ANNEX XI: APPENDIX A

REVIEW OF WATER AND SEDIMENT QUALITY DATA FROM OTHER PROGRAMS

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Abbreviations

Abbreviation	Definition
AEMP	Aquatic Effects Monitoring Program
CCME	Canadian Council of Ministers of the Environment
CI	confidence interval
CWQG	Canadian Water Quality Guideline
DDMI	Diavik Diamond Mines Inc.
Diavik Mine	Diavik Diamond Mine
Dominion Diamond	Dominion Diamond Ekati Corporation
e.g.	for example
Ekati Mine	Ekati Diamond Mine
et al.	and more than one additional author
FF	far-field
i.e.	that is
ISQG	Interim Sediment Quality Guidelines
Project	Jay Project
KPSF	King Pond Settling Facility
LDG	Lac de Gras
LDS	Lac du Sauvage
LLCF	Long Lake Containment Facility
MF	mid-field
No.	number of samples
NF	near-Field
NTU	nephelometric turbidity units
NWT	Northwest Territories
PCDD	polychlorinated dibenzo-p-dioxin
PCDF	polychlorinated dibenzofuran
PEL	probable effect level
Rescan	Rescan Environmental Services Ltd.
SOI	substances of interest
SQG	Sediment Quality Guidelines
SSWQO	Site-Specific Water Quality Objectives
TDS	total dissolved solids
TEQs	toxic equivalencies
TKN	total Kjeldahl nitrogen
TOC	total organic carbon
TN	total nitrogen
TP	total phosphorus
TSS	total suspended solids

Units of Measure

Unit	Definition
%	percent
<	less than
>	greater than
°C	degrees Celsius
cm	centimetre
km	kilometre
km^2	square kilometre
m	metre
ng	nanograms
µg/L	micrograms per litre
mg/kg dw	milligrams per kilogram dry weight
mg/L	milligrams per litre
mm	millimetre
pg/g dw	picograms per gram dry weight

A1 INTRODUCTION

A1.1 Background and Scope

The water and sediment quality baseline report (Annex XI) provides 2013 sampling results and a brief review of pre-existing water and sediment quality in Lac du Sauvage and downstream basins. This appendix provides additional context of available pre-existing data to supplement the baseline report.

Water and sediment quality data have been collected in the study area by the Ekati Diamond Mine (Ekati Mine) and Diavik Diamond Mine (Diavik Mine) as part of their baseline and aquatic effects monitoring programs (e.g., DDMI 2013; ERM Rescan 2013). Pre-existing data from these reports were reviewed and relevant data compiled to provide context for data collected in 2013 specifically for the Jay Project (Project). A review of other studies was also conducted (e.g., Pienitz et al. 1997; Rühland and Smol 1998; Wilson et al. 2011) for additional context on water and sediment quality in the baseline study area and in the Arctic in general. The pre-existing data review is focused on water and sediment quality data from Lac du Sauvage, Ursula Lake, Nanuq Lake, and Lac de Gras.

A1.2 Objectives

The overall objective of this appendix is to review and summarize pre-existing water and sediment quality data from other baseline and aquatic monitoring programs conducted in the baseline study area. This compiled dataset will be used in addition to the 2013 data in the quantitative environmental assessment of potential Project and cumulative effects. To achieve this objective, the following tasks were undertaken:

- available water and sediment quality data from pre-existing data sources for the baseline study area were reviewed;
- relevant pre-existing water and sediment quality data were collated into a master database for water quality modelling purposes;
- baseline/background water quality and sediment quality conditions in lakes in the baseline study area were characterized; and,
- water quality and sediment quality conditions were differentiated between natural background conditions, current environmental conditions, and effects from past development activities, such as, the existing Ekati Mine operations, or existing Diavik Mine operations on pre-existing water quality and sediment quality.

A1.3 Spatial Boundaries

The baseline study area is located within the Lac de Gras drainage basin, which is in the headwaters of the Coppermine drainage, and consists of sub-basins that flow directly into Lac du Sauvage or Lac de Gras (Map A1.3-1). The Lac de Gras basin is situated in the sub-Arctic of the Canadian Shield physiographic region and contains a maze of small lakes, wetlands, and creeks. The total area of the Lac de Gras basin is 3,560 square kilometres (km^2) with approximately 1,425 km^2 covered by surface water (i.e., lakes, wetlands, creeks, and poorly drained areas). The physical setting of the study area is described in Section 1.3.2 in Annex XI. The baseline study area includes the following major basins:

- Lac du Sauvage and the Af sub-basin containing Lake Af1 and Duchess Lake;
- lakes and streams within the Lac du Sauvage basin, such as Lake D3 (Counts Lake) in D basin, and Lake E1 and Ursula Lake in the E basin;
- lakes and streams within the Paul Lake basin, including Paul Lake;
- Lac de Gras and lakes in the Lac de Gras basin, such as Vulture Lake and Nanuq Lake; and,
- tributaries to Lac de Gras.

This appendix focuses on lakes that could potentially be affected by the Project (namely, Lac du Sauvage and Lac de Gras), and those that are not influenced by anthropogenic impacts (namely, Nanuq and Ursula lakes). These lakes currently removed from mining-related impacts display natural conditions and may be considered as potential reference lakes in future aquatic effects monitoring programs (AEMP). Streams were not included in this review.

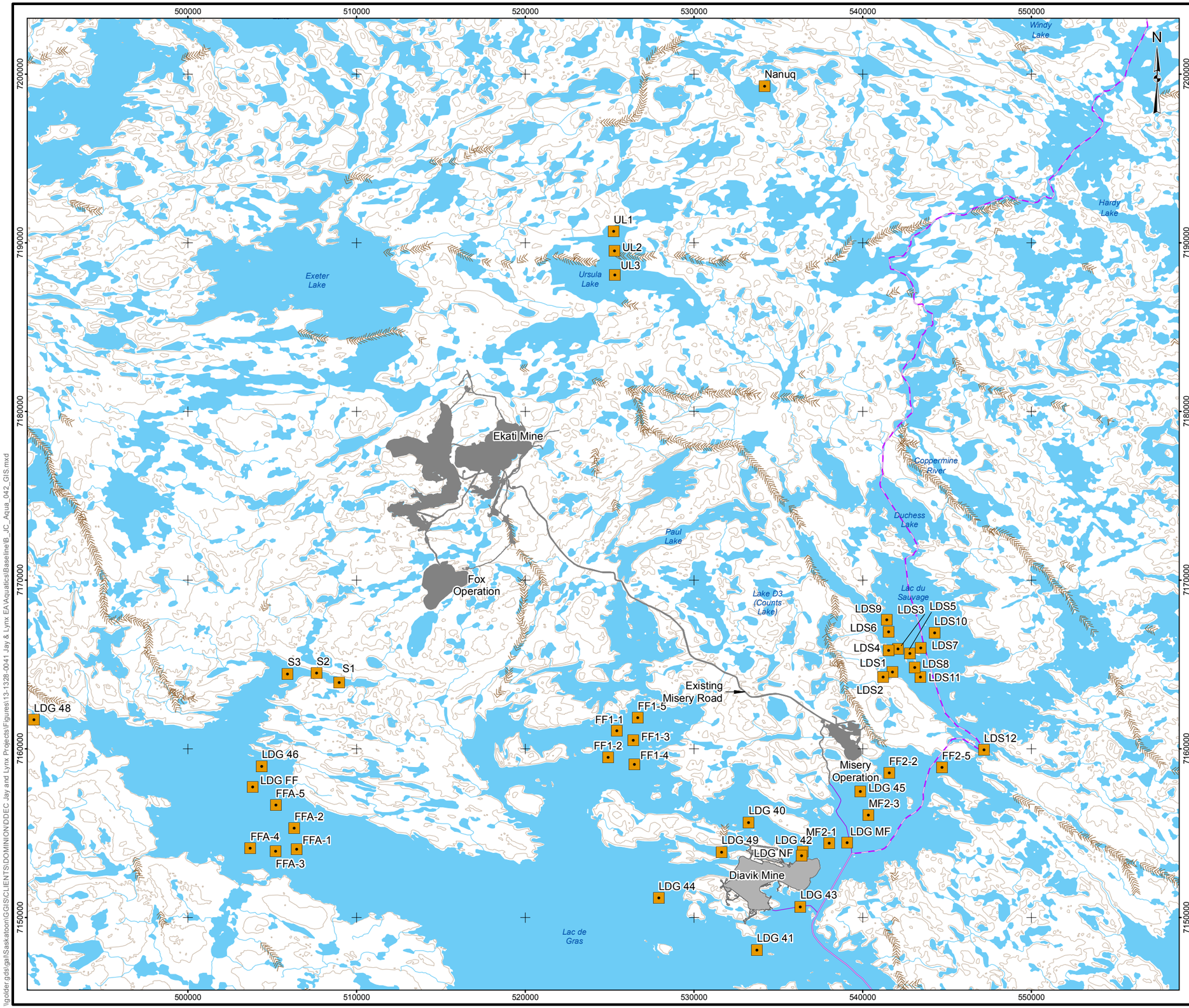
A1.4 Data Sources

Sources of water and sediment quality data included in this review are listed in Table A1.4-1.

Table A1.4-1 Sources of Water and Sediment Quality Data from Other Programs

Program	Owner/Proponent	Sampling Years	Lakes of Interest
Ekati Diamond Mine AEMP	Dominion Diamond Ekati Corporation	1997 to 2012 [(a)]	Lac du Sauvage, Lac de Gras, Nanuq Lake
Jay Pipe Aquatic Baseline Study	Dominion Diamond Ekati Corporation	2006	Lac du Sauvage, Ursula Lake
Diavik Diamond Mine Baseline and AEMP	Diavik Diamond Mines Inc.	1994 to 2012 [(a)]	Lac de Gras

a) water quality data from 2010 to 2012 were included in the baseline dataset for the water quality model.
AEMP = Aquatic Effects Monitoring Program.



LEGEND

- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT
- WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- ELEVATION CONTOUR (20 m INTERVAL)
- ESKER
- WATERCOURSE
- WATERBODY
- HISTORICAL STATION

REFERENCE

NATIONAL TOPOGRAPHIC BASE DATA (NTDB) 1:250,000
NATURAL RESOURCES CANADA, CENTRE FOR TOPOGRAPHIC INFORMATION, 2012
DATUM: NAD83 PROJECTION: UTM ZONE 12N

DOCUMENT

WATER AND SEDIMENT QUALITY BASELINE REPORT

5 0 5
SCALE 1:225,000 KILOMETRES

PROJECT
DOMINION DIAMOND™
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
HISTORIC WATER AND SEDIMENT QUALITY SAMPLING LOCATIONS

Golder Associates

PROJECT		13-1328-0041	FILE No. B_JC_Aqua_042_GIS	
DESIGN	KS	20/06/14	SCALE AS SHOWN	REV 0
GIS	JG	11/09/14		
CHECK	CG	11/09/14	MAP A1.3-1	
REVIEW	SM	11/09/14		

\\golder.gds\gal\Saskatoon\GIS\CLIENTS\DOMINION\DDEC Jay and Lynx Projects\Figures\13-1328-0041 Jay & Lynx EA\Aquatics\Baseline\B_JC_Aqua_042_GIS.mxd

A2 METHODS

In this section, the overall study design for each monitoring or baseline program is described. Monitoring programs have changed over the years in number and location of sites, number of parameters monitored, sample type, and detection limits achieved. Data that are more recent (i.e., since 2006) were compiled into an electronic database and presented as medians and ranges. Earlier data (i.e., pre-2006) are presented in the same format (i.e., tables were re-created) as presented in the original report.

A2.1 Ekati Diamond Mine Water and Sediment Quality Monitoring

Ekati Diamond Mine (Ekati Mine) is an active diamond mine in the Koala watershed, which drains into the west bay of Lac de Gras, and the King-Cujo watershed, which drains into the west bay of Lac du Sauvage (ERM Rescan 2013). The Ekati Mine is operated by Dominion Diamond Ekati Corporation (Dominion Diamond). An AEMP has been conducted annually since 1997 to monitor for effects of mine water discharge and mining activities on the receiving environments: the Koala watershed, which is monitored in Leslie Lake through to Lac de Gras, and the Christine (sub-basin B) watershed, which is monitored in Cujo Lake through to Lac du Sauvage. The majority of the mining activities and mine water discharge occurs in the Koala watershed.

For the Ekati Mine AEMP, water and sediment sample collection is focused on lakes and streams downstream of the Long Lake Containment Facility (LLCF) and downstream of the King Pond Settling Facility (KPSF). Water released from the LLCF first enters Leslie Lake, then Moose Lake, Nero Lake, Nema Lake, and Slipper Lake, before entering Lac de Gras (i.e., stations S2 and S3 in Slipper Lake Bay; Map A1.3-1). Water released from the KPSF first enters Cujo Lake, then Christine Lake entering Lac du Sauvage (i.e., stations LDS2 and LDS1; Map A1.3-1). The Ekati Mine AEMP uses the following three reference lakes (ERM Rescan 2013):

- Vulture Lake (internal reference lake located upstream of the LLCF in the Koala watershed);
- Nanuq Lake (external reference lake for the Koala watershed and is located outside of the mine zone of influence); and,
- Counts Lake (external reference lake for the Christine watershed, located outside the zone of mine influence but within 5 kilometres [km] of Misery Road).

For purposes of this pre-existing data review, only data from stations in Lac du Sauvage and Lac de Gras (the final receiving waterbodies), and data from Nanuq Lake were included. Lac du Sauvage and Lac de Gras were included because they will potentially be affected by the Project, either by direct input of mine water (Lac du Sauvage) or as the further downstream environment (Lac de Gras). Nanuq Lake was included because it may be considered as a reference lake in the future AEMP for the Project; it was also included because it illustrates characteristics of regional water quality. Data from Vulture and Counts lakes were not included in this historical review because although they are reference lakes for smaller affected lakes associated with the Ekati Mine, they are not considered suitable as reference lakes for the Project (i.e., for Lac du Sauvage).

Within the AEMP, samples for water quality analysis are collected annually from the monitored lakes during ice-covered and open-water conditions. Multiple discrete grab samples are collected at various depths within the water column, including 1 metre (m) below surface, mid-depth, and 2 m from bottom, depending on the sampling period (April or early August) and water depth at the station. For the small lakes in the study, samples are collected from the deepest area of the lake. Twenty-four water quality parameters are analyzed as part of the AEMP: pH, total alkalinity, total hardness, total dissolved solids (TDS), chloride, sulphate, potassium, ammonia, nitrite, nitrate, orthophosphate, total phosphorus (TP), total organic carbon (TOC), aluminum, antimony, arsenic, copper, iron, molybdenum, nickel, selenium, strontium, uranium, and zinc. Water column profile measurements for dissolved oxygen and water temperature are also collected; these data were not included in the tabulated summary, but ranges were provided if they were available in the original reports.

Samples for sediment quality analysis are collected once every three years from the downstream lakes. The most recent sediment collection was during the 2011 AEMP (Rescan 2012). Triplicate samples were collected at two lake depths from Lac de Gras, Lac du Sauvage, and Nanuq Lake: mid (near shore) and deep. Chemistry data from the Ekman grab samples (top 2 centimetres [cm]) were used in the review[1]. Twelve sediment quality parameters were analyzed as part of the 2011 AEMP: TOC, available phosphorus, total nitrogen (TN), aluminum, arsenic, antimony, copper, molybdenum, nickel, selenium, strontium, and zinc.

A2.2 Jay Pipe – 2006 Aquatic Baseline

Rescan Environmental Services Ltd. (Rescan) conducted a study in 2006 to summarize baseline conditions of the aquatic environment near the proposed Jay kimberlite pipe (Jay Pipe) development (Rescan 2007). The study was designed as a pre-development AEMP to support post-development interpretation of potential impacts as a result of the Jay Pipe development. As such, water quality sampling was conducted in Lac du Sauvage as the main receiving environment, and Ursula Lake (in the sub-watershed draining to Lake E1) as the proposed reference lake. Sampling was also conducted in Christine Lake as a potential alternate exposure lake in the event that two of the Lac du Sauvage stations would be negatively affected by construction activities due to the Jay Pipe development. For the purposes of this pre-existing baseline data review, only data from Lac du Sauvage and Ursula Lake were included. Christine Lake is downstream of the KPSF and is influenced by this discharge; therefore, measured water and sediment quality in Christine Lake was not considered representative of baseline conditions in the Project baseline study area.

Water samples were collected in Lac du Sauvage and Ursula Lake during ice-covered (February, March, and May 2006) and open-water conditions (July, August, and September 2006), and surficial sediment samples were collected during open-water conditions (August 2006). There were 12 sampling locations in Lac du Sauvage; two of the sampling locations in Lac du Sauvage (i.e., LDS1 and LDS2) are in the downstream flow path from the KPSF, and the other 10 locations (LDS3 to LDS12) are located in the main basin of the lake (Map A1.3-1). In Ursula Lake, water and sediments samples were collected from three sampling locations (Map A1.3-1).

[1] The 2011 AEMP collected and analyzed sediment samples in three ways: with an Ekman grab sampler (top 2 cm retained for analysis) and with a sediment corer (top 0 to 1 cm and 1 to 2 cm horizons analyzed separately) (Rescan 2012). This review focuses on the Ekman sediment sampling to be comparable to historical sampling.

Water samples were collected as discrete grab samples from multiple depths within the water column, including 1 m below surface, mid-depth, and 2 m from bottom, depending on the sampling period (i.e., winter or summer). Water samples were analyzed for the following parameters:

- conventional parameters (i.e., total alkalinity, conductivity, pH, total suspended solids, turbidity, hardness, and TDS);
- major ions (i.e., bicarbonate, calcium, carbonate, chloride, hydroxide, magnesium, potassium, silicon, sodium, and sulphate);
- nutrients (i.e., total ammonia, nitrate, nitrite, orthophosphate, TP, TOC, and total Kjeldahl nitrogen [TKN]); and,
- total metals, metalloids, and non-metals[2] (i.e., aluminum, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, strontium, uranium, vanadium, and zinc).

Triplicate sediment samples were collected in Lac du Sauvage and Ursula Lake using an Ekman grab sampler with the top 2 cm layer retained for analysis of particle size distribution (i.e., percent gravel, sand, silt, clay), moisture content, nutrients (i.e., available phosphorus, TP, TN, TOC), and total metals (i.e., aluminum, arsenic, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, and zinc).

A2.3 Diavik Diamond Mine Water and Sediment Quality Baseline

Baseline water and sediment quality data were collected in Lac de Gras between 1994 and 2000 before the start of construction and operation of the Diavik Mine (DDMI 2001), which commenced in 2000. During this period, baseline data collected between 1994 and 1997 supported the Project Description and Environmental Assessment for the mine. Between 1998 and 2000, project activities were limited. By the end of 2000, construction was underway, but it was limited to infrastructure development on East Island. There was no direct discharge of mine water to Lac de Gras with the exception of treated sewage via an adjacent wetland (DDMI 2001).

The number of stations, sample type (discrete or depth-integrated), and sample depth (surface, mid, depth-integrated) in this monitoring period varied between years and sampling events (under ice or open water). The detection limits also varied between years for many of the parameters, although detection limits generally improved over time. These issues limit the comparability of pre-2001 water quality data to the subsequent construction and operations water quality data from Lac de Gras; however, the data provide an indication of pre-development water quality in Lac de Gras.

[2] Henceforth, metals, metalloids (e.g., arsenic), and non-metals (e.g., selenium) will be referred to as metals.

Diavik Diamond Mines Inc. (DDMI) established long-term monitoring stations for the 2001 AEMP. To provide sufficient data for statistical analysis, baseline stations were matched to be as similar as possible in location and sampling depth to the long-term monitoring stations (Table 1-4 in DDMI 2001). Based on the compiled dataset, DDMI (2001) reported baseline summary statistics (number of samples, median, range, and percent of samples less than the detection limit) for the long-term monitoring stations. These stations were located in the mid-field area (LDG40, LDG41, LDG42, LDG43, LDG44, LDG45, and LDG49), and in the far-field area (LDG46, LDG48, and BHP-S) (Map A1.3-1). Station BHP-S included stations S1, S2, and S3 from the Ekati Mine AEMP.

Only results for water quality parameters contained in the Type A Water Licence were provided in DDMI (2001). These parameters are pH, total suspended solids (TSS), turbidity, ammonia, nitrite, TP, and total metals (aluminum, arsenic, cadmium, chromium, copper, lead, nickel, and zinc). These results were used to characterize general water quality in Lac de Gras before development.

Baseline sediment quality samples were collected from the near-field, mid-field, and far-field areas. Only results for 11 parameters were provided (DDMI 2007): TKN, TOC, TP, aluminum, arsenic, cadmium, chromium, copper, lead, nickel, and zinc.

A2.4 Diavik Diamond Mine Water and Sediment Quality Monitoring

Diavik Diamond Mine (Diavik Mine) is an active diamond mine on Lac de Gras in the Northwest Territories. An AEMP has been conducted annually since 2000 to monitor effects of mine water discharge on the receiving environment of Lac de Gras.

For the Diavik Mine AEMP, collection of water and sediment quality samples is focused within Lac de Gras, with occasional sample collection near the outlet of Lac du Sauvage. The AEMP was designed to evaluate five areas of Lac de Gras; each area was defined by a distance from the diffuser (Golder 2014). The AEMP areas include the near-field (NF; near the diffuser), the far-field exposure (FF2), and three reference areas (FF1, FFA, and FFB). There are also three mid-field areas between the NF and each reference area (MF1, MF2, and MF3) (Map A1.3-1). Each area is represented by up to five individual sampling stations, and not replicate samples, to provide adequate statistical power.

Samples for water quality analysis are collected annually from the various stations during ice-covered and open-water conditions. Discrete grab samples are collected at three depths in the NF and MF areas (2 m from surface, mid-depth, and 2 m from bottom), and at one depth in the FF and reference areas (mid-depth). Twenty water quality parameters (termed substances of interest [SOI]) are analyzed as part of the AEMP: TDS, alkalinity, calcium, magnesium, potassium, sodium, chloride, fluoride, sulphate, ammonia, TOC, total aluminum, total arsenic, total copper, total iron, total manganese, total molybdenum, total strontium, total uranium, and total zinc. Supporting variables such as bicarbonate, carbon, nitrogen, and phosphorus are also measured.

Samples for sediment quality analysis are collected every year from within the mixing zone of the diffuser in Lac de Gras (part of the Surveillance Network Program), and once every three years from the near-field, mid-field, and reference areas under the AEMP. Samples are not collected in Lac du Sauvage. Sediments are analyzed for particle size distribution, TOC, total organic matter, moisture content, TN, TP, total metals (i.e., aluminum, antimony, arsenic, barium, beryllium, bismuth, cadmium, calcium, chromium, cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium, uranium, vanadium, zinc), and total extractable metals (i.e., cadmium, copper, lead, mercury, nickel). Depending on the sampling period, samples have been collected using an Ekman grab sampler and/or a sediment corer; equipment and depth interval are specified in Section A4.2.

A3 RESULTS – WATER QUALITY

A3.1 Lac du Sauvage

A3.1.1 During Ekati Mining Operations

From the operations at Misery, mine wastewater is released from the KPSF into the King-Cujo watershed where water flows into Cujo Lake, Christine Lake, and finally into Lac du Sauvage. Water quality is monitored in Cujo Lake, Cujo Lake outflow, Christine Lake outflow, and Lac du Sauvage. Two monitoring stations are located in Lac du Sauvage: LDS2 is located closest to the shore, and LDS1 is located furthest from the shore.

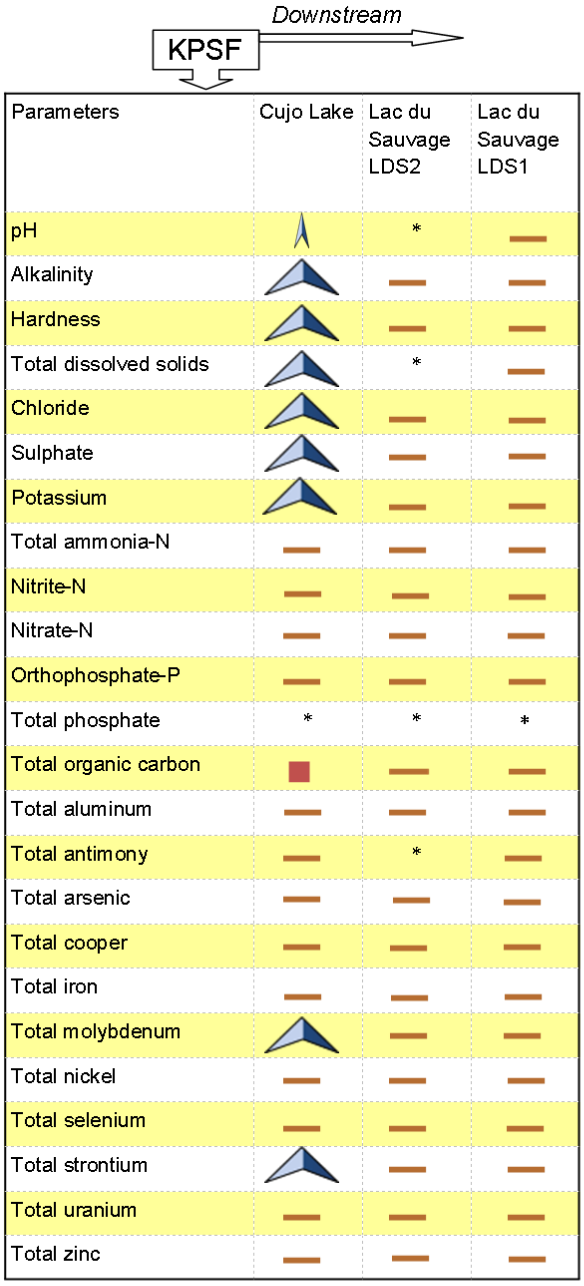
Each annual AEMP report for Ekati Mine provides a summary of mine-related changes in water quality and biological parameters over time in downstream lakes and streams compared to reference lakes or streams (e.g., ERM Rescan 2013). For the purposes of this review, a version of the figure from the 2012 report (ERM Rescan 2013) has been recreated that shows water quality trends in the monitored lakes (i.e., Cujo Lake and Lac du Sauvage) (Figure A3.1-1).

As of 2012, nine of the twenty-four monitored parameters in Cujo Lake have increased through time: pH, total alkalinity, hardness, TDS, chloride, sulphate, potassium, total molybdenum, and total strontium (Figure A3.1-1). The change in concentration of these parameters through time deceases with increasing distance from the KPSF (i.e., from Cujo Lake, through Cujo Outflow, and Christine-Lac du Sauvage stream; see ERM Rescan 2013). However, no changes in water quality have been noted in Lac du Sauvage (Figure A3.1-1). Concentrations of the nine identified parameters in reference lakes have remained consistent over time. Previously elevated concentrations of total copper, total ammonia, and total iron returned to levels consistent with baseline conditions by 2012 (ERM Rescan 2013). Concentrations of TOC are elevated compared to reference lakes, but concentrations have not increased over time.

ERM Rescan (2013) calculated 95 percent (%) confidence intervals (CI) of the 2012 fitted mean water quality concentrations for all downstream lakes and streams. For parameters with site-specific water quality objectives (SSWQOs; chloride, sulphate, potassium, nitrate, molybdenum, and vanadium) and Canadian water quality guidelines (CWQGs) for the protection of aquatic life, the 95% CI were below their respective objectives and guidelines with the exception of pH, total ammonia, total phosphate[3], and total aluminum. In Lac du Sauvage, the 95% CI for pH, total phosphate, and total aluminum exceeded CWQGs. However, concentrations of these parameters in reference lakes also exceeded SSWQOs and CWQGs. Thus, concentrations of these parameters are considered to be naturally elevated in these lakes, and not due to mine sources.

[3] ERM Rescan (2013) compared total phosphate concentrations to lake-specific benchmark trigger values that were established using guidelines set out in the *Canadian Guidance Framework for the Management of Phosphorus in Freshwater Systems* (Environment Canada 2004), the Ontario Ministry of Natural Resources (1994), and CCME (2004).

Figure A3.1-1 Mine-Related Water Quality Changes Between the King-Cujo Watershed and Lac du Sauvage, 2012



Legend: Increased over time in comparison to reference lakes or different from constant

- 0-25%
- 26-50%
- 51-75%
- 76-100%
- Elevated, but has not changed through time
- Did not change over time or differ significantly from reference lakes
- * Indicates that the upper bound of the 95% CI exceeded the SSWQO or CWQG during the ice-covered or open water season.

Notes:

KPSF = King Pond Settling Facility; % = percentage.

[+] The direction and degree of change was inferred from historical data. For water quality data, differences were assessed relative to data from 2000 (August lakes), 2002 (April lakes), or the first year in which data was collected (i.e. TOC = 2005). The season in which the greatest changed occurred (i.e. April or August) is represented in the table.

+ For water quality data, % change was calculated as 1-(historical concentration/current concentration).

(Modified from figure 5-1a in ERM Rescan 2013)

A3.1.2 Current Conditions

As discussed in Section A3.1.1, mine effects on water quality in the King-Cujo watershed have not yet been measured in Lac du Sauvage (ERM Rescan 2013). Therefore, the current water quality and sediment quality conditions measured in Lac du Sauvage are likely representative of pre-mining conditions, which includes data from the Jay Pipe 2006 baseline study (LDS1 to LDS12; Rescan 2007); Rescan (2007) noted that water quality in Lac du Sauvage was typical of that found in other northern lakes.

Data from the 2006 study (Rescan 2007) and Lac du Sauvage stations LDS1 and LDS2 from the 2010 to 2012 AEMP studies (Rescan 2011, 2012; ERM Rescan 2013) were combined to represent the pre-mining or current condition. The combined parameter ranges and median values for open-water and under-ice water samples (note that differences in detection limits occur for certain parameters) are presented in Table A3.1-1.

Based on the 2006, and 2010 to 2012 data, water quality in Lac du Sauvage is characterized as follows:

- clear, with Secchi depths ranging from 4 to 8 m;
- relatively cool with sufficient dissolved oxygen to support aquatic life (i.e., not below the lower bound CWQG for the protection of aquatic life of 6.5 mg/L for cold water - other life stages [CCME 1999]);
- low in alkalinity (i.e., sensitive to acid inputs as per the lake acid sensitivity scale of Saffran and Trew [1996]);
- low in hardness (i.e., very soft water as per the scale of water hardness in McNeely et al. [1979]);
- slightly acidic (pH was generally within the CWQG range in open-water samples [median pH of 6.7] and sometimes below the lower CWQG of pH 6.5 in under-ice samples [median pH of 6.7]);
- low in nutrients (nitrogen and phosphorus), with TP concentrations being within the range for oligotrophic lakes (as per the CCME [2004] trophic status classification); and,
- low in metals concentrations, which were either not detected or below the CWQG, with several exceptions where maximum concentrations for aluminum, cadmium, chromium, and lead were higher than their respective CWQGs.

In general, no spatial trends were discernible in the under-ice conditions (possibly due to smaller sample size and higher inter-sample variability) or open-water conditions (i.e., the lake is homogeneous and well-mixed). However, higher concentrations of major ions, nutrients, and metals were measured in under-ice water samples compared to open-water samples.

Table A3.1-1 Lac du Sauvage Water Quality 2006 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	108	4.1	3.0 to 5.5	83	5.2	2.2 to 9.9
Conductance	µS/cm	-	-	-	-	-	108	13	12 to 25	83	15	13 to 29
Hardness	mg/L	-	-	-	-	-	109	4.4	3.9 to 5.0	83	5.3	4.2 to 9.5
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	108	6.7	**6.4**[(C,D)] to 7.6	83	6.7	**6.2**[(C,D)] to 8.0
Total dissolved solids (TDS)	mg/L	-	-	500	-	-	27	9.5	8.6 to 12	12	12	8.2 to 15
TDS (Calculated)	mg/L	-	-	-	-	-	81	6.1	5.5 to 8.5	71	7.6	5.6 to 16
Total suspended solids	mg/L	-	-	-	-	-	108	<3.0	<3.0 to 4.1	83	<3.0	<3.0
Turbidity	NTU	-	-	-	-	-	108	0.61	0.37 to 1.7	83	0.22	0.12 to 1.6
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	108	4.1	3.0 to 5.5	83	5.1	<2.0 to 9.9
Calcium	mg/L	-	-	-	-	-	109	0.82	0.76 to 0.92	83	0.99	0.82 to 1.9
Chloride	mg/L	640	120	250	-	64.5	108	<0.5	<0.5 to 0.8	83	<0.5	<0.5 to 0.95
Fluoride	mg/L	-	0.12	1.5	-	-	81	0.02	<0.02 to 0.027	71	0.025	0.022 to 0.041
Magnesium	mg/L	-	-	-	-	-	109	0.56	0.48 to 0.68	83	0.67	0.51 to 1.2
Potassium	mg/L	-	-	-	112	41	109	0.53	0.47 to 0.59	83	0.62	0.5 to 1.2
Sodium	mg/L	-	-	200	-	-	109	0.55	0.51 to 0.74	83	0.66	0.53 to 1.3
Sulphate	mg/L	-	-	500	250	23	108	1.2	1.1 to 1.9	83	1.5	1.3 to 3.1
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	106	3.4	2.1 to 5.0	83	3.2	2.0 to 7.3
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	106	0.18	0.06 to 2.2	83	0.21	0.089 to 0.32
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	106	0.0068	<0.005 to 0.017	83	0.024	<0.005 to 0.039
Nitrate	mg-N/L	124	2.9	10	-	0.57	108	<0.005	<0.005 to 0.089	83	0.02	<0.005 to 0.07
Nitrite	mg-N/L	-	0.06	1.0	-	-	108	<0.001	<0.001 to <0.001	83	<0.001	<0.001 to 0.0015
Total phosphorus	mg-P/L	-	-	-	-	-	106	0.0065	0.0042 to 0.018	83	0.0052	0.0034 to 0.0082
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	108	<0.001	<0.001 to 0.0019	83	0.0022	<0.001 to 0.0058
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	109	9.0	5.4 to 23	83	3.7	1.5 to 58
Antimony	µg/L	-	-	6.0	-	-	109	<0.1	<0.1	83	<0.1	<0.1
Arsenic	µg/L	-	5.0	10	-	-	109	0.29	0.25 to 0.35	83	0.29	0.22 to 0.47
Barium	µg/L	-	-	1,000	-	-	109	1.3	1.0 to 3.2	83	1.3	1.1 to 3.5
Beryllium	µg/L	-	-	-	-	-	109	<0.2	<0.01 to <0.2	83	<0.2	<0.01 to <0.2
Boron	µg/L	29,000	1,500	5,000	-	-	109	1.1	<1.0 to <5.0	83	1.4	<1.0 to 6.8
Cadmium	µg/L	0.11 to 0.19	0.04	5.0	-	-	109	**<0.05**[(DL>C)]	<0.01 to **0.074**[(C)]	83	**<0.05**[(DL>C)]	<0.01 to **<0.05**[(DL>C)]
Chromium	µg/L	-	1.0	50	-	-	109	<0.1	<0.1 to **1.6**[(C)]	83	0.17	<0.1 to 0.42
Cobalt	µg/L	-	-	-	-	-	109	<0.1	<0.1 to <0.1	83	<0.1	<0.1 to 0.51
Copper	µg/L	-	2.0	1,000	-	-	109	0.61	0.38 to 1.9	83	0.62	0.5 to 1.2
Iron	µg/L	-	300	300	-	-	109	17	<10 to 82	83	<10	<10 to 87

Table A3.1-1 Lac du Sauvage Water Quality 2006 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (continued)												
Lead	µg/L	-	1.0	10	-	-	109	0.17	<0.01 to **34**$^{(C, D)}$	83	<0.05	<0.01 to 0.18
Manganese	µg/L	-	-	50	-	-	109	5.0	2.6 to 14	83	1.7	0.18 to 39
Mercury	µg/L	-	0.026	1.0	-	-	109	<0.02	<0.02 to <0.02	83	<0.02	<0.02 to <0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	109	<0.05	<0.05 to 0.26	83	<0.05	<0.05
Nickel	µg/L	-	25	-	-	-	109	0.33	0.22 to 1.1	83	0.3	0.21 to 1.8
Selenium	µg/L	-	1.0	10	-	-	109	<0.1	<0.04 to <0.2	83	<0.1	<0.04 to <0.2
Silver	µg/L	-	0.1	-	-	-	109	<0.1	<0.01 to <0.1	83	<0.1	<0.01 to <0.1
Strontium	µg/L	-	-	-	-	-	109	5.2	4.9 to 5.9	83	6.3	5.2 to 12
Uranium	µg/L	33	15	20	-	-	109	0.023	0.017 to 0.029	83	0.022	0.013 to 0.038
Vanadium	µg/L	-	-	-	540	30	109	<0.05	<0.05 to <0.5	83	<0.05	<0.05 to 0.17
Zinc	µg/L	-	30	5,000	-	-	109	<1.0	<1.0 to 7.3	83	<1.0	<1.0 to 6.6

Source: Rescan (2007, 2011, 2012); ERM Rescan (2013).
Notes: Stations: Open = LDS1 to LDS12 (2006 data) and LDS1 and LDS2 (AEMP); Ice = LDS1 to LDS3, LDS5, LDS9 to LDS12 (2006 data) and LDS1 (AEMP).
Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.
Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.
Samples were collected from mid-depth.
Bolded concentrations are higher than relevant water quality guidelines.
C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or dissolved oxygen (DO) concentration range.
D) = concentration higher than the relevant drinking water guideline or beyond the recommended pH or DO concentration range.
DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.
a) Ammonia guideline calculation based on pH = 6.8; water temperature = 6°C (Open Water) and 2°C (Under Ice).
CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microsiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

A3.2 Lac de Gras

A3.2.1 Pre-mining

Baseline water quality data were collected in Lac de Gras between 1994 and 2000 before the start of construction and operation of the Diavik Mine. These data have been used as the reference dataset for Diavik's AEMP long-term monitoring stations (DDMI 2001); a summary of water quality data specific to the Type A Water Licence, including median values and data ranges (i.e., 25th to 75th percentiles) is provided in Table A3.2-1.

As noted by DDMI (2001), Lac de Gras is an oligotrophic lake with high clarity, low dissolved solids, and concentrations of many metals and nutrients at or below analytical detection limits and slightly acidic pH (median pH of 6.6). Concentrations of total suspended solids (TSS) were often below detection limit and turbidity was generally less than 1 nephelometric turbidity units (NTU), indicating clear water. Total phosphorus (TP) was detected at various detection limits (i.e., 0.0002, 0.001 and 0.003 mg/L) with a median concentration of 0.003 mg/L; however, samples analyzed with the lowest detection limit showed higher TP concentrations (0.004 to 0.008 mg/L) compared to samples analyzed at higher detection limits. Ammonia concentrations were often below detection limits, but measured concentrations generally ranged from 0.005 to 0.010 mg/L. Detection limits for nitrite improved during the baseline period (i.e., from 0.2 to 0.002 mg/L) with concentrations consistently at or below detection limits.

For total metals, the following was observed:

- Aluminum was detected in more than 90% of samples with a median concentration of 7.95 µg/L. Detected concentrations were below the applicable CWQG.
- Arsenic was detected in more than 75% of samples with a median concentration of 0.20 µg/L.
- Cadmium was detected in 5% of samples, although the detection limit was higher than the CWQG in most samples.
- Chromium was detected in 63% of samples, with a median concentration of 0.33 µg/L. In some years, the detection limit was above the Canadian Water Quality Objective. The 75th percentile concentration (1.2 µg/L) is above the CWQG, but this may be an artifact of the varying detection limits.
- Copper was detected in approximately 50% of the samples with a median concentration of 0.7 µg/L, which is below the CWQG.
- Lead was only detected in 15% of the samples with a median concentration at the detection limit of 0.05 µg/L.
- Nickel was detected in more than 85% of the samples with a median concentration of 0.69 µg/L, which is well below the CWQG.
- Zinc was detected in approximately 50% of the samples with a median concentration of 1.0 µg/L, which is below the CWQG.

Table A3.2-1 Baseline Water Quality Data – Lac de Gras from 1994 to 2000

Parameter	Unit	Guidelines			Objectives		Count (n)	Median	Range (25th to 75th Percentile)	Percent of Samples Less than Analytical Detection Limit
		Aquatic Life								
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term Water Quality Objective	Long-Term Water Quality Objective				
Conventional Parameters										
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	1,429	6.56	**6.32** (C) to 6.74	-
Total suspended solids	mg/L	-	-	-	-	-	433	2.0	1.0 to 3.0	75
Turbidity	NTU	-	-	-	-	-	798	0.3	0.1 to 0.9	-
Nutrients										
Ammonia	mg/L	-	45-72	-	-	-	433	0.007	0.005 to 0.010	59
Nitrite	mg/L	-	0.06	1.0	-	-	130	0.004	0.002 to **0.200** (DL>C)	100
Total phosphorus	mg/L	-	-	-	-	-	448	0.0030	0.002 to 0.0042	25
Total Metals										
Aluminum	µg/L	-	5.0 or 100	100	-	-	458	7.95	3.2 to 18.75	7
Arsenic	µg/L	-	5.0	10	-	-	411	0.2	0.18 to 0.21	23
Cadmium	µg/L	0.11	0.04	5.0	-	-	465	**0.05** (DL>C)	**0.05** (DL>C) to **0.2** (DL>C)	95
Chromium	µg/L	-	1.0	50	-	-	459	0.33	0.185 to **1.2** (C)	37
Copper	µg/L	-	2.0	1,000	-	-	459	0.7	0.6 to 1.0	51
Lead	µg/L	-	1.0	10	-	-	388	0.05	0.05 to 0.07	85
Nickel	µg/L	-	25	-	-	-	459	0.69	0.5 to 1.40	16
Zinc	µg/L	-	30	5,000	-	-	369	1	0.8 to 6.5	46

Source: DDMI (2001).
Notes: Stations included: Lac de Gras Mid-field Stations (LDG40, LDG41, LDG42, LDG43, LDG44, LDG45, LDG49), and Lac de Gras Far-field Stations (LDG46, LDG48, BHP-S); see DDMI (2001) for station locations within Lac de Gras.
Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature, and are not included in the percent exceedance calculations.
Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines.
Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.
Bolded concentrations are higher than relevant water quality guidelines.
C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or dissolved oxygen (DO) concentration range.
DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.
CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; mg/L = milligrams per litre; µS/cm = microsiemens per centimetre; NTU = nephelometric turbidity units; µg/L = micrograms per litre; - = no guideline or data.

A3.2.2 During Mining Operations

A3.2.2.1 Lac de Gras in Vicinity of Slipper Lake Bay

For the main operations at Ekati Mine, mine wastewater is released from the Long Lake Containment Facility (LLCF) into the Koala watershed and Lac de Gras. Mine water flows from the LLCF into a series of lakes before it flows to a bay in Lac de Gras; this bay is identified as Slipper Lake Bay since it receives outflow from Slipper Lake. Water quality is monitored in Leslie Lake, Moose Lake, and Nema Lake, including their outlets, and at two stations in Slipper Lake Bay of Lac de Gras (i.e., S2 [closest to shore], and S3 [further from shore]).

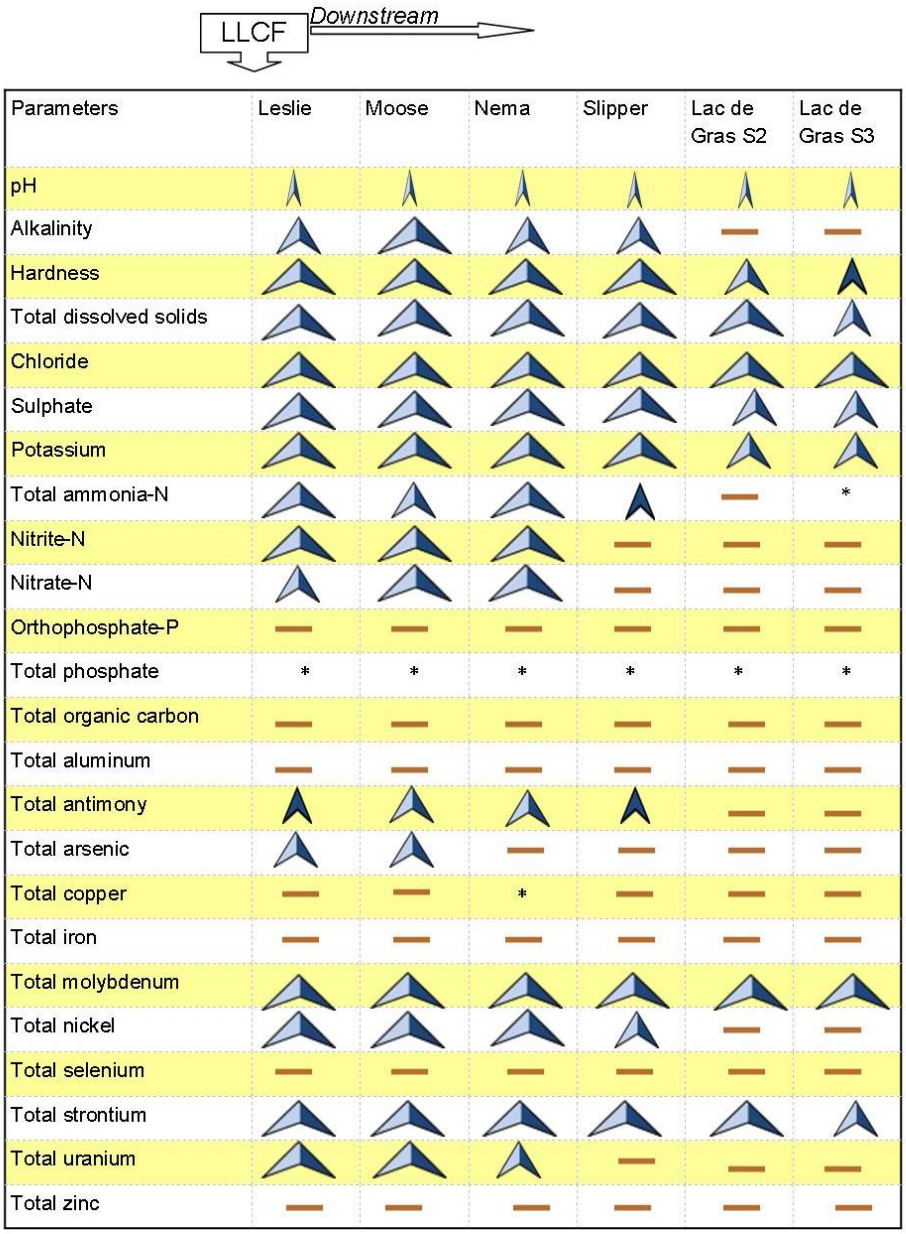
As stated in Section A.3.1.1, a summary of mine-related changes in water quality parameters is provided in the annual AEMP report for the Ekati Mine (e.g., ERM Rescan 2013). For the purposes of this review, a version of the figure from the 2012 report that shows the water quality trends in monitored lakes of the Koala watershed and in Lac de Gras has been recreated (Figure A3.2-1). In Leslie Lake, 16 of the 23 parameters have changed through time in varying magnitude as a result of mine water release from the LLCF (Figure A3.2-1); at Station S2 in Slipper Lake Bay of Lac de Gras, 8 of the 23 parameters have changed through time. For these parameters, these changes, and magnitude of changes, indicate elevated concentrations relative to baseline or reference conditions. The elevated downstream trends for these parameters are summarized as follows:

- pH, hardness, TDS, chloride, sulphate, potassium, total molybdenum, and total strontium from Leslie Lake through to Lac de Gras;
- total alkalinity, total ammonia, total antimony, and total nickel from Leslie Lake through to Slipper Lake;
- nitrate, nitrite, and total uranium from Leslie Lake through to Nema Lake; and,
- total arsenic from Leslie Lake to Moose Lake.

As noted in Section A.3.1.1 for the King-Cujo watershed, the change in concentration of these parameters through time in the Koala watershed generally deceases with increasing distance from the source of mine water (i.e., LLCF). Concentrations of the parameters in reference lakes have remained consistent over time (ERM Rescan 2013).

To compare to objectives and guidelines, ERM Rescan (2013) calculated 95% CI of the 2012 fitted mean water quality concentrations for all downstream lakes and streams. For parameters with SSWQOs (chloride, sulphate, potassium, nitrate, molybdenum, and vanadium) and CWQGs, the 95% CI were below their respective objectives and guidelines, with the exception of pH, total ammonia, total phosphate, total aluminum, total copper, and total iron. Concentrations of pH, total ammonia, total phosphate, total aluminum, total copper, and total iron in reference lakes were also higher than CWQGs, suggesting that their measured concentrations are not related to mine inputs to the watershed but reflect background conditions and natural variability.

Figure A3.2-1 Mine-Related Water Quality Changes Between the Koala Watershed and Lac de Gras, 2012



Legend:

Increased over time in comparison to reference lakes or different from constant

0-25% 26-50% 51-75% 76-100%

— Did not change over time or differ significantly over time from reference lakes.

* Indicates that the upper bound of the 95% CI exceeded the SSWQO or CWQG during the ice-covered or open water season.

Observed and fitted mean concentrations of potassium and nitrite were above CWQG and are likely related to mine inputs (ERM Rescan 2013). For nitrite, the upper 95% CI in Leslie Lake was higher than the CWQG, but the observed and fitted mean concentrations were less than the CWQG. The 95% CI were lower than the CWQG for all other downstream lakes. For potassium, observed and fitted mean concentrations were higher than the SSWQO in Leslie and Moose lakes, but the 95% CI were lower than the SSWQO in downstream lakes (i.e., Nema Lake, Slipper Lake, and Lac de Gras).

A3.2.2.1 Lac de Gras in Vicinity of Diavik Mine

Diavik releases mine wastewater via a diffuser into Lac de Gras at the north end of East Island. As described in Section A2.3, water quality is monitored in five areas of Lac de Gras as defined by distance from the diffuser. These areas include the near-field (NF; near the diffuser), three mid-field areas (MF1, MF2, and MF3), the far-field exposure (FF2), and three reference areas (FF1, FFA, and FFB) (Map A1.3-1).

Time series plots of substances of interest (SOIs) from 1996 to 2012 are presented in the Diavik AEMP 2012 report (Appendix III of DDMI 2013). Temporal trends generally persisted through the 2012 monitoring period and these trends as presented in DDMI (2013) are summarized as follows:

- The concentrations of certain SOIs were elevated in the near-field (NF) stations with an increasing trend over time, and higher than normal ranges in the mid-field (MF) stations[4].
  - Incomplete mixing was present in the NF area with higher SOI concentrations at mid and bottom depths compared to surface samples.
- In general, the MF areas demonstrated a decline in SOI concentrations with increasing distance from the diffuser.
- Observed temporal trends at MF stations were less pronounced or absent.
- Higher SOI concentrations were noted in the ice-cover period when less mixing occurs. No SOIs have exceeded established AEMP benchmarks that were based on the lower of CCME CWQGs and Canadian Drinking Water Guidelines where available. Where these guidelines were not available, the benchmarks were based on guidelines from other jurisdictions.
- Increasing trends were noted for TDS, total alkalinity, chloride, sulphate, total molybdenum, and total strontium. These SOIs have been increasing gradually over time during the ice-cover and open-water periods in each exposure area (NF, MF and FF2). Concentrations of SOIs generally increased above the normal range by 2007 or thereafter, and remained above the normal range through to 2012.

[4] The normal range of SOIs was estimated as the mean concentration plus or minus the standard deviation of pooled (2007 to 2010) data from the three far-field (FF) reference areas. The normal range was calculated separately for the ice-cover and open-water periods.

Other notable observations include the following:

- Total barium concentrations increased in the NF area between 2002 and 2007, and have been decreasing at all stations since 2007. This decrease reflects a decreasing barium loading from the Diavik Mine effluent since 2007. The distribution of barium at AEMP exposure areas indicated that effluent was mixing within the NF area and along each of the MF transects.
- Total uranium concentrations peaked in 2002 in most areas and since then have declined. By 2007, uranium concentrations generally stabilized, and concentrations have remained within the normal range in the NF and MF areas since that time.
- Total arsenic concentrations increased between 1996 and 2010 in the NF area. In 2011 and 2012, an increasing trend was apparent in other exposure areas reflecting the higher arsenic loadings from the Diavik Mine effluent.
- No visual temporal trends were noted for total aluminum or total manganese through to 2012. Total manganese concentrations were generally within the normal range, while total aluminum concentrations were often above the normal range.
- Before 2011, no trends in total iron were detected. From the 2011 and 2012 AEMP data, a possible increasing trend in the NF area and along MF transects during open-water period has been suggested. However, data were highly variable in the open-water period and no trend was noted in the ice-cover period, making the presence of a trend uncertain. Generally, total iron concentrations have been below the normal range.
- Ammonia concentrations were variable and did not have any visually apparent trends. This assessment included an alternative dataset from the University of Alberta (DDMI 2013) as the 2011 and 2012 AEMP data (analyzed at a different laboratory) were potentially contaminated.

Three additional parameters (i.e., fluoride, TOC, and total zinc) were determined to be SOIs for the first time in 2011, but trend assessments have not yet been completed for these SOIs. These SOIs were added because their concentrations were elevated in the NF area compared to reference areas on at least one sample period. Total zinc has an AEMP benchmark for aquatic life of 30 µg/L; all results from 2011 and 2012 at the mixing zone boundary and at AEMP exposure stations were below this benchmark value. No AEMP benchmarks have yet been established for fluoride or TOC.

A3.2.3 Current Conditions

Water quality in the far-field reference areas are considered representative of current conditions in this lake. Based on the 2010 to 2012 Diavik AEMP monitoring in the reference and far-field areas (Table A3.2-2, MF2; Table A3.2-3, FF2; Table A3.2-4, FF1; and Table A3.2-5, FFA), water quality in Lac de Gras is characterized as follows:

- low in alkalinity (i.e., sensitive to acid inputs as per the lake acid sensitivity scale of Saffran and Trew [1996]);
- low in hardness (i.e., very soft water as per the scale of water hardness in McNeely et al. [1979]);

- slightly acidic (pH was within the CWQG range in open-water and under-ice samples with median pH ranging from 6.6 to 6.9; two samples were below pH 6.5 at stations MF2-2 and MF2-4 during open water, and one sample each at station MF2-3 and station FFA-4 under ice);
- low in nutrients (nitrogen and phosphorus), with TP concentrations being within the range for oligotrophic lakes (as per the CCME [2004] trophic status classification); and,
- low in metals, which were either not detected or below the CWQG, although occasionally the detection limits for cadmium and mercury were higher than the CWQG.

Table A3.2-2 Lac de Gras Water Quality – Station MF2, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	78	5.0	3.8 to 7.3	24	<5.0	3.9 to 7.1
Conductance	µS/cm	-	-	-	-	-	78	26	21 to 29	24	26	22 to 48
Hardness	mg/L	-	-	-	-	-	78	7.1	6.2 to 8.3	24	8.2	7.1 to 13
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	78	6.9	6.7 to 7.1	24	6.8	**6.5**[(C,D)] to 7
Total dissolved solids (TDS)	mg/L	-	-	500	-	-	78	16	8.0 to 28	24	22	<5.0 to 46
TDS (calculated)	mg/L	-	-	-	-	-	36	9.5	8.0 to 14	12	10	9.0 to 18
Total suspended solids	mg/L	-	-	-	-	-	42	<3.0	<1.0 to 8.1	12	<3.0	<3.0 to 3.0
Turbidity	NTU	-	-	-	-	-	42	0.23	0.16 to 0.45	12	0.16	0.12 to 0.2
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	78	6.1	4.6 to 8.9	24	5.9	4.7 to 8.6
Calcium	mg/L	-	-	-	-	-	78	1.4	1.2 to 1.6	24	1.6	1.4 to 2.8
Chloride	mg/L	640	120	250	-	64.5	78	2.1	1.5 to 2.8	24	2.3	1.7 to 5.7
Fluoride	mg/L	-	0.12	1.5	-	-	78	0.03	0.02 to <0.05	24	0.03	0.02 to <0.05
Magnesium	mg/L	-	-	-	-	-	78	0.89	0.8 to 1.0	24	1.0	0.88 to 1.5
Potassium	mg/L	-	-	-	112	41	78	0.76	0.51 to 0.97	24	0.83	0.68 to 1.3
Sodium	mg/L	-	-	200	-	-	78	1.4	1.2 to 1.8	24	1.5	1.3 to 3.3
Sulphate	mg/L	-	-	500	250	23	78	2.7	1.8 to 3.5	24	2.9	1.9 to 3.8
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	63	2.7	2.2 to 4.2	24	2.5	1.8 to 3.1
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	78	0.2	<0.02 to 1.11	24	0.2	<0.02 to 0.6
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	78	0.017	<0.005 to 0.099	24	0.019	0.006 to 0.054
Nitrate	mg-N/L	124	2.9	10	-	0.57	78	<0.02	<0.002 to 0.28	24	0.047	<0.02 to 0.13
Nitrite	mg-N/L	-	0.06	1.0	-	-	78	<0.002	<0.002 to <0.005	24	<0.0035	<0.002 to 0.008
Total phosphorus	mg-P/L	-	-	-	-	-	78	0.0037	<0.001 to 0.009	24	<0.005	<0.001 to 0.012
Total dissolved phosphorus	mg-P/L	-	-	-	-	-	78	<0.002	<0.001 to <0.005	24	0.0027	<0.001 to <0.005
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	78	<0.001	<0.001 to <0.005	24	0.0012	<0.001 to <0.005
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	78	5.9	3.8 to 68	24	5.3	2.6 to 20
Antimony	µg/L	-	-	6.0	-	-	78	0.02	<0.02 to <0.1	24	<0.03	<0.02 to 0.04
Arsenic	µg/L	-	5.0	10	-	-	78	0.24	0.17 to 0.5	24	0.23	0.19 to 0.32
Barium	µg/L	-	-	1,000	-	-	78	2.9	2.4 to 3.4	24	3.1	2.7 to 5.6
Beryllium	µg/L	-	-	-	-	-	78	<0.01	<0.01 to <0.2	24	<0.11	<0.01 to <0.2
Bismuth	µg/L	-	-	-	-	-	42	<0.005	<0.005 to <0.03	12	<0.005	<0.005
Boron	µg/L	29,000	1,500	5,000	-	-	78	<5.0	1.7 to <300	24	2.8	1.5 to <50
Cadmium	µg/L	0.12 to 0.26	0.04	5.0	-	-	78	0.008	<0.005 to **<0.05**[(DL>C)]	24	0.013	<0.005 to **<0.05**[(DL>C)]
Chromium	µg/L	-	1.0	50	-	-	78	<0.1	<0.05 to <0.5	24	0.094	<0.06 to <0.1
Cobalt	µg/L	-	-	-	-	-	78	0.018	0.009 to 0.11	24	0.017	0.009 to <0.1

Table A3.2-2 Lac de Gras Water Quality – Station MF2, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (Continued)												
Copper	µg/L	-	2.0	1,000	-	-	78	<0.6	0.45 to 1.8	24	<0.6	0.49 to 1.0
Iron	µg/L	-	300	300	-	-	78	6.2	4.0 to 95	24	<5.0	1.0 to 5.0
Lead	µg/L	-	1.0	10	-	-	78	0.046	<0.005 to 0.11	24	0.024	<0.005 to <0.05
Lithium	µg/L	-	-	-	-	-	42	1.5	1.3 to <3.0	12	1.7	1.4 to 2.3
Manganese	µg/L	-	-	50	-	-	78	1.9	1.4 to 16	24	0.92	0.56 to 2.9
Mercury	µg/L	-	0.026	1.0	-	-	63	<0.02	<0.01 to **<0.05**$^{(DL>C)}$	24	<0.015	<0.01 to <0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	78	0.5	0.32 to 0.74	24	0.54	0.29 to 1.6
Nickel	µg/L	-	25	-	-	-	78	0.66	0.55 to 1.4	24	0.66	0.59 to 1.0
Selenium	µg/L	-	1.0	10	-	-	78	0.08	<0.04 to 0.4	24	<0.07	<0.04 to <0.1
Silver	µg/L	-	0.1	-	-	-	78	<0.005	<0.005 to <0.1	24	<0.053	<0.005 to <0.1
Strontium	µg/L	-	-	-	-	-	78	15	12 to 18	24	15	12 to 38
Thallium	µg/L	-	0.8	-	-	-	42	<0.002	<0.002 to 0.01	12	<0.002	<0.002 to 0.003
Tin	µg/L	-	-	-	-	-	42	<0.01	<0.01 to 0.13	12	<0.01	<0.01 to 0.02
Titanium	µg/L	-	-	-	-	-	42	<0.5	<0.5 to 3.2	12	<0.5	<0.5
Uranium	µg/L	33	15	20	-	-	78	0.076	0.061 to 0.15	24	0.1	0.067 to 0.23
Vanadium	µg/L	-	-	-	540	30	78	<0.1	<0.05 to <1.0	24	<0.13	<0.05 to <0.2
Zinc	µg/L	-	30	5,000	-	-	78	<0.8	0.2 to 5.3	24	<0.8	0.4 to 5.1

Sources: DDMI (2011, 2012, 2013).

Notes: Stations: Open and ice-covered = MF2-1, MF2-2, MF2-3, MF2-4, MF2-5.

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Samples were collected from mid-depth.

Bolded concentrations are higher than relevant water quality guidelines.

C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or dissolved oxygen (DO) concentration range.

D) = concentration higher than the relevant drinking water guideline or beyond the recommended pH or DO concentration range.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8;Water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

Table A3.2-3 Lac de Gras Water Quality – Station FF2, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	36	<5.0	3.7 to 6.4	10	<5.0	3.8 to 5.9
Conductance	µS/cm	-	-	-	-	-	36	25	21 to 28	10	24	23 to 36
Hardness	mg/L	-	-	-	-	-	36	6.9	6.3 to <10	10	7.2	6.6 to 14
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	36	6.9	6.8 to 7.2	10	6.7	6.5 to 6.8
Total dissolved solids (TDS)	mg/L	-	-	500	-	-	36	14	7.0 to 28	10	17	14 to 22
TDS (calculated)	mg/L	-	-	-	-	-	15	8.9	8.4 to 12	5	5.3	5.1 to 8.7
Total suspended solids	mg/L	-	-	-	-	-	21	<3.0	<1.0 to <3.0	5	<3.0	<3.0 to 3.0
Turbidity	NTU	-	-	-	-	-	21	0.29	0.21 to 0.45	5	0.13	0.11 to 0.15
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	36	5.9	4.5 to 7.8	10	5.8	4.6 to 7.2
Calcium	mg/L	-	-	-	-	-	36	1.3	1.2 to 1.6	10	1.4	1.3 to 3.9
Chloride	mg/L	640	120	250	-	64.5	36	1.9	1.6 to 2.6	10	1.2	<0.5 to 2.5
Fluoride	mg/L	-	0.12	1.5	-	-	36	0.03	0.02 to <0.05	10	0.03	0.02 to <0.05
Magnesium	mg/L	-	-	-	-	-	36	0.88	0.79 to 0.93	10	0.92	0.83 to 1.3
Potassium	mg/L	-	-	-	112	41	36	0.75	0.51 to 0.95	10	0.79	0.64 to 1.2
Sodium	mg/L	-	-	200	-	-	36	1.4	1.2 to 1.6	10	1.5	1.3 to 1.8
Sulphate	mg/L	-	-	500	250	23	36	2.5	1.7 to 3.1	10	1.1	0.49 to 3.4
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	30	2.9	2.4 to 5.0	10	2.3	2.2 to 3.8
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	36	0.22	0.064 to 0.55	10	0.18	<0.05 to 0.26
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	36	0.01	<0.005 to 0.042	10	0.012	0.0091 to 0.049
Nitrate	mg-N/L	124	2.9	10	-	0.57	36	0.018	<0.002 to 0.03	10	0.049	0.02 to 0.19
Nitrite	mg-N/L	-	0.06	1.0	-	-	36	<0.002	<0.002 to <0.005	10	<0.0035	<0.002 to 0.005
Total phosphorus	mg-P/L	-	-	-	-	-	36	0.0045	<0.001 to 0.01	10	0.0025	0.0018 to <0.005
Total dissolved phosphorus	mg-P/L	-	-	-	-	-	36	0.0027	<0.001 to <0.005	10	0.0013	<0.001 to <0.005
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	36	<0.001	<0.001 to <0.005	10	<0.003	<0.001 to <0.005
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	36	5.6	4.1 to 7.7	10	3.6	2.8 to 12
Antimony	µg/L	-	-	6.0	-	-	36	<0.02	<0.02 to <0.03	10	<0.025	<0.02 to <0.03
Arsenic	µg/L	-	5.0	10	-	-	36	0.24	0.19 to 0.29	10	0.23	0.21 to 0.39
Barium	µg/L	-	-	1,000	-	-	36	2.8	2.3 to 3.1	10	2.8	2.6 to 3.6
Beryllium	µg/L	-	-	-	-	-	36	<0.01	<0.01 to <0.2	10	<0.11	<0.01 to <0.2
Bismuth	µg/L	-	-	-	-	-	21	<0.005	<0.005	5	<0.005	<0.005
Boron	µg/L	29,000	1,500	5,000	-	-	36	<5.0	1.7 to <50	10	2.3	1.4 to <50
Cadmium	µg/L	0.11 to 0.28	0.04	5.0	-	-	36	<0.005	<0.005 to **<0.05**[(DL>C)]	10	0.008	<0.005 to **<0.05**[(DL>C)]
Chromium	µg/L	-	1.0	50	-	-	36	<0.1	<0.05 to 0.28	10	<0.08	<0.06 to 0.2
Cobalt	µg/L	-	-	-	-	-	36	0.018	0.012 to <0.1	10	0.016	0.006 to <0.1

Table A3.2-3 Lac de Gras Water Quality – Station FF2, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (continued)												
Copper	µg/L	-	2.0	1,000	-	-	36	<0.6	0.5 to 0.75	10	<0.6	0.57 to 0.97
Iron	µg/L	-	300	300	-	-	36	6.5	<5.0 to 24	10	<5.0	1.0 to 10
Lead	µg/L	-	1.0	10	-	-	36	0.0055	<0.005 to 0.051	10	0.19	0.007 to 0.38
Lithium	µg/L	-	-	-	-	-	21	1.4	1.2 to 1.6	5	1.4	1.4 to 2.0
Manganese	µg/L	-	-	50	-	-	36	1.9	1.5 to 4.0	10	1.0	0.82 to 1.2
Mercury	µg/L	-	0.026	1.0	-	-	31	<0.02	<0.01 to <0.02	5	<0.02	<0.02 to <0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	36	0.47	0.38 to 0.59	10	0.45	0.31 to 0.49
Nickel	µg/L	-	25	-	-	-	36	0.6	0.52 to 0.77	10	0.67	0.59 to 0.82
Selenium	µg/L	-	1.0	10	-	-	36	<0.04	<0.04 to <0.1	10	<0.07	<0.04 to <0.1
Silver	µg/L	-	0.1	-	-	-	36	<0.005	<0.005 to <0.1	10	<0.053	<0.005 to <0.1
Strontium	µg/L	-	-	-	-	-	36	15	14 to 16	10	13	12 to 18
Thallium	µg/L	-	0.8	-	-	-	21	<0.002	<0.002	5	<0.002	<0.002 to 0.002
Tin	µg/L	-	-	-	-	-	21	<0.01	<0.01 to 0.18	5	0.01	<0.01 to 0.08
Titanium	µg/L	-	-	-	-	-	21	<0.5	<0.5 to <0.5	5	<0.5	<0.5 to 1.4
Uranium	µg/L	33	15	20	-	-	36	0.069	0.058 to 0.096	10	0.088	0.052 to 0.12
Vanadium	µg/L	-	-	-	540	30	36	<0.1	<0.05 to <0.2	10	<0.13	<0.05 to <0.2
Zinc	µg/L	-	30	5,000	-	-	36	<0.8	0.2 to 4.4	10	1.3	0.86 to 4.1

Source: DDMI (2011, 2012, 2013).

Notes: Stations: Open and ice-covered = FF2-1, FF2-2, FF2-3, FF2-4, FF2-5

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Bolded concentrations are higher than relevant water quality guidelines.

Samples were collected from mid-depth.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8; water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

Table A3.2-4 Lac de Gras Water Quality – Station FF1, 2010 to 2011

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	30	4.8	2.7 to 5.1	10	4.3	3.3 to <5.0
Conductance	µS/cm	-	-	-	-	-	30	17	16 to 20	10	19	18 to 23
Hardness	mg/L	-	-	-	-	-	30	5.6	5.2 to 6.0	10	6.3	5.5 to 7.5
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	30	6.9	6.6 to 7	10	6.6	**6.5**[C, D] to 6.7
Total dissolved solids (TDS)	mg/L	-	-	500	-	-	30	12	8.0 to 21	10	15	10 to 18
TDS (calculated)	mg/L	-	-	-	-	-	15	5.4	4.7 to 8.5	5	3.2	2.9 to 4.9
Total suspended solids	mg/L	-	-	-	-	-	15	<3.0	<3.0	5	<3.0	<3.0
Turbidity	NTU	-	-	-	-	-	15	0.21	<0.1 to 0.26	5	0.14	0.1 to 0.14
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	30	5.1	3.3 to 6.2	10	5.1	4.0 to 5.7
Calcium	mg/L	-	-	-	-	-	30	1.0	0.96 to 1.1	10	1.2	1.0 to 1.4
Chloride	mg/L	640	120	250	-	64.5	30	0.89	0.5 to 17	10	0.7	<0.5 to 1.1
Fluoride	mg/L	-	0.12	1.5	-	-	30	0.04	0.01 to <0.05	10	0.03	0.02 to <0.05
Magnesium	mg/L	-	-	-	-	-	30	0.72	0.66 to 0.81	10	0.79	0.71 to 0.98
Potassium	mg/L	-	-	-	112	41	30	0.58	0.37 to 0.73	10	0.63	0.56 to 0.98
Sodium	mg/L	-	-	200	-	-	30	0.89	0.71 to <1.0	10	0.97	0.78 to 1.0
Sulphate	mg/L	-	-	500	250	23	30	2.2	1.2 to 2.9	10	0.87	0.55 to 2.5
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	30	2.6	1.3 to 3.6	10	2.2	1.7 to 2.5
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	30	0.16	0.09 to 0.80	10	0.23	<0.05 to 0.39
Total ammonia	mg-N/L	-	18 – 25[a]	-	-	-	30	<0.005	<0.005 to 0.088	10	0.019	0.015 to 0.023
Nitrate	mg-N/L	124	2.9	10	-	0.57	30	<0.013	<0.006 to 0.02	10	0.0068	<0.006 to <0.02
Nitrite	mg-N/L	-	0.06	1.0	-	-	30	<0.0035	<0.002 to <0.005	10	<0.0035	<0.002 to <0.005
Total phosphorus	mg-P/L	-	-	-	-	-	30	0.0049	<0.001 to <0.005	10	0.0022	0.0019 to <0.005
Total dissolved phosphorus	mg-P/L	-	-	-	-	-	30	0.0031	<0.001 to <0.005	10	0.0015	<0.001 to <0.005
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	30	<0.003	<0.001 to <0.005	10	<0.003	<0.001 to <0.005
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	30	5.6	4.3 to 9.2	10	3.3	2.6 to 4.3
Antimony	µg/L	-	-	6.0	-	-	30	<0.03	<0.02 to <0.1	10	<0.025	<0.02 to <0.03
Arsenic	µg/L	-	5.0	10	-	-	30	0.17	0.13 to 0.7	10	0.18	0.17 to 0.2
Barium	µg/L	-	-	1,000	-	-	30	1.7	1.6 to 1.9	10	2.0	1.7 to 2.3
Beryllium	µg/L	-	-	-	-	-	30	<0.13	<0.01 to <0.2	10	<0.11	<0.01 to <0.2
Bismuth	µg/L	-	-	-	-	-	15	<0.005	<0.005 to <0.03	5	<0.005	<0.005 to <0.005
Boron	µg/L	29,000	1,500	5,000	-	-	30	3.4	1.4 to <300	10	2.1	1.3 to <50
Cadmium	µg/L	0.11 to 0.15	0.04	5.0	-	-	30	<0.04	<0.005 to **<0.05**[DL>C]	10	<0.028	<0.005 to **<0.05**[DL>C]
Chromium	µg/L	-	1.0	50	-	-	30	<0.08	<0.06 to <0.5	10	<0.08	<0.06 to <0.1
Cobalt	µg/L	-	-	-	-	-	30	0.056	0.01 to <0.1	10	0.013	0.007 to <0.1

Table A3.2-4 Lac de Gras Water Quality – Station FF1, 2010 to 2011

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (Continued)												
Copper	µg/L	-	2.0	1,000	-	-	30	<0.6	0.48 to 0.8	10	<0.6	0.55 to 0.69
Iron	µg/L	-	300	300	-	-	30	5.0	<5.0 to 8.0	10	4.0	1.0 to 8.5
Lead	µg/L	-	1.0	10	-	-	30	0.03	<0.005 to <0.05	10	0.025	<0.005 to 0.39
Lithium	µg/L	-	-	-	-	-	15	1.2	1.2 to <3.0	5	1.5	1.2 to 2.2
Manganese	µg/L	-	-	50	-	-	30	1.6	1.4 to 2.4	10	1.7	0.79 to 2.9
Mercury	µg/L	-	0.026	1.0	-	-	25	<0.02	<0.01 to **<0.05**$^{(DL>C)}$	5	<0.02	<0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	30	0.11	0.067 to <0.3	10	0.08	0.06 to 0.1
Nickel	µg/L	-	25	-	-	-	30	0.77	0.62 to 0.9	10	0.88	0.79 to 0.96
Selenium	µg/L	-	1.0	10	-	-	30	<0.1	<0.04 to 0.3	10	<0.07	<0.04 to <0.1
Silver	µg/L	-	0.1	-	-	-	30	<0.065	<0.005 to <0.1	10	0.008	<0.005 to <0.1
Strontium	µg/L	-	-	-	-	-	30	8.4	7.9 to 9.3	10	8.4	7.8 to 10
Thallium	µg/L	-	0.8	-	-	-	15	<0.002	<0.002 to <0.01	5	<0.002	<0.002 to <0.002
Tin	µg/L	-	-	-	-	-	15	<0.01	<0.01 to 0.05	5	<0.01	<0.01 to 0.05
Titanium	µg/L	-	-	-	-	-	15	<0.5	<0.5 to <3.0	5	<0.5	<0.5
Uranium	µg/L	33	15	20	-	-	30	0.034	0.01 to <0.05	10	0.034	0.026 to <0.05
Vanadium	µg/L	-	-	-	540	30	30	<0.13	<0.05 to <1.0	10	<0.13	<0.05 to <0.2
Zinc	µg/L	-	30	5,000	-	-	30	<0.8	0.3 to 1.2	10	1.1	0.6 to 1.6

Source: DDMI (2011, 2012, 2013).

Notes: Stations: Open and ice-covered = FF1-1, FF1-2, FF1-3, FF1-4, FF1-5.

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Samples were collected from mid-depth.

Bolded concentrations are higher than relevant water quality guidelines.

C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or DO concentration range.

D) = concentration higher than the relevant drinking water guideline or beyond the recommended pH or DO concentration range.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8; Water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

Table A3.2-5 Lac de Gras Water Quality – Station FFA, 2010 to 2011

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	30	4.3	3.2 to <5.0	5	3.7	3.4 to 4.5
Conductance	µS/cm	-	-	-	-	-	30	18	15 to 20	10	19	17 to 22
Hardness	mg/L	-	-	-	-	-	30	5.5	4.7 to <10	10	6.4	5.9 to 7.1
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	30	6.8	6.7 to 7	10	6.7	**6.5**[(C, D)] to 7
Total dissolved solids (TDS)	mg/L	-	-	500	-	-	30	13	<5.0 to 30	10	12	9.0 to 21
TDS (calculated)	mg/L	-	-	-	-	-	15	5.5	5.2 to 5.9	5	6.2	6.1 to 6.5
Total suspended solids	mg/L	-	-	-	-	-	15	<3.0	<3.0 to 3.0	5	<3.0	<3.0
Turbidity	NTU	-	-	-	-	-	15	0.16	0.12 to 0.28	5	0.17	<0.1 to 0.19
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	30	<5.0	3.9 to 5.9	10	<5.0	4.2 to 5.5
Calcium	mg/L	-	-	-	-	-	30	1.1	0.89 to 1.1	10	1.2	1.1 to 1.3
Chloride	mg/L	640	120	250	-	64.5	30	1.0	0.81 to 1.7	10	0.93	0.8 to 1.2
Fluoride	mg/L	-	0.12	1.5	-	-	30	0.03	0.01 to <0.05	10	0.03	0.02 to <0.05
Magnesium	mg/L	-	-	-	-	-	30	0.71	0.61 to 0.76	10	0.8	0.75 to 0.92
Potassium	mg/L	-	-	-	112	41	30	0.59	0.35 to 0.7	10	0.64	0.61 to 0.75
Sodium	mg/L	-	-	200	-	-	30	0.82	0.76 to <1.0	10	0.95	0.8 to <1.0
Sulphate	mg/L	-	-	500	250	23	30	2.5	1.4 to 3.2	10	2.6	2.3 to 2.8
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	30	2.6	1.5 to 3.0	10	2.5	<0.5 to 2.7
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	30	0.19	<0.05 to 0.431	10	0.19	0.13 to 0.26
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	30	0.0085	<0.005 to 0.042	10	0.024	0.015 to 0.046
Nitrate	mg-N/L	124	2.9	10	-	0.57	30	<0.013	<0.006 to <0.02	10	<0.013	<0.006 to <0.02
Nitrite	mg-N/L	-	0.06	1.0	-	-	30	<0.0035	<0.002 to <0.005	10	<0.0035	<0.002 to <0.005
Total phosphorus	mg-P/L	-	-	-	-	-	30	0.0049	<0.001 to <0.005	10	0.0033	0.002 to <0.005
Total dissolved phosphorus	mg-P/L	-	-	-	-	-	30	0.0022	<0.001 to 0.006	10	0.0021	0.001 to <0.005
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	30	<0.003	<0.001 to <0.005	10	<0.003	<0.001 to <0.005
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	30	5.0	3.2 to 7.2	10	3.7	3.0 to 4.6
Antimony	µg/L	-	-	6.0	-	-	30	<0.025	<0.02 to <0.03	10	<0.025	<0.02 to 0.43
Arsenic	µg/L	-	5.0	10	-	-	30	0.18	0.15 to 0.23	10	0.16	0.081 to 0.19
Barium	µg/L	-	-	1,000	-	-	30	1.8	1.7 to 2.8	10	2.0	1.8 to 2.3
Beryllium	µg/L	-	-	-	-	-	30	<0.11	<0.01 to <0.2	10	<0.11	<0.01 to <0.2
Bismuth	µg/L	-	-	-	-	-	17	<0.005	<0.005 to <0.2	5	<0.005	<0.005
Boron	µg/L	29,000	1,500	5,000	-	-	30	5.5	1.4 to <50	10	2.0	1.1 to <50
Cadmium	µg/L	0.11 to 0.14	0.04	5.0	-	-	30	0.006	<0.005 to **<0.05**[(DL>C)]	10	<0.028	<0.005 to **<0.05**[(DL>C)]
Chromium	µg/L	-	1.0	50	-	-	30	<0.1	<0.06 to 0.21	10	0.074	<0.06 to <0.1
Cobalt	µg/L	-	-	-	-	-	30	0.028	0.019 to <0.1	10	0.02	0.006 to 0.19

Table A3.2-5 Lac de Gras Water Quality – Station FFA, 2010 to 2011

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (Continued)												
Copper	µg/L	-	2.0	1,000	-	-	30	<0.6	0.48 to 1.0	10	0.61	0.53 to 0.67
Iron	µg/L	-	300	300	-	-	30	5.8	4.0 to 9.5	10	3.0	1.0 to 9.1
Lead	µg/L	-	1.0	10	-	-	30	0.01	<0.005 to 0.056	10	0.028	<0.005 to 0.074
Lithium	µg/L	-	-	-	-	-	15	1.2	1.0 to 1.2	5	1.2	1.2 to 1.4
Manganese	µg/L	-	-	50	-	-	30	2.5	1.8 to 4.2	10	1.2	0.62 to 1.6
Mercury	µg/L	-	0.026	1.0	-	-	25	<0.02	<0.01 to 0.02	10	<0.015	<0.01 to <0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	30	0.12	0.073 to 0.73	10	0.13	0.08 to 0.15
Nickel	µg/L	-	25	-	-	-	30	0.94	0.79 to 1.3	10	1.0	0.92 to 1.7
Selenium	µg/L	-	1.0	10	-	-	30	<0.07	<0.04 to <0.1	10	<0.07	<0.04 to 0.1
Silver	µg/L	-	0.1	-	-	-	30	<0.053	<0.005 to <0.1	10	<0.053	<0.005 to <0.1
Strontium	µg/L	-	-	-	-	-	30	8.7	7.9 to 9.8	10	8.3	7.7 to 10
Thallium	µg/L	-	0.8	-	-	-	17	<0.002	<0.002 to <0.1	5	<0.002	<0.002
Tin	µg/L	-	-	-	-	-	17	<0.01	<0.01 to <0.4	5	<0.01	<0.01 to 0.01
Titanium	µg/L	-	-	-	-	-	17	<0.5	<0.5 to <5.0	5	<0.5	<0.5
Uranium	µg/L	33	15	20	-	-	30	0.03	0.02 to <0.05	10	0.031	0.023 to 0.05
Vanadium	µg/L	-	-	-	540	30	30	<0.13	<0.05 to <0.2	10	<0.13	<0.05 to <0.2
Zinc	µg/L	-	30	5,000	-	-	30	<0.8	0.3 to 3.3	10	1.3	0.5 to 2.3

Source: DDMI (2011, 2012, 2013).

Notes: Stations: Open and ice-covered = FFA-1, FFA-2, FFA-3, FFA-4, FFA-5.

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Bolded concentrations are higher than relevant water quality guidelines.

Samples were collected from mid-depth.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8; water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

A3.3 Regional Water Quality

A3.3.1 Ursula Lake

Ursula Lake was sampled in 2006 as a reference lake during the Jay Pipe 2006 baseline study (Rescan 2007). Based on the data collected during that study (Table A3.3-1), the water quality in this lake is characterized as follows:

- Low in alkalinity (i.e., sensitive to acid inputs as per the lake acid sensitivity scale of Saffran and Trew [1996]).
- Low in hardness (i.e., very soft water as per the scale of water hardness in McNeely et al. [1979]).
- Slightly acidic (pH was generally within the CWQG range in open-water with median pH of 6.6, while the under ice were below the range with median pH of 6.4).
- Low in nutrients (nitrogen and phosphorus), with TP concentrations being within the range for oligotrophic lakes (as per CCME [2004] trophic status classification).
- Low in metals, which were generally either not detected or below the CWQG; cadmium was non-detectable in all samples except one, but the detection limits for cadmium were higher than the CWQG. The median lead concentration was above the CWQG in the open-water season.

A3.3.2 Nanuq Lake

Nanuq Lake has been sampled as a reference lake for the Ekati Mine AEMP since 1997. The median and range of water quality data as reported in Rescan (2011, 2012) and ERM Rescan (2013) are summarized in Table A3.3-2. Based on the 2010 to 2012 data, the lake water quality is characterized as follows:

- low in alkalinity (i.e., sensitive to acid inputs as per the lake acid sensitivity scale of Saffran and Trew [1996]);
- low in hardness (i.e., very soft water as per the scale of water hardness in McNeely et al. [1979]);
- slightly acidic (pH was generally within the CWQG range in open-water with median pH of 6.7, while the under ice were below the range with median pH of 6.3);
- low in nutrients (nitrogen and phosphorus), with TP concentrations being within the range for oligotrophic lakes (as per the CCME [2004] trophic status classification); and,
- low in metals, which were generally either not detected or below the CWQG; maximum aluminum concentration was above the pH-dependent CWQG in the ice-covered season.

Table A3.3-1 Ursula Lake Water Quality, 2006

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	21	2.5	<2.0 to 3.9	7	3.2	2.6 to 4.7
Conductance	µS/cm	-	-	-	-	-	21	8.1	7.3 to 8.8	7	12	11 to 15
Hardness	mg/L	-	-	-	-	-	21	2.8	2.7 to 3.0	7	3.8	3.6 to 4.5
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	21	6.6	**6.5**[(C, D)] to 6.8	7	**6.4**[(C, D)]	**6.2**[(C, D)] to **6.4**[(C, D)]
TDS (calculated)	mg/L	-	-	-	-	-	21	4.2	2.8 to 5.0	7	5.6	5.1 to 6.6
Total suspended solids	mg/L	-	-	-	-	-	21	<3.0	<3.0	7	<3.0	<3.0
Turbidity	NTU	-	-	-	-	-	21	0.57	0.31 to 1.5	7	0.13	0.12 to 0.14
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	21	2.5	<2.0 to 3.9	7	<2.0	<2.0
Calcium	mg/L	-	-	-	-	-	21	0.53	0.49 to 0.56	7	0.71	0.64 to 0.87
Chloride	mg/L	640	120	250	-	64.5	21	<0.5	<0.5	7	<0.5	<0.5
Fluoride	mg/L	-	0.12	1.5	-	-	21	<0.02	<0.02	7	<0.02	<0.02
Magnesium	mg/L	-	-	-	-	-	21	0.37	0.33 to 0.39	7	0.5	0.48 to 0.58
Potassium	mg/L	-	-	-	112	41	21	0.32	0.3 to 0.35	7	0.41	0.36 to 0.49
Sodium	mg/L	-	-	200	-	-	21	0.37	0.35 to 0.39	7	0.48	0.42 to 0.55
Sulphate	mg/L	-	-	500	250	23	21	1.1	1.1 to 1.2	7	1.5	1.3 to 1.8
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	21	3.0	2.0 to 3.9	7	2.0	1.6 to 2.1
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	21	0.13	0.091 to 0.16	7	0.09	0.08 to 0.11
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	21	<0.005	<0.005 to 0.0087	7	0.015	0.012 to 0.017
Nitrate	mg-N/L	124	2.9	10	-	0.57	21	<0.005	<0.005 to <0.005	7	<0.005	<0.005 to 0.043
Nitrite	mg-N/L	-	0.06	1.0	-	-	21	<0.001	<0.001	7	<0.001	<0.001 to 0.001
Total phosphorus	mg-P/L	-	-	-	-	-	21	0.0038	0.003 to 0.01	7	0.0027	0.0025 to 0.0028
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	21	<0.001	<0.001	7	<0.001	<0.001 to 0.002
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	21	7.3	5.1 to 11	7	3.0	2.6 to 3.1
Antimony	µg/L	-	-	6.0	-	-	21	<0.1	<0.1	7	<0.1	<0.1
Arsenic	µg/L	-	5.0	10	-	-	21	0.11	0.092 to 0.13	7	0.12	0.1 to 0.14
Barium	µg/L	-	-	1,000	-	-	21	1.7	1.5 to 2.1	7	2.1	1.8 to 3.6
Beryllium	µg/L	-	-	-	-	-	21	<0.2	<0.2	7	<0.2	<0.2
Boron	µg/L	29,000	1,500	5,000	-	-	21	<1.0	<1.0 to 1.0	7	1.1	<1.0 to 1.2
Cadmium	µg/L	0.11	0.04	5.0	-	-	21	**<0.05**[(DL>C)]	**<0.05**[(DL>C)]	7	**<0.05**[(DL>C)]	**<0.05**[(DL>C)] to **0.067**[(C)]
Chromium	µg/L	-	1.0	50	-	-	21	<0.1	<0.1 to 0.28	7	<0.1	<0.1
Cobalt	µg/L	-	-	-	-	-	21	<0.1	<0.1	7	<0.1	<0.1 to 0.19
Copper	µg/L	-	2.0	1,000	-	-	21	<0.5	<0.5	7	<0.5	<0.5
Iron	µg/L	-	300	300	-	-	21	21	<10 to 32	7	<10	<10
Lead	µg/L	-	1.0	10	-	-	21	**1.9**[(C)]	0.093 to **33**[(C, D)]	7	<0.05	<0.05
Manganese	µg/L	-	-	50	-	-	21	2.7	2.2 to 4.0	7	0.61	0.47 to 2.3

Table A3.3-1 Ursula Lake Water Quality, 2006

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals (continued)												
Mercury	µg/L	-	0.026	1.0	-	-	21	<0.02	<0.02	7	<0.02	<0.02
Molybdenum	µg/L	-	73	-	223,000	19,000	21	<0.05	<0.05	7	<0.05	<0.05
Nickel	µg/L	-	25	-	-	-	21	0.29	0.19 to 0.52	7	0.29	0.23 to 0.49
Selenium	µg/L	-	1.0	10	-	-	21	<0.1	<0.1	7	<0.1	<0.1
Silver	µg/L	-	0.1	-	-	-	21	<0.1	<0.1	7	<0.1	<0.1
Strontium	µg/L	-	-	-	-	-	21	3.8	3.6 to 4.1	7	5.0	4.4 to 6.1
Uranium	µg/L	33	15	20	-	-	21	0.012	<0.01 to 0.014	7	0.01	<0.01 to 0.012
Vanadium	µg/L	-	-	-	540	30	21	<0.05	<0.05 to 0.083	7	<0.05	<0.05 to <0.05
Zinc	µg/L	-	30	5,000	-	-	21	<1.0	<1.0 to 2.0	7	1.4	<1.0 to 2.6

Source: Rescan (2007).

Notes: Stations: Open and ice-covered = UL1, UL2, UL3.

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Samples were collected from mid-depth.

Bolded concentrations are higher than relevant water quality guidelines.

C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or dissolved oxygen (DO) concentration range.

D) = concentration higher than the relevant drinking water guideline or beyond the recommended pH or DO concentration range.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8; water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

Table A3.3-2 Nanuq Lake Water Quality, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Conventional Parameters												
Alkalinity, total (as $CaCO_3$)	mg/L	-	-	-	-	-	18	3.2	2.6 to 4.0	12	3.7	3.1 to 4.2
Conductance	µS/cm	-	-	-	-	-	18	10	10 to 12	12	13	12 to 14
Hardness	mg/L	-	-	-	-	-	18	3.5	3.4 to 3.7	12	4.1	3.9 to 4.6
pH	-	-	6.5 - 9.0	6.5 - 8.5	-	-	18	6.7	**6.4**[(C,D)] to 6.8	12	**6.3**[(C, D)]	**6.2**[(C,D)] to 6.7
Total dissolved solids	mg/L	-	-	500	-	-	18	7.8	6.8 to 8.8	12	7.8	5.6 to 9.3
Total suspended solids	mg/L	-	-	-	-	-	18	<3.0	<3.0 to <3.0	12	<3.0	<3.0
Turbidity	NTU	-	-	-	-	-	18	0.37	0.27 to 0.76	12	0.24	0.15 to 0.46
Major Ions												
Bicarbonate	mg/L	-	-	-	-	-	18	3.2	2.6 to 4.0	12	3.7	3.1 to 4.2
Calcium	mg/L	-	-	-	-	-	18	0.69	0.65 to 0.73	12	0.8	0.74 to 0.87
Chloride	mg/L	640	120	250	-	64.5	18	<0.5	<0.5	12	<0.5	<0.5
Magnesium	mg/L	-	-	-	-	-	18	0.44	0.43 to 0.46	12	0.53	0.49 to 0.58
Potassium	mg/L	-	-	-	112	41	18	0.38	0.36 to 0.39	12	0.4	0.39 to 0.42
Sodium	mg/L	-	-	200	-	-	18	0.47	0.45 to 0.49	12	0.51	0.49 to 0.53
Sulphate	mg/L	-	-	500	250	23	18	1.6	1.4 to 1.7	12	1.4	1.2 to 1.8
Nutrients and Biological Indicators												
Total organic carbon	mg/L	-	-	-	-	-	18	2.3	1.9 to 3.1	12	1.8	1.1 to 2.2
Total Kjeldahl nitrogen	mg-N/L	-	-	-	-	-	18	0.1	<0.05 to 0.15	12	0.11	<0.05 to 0.32
Total ammonia	mg-N/L	-	18 – 25[(a)]	-	-	-	18	<0.005	<0.005 to 0.009	12	0.013	0.0065 to 0.023
Nitrate	mg-N/L	124	2.9	10	-	0.57	18	<0.005	<0.005 to 0.012	12	0.044	0.022 to 0.098
Nitrite	mg-N/L	-	0.06	1.0	-	-	18	<0.001	<0.001 to 0.0052	12	<0.001	<0.001
Total phosphorus	mg-P/L	-	-	-	-	-	18	0.0025	<0.002 to 0.0057	12	0.0024	<0.002 to 0.0037
Dissolved orthophosphate	mg-P/L	-	-	-	-	-	18	<0.001	<0.001	12	<0.001	<0.001
Total Metals												
Aluminum	µg/L	-	5 or 100	100	-	-	18	7.3	4.9 to 24	12	4.6	3.6 to **6.3**[(C)]
Antimony	µg/L	-	-	6.0	-	-	18	<0.1	<0.1	12	<0.1	<0.1
Arsenic	µg/L	-	5.0	10	-	-	18	0.11	0.094 to 0.12	12	0.1	0.099 to 0.12
Barium	µg/L	-	-	1,000	-	-	18	1.6	1.5 to 2.2	12	2.0	1.7 to 2.5
Beryllium	µg/L	-	-	-	-	-	18	<0.01	<0.01 to <0.2	12	<0.01	<0.01 to <0.2
Boron	µg/L	29,000	1,500	5,000	-	-	18	<5.0	3.7 to 5.6	12	<5.0	1.5 to <5.0
Cadmium	µg/L	0.11	0.04	5.0	-	-	18	<0.01	<0.01	12	<0.01	<0.01
Chromium	µg/L	-	1.0	50	-	-	18	<0.1	<0.1 to 0.24	12	<0.1	<0.1 to <0.2
Cobalt	µg/L	-	-	-	-	-	18	<0.1	<0.1	12	<0.1	<0.1 to 0.11
Copper	µg/L	-	2.0	1,000	-	-	18	0.46	0.36 to 0.88	12	0.43	0.13 to 0.6
Iron	µg/L	-	300	300	-	-	18	<10	<10 to 13	12	10	<10 to 25
Lead	µg/L	-	1.0	10	-	-	18	0.018	<0.01 to 0.45	12	<0.01	<0.01 to <0.05
Manganese	µg/L	-	-	50	-	-	18	1.7	1.4 to 2.8	12	6.4	1.0 to 43
Mercury	µg/L	-	0.026	1.0	-	-	18	<0.02	<0.02	12	<0.02	<0.02

Table A3.3-2 Nanuq Lake Water Quality, 2010 to 2012

Parameter	Unit	Guidelines			Objectives		Open Water			Under Ice		
		Aquatic Life										
		Acute (CCME)	Chronic (CCME)	Drinking Water	Short-Term SSWQO	Long-Term SSWQO	Count	Median	Range	Count	Median	Range
Total Metals												
Molybdenum	µg/L	-	73	-	223,000	19,000	18	<0.05	<0.05	12	<0.05	<0.05
Nickel	µg/L	-	25	-	-	-	18	0.22	0.18 to 0.52	12	0.25	0.19 to 0.47
Selenium	µg/L	-	1.0	10	-	-	18	<0.04	<0.04 to <0.1	12	<0.04	<0.04 to <0.2
Silver	µg/L	-	0.1	-	-	-	18	<0.01	<0.01 to <0.1	12	<0.01	<0.01 to <0.1
Strontium	µg/L	-	-	-	-	-	18	4.7	4.5 to 5.0	12	5.6	5.2 to 6.4
Uranium	µg/L	33	15	20	-	-	18	0.016	0.015 to 0.019	12	0.016	0.013 to 0.018
Vanadium	µg/L	-	-	-	540	30	18	<0.05	<0.05 to 0.062	12	<0.05	<0.05
Zinc	µg/L	-	30	5,000	-	-	18	<1.0	<1.0 to 2.0	12	<1.0	<1.0 to 1.7

Source: Rescan (2011, 2012) ERM Rescan (2013).

Notes: Station: Open and ice-covered = Nanuq.

Guideline exceedances by median concentrations are based on guidelines calculated using median values of hardness, pH, and temperature.

Water quality data and guidelines shown in this table were rounded to reflect laboratory or field instrument precision *after* comparisons to guidelines. Therefore, values slightly above guidelines may be displayed as being equal to the guidelines and identified as exceedances. Measured concentrations equal to the guideline values were not identified as exceedances.

Samples were collected from mid-depth.

Bolded concentrations are higher than relevant water quality guidelines.

C) = concentration higher than the relevant chronic aquatic life guideline or beyond the recommended pH or dissolved oxygen (DO) concentration range.

D) = concentration higher than the relevant drinking water guideline or beyond the recommended pH or DO concentration range.

DL>C) = analytical detection limit was higher than the relevant chronic aquatic life guideline.

a) Ammonia guideline calculation based on pH = 6.8; water temperature = 6°C (Open Water) and 2°C (Under Ice).

CCME = Canadian Council of Ministers of the Environment; SSWQO = site-specific water quality objectives; $CaCO_3$ = calcium carbonate; mg/L = milligrams per litre; µS/cm = microSiemens per centimetre; TDS = total dissolved solids; < = less than; NTU = nephelometric turbidity units; mg-N/L = milligrams per litre as nitrogen; mg-P/L = milligrams per litre as phosphorus; µg/L = micrograms per litre; - = no guideline or data.

A3.4 Water Quality Summary

Lac du Sauvage has water quality typical of northern lakes within the Canadian Shield; that is dilute water (i.e., low TDS concentrations), circumneutral (i.e., slightly acidic to slightly basic pH), nutrient poor, and low in metals (Pienitz et al. 1997; Rühland and Smol 1998; Golder 2012; Medeiros et al. 2012). Although discharges from the Misery operations of Ekati Mine are currently released to Lac du Sauvage, the lake does not currently show signs of being affected by the local mining operations and maintains water quality characteristics consistent with pre-mining conditions. Lac du Sauvage possesses water quality that is therefore similar to Ursula and Nanuq lakes, and other Arctic lakes, having low alkalinity and hardness, being slightly acidic, and having nutrients and metal concentrations generally at or below detection, and/or below CWQG.

Lac de Gras water quality is also typical of a northern lake, but is experiencing changes in water quality as a result of the mining operations at the Ekati and Diavik mines. Downstream of discharges from Ekati Mine, the stations in Slipper Lake Bay showed increases for pH, total hardness, TDS, chloride, sulphate, potassium, total molybdenum, and total strontium; however, concentrations of these parameters remain below applicable CWQG and SSWQO. Discharges from the Diavik Mine are attributed to increases in six parameters (i.e., TDS, alkalinity, chloride, sulphate, total molybdenum, and total strontium) in the near-field monitoring locations of Lac de Gras, with increases extending into the mid- and far-field for certain parameters. However, the concentrations of these parameters remain less than applicable CWQG and benchmarks.

A4 RESULTS – SEDIMENT QUALITY

A4.1 Lac du Sauvage

As reviewed in the water quality section, sediments were collected in Lac du Sauvage as part of the Jay 2006 program (Rescan 2007) and every three years as part of the Ekati Mine AEMP (e.g., Rescan 2012).

Concentrations of sediment quality parameters measured in Lac du Sauvage (stations LDS1 to LDS12) (Rescan 2007; Map A1.3-1) were variable across stations (Table A4.1-1). Dominant particle sizes at the sampled stations ranged from clay to sand but were generally dominated by clays and silts, with median clay and silt proportions of 40% and 48%, respectively; sand was dominant at two stations (LDS1 and LDS11). Median total organic carbon (TOC) was 1.3% and ranged from 0.5% to 3.4%. Median total nitrogen (TN) was 0.12%, ranging from less than 0.1% to 0.3%.

Metals concentrations were also variable among sediment samples, but this is attributed to the variability in texture. Key summary information for metals is as follows:

- Arsenic concentrations were above the Interim Sediment Quality Guidelines (ISQG) and probable effects level (PEL) at most stations, but ranged from below detection (less than 5 milligrams per kilogram dry weight [mg/kg dw]) to 563 mg/kg dw (LDS3), with a median concentration of 43.8 mg/kg dw.
- The median chromium concentration of 65.8 mg/kg dw was above the ISQG, but sample results for all sites were below the PEL.
- The maximum copper concentration of 40.8 mg/kg dw (LDS8) was above the ISQG, with sample results for all stations below the PEL.
- Mercury concentrations were variable among stations ranging from less than 0.005 to 5.61 mg/kg dw; the maximum concentration (5.61 mg/kg dw) collected at LDS3 was well above the ISQG and PEL. The median mercury concentration (0.0259 mg/kg dw) and the results for all other stations were below the ISQG.
- Lead and zinc concentrations were below the ISQG in all samples.
- Barium, beryllium, molybdenum, nickel, and vanadium were at detectable concentrations (there are no ISQG or PEL values for comparison for these metals).
- Antimony, cadmium, lead, selenium, silver, thallium, and tin were non-detectable in all samples.

Table A4.1-1 Sediment Chemistry in Lac du Sauvage, 2006

Parameter	Unit	CCME SQG		Lac du Sauvage		
		ISQG	PEL	No.	Median	Range
Physical Characteristics						
Clay (<0.004 mm)	%	-	-	28	40.2	4.7 to 46.6
Silt (0.004 to 0.063 mm)	%	-	-	28	48.3	24 to 63.2
Sand (0.063 to 2.0 mm)	%	-	-	28	10.1	5.1 to 71.3
Gravel (>2 mm)	%	-	-	28	<0.1	<0.1
Nutrients						
Total nitrogen	%	-	-	30	0.12	<0.1 to 0.3
Total organic carbon	%	-	-	31	1.27	0.47 to 3.35
Total Metals						
Antimony	mg/kg dw	-	-	31	<10	<10
Arsenic	mg/kg dw	5.9	17	31	**43.8**	<5 to **563**
Barium	mg/kg dw	-	-	31	141	83.5 to 324
Beryllium	mg/kg dw	-	-	31	<0.5	<0.5 to 0.55
Cadmium	mg/kg dw	0.6	3.5	31	<0.5	<0.5
Chromium	mg/kg dw	37.3	90	31	**65.8**	35.4 to **75.2**
Cobalt	mg/kg dw	-	-	31	20	5.8 to 46.3
Copper	mg/kg dw	35.7	197	31	30.3	8.2 to **40.8**
Lead	mg/kg dw	35	91.3	31	<30	<30
Mercury	mg/kg dw	0.17	0.486	31	0.0259	<0.005 to **5.61**
Molybdenum	mg/kg dw	-	-	31	<4	<4 to 13.4
Nickel	mg/kg dw	-	-	31	41.9	16.5 to 68.8
Selenium	mg/kg dw	-	-	31	<2	<2
Silver	mg/kg dw	-	-	31	<2	<2
Thallium	mg/kg dw	-	-	31	<1	<1
Tin	mg/kg dw	-	-	31	<5	<5
Vanadium	mg/kg dw	-	-	31	55.7	25.9 to 67.3
Zinc	mg/kg dw	123	315	31	75.9	31.9 to 93.7

Source: Rescan (2007).

Bold indicates concentration is less than or equal to ISQG.

Bold and underlined indicates that concentration is above PEL.

CCME SQG = Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines (SQG) (CCME 1999); ISQG = Interim Sediment Quality Guidelines; PEL = Probable Effect Level; % = percent; < = less than; mm = millimetre; > = greater than; mg/kg dw = milligrams per kilogram as dry weight; - = no guideline available; No. = number of samples.

For the Ekati Mine AEMP, sediments are collected every three years from Lac du Sauvage; sediment samples were last collected for the AEMP in 2011. Sediments collected from Lac du Sauvage in 2011 were analyzed with better detection limits than the previous 2006 program, and there were additional metal parameters analyzed in the 2011 compared to the 2006 dataset (e.g., aluminum, iron, strontium). As such, data from 2011 are provided separately (Table A4.1-2). For the parameters that are consistent between the two programs, median concentrations in 2011 are similar to the 2006 summary data, and within the concentration ranges observed in 2006. In addition, detectable concentrations of lead, molybdenum, selenium, and thallium were measured in 2011, whereas most were non-detectable in 2006 because of the higher analytical detection limits in 2006 as compared to 2011.

Table A4.1-2 Sediment Chemistry in Lac du Sauvage, 2011

Parameter	Units	CCME SQG		LDS1		
		ISQG	PEL	No.	Median	Range
Nutrients						
Total nitrogen	%	-	-	3	0.182	0.176 to 0.208
Phosphorus	mg/kg dw	-	-	3	1,200	896 to 1,370
Total organic carbon	%	-	-	3	1.69	1.54 to 1.91
Total Metals						
Aluminum	mg/kg dw	-	-	3	16,700	16,400 to 17,500
Arsenic	mg/kg dw	5.9	17	3	**46.6**	**25.6** to **81.8**
Barium	mg/kg dw	-	-	3	156	135 to 162
Beryllium	mg/kg dw	-	-	3	0.48	0.48 to 0.51
Bismuth	mg/kg dw	-	-	3	0.28	0.27 to 0.28
Cadmium	mg/kg dw	0.6	3.5	3	0.149	0.141 to 0.157
Chromium	mg/kg dw	37.3	90	3	**61.2**	**59.9** to **64.4**
Cobalt	mg/kg dw	-	-	3	22.5	17.5 to 24.9
Copper	mg/kg dw	35.7	197	3	25.6	25.4 to 26.9
Iron	mg/kg dw	-	-	3	41,100	30,600 to 49,000
Lead	mg/kg dw	35	91.3	3	4.89	4.86 to 5.27
Lithium	mg/kg dw	-	-	3	45.9	45.5 to 48
Manganese	mg/kg dw	-	-	3	3,780	1,480 to 3,870
Mercury	mg/kg dw	0.17	0.486	3	0.0132	0.0105 to 0.0146
Molybdenum	mg/kg dw	-	-	3	1.77	1.29 to 2.47
Nickel	mg/kg dw	-	-	3	44	42.4 to 47.2
Selenium	mg/kg dw	-	-	3	0.16	0.13 to 0.16
Strontium	mg/kg dw	-	-	3	12.6	11.1 to 12.9
Thallium	mg/kg dw	-	-	3	0.26	0.258 to 0.274
Titanium	mg/kg dw	-	-	3	1,020	960 to 1040
Uranium	mg/kg dw	-	-	3	2.47	2.43 to 2.59
Vanadium	mg/kg dw	-	-	3	49.8	49.3 to 52.7
Zinc	mg/kg dw	123	315	3	66.7	65.3 to 70.1

Source: Rescan (2012)

Sediment samples were collected in triplicate with an Ekman sampler and the top 2 cm analyzed.

Bold indicates concentration is less than or equal to the ISQG.

Bold and underlined indicates that the concentration is above the PEL.

CCME = Canadian Council of Ministers of the Environment; ISQG = Interim Sediment Quality Guidelines; PEL = probable effect level; mg/kg dw = milligrams per kilogram dry weight; % = percent; < = less than; µm = micrometre - = no guideline or data available; No. = number of samples.

A4.2 Lac de Gras

A4.2.1 Pre-mining

Baseline sediment sampling for Diavik Mine was conducted between 1997 and 2000 (summarized in DDMI 2007). Most samples (86%) were collected using a sediment corer, with the top 5 to 6 cm of the core being analyzed. The remaining samples (14%) were collected using an Ekman grab sampler. Samples were collected in triplicate at each station. Stations were classified as near-field, mid-field, and far-field, which is similar to the spatial characterization of the water quality sampling locations in Lac de Gras.

The sediment chemistry in Lac de Gras was characterized by DDMI (2007) as typical for the Slave Geological Province; summary sediment quality statistics from DDMI (2007) are provided in Table A4.2-1. In general, metals concentrations were similar among the near-, mid- and far-field areas, with results summarized as follows:

- arsenic concentrations were highest in the near-field, and median values were above the PEL in all areas;
- median chromium and copper concentrations were above the ISQG in all areas;
- median lead and zinc concentrations were below the ISQG in all areas;
- cadmium concentrations were below the ISQG, and median cadmium and nickel concentrations were lower in the near- and mid-field areas compared to the far-field area;
- median concentrations of total phosphorus and TOC were highest in the mid-field stations; and,
- median TKN increased from the near-field to the mid-field with no data available for the far-field stations.

Table A4.2-1 Baseline Sediment Chemistry Near-, Mid-, and Far-Fields in Lac de Gras, 1997 to 2000

Parameter	CCME SQG		Far-Field			Mid-Field			Near-Field		
	ISQG	PEL	No.	Median	Range	No.	Median	Range	No.	Median	Range
Nutrients											
Total Kjeldahl nitrogen	-	-	0	-	-	9	1,363	1,175 to 1,615	9	759	359 to 931
Total organic carbon	-	-	11	1.68	1.60 to 3.27	18	1.76	1.38 to 2.01	36	1.31	0.85 to 2.33
Total phosphorus	-	-	11	833	615 to 948	18	1,095	763 to 1,187	12	900	598 to 1,375
Total Metals											
Aluminum	-	-	11	13,400	12,250 to 16,600	18	13,900	11,800 to 16,850	42	14,600	12,400 to 16,425
Arsenic	5.9	17	11	**19.5**	**14.7** to **26.6**	18	**32.5**	16.6 to **71.6**	42	**49.8**	**17.2** to **140.5**
Cadmium	0.6	3.5	11	0.30	0.17 to 0.47	18	0.17	0.09 to 0.23	42	0.10	0.10 to 0.18
Chromium	37.3	90	11	**55.7**	**45.9** to **89.5**	18	**61.5**	**52.8** to **75.9**	42	**53.4**	**46.8** to **58.7**
Copper	35.7	197	11	**45.1**	33.4 to **64.9**	18	**43.9**	**36.7** to **52.6**	42	**42.1**	28.9 to **48.4**
Lead	35	91.3	11	3.42	2.71 to 6.58	18	4.23	4.03 to 6.78	42	4.29	3.65 to 5.28
Nickel	-	-	11	56.40	52.55 to 73.8	18	26.70	19.90 to 59.95	42	33.15	22.13 to 42.38
Zinc	123	315	11	74.6	69.6 to 82.0	18	73.4	64.8 to 81.3	42	68	56.4 to 73.5

Source: DDMI (2007).

Notes: Range presented from 25th percentile (min) to 75th percentile (max).

Units mg/kg dw except for total organic carbon where units are%.

Values above ISQG are **bolded**; values above PEL are **bolded and underlined**.

CCME SQG = Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines (SQG) (CCME 1999); ISQG = Interim Sediment Quality Guidelines; PEL = Probable Effect Level; % = percent; mg/kg dw = milligrams per kilogram (as dry weight); - = no guideline or no data; No. = number of samples.

A4.2.2 During Mining Operations

A4.2.2.1 Lac de Gras in the Vicinity of Diavik Mine

A4.2.2.1.1 2001 to 2006

Post-baseline AEMP monitoring of sediments began in 2001 and continued annually to 2006. The sediment sampling approach was similar to baseline monitoring with samples collected from each station in each area. At each station, three replicate cores were collected and the top 5 to 6 cm of sediment from each core were retained for analysis. In 2005, under a request from the Wek'èezhìı Land and Water Board, sediment core samples at each station were further portioned into the top 2 cm (current) and 2 to 5 cm (pre-industrial) fractions to test for differences between recent post-settlement changes in sediment quality. As per palaeolimnological studies on Arctic lakes, sedimentation rates are low and the upper 5 cm are estimated to cover the recent period through to the pre-industrial (ca A.D. 1850) period (Stephens 1999; Crann 2013). For consistency to other sediment data, this review focuses on the comparable top 5 cm fraction for all years. Three sampling stations were established at increasing distance from the Diavik Mine discharge as follows:

- near-field (LDG NF) – approximately 1 km east of the Diavik Mine discharge;
- mid-field (LDG MF) – approximately 4 km east of the Diavik Mine discharge; and,
- far-field (LDG FF) – near the outlet of Lac de Gras to the Coppermine River.

The median values for eight metals, phosphorus, total Kjeldahl nitrogen (TKN), TOC, and percent silt are presented in Tables A4.2-2 to A4.2-4. Organic matter content and finer particle size (i.e., clay) was higher in the far-field sediments (DDMI 2007), which can be indicative of a higher depositional environment. Phosphorus and TKN were also higher in the far-field stations compared to the near-field and mid-field stations, which may be due to the higher TOC content. Metal concentrations, especially arsenic, cadmium, copper, nickel, and zinc, were also generally higher in the far-field compared to the mid- and near-field stations. Concentrations of arsenic, chromium, copper, lead, and zinc concentrations were consistent with baseline condition. Metal concentrations relative to guidelines were as follows:

- median arsenic concentrations were above the PEL in all areas and were highly variable among sites and years;
- median chromium and copper concentrations were above the ISQG in all areas;
- median lead concentrations were well below ISQG at all fields; and,
- median zinc concentrations were below ISQG in the near-field and mid-field, and in the far-field except for years 2002 and 2004 where concentrations were above the ISQG.

Table A4.2-2 Median Sediment Concentrations in Lac de Gras (Near-Field – LDG NF), 2001 to 2006

Analyte	Unit	2001	2002	2003	2004	2005	2006
Silt	%	83	82	78	82	84	78
Total Kjeldahl nitrogen	mg/kg dw	2,500	2,200	1,700	2,500	2,100	2,400
Total phosphorus	mg/kg dw	1,100	1,075	1,050	980	1,120	1,080
Total organic carbon	% wt	3.80	2.60	1.60	3.00	2.30	2.70
Total aluminum	mg/kg dw	20,000	15,500	16,300	13,300	15,400	15,200
Total arsenic	mg/kg dw	**21.6**	**25.0**	**24.4**	**47.5**	**101**	**31.4**
Total cadmium	mg/kg dw	0.10	0.30	0.20	0.20	0.20	0.30
Total chromium	mg/kg dw	**63.3**	**58.9**	**60.5**	**40.4**	**47.8**	**52.9**
Total copper	mg/kg dw	**49.9**	**47.0**	**46.2**	**37.7**	**38.5**	**38.6**
Total lead	mg/kg dw	4.90	9.20	8.20	10.0	9.40	12.3
Total nickel	mg/kg dw	37.5	56.2	42.6	47.0	49.7	54.3
Total zinc	mg/kg dw	77.4	86.0	84.0	80.0	75.0	74.0

Source: DDMI (2007)

Notes: **Bold** = indicates concentration is less than or equal to ISQG; **Bold and underline** = indicates that concentration is above PEL;

LDG = Lac de Gras; NF = near-field; mg/kg dw = milligrams per kilogram as dry weight; % = percent; wt = weight.

Table A4.2-3 Median Sediment Concentrations in Lac de Gras (Mid-Field – LDG MF), 2001 to 2006

Analyte	Unit	2001	2002	2003	2004	2005	2006
Silt	%	81	85	81	85	81	83
Total Kjeldahl nitrogen	mg/kg dw	2,600	1,800	2,100	2,300	1,900	2,200
Total phosphorus	mg/kg dw	1,100	1,100	1,140	1,030	1,390	1,170
Total organic carbon	% wt	2.50	2.20	2.00	2.80	2.20	2.10
Total aluminum	mg/kg dw	21,600	18,200	16,800	19,500	18,200	19,300
Total arsenic	mg/kg dw	**60.1**	**21.8**	**21.6**	**23.2**	**152**	**22.3**
Total cadmium	mg/kg dw	0.10	0.10	0.10	0.10	0.20	0.10
Total chromium	mg/kg dw	**62.9**	**68.6**	**61.8**	**58.7**	**59.3**	**68.3**
Total copper	mg/kg dw	**47.5**	**51.0**	**47.2**	**50.2**	**47.6**	**46.5**
Total lead	mg/kg dw	5.40	5.90	5.80	6.00	5.9	6.10
Total nickel	mg/kg dw	42.5	43.7	37.5	39.1	45.2	39.2
Total zinc	mg/kg dw	79.0	88.0	78.0	79.0	76.0	71.0

Source: DDMI (2007).

Notes: **Bold** = indicates concentration is less than or equal to ISQG; **Bold and underline** = indicates that concentration is above PEL.

LDG = Lac de Gras; MF = mid-field; mg/kg dw = milligrams per kilogram as dry weight; % = percent; wt = weight.

Table A4.2-4 Median Sediment Concentrations in Lac de Gras (Far-Field – LDG FF), 2001 to 2006

Analyte	Unit	2001	2002	2003	2004	2005	2006
Silt	%	69	65	63	64	76	78
Total Kjeldahl nitrogen	mg/kg dw	4,700	4,400	5,200	6,500	4,800	5,100
Total phosphorus	mg/kg dw	1,400	1,300	1,340	2,060	2,070	2,030
Total organic carbon	% wt	6.40	7.00	6.70	7.60	5.2	5.90
Total aluminum	mg/kg dw	21,000	14,700	13,700	19,300	19,500	18,300
Total arsenic	mg/kg dw	**15.8**	**36.0**	**36.9**	**109**	**172**	**166**
Total cadmium	mg/kg dw	0.40	0.50	0.40	0.50	0.50	0.50
Total chromium	mg/kg dw	**54.8**	**55.1**	**50.6**	**59.3**	**55.9**	**60.7**
Total copper	mg/kg dw	**90.6**	**91.0**	**71.5**	**110**	**108**	**103**
Total lead	mg/kg dw	4.30	7.40	8.40	8.80	7.1	6.70
Total nickel	mg/kg dw	63.1	81.2	79.1	94.6	90.7	94.7
Total zinc	mg/kg dw	102	**125**	102	**129**	117	114

Source: DDMI (2007)

Notes: **Bold** = indicates concentration is less than or equal to ISQG; **Bold and underline** = indicates that concentration is above PEL.

LDG = Lac de Gras; FF = far-field; mg/kg dw = milligrams per kilogram as dry weight; % = percent; wt = weight.

A4.2.2.1.2 2007 to 2010

Post 2006, the sampling design for sediment in the Diavik AEMP was modified. Sediment samples from 2007 to 2010 (DDMI 2008, 2009, 2010, 2011) were collected using a sediment corer but with only the top 1 cm analyzed for sediment chemistry. The change in the collected depth of sediment was to increase the sensitivity in assessing sediment contamination given the low sediment deposition rates in Lac de Gras. However, sediment samples for particle size and TOC were collected using an Ekman grab sampler using the top 5 cm. Additionally, new station locations in Lac de Gras were established for the near-field (5 stations), mid-field (12 stations), and far-field (20 stations).

For this review, sediment quality data are presented only for the far-field 2 (FF2) stations near the outlet of Lac du Sauvage, and the far-field A (FFA) stations at the west end of Lac de Gras near the previous 2006 far-field station (LDG FF). The FF2 stations are potentially influenced by Diavik Mine discharge but are a key site with respect to outflow from Lac du Sauvage as it is downstream of the proposed Jay Project. The FFA stations are the closest reference stations to the Slipper Lake outlet and mine releases from LLCF. The median values and ranges for particle size, metals, phosphorus, TKN, and TOC are presented in Table A4.2-5. There was no evidence of nutrient enrichment in the sediments as measured by TOC in sediment because TOC did not vary considerably among sampling areas.

The particle sizes of FF2 stations were variable ranging from 4% to 40% clay, 58% to 90% silt, and 2% to 15% sand, with TOC ranging from 1.9% to 2.9% (Table A4.2-5). The particle sizes of FFA stations were also variable ranging from 2% to 15% clay, 22% to 80% silt, and 7% to 76% sand, with TOC ranging from 1% to 8% (Table A4.2-5). Concentration of metals in these sediments is summarized as follows:

- median arsenic concentrations were above the PEL at all stations;

- certain samples had cadmium concentrations over the ISQG, but the median concentration was less than the ISQG;
- median chromium and copper concentrations were above the ISQG;
- median lead and zinc concentrations were below the ISQG, but the maximum zinc concentration at FFA was above the ISQG; and,
- lower concentrations of arsenic, cadmium, copper, and zinc were found at FF2 stations as compared to FFA stations.

Concentrations of bismuth, lead, and uranium in sediments exhibited a decreasing trend with increasing distance from effluent discharge. Near-field concentrations of these three metals were frequently measured above the normal range in the NF area with a declining trend through one or more of the MF areas (the normal range was based on data collected from reference areas FF1, FFA, and FFB but not FF2 as potentially impacted by treated effluent discharge [Golder 2011]). The elevation in concentration of these metals in the near-field region may be related to mine water effluent discharges, as dike monitoring studies have also reported increasing concentrations of bismuth, lead, and uranium near the A154 dike. Seepages through the A154 dike (mine water seepage or clean water seepage through dike material) may influence these concentrations.

Table A4.2-5 Sediment Chemistry from FF2 and FFA Areas of the Diavik Aquatic Effects Monitoring Program, 2007 to 2010

Parameter	Unit	CCME SQG		FF2-1 to FF2-5			FFA-1 to FFA-5		
		ISQG	PEL	No.	Median	Range	No.	Median	Range
Physical Characteristics									
Total organic matter	%	-	-	15	3.84	3.2 to 4.6	14	5.8	1.7 to 14.4
Clay (<4 µm)	%	-	-	20	9	4.0 to 40.2	16	11	2 to 15
Silt (4 µm to 0.063 mm)	%	-	-	20	83	57.5 to 90.0	16	66.5	21.5 to 80.0
Sand (0.063 mm to 2 mm)	%	-	-	20	5.5	2.4 to 15.0	16	22.5	7.0 to 75.8
Nutrients									
Total nitrogen	mg/kg dw	-	-	19	2,000	1,300 to 2,800	17	2,800	1,000 to 4,300
Phosphorus	mg/kg dw	-	-	20	980	660 to 1,640	17	1,240	810 to 1,720
Total organic carbon	%	-	-	20	2.2	1.9 to 2.9	16	3.5	1.0 to 8.3
Total Metals									
Aluminum	mg/kg dw	-	-	20	15,800	14,100 to 18,100	16	15,550	11,900 to 18,200
Arsenic	mg/kg dw	5.9	17	20	**21.6**	**16.6** to **66.8**	16	**77.5**	**29.9** to **511**
Barium	mg/kg dw	-	-	20	132	111 to 171	16	114.5	73.2 to 564
Beryllium	mg/kg dw	-	-	20	0.5	0.4 to 0.6	16	0.63	0.48 to 0.80
Bismuth	mg/kg dw	-	-	20	0.9	0.5 to 1.4	5	0.4	<0.5 to 0.5
Cadmium	mg/kg dw	0.6	3.5	20	0.3	0.2 to **0.8**	16	0.5	0.2 to **2.6**
Chromium	mg/kg dw	37.3	90	20	**57.6**	**53 to 62.2**	16	**47.2**	**36.4** to **54.7**
Cobalt	mg/kg dw	-	-	20	29.4	21.7 to 50.8	16	104.5	32.5 to 367
Copper	mg/kg dw	35.7	197	20	**38.1**	32.8 to **48.5**	16	**75**	**54** to **107**
Iron	mg/kg dw	-	-	20	30,550	22,900 to 45,700	16	54,500	28,800 to 127,000
Lead	mg/kg dw	35	91.3	20	7.9	5.5 to 12.2	16	7	4.0 to 12.1
Lithium	mg/kg dw	-	-	5	41.3	39 to 43.4	5	36.9	31.7 to 46.7
Manganese	mg/kg dw	-	-	20	18,100	2,090 to 49,200	16	8,415	1,130 to 128,000
Mercury	mg/kg dw	0.17	0.486	20	<0.05	<0.05	1	<0.05	<0.05 to 0.06
Molybdenum	mg/kg dw	-	-	20	3.2	1.8 to 4.9	16	4.7	2.7 to 12.1
Nickel	mg/kg dw	-	-	20	45.4	37.6 to 114	16	95.2	46.7 to 341
Selenium	mg/kg dw	-	-	20	0.5	0.3 to 0.78	16	1	0.5 to 1.4

Table A4.2-5 Sediment Chemistry from FF2 and FFA Areas of the Diavik Aquatic Effects Monitoring Program, 2007 to 2010

Parameter	Unit	CCME SQG		FF2-1 to FF2-5			FFA-1 to FFA-5		
		ISQG	PEL	No.	Median	Range	No.	Median	Range
Total Metals (continued)									
Strontium	mg/kg dw	-	-	20	13.5	9.8 to 19.7	16	12	7 to 21
Thallium	mg/kg dw	-	-	15	0.32	0.296 to 0.483	13	0.32	<0.05 to 2.13
Titanium	mg/kg dw	-	-	20	928	674 to 1,060	16	653	420 to 761
Uranium	mg/kg dw	-	-	20	4.75	3.49 to 5.85	16	4.46	3.38 to 5.56
Vanadium	mg/kg dw	-	-	20	46.3	43.4 to 50.5	16	38	32.1 to 48.8
Zinc	mg/kg dw	123	315	20	73.2	66.9 to 92.0	16	97	68 to **156**

Source: DDMI (2008, 2009, 2010, 2011).

Notes: **Bold** indicates concentration is less than or equal to the ISQG.

Bold and underline indicates that the concentration is above the PEL.

Samples were collected with a sediment corer with the top 1 cm used for metals analysis.

Notes on specific years: 2007 = nitrogen and phosphorus were analyzed from 5 cm layer; 2008 = mercury analyzed from 1 cm layer; 2009 = metals analyzed from 1 cm layer, nutrients taken at 5 cm; 2010 = phosphorus analyzed from 1 cm layer, metals analyzed from 1 cm layer and nutrients analyzed at 5 cm layer.

CCME = Canadian Council of Ministers of the Environment; ISQG = Interim Sediment Quality Guidelines; PEL = probable effect level; mg/kg = milligrams per kilogram; % = percent; < = less than; µm = micrometre; "-" = no guideline or data available; No. = number of samples.

A4.2.2.2 Lac de Gras in Vicinity of Slipper Lake Bay (2011)

As discussed in Section A2.1, two stations in the west bay of Lac de Gras near the outflow of Slipper Lake (Slipper Lake Bay of Lac de Gras) (stations S2 and S3; Rescan 2012) are monitored as part of the Ekati Mine AEMP. The top 2 cm of sediment collected using an Ekman grab sampler was retained for analysis so that recent data can be compared to historical data. For the AEMP, sediments are collected every three years; data from the 2011 are summarized (Table A4.2-6).

Median total organic carbon was 5% and 4% for S2 and S3, respectively (Table A4.2-6). Median total nitrogen was 0.5% and 0.4% for S2 and S3, respectively. Particle size at S2 and S3 was dominated by silt (61% and 77%) and clay (34% and 16%), and each had a small fraction of sand (5% and 7%, respectively). The concentration of metals in these sediments is summarized as follows:

- median arsenic concentrations were above the PEL at both stations;
- median concentrations of cadmium, chromium, and copper were over their respective ISQGs at both stations;
- median concentrations of lead and mercury concentrations were below the ISQG at both stations; and,
- median zinc concentrations were above ISQG at both stations.

Sediment quality in Lac de Gras downstream of Slipper Lake (Table A4.2-6) is similar to sediment quality in the main lake at area FFA (Table A4.2-5), with median or maximum concentrations of arsenic, cadmium, chromium, copper, and zinc above sediment quality guidelines.

Table A4.2-6 Sediment Chemistry from Lac de Gras (S2 and S3), 2011

Parameter	Unit	CCME SQG		S2			S3		
		ISQG	PEL	No.	Median	Range	No.	Median	Range
Physical Characteristics									
Clay (<4 µm)	%	-	-	3	34.1	23.4 to 37.9	3	16.3	11.2 to 23.2
Silt (4 µm to 0.063 mm)	%	-	-	3	61.1	56.8 to 71.8	3	77.1	69.4 to 84.8
Sand (0.063 mm to 2 mm)	%	-	-	3	4.84	4.76 to 5.28	3	6.65	3.98 to 7.48
Gravel (> 2mm)	%	-	-	3	<0.10	<0.10	3	<0.10	<0.10
Nutrients									
Total nitrogen	%	-	-	3	0.513	0.470 to 0.523	3	0.404	0.334 to 0.501
Phosphate, available-P	mg/kg dw	-	-	3	2	<2.0 to 2.2	3	8.3	2.7 to 8.3
Phosphorus	mg/kg dw	-	-	3	1,450	1,430 to 1,460	3	1490	1,170 to 1,580
Total organic carbon	%	-	-	3	5.33	4.80 to 5.62	3	4.22	3.30 to 5.42
Total Metals									
Aluminum	mg/kg dw	-	-	3	19,000	18,500 to 20,200	3	18,900	15,900 to 25,200
Arsenic	mg/kg dw	5.9	17	3	**132**	**97** to **174**	3	**63**	**52** to **264**
Barium	mg/kg dw	-	-	3	188	153 to 202	3	238	149 to 457
Beryllium	mg/kg dw	-	-	3	0.84	0.82 to 0.87	3	0.89	0.83 to 0.95
Bismuth	mg/kg dw	-	-	3	0.62	0.59 to 0.62	3	0.55	0.48 to 0.61
Cadmium	mg/kg dw	0.6	3.5	3	**0.713**	**0.701** to **0.774**	3	**0.948**	0.388 to **1.09**
Chromium	mg/kg dw	37.3	90	3	**55.9**	**53.3** to **58.0**	3	**53.9**	**43.6** to **74.1**
Cobalt	mg/kg dw	-	-	3	112	94 to 117	3	159	64 to 242
Copper	mg/kg dw	35.7	197	3	**71.2**	**68.5** to **73.1**	3	**77.6**	**69.7** to **81.1**
Iron	mg/kg dw	-	-	3	85,600	81,300 to 112,000	3	51,600	50,800 to 127,000
Lead	mg/kg dw	35	91.3	3	7.03	6.84 to 7.14	3	7.69	6.77 to 7.81
Lithium	mg/kg dw	-	-	3	39.9	38.6 to 42.5	3	39	26.8 to 60.8
Manganese	mg/kg dw	-	-	3	3,070	1,910 to 6,810	3	18,500	4,760 to 23,000
Mercury	mg/kg dw	0.17	0.486	3	0.0556	0.0538 to 0.0556	3	0.0514	0.0297 to 0.0515
Molybdenum	mg/kg dw	-	-	3	4.86	3.92 to 6.22	3	7.13	4.79 to 7.34
Nickel	mg/kg dw	-	-	3	128	126 to 134	3	164	118 to 214

Table A4.2-6 Sediment Chemistry from Lac de Gras (S2 and S3), 2011

Parameter	Unit	CCME SQG		S2			S3		
		ISQG	PEL	No.	Median	Range	No.	Median	Range
Total Metals (continued)									
Selenium	mg/kg dw	-	-	3	0.71	0.67 to 0.71	3	0.73	0.38 to 0.85
Strontium	mg/kg dw	-	-	3	16.8	15.2 to 20.0	3	20.5	13.2 to 23.3
Thallium	mg/kg dw	-	-	3	0.543	0.518 to 0.563	3	0.748	0.504 to 0.814
Titanium	mg/kg dw	-	-	3	560	547 to 622	3	510	410 to 989
Uranium	mg/kg dw	-	-	3	5.59	5.28 to 5.63	3	5.09	4.72 to 5.28
Vanadium	mg/kg dw	-	-	3	48.4	45.8 to 49.8	3	47.4	39.6 to 62.8
Zinc	mg/kg dw	123	315	3	**131**	**129** to **132**	3	**138**	114 to **155**

Source: Rescan (2012).

Notes: Sediment samples were collected in triplicate with an Ekman sampler and the top 2 cm analyzed.

Bold indicates concentration is less than or equal to the ISQG.

Bold and underline indicates that the concentration is above the PEL.

CCME = Canadian Council of Ministers of the Environment; ISQG = Interim Sediment Quality Guidelines; PEL = probable effect level; mg/kg dw = milligrams per kilogram dry weight; % = percent; < = less than; µm = micrometre; P = phosphorus; No. = number of samples.

A4.3 Regional Sediment Quality

A4.3.1 Ursula Lake 2006

Compared to Lac du Sauvage (Table A4.1-1), Ursula Lake sediments (Table A4.3.1) were dominated by clay (62.2 to 68.7%), then silt (30.8 to 37.6%), with little to no sand (0.2 to 0.6%) (Rescan 2007). Total nitrogen (0.7% to 0.91%) and TOC (11.8% to 12%) were higher in Ursula Lake compared to Lac du Sauvage. Median metal concentrations were generally similar or lower in Ursula Lake, but within the range measured in Lac du Sauvage. Notable exceptions were as follows:

- median copper (63.8 mg/kg dw) and zinc (154 mg/kg dw) in Ursula Lake exceeded their respective ISQGs; median concentrations of these metals in Lac du Sauvage were less than the ISQGs (Tables A4.1-1 and A4.1-2);
- median mercury concentration (0.121 mg/kg dw) was also higher in Ursula Lake than Lac du Sauvage; and,
- median arsenic concentration (24.8 mg/kg dw) exceeded the PEL in Ursula Lake, but was approximately half the median concentration reported in Lac du Sauvage.

Table A4.3-1 Sediment Chemistry in Ursula Lake, 2006

Parameter	Unit	CCME SQG		Ursula Lake		
		ISQG	PEL	No.	Median	Range
Physical Characteristics						
Clay (<0.004 mm)	%	-	-	3	63.7	62.2 to 68.7
Silt (0.004 to 0.063 mm)	%	-	-	3	35.7	30.8 to 37.6
Sand (0.063 to 2.0 mm)	%	-	-	3	0.5	0.2 to 0.6
Gravel (>2 mm)	%	-	-	3	<0.1	<0.1
Nutrients						
Total nitrogen	%	-	-	3	0.9	0.7 to 0.91
Total organic carbon	%	-	-	3	11.9	11.8 to 12
Total Metals						
Antimony	mg/kg dw	-	-	3	<10	<10
Arsenic	mg/kg dw	5.9	17	3	**24.8**	**21** to **25.8**
Barium	mg/kg dw	-	-	3	60.8	59.9 to 68.5
Beryllium	mg/kg dw	-	-	3	0.94	0.92 to 0.95
Cadmium	mg/kg dw	0.6	3.5	3	<0.5	<0.5
Chromium	mg/kg dw	37.3	90	3	34	33.6 to 34.6
Cobalt	mg/kg dw	-	-	3	20.3	15.3 to 20.5
Copper	mg/kg dw	35.7	197	3	**63.8**	**62.3** to **63.9**
Lead	mg/kg dw	35	91.3	3	<30	<30
Mercury	mg/kg dw	0.17	0.486	3	0.121	0.114 to **0.249**
Molybdenum	mg/kg dw	-	-	3	<4	<4
Nickel	mg/kg dw	-	-	3	35.3	33.7 to 35.6

Table A4.3-1 Sediment Chemistry in Ursula Lake, 2006

Parameter	Unit	CCME SQG		Ursula Lake		
		ISQG	PEL	No.	Median	Range
Total Metals (Continued)						
Selenium	mg/kg dw	-	-	3	<2	<2
Silver	mg/kg dw	-	-	3	<2	<2
Thallium	mg/kg dw	-	-	3	<1	<1
Tin	mg/kg dw	-	-	3	<5	<5
Vanadium	mg/kg dw	-	-	3	33.7	32.6 to 33.8
Zinc	mg/kg dw	123	315	3	**154**	**152** to **157**

Source: Rescan (2007).

Notes: **Bold** = indicates concentration is less than or equal to ISQG; **Bold and underline** = indicates that concentration is above PEL.

CCME SQG = Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines (SQG) (CCME 1999); ISQG = Interim Sediment Quality Guidelines; PEL = Probable Effect Level;% = percent; < = less than; mm = millimetre; > = greater than; mg/kg dw = milligrams per kilogram as dry weight; - = no guideline available; No. = number of samples.

A4.3.2 Nanuq Lake

The most recent sediment collection in Nanuq Lake (Table A4.3-2) was during the 2011 AEMP (Rescan 2012). The most recent data were used to characterize sediment quality in Nanuq Lake because these data were analyzed with the best detection limits, and as based on the AEMP studies, sediment quality in this lake has not changed over time; thus using data from 2011 is appropriate. Sediment samples were collected from a mid-water depth station (5.1 to 10 m water depth) and a deep water station (more than 10 m deep). More sand was associated with the mid-depth station compared to the deep water station. Total nitrogen (0.5%) and TOC (6%) were higher in Nanuq Lake than in Lac du Sauvage, but slightly lower than in Ursula Lake. Metal concentrations in the sediment from Nanuq Lake is summarized as follows:

- median metal concentrations in Nanuq Lake were generally comparable or lower than metal concentrations in Lac du Sauvage (Table A4.1-2);
- similar to Ursula Lake, Nanuq Lake had lower arsenic and chromium concentrations but higher copper, mercury, and zinc concentrations compared to Lac du Sauvage;
- with the better detection limits for sediment analysis in 2011, median cadmium and lead concentrations were slightly higher in Nanuq Lake compared to Lac du Sauvage; and,
- median and maximum concentrations of arsenic, cadmium, chromium, copper, and zinc were above sediment quality guidelines in Nanuq Lake.

Table A4.3-2 Sediment Chemistry in Nanuq Lake, 2011

Parameter	Unit	CCME SQG		Nanuq Lake		
		ISQG	PEL	No.	Median	Range
Physical Characteristics						
Clay (<4 µm)	%	-	-	6	25	6.08 to 48.20
Silt (4 µm to 0.063 mm)	%	-	-	6	55.4	48.1 to 63.2
Sand (0.063 mm to 2 mm)	%	-	-	6	15.5	3.71 to 37.3
Gravel (>2mm)	%	-	-	6	0.1	<0.1 to 1.3
Nutrients						
Total Nitrogen	%	-	-	6	0.532	0.273 to 0.981
Phosphate, Available-P	mg/kg dw	-	-	5	28	<2.0 to 100
Phosphorus	mg/kg dw	-	-	6	761	373 to 1,240
Total Organic Carbon	%	-	-	6	6.1	3.2 to 10.2
Total Metals						
Aluminum	mg/kg dw	-	-	6	14,300	10,200 to 16,300
Arsenic	mg/kg dw	5.9	17	6	**13.4**	**6.98** to **29.3**
Barium	mg/kg dw	-	-	6	94.4	72.0 to 99.9
Beryllium	mg/kg dw	-	-	6	0.57	0.48 to 0.71
Bismuth	mg/kg dw	-	-	6	0.35	0.23 to 0.42
Cadmium	mg/kg dw	0.6	3.5	6	0.37	0.29 to **0.7**
Chromium	mg/kg dw	37.3	90	6	**41.3**	30.4 to **43.1**
Cobalt	mg/kg dw	-	-	6	11.5	8.81 to 14.6
Copper	mg/kg dw	35.7	197	6	**62.2**	**37.1** to **77.2**
Iron	mg/kg dw	-	-	6	22,100	16,900 to 39,000
Lead	mg/kg dw	35	91.3	6	6.13	4.11 to 9.01
Lithium	mg/kg dw	-	-	6	26.1	21.3 to 30.5
Manganese	mg/kg dw	-	-	6	276	202 to 633
Mercury	mg/kg dw	0.17	0.486	6	0.0336	0.0159 to 0.0617
Molybdenum	mg/kg dw	-	-	6	1.28	1.17 to 2.18
Nickel	mg/kg dw	-	-	6	29.5	28.4 to 43.4
Selenium	mg/kg dw	-	-	6	0.7	0.39 to 1.09
Strontium	mg/kg dw	-	-	6	13.2	9.4 to 15.0
Thallium	mg/kg dw	-	-	6	0.211	0.195 to 0.262
Titanium	mg/kg dw	-	-	6	460	394 to 596
Uranium	mg/kg dw	-	-	6	5.67	4.04 to 6.67
Vanadium	mg/kg dw	-	-	6	35	28 to 38.4
Zinc	mg/kg dw	123	315	6	98.8	82.8 to **137**

Source: Rescan (2012).

Notes: Sediment samples were collected in triplicate with an Ekman sampler and the top 2 cm analyzed.

Bold indicates concentration is less than or equal to the ISQG.

Bold and underline indicates that the concentration is above the PEL.

CCME = Canadian Council of Ministers of the Environment; ISQG = Interim Sediment Quality Guidelines; PEL = probable effect level; mg/kg dw = milligrams per kilogram dry weight; % = percent; < = less than; µm = micrometre; - = no guideline or data available; No. = number of samples.

A4.4 Environment Canada Dioxins and Furans

Environment Canada conducted a limited study to investigate the link between compounds deposited on land and lake surfaces from incinerator stacks and their potential accumulation in aquatic systems (Wilson et al. 2011). Sediment core samples were collected in April 2008 at two sites at Kodiak Lake (K1 and K2; exposure sites) and Counts Lake (C1; reference site).

Five replicate cores, 2 to 3 m apart, were collected at each site in the deeper areas of the lakes (water depth of 9.8 to 10.5 m for K1, approximately 6 m for K2, and 10.5 to 11.0 m for C1), frozen, and shipped to the Environment Science and Technology Centre in Ottawa, Ontario for analysis. The top 5 cm of the cores were used for the assessment; each 5 cm core segment was sectioned at the Environment Science and Technology Centre into four layers (approximating 1 cm thickness) representing differing time horizons. The visible (or surface segment) horizon for the K1 and K2 samples were noted by the authors as the result of a sedimentation event in 1997 in Kodiak Lake. Each layer was analyzed for 17 polychlorinated dibenzo-*p*-dioxin (PCDD), polychlorinated dibenzofuran (PCDF) congeners, and toxic equivalencies (TEQs), which were calculated based on toxic equivalency factors for fish.

The highest PCDD/PCDF concentrations were found in the top two layers at each site. Across all layers, total PCDD ranged from 146.4 to 25.0 picograms per gram (pg/g) dw at K1, 122.4 to 41.2 pg/g dw at K2, and 45.8 to 10.5 pg/g dw at C1. Total PCDF ranged from 52.4 to 10.5 pg/g dw at K1, 43.3 to 15.4 pg/g dw at K2, and 11.1 to 7.1 pg/g dw at C1. Based on spatial and temporal considerations, the authors suggested that mine incinerator emissions were affecting PCDD and PCDF sediment concentrations in Kodiak Lake. The PCDD and PCDF sediment concentrations measured in Counts Lake were attributed to long-range atmospheric transport and deposition, and infrequent occasions when it is downwind of the mine site. The data do not necessarily represent pre-development conditions, but do represent current conditions.

The TEQs in the visible layer were approximately two times higher in K1 and K2 (approximately 1.5 nanograms [ng] TEQ/kg dw) compared to C1 and were above the ISQG threshold of 0.85 ng TEQ/kg dw. The TEQs dropped in subsequent layers or time horizons with the surface layer representing 10 to 11 years of sediment accumulation (1997 to 2008).

A4.5 Sediment Quality Summary

Sediment data from monitoring programs suggest the sediment quality in Lac du Sauvage has not changed because of mining development and is similar to non-affected lakes in the area. Concentrations of metals (e.g., arsenic, cadmium, chromium, copper, and zinc) in Lac du Sauvage, Nanuq Lake, and Ursula Lake that are above sediment quality guidelines indicate background sediment chemistry and are not attributable to anthropogenic influences. Mercury was generally below sediment quality guidelines in Lac du Sauvage, Nanuq Lake, and Ursula Lake. Sediments in these lakes are similar to results reported by Peramaki and Stone (2005) and Golder (2012). The range of sediment quality parameters in Lac du Sauvage sediments are generally in the range of sediment quality parameters for other regional lakes as follows:

- arsenic concentrations are commonly above the ISQG and even PEL in many sediments;
- cadmium, mercury, and zinc concentrations are rarely above the ISQG;

- chromium concentrations are often above the ISQG but never above the PEL (in this dataset); and,
- copper concentrations in lakes vary, and range from above the ISQG to below the ISQG.

Sediment quality in the western basin of Lac de Gras (FFA) is considered reflective of background concentrations and does not appear to be affected by anthropogenic influences. Similar to the reference lakes, concentrations of arsenic, cadmium, chromium, copper, and zinc are above sediment quality guidelines at these stations. Downstream of the Lac du Sauvage outlet (FF2) is potentially influenced by treated effluent discharge from Diavik Mine with elevated bismuth concentrations. Within the near-field and mid-field stations in the vicinity of Diavik Mine, elevated concentrations of bismuth, lead, and uranium have been measured, which suggest mine influences to sediment chemistry; these concentrations attenuate with distance from the mine. Concentrations of many parameters are higher in Lac de Gras sediments than Lac du Sauvage sediments (Table A4.5-1). The ranges reported by the Diavik and Ekati mine AEMP studies are similar to those reported by Peramaki and Stone (2005) for Lac de Gras.

Environment Canada sampled sediments in Kodiak and Counts lakes to measure PCDDs, PCDFs, and TEQ (Wilson et al. 2011). Surface samples at Kodiak Lake exceeded the ISQG threshold of 0.85 ng TEQ/kg dw. The elevated sediment concentrations of PCDD and PCDF in Kodiak Lake compared to Counts Lake suggest a mine influence (i.e., remote camp waste incineration activities) on the levels of these parameters in Kodiak Lake.

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