream of the corresponding lake outlet. Lake and ocean samples were collected at 1 m below the water surface. Most lake stations were in the deepest area of the lakes, with the exception of Meliadine Lake, which had multiple stations. An ocean station was located in Hudson Bay near the mouth of the Meliadine River.

Water samples for chemical analysis were collected in open-water conditions in streams and in open-water and under-ice conditions in lakes (Table 5-5). Limnology profiles (surface to bottom) of dissolved oxygen and water temperature were collected at select stations and sampling events. Surface limnology measurements were collected with most chemistry samples. Sample locations were accessed by boat or helicopter in the summer.

For most sampling events, coordinates for each sampling location were recorded using a global positioning system (GPS) unit. The available coordinates are included in the water quality tables presented in Appendix B, Tables B1-1 to B1-8 and B2-1 to B2-13.

Table 5-5: Timing of Water Quality Sampling, 1994 to 2009

Year	Waterbody Type	Timing of Sampling
1994	Lake	Summer (i.e., base flow conditions)
1995	Lakes and Streams	Summer
1997	Streams and Rivers	Spring (i.e., freshet conditions) and Summer
	Lakes	Summer
1998	Streams and Rivers	Spring and Summer
	Lakes	Late Winter (i.e., most “stressed” period[a]) and Summer
1999	Streams and Rivers	Spring
	Lakes	Summer
2000	Streams and Rivers	Spring
	Lakes	Summer
2007	Streams	Summer and Fall
	Lakes and Ponds	Summer and Fall
2008	Streams and Rivers	Spring and Summer
	Lakes	Summer
2009	Lakes	Late Winter and Summer

[a] Concentrations of major ions are typically highest in late winter because of ice formation, which concentrates the ions in the remaining water column. Oxygen depletion can also result in anoxic conditions and releases of metals from the sediment.

Field measurements included water temperature, dissolved oxygen, pH, and specific conductivity[2]. Table 5-6 provides a list of field equipment and methods used during the various baseline studies.

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[2] Not all results of field measurements were reported. For example, Dillon (1994) stated that dissolved oxygen concentrations were measured in the field, but these values are not included in their water quality table.

Table 5-6: Summary of Equipment used for Water Quality Sampling

Year(s)	Grab Sampler	In situ Measurements	Reference
1994, 1995	Not provided	Perstorp Ltd. – Aquacheck portable water analyzer	Dillon 1994, 1995
1997, 1998, 1999	4-L Van Dorn	Oxyguard™ Handy Mark II Dissolved Oxygen and Temperature meter, Fisher Scientific Accumet™ pH meter, Oakton™ WD-35607-10 Conductivity meter	RL&L 1998, 1999, 2000
2000	4-L Van Dorn	Fisher Scientific Accumet™ pH meter or pHTestr™ pH meter, Oakton™ WD-35607-10 Conductivity meter or TDSTestr3™ conductivity meter	RL&L 2001
2007	Not used[a]	Hanna pH-Temperature meter	S. Barham, Comaplex, 2009, pers. comm.
2008	4-L Kemmerer	YSI 556 Multimeter or WTW 3400i meter	Golder 2008
2009	4-L Kemmerer	YSI 556 Multimeter or YSI 650QS Meter	This report

[a] Water samples were collected at the water surface (i.e. within 30 cm of surface) from shore.

5.1.5 Sample Analysis

5.1.5.1 Parameter Groups

Water samples were generally analyzed for conventional parameters, major ions, nutrients and chlorophyll *a*, cyanides, total and dissolved metals, and organic compounds (Table 5-7).

Table 5-7: Water Quality Parameter List

Group Name	Parameters [a]
Field Measurements	Water temperature, dissolved oxygen, pH, specific conductivity, Secchi disk depth
Conventional Parameters	pH, specific conductivity, total dissolved solids, total alkalinity, total hardness, total suspended solids, total volatile solids, turbidity
Major Ions	Bicarbonate, bromide, calcium, carbonate, chloride, fluoride, hydroxide, magnesium, potassium, reactive silica, silicate, sodium, sulphate, ion balance
Organic/Inorganic carbon	Total carbon, total organic carbon, dissolved organic carbon, total inorganic carbon
Nutrients and Chlorophyll *a*	Total ammonia, nitrate, nitrite, total Kjeldahl nitrogen, total phosphorus, total dissolved phosphorus, orthophosphate, chlorophyll *a*
Cyanides	Total cyanide
Total and Dissolved Metals	Aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, cesium, chromium, cobalt, copper, iron, lead, lithium, manganese, mercury, molybdenum, nickel, rubidium, selenium, silicon, silver, strontium, thallium, tin, titanium, tungsten, uranium, vanadium, zinc
Organic Compounds	Oil and grease, phenols, benzene, ethylbenzene, toluene, xylenes, F1 (C6-C10), F1 (BTEX), F2 (>C10-C16), F3 (C16-C34), F4 (C34-C50), total volatiles, total extractables, total extractable hydrocarbons (C9-C40), total extractable hydrocarbons (C10-30)
Other	Biological oxygen demand, fecal coliforms

[a] Not all parameters were analyzed during every sampling program.

5.1.5.2 Analytical Methods

Samples were shipped to an accredited environmental laboratory for analysis[3]. Table 5-8 lists the analytical laboratory used for each baseline study.

Table 5-8: Analytical Laboratories used in the Baseline Studies

Year	Laboratory	Reference
1994, 1995	Analytical Service Laboratories Ltd., Vancouver, BC[a]	Dillon 1994, 1995
1997	Taiga Environmental Laboratory, Yellowknife, NT	RL&L 1998
1998, 1999, 2000	Enviro-Test Laboratories, Edmonton, AB[b]	R&L 1999, 2000, 2001
2007	ALS Laboratory Group, Edmonton, AB	S. Barham, Comaplex, 2009, pers. comm.
2008, 2009	ALS Laboratory Group, Edmonton, AB and Vancouver, BC	Golder 2008 and this report

[a] Now ALS Laboratory Group, Vancouver, BC.
[b] ALS Laboratory Group, Edmonton, AB.

Parameters were analyzed by standard methods published by internationally recognized agencies, such as the American Public Health Association (APHA) and the United States Environmental Protection Agency (US EPA). For example, conventional parameters, major ions, nutrients, and total cyanide were analyzed according to the procedures described in “Standard Methods for the Examination of Water and Wastewater” published by the American Public Health Association (e.g., APHA 1992 in Dillon 1994, 1995).

In general, improvements in analytical procedures resulted in lower detection limits in more recent studies. Analytical methods for metals in water involved acid digestion and instrumental analysis by either atomic absorption spectrophotometry (AAS), inductively coupled argon plasma/atomic emission spectrophotometry (ICP-AES), inductively coupled plasma mass spectrophotometry (ICP-MS), or cold vapour atomic fluorescence spectrophotometry (CVAFS; mercury only). Detection limits were highest in Dillon (1994, 1995) and lowest in more recent studies (e.g., Golder 2008).

Phenols were analyzed by a colourimetric method using an ultraviolet-visible spectrophotometer. Other organic compounds, such as benzene, toluene, ethylbenzene, xylene (BTEX) or total extractable hydrocarbons, were analyzed with a liquid-liquid extraction using an organic solvent following by capillary column gas chromatography with flame ionization detection (GC-FID) or gas chromatography mass spectrophotometry (GC-MS).

Detection limits varied among the studies. In general, detection limits were higher in the older datasets (e.g., 1994/1995) than in more recent datasets (e.g., 2008/2009). The detection limits used in each study are provided in Table 5-9.

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[3] The Canadian Association of Environmental Analytical Laboratories (CAEAL) laboratory accreditation program began in 1994. It is assumed that the laboratories used in the 1994 to 2000 baseline studies had CAEAL accreditation for most or all of the parameters.

Table 5-9: Detection Limits Used in the Baseline Studies

Parameter	Units	1994/1995[a]	1997[b]	1998[c]	1999[d]	2000[e]	2007[f]	2008[g]	2009
Conventional Parameters (Laboratory-Measured)									
pH	pH units	0.01	0.05	N/A	N/A	N/A	0.1	0.01 or 0.1	0.1
Conductivity	µS/cm	1.0	0.3	0.2	0.2	0.2	0.2	0.2 or 2	0.2
Total Dissolved Solids	mg/L	N/A	10	1	1	N/A	N/A	5 or 10	5
Total Alkalinity	mg $CaCO_3$/L	N/A	0.3	1	1	5	5	2 or 5	5
Total Hardness	mg $CaCO_3$/L	0.01	0.09	1	1	1	N/A	0.7	N/A
Total Suspended Solids	mg/L	1	3	2	3	3	3	3	3
Turbidity	NTU	0.1	0.1	0.1	0.1	0.1	0.1	N/A	N/A
Major Ions									
Bicarbonate	mg/L	N/A	0.3	1	1	5	5	5	5
Calcium	mg/L	0.05	0.03	0.05	0.05	0.004	0.5	0.1 or 0.5	0.05 or 0.1
Carbonate	mg/L	N/A	0.3	1	1	5	5	5	5
Chloride	mg/L	0.5	0.08	0.05	0.05	1	1	0.5 or 1	0.5
Fluoride	mg/L	0.02	N/A	N/A	N/A	N/A	N/A	0.02 or 0.05	N/A
Hydroxide	mg/L	N/A	N/A	1	1	5	5	5	5
Magnesium	mg/L	0.01	0.005	0.01	0.01	0.004	0.1	0.1	0.05 or 0.1
Potassium	mg/L	0.010 or 2	0.002	0.01	0.01	0.005	0.5	0.5 or 2	0.05 or 2
Reactive Silica	mg/L	N/A	0.005	0.1	0.1	0.1	0.1	N/A	N/A
Silicate	mg/L	1.0	N/A	N/A	0.05	N/A	0.5	N/A	N/A
Sodium	mg/L	0.010	0.02	0.1	0.1	0.005	1	1 or 2	0.05 or 2
Sulphate	mg/L	1.0	3	0.05	0.05	0.05 or 0.5	N/A	0.5	0.5
Organic/Inorganic Carbon									
Total Carbon	mg/L	N/A	0.2	0.5	0.5	N/A	1	0.5 or 1	1
Total Organic Carbon	mg/L	N/A	0.2	0.2	0.5	0.5	1	0.5 or 1	1
Dissolved Organic Carbon	mg/L	N/A	N/A	N/A	N/A	N/A	N/A	0.5	1
Total Inorganic Carbon	mg/L	N/A	0.2	0.2	0.5	0.5	N/A	0.5 or 1	1
Nutrients and Chlorophyll *a*									
Total Ammonia	mg N/L	N/A	0.002	0.005	0.005	0.005	0.05	0.02 or 0.05	0.05
Nitrate	mg N/L	0.005	0.008	0.006	0.006	0.006	0.1	0.005 to 0.1	0.05
Nitrite	mg N/L	0.001	N/A	N/A	N/A	N/A	0.05	0.001 to 0.05	0.05

Table 5-9: Detection Limits Used in the Baseline Studies (continued)

Parameter	Units	1994/1995[a]	1997[b]	1998[c]	1999[d]	2000[e]	2007[f]	2008[g]	2009
Nitrate-Nitrite	mg N/L	0.005	0.008	0.006	0.006	0.006	0.1	0.1	0.071
Total Kjeldahl Nitrogen	mg/L	N/A	0.01	0.05	0.05	0.05	0.2	0.05 to 0.2	0.2
Total Phosphorus	mg/L	0.3	0.002	0.001	0.001	0.001	0.02	0.001 or 0.002	0.001
Dissolved Phosphorus	mg/L	N/A	0.002	0.001	0.001	0.001	0.02	0.001 or 0.002	0.001
Orthophosphate	mg/L	N/A	0.002	0.001	0.001	0.001	0.01	0.001	0.001
Chlorophyll *a*	µg/L	N/A	0.01	0.01	0.01	0.01	N/A	1	N/A
Cyanides									
Total Cyanide	µg/L	N/A	N/A	1	2	2	N/A	2 or 5	2
Total Metals									
Aluminum	µg/L	200	0.5 or 5	0.3	0.3	0.3	10	0.3 or 5	5 or 8
Antimony	µg/L	200	0.1	0.03	0.03	0.03	0.4	0.03 to 0.5	0.2 to 0.5
Arsenic	µg/L	0.1	0.2	0.03	0.03	0.03	0.4	0.03 to 0.5	0.02 to 3
Barium	µg/L	10	0.1	0.05	0.05	0.05	3	0.05 to 20	1 or 20
Beryllium	µg/L	5	0.1	0.2	0.2	0.2	1	0.2 or 1	1
Bismuth	µg/L	100	0.1	0.05	0.03	N/A	N/A	N/A	1
Boron	µg/L	100	N/A	N/A	N/A	1	50	1 to 100	50 to 100
Cadmium	µg/L	0.2	0.1	0.1	0.02	0.05	0.1	0.017 or 0.05	0.01
Cesium	µg/L	N/A	0.1	0.1	0.1	N/A	N/A	N/A	N/A
Chromium	µg/L	15	0.2	0.06	0.06	0.06	5	0.06 or 1	1 or 4
Cobalt	µg/L	15	0.1	0.1	0.1	0.1	2	0.1 to 2	0.3
Copper	µg/L	10	0.1	0.6	0.6	0.6	1	0.6 or 1	1
Iron	µg/L	30	12	10	5	5	5	5 or 30	30
Lead	µg/L	1	0.2	0.05	0.05	0.05	0.1	0.05 to 0.5	0.5
Lithium	µg/L	15	0.1	0.1	0.1	N/A	3	5 or 10	5 or 10
Manganese	µg/L	5	0.1	0.1	0.1	0.1	1	0.1 to 1	0.3 or 1
Mercury	µg/L	0.05	0.01	0.01	0.02	0.02	0.1	0.02 or 0.002	0.02
Molybdenum	µg/L	30	0.1	0.06	0.06	0.06	5	0.06 to 5	1
Nickel	µg/L	20	0.1	0.1	0.06	0.06	2	0.06 to 2	1
Selenium	µg/L	0.5	1 to 10	0.1	0.1	0.1	0.4	0.1 to 1	0.5 or 1
Silicon	µg/L	50	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Silver	µg/L	0.1	0.1	0.1	0.1	0.1	0.1	0.02 to 0.4	0.02
Strontium	µg/L	1	0.1	0.1	0.1	0.1	N/A	0.1	1
Thallium	µg/L	100	0.1	0.05	0.03	N/A	0.1	0.03 to 0.2	0.2
Tin	µg/L	300	N/A	N/A	N/A	N/A	50	0.5 or 50	0.5

Table 5-9: Detection Limits Used in the Baseline Studies (continued)

Parameter	Units	1994/1995[a]	1997[b]	1998[c]	1999[d]	2000[e]	2007[f]	2008[g]	2009
Titanium	µg/L	10	0.1	0.1	0.1	N/A	1	1 or 10	10
Tungsten	µg/L	100	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Uranium	µg/L	N/A	0.1	0.05	0.05	0.05	0.1	0.05 to 0.2	0.01 or 0.2
Vanadium	µg/L	30	0.1	0.1	0.05	0.05	1	0.05 to 1	1
Zinc	µg/L	5	0.5 or 5	0.8	0.8	0.8	2	0.8 to 5	5
Organic Compounds									
Oil and Grease	µg/L	N/A	N/A	N/A	N/A	N/A	1	500	N/A
Phenols	µg/L	N/A	2	1	1	1	N/A	1.0	N/A
Benzene	µg/L	N/A	0.5	0.5	N/A	N/A	N/A	0.5	N/A
Toluene	µg/L	N/A	0.5	0.5	N/A	N/A	N/A	0.5	N/A
Ethylbenzene	µg/L	N/A	0.5	0.5	N/A	N/A	N/A	0.5	N/A
Xylenes	µg/L	N/A	0.5	0.5	N/A	N/A	N/A	0.5	N/A
F1 (C6-C10)	µg/L	N/A	N/A	N/A	N/A	N/A	N/A	100	N/A
F1 -BTEX	µg/L	N/A	N/A	N/A	N/A	N/A	N/A	100	N/A
F2 (>C10-C16)	µg/L	N/A	N/A	N/A	N/A	N/A	N/A	50	N/A
F3 (C16-C34)	µg/L	N/A	N/A	N/A	N/A	N/A	N/A	50	N/A
F4 (C34-C50)	µg/L	N/A	N/A	N/A	N/A	N/A	N/A	50	N/A
Total Volatile Hydrocarbons	µg/L	N/A	100	100	N/A	N/A	N/A	N/A	N/A
Total Extractable Hydrocarbons	µg/L	N/A	50	50	N/A	N/A	N/A	N/A	N/A
Other									
Biological Oxygen Demand	mg/L	N/A	N/A	N/A	N/A	N/A	2	N/A	N/A
Fecal Coliforms	CFU/100 mL	N/A	N/A	N/A	N/A	N/A	1	N/A	N/A

Notes: µS/cm = microSiemens per centimetre; mg/L= milligrams per litre; mg $CaCO_3$/L = milligrams per litre as calcium carbonate; NTU= nephelometric turbidity unit; mg N/L= milligrams per litre as nitrogen; µg/L = micrograms per litre; CFU/100 mL = colony forming unit per 100 millilitres

[a] Source: Dillon 1994/1995. Not all parameters were analyzed in the 1995 samples.

[b] Source: Table 2.2 in RL&L 1998.

[c] Source: Table 2.2 in RL&L 1999.

[d] Source: Table 2.2 in RL&L 2000.

[e] Source: Table 2.2 in RL&L 2001.

[f] Source: S. Barham, Comaplex, 2008b, pers. comm.

[g] Source: Golder 2008. Detection limits varied among sample batches (samples were submitted in multiple batches during the spring and summer sampling events).

N/A = parameter not measured or detection limit not provided.

5.1.5.3 Quality Assurance/Quality Control

Quality assurance/quality control (QA/QC) programs in water quality studies are sampling and analytical procedures that are followed to limit the introduction of error into analytical data. Quality assurance (QA) procedures include appropriate training of sampling personnel, use of standard operating procedures when collecting the samples, appropriate sample handling and storage, use of accredited analytical laboratories, and data management systems. Quality control (QC) procedures are designed to assess data quality including potential laboratory and field contamination through use of blanks, replicates, and spiked or reference materials.

Most reports discussed appropriate QA procedures that were followed during the baseline studies such as:

- rinsing the grab sampler between stations;
- wearing polyethylene or nitrile gloves during sampling to prevent cross-contamination;
- using certified sample containers provided by the analytical laboratory;
- preserving the samples according to standard methods; and
- maintaining sample integrity by storing the samples cold and shipping them to the analytical laboratory as soon as possible after sampling.

Water chemistry samples in 2008 and 2009 were collected in accordance with Golder Technical Procedure 8.3-1 Surface Water Sampling Methods (unpublished file information), which are consistent with standard methods (e.g., American Public Health Association [APHA] 1992; Environment Canada 1993) and include standard collection, preservation, storage, and shipping protocols. Field personnel also used Specific Work Instructions (SWI), which detailed project-specific sampling instructions. Samples were submitted to an accredited analytical laboratory (i.e., ALS Laboratory Group, Edmonton, Alberta or Vancouver, British Columbia) for analysis.

Appropriate QC samples were included in most studies[4], including the following:

- Duplicate field samples were used to detect variability at a site and verify field-sampling methods.
- Field blanks were used to detect sample contamination during the collection, shipping, and analysis of samples. Field blanks are samples prepared in the field using ultra-pure water.
- Trip blanks were used to detect sample contamination during transport and pre-sampling bottle contamination[5].

Field duplicate values were within acceptable ranges in most analytical determinations. There were some detectable concentrations in the field and trip blanks but most concentrations were at or near the detection limit. Of the QC sample results, only results for field duplicates were included in the database.

The results of laboratory quality control samples were not reported for most studies. Laboratory QC protocols in the 2008 and 2009 water quality studies included the analysis of one or more method blanks, laboratory duplicates, internal or certified reference materials, matrix spikes, with the following results:

- Method blanks did not have detectable concentrations of any parameter.
- Laboratory duplicates were within acceptable limits (i.e., ≤20%) for all parameters analyzed.

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[4] Field QC samples were not analyzed as part of the 2007 sampling events .

[5] Trip blanks were only used in the Golder baseline studies.

- Recoveries of internal reference materials, certified reference materials, and matrix spikes were within laboratory data quality objectives.

Some issues were identified in the database that resulted in the removal of particular data:

Cation/anion balances in the 1997 data were reported in units of mg/L and the reported values were very low (i.e., less than 20 mg/L). This parameter (also referred to as ion balance) is typically reported as a percentage. In natural waters, ion balance is near 100%. The calculation of this parameter in 1997 could not be verified; therefore, these data were removed from the database.

Dissolved organic carbon concentrations in the winter 2009 samples were higher than concentrations of total organic carbon and total carbon. The source of the discrepancy could not be verified; therefore, these data were removed from the database.

Values of pH measured in the laboratory were generally higher than values measured in the field. The differences between field and laboratory pH measurements are most likely due to changes in the sample during storage or handling (e.g., loss of carbon dioxide). In addition, changes in sample temperature affect the activity of hydrogen ions, thereby affecting pH. Field pH measurements were also performed at lower temperatures than those typically found in the laboratory (i.e., room temperature is approximately 20 to 25°C). Field pH values were discussed in the results summaries and used to assess exceedances for pH-dependent parameters (i.e., total ammonia and aluminum). Laboratory-measured pH values were used when field pH values were not available.

For a few samples, the dissolved metal concentration for a given metal was greater than the corresponding total concentration. This discrepancy may be due to one or more of the following factors: laboratory method variability; field sampling method variability; bias introduced during handling, storage, transportation and/or analysis of the sample; field sample filtration; or field sample heterogeneity. Results obtained from screening the chemistry data against guidelines are not affected by this discrepancy because guidelines are based on total metal concentrations.

5.1.6 Data Analysis

All historical and recent water quality data were compiled into a database organized by waterbody type (streams or lakes), drainage basin, location, and sampling date (Appendix B, Tables B1-1 to B1-8 [streams] and Tables B2-1 to B2-13 [lakes]). Spatial and temporal trends in streams (Section 5.2) and lakes (Section 5.3) were described by drainage basin. For the purposes of this report, sampling events were divided into the following seasons:

- Spring = May to June
- Summer = July and early August
- Fall = late August to early October
- Winter = late October to April

Water chemistry were compared to both the most recent Canadian Council of Ministers of the Environment's (CCME) Canadian Water Quality Guidelines (CWQG) for the protection of aquatic life and Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) (CCME 2007a; Health Canada 2008) (Table 5-10).

Water quality guidelines are nationally endorsed indicators of environmental quality for the protection of aquatic ecosystems and designated water uses (CCME 2007a; Health Canada 2008). The aquatic life guidelines are based on the most current, scientifically defensible toxicological data and are intended to be protective of all forms and life stages of aquatic life (CCME 2007a). Exceedance of a guideline does not, therefore, automatically imply unacceptable or harmful conditions. Guideline exceedances observed during baseline investigations are a result of naturally occurring conditions and thus are not of concern as local flora and fauna will be adapted to these natural conditions in the environment.

Table 5-10: Water Quality Guidelines for the Protection of Aquatic Life and Human Health

Parameter	Units	Freshwater CWQG[a]	Marine CWQG	GCDWQ[b]
Conventional Parameters (Field-Measured)				
Dissolved Oxygen	mg/L	6.5-9.5[c]	>8.0[d]	-
pH	pH	6.5-9	7.0-8.7	6.5-8.5[e]
Conventional Parameters (Laboratory-Measured)				
pH	pH	6.5-9	7.0-8.7	6.5-8.5[e]
Total Dissolved Solids	mg/L	-	-	500[e]
Turbidity	NTU	-	-	-[f]
Major Ions				
Chloride	mg/L	-	-	250[e]
Fluoride	mg/L	-	-	1.5
Sodium	mg/L	-	-	200[e]
Sulphate	mg/L	-	-	500[eg]
Nutrients				
Total Ammonia as Nitrogen	mg/L	-[h]	-	-
Nitrate as Nitrogen	mg/L	2.9[i]	3.6[i]	10
Nitrite as Nitrogen	mg/L	0.060	-	0.97[j]
Phosphorus, Total	mg/L	-[k]	-[l]	-
Cyanides				
Cyanide, Total	µg/L	5[m]	-	200
Total Metals				
Aluminum (Al)	µg/L	5 - 100[n]	-	[o]
Antimony (Sb)	µg/L	-	-	6
Arsenic (As)	µg/L	5.0	12.5	10

Table 5-10: Water Quality Guidelines for the Protection of Aquatic Life and Human Health (continued)

Parameter	Units	Freshwater CWQG[a]	Marine CWQG	GCDWQ[b]
Barium (Ba)	µg/L	-	-	1000
Boron (B)	µg/L	-	-	5000
Cadmium (Cd)	µg/L	0.017[p]	0.12	5
Chromium (Cr)	µg/L	8.9 / 1.0[q]	56 / 1.5[r]	50
Copper (Cu)	µg/L	2 - 4[s]	-	1000[e]
Iron (Fe)	µg/L	300	-	300[e]
Lead (Pb)	µg/L	1 - 7[t]	-	10
Manganese (Mn)	µg/L	-	-	50[e]
Mercury (Hg)	µg/L	0.026[u]	0.016[v]	1
Molybdenum (Mo)	µg/L	73	-	-
Nickel (Ni)	µg/L	25 - 150[w]	-	-
Selenium (Se)	µg/L	1.0 [x]	-	10
Silver (Ag)	µg/L	0.1	-	-
Thallium (Tl)	µg/L	0.8	-	-
Uranium (U)	µg/L	-	-	20
Zinc (Zn)	µg/L	30	-	5000[e]
Organic Compounds				
Phenols	µg/L	4.0	-	-
Benzene	µg/L	370	110	5
Ethylbenzene	µg/L	90	25	2.4[e]
Toluene	µg/L	2.0	215	24[e]
Xylenes	µg/L	-	-	300[e]
Other				
Fecal Coliforms	CFU/100 mL	-	-	ND [y]

Notes:

(-) = No guideline available; mg/L= milligrams per litre; µg/L= micrograms per litre; CFU/100 mL= colony forming units per 100 millimetres

[a] Canadian water quality guidelines for the protection of aquatic life - freshwater (CWQG; Canadian Council of Ministers for the Environment [CCME] 2007a).

[b] Guidelines for Canadian Drinking Water Quality (GCDWQ; Health Canada 2008).

[c] Dissolved oxygen guideline for cold water freshwater biota is 9.5 mg/L for early life stages and 6.5 mg/L for other life stages.

[d] Dissolved oxygen for marine species; see CCME 1999 for narrative.

[e] Aesthetic objective.

[f] Available GCDWQs are for filtration systems not untreated water and thus are not applicable to this study.

[g] There may be a laxative effect in some individuals when sulphate concentrations exceed 500 mg/L.

[h] Toxicity of ammonia relates primarily to concentration of the unionized form, which increases with increasing temperature and pH. Sample-specific total ammonia guidelines were calculated as per CCME 2009.

[i] Guideline is for protection from direct toxic effects and does not consider effects due to eutrophication.

[j] Where nitrate and nitrite are determined separately, levels of nitrite should not exceed 3.2 mg nitrite/L.

[k] The Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (CCME 2004). The following trigger values can be applied to interpret the data but not for screening: ultra-oligotrophic <4 µg/L; oligotrophic 4-10 µg/L; mesotrophic 10-20 µg/L; meso-eutrophic 20-35 µg/L; eutrophic 35-100 µg/L; hyper-eutrophic >100 µg/L.

Table 5-10: Water Quality Guidelines for the Protection of Aquatic Life and Human Health (continued)

[l] The Canadian Guidance Framework for the Management of Nearshore Marine Systems is for developing nutrient (phosphorus and nitrogen) guidelines for nearshore marine systems. Refer to the factsheet for details (CCME 2007b).

[m] Guideline is for free cyanide.

[n] Aluminum guideline/objective is pH dependent. At pH <6.5, guideline is 5 µg/L. At pH ≥6.5, guideline is 100 µg/L.

[o] The GCDWQ for aluminum is an operational guidance value designed to apply only to drinking water treatments using aluminum-based coagulants and thus is not applicable to this study.

[p] Cadmium guideline is hardness dependent and is calculated for each sample according to the following equation: CWQG(cadmium) = 10e{0.86[log(hardness)]-3.2}. The reported guideline value is for a hardness of 48.5 mg/L and was applied to samples with hardnesses of 48.5 mg/L or lower.

[q] Chromium freshwater guideline is speciation dependent and is 8.9 µg/L for trivalent chromium and 1.0 µg/L for hexavalent chromium.

[r] Chromium marine guideline is speciation dependent and is 56 µg/L for trivalent chromium and 1.5 µg/L for hexavalent chromium.

[s] Copper guideline is hardness dependent. At a hardness of 0-120 mg/L, the guideline is 2 µg/L; at a hardness of 120-180 mg/L, the guideline is 3 µg/L; at a hardness greater than 180 mg/L, the guideline is 4 µg/L.

[t] Lead guideline is hardness dependent. At a hardness of 0-60 mg/L, the guideline is 1 µg/L; at a hardness of 60-120 mg/L, the guideline is 2 µg/L; at a hardness of 120-180 mg/L, the guideline is 4 µg/L; at a hardness greater than 180 mg/L, the guideline is 7 µg/L.

[u] Mercury freshwater guideline is for inorganic mercury; this guideline may not prevent accumulation of methylmercury in aquatic life and therefore may not protect wildlife that consume aquatic life.

[v] Mercury marine guideline may not fully protect higher trophic level fish; see factsheet for details (CCME 2003).

[w] Nickel guideline is hardness dependent. At a hardness of 0-60 mg/L, the guideline is 25 µg/L; at a hardness of 60-120 mg/L, the guideline is 65 µg/L; at a hardness of 120-180 mg/L , the guideline is 110 µg/L; at a hardness of greater than 180 mg/L, the guideline is 150 µg/L.

[x] Selenium guideline is based on waterborne exposure. However, selenium has a bioaccumulation pathway similar to mercury; therefore, the guideline may not be protective of effects through reproductive impairment due to material transfer, resulting in embryotoxicity and teratogenicity (Chapman et al. 2009).

[y] The maximum acceptable concentration of *Escherichia coli* in public, semi-public, and private drinking water systems is none detectable per 100 mL.

5.2 Streams

5.2.1 Meliadine Lake Drainage

Water quality samples were collected from 2 streams that flow into the southeast basin of Meliadine Lake (Figure 5-1; Appendix B, Table B1-1):

- NEW-1 (spring and summer 2008; outflow of watershed B of the Discovery Area into Meliadine Lake); and
- DI-4 (summer 2008; outlet of Lake DI4 into Meliadine Lake).

The 2 streams were well oxygenated during the open-water seasons, with dissolved oxygen concentrations ranging from 11.4 to 12.3 mg/L and water temperatures from 11.5 to 12.8°C. All values were above the 9.5 mg/L CWQG for protection of early life stages of cold water fish.

Water quality was similar between the 2 streams, although there were seasonal differences in the concentrations of some parameters. Field pH values were 7.9 to 8.1 in the spring samples compared to pH 7.0 in the summer sample. All pH values were within the range of applicable guidelines. Field-measured conductivity was higher in summer (137 µS/cm) than in spring (72 and 80 µS/cm). A similar pattern was observed in the TDS concentrations. Major ions were dominated by bicarbonate (28 to 47 mg/L), calcium (8.5 to 13.7 mg/L), chloride (9 to 18 mg/L), and sodium (7 to 11 mg/L).

Total alkalinity values were 23 and 26 mg/L in the spring compared to 39 mg/L in the summer. Total hardness concentrations ranged from 29 to 47 mg/L, which indicated the stream waters were very soft to soft (Table 5-3; McNeely et al. 1979). Total suspended solids concentrations were below the detection limit of 3 mg/L in every sample. Total cyanide was not detected in any stream sample.

Nutrient concentrations were similar between streams and sampling events. Total phosphorus concentrations ranged from 0.009 to 0.012 mg/L, which were lower than the guideline of 0.3 mg/L in NT and Nunavut. Total dissolved phosphorus (the phosphorus form available for primary production) was less than half the total phosphorus concentrations. Total Kjeldahl nitrogen was 0.4 mg/L in all samples whereas nitrate and total ammonia concentrations were below the detection limits. Nitrite was detected above the CWQG of 0.06 mg N/L in stream DI-4 (0.09 mg/L). It was not detected in the other samples (detection limit was 0.05 mg N/L). Chlorophyll *a* concentrations were less than 1 µg/L in the summer and 3 µg/L in the spring. Total organic carbon ranged from 5 to 9 mg/L.

For all total metals except cadmium and silver, detection limits were at or below the most conservative guideline:

- Cadmium was not detected in any sample (detection limits ranged from 0.017 to 0.05 µg/L while the CWQC is 0.017 µg/L).
- Silver was not detected in any sample (detection limits ranged from 0.1 to 0.4 µg/L while the CWQC is 0.1 µg/L).

With the exception of iron, total metal concentrations were either below detection limits or below applicable guidelines. Total iron concentration in stream NEW-1 (summer) was 587 µg/L, which was above the CWQG and CDWQG of 300 µg/L. Iron concentrations in the spring samples were 95 and 207 µg/L.

5.2.1.1 Peninsula Streams

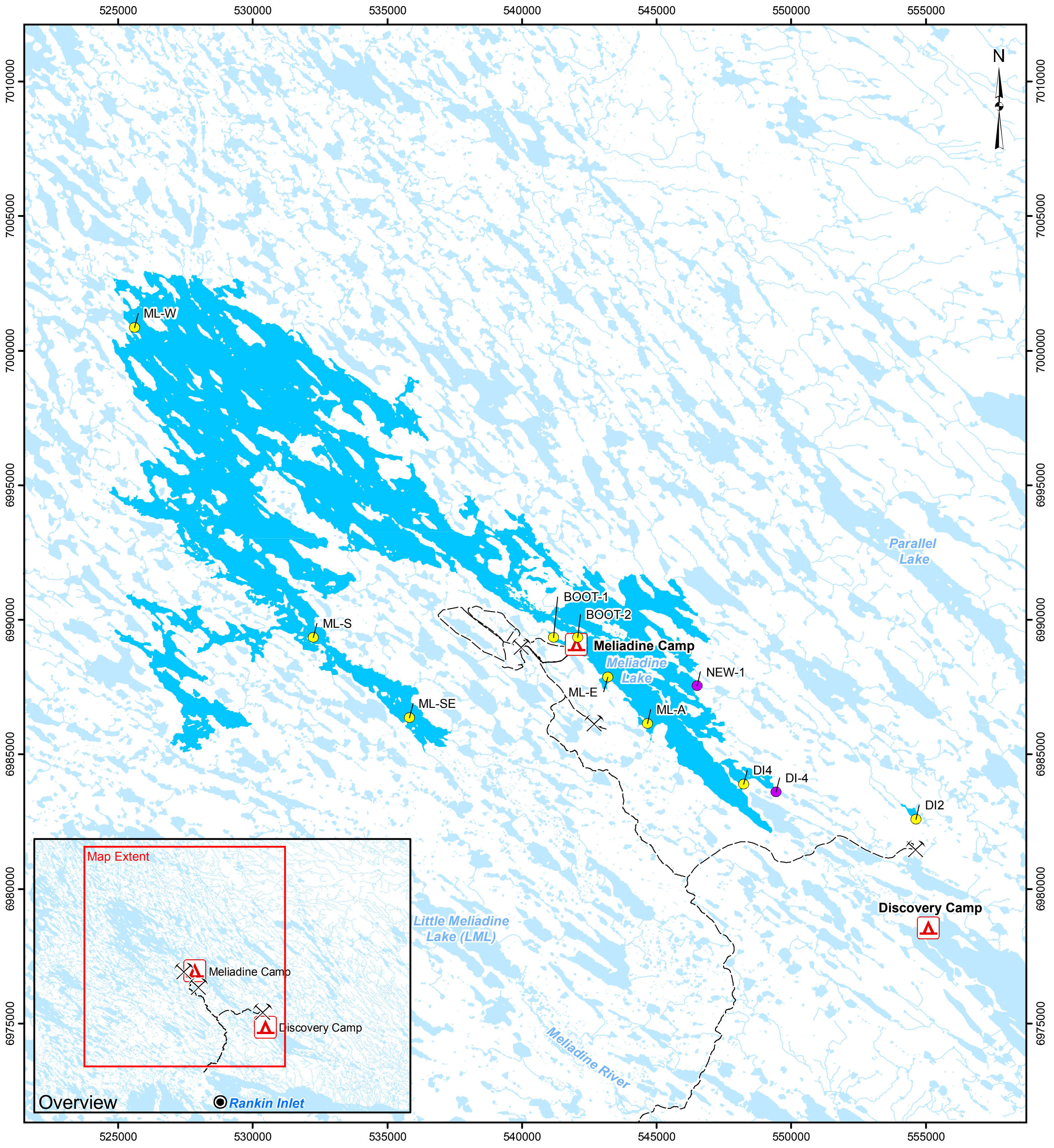
Peninsula Basin A

Water quality samples were collected from 3 streams in Basin A of the Peninsula (Figure 5-2; Appendix B, Table B1-2):

- A0-1 (spring 1997, spring and summer 1998, spring 1999, and spring 2000);
- A5-6 (spring 1997, spring and summer 1998); and
- A7-8 (spring 1997, spring and summer 1998, summer and fall 2007, spring and summer 2008).

The 3 streams were well-oxygenated during the open water seasons with dissolved oxygen concentrations ranging from 11.0 to 13.3 mg/L and associated water temperatures from 4.0 to 16.7°C. All dissolved oxygen values were above the 9.5 mg/L CWQG for protection of early life stages of cold water fish.

Field pH values were generally similar among streams and sampling events. Values ranged from 7.0 to 8.1 except in stream A7-8 during the summer of 2008, which had a field pH of 6.5. All pH values were within the range of applicable guidelines.



5,000 0 5,000

SCALE 1:200,000 METRES

LEGEND

Water Sampling Location

- ● Lake
- ● Stream
- Camp
- ✕ Proposed Mine Site
- — — Proposed Road
- Watercourse
- 🟦 Sampled Waterbody
- 🟦 Waterbody

REFERENCE

Base data obtained from Comaplex Minerals Corporation. Water quality data obtained from the field.
Projection: UTM Zone 15 Datum: NAD 83

DRAFT

PROJECT

COMAPLEX MINERALS CORP

COMAPLEX MINERALS CORPORATION
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

WATER QUALITY SAMPLING LOCATIONS IN MELIADINE LAKE

Golder Associates
Edmonton, Alberta

PROJECT NO. 09-1373-0010			PHASE No. 1000	
DESIGN	KS	06 Oct. 2009	SCALE AS SHOWN	REV. 0
GIS	CDB	06 Oct. 2009	FIGURE 5-1	
CHECK	KS	27 Oct. 2009		
REVIEW	PMC	27 Oct. 2009		

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Water quality was similar among the 3 streams with slightly higher concentrations of some parameters in the summer and fall samples. Lab-measured conductivity ranged from 68 to 138 µS/cm and TDS concentrations ranged from 32 to 82 mg/L. Major ions were dominated by bicarbonate (25 to 50 mg/L), calcium (8.0 to 17.1 mg/L), and chloride (3.2 to 17 mg/L). Total suspended solids concentrations ranged from 2 to 4 mg/L. Total cyanide was not detected in any stream sample (detection limits ranged from 1 to 5 mg/L).

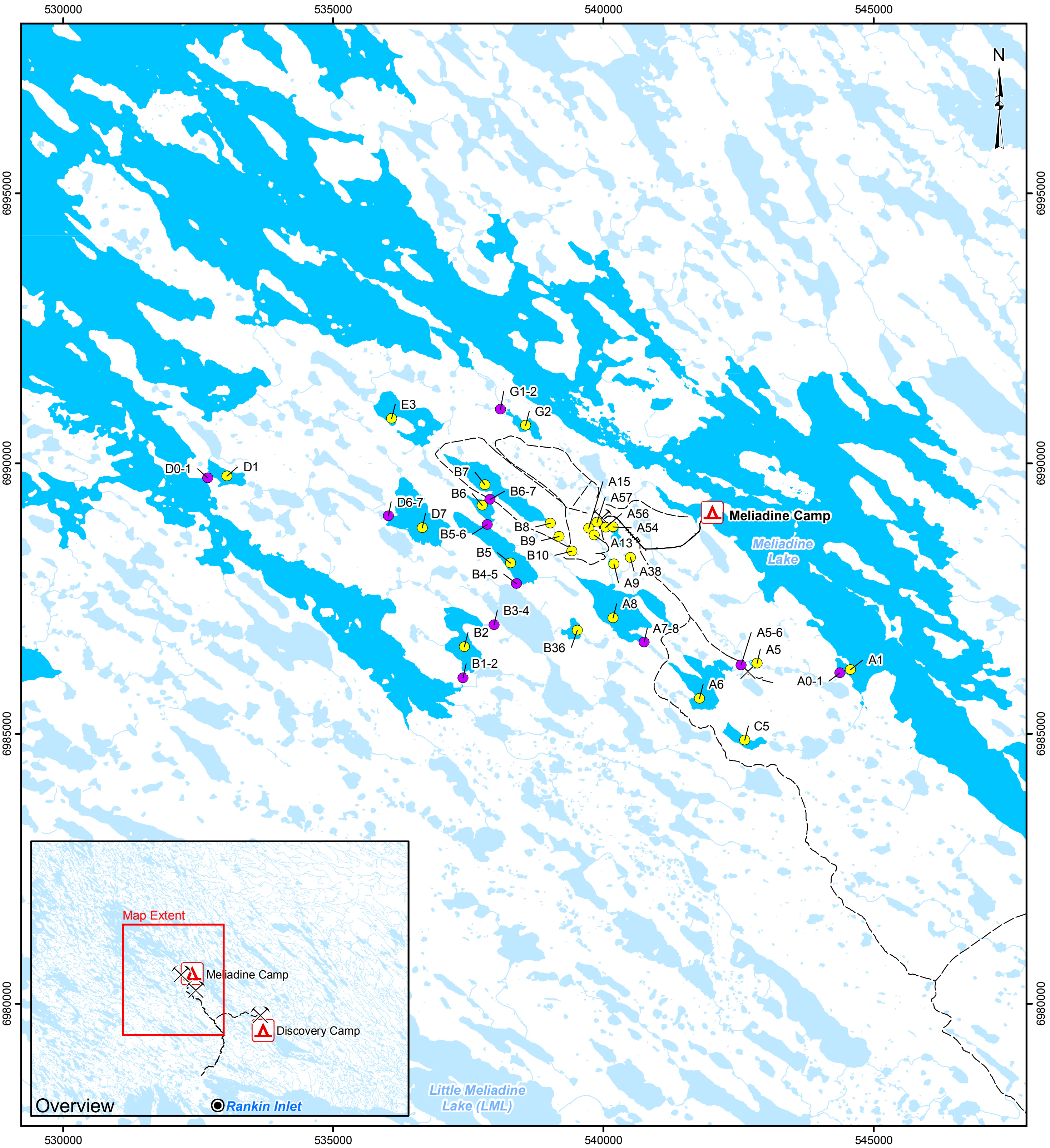
Total alkalinity values ranged from 24 to 41 mg/L. Total hardness concentrations ranged from 26 to 52 mg/L, indicating that the stream waters were very soft to soft (Table 5-3; McNeely et al. 1979).

Nutrient concentrations were similar among streams and sampling events. Total phosphorus concentrations ranged from 0.004 to 0.009 mg/L, lower than the guideline of 0.3 mg/L in NT and Nunavut. Total Kjeldahl nitrogen concentrations ranged from 0.12 to 0.77 mg N/L. Total ammonia was detected in most samples at concentrations ranging from 0.004 to 0.028 mg N/L. Nitrate and nitrite were occasionally detected at concentrations ranging from 0.001 to 0.0168 mg N/L. Chlorophyll *a* concentrations were measured in only 2 samples from stream A7-8. Concentrations were higher in the summer (17 µg/L) than in the spring (0.012 µg/L). Total organic carbon ranged from 2.7 to 5.9 mg/L.

Detection limits for total metal concentrations were at or below the CWQG except for cadmium and chromium. Total metal concentrations were either below detection limits or below applicable guidelines with 3 exceptions:

- Cadmium concentration in the 1997 sample from stream A7-8 was 0.1 µg/L, which was higher than the CWQG of 0.017 µg/L. Cadmium was not detected in any other sample (detection limits ranged from 0.017 to 0.1 µg/L).
- Chromium concentrations in one sample from stream A0-1 (1.4 µg/L) and in one sample from stream A7-8 (3.3 µg/L) were higher than the CWQG for hexavalent chromium (1.0 µg/L) but lower than the CWQG for trivalent chromium (8.9 µg/L). Chromium was detected in other samples at concentrations that ranged from 0.3 to 0.7 µg/L. Detection limits were generally at or below the most conservative CWQG except for 2 samples collected in 2007, which had detection limits of 5 µg/L.
- Silver was detected in one sample from stream A0-1 at 0.1 µg/L. Silver was not detected in any other sample and detection limits were at or below the CWQG of 0.1 µg/L.

Organic compounds were measured in 11 stream samples. Phenol concentrations ranged from 1 to 3 µg/L, below the CWQG of 4.0 µg/L. There were no detected concentrations of volatile organic compounds such as benzene, toluene, ethylbenzene, xylene (BTEX), total volatiles, or total extractables.



2,500 0 2,500

SCALE 1:100,000 METRES

LEGEND

Water Sampling Location

- ● Lake
- ● Stream
- Δ Camp
- ✕ Proposed Mine Site
- — — Proposed Road
- — Watercourse
- ▇ Sampled Waterbody
- ▇ Waterbody

REFERENCE

Base data obtained from Comaplex Minerals Corporation. Water quality data obtained from the field.
Projection: UTM Zone 15 Datum: NAD 83

DRAFT

PROJECT

COMAPLEX
MINERALS CORP

COMAPLEX MINERALS CORPORATION
MELIADINE GOLD PROJECT
NUNAVUT

TITLE

WATER QUALITY SAMPLING LOCATIONS IN PENINSULA BASINS

Golder Associates
Edmonton, Alberta

PROJECT NO. 09-1373-0010			PHASE No. 1000	
DESIGN	KS	06 Oct. 2009	SCALE AS SHOWN	REV. 0
GIS	CDB	06 Oct. 2009	FIGURE 5-2	
CHECK	KS	27 Oct. 2009		
REVIEW	PMC	27 Oct. 2009		

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Peninsula Basin B

Water quality samples were collected from 5 streams in Basin B of the Peninsula (Figure 5-2; Appendix B, Table B1-3):

- B1-2 (summer and fall 1997, spring and summer 1998, spring 1999, and spring 2000);
- B3-4 (spring 1997, spring and summer 1998);
- B4-5 (spring and summer 1997, spring and summer 1998, spring and summer 2008);
- B5-6 (spring and summer 1998); and
- B6-7 (spring 1997, spring and summer 1998, spring and summer 2008).

The 5 streams were well oxygenated during the open-water seasons with dissolved oxygen concentrations ranging from 10.0 to 13.5 mg/L and associated water temperatures from 2.5 to 16.7°C. All dissolved oxygen values were above the 9.5 mg/L CWQG for protection of early life stages of cold water fish.

Field pH values were generally similar among streams and sampling events. Values ranged from 6.6 to 7.6 except in stream B6-7 during the spring of 2008, which had a field pH of 8.3. All pH values were within the range of applicable guidelines.

Water quality was similar among the 5 streams. Field-measured conductivity ranged from 48 to 116 µS/cm and TDS concentrations ranged from 18 to 79 mg/L. Major ions were dominated by bicarbonate (17 to 35 mg/L), calcium (4.8 to 15.2 mg/L), and chloride (1.9 to 14.5 mg/L). Total suspended solids concentrations ranged from 2 to 8 mg/L. Total cyanide was not detected in any stream sample (detection limits ranged from 1 to 5 mg/L).

Total alkalinity values ranged from 14 to 35 mg/L. Total hardness concentrations ranged from 15 to 45 mg/L, suggesting that the stream waters were very soft to soft (Table 5-3; McNeely et al. 1979).

Nutrient concentrations were similar among streams and sampling events. Total phosphorus concentrations ranged from 0.004 to 0.020 mg/L, which were lower than the guideline of 0.3 mg/L in NT and Nunavut. Total Kjeldahl nitrogen ranged from 0.13 to 0.50 mg N/L. Total ammonia was detected in approximately half of the samples, at concentrations ranging from 0.008 to 0.027 mg N/L. Nitrate was occasionally detected at concentrations ranging from 0.007 to 0.027 mg N/L. Chlorophyll *a* concentrations were measured in only 4 samples from streams B4-5 and B6-7. Concentrations were higher in the summer (9 and 17 µg/L) than in the spring (0.0616 and 0.595 µg/L). Total organic carbon ranged from 2.5 to 5.6 mg/L.

Detection limits were at or below the CWQG except for cadmium, chromium, and selenium. Total metal concentrations were either below detection limits or below applicable guidelines with 3 exceptions:

- Cadmium concentration in one sample from stream B1-2 was 0.18 µg/L, which was higher than the CWQG of 0.017 µg/L. Cadmium was not detected in any other sample, although detection limits (0.017 to 0.1 µg/L) were at or higher than the CWQG.
- Chromium concentration in one sample from stream B1-2 (1.18 µg/L) was higher than the CWQG for hexavalent chromium (1.0 µg/L) but lower than the CWQG for trivalent chromium (8.9 µg/L). Chromium was detected in other samples at concentrations that ranged from 0.2 to 0.8 µg/L. Detection limits were

generally at or below the most conservative CWQG except for 4 samples, which had detection limits ranging from 1 to 2 µg/L.

- Detected concentrations of selenium ranged from 0.1 to 0.2 µg/L, which are below the CWQG of 1.0 µg/L. Selenium was not detected in any other sample, although detection limits in 5 of these samples (10 µg/L) were higher than the CWQG.

Organic compounds were measured in most stream samples. Phenol concentrations were equal to or higher than the CWQG of 4.0 µg/L in 5 samples from streams B1-2, B4-5, and B6-7. Concentrations in these samples ranged from 4 to 5 µg/L. Concentrations of BTEX, total volatiles, or total extractables were below detection limits in most samples. In one sample from stream B5-6, ethylbenzene, toluene, and xylene concentrations were 1.0 µg/L, 1.1 µg/L, and 5.4 µg/L, respectively. These concentrations were less than the applicable guidelines.

Peninsula Basin D

Water quality samples were collected from 2 streams in Basin D of the Peninsula (Figure 5-2; Appendix B, Table B1-4):

- D0-1 (spring and summer 1997); and
- D6-7 (spring and summer 1997).

The 2 streams were well-oxygenated during the open water seasons with dissolved oxygen concentrations ranging from 10.8 to 12.7 mg/L and water temperatures from 7.0 to 12.7°C. All dissolved oxygen values were above the 9.5 mg/L CWQG for protection of early life stages of cold water fish. Field pH values ranged from 7.1 to 7.6, which were within the range of applicable guidelines.

Water quality was similar between the 2 streams, although there were seasonal differences in the concentrations of some parameters. Field-measured conductivity was higher in fall (138 and 157 µS/cm) than in spring (79 and 95 µS/cm). Major ions were dominated by bicarbonate (26 to 50 mg/L), calcium (10 to 16 mg/L), and chloride (3.3 to 8.1 mg/L).

Total alkalinity and total hardness were also higher in the fall. Total alkalinity values were 45 and 50 mg/L in the fall compared to 26 and 34 mg/L in the spring. Total hardness concentrations were 48 and 51 mg/L in the fall and 30 and 37 mg/L in the spring. Based on these data, the stream waters were considered to be very soft to soft (Table 5-3; McNeely et al. 1979). Total suspended solids concentrations were 3 mg/L or less. Total cyanide was not measured in any sample.

Nutrient concentrations were higher in the fall than in the spring. Total phosphorus concentrations were approximately 3 times higher in the fall (0.019 to 0.020 mg/L) than in the spring samples (0.006 to 0.007 mg/L), but all concentrations were lower than the guideline of 0.3 mg/L in NT and Nunavut. Total Kjeldahl nitrogen concentrations were 0.26 and 0.30 mg N/L in the spring samples compared to 0.38 and 0.55 mg/L in the fall samples. Total ammonia concentrations were also approximately 2 to 5 times higher in the fall than in the spring samples. Nitrate was not detected in the spring samples (detection limit was 0.008 mg N/L) and concentrations were 0.025 and 0.080 mg N/L in the fall samples. Chlorophyll *a* concentrations were not measured in any sample. Total organic carbon concentrations were 2.3 mg/L in the spring samples compared to 4.5 and 7.2 mg/L in the fall samples.

Detection limits for total metals were at or below the CWQG except for cadmium, chromium, and selenium. Silver was not detected in any sample, but the detection limit was equal to the CWQG of 0.1 µg/L. Total metal concentrations were either below detection limits or below applicable guidelines with 5 exceptions:

- Cadmium concentration in one sample from stream D6-7 was 0.1 µg/L, which was higher than the CWQG of 0.017 µg/L. Cadmium was not detected in any other sample (detection limit was 0.1 µg/L).
- Chromium concentration in the fall sample from stream D6-7 (2.0 µg/L) was higher than the CWQG for hexavalent chromium (1.0 µg/L) but lower than the CWQG for trivalent chromium (8.9 µg/L). Chromium was detected in the spring sample from stream D6-7 (0.9 µg/L), but was not detected in either of the samples from stream D0-1 (detection limits were 0.2 to 2 µg/L).
- Iron concentration in the fall sample from stream D1 was 305 µg/L, which was higher than both the CWQG and GCDWQ. Iron concentrations in the other samples ranged from 84 to 133 µg/L.
- Manganese concentration in the fall sample from stream D1 was 61.5 µg/L, which was higher than the GCDWQ of 50 µg/L (aesthetic objective). Manganese concentrations in the other samples ranged from 6.8 to 16.7 µg/L.
- Selenium concentration in the fall sample from stream D6-7 was 1.0 µg/L, which was the same as the CWQG. Selenium was not detected in the other samples; however, the detection limit in these samples was 10 µg/L, which was higher than the CWQG of 1.0 µg/L.

Organic compounds were measured in all stream samples. Concentrations of phenols, BTEX, total volatiles, or total extractables were below detection limits in all samples.

Peninsula Basin G

A water quality sample was collected in spring 1997 from stream G1-2 (Figure 5-2; Appendix B, Table B1-5). This stream was well-oxygenated at the time of sampling, with a dissolved oxygen concentration of 10.4 mg/L and a water temperature of 18.5°C. Field-measured pH was 8.1 and field-measured conductivity was 72 µS/cm. Major ions were dominated by bicarbonate (25 mg/L), calcium (9.6 mg/L), and chloride (2.7 mg/L).

Total alkalinity and total hardness were 25 mg/L and 28 mg/L, respectively. These values indicate that the stream water was very soft (Table 5-3; McNeely et al. 1979). Total suspended solids concentration was less than the detection limit of 3 mg/L. Total cyanide was not measured.

Nutrient concentrations were similar to other Peninsula streams. Total phosphorus concentration was 0.006 mg/L, which was lower than the guideline of 0.3 mg/L in NT and Nunavut. Total Kjeldahl nitrogen concentration was 0.41 mg N/L whereas total ammonia and nitrate concentrations were 0.006 mg/L and 0.012 mg/L, respectively. Chlorophyll *a* concentrations were not measured.

Detection limits for total metals were at or below the CWQG except for cadmium (0.1 µg/L) and selenium (10 µg/L). Total metal concentrations were either below detection limits or below applicable guidelines.