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12.0 SUBJECT OF NOTE: FISH AND AQUATIC HABITAT

12.1 Introduction

12.1.1 Context

This section of the Developer's Assessment Report (DAR) for the NICO Cobalt-Gold-Copper-Bismuth Project (NICO Project) consists solely of the Subject of Note (SON): Fish and Aquatic Habitat. In the Terms of Reference (TOR) for the NICO Project's DAR issued on 30 November 2009, the Mackenzie Valley Review Board (MVRB) identified fish and aquatic habitat as one of 7 top priority valued components requiring a high level of consideration by the developer (MVRB 2009).

As identified within the TOR, this SON for fish and aquatic habitat details any effects the NICO Project may have on aquatic organisms and habitat (i.e., plankton, benthic invertebrates, and physical habitat), fish abundance and communities, and health of the aquatic system.

All effects on fish and aquatic habitat by the NICO Project are assessed in detail in this SON; however, issues addressed in the following other Key Lines of Inquiry (KLOI) and SON may overlap with this SON:

- KLOI: Water Quality (Section 7);
- KLOI: Closure and Reclamation (Section 9);
- SON: Air Quality (Section 10);
- SON: Water Quantity (Section 11);
- SON: Human Environment (Section 16); and
- Section 18: Biophysical Environment Monitoring and Management Plans.

12.1.2 Purpose and Scope

The purpose of the SON: Fish and Aquatic Habitat is to assess the effects of the NICO Project on fish and aquatic habitat as outlined in the TOR issued by the MVRB. The TOR for the SON: Fish and Aquatic Habitat are shown in Table 12.1-1. The entire TOR document is included in Appendix 1.I and the complete table of concordance for the DAR is provided in Appendix 1.II.

The SON: Fish and Aquatic Habitat includes an assessment of direct effects on all life stages of fish and the aquatic habitat within the study area. This assessment includes potential changes resulting from NICO Project-related components and associated activities, including air and dust emissions, effluent discharge, water withdrawal, and watercourse crossings within the study area.

The effects assessment will evaluate all NICO Project phases, including construction, operation, and closure and reclamation. Cumulative effects are discussed throughout this section, where applicable, to a level of detail appropriate for the particular effect or Valued Component (VC) under consideration. Given the NICO Project is proposed to be constructed at the upstream end of the watershed, the effects from the NICO Project must be considered in combination with other developments, activities, and natural factors that influence fish and aquatic habitat within the study area.

Information from other components of the DAR, including air quality, water quality and quantity, and traditional and non-traditional land use, as well as information from existing developments, is incorporated in the effects assessment for fish and aquatic habitat. More detailed information on the requirements of the DAR TOR for this SON can be found in Table 12.1-1.

Table 12.1-1: Subject of Note: Fish and Aquatic Habitat Concordance with the Terms of Reference

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
3.2.3	An overall environmental assessment study area and the rationale for its boundaries;	12.3.1.2, 12.3.1.3
	Fortune's chosen spatial boundaries for the assessment of potential impacts for each of the valued components considered; and	12.3.1.2, 12.3.1.3
	The temporal boundaries chosen for the assessment of impacts on each valued component.	12.2
3.2.4	**Description of the Existing Environment** A detailed description of the existing environment is required, including current status and trends for all valued components. Wherever possible, the developer is responsible for providing a clear picture of what typical environmental conditions existed in the environmental assessment study area prior to any industrial activity occurring. This must consider the current state of the baseline conditions and the natural range of background conditions.	12.2
3.3.1	**Impact Assessment Steps and Significance Determination Factors** In assessing impacts on the biophysical environment, the *Developer's Assessment Report* will for each subsection:	
	• Identify any valued components used and how they were determined;	12.1.1, 12.1.2
	• For each valued component, identify and provide a rationale for the criteria and indicators used;	12.1.2
	• Identify the sources, timelines and methods used for data collection;	12.2
	• Identify natural range of background conditions (where historic data are available), and current baseline conditions, and analyze for discernible trends over time in each valued component, where appropriate, in light of the natural variability for each;	12.2
	• Identify any potential direct and indirect impacts on the valued components that may occur as a result of the proposed development, identifying all analytical assumptions;	12.3
	o Predict the likelihood of each impact occurring prior to mitigation measures being implemented, providing a rationale for the confidence held in the prediction;	12.3
	o Describe any plans, strategies or commitments to avoid, reduce or otherwise manage the identified potential adverse impacts, with consideration of best management practices in relation to the valued component or development component in question;	12.3
	o Describe techniques, such as models utilized in impact prediction including techniques used where any uncertainty in impact prediction was identified;	12.4

Table 12.1-1: Subject of Note: Fish and Aquatic Habitat Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
3.3.1 (continued)	• Assess and provide an opinion on the significance of any residual adverse impacts predicted to remain after mitigation measures; and	12.8.2
	• Identify any monitoring, evaluation and adaptive management plans required to ensure that predictions are accurate and if not, to proactively manage against adverse impacts when they are encountered.	Appendix 18.I
	The developer will characterize each predicted impact. These criteria will be used by the developer as a basis for its opinions on the significance of impacts on the biophysical environment.	12.7.2
3.3.6	**Fish and aquatic habitat** Describe the following potential impacts of the NICO Project on fish and aquatic habitat.	
	• Identify the fish bearing lakes and rivers that the project may affect.	12.3
	• Describe the potential impacts on aquatic life, including changes to water quality and quantity, riparian areas and any introduction of contaminants to aquatic food chains.	12.4
	• Describe in detail the mitigations Fortune will do to avoid or reduce impacts to fish and aquatic habitat, and predict the effects from the NICO Project after those mitigations.	12.3.2
Appendix A	**Existing Environment**	
	Biophysical environment Describe the biophysical environment within the relevant environmental assessment study areas. The following description should be at a level of detail sufficient to allow for a thorough assessment of NICO Project effects. Describe the following:	
	7) Aquatic organisms and aquatic habitat in the environmental assessment study area. Include waterbodies on the mine site, water sources and downstream areas. Describe the following for key aquatic species:	12.2
	a. seasonal and life cycle movements;	12.2
	b. local and regional abundance and distribution;	12.2
	c. known or suspected sensitive habitat areas for different development stages and times of year;	12.2.3
	d. the food chain that supports the species; and	12.2
	e. any known issues currently affecting fish and other aquatic life forms in the area	12.3
Appendix E	**Fish and aquatic habitat** When assessing impacts on fish and aquatic habitat:	
	1) Describe fish and aquatic habitat in Lou Lake, Peanut Lake, Nico Lake, and any other water bodies within the mine site on the Fortune claim block, Burke Lake, Hislop Lake and any water bodies the NICO access road crosses or that the development otherwise affects.	12.2

Table 12.1-1: Subject of Note: Fish and Aquatic Habitat Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
Appendix E (continued)	2) Describe the impacts of the NICO Project on aquatic organisms and habitat, including potential impacts from:	
	a. changes to flow or habitat, including alterations to banks, shores and riparian areas of waterbodies near road water crossings, and associated changes in habitat availability;	12.3.2
	b. reduced oxygen concentration;	12.3.2.1
	c. increased concentrations of metals, nutrients and other contaminations (including arsenic and mercury) in water, sediment and the aquatic food chain;	12.3.2.1
	d. increased sedimentation in watercourses and Burke Lake, especially from the mine rock management area, the mine site, airstrip and road activities; and	12.3.2.1
	e. alteration of pH.	12.3.2
	3) Describe the developer's commitments to:	
	a. mitigate any habitat losses (such as habitat creation); and	
	b. specific management activities and plans, such as the adoption of relevant Operational Statements of the Department of Fisheries and Oceans.	18, Appendix 18.I
	4) Identify best management practices to minimize impacts on fish in this type of environment (including specific consideration of activity timing windows to avoid spawning and incubation periods and proper sedimentation and erosion control measures in close proximity to water bodies), a listing of all commitments to mitigate impacts on fish, fish habitat and other aspects of the aquatic ecosystem, and, where the two differ, a rationale for why certain management practices have not been adopted.	12.3.2
	5) Describe the potential for the NICO Project to affect fish in Hislop Lake, or to affect fish downstream of the project which may migrate to Hislop Lake.	12.4.2.4
	6) Describe all water crossings along the NICO access road and roads on the mine site, providing details on flow, fish passage, sediment and erosion control measures and any monitoring plans.	Annex C
	7) Describe potential impacts to fish and fish habitat, including riparian zones, arising from construction, operation, maintenance and decommissioning of the Marian River crossing.	12.3.2.1
	8) Discuss how accidents, malfunctions or impacts of the environment on the development could create additional impacts on fish and aquatic species, and how the developer will minimize the potential for these scenarios to occur and manage them via contingency plans if they do occur.	12.3.2

Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important by society. Fish are an important ecological, cultural, and economic resource of the Northwest Territories (NWT). Disturbance and contamination of fish habitat have the potential to adversely affect fish health and populations, while contaminants in the fish and changes to the populations can have the potential to adversely affect human health.

Assessment endpoints represent the key properties of the VC that should be protected for their use by future human generations, while measurement endpoints are quantifiable (i.e., measurable) expressions of changes to assessment endpoints (Section 6.2). Assessment endpoints for fish and aquatic habitat are presented in Table 12.1-2. In addition, the measurement endpoints used to evaluate the assessment endpoints, are presented.

Table 12.1-2: Summary of the Assessment and Measurement Endpoints for Subject of Note Fish and Aquatic Habitat

Valued Component	Assessment Endpoints	Measurement Endpoints
Fish and aquatic habitat	• Persistence of fish populations and condition of aquatic habitat • Continued opportunity for traditional and non-traditional use of fish	• Habitat quantity and fragmentation • Habitat quality • Relative abundance and distribution of fish species • Survival and reproduction
People		• Access to fish • Availability of fish

12.1.3 Study Areas

12.1.3.1 General Setting

The NICO Project is approximately 160 kilometres (km) northwest of Yellowknife in the NWT (Figure 7.1-1). The NICO Project is located within the Marian River drainage basin, approximately 10 km east of Hislop Lake at a latitude of 63 °33' North and a longitude of 116 °45' West, and within the Taiga Shield and Taiga Plains Ecoregions (Ecosystem Classification Group 2007, 2008). The NICO Project spans 2 Level II Ecoregions: Taiga Shield and Taiga Plains.

The NICO Project intersects both the Lou Lake and Burke Lake watersheds. Both drainage systems discharge water to the southwest to the Marian River. The Marian River generally flows towards the south joining first with the Emile River and second with the La Martre River. The Marian River drains into Marian Lake, which drains to the North Arm of Great Slave Lake. Great Slave Lake is drained by the Mackenzie River, which discharges to the Beaufort Sea.

12.1.3.2 Regional Study Area

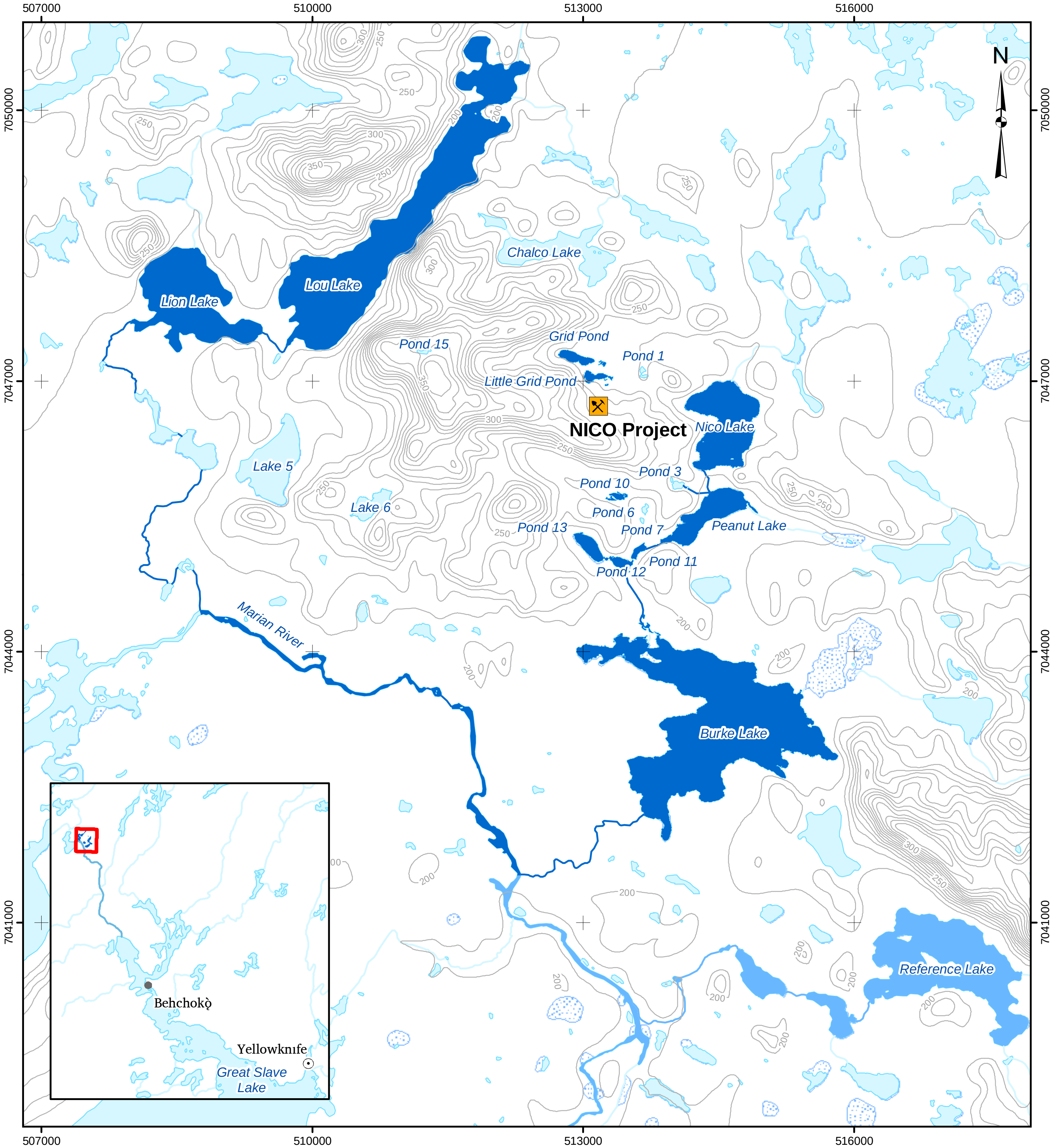
The regional study area (RSA) includes those waterbodies within the local study area (LSA) plus the Marian River to the north arm of Great Slave Lake (Figure 12.1-1). In addition, one lake located outside the area of potential impact was selected as a reference site (Reference Lake). Reference Lake was selected based on similar water quality and fauna characteristics to lakes found in the LSA and because it will not be impacted by the NICO Project. Water quality data also have been collected in the inflow and outflow of Hislop Lake in 2009 and 2010 because of the proximity to the NICO Project and importance to First Nations' communities. Hislop

Lake is located upstream of the proposed NICO Project and, therefore, will not be affected by any NICO Project discharges.

12.1.3.3 Local Study Area

The extent of the LSA is defined as the expected limit of potential direct effects on the aquatic ecosystem from the proposed mine development. The LSA includes the entire hydrologic pathway from the main ore body downstream to the Marian River, including Grid Pond, Little Grid Pond, Nico Lake, Peanut Lake, Pond 11, Pond 12, Pond 13, Burke Lake, and the Marian River downstream of the Burke Lake confluence, and their interconnecting streams (Figure 12.1-1).The LSA also includes Lou Lake, which is where the exploration camp was located and is proposed as the NICO Project water source; Lion Lake, which is downstream of Lou Lake; and Ponds 8, 9, and 10, which drain the south area of the main ore body into the Burke Lake watershed (Figure 12.1-1).

Also included in the LSA is the proposed NICO Project Access Road (NPAR), which is a 27 km access road to the NICO Project site from the existing winter road. The only permanently flowing stream found within the proposed road corridor is the Marian River (Golder 2007); therefore, only this watercourse crossing is addressed.



LEGEND

- NICO PROJECT
- CONTOUR (10 METRE INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- LOCAL STUDY AREA WATERCOURSE
- REGIONAL STUDY AREA WATERCOURSE
- LOCAL STUDY AREA WATERBODY
- REGONAL STUDY AREA WATERBODY

1.5 0 1.5

SCALE 1:60,000 KILOMETRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

NICO PROJECT LOCAL AND REGIONAL STUDY AREA

Golder Associates
Edmonton, Alberta

FILE No. E-Aqua-001-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	SM	19 Sep. 2008	FIGURE: 12.1-1	
GIS	RLP	24 Jan. 2011		
CHECK	GRA	04 May 2011		
REVIEW	GRA	04 May 2011		

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12.1.4 Content

To present the required material in an organized and readable format, the SON sections move from introductory or background information, through a detailed development description, into the existing environment and detailed effects assessment, and conclude with a clear description of the predicted impacts of the NICO Project.

The general organization of this SON is outlined in Table 12.1-3. To verify that the contents of the TOR are addressed in this report, a table of concordance that cross-references the TOR to the information and location in this DAR is contained in Table 12.1-1.

Table 12.1-3: Subject of Note: Fish and Fish Habitat Organization

Section	Content
Section 12.1	**Introduction -** Provides an introduction to the fish and fish habitat SON by defining the context, purpose and scope, study areas, and provides an overview of the SON organization
Section 12.2	**Existing Environment** - Provides a summary of the existing conditions for the NICO Project area
Section 12.3	**Pathway Analyses** - Provides a description of the pathway analyses used to identify the activities that have primary and secondary linkages to potential effects of the NICO Project on fish and fish habitat
Section 12.4	**Summary of Effects to Aquatic Habitat –** Provides a summary of the effects assessment for aquatic habitat
Section 12.5	**Related Effects to People –** Provides an assessment of the potential effects of the NICO Project with respect to fish and fish habitat on people
Section 12.6	**Residual Effects Summary** - Provides a description of the potential effects of the NICO Project on fish and fish habitat that remain after implemention of mitigation measures and reclamation
Section 12.7	**Residual Impact Classification** - Provides a summary of the impact classification for the residual effects identified in the environmental assessment
Section 12.8	**Environmental Significance** - Provides a discussion of the environmental significance of the impacts identified in the environmental assessment
Section 12.9	**Uncertainty** - Provides a discussion of the uncertainty related to the effects and impact assessments completed in the environmental assessment
Section 12.10	**Monitoring and Follow-up** - Provides a summary of the proposed monitoring and follow-up programs that will be implemented to evaluate the actual impacts of the Project on aquatic habitat and fish populations

In addition to the content included in this SON, the following provides additional detailed baseline information for and proposed monitoring and follow-up programs:

- Annex C: Aquatic Baseline Report for the Proposed NICO Project
- Annex G: Hydrology Baseline for the Proposed NICO Project
- Biophysical Environment Monitoring and Management Plans (Section 18)

12.2 Existing Environment

The following section provides a description of the existing environment in the NICO LSA and RSA that is directly relevant to this SON. Components of the existing conditions discussed herein include surface water quantity, water quality, physical aquatic habitat, lower trophic levels, and fish distribution, abundance, and life history. The focus of the descriptions below is on baseline results for each component. For more details on methods or results, supplementary information regarding the existing environment is provided in Annex C and Annex G.

12.2.1 Surface Water Quantity

The following section describes the hydrological conditions for the proposed LSA.

12.2.1.1 Methods

Lake bathymetric surveys were carried out in 2004 on the following waterbodies that may potentially be impacted by the NICO Project:

- Lou Lake
- Nico Lake
- Peanut Lake
- Burke Lake
- Grid Pond
- Little Grid Pond
- Ponds 8, 9, 10, 11, 12, and 13

Other surveyed waterbodies are summarized in Annex C and Annex G.

Where adequate depths permitted (i.e., maximum depths >2 metres [m]), surveys were completed using a Garmin GPSMap® 168 Sounder. The recorded information was then transferred to a Geographic Information System to generate bathymetry maps.

To obtain a bathymetric profile for the shallow waterbodies located in the LSA (i.e., Ponds 8, 9, 10, 11, 12, and 13, Grid Pond, and Little Grid Pond), bathymetry data were collected using a sounding ball and gauged line in combination with a depth sounder. Water depths were measured at regular intervals along transects designed to provide a general overall coverage of each waterbody. The number of transects and depths taken were proportionate to the overall waterbody size and shape.

12.2.1.2 Results

12.2.1.2.1 Project Area Lakes and Ponds

The key morphological characteristics of the lakes and ponds that potentially could be affected in the LSA are detailed in Table 12.2-1.

Table 12.2-1: Summary of Lake Morphometry

Lake	Lake Area (ha)	Lake Volume (m^3)	Maximum Lake Depth (m)
Grid Pond	3.3	32 400	2.0
Little Grid Pond	2.0	10 150	1.4
Nico Lake	51	1 570 000	7.9
Peanut Lake	23.2	824 427	11.0
Ponds 8, 9, and 10	0.9	6 321[a]	2.0
Ponds 11, 12, and 13	2.6 to 5.1	21 600 to 37 050	<1.0 to 1.9
Burke Lake	234.1	3 420 000	8.5
Lou Lake	204.7	13 400 000	>23.0

[a] Ponds 8 and 9 only.

ha = hectare; m = metre; m^3 = cubic metre; < = less than; > = greater than

Grid Ponds

Grid Pond is a small shallow waterbody located at the top of the Burke Lake watershed and receives water mostly through a small ephemeral stream and underground flow from the NICO deposit area to the northwest. Grid Pond has only one short outflow, which flows south approximately 60 m into Little Grid Pond. Grid Pond is approximately 400 m long and 110 m at its widest point. It is a shallow waterbody with a flat bottom (see Annex C: Figure 2.2-1). Grid Pond has an average depth of 0.98 m, maximum depth of just over 2.0 m, and a total volume of 32 400 cubic metres (m^3).

Little Grid Pond is a small, shallow (maximum 1.4 m depth) waterbody (see Annex C: Figure 2.2-2). It has one inflow from Grid Pond to the northwest and no discernable outflow, as the pond drains to the east through the muskeg, eventually discharging into Nico Lake. Little Grid Pond is approximately 325 m in length and has a maximum width of approximately 140 m. The mean depth of Little Grid Pond was approximately 0.53 m, with an estimated total volume of about 10 150 m^3.

Ponds 11, 12, and 13

Peanut Lake discharges to the southwest, through a series of beaver impoundments, with the creek eventually entering Pond 11, about 200 m downstream from Peanut Lake. Pond 11 is a small, shallow waterbody (<1.0 m depth) (see Annex C: Figure 2.2-6). Pond 11 discharges directly into a small triangular shaped waterbody, Pond 12, to the southwest.

Pond 12 is a small waterbody with a maximum length of about 200 m and a maximum width of about 260 m. Pond 12 receives water from Pond 11 to the east and Pond 13 to the west; it then discharges through a series of beaver impoundments to the south for approximately 800 m before entering Burke Lake. Pond 12 has a total area of about 2.9 ha and an estimated volume of 21 600 m^3. Pond 12 had a maximum depth of 1.9 m, and a mean depth of about 0.76 m.

Pond 13 is a shallow, oval pond, with no discernable inflow. It has a maximum length of approximately 420 m, a mean depth of about 0.72 m, and a maximum depth of about 1.5 m. Pond 13 is the largest of the 3 ponds, with a surface area of approximately 5.1 ha and a volume of about 37 050 m^3.

Ponds 8, 9, and 10

Ponds 8, 9, and 10 are hydrologically connected waterbodies (i.e., form a pond or wetland complex) with one small ephemeral inflow originating from the northwest and one small outflow from the east side of Pond 8 flowing through a series of beaver impoundments before entering Pond 11. The system does not directly drain into Peanut Lake. The maximum depth of the 3 ponds was 2.0 m, found in the central basin (Pond 9) (see Annex C: Figure 2.2-5), and the mean depth was below measurable limits (<1.0 m). Total open water surface area of the 3 ponds was approximately 0.9 ha. Because detailed bathymetric data could not be collected for Pond 10 due to insufficient depth, the estimated total volume of 6321 m^3 represents Ponds 8 and 9, only.

Nico Lake

Nico Lake is approximately 1.0 km long, with an average width of 610 m and a maximum width of 800 m. The lake is a crescent shaped waterbody and has 3 small islands. Nico Lake has a total wetted area of approximately 51.0 ha and contains an estimated total volume of 1.57 million cubic metres (M-m^3). Nico Lake has one discernable inflow, originating from a muskeg area to the north, but the main source of water into Nico Lake originates from the Grid Ponds to the west, which drain through muskeg and underground flow into the lake. Nico Lake has a single moderately deep basin, with a mean depth of 3.1 m and maximum recorded depth of 7.9 m, near the south end of the lake (see Annex C: Figure 2.2-3).

Peanut Lake

Peanut Lake has a maximum length of 1080 m, and a maximum width of about 380 m. The primary inflow into Peanut Lake is from the east, with 2 other small inflows draining the muskeg to the east and a series of small lakes, including Nico Lake, to the north.

The north and south ends of Peanut Lake were characterized with shallow sloping bathymetric profiles (see Annex C: Figure 2.2-4). One small basin with a maximum depth of 8 m was found in a small embayment by the northwest shoreline. The second, larger basin formed the remainder of the lake and had a maximum depth of approximately 11 m. Maximum depth of Peanut Lake was somewhat variable throughout the study, as lake levels fluctuated due to the presence of a beaver impoundment on the lake outflow, but generally ranged between 10.5 and 11.0 m, with a mean lake depth of 3.5 m. At the time of data collection in 2004, the total volume of Peanut Lake was estimated at 824 427 m^3, and the lake covered a surface area of about 23.2 ha.

Burke Lake

Burke Lake is the largest lake found in the NICO Project LSA. It has a surface area of about 234.1 ha, an estimated volume of 3.42 M-m^3, and a maximum length of approximately 3 km (Annex C). Burke Lake has 2 northern inflow streams and one outflow, which drains into the Marian River, 1.5 km to the southwest. The primary Burke Lake inflow drains Pond 12, which has inflows that originate from the NICO Project deposit area. The other inflow drains the muskeg to the northeast.

The Burke Lake bathymetric profile is dominated by a large, shallow basin, and the deepest location was found in the north-central area of the lake (see Annex C: Figure 2.2-7). The mean depth of the lake was approximately 1.5 m, and the maximum recorded depth was 8.5 m.

Lou Lake

Lou Lake is a long, narrow waterbody with a maximum length of approximately 4 km. Although Lou Lake is not located along the hydrologic path that originates from the mine site, this lake will serve as the primary water source for mining operations and as the potable water source. Lou Lake has 2 inflows at the northern end of the lake and one short outflow (350 m in length) draining southwest into Lion Lake.

Lou Lake consists of 3 main basins (Figure 12.2-5). The north and south basins were of similar size and depth, and had maximum recorded depths of 15.5 m and 13.5 m, respectively. The central basin was much deeper than the other 2 basins and reached depths exceeding 23.0 m. Although Lou Lake covers an area of 204.7 ha, it had a mean depth of 6.6 m, resulting in an estimated volume of 13.4 M-m^3, exceeding the estimated volume of any other lake in the Project area.

12.2.2 Surface Water and Sediment Quality

The following section provides an overview of the baseline surface water quality and sediment quality for the NICO LSA that is directly relevant to this SON. A forest fire burned through the Marian River watershed from mid July to early August 2008 and affected some of the watersheds within the LSA as well as the Reference Lake watershed. Impacted areas included a burnt section between Nico and Peanut lakes, and the shorelines of Burke and Reference lakes. The most intense burn period was in early August 2008. For additional information regarding surface water and sediment quality, including dissolved oxygen (DO)-temperature profiles and a comparison of water and sediment quality before and after the forest fire, the reader is referred to Section 7.3 and Annex C.

12.2.2.1 Surface Water Quality

12.2.2.1.1 Methods

Water quality monitoring was undertaken in lakes and streams located within 3 drainage systems that flow into the Marian River (i.e., the Burke Lake watershed, Reference Lake watershed, and Lou Lake watershed). The Marian River flows south from the NICO Project area and ultimately flows into Great Slave Lake. Lake and pond stations included Grid Pond, Little Grid Pond, Nico Lake, Peanut Lake, Burke Lake, Reference Lake, Lou Lake, and Ponds 4, 8, 9, 11, 12, and 13. The inflow and outflow to Hislop Lake, located upstream of the Project area, were also sampled. Hislop Lake drains into the Marian River. Data used in the assessment were from open-water and under-ice sampling surveys during select periods between 2005 and 2010.

Monitoring stations were established at 2 sampling locations representing shallow and deep regions (basins) in Reference, Burke, Lou, Nico, and Peanut lakes. At sites with water depths >3 m, one water sample was collected 1 m from lake bottom using a Kemmerer water sampler and another sample was collected from near the water surface by hand. At shallower sites, one surface grab sample was collected. In-situ field measurements of pH, water temperature, DO, and conductivity, were collected at the time of sampling. Temperature and DO measurements were collected throughout the water column at 1 m increments, starting at 1 m above the lake bottom. Where depths permitted, Secchi depths (a common measure of water transparency) were measured.

Streams within the LSA and Reference Lake inflow/outflow were sampled at existing hydrology monitoring stations, where available. Sampling focused mainly on the open-water period, but limited winter sampling was undertaken in March/April 2008 to 2010. Water samples were collected about 0.1 m below the water surface in the middle of each watercourse. In situ field measurements also were collected at the time of sampling.

Water samples were analyzed for a suite of parameters, including for conventional parameters (e.g., totals suspended solids, laboratory conductivity, laboratory pH), major ions, total and dissolved nutrients, and total and dissolved metals, metalloids, and non-metals[1]. Arsenic speciation was determined in water samples collected during the open-water and under-ice periods in 2008.

12.2.2.1.2 Results and Discussion

Mine development associated with the Project is proposed to occur predominantly within the Burke Lake watershed. The Grid ponds at the top of the Burke Lake watershed are located in close proximity to the main ore body within an area that is naturally rich in arsenopyrite and muskeg. The water quality of these ponds is characteristically different from that of other waterbodies within the LSA that are located farther downstream. For example, Grid Pond and Little Grid Pond have substantially higher total ion concentrations and are moderately hard compared to the low ion content, near-neutral pH, low to moderate alkalinity and soft waters of the other waterbodies. The hydrological path extends from the Grid ponds down through muskeg to Nico Lake, and then to Peanut and Burke lakes via connecting streams and ponds, and finally to the Marian River.

Similar to other watersheds within the vicinity of Yellowknife, arsenic is naturally elevated in the water column of some waterbodies within the Burke Lake watershed, particularly in the headwaters close to the ore body (e.g., the Grid ponds, Nico Lake). Arsenic concentrations typically decrease along the hydrological gradient from Grid Stream to Burke Lake. The main natural sources of arsenic are weathering and erosion of arsenic-containing rocks and soil (Wang and Mulligan 2006). At the top of the gradient (in the inflow to Grid Pond, Grid Pond, and Little Grid Pond), arsenic concentrations often exceeded 200 micrograms per litre (µg/L), which is 40 times the Canadian Council for Ministers of the Environment Canadian Water Quality Guidelines (CWQG; CCME 1999). Within the LSA, arsenic is mostly present in dissolved forms, which are considered to be potentially more bioavailable to aquatic life. However, when concentrations are naturally elevated in mineralized areas, such as the LSA, resident aquatic biota adapt to prevailing conditions through various compensatory mechanisms. The CWQGs are intended for national application, and are inherently conservative, as they do not take into account site-specific considerations, such as naturally elevated concentrations and the acclimation of resident biota (CCME 2007b).

There was a marked reduction in total arsenic concentrations downstream of the Grid Ponds. Total arsenic concentrations were elevated in Nico Lake, Grid Pond, and Little Grid Pond, and showed a substantial concentration gradient between Nico and Burke lakes. Elevated total arsenic concentrations were measured in Nico Lake, before and after the 2008 forest fire. Total arsenic concentrations were higher in Nico Lake and Peanut Lake after the 2008 forest fire. Between Peanut and Burke lakes, pre-fire values dropped below the CWQG. After the forest fire, arsenic concentrations increased in Nico Lake, Peanut Lake, Reference Lake, Pond 11, and inflows to Nico and Burke lakes. Baseline arsenic concentrations in Burke Lake and the Marian River were low (<1 µg/L) and below the CWQG, as were arsenic concentrations in Reference, Lou, and Hislop lakes, which were not hydrologically connected to the Grid ponds.

Natural guideline exceedences were observed for several other metals. Open-water and/or under-ice median concentrations of iron were elevated above the CWQG (0.3 mg/L) in Nico Lake, but below the CWQG in Peanut, Burke, Reference, and Lou lakes. The main exception was close to the sediment in the deep basins of these lakes after the forest fire in 2008, when higher iron concentrations were measured. Exceedences of CWQGs were also observed for aluminum, cadmium, copper, and mercury in the Grid ponds, Nico Lake, Peanut Lake, and Burke Lake. As with arsenic, concentrations of these metals decreased downstream of the Grid ponds.

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

Waterborne selenium concentrations in monitored LSA waterbodies were either close to or below the analytical detection limits and were below the CWQG (1 µg/L).

Nutrient concentrations in LSA waterbodies were higher than would be normally expected in northern subarctic lakes, which tend to be nutrient poor (e.g., Golder 2009; DeBeers 2010; Golder 2010). Monitored lakes and ponds in the LSA were classified as mesotrophic to meso-eutrophic (i.e., moderately productive) according to total phosphorus (TP) concentrations, with the exception of the Grid ponds. The Grid ponds had higher TP concentrations than downstream waterbodies and were classified as eutrophic (i.e., highly productive). Nico Lake was classified as mesotrophic/meso-eutrophic, whereas Peanut, Reference, Burke, and Lou lakes were classified as mesotrophic.

12.2.2.2 Sediment Quality

12.2.2.2.1 Methods

Lake and pond sediments were sampled concurrently with water sampling in July 2005, August 2005, August 2008, and August-September 2009. Sediment sampling locations were located within 3 drainage systems that flow into the Marian River (Burke Lake watershed, Reference Lake watershed, and Lou Lake watershed). Sediment samples were collected from Nico Lake, Peanut Lake, Burke Lake, Lou Lake, and Reference Lake, as well as from several ponds (i.e., Grid Pond, Little Grid Pond, and Ponds 4, 9, 11, 12, and 13). Samples were collected by Ekman grab sampler (surficial grab) or by Tech-Ops™ core sampler (upper 2 cm horizon). A comparison of the two sampling methods indicated that there were no substantial differences in resulting metal concentrations. Sediment samples were analyzed by an accredited analytical laboratory for metals (all years), major ions (2005), total Kjeldahl nitrogen (2005), and polycyclic aromatic hydrocarbon (a sub-set of 5 stations in 2009).

12.2.2.2.2 Results and Discussion

The following section describes the results of the metals analyses in the sediments; for more information on other parameters, the reader is referred to Section 7.3 and Annex C.

Mine development is proposed to occur predominantly within the Burke Lake watershed. Metal concentrations in sediments of this watershed are elevated above those measured in the Reference Lake or Lou Lake watersheds. The Grid ponds at the top of the Burke Lake watershed are located within close proximity of the main ore body, and, in general, metal concentrations in sediments from these ponds were naturally elevated above other lakes and ponds. The hydrological pathway from the Grid ponds flows down through Nico, Peanut, and Burke lakes before reaching the Marian River. Concentrations of arsenic, copper, selenium, antimony, cobalt, and molybdenum in the Grid ponds were consistently greater than 10 times Reference Lake sediment concentrations, and tended to be higher than those measured in downstream lakes and ponds (this was particularly pronounced for arsenic and copper).

There was a decrease in metals concentrations in sediment from the Grid ponds and Nico Lake (located at the top of the watershed) with distance from the ore body (Peanut Lake to Burke Lake). This trend was particularly evident for arsenic. Concentrations of arsenic in the Grid Ponds and Nico Lake sediment were more than 10 times greater than those measured in Reference Lake sediments in any sampling year. In Burke Lake, arsenic sediment concentrations were less than 2 times those in the Reference Lake.

12.2.3 Aquatic Habitat

The following section provides an overview of the baseline aquatic habitat for lakes and streams in the LSA included in the effects assessment. For additional information regarding aquatic habitat (including habitat maps), the reader is referred to Annex C.

12.2.3.1 Methods

Habitat assessments, including seasonal fish spawning surveys, were conducted during 8 years between 1998 and 2009. Each of the sampling programs focused on the collection of seasonally relevant data.

Lake habitat for lakes and ponds included in the effects assessment was mapped for Grid and Little Grid ponds, Nico, Peanut, Burke, and Lou lakes, as well as for Ponds 8, 9, 10, 11, 12, and 13, during the 2004 surveys. Results from additional surveyed lakes, including Chalco, Lion, and Reference lakes, are presented in Annex C (Aquatics Baseline).

Stream habitat assessments and potential spawning areas in Grid Stream, Nico Lake Outflow, Peanut Lake Outflow, Burke Lake Outflow, and Lou Lake Outflow were identified and mapped during the 2005 and 2006 surveys. Additional ground-truthing was carried out in 2009 to verify habitat conditions and overwintering potential.

12.2.3.2 Results

Potential spawning, rearing, holding, and over-wintering habitats were identified for northern pike (*Esox lucius*), lake whitefish (*Coregonus clupeaformis*), white sucker (*Catostomus commersonii*), longnose sucker (*Catostomus catostomus*), cisco (*Coregonus artedi*), burbot (*Lota lota*), and walleye (*Sander vitreus*) in the LSA lakes, ponds, and streams (Table 12.2-2).

Spawning habitats for northern pike were identified in Nico, Peanut, and Burke lakes, as well as Ponds 11, 12, and 13, and several inflows and outflows to these waterbodies (Table 12.2-2). The presence of eggs or spawning adults confirmed the use of the identified spawning habitat in Peanut and Burke lakes, and the outflows of Burke and Lou lakes. Juvenile fish were captured in Nico, Burke, and Lou lakes, Ponds 9, 11, 12, and 13, the outflows of Peanut and Burke lakes, Pond 12 Outflow, and the Marian River (Table 12.2-2).

Table 12.2-2: Habitat Summary for Lakes and Streams Sampled in the NICO LSA, 2005 to 2009

Waterbody	Species	Spawning/ Rearing Potential	Spawning Fish/ Egg Presence Documented	Juvenile Presence Documented	Overwintering Potential
Grid Stream	small-bodied fish (not present)	good	no	no	none
Grid and Little Grid Ponds	small-bodied fish (not present)	good	no	no	none
Nico Lake	Northern pike	good	no	yes	marginal
Nico Lake Outflow	White sucker	good	no	no	none
Peanut Lake	Northern pike	good	no	no	marginal
	Lake whitefish	good	yes	no	marginal
Peanut Lake Outflow	Northern pike	good	no	yes	none
	White sucker	good	no	yes	none

Table 12.2-2: Habitat Summary for Lakes and Streams Sampled in the NICO Project Area, 2005 to 2009 (continued)

Waterbody	Species	Spawning/ Rearing Potential	Spawning Fish/ Egg Presence Documented	Juvenile Presence Documented	Overwintering Potential
Ponds 8, 9, and 10	Northern pike	marginal	no	yes	none
Ponds 11, 12, and 13	Northern pike	good	no	yes	none
	White sucker	poor	no	no	none
Pond 12 Outflow	Northern pike	good	no	yes	none
Burke Lake	Northern pike	good	yes	yes	good
	Lake whitefish	good	no	no	marginal
Burke Lake Outflow	Northern pike	good	no	yes	none
	White sucker	good	yes	no	none
Lou Lake Inflow	Northern pike (not captured)	marginal	no	no	none
Lou Lake	Northern pike	good	no	yes	good
	Lake whitefish	good	yes	yes	good
	Longnose sucker	good	no	no	good
	White sucker	good	no	no	good
	Walleye	good	no	yes	good
	Cisco	good	no	no	good
Lou Lake Outflow	Northern pike	good	no	no	none
	Lake whitefish	none	no	no	none
	White sucker	good	yes	no	none
	Walleye	good	yes	no	none
Marian River (road crossing area)	Northern pike	marginal	no	yes	good
	White sucker	good	no	yes	good

Lake whitefish spawning and rearing habitats were identified in Peanut, Burke, and Lou lakes, as well as Lou Lake Inflow and Outflow. Presence of eggs or spawning adults confirmed use of these identified spawning habitats in Peanut and Lou lakes (Table 12.2-2).

Walleye spawning and rearing habitat was identified in Lou Lake and Lou Lake Outflow. Eggs were found in the identified spawning habitat in Lou Lake Outflow, and juvenile walleye were captured in Lou Lake (Table 12.2-2).

The lakes in the study area and the Marian River provide overwintering habitat for fish; however, the ponds and streams are typically shallow and likely freeze to the substrate or near to the substrate most winters (Table 12.2-2).

12.2.3.2.1 NICO Project Area Lakes and Ponds

Grid and Little Grid Ponds

The shoreline of Grid Pond featured primarily cobble/gravel substrate, with a small area of boulder/cobble substrate on the northeast shoreline. The main basin and a small area along the north shoreline were composed of organic/silt substrate.

The entire basin of Little Grid Pond was dominated by organics/silt substrate. Emergent and inundated vegetation dominated the shoreline. A small wetland area was present at the east end of the pond.

Grid Pond and Little Grid Pond do not appear to support fish communities due to the poor water quality (e.g., elevated metals) and shallow depths. Both ponds have maximum depths of 2 m or less, suggesting that they freeze to the substrate in winter. Fish were not captured in these waterbodies during the 2003 and 2005 surveys.

Nico Lake

The surveyed shoreline zones extended to approximately 3 m depth. The shoreline substrate of Nico Lake was dominated by cobble/gravel on the west and north shores, with one small area of organics/silt on the northwest shore. Organics/silt was the dominant substrate on the east and south shores, with 2 small areas of boulder/cobble. Emergent vegetation was present in the organics/silt area along the northwest shore, as well as along the southwest and southeast shores. Narrow bands of wetland were present along the north shore and the southwest shore.

Potential northern pike spawning and rearing habitat was identified in the areas of emergent vegetation on both the organics/silt and cobble/gravel substrates. During spring spawning surveys, juvenile northern pike were present in the identified suitable spawning areas along the northwest and southwest shores. Overwintering habitat was available in the main basin of the lake, which reached a maximum depth of 8 m.

Peanut Lake

Peanut Lake is a moderately deep waterbody, with a maximum depth of approximately 11 m. The shoreline substrate was composed primarily of organic/silt substrate, with emergent vegetation at the northeast and southwest ends of the lake. One small cobble/gravel area was present in a steep slope area near the west shore, extending from 2 m depth to approximately 6 m.

The vegetated areas potentially provide suitable spawning and rearing habitat for northern pike. Spawning lake whitefish were captured during fall assessments in 2006, 2007, and 2009 on the gravel/cobble shoal near the northwest shoreline. The deeper basin of the lake provides overwintering habitat for fish.

Ponds 8, 9, and 10

The substrate of Ponds 8, 9, and 10 is primarily organics/silt and each pond is surrounded by emergent vegetation. The vegetated habitats in these ponds could provide potential spawning and rearing habitat for northern pike, although the ponds are connected to other fish bearing waterbodies only intermittently during high water events. Pond 9 is the deepest of the 3 ponds, with a maximum depth of 2 m, suggesting that all 3 ponds freeze to or near to the substrate in the winter. One juvenile northern pike was captured in Pond 9 in gill nets set in June 2008, but fish were not captured during gill netting in August 2009. The shallow nature of these waterbodies and limited connectivity to downstream habitats results in these ponds providing only marginal fish habitat.

Pond 11, 12, and 13

The main basins of Ponds 12 and 13 were less than 2 m deep, with organics/silt substrate surrounded by emergent vegetation and woody debris dispersed within the open areas of the ponds. Pond 11 was shallow and consisted entirely of emergent vegetation in organics/silt substrates. All 3 ponds likely freeze to the substrate during winter.

The shallow vegetated habitats in the 3 ponds provide potential spawning and rearing habitat for northern pike. In total, 5 juvenile northern pike were captured or observed in Pond 12 during fish sampling surveys, and 6 northern pike were captured in Pond 13. One white sucker was captured in Pond 12. Spawning habitat was not identified for white sucker.

Burke Lake

The majority of Burke Lake is less than 4 m deep, with one deep hole (8.5 m) on the northeast side. The shoreline is dominated by organics/silt. The south shoreline is approximately 50 percent (%) boulder/cobble, and the east and west shorelines each have a section of cobble/gravel. Emergent vegetation was present on the northwest, southwest, and east ends of the lake, as well as in the pond connected to the northeast side of the lake. Beaver dams were observed at the north inflow and the southwest outflow of Burke Lake.

The shallow, vegetated areas in the northwest, southwest, and east ends of Burke Lake, as well as the shallow vegetated pond to the east, provide potential spawning and rearing habitat for northern pike. Potential lake whitefish spawning and rearing habitat was identified in the cobble/gravel and boulder/cobble substrates on the east, south, and west sides of the lake.

Juvenile northern pike were observed within the northwest arm and several northern pike eggs were found along the north shore to the east of the inflow. Two spent females and one spent male northern pike were captured near the inflow from the north (Pond 12 Outflow). Ripe and seasonally developed lake whitefish were captured in the identified spawning areas during the fall sampling programs in 2005, 2006, 2007, and 2009.

Lou Lake

Lou Lake is a long, narrow lake, characterized by a steep shoreline along the east side of the lake, and depths in excess of 23 m in the central portion of the lake. The west shore of Lou Lake has a more gradual slope, with cobble and gravel substrates.

The near-shore substrates were dominated by organics/silt. The southwest end of the lake consisted of cobble/gravel substrate, and boulder/cobble substrate was reported in 2 areas on the east shore near the northern end of the lake. Three deeper areas were present in Lou Lake. The northern area had a depth of 15 m, and the southern area had a depth of 13 m; the deepest area (23 m) was recorded in the middle of the basin.

The north end of the lake has abundant emergent vegetation, which provides northern pike spawning and rearing habitat. Northern pike fry were found in these shallow areas at the far north end of the lake to the west of the northeast inflow.

Potential lake whitefish, walleye, cisco, and sucker species spawning and rearing habitats were identified in the cobble/gravel area at the south end of Lou Lake. Adult lake whitefish in ripe spawning condition and juveniles were captured in this area during the 2005 to 2007 fish surveys.

12.2.3.2.2 NICO Project Area Streams

Grid Stream

Grid Stream is a narrow, low flow stream that originates from subsurface flow approximately 300 m west of Grid Pond. A small bog drains into Grid Stream near the origin of the defined channel upstream of the existing exploration road, and flows through the muskeg area west of Grid Pond. The main stream channel ranged from 0.5 to 0.9 m in width, with depths between 0.1 and 0.5 m. One small pond area (8 by 30 m) was present approximately 40 m downstream of the road crossing. Most of the stream substrate consisted of boulders, with cobble in the section near Grid Pond and silt at the upstream origin. A steep bedrock shelf was present approximately halfway between the existing road and Grid Pond.

Sampling in the creek indicated fish were not present, likely due to poor water quality (e.g., high metals), limited flow, and shallow depth (i.e., would freeze to the bottom in winter).

Nico Lake Outflow

Nico Lake Outflow flows through muskeg/grass riparian habitat within mixed forest. The stream ranged from approximately 2 to 5 m in width, and depth ranged from 0.3 to 0.8 m, suggesting that the stream freezes to the substrate over winter. The upper reaches of the stream alternate between sections of riffle and shallow run habitats with primarily cobble and boulder substrates. The middle reach of the stream consists of a series of low vertical drops composed of bedrock substrates through a narrow channel. The lower reaches of the stream alternate between sections of shallow pool and shallow run habitats, separated by low vertical drops. The substrates were primarily boulder and cobble.

Overhanging shrubs and vegetation lined the banks of most of the stream channel, providing cover for fish. Woody debris and fallen trees also provide cover for fish within the stream channel. The shallow depths over small cobble substrates may provide spawning and rearing habitat for white sucker, though the vertical drops may impede fish migration through the stream. A spring spawning survey completed in June 2006 from Nico Lake downstream to Peanut Lake, did not find evidence of deposited eggs or observations of any spawning fish.

Peanut Lake Outflow

Peanut Lake Outflow flows through coniferous forest to Pond 11. The stream headwater is a divided channel originating from a beaver dammed area at the outflow of Peanut Lake. The stream ranged from 0.3 to 0.9 m in depth and was approximately 2 to 20 m wide. The substrate in the upper reaches of the divided channel consisted primarily of silt and organics. The remainder of the channel was dominated by cobble, with boulders and small areas of gravel and sand. Cover for fish was provided by patches of emergent vegetation that were often associated with large boulders in the channel, and sections of woody debris.

The northern channel in the upper reach featured riffle habitat and the middle channel consisted of shallow run and riffle habitat. The south upper channel alternated between shallow run and riffle, with a wide section of shallow pool habitat. The mid and lower reaches of the stream consisted of riffle and shallow run habitat.

Potential spawning and rearing habitat for white sucker was available in the shallow run stream sections with gravel/cobble substrates. Northern pike spawning and rearing habitat was also available in the shallow vegetated sections of Peanut Lake Outflow. During the June 2005 survey of Peanut Lake Outflow, 2 juvenile white sucker were captured in the main channel after the confluence of the 3 channels, and 1 juvenile northern pike was captured below the beaver dam in the northern channel.

Pond 12 Outflow

Pond 12 Outflow drains Pond 12 into the north basin of Burke Lake This stream is a wide, slow moving channel with emergent vegetation, woody debris, and several fallen trees. The substrate in the surveyed area was silt/sand. The vegetated areas provide suitable spawning and rearing habitat for northern pike. One northern pike juvenile was captured in this stream in August 2005.

Burke Lake Outflow

Burke Lake Outflow flows southwest through mixed and coniferous forest to the Marian River. The channel ranges from approximately 3 to 25 m in width, with maximum depths greater than 1 m. Most of the stream channel likely freezes to the substrate in winter. The upper reaches of the stream were dominated by riffle habitats. Small vertical falls were present approximately 55 and 70 m downstream of Burke Lake. The lower sections contained shallow run and riffle habitats (Annex C).

Most of the stream substrate was cobble with boulder or gravel. Sections of silt/sand and silt/organics were present in the upper and lower reaches of the stream. Coarse and fine substrate bars were present in the upper reach of the stream. Boulder and gravel deposits were common throughout the surveyed stream section. Unstable, undercut banks lined approximately two-thirds of the surveyed section and overhanging shrubs also provided some cover for fish. Emergent vegetation was abundant in upstream areas. Several backwaters and eddies provide resting areas for fish.

Potential spawning and rearing habitat was available for white sucker in the shallow gravel and cobble areas. White sucker eggs were found in a shallow area (0.48 m depth) of slow moving water directly behind a large boulder. The eggs were located in gravel and large cobble substrate in an area where there was a widening of the stream (25 m at the widest point).

Potential northern pike spawning and rearing habitat was identified in several shallow vegetated sections of the stream. A juvenile northern pike was captured near the water quality station near the Marian River, within a shallow, silty backwater pool off the main channel of the stream.

Lou Lake Inflows and Outflow

Lou Lake has 2 inflows, one from the north and one from the east, which enter the lake at the northeast end. The inflows are characterized by silt substrate, due to the numerous beaver impoundments present in the system. Although this section of creek has the potential to provide spawning and rearing habitat for northern pike, the impoundments likely restrict fish movements into the stream during most of the year. A spring spawning survey in June 2006 did not record any fish in the system.

Lou Lake Outflow is a short stream flowing southeast from Lou Lake. The stream ranged from approximately 5 to 10 m in width, and 1 to 2 m in depth. The substrate in the deep run habitat near Lou Lake consisted primarily of boulders, with a coarse substrate bar along the east shore where the stream widens. Small gravel/silt patches were present in the northern portion of the stream. Downstream from the boulder section, the stream widens into a deep flat habitat, with silt/sand substrates. The shorelines were lined with inundated grasses and emergent vegetation.

Cobble/gravel substrates provide suitable spawning and rearing habitat for white sucker and walleye. Eggs of both species were found in the cobble area of Lou Lake Outflow in 2005 and 2006. The area also had sparse submergent and emergent horsetail.

The vegetated shorelines provide potential spawning and rearing habitat for northern pike. Northern pike fry were found within an open area dominated by submergent and emergent grasses and horsetail, which confirmed stream use for rearing.

12.2.3.2.3 Marian River

Several areas of potential spawning and rearing habitat were sampled in the Marian River near the proposed road crossing in an attempt to document the presence of fry and eggs. A section of rapids was present downstream of the NPAR crossing location, likely a barrier to upstream migration A vegetated, silt/sand backwater along the right downstream bank downstream of the crossing was sampled. Several unidentified young-of-the-year fish and unidentified small-bodied fish were observed. One juvenile white sucker was captured.

A small inflow is present on the left downstream bank downstream of the crossing. The mouth of the stream had cobble/gravel substrate on the left downstream bank and organic/silt substrate with emergent vegetation on the right downstream bank. No fish fry or eggs were found. Upstream of the crossing, a deep silt substrate backwater pool was present on both the right downstream bank and left downstream bank. Several small northern pike were observed in the right downstream bank backwater, and several unidentified young-of-the-year fish were captured in the left downstream bank backwater.

Spawning potential for white sucker and lake whitefish was considered low, because of the small amount of cobble/gravel substrate present at the crossing. However, the presence of young-of-the-year suggests that spawning for these species (e.g., lake whitefish and white sucker) may occur elsewhere within the Marian River.

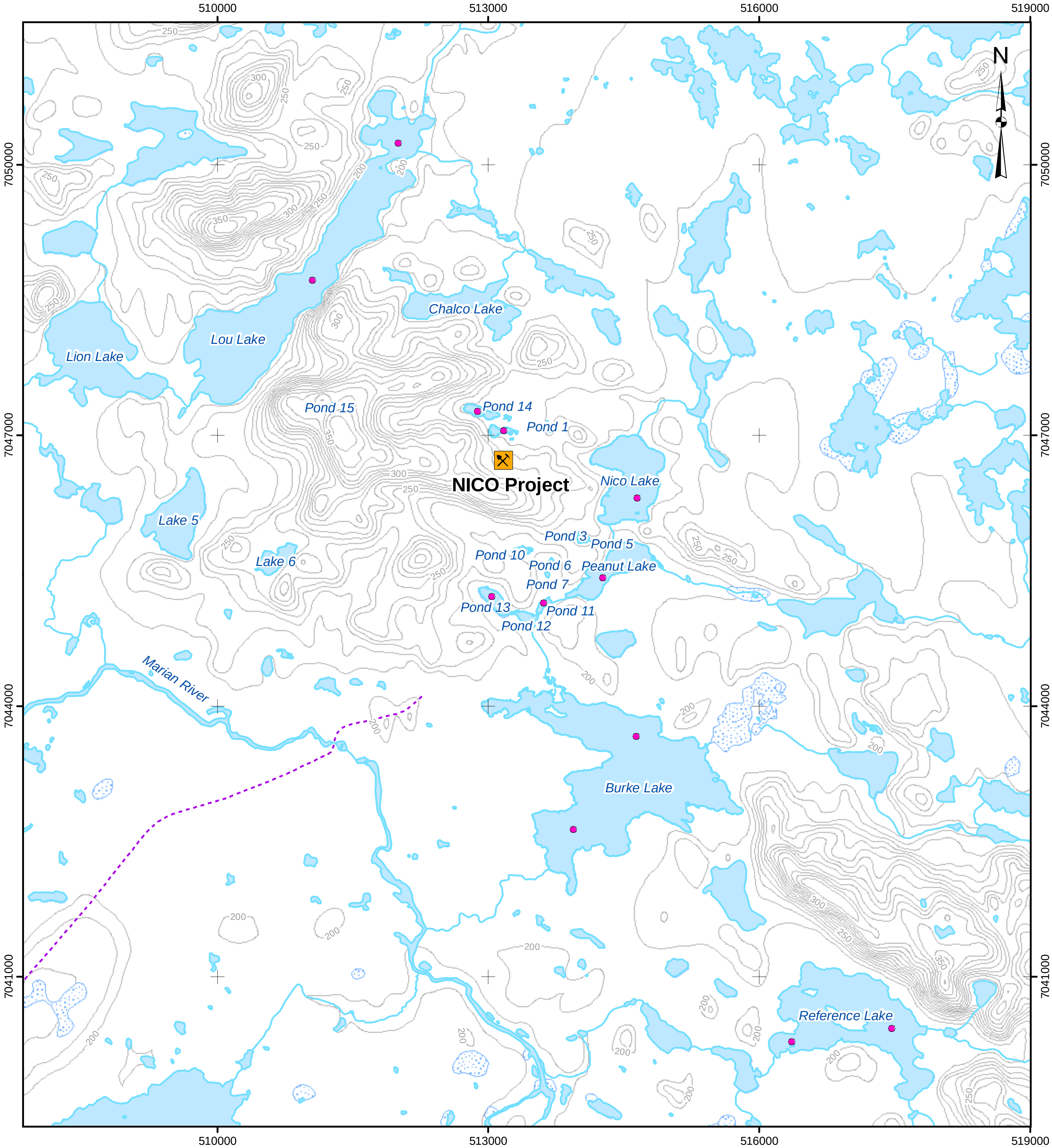
12.2.4 Lower Trophic Levels

The following section describes the baseline conditions for the lower trophic level communities (i.e., plankton and benthic invertebrates) for the NICO Project. For additional information regarding lower trophic levels, refer to the limnology and lower trophic level sections of Annex C.

12.2.4.1 Methods

Lower trophic level studies in the Fortune RSA were performed in 2005 and 2009. Plankton and zooplankton community samples, as well as chlorophyll *a* samples, were collected from 9 waterbodies associated with the Project (Figure 12.2-1). Benthic invertebrate community samples were collected from 1 or 2 stations (Figure 12.2-2), depending on water depth, at 11 waterbodies using a standard Ekman grab.

Plankton and benthic invertebrate community samples were processed following published methods (e.g., Moss 1967a, b; Bottrell et al. 1976; Wrona et al. 1982). Results are presented for those waterbodies potentially impacted by the NICO Project as well as for Reference Lake. Details regarding additional waterbodies are presented in Annex C (Aquatics Baseline).



LEGEND

	NICO PROJECT		PLANKTON SAMPLING LOCATION
	CONTOUR (10 METRE INTERVAL)		
	PROPOSED NICO PROJECT ACCESS ROAD		
	WATERCOURSE		
	WATERBODY		
	WETLAND		

1.5 0 1.5

SCALE 1:60,000 KILOMETRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

PLANKTON SAMPLING LOCATIONS, 2005

Golder Associates
Edmonton, Alberta

FILE No. E-Aqua-027-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	SM	19 Sep. 2008	FIGURE: 12.2-1	
GIS	RLP	25 Jan. 2011		
CHECK	GRA	04 May 2011		
REVIEW	GRA	04 May 2011		

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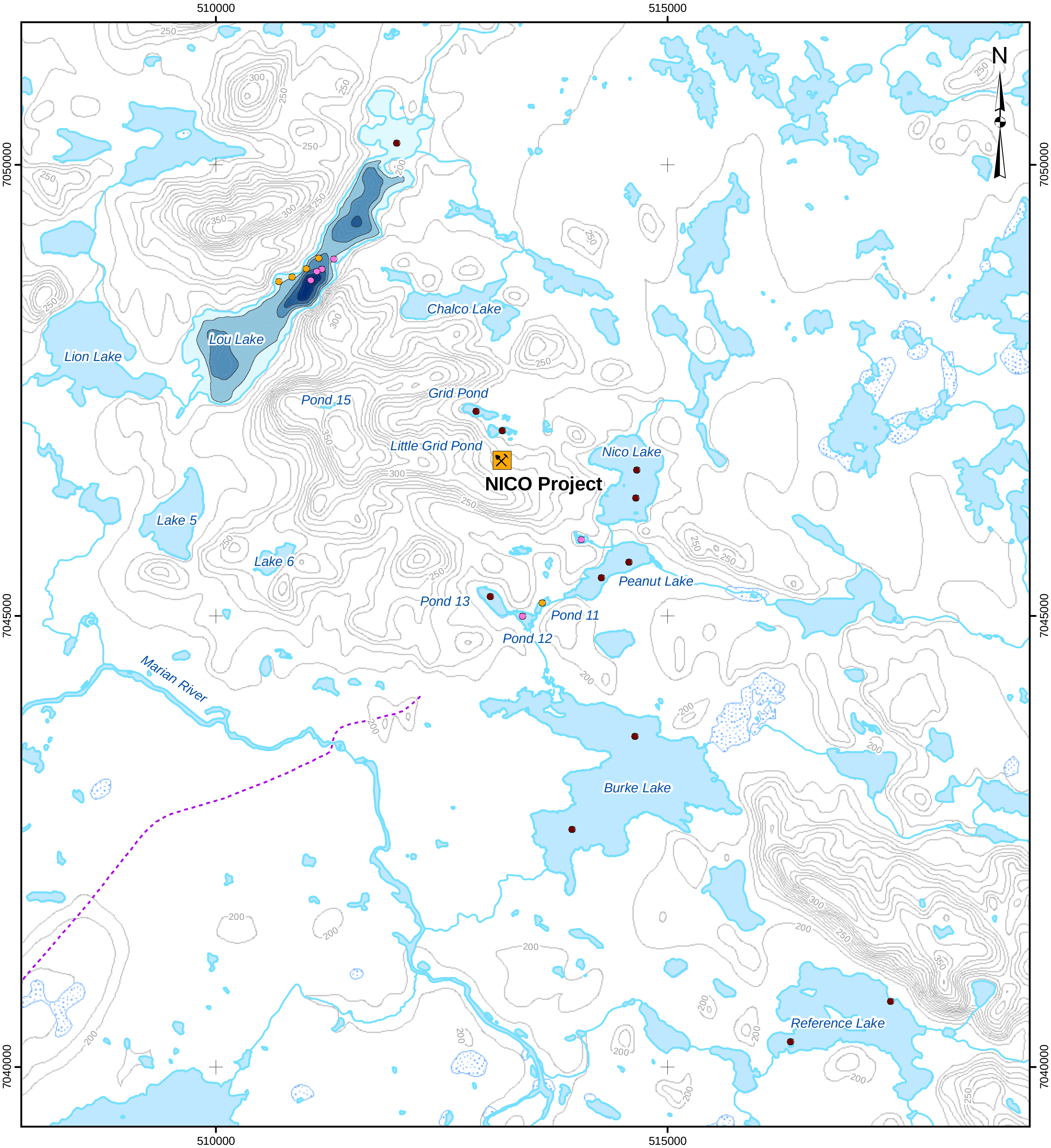

LEGEND

- NICO PROJECT
- CONTOUR (10 METRE INTERVAL)
- PROPOSED NICO PROJECT ACCESS ROAD
- WATERBODY
- WATERCOURSE
- WATERBODY
- WETLAND
- 2005 BENTHIC SAMPLING LOCATION
- 2005 AND 2009 BENTHIC SAMPLING LOCATION
- 2009 BENTHIC SAMPLING LOCATION

1.5 0 1.5

SCALE 1:60,000 KILOMETRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

BENTHIC SAMPLING LOCATIONS, 2005 AND 2009

FILE No. E-Aqua-028-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	CC	08 Jan. 2010		
GIS	RLP	25 Jan. 2011		
CHECK	GRA	04 May 2011	FIGURE: 12.2-2	
REVIEW	GRA	04 May 2011		

Golder Associates
Edmonton, Alberta

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12.2.4.2 Results

Plankton

Phytoplankton communities in the RSA consisted of representatives of 7 major taxonomic groups, including the following:

- Cyanobacteria (blue-green algae);
- Chlorophyta (green algae);
- Chrysophyta (golden algae);
- Cryptophyta (biflagellates with chloroplasts);
- Bacillariophyta (diatoms);
- Pyrrophyta (dinoflagellates); and
- Euglenophyta (euglenoids).

Phytoplankton species richness was variable across waterbodies within the study area, ranging from 26 species in Pond 13 to 41 species in Burke Lake – Deep Station (Table 12.2-3). The greatest diversity was exhibited in Cyanobacteria, followed by Chlorophyta, Chrysophyta, and Cryptophyta.

Cyanobacteria was by far the most abundant taxonomic group, accounting for at least 60% of the phytoplankton abundance in all but one waterbody. Pond 11 was dominated by Chrysophyta. In the remaining lakes, either Chlorophyta or Chrysophta were next most abundant species, even though abundance of these taxa was low. Remaining taxonomic groups were present in very low abundance (see Annex C; Figure 5.3-2).

Although Cyanobacteria abundance was high, this group accounted for a small proportion of phytoplankton biomass in most waterbodies. Chlorophyta and Chrystophyta were variable in biomass, but usually contributed at least 20% towards total biomass. Variation in total phytoplankton biomass and community composition may be a reflection of the seasonal differences in sample collection times (see Annex C: Figure 5.3-4).

Chlorophyll a

Chlorophyll *a* concentrations varied between waterbodies within the study area, but higher chlorophyll *a* concentrations were measured in waterbodies with higher total phytoplankton biomass. Based on chlorophyll *a* content, all waterbodies potentially affected by the NICO Project were classified as oligotrophic (0.3 to 4.5 milligrams per cubic metre [mg/m^3]) (Wetzel 2001).

Table 12.2-3: Phytoplankton Species Level Richness in Waterbodies within the NICO Project Regional Study Area, 2005

Waterbody	Bacillariophyta	Euglenophyta	Pyrrophyta	Cryptophyta	Chrysophyta	Chlorophyta	Cyanobacteria	Total Species
Grid Pond	2	0	2	5	6	11	2	28
Little Grid Pond	2	0	1	4	8	16	4	35
Nico Lake-Deep	2	1	5	5	9	11	7	40
Peanut Lake	2	0	1	4	11	12	6	36
Pond 11	5	0	1	5	4	10	4	29
Pond 13	1	0	1	5	9	5	5	26
Burke Lake -Shallow	3	1	2	5	8	13	7	39
Burke Lake-Deep	0	1	1	5	11	15	8	41
Lou Lake-Shallow	5	1	2	5	6	12	7	38
Lou Lake-Deep	3	0	2	4	9	10	6	34
Reference Lake-Shallow	5	2	2	5	6	8	8	36
Reference Lake-Deep	8	1	2	5	4	10	9	39

Zooplankton

Zooplankton communities in the RSA consisted of representatives from 4 major taxonomic groups: Cladocera, Calanoida, Cyclopoida, and Rotifera. Zooplankton species richness was less variable across waterbodies in comparison to phytoplankton species richness, ranging from 5 species in the Grid Pond to 16 species in Pond 13, Burke Lake-Shallow, and Lou Lake-Shallow (Table 12.2-4).

Rotifera had the highest species diversity whereas Cyclopoida had the lowest species diversity (Table 12.2-4). Rotifera was more abundant in the deeper lakes, but had a disproportionately low contribution to biomass due to the small size of these taxa (see Annex C: Figure 5.3-3). High Rotifera abundance in deeper lakes resulted from low abundance of typical Rotifera predators (i.e., Cyclopoida and Calanoida).

Zooplankton biomass was highest in Grid and Little Grid ponds, likely due to the lack of fish predators in these waterbodies (see Annex C: Figure 5.3-4). Biomass was lowest at Pond 11 and Lou Lake.

Table 12.2-4: Zooplankton Species Level Richness in Waterbodies within the NICO Project Regional Study Area, 2005

Waterbody	Cladocera	Calanoida	Cyclopoida	Rotifer	Total Species
Grid Pond	0	2	1	2	5
Little Grid Pond	2	2	1	6	11
Nico Lake-Deep	4	5	1	4	14
Peanut Lake	3	2	1	6	12
Pond 11	5	1	1	6	13
Pond 13	6	2	1	7	16
Burke Lake Shallow	4	1	1	10	16
Burke Lake-Deep	3	1	1	7	12
Lou Lake-Shallow	1	2	1	6	10
Lou Lake-Deep	4	3	1	6	14
Reference Lake-Shallow	3	2	1	10	16
Reference Lake-Deep	3	1	1	9	14

Benthic Invertebrates

Benthic invertebrate abundance was variable between years and across sites but, overall, abundance at most stations was low for Arctic/sub-Arctic lakes (Figure 12.2-3). A comparison of mean benthic invertebrate abundances suggests that the shallow stations in Peanut and Lou lakes (2005 sampling events) were the most productive, followed by Little Grid Pond (2009) and Pond 13 (2005). These stations had greater than 8500 organisms/square metre (m^2). Deeper water stations (i.e., Peanut Lake–Deep in 2005 and 2009; Nico Lake–Deep in 2009; and Lou Lake – >20 m in 2005) were the least productive, with less than 500 organisms/m^2. Generally, shallow lake stations and ponds supported benthic invertebrate communities with greater abundances than deep lake stations. Numerically dominant invertebrate groups in the RSA waterbodies included chironomids, molluscs (snails and fingernail clams), and, to a lesser extent, ostracods and amphipods (see Annex C: Figure 6.3-2). Overall, the benthic invertebrate communities within the NICO Project area were similar in many respects to benthic invertebrate communities of many other small lakes in the Canadian Arctic and sub-Arctic (RL&L 1997, 1998, 1999).

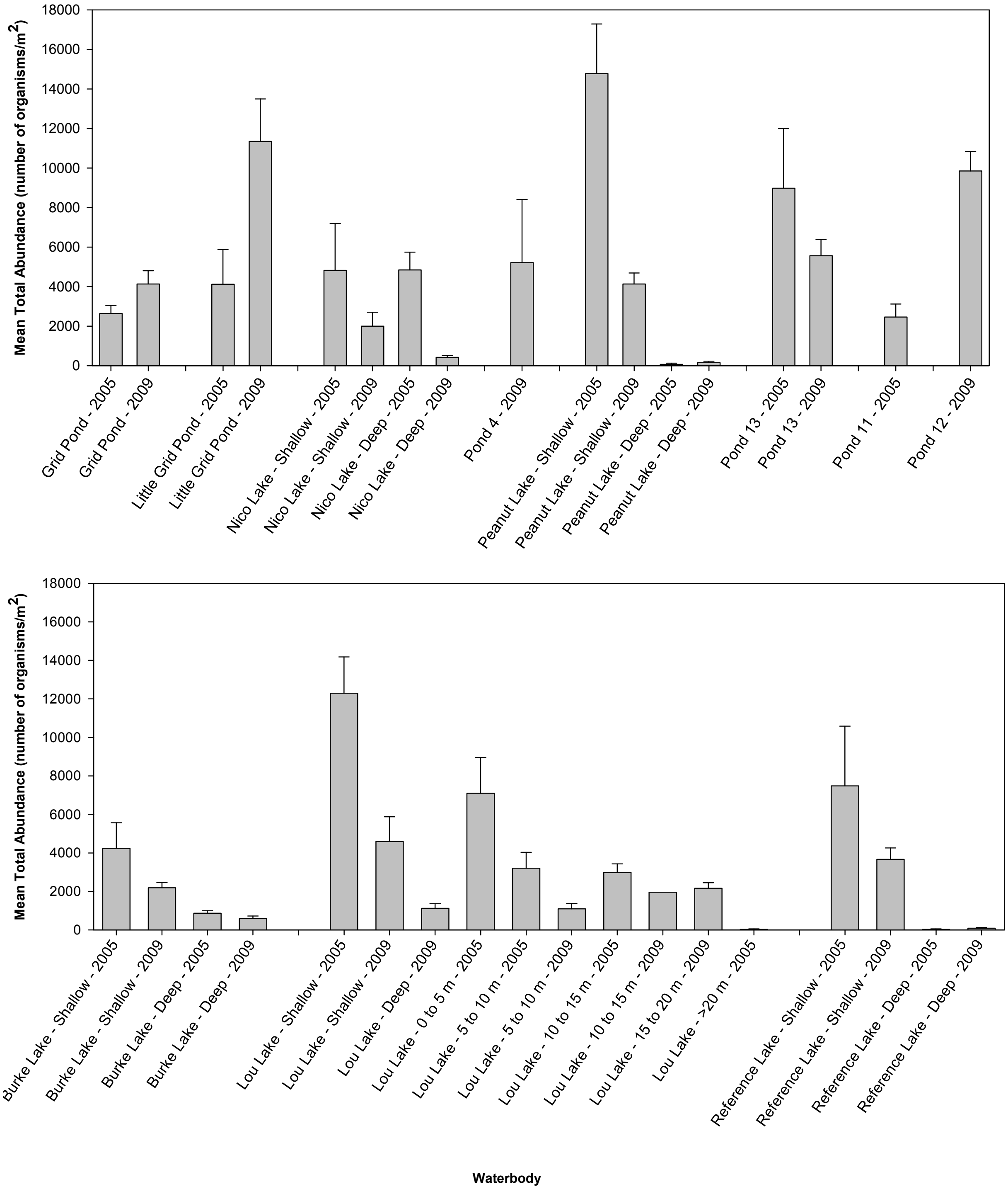


Figure 12.2-3: Mean Total Abundance of Benthic Invertebrates, NICO Regional Study Area, 2005 and 2009

Richness was also low at the majority of stations in both years, with most values below 10 taxa (Table 12.2-5). Ponds 12 and 13 (2005 sampling events), and Nico, Peanut, and Burke lakes (all shallow stations, 2009 sampling events) had higher taxonomic richness, with 13 taxonomic groups or greater. Deeper stations (i.e., Lou Lake – >20 m in 2005, Lou Lake–Deep in 2009) had lower richness values, with either 1 or 2 taxa present at the stations sampled.

Table 12.2-5: Benthic Invertebrate Family Level Richness from Waterbodies in the Regional Study Area, 2005 and 2009

Waterbody	Number of Families	
	2005	2009
Grid Pond	8	8
Little Grid Pond	6	8
Nico Lake–Shallow	13	9
Nico Lake–Deep	5	3
Pond 4	–	10
Peanut Lake–Shallow	13	7
Peanut Lake–Deep	3	3
Pond 13	9	16
Pond 12	–	20
Pond 11	10	–
Burke Lake–Shallow	13	6
Burke Lake–Deep	4	4
Lou Lake–Shallow	12	9
Lou Lake – 0 to 5 m	11	–
Lou Lake – 5 to 10 m	7	6
Lou Lake – 10 to 15 m	4	5
Lou Lake – 15 to 20 m	–	6
Lou Lake – >20 m	2	–
Lou Lake – Deep	–	1
Reference Lake–Shallow	8	9
Reference Lake–Deep	1	2

m = metre

Habitat characteristics influence benthic invertebrate community variables. There is a negative relationship between both benthic invertebrate abundance and richness with water depth. Furthermore, deep water habitats can have anoxic, or near anoxic, conditions as recorded in the deep basins of Peanut Lake (2005 and 2009), and Lou Lake (2009). This may have been a limiting factor of benthic invertebrate abundance and richness at these stations. Lower benthic invertebrate densities in deeper waters may also reflect reduced light penetration (Coffman and Ferrington 1996). Reduced light limits the growth of aquatic plants and benthic algae, which in turn can limit cover and food sources for invertebrates.

Sediment chemistry analysis (see Annex C, Section 4.0) identified arsenic, chromium, copper, and zinc as periodically or frequently exceeding sediment quality guidelines for the protection of aquatic life (Interim

Sediment Quality Guidelines, Probable Effects Levels, and/or Government of the Northwest Territories Guidelines, CCME 2002, GNWT 2003). There was no statistically significant relationship between invertebrate abundance and arsenic, copper, or zinc (Spearman rank correlation coefficients [ρ] ranged from -0.02 to -0.22, $p > 0.27$). Abundance was significantly negatively related to chromium concentration ($\rho = -0.44$, $p = 0.02$). There was no significant relationship between invertebrate richness and arsenic, copper, chromium, or zinc (ρ ranged from -0.03 to -0.36, $p > 0.07$). These results suggest that background variation in sediment metal concentrations does not strongly influence benthic invertebrate communities in the lakes sampled, despite the occasionally elevated metal concentrations.

12.2.5 Fish

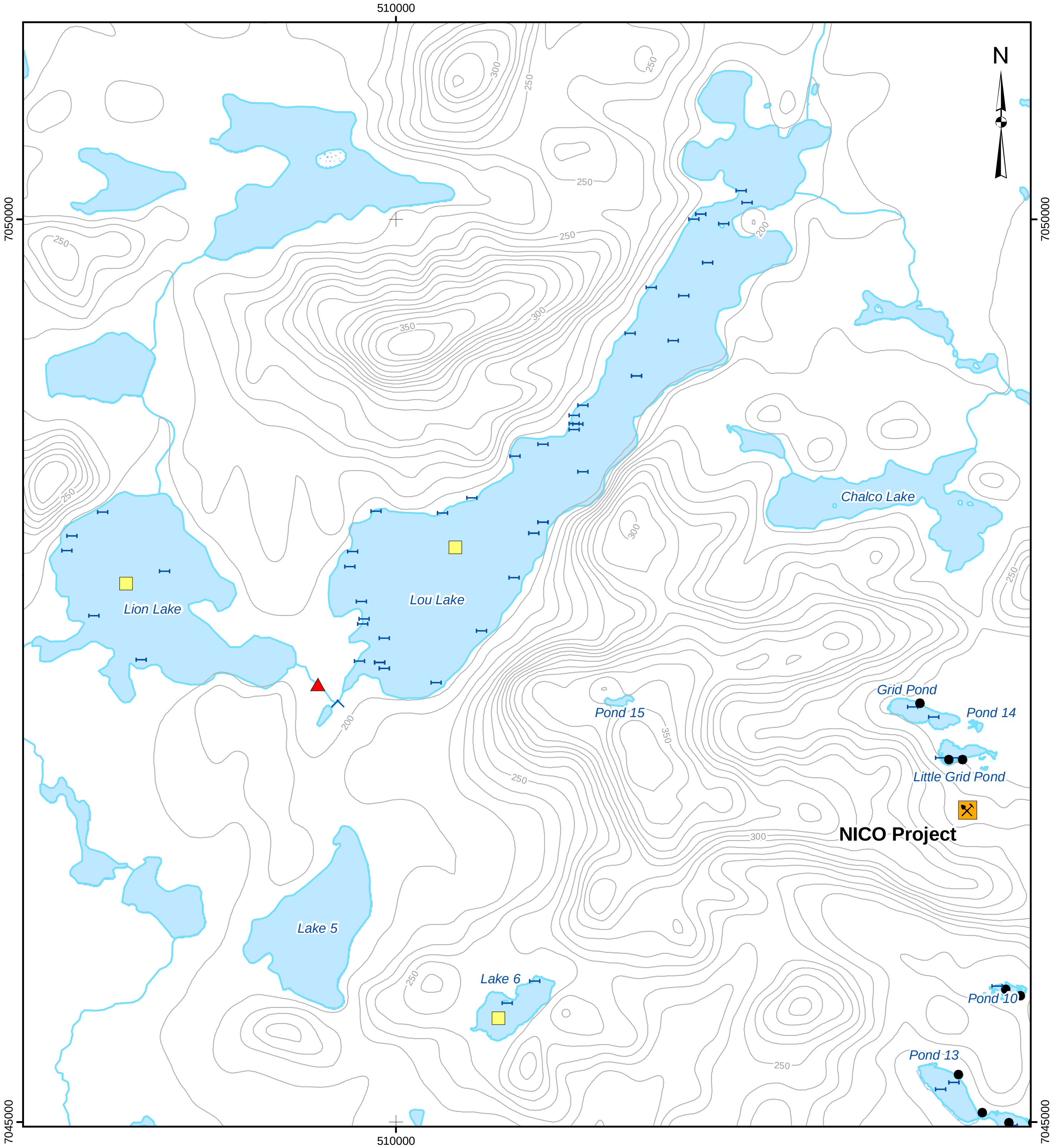
The following section provides an overview of the fish data collected for the proposed NICO Project. For additional information regarding fish, the reader is referred to Annex C (Aquatics Baseline).

12.2.5.1 Methods

Fish surveys were conducted in 1998 and from 2003 through 2009. The less extensive survey conducted in 2008 was designed to address data gaps by focussing on the collection of fish data from Pond 9, Lake 6, Nico Lake, and Peanut Lake, and to assess the impacts from the forest fire in July 2008. The surveys in 2009 were designed to address data gaps for use in preparation of the DAR, and to collect fish data pertinent to the Environmental Effects Monitoring and Aquatics Effects Monitoring Program to be implemented following mine development.

The NICO Project area fish surveys encompassed Nico, Peanut, Burke, Lou, Lion, Chalco, and Reference lakes, Lake 6, Grid and Little Grid ponds, Ponds 6, 8, 9, 10, 11, 12, and 13, Marian River, and the connecting streams (Figures 12.2-4 and 12.2-5).

Fish communities within key waterbodies and streams in the NICO Project area (Figures 12.2-4 and 12.2-5) were sampled for relative fish abundance using a combination of methods. Areas sampled focused on potential spawning habitats (i.e., submerged macrophyte beds, flooded emergent vegetation, and cobble/gravel shoals). Life history data were collected from all captured fish and detailed life history assessments were performed for fish that succumbed during sampling or were retained for tissue analysis. Life history data from individual fish were used to calculate the life history statistics for each species and waterbed. Catch-per-unit-effort values were calculated for each sampling method as an index of relative abundance. Fish growth patterns were analysed using length-weight regressions (Annex C). The common and scientific names of fish species captured in the RSA, as well as their coded abbreviations, are presented in Table 12.2-6.



LEGEND

- NICO PROJECT
- CONTOUR (10 METRE INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND

FISH SAMPLING LOCATION

- ANGLING
- BACKPACK ELECTROFISHING
- FISH FENCE
- GILL NETTING
- MINNOW TRAPPING

1,000 0 1,000

SCALE 1:30,000 METRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

FISH SAMPLING LOCATIONS, NORTH

Golder Associates
Edmonton, Alberta

FILE No. E-Aqua-030-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	AH	02 Jun. 2009	FIGURE: 12.2-4	
GIS	RLP	25 Jan. 2011		
CHECK	AH	04 May 2011		
REVIEW	GA	04 May 2011		

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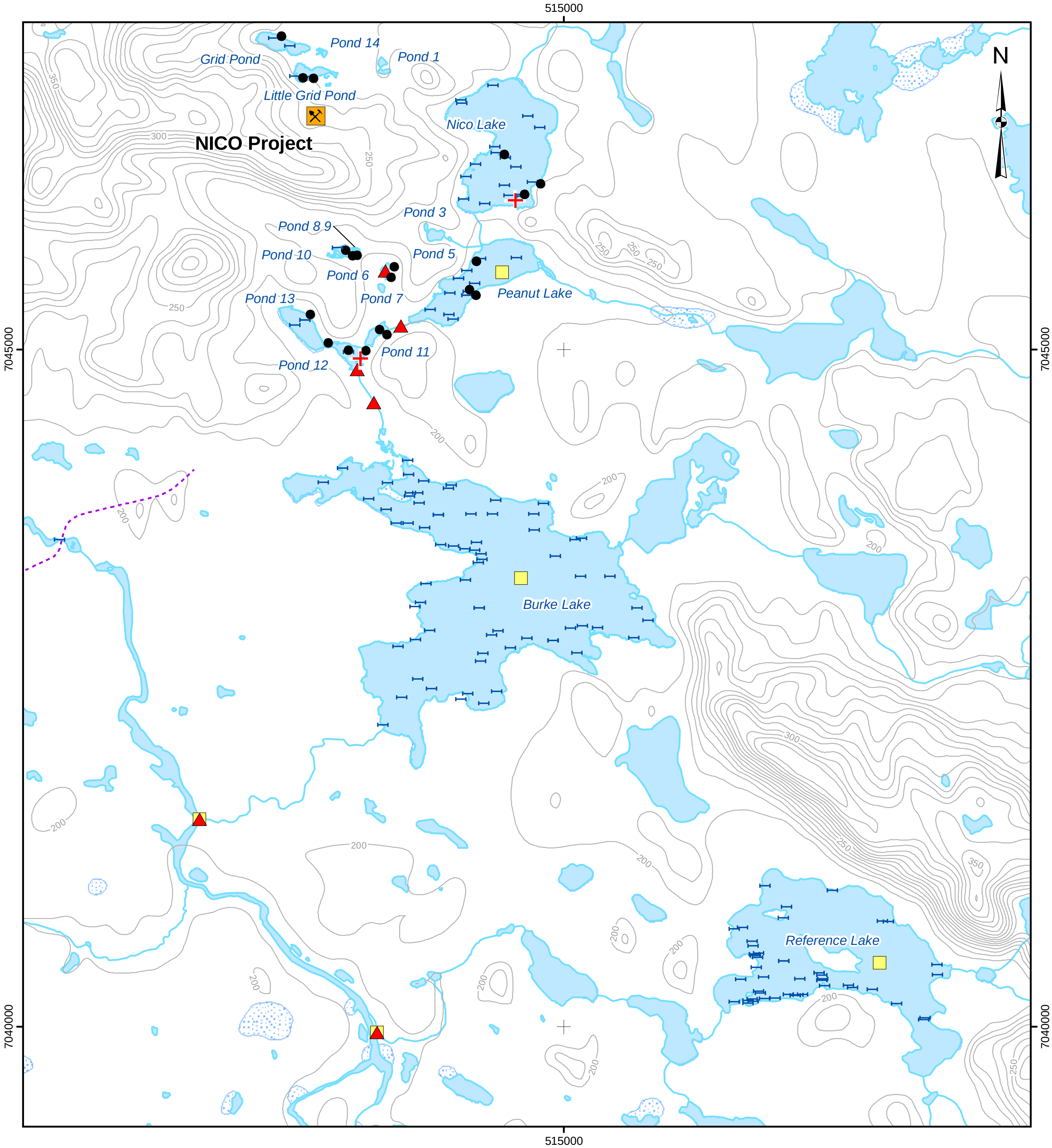

LEGEND

NICO PROJECT
CONTOUR (10 METRE INTERVAL)
PROPOSED NICO PROJECT ACCESS ROAD
WATERCOURSE
WATERBODY
WETLAND

FISH SAMPLING

ANGLING
BACKPACK ELECTROFISHING
FYKE NETTING
GILL NETTING
MINNOW TRAPPING

1,000 0 1,000
SCALE 1:40,000 METRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

FISH SAMPLING LOCATIONS, SOUTH

Golder Associates
Edmonton, Alberta

FILE No. E-Aqua-031-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	AH	02 Jun. 2009	FIGURE: 12.2-5	
GIS	RLP	25 Jan. 2011		
CHECK	GRA	04 May 2011		
REVIEW	GRA	04 May 2011		

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Table 12.2-6: Names and Codes of Fish Species Captured in the Regional Study Area, 1998 to 2009

Family	Common Name	Scientific Name	Code
Catostomidae	Longnose sucker	*Catostomus catostomus* (Forster)	LNSC
	White sucker	*Catostomus commersonii* (Lacepède)	WHSC
Cottidae	Slimy sculpin	*Cotus cognatus* Richardson	SLSC
Esocidae	Northern pike	*Esox lucius* Linnaeus	NRPK
Gasterosteidae	Ninespine stickleback	*Pungitius pungitius* (Linnaeus)	NNST
Lotidae	Burbot	*Lota lota* (Linnaeus)	BURB
Percidae	Walleye	*Sander vitreus* (Mitchill)	WALL
Salmonidae	Arctic grayling[a]	*Thymallus arcticus* (Pallas)	ARGR
	Cisco	*Coregonus artedi* Lesueur	CISC
	Lake trout	*Salvelinus namaycush* (Walbaum)	LKTR
	Lake whitefish	*Coregonus clupeaformis* (Mitchill)	LKWH

[a] not captured by the study team, but reported to be present in the Marian River by exploration camp personnel.

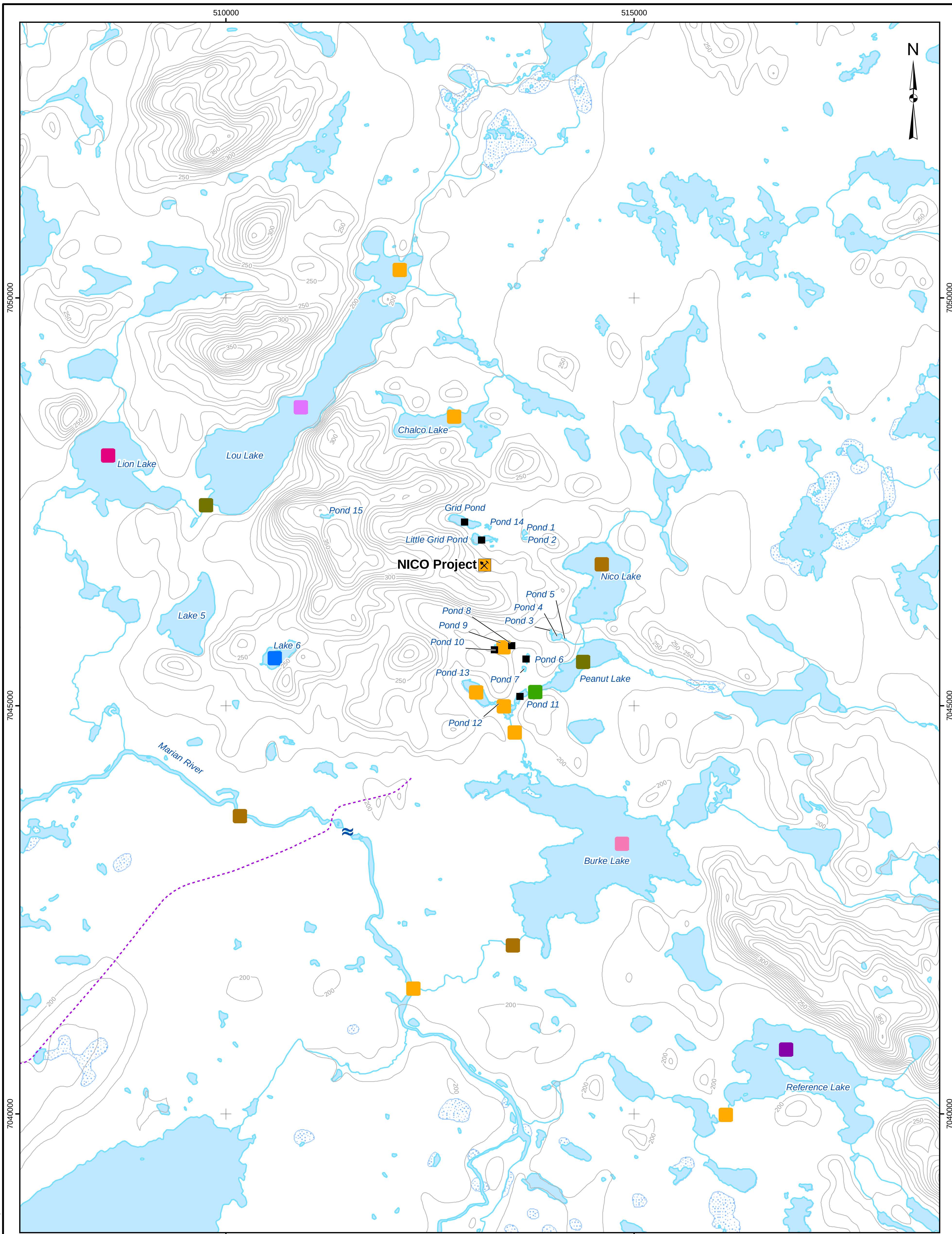
12.2.5.2 Results

In total, 1186 fish were captured or observed in the RSA during the 1998 and 2003 to 2009 fish studies. They represented 10 species of fish including walleye, northern pike, lake whitefish, cisco, lake trout (*Salvelinus namaycush*), longnose sucker, white sucker, ninespine stickleback, and slimy sculpin (*Cotus cognatus*) (Table 12.2-7). In addition, Arctic grayling (*Thymallus arcticus*) have been reported present in the Marian River by the exploration camp personnel; however, they were not captured by the study team.

Northern pike and lake whitefish were the only species of fish common to most fish bearing waterbodies in the NICO Project area (Figure 12.2-6). Walleye were captured only in Lou Lake, lake trout were captured only in Lake 6, and burbot were captured only in Reference Lake. Slimy sculpin (one specimen) was captured only in Burke Lake, and ninespine stickleback were captured in the Peanut Lake Outflow, Burke Lake, and Reference Lake. Fish were not captured in Grid Pond, Little Grid Pond, Ponds 6, 8, 10, and 11, and these waterbodies are assumed to be non-fish bearing.

Table 12.2-7: Number of Fish Captured in NICO Regional Study Area, 1998 and 2003 to 2009

Waterbody	Burbot	Cisco	Lake Trout	Lake Whitefish	Longnose Sucker	Ninespine Stickleback	Northern Pike	Slimy Sculpin	Unknown	Walleye	White Sucker	Total
Nico Lake	0	0	0	0	0	0	32	0	0	0	7	**39**
Peanut Lake	0	0	0	71	0	0	13	0	0	0	0	**84**
Peanut Lake Outflow	0	0	0	0	0	3	5	0	1	0	2	**11**
Pond 9	0	0	0	0	0	0	1	0	0	0	0	**1**
Pond 12	0	0	0	0	0	0	5	0	0	0	1	**6**
Pond 12 Outflow	0	0	0	0	0	0	1	0	0	0	0	**1**
Pond 13	0	0	0	0	0	0	6	0	0	0	0	**6**
Burke Lake	0	1	0	126	0	95	98	1	0	0	5	**326**
Burke Lake Outflow	0	0	0	0	0	0	1	0	0	0	2	**3**
Reference Lake	2	11	0	169	0	24	71	0	0	0	0	**277**
Reference Outflow/ Marian River	0	0	0	0	0	0	1	0	0	0	0	**1**
Burke Outflow/ Marian River	0	0	0	0	0	0	4	0	0	0	0	**4**
Lou Lake	0	47	0	108	1	0	41	0	0	59	9	**265**
Lou Lake Inflow	0	0	0	0	0	0	2	0	0	0	0	**2**
Lou Lake Outflow	0	0	0	3	0	0	32	0	0	0	0	**35**
Lion Lake	0	38	0	45	0	0	12	0	0	0	0	**95**
Lake 6	0	0	6	0	0	0	0	0	13	0	0	**19**
Chalco Lake	0	0	0	0	0	0	6	0	0	0	0	**6**
Marian River	0	0	0	0	0	0	2	0	0	0	1	**3**
Total	**2**	**97**	**6**	**522**	**1**	**122**	**333**	**1**	**14**	**59**	**27**	**1184**



LEGEND

- NICO PROJECT
- CONTOUR (10 METRE INTERVAL)
- PROPOSED NICO PROJECT ACCESS ROAD
- RAPIDS
- WATERCOURSE
- WATERBODY
- WETLAND

FISH SAMPLING

- NO FISH CAUGHT
- BURBOT, CISCO, LAKE WHITEFISH, NINESPINE STICKLEBACK, NORTHERN PIKE
- CISCO, NORTHERN PIKE, WALLEYE, LAKE WHITE-FISH, LONGNOSE SUCKER, WHITE SUCKER
- CISCO, LAKE WHITEFISH. NINESPINE STICKLEBACK, NORTHERN PIKE, SLIMY SCULPIN, WHITE SUCKER
- CISCO, LAKE WHITEFISH, NORTHERN PIKE
- NINESPINE STICKLEBACK, NORTHERN PIKE, WHITE SUCKER
- LAKE WHITEFISH, NORTHERN PIKE
- NORTHERN PIKE, WHITE SUCKER
- NORTHERN PIKE
- LAKE TROUT

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

1.5 0 1.5
SCALE 1:45,000 KILOMETRES

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

FISH SPECIES DISTRIBUTION
IN THE NICO PROJECT AREA

Golder Associates
Edmonton, Alberta

FILE No. E-Aqua-032-GIS

PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	KK	17 Jan. 2011	FIGURE: 12.2-6	
GIS	AB	15 Apr. 2011		
CHECK	GRA	11 May 2011		
REVIEW	GRA	11 May 2011		

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Lake whitefish dominated the overall catch (44%) and northern pike was also abundant (28%) (Table 12.2-7). Overall, 73.3% of the fish captured were collected in Burke, Reference, and Lou lakes. Fish were more abundant in Burke Lake, located farthest downstream from the NICO mineral deposit, and the abundance decreased in the upstream direction through the system towards Nico Lake. Fish were absent from the Grid ponds. This corresponds to the general increase in water quality moving downstream from the Grid ponds to Burke Lake (Annex C, Section 7).

Data from individual fish, summary statistics (length, weight, condition factor, and age), length-at-age and weight-at-age summary statistics, and length-weight regression analysis are presented in Annex C. The catch-per-unit-effort for fish captured between 1998 and 2009 are also presented in Annex C.

The following section provides a summary of fish data collected during the baseline studies for those waterbodies potentially affected by the NICO Project. Additional data from Lion Lake, Chalco Lake, Reference Lake, and Lake 6 are presented in Annex C.

12.2.5.2.1 Grid and Little Grid Ponds

Grid Pond was sampled on 14 and 15 September 2003 and on 16 and 17 August 2005. Little Grid Pond was sampled on 15 September 2003 and on 17 and 18 August 2005. Fishing methods included minnow traps and gill nets. Fish were not captured in either pond. Grid and Little Grid ponds do not support fish populations due to shallow depths that freeze to the substrate over winter and potentially due to high arsenic and copper concentrations in the water and sediment (Annex C, Section 7).

12.2.5.2.2 Nico Lake

Species Composition and Relative Abundance

Nico Lake was sampled in 1998 and annually from 2005 to 2009. Sampling methods included gill nets, baited minnow traps, boat electrofishing, fyke net, and snorkelling; however, fish were captured only by gill nets and boat electrofishing. Fish were not captured in 2005.

In total, 32 northern pike and 7 white sucker were captured (Table 12.2-8). Although small-bodied fish are likely present in Nico Lake, fish were not captured or observed with the small-fish sampling methods used during the 2005 and 2009 sampling programs, despite considerable effort.

Table 12.2-8: Number of Fish captured in Nico Lake, 1998 and 2006 to 2009

Sampling Method	Year	Northern Pike	White Sucker	Total
Boat Electrofishing	2009	5	0	**5**
Gill Netting	1998	7	1	**8**
	2006	2	0	**2**
	2007	5	0	**5**
	2008	6	1	**7**
	2009	7	5	**12**
Total		**32**	**7**	**39**

Nico Lake appears to have adequate depth and habitat characteristics to support select fish populations, but population densities were low in comparison to other waterbodies in the NICO Project area. Lake whitefish have not been captured in Nico Lake. The abundant aquatic vegetation found around the entire shallow perimeter of the lake (i.e., at depths less than 1.5 m) is likely decomposing in the winter and creating low oxygen conditions for fish (Annex C). Although surface DO concentrations exceed the CWQG for PAL of 6.5 mg/L in most of samples collected during the open-water period in Nico Lake, under-ice sampling indicates that surface DO concentrations are often below 6.5 mg/L in both the deep and shallow basins.

Life History Data

Northern pike fork lengths ranged from 271 to 585 mm, weights ranged from 150 to 1500 grams (g), and condition factors ranged from 0.43 to 0.82. The northern pike that have been aged ranged from 3 to 10 years old. Based on 10 northern pike stomach contents, diet consisted primarily of invertebrates. Analysis of length frequency distribution data from Nico Lake northern pike shows a broad distribution of size-classes in the sample, with the greatest frequency occurring between 400 and 500 mm (Figure 12.2-7). Northern pike length-weight regression analysis indicated near isometric growth, suggesting that fish body shape does not change with length.

White sucker had fork lengths between 318 to 493 mm, weights between 493 and 2000 g, and condition factors between 1.38 and 1.67.

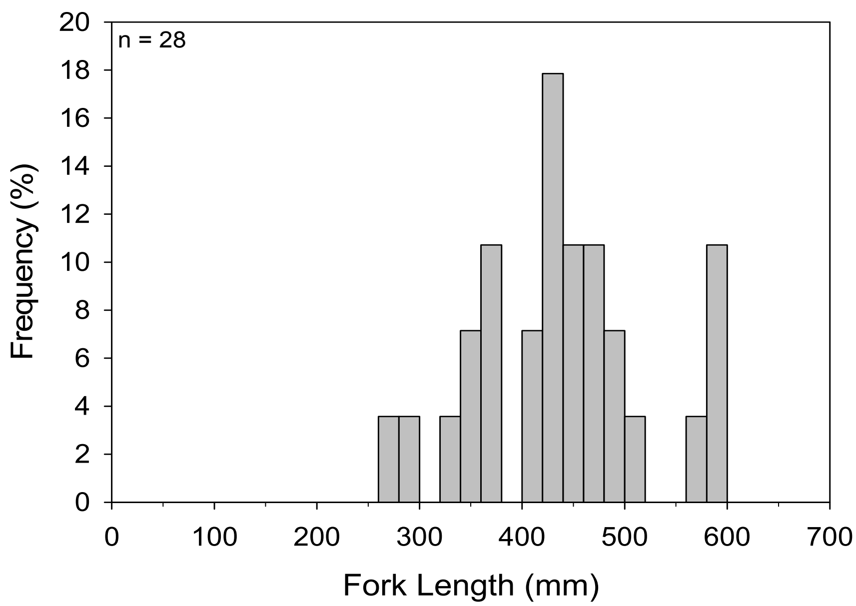


Figure 12.2-7: Length-Frequency Distribution of Northern Pike Captured in Nico Lake, 1998 and 2006-2009

12.2.5.2.3 Peanut Lake and Peanut Lake Outflow

Species Composition and Relative Abundance

Peanut Lake was sampled in 1998 and annually from 2005 to 2009. In total, 71 lake whitefish and 13 northern pike were captured in Peanut Lake (Table 12.2-9). In Peanut Lake Outflow, 2 juvenile white sucker, one juvenile northern pike, and 3 ninespine stickleback were captured. In addition, 4 northern pike and one unidentified fish were observed in Peanut Lake Outflow (Table 12.2-9). Catch rates were lower in 2008 than in 2009, which may be related to the forest fire that burned the north shore of Peanut Lake in July, 2008.

Table 12.2-9: Number of Fish Captured in Peanut Lake and Peanut Lake Outflow, 1998 and 2005 to 2009

Sampling Method	Year	Lake Whitefish	Ninespine Stickleback	Northern Pike	Unknown	White Sucker	Total
Peanut Lake							
Angling	2006	0	0	2	0	0	**2**
	2007	0	0	1	0	0	**1**
	2009	0	0	1	0	0	**1**
Boat Electrofishing	2009	3	0	2	0	0	**5**
Gill Netting	1998	4	0	0	0	0	**4**
	2005	32	0	6	0	0	**38**
	2006	12	0	0	0	0	**12**
	2007	4	0	0	0	0	**4**
	2008	9	0	1	0	0	**10**
	2009	7	0	0	0	0	**7**
Total		**71**	**0**	**13**	**0**	**0**	**84**
Peanut Lake Outflow							
Backpack Electrofishing	2005	0	3	1	0	2	**6**
Observed	2005	0	0	1	0	0	**1**
	2008	0	0	3	1	0	**4**
Total		**0**	**3**	**5**	**1**	**2**	**11**

Life History Data

Lake whitefish captured in Peanut Lake ranged from 90 to 476 mm in fork length. Analysis of length frequency distribution data revealed a broad distribution of size-classes in the sample, with the greatest frequency occurring between 300 and 460 mm (Figure 12.2-8).

Lake whitefish weighed between 7 and 1600 g (Annex C). The mean condition factor was 1.37 (SD 0.18). Lake whitefish length-weight regression analysis indicated that growth was positively allometric, suggesting fish get more robust as they increase in length. The most abundant age-classes were 3 to 6 year old fish, comprising approximately 60% of the aged catch.

Fork lengths of northern pike captured and measured in Peanut Lake ranged from 231 to 940 mm, with weights ranging from 80 to 6600 g and condition factors ranging from 0.60 to 0.82. Due to the small sample size, statistical comparisons of age and growth were not conducted. One juvenile northern pike was captured and measured in Peanut Lake Outflow. This fish was 108 mm in fork length and weighed 6 g.

The 2 captured white sucker from Peanut Lake Outflow were 129 and 130 mm in fork length and each weighed 26 g. The 3 captured ninespine stickleback ranged from 37 to 47 mm in total length.

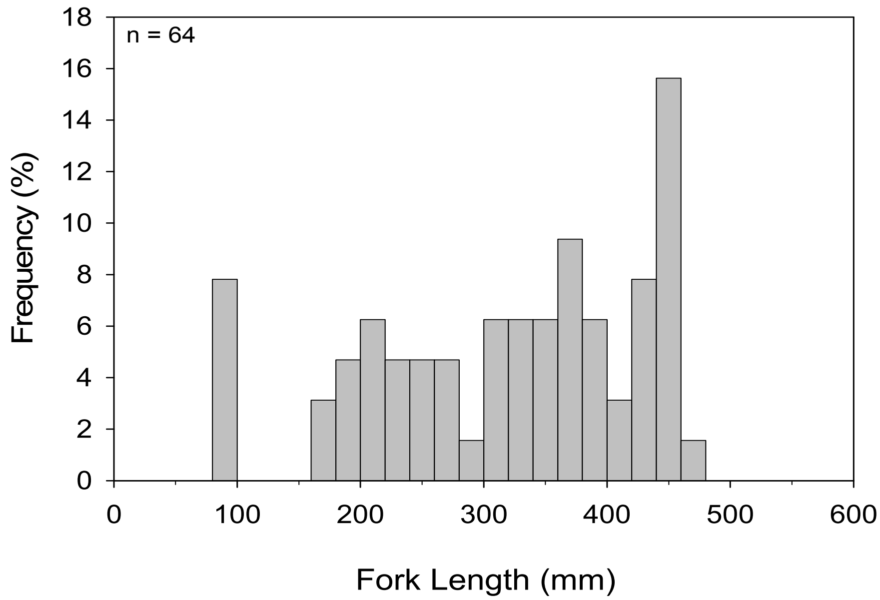


Figure 12.2-8: Length-Frequency Distribution of Lake Whitefish Captured in Peanut Lake, 1998 and 2005-2009

12.2.5.2.4 Ponds 8, 9, 10, 11, 12, and 13

Ponds 8, 9, 10, 11, 12, and 13 were sampled between 1998 and 2009. Combinations of baited minnow traps, backpack electrofishing, gill nets, fyke nets, and/or a boat electrofisher were used.

In total, 14 fish were captured in the ponds (Table 12.2-10). One juvenile northern pike was captured by gill-netting in Pond 9 in 2008. Five northern pike (ranging from 192 to 280 mm in fork length) and one white sucker (313 mm fork length) were captured in gill nets in Pond 12. One juvenile northern pike (171 mm fork length) was captured with the backpack electrofisher in Pond 12 Outflow. Six northern pike (ranging from 98 to 313 mm in fork length) were captured in Pond 13. Fish were not captured or observed during the sampling programs in Ponds 8, 10, and 11.

12.2.5.2.5 Burke Lake and Burke Lake Outflow

Burke Lake was sampled in 1998 and annually between 2004 and 2009. Sampling methods included gill nets, fyke nets, baited minnow traps, boat electrofishing, and angling. In total, 126 lake whitefish, 98 northern pike, 5 white sucker, 1 cisco, and 95 ninespine stickleback were captured in Burke Lake (Table 12.2-11). In addition, 2 ninespine stickleback, 1 slimy sculpin, and a small school of unidentified young-of-the-year fish were observed in Burke Lake. Two white sucker and 1 northern pike were observed in Burke Lake Outflow.

Table 12.2-10: Number of Fish Captured in Ponds 9, 12, and 13, and in Pond 12 Outflow, 2004 to 2009

Sampling Method	Year	Northern Pike	White Sucker	Total
Pond 9				
Gill Netting	2008	1	0	**1**
Total		**1**	**0**	**1**
Pond 12				
Gill Netting	2004	3	1	**4**
	2005	1	0	**1**
	2006	1	0	**1**
Total		**5**	**1**	**6**
Pond 12 Outflow				
Backpack Electrofishing	2005	1	0	**1**
Total		**1**	**0**	**1**
Pond 13				
Boat Electrofishing	2009	1	0	**1**
Gill Netting	2004	1	0	**1**
	2009	4	0	**4**
Total		**6**	**0**	**6**

Table 12.2-11: Number of Fish Captured in Burke Lake and Burke Lake Outflow, 1998, 2004 to 2009

	Year	Cisco	Lake Whitefish	Ninespine Stickleback	Northern Pike	Slimy Sculpin	White Sucker	Total
Burke Lake								
Angling	2005	0	0	0	10	0	0	**10**
	2006	0	0	0	10	0	0	**10**
	2007	0	0	0	8	0	0	**8**
	2008	0	0	0	4	0	0	**4**
Boat Electrofishing	2009	0	0	93	5	0	1	**99**
Gill Netting	1998	0	2	0	23	0	1	**26**
	2004	0	3	0	7	0	0	**10**
	2005	0	78	0	20	0	2	**100**
	2006	0	18	0	4	0	1	**23**
	2007	1	15	0	0	0	0	**16**
	2008	0	4	0	2	0	0	**6**
	2009	0	6	0	2	0	0	**8**
Observed	2005	0		2	3	1	0	**6**
Total		**1**	**126**	**95**	**98**	**1**	**5**	**326**
Burke Lake Outflow								
Observed	2005	0	0	0	1	0	2	**3**
Total		**0**	**0**	**0**	**1**	**0**	**2**	**3**

Life History Data

The captured lake whitefish had a unimodal length-frequency distribution, with lengths ranging from 210 to 565 mm and the greatest frequency of fish in the 460 to 540 mm range (Figure 12.2-9). Weight ranged from 100 to 3000 g, and the mean condition factor was 1.63 (SD 0.26) (Annex C). Length-weight regression analysis indicated that lake whitefish growth was negatively allometric, suggesting fish get slightly thinner as they increase in length. However, the sampled population does not include fish smaller than 200 mm, which may result in the skewed relationship. The most abundant age-classes were between 5 and 7 years, which accounted for over 70% of the aged catch. The fork length and weight of lake whitefish in Burke Lake demonstrated a considerable amount of variation within year-classes. On average, lake whitefish demonstrated limited increase in length and weight after reaching 4 years of age.

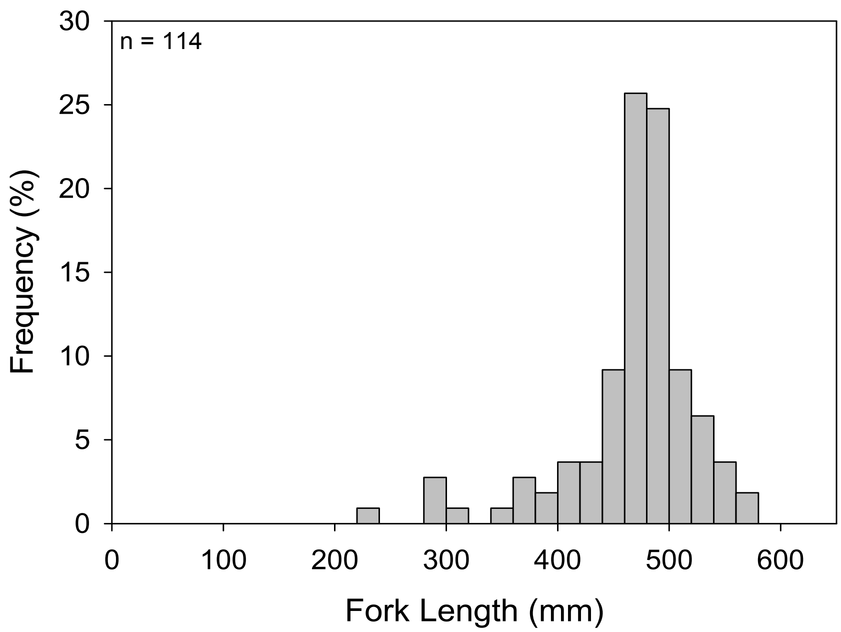


Figure 12.2-9: Length-Frequency Distribution of Lake Whitefish Captured in Burke Lake, 1998-2009

The fork lengths of captured northern pike ranged from 105 to 906 mm. The length-frequency distribution showed a unimodal distribution, with the largest proportion of fish between 420 and 560 mm (Figure 12.2-10). Northern pike weighed between 10 and 5250 g, and the mean condition factor was 0.65 (SD 0.15). Length-weight regression analysis indicated that growth was positively allometric. Age-frequency distribution indicated that age 4 and 7 fish were the most frequent age-classes in the samples from Burke Lake.

Five white sucker captured in Burke Lake ranged between 151 and 560 mm in fork length and weighed between 43 and 2022 g. The condition factors ranged from 1.14 to 1.59.

One cisco was captured in Burke Lake. Fork length for this fish was 195 mm, weight was 85 g, and the condition factor was 1.15.

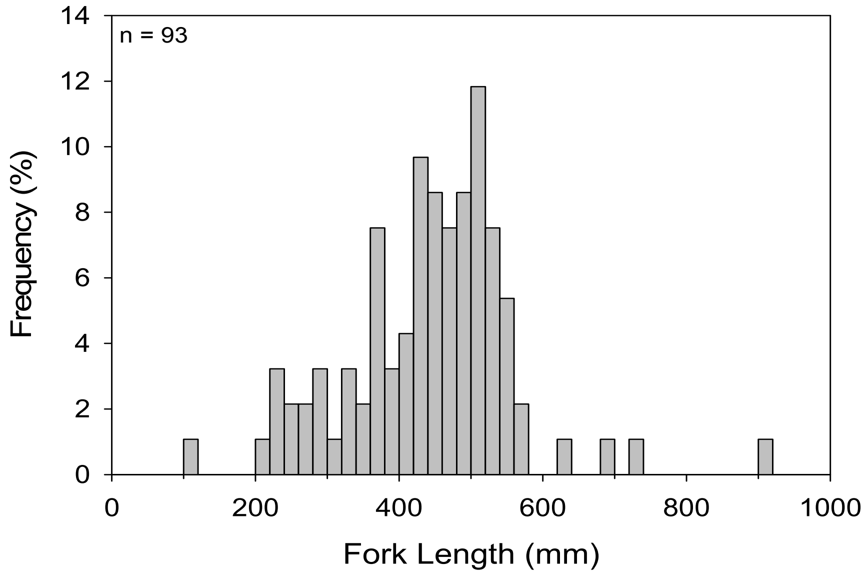


Figure 12.2-10: Length-Frequency Distribution of Northern Pike in Burke Lake, 1998-2009

12.2.5.2.6 Lou Lake and Lou Lake Outflow

Species Composition and Relative Abundance

Fish surveys were carried out in Lou Lake in 1998 and 2005 to 2009. Fishing methods included gill netting, and angling. Lou Lake Outflow was sampled in 2007 using a fish fence and backpack electrofishing. In total, 111 lake whitefish, 75 northern pike, 59 walleye, 47 cisco, 9 white sucker, and 1 longnose sucker were captured in Lou Lake, Lou Lake Inflow, and Lou Lake Outflow (Table 12.2-13).

Only 3 lake whitefish and 30 northern pike were captured at the fish fence installed in Lou Lake Outflow in 2007. During all sampling years in Lou Lake, lake whitefish dominated the gill net catch.

Table 12.2-13: Number of Fish Captured in Lou Lake and Lou Lake Outflow, 1998 and 2005 to 2009

Sampling Method	Year	Cisco	Lake Whitefish	Longnose Sucker	Northern Pike	Walleye	White Sucker	Total
Lou Lake								
Angling	2005	0	1	0	0	0	0	**1**
	2006	0	0	0	5	2	0	**7**
	2007	0	0	0	2	16	0	**18**
	2008	0	0	0	0	1	0	**1**
	2009	0	0	0	4	0	0	**4**
Gill Netting	1998	21	13	0	8	4	5	**51**
	2005	24	31	0	9	15	1	**80**
	2006	2	22	0	7	12	1	**44**
	2007	0	23	1	3	0	0	**27**
	2009	0	18	0	3	9	2	**32**
Total		**47**	**108**	**1**	**41**	**59**	**9**	**265**
Lou Lake Inflow								
Observed	2006	0	0	0	2	0	0	**2**
Total		**0**	**0**	**0**	**2**	**0**	**0**	**2**
Lou Lake Outflow								
Backpack Elecrofishing	2007	0	0	0	1	0	0	**1**
Fish Fence	2007	0	3	0	30	0	0	**33**
Observed	2007	0	0	0	1	0	0	**1**
Total		**0**	**3**	**0**	**32**	**0**	**0**	**35**

Life History Data

Fork lengths of lake whitefish captured in Lou Lake ranged from 135 to 506 mm. The length-frequency distribution was bimodal with approximately 63% of the fish ranging between 360 and 460 mm (Figure 12.2-11). Captured lake whitefish were between 33 and 1985 g in weight, and the mean condition factor was 1.30 (SD 0.16) (Annex C). Length-weight regression analysis for lake whitefish in Lou Lake indicated positive allometric growth. Aged lake whitefish were between 3 and 18 years old. Approximately 41% of the fish were between 7 and 10 years old, and 20% were 13 to 14 years old.

Northern pike captured in Lou Lake ranged from 241 to 1020 mm in fork length. The most common length-class (approximately 15%) of northern pike was between 380 and 400 mm (Figure 12.2-12). Based on the small sample size, the length-frequency distribution shows a somewhat bimodal trend. Weights ranged from 100 to 4000 g for the captured northern pike in Lou Lake and the mean condition factor was 0.62 (SD 0.07). The fish caught in the fish fence moving into Lou Lake Outflow had a slightly greater mean condition factor (0.71; SD 0.09) than the fish captured in the lake; northern pike captured in Lou Lake showed positive allometric growth. The 15 aged northern pike were between 2 and 15 years old.

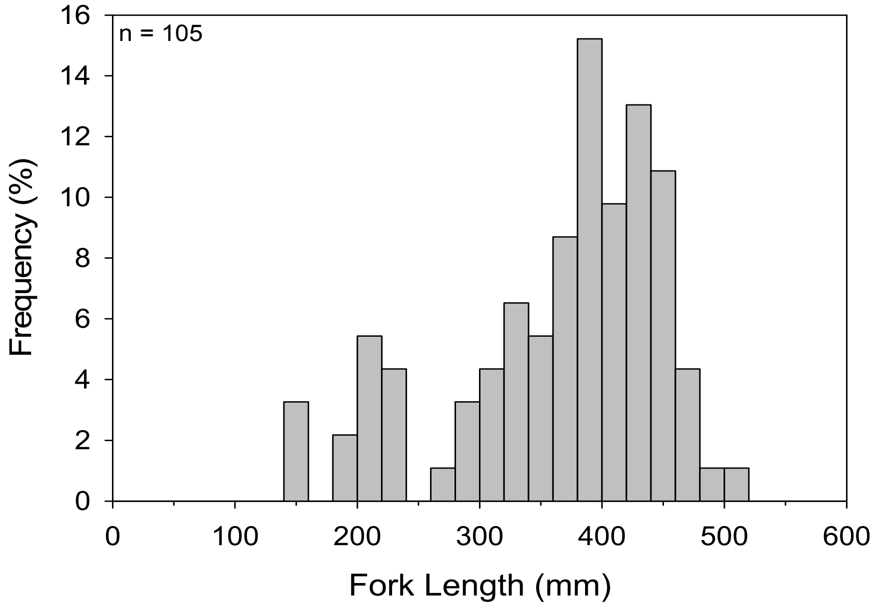


Figure 12.2-11: Length-Frequency Distribution of Lake Whitefish Captured in Lou Lake, 1998 and 2005-2009

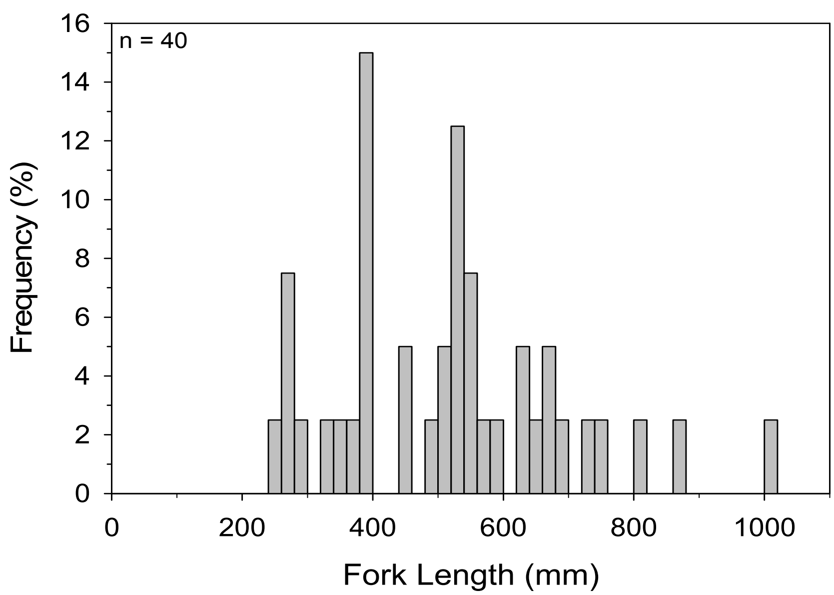


Figure 12.2-12: Length-Frequency Distribution of Northern Pike Captured in Lou Lake, 1998 and 2005-2009

Walleye captured in Lou Lake had fork lengths between 185 and 506 mm. The length-frequency distribution indicated that approximately 66% of the captured fish ranged between 320 and 440 mm in fork length

(Figure 12.2-13). Walleye weights ranged from 59 to 1263 g, and the mean condition factor was 1.06 (SD 0.16). Based on the length-weight regression, Walleye growth is negatively allometric in Lou Lake. Ages of walleye captured in Lou Lake ranged from 3 to 11 years old, with age 4 fish contributing 25% and age 8 fish contributing 20% of the captured fish.

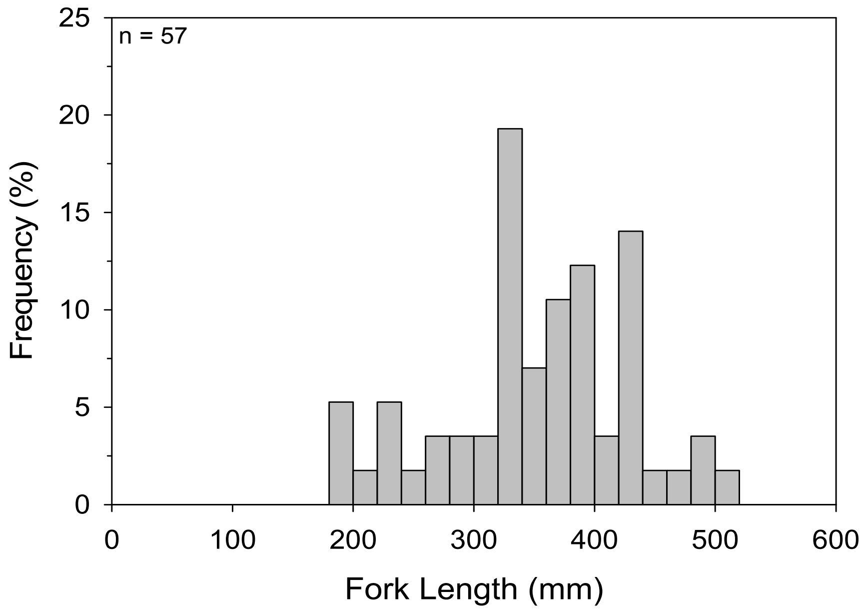


Figure 12.2-13: Length-Frequency Distribution of Walleye Captured in Lou Lake, 1998 and 2005-2009

Fork lengths for the cisco captured in Lou Lake ranged from 90 to 288 mm. The most abundant size-class (27% of the total catch) was between 140 and 160 mm in fork length (Figure 12.2-14). The captured cisco weighed between 21 and 245 g. The mean condition factor was 1.18 (SD 0.22). Cisco growth was negatively allometric based on length-weight regression analysis.

The 9 captured white sucker ranged from 225 to 488 mm in fork length and from 250 to 1700 g in weight (mean condition factor of 1.62 (SD 0.25). The one longnose sucker captured in Lou Lake was 415 mm in fork length and 1064 g in weight.

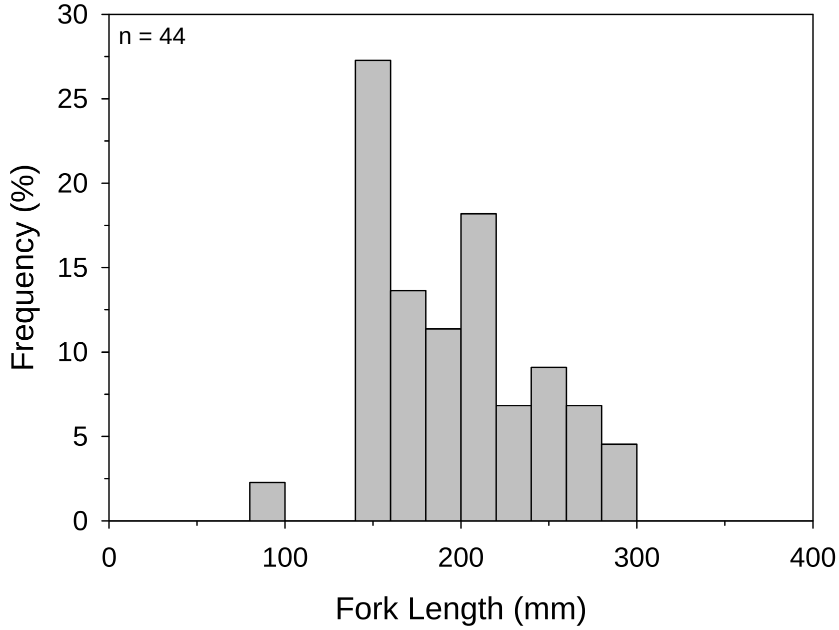


Figure 12.2-14: Length-Frequency Distribution of Cisco Captured in Lou Lake, 1998 and 2005-2006

12.2.5.2.7 Marian River

An area of the Marian River near the NPAR was sampled for fish presence in 2005 using kick nets and backpack electrofishing, and in 2006 using gill nets. The tributaries connecting Burke and Reference lakes and the Marian River were sampled by angling in 2005.

Four northern pike were captured in the tributary between Burke Lake and the Marian River. One northern pike was observed in the tributary between Reference Lake and the Marian River. One white sucker was captured in the Marian River near the NPAR, and 2 northern pike and several young-of-the-year lake whitefish were observed in this area. The captured northern pike had condition factors between 0.54 and 0.69. Northern pike and lake whitefish were also captured at the proposed road crossing location in 2004 (Golder 2007).

12.2.6 Fish Tissue

The following section details the methods taken in prioritizing archived samples for analysis, and synthesizes the results of the analysis. In addition, a comparison is made between tissue metal concentrations in samples collected before the large forest fire that burned in the LSA (2005-2007), and following the fire (2008-2009). The lakes impacted by the forest fire included Peanut, Burke, and Reference lakes. Nico Lake is not expected to have received surface water flow from the burn area, though it was in close proximity to the fire line. Lou Lake was located outside the burn area.

For additional information regarding fish tissue metal concentrations, the reader is referred to Annex C.

12.2.6.1 Methods

Fish tissue samples from the NICO Project area were collected opportunistically during baseline sampling programs carried out between 2005 and 2008, and were archived as frozen samples of liver and dorsal muscle tissue for potential future analysis of fish tissue chemistry. A subset of archived samples were selected to characterize tissue chemistry in fish collected during both pre-fire (2005-2007) and post-fire (2008-2009) sampling periods. Metals analysis had been completed previously on liver and muscle tissue for 17 fish from the pre-fire sampling period. Where the number of archived tissue samples allowed, and including samples already analyzed, a target of 8 fish of each species (lake whitefish and northern pike) was desired from each of Burke, Lou, Nico, and Peanut lakes. This sample size was based on a power analysis using existing fish tissue data, which indicated that a sample size of 8 would provide sufficient power (80%) to be able to detect 25% change in arsenic concentrations in muscle tissue and a 20% change in selenium concentrations in muscle tissue.

All 33 fish collected after the forest fire in August 2008 were archived, and liver and muscle tissues from 31 of these fish were submitted for total metals analysis. In most cases, the available samples were insufficient to achieve the target sample size of 8 fish per species per location; therefore, additional sampling was performed in 2009 for an additional 32 individuals to fill the data gaps for additional post-fire tissue samples.

In 2009, an additional 20 ninespine stickleback were collected and submitted for whole body total metals analysis. Ten individual fish from each of Reference and Burke lakes were composited for analysis.

12.2.6.2 Results

Fish tissue concentrations of arsenic, copper, iron, lead, mercury, and selenium were above USEPA risk screening levels for human health risk assessments in a number of samples from lake whitefish and northern pike from the NICO Project area.

The concentrations of most metals tended to be lower in lake whitefish than northern pike, and the concentrations of iron and copper were generally 1 to 2 orders of magnitude higher in liver than muscle tissue. Selenium and mercury were also often elevated relative to the other metals despite being found in low concentrations in the water, due to the biotransformation of these metals into organic forms and subsequent bioaccumulation. Lead and thallium concentrations were consistently low in both tissue types and in both species.

Following the forest fire in 2008, copper and thallium concentrations tended to decrease in lake whitefish liver tissue from lakes impacted by the fire (Peanut, Burke, and Reference lakes). Copper and iron (and less consistently selenium and thallium) tended to decrease in northern pike muscle tissue following the fire. Interestingly, arsenic concentrations in lake whitefish liver from Burke Lake (which was surrounded by the fire in 2008) increased noticeable following the fire; a similar increase in liver arsenic concentrations was not observed in northern pike tissue samples. The increase in arsenic concentrations in lake whitefish livers was the only instance of a measureable increase in concentration of metals post-fire.

Ten ninespine stickleback were collected from each of Reference and Burke lakes following the fire (2009). The levels of arsenic and lead measured in the whole body of the fish from Reference Lake were above USEPA screening levels (arsenic = 0.082 milligrams per kilograms (mg/kg), lead = 0.135 mg/kg). Similarly, the ninespine stickleback collected from Burke lake had exceedences in whole body arsenic and lead, as well as mercury concentrations (arsenic = 0.253 mg/kg, lead = 0.045 mg/kg, mercury = 0.103 mg/kg). The majority of other metals in the ninespine stickleback were above detection limits, but were below USEPA screening levels.

Bioavailable organic arsenic was present in higher concentrations in muscle than in liver tissue in both northern pike and lake whitefish, whereas inorganic arsenic was present in higher concentrations in liver tissue. Northern pike from Nico Lake had the highest percent bioavailable arsenic relative to the other waterbodies.

12.2.6.3 Traditional and Non-traditional Use

The existing winter road system in the region provides angler access to many waterbodies, including locations where there are healthy populations of sport fish (e.g., Marian Lake, Faber Lake, Rae Lakes, and Lac La Martre). These existing fishing locations can be directly and easily accessed by nearby Tłįchǫ communities. In addition, Marian Lake is currently accessible by an all-weather road from Highway 3.

Aboriginal communities (Gamètì and Whatì) use lakes in the region, such as Lou Lake, for subsistence fishing (also see Section 5). Both communities have identified Hislop Lake, west of the LSA, as a lake where individuals fish and have fished historically. There are reports of historical fishing in Peanut Lake and Nico Lake, and that fishing was good in these lakes, but these lakes may not be currently used for fishing. However, most fishing is currently done in Lac La Martre. Perceptions of fish health by traditional users range from healthy in the RSA and LSA to a reduction in health in waterbodies near other mining developments. Section 5 provides additional information on traditional use of aquatic resources.

The Lac la Martre fishing lodge, located in the nearby area, boasts excellent northern pike, lake trout, and grayling fishing (LMA 2011), and is located on an island in the middle of Lac la Martre; however, the lodge itself is not road-accessible and only operates during the summer months (see Annex D, Wildlife Baseline). At the lodge, non-traditional fishing is governed by the Northwest Territories Fishery Regulations, under the federal Fisheries Act. These regulations include daily catch limits, possession limits and fishing seasons for sport (i.e., non-traditional) fishing. Some lakes and rivers also have unique regulations where special management is necessary (ENR 2010).

12.3 Pathway Analyses

12.3.1 Methods

Pathway analysis identifies and assesses the linkages between NICO Project components or activities and the correspondent potential residual effects to VCs (e.g., water quantity, soil, wildlife, and socio-economics). Potential pathways through which the NICO Project could affect VCs were identified from a number of sources including the following:

- a review of the Development Description and scoping of potential effects by the environmental and engineering teams for the NICO Project;
- scientific knowledge, and experience with other mines in the NWT;
- engagement with the public, Aboriginal people, communities, and government; and
- consideration of potential effects identified from the TOR for the NICO Project.

The first part of the analysis is to produce a list of all potential effects pathways for the NICO Project (Section 6.3). Each pathway is initially considered to have a linkage to potential effects on VCs. This step is followed by the development of environmental design features that can be incorporated into the Development Description to remove a pathway or limit (mitigate) the effects to VCs. Environmental design features include NICO Project design elements, environmental best practices, management policies and procedures, and social programs. Environmental design features are developed through an iterative process between the NICO Project's engineering and environmental teams to avoid or mitigate effects.

Knowledge of the environmental design features is then applied to each of the pathways to determine the expected amount of NICO Project-related changes to the environment and the associated residual effects (i.e., effects after mitigation) on VCs. Changes to the environment can alter physical measurement endpoints (e.g., water and soil chemistry, and amount of habitat) and biological measurement endpoints such as animal behaviour, movement, and survival (Section 6.2). For an effect to occur, there has to be a source (NICO Project component or activity) that results in a measurable environmental change (pathway) and a correspondent effect on a VC.

Project activity → change in environment → effect on VC

Pathway analysis is a screening step that is used to determine the existence and magnitude of linkages from the initial list of potential effects pathways for the NICO Project. This screening step is largely a qualitative assessment, and is intended to focus the effects analysis on pathways that require a more comprehensive assessment of effects on VCs. Pathways are determined to be primary, secondary (minor), or as having no linkage based on scientific and traditional knowledge, logic, and experience with similar developments and environmental design features. Each potential pathway is assessed and described as follows:

- no linkage – pathway is removed by environmental design features so that the NICO Project results in no detectable environmental change and residual effects to a VC relative to baseline or guideline values;
- secondary – pathway could result in a minor environmental change, but would have a negligible residual effect on a VC relative to baseline or guideline values; or
- primary – pathway is likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values.

Primary pathways require further effects analysis and impact classification to determine the environmental significance from the NICO Project on VCs. Pathways with no linkage to a VC or that are considered minor (secondary) are not analyzed further or classified in the DAR because environmental design features will remove the pathway (no linkage) or residual effects to the VC can be determined to be negligible through a simple qualitative evaluation of the pathway. Pathways determined to have no linkage to a VC or those that are considered secondary are not predicted to result in environmentally significant effects on VCs. All primary pathways are assessed in the DAR.

12.3.2 Results

Pathways potentially leading to effects on water quality, aquatic habitat, and fish in the NICO Project area include direct and indirect effects. These changes may ultimately affect the suitability of water quality to support a viable aquatic ecosystem, persistence of desired population(s) of key fish species, continued opportunity for traditional and non-traditional use of water and fish, and the protection of human health. Evaluation of effects on water quality, aquatic habitat (i.e., lower trophic levels, benthic invertebrates), and fish in the NICO Project area also considers changes to permafrost, hydrogeology, hydrology, and air quality, and during the construction, operations, and closure phases of the NICO Project, as well as effects remaining after closure. Table 12.3-1 summarizes the environmental design features and mitigation that were incorporated into the NICO Project to eliminate or reduce effects to aquatic habitat and fish in the NICO Project area during construction, operations, and closure.

Potential pathways are based primarily on public concerns identified during the Mackenzie Valley Review Board (MVRB) scoping process (MVRB 2009). The issues are screened and considered for inclusion as pathways that could lead to effects. Some issues may not represent actual pathways, and in other instances, the preliminary screening and/or analysis may show that potential effects considered during issues scoping are so small that they are not relevant. Other concerns may be screened out through the incorporation of environmental design features and mitigation during the development of the NICO Project, which address these issues by reducing or eliminating potential effects. Other potential pathways may be primary pathways and are included in the effects analysis. The following sections discuss the potential pathways relevant to water quality and fish in the NICO Project area.

Potential pathways through which the NICO Project could affect VCs are also presented in Table 12.3-1. Environmental design features incorporated into the NICO Project description to remove a pathway or limit (mitigate) the effects to VCs are listed, and pathways are determined to be primary, secondary (minor), or as having no linkage. The following section discusses the potential pathways relevant to the aquatic habitat (e.g., lower trophic levels, fish habitat) and fish.

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Mine construction	Site clearing, contouring, and excavation can cause soil erosion and sedimentation. Through surface runoff and sediment deposition, this may affect water quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Best management practices and sediment and erosion control measures will limit wind and water erosion on growth media and overburden stockpiles (e.g., vegetation, erosion mats). Construction runoff will be captured and discharged into a polishing pond (e.g., Surge Pond), to settle out suspended sediments prior to release to Peanut Lake. The layout of the mine footprint will limit the area that is disturbed.	No Linkage
	Air emissions (acidifying emissions, dust, and associated metal deposition) can cause changes to surface water and sediment quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	The current layout of the mine footprint will limit the area that is disturbed. Compliance with regulatory emission requirements. Implementation of best management practices plan for controlling fugitive and exhaust emissions, and improving energy efficiencies, including the following: • Watering of roads and enforcing speed limits to suppress dust production. • Use of upswept exhausts on construction equipment. • Equipment and fleet equipped with industry-standard emission control systems. • NICO Project Access Road will be as narrow as possible, while maintaining safe construction practices. • Enclosing conveyance systems and processing facilities. • Processing equipment with high efficiency bag houses to reduce emissions of particulate matter. • Operating procedures will be developed that reduce dust generation and air emissions (e.g., regular maintenance of equipment to meet emission standards). • Equipment and fleet equipped with industry-standard emission control systems.	Primary

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat (continued)

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Mine construction (continued)	Sediment releases during the construction of the water intake in Lou Lake and the effluent outfall in Peanut Lake can affect surface water quality, affecting aquatic habitat and fish in Lou Lake and Peanut Lake.	benthic invertebrates, plankton, fish, fish habitat	Construction work will be under dry conditions (i.e., a cofferdam will be constructed to isolate the construction area in the lake) and sediment and erosion control measures (e.g., silt curtains, runoff management) will be used to control sediment releases during construction.	No Linkage
Mine infrastructure footprint (e.g., Open Pit, site road, Co-Disposal Facility, and Airstrip) NICO Project Access Road footprint	Physical loss or alteration of local surface waters (e.g., Grid ponds), drainage patterns (distribution), and drainage areas from the NICO Project footprint can affect surface water quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	The current layout of the mine footprint will limit the area that is disturbed (updated from 30 January 2009). Access roads will be as narrow as possible, while maintaining safe construction and operation practices.	Secondary
	Physical loss or alteration of local watercourses (e.g., Marian River) can affect surface water quality, affecting aquatic habitat and fish.	benthic invertebrates, fish, fish habitat	Use of culverts and standard environmental design features that reduce impacts to local flows and drainage patterns and drainage areas. Instream work during road crossing construction along the NICO Project Access Road will be avoided, or limited to the minimum extent possible. For example, the Marian River crossing will be a single-span bridge from bank-to-bank.	Secondary
	Impediments to fish passage at stream crossings (e.g., along NICO Project Access Road) may affect fish and fish habitat.	fish, fish habitat	With the exception of the Marian River, all other crossings are intermittent streams and not considered to be fish habitat. A single clear-span bridge will be installed at the Marian River crossings, so will not impact fish habitat.	No Linkage
	Physical alteration of fish habitat in Lou Lake as a result of water intake structures established in the lake.	benthic invertebrates, plankton, fish, fish habitat	Rip-rap and aggregate placed on top of the intake structure will create higher quality habitat than what is affected. If required, fish habitat compensation will be developed in consultation with DFO and other regulatory agencies.	Secondary
	Physical alteration of fish habitat in Peanut Lake as a result of water discharge structures established in the lake.	benthic invertebrates, plankton, fish, fish habitat	Rip-rap and aggregate placed on top of the discharge pipe and around the diffuser structure will create higher quality habitat than what affected. If required, fish habitat compensation will be developed in consultation with DFO and other regulatory agencies.	Secondary

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat (continued)

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Co-Disposal Facility	Vertical and lateral seepage from the Co-Disposal Facility may cause changes to groundwater quality, surface water quality, and sediment quality in nearby lakes and streams, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Runoff from the Co-Disposal Facility will be captured in Seepage Collection Ponds and diverted to the Mineral Process Plant for recycling, or the Effluent Treatment Facility.	Secondary
	Leaching and runoff of dissolved metals from Mine Rock may cause changes to groundwater quality, surface water quality, and sediment quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Runoff from the Co-Disposal Facility will be captured in Seepage Collection Ponds and diverted to the Mineral Process Plant for recycling, or the Effluent Treatment Facility. Any potential acid-generating Mine Rock will be sequestered within the interior of the Co-Disposal Facility. Overburden directed to the Co-Disposal Facility will be used to cover any areas in the core of the pile where potential metal-leaching Mine Rock is to be sequestered to reduce any infiltration.	Secondary
General operation of mine and supporting infrastructure	Release of treated mine wastewater and sewage may cause changes to surface water quality and sediment quality, affecting aquatic habitat and fish in Peanut Lake and downstream waterbodies.	benthic invertebrates, plankton, fish, fish habitat	Sewage will be treated in the Sewage Treatment Plant and the effluent will either be re-used during processing or discharged to Peanut Lake through the Effluent Treatment Facility. The site Water Management Plan will contain surface water on site. Mine wastewater will be treated and tested before release to surface waters.	Primary
	Process and potable water requirements for the Project may decrease drainage flows and surface water levels (e.g., Lou Lake), thus changing the surface water environment (e.g., migration potential) and affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Capture and reuse site water to reduce fresh water requirements. Water from tailings thickener and from the tailings basin will be recycled for grinding operations. Excess water from the collection pond (tailings basin) will be recycled in mill operations.	Secondary
	Impingement and entrainment of fish in Lou Lake intake pumps may cause injury and mortality to fish.	fish	Appropriately sized fish screens, which meet DFO guidelines, will be fitted to pumps to limit fish access and to protect fish from entrainment and impingement	No Linkage

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat (continued)

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
General operation of mine and supporting infrastructure (continued)	Air emissions (acidifying emissions, dust, and associated metal deposition) can cause changes to surface water and sediment quality, affecting aquatic habitat and fish in nearby surface waters.	benthic invertebrates, plankton, fish, fish habitat	The layout of the mine footprint will limit the area that is disturbed. Watering of roads will suppress dust production. Enforcing speed limits will assist in reducing dust. Conveyance systems and processing facilities will be enclosed and processing equipment will be fitted with high efficiency bags to reduce emissions of particulate matter. Operating procedures will be developed that reduce dust generation and air emissions (e.g., regular maintenance of equipment to meet emission standards).	Primary
	Spills and leaks resulting from equipment operation (e.g., petroleum products, reagents, washdown) on the mine site or along the NICO access road can impact surface water quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Hazardous materials and fuel will be stored according to regulatory requirements to protect the environment and workers (i.e., Materials and Waste Management Plan). Smaller storage tanks (e.g., engine oil, hydraulic oil, and waste oil and coolant) will be double walled, and located in lined and bermed containment areas. Separate areas will be established for the handling and temporary storage of hazardous wastes. Reagents and fuel Enviro-Tanks will be located in larger, double-walled containers. Domestic and recyclable waste dangerous goods will be stored on site in appropriate containers to prevent exposure until they are shipped off site to an approved facility. Individuals working on site and handling hazardous materials will be trained in the Transportation of Dangerous Goods.	No linkage

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat (continued)

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
General operation of mine and supporting infrastructure (continued)			Soils from petroleum spill areas will be deposited and spread in a lined landfarm cell for bioremediation. An Emergency Response and Spill Contingency Plan has been developed and will be implemented. Emergency spill kits will be available wherever toxic materials or fuel are stored and transferred. Operations and mining equipment, machinery, and vehicles will be regularly maintained.	
	Improved access for harvesting from the NICO Project Access Road and the Proposed Tłįchǫ Road Route can affect sportfish populations in the Marian River-Hislop Lake system and opportunities for traditional and non-traditional fishing.	Fish	Site staff will not be permitted to fish. Prohibit the use of recreational all terrain vehicles at site.	Primary
Closure – Decommissioning phase; and Closure – Long-term and reclamation	Air emissions (acidifying emissions, dust and associated metal deposition) can affect surface water and sediment quality of nearby surface waters, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Compliance with regulatory emission requirements. Implementation of best management practices plan for controlling fugitive and exhaust emissions, and improving energy efficiencies during active closure including the following: • Watering of roads and enforcing speed limits to suppress dust production. • Use of upswept exhausts on construction equipment. • Equipment and fleet equipped with industry-standard emission control systems.	Secondary

Table 12.3-1: Potential Pathways for Effects to the Persistence of Fish and Condition of Aquatic Habitat (continued)

NICO Project Component/ Activity	Effect Pathways	Valued Components	Environmental Design Features and Mitigation	Pathway Assessment
Closure – Decommissioning phase; and Closure – Long-term and reclamation (continued)	Residual ground disturbance can cause permanent alteration of local surface water quality and quantity, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	Sediment and erosion control measures (e.g., silt curtains, runoff management) will be used to control sediment releases during land reclamation. Limit size of NICO Project footprint. Develop and implement a closure and reclamation plan.	Secondary
	Runoff and seepage from the abandoned tailings and mine rock Co-Disposal Facility can affect nearby Nico Lake and potentially other surface waters, where it can affect surface water quality and sediment quality, affecting aquatic habitat and fish.	benthic invertebrates, plankton, fish, fish habitat	If the water quality in the discharge from the open pit does not meet water quality standards at the time of discharge, then discharge water will be treated using an active (water treatment plant) or passive (wetland treatment system) prior to discharge into Peanut Lake. Co-disposal area will be capped during closure to isolate Mine Rock and tailings and minimize leaching. Any seepage from the Co-Disposal Facility will be intercepted and treated in a passive wetland treatment facility prior to discharge to Nico Lake.	Secondary

12.3.2.1.1 Pathways with No Linkage

A pathway may have no linkage if the activity does not occur (e.g., effluent is not released), or if the pathway is removed by environmental design features so that the NICO Project results in no detectable (measurable) environmental change and residual effects to aquatic habitat and fish in the NICO Project area. The following pathway is anticipated to have no linkage to the persistence of fish and condition of aquatic habitat and will not be carried through the effects assessment.

- **Site clearing, contouring, and excavation can cause soil erosion and sedimentation. Through surface runoff and sediment deposition, this may affect aquatic habitat and fish.**

The NICO Project footprint, or the total area disturbed, is estimated to be 485.4 ha. NICO Project Site clearing will occur during the winter when streams within or adjacent to the NICO Project site are not flowing or after the spring freshet when flows are generally low. This will minimize the potential for sediment releases. All construction activities will be subject to a sediment control plan. For example, standard erosion and sediment control measures (e.g., vegetation, erosion mats, and silt curtains) will be used during construction around areas to be disturbed to limit wind and water erosion on topsoil and overburden stockpiles.

Most of NICO Project infrastructure, and subsequent site clearing, contouring, and excavation, will be located in areas where runoff will be captured and discharged into the Water Management Ponds. Suspended sediments will settle out prior to runoff being released into Peanut Lake. If necessary, runoff will be treated in line with flocculent to reduce suspended sediment concentrations before being release.

The layout of the NICO Project footprint will help to minimize the area that is disturbed. Mine site roads will be as narrow as possible, while maintaining safe construction and operation practices. The Co-Disposal Facility (CDF) design requires a smaller footprint than if tailings and mine rock disposal were separate, thus reducing the area to be cleared, contoured, and excavated. Additionally, the surface area of tailings exposed to wind and water erosion will be reduced by placing tailings in cells which will be covered with mine rock after they are filled.

Thus, given the environmental design features in place and mitigation, this pathway was determined to have no linkage to effects to lower trophic levels, fish and fish habitat.

- **Spills and leaks resulting from accidents and malfunctions on the mine site or along the NICO Project Access Road can affect surface water quality and sediment quality, affecting aquatic habitat and fish.**

Chemical spills are usually localized, and are quickly reported and managed. Mitigation practices identified in the Emergency Response and Spill Contingency Plan (Appendix 3.VI) and environmental design features (Table 12.3-1) will be in place to limit the frequency and extent of chemical spills that result from NICO Project activities. Hazardous material and fuel will be stored according to regulatory requirement to protect the environment and workers (i.e., Hazardous Substances Management Plan; [Appendix 3.V]). Smaller storage tanks (e.g., engine oil, hydraulic oil, waste oil, and coolant) will be double walled, and located in lined and bermed containment areas. Individuals working on-site and handling hazardous materials will be trained in the Transportation of Dangerous Goods. Emergency spill kits will be available wherever toxic materials or fuel are stored and transferred.

The implementation of the Emergency Response and Spill Contingency Plan (Appendix 3.VI), and environmental design features are expected to result in no detectable change to surface water and sediment quality, and fish habitat and aquatic health. Consequently, this pathway was determined to have no linkage to effects to lower trophic levels, fish, and fish habitat.

- **Sediment release into Lou Lake as a result of construction of the water intake structures may affect surface water quality, affecting aquatic habitat and fish.**
- **Sediment release into Peanut Lake as a result of construction of the water outlet structures may affect surface water quality, affecting aquatic habitat and fish.**

Sediment may be released as a direct result of construction of the water intake and outlet structures. Construction work within both Lou and Peanut lakes will be under dry conditions, a cofferdam will be constructed to isolate the construction area in the lake and standard erosion control measures will be implemented. During construction of structures on land (e.g., pipe installation), sediment control measures (e.g., silt curtains, runoff management) will be used to control sediment releases. Site runoff from these areas will be treated with flocculent, prior to release into Lou or Peanut lakes.

The potential for erosion of lake-bottom sediments in Lou and Peanut lakes also exists. Constructed channel outfalls or diffusers will be used to reduce the erosive energy of water pumped out of Lou Lake for mine site usage, and of water pumped into Peanut Lake from the Effluent Treatment Facility. Within Peanut Lake, outfalls will be constructed to diffuse the velocity of the discharge and the diffuser will be positioned at a 30 degree angle (from the horizontal plane) and located at a depth of about 8.75 m, and a minimum of 0.25 m above lake bottom. Cobble and boulder will be placed at the base of the diffuser to reduce erosion potential on the bottom of Peanut Lake. Although some sediment may be mobilized despite these measures, the extent of this effect is likely to be limited to the zone of turbulence immediately adjacent to the diffuser, and is likely to quickly diminish after sediments in the zone of turbulence are mobilized and become re-deposited farther away from the outfall.

Sediment release from the installation of the water intake and outlet structures are not expected to result in changes to surface water quality in Lou Lake and Peanut Lake and subsequently no changes in lower trophic levels, fish, or fish habitat. This pathway was identified as being a no linkage pathway for the DAR.

- **Impingement and entrainment of fish in Lou Lake intake pumps may cause injury and mortality to fish.**

The freshwater intake and pumphouse will be located north of the current dock on the southern shore of Lou Lake. The intake will consist of vertical filtration wells fitted with vertical turbine pumps that supply water on demand. The intake will be connected to the pumphouse piping buried under a rock-filled embankment. The overlaid embankment will act as a secondary filtration screen, which will prevent fish from becoming entrained.

The implementation of fish screens on the intake and a buried intake under rock fill is anticipated to reduce fish mortality resulting from impingement or entrainment. The intake for the pumps used to provide water for plant processes will be appropriately screened following DFO guidelines to prevent fish entrainment or impingement (DFO 1995). The appropriate screen mesh size will be determined in consultation with DFO for the planned pumping rates to prevent fish from entering the pump during water withdrawal. This includes the determination of a maximum approach velocity for water at the screen surface to prevent fish from being entrained or impinged on the screen. The intake screen mesh size and dimensions will be influenced by the species found within Lou Lake, as well as the swimming abilities of these species and the likely age-classes of fish present at the water withdrawal location. Fish species captured in Lou Lake include lake whitefish, northern pike, walleye, cisco, white sucker, and longnose sucker.

With proper design, installation, and maintenance, impingement and entrainment of fish in Lou Lake water intake was determined to have no linkage to injury and mortality to fish.

12.3.2.1.2 Secondary Pathways

In some cases, both a source and a pathway exist, but the change caused by the NICO Project is anticipated to result in a minor environmental change, and would have a negligible residual effect on aquatic habitat (e.g., lower trophic levels) and fish relative to baseline or guideline values (e.g., a slight increase in a water quality parameter above Canadian Council of Ministers of the Environment [CCME] guidelines, but would not affect fish health). The following pathways are anticipated to be secondary, or minor, and will not be carried through the effects assessment.

- **Mine site stormwater (surface water runoff from the core mine facilities area) can impact surface water quality, affecting aquatic habitat and fish.**
- **Water discharge from the Flooded Open Pit will increase flow which can impact surface water quality, affecting aquatic habitat and fish.**

Surface water runoff from the Open Pit and the Plant facilities area could potentially affect the downstream aquatic environment. These facilities incorporate several environmental design features to prevent release of untreated site water into the receiving environment (Table 12.3-1).

During operations, water which collects in the Open Pit sump, which will include seepage into the pit as well as runoff from rainfall and snow, will be pumped to the Surge Pond. Runoff from the Mineral Processing Plant (Plant) area will be collected in a site runoff collection pond and then transferred to the Surge Pond. Sewage will be treated and the effluent will either be re-used during processing or discharged to Peanut Lake through the Effluent Treatment Facility. Water collected in the Surge Pond will be be used to meet water demands of the Plant to the extent that it is needed; all excess water will be pumped to the Effluent Treatment Facility. Following treatment, the water will be discharged through a diffuser into Peanut Lake.

At closure, the Plant will be demolished and the area will be covered with till and re-vegetated. Runoff from part of the area will drain into the Surge Pond and thence into Wetland Treatment System No. 4. Runoff from the remainder of the area will drain directly into Wetland Treatment System No. 4, which will discharge into Nico Lake. Closure of the CDF will focus on reducing the risk of wind and water erosion of tailings. The exposed tailings will be covered with a 0.5 m thick layer of glacial till underlain by a 0.25 m layer of sand. Erosion control practices (e.g., erosion mats) will be used to limit erosion of topsoil stockpiles.

After closure, dewatering of the Open Pit will cease and the pit will slowly fill with water. The water level is expected to reach Elev. 260 m roughly 120 years after closure, at which point it will overflow. At that time, the Flooded Open Pit overflow water will be treated be via Wetland Treatment System No. 4 (Section 9.4.3.3). After treatment in Wetlands Treatment System No. 4, the Open Pit water will discharge into Peanut Lake.

After Open Pit overflow occurs, the discharge into Peanut Lake through the Wetland Treatment System No. 4 will vary from 242 000 to 601 000 m^3 per year (average 385 000 m^3 per year) for the climatic scenarios evaluated (Section 3.9.3). The discharges when the Open Pit overflows are greater than those or the operations phase the increase in discharge from Peanut Lake will be approximately 7.7% of the annual average discharge and less than 2% of the peak. Similarly for Burke Lake, the annual average discharge will be approximately 5.7% higher and less than 1% higher during peak discharge. As such, the increase in discharge at and downstream of Peanut Lake from the NICO Project is expected to result in a minor change to the hydrology in the LSA relative to baseline conditions, which should have a negligible effect on Peanut Lake and downstream waterbodies such as Pond 11, 12, and 13, and Burke Lake, subsequently Flooded Open Pit discharge was determined to have a negligible effect to surface water quality, lower trophic levels, fish, and fish habitat.

During operation and at closure the Water Management Ponds are designed to accommodate extreme precipitation events (i.e., intense, prolonged or above average rainfall – snowmelt events), up to return periods that are acceptably long (Section 3.14.8, Appendix 3.III.10.3). Should longer return period events occur, the dams forming the ponds are designed to include spillways to protect against overtopping. Thus, stormwater during operation and closure was determined to have negligible effects to lower trophic levels, fish, and fish habitat.

- **Vertical and lateral seepage from the Co-Disposal Facility may cause changes to local surface water quality, affecting aquatic habitat and fish.**
- **Leaching of dissolved metals and arsenic from the Co-Disposal Facility may cause changes to local surface water quality, affecting aquatic habitat and fish.**
- **Long-term seepage from the Co-Disposal Facility may change local surface water quality, affecting aquatic habitat and fish.**

During the life of the NICO Project, there is the potential for leachate (e.g., acidity and metals) from the tailings and mine rock CDF to seep through the co-disposed wastes and report as seepage into the Seepage Collection Ponds. Additionally, there is potential for arsenic as well as other metals (i.e., aluminum, cadmium, cobalt, lead, selenium, and uranium) to be present in the leachate. Such water-borne chemicals could adversely affect the downstream aquatic environment through surface water runoff and seepage. Environmental design features and mitigation have been incorporated into the NICO Project to reduce the potential for water to contact metal leaching Mine Rock, tailings, and potentially acid generating rock, thereby reducing potential effects to the environment from surface water runoff and seepage from the CDF (Table 12.3-1).

The CDF is designed to limit runoff and seepage from contacting potentially acid generating and metal leaching Mine Rock by placing this material in the interior of the CDF interlayered with tailings. The cover placed on the top of the CDF at closure will limit infiltration into the interior of the CDF where potentially acid generating and metal leaching rock is located.

Runoff and seepage from the CDF will not be released directly to the surrounding aquatic environment during construction or operations. Runoff and seepage from the CDF will report to 1 of 5 Seepage Collection Ponds. During operations, water in the Seepage Collection Ponds will be pumped to the Surge Pond. Water from the Surge Pond will be pumped for use in the Plant or pumped to the Effluent Treatment Facility for treatment prior to release into Peanut Lake. Runoff and seepage from the CDF reporting to the Seepage Collection Ponds, and pumped to the Surge Pond, may seep through the lined base of these ponds and report to Nico Lake. However, the total predicted quantity of seepage losses to Nico Lake is very small (i.e., 0.78 litres per second during the open water season) relative to existing estimated average flows reporting to Nico Lake from the Grid ponds and will be distributed over a larger distance along the west shore of Nico Lake.

At closure, the surface of the CDF will be covered; thereafter, runoff from the CDF will not be in contact with the mine rock or tailings materials. Seepage out of the toe of the CDF will continue to be collected in the Seepage Collection Ponds. Water from Seepage Collection Ponds Nos. 1, 2, 3, and 5 and the Surge Pond will pass through constructed Wetland Treatment Systems prior to draining into Nico Lake. The use of wetland treatment will be subject to demonstration of its technical feasibility by testing during the operating life of the mine. The Open Pit will slowly fill after closure. The water level is expected to reach Elev. 260 m roughly 120 years after closure, at which point it will overflow. At that time the Flooded Open Pit overflow water will be directed through a ditch to Wetland Treatment System No. 4, which will discharge into Peanut Lake.

The Grid Ponds currently produce measureable natural arsenic loadings into Nico Lake. During operations, all releases from the NICO Project site into Peanut Lake will be subject to monitoring and treatment by active means. Overall, runoff and seepage from the CDF is not expected to result in a detectable change to aquatic habitat outside of the NICO Project footprint area relative to baseline conditions. Therefore, these pathways were determined to have negligible effects to local surface water quality, lower trophic levels, fish and fish habitat.

- **Residual ground disturbance can cause permanent alteration of local surface water quality and quantity, affecting aquatic habitat and fish.**

The total area of the NICO Project footprint is estimated to be 485.4 ha. Following closure, approximately 402 ha will be reclaimed. Reclamation trials will be implemented as part of the mitigation and monitoring program to acquire knowledge during operations regarding re-vegetation processes and techniques that can be applied during the reclamation phase. The area of residual ground disturbance (i.e., are that will not be reclaimed at closure) is predicted to be approximately 84 ha. Non-reclaimed land is associated with residual disturbances including the Flooded Open Pit, constructed wetlands, Seepage Collection/Surge Ponds, and excavated ditch. To the extent possible, all disturbed areas will be reclaimed and the surface stabilized. This will include re-grading and placing till or Mine Rock, as appropriate to prevent dust generation and erosion. Drainage patterns will also be re-established as close to pre-operational conditions as possible, with drainage ditches contoured or backfilled as appropriate to remove any hazards to wildlife.

After the closure phase, Fortune will offer the NPAR and Airstrip to the Tłı̨chǫ Government. If neither party want the NPAR or Airstrip transferred to them, this infrastructure, along with the buildings and other related structures, will be closed and reclaimed by Fortune. Dismantling of the NPAR would involve removing culverts and stream-crossing structures. The corresponding surface area will be contoured to eliminate potential hazards to wildlife and to re-establish natural drainage. While doing so, proper sediment and erosion control measures (e.g., silt curtains and runoff management) will be taken as part of best management practices.

Although the CDF will be reclaimed during operation and at closure by being covered with overburden, the Grid Ponds will be permanently disturbed. However, because the Grid Ponds are classified as poor fish habitat and do not contain fish, permanent alteration of fish habitat would not occur. The CDF is designed to limit runoff and seepage from contacting tailings and metal leaching Mine Rock (see section 12.3.2.1.2 seepage pathway for discussion), thereby reducing underground seepage into Nico Lake. The cover placed on the top of the CDF at closure will limit water infiltration into the interior of the CDF where potentially acid generating and metal leaching rock is located.

As such, residual ground disturbance was determined to have a secondary linkage to permanent alteration of local surface water quality, lower trophic levels, fish and fish habitat. Effects are anticipated negligible in magnitude.

- **Process and potable water requirements for the NICO Project may decrease drainage flows and surface water levels (e.g., Lou Lake), thus changing the surface water environment (e.g., winter DO levels) and affecting aquatic habitat and fish.**

The NICO Project will withdraw freshwater for dust suppression, potable water, and plant operations from Lou Lake. Department of Fishery and Oceans allowable lake under ice withdrawal volumes are 10% of the available water volume calculated using the appropriate maximum expected ice thickness (DFO 2010). The available water volume of Lou Lake is 9.42 Mm^3 (Fortune 2006). Thus the allowable volume that could be pumped from Lou Lake in winter without detrimentally affecting fish habitat is approximately 942 000 m^3. Throughout the life of the NICO Project it is anticipated that fresh water withdrawals during construction and operations will range from 112 000 m^3/year under average climatic conditions up to 146 000 m^3/year during a 1:25 year dry period (Section 11.3.2.2). This is below the allowable volume of water that could be taken from Lou Lake. It is anticipated that fresh water withdrawal will occur at a constant rate year round, so only a portion of the annual requirement would be taken during winter. The construction phase of the NICO Project will require substantially less water than during operations. This is well below the allowable volume of water that could be taken from Lou Lake. Further, previous research has shown that DO concentrations in relatively deep lakes such as Lou Lake are unaffected by water extraction of up to 15% of the under-ice volume (Clilverd et al. 2009).

The major concern with water extraction is the protection of overwintering fish habitat, specifically, a shift in the hydrologic budget such that dissolved oxygen levels are lowered beyond a safe threshold. Dissolved oxygen often becomes the primary concern for fish survival at the end of winter. For Lou Lake, surface temperature and DO data were available during open-water in 2005 to 2009 and under-ice in April 2006, 2008, 2009, and 2010. Surface DO remained above the Canadian Water Quality Guidelines (CWQG) (6.5 mg/L) but periodically dropped below the CWQG for the protection of early stages of aquatic life (9.5 mg/L) (Annex C). Generally, Arctic lakes >7 m depth can maintain high DO (>8 mg/L; 54% DO saturation) (Clilverd et al. 2009), and Lou Lake has a maximum depth of 32 m (Annex C). It is expected that the planned water withdrawals for human consumption and mine processing will result in no-to-negligible changes in DO levels (i.e., fish habitat) in Lou Lake.

Environmental design features will be implemented to reduce the amount of water required for plant operations and domestic uses. Site water will be captured and reused in the Plant. Water from tailings thickener and from the Open Pit will be recycled for grinding operations (Table 12.3-1). Excess water from the Seepage Collection Ponds will be recycled and treated prior to release, if not used in the Plant Water requirements for the NICO Project are not expected to decrease drainage flows and surface water levels in Lou Lake below baseline conditions (Section 11.2.2), and should result in only a minor change to wetland hydroperiods, riparian habitat, Lou Lake outlet flows, and Lou Lake water levels. Therefore, this pathway is expected to have negligible residual effects to surface water quality (e.g., dissolved oxygen levels), fish, fish habitat, and aquatic health relative to baseline conditions.

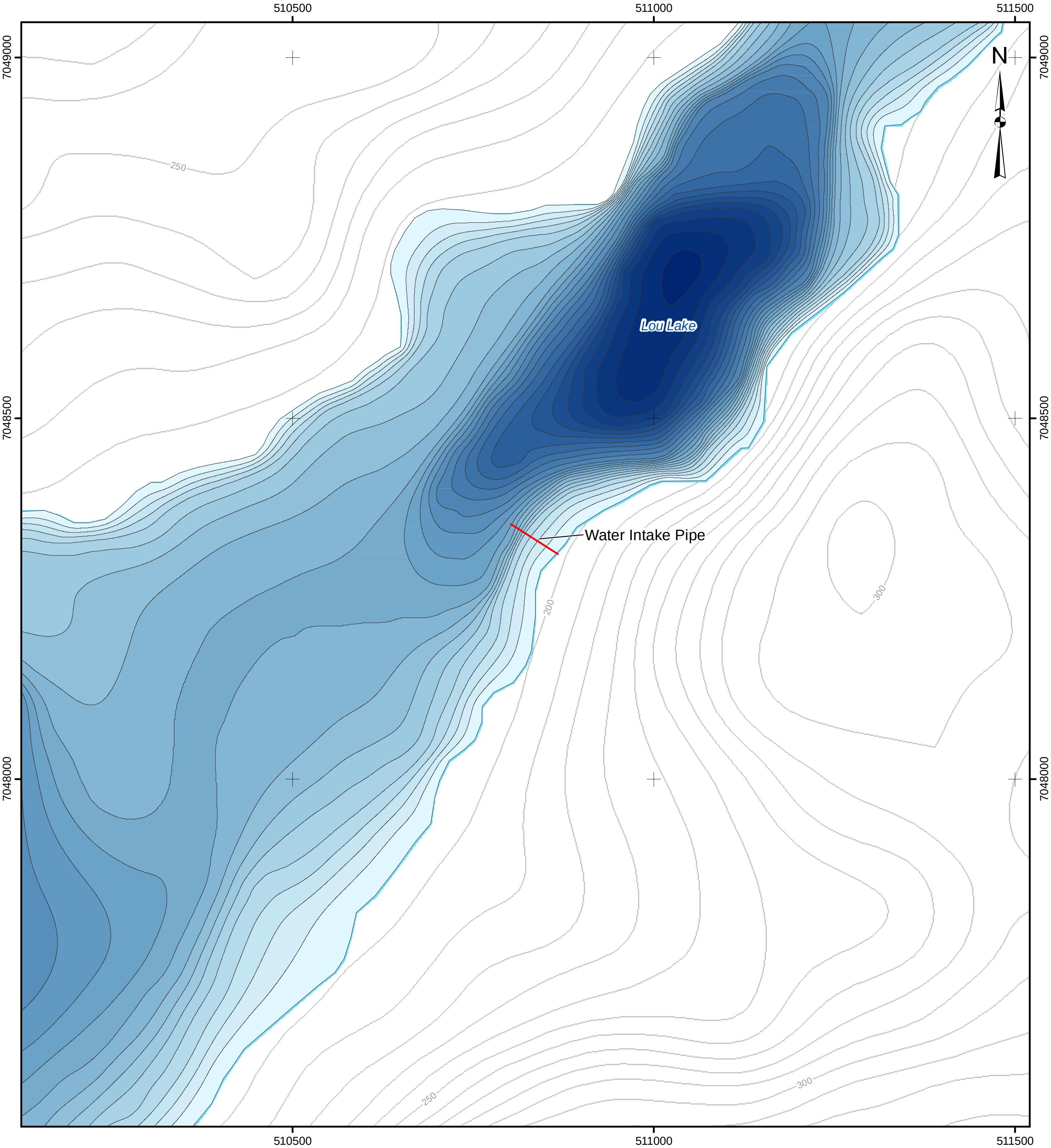
- **Physical loss of fish habitat from Lou Lake as a result of water intake structures established in the lake.**

The NICO Project will require an intake pipe for processing and potable water requirements. The intake pipe will be installed at a shoreline location on the east side of Lou Lake (Figure 12.3-1). The pipe will be installed over the lake bottom and covered with aggregate fill. The aggregate fill and intake pipe will cover an area extending 60.8 m perpendicular from the shoreline by 3-m wide (182.4 m^2). The aggregate will include fine aggregate (2 to 5 centimetres [cm] diameter) immediately over the pipe and lake bottom, with an outer layer of coarse rock (5 to 15 cm) and protective rip-rap. The aggregate fill (i.e., gravel/ cobble) and rip-rap cover should create fish habitat and provide adequate compensation to offset any harmful alteration, disruption, or destruction of existing fish habitat that might occur in Lou Lake.

To assess fish habitat gains or losses from the installation of the water intake pipe, a modified Habitat Evaluation Procedure (USFWS 1980) was used. The Habitat Evaluation Procedure approach combined habitat suitability indices (HSIs) with information on habitat quantity for the calculation of habitat units (HUs), where an HU is a measure of both habitat quantity (i.e., surface area expressed in units of m^2) and quality (or suitability) of available habitat. The HSIs were based on previously published models (e.g., USFWS models; Inskip 1982; Edwards 1983; Twomey et al.1984; McMahon et al. 1984; De Beers 2004; Golder 2008; Golder 2009). Thus, the number of HUs available under baseline conditions was compared to those available post-construction. Changes to the quality and quantity of fish habitat in Lou Lake were evaluated for 4 classes of fish habitat (spawning, nursery, rearing, and foraging), and 6 resident species in Lou Lake.

Based on field reconnaissance of the proposed site in late summer of 2009, there are 2 distinct types of habitat at the water intake pipe location: a shoreline area where water depths range from 0 to 4 m, and a deep water section where depths are greater than 4 m in depth (R. Schryer, Fortune, 2011, pers. comm.). The shoreline area has sparse cover of emergent and submergent macrophytes (5 to 10% cover), and a mix of boulder with some cobble and silt and organic detritus as substrates. The substrate type in the deep water section was largely of silt and detritus, with some intermittent boulder as cover. The area of shoreline habitat (shallow water) to be affected is 163.8 m^2, and the area of deep water habitat to be affected is 18.6 m^2. The areas of affected habitat types were derived using current Geographic Information System information and to-scale construction schematics provided by Fortune.

Species-specific summaries of net changes in Hus resulting from the installation of the water intake are provided in Table 12.3-2. For sucker species, there will be a gain of 46 HUs of foraging habitat. The habitat gain for spawning and nursery stages was small given that lake shorelines are generally not optimum habitats for sucker species (Annex C, Section 2.3.16; Edwards 1983; Twomey et al. 1984). The anticipated change in walleye habitat will be a 49 HU gain of nursery habitat, whereas there will be a net loss of HUs for rearing and foraging habitat. This result was expected given the change in substrate type upon intake instalment, and the differences in requirements between walleye life history stages (e.g., RL&L 1992; Kerr et al. 1997; Langorne et al. 2001). There will also be a small, net loss of habitat for northern pike under the assumption that habitat is limiting for populations in the region. The net loss of habitat will be about 11 HUs for spawning and nursery habitat (Table 12.3-2). However, habitat gains are expected for lake whitefish and cisco. For lake whitefish, it is expected that there will be a net gain of about 46 HUs of spawning and nursery habitat upon installation of the intake pipe, and will benefit the lake whitefish population assuming that the availability of spawning and rearing habitat is a limiting factor for the population in the lake. The anticipated change in habitat units for cisco will be an 82 HU gain of nursery habitat following construction (Table 12.3-2).



LEGEND

- FLOW DIRECTION
- CONTOUR (10 METRE INTERVAL)
- WATERCOURSE
- WATERBODY
- WETLAND
- ISOBATH (1 METRE INTERVAL)
- INTAKE PIPE

WATER DEPTH (m)

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24

200 0 200

SCALE 1:7,500 METRES

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

LOU LAKE WATER INTAKE PIPE LOCATION

Golder Associates
Calgary, Alberta

FILE NO. E-Aqua-034-GIS			
PROJECT No. 09-1373-1004		SCALE AS SHOWN	REV. 0
DESIGN	SM	02 Dec. 2008	FIGURE: 12.3-1
GIS	BS	31 Mar. 2011	
CHECK	GRA	04 May 2011	
REVIEW	GRA	04 May 2011	

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Table 12.3-2: Summary of Net Change in Habitat Units After the Installation of the Water Intake Pipe at the Lou Lake Location

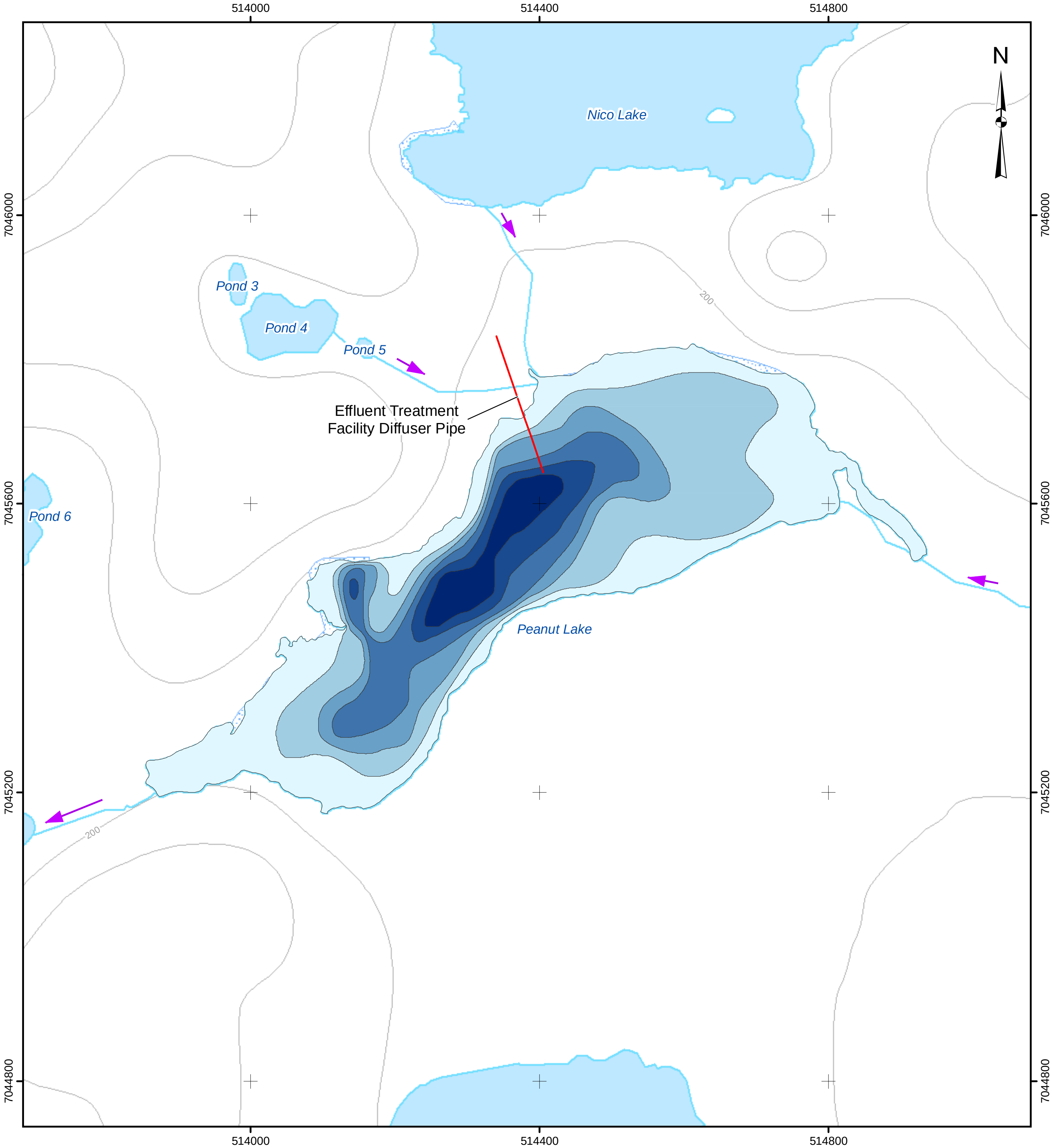
Species	Spawning HUs	Nursery HUs	Rearing HUs	Foraging HUs
Longnose sucker	5.58	11.2	0	45.61
White sucker	5.58	11.2	0	45.61
Walleye	11.17	49.28	-36.28	-36.28
Northern pike	-11.17	-11.17	-9.32	-9.32
Lake whitefish	45.59	45.59	11.17	11.17
Cisco	40.94	81.88	40.94	11.17

HU = habitat units

The overall anticipated change in habitat units for all fish species upon installation of the intake pipe is a 360.1 HU gain (Table 12.3-2). This gain was expected given the proposed placement of aggregate and rip-rap over the intake pipe. Gravel, cobble, and boulder substrate are key habitat features for many coldwater fish species in lakes (e.g., Machniak 1975; Richardson et al. 2001; Golder 2009). It is also important to highlight results from baseline studies that failed to find key spawning and rearing habitats at the proposed intake location, which is located on the east side of the lake (Annex C; Section 2.3.16). Potential spawning and rearing habitats for lake whitefish, walleye, cisco, and sucker species were identified in cobble/gravel areas at the south end of Lou Lake. Also, previously completed baseline work showed that the Lou Lake outflow (at the south end of Lou Lake) provides key spawning and rearing habitat for northern pike, sucker spp., and walleye, whereas the north end of the lake has abundant emergent vegetation for northern pike spawning and rearing requirements. Thus, this pathway is expected to have negligible residual effects to fish habitat and the persistence of fish populations.

- **Physical loss of fish habitat from Peanut Lake as a result of water discharge structure (i.e., diffuser) established in the lake.**

The NICO Project will require a diffuser pipe extending from the Effluent Treatment Facility. The proposed diffuser location is Peanut Lake, where the diffuser will be positioned west of the entrance of the Nico Lake outlet, entering Peanut Lake from a north-northwesterly direction (Figure 12.3-2). The slope of the affected area is low at approximately 10.3% (i.e., there is a 1 m vertical decline with a 9.7 m of run). The anticipate length of submerged pipe is 86 m. The pipe will be installed over the lake bottom to a water depth of about 9 m and will be covered with aggregate fill up until a depth of 4 m. The nozzle depth of the diffuser structure at the end of the pipe will be at 8.75 m (25 cm off the bottom), anchored, and at a 30 degree angle from the bottom. The expected output rate from the Effluent Treatment Facility for average conditions during operations is an exit velocity of about 4 m/s. The aggregate will include fine aggregate (2 to 5 cm diameter) immediately over the pipe and lake bottom, with an outer layer of coarse rock (5 to 15 cm) and protective rip-rap. The first 25 m of submerged pipe will be covered with aggregate. The use of aggregate fill (i.e., gravel/ cobble) should create fish habitat and provide adequate compensation for the harmful alteration, disruption, or destruction of existing fish habitat in Peanut Lake.



LEGEND

FLOW DIRECTION	ISOBATH (2 METRE INTERVAL)
CONTOUR (10 METRE INTERVAL)	EFFLUENT TREATMENT FACILITY DIFFUSER
WATERCOURSE	
WATERBODY	
WETLAND	

WATER DEPTH (m)

0 2 4 6 8 10 12

REFERENCE

Base data obtained from GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

200 0 200

SCALE 1:7,500 METRES

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

PEANUT LAKE EFFLUENT TREATMENT FACILITY DIFFUSER LOCATION

Golder Associates
Calgary, Alberta

PROJECT NO. E-Aqua-035-GIS

PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	SM	02 Dec. 2008	FIGURE: 12.3-2	
GIS	BS	31 Mar. 2011		
CHECK	GRA	04 May 2011		
REVIEW	GRA	04 May 2011		

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To assess fish habitat gains, or losses, a modified Habitat Evaluation Procedure was used (USFWS 1980). The Habitat Evaluation Procedure approach combined HSIs with information on habitat quantity for the calculation of HUs, where an HU is a measure of both habitat quantity (i.e., surface area expressed in units of m^2) and quality (or suitability) of available habitat. The HSIs were based on previously published models (e.g., USFWS models; Inskip 1982; Edwards 1983; Twomey et al. 1984; McMahon et al. 1984; De Beers 2004; Golder 2008; Golder 2009). To determine the total number of HUs lost or gained for each fish species, the number of HUs available under baseline conditions was compared to those available post-construction. The evaluation considered multiple life history stages (spawning, nursery, rearing, and foraging), and 2 species of resident fish of Peanut Lake (northern pike, and lake whitefish; Annex C, Section 7.3.7). Lake whitefish are the most abundant species in Peanut Lake followed by northern pike.

Based on field reconnaissance in late summer of 2009, the proposed diffuser location has substrate dominated by silt and detritus, with some intermittent boulder. Habitat is generally homogenous at the location, although the shoreline area had sparse cover of emergent and submergent macrophytes (<5% cover) that was absent from deeper water locations (> 4 m depths) (R. Schryer, Fortune, 2011, pers. comm.). The total area of fish habitat that would be altered is 108 m^2. The areas of affected habitat types were derived using current Geographic Information System information and to-scale construction schematics.

Results indicate that the installation of the diffuser pipe and use of aggregate and rip-rap fill will result in the loss of shoreline habitat for northern pike spawning, nursery, rearing, and foraging habitat types (Table 12.3-3). The replacement of shoreline emergent and submergent vegetation (HSI = 0.25) with gravel/cobble fill will result in a new HSI value of 0 for shallow water habitat for this species. The scoring was based on the anticipated removal of aquatic vegetation and the well established habitat-use characteristic that northern pike require aquatic vegetation for spawning, nursery, rearing, and foraging (e.g., Franklin and Smith 1963; Inskip 1982; Nelson and Paetz 1992). At the proposed diffuser location, water deeper than 0.5 m was not considered to be appropriate for spawning and nursery habitats (McCarraher and Thomas 1972). Also, rearing and foraging habitat rarely occurs deeper than 4 m (Diana et al. 1977). Thus, there will be a small, net loss of habitat for northern pike under the assumption that habitat is limiting for populations in the lake. The maximum net loss of habitat for northern pike will be about 23 HUs (for rearing or foraging habitat; Table 12.3-3).

Table 12.3-3: Summary of Net Change in Habitat Units After the Installation of the Diffuser Pipe at the Peanut Lake Location

	Spawning HUs	Nursery HUs	Rearing HUs	Foraging HUs
Northern pike	-4.69	-4.69	-23.44	-23.44
Lake whitefish	0	9.38	37.50	37.50

HU = habitat units

The installation of the diffuser pipe is expected to result in an increase of suitable nursery, rearing, and foraging habitat for lake whitefish (Table 12.3-3). Although some boulder cover is present along the shoreline, there is no large accumulation of gravel or cobble substrate. Such substrate types are key habitat features for lake whitefish populations in lakes (e.g., Machniak 1975; Golder 2009). Thus, it was assumed that the current location is not optimum habitat for spawning and as nursery habitat (Table 12.3-3), and was assigned an HSI value of 0.25. Similarly, for rearing habitat, shoreline habitat >1 m deep was assigned an HSI value of 0.50. The addition of the gravel and cobble fill will generally increase the suitability of the substrate for all life history stages. However, the suitability of deeper water (>4 m) will not noticeably change in quality. Overall, it is expected that there will be a maximum net gain of about 38 HUs (for rearing or foraging habitat) upon installation of the diffuser pipe, and will benefit the lake whitefish population assuming that the availability of spawning and rearing habitat is a limiting factor for the population in the lake (Table 12.3-3).

The overall anticipated change in habitat in Peanut Lake was a gain of 28 HUs (Table 12.3-3). It is important to note that baseline surveys failed to identify key habitats in the vicinity of the proposed diffuser location (Annex C; Section 2.3.16). The northeast and southwest ends of the lake supported extensive emergent vegetation suitable for spawning and rearing northern pike. Additionally, spawning habitat for lake whitefish was observed along the northwest shoreline south of the proposed diffuser location where there is a gravel/cobble shoal. Thus, this pathway is expected to have negligible residual effects to fish habitat and the persistence of fish populations.

- **Physical loss or alteration of local surface waters (e.g., Grid Ponds to the Co-disposal Facility) from the NICO Project footprint can cause loss of aquatic habitat.**
- **Loss or alteration of local watercourses, drainage patterns (distribution), and drainage areas from the NICO Project footprint can affect surface water quality, affecting aquatic habitat and fish.**
- **Impediments to fish passage at stream crossings (e.g., roads) may affect fish.**

Water diversions are not required for the development of the NICO Project infrastructure footprint, as the footprint is located near the top of a watershed; however, the CDF will eliminate the Grid Ponds, which are situated in a runoff catchment. The loss of the Grid Ponds is expected to result in represent minor fluctuations in water level relative to baseline values of Nico Lake (Section 11.3.2.2).

Because treated effluent will immediately mix with water from Peanut Lake, flows from Peanut Lake into Burke Lake will be increased during periods of effluent discharge. In general, the influence of discharge from the NICO Project to Peanut Lake is anticipated to result in little to no effect on water levels in downstream waterbodies, including Ponds 11, 12, and 13, and Burke Lake relative to baseline conditions (Section 11.3.2.2). The water management system for the NICO Project has been optimized in terms of internal recycling within the Plant, thickening of the tailings, and high level of reclaim water from the CDF back to the Plant. The implementation of the mitigation practices and environmental design features is expected to result in a minor change (secondary pathway) to the hydrology in the LSA from the NICO Project relative to baseline conditions, which should have a negligible effect on Peanut Lake and downstream waterbodies such as Pond 11, 12, and 13, and Burke Lake.

Access roads will be as narrow as possible, while maintaining safe construction and operation practices. Further, access roads on the mine site will not cross fish-bearing watercourses.

The NPAR will cross the Marian River, which is a tributary to Great Slave Lake. The crossing is located approximately 4.2 km downstream of Hislop Lake. Fish species recorded at the Marian River include northern pike, lake whitefish, burbot, and white sucker. Arctic grayling have been reported in the Marian River, though they were not collected during baseline field surveys.

At the Marian River crossing, a single clear-span bridge will be constructed at a narrowing of the Marian River (15 m wide) as it passes along outcropping bedrock. The proposed bridge will be built of prefabricated steel girder assembled on-site. Rock at the crossing site is competent and has moderate fracture spacing (EBA 2007). The Marian River Bridge road top will have a width of 6 m with a 25 m span. To configure the Marian River

Bridge opening and height, 100 year flood flow conditions and the river's use by summer canoeists were considered (Golder 2007).

Proper construction practices and mitigation measures (e.g., sediment and erosion control measures such as silt curtains and runoff management) during construction are expected to minimize negative impacts on aquatic resources. In addition to specific mitigation measures outlined for the NICO Project to protect aquatic resources, any conditions and/or mitigations outlined by regulatory agencies under the following *Acts* or licence requirements should additionally be adhered to:

- *Federal Fisheries Act;*
- *Mackenzie Valley Resource Management Act;*
- *Navigable Waters Protection Act;* and
- Class A Water Licence and Land Use Permit.

As such, the NICO Project footprint was determined to have a secondary linkage to effects to fish and fish habitat. Effects to benthic invertebrates, fish and fish habitat are anticipated to be of negligible magnitude.

- **During closure and reclamation, air emissions (acidifying emissions, dust, and associated metal deposition) can affect surface water and sediment quality of nearby surface waters, affecting aquatic habitat and fish.**

Air emissions can increase deposition of sulphur dioxide, nitrogen oxides, particulate matter, and total suspended particulates, to nearby surface waters. This deposition may increase acidity, suspended solids, and metals in the waterbodies adjacent to the mine site and roads. Environmental design features and mitigation have been incorporated into the NICO Project to reduce potential effects from emissions and dust deposition (Table 12.3-1). Dust suppressions measures will include enforcement of speed limits, maintaining industry-standard emission control systems in equipment and fleet vehicles, and watering roads, Airstrip, and laydown areas during the non-winter period. During closure and reclamation, dust production will be reduced because most facilities will be capped and there will be less site traffic. Therefore, this pathway was determined to have negligible effects to surface water and sediment quality, and deemed as a secondary pathway for lower trophic levels, fish and fish habitat.

12.3.2.2 Primary Pathways

The remaining pathways for the persistence of fish and condition of aquatic habitat in the NICO Project area are classified as primary and are carried forward as effects statements (Table 12.3-1) to be assessed in the effects analysis sections (Sections 12.5 to 12.7). The following primary pathways were identified for linking NICO Project-related activities to effects on fish and aquatic habitat.

- **Air emissions (acidifying emissions, dust, and associated metal deposition) during construction and operation can cause changes to surface water and sediment quality, affecting aquatic habitat and fish.**
- **Release of treated mine wastewater and sewage during construction and operation may cause changes to surface water quality and sediment quality, affecting aquatic habitat and fish in Peanut Lake and downstream waterbodies.**

- **Improved access for harvesting from the Proposed Tłįchǫ Road Route and the NPAR can affect sizes of fish populations (e.g., northern pike and lake whitefish).**

12.4 Effects to Aquatic Habitat and Fish

This section assesses the potential for effects to lower trophic levels, fish and fish habitat in the NICO Project area watershed resulting from changes to water quality (i.e., total suspended solids (TSS), nutrients, and metals). Summaries of the valid pathways are presented in Table 12.4-1. Effects to water quality and resulting effects to fish health were also assessed in Section 7.6. Section 12.4.1 provides an overview of the methodology used to analyze the effects to aquatic habitat and fish in the NICO Project area. For the purposes of the assessment, fish habitat is defined as the area required by fish for spawning, nursery, rearing, food supply (e.g., benthic invertebrates), overwintering, and migration.

Table 12.4-1: Valid Pathways for Effects to Aquatic Habitat and Fish in the NICO Project Area

NICO Project Activity	Pathway	Effects Statement
Construction and general operation of mine and supporting infrastructure	Release of treated mine wastewater and sewage can cause changes to surface water and sediment quality, affecting aquatic habitat and fish in Peanut Lake and downstream waterbodies.	Effects of NICO Project construction and operation to lower trophic levels, fish and fish habitat within Nico and Peanut lakes and downstream waterbodies.
	Air emissions and dust deposition can cause changes to surface water and sediment quality, affecting aquatic habitat and fish in Nico Lake and downstream waterbodies.	
	Improved access for harvesting from the NPAR can affect fish population size in the Marian River-Hislop Lake system and opportunities for traditional and non-traditional fishing.	Effects of the NPAR on angler access of the Marian River and Hislop Lake.

NPAR = NICO Project Access Road

12.4.1 Methods

12.4.1.1 Effects of Dust Deposition

Windborne dust and air emissions from NICO Project facilities may result in increased deposition of dust in the surrounding area. Changes in TSS in lake water from deposition on lake surfaces and within the NICO Project area watershed were quantified in the water quality assessment (Section 7.6). Predicted changes in TSS and concentrations of associated metals for Nico, Peanut, and Burke lakes, and the Marian River were considered to be conservative (high) estimates of the maximum potential changes that could occur during construction and operations.

To provide an indication of the potential effects of increased TSS on fish in these waterbodies, the Newcombe and Jensen (1996) dose-response relationship was applied. This relationship estimates the magnitude of adverse effect expected when fish are exposed to a given concentration of sediment over a given period. Their dose-response relationship generated a severity of effect value ranging from 0 to 14. A severity of effect value of zero implied no effect. Severity of effect values of 1 to 3 indicated behavioural changes are expected, 4 to 8 indicated sublethal effects ranging from increased respiration and coughing rates to major physiological stress. Lethal and paralethal effects are expected with severity of effect values of 9 to 14.

Potential effects to water quality and the condition of aquatic habitat from dust and metals deposition were evaluated in the water quality assessment (Section 7.6.2). The results of the assessment were then used to describe and assess changes that relate to the condition of aquatic habitat and persistence of fish (e.g., population size) (Section 12.4.1.3 and Section 12.4.2.3). A discussion of the methods, models, and assumptions used in the water quality and aquatic health assessments can be found in Section 7.6.2.

12.4.1.2 Effects of Changes in Nutrient Levels

The release of treated mine wastewater and dust deposition on lake surfaces and within the NICO Project area watershed were anticipated to increase nutrient levels and have residual effects for Nico, Peanut, and Burke lakes, and the Marian River. Changes in nutrient concentrations in lake and river water were quantified in the water quality assessment (Section 7.6.3). Predicted changes in nutrient concentrations were considered to be conservative (high) estimates of the maximum potential changes that could occur during construction and operations. Effects on aquatic habitat and fish from changes in nutrient concentrations were predicted using qualitative methods, relying largely on trophic classification of aquatic ecosystems based on nutrient concentrations (Environment Canada 2004), scientific literature on the effects of nutrient enrichment, and experience from effects monitoring at operating northern mines.

Quantitative relationships between the physical/chemical features of sub-arctic lakes and lower trophic community characteristics are not available; however, the relationship between nutrient concentrations and aquatic productivity has been well studied (Wetzel 2001; Environment Canada 2004). Several studies (commonly referred to as “fertilization” studies or experiments) have documented changes in benthic community structure in sub-arctic and northern temperate lakes in response to nutrient additions (Morgan 1966; Smith 1969; Welch et al. 1988; Hershey 1992; Jorgenson et al. 1992; Clarke et al. 1997; Johnston et al. 1999). Aquatic effects monitoring programs at existing diamond mines in the NWT also have reported changes in lower trophic community characteristics with increasing levels of nutrients (De Beers 2010; Golder 2010), which is directly applicable to potential effects in Nico, Peanut, and Burke lakes.

A qualitative assessment of effects related to closure and post-closure also was completed for lower trophic communities in Nico, Peanut, and Burke lakes, and the Marian River. That assessment used the results of the assessments of effects to water quantity (Section 11.3) and water quality (Section 7.6).

Effects of changes in lower trophic communities and fish and fish habitat, due to changes in nutrient levels and trophic status, were qualitatively assessed based on published literature regarding trophic interactions, food web complexity, and known effects of nutrient additions on fish communities in sub-arctic mesotrophic/meso-eutrophic lakes similar to Nico, Peanut, and Burke lakes.

12.4.1.3 Effects of Changes in Metal Concentrations

The metals assessment was based on water quality predictions for Nico Lake and downstream waterbodies, and considered both treated mine effluent and dust deposition pathways. The assessment emphasized fish measurement endpoints, but it is important to note that benthic invertebrate communities and lower trophic levels may be continuously exposed to chemicals of potential concern (COPCs). Fish are considered to be a reliable component of aquatic monitoring and assessments because they integrate the effect of detrimental environmental changes as consumers (e.g., Strydom et al. 2006). Fish abundance and habitat can be affected by changes in water quality if the changes in water quality result in changes in the condition of aquatic habitat (i.e., individual fish and invertebrate health).

Exposure of species to chemicals in waterbodies downstream of the NICO Project is dependent on the size of the home range, diet items, and position in the food chain (for chemicals that biomagnify) (reviewed in Golder [2010] risk assessment for the Lorado uranium tailings site in Saskatchewan). Exposure to COPCs is likely higher for individuals of forage fish (e.g., ninespine stickleback) occupying shallow areas in close proximity to the footprint, compared to larger species such as northern pike, lake whitefish, and white sucker that would spend only a portion of their time foraging in specific shoreline areas. Larger species will generally feed in deeper waters, though this can vary seasonally. Pelagic species are typically exposed to COPCs in the water column through sorption to respiratory surfaces, and through diet. For pelagic species, direct exposure to sediment is typically not a relevant pathway of exposure. It is recognized that bottom feeding species, such as lake whitefish and white sucker, in addition to being exposed via sorption from the water column and diet, may also incidentally ingest some sediment during feeding and thereby be exposed directly to COPC in sediment.

Exposure of fish to COPCs is also a function of the physico-chemical properties of the COPC, and the characteristics of the surface water quality (reviewed in Golder 2010). The risk posed by metals in the aquatic environment is determined by the amount of biologically available metal (i.e., the free ion). Under the free ion activity model, the toxicity of metals is considered to be controlled mainly by the availability of the metal in a biologically reactive form. However, for most metals, a number of factors such as pH and the presence of reactive ligands govern the availability of free ions, with the result that the concentration of free metal ion can often be lower than predicted. Even where free or readily ionisable species of metals are present in the water column, the presence of other competing ions can influence the potential toxicity of a metal in solution.

The amount of biologically available metals in the water column, therefore, is controlled by a number of other factors that are usually specific to the body of water (reviewed in Golder 2010). The presence of other ligands that can complex metals can reduce the potentially bioavailable fraction. In the water column, these include the presence of other ions, such as calcium and magnesium, that can compete with metals for uptake sites in the organism, and the presence of organic ligands, such as humic and fulvic acids, and inorganic ligands, such as reactive sulphides and iron/manganese hydroxides, that can complex metals and reduce biological availability. As a result, essential elements for physiological functioning such as calcium and magnesium can result in a reduction in exposure to other metals in the water column.

Uptake of metals by aquatic organisms can occur directly from water or indirectly through diet. In pelagic organisms, the major route of exposure is considered to be from the water column, and therefore adsorption to respiratory surfaces has been identified as the major route of uptake for most metals. For most water column organisms, ingestion of metals has been considered a minor pathway of uptake, and the focus has been on those forms of metals taken up through the waterborne route and that can interfere with respiration (usually through adsorption to gill surfaces as can occur with aluminum and iron), or induce toxicity at the cellular level after being absorbed through respiratory, and sometimes dermal, surfaces as is the case for most divalent metals (Barron et al. 2002; Paquin et al. 2002).

Metal behaviour in sediments is similarly complex, and is affected by a number of factors, such as pH, particle size and type, and the presence of other complexing agents (e.g., Tessier and Campbell 1987; Mok and Wai 1990). Metal accumulation from sediments can be directly through ingestion of metal contaminated sediments, or through sorption of free ions from pore water. However, for most organisms in Peanut and Nico lakes, the major exposure pathway for metals would be the solubilized (free ionic) form, which, as noted above, is controlled by the presence of other complexing ligands. Ingestion, while important in some cases, typically appears to be a minor pathway, because of the strength of binding of COPCs to sediment organic and mineral constituents (e.g., Tessier and Campbell 1987; Mok and Wai 1990).

12.4.2 Results

12.4.2.1 Effects of Dust Deposition

Accumulation of dust (i.e., total suspended particulate deposition) and concentrations of air emissions produced from the NICO Project may result in dust entering local surface waters as runoff (Section 10.4.2). Sources of dust deposition and air emissions modelled in the application case (maximum effect case) include blasting activities, haul roads, the Plant, activities at the Open Pit and other ancillary facilities, and vehicle traffic along the NPAR and the Proposed Tłı̨chǫ Road Route. Environmental design features and mitigation have been incorporated into the NICO Project to reduce potential effects from dust deposition (Table 12.3-1). For example, the watering of roads, Airstrip, and laydown areas during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates.

The spatial extent of dust and metal deposition is anticipated to be restricted to localized areas within and close to the NICO Project Lease Boundary, with maximum deposition expected to occur near the Open Pit and haul roads, and primarily reflect winter fugitive road dust emissions (Section 10.4). The increased deposition of dust may enter surface waters, particularly during spring freshet, and could result in increased concentrations of suspended sediments in lake water. The concentrations of TSS in nearby lakes may be elevated during and after spring freshets (Table 12.4-2).

Table 12.4-2: Summary of Predicted Mean and 95th Percentile Total Suspended Solid Concentrations (mg/L) in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

	Baseline	Construction	Operations	Closure	Post-Closure
Means					
Nico Lake	3.22	8.20	18.61	13.82	3.57
Peanut Lake	3.34	8.31	10.50	7.33	3.44
Burke Lake	3.36	5.42	8.81	6.72	3.43
Marian River	3.42	3.49	3.65	3.56	3.43
95th Percentiles					
Nico Lake	3.44	9.09	27.90	22.42	3.86
Peanut Lake	3.73	11.73	17.23	12.19	3.85
Burke Lake	3.72	5.93	13.95	11.78	3.77
Marian River	8.85	9.00	9.04	9.08	8.85

Note: Total suspended solid estimates are very conservative, for example, they are based on particulate matter of particle diameter less than 10 micometres remaining in suspension indefinitely; it was assumed that the 95th percentile prediction output would be representative of a conservative upper bound of concentrations during a dry year.

mg/L = milligrams per litre

During construction, the predicted maximum (95th percentile) TSS concentrations ranged from 5.9 milligrams per litre (mg/L) in Burke Lake to 11.7 mg/L in Peanut Lake. During operations, the predicted maximum TSS concentrations ranged from 9.0 mg/L in the Marian River to 27.9 mg/L in Nico Lake. Total suspended solid concentrations generally peaked during the operation phase, decreasing at closure and approaching baseline values during post-closure. The largest maximum TSS concentrations were for Nico Lake (27.9 mg/L) and Peanut Lake (17.2 mg/L). For the Marian River, the farthest downstream site under examination in this assessment, TSS concentrations are anticipated to remain similar to baseline values with the application of the NICO Project to the landscape.

The nature and extent of adverse effects of increased TSS on fish is influenced by both the TSS concentration and the duration of exposure. Fish can tolerate low TSS concentrations for long periods and high concentrations for short periods without suffering adverse effects. Fortunately, the period of elevated TSS in affected lakes is expected to be short. The largest load of suspended sediments entering surface waters would occur during spring freshet, when dust deposited to snow during winter and eroded materials enter surface waters. Sediment inputs during other times of the year are anticipated to be sporadic and too small to result in measurable changes in TSS concentrations in Nico and Peanut lakes. The length of the freshet period is estimated to range from approximately a few days to a few weeks, depending on lake size. The particles would be expected to settle fairly quickly, within less than a month.

Based on the Newcombe and Jensen (1996) dose-response relationship, the severity of effect values suggest that exposure to peak TSS concentrations in Nico Lake could cause responses ranging from moderate habitat degradation to major physiological stress (i.e., reduction in feeding rate and feeding success) during the operation phase. Affected species will include northern pike and white sucker, but no lethal or paralethal effects are anticipated. In Peanut Lake and Burke Lake, exposure to peak TSS concentrations could cause moderate physiological stress (e.g., increased respiration rates) and moderate (temporary) degradation of habitat for short periods during the operation phase.

It is important to note that these predictions are likely an overestimation. Predicted changes in TSS are considered to be conservative (high) estimates of the maximum potential changes that could occur during construction and operations (Section 7.6). Also, the period of exposure in the dose-response relationship is to peak concentrations; however, the peak levels are transitory, with the particles settling fairly quickly after snowmelt. As a result, the model likely overestimates the true duration period. Nevertheless, the overestimation was used as a worse-case scenario for the dose-response relationship; the actual response is expected to be less. Furthermore, fish are routinely exposed to higher TSS levels during spring freshet periods and would tolerate the levels in the short-term. Fish species such as northern pike and white sucker can actually thrive under moderate levels of turbidity (Stevens et al. 2010).

The increases in sediment would be too small to produce measurable effects on fish habitat outside the range of baseline conditions. Most of the increased suspended sediment will occur during spring freshet. Although it will settle out of the water column fairly quickly, the high water levels, wave action, and currents will move the sediment off any sensitive habitat areas in the nearshore areas of lakes (e.g., spawning shoals or vegetation) into the deeper main basin of the lake. Further, there are numerous beaver ponds between Peanut Lake and Burke Lake (i.e., in the Peanut lake outflow; Section 12.2.3.2) that will likely trap and contain the majority of suspended sediments before entering Burke Lake and downstream waterbodies, similar to the process described by Naiman et al. (1998).

In summary, effects of TSS from dust and particulate deposition are expected to be localized in the immediate vicinity of the NICO Project (i.e., Nico and Peanut lakes) and temporally restricted to the weeks during and after freshet during each phase (construction and operation). As the NICO Project timeline approaches closure and TSS concentrations are reduced, effects should be eliminated from all waterbodies upon the post-closure phase.

12.4.2.2 Effects of Changes to Nutrient Levels

As discussed in the water quality assessment (Section 7.7.1) and the uncertainty section (Section 12.9), predicted nitrogen concentrations primarily reflect loading of ammonia and nitrate from blasting residue in small quantities of seepages to Nico Lake and treated effluent discharges to Peanut Lake. At closure, it is expected that there will be only small residual quantities of ammonia and nitrate from blast residue in seepages from the reclaimed CDF reporting to Wetland Treatment Systems No. 1, 2 and 3. There is a moderate level of certainty around the dataset used to derive a nutrient concentration for this water type. Prior to construction of the facility, and throughout operations, additional geochemical testing and site monitoring will be completed to obtain accurate estimates of concentrations, and if needed, mitigation may be implemented to reduce long-term loadings to Nico and Peanut lakes.

Based on total phosphorus (TP) concentrations, Nico, Peanut, and Burke lakes are classified as being mesotrophic/meso-eutrophic (moderately productive) at baseline conditions (Annex C) as well as during all stages of mine construction, operations, and closure. The most conservative case (95^{th} percentile) for TP concentrations yields values ranging from 0.018 mg/L at closure in Burke Lake, to 0.023 mg/L during operations in Nico Lake (Table 12.4-3 and Section 7.6). During post-closure, all TP values are similar to baseline conditions (i.e., all mean post-closure concentrations are below baseline 95^{th} percentile concentrations). Lakes closer to the mine footprint exhibit greater differences between baseline and operations conditions, with Nico Lake experiencing the greatest change and Burke Lake experiencing the smallest change. At each lake, however, mean and 95^{th} percentile concentrations overlap during each phase of the mine. Conditions in the Marian River vary little from pre-construction baseline to post-closure.

Concentrations of ammonia, nitrate, total Kjeldahl nitrogen, and total nitrogen are predicted to peak during operations and be highest in waterbodies adjacent to NICO Project activities (Table 12.4-3 and Section 7.6). The greatest change is predicted to occur at Nico Lake with over a 16-fold increase in mean ammonia concentrations between baseline and operations due primarily to small quantities of seepage inputs containing blasting residues, whereas Peanut Lake is predicted to experience a 10-fold increase and Burke Lake is predicted to experience a 7-fold increase. Similar trends are expected for nitrate but to a lesser extent. For example, mean nitrate concentrations are predicted to increase 6-fold over baseline in Nico Lake. The concentrations of ammonia and nitrate (average and 95^{th} percentile predictions), however, are still below both CCME CWQG for the protection of aquatic life (1999), as well as the site-specific water quality objectives (SSWQOs).

Phosphorus is generally the limiting nutrient for primary production in most Canadian Shield lakes (Schindler 1974), because of its scarcity in bedrock and overburden on Shield watersheds and efficient retention by upland forests and wetlands (Allan et al. 1993; Devito et al. 1989 cited in Steedman et al. 2004). Studies have shown that TP is the nutrient limiting primary productivity and also fish production in northern lakes (Dillon et al. 2004). Productivity is especially low in arctic waters, as arctic soils are shallow and frozen for most of the year, so the weathering rate and hence production of dissolved nutrients is slower than farther south.

Table 12.4-3: Summary of Predicted Mean and 95th Percentile Ammonia, Total Nitrogen, Nitrate, Total Kjeldahl Nitrogen, and Total Phosphorus Concentrations in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

	Ammonia[a] (mg N/L)		Total Nitrogen (mg/L)		Nitrate[b] (mg N/L)		Total Kjeldahl Nitrogen (mg/L)		Total Phosphorus (mg/L)	
	Average	95th P	Average	95th P	Average	95th P	Average	95th P	Average	95th P
Nico Lake										
Baseline	0.025	0.048	0.79	1.19	0.070	0.137	0.72	1.05	0.020	0.023
Constructions	0.024	0.035	0.83	1.02	0.090	0.118	0.74	0.90	0.020	0.022
Operations	0.41	0.65	1.52	1.96	0.45	0.68	1.07	1.28	0.019	0.023
Closure	0.36	0.58	1.37	1.80	0.39	0.61	0.98	1.18	0.018	0.022
Post Closure	0.11	0.17	0.76	1.05	0.14	0.19	0.62	0.86	0.017	0.020
Peanut Lake										
Baseline	0.020	0.050	0.66	1.27	0.056	0.16	0.60	1.11	0.015	0.018
Constructions	0.021	0.041	0.67	1.03	0.066	0.13	0.60	0.89	0.016	0.019
Operations	0.27	0.52	1.08	1.73	0.31	0.53	0.78	1.19	0.017	0.020
Closure	0.17	0.40	0.92	1.63	0.20	0.42	0.72	1.21	0.016	0.020
Post Closure	0.041	0.072	0.65	1.25	0.073	0.16	0.58	1.08	0.015	0.017
Burke Lake										
Baseline	0.020	0.043	0.65	1.05	0.052	0.12	0.60	0.94	0.015	0.017
Constructions	0.018	0.029	0.69	0.86	0.074	0.11	0.62	0.75	0.017	0.020
Operations	0.13	0.22	0.83	1.26	0.16	0.26	0.67	0.99	0.016	0.018
Closure	0.13	0.26	0.83	1.29	0.16	0.29	0.68	1.00	0.015	0.018
Post Closure	0.032	0.054	0.65	1.05	0.059	0.13	0.59	0.93	0.014	0.017
Marian River										
Baseline	0.028	0.065	0.82	1.66	0.057	0.15	0.76	1.51	0.009	0.018
Constructions	0.028	0.066	0.82	1.67	0.058	0.15	0.76	1.52	0.009	0.018
Operations	0.031	0.071	0.82	1.66	0.061	0.16	0.76	1.50	0.009	0.018
Closure	0.031	0.072	0.83	1.67	0.061	0.16	0.76	1.51	0.009	0.018
Post Closure	0.028	0.065	0.82	1.66	0.058	0.15	0.76	1.50	0.009	0.018

Note: it was assumed that the 95th percentile prediction output would be representative of a conservative upper bound of concentrations during a dry year.

[a] Ammonia guideline/objective: CCME CWQG for the protection of aquatic life = 2.6 mg N/L; site-specific water quality objectives = 4.16 mg N/L. All values are below guideline/objective. The guideline/objective for total ammonia were based on a water temperature of 11°C and a pH of 7.5.

[b] Nitrate guideline/objective: CCME CWQG for the protection of aquatic life = 2.93 mg/L; site-specific water quality objectives = 30 mg/L. All values are below guideline/objective.

P = percentile; mg/L = milligrams per litre

Under baseline conditions, the NICO Project lakes are either nutrient sufficient or exhibit low phosphorus limitation indicated by nitrogen (N) to phosphorus (P) molar ratios ranging from 18 to 20. During construction, operations, and closure periods, the ratios are slightly elevated with values between 18.5 to 39.3. Phosphorus limitation increases throughout operations and begins to decrease during closure, reaching ratios similar to baseline conditions during the post-closure phase.

Changes to Aquatic Condition

Phytoplankton

In moderately productive lakes such as those in the NICO Project area watershed, phytoplankton biomass is generally low and fairly evenly divided among Chrysophyta, Cryptophyta, and Bacillariophyta. This community structure is what was observed in the baseline studies for Nico, Peanut, and Burke lakes (Annex C). Nico Lake and Burke Lake were dominated by 3 groups: for Nico Lake: Chrysophyta, Pyrrophyta, and Cryptophyta dominated; for Burke Lake: Chrysophyta, Chlorophyta, and Cryptophyta dominated; and for Peanut Lake, Chrysophyta alone dominated the community. In terms of abundance, all 3 lakes were dominated by Cyanobacteria, comprising 64 to 98% of the community abundance. However, despite the high abundance, Cyanobacteria accounted for a low proportion of the biomass; this disparity is likely the result of most of the cyanbacterial species being small colonial and/or filamentous in form (*Aphanothece* spp., *Anabaena* spp., *Oscillatoria* spp.) in these waterbodies.

Nutrient predictions for the NICO Project lakes show that nutrient enrichment is likely to be restricted to increases in N from dust deposition in runoff (not effluent discharge, and not P) (Table 12.4-3; Figure 12.4-1; Section 7.6). The Redfield Ratio (106C:16N:1P), which is based on nutrient totals in a waterbody, can be used to predict nutrient requirements for optimal algal growth. The N: P molar ratio was used in the current study to make predictions on phytoplankton community composition (Figure 12.4-1). An N: P molar ratio greater than 22 indicates P-limitation, an N: P ratio of less than 13 indicates N-limitation, whereas values between 13 and 22 indicate nutrient sufficiency (Hillebrand and Sommer 1999). The N: P timeline figure, showing baseline, construction, operations, and closure of the NICO Project, demonstrates that the lakes are moving from P and N sufficiency to severe P-limitation during operations and then returning to P-sufficiency during post-closure. The degree to which P-limitation is observed during operations and closure in each system appears to be based on its relative proximity to the NICO Project footprint. Nico Lake is the first to receive dust deposition runoff, and thus has the highest N: P molar ratios. Flow from Nico Lake continues on into Peanut Lake, which has the second highest N: P molar ratios, and then to Burke Lake, which has the lowest N: P molar ratios. Marian River is farther downstream from the lakes and is likely not to be affected by nutrient additions and, therefore, shows no change in the N: P molar ratio from baseline to operations (Figure 12.4-1).

Based on the above information, a change in trophic status, based on P concentrations, is not predicted for Nico, Peanut, or Burke lakes; however, assuming all other factors (light, temperature, and grazing pressure) remain the same, the increase in nitrogen may cause an initial summer increase in phytoplankton biomass, especially in Nico Lake and to a lesser extent Peanut Lake. However, the early-on biomass increases will likely come to an end and stabilize after a couple of years, once the lakes become completely N-saturated (Wetzel 2001). Major community compositional changes are not predicted to occur in the phytoplankton.

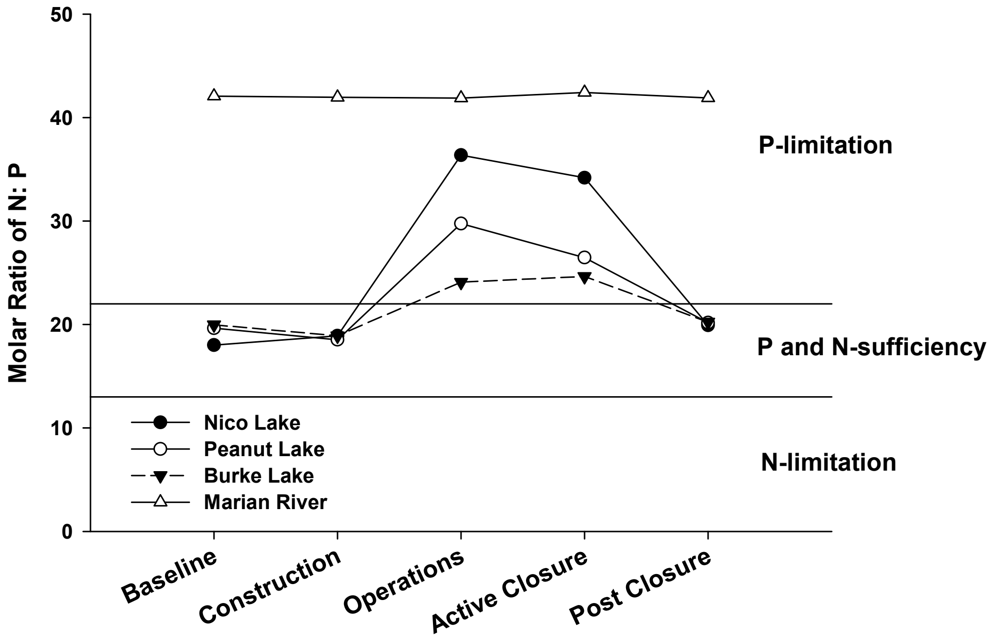

Figure 12.4-1: Predicted Molar Ratio of N: P in Nico Lake, Peanut Lake, Burke Lake, and Marian River from Baseline to Post-closure

N=Nitrogen; P=Phosphorus; N:P ratio <13 = N-limitation; N:P ratio >22 = P-limitation (Hillebrand and Sommer 1998)

Zooplankton

Copepoda dominated the zooplankton communities in Nico, Burke, and Peanut lakes during the baseline study in 2005 (Section 12.2.4 and Annex C); however, species richness for Copepoda was low. Cladocera richness was slightly higher than Copepoda, though contribution to biomass was very low. Species richness for rotifers was highest although this group contributed very little to biomass.

While studies have shown that zooplankton biomass is often enhanced in lakes as a result of nutrient enrichment (LeBrasseur et al. 1978), the predicted increase in zooplankton biomass in Nico, Peanut, and Burke lakes will be within range of baseline values given that primary productivity will be relatively unchanged. Furthermore, proportional increases in zooplankton biomass will likely be even lower than that of phytoplankton because the energy transfer between trophic levels is inefficient (McCauley and Kalff 1981; Kalff 2002). During the post-closure phase, zooplankton biomass should return to baseline conditions in response to nutrient levels also returning to baseline conditions.

It is possible that changes in zooplankton community composition may occur; however, this is very difficult to predict because zooplankton species composition is more strongly controlled by top-down factors (i.e., predation) than bottom-up factors (i.e., food availability) (McQueen et al. 1986; Carpenter 1989; Carpenter et al. 2001). A small increase in phytoplankton/food availability will not likely impact zooplankton community composition.

No measureable changes in the zooplankton communities are predicted for the Marian River because nutrient levels stay at baseline values throughout the life-span of the mine, including post closure. This is expected due to this system being located well downstream of the NICO Project footprint.

Benthic Invertebrates

The benthic invertebrate community in Nico, Peanut, and Burke lakes is dominated mainly by Mollusca and Chironomidae (Section 12.2.4 and Annex C). Invertebrate abundance in most years appears to be low for Arctic/sub-Arctic lakes.

Nutrient enrichment in Nico, Peanut, and Burke lakes is low, with N to P molar ratios only slightly higher than ratios of 13 to 22, which indicate nutrient sufficiency (Figure 12-4.1). Nutrient enrichment has been shown to result in an increase in benthic invertebrate biomass (Rasmussen and Kalff 1987; Jorgenson et al. 1992; Clarke et al. 1997) as well as have no effect on invertebrate biomass (Dinsmore et al. 1999). Given that nutrient enrichment is low, and energy transfer between trophic levels is inefficient, increases in benthic invertebrate biomass will likely be within range of baseline values. If increases do occur, the response may be delayed by several years as shown in an experimentally fertilized lake (Hershey 1992). During the post-closure phase, invertebrate biomass will eventually return to baseline levels in response to nutrient levels also returning to baseline conditions.

Similar, to zooplankton communities, no changes in benthic invertebrate communities are predicted for the Marian River because nutrient levels stay near constant in the river. This is expected due to the river being located well downstream of the NICO Project footprint.

Changes to Fish and Fish Habitat

Many studies also have shown that nutrients, and in particular TP, control the rate of fish production in lakes (Colby et al. 1972; Hanson and Leggett 1982; Plante and Downing 1993), including cold-water fish production (Dillon et al. 2004). The effect of increased primary and secondary production on fish in lakes, however, is complex and is dependent on several factors. These factors include the physical and chemical conditions of the water and lake sediments (Schindler 1974), the complexity of the food web (Schindler 1974; Carpenter et al. 1985; Elser et al. 1990), the efficiency of energy transfers between trophic levels (McQueen 1990; Micheli 1999), and the relative importance of “bottom-up” (i.e., resource availability) or “top-down” (i.e., predation) control of lake productivity (Power 1992; Carpenter et al. 1985; McQueen et al. 1986). Increases in nutrient concentrations, particularly phosphorous, and changes in trophic status may have the following potential effects on fish and fish habitat:

- increase in fish production through increased primary and secondary productivity;
- elevated nutrient concentrations in lake sediments and the water column causing excessive plant and algae growth and subsequent degradation of fish spawning and nursery habitat; and
- reduction in dissolved oxygen concentrations of the lake, particularly a reduction in winter habitat.

Although a change in trophic status based on P concentrations, is not predicted for the NICO Project lakes, the increase in nitrogen may cause an initial summer increase in phytoplankton biomass, especially in Nico Lake and to a lesser extent Peanut Lake. Phytoplankton is a very important component of the food web in all lakes, and algal abundance may strongly influence the biomass and productivity of higher trophic levels, including fish.

However, the early-on biomass increases will likely come to an end and stabilize after a couple of years, once the lakes become completely N-saturated (Wetzel 2001). Any short-term increases in fish production should be within the range of baseline values for both Nico Lake and Peanut Lake.

However, an increase in nutrient concentrations in the study lakes may lead to increased algal growth and hypoxia on spawning areas used by shoal spawners, such as lake whitefish, and sucker species. An increase in attached algae on spawning shoals can potentially affect the recruitment of such fish species, as reproduction relies upon the presence of suitable spawning shoal habitat for successful egg incubation and fry emergence. For example, degradation of shoal habitat related to eutrophication was implicated as a contributing factor in the recruitment failure of lake trout and lake whitefish in Lake Simcoe, Ontario (Evans and Waring 1987; Evans et al. 1988; McMurtry et al. 1997). However, Nico Lake supports only one gravel-spawning species, white sucker; whereas, Peanut Lake supports a lake whitefish population and a white sucker population. Neither lake supports a walleye population. Given that the predicted increase in algae on spawning shoals is likely to remain within the range of baseline conditions, the effect on the lake whitefish and white sucker populations will be either undetectable or within the range of baseline population sizes. It is expected that currents and wave action will lessen the growth of algae on these exposed shoals. As indicated in the secondary pathway assessment (Section 12.3.2.1.2), the rock cover over the water intake line in Lou Lake and the effluent diffuser line in Peanut lake will likely act as spawning enhancement structures. Fitzsimons (1996) documented spawning on artificial reefs created in Snap Lake.

In Arctic lakes, there may be challenges for coldwater species, such as lake whitefish, with respect to oxygen depletion during winter due to the length of the season with ice cover, the depth of the ice, and the lack of inflows. With the application of the NICO Project, and potential increases in phytoplankton production, winter respiration rates may increase and DO concentrations may decline (Lienesch et al. 2005). However, this decline should be very small or negligible, and Peanut Lake should maintain late winter DO levels that meet the criteria for optimum habitat for lake whitefish spawning and nursery (i.e., that levels remain above 7 mg/L) (Golder 2008). For example, studies of winter respiration of experimentally fertilized arctic lakes found that phytoplankton production increased by 77%, whereas winter respiration rate showed only a small increase of 19% (Welch and Bergman 1985). Winter respiration may lag behind lake production, and may not increase to the same extent. Further, existing winter habitat conditions for Peanut Lake are characterized by DO levels above the CWQG for protection of aquatic life. Thus, with the application of the NICO Project, it is anticipated that changes to winter habitat conditions may affect the lake whitefish population in Peanut Lake, but that the abundances and available habitat should remain within baseline values. Effects should be temporally restricted to only a few years during construction and operation. Importantly, changes to winter habitat conditions should not affect the persistence of populations for species more tolerant of low dissolved oxygen levels. Tolerant species characterize the assemblages of Nico and Peanut lakes (e.g., northern pike and white sucker).

12.4.2.3 Effects of Changes in Metal Concentrations

The existing water quality environment (Section 7.3) includes elevated levels of arsenic and iron in water in Nico Lake. Baseline median arsenic concentrations in Nico Lake are about 1 to 3 times the CWQG, but median iron concentrations were only marginally above the CWQG. Selenium concentrations in all NICO Project waterbodies appear to be either close to, or below the method detection limit, and below the CWQG. However, baseline fish tissue concentrations for lake whitefish and northern pike in the NICO Project area are elevated for selenium, as well as for a suite of other chemicals of potential concern (i.e., arsenic, copper, iron, lead, and mercury). In general, pronounced differences in metals concentrations between pre/post-fire monitoring periods were not evident in most waterbodies. Arsenic concentrations increased in Nico and Peanut lakes, but remained similar in Burke, Reference, and Lou lakes (Annex C).

Potential effects to the condition of aquatic habitat and fish from changes in metal concentration were qualitatively evaluated, but were based on quantitative predictions and changes relative to baseline scenarios (see Section 7.6.3). Baseline scenarios generated elevated concentrations (above CWQG for protection of aquatic life) for total and dissolved arsenic, total cadmium, and total and dissolved iron in Nico Lake; for total aluminum, total cadmium, and total and dissolved iron in Peanut and Burke lakes; and for total and dissolved cadmium, and total mercury in the Marian River (see Section 7, Tables 7.6-10 to 7.6-13).

For total and dissolved metals in water, concentrations will generally remain below SSWQOs; however, total aluminum and iron concentrations are predicted to exceed objectives (Table 12.4-4). Elevated total aluminum concentrations are predicted for operations and closure in Nico Lake, construction through to closure in Peanut Lake, and during the operation phase and closure in Burke Lake. The maximum concentration of total aluminum is estimated to be 1.31 mg/L and will occur during the operation phase in Nico Lake. This concentration is almost 4-times higher than that predicted under the baseline scenario in Nico Lake.

Table 12.4-4: Summary of Predicted Total Concentrations of Metal Chemicals of Potential Concern in Water Under Baseline, Construction, Operation, Closure, and Post-Closure Scenarios for NICO Project Lakes and the Marian River

Metal COPC	Site	Baseline		Construction		Operations		Closure		Post-Closure	
		Average	95th P	Average	95th P	Average	95th P	Average	95th P	Average	95th P
Total Aluminum	Nico	0.056	0.07	0.29	0.33	0.84	1.31[a]	0.64	1.09	0.15	0.20
	Peanut	0.099	0.14	0.33	0.51	0.43	0.73	0.29	0.53	0.12	0.17
	Burke	0.090	0.12	0.18	0.21	0.34	0.58	0.25	0.49	0.11	0.14
	Marian	0.032	0.07	0.035	0.07	0.044	0.10	0.040	0.09	0.033	0.07
Total Iron	Nico	0.38	0.46	0.84	0.95	2.21	3.29[a]	1.79	2.89	0.72	0.87
	Peanut	0.37	0.48	0.85	1.22	1.12	1.81	0.83	1.42	0.46	0.58
	Burke	0.38	0.47	0.55	0.63	0.94	1.48	0.73	1.31	0.43	0.52
	Marian	0.14	0.27	0.14	0.28	0.16	0.31	0.15	0.30	0.14	0.28
Total Arsenic	Nico	0.014	0.016	0.019	0.021	0.028	0.044[a]	0.024	0.040	0.012	0.019
	Peanut	0.0040	0.0047	0.011	0.017	0.013	0.024	0.009	0.017	0.0038	0.006
	Burke	0.0028	0.0032	0.0059	0.007	0.0100	0.018	0.0068	0.015	0.0025	0.004
	Marian	0.00041	0.0010	0.00047	0.0012	0.00063	0.002	0.00053	0.001	0.00043	0.001

Note: See section 7.6 for a complete summary of predictions for metals, and the methods used to derive those predictions. Shaded values are above the site-specific water quality objectives.

[a] Maximum predicted concentrations per COPC.

CWQG for protection for aquatic life for total aluminum = 0.1 mg/L (based on a pH ≥ 6.5), iron = 0.3 mg/L, and arsenic = 0.005 mg/L.

SSWQO for total aluminum = 0.41 mg/L (based on a pH of 7.44, which is the average baseline pH in Peanut Lake), iron = 1.5 mg/L, and arsenic = 0.05 mg/L (see highlighted cells in grey).

COPC = chemical of potential concern; P = Percentile

Total iron concentrations are also expected to exceed SSWQOs (Table 12.4-4). Elevated total iron concentrations are predicted for operations and closure in Nico Lake, and for the operation phase in Peanut Lake. The maximum concentration of total iron is predicted to be 3.29 mg/L and will occur during the operation phase in Nico Lake. This concentration is almost 7-times higher than that predicted under the baseline scenario in Nico Lake, and are a little over twice the SSWQOs.

Although total arsenic concentrations are predicted to remain below SSWQOs, concentrations generally increase with the application of the NICO Project, returning to baseline values at post-closure (Table 12.4-4). Total arsenic concentrations will be higher in waterbodies closest to the NICO Project footprint, peaking in Nico Lake. The maximum concentration of total arsenic will be 0.044 mg/L and will occur during operations in Nico Lake. This concentration is almost 3-times higher than that predicted for baseline conditions in Nico Lake.

Sediment quality predictions showed that, upon application of the NICO Project (for more details see Section 7.6.4), deposition of dust and associated metals from air emissions will not result in sediment quality guideline exceedences, where there were none before in the receiving environment.

Anticipated increases in aluminum concentrations in water with the application of the operation phase (and possibly construction phase) have the potential to affect fish abundances in Nico Lake, Peanut Lake, and possibly Burke Lake (e.g., Weatherly et al. 1990; Vuorinen et al. 1993). Increases in aluminum concentrations may lead to retardation of early stages of fish development, such as delayed yolk sac absorption. Also, as aluminum concentrations increase in water, it precipitates on eggs, larvae, and mucous lining of fish gills and can eventually suffocate the fish by coagulating the mucous. As a result, aluminum-affected lakes can lead to reductions in fish populations and local extirpations.

However, the effects of metal, such as aluminum and iron, generally manifest under low pH condition (e.g., Vuorinen et al. 1993; Peuranen et al. 2003). Metal solubility is controlled by pH, with higher concentrations of free ions present only at low pH. Aluminum toxicity appears to be greatest in the range of pH 5 to 6, where complete dissolution to free ions (the most biologically reactive form) occurs (Spry and Wiener 1991). Above pH 6, insoluble aluminum hydroxides predominate. In most natural waters, aluminum is not a concern. Suter and Tsao (1996) recommended a chronic guideline for fish of 3.3 mg/L and for invertebrates (daphnids) of 1.9 mg/L for circumneutral pH waters. These thresholds are above the maximum predicted concentration for total aluminum for the NICO Project (1.31 mg/L). The pH values of lakes within the NICO Project watershed are anticipated to remain neutral-to-alkaline for the duration of the NICO Project. Baseline field data indicated that the pH of Nico Lake ranges from 6.5 to 7.8, and the pH of Peanut Lake ranges from 7 to 7.8.

Compared to aluminum and arsenic, there is a general paucity of information on iron toxicity and the consequences of elevated levels for aquatic ecosystems. However, unsafe levels of iron in mining effluent can cause various cellular pathologies for fish (Payne et al. 2001). For example, iron-ore effluent in Labrador was linked to changes in skin pigmentation and skin whitening in lake trout. Also, exposure to high levels of iron can lead to gill damage and respiratory distress, through mechanisms similar to those described for aluminum (e.g., Peuranen et al. 1994; Peuranen et al. 2003). In aquatic systems, total iron levels between 8 to 10 mg/L are generally considered to be high, leading to severe degradation of fish habitat (Amisah and Cowx 2000). Although total iron concentrations were predicted to exceed SSWQOs in Nico Lake (potentially as high as 3.3 mg/L in Nico Lake during operations), dissolved concentrations of all metals, including iron, will generally remain under SSWQOs for the NICO Project (Section 7.6.3.3). The risks posed by metals, such as iron and aluminum, to the aquatic environment are determined by the amount of biologically available metal, i.e. the free ion (e.g., reviewed in Golder 2010).

The primary input source for most of the metals is in particulate form, as part of the runoff and accumulation of dust (i.e., total suspended particulate deposition) produced from the NICO Project. Sources of dust deposition and air emissions modelled in the application case (maximum effect case) include blasting activities, haul roads, the Plant, activities at the Open Pit and other ancillary facilities, and vehicle traffic along the NPAR and the Proposed Tłįchǫ Road Route. Environmental design features and mitigation have been incorporated into the NICO Project to reduce potential effects from dust deposition (Table 12.3-1). For example, the watering of roads, Airstrip, and laydown areas during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use, which will reduce particulate emissions. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates of emission concentrations and deposition rates.

Thus, with the application of the NICO Project, it is anticipated that changes to water concentrations of metals may affect the condition of aquatic habitat and fish for Nico Lake and Peanut Lake, but that the fish abundances and general conditions of the lakes should remain within the range of baseline values (<10% effect size). Effects should be largely restricted to operation and closure phases and to Nico Lake. Metal concentrations will be below site specific objectives at post-closure. It is anticipated that changes to metal concentrations in Burke Lake will not noticeably affect the condition of the lake, including the persistence of populations for species generally considered more tolerant to disturbance. Tolerant species (e.g., northern pike and white sucker) generally characterize the assemblages of Nico and Peanut lakes.

12.4.2.4 Effects to Fish Populations in Hislop Lake

Increased angler access from the NPAR and downstream influences related to changes in water quality and quantity are possible mechanisms by which fish populations in the Hislop Lake-Marian River system may be affected by the NICO Project. The following ‘sportfish’ species may be affected:

- burbot;
- lake whitefish;
- longnose sucker;
- northern pike;
- walleye; and
- white sucker.

Given the position of Hislop Lake in the Marian River watershed, it is unlikely that downstream changes in water quality from the NICO Project will affect the persistence of fish populations in Hislop Lake. Hislop Lake is located upstream of the proposed NICO Project. The effects of the NICO Project on fish and fish habitat beyond Peanut Lake are anticipated to be negligible in magnitude, and effects on fish and fish habitat in Lou Lake (and downstream locations) are anticipated to be undetectable.

Increased angler access may also affect fish populations in Hislop Lake. The NPAR crosses the Marian River, and will pass Hislop Lake at which point the lake can be visited by anglers using the existing winter road portage that will intersect with the NPAR, by either snowmachine, all-terrain vehicles, foot, or 4x4 truck. However, Hislop Lake is a shallow, turbid lake, and is generally not considered an important fish-bearing waterbody, although it has been identified as a traditional fishing location (Section 5.3). Due to the nearby proximity of Lac la Martre, a popular fishing destination, angler access by traditional and non-traditional users should remain within the range of existing conditions for Hislop Lake. It is predicted that only a few anglers will take advantage of increased access to Hislop Lake (i.e., change will be undetectable). Also, it should be noted that Fortune will ban angling by staff and contractors on site and while travelling on the NPAR for work purposes. This, along with the ability of the regulators to implement management regulations to limit fish harvesting, should protect the fisheries resources in Hislop Lake and the Marian River.

In summary, residual effects to fish populations in Hislop Lake are expected, although population sizes should not noticeably change from baseline values (<1%). The duration of the effect will approximate the duration of the NPAR, from opening to closure of the road, and the spatial extent of the effect may extend to the regional study area, and include the Marian River and Hislop Lake.

12.5 Related Effects to People

A measurable change in the abundance and distribution of sportfish populations is predicted for Nico Lake, and possibly Peanut Lake, which will likely influence the availability of fish for harvesting for traditional and non-traditional users. The magnitude of the decrease from the NICO Project on populations of northern pike and lake whitefish is expected to be within the range of existing conditions (i.e., natural population fluctuations). Current fishing pressure in NICO Project lakes appears to be low and indicates that fishing pressure is unlikely to be a limiting factor for these populations (Section 5.3). Therefore, the decrease in the availability of fish for harvesting from NICO Project related effects is predicted to be within the range of baseline values (i.e., people that fish in the region should not observe a change in the availability of fish due to effects from the NICO Project, relative to current natural changes in population sizes).

Currently, spring to autumn access into the region is limited to aircraft or watercraft that can be portaged. Access is less limited in the winter because existing winter roads pass through the effects study area for fish. Snowmobiles can access the region through existing trails and along winter roads before it is open and after it closes to vehicle traffic. The NPAR and the Proposed Tłįchǫ Road Route will allow anglers more vehicle access to fishing location near the NICO Project and the Proposed Tłįchǫ Road Route, which has the potential to increase harvesting pressure on fish populations.

Fortune will not permit hunting, trapping, harvesting, or fishing by staff and contractors and will prohibit the recreational use of all-terrain vehicles at site, so that people working on-site will not benefit from increased access to the region. However, the Proposed Tłįchǫ Road Route, as well as the NPAR, may still be used by outside anglers to fish for northern pike and lake whitefish. A study on the Tibbitt-to-Contwoyto Winter Road reported that hunting was the most common land use along the road, followed by fishing, sightseeing, and camping (Ziemann 2007). It is important to note that Fortune will have no control of angler access via the Proposed Tłįchǫ Road Route, only access via the NPAR.

Currently in the NWT, fish species are managed mostly by controlling the fishing season for resident and non-resident anglers (ENR 2010). Non-traditional fishing is governed by the NWT Fishery Regulations, under the federal *Fisheries Act*. These regulations include daily catch limits, possession limits, and fishing seasons for sport (i.e., non-traditional) fishing. Some lakes and rivers also have unique regulations where special management is necessary (ENR 2010).

Although the NICO Project may result in measurable changes to sportfish fish population sizes and fishing opportunities, effects will be reduced using appropriate environmental design features and mitigation. To manage the possible effects of fishing resulting from new angler access, Fortune will not permit recreational fishing by their staff or contractors at the NICO Project site, or when on the NPAR for work purposes (e.g., construction or travel). If concerns regarding over-fishing along the NPAR do arise, non-traditional fishing may be managed through waterbody-specific regulations. For example, the lakes along the Ingraham Trail have restrictions on possession of trout (ENR 2010). Traditional fishing may be managed by the Wek'èezhìi Renewable Resource Board. Importantly, the NPAR will be decommissioned following closure so that access will be restricted into the future, unless the Tłı̨chǫ Government wants to take over responsibility for the road.

12.6 Residual Effects Summary

12.6.1 Effects of Dust Deposition

Windborne dust and air emissions from NICO Project facilities may result in increased deposition of dust in the surrounding area. Based on modelling, the predicted maximum (95^{th} percentile) TSS concentrations ranged from 5.9 mg/L in Burke Lake to 11.7 mg/L in Peanut Lake during construction phases. During operations, the predicted maximum TSS concentrations ranged from 9.0 mg/L in the Marian River to 27.9 mg/L in Nico Lake. Total suspended solid concentrations generally peaked during the operation phase, decreasing at closure, and approaching baseline values during post-closure. The largest maximum TSS concentrations were for Nico Lake (27.9 mg/L) and Peanut Lake (17.2 mg/L) during the operation phase. For the Marian River, the farthest downstream site under examination in this assessment, TSS concentrations are anticipated to remain similar to baseline values with the application of the NICO Project to the landscape. Residual effects of TSS from dust and particulate deposition on fish and fish habitat are generally expected to be localized in the immediate vicinity of the NICO Project (i.e., Nico and Peanut lakes) and temporally restricted to the period during and after freshet. Further, the increases in sediment would be too small to produce measurable effects on fish and fish habitat beyond the range of baseline conditions. Although it will settle out of the water column fairly quickly, the high water levels, wave action, and currents will move the sediment off any sensitive habitat areas in the nearshore areas of lakes (e.g., spawning shoals or vegetation) into the deeper main basin of the lake, as occurs naturally. Also, there are numerous beaver ponds between Peanut Lake and Burke Lake (i.e., in the Peanut lake outflow) that will likely trap and contain the majority of suspended sediments before entering Burke Lake and downstream waterbodies (Naiman et al. 1998). In summary, residual effects of TSS from dust and particulate deposition are expected to be localized in the immediate vicinity of the NICO Project (i.e., Nico and Peanut lakes) and temporally restricted to the weeks during and after freshet during construction and operation phases. As the NICO Project timeline approaches closure and TSS concentrations are reduced, residual effects should be eliminated from all waterbodies upon the post-closure phase.

12.6.2 Effects of Changes to Nutrient Levels

Predicted nitrogen concentrations primarily reflect loading of ammonia and nitrate from blasting residue in seepages to Nico Lake and treated effluent discharges to Peanut Lake. At closure, it is expected that there will be only small residual quantities of ammonia and nitrate from blast residue in seepages from the reclaimed CDF reporting to Wetlands Treatment System No. 1, 2, and 3. There is a moderate level of certainty around the dataset used to derive a nutrient concentration for this water type. Based on total phosphorus concentrations, Nico, Peanut, and Burke lakes are classified as being mesotrophic/meso-eutrophic (moderately productive) at baseline conditions as well as during all stages of mine construction, operations, and closure. The most conservative case (95^{th} percentile) for TP concentrations yields values ranging from 0.017 mg/L at closure in Burke Lake to 0.023 mg/L during operations in Nico Lake. During post-closure, all TP values are similar to baseline conditions (i.e., all mean post-closure concentrations are below baseline 95^{th} percentile concentrations). A change in trophic status, based on TP concentrations, is not predicted for Nico, Peanut, or Burke lakes.

However, nutrient predictions for the NICO Project lakes show increases in N from the mine discharge. Although the lakes are not, and likely will never be, N-limited, the increase in nitrogen may cause an initial summer increase in phytoplankton biomass, especially in Nico Lake, and to a lesser extent Peanut Lake. The early-on biomass increases will likely come to an end and stabilize after a couple of years, once the lakes become completely N-saturated (Wetzel 2001). Furthermore, proportional increases in zooplankton biomass (and benthic invertebrate biomass) will likely be even lower than that of phytoplankton because the energy transfer between trophic levels is inefficient (McCauley and Kalff 1981; Kalff 2002). Thus, the predicted increase in zooplankton biomass in Nico Lake, Peanut Lake, and possibly Burke Lake will be within range of baseline values given that primary productivity will be relatively unchanged. During the post-closure phase, zooplankton and benthic invertebrate biomass should return to baseline conditions in response to nutrient levels also returning to baseline conditions.

An increase in nutrient concentrations can also have implications for the dynamics of fish populations. An increase in nutrient concentrations may lead to increased algal growth or hypoxia on spawning shoals used by fish species. Nico Lake supports only one gravel-spawning species, white sucker; whereas Peanut Lake supports a lake whitefish population and a white sucker population. Neither lake supports a walleye population. Given that the predicted increase in algae on spawning shoals is likely to remain within the range of baseline conditions, the residual effect on the lake whitefish and white sucker populations will be either undetectable or within the range of baseline population sizes. It is expected that current and wave action will lessen the growth of algae on these exposed shoals. In addition, the rock cover over the water intake and effluent diffuser lines likely will provide additional spawning and nursery habitat for some fish species.

In Arctic lakes, there may be challenges for overwintering whitefish populations with respect to oxygen depletion due to the length of the season with ice cover, the depth of the ice, and the lack of inflows. However, the water column for Peanut Lake does not stratify during winter, and DO levels appear to remain high year round. With the application of the NICO Project and potential increases in phytoplankton production, winter respiration rates may increase and DO concentrations may decline (Lienesch et al. 2005); however, this decline should be within the range of baseline values. Winter respiration rates may lag behind lake production, and may not increase to the same extent (Welch and Bergman 1985). Thus, Peanut Lake should maintain late winter DO levels that meet the criteria for optimum habitat for lake whitefish spawning and nursery (i.e., that levels remain above 7 mg/L) (Golder 2008). Residual effects should be temporally restricted to only a few years during the start of each construction and operation phase. Changes to winter habitat conditions will not affect the persistence of populations for species more tolerant of low dissolved oxygen levels (e.g., northern pike and white sucker).

12.6.3 Effects of Changes in Metals Levels

The existing water quality environment includes high levels of arsenic and iron in water in Nico Lake. With the application of the NICO Project, metal concentrations in water (total and dissolved) generally remain below

SSWQOs. However, total aluminum concentrations are predicted to exceed objectives during at least one phase of the NICO Project in Nico, Peanut, and Burke lakes. Elevated total aluminum concentrations are predicted for operations and closure in Nico Lake, construction through to closure in Peanut Lake, and during operations and closure in Burke Lake. The maximum concentration of total aluminum will be 1.31 mg/L and will be during the operation phase in Nico Lake. Total iron concentrations are also expected to exceed SSWQOs in Nico and Peanut lakes. Elevated total iron concentrations are predicted for operations and closure in Nico Lake, and for the operation phase in Peanut Lake. The predicted maximum concentration (conservative estimate) of total iron will be 3.29 mg/L and will be during the operation phase in Nico Lake.

However, the effects of metal, such as aluminum and iron, generally manifest under low pH condition (e.g., Vuorinen et al. 1993; Peuranen et al. 2003), and the pH values of lakes within the NICO Project watershed are anticipated to remain neutral-to-alkaline for the duration of the NICO Project. Suter and Tsao (1996) recommended a chronic guideline for fish of 3.3 mg/L and for invertebrates (daphnids) of 1.9 mg/L. These thresholds were calculated on the basis of circumneutral pH, and are above the maximum predicted concentration for total aluminum for the NICO Project (1.31 mg/L). For iron, levels between 8 to 10 mg/L are generally considered to be high, leading to severe degradation of fish habitat (Amisah and Cowx 2000). Although total iron concentrations were predicted to exceed SSWQOs in Nico Lake (potentially as high as 3.3 mg/L in Nico Lake during operations), dissolved concentrations of all metals, including iron, will generally remain under SSWQOs for the NICO Project. The risks posed by metals, such as iron and aluminum, to the aquatic environment are determined by the amount of biologically available metal (i.e. the free ion) (reviewed in Golder 2010).

The primary input source for most metal for Nico and Peanut lakes will be in particulate form, as part of the runoff and accumulation of dust (i.e., total suspended particulate deposition) produced from the NICO Project. Sources of dust deposition and air emissions modelled in the application case include blasting activities, haul roads, the Plant, activities at the Open Pit and other ancillary facilities, and vehicle traffic along the NPAR and the Proposed Tłįchǫ Road Route. Environmental design features and mitigation have been incorporated into the NICO Project to reduce potential effects from dust deposition. For example, the watering of roads, Airstrip, and laydown areas during the non-winter period will facilitate dust suppression. In addition, programs will be implemented to review power and heat use to reduce energy use and emissions. Although these environmental design features and mitigation should reduce dust deposition and air emissions, assumptions incorporated into the model are expected to contribute to conservative estimates (i.e., high) of air emission concentrations, surficial deposition rates, and metal concentrations in water.

Thus, with the application of the NICO Project, it is anticipated that changes to water concentrations of metals due to dust deposition may affect the condition of the aquatic ecosystem for Nico Lake and Peanut Lake, but that the fish abundances and general condition of the lakes should remain within the range of baseline values (i.e., <10% effect size). Effects should be largely restricted to operation and closure phases and to Nico Lake. It is anticipated that changes to metal concentrations in Burke Lake will not noticeably affect the ecological condition of the lake, including the persistence of populations for species generally considered more tolerant to disturbance. Tolerant species (e.g., northern pike and white sucker) characterize the assemblages of NICO Project lakes.

As the NICO Project timeline approaches closure and dust deposition concentrations are reduced, residual effects to water quality and the aquatic ecosystems should be noticeably reduced from waterbodies upon the post-closure phase. Although there is uncertainty associated with the anticipated time required for a complete recovery of Nico and Peanut lakes, the condition of aquatic habitat and the ecological health of the ecosystem will improve immediately and recover quickly (e.g., Amisah and Cowx 2000). Metal concentrations will be below SSWQOs at post-closure. This prediction is consistent with trends in water quality and sediment chemistry pre- and post-fire in the region that show rapid responses in aquatic habitat following disturbance (see Section 7.3 and Annex C).

12.6.4 Summary of Risk to Aquatic and Human Health

An aquatic risk assessment was completed for the NICO Project to determine the potential impacts on aquatic life (including aquatic plants, plankton, benthic invertebrates, and fish) from NICO Project-related emissions to surface waterbodies. The assessment was based on water quality predictions for Nico Lake and downstream waterbodies (i.e., Peanut and Burke lakes, and the Marian River). It considered chemical releases associated with dust generation and deposition to surface water as well as water discharges to surface water. Potential aquatic health impacts were determined during the construction, operations, closure, and post-closure phases of the NICO Project.

Overall, for all chemicals of potential concern and all phases of the NICO Project, the NICO Project-related risks to aquatic life are concluded to be either negligible, or low and likely negligible. Risk was considered to be negligible if calculated hazard quotients were less than target risk levels of 1, which is consistent with standard practice in risk assessment. Risks were considered low and likely negligible if hazard quotients were greater than 1 but less than or equal to 10 and based on the results of a magnitude of effect assessment which considered background concentrations and the degree of conservatism used in the derivation of the risk levels. In general terms, negligible risk indicates that there is unlikely to be adverse health impacts to aquatic life as a result of the NICO Project. Low and likely negligible risk indicates a possibility of adverse health impacts to the most sensitive aquatic species.

Of the reasonably foreseeable projects identified in the DAR, none are expected to result in changes to water quality. Particular concern has been expressed by the Tłı̨chǫ Government, Tłı̨chǫ citizens, and in the TOR (MVRB 2009) with respect to the potential cumulative effects due to the Rayrock and Colomac mines. However, given that impacts to aquatic health are considered negligible downstream of Burke Lake and the former Rayrock mine site is located at least 15 km downstream of Burke Lake, the cumulative effects on aquatic life are considered negligible. The former Colomac mine is located 120 km to the northeast in another drainage system which eliminates the potential for a cumulative effect with the NICO Project.

A human health risk assessment was also carried out to assess the potential risks to people that may be impacted as a result of the proposed NICO Project. Overall, based on the calculated exposure doses, it is anticipated that aerial depositions and hydrological discharges from the NICO Project will result in no anticipated change in human health outcomes in comparison to baseline conditions from the NICO Project. The exposure doses were calculated using the maximum predicted concentrations of chemicals of potential concern, which were predicted during the operations phase of the NICO Project because it had the highest predicted concentrations of all phases. Because no significant changes to human health are anticipated during this phase of the NICO Project, it can be anticipated that health risks will also be negligible during the construction, closure, and post-closure phases of the NICO Project given that concentrations of chemicals of potential concern have been predicted to be present at lesser concentrations.

12.6.5 Related Effects to People

A measurable change in the abundance and distribution of sport fish populations is predicted for Nico Lake, and possibly Peanut Lake, which may influence the availability of fish for harvesting for traditional and non-traditional users. The magnitude of the decrease from the NICO Project on fish populations is expected to be within the range of existing conditions. Current fishing pressure in NICO Project lakes appears to be low and indicates that fishing pressure is unlikely to be a limiting factor for these populations. Therefore, the small decrease in the availability of fish for harvesting from NICO-Project related effects is predicted to be within the range of baseline values (i.e., people that fish in the region should not observe a change in the availability of animals due to effects from the NICO Project, relative to current natural changes in population sizes).

Increased angler access from the NPAR road may also affect populations of sport fish in the Hislop Lake-Marian River system (i.e., lake whitefish and walleye). The NPAR crosses the Marian River, and will pass Hislop Lake at which point the lake can be visited by anglers using the existing winter road portage that will intersect with the NPAR, by either snowmachine, all-terrain vehicles, foot, or 4x4 truck. However, Hislop Lake is a shallow, turbid lake, and is generally not considered an important fish-bearing waterbody (although the lake has been identified as a traditional fishing location). Due to the nearby proximity of Lac La Martre, a popular fishing destination, angler access by traditional and non-traditional users should remain within the range of existing conditions for Hislop Lake. It is predicted that only a few anglers will take advantage of increased access to Hislop Lake (i.e., change will be undetectable).

In summary, residual effects to people are expected, although changes to sportfish fish population sizes and opportunities for traditional and non-traditional users should be within range of baseline values (<10% magnitude). If angling pressure increase to the point where it is expected to affect fish populations, the impacts could be mitigated through changes in the sport fishing regulation for the affected waterbody. The duration of the effect will approximate the duration of the NPAR, from opening to closure of the road, or extend beyond closure if the NPAR is decommissioned with the mine. The spatial extent of effect may extend to the regional study area, including the Marian River and Hislop Lake.

12.7 Residual Impact Classification

The purpose of the residual effect classification is to describe the residual effects from the NICO Project on fish and fish habitat using a scale of common words, rather than numbers or units. The use of common words or criteria is a requirement in the TOR (MVRB 2009). The following criteria were used to assess the residual effects from the Project (Table 12.7-1):

- direction;
- magnitude;
- geographic extent;
- duration;
- reversibility;
- frequency; and
- likelihood.

12.7.1.1 Methods

The term “effect”, used in effects statements, has been changed to “impact” in this section on Residual Impact Classification. The term “impact” is only used during the classification process. Therefore, in the Residual Impact Classification section of the DAR, all residual effects are discussed and classified in terms of impacts to VC endpoints.

Generic definitions have been provided for each of the impact criteria in the Assessment Approach (Section 6). For criteria such as frequency and likelihood, the definitions can be applied consistently across all VC endpoints (Table 12.7-1). Similarly, reversibility is defined as the likelihood and time required for a component (e.g., population) or system to recover after removal of the stressor and is a function of resilience. Reversibility (Table 12.7-1) is applied to all combinations of magnitude, geographic extent, and duration.

The scale of classifications (e.g., high, low, local, regional, short-term, and long-term) for magnitude, geographic extent, and duration is dependent on each VC endpoint, and the associated effects statement. To provide transparency in the DAR, the definitions of these scales are specifically based on fish and fish habitat. Although professional judgement is inevitable in some cases, a strong effort was made to classify effects using scientific principles, supporting evidence, and a conservative approach where uncertainties exist.

Where quantitative values were available (e.g. habitat loss and fragmentation, habitat suitability), the magnitude of an effects pathway for fish and fish habitat was determined as follows:

- negligible: no detectable change from the NICO Project relative to baseline values;
- low: less than, or equal to 10% change from the NICO Project relative to baseline values;
- moderate: 11 to 20% change from the NICO Project relative to baseline values; and
- high: more than 20% change from the NICO Project relative to baseline values, and there is likely a change of state from baseline conditions.

Table 12.7-1: Definitions of Terms Used in the Residual Impact Classification

Direction	Magnitude	Geographic Extent	Duration	Reversibility[a]	Frequency	Likelihood
Negative: a less favourable change relative to baseline values or conditions **Positive:** an improvement over baseline values or conditions	**Negligible:** no predicted detectable change from baseline values (<1%) **Low:** impact is predicted to be within the range of baseline values (≤ 10%) **Moderate:** impact is predicted to be at or slightly exceeds the limits of baseline values (11% to 20%) **High:** impact is predicted to be beyond the upper or lower limit of baseline values so that there is likely a change of state from baseline conditions (more than 20%)	**Local:** small-scale direct and indirect impact from the Project (e.g., footprint, physical hazards, and dust deposition) **Regional:** the predicted maximum spatial extent of combined direct and indirect impacts from the Project that exceed local-scale effects (can include cumulative direct and indirect impacts from the Project and other developments at the regional scale) **Beyond Regional:** cumulative local and regional impacts from the Project and other developments extend beyond the regional scale	**Short-term:** impact is reversible at end of construction **Medium-term:** impact is reversible at the end of closure **Long-term:** impact is reversible within a defined length of time beyond closure	**Reversible:** impact will not result in a permanent change of state of the aquatic system compared to "similar" environments not influenced by the Project **Irreversible:** impact is not reversible within the temporal boundary of the assessment (i.e., duration of impact is undefined or permanent)	**Isolated:** confined to a specific discrete period **Periodic:** occurs intermittently but repeatedly over the assessment period **Continuous:** will occur continually over the assessment period	**Unlikely:** the impact is likely to occur less than once in 100 years **Possible:** the impact is possible within a year; or at least one chance of occurring in the next 100 years **Likely:** the impact is probable within a year; or at least one chance of occurring in the next 10 years **Highly Likely:** the impact is very probable (100% chance) within a year

[a] "similar" implies an environment of the same type, region, and time period.

12.7.2 Results

Direct impacts from air emissions and treated effluent from the NICO Project will be local in geographic extent (Table 12.9-2), if the worst case scenario is observed. There are no other human developments in the RSA. The primary source of contaminants for Nico and Peanut lakes will be in particulate form, as part of the accumulation of dust (i.e., total suspended particulate deposition) in runoff. The magnitude of the impacts from changes to TSS, nutrients, DO, and metals on aquatic habitat and fish is predicted to be negligible to low in magnitude. Fish abundances and the general condition of lakes in the LSA should remain within the range of baseline values (i.e., impacts should be negligible to low). Modelling indicated that both aluminum and iron will exceed site-specific guidelines in Nico Lake and Peanut Lake. However, it is anticipated that impacts from air emission and treated effluent on Burke Lake will likely be negligible. The structure and function of Burke Lake and downstream ecosystems should remain intact given the low level of upstream inputs of TSS, nutrients and metals. Impacts from treated effluent from the NICO Project will be continuous over the duration of the assessment period, whereas impacts from air emission and dust deposition will be periodic (Table 12.9-2). Impacts will be strongest and largely restricted to the period during and after the spring freshet. Although there is uncertainty associated with the anticipated time required for a complete recovery of Nico and Peanut lakes, recovery should be quick and the condition of aquatic habitat will rapidly improve over time (i.e., impacts will reversible to irreversible). Aluminum and iron concentrations will be below site specific objectives at post-closure.

The cumulative impact assessment included existing angling pressures, and with the development of the NPAR and Proposed Tłı̨chǫ Road Route, anglers would be able to make more use of vehicles (including snow machines) to access areas in the region. The spatial extent of incremental and cumulative impacts from the access roads, and existing winter roads on fish populations in the region from changes in harvesting pressure is expected to be regional and include the Marian River and Hislop Lake (Table 12.9-2). Impacts to fish populations from harvesting will likely be continuous (i.e., over summer and winter seasons). Should fishing on the Proposed Tłı̨chǫ Road Route or NPAR reach a level of concern, the Tłı̨chǫ Government or the Wek'èezhìi Renewable Resources Board could enact regulations to control the harvest. However, current fishing pressure in NICO Project lakes appears to be low and indicates that fishing pressure is unlikely to be a limiting factor for regional populations of sportfish. Therefore, the decrease in the availability of fish for harvesting from NICO-Project related impacts is predicted to be within the range of baseline values. People that fish in the region, should not observe a change in the availability of fish due to impacts from the NICO Project, relative to current natural changes in population sizes. Thus, it is expected that the incremental and cumulative increase in the harvest of fish from the NPAR and Proposed Tłı̨chǫ Road Route will be similar to baseline harvesting values (negligible magnitude) (Table 12.9-2). The duration of impacts to fish from increased access is considered to be permanent as these roads will likely be maintained well beyond the temporal boundary of the assessment (i.e., more than 21 years [construction through closure]).

Changes to the abundance and distribution of sportfish population from development may negatively influence the traditional and non-traditional harvesting of northern pike and lake whitefish. The predicted magnitude of the incremental and cumulative impact from the NICO Project on fish and fish habitat will generally be low or even negligible for most waterbodies in the RSA. Therefore, the magnitude of changes to the harvesting potential of fish from the incremental and cumulative impacts from the NICO Project and other developments are expected to be low for Nico Lake, but likely negligible for other waterbodies in the RSA (Table 12.9-2). The duration of the impacts to fish is expected to be reversible in the long-term.

Table 12.9-2: Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects to Aquatic Habitat and Fish Populations

Pathway	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
Air emissions during construction and operation can cause changes to aquatic habitat and fish	Negative	Negligible to low	Negligible to low	Local	Local	Long-term	Periodic	Reversible	Likely
Release of treated mine wastewater and sewage can cause changes to aquatic habitat and fish	Negative	Negligible	Negligible	Local	Local	Long-term	Continuous	Reversible	Highly likely
Improved angler access can affect sportfish populations	Negative	Negligible	Negligible	Regional	Regional	Long-term	Continuous	Reversible	Likely
Effects on fish population can change the availability for traditional and non-traditional use	Negative	Negligible to low	Negligible to low	Regional	Regional	Long-term	Continuous	Reversible	Likely

12.8 Environmental Significance

12.8.1.1 Methods

The TOR requires that the developer "assess and provide an opinion on the significance of any residual adverse impacts predicted to remain after mitigation measures" (MVRB 2009). Environmental significance was used to evaluate the significance of incremental and cumulative impacts from the NICO Project and other developments on aquatic habitat and fish, and by extension, on the use of fish (i.e., lake whitefish and northern pike) by people. The evaluation of significance was based on ecological principles, to the extent possible, but also involved professional judgment and experienced opinion.

The classification of residual impacts on primary pathways provides the foundation for determining environmental significance from the NICO Project on the persistence of fish and condition of aquatic habitat. Magnitude, geographic extent, and duration are the principal criteria used to predict significance (Section 6.6.3). Other criteria, such as frequency and likelihood, are used as modifiers (where applicable) in the determination of significance.

Frequency may or may not modify duration, depending on the magnitude of the impact. Likelihood will also act as a modifier that can influence environmental significance. Environmental impact assessment considers impacts that are likely or highly likely to occur; however, within the definition of likelihood there can be a range of probabilities that impacts will occur. In special circumstances, the environmental significance may be lowered if an impact is considered to have a very low likelihood of occurring, and increased for impacts with a very high likelihood of occurring.

Duration of impacts, which includes reversibility, is a function of ecological resilience, and these ecological principles are applied to the evaluation of significance (Section 6.6.3). Although difficult to measure, resilience is the capacity of the system to absorb disturbance, and reorganize and retain the same structure, function, and feedback responses. Resilience includes resistance, capability to adapt to change, and how close the system is to a threshold before shifting states (i.e., precariousness).

The evaluation of significance considered the entire set of primary pathways that influence the assessment endpoint (e.g., persistence of fish population sizes). The relative contribution of each pathway is used to determine the significance of the NICO Project on the persistence of fish and condition of aquatic habitat, which represents a weight of evidence approach (Section 6.6.3). For example, a pathway with a high magnitude, large geographic extent, and long-term duration is given more weight in determining significance relative to pathways with smaller scale effects. The relative impact from each pathway is discussed; however, pathways that are predicted to have the greatest influence on the persistence of fish and the ecological condition of lake ecosystems are also assumed to contribute the most to the determination of environmental significance.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to, for example, lake whitefish population sizes. The following definitions are used for assessing the significance of impacts on aquatic habitat and fish, and the associated continued opportunity for traditional use of fish.

Not significant – impacts are measurable at the individual level, and strong enough to be detectable at population and ecosystem levels, but are not likely to decrease resilience and increase the risk to the persistence of fish populations and the condition of aquatic habitat.

Significant – impacts are measurable at the population and ecosystem level and likely to decrease resilience and increase the risk to persistence of fish populations and condition of aquatic habitat. A number of high magnitude and irreversible impacts that extend beyond regional scale would likely be significant.

12.8.2 Results

The results predict that impacts from the NICO Project should not significantly influence the persistence of fish populations and the condition of aquatic habitat. For all primary pathways influencing fish, cumulative impacts (where other human activities involved existing angler pressure only) were determined to be regional in geographic extent (Table 12.9-2). For incremental impacts, the geographic extent of pathways ranged from local to regional. Local impacts to fish and aquatic habitat were associated with the NICO Project footprint, while regional changes in fish were from existing angling pressures and anticipated angler access associated with the development of the NPAR and Proposed Tłı̨chǫ Road Route. The likelihood of the impacts occurring is expected to be “likely” to “highly likely” for all pathways, which does not change the expected magnitude and duration (or environmental significance). Similarly, the frequency of most impacts is anticipated to occur periodically or continuously throughout the life of the NICO Project.

Dust deposition impacts (e.g., from increases in metal concentrations in Nico and Peanut lakes) associated with mining activities and roads on the persistence of fish populations are anticipated to be reversible over the long-term (26 to 31 years [about 1 to 2 life spans for either lake whitefish or northern pike]); however, potential harvesting of fish in Hislop Lake and the Marian river (via Proposed Tłı̨chǫ Road Route and the NPAR) likely will continue well beyond the temporal boundary of the assessment (i.e., considered to be a permanent impact for the Proposed Tłı̨chǫ Road Route).

The magnitude for the 4 primary pathways impacting aquatic habitat and fish ranged from negligible to low (Table 12.9-2). The magnitude of the impact from air emissions during construction and operation is expected to be low for Nico and Peanut lakes, and negligible for Burke Lake and the Marian River. Based on 95th percentiles, elevated total aluminum concentrations are predicted for operations and closure in Nico Lake, construction through to closure in Peanut Lake, and during the operation phase and closure in Burke Lake. Elevated total iron concentrations are predicted for operations and closure in Nico Lake, and for the operation phase in Peanut Lake. The primary input source for most of the metals for the lakes will be in particulate form, as part of the accumulation of dust (i.e., total suspended particulate deposition) in the spring freshet. Thus, the magnitude of the impact from treated effluent is anticipated to be much lower than that from air emissions and dust deposition, but occur continuously. The magnitude of the impact (incremental and cumulative) from increased angler access is anticipated to be negligible and occur periodically (Table 12.9-2).

There is a moderate degree of uncertainty associated with the prediction of no significant adverse impacts on fish and aquatic habitat, which is primarily related to the duration of impacts and the variability inherent in making long-term predictions in ecological systems. The uncertainties in air emissions and dust deposition rates, the primary mechanism for elevated TSS and metal concentrations in Nico and Peanut lakes, were mitigated with methods and assumptions deemed as ecologically conservative, for example (Section 10.8):

- The modelling was based on the assumption that most equipment will be operating at maximum capacity on a continuous basis. This assumption can lead to an overestimation of the potential NICO Project impacts for the longer averaging periods (24-h and annual).

- Although precipitation and snow accumulation on the haul road surface will provide some degree of natural mitigation of the road dust emissions during the winter, the winter road dust emissions modelled in the Application Case were based on the conservative assumption of no natural mitigation. The predicted concentrations, therefore, are conservative (i.e., high).

It is also important to note that the effects analysis was based on water quality predictions of 95th percentiles, which are highly conservative estimates to increase confidence that the assessment would not underestimate impacts (Section 7.6). It was assumed that the 95th percentile prediction output would be representative of a conservative upper bound of concentrations during a dry year. High concentrations of aluminum are not an issue in Burke Lake when considering averages as the statistical unit, rather than 95th percentile predictions.

There are natural environmental factors that operate over large scales of space and time that likely have greater influences on the persistence of fish populations relative to the incremental and cumulative impacts from the NICO Project and other developments. For example, climate change can influence the abundance and distribution of fish by modifying water levels, water temperatures, and the frequency and intensity of burns within the watershed that can release metals into receiving waters (e.g., Chu et al. 2005; Ficke et al. 2007; Winfield et al. 2008; Lyons et al. 2010; Annex C).

Overall, the weight of evidence from the analysis of the primary pathways predicts that the incremental and cumulative impacts from the NICO Project will not have a significant adverse impact on the persistence of fish populations and the condition of aquatic habitat. The implementation of environmental design features at the NICO Project should mitigate potential for most adverse effects, and thereby not negatively influence the resilience of aquatic ecosystem. Species such as white sucker and northern pike have the capability to adapt to different disturbances and environmental selection pressures (Holling 1973; Stevens et al. 2010; Whittier et al. 2007; Winfield et al. 2008; Annex C). Their survival and reproduction rates appear to have the flexibility to respond to changes through time and across the landscape. The resilience of the local aquatic ecosystems to natural disturbances (Holling 1973; Gunderson 2000; Annex C) suggests that the impacts from the NICO Project will be reversible and not significantly affect the future persistence of fish populations and the condition of aquatic habitat. Subsequently, impacts from development are not predicted to have a significant adverse effect on continued opportunities for use of fish by people that value these animals as part of their culture and livelihood. This prediction is consistent with trends in the aquatic condition pre- and post-fire reported as part of baseline monitoring in the region. Baseline monitoring has documented rapid responses in aquatic habitat following disturbance (see Section 7.3 and Annex C).

12.9 Uncertainty

Key areas of uncertainty for the assessment of effects to water quality, aquatic habitat and fish in NICO Project lakes include the following:

- water quality predictions (TSS, metals, and nutrients), particularly for Nico and Peanut lakes; and
- air emission predictions for NICO Project watershed.

Each area of uncertainty is discussed in more detail below. The following discussion also includes a description of the approaches used to account for uncertainty in the effects analysis, so that potential effects were not underestimated. Where relevant, the inherent advantages of the design of the NICO Project are also discussed, in terms of how they influence uncertainty in the assessment of effects to water quality and fish, emphasizing Nico and Peanut lakes.

12.9.1 Air Emissions Predictions

Dispersion models simplify the atmospheric processes associated with air mass movement and turbulence. This simplification limits the capability of a model to replicate discrete events and therefore introduces uncertainty. As a result of the uncertainty, dispersion models are coupled with model inputs that are generally designed to conservatively model concentration and deposition values. In doing so, practitioners can apply model results with the understanding that effects are likely over-estimated.

The air modelling as applied to the NICO Project (Appendix 10.I) has a number of limitations that result in model uncertainty. These include the following:

- Emissions associated with industrial activities are reasonably well defined and were largely taken from recent applications. However, the emissions from non-industrial activities within regional communities are more difficult to predict.
- Emissions from area sources are difficult to estimate and simulate in dispersion models. The NICO Project area emission sources include Open Pit, roads, and Mine Rock piles.
- Characterization of emissions near Open Pit and other sources of mechanically generated particulate are uncertain. Most estimates of particulate emissions for mining activities are based on U.S. EPA emission factors. Many of these factors have limited applicability outside of the area in which they were developed (typically south-western United States coal mines).
- In cold weather conditions, such as those experienced at the NICO Project, the conversion of nitric oxide concentrations to nitrogen dioxide will occur at a slower rate than in warmer conditions. Models assume the conversion is instantaneous, introducing uncertainty into the location and magnitude of predicted nitrogen dioxide concentrations.
- When reliable emission estimation methods were not available for a particular compound, representative monitoring data were added to the model predictions. This approach was adopted for nitrogen oxides, sulphur dioxide, particulate matter of particle diameter less than 2.5 µm and 10 µm, and total suspended particulate.

Predictions of changes in TSS and metals concentrations as a result of dust deposition were conservative for the following reasons:

- It was based on air quality modelling, which incorporated conservative assumptions, such as, no dust suppression was assumed during the winter months even though precipitation and snow accumulation on the ground surface will provide some degree of mitigation (Section 10.4.2.1.2).
- Predicted annual deposition rates were based on the maximum of the daily road dust emissions during summer and winter.
- No retention of particulates or metals was assumed in the lake catchment areas.

- Geochemistry data used to estimate metal concentrations in dust included a large proportion of concentrations below the analytical detection limit for cadmium and selenium.

12.9.2 Water Quality Modelling

The predictions of water quality in Nico, Peanut, and Burke lakes, and the Marian River during construction, operations, and closure, prior to discharge from the Flooded Open Pit, was completed using a dynamic flow and mass-balance model built within the GoldSim™ modelling environment, which is widely used in environmental assessments. The GoldSim™ model was specifically used to simulate water quality outcomes in a receiving environment over time with multiple input variables.

The GoldSim™ water quality model was based on background surface water flow time series derived for the Burke Lake and Lou Lake watersheds and for the Marian River, and included inputs of material from the following sources:

- background surface water flows;
- deposition of dust and metals during construction and operations (discussed above);
- seepages from the NICO Project site to Nico Lake during operations;
- discharges from the ETF to Peanut Lake during operations; and
- discharges from Wetland Treatment System No. 1, 2, and 3 to Nico Lake beginning at closure.

The main sources of uncertainty and conservatism in the water quality modelling are from natural variability in baseline water quality, NICO Project water balance and chemistry, and modelled receiving water quality predictions. Uncertainty and conservatism in the water quality modelling are detailed in Section 7.13.2 and summarized here.

Natural variability in baseline water quality can lead to uncertainty in modelling results; however most of the natural variability was accounted for by the following means:

- use of daily background surface water flow time series derived from hydrometric monitoring records over a period of 26 years;
- incorporating natural variability into the model by deriving statistical distributions of water quality constituent and suspended sediment concentrations from baseline monitoring program; and
- incorporating surface water partition coefficients into the model derived from suspended solids concentrations and associated total and dissolved constituent concentrations measured in water samples collected during the baseline monitoring program.

The water quality model background inputs and related design features described herein and in Section 7.13.2 support a high level of confidence that natural variability has been accounted for in the water quality modelling predictions.

Sources that led to conservatism and uncertainty in the NICO Project water balance and chemistry, and their application within the GoldSim™ water quality model, are as follows:

- use of average condition site water balances in the site water chemistry predictions is a potential source of uncertainty in the receiving water quality model, as site water chemistry will likely vary during drier and wetter years;
- use of the analytical detection limit value for constituent concentrations that were less than the detection limit and not permitting mineral precipitation and metal sorption processes to occur in the site water quality predictions will tend to overestimate constituent concentrations;
- ammonia and nitrate concentrations were determined on an annual basis for steady state and worst case conditions, with the single highest worst case concentration predictions conservatively applied within the GoldSim™ water quality model;
- there is a moderate to high level of conservatism in including in seepage estimates in the receiving water quality predictive modelling, as seepage analysis has not yet been completed to verify the flow rates, no interception was assumed, and attenuation of constituent concentrations in seepages along the flow path to Nico Lake was not included in the model; and
- conservatism was applied to the quality of the discharge from the treatment wetlands after closure, in that the predicted outflow quality is generally expected be better than the influent quality predictions that were applied to the outflows.

Water quality predictions were presented and interpreted at the 95^{th} percentile level, and are conservative estimates to increase confidence that the assessment will not underestimate impacts. Given the cumulative conservatism incorporated into the model inputs described above, it was considered that the 95^{th} percentile prediction output would be representative of upper bound of concentrations during a dry year.

12.10 Monitoring and Follow-up

Upon approval of the NICO Project, an Aquatic Effects Monitoring Program (AEMP) will be implemented to limit effects to water quality and other aquatic components and to test impact predictions (Section 18.5.2.2, Appendix 18.I). The final AEMP will include provisions for environmental effects monitoring as required under the Metal Mining Effluent Regulations of the *Fisheries Act* (see Environment Canada 2002). The AEMP will consider the Indian and Northern Affairs Canada (INAC) Guidelines on designing and implementing aquatic effects monitoring programs in the NWT (INAC 2009a), and the draft Adaptive Management (Monitoring Response) guidelines from the Wek'èezhìi Land and Water Board (WLWB) (2010), as appropriate. Fortune intends to combine the AEMP with the Surveillance Network Program required by the NICO Project Water License and with the Metal Mining Effluent Regulations Program, to make certain that the AEMP uses all available monitoring data in the receiving environment.

Specific objectives of the AEMP include the following:

- provide information to test predicted impacts from the NICO Project DAR, and reduce uncertainty;
- incorporate local traditional and ecological knowledge, where applicable and available;
- propose action levels or adaptive management triggers that can be used as early warning signs for reviewing and implementing mitigation practices and policies;
- design studies and data collection protocols that are consistent with other programs in the region; and

- consider existing regional and collaborative programs, such as Cumulative Impact Monitoring Program.

It is anticipated that the objectives of the AEMP will also include links to management responses, as follows:

- evaluate the short-term and long-term predicted effects of the NICO Project on the physical, chemical, and biological components of the aquatic ecosystem of the NICO Project area and downstream waterbodies;
- estimate the spatial extent of predicted effects;
- compare monitoring results to effect predictions;
- provide the necessary input for monitoring responses to potential unacceptable effects on the aquatic ecosystem; and
- evaluate the effectiveness of monitoring responses.

It is anticipated that components of the AEMP specific to this SON will include benthic invertebrates, fish health, fish habitat (physical characteristics), and fish usability (tissue chemistry) (Appendix 18.I). These components are also linked to the components of effluent characterization (physical, chemical, and toxicological characteristics), effluent plume modelling, water quality in Nico Lake and downstream waterbodies, and sediment quality in Peanut, Nico, Burke, and Reference lakes. More information regarding the AEMP can be found in Appendix 18.I.

12.11 References

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