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7.0 KEY LINE OF INQUIRY: WATER QUALITY

7.1 Introduction

7.1.1 Context

This section of the Developer's Assessment Report (DAR) for the NICO Cobalt-Gold-Copper-Bismuth Project (NICO Project) consists solely of the Key Line of Inquiry (KLOI) for Water Quality. In the Terms of Reference (TOR) for the NICO Project's DAR issued on 30 November 2009, the Mackenzie Valley Review Board (MVRB) identified water quality as 1 of 3 top priority valued components (VCs) requiring a high level of consideration by the developer (MVRB 2009).

The KLOI: Water Quality includes a detailed and comprehensive assessment of all potential impacts from the NICO Project on ground and surface water quality and sediment quality. It also includes related effects to human, wildlife, and aquatic health in the vicinity of the NICO Project and downstream for use in other sections to assess how the predicted changes to the water quality as a result of the NICO Project may affect the opportunity for use of wildlife and fish by people that value the animals as part of their culture and livelihood.

All effects on water quality are assessed in detail in this KLOI; however, issues addressed in other KLOI and Subjects of Note (SON) may overlap with this KLOI:

- KLOI: Caribou and Caribou Habitat (Section 8);
- KLOI: Closure and Reclamation (Section 9);
- SON: Air Quality (Section 10);
- SON: Hydrology (Section 11)
- SON: Fish and Aquatic Habitat (Section 12);
- SON: Wildlife (Section 15);
- Section 18: Biophysical Environment Monitoring and Management Plans; and
- Appendix 3.III: Water Management Plan

7.1.2 Purpose and Scope

The purpose of the KLOI: Water Quality is to assess the effects of the NICO Project on water and sediment quality and to meet the TOR issued by the MVRB. The terms for the KLOI: Water Quality are shown in Table 7.1-1. The entire TOR document is included in Appendix 1.I, and the complete table of concordance for the DAR is in Appendix 1.II of Section 1.

The KLOI: Water Quality includes an assessment of direct and indirect effects from the NICO Project on surface and groundwater quality and sediment quality 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. Cumulative effects are discussed throughout this section, where applicable, to a level of detail appropriate for the particular effect or valued component under consideration. The effects from the NICO Project are considered in combination with other developments, activities, and natural factors that influence fish and aquatic habitat within the study area.

The effects assessment will evaluate all NICO Project phases, including construction, operation, closure and reclamation, and post-closure; where applicable indirect and cumulative effects have been incorporated throughout this section. Information from other components of the DAR, including hydrology, geochemistry, hydrogeology, and air quality, as well as information from existing developments, is incorporated in the water quality impact assessment. More detailed information on the requirements of the DAR TOR for this KLOI can be found in Table 7.1-1.

Table 7.1-1: Key Line of Inquiry: Water Quality 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;	7.1.3
	Fortune's chosen spatial boundaries for the assessment of potential impacts for each of the valued components considered; and	7.1.3
	The temporal boundaries chosen for the assessment of impacts on each valued component.	7.1.2, 7.5
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.	7.3, Annex C
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;	7.1.2
	• For each valued component, identify and provide a rationale for the criteria and indicators used;	7.1.1, 7.1.2
	• Identify the sources, timelines and methods used for data collection;	7.3, Annex C
	• 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;	7.3, Annex C
	• 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;	7.5, 7.6
	o Predict the likelihood of each impact occurring prior to mitigation measures being implemented, providing a rationale for the confidence held in the prediction;	7.5, 7.6

Table 7.1-1: Key Line of Inquiry: Water Quality Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
3.3.1 (continued)	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;	3.9, Appendix 3.III, 7.4, 7.5
	o Describe techniques, such as models utilized in impact prediction including techniques used where any uncertainty in impact prediction was identified;	7.6
	• Assess and provide an opinion on the significance of any residual adverse impacts predicted to remain after mitigation measures; and	7.12.2
	• 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.	7.14, 18.5.2.2, Appendix 18.1
	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.	7.11.2
3.3.2	**Key Line of Inquiry: Water Quality** During the issues scoping process, potential impacts of the NICO Project on water quality was identified as a top priority by most interested parties, including the developer. The developer will consider all potential impacts on water quality in the watershed to the point where no mine-related changes can be measured and present this in a stand-alone section of the Developer's Assessment Report. The developer will:	
	• Describe the impacts of the proposed project on water quality around the NICO mine site and downstream. Include discussion of predicted physical or chemical changes. This will include predictions of any changes in levels of contaminants, pollutants or other harmful or deleterious substances caused entirely or partly by the NICO Project. Discuss these in terms of:	7.5, 7.6, 7.10, 7.11
	o changes to water quality and impacts on aquatic resources and wildlife; and	7.6, 7.7, 7.8
	o changes to the quality of water for drinking in Behchokǫ̀ and for people on the land.	7.9
	• Describe any predicted changes from the NICO Project on:	
	o surface waterbodies in the Fortune claim block;	7.6
	o surface waterbodies downstream of the project until no mine related changes can be measured; and	7.6
	o Marian River, Marian Lake and Hislop Lake.	7.6
	• Predict potential impacts on groundwater flows from the project area.	11.3.2.2
	• Describe mitigation measures to minimize impacts to water quality.	7.4, 7.5

Table 7.1-1: Key Line of Inquiry: Water Quality Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
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:	7.3, Annex C, Appendix 7.III
	6) Current and historic data on surface water and groundwater quality for the NICO mine site area. This should include recent arsenic data and changes in baseline arsenic levels with reference to the recent forest fire, and should contrast baseline levels following the fire with the overall range of natural variability of background conditions.	7.3, Annex C, Appendix 7.III
Appendix C	**Water Quality**	
	In predicting the impacts on water quality from NICO Project, the developer will:	
	1) Identify, describe, and estimate amounts of contaminants from all potential sources at the NICO mine site. Predict the likelihood and consequences for each of the following, alone or in combination, to leach metals, create acid rock drainage, or otherwise affect water quality:	7.5, Appendix 7.II
	a. mine water from the underground workings and open pit;	7.5, Appendix 7.II
	b. the mine rock management area, unless co-mingled with tailings;	7.5, Appendix 7.II
	c. the tailings management area, or co-mingled tailings management area;	7.5, Appendix 7.II
	d. reagent chemicals, hydrocarbons, explosives, and any other potentially hazardous products used at the mine site;	7.5, Appendix 7.II
	e. any other materials stored on surface at the NICO mine site, including aggregates; and,	7.5, Appendix 7.II
	f. other site runoff.	7.5, Appendix 7.II
	This discussion will include estimates of how much of the waste rock will likely be placed in the mine rock management area, delineation of all potential contaminant pathways and receptors, and post-closure locations, predicted amounts, and management systems for all surface materials storage systems.	3.7, 3.8, 3.9, Appendix 7.II
	2) Predict the water quality and quantity of final effluent discharged to the environment during all phases of the NICO Project life cycle, incorporating:	
	a. identification of the constituents of, and quantity likely to come out of, each on-site water source;	Appendix 7.II

Table 7.1-1: Key Line of Inquiry: Water Quality Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
Appendix C (continued)	b. present discharge criteria for treated effluent;	3.9.5, Appendix 7.VII
	c. predicted changes over time in the amount or quality of mine water outflows;	Appendix 7.II
	d. all relevant water quality parameters including pH, temperature, concentrations of metals, nutrients, total suspended solids, major ions, process chemicals and bacteria;	2.4, 3.9.5, Appendix 7.II, Appendix 7.IV, 7.V
	e. identification of all committed-to mitigation measures to minimize initial water contamination (e.g. mitigative measures to limit blasting residues) and to remove contaminants via the treatment process; and	3.7,3.8, 3.9, 7.5
	f. identification of the uncertainties and confidence levels in the predictions, the assumptions used, and the likely range of variation for the parameters identified.	Appendix 7.II
	3) Describe naturally occurring arsenic, the range of natural variation, flows and ecological pathways in surface and groundwater, and how the NICO Project will affect this range of conditions. Describe how arsenic solubility under site conditions (both acidic and neutral) has been considered in long term mine planning and engineering designs.	7.3, 7.6, Annex C, Appendix 7.II, 9.0
	4) Assess potential impacts of effluent discharge in Peanut Lake, Nico Lake, Burke Lake, Marian River and Marian Lake (to the point that no changes are measurable) including the predicted likelihood and severity of:	7.6
	a. changes to pH in downstream watercourses;	7.6
	b. increasing sediment levels and water turbidity;	7.6
	c. increasing contaminant concentrations (including arsenic and mercury) in the sediments, fish and other aquatic organisms, including consideration of bio-accumulation effects;	7.6, 12.4
	d. discharge of ammonia and other nutrients, including possible changes in nutrients available in the food chain in downstream water bodies; and	7.6, 12.6
	e. any other impacts which may alter water quality or aquatic ecosystem integrity downstream of the mine.	7.6, 12.6
	5) For Peanut Lake, describe:	
	a. method and location of effluent discharge; and	Appendix 7.IV
	b. plume behaviour of effluent including an estimate of mixing behaviour and an estimate of where the plume will be sufficiently mixed so that there is no chronic toxicity.	Appendix 7.IV
	6) For Peanut Lake, Burke Lake and water bodies in between, describe:	
	a. contaminant mobility in water under likely environmental conditions;	7.6

Table 7.1-1: Key Line of Inquiry: Water Quality Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
Appendix C (continued)	b. effects on dissolved oxygen and nutrient levels, especially during winter; and	12.4.2.2
	c. potential increase in sedimentation and erosion (including lake bed and banks).	7.5.2.1, 12.3.2.1.1
	7) Identify any potential sources of contaminated groundwater not captured in the mine water management system. This discussion should identify:	7.5, 7.6, 3.9, Appendix 3.III
	a. where losses to the groundwater system could occur;	7.6, 3.9, Appendix 3.III, Appendix 7.II
	b. estimated quantities of contaminated groundwater loss; and	7.6, 3.9, Appendix 3.III, Appendix 7.II
	c. potential impacts of contaminated groundwater on the environment and their likely geographic distribution.	7.6
	8) Describe potential effects on NICO Project effluent from incoming groundwater quality, and resulting impacts on the environment.	Appendix 7.II, 7.6
	9) Describe:	
	a. site-specific characteristics of the receiving environment;	7.3, Annex C
	b. proposed site-specific water quality objectives for all stressors of potential concern, effluent quality levels, limits and proposed thresholds for water quality that the developer is committed to meeting in order to protect the downstream environment;	Appendix 7.VII
	c. Fortune's proposed draft framework for aquatic effects monitoring and environmental effects monitoring programs, considering historical arsenic levels.	7.14, 18.0, Appendix 18.I
	10) Describe Fortune's evaluation of water treatment alternatives. For the proposed water management and treatment facilities, provide an analysis of the adequacy of:	2.0
	a. the effluent treatment facility, specifically to meet site specific water quality objectives for:	3.9.4, Appendix 7.VII
	i. Metal Mining Effluent Regulation metals; and	2.0
	ii. other applicable parameters such as selenium, iron, cobalt, bismuth, total suspended solids, ammonia, cyanide and radium-226.	2.0
	b. all water collection systems, including that surrounding the mine rock and tailings management areas;	3.9
	c. the sewage treatment system; and	3.9.5
	d. any water storage facilities.	3.9

Table 7.1-1: Key Line of Inquiry: Water Quality Concordance with the Terms of Reference (continued)

Section in Terms of Reference	Requirement	Section in Developer's Assessment Report
Appendix C (continued)	This discussion should emphasize the ability of these facilities and the system as a whole to handle expected increased mine water inflows and retention capacity timelines and contingency plans for greater than expected outflows, the ability to handle greater than predicted concentrations of contaminants in pre-discharge waters or other treatment upsets, and impacts of any identified failure mode. Include discussion of seasonal effects on the effectiveness of the effluent treatment facility.	3.9
	11) Describe the likelihood and consequences of accidents, malfunctions, or impacts of the environment on the development influencing water quantity and quality and the ability of the water management system to function. This discussion should include the required circumstances for a failure to occur, and what monitoring, evaluation and adaptive management systems will be in place to identify, proactively avoid and address them. The following scenarios, at a minimum should be considered:	17.0
	a. extreme short-term precipitation events, snowpack build-up or other factors leading to flooding events;	17.5
	b. geologic instability or seismic activity causing slope failures at or near the NICO mine, impacts on the mine workings, or compromising of the mine rock management area;	17.5
	c. failure of existing dams/containment structures;	17.5
	d. freezing effects on water transportation systems;	17.3.4
	e. how mine water will be managed if the water treatment system malfunctions, with a focus on retention capacity timelines for water storage facilities and contingency water treatment plans;	Appendix 3.III
	f. potential impacts to water from accidents in transport of processing chemicals and other dangerous goods; and	17.3, 17.5
	g. potential impacts to water from tailings spills or leaks.	17.3, 17.5
	12) Describe the effect of water recycling on water quality for different water recycling scenarios.	2.0
	13) Describe water quality monitoring and management during operations including:	
	a. contingency plans in case metals leaching or acid rock drainage occurs;	Appendix 3.I, Appendix 3.II
	b. contingency plans for unacceptable effluent quality;	Appendix 3.III
	c. spill contingency plans on-site and along transportation routes;	17.5.5
	d. conceptual plans for surface water and groundwater monitoring; and	7.14, 18.5.2.2, Appendix 18.I
	e. whether and how Fortune will incorporate Wek'eezhii Settlement Area residents in environmental monitoring, and how it will report monitoring results to potentially-affected communities.	18.0

Valued components represent physical, biological, cultural, social, and economic properties of the environment that are considered to be important by society. Surface and ground water quality, hydrology (water quantity), fish and aquatic habitat, wildlife, and people were selected as the VCs for this effects assessment. Water quality and hydrology (water quantity) are fundamental components of the natural ecosystem because of the biological importance to all living organisms including wildlife, fish, and humans. Water contaminants and changes to hydrology can have the potential to adversely affect ecological and 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 the water quality KLOI are presented in Table 7.1-2. In addition, the measurement endpoints, used to evaluate the assessment endpoints, are presented.

Table 7.1-2: Summary of the Assessment and Measurement Endpoints for the Water Quality Key Line of Inquiry

Valued Component	Assessment Endpoints	Measurement Endpoints
Surface and groundwater quality	• suitability of water to support a viable and self-sustaining aquatic ecosystem Persistence of fish habitat and populations • Persistence of wildlife populations • Continued opportunity for traditional and non-traditional use of fish and wildlife	• Physical analytes (e.g., pH, conductivity, turbidity) • Major ions and nutrients • Total and dissolved metals • Physical and chemical properties of sediment
Hydrology		• Flow rate and the spatial and temporal distribution of water • Surface topography, drainage boundaries, and waterbodies (e.g., streams, lakes, and drainages)
Fish and aquatic habitat		• Survival and reproduction
Wildlife		• Survival and reproduction
People		• Access to fish and wildlife • Availability of fish and wildlife • Human health

7.1.3 Study Areas

7.1.3.1 General Setting

The NICO Project is approximately 160 kilometres (km) northwest of the city of Yellowknife in the Northwest Territories (NWT). 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 is drained by the Mackenzie River, which discharges to the Beaufort Sea.

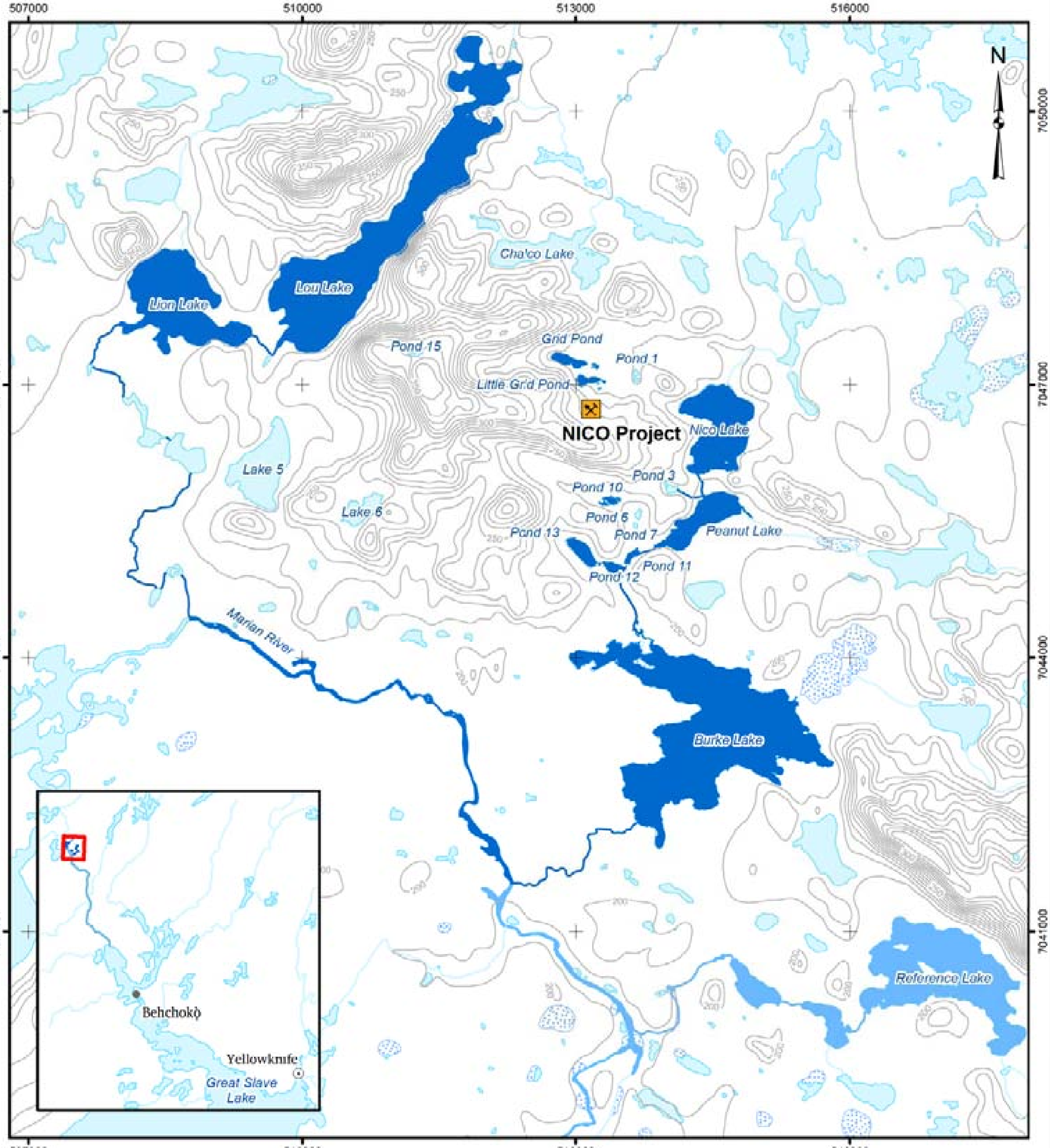
7.1.3.2 Regional Study Area

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 7.1-1). 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 have also been collected in the inflow and outflow of Hislop Lake in 2009 and 2010 because of the proximity to the RSA 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.

7.1.3.3 Local Study Area

The extent of the LSA was 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 7.1-1). The LSA also includes Lou Lake, which is where the exploration camp was located and is proposed as the NICO Project potable water source, and Ponds 8, 9, and 10, which drain the south area of the main ore body into the Burke Lake watershed (Figure 7.1-1).

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.



LEGEND

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

LOCAL AND REGIONAL STUDY AREAS

Golder Associates
Edmonton, Alberta

FILE No. E-WQ-003-GIS				
PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	SM	19 Sep. 2008	FIGURE: 7.1-1	
GIS	CW	13 May 2011		
CHECK	JG	13 May 2011		
REVIEW	JG	13 May 2011		

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7.1.4 Content

To present the required material in an organized and readable format, the KLOI 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 KLOI is outlined in Table 7.1-3. 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 7.1-1.

Table 7.1-3: Key Line of Inquiry: Water Quality Organization

Section	Content
Section 7.1	**Introduction** - Provides an introduction to the water quality KLOI by defining the context, purpose, scope, and study areas, and providing an overview of the KLOI organization
Section 7.2	**Summary** - Provides a non-technical summary of the water quality KLOI
Section 7.3	**Existing Environment** - Provides a summary of the existing conditions for the NICO Project area
Section 7.4	**Water Management Plan Summary -** Provides a summary of the water use and waste discharge plans for the NICO Project based on the Water Management Plan (Appendix 3.III)
Section 7.5	**Pathway Analyses** - Provides a description of the pathway analyses used to identify the activities that have linkages to potential effects of the NICO Project on water quality
Section 7.6	**Effects to Surface Water Quality** - Provides a detailed assessment of the potential effects of the NICO Project to water quality, including modelling results and downstream water quality predictions
Section 7.7	**Related Effects to Fish -** Provides an assessment of the potential effects of the NICO Project to fish and fish habitat as a result of the effects to water quality
Section 7.8	**Related Effects to Wildlife -** Provides an assessment of the potential effects of the NICO Project to wildlife as a result of the effects to water quality
Section 7.9	**Related Effects to People** - Provides an assessment of the potential effects of the NICO Project to people as a result of the effects to water quality
Section 7.10	**Residual Effects Summary -** Provides a description of the potential effects of the NICO Project on water quality that remain after implemention of mitigation measures and reclamation
Section 7.11	**Residual Impact Classification -** Provides a summary of the impact classification for the residual effects identified in the environmental assessment
Section 7.12	**Environmental Significance** - Provides a discussion of the environmental significance of the impacts identified in the environmental assessment
Section 7.13	**Uncertainty** - Provides a discussion of the uncertainty related to the effects and impact assessments completed in the environmental assessment
Section 7.14	**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 NICO Project on water quality

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

- Appendix 7.I: Receiving Water Quality Modelling Methods
- Appendix 7.II: Site Water Quality Predictions
- Appendix 7.III: Groundwater Quality
- Appendix 7.IV: Peanut Lake Conceptual Diffuser Design
- Appendix 7.V: Receiving Water Quality Modelling Results
- Appendix 7.VI: Flooded Open Pit Hydrodynamic Modelling
- Appendix 7.VII: Site Specific Water Quality Objectives
- 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)

7.2 Summary

The NICO Project is approximately 160 km northwest of Yellowknife in the NWT. The NICO Project is located within the Marian River drainage basin, approximately 10 km east of Hislop Lake, and 50 km northeast of Whatì and 70 km south of Gamètì. Other communities include Behchokǫ̀, approximately 85 km southeast of the NICO Project, and Wekweetì, located approximately 140 km northeast of the NICO Project.

This section of the DAR addresses the NICO Project's predicted direct and indirect effects on surface and groundwater quality, and sediment quality, within waterbodies immediately adjacent to and downstream of the NICO Project area. It also includes an assessment of potential changes resulting from NICO Project components and associated activities within the study area, including air and dust emissions, effluent discharge, water withdrawal, and watercourse crossings.

The impact assessment evaluates all NICO Project phases, including construction, operation, closure and reclamation, including the post-closure period. The NICO Project includes the anticipated mine site (i.e., Camp, Open Pit, Co-Disposal Facility [CDF], and Effluent Treatment Facility [ETF]), and the 27 km long NPAR). NICO Project-specific (incremental) and cumulative effects have been evaluated throughout this section, where applicable. The NICO Project intersects both the Lou Lake and Burke Lake watersheds, which 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.

The LSA includes the entire hydrologic pathway from the main ore body downstream to the Marian River, and was defined based on the expected limit of potential direct effects on the aquatic ecosystem from the proposed mine development. Surface waters in the LSA include the Grid Pond, Little Grid Pond, Nico Lake, Peanut Lake, Ponds 8, 9, 10, 11, 12, and 13, Burke Lake, and the Marian River downstream of the Burke Lake confluence, and their interconnecting streams. Under existing conditions, this system is characterized by naturally elevated concentrations of major ions, nutrients (i.e., phosphorus), and metals (i.e., arsenic), particularly in the Grid ponds and Nico Lake due to the highly mineralized upper catchment. The LSA also includes Lou Lake lakes, which is located in an adjacent watershed, to the northwest of the NICO Project area.

The RSA includes waterbodies within the LSA plus the Marian River to the North Arm of Great Slave Lake. In addition, one lake located outside the LSA was included as a reference site (Reference Lake), based on similar water quality and aquatic communities to lakes found in the LSA. Water quality data were also collected in the inflow and outflow of Hislop Lake in 2009 and 2010 because of its proximity to the RSA 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 activities.

Pathways for effects on water and sediment quality in waterbodies adjacent to and downstream of the NICO Project include mine-related activities associated with mining ore, processing ore, depositing and storing waste rock material, and managing water and wastewater on-site. Pathways include the deposition of acidifying substances, dust, and associated metals to nearby surface waters, effects of operational discharges from the ETF to Peanut Lake, and operational and closure discharges of seepage from the CDF to Nico Lake through the Wetland Treatment Systems.

Water that comes into contact with the mine facilities during construction, operations, closure and reclamation, and post-closure, including site drainage and inflows to the mine pit, will be managed. This water will be contained and reused or treated, as required, and released to Peanut Lake. Treated sewage effluent will be discharged to Peanut Lake along with the ETF effluent. Seepage out of the toe of the CDF during the post-closure period will be directed to Nico Lake through Wetland Treatment Systems, which will be constructed progressively during operations. The Wetland Treatment Systems will be constructed and tested during the operations phase to demonstrate that they will achieve the desired results. At closure, pumping water out of the Open Pit will cease. The Open Pit will be refilled with natural drainage and runoff from the top surface of the CDF. It will take approximately 120 years to reach a level for overflow through the haul road ramp to Peanut Lake through constructed wetlands.

Pathway analysis was used to identify and assess the linkages between NICO Project components and activities, and water and sediment quality. Three pathways were identified as likely or highly likely to lead to negative residual effects on water and sediment quality, and ultimately aquatic health:

- air emissions (acidifying emissions, dust, and associated metal deposition) during construction and operations can affect surface water and sediment quality of nearby surface waters;
- discharge of effluent from the mine water treatment plant can affect surface water quality in Peanut Lake and in downstream surface waters; and
- long-term seepage from the CDF can affect surface water quality in downstream surface waters.

These pathways were further analyzed and the significance of the resulting effects on the suitability of water in affected lakes to support a viable and self-sustaining aquatic ecosystem was assessed.

Acidifying air emissions from the NICO Project may result in the deposition of acidifying substances, such as sulphur and nitrogen oxides, to lakes in the LSA and RSA. The potential for lake acidification was evaluated by comparing potential acid input (PAI) to lake-specific critical loads. During peak emission periods during construction and operations, PAI values are anticipated to be remain below critical loads. The annual deposition of nitrogen during construction and operations is anticipated to be less than 5 kilograms per hectare per year, within the range that can be assimilated by the terrestrial ecosystem. Based on these results, lake acidification from NICO Project-related deposition in the RSA and LSA is not expected.

Changes to total suspended solids (TSS) and concentrations of selected trace metals in assessed lakes in the RSA from deposition of fugitive dust and particulates will potentially exceed average baseline concentrations by greater than 100 percent (%). However, the spatial extent of dust and metal deposition is anticipated to be restricted to localized areas within and immediately adjacent to the active mine area, and temporally restricted to the period during and after freshet when winter deposition on snow and ice within the watershed is transported by snow melt to lakes and streams. Areas of maximum deposition are expected immediately to the north and east of the NICO Project mine footprint, reflecting haul road traffic to and from the CDF and prevailing wind direction. Concentrations of TSP above the NWT air quality standard are not expected beyond approximately 2 km from the development area boundary.

Incremental increases in the concentrations of all assessed water quality variables are predicted in Nico, Peanut, and Burke lakes as a result of NICO Project activities. In most cases, concentrations are predicted to peak in Peanut and Nico lakes during operations due to NICO Project discharges and air emissions. Concentrations are generally predicted to decline with time following closure. In a few cases, however, concentrations are predicted to increase further following closure and reach a long-term steady state concentration within several years.

Increases of TSS concentrations from dust and particulate deposition resulting from NICO Project-related emissions are expected to be localized close to the NICO Project (i.e., Nico and Peanut lakes) and temporally limited to a period during and after freshet, during the construction and operations phases. Following closure, these emission sources will come to an end. Total suspended solids concentrations in the Marian River are predicted to remain similar to baseline values over the period of the assessment.

Concentrations of Total Dissolved Solids (TDS) and major ions are expected to change in the chain of lakes within the Burke Lake watershed during construction and operations, and post-closure, as a result of NICO Project activities. A decreasing gradient of concentrations is expected from Nico Lake to Burke Lake. The changes will reflect the loss of the Grid Pond system, which will result in TDS and other major ion concentrations dropping below baseline conditions, particularly in Nico Lake. As discharge rates from the ETF increase during operations, concentrations of TDS and major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) in Peanut Lake and Burke Lake are predicted to increase. In the later stages of operations and following closure, major ion concentrations are predicted to increase in Nico Lake due to higher loadings from seepage from the CDF. Concentrations of TDS and major ions in the Marian River are predicted to remain similar to baseline conditions during all phases of the NICO Project. The changes in TDS and major ion concentrations in Nico, Peanut, and Burke lakes are not expected to impact aquatic life. In particular, chloride and sulphate concentrations are anticipated to remain well below available site-specific water quality objectives (SSWQO) values through all NICO Project phases.

Concentrations of ammonia and nitrate in Nico, Peanut, and Burke lakes are predicted to change but are anticipated to remain below SSWQO values during all phases of the NICO Project. These nutrients will increase during operations, primarily as a result of seepage through the Wetland Treatment Systems to Nico Lake, and treated effluent discharges from the ETF (including sewage treatment effluent) to Peanut Lake. Concentrations are predicted to decrease following closure, as seepage reporting to Nico Lake via the Wetland Treatment Systems is expected to have little nitrate and ammonia concentrations remaining from blast residues, and the

ETF discharges will cease. NICO Project-related total phosphorus loading to Nico, Peanut, and Burke lakes will be primarily sourced from dust deposition, ETF discharges and seepages from the Wetland Treatment Systems. The incremental change to these lakes accounts for the reduced background mass inputs from the Grid Pond System (where phosphorus was naturally elevated) to the watershed. Concentrations of phosphorus are predicted to decrease during closure, as dust deposition due to NICO Project activities ceases, and loading from seepage through the Wetland Treatment Systems is expected to be lower than loading from the Grid Ponds under baseline conditions. Total phosphorus concentrations in the Marian River during operations and closure are predicted to be within the natural variation of baseline concentrations.

Concentrations of metals in Nico, Peanut, and Burke lakes, and the Marian River, are expected to change as a result of fugitive dust and air emissions from NICO Project facilities, seepage inputs in the treatment wetland system to Nico Lake, and treated effluent discharges to Peanut Lake. Three general trends in metals concentrations due to NICO Project inputs were identified in the water quality modelling results for Nico, Peanut, and Burke lakes:

- an increase during operations and decline post-closure. Metals with this trend are primarily associated with dust deposition and particulates from air emissions during construction and operations, and ETF discharges to Peanut Lake during operations, and include:
  - aluminum, arsenic, cadmium, cobalt, iron, and selenium specifically in Nico, Peanut, and Burke lakes during the construction and operations phases;
  - beryllium, boron, copper, and silver in Peanut and Burke lakes; and
  - barium, chromium, and vanadium in Burke Lake.
- an increase during operations and remain elevated post-closure. Metals with this trend are primarily associated with seepage from the CDF directed through the Wetland Treatment Systems to Nico Lake, and include:
  - barium, chromium, and vanadium are predicted to increase in Nico and Peanut lakes;
  - copper in Nico Lake; and
  - manganese and nickel in Burke Lake.
- an increase during operations and a further increase following closure and reclamation. Metals with this trend are primarily associated with seepage from the CDF through the Wetland Treatment Systems to Nico Lake, which is anticipated to be greater than loading to Peanut and Burke during operations due to a higher rate of seepage reporting to Nico Lake following closure, and include:
  - antimony, lead, mercury, molybdenum, thallium, uranium, and zinc in Nico, Peanut, and Burke lakes following closure;
  - manganese and nickel in Nico and Peanut lakes; and
  - beryllium, boron, and silver in Nico Lake.

During the construction, operations, and closure phases of the NICO Project, a number of metals will increase to concentrations that will occasionally exceed SSWQOs or Canadian Council for Ministers of the Environment (CCME) guidelines for the protection of aquatic life. These exceedances are predicted to occur primarily in Nico and Peanut lakes, as they are subject to a higher exposure to deposition of air emissions than other lakes in the LSA or RSA, given their proximity to the NICO Project area, as well as receiving direct mine-related discharge through the ETF via a diffuser or Wetland Treatment Systems.

Metals anticipated to be higher than SSWQOs include:

- total aluminum and iron during operations in Nico, Peanut, and Burke lakes primarily as a result of the deposition of fugitive dust; and
- total arsenic concentrations on very limited occasions in Nico Lake due to dust deposition during operations.

Metals that do not have established SSWQOs values, but are anticipated to be higher than CCME guidelines include:

- total chromium during operations and post-closure in Nico Lake and Peanut Lake, and only during operations in Burke Lake;
- total mercury in Nico Lake during the closure and reclamation phase due to the discharge of seepage through the Wetland Treatment Systems; and
- total silver and thallium in Nico Lake during operations and post-closure, and silver concentrations in Peanut Lake near the end of operations.

Metal concentrations in the Marian River are predicted to increase relative to baseline conditions throughout construction, operation and following closure and reclamation of the NICO Project. However, all metals are predicted to remain below applicable SSWQOs values, and metals predicted to exceed CCME guidelines are largely attributable to natural background variability in the Marian River during the open water season. In many cases, the incremental change is anticipated to be indistinguishable from natural background variability.

Sediment quality is expected to change in the chain of lakes within the Burke Lake watershed during construction and operation of the NICO Project. The primary cause of these changes in Nico, Peanut, and Burke lakes is the cumulative dust deposition during construction and operations. Predicted changes in sediment quality in Nico, Peanut, and Burke lakes due to the deposition of fugitive dust and other air emissions are not expected to result in the exceedance of available sediment quality guidelines, where no exceedances occurred under baseline conditions.

Cumulative impacts from the NICO Project, other developments, and natural factors, are beyond regional, and effects to water and sediment quality beyond regional waterbodies are not predicted. The potential for cumulative effects from other developments, such as the Rayrock and Colomac mines, to water quality has been identified as a concern by the Tłı̨chǫ Government and Tłı̨chǫ citizens. The former Rayrock mine site is located at least 15 km downstream of Burke Lake, so the cumulative effects to water quality and subsequently aquatic health from the NICO Project 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 to water quality with the NICO Project.

There is a moderate degree of uncertainty associated with the analysis of effects to water and sediment quality, with conservatism primarily related to the following:

- prediction of changes to water and sediment quality from air emissions and dust deposition;
- mine site water quality predictions for treated effluent discharges from the NICO Project; and
- the primary mechanisms for elevated TSS and metal concentrations in Nico and Peanut lakes.

Additionally, the assessment of effects of treated effluent discharges to water quality was based on water quality predictions at the 95th percentile. These approaches were used to increase confidence that the assessment would not underestimate impacts. In addition, the implementation of environmental design features at the NICO Project, such as dust emission controls, maintenance of treatment efficiency for mine effluent, and the development of treatment wetland systems for CDF seepage and Open Pit overflow, should mitigate the potential for most effects assessed in this KLOI.

Under existing conditions, Nico and Peanut lakes are subject to direct and indirect inflows with elevated metals concentrations characteristic of the highly mineralized geology of the upper watershed. The NICO Project will eliminate this inflow source and replace it with active operational and post-closure point source discharges to Peanut and Nico lakes, respectively. These changes will alter water quality in the Burke Lake watershed through operations and closure; however, changes are not anticipated to extend beyond Burke Lake. Overall, the weight of evidence from the primary pathway analysis predicts that the incremental impacts from the NICO Project will result in changes to water and sediment quality in Nico, Peanut, and Burke lakes, but that these changes will not have significant adverse impacts on the suitability of water in these lakes to support viable and self-sustaining aquatic ecosystems.

7.3 Existing Environment

The following section provides an overview of the baseline surface water quality and sediment quality for key lakes and streams that may receive direct impact from the proposed mine development downstream to the Marian River. The baseline setting is defined using several seasons of investigations completed by Golder and other consulting teams in the NICO Project LSA and RSA starting in 1998. For additional information regarding surface water and sediment quality, the reader is referred to Annex C (Aquatic Baseline).

7.3.1 Water Quality

Background water quality data have been collected from aquatic ecosystems within, and adjacent to, the NICO Project LSA and RSA since 1998. Data collected between 1998 and 2004 have been characterized as historic data, with data collected between 2005 and 2010 representing baseline data. For this summary, data collected in 2003 and 2004 were combined with data from 2005 to 2010 because sampling methods and locations were more clearly defined and typically consistent for these years. Data collected prior to 2003 represented a range of sampling locations using a variety of sampling methods.

Baseline sampling stations were established in 3 watersheds of the Marian River. Two of the watersheds (i.e., Lou Lake and Burke Lake) were located within the LSA, and the Reference Lake watershed was located outside of the LSA, in the RSA. 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. Conditions in the smaller unnamed streams were representative of the outflow from the lakes monitored in the study area. Sampling also was completed in the Marian River and Hislop Lake.

A forest fire burned from mid-July to early-August 2008 between Nico and Peanut lakes, and along the shorelines of Burke and Reference lakes. Comparison of water quality data collected before and after the 2008 forest fire provides an estimate of the potential changes in baseline water quality resulting from fire effects within the 2 watersheds.

7.3.1.1 Methods

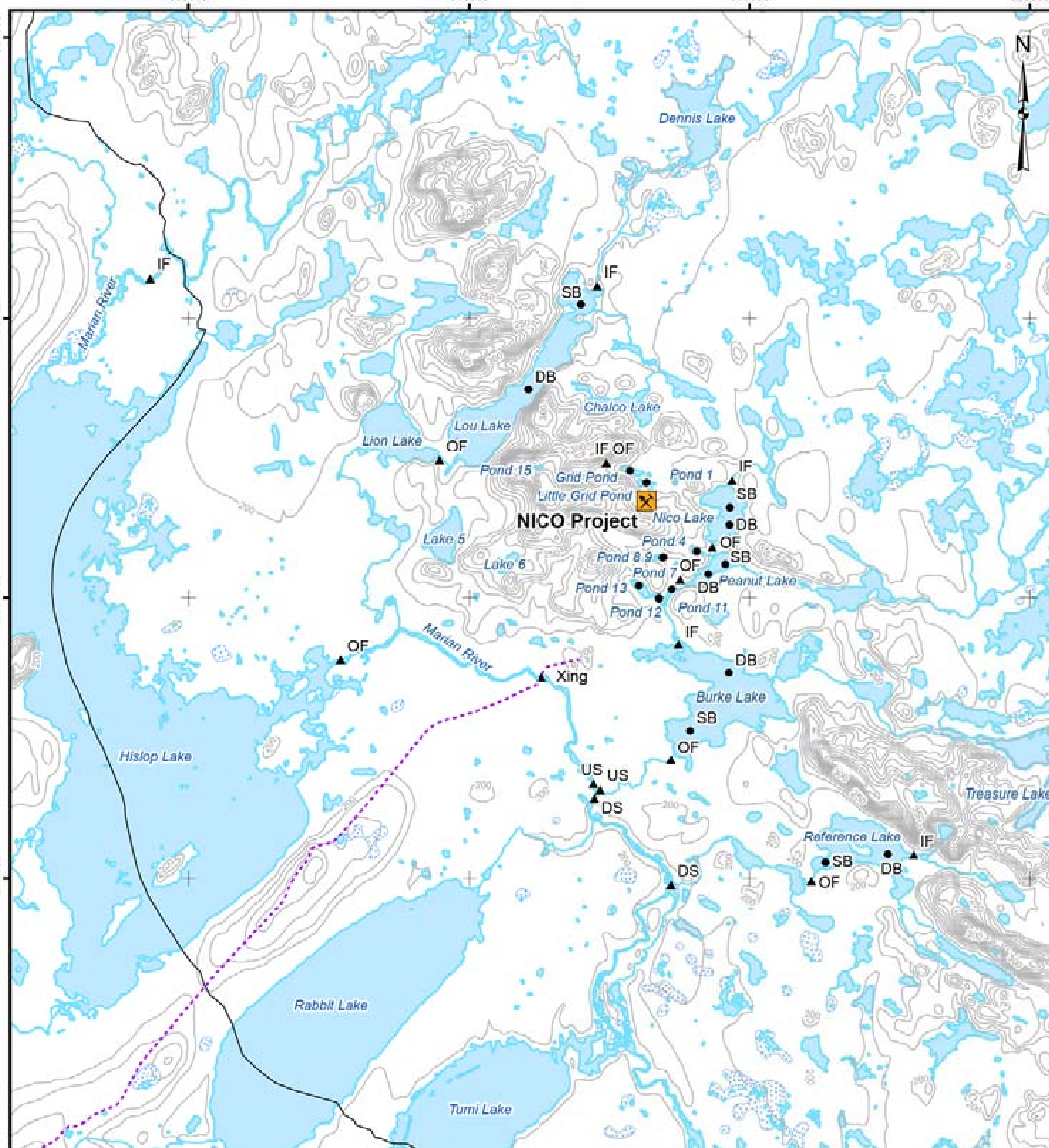
7.3.1.1.1 Sampling and Analysis

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; and at a single sampling point in ponds and watercourses (Table 7.3-1; Figure 7.3-1). Historic data from 2003 and 2004 were also used where data were collected from locations that were consistent with 2005 to 2010 sampling locations (e.g., Grid Pond, Little Grid Pond). Baseline water quality sampling was primarily completed during open water conditions, with limited winter (under-ice) sampling completed in March/April 2008, 2009, and 2010.

In-situ field water quality measurements (i.e., pH, temperature, dissolved oxygen [DO], and conductivity) were obtained through the water column at each sampling location at the time of sampling. Typically, DO and water temperature data were measured through the water column at 1 metre (m) intervals, starting 1 m above the lake bottom. Where water depth permitted (i.e., >3 m), Secchi depth, a measure of water transparency, was also determined. Temperature data were also collected in the Marian River and at the inflow and outflow of Burke, Lou, Nico, and Peanut lakes during the 2005 spring sampling event.

During open water conditions, water samples from the lake sampling locations were collected using a Kemmerer sampler at 2 depths: 1 m above the lake bottom and 1 m below the water surface. During under-ice conditions, surface water samples were collected approximately 1 m below the ice. Water samples collected from the stream sampling locations were grab samples, collected approximately 0.1 m below the water surface in the middle of the watercourse.

Samples were collected for conventional parameters (e.g., totals suspended solids, laboratory conductivity, laboratory pH), major ions, total and dissolved nutrients, and total and dissolved metals. In 2008, additional samples were collected for arsenic speciation during open water and ice covered conditions. Sample bottles for each parameter sampled were provided by the analytical service laboratories in a ‘ready-for-use’ condition. During open water conditions, sample bottles for unfiltered samples were filled directly in the field and samples were obtained for filtered samples (i.e., for dissolved parameters), which were filtered at the camp site. Prior to filling the bottle directly or with filtered sample, sample bottles were triple-rinsed. During ice covered conditions, two 4-litre (L) jugs were filled in the field and taken back to the camp for sample processing. Filtering at the camp during open water and ice covered conditions was completed using a standard filtering assembly and a 0.45 micron (µm) filter. Quality control samples were also collected during the baseline sampling programs, and typically included field blanks and replicate samples. Water chemistry analyses were undertaken by laboratories accredited by the Canadian Association of Laboratory Accreditation, using standard operating procedures.



LEGEND

NICO PROJECT	LAKE/POND WATER QUALITY SAMPLING LOCATION
CONTOUR (10 METRE INTERVAL)	STREAM WATER QUALITY SAMPLING LOCATION
EXISTING WINTER ROAD	DB DEEP BASIN
PROPOSED NICO PROJECT ACCESS ROAD	SB SHALLOW BASIN
WATERCOURSE	OF OUTFLOW
WATERBODY	IF INFLOW
WETLAND	US UPSTREAM
	DS DOWNSTREAM
	Xing CROSSING

2.5 0 2.5

SCALE 1:100,000 KILOMETRES

REFERENCE

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

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE
BASELINE WATER QUALITY SAMPLING LOCATIONS FOR THE NICO PROJECT (1999 TO 2010)

Golder Associates
Edmonton, Alberta

FILE No. E-WQ-004-GIS

PROJECT No. 09-1373-1004		SCALE AS SHOWN	REV. 0
DESIGN	JG	15 Apr. 2011	
GIS	CW	13 May 2011	
CHECK	JG	13 May 2011	
REVIEW	JG	13 May 2011	

FIGURE: 7.3-1

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Table 7.3-1: Water Quality Sampling Station Coordinates for the NICO Project, 2005 to 2010

Lake/Pond		Stream/Watercourse	
Sampling Station	**UTM Coordinates**	**Sampling Station**	**UTM Coordinates**
Grid Pond	11V 512880E 7047268N	Grid Stream/Inflow	11V 512454E 7047414N
Little Grid Pond	11V 513169E 7047055N	Little Grid-Grid Stream (OF)	11V 512454E 7047414N
Nico Lake (DB)	11V 514648E 7046310N	Nico Inflow	11V 514693E 7047104N
Nico Lake (SB)	11V 514657E 7046617N	Nico – Peanut Creek (OF)	11V 514339E 7045906N
Peanut Lake (DB)	11V 514270E 7045424N	Peanut Lake (OF)	11V 513769E 7045332N
Peanut Lake (SB)	11V 514572E 7045596N	Burke Inflow	11V 513737E 7044178N
Pond 4	11V 514064E 7045833N	Burke Outflow	11V 513600E 7042119N
Pond 8	11V 513465E 7045732N	Reference Inflow	11V 517929E 7040420N
Pond 9	11V 513458E 7045716N	Reference Outflow	11V 516105E 7039953N
Pond 11	11V 513612E 7045145N	Lou Inflow	11V 512294E 7050578N
Pond 12	11V 513393E 7044996N	Lou Outflow	11V 509469E 7047463N
Pond 13	11V 513039E 7045217N	Marian River Crossing	11V 511288E 7043592N
Burke Lake (DB)	11V 514637E 7043665N	Marian U/S Reference	11V 512225E 7041682N
Burke Lake (SB)	11V 513943E 7042633N	Marian D/S Reference	11V 513599E 7039884N
Reference Lake (DB)	11V 517471E 7040430N	Marian-U/S Burke	11V 512346E 7041579N
Reference Lake (SB)	11V 516360E 7040283N	Marian-D/S Burke	11V 512241E 7041439N
Lou Lake (DB)	11V 511054E 7048725N	Hislop Lake Inflow	11V 504320E 7050712N
Lou Lake (SB)	11V 512001E 7050242N	Hislop Lake Outflow	11V 507707E 7043907N

UTM = Universal Transverse Mercator; SB = Shallow Basin; DB = Deep Basin; OF = Outflow; U/S = Upstream; D/S = Downstream.

7.3.1.1.2 Data Analysis

All data from the baseline study (Annex C) were classified as in-situ (spot or profile physico-chemical measurements), grab samples, or vertical profile sampling. Summary statistics for water and sediment quality, including the median, minimum, and maximum values, as well as the range of sample sizes, were prepared for each parameter analyzed and are presented in Annex C in tabular format. Water quality summaries are listed for both under-ice and open water conditions.

Within this section, summary water quality data are presented in 2 main formats.

- Tables are provided for each sampled lake, which list the percentage of samples that had concentrations above CCME Canadian Water Quality Guidelines (CWQGs) for the protection of freshwater aquatic life (CCME 1999; with subsequent updates) (Table 7.3-2). Percentages shown in these tables represent the percentage of samples above guidelines for each lake in the LSA during open water and ice-covered conditions. Percentages include surface and bottom samples collected at the same site on the same day, but do not include replicate samples.
- Summary descriptions and selected figures of field physico-chemical data (e.g., DO and temperature) and conventional water quality parameters (e.g., totals suspended solids, laboratory conductivity, laboratory pH), major ions, total and dissolved nutrients, and total and dissolved metals.

Median, minimum, and maximum parameter data during open water or under-ice conditions were used to generate figures and were screened against CCME CWQGs for the protection of freshwater aquatic life (CCME 1999) (Table 7.3-2).

Table 7.3-2: Guidelines Used for Comparison to Baseline Data

Parameter	Units	CCME Protection of Freshwater Aquatic Life[a]
pH	-	6.5 – 9.0[b]
Dissolved Oxygen	mg/L	6.5 – 9.5[c]
Nitrate	mg N/L	2.93
Nitrite	mg N/L	0.06
Ammonia	mg/L	0.019[d]
Total Aluminum	µg/L	5 -100[e]
Total Arsenic	µg/L	5
Total Boron	µg/L	1500
Total Cadmium	µg/L	0.017[f]
Total Chromium	µg/L	1
Total Copper	µg/L	2 – 4[g]
Total Iron	µg/L	300
Total Lead	µg/L	1 – 7[h]
Total Mercury	µg/L	0.026
Total Molybdenum	µg/L	73
Total Nickel	µg/L	25 – 150[i]
Total Selenium	µg/L	1
Total Silver	µg/L	0.1
Total Thallium	µg/L	0.8
Total Zinc	µg/L	30

[a] Canadian Council of the Ministers of the Environment Protection of Freshwater Aquatic Life Guidelines.

[b] Guideline represents a range.

[c] 6.5 = guideline for early life stages in cold water, 9.5 = guideline for is for other life stages in cold water.

[d] Guideline is for un-ionized ammonia.

[e] 5.0 µg/L for pH<6.5, 100 µg/L for pH≥6.5.

[f] Cadmium guideline = $10^{(0.86(\log(\text{hardness}))-3.2)}$

[g] 2 µg/L at hardness of 0 to 120 mg/L, 3 µg/L at hardness of 120 to 180 mg/L, 4 µg/L at hardness of >180 mg/L.

[h] 1 µg/L at hardness of 0 to 60 mg/L, 2 µg/L at hardness of 60 to 120 mg/L, 4 µg/L at hardness of 120 to 180 mg/L, 7 µg/L at hardness of >180 mg/L.

[i] 25 µg/L at hardness of 0 to 60 mg/L, 65 µg/L at hardness of 60 to 120 mg/L, 110 µg/L at hardness of 120 to 180 mg/L, 150 µg/L at hardness of >180 mg/L.

CCME = Canadian Council of the Ministers of the Environment; - = no guideline; mg/L = milligrams per litre; µg/L = micrograms per litre.

When calculating the median, minimum, and maximum values, data were classified into the following 3 categories, based on the proportion of values below their respective method detection limits (MDLs), and analyzed separately:

- data series where values below the MDL consisted of approximately one-third (or less) of the data series;

- data series where values below the MDL consisted of approximately one-third to two-thirds of the data series; and
- data series where values below the MDL consisted of approximately two-thirds (or more) of the data series.

When the data series occurred in the first category, all values below the MDL were assigned a value of one-half of the most sensitive MDL and descriptive statistics (e.g., minimum, median, and maximum) were calculated. By using a value of half of the most sensitive MDL in this case, a representative statistical analysis of the natural conditions could be accomplished.

For data in the second category, descriptive statistics were calculated on values at or above the MDL only. If a value of half the most sensitive MDL was used in this case, the data series may have become skewed.

For data series in the final category, only minimum and maximum values were provided. By using a value of half the most sensitive MDL in this case, descriptive statistics may have provided a median below the most sensitive MDL.

7.3.1.1.3 Quality Control

A combination of field blanks and/or replicate samples were collected during each year of monitoring between 2005 and 2010 (detailed information are provided in Annex C). In summary, deviations from quality control criteria were rare and minor, and were considered in the interpretation of results. The analytical laboratories' internal quality control procedures included evaluations of precision and accuracy, and laboratory blanks, and did not indicate any issues with analyses performed during the 2005 to 2010 baseline program. Results of quality control sampling and analysis for historical sample collection programs (i.e., 2003 and 2004) were presented in a summary report (Golder 2005).

Detection limit issues were identified in some of the baseline data collected during the 2005 and 2007 sampling programs. Some parameters had detection limits above the CWQGs for the Protection of Aquatic Life, including cadmium, chromium, lead, mercury, silver, and thallium. These analytical deficiencies were addressed in subsequent (i.e., 2008 through 2010) baseline programs.

7.3.1.2 Results

7.3.1.2.1 Baseline Water Quality Characteristics and Comparison to Guidelines

The proportion of exceedances of water quality guidelines for each lake within the LSA during open water and ice-covered conditions is provided in Table 7.3-3. The data provide a general understanding of the parameters that have naturally elevated concentrations. Most water quality parameters measured in the baseline program typically meet guidelines, with the exception of field measured pH and DO, and some metals. Metals commonly above guidelines included total aluminum, arsenic, cadmium, chromium, copper, and iron. Cadmium and copper results were sometimes confounded in earlier years due to high method detection limits, which were above guideline values for these parameters; however, parameter results below the detection limit were not considered when calculating the percentage of guideline exceedances for any lake (e.g., concentrations associated with a non-detectable result may be flagged as an exceedance in Table 7.3-3, but would not be included in the calculation of the guideline exceedance ratio).

A summary of Marian River water quality data, downstream of Hislop Lake, is included with the summary of the lakes in the LSA. The water quality parameters that exceeded guidelines for the protection of freshwater aquatic life in the Marian River, including the inflow to and outflow from Hislop Lake, were pH and total aluminum, cadmium, copper, iron, and zinc.

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area

Parameter Name	Unit	Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	3	**5.2**[c]	**6.33**[c]	6.9	7	**6.4**[c]	7.3	7.8	6.5 - 9[d]	67%	14%
Temperature	°C	4	0	0.76	2.4	7	10.1	15.1	18.9	-	-	-
Specific Conductance	µS/cm	3	62.6	349	372	7	122	197	316	-	-	-
Dissolved Oxygen	mg/L	4	**1.19**[c]	1.51[c]	**5.02**[c]	7	8.3	9.66	10.21	6.5 or 9.5[e]	100%/100%	0%/43%
Turbidity	NTU	3	4.6	29.9	46.7	5	1.12	1.89	49.2	-	-	-
Secchi depth	m	1	-	1.8	-	3	0.9	1.5	1.6	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	3	349	410	424	10	125	189	217	-	-	-
Dissolved Organic Carbon	mg/L	2	8.3	-	9.7	5	8.6	9.7	11.6	-	-	-
Hardness	mg/L	3	165	190	192	10	53.2	90.5	100	-	-	-
pH	pH units	3	7.6	7.7	7.8	10	7.6	7.9	8.1	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	3	111	130	140	8	38	57.8	60	-	-	-
Total Dissolved Solids	mg/L	1	-	239	-	4	114	125	150	-	-	-
Total Organic Carbon	mg/L	2	8.6	-	10	7	8	10	12.4	-	-	-
Total Suspended Solids	mg/L	3	1.5	2	4	7	1.5	3	4	-	-	-
Turbidity	NTU	2	1.9	-	2.3	6	0.5	0.98	4.5	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	3	136	160	171	8	46	70.2	73	-	-	-
Calcium	mg/L	3	42.7	51	51.5	10	13.7	22.6	26.1	-	-	-
Carbonate, as $CaCO_3$	mg/L	3	<5	-	<1	8	<5	-	<0.5	-	-	-
Chloride	mg/L	3	0.25	1	1	9	0.3	1	3	230	0%	0%
Magnesium	mg/L	3	14.2	15.3	16	10	4.6	8.0	8.7	-	-	-
Potassium	mg/L	3	2.4	2.6	3	10	1.2	1.7	2	-	-	-
Sodium	mg/L	3	5.4	6	8.4	10	2.6	4	4.4	-	-	-
Sulphate	mg/L	3	66.4	72.7	78	8	20	34.8	37.2	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nutrients												
Nitrate	mg-N/L	3	<0.2	-	<0.05	10	0.001	0.0115	0.3	2.93	0%	0%
Nitrite	mg-N/L	3	<0.06	-	<0.05	10	<0.05	-	<0.002	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	3	<0.2	-	<0.071	10	0.001	0.0115	0.3	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	3	0.41	0.417	0.54	10	0.0025	0.0283	0.065	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	3	0.84	1.2	1.23	10	0.3	0.445	0.705	-	-	-
Nitrogen (N), Total	mg/L	1	-	<1	-	3	0.43	0.48	0.57	-	-	-
Phosphorus, total	mg/L	3	0.0188	0.021	0.06	9	0.0271	0.068	0.1	50	0%	0%
Phosphorus, dissolved	mg/L	2	0.0147	-	0.05	4	0.0109	0.0135	0.05	-	-	-
Total Metals												
Aluminum	µg/L	3	26	37	40	11	44.3	69	**200[c]**	5-100[g]	0%	18%
Antimony	µg/L	3	0.68	0.7	0.8	11	0.8	1.1	2.4	-	-	-
Arsenic	µg/L	3	**186[c]**	**190[c]**	**270[c]**	11	**160[c]**	**217[c]**	**257[c]**	5	100%	100%
Barium	µg/L	3	13.4	17.3	20	11	5	7.2	16.2	-	-	-
Beryllium	µg/L	3	<1	-	<1	11	<2	-	0.05	-	-	-
Bismuth	µg/L	1	-	<0.1	-	9	<1000	-	0.1	-	-	-
Boron	µg/L	3	<50	-	<20	11	10	14.5	25	1500	0%	0%
Cadmium	µg/L	3	0.01	0.08	**0.1[c]**	11	<1	-	**0.074[c]**	0.017[h]	33%	9%
Calcium	µg/L	3	46100	50000	54400	11	14100	23700	27900	-	-	-
Cesium	µg/L	1	-	<50	-	8	<50	-	0.04	-	-	-
Chromium	µg/L	3	<1	-	<0.8	11	0.1	0.655	**2.6[c]**	1	0%	18%
Cobalt	µg/L	3	10.4	11.7	20	11	4.19	5.5	7.3	-	-	-
Copper	µg/L	3	**6[c]**	**8[c]**	**8.6[c]**	11	**8.35[c]**	**11[c]**	**19[c]**	2-4[i]	100%	100%
Iron	µg/L	3	**694[c]**	**1120[c]**	**1300[c]**	11	43	71	113	300	100%	0%
Lead	µg/L	3	0.1	0.11	0.5	11	0.025	0.165	**2.5[c]**	1-7[j]	0%	0%
Lithium	µg/L	3	<20	-	<6	11	1.8	2.55	5	-	-	-
Magnesium	µg/L	3	15000	15300	16500	11	4800	7500	10100	-	-	-
Manganese	µg/L	3	50	73	84	11	2	2.62	6.82	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Mercury	µg/L	3	<0.1	-	<0.02	11	<0.2	-	0.02	0.026	0%	0%
Molybdenum	µg/L	3	2.5	2.8	3.8	11	2.1	2.7	3.9	73	0%	0%
Nickel	µg/L	3	1	1.7	2.5	11	0.25	0.8	6.6	25-150[k]	0%	0%
Potassium	µg/L	3	2530	2900	3000	11	1270	1700	2220	-	-	-
Rubidium	µg/L	1	-	<50	-	8	2.4	2.5	25	-	-	-
Selenium	µg/L	3	0.2	0.5	0.5	11	<0.5	-	0.15	1	0%	0%
Silicon	µg/L	1	-	4700	-	3	1270	1730	2190	-	-	-
Silver	µg/L	3	<0.4	-	<0.1	11	<5	-	<0.005	0.1	0%	0%
Sodium	µg/L	3	5900	7000	7500	11	1900	4000	5000	-	-	-
Strontium	µg/L	2	117	-	120	9	38.6	58.7	65.4	-	-	-
Sulphur	µg/L	1	-	25000	-	1	-	14000	-	-	-	-
Thallium	µg/L	3	<0.2	-	<0.1	11	<50	-	0.004	0.8	0%	0%
Tin	µg/L	3	0.2	5	25	10	<50	-	0.07	-	-	-
Titanium	µg/L	3	0.5	3	3	11	0.25	1	32	-	-	-
Uranium	µg/L	3	4.9	6.9	7.8	11	1.4	2.9	25	-	-	-
Vanadium	µg/L	3	0.1	1	1	11	0.1	0.25	2.7	-	-	-
Zinc	µg/L	3	4.7	6	15	11	2	6	14	30	0%	0%
Zirconium	µg/L	0	-	-	-	2	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	3	18.3	23	30	9	27.9	49.7	62.5	-	-	-
Antimony	µg/L	3	0.1	0.68	0.8	9	0.79	1.1	1.5	-	-	-
Arsenic	µg/L	3	146	159	220	9	150	208	254	-	-	-
Barium	µg/L	3	10	13.8	18.3	9	4.9	7	10	-	-	-
Beryllium	µg/L	3	<1	-	<0.5	9	<1	-	0.01	-	-	-
Bismuth	µg/L	1	-	<0.05	-	7	<1000	-	0.05	-	-	-
Boron	µg/L	3	10	18	25	9	6	10.5	25	-	-	-
Cadmium	µg/L	3	0.03	0.04	0.05	9	0.005	0.017	0.5	-	-	-
Cesium	µg/L	1	-	<0.1	-	6	<50	-	0.03	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Chromium	µg/L	3	<1	-	<0.4	9	0.1	1.1	2.5	-	-	-
Cobalt	µg/L	3	9	9.5	11	9	3.24	4	6.8	-	-	-
Copper	µg/L	3	3.6	3.7	4.5	9	6.2	9.8	15.7	-	-	-
Iron	µg/L	3	441	873	1300	9	15	41	64	-	-	-
Lead	µg/L	3	0.05	0.2	0.2	9	0.04	0.05	2.5	-	-	-
Lithium	µg/L	3	3.4	3.4	10	9	1.5	2	5	-	-	-
Manganese	µg/L	3	48	76	78	9	0.5	1.8	3	-	-	-
Mercury	µg/L	3	<0.1	-	<0.02	8	<0.2	-	<0.01	-	-	-
Molybdenum	µg/L	3	2.4	2.5	2.7	9	1.8	2.5	2.82	-	-	-
Nickel	µg/L	3	1	1.7	2.4	9	0.2	0.39	1	-	-	-
Rubidium	µg/L	1	-	<50	-	6	2.6	2.6	25	-	-	-
Selenium	µg/L	3	<1	-	<0.4	9	<0.5	-	0.8	-	-	-
Silicon	µg/L	1	-	5000	-	3	1360	1680	2460	-	-	-
Silver	µg/L	3	<0.2	-	<0.1	9	<5	-	<0.005	-	-	-
Strontium	µg/L	2	120	-	123	7	35.9	52.8	67	-	-	-
Sulphur	µg/L	1	-	25000	-	1	-	15000	-	-	-	-
Thallium	µg/L	3	<0.2	-	<0.05	9	<50	-	0.004	-	-	-
Tin	µg/L	3	0.1	7	25	9	<50	-	0.15	-	-	-
Titanium	µg/L	3	0.5	1	1	9	<1	-	0.6	-	-	-
Uranium	µg/L	3	5.2	6.3	6.5	9	1.4	2.9	25	-	-	-
Vanadium	µg/L	3	0.05	2	2	9	0.2	0.26	0.5	-	-	-
Zinc	µg/L	3	4.5	8	12	9	1.4	5	13.5	-	-	-
Zirconium	µg/L	0	-	-	-	3	<5	-	<0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Little Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	3	**5.03**[c]	**6.17**[c]	6.8	5	**6.28**[c]	6.9	7.3	6.5 - 9[d]	67%	20%
Temperature	°C	4	0.72	1.1	2.1	6	6.9	14.8	18.2	-	-	-
Specific Conductance	µS/cm	3	72.7	335	368	6	115	182	784	-	-	-
Dissolved Oxygen	mg/L	4	**0.33**[c]	**0.83**[c]	**3.06**[c]	6	6.8	8.31	9.36	6.5 or 9.5[e]	100%/100%	0%/100%
Turbidity	NTU	3	36.4	42	69.2	4	1.7	3.2	7.3	-	-	-
Secchi depth	m	0	-	-	-	3	0.55	1.3	1.4	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	3	359	369	400	10	123	176	210	-	-	-
Dissolved Organic Carbon	mg/L	2	10.6	-	11.1	5	9	10.2	11.6	-	-	-
Hardness	mg/L	3	160	170	200	10	55	81.7	102	-	-	-
pH	pH units	3	7.56	7.6	7.8	10	7.5	7.75	7.96	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	3	122	140	140	8	37	57.5	62.4	-	-	-
Total Dissolved Solids	mg/L	1	-	235	-	4	80	107	130	-	-	-
Total Organic Carbon	mg/L	2	10.5	-	13	7	9	10.7	12.7	-	-	-
Total Suspended Solids	mg/L	3	4	4	7	8	1.5	4	14	-	-	-
Turbidity	NTU	2	1.3	-	2.2	6	0.55	1.35	12	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	3	149	170	171	8	45	70.5	76.1	-	-	-
Calcium	mg/L	3	41.8	43.5	51	10	13.8	20.7	25.8	-	-	-
Carbonate, as $CaCO_3$	mg/L	3	<5	-	<1	8	<5	-	<0.5	-	-	-
Chloride	mg/L	3	0.5	0.77	2	10	0.3	1.5	6.2	230	0%	0%
Magnesium	mg/L	3	13.5	15	17	10	4.9	7.5	9.1	-	-	-
Potassium	mg/L	3	2.4	3.4	3.4	10	1.1	1.5	1.9	-	-	-
Sodium	mg/L	3	5.9	6	8.8	10	3	3.8	4.7	-	-	-
Sulphate	mg/L	3	51.8	52.8	68	8	19.2	25.3	31	-	-	-
Nutrients												
Nitrate	mg-N/L	3	0.191	0.6	0.8	10	0.003	0.127	0.2	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Little Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	3	<0.06	-	<0.05	10	<0.05	-	0.003	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	3	0.191	0.6	0.8	10	0.003	0.13	0.2	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	3	0.58	0.68	0.697	10	0.0141	0.0295	0.204	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	3	1.74	1.9	2.7	10	0.4	0.55	0.812	-	-	-
Nitrogen (N), Total	mg/L	1	-	2	-	3	0.6	0.7	0.8	-	-	-
Phosphorus, total	mg/L	3	0.0193	0.026	0.07	9	0.0311	0.076	0.1	50	0%	0%
Phosphorus, dissolved	mg/L	2	0.014	-	0.05	4	0.0118	0.0131	0.05	-	-	-
Total Metals												
Aluminum	µg/L	3	23	26.9	40	11	30	42.2	**170**[c]	5-100[g]	0%	18%
Antimony	µg/L	3	0.52	1	1	11	0.53	0.78	3.2	-	-	-
Arsenic	µg/L	3	**120**[c]	**168**[c]	**220**[c]	11	**129**[c]	**191**[c]	**207**[c]	5	100%	100%
Barium	µg/L	3	14.8	16.4	20	11	5.4	8.22	11.4	-	-	-
Beryllium	µg/L	3	<1	-	<1	11	<2	-	0.01	-	-	-
Bismuth	µg/L	1	-	<0.1	-	9	<1000	-	0.008	-	-	-
Boron	µg/L	3	<50	-	<20	11	<50	-	16	1500	0%	0%
Cadmium	µg/L	3	0.03	0.06	**0.1**[c]	11	0.005	0.01	**0.5**[c]	0.017[h]	0%	0%
Calcium	µg/L	3	42000	45600	48000	11	13300	21600	25700	-	-	-
Cesium	µg/L	1	-	<50	-	8	<50	-	0.04	-	-	-
Chromium	µg/L	3	<1	-	<0.8	11	0.1	0.355	**2.5**[c]	1	0%	9%
Cobalt	µg/L	3	7.1	12.6	19	11	3.2	4	7.7	-	-	-
Copper	µg/L	3	**4**[c]	**8.5**[c]	**10**[c]	11	**4.2**[c]	**6**[c]	**14**[c]	2-4[i]	100%	100%
Iron	µg/L	3	**544**[c]	**920**[c]	**1300**[c]	11	11	92	**1020**[c]	300	100%	9%
Lead	µg/L	3	0.05	0.2	0.6	11	0.03	0.06	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	3	<20	-	<6	11	1.8	2.3	5	-	-	-
Magnesium	µg/L	3	13800	15000	15900	11	4600	7280	10700	-	-	-
Manganese	µg/L	3	56	60.7	63	11	2.5	6.3	25	-	-	-
Mercury	µg/L	3	<0.1	-	<0.02	11	<0.2	-	<0.01	0.026	0%	0%
Molybdenum	µg/L	3	2.5	3.5	5.8	11	1	2.7	4.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Little Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	3	1	2.3	2.7	11	0.1	0.655	2.9	25-150[k]	0%	0%
Potassium	µg/L	3	2570	3100	3300	11	1200	1500	2240	-	-	-
Rubidium	µg/L	1	-	<50	-	8	2.5	2.7	25	-	-	-
Selenium	µg/L	3	<1	-	<0.4	11	<0.5	-	0.5	1	0%	0%
Silicon	µg/L	1	-	3900	-	3	270	1670	2150	-	-	-
Silver	µg/L	3	<0.4	-	<0.1	11	<5	-	<0.005	0.1	0%	0%
Sodium	µg/L	3	6000	6300	7400	11	2000	3420	5320	-	-	-
Strontium	µg/L	2	96.9	-	120	9	37.4	56.2	68.1	-	-	-
Sulphur	µg/L	1	-	22000	-	1	-	11000	-	-	-	-
Thallium	µg/L	3	<0.2	-	<0.1	11	<50	-	0.004	0.8	0%	0%
Tin	µg/L	3	0.2	9	25	10	<50	-	0.6	-	-	-
Titanium	µg/L	3	0.5	2	2.5	11	0.25	0.9	2.5	-	-	-
Uranium	µg/L	3	7.4	7.53	12	11	1.4	2.8	25	-	-	-
Vanadium	µg/L	3	0.1	1	1	10	0.1	0.3	1.5	-	-	-
Zinc	µg/L	3	2	10	19	11	2	3.3	13	30	0%	0%
Zirconium	µg/L	0	-	-	-	2	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	3	12	19.6	30	9	20	30	40.5	-	-	-
Antimony	µg/L	3	0.1	0.54	1.2	9	0.54	0.82	1.1	-	-	-
Arsenic	µg/L	3	83.9	100	153	9	135	187	218	-	-	-
Barium	µg/L	3	10	16.9	17.4	9	5.1	7	11.9	-	-	-
Beryllium	µg/L	3	<1	-	<0.5	9	<1	-	0.01	-	-	-
Bismuth	µg/L	1	-	<0.05	-	7	<1000	-	0.008	-	-	-
Boron	µg/L	3	10	16	25	9	7	11.5	25	-	-	-
Cadmium	µg/L	3	0.03	0.11	0.2	9	0.005	0.016	0.5	-	-	-
Cesium	µg/L	1	-	<0.1	-	6	<50	-	<0.03	-	-	-
Chromium	µg/L	3	<1	-	<0.4	9	0.1	0.9	2.5	-	-	-
Cobalt	µg/L	3	6.3	13.3	16	9	2.9	4	10.3	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Little Grid Pond								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2003 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	3	2.3	5.8	10.6	9	3.2	4.98	9.4	-	-	-
Iron	µg/L	3	409	410	1030	9	15	62	405	-	-	-
Lead	µg/L	3	0.05	0.4	0.4	9	0.04	0.04	2.5	-	-	-
Lithium	µg/L	3	2.7	2.7	10	9	1.5	2	5	-	-	-
Manganese	µg/L	3	60.2	61	62	9	2	4.6	27	-	-	-
Mercury	µg/L	3	<0.1	-	<0.02	8	<0.2	-	<0.01	-	-	-
Molybdenum	µg/L	3	2.5	3.8	4.4	9	0.8	2.7	3.1	-	-	-
Nickel	µg/L	3	1	2.5	2.6	9	<2	-	0.8	-	-	-
Rubidium	µg/L	1	-	<50	-	6	2.52	2.6	25	-	-	-
Selenium	µg/L	3	<1	-	<0.4	9	<0.5	-	0.7	-	-	-
Silicon	µg/L	1	-	4300	-	3	240	1590	2430	-	-	-
Silver	µg/L	3	<0.2	-	<0.1	9	<5	-	<0.005	-	-	-
Strontium	µg/L	2	109	-	120	7	35.9	49.3	76.6	-	-	-
Sulphur	µg/L	1	-	23000	-	1	-	12000	-	-	-	-
Thallium	µg/L	3	<0.2	-	<0.05	9	<50	-	0.003	-	-	-
Tin	µg/L	3	0.1	7	25	9	<50	-	0.18	-	-	-
Titanium	µg/L	3	0.5	0.9	1	9	<1	-	<0.3	-	-	-
Uranium	µg/L	3	7.3	8.2	9.9	9	0.8	2.8	25	-	-	-
Vanadium	µg/L	3	0.05	2	2	9	0.05	0.28	0.5	-	-	-
Zinc	µg/L	3	2	15	21	9	0.9	4	10	-	-	-
Zirconium	µg/L	0	-	-	-	3	<5	-	<0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Lou Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	4	**5.03**[c]	**5.73**[c]	7	18	**6.31**[c]	7.08	7.6	6.5 - 9[d]	75%	6%
Temperature	°C	6	0	0.96	1.7	18	6.5	13.8	19.5	-	-	-
Specific Conductance	µS/cm	6	8.7	71.5	92	18	39	62	105	-	-	-
Dissolved Oxygen	mg/L	5	6.9	11.27	17	16	6.9	9.64	12.8	6.5 or 9.5[e]	0%/40%	0% /31%
Turbidity	NTU	4	0	13	45.1	10	0.3	3.7	50.6	-	-	-
Secchi depth	m	0	-	-	-	10	1.45	1.83	2.2	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	9	67	70.6	78	22	55.9	58.9	65.8	-	-	-
Dissolved Organic Carbon	mg/L	6	11.9	14.9	17.8	18	12	13.2	14.9	-	-	-
Hardness	mg/L	9	30	31	33.3	28	25	28	30	-	-	-
pH	pH units	9	7.12	7.47	7.5	22	6.9	7.4	7.8	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	9	29	30.7	34	19	23	26	30	-	-	-
Total Dissolved Solids	mg/L	3	32	34	40	13	36	50	80	-	-	-
Total Organic Carbon	mg/L	6	11.8	14.9	16	16	12	14	17	-	-	-
Total Suspended Solids	mg/L	9	0.5	4	7	14	1	2.5	4	-	-	-
Turbidity	NTU	6	0.5	1.05	4.1	14	1.1	1.85	4.2	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	9	35	37.5	41	19	28	31.2	36	-	-	-
Calcium	mg/L	9	6.4	7	7.32	25	5.4	6.2	6.7	-	-	-
Carbonate, as $CaCO_3$	mg/L	9	<5	-	<1	19	<5	-	<0.5	-	-	-
Chloride	mg/L	9	0.5	1.3	2	23	0.6	2	7.5	230	0%	0%
Magnesium	mg/L	9	3.2	3.4	3.7	25	2.7	3.0	3.2	-	-	-
Potassium	mg/L	9	1	1.1	1.9	25	0.6	1.0	1.4	-	-	-
Sodium	mg/L	9	2	2.3	3.6	25	1.8	2.1	3	-	-	-
Sulphate	mg/L	9	1	2	2.1	19	0.3	1.5	4.2	-	-	-
Nutrients												
Nitrate	mg-N/L	9	0.025	0.096	0.1	25	0.001	0.079	0.2	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Lou Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	9	<0.06	-	<0.05	25	<0.05	-	0.002	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	9	<0.2	-	0.1	25	0.001	0.079	0.2	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	9	0.0025	0.0335	0.08	25	<0.05	-	0.039	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	9	0.58	1	1.43	25	0.29	0.5	0.96	-	-	-
Nitrogen (N), Total	mg/L	3	0.5	1	1	9	0.41	0.47	0.67	-	-	-
Phosphorus, total	mg/L	9	0.0097	0.013	0.0358	23	0.007	0.0106	0.03	50	0%	0%
Phosphorus, dissolved	mg/L	6	0.0081	0.0093	0.05	12	0.0027	0.0048	0.05	-	-	-
Total Metals												
Aluminum	µg/L	9	17	32	**800**[c]	25	5	60.4	**240**[c]	5-100[g]	11%	16%
Antimony	µg/L	9	<0.4	-	1.5	25	0.02	0.5	1.3	-	-	-
Arsenic	µg/L	9	0.5	0.59	0.81	25	0.4	0.61	1.2	5	0%	0%
Barium	µg/L	9	5	6	14.6	25	5.2	6.2	11	-	-	-
Beryllium	µg/L	9	<1	-	<1	25	<2	-	0.02	-	-	-
Bismuth	µg/L	3	<0.1	-	<0.1	19	<1000	-	<0.005	-	-	-
Boron	µg/L	9	<50	-	<20	25	<50	-	11	1500	0%	0%
Cadmium	µg/L	9	0.005	0.09	**0.15**[c]	25	<1	-	**0.03**[c]	0.017[h]	33%	8%
Calcium	µg/L	9	6200	7200	7600	25	5030	5960	6920	-	-	-
Cesium	µg/L	3	<50	-	<50	16	<50	-	0.08	-	-	-
Chromium	µg/L	9	<1	-	**1.5**[c]	25	0.1	0.4	**2.5**[c]	1	11%	8%
Cobalt	µg/L	9	<2	-	0.5	25	0.029	0.043	1	-	-	-
Copper	µg/L	9	1	1.5	**3**[c]	25	1	1.5	**3**[c]	2-4[i]	11%	8%
Iron	µg/L	9	52	110	989	25	55	188	650	300	22%	22%
Lead	µg/L	9	0.05	0.3	1	25	0.04	0.06	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	9	<20	-	<6	25	2	2.3	5	-	-	-
Magnesium	µg/L	9	3100	3400	3780	25	2500	2900	3430	-	-	-
Manganese	µg/L	9	2.5	7	82.5	25	1	14.9	235	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	25	<0.2	-	**0.2**[c]	0.026	0%	16%
Molybdenum	µg/L	9	0.1	0.4	2.5	25	0.07	0.09	2.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Lou Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	9	0.6	1	1.8	25	0.25	0.6	1	25-150[k]	0%	0%
Potassium	µg/L	9	1040	1200	1600	25	900	1020	1210	-	-	-
Rubidium	µg/L	3	<50	-	<50	16	0.97	1	25	-	-	-
Selenium	µg/L	9	<1	-	<0.4	25	<0.5	-	0.4	1	0%	0%
Silicon	µg/L	3	1100	1200	1400	9	943	1110	1580	-	-	-
Silver	µg/L	9	<0.4	-	**0.2**[c]	25	<5	-	0.02	0.1	11%	0%
Sodium	µg/L	9	2000	2500	3500	25	1700	2000	45000	-	-	-
Strontium	µg/L	6	20	28	30	19	21.5	25.7	32	-	-	-
Sulphur	µg/L	3	800	800	1000	3	<3000	-	<3000	-	-	-
Thallium	µg/L	9	<0.2	-	<0.1	25	<50	-	<0.002	0.8	0%	0%
Tin	µg/L	9	<50	-	9	25	<50	-	0.16	-	-	-
Titanium	µg/L	9	0.5	2.5	29	25	0.25	2	9	-	-	-
Uranium	µg/L	9	0.3	0.36	0.8	25	0.26	0.31	25	-	-	-
Vanadium	µg/L	9	0.1	2	2	25	<1	-	0.5	-	-	-
Zinc	µg/L	9	1.5	9	9	25	0.5	4.15	12	30	0%	0%
Zirconium	µg/L	0	-	-	-	6	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	9	11	19.7	30	25	6.8	20.2	60	-	-	-
Antimony	µg/L	9	<0.4	-	0.6	25	<0.4	-	0.9	-	-	-
Arsenic	µg/L	9	0.5	0.54	0.9	25	0.46	0.6	1.13	-	-	-
Barium	µg/L	9	5	6.3	7.8	25	4.8	6	10	-	-	-
Beryllium	µg/L	9	<1	-	<0.5	25	<1	-	0.07	-	-	-
Bismuth	µg/L	3	<0.05	-	<0.05	19	<1000	-	<0.005	-	-	-
Boron	µg/L	9	8	9	25	25	<50	-	9	-	-	-
Cadmium	µg/L	9	0.005	0.04	0.4	25	<1	-	0.03	-	-	-
Cesium	µg/L	3	<0.1	-	<0.1	16	<50	-	<0.03	-	-	-
Chromium	µg/L	9	<1	-	1	25	<5	-	1.6	-	-	-
Cobalt	µg/L	9	<2	-	<0.1	25	0.01	0.03	5.6	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Lou Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	9	0.5	1.4	2.4	25	0.5	1.4	2.7	-	-	-
Iron	µg/L	9	30	50	371	25	19	72	263	-	-	-
Lead	µg/L	9	<0.2	-	0.4	25	0.007	0.075	2.5	-	-	-
Lithium	µg/L	9	2.1	2.2	10	25	1.5	2.1	5	-	-	-
Manganese	µg/L	9	2	3	552	25	0.26	2.5	168	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	23	<0.2	-	0.09	-	-	-
Molybdenum	µg/L	9	0.1	0.1	2.5	25	0.05	0.09	2.5	-	-	-
Nickel	µg/L	9	0.6	0.8	1.2	25	0.25	0.6	1.1	-	-	-
Rubidium	µg/L	3	<50	-	<50	16	0.95	1	25	-	-	-
Selenium	µg/L	9	<1	-	<0.4	25	<0.5	-	0.7	-	-	-
Silicon	µg/L	3	1100	1100	1200	9	945	1020	1610	-	-	-
Silver	µg/L	9	<0.2	-	0.1	25	<5	-	<0.005	-	-	-
Strontium	µg/L	6	20	28.2	31.3	19	22.8	25	29.6	-	-	-
Sulphur	µg/L	3	800	800	1100	3	<3000	-	<3000	-	-	-
Thallium	µg/L	9	<0.2	-	0.05	25	<50	-	<0.002	-	-	-
Tin	µg/L	9	<50	-	10	25	<50	-	0.06	-	-	-
Titanium	µg/L	9	0.4	0.5	0.6	25	<1	-	1.5	-	-	-
Uranium	µg/L	9	0.3	0.3	0.34	25	0.25	0.3	25	-	-	-
Vanadium	µg/L	9	<1	-	<0.1	25	<1	-	0.5	-	-	-
Zinc	µg/L	9	2	3	16	25	1	3.1	7.9	-	-	-
Zirconium	µg/L	0	-	-	-	9	<5	-	0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Nico Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	4	**5.23**[c]	**5.59**[c]	**6.14**[c]	15	**6.06**[c]	7.2	7.6	6.5 - 9[d]	100%	13%
Temperature	°C	5	0.77	1.35	3	15	6.2	14.88	20.9	-	-	-
Specific Conductance	µS/cm	5	15.2	98	132	15	51	78	147	-	-	-
Dissolved Oxygen	mg/L	5	**4.5**[c]	6.68	12	15	**6.4**[c]	9.68	14.1	6.5 or 9.5[e]	40%/80%	7%/33%
Turbidity	NTU	4	50.1	72.7	105	5	1.76	2.31	32.1	-	-	-
Secchi depth	m	0	-	-	-	9	1.4	1.7	2	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	9	93.3	110	125	20	55.2	70	76	-	-	-
Dissolved Organic Carbon	mg/L	6	17.7	18.7	19.8	13	14.7	16.5	19	-	-	-
Hardness	mg/L	9	42.7	47	57.1	23	26	33.4	40.7	-	-	-
pH	pH units	9	7.26	7.4	7.6	20	7.1	7.5	7.8	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	9	38.1	43	56.2	19	22	29	33	-	-	-
Total Dissolved Solids	mg/L	3	50	53	54	11	48	70	90	-	-	-
Total Organic Carbon	mg/L	6	19	19.9	23	16	16	18	21	-	-	-
Total Suspended Solids	mg/L	9	0.5	4	12	12	1.5	2	10	-	-	-
Turbidity	NTU	6	0.25	0.95	2.1	12	0.9	1.5	15	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	9	46.5	52	68.5	19	27	35	40	-	-	-
Calcium	mg/L	9	9.8	11	14.3	23	6.1	7.8	9.3	-	-	-
Carbonate, as $CaCO_3$	mg/L	9	<5	-	<1	19	<5	-	<0.5	-	-	-
Chloride	mg/L	9	0.5	0.8	2	20	0.5	1	2	230	0%	0%
Magnesium	mg/L	9	4.4	4.8	5.2	23	2.6	3.3	4.3	-	-	-
Potassium	mg/L	9	1.1	1.3	1.6	23	0.8	1.0	1.4	-	-	-
Sodium	mg/L	9	2.6	3	3.3	23	2	2.1	3	-	-	-
Sulphate	mg/L	9	4	5.7	6.6	19	1.7	3.4	5	-	-	-
Nutrients												
Nitrate	mg-N/L	9	0.025	0.2	0.4	23	0.001	0.018	0.2	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Nico Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	9	<0.06	-	<0.05	23	<0.05	-	0.002	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	9	0.0355	0.2	0.4	23	0.001	0.02	0.2	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	9	0.0025	0.03	0.603	23	0.0025	0.015	0.32	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	9	0.78	1	1.58	23	0.34	0.67	1.05	-	-	-
Nitrogen (N), Total	mg/L	3	1	1	1	7	0.49	0.67	0.72	-	-	-
Phosphorus, total	mg/L	9	0.01	0.0175	0.0448	23	0.01	0.0199	0.1	50	0%	0%
Phosphorus, dissolved	mg/L	6	0.0101	0.0112	0.05	10	0.0057	0.0067	0.05	-	-	-
Total Metals												
Aluminum	µg/L	9	23	33	50	23	5	44	80	5-100[g]	0%	0%
Antimony	µg/L	9	<0.4	-	<0.2	23	0.11	0.16	0.7	-	-	-
Arsenic	µg/L	9	5	**7.7**[c]	**163**[c]	23	**10.4**[c]	**12.4**[c]	**163**[c]	5	89%	100%
Barium	µg/L	9	8.3	10	19.3	23	5.95	7	10	-	-	-
Beryllium	µg/L	9	<1	-	<1	23	<2	-	0.05	-	-	-
Bismuth	µg/L	3	<0.1	-	<0.1	17	<1000	-	<0.005	-	-	-
Boron	µg/L	9	<50	-	<20	23	<50	-	11	1500	0%	0%
Cadmium	µg/L	9	0.005	**0.05**[c]	**0.1**[c]	23	<1	-	**2**[c]	0.017[h]	33%	22%
Calcium	µg/L	9	10000	11200	15300	23	5700	7730	9100	-	-	-
Cesium	µg/L	3	<50	-	<50	14	<50	-	0.09	-	-	-
Chromium	µg/L	9	<1	-	**1.6**[c]	23	<5	-	0.6	1	11%	0%
Cobalt	µg/L	9	0.1	0.4	6.4	23	0.1	0.254	3	-	-	-
Copper	µg/L	9	1.1	2	**2.2**[c]	23	1	1.73	**3.1**[c]	2-4[i]	33%	4%
Iron	µg/L	9	80	180	**6990**[c]	23	169	**385**[c]	**5180**[c]	300	11%	87%
Lead	µg/L	9	<0.2	-	0.4	23	0.028	0.0915	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	9	<20	-	<6	23	<10	-	2.1	-	-	-
Magnesium	µg/L	9	4690	4900	5500	23	2500	3230	4040	-	-	-
Manganese	µg/L	9	8	21	897	23	4	22.8	494	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	23	<0.2	-	**0.23**[c]	0.026	0%	13%
Molybdenum	µg/L	9	0.5	0.7	2.5	23	0.3	0.445	2.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Nico Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	9	0.7	1	1.4	23	0.25	0.4	1	25-150[k]	0%	0%
Potassium	µg/L	9	1190	1400	1700	23	700	940	1100	-	-	-
Rubidium	µg/L	3	<50	-	<50	14	<50	-	1.62	-	-	-
Selenium	µg/L	9	<1	-	<0.4	23	<0.5	-	0.4	1	0%	0%
Silicon	µg/L	3	400	400	400	7	444	460	580	-	-	-
Silver	µg/L	9	<0.4	-	<0.1	23	<5	-	0.04	0.1	0%	0%
Sodium	µg/L	9	2700	3000	4000	23	1000	2000	2610	-	-	-
Strontium	µg/L	6	30	33.75	38.4	17	22	26	40	-	-	-
Sulphur	µg/L	3	2300	2400	2400	3	<3000	-	<3000	-	-	-
Thallium	µg/L	9	<0.2	-	<0.1	23	<50	-	0.003	0.8	0%	0%
Tin	µg/L	9	0.2	6	25	23	<50	-	<0.01	-	-	-
Titanium	µg/L	9	0.5	1	2.5	23	0.25	1	2.5	-	-	-
Uranium	µg/L	9	0.3	0.3	0.67	23	0.231	0.29	25	-	-	-
Vanadium	µg/L	9	0.1	1	1	23	<1	-	0.4	-	-	-
Zinc	µg/L	9	<4	-	4	23	0.4	3	9	30	0%	0%
Zirconium	µg/L	0	-	-	-	4	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	9	17	23.2	40	23	7.2	30	60	-	-	-
Antimony	µg/L	9	0.1	0.7	0.9	23	0.11	0.16	0.9	-	-	-
Arsenic	µg/L	9	5	5.5	83.4	23	8.44	11.5	94.1	-	-	-
Barium	µg/L	9	5	8.3	17.5	23	5	6.7	8	-	-	-
Beryllium	µg/L	9	<1	-	<0.5	23	<1	-	<0.01	-	-	-
Bismuth	µg/L	3	<0.05	-	<0.05	17	<1000	-	0.06	-	-	-
Boron	µg/L	9	9	10	25	23	<50	-	7	-	-	-
Cadmium	µg/L	9	0.005	0.06	0.06	23	<1	-	0.7	-	-	-
Cesium	µg/L	3	<0.1	-	<0.1	14	<50	-	<0.03	-	-	-
Chromium	µg/L	9	<1	-	<0.4	23	<5	-	1.2	-	-	-
Cobalt	µg/L	9	0.15	0.65	6.1	23	0.05	0.14	2.9	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Nico Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	9	0.5	1.5	1.9	23	0.5	1.2	3.8	-	-	-
Iron	µg/L	9	60	134	3790	23	37	295	2280	-	-	-
Lead	µg/L	9	0.05	0.2	0.5	23	0.006	0.08	2.5	-	-	-
Lithium	µg/L	9	1.8	2	10	23	1.2	1.5	5	-	-	-
Manganese	µg/L	9	6	15	860	23	0.21	3	229	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	21	<0.2	-	0.04	-	-	-
Molybdenum	µg/L	9	0.5	0.7	2.5	23	0.35	0.4	2.5	-	-	-
Nickel	µg/L	9	0.5	0.9	1.1	23	<2	-	0.8	-	-	-
Rubidium	µg/L	3	<50	-	<50	14	<50	-	1.58	-	-	-
Selenium	µg/L	9	<1	-	<0.4	23	<0.5	-	0.5	-	-	-
Silicon	µg/L	3	400	400	400	7	400	430	590	-	-	-
Silver	µg/L	9	<0.2	-	<0.1	23	<5	-	<0.005	-	-	-
Strontium	µg/L	6	30	38.9	56.4	17	19.6	24.5	31.9	-	-	-
Sulphur	µg/L	3	2700	2700	3000	3	<3000	-	<3000	-	-	-
Thallium	µg/L	9	<0.2	-	<0.05	23	<50	-	<0.002	-	-	-
Tin	µg/L	9	0.1	6	25	23	<50	-	0.14	-	-	-
Titanium	µg/L	9	0.3	0.3	0.5	23	<1	-	0.7	-	-	-
Uranium	µg/L	9	0.3	0.3	0.59	23	0.2	0.26	25	-	-	-
Vanadium	µg/L	9	<1	-	<0.1	23	<1	-	1.5	-	-	-
Zinc	µg/L	9	2	4	9	23	0.5	4.1	13	-	-	-
Zirconium	µg/L	0	-	-	-	7	<5	-	<0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Peanut Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	4	**4.27**[c]	**5.08**[c]	**5.77**[c]	13	6.53	7.06	7.6	6.5 - 9[d]	100%	0%
Temperature	°C	5	0	1.02	1.7	13	6.8	16.1	18.91	-	-	-
Specific Conductance	µS/cm	4	10.1	54.4	99	13	55	74	129	-	-	-
Dissolved Oxygen	mg/L	4	**2.34**[c]	**6.06**[c]	9.2	12	7.1	10.08	13.8	6.5 or 9.5[e]	50%/100%	0%/33%
Turbidity	NTU	4	93.9	105	158	5	0.6	2.1	22.2	-	-	-
Secchi depth	m	0	-	-	-	7	1.4	1.6	2.6	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	7	86.5	88.6	90	19	60.1	70.6	76.2	-	-	-
Dissolved Organic Carbon	mg/L	5	12.2	13.3	13.5	12	12.2	14.9	17.6	-	-	-
Hardness	mg/L	7	35	37.8	39	22	27	32.5	38.2	-	-	-
pH	pH units	7	7.1	7.39	7.5	19	7	7.5	7.8	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	7	33	41	42	18	28	33	34.5	-	-	-
Total Dissolved Solids	mg/L	2	44	-	45	10	46	67	80	-	-	-
Total Organic Carbon	mg/L	5	12.9	13.7	15	16	13	15.3	17	-	-	-
Total Suspended Solids	mg/L	7	<3	-	2	11	<3	-	4	-	-	-
Turbidity	NTU	4	3.2	3.85	4.7	11	0.8	2.4	4.2	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	7	40	50.8	52	18	34	40	42	-	-	-
Calcium	mg/L	7	7.8	8.4	8.6	22	6.2	7.4	8.8	-	-	-
Carbonate, as $CaCO_3$	mg/L	7	<5	-	<1	18	<5	-	<0.5	-	-	-
Chloride	mg/L	7	0.5	0.9	8	19	0.6	1	2	230	0%	0%
Magnesium	mg/L	7	3.7	4.1	4.2	22	2.9	3.3	3.9	-	-	-
Potassium	mg/L	7	1.3	1.5	1.7	22	1	1.2	1.4	-	-	-
Sodium	mg/L	7	2.8	3	3.7	22	2	2.6	3.2	-	-	-
Sulphate	mg/L	7	0.6	1	1.8	18	0.3	1.5	2.8	-	-	-
Nutrients												
Nitrate	mg-N/L	7	0.05	0.105	0.108	19	0.011	0.102	0.449	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Peanut Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	7	<0.06	-	<0.05	19	<0.05	-	0.003	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	7	0.05	0.105	0.108	22	0.01	0.102	0.451	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	7	0.0025	0.012	0.0397	22	0.0025	0.0135	0.308	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	7	0.5	1	1.2	22	0.12	0.5	0.979	-	-	-
Nitrogen (N), Total	mg/L	2	<1	-	<1	6	0.33	0.455	0.59	-	-	-
Phosphorus, total	mg/L	7	0.01	0.0145	0.018	22	0.009	0.0141	0.04	50	0%	0%
Phosphorus, dissolved	mg/L	5	0.0072	0.008	0.05	9	0.0033	0.0056	0.05	-	-	-
Total Metals												
Aluminum	µg/L	7	93.5	**130**[c]	**180**[c]	22	38	89.7	**150**[c]	5-100[g]	86%	45%
Antimony	µg/L	7	<0.4	-	<0.2	22	0.025	0.24	0.7	-	-	-
Arsenic	µg/L	7	0.5	0.7	3.1	22	2.9	4.6	**10.2**[c]	5	0%	27%
Barium	µg/L	7	8.3	9.8	10.1	22	6.8	8.6	49	-	-	-
Beryllium	µg/L	7	<1	-	<1	22	<2	-	<0.01	-	-	-
Bismuth	µg/L	2	<0.1	-	<0.1	16	<1000	-	<0.005	-	-	-
Boron	µg/L	7	<50	-	<20	22	<50	-	9	1500	0%	0%
Cadmium	µg/L	7	<0.2	-	**0.04**[c]	22	<1	-	**0.37**[c]	0.017[h]	29%	9%
Calcium	µg/L	7	8200	8400	9050	22	5700	7300	8200	-	-	-
Cesium	µg/L	2	<50	-	<50	13	<50	-	0.11	-	-	-
Chromium	µg/L	7	<1	-	<0.8	22	<5	-	**1.2**[c]	1	0%	5%
Cobalt	µg/L	7	<2	-	<0.2	22	<2	-	0.48	-	-	-
Copper	µg/L	7	<1	-	1	22	0.5	1	**2.8**[c]	2-4[i]	0%	5%
Iron	µg/L	7	230	**317**[c]	**371**[c]	22	129	254	**761**[c]	300	30%	56%
Lead	µg/L	7	<0.2	-	0.1	22	0.048	0.08	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	7	<20	-	<6	22	<10	-	2.1	-	-	-
Magnesium	µg/L	7	4000	4110	4330	22	2700	3300	3890	-	-	-
Manganese	µg/L	7	16	18	121	22	0.5	11.6	173	-	-	-
Mercury	µg/L	7	<0.1	-	<0.02	22	<0.2	-	**0.2**[c]	0.026	0%	14%
Molybdenum	µg/L	7	<5	-	0.1	22	0.1	0.2	2.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Peanut Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	7	0.7	1.1	1.4	22	0.25	0.6	2.2	25-150[k]	0%	0%
Potassium	µg/L	7	1340	1600	1800	22	1000	1130	1320	-	-	-
Rubidium	µg/L	2	<50	-	<50	13	<50	-	1.5	-	-	-
Selenium	µg/L	7	<1	-	<0.4	22	<0.5	-	0.8	1	0%	0%
Silicon	µg/L	2	1100	-	1100	6	305	577	870	-	-	-
Silver	µg/L	7	<0.4	-	<0.1	22	<5	-	<0.005	0.1	0%	0%
Sodium	µg/L	7	2900	3200	3400	22	2000	2400	3000	-	-	-
Strontium	µg/L	4	30	35.5	40	16	27.5	32.8	37	-	-	-
Sulphur	µg/L	2	500	-	600	3	<3000	-	<3000	-	-	-
Thallium	µg/L	7	<0.2	-	<0.1	22	<50	-	0.003	0.8	0%	0%
Tin	µg/L	7	<50	-	11	22	<50	-	0.07	-	-	-
Titanium	µg/L	7	2.6	7	7.3	22	1.5	2.5	8	-	-	-
Uranium	µg/L	7	0.16	0.2	0.2	22	0.15	0.2	25	-	-	-
Vanadium	µg/L	7	0.2	0.65	1	22	<1	-	0.4	-	-	-
Zinc	µg/L	7	<4	-	<3	22	0.4	3	**38**[c]	30	0%	5%
Zirconium	µg/L	0	-	-	-	3	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	7	24	34	53.7	22	2.5	21.6	40	-	-	-
Antimony	µg/L	7	<0.4	-	0.5	22	0.04	0.09	0.5	-	-	-
Arsenic	µg/L	7	0.6	1	2.9	22	2.6	3.7	8.7	-	-	-
Barium	µg/L	7	5	8.9	9.5	22	6	7	10	-	-	-
Beryllium	µg/L	7	<1	-	<0.5	22	<1	-	<0.01	-	-	-
Bismuth	µg/L	2	<0.05	-	<0.05	16	<1000	-	<0.005	-	-	-
Boron	µg/L	7	<50	-	11	22	<50	-	10	-	-	-
Cadmium	µg/L	7	0.005	0.01	0.05	22	<1	-	0.12	-	-	-
Cesium	µg/L	2	<0.1	-	<0.1	13	<50	-	<0.03	-	-	-
Chromium	µg/L	7	<1	-	<0.4	22	<5	-	1.1	-	-	-
Cobalt	µg/L	7	<2	-	0.2	22	<2	-	1.5	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Peanut Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	7	0.5	0.85	1.1	22	0.5	1.03	2	-	-	-
Iron	µg/L	7	120	147	168	22	35	148	347	-	-	-
Lead	µg/L	7	<0.2	-	0.12	22	<5	-	0.15	-	-	-
Lithium	µg/L	7	<20	-	2.2	22	1.5	1.8	5	-	-	-
Manganese	µg/L	7	14	16	105	22	0.5	2.5	216	-	-	-
Mercury	µg/L	7	<0.1	-	<0.02	20	<0.2	-	0.1	-	-	-
Molybdenum	µg/L	7	<5	-	0.1	22	0.1	0.18	2.5	-	-	-
Nickel	µg/L	7	0.5	0.7	1.4	22	0.3	0.47	1	-	-	-
Rubidium	µg/L	2	<50	-	<50	13	<50	-	1.65	-	-	-
Selenium	µg/L	7	<1	-	<0.4	22	<0.5	-	0.04	-	-	-
Silicon	µg/L	2	900	-	1000	6	260	415	790	-	-	-
Silver	µg/L	7	<0.2	-	<0.1	22	<5	-	<0.005	-	-	-
Strontium	µg/L	4	30	34.4	39	16	23.9	30	34	-	-	-
Sulphur	µg/L	2	1100	-	1500	3	<3000	-	<3000	-	-	-
Thallium	µg/L	7	<0.2	-	<0.05	22	<50	-	<0.002	-	-	-
Tin	µg/L	7	<50	-	12	22	<50	-	0.05	-	-	-
Titanium	µg/L	7	0.5	1.45	1.9	22	<1	-	0.8	-	-	-
Uranium	µg/L	7	0.1	0.15	0.2	22	0.14	0.192	25	-	-	-
Vanadium	µg/L	7	0.05	2	2	22	<1	-	1.3	-	-	-
Zinc	µg/L	7	2	3.5	4	22	1	4.65	12	-	-	-
Zirconium	µg/L	0	-	-	-	6	<5	-	0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Burke Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	6	**4.55**[c]	**5.87**[c]	7.2	20	**6.15**[c]	7.25	8.2	6.5 - 9[d]	67%	10%
Temperature	°C	6	0	1.30	2.2	20	4.5	15.3	22.5	-	-	-
Specific Conductance	µS/cm	5	15.3	100	117	20	50	63.5	130	-	-	-
Dissolved Oxygen	mg/L	6	**5.6**[c]	**5.95**[c]	8.8	20	7.4	10.07	15.2	6.5 or 9.5[e]	67%/100%	0%/25%
Turbidity	NTU	4	18.8	51.2	90	5	2.41	13.1	59.8	-	-	-
Secchi depth	m	0	-	-	-	13	1.2	1.7	2.3	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	7	98	111	138	26	59.2	70.2	78	-	-	-
Dissolved Organic Carbon	mg/L	5	14.7	16.2	19.5	12	11.6	12.4	14.6	-	-	-
Hardness	mg/L	7	45	48.9	61.3	25	22	31.3	36.6	-	-	-
pH	pH units	7	7.3	7.4	7.5	26	7.21	7.6	7.8	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	7	45	48.3	66.3	22	24	30.6	33	-	-	-
Total Dissolved Solids	mg/L	2	50	-	53	15	54	62	80	-	-	-
Total Organic Carbon	mg/L	5	16.4	17	20	19	12.1	14	20	-	-	-
Total Suspended Solids	mg/L	7	0.5	7	32	17	1.5	4	64	-	-	-
Turbidity	NTU	4	1.4	2.2	4.8	16	0.9	1.9	3.4	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	7	55	58.9	80.9	22	30	37.5	41	-	-	-
Calcium	mg/L	7	10.7	11.5	15.2	25	5	7.4	8.2	-	-	-
Carbonate, as $CaCO_3$	mg/L	7	<5	-	<1	22	<5	-	<0.5	-	-	-
Chloride	mg/L	7	1	1.8	2	25	1	2	3	230	0%	0%
Magnesium	mg/L	7	4.4	4.9	5.7	25	2.2	3.2	3.6	-	-	-
Potassium	mg/L	7	1.4	1.5	1.8	25	0.8	1.1	1.3	-	-	-
Sodium	mg/L	7	3.2	3.4	4	25	2	2.2	3	-	-	-
Sulphate	mg/L	7	0.9	2.4	4.1	22	0.3	1.9	3.0	-	-	-
Nutrients												
Nitrate	mg-N/L	7	0.025	0.182	0.2	22	<0.1	-	0.2	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Burke Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	7	<0.06	-	<0.05	22	<0.05	-	<0.002	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	7	0.0355	0.182	0.2	25	<0.1	-	0.2	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	7	0.0025	0.05	0.639	25	0.0025	0.0108	0.025	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	7	0.66	1.08	1.91	25	0.45	0.59	0.8	-	-	-
Nitrogen (N), Total	mg/L	2	0.5	-	1	6	0.46	0.51	0.87	-	-	-
Phosphorus, total	mg/L	7	0.01	0.015	0.0479	25	0.009	0.0138	0.053	50	0%	0%
Phosphorus, dissolved	mg/L	5	0.0061	0.009	0.05	9	0.0024	0.0059	0.05	-	-	-
Total Metals												
Aluminum	µg/L	7	17	52.5	**240**[c]	26	20	65	**210**[c]	5-100[g]	29%	19%
Antimony	µg/L	7	<0.4	-	3.5	26	<0.4	-	0.9	-	-	-
Arsenic	µg/L	7	1	2.5	**38.9**[c]	26	1.6	2.3	3.3	5	14%	0%
Barium	µg/L	7	9.9	10.2	27.7	26	7	8	9.1	-	-	-
Beryllium	µg/L	7	<1	-	<1	26	<2	-	<0.01	-	-	-
Bismuth	µg/L	2	0.05	-	0.1	20	<1000	-	<0.005	-	-	-
Boron	µg/L	7	<50	-	<20	26	<50	-	7	1500	0%	0%
Cadmium	µg/L	7	0.005	**0.04**[c]	**0.1**[c]	26	<1	-	**0.02**[c]	0.017[h]	43%	4%
Calcium	µg/L	7	9900	11800	16100	26	5800	7355	8660	-	-	-
Cesium	µg/L	2	<50	-	<50	17	<50	-	0.08	-	-	-
Chromium	µg/L	7	<1	-	<0.8	26	0.18	0.5	**2.5**[c]	1	0%	4%
Cobalt	µg/L	7	<2	-	5.2	26	<2	-	0.093	-	-	-
Copper	µg/L	7	1	1.3	**3.7**[c]	26	0.5	1	**4**[c]	2-4[i]	14%	8%
Iron	µg/L	7	150	**470**[c]	**12800**[c]	26	44	230	**498**[c]	300	90%	40%
Lead	µg/L	7	<0.2	-	0.36	26	0.05	0.0965	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	7	<20	-	<6	26	<10	-	2.2	-	-	-
Magnesium	µg/L	7	4400	5230	5940	26	2500	3050	3730	-	-	-
Manganese	µg/L	7	38.8	100	3200	26	2	12.7	87.3	-	-	-
Mercury	µg/L	7	<0.1	-	<0.02	26	<0.2	-	**0.29**[c]	0.026	0%	12%
Molybdenum	µg/L	7	<5	-	0.3	26	0.16	0.2	2.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Burke Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	7	0.7	1.05	1.6	26	0.25	0.47	1	25-150[k]	0%	0%
Potassium	µg/L	7	1440	1700	1800	26	900	1095	1420	-	-	-
Rubidium	µg/L	2	<50	-	<50	17	<50	-	1.13	-	-	-
Selenium	µg/L	7	<1	-	<0.4	26	<0.5	-	**1.2**[c]	1	0%	4%
Silicon	µg/L	2	800	-	1200	6	369	381	400	-	-	-
Silver	µg/L	7	<0.4	-	<0.1	26	<5	-	<0.005	0.1	0%	0%
Sodium	µg/L	7	3300	3500	4000	26	1900	2020	3000	-	-	-
Strontium	µg/L	4	40	42.1	46.7	20	23.6	30.5	37	-	-	-
Sulphur	µg/L	2	800	-	800	3	<3000	-	<3000	-	-	-
Thallium	µg/L	7	<0.2	-	<0.1	26	<50	-	<0.002	0.8	0%	0%
Tin	µg/L	7	<50	-	15	25	<50	-	0.06	-	-	-
Titanium	µg/L	7	0.5	6.55	12	26	0.5	2.5	8	-	-	-
Uranium	µg/L	7	0.19	0.3	0.51	26	0.153	0.21	25	-	-	-
Vanadium	µg/L	7	0.1	1.2	2	26	0.21	0.55	27.3	-	-	-
Zinc	µg/L	7	<4	-	7.7	26	0.5	4.6	**49**[c]	30	0%	4%
Zirconium	µg/L	0	-	-	-	3	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	7	5	20	30	25	6.8	20	51.4	-	-	-
Antimony	µg/L	7	<0.4	-	<0.2	25	0.025	0.4	0.6	-	-	-
Arsenic	µg/L	7	0.5	2.1	38.5	25	1.6	1.9	2.8	-	-	-
Barium	µg/L	7	5	10.6	25.1	25	5.9	7	8.4	-	-	-
Beryllium	µg/L	7	<1	-	<0.5	25	<1	-	0.06	-	-	-
Bismuth	µg/L	2	<0.05	-	<0.05	19	<1000	-	0.07	-	-	-
Boron	µg/L	7	<50	-	11	25	<50	-	10	-	-	-
Cadmium	µg/L	7	0.005	0.03	0.06	25	<1	-	0.07	-	-	-
Cesium	µg/L	2	<0.1	-	<0.1	16	<50	-	0.03	-	-	-
Chromium	µg/L	7	<1	-	<0.4	25	<5	-	0.8	-	-	-
Cobalt	µg/L	7	0.1	0.1	5	25	<2	-	0.2	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Burke Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	7	0.5	0.9	1.6	25	0.5	1.27	6.2	-	-	-
Iron	µg/L	7	60	329	9500	25	20	166	262	-	-	-
Lead	µg/L	7	<0.2	-	<0.1	25	0.05	0.1095	2.5	-	-	-
Lithium	µg/L	7	<20	-	2.3	25	1.3	2.1	5	-	-	-
Manganese	µg/L	7	35.8	96	2970	25	0.5	2.5	24.2	-	-	-
Mercury	µg/L	7	<0.1	-	<0.02	22	<0.2	-	0.28	-	-	-
Molybdenum	µg/L	7	0.1	0.3	2.5	25	0.1	0.2	2.5	-	-	-
Nickel	µg/L	7	0.7	0.75	1	25	0.3	0.47	1.1	-	-	-
Rubidium	µg/L	2	<50	-	<50	16	<50	-	1.17	-	-	-
Selenium	µg/L	7	<1	-	<0.4	25	<0.5	-	0.06	-	-	-
Silicon	µg/L	2	800	-	900	6	310	413	440	-	-	-
Silver	µg/L	7	<0.2	-	0.17	25	<5	-	<0.005	-	-	-
Strontium	µg/L	4	40	44.35	52.5	19	25.1	28	36.2	-	-	-
Sulphur	µg/L	2	800	-	900	3	<3000	-	<3000	-	-	-
Thallium	µg/L	7	<0.2	-	0.05	25	<50	-	0.009	-	-	-
Tin	µg/L	7	<50	-	6	25	<50	-	2.08	-	-	-
Titanium	µg/L	7	0.4	0.5	1.1	25	<1	-	1.6	-	-	-
Uranium	µg/L	7	0.1	0.2	0.49	25	0.161	0.2	25	-	-	-
Vanadium	µg/L	7	<1	-	1	25	<1	-	0.9	-	-	-
Zinc	µg/L	7	<4	-	3	25	0.5	3.5	8	-	-	-
Zirconium	µg/L	0	-	-	-	6	<5	-	<0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Reference Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2005 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	4	**5.5**[c]	5.735	**6.04**[c]	18	6.55	7.25	**9.24**[c]	6.5 - 9[d]	100%	6%
Temperature	°C	5	0.81	1.05	1.82	19	10.1	14.9	20	-	-	-
Specific Conductance	µS/cm	5	18.2	140	158	19	12.6	99	179	-	-	-
Dissolved Oxygen	mg/L	5	**3.58**[c]	4.58	6.79	18	6.9	9.85	14.1	6.5 or 9.5[e]	80%/100%	0%/28%
Turbidity	NTU	4	14.7	56	101	7	3.9	6.2	24.1	-	-	-
Secchi depth	m	0	-	-	-	10	1.3	1.5	2.1	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	8	120	135	155	27	95.3	103	110	-	-	-
Dissolved Organic Carbon	mg/L	6	9.8	12.9	17	15	12	13.2	17.8	-	-	-
Hardness	mg/L	8	57	61.3	72	27	43	51.2	64.4	-	-	-
pH	pH units	8	7.55	7.6	7.7	27	7.2	7.7	7.9	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	8	55	60.5	72	21	43	48	51.9	-	-	-
Total Dissolved Solids	mg/L	3	63	63	72	18	67	82	100	-	-	-
Total Organic Carbon	mg/L	5	13.1	14	16	18	12.2	14	18.2	-	-	-
Total Suspended Solids	mg/L	8	0.5	4	12	18	1.5	3	11	-	-	-
Turbidity	NTU	5	0.45	1.6	8.8	18	1.1	2.25	6.1	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	8	67	73.6	87	21	52	59	63.3	-	-	-
Calcium	mg/L	8	15	16.2	19.1	27	11.3	13.8	14.7	-	-	-
Carbonate, as $CaCO_3$	mg/L	8	<5	-	<1	21	<5	-	<0.5	-	-	-
Chloride	mg/L	8	1	1.9	3	27	1.2	2	3	230	0%	0%
Magnesium	mg/L	8	4.7	5.1	5.8	27	3.5	4.1	4.4	-	-	-
Potassium	mg/L	8	1.2	1.4	1.5	27	0.79	1.1	1.4	-	-	-
Sodium	mg/L	8	3	3.4	4	27	2	3	3.2	-	-	-
Sulphate	mg/L	8	2	4	4.7	21	0.25	3.0	3.7	-	-	-
Nutrients												
Nitrate	mg-N/L	8	0.1	0.121	0.3	24	0.001	0.1	0.39	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Reference Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2005 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrite	mg-N/L	8	<0.06	-	<0.05	24	<0.05	-	0.004	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	8	0.1	0.121	0.3	27	0.001	0.1	0.39	2.93	0%	0%
Nitrogen - Ammonia	mg-N/L	8	0.0025	0.01	0.025	27	0.0025	0.023	0.413	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	8	0.658	0.802	1.3	27	0.2	0.6	1.62	-	-	-
Nitrogen (N), Total	mg/L	3	0.5	1	1	9	0.45	0.72	1.63	-	-	-
Phosphorus, total	mg/L	8	0.01	0.0188	0.1	27	0.01	0.019	0.161	50	0%	0%
Phosphorus, dissolved	mg/L	6	0.0096	0.0101	0.05	12	0.0031	0.008	0.1	-	-	-
Total Metals												
Aluminum	µg/L	8	8.5	11.1	**280**[c]	27	5	32	**120**[c]	5-100[g]	25%	7%
Antimony	µg/L	8	0.2	0.6	0.7	27	0.025	0.135	1.2	-	-	-
Arsenic	µg/L	8	0.5	0.62	0.7	27	0.4	0.7	1.9	5	0%	0%
Barium	µg/L	8	10	14.3	20	27	8.8	11	19.3	-	-	-
Beryllium	µg/L	8	<1	-	<1	27	<2	-	<0.01	-	-	-
Bismuth	µg/L	2	<0.1	-	<0.1	21	<1000	-	<0.005	-	-	-
Boron	µg/L	8	25	30	40	27	<50	-	33	1500	0%	0%
Cadmium	µg/L	8	0.005	0.07	**0.1**[c]	27	<1	-	**0.05**[c]	0.017[h]	38%	7%
Calcium	µg/L	8	14000	17000	20400	27	11400	13600	17100	-	-	-
Cesium	µg/L	2	<50	-	<50	18	<50	-	0.1	-	-	-
Chromium	µg/L	8	<1	-	<0.8	27	<5	-	**2**[c]	1	0%	4%
Cobalt	µg/L	8	<2	-	0.3	27	0.04	0.062	1	-	-	-
Copper	µg/L	8	0.5	1.05	1.7	27	0.5	1	**3.9**[c]	2-4[i]	0%	4%
Iron	µg/L	8	30	108	470	27	44	152	**2910**[c]	300	25%	22%
Lead	µg/L	8	0.05	0.2	0.2	27	0.05	0.12	**2.5**[c]	1-7[j]	0%	0%
Lithium	µg/L	8	<20	-	<6	27	1.8	2.1	5	-	-	-
Magnesium	µg/L	8	4600	5270	6200	27	3300	4000	5240	-	-	-
Manganese	µg/L	8	2.5	29.7	170	27	6	28.9	547	-	-	-
Mercury	µg/L	8	<0.1	-	<0.02	27	<0.2	-	**1.1**[c]	0.026	0%	11%
Molybdenum	µg/L	8	0.1	0.3	2.5	27	0.15	0.215	2.5	73	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Reference Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2005 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nickel	µg/L	8	0.6	1.4	2	27	0.2	0.47	2.6	25-150[k]	0%	0%
Potassium	µg/L	8	1300	1450	1700	27	900	1100	1430	-	-	-
Rubidium	µg/L	2	<50	-	<50	18	1.1	1.1	25	-	-	-
Selenium	µg/L	8	<1	-	0.4	27	<0.5	-	0.7	1	0%	0%
Silicon	µg/L	3	1200	1700	1800	9	910	1060	1980	-	-	-
Silver	µg/L	8	<0.4	-	<0.1	27	<5	-	0.02	0.1	0%	0%
Sodium	µg/L	8	3200	3650	4000	27	2000	3000	3780	-	-	-
Strontium	µg/L	5	37.2	40	46.7	21	27.5	35	53	-	-	-
Sulphur	µg/L	3	900	1000	1000	3	<3000	-	<3000	-	-	-
Thallium	µg/L	8	<0.2	-	<0.1	27	<50	-	<0.002	0.8	0%	0%
Tin	µg/L	8	0.2	11	25	27	<50	-	0.15	-	-	-
Titanium	µg/L	8	0.5	9	16	27	0.5	1.3	5.8	-	-	-
Uranium	µg/L	8	0.19	0.2	0.3	27	0.16	0.2	25	-	-	-
Vanadium	µg/L	8	0.1	2	2	27	0.16	0.33	2	-	-	-
Zinc	µg/L	8	<4	-	3	27	0.5	4	15.6	30	0%	0%
Zirconium	µg/L	0	-	-	-	6	<5	-	<5	-	-	-
Dissolved Metals												
Aluminum	µg/L	8	2.5	10	78	27	5	8.6	20	-	-	-
Antimony	µg/L	8	<0.4	-	0.4	27	0.025	0.1	0.7	-	-	-
Arsenic	µg/L	8	0.5	0.8	1.1	27	0.5	0.79	1.7	-	-	-
Barium	µg/L	8	5	14.6	18.4	27	8.8	10	20.4	-	-	-
Beryllium	µg/L	8	<1	-	<0.5	27	<1	-	<0.01	-	-	-
Bismuth	µg/L	2	<0.05	-	<0.05	21	<1000	-	<0.005	-	-	-
Boron	µg/L	8	20	30	38	27	19	24	31	-	-	-
Cadmium	µg/L	8	0.005	0.04	0.05	27	0.005	0.024	0.5	-	-	-
Cesium	µg/L	2	<0.1	-	<0.1	18	<50	-	<0.03	-	-	-
Chromium	µg/L	8	<1	-	<0.4	27	<5	-	0.8	-	-	-
Cobalt	µg/L	8	<2	-	0.2	27	0.02	0.03	1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Reference Lake								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2008 - 2010)				Open Water[b] (2005 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Copper	µg/L	8	0.5	1.2	1.3	27	0.48	1.3	3.9	-	-	-
Iron	µg/L	8	15	63.5	154	27	11	40	2340	-	-	-
Lead	µg/L	8	<0.2	-	0.3	27	0.044	0.071	2.5	-	-	-
Lithium	µg/L	8	<20	-	2.3	27	1.3	1.8	5	-	-	-
Manganese	µg/L	8	2.5	22.1	77	27	0.5	2.5	506	-	-	-
Mercury	µg/L	8	<0.1	-	<0.02	24	<0.2	-	0.31	-	-	-
Molybdenum	µg/L	8	0.2	0.3	2.5	27	0.15	0.205	2.5	-	-	-
Nickel	µg/L	8	0.7	0.9	1.3	27	<2	-	0.9	-	-	-
Rubidium	µg/L	2	<50	-	<50	18	0.92	1.1	25	-	-	-
Selenium	µg/L	8	<1	-	<0.4	27	<0.5	-	0.04	-	-	-
Silicon	µg/L	3	1200	1400	1400	9	750	990	2240	-	-	-
Silver	µg/L	8	<0.2	-	0.2	27	<5	-	<0.005	-	-	-
Strontium	µg/L	5	30	40	51.1	21	29.9	33	39.9	-	-	-
Sulphur	µg/L	3	900	1100	1100	3	<3000	-	<3000	-	-	-
Thallium	µg/L	8	<0.2	-	<0.05	27	<50	-	0.01	-	-	-
Tin	µg/L	8	0.1	4	25	27	<50	-	1.98	-	-	-
Titanium	µg/L	8	0.4	0.6	7	27	<1	-	0.8	-	-	-
Uranium	µg/L	8	0.1	0.2	0.25	27	0.13	0.2	25	-	-	-
Vanadium	µg/L	8	0.05	1	2	27	<1	-	0.8	-	-	-
Zinc	µg/L	8	<4	-	6	27	0.5	3.5	19.1	-	-	-
Zirconium	µg/L	0	-	-	-	9	<5	-	0.1	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Marian River								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Field measured												
pH	pH units	2	6.55	-	6.79	8	7.13	7.35	7.56	6.5 - 9[d]	0%	0%
Temperature	°C	2	0.61	-	1.15	8	14	15.45	17.6	-	-	-
Specific Conductance	µS/cm	2	249	-	251	8	228	252	276	-	-	-
Dissolved Oxygen	mg/L	2	10.31	-	13.49	8	9.56	10.27	11.37	6.5 or 9.5[e]	0%/0%	0%/0%
Turbidity	NTU	2	7.2	-	10	4	0.5	3.25	4.5	-	-	-
Secchi depth	m	0	-	-	-	0	-	-	-	-	-	-
Conventional Parameters												
Specific Conductance	µS/cm	9	204	257	280	16	72	154	180	-	-	-
Dissolved Organic Carbon	mg/L	5	7.8	9.5	11.1	11	9.2	11.3	23	-	-	-
Hardness	mg/L	9	94	120	150	16	31	77.5	98.7	-	-	-
pH	pH units	9	7.7	7.8	7.93	16	7.4	7.89	8.1	6.5 - 9[d]	0%	0%
Total Alkalinity, as $CaCO_3$	mg/L	9	84	101	110	13	31	59	70	-	-	-
Total Dissolved Solids	mg/L	3	145	147	149	8	70	111	130	-	-	-
Total Organic Carbon	mg/L	6	9.4	10.5	14	13	10	11.9	17	-	-	-
Total Suspended Solids	mg/L	9	0.5	4	5	8	1.5	4.5	6	-	-	-
Turbidity	NTU	7	0.55	1	3.5	8	0.8	2.9	6.2	-	-	-
Major Ions												
Bicarbonate, as $CaCO_3$	mg/L	9	102	123	130	13	38	72	85	-	-	-
Calcium	mg/L	9	22.2	28	34	16	7.4	17.7	20.3	-	-	-
Carbonate, as $CaCO_3$	mg/L	9	<5	-	<1	13	<5	-	<5	-	-	-
Chloride	mg/L	9	2	3	4	16	1.4	2	3.3	230	0%	0%
Magnesium	mg/L	9	9.3	12.2	15	16	3.1	8.1	9.1	-	-	-
Potassium	mg/L	9	1.8	2	2.9	16	0.9	1.3	1.5	-	-	-
Sodium	mg/L	9	3.7	4	5.6	16	1.5	2.8	4.4	-	-	-
Sulphate	mg/L	9	15.7	24.5	26.5	13	2.2	15	16.4	-	-	-
Nutrients												
Nitrate	mg-N/L	9	0.05	0.093	0.1	13	<0.1	-	<0.006	2.93	0%	0%
Nitrite	mg-N/L	9	<0.06	-	<0.05	13	<0.05	-	<0.002	0.06	0%	0%
Nitrate + Nitrite	mg-N/L	9	0.05	0.093	0.1	16	<0.1	-	0.011	2.93	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Marian River								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Nitrogen - Ammonia	mg-N/L	9	0.02	0.025	0.05	16	0.0025	0.027	0.11	0.019[f]	0%	0%
Nitrogen - Kjeldahl	mg-N/L	9	0.54	0.8	1.13	16	0.37	0.568	0.814	-	-	-
Nitrogen (N), Total	mg/L	3	<1	-	<1	3	0.39	0.52	0.62	-	-	-
Phosphorus, total	mg/L	9	0.0061	0.0097	0.013	16	0.009	0.0127	0.03	50	0%	0%
Phosphorus, dissolved	mg/L	5	0.0042	0.0051	0.05	8	0.0017	0.0034	0.0044	-	-	-
Total Metals												
Aluminum	µg/L	9	10	24	**110**[c]	16	39.4	60	**253**[c]	5-100[g]	11%	25%
Antimony	µg/L	9	<0.4	-	<0.2	16	<0.4	-	0.04	-	-	-
Arsenic	µg/L	9	0.2	0.55	1.2	16	0.2	0.52	2.7	5	0%	0%
Barium	µg/L	9	14.5	16.6	20	16	9	13	17.2	-	-	-
Beryllium	µg/L	9	<1	-	<1	16	<2	-	0.01	-	-	-
Bismuth	µg/L	4	<0.1	-	0.1	8	<1000	-	0.006	-	-	-
Boron	µg/L	9	10	20	25	16	<50	-	30	1500	0%	0%
Cadmium	µg/L	9	0.005	0.03	**0.1**[c]	16	<1	-	**0.065**[c]	0.017[h]	0%	13%
Calcium	µg/L	9	23200	29000	30100	16	7500	17050	23400	-	-	-
Cesium	µg/L	4	<50	-	<50	5	<50	-	<50	-	-	-
Chromium	µg/L	9	<1	-	<0.8	16	<5	-	0.7	1	0%	0%
Cobalt	µg/L	9	<2	-	<0.2	16	<2	-	0.29	-	-	-
Copper	µg/L	9	0.5	0.95	1.1	16	0.5	1	2	2-4[i]	0%	0%
Iron	µg/L	9	87	124	**380**[c]	16	64	108	**653**[c]	300	11%	19%
Lead	µg/L	9	<0.2	-	<0.1	16	<5	-	0.20	1-7[j]	0%	0%
Lithium	µg/L	9	<20	-	<6	16	<10	-	5	-	-	-
Magnesium	µg/L	9	9800	12800	13300	16	3200	7400	10200	-	-	-
Manganese	µg/L	9	22.2	38	56	16	9.7	16.5	35.4	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	16	<0.2	-	<0.01	0.026	0%	0%
Molybdenum	µg/L	9	0.1	0.2	2.5	16	<5	-	0.2	73	0%	0%
Nickel	µg/L	9	0.6	1	1.9	16	<2	-	1.6	25-150[k]	0%	0%
Potassium	µg/L	9	2000	2200	2600	16	920	1340	1690	-	-	-
Rubidium	µg/L	4	<50	-	<50	5	<50	-	<10	-	-	-
Selenium	µg/L	9	<1	-	0.4	16	<0.5	-	0.9	1	0%	0%

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Marian River								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Silicon	µg/L	3	1400	1400	1500	3	960	1010	1400	-	-	-
Silver	µg/L	9	<0.4	-	<0.1	16	<5	-	**0.13**[c]	0.1	0%	6%
Sodium	µg/L	9	3900	4000	5000	16	1700	3000	4610	-	-	-
Strontium	µg/L	7	82.4	95.7	120	8	31	65.5	94.7	-	-	-
Sulphur	µg/L	3	8600	8700	8900	3	1500	8000	8000	-	-	-
Thallium	µg/L	9	<0.2	-	<0.1	16	<50	-	0.003	0.8	0%	0%
Tin	µg/L	9	<50	-	<0.4	16	<50	-	0.13	-	-	-
Titanium	µg/L	9	0.5	2	2.5	16	1	2.6	11.3	-	-	-
Uranium	µg/L	9	0.7	0.9	1.4	16	0.21	0.54	25	-	-	-
Vanadium	µg/L	9	0.1	1	1	16	<1	-	1.4	-	-	-
Zinc	µg/L	9	<4	-	<3	16	2	4	**70**[c]	30	0%	6%
Zirconium	µg/L	0	-	-	-	0	-	-	-	-	-	-
Dissolved Metals												
Aluminum	µg/L	9	4	6	60	15	9.7	17.1	66.4	-	-	-
Antimony	µg/L	9	0.1	0.45	0.5	15	<0.4	-	0.03	-	-	-
Arsenic	µg/L	9	0.4	0.5	1.1	15	0.2	0.51	2.2	-	-	-
Barium	µg/L	9	10	16.4	20	15	8	11.4	14.7	-	-	-
Beryllium	µg/L	9	<1	-	<0.5	15	<1	-	0.01	-	-	-
Bismuth	µg/L	4	<0.05	-	<0.05	7	<1000	-	<0.005	-	-	-
Boron	µg/L	9	10	23	30	15	<50	-	<50	-	-	-
Cadmium	µg/L	9	0.005	0.03	0.05	15	<1	-	0.04	-	-	-
Cesium	µg/L	4	<0.1	-	<0.1	4	<50	-	<50	-	-	-
Chromium	µg/L	9	<1	-	<0.4	15	<5	-	0.4	-	-	-
Cobalt	µg/L	9	<2	-	0.1	15	<2	-	0.213	-	-	-
Copper	µg/L	9	0.5	0.8	1	15	0.5	1	1	-	-	-
Iron	µg/L	9	30	75	233	15	15	35	431	-	-	-
Lead	µg/L	9	<0.2	-	0.1	15	<5	-	0.11	-	-	-
Lithium	µg/L	9	2.8	3.1	10	15	<10	-	4.4	-	-	-
Manganese	µg/L	9	21.3	34	49	15	0.5	11	23.5	-	-	-
Mercury	µg/L	9	<0.1	-	<0.02	15	<0.2	-	<0.01	-	-	-

Table 7.3-3: Summary of Baseline Surface Water Quality (2003 to 2010) Within the Local Study Area (continued)

Parameter Name	Unit	Marian River								Canadian Council of the Ministers of Environment		
		Ice Cover[a] (2006 - 2010)				Open Water[b] (2004 - 2009)				Protection of Freshwater Aquatic Life		
		n=	Minimum	Median	Maximum	n=	Minimum	Median	Maximum	Guideline	% Ice-covered Results Above Guideline	% Open Water Results Above Guideline
Molybdenum	µg/L	9	0.1	0.2	2.5	15	<5	-	0.16	-	-	-
Nickel	µg/L	9	0.6	1	2.1	15	<2	-	1.4	-	-	-
Rubidium	µg/L	4	<50	-	<50	4	<50	-	<50	-	-	-
Selenium	µg/L	9	<1	-	<0.4	15	<0.5	-	0.04	-	-	-
Silicon	µg/L	3	1500	1500	1600	3	927	989	1450	-	-	-
Silver	µg/L	9	<0.2	-	<0.1	15	<5	-	0.005	-	-	-
Strontium	µg/L	7	87.8	107	120	7	29	62	81.5	-	-	-
Sulphur	µg/L	3	8700	8900	9700	3	1500	7000	7000	-	-	-
Thallium	µg/L	9	<0.2	-	<0.05	15	<50	-	0.009	-	-	-
Tin	µg/L	9	<50	-	<0.2	15	<50	-	0.04	-	-	-
Titanium	µg/L	9	<1	-	1.6	15	0.5	1	2.5	-	-	-
Uranium	µg/L	9	0.7	0.9	1	15	0.183	0.54	25	-	-	-
Vanadium	µg/L	9	0.05	1	1	15	<1	-	0.4	-	-	-
Zinc	µg/L	9	0.5	3	8	15	0.5	3	8	-	-	-
Zirconium	µg/L	0	-	-	-	3	0.05	0.6	0.6	-	-	-

[a] Ice cover season defined as November through April.

[b] Open water season defined as May through October.

[c] Result exceeds Canadian Council of the Minister of the Environment Protection of Freshwater Aquatic Life Guideline (CCME 1999), is beyond the pH guideline range, or is below the minimum DO guideline.

[d] Guideline represents a range.

[e] 6.5 = Guideline for early life stages in cold water, 9.5 = Guideline is for other life stages in cold water; exceedance summary reflects percentage of observations below the respective guideline values.

[f] Guideline is for un-ionized ammonia; total ammonia guideline concentrations were calculated using sample specific pH and temperature values for comparison to analytical results.

[g] 5.0 for pH<6.5, 100 for pH≥6.5.

[h] Cadmium Guideline = $10^{(0.86(\log(\text{hardness}))-3.2)}$

[i] 2 µg/L at hardness of 0 to 120 mg/L, 3 µg/L at hardness of 120 to 180 mg/L, 4 µg/L at hardness of > 180 mg/L.

[j] 1 µg/L at hardness of 0 to 60 mg/L, 2 µg/L at hardness of 60 to 120 mg/L, 4 µg/L at hardness of 120 to 180 mg/L, 7 µg/L at hardness of > 180 mg/L.

[k] 25 µg/L at hardness of 0 to 60 mg/L, 65 µg/L at hardness of 60 to 120 mg/L, 110 µg/L at hardness of 120 to 180 mg/L, 150 µg/L at hardness of > 180 mg/L.

n = number of samples; mg/L = milligrams per litre; °C = degrees Celcius; µS/cm = microSiemens per centimeter; NTU = Nephelometric turbidity units; mg-N/L = milligram nitrogen per litre; µg/L = micrograms per litre; percent represents percent of results per season per water body that was above guidelines; CCME = Canadian Council of the Ministers of Environment; PFAL = Protection of Freshwater Aquatic Life.

Bold values indicate summary statistic exceeding a guideline.

7.3.1.2.2 Field Physico-chemical Parameters

Ponds and lakes were generally well mixed during the summer months and stratified during spring months, with some thermal stratification evident during the winter months (Annex C, Appendix V). Seasonal field physico-chemical water column profiles from Burke Lake are provided as an example of the field temperature and DO conditions within the deeper lakes of the LSA (Figures 7.3-2 and 7.3-3). The Burke Lake temperature and DO profiles are generally representative of conditions observed in other lakes in the LSA.

During winter conditions, where stratification was evident, water temperature increased slightly with depth, while DO concentrations decreased with depth. During under-ice conditions, maximum DO concentrations near the surface in ponds and lakes tended to be below 6.5 milligrams per litre (mg/L) (e.g., Burke Lake, Figure 7.3-2). Thermal stratification with low near bottom DO concentrations continued into the spring.

During the summer/fall season, thermal stratification did not typically occur in the shallow lakes and ponds, but in the deeper lake basins of Reference, Burke, and Lou lakes, thermal stratification occurred. Concentrations of DO were measured below the CWQG for the protection of early life stages (9.5 mg/L) for some profiles, but above the CWQG for the protection of other life stages (6.5 mg/L), with the exception of the near-bottom results. This observation is typical of many Canadian lakes that stratify in summer when water temperatures and primary productivity peak. After fall turnover, lakes within the NICO Project LSA and RSA tended to remain well mixed and isothermic, with many DO concentrations above the CWQG for the protection of early stages of aquatic life (9.5 mg/L).

Field pH and DO were commonly outside the CCME guideline ranges. Dissolved oxygen concentrations under-ice were more commonly below the CCME guideline for other life stages in cold water than open water DO concentrations.

7.3.1.2.3 General Parameters

Ponds and lakes generally were clear, calcium bicarbonate-dominated waterbodies with soft water, low ion content, near-neutral pH, and low to moderate alkalinity. The exceptions were Grid Pond and Little Grid Pond, which were moderately hard and had substantially higher major ion concentrations. Grid Pond had specific conductance (conductivity) readings that ranged from 63 to 372 microSiemens per centimetre (µS/cm) and included some of the highest conductivity readings in the baseline data. During the open water period, conductivity readings in Grid Pond appeared to be highest before the 2008 forest fire (Figure 7.3-4).

Conductivity measurements in other waterbodies were lower (i.e., 55 to 80 µS/cm), with Lou Lake outside of the Burke Lake watershed having the lowest range of conductivity values. Reference Lake had relatively high conductivity values (i.e., 95 to 100 µS/cm) compared to these lakes (Figure 7.3-5). Higher conductivity in Reference Lake may be attributed to the possible influence of groundwater upwelling, and is supported by elevated near-bottom iron concentrations with low total suspended solids compared to other lakes.

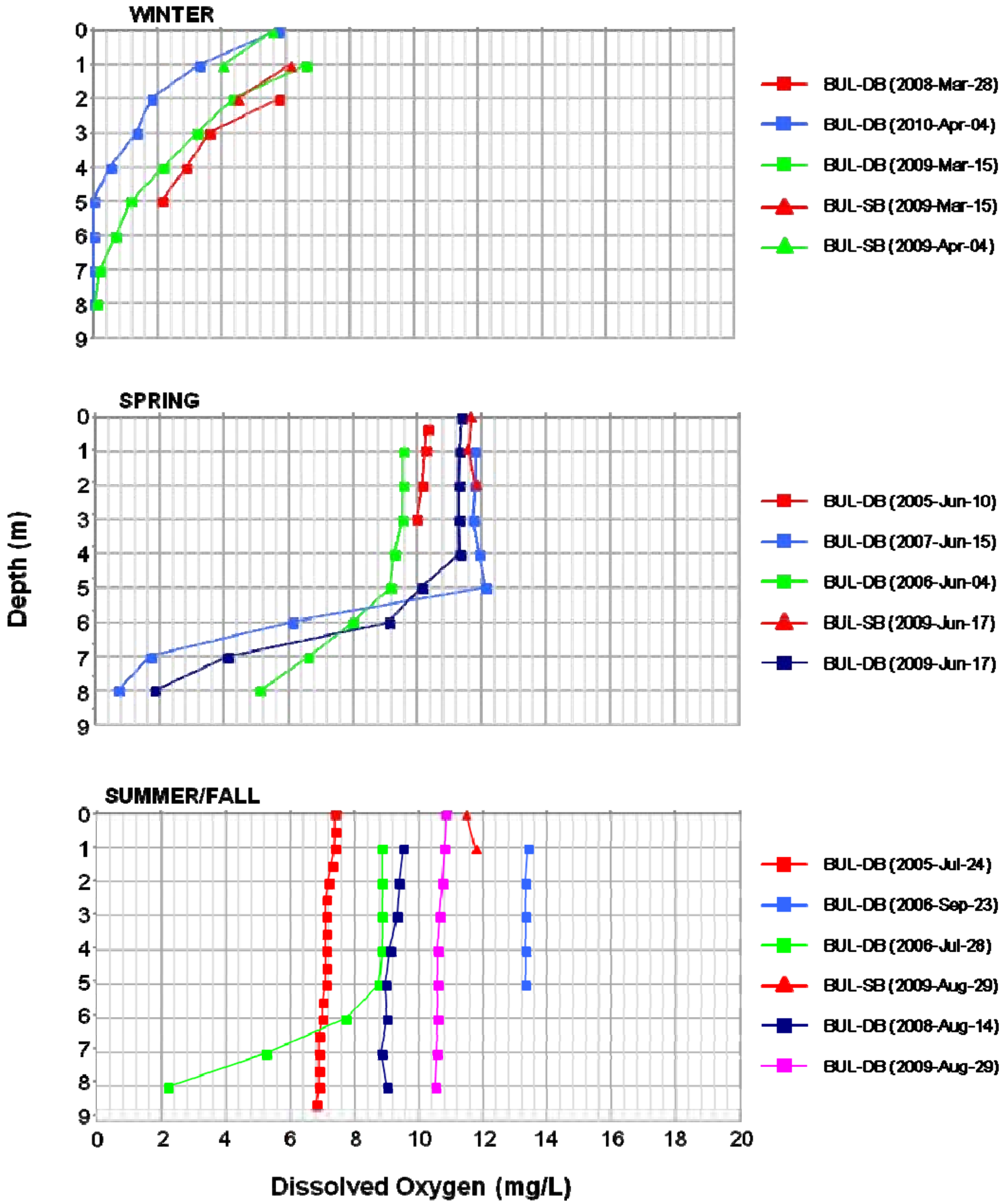


Figure 7.3-2: Dissolved Oxygen Profiles in Burke Lake during Winter, Spring, and Summer/Fall Periods (2005 to 2010)

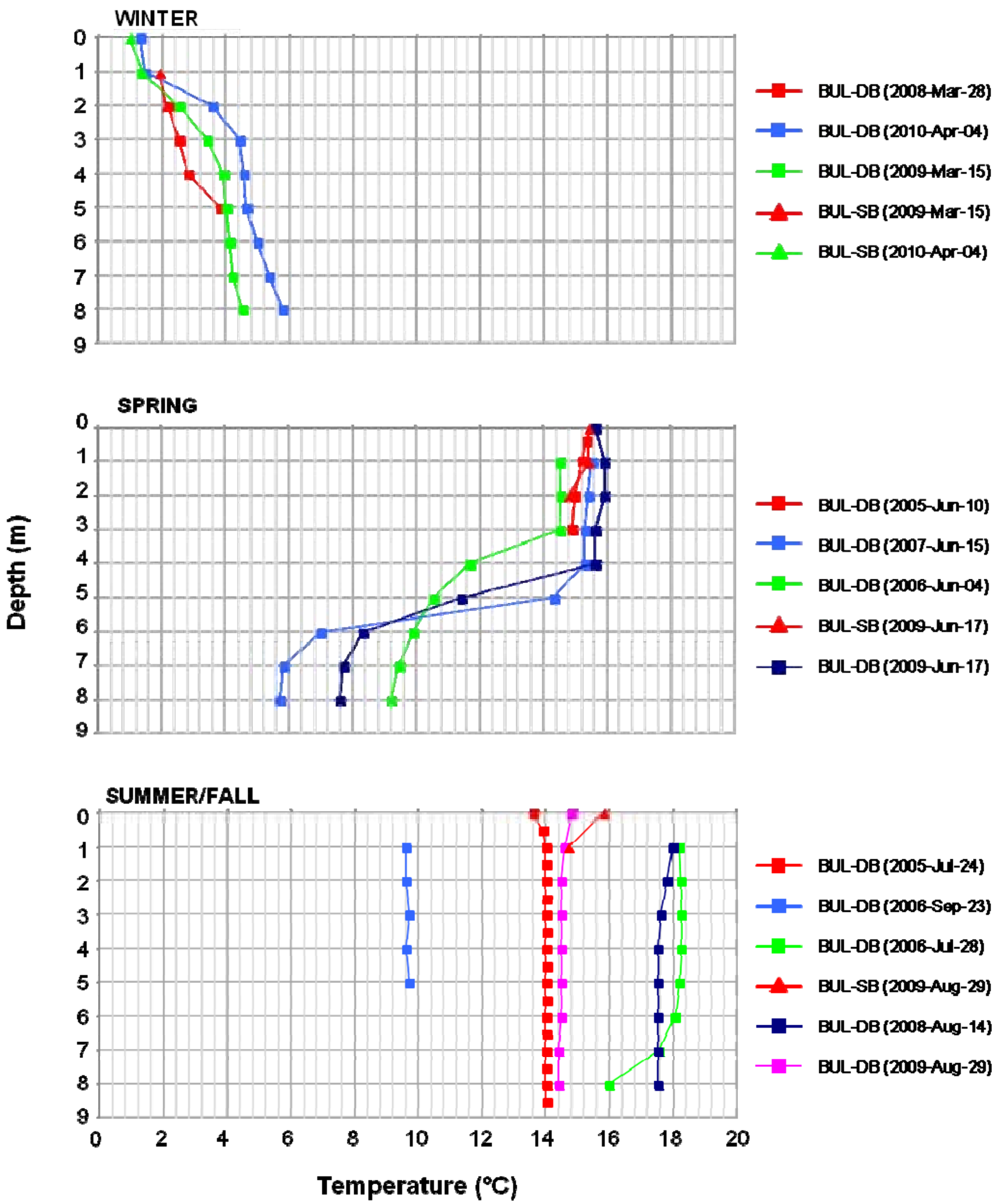
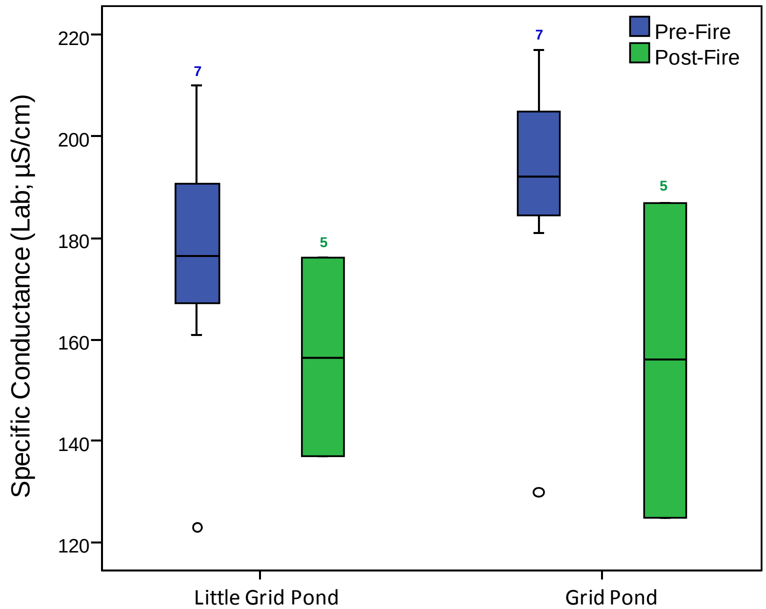


Figure 7.3-3: Temperature Profiles in Burke Lake during Winter, Spring, and Summer/Fall Periods (2005 to 2010)

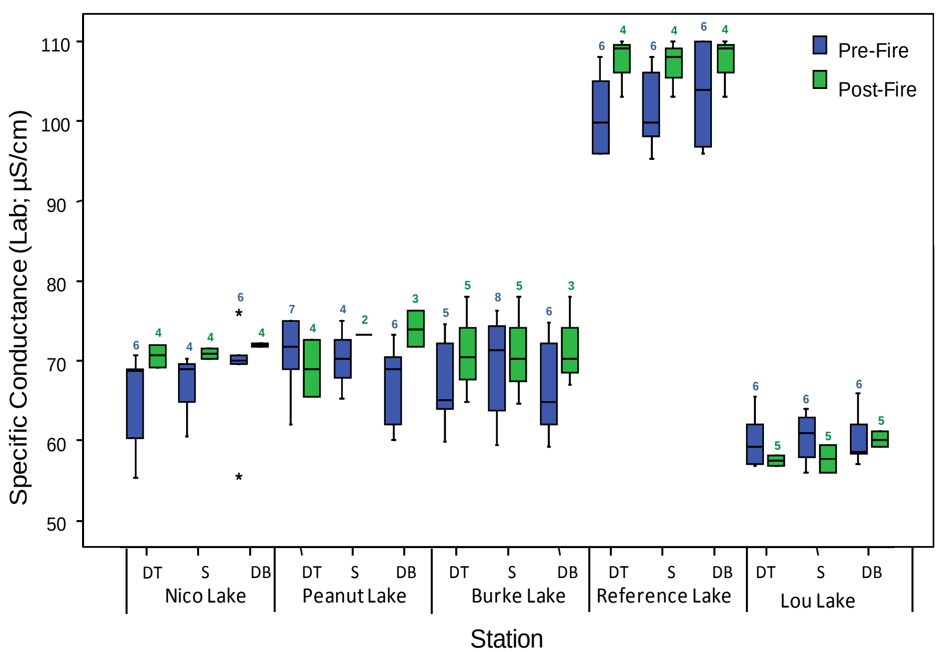


Numbers at the top of each plot indicate the sample size (n) used to generate the box plot for each sampling station.

◦ = outlying values

* = extreme values

Figure 7.3-4: Specific Conductance in Water Samples Collected from the Grid Ponds During the Open Water Period



Numbers at the top of each plot indicate the sample size (n) used to generate the box plot for each sampling station.

DT = Deep Basin Top

S = Shallow Basin

DB = Deep Basin Bottom

Figure 7.3-5: Specific Conductance in Water Samples Collected from Nico, Peanut, Burke, Reference, and Lou Lakes During the Open Water Periods

7.3.1.2.4 Nutrients

Based on total phosphorus concentrations, most lakes in the Burke Lake watershed downstream of the NICO Project could be classified as mesotrophic to meso-eutrophic (i.e., moderately productive; mesotrophic trigger level = 0.010 to 0.020 mg/L and meso-eutrophic = 0.020 to 0.035 mg/L) based on CCME (2004). The exception to this trophic status was Grid Pond (Figure 7.3-6), which could be classified as eutrophic (highly productive; eutrophic = 0.035 to 0.100 mg/L) with pre-fire open water concentrations as high as 0.1 mg/L. Total phosphorus data from Reference Lake was similar to the lakes in the Burke Lake watershed (Figure 7.3-7), with the exception of deep water post-fire samples. The total phosphorus concentrations from Lou Lake tended to be lower (i.e., mesotrophic) (Figure 7.3-7). Phosphorus inputs to these lakes potentially include notable natural geochemical sources, such as releases of nutrients from the weathering of the surrounding rock, and surface and/or groundwater drainage from the surrounding peatland (muskeg).

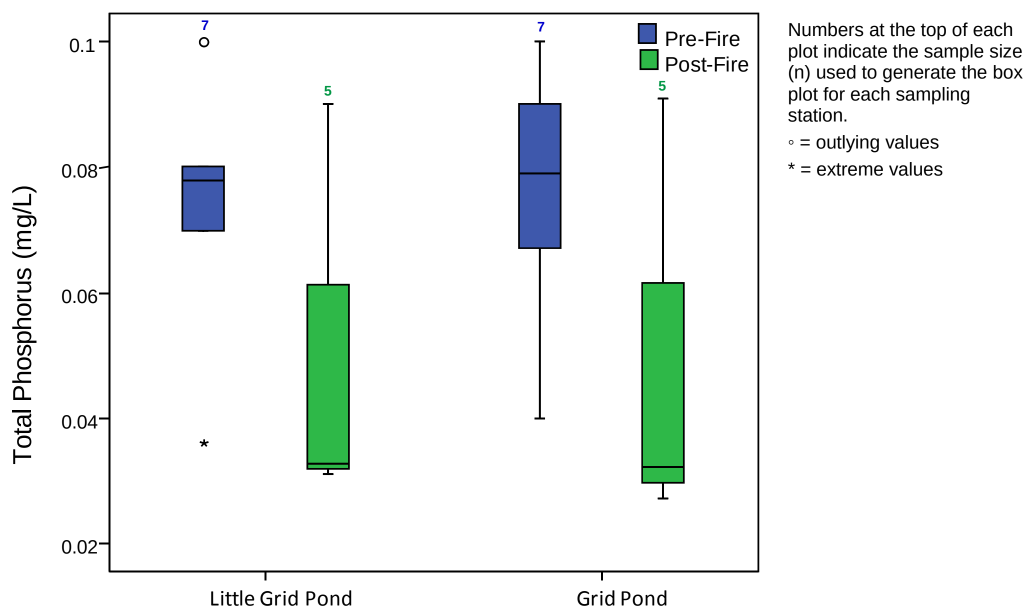


Figure 7.3-6: Total Phosphorus Measured in Water Samples Collected in the Grid Ponds During the Open Water Period

Total nitrogen data (Figure 7.3-8 and Figure 7.3-9) represent the sum of total Kjeldahl nitrogen, total nitrate, and total nitrite concentrations. Total Kjeldahl nitrogen represents organically bound nitrogen and total ammonia. Concentrations of total nitrogen were high in the lakes of 3 watersheds (i.e., Lou, Burke, and Reference lakes) relative to other lakes within the central Arctic region of the NWT. However, results for ammonia, nitrate, or nitrite were not measured above CCME guidelines (CCME 1999). The highest concentrations of total nitrogen were near the bottom of the deep water site in Reference Lake during pre-fire conditions, with the exception of one outlier near the surface.

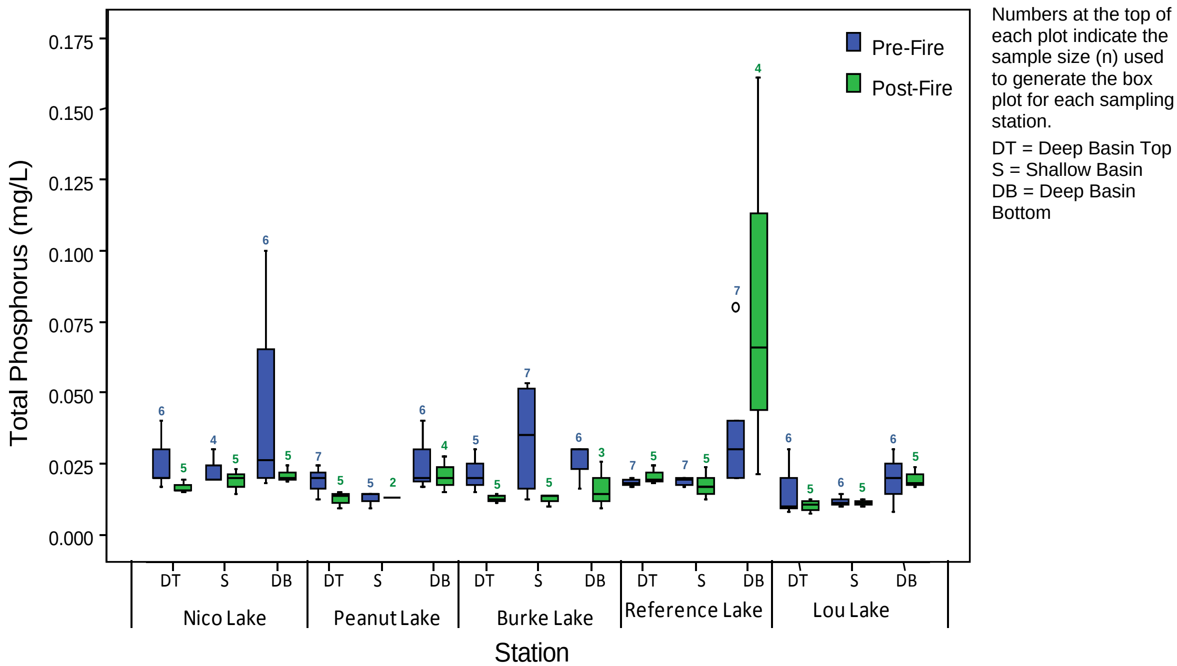


Figure 7.3-7: Total Phosphorus Measured in Water Samples Collected During the Open Water Period

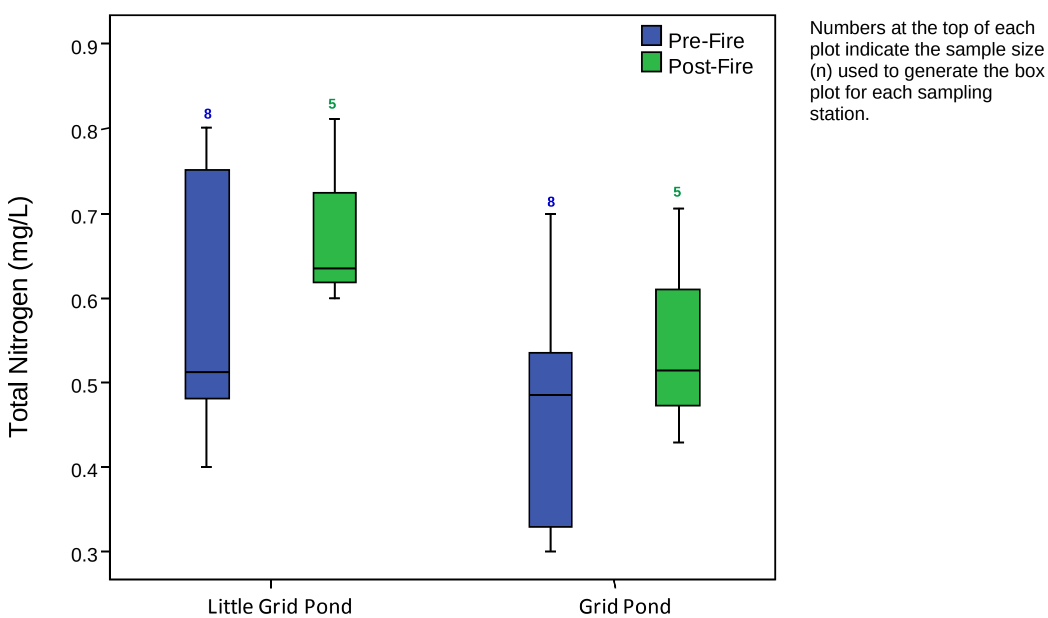


Figure 7.3-8: Total Nitrogen Measured in Water Samples Collected in the Grid Ponds During the Open Water Period

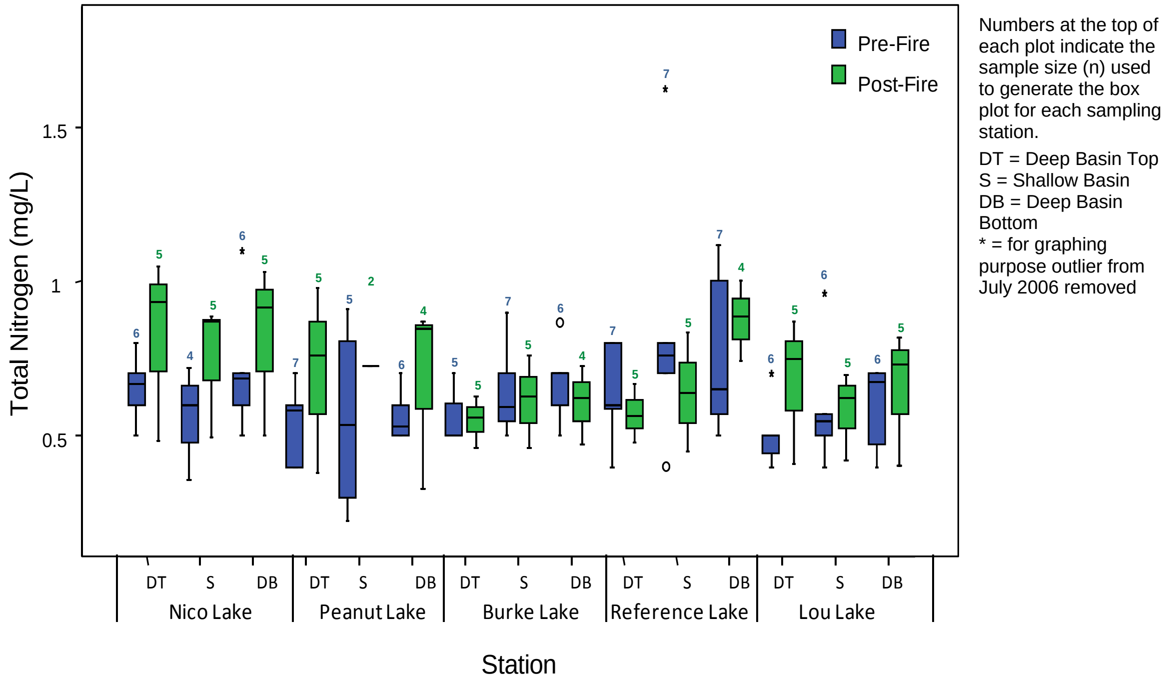


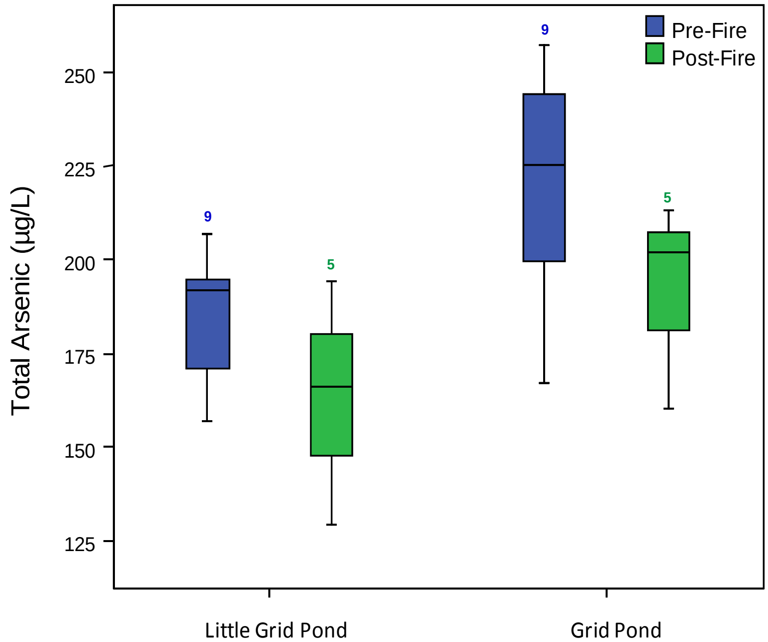
Figure 7.3-9: Total Nitrogen Measured in Water Samples Collected During the Open Water Period

7.3.1.2.5 Metals

Metals that were above guidelines for a notable proportion of results included aluminum, arsenic, cadmium, chromium, copper, iron, manganese, mercury, molybdenum, silver, and thallium. Some of these exceedances may have been due to high detection limits for cadmium, chromium, lead, mercury, silver, and thallium. The occurrence of naturally elevated concentrations of these metals in the Burke Lake watershed reflects the highly mineralized catchment of the NICO Project LSA and metal inputs to these lakes from natural geochemical sources, such as the weathering of the surrounding rock, and surface and/or groundwater drainage. For a number of metals, the 2008 fire resulted in a further short-term elevation of metals concentrations, particularly metals associated with the high mineralization associated with the geology in the catchment.

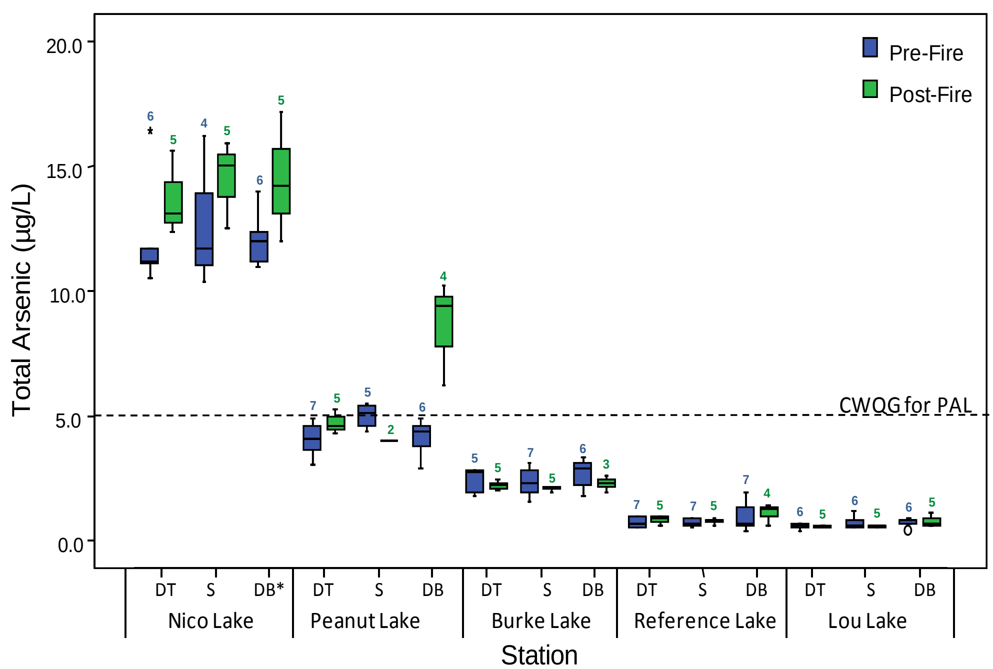
Notable metals include the following:

- **Aluminum:** Total aluminum concentrations were commonly above guidelines in Peanut, Burke, and Reference lakes. These elevated levels may have also been influenced from the forest fire.
- **Arsenic:** 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. Arsenic is mostly found in the earth's crust as an arsenide of true metals (Merck 1989), resulting in the expectation that it would be elevated in Grid Pond and Little Grid Pond, which are closely associated with the ore body. Elevated total arsenic concentrations were measured in Nico Lake, before and after the forest fire (Figure 7.3-10 and Figure 7.3-11). Total arsenic concentrations were higher in Nico Lake and Peanut Lake after the 2008 forest fire.



Numbers at the top of each plot indicate the sample size (n) used to generate the box plot for each sampling station.

Figure 7.3-10: Total Arsenic Measured in Water Quality Collected in the Grid Ponds During the Open Water Period



Numbers at the top of each plot indicate the sample size (n) used to generate the box plot for each sampling station.

DT = Deep Basin Top
S = Shallow Basin
DB = Deep Basin Bottom
* = for graphing purpose outlier from July 2006 removed
CWQG = Canadian Water Quality Guideline
PAL = Protection of Aquatic Life

Figure 7.3-11: Total Arsenic Concentrations Measured in Water Samples Collected During the Open Water Period

- **Copper:** Copper concentrations were above guidelines in Grid Pond and Little Grid Pond, which is not surprising as these waterbodies are in close proximity to the ore body. Other elevated copper concentrations were measured in lakes downstream of these ponds.
- **Iron:** A gradient of iron concentrations within the Burke Lake watershed was evident. Iron concentrations above the CWQG were also measured in lakes whose drainage areas were affected by the 2008 forest fire (i.e., Reference Lake) (Figure 7.3-12 and Figure 7.3-13). This is supported by the increase in post-fire deep water total iron concentrations in Reference Lake relative to the pre-fire deep water total iron concentrations. Grid Pond and Little Grid Pond had total and dissolved iron concentrations similar to deep water iron concentrations in Reference Lake.
- **Selenium:** Selenium was identified as an analyte of concern with respect to ore processing. Baseline total selenium concentrations were below the CCME guideline for the protection of freshwater aquatic life. However, most results were below the detection limit, which was at the guideline value of 1 microgram per litre (µg/L).

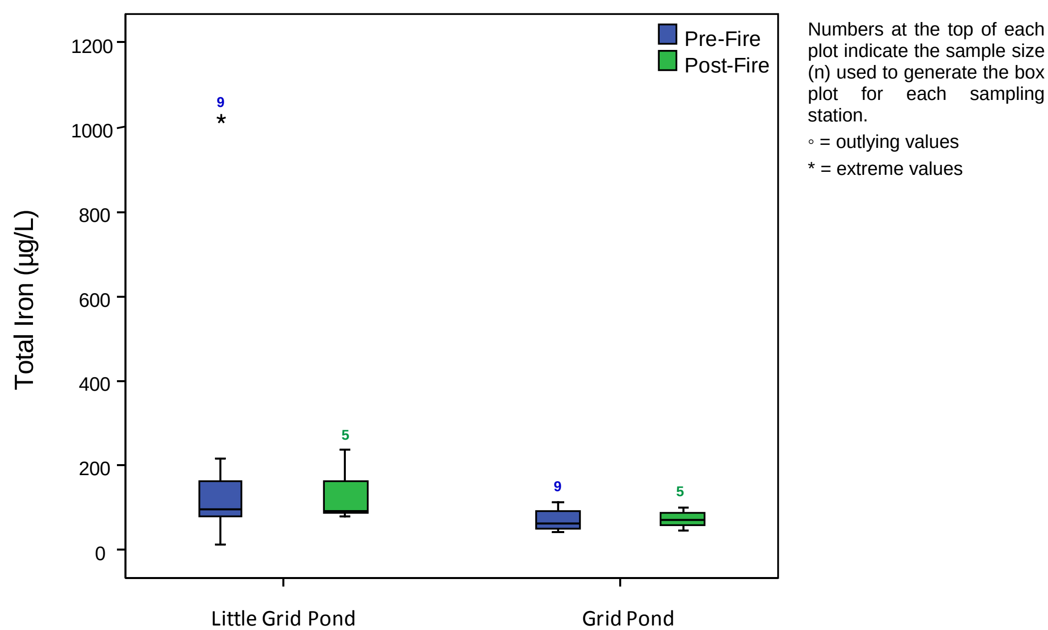


Figure 7.3-12: Total Iron Measured in Water Samples Collected in the Grid Ponds During the Open Water Period

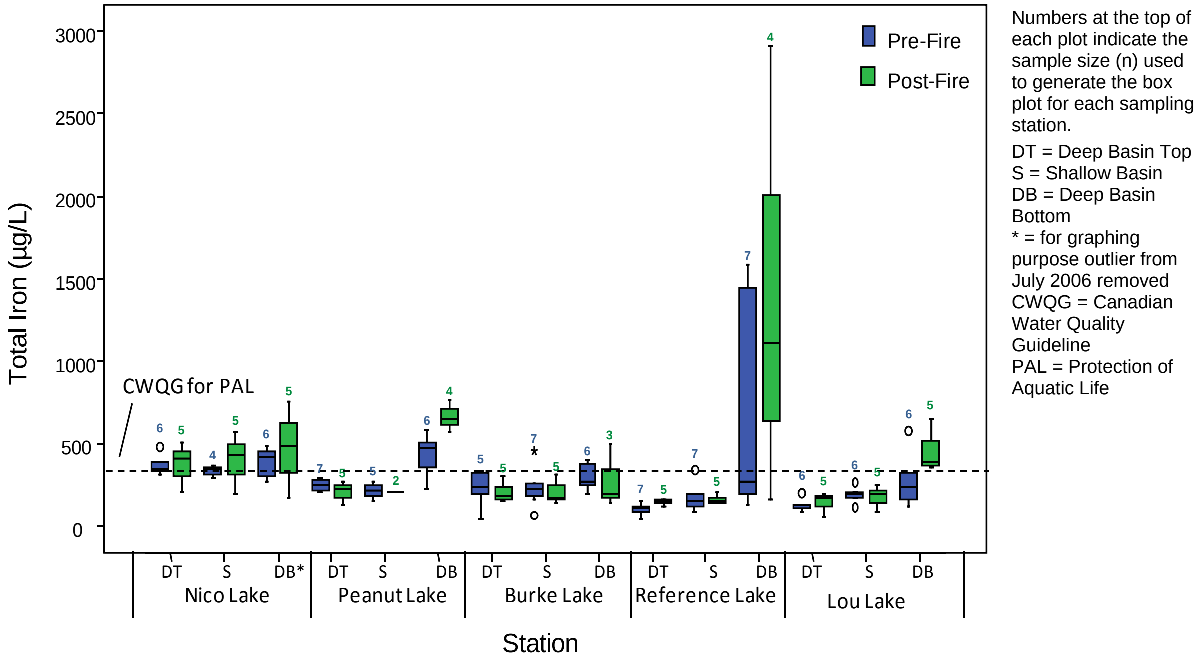


Figure 7.3-13: Total Iron Concentrations Measured in Water Samples Collected During the Open Water Period

7.3.2 Sediment Quality

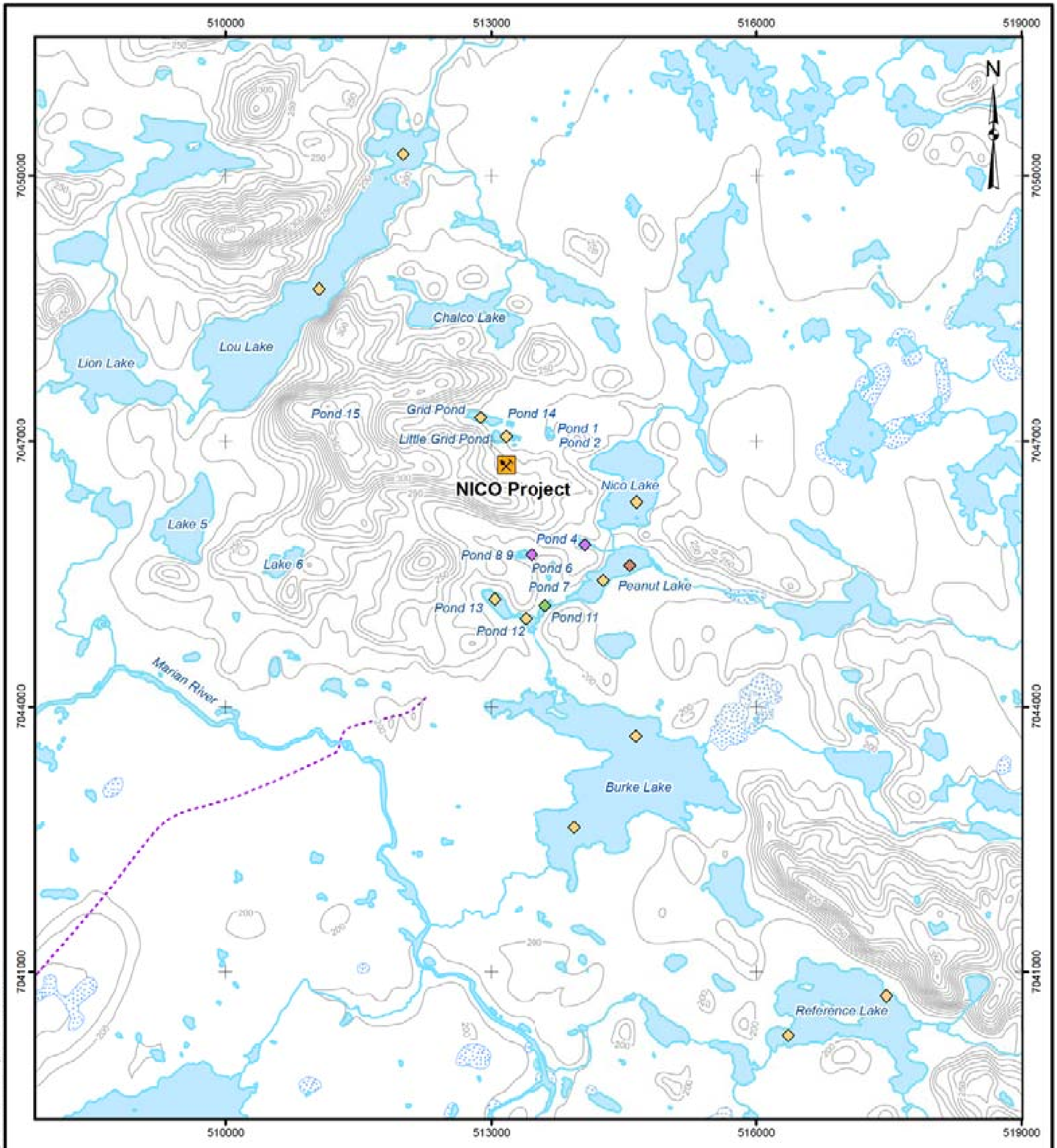
Bottom sediments in lakes act as both a source and a sink for metals, metalloids, and non-metals[1]. Metals in lake sediments can influence water quality, as well as benthic invertebrate and fish communities. Baseline concentrations of parameters of concern in sediment were characterized to provide information on naturally occurring concentrations, which can be used in the assessment of potential contamination as a result of mining activities.

This section provides an overview of baseline sediment quality for lakes within the Burke Lake watershed downstream of the NICO Project, as well as in Lou and Reference lakes, which are directly relevant to this KLOI. For additional information regarding sediment quality, the reader is referred to Annex C.

7.3.2.1 Methods

Lake and pond sediments were sampled concurrently with water sampling in July 2005, August 2005, August 2008, and August-September 2009. Sediment samples were collected from 10 waterbodies in 2005 and 2008, and 11 waterbodies in 2009 (Table 7.3-4; Figure 7.3-14). Sediment samples were collected in 3 drainage systems that flow into the Marian River (Burke Lake watershed, Reference Lake watershed, and Lou Lake watershed). Both shallow and deep basins were sampled in some lakes.

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



LEGEND

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

SEDIMENT SAMPLING LOCATION

- 2005 & 2008
- 2005 & 2008 & 2009
- 2008 & 2009
- 2009

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

SEDIMENT SAMPLING LOCATIONS, 2005, 2008, AND 2009

FILE No. E-WQ-005-GIS

PROJECT No. 09-1373-1004			SCALE AS SHOWN	REV. 0
DESIGN	SM	19 Sep. 2008	FIGURE: 7.3-14	
GIS	CW	13 May 2011		
CHECK	JG	13 May 2011		
REVIEW	JG	13 May 2011		

Golder Associates
Edmonton, Alberta

I:\CLIENTS\FORTUNE_MINERALS\08-1373-0017\Mapping\MXD\WaterQuality\E-WQ-005-GIS.mxd

Table 7.3-4: Summary of Sediment Sampling Stations in Waterbodies in the NICO Project Study Areas, 2005, 2008, and 2009

Waterbody		UTM Coordinates[b]		2005		2008		2009	
	Location[a]	Easting	Northing	Date	Water Depth (m)	Date	Water Depth (m)	Date	Water Depth (m)
Grid Pond	–	512880	7047268	17-Aug-05	0.8	17-Aug-08	2.1	31-Aug-09	1.8
Little Grid Pond	–	513169	7047055	17-Aug-05	0.5	18-Aug-08	1.4	31-Aug-09	1.1
Nico Lake	Shallow	514572	7045596	–	–	24-Jul-08	3.0	28-Aug-09	1.7
Nico Lake	Deep	514648	7046310	24-Jul-05	6.0	24-Jul-08	7.2	28-Aug-09	7.0
Pond 4	–	514064	7045833	–	–	–	–	1-Sep-09	0.2
Pond 9	–	513458	7045716	–	–	–	–	1-Sep-09	1.5
Peanut Lake	Shallow	514572	7045596	–	–	25-Jul-08	2.5	31-Aug-09	2.4
	Deep	514270	7045424	25-Jul-05	8.0	25-Jul-08	7.0	31-Aug-09	7.2
Pond 11	–	513612	7045145	18-Aug-05	0.4	17-Aug-08	1.0	–	–
Pond 12	–	513393	7044996	18-Aug-05	1.9	17-Aug-08	1.3	1-Sep-09	1.4
Pond 13	–	513039	7045217	25-Jul-05	1.0	18-Aug-08	1.3	1-Sep-09	1.3
Burke Lake	Shallow	513943	7042633	24-Jul-05	1.0	24-Jul-08	3.0	29-Aug-09	1.7
	Deep	514637	7043665	24-Jul-05	7.0	24-Jul-08	7.0	29-Aug-09	8.7
Lou Lake	Shallow	512001	7050242	20-Aug-05	1.0	20-Aug-08	1.8	26-Aug-09	2.1
	Deep	511054	7048725	20-Aug-05	20.0	20-Aug-08	22.3	26-Aug-09	23.5
Reference Lake	Shallow	516360	7040283	23-Jul-05	3.0	23-Jul-08	1.7	27-Aug-09	3.5
	Deep	517471	7040730	23-Jul-05	12.2	23-Jul-08	12.0	27-Aug-09	13.5

[a] Sampling location applies to waterbodies where samples were collected from both shallow (i.e., ≤3.5 m) and deep (i.e., >3.5 m) stations.

[b] UTM coordinates were collected in NAD 83, Zone 11V.

UTM = Universal Transverse Mercator; m = metre; Jul = July; Aug = August; – = not applicable or data not available.

An Ekman grab was used to collect sediment grab samples in 2005 and 2009, and a Tech-Ops™ core sampler was used to collect sediments from the upper 2 centimetre (cm) layer of sediments in 2008 and 2009. At each station 2 or 3 replicate samples were homogenized and combined to prepare a composite sample. A comparison of the 2 sampling methods indicated that there were no substantial differences in metal concentrations. Sediment samples were analyzed for metals (all years), major ions (2005), total Kjeldahl nitrogen (2005), and polycyclic aromatic hydrocarbons (2009, at a sub-set of 5 stations).

Quality control procedures included collection of field replicate samples. Comparison of duplicate and triplicate sample results indicated that replicate measurements were generally within data quality objectives. Some variability was observed in triplicate core samples, which is common in lake environments, and was accounted for by collecting composite samples. Sediment chemistry analyses were undertaken by laboratories accredited by the Canadian Association of Laboratory Accreditation, using standard operating procedures. Laboratory quality control included analyzing blanks, replicate samples, and spiked samples. Sample results met the laboratory's criteria for precision, accuracy, and laboratory blanks (Annex C, Appendix VII).

Chemistry data were compared to CCME sediment quality guidelines for the protection of aquatic life (i.e., the Interim Sediment Quality Guidelines [ISQGs] and Probable Effect Levels [PELs]) (CCME 1999). Concentrations below the ISQGs are unlikely to result in effects to aquatic organisms. The PELs represent the concentrations above which adverse effects on aquatic organisms are expected to occur frequently.

Arsenic concentrations are naturally elevated in sediments in and around the NICO Project LSA and RSA, with concentrations often above sediment quality guidelines. Arsenic concentrations were also compared to the GNWT Remediation Objective for arsenic (GNWT 2003). This objective was developed to account for naturally elevated arsenic concentrations in and around Yellowknife, NWT. As the LSA and RSA are close to, but outside the Yellowknife area, the full applicability of this guideline as a site-specific guideline for the LSA and RSA remains to be determined.

Total metal concentrations in sediments from each of the LSA waterbodies were also compared to concentrations in Reference Lake. This comparison identified metals with concentrations that naturally exceeded reference conditions as defined by sediment quality in Reference Lake.

A forest fire burned through the Marian River watershed during mid-July to early August, 2008, including some of the smaller watersheds within the LSA, and the Reference Lake watershed. Impacted areas included a section between Nico and Peanut lakes, and the shorelines of Burke and Reference lakes. The most intense burn period was in early August, before the 2008 sediment quality survey. Concentrations of metals measured in 2005 were compared to those measured in 2008/2009 to evaluate the potential effects of the forest fire.

7.3.2.2 Results

The following section describes baseline concentrations of selected metals; for more information on other parameters such as polycyclic aromatic hydrocarbons and nutrients, the reader is referred to Annex C.

Median and maximum concentrations of arsenic, chromium, copper, and zinc either frequently or periodically exceeded sediment quality guidelines in all lakes and ponds sampled. Concentrations of cadmium, lead, and mercury were below guidelines. The following discussion focuses on arsenic, chromium, copper, selenium, and zinc. Selenium is included because of the potential for predicted selenium concentrations in the receiving environment to be above the site-specific water quality objective. Concentrations are described on a dry weight basis.

7.3.2.2.1 Arsenic

Arsenic concentrations frequently exceeded sediment quality guidelines (Figures 7.3-15 and 7.3-16). The ISQG for arsenic (5.9 milligrams per kilograms [mg/kg]) was exceeded in sediments from all sampling locations with the exception of the shallow basin of Reference Lake in 2005 and 2009. The PEL for arsenic (17.0 mg/kg) was exceeded in several samples from Grid Pond, Little Grid Pond, Nico Lake, Peanut Lake, and Burke Lake. The GNWT Remediation Objective (150 mg/kg) was consistently exceeded in Grid Pond, Little Grid Pond, and Nico Lake.

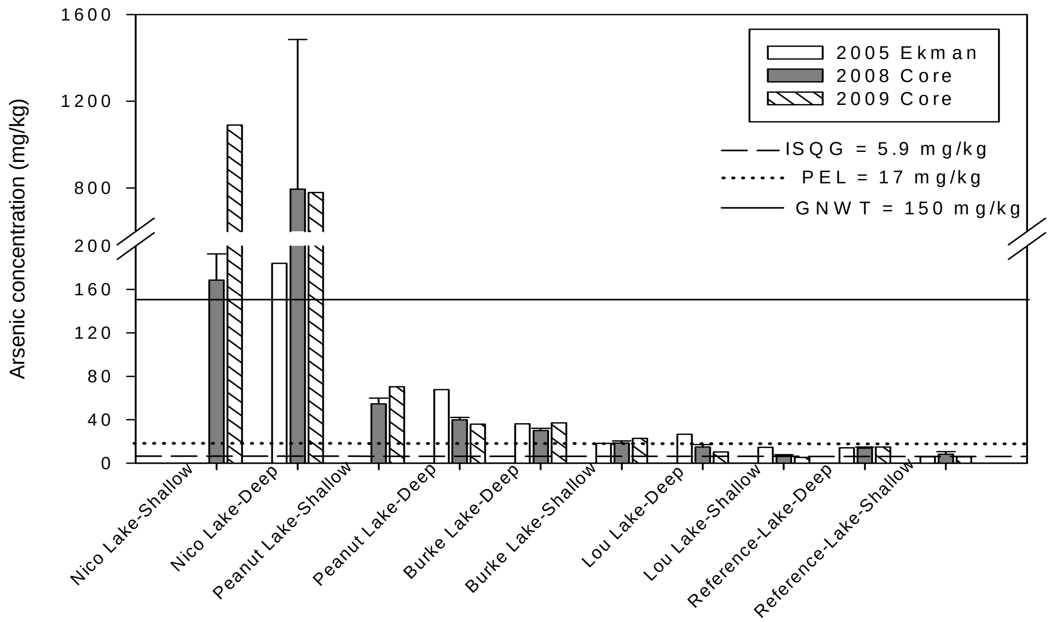


Figure 7.3-15: Total Arsenic Concentrations in Sediments from Lakes within the NICO Project Study Areas in 2005, 2008, and 2009

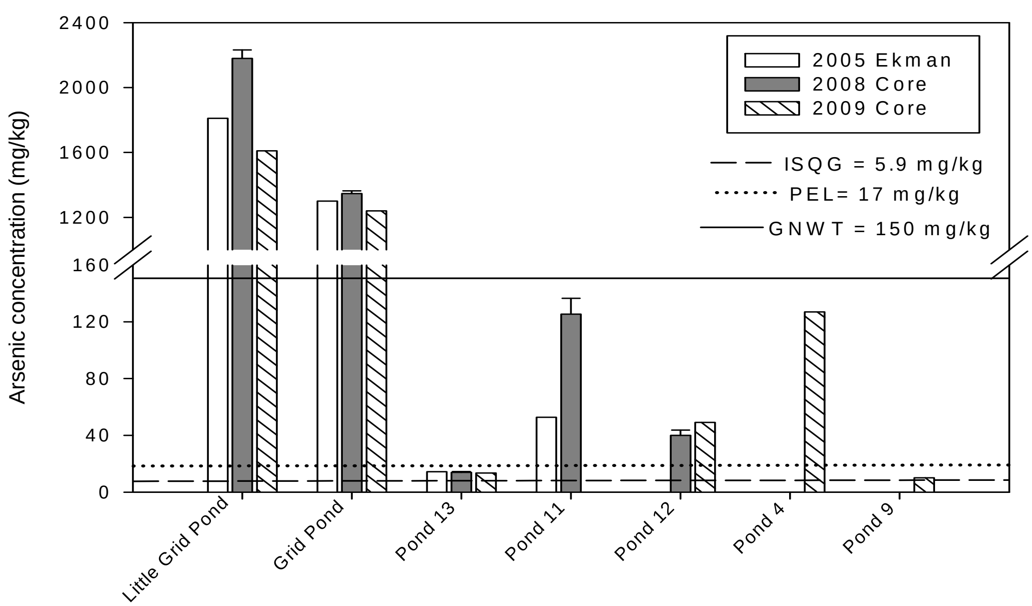


Figure 7.3-16: Total Arsenic Concentrations in Sediments from Ponds within the NICO Project Study Areas in 2005, 2008, and 2009

ISQG = Interim Sediment Quality Guideline (CCME 1999); PEL = Probable Effect Level (CCME 1999); GNWT = Government of the Northwest Territories Remediation Objective.

Ponds are ordered according to proximity to the ore body.

Data for 2008 represent the mean (± SD) of 3 replicate samples.

For 2005 and 2009, *n* = 1.

Arsenic concentrations in sediments decreased from naturally high concentrations at the top of the watershed (in the Grid Ponds and Nico Lake) to concentrations below the PEL with distance from the ore body. Arsenic concentrations in the Grid Ponds and Nico Lake were more than 10 times higher than those measured in Reference Lake in any sampling year.

Sediment concentrations of arsenic in Nico Lake increased substantially in the deep basin after the forest fire in 2008 compared to 2005 pre-fire concentrations. Although the Peanut Lake watershed was affected by the fire, arsenic concentrations appeared to decrease between 2005 and 2008/2009. This occurred despite observation of a thin, milky layer on the sediment surface, which was likely ash deposited after the 2008 forest fire. The watershed of Lou Lake was not affected by the fire, and arsenic concentrations in sediments were slightly lower in 2008/2009 compared to 2005. The differences between 2005 and 2008/2009 concentrations could have been due to the different sampling methods (Ekman grab sampler vs. corer), or could reflect natural temporal and spatial variability in arsenic concentrations.

7.3.2.2.2 Chromium

Chromium concentrations exceeded the ISQG (37.3 mg/kg) in sediments from most sampling locations. Exceptions included the deep basin of Nico Lake and Pond 4 in 2009, and Little Grid Pond and Grid Pond in most years with available data (Figures 7.3-17 and 7.3-18). The PEL for chromium (90.0 mg/kg) was not exceeded in any samples. The available data suggest that the 2008 forest fire did not appear to affect chromium concentrations in sediments in Nico, Peanut, Burke, and Reference lakes, because post-fire concentrations were either similar to, or lower than those measured before the fire in 2008.

7.3.2.2.3 Copper

Copper concentrations exceeded the ISQG (35.7 mg/kg) occasionally in Nico, Peanut, Burke, Lou, and Reference lakes (Figures 7.3-19 and 7.3-20). The PEL for copper (197 mg/kg) was exceeded in the deep basin of Nico Lake in 2008, and in Little Grid and Grid ponds. Copper concentrations in sediment from the Grid Ponds were more than 10 times greater than those measured in Reference Lake. Sediments from Nico Lake (2008) and Pond 9 (2009) had copper concentrations that were more than 2 times higher than corresponding concentrations in Reference Lake. Apart from the spike in copper concentrations in Nico Lake (deep basin, 2008), the available data did not appear to suggest an effect of the forest fire on copper concentrations in Nico, Peanut, Burke, or Reference lakes.

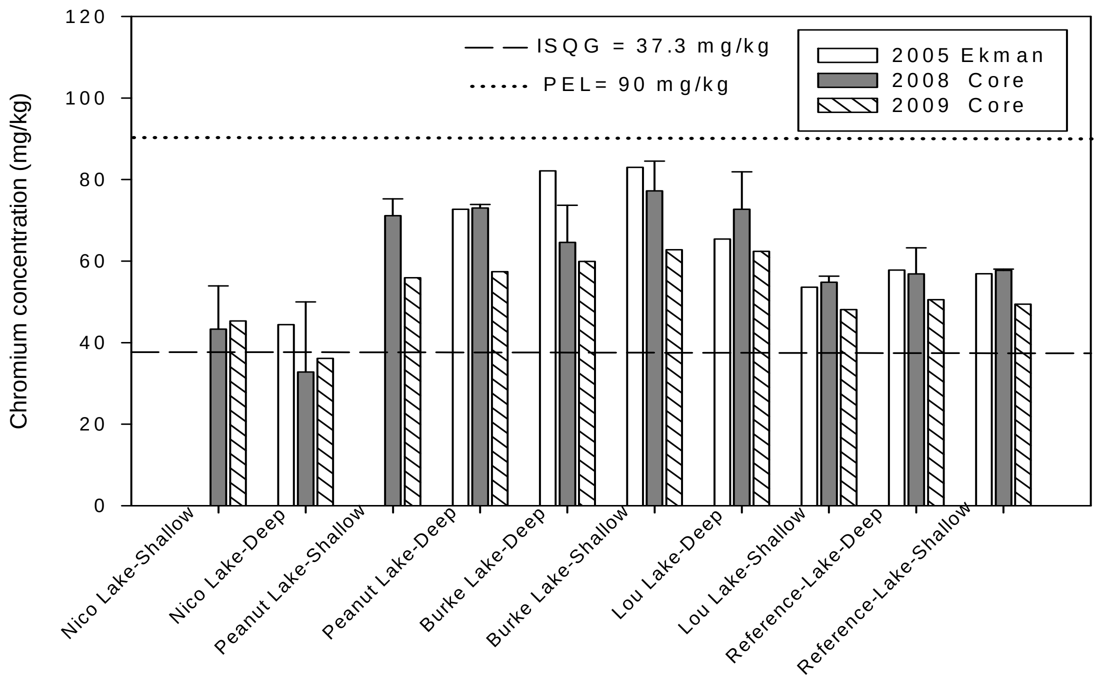


Figure 7.3-17: Total Chromium Concentrations in Sediments from Lakes within the NICO Project Study Areas in 2005, 2008, and 2009

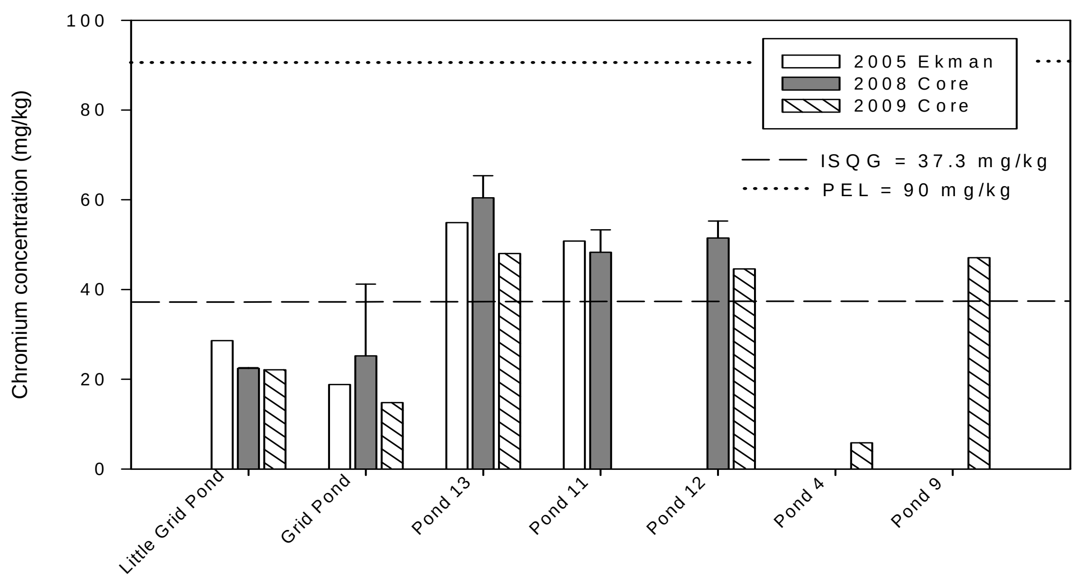


Figure 7.3-18: Total Chromium Concentrations in Sediments from Ponds within the NICO Project Study Aresa in 2005, 2008, and 2009

ISGQ = Interim Sediment Quality Guideline (CCME 1999); PEL = Probable Effects Level (CCME 1999).
Ponds are ordered according to proximity to the ore body.
Data for 2008 represent the mean (± SD) of 3 replicate samples.
For 2005 and 2009, n = 1.

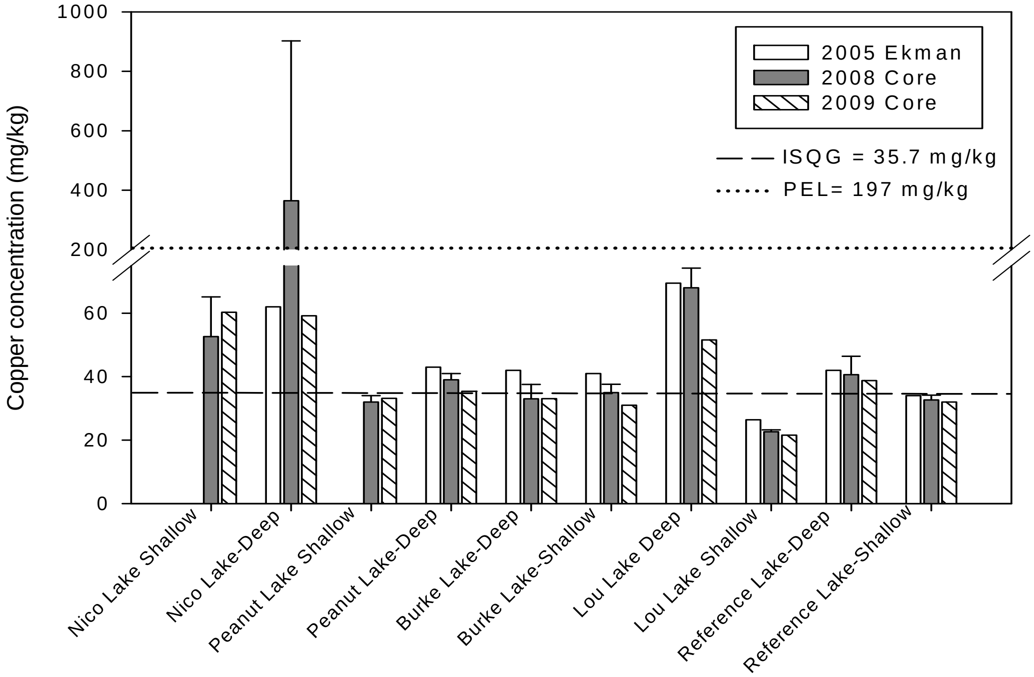


Figure 7.3-19: Total Copper Concentrations in Sediments from Lakes within the NICO Project Study Areas in 2005, 2008, and 2009

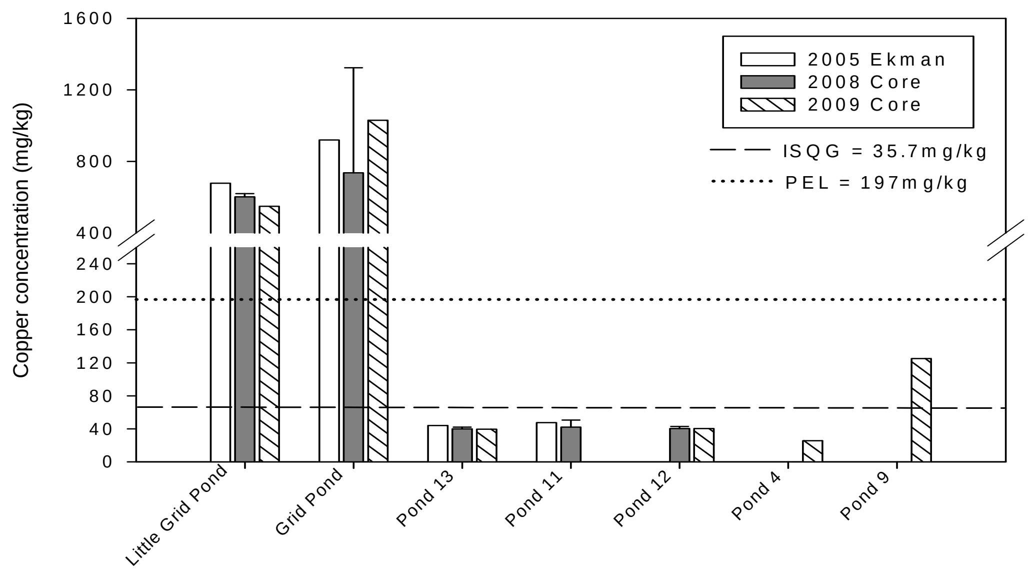


Figure 7.3-20: Total Copper Concentrations in Sediments from Ponds within the NICO Project Study Areas in 2005, 2008, and 2009

ISGQ = Interim Sediment Quality Guideline (CCME 1999); PEL = Probable Effects Level (CCME 1999).
Ponds are ordered according to proximity to the ore body.
Data for 2008 represent the mean (± SD) of 3 replicate samples.
For 2005 and 2009, *n* = 1.

7.3.2.2.4 Selenium

The highest selenium concentrations in sediment were measured in the Grid Ponds (2.79 to 3.33 mg/kg). Selenium concentrations in the other lakes and ponds were lower, at less than 1 mg/kg, with the exception of the 2008 sample from the deep basin of Nico Lake, which had 3.6 mg/kg of selenium. Selenium concentrations in sediments collected from Grid Pond (2005) and Little Grid Pond (2005 and 2008) were more than 10 times greater than those measured in sediment from the shallow basin of Reference Lake in those years (Figures 7.3-21 and 7.3-22). In other years, selenium concentrations in sediment from these ponds were between 2 and 10 times higher than Reference Lake concentrations. Selenium concentrations in sediments from other LSA lakes and ponds were less than 2 times the corresponding concentrations in Reference Lake. These results show that naturally high selenium concentrations exist in lake sediments close to the ore body, and rapidly decrease with distance down the hydrological gradient towards the Marian River, to concentrations similar to those in Reference Lake.

Selenium concentrations were higher in sediments of Nico, Peanut, Burke, and Reference lakes after the forest fire in 2008. However, concentrations were low relative to those observed in the Grid Ponds and remained within 5 times the analytical detection limit (<0.2 mg/kg).

7.3.2.2.5 Zinc

Zinc sediment concentrations exceeded the ISQG (123 mg/kg) occasionally in Grid and Little Grid ponds, and in Nico, Peanut, and Burke lakes (Figures 7.3-23 and 7.3-24). The PEL for zinc (315 mg/kg) was slightly exceeded by the mean sediment concentration in the shallow basin of Peanut Lake in 2008, but the mean value primarily reflected the higher zinc concentration in one replicate (920 mg/kg) compared to the other replicates (100 mg/kg).

Zinc concentrations in sediments collected from Grid Pond (2009) and the shallow basins of Nico (2009) and Peanut (2008) lakes were between 2 and 10 times higher than the concentrations in Reference Lake. All other sediment samples were within 2 times the Reference Lake concentrations. The available data did not indicate that the zinc concentrations in sediments were affected by the 2008 forest fire.

7.3.2.2.6 Other Metals

Waterbodies close to the main ore body typically had metal concentrations in sediments that were elevated above background concentrations. The metals with elevated concentrations were typical of those in the main ore body. In addition to the metals discussed above, antimony, cobalt, and molybdenum had concentrations in sediments of the Grid Ponds that were more than 10 times those in Reference Lake. In 2009, molybdenum concentrations were 10 times higher in Nico Lake, and Ponds 7 and 9, and uranium concentrations were 10 times higher in Pond 4 than in the Reference Lake. Several other metals (i.e., antimony, cobalt, mercury, molybdenum, and uranium) were present at concentrations greater than 2 times the corresponding concentrations in Reference Lake in the Grid Ponds, Nico Lake, Peanut Lake, Lou Lake, and several ponds (i.e., 4, 9, 11, 12, and 13) in one or more years. Farther downstream, in Burke Lake, only arsenic was present in concentrations more than 2 times those in the Reference Lake.

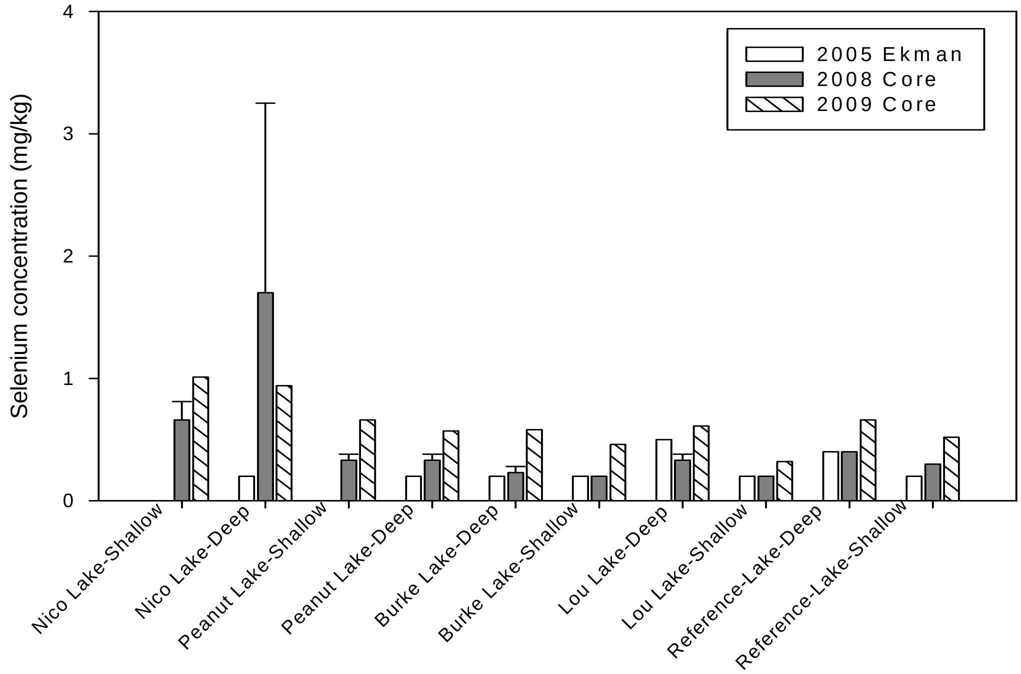


Figure 7.3-21: Total Selenium Concentrations in Sediments from Lakes within the NICO Project Study Areas in 2005, 2008, and 2009

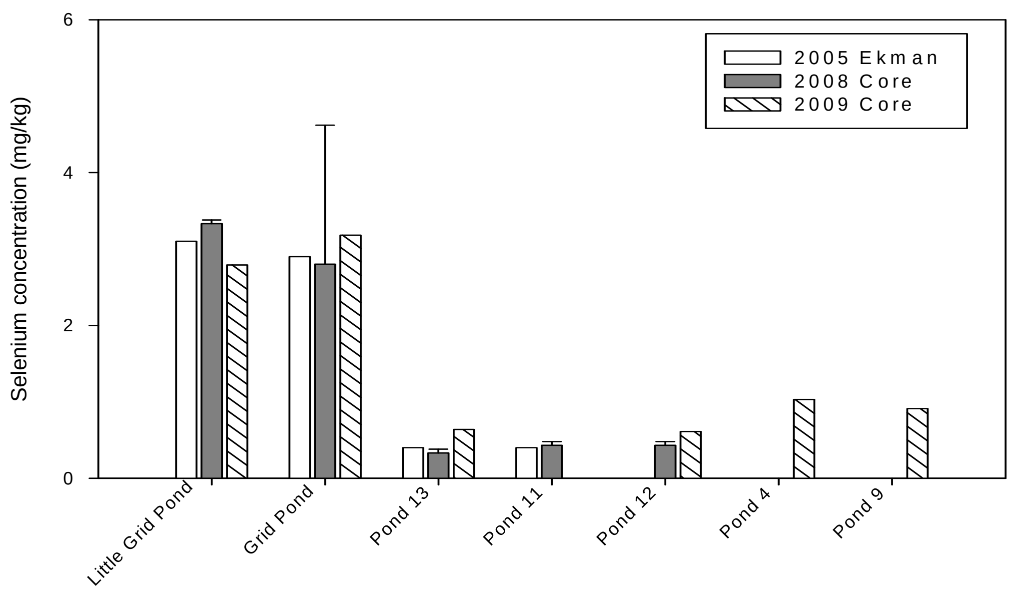


Figure 7.3-22: Total Selenium Concentrations in Sediments from Ponds within the NICO Project Study Areas in 2005, 2008, and 2009

Lakes and Ponds are ordered according to proximity to the ore body.
Data for 2008 represent the mean (± SD) of 3 replicate samples.
For 2005 and 2009, *n* = 1.

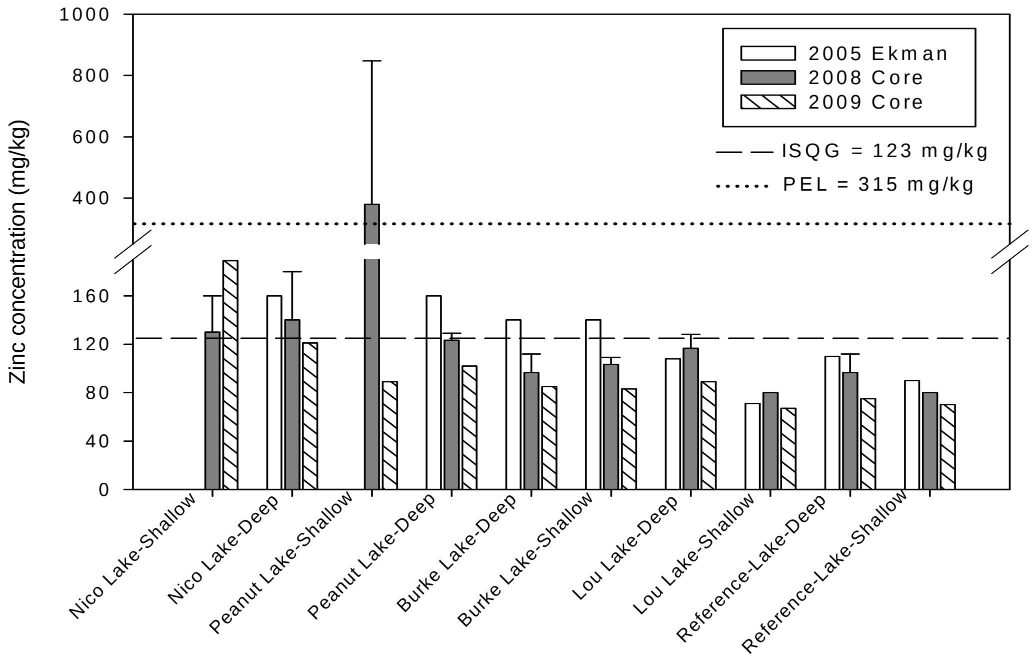


Figure 7.3-23: Total Zinc Concentrations in Sediments from Lakes within the NICO Project Study Areas in 2005, 2008, and 2009

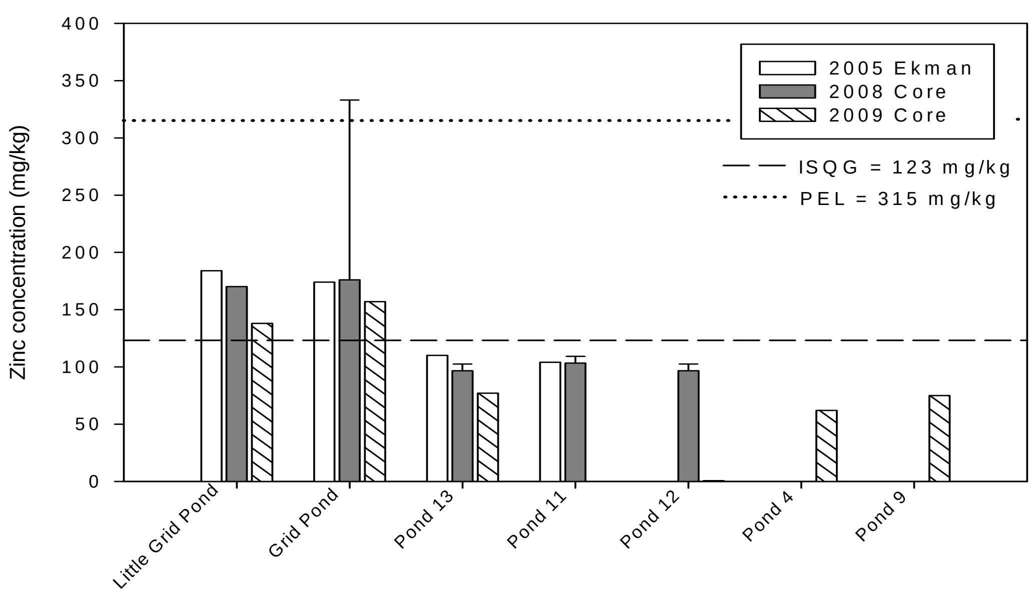


Figure 7.3-24: Total Zinc Concentrations in Sediments from Ponds within the NICO Project Study Areas in 2005, 2008, and 2009

ISQG = Interim Sediment Quality Guideline (CCME 1999); PEL = Probable Effects Level (CCME 1999).
Ponds are ordered according to proximity to the ore body.
Data for 2008 represent the mean (± SD) of 3 replicate samples.
For 2005 and 2009, *n* = 1.

7.4 Water Management Plan Summary

The Water Management Plan (Appendix 3.III) and Section 3.9.2 (Site Water Management) outline the environmental design features and mitigation that will be used to manage water that comes into contact with the mine facilities during construction, operations, closure and reclamation, and post-closure. Contact water will be contained and treated in an ETF, if necessary, to meet the SSWQOs. Facilities to collect and manage contact water post-closure will be constructed progressively during operations.

A freshwater intake will be set in Lou Lake to provide process water for the Mineral Processing Plant (Plant), water for dust control, and potable water for the camp. The intake structure will be designed to meet Department of Fisheries and Oceans Canada (DFO) guidelines for water intakes. Water withdrawal rates will also be within DFO guidelines (Section 3.9.2, Section 11.3.2.2). The water management system for the NICO Project has been optimized to reduce the fresh water requirement through internal recycling within the Plant, thickening of the tailings, and high level of reclaim water from the CDF back to the Plant, including the capture and reuse of site water and excess water from the Seepage Collection Ponds (SCPs) in the Plant operations.

Water management facilities will be constructed to channel and contain contact water and to transfer this water either for reuse in the Plant or for treatment in the ETF (Section 3.9.2). During construction, water that cannot be released to the environment will be impounded in Water Management Ponds (i.e., Surge Pond and SCP) until the ETF is commissioned. During operations, contact water will be contained in a Reclaim Pond on the CDF, in SCPs, in the Surge Pond, or in the Plant site runoff pond (Section 3.9.4.2).

Water must be pumped from the currently flooded exploration workings before underground mining can commence. A water quality monitoring program will be established during the underground mine dewatering stage. Water that does not meet SSWQOs will be impounded until the ETF is commissioned, and then treated prior to discharge to Peanut Lake. In practice, the underground water will be continuously monitored during pumping and released if it meets SSWQOs.

During operations, contact water collected in the Water Management Ponds, steady state inflows into the underground mine workings, and inflow water from the base of the Open Pit will be pumped to the Surge Pond. Water from the Surge Pond will be re-used in the Plant or pumped to the ETF for treatment. Treated effluent will be discharged to Peanut Lake.

The Camp sewage and grey water will be treated with a Rotary Biologic Contactor adjacent to the ETF. Treated sewage effluent will be discharged to Peanut Lake along with the ETF effluent. During construction treated liquid effluent from the Sewage Treatment Plant (STP) will be well below SSWQOs and will be released directly into Peanut Lake.

At closure, pumping of water out of the Open Pit will cease and the Open Pit will slowly fill with natural drainage and runoff from the CDF. Runoff from the top surface of the CDF will be directed into the Open Pit to aid backfilling rates. Modelling indicates that, for the base case water management, it will take roughly 120 years for the Open Pit water level to rise to an elevation of 260 m, at which time the Flooded Open Pit will begin to overflow through the haul road ramp.

Just prior to Open Pit overflow, the water quality at the top of the Flooded Open Pit will be evaluated, and a decision will be made about post-overflow treatment (Section 9.4.3.3). The base case assumption, inferred from the hydrodynamic modelling, is that the water in the Open Pit will require and will be amenable to passive treatment in Wetland Treatment System No. 4, which will be constructed on the west shore of Peanut Lake.

Water that has been affected by contact with tailings will continue to seep out of the toe of the CDF after closure and reclamation, at a reduced rate because of the cessation of active tailings deposition and the application of the closure cover, which will reduce infiltration. This seepage water will continue to be collected in the SCPs over the long-term, and will require treatment prior to release. Water will be passively treated in a Wetland Treatment System No. 1, 2, and 3 prior to discharge to Nico Lake. The wetland treatment systems will be constructed and tested during the operations phase to demonstrate that it will achieve the desired results.

7.5 Pathway Analysis

7.5.1 Methods

Pathway analysis identifies and assesses the linkages between NICO Project components or activities, and the corresponding 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:

- 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). 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 and mitigation that can be incorporated into the development description to remove a pathway or limit (mitigate) the effects to VCs. Environmental design features include 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 and mitigation 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 measurement endpoints (e.g., surface water chemistry). 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 corresponding 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 using 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 and mitigation 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 and mitigation 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.

7.5.2 Results

Potential pathways through which the NICO Project could affect water quality are presented in Table 7.5-1. Environmental design features and mitigation that were 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, or as having no linkage. The following section discusses the potential pathways relevant to the surface water environment.

Table 7.5-1: Potential Pathways for Effects to Water Quality

NICO Project Component/ Activity	Effects Pathways	Environmental Design Features	Pathway Assessment
Construction of mine and supporting infrastructure (e.g., Open Pit, winter road, site roads, Co-Disposal Facility, and airstrip)	Sediment releases from road construction including watercourse crossings can affect surface water quality of nearby surface waters.	Sediment and erosion control measures (e.g., silt curtains, runoff management) will be used to control sediment releases during construction. In-stream work during road crossing construction will either be avoided or be limited to when watercourses within or adjacent to the construction area are not flowing or during low flows conditions.	No linkage
	Sediment releases from land disturbance during mine construction can affect surface water quality of nearby surface waters.	The layout of the mine footprint will limit the area that is disturbed. Sediment and erosion control measures (e.g., silt curtains, runoff management) will be used to control sediment releases during construction. 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.	No linkage
	Sediment releases during the construction of the water intake in Lou Lake and the effluent outfall in Peanut Lake can affect surface water quality in Lou Lake and Peanut Lake.	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
	Air emissions (acidifying emissions, dust, and associated metal deposition) can affect surface water and sediment quality of nearby surface waters.	The 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).	Primary

Table 7.5-1: Potential Pathways for Effects to Water Quality (continued)

NICO Project Component/ Activity	Effects Pathways	Environmental Design Features	Pathway Assessment
Construction of mine and supporting infrastructure (e.g., Open Pit, winter road, site roads, Co-Disposal Facility, and airstrip) (continued)	Spills and leaks from equipment operation (e.g., petroleum products, reagents, wash-down) on the mine site or along the NICO Project Access Road can affect groundwater, surface water, and sediment quality of nearby surface waters.	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, or 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. 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. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	No Linkage
Mining activity	Dewatering of mine workings and discharge of this water can affect surface water quality in the receiving environment.	If water quality does not meet site-specific water quality objectives, water will be impounded in the Surge Pond or in Seepage Collection Ponds No. 1, 2, and 3 until the Effluent Treatment Facility is commissioned where it will be treated prior to release to Peanut Lake.	Secondary
	Air emissions (acidifying emissions, dust and associated metal deposition) can affect surface water and sediment quality of nearby surface waters.	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. Equipment and fleet equipped with industry-standard emission control systems. Enclosing conveyance systems and processing facilities.	Primary

Table 7.5-1: Potential Pathways for Effects to Water Quality (continued)

NICO Project Component/ Activity	Effects Pathways	Environmental Design Features	Pathway Assessment
		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).	
Mining activity (continued)	Spills and leak from equipment operation (e.g., petroleum products, reagents, wash-down) on the mine site or along the NICO Project Access Road can affect groundwater, surface water, and sediment quality of nearby surface waters.	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, or 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. 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. Construction and mining equipment, machinery, and vehicles will be regularly maintained.	No Linkage
Mine site water management	Process and potable water requirements for the NICO Project may decrease drainage flows and surface water levels in Lou Lake and can thus affect surface water quality in downstream surface waters.	Capture and reuse site water to reduce fresh water requirements. Water from tailings thickener and from the Open Pit will be recycled for Mineral Processing Plant operations. Excess water from the Seepage Collection Ponds will be recycled and treated prior to entering the receiving environment.	Secondary

Table 7.5-1: Potential Pathways for Effects to Water Quality (continued)

NICO Project Component/ Activity	Effects Pathways	Environmental Design Features	Pathway Assessment
Mine site water management (continued)	Surface water runoff from the core mine facilities, including releases of nitrogen compounds from blasting residues, can affect surface water and sediment quality of nearby surface waters.	The Water Management Plan will control surface water on-site. Runoff from the mine site will be captured and will either be treated in the Effluent Treatment Facility and discharged to Peanut Lake or will be re-used in the Mineral Processing Plant. Any water that cannot be released will be impounded in the Water Management Ponds (e.g., Surge Pond, Seepage Collection Ponds). The site will have sufficient storage capacity in Surge Ponds to store both operating flows and storm events.	Secondary
	Water pumped from the Open Pit as a result of groundwater inflows and runoff from the Open Pit watershed can affect surface water quality in downstream surface waters.	Water from the Open Pit will be pumped to the Surge Pond and then either to the Mineral Processing Plant for re-use or to the Effluent Treatment Facility for treatment prior to discharge to Peanut Lake.	Secondary
	Discharge of effluent from the sewage treatment plant can affect surface water quality in Peanut Lake and in downstream surface waters.	Sewage and grey water will be treated with a Rotary Biologic Contactor and the effluent will be pumped to Reclaim Pond in the Co-Disposal Facility, only if unsuitable for discharge. Water from the Reclaim Pond will be treated in the Effluent Treatment Facility prior to discharge.	Secondary
	Discharge of effluent from the Effluent Treatment Facility can affect surface water quality in Peanut Lake and in downstream surface waters.	Treated water from the Effluent Treatment Facility will be pumped through a diffuser directly to Peanut Lake. If additional settling, polishing, or further treatment is required, then the treated water from the Effluent Treatment Facility will be discharged to the Surge Pond.	Primary
Operation of Co-Disposal Facility	Vertical and lateral seepage from the Co-Disposal Facility may cause changes to groundwater, surface water, and sediment quality in nearby lakes and streams. Leaching and runoff of dissolved metals from Mine Rock may cause changes to groundwater, surface water, and sediment quality.	Runoff from the Co-Disposal Facility will be captured in Seepage Collection Ponds and diverted to the Mineral Processing Plant for recycling, or the Effluent Treatment Facility. At closure and post-closure, runoff will flow to constructed wetlands for treatment or the Open Pit. 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

Table 7.5-1: Potential Pathways for Effects to Water Quality (continued)

NICO Project Component/ Activity	Effects Pathways	Environmental Design Features	Pathway Assessment
Closure and reclamation activities	Sediment releases from land disturbance can affect surface water quality of nearby surface waters.	Sediment and erosion control measures (e.g., silt curtains, runoff management) will be used to control sediment releases during land reclamation.	No linkage
	Air emissions (acidifying emissions, dust and associated metal deposition) can affect surface water and sediment quality of nearby surface waters.	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
Post-closure	Water quality in the Flooded Open Pit and outflow can affect surface water quality in downstream surface waters.	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.	Secondary
	Long-term seepage from the Co-Disposal Facility can affect surface water quality in downstream surface waters.	Co-Disposal Facility area will be capped during closure to isolate Mine Rock and tailings and minimize leaching. Any seepage from the co Co-Disposal Facility will be intercepted in passive Wetland Treatment Systems prior to discharge to Nico Lake.	Primary
	Surface water and sediment quality of the Flooded Open Pit may be poor, thereby preventing the development of a viable aquatic ecosystem.	As part of the closure plan, the Flooded Open Pit is not intended to be a functioning part of the ecosystem.	Secondary

7.5.2.1 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 and mitigation so that the NICO Project results in no detectable (measurable) environmental change and residual effects to surface water quality relative to baseline or guideline values.

The following pathways are anticipated to have no linkage to surface water quality and not carried through the effects assessment:

- **Sediment releases from road construction including watercourse crossings can affect surface water quality of nearby surface waters.**
- **Sediment releases from land disturbance during mine construction or during closure and reclamation activities can affect surface water quality of nearby surface waters.**

The NICO Project footprint, or the total area disturbed, is estimated to be 485.4 hectares (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. Most of the other construction activities will occur in the summer. All construction activities will be subject to a sediment control plan. For example, standard erosion and sediment control measures (e.g., vegetation, erosion mats) will be used during construction around areas to be disturbed to limit wind and water erosion of topsoil and overburden stockpiles.

Most 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, they will be treated with flocculent to reduce suspended sediment concentrations before being released.

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 design of the CDF requires a smaller footprint than separate tailings and Mine Rock disposal areas, 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 that will be covered with Mine Rock after they are filled. Therefore, this pathway was determined to have no linkage to effects to surface water quality.

- **Sediment releases during the construction of the water intake in Lou Lake and the effluent outfall in Peanut Lake can affect surface water quality in Lou Lake and Peanut Lake.**

Sediment may be released as a direct result of construction of the water intake and outlet structures. Construction activities 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. Therefore, this pathway was determined to have no linkage to effects to surface water quality in Lou Lake and Peanut Lake.

- **Spills and leaks from equipment operation (e.g., petroleum products, reagents, washdown) on the mine site or along the NICO Project Access Road during construction and operations can affect groundwater, surface water, and sediment quality of nearby surface waters.**

Chemical spills on other northern mine sites are usually localized, and are quickly reported and managed (Tahera 2008; BHPB 2010; DDMI 2010; De Beers 2010). Mitigation identified in the Emergency Response and Spill Contingency Plan (Appendix 3.VI) and other environmental design features will be in place to limit the frequency and extent of spills that result from NICO Project activities (Table 7.5-1). Hazardous materials and fuel will be stored according to regulatory requirements 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 and environmental design features are anticipated to reduce the frequency and severity of spills on the environment. Thus, spills in the mine area and on the NPAR are not predicted to result in detectable changes to groundwater, surface water or sediment quality relative to baseline conditions. Therefore, this pathway was determined to have no linkage to effects to groundwater, surface water and sediment quality.

7.5.2.2 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 surface water quality relative to baseline or guideline values. The following pathways are anticipated to be secondary and will not be carried through the effects assessment.

- **Dewatering of mine workings and discharge of this water during construction can affect surface water quality in the receiving environment.**

Approximately 50 000 cubic metres (m^3) of water will have to be pumped from the currently flooded exploration workings before underground mining can commence (Section 3.9.3). A water quality monitoring program will be established during the underground mine dewatering stage. If water quality meets SSWQOs, then it can be discharged to the environment. Water that does not meet SSWQOs will be held in the Surge Pond or in Seepage Collection Ponds (i.e., No. 1, 2, or 3) for use in the Plant or until the ETF is commissioned and then treated prior to discharge to Peanut Lake. Treated water will meet SSWQOs. Therefore, the residual effects to surface water quality are predicted to be negligible.

- **Process and potable water requirements for the NICO Project may decrease drainage flows and surface water levels in Lou Lake and can thus affect surface water quality in downstream surface waters.**

The NICO Project will withdraw fresh water from Lou Lake for potable water and plant operations, and other operational requirements as needed (e.g., dust suppression). Allowable lake under-ice withdrawal volumes (DFO 2010) are 10% of the available water volume in Lou Lake, calculated using the appropriate maximum expected ice thickness. The water volume of Lou Lake is 9.42 million cubic metres (Mm^3) (Fortune 2006). Thus the allowable volume that could be pumped from Lou Lake in winter is approximately 942 000 m^3. The annual fresh water requirement for the NICO Project is anticipated to be approximately 112 000 m^3 under average climatic conditions but may increase to 146 000 m^3 during a 1:25 year dry period (Golder 2010). The maximum potential fresh water withdrawal is 179 000 m^3/year during the approximate 1-year construction phase. Thus the anticipated fresh water requirement for the NICO Project is well below the allowable volume of water that could be taken from Lou Lake.

The effect of fresh water extraction on Lou Lake water levels were modelled (Section 11.3.2.2). The modelling predicted that the maximum change in water level in Lou Lake relative to the natural (modelled baseline) conditions is approximately 4.7 cm in a 1:25 year dry period coinciding with the maximum required water withdrawal, which occurs during construction. In general, it is anticipated that the average fresh water withdrawal condition in Lou Lake would not exceed 3.7% of the mean annual discharge relative to baseline conditions, which is expected to have negligible residual effect on water level in Lou Lake and downstream flow to the Marian River (secondary pathway; Table 11.3-1).

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 the tailings thickener and from the Open Pit will be recycled for grinding operations (Table 7.5-1). Excess water from the SCPs will be recycled and treated prior to release, if not used in the Plant.

- **Discharge of effluent from the Sewage Treatment Plant can affect surface water quality in Peanut Lake and in downstream surface waters.**

Sewage and grey water will be treated with a Rotary Biologic Contactor and will be discharged to Peanut Lake, as ammonia concentrations in the treated sewage effluent are expected to be below the SSWQOs value (Section 3.9.5). If the treated sewage effluent does not meet the ammonia SSWQOs, the effluent will treated in the ETF prior to discharge.

Phosphorus concentrations in the treated sewage effluent are predicted to be 1 mg/L. Due to the expected low rate of release of treated sewage effluent to Peanut Lake during construction and operations, relative to discharges from the ETF and receiving environment flows, and loss of the Grid Pond system, a background source of phosphorus to Nico and Peanut lakes, loading to Peanut Lake is not expected to result in changes in phosphorus concentrations in the receiving environment that could result in an upward shift in trophic status from baseline conditions. The lakes are still expected to remain phosphorus limited. The residual effects to surface water quality from the discharge of treated effluent from the STP are therefore predicted to be negligible and the pathway is considered secondary.

- **Surface water runoff from the core mine facilities during mining operations, including releases of nitrogen compounds from blasting residues, can affect surface water and sediment quality of nearby surface waters.**
- **During operations, water pumped from the Open Pit as a result of groundwater inflows and runoff from the Open Pit watershed can affect surface water quality in downstream surface waters.**

Surface water runoff from the Open Pit and Plant facilities area could potentially affect surface water quality in downstream waterbodies. The Water Management Plan will contain surface water on-site and prevent release of untreated site water into the receiving environment (Table 7.5-1).

During operations, water that 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 Plant area will be collected in a site runoff collection pond and then transferred to the Surge Pond. Water collected in the Surge Pond will be used to meet water demands of the Plant to the extent it is needed; all excess water will be pumped to the ETF. Following treatment, water will meet SSWQOs, with the possible exception of selenium (Appendix 7.I), and will be discharged through a diffuser into Peanut Lake.

Implementation of these environmental design features to manage and treat site runoff and groundwater inflows is expected to result in no detectable changes to surface water and sediment quality in waterbodies adjacent to the NICO Project. Therefore, the residual effects to surface water quality are predicted to be negligible.

- **Vertical and lateral seepage from the Co-Disposal Facility may cause changes to groundwater, surface water, and sediment quality in nearby lakes and streams.**
- **Leaching and runoff of dissolved metals from Mine Rock may cause changes to groundwater, surface water, and sediment quality.**

During the life of the NICO Project, there is the potential for leachate (e.g., metals) from the tailings and Mine Rock in the CDF to seep through the co-disposed wastes and report as seepage to the SCPs. Additionally, there is potential for arsenic as well as other metals (i.e., aluminum, arsenic, cadmium, cobalt, lead, selenium, and uranium) to be present in the leachate. Such water-borne elements could adversely affect downstream waterbodies 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 7.5-1).

The CDF is designed to limit runoff and seepage from contacting tailings 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, operations, closure, and post closure. Runoff and seepage from the CDF will report to 1 of 5 SCPs. During operations, water in the SCPs will be pumped to the Surge Pond. Water from the Surge Pond will be pumped for use in the Plant, or pumped to the ETF for treatment prior to release into Peanut Lake. Runoff and seepage from the CDF reporting to the SCPs, 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; Section 3.9.4) 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.

The Grid ponds currently produce 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 surface water and sediment quality outside of the project footprint area relative to baseline conditions. Therefore, these pathways were determined to have negligible effects to surface water and sediment quality.

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

Air emissions can increase sulphur dioxide, nitrogen oxides, particulate matter, and TSP deposition, 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 dust deposition (Table 7.5-1). Dust suppression measures will include enforcing 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.

- **Water quality in the Flooded Open Pit and outflow post-closure can affect surface water and sediment quality in downstream surface waters.**
- **Surface water and sediment quality of the Flooded Open Pit post-closure may be poor, thereby preventing the development of a viable aquatic ecosystem.**

A Flooded Open Pit will form in the NICO Open Pit after mining is complete. The main sources of water that will contribute to the formation of the post-closure Flooded Open Pit will include precipitation, runoff from the pit walls, groundwater inflow, up-gradient runoff, and runoff from the CDF. It will take approximately 120 years for the Flooded Open Pit to reach the spill point elevation of 260 m.

The results of the hydrodynamic model for the NICO Open Pit suggest that a limited monolimnion (approximately 3% of the filled volume of 28 000 000 m^3) will form. The remaining volume of the Flooded Open Pit will be fully mixed. Post-closure Flooded Open Pit water quality predictions were performed assuming fully mixed conditions, as it is unlikely that the monolimnion will make a substantial difference to the composition of Flooded Open Pit water at initial discharge. Parameters that could occur at concentrations in excess of the site specific water quality predictions after the pit lake has reached the spill-point elevation include aluminum, arsenic, cobalt, copper, and selenium.

Ultimately, it will be necessary to monitor the quality of the water at the top of the Flooded Open Pit prior to overflow. If the water quality meets the SSWQOs without treatment, then a ditch will be constructed to simply direct the overflow water into Peanut Lake. The base case assumption, inferred from the hydrodynamic modelling, is that the water in the Open Pit will require treatment. Prior to Open Pit overflow, Wetland Treatment System No. 4 will be constructed on the west shore of Peanut Lake. This passive treatment system will be constructed and tested with the first waters that overflow from the Open Pit. If it becomes clear that the water in the Open Pit is not amenable to wetland treatment, alternatives for treatment prior to discharge to Peanut Lake will be considered. In situ treatment by chemical addition or biological treatment methods to adjust the pH and/or metal concentrations in Flooded Open Pit water is also an option that could be considered to condition the water prior to discharge into the Wetland Treatment Systems. Another possibility, only if necessary, would be construction of a new ETF for active treatment prior to discharge into Peanut Lake. Therefore, these pathways effects to downstream water and sediment quality are predicted to be negligible.

7.5.2.3 Primary Pathways

The remaining pathways for surface water quality are classified as primary and are carried forward as effect statements (Table 7.5-2) to be assessed in the effects analysis sections (Sections 7.6 to 7.9). The following primary pathways were determined that link NICO Project-related activities to effects on surface water quality.

- **Air emissions (acidifying emissions, dust, and associated metal deposition) during construction and operations can affect surface water and sediment quality of nearby surface waters.**
- **Discharge of effluent from the mine water treatment plant can affect surface water quality in Peanut Lake and in downstream surface waters.**
- **Long-term seepage from the Co-Disposal Facility can affect surface water quality in downstream surface waters.**

Table 7.5-2: Primary Pathways for Effects to Water and Sediment Quality in the NICO Project Area

NICO Project Component/ Activity	Pathways	Effects Statement
Construction of mine and supporting infrastructure; mining activity	Acidifying emissions during construction and operations can affect the quality of nearby surface waters	NICO Project effects to water quality in lakes in the regional study area
	Dust and associated metal deposition during construction and operations can affect water and sediment quality of nearby surface waters	
Construction of mine and supporting infrastructure; mining activity	Acidifying emissions during construction and operations can affect the quality of nearby surface waters	NICO Project effects to water and sediment quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River
	Dust and associated metal deposition during construction and operations can affect water and sediment quality of nearby surface waters	
Mine site water management	Discharge of effluent from the Effluent Treatment Facility can affect surface water quality in Peanut Lake and in downstream surface waters	
Post-Closure	Long-term seepage from the Co-Disposal Facility can affect surface water quality in downstream surface waters	

7.6 Effects to Surface Water Quality and Sediment Quality

7.6.1 Deposition of Acidifying Substances from Air Emissions to Waterbodies in the Regional Study Area

7.6.1.1 Introduction

Mining activities have the potential to affect aquatic ecosystems through the release of air emissions that result in increased deposition rates of sulphate (SO_4^{2-}) and nitrate (NO_3^-). Deposition of SO_4^{2-} and NO_3^- can lead to a reduction in pH in acid-sensitive lakes, which in turn might alter other aspects of water chemistry (e.g., the solubility of aluminum), ultimately resulting in adverse effects on aquatic life.

This section evaluates the potential for acidification of surface waters from NICO Project-related air emissions. Sections 7.6.1.2 and 7.6.1.3 summarize the assessment approach and study area, respectively. Section 7.6.1.4 summarizes the assessment methods. Section 7.6.1.5 provides the results of the analysis for baseline conditions, and peak emissions during construction and operations.

7.6.1.2 Assessment Approach

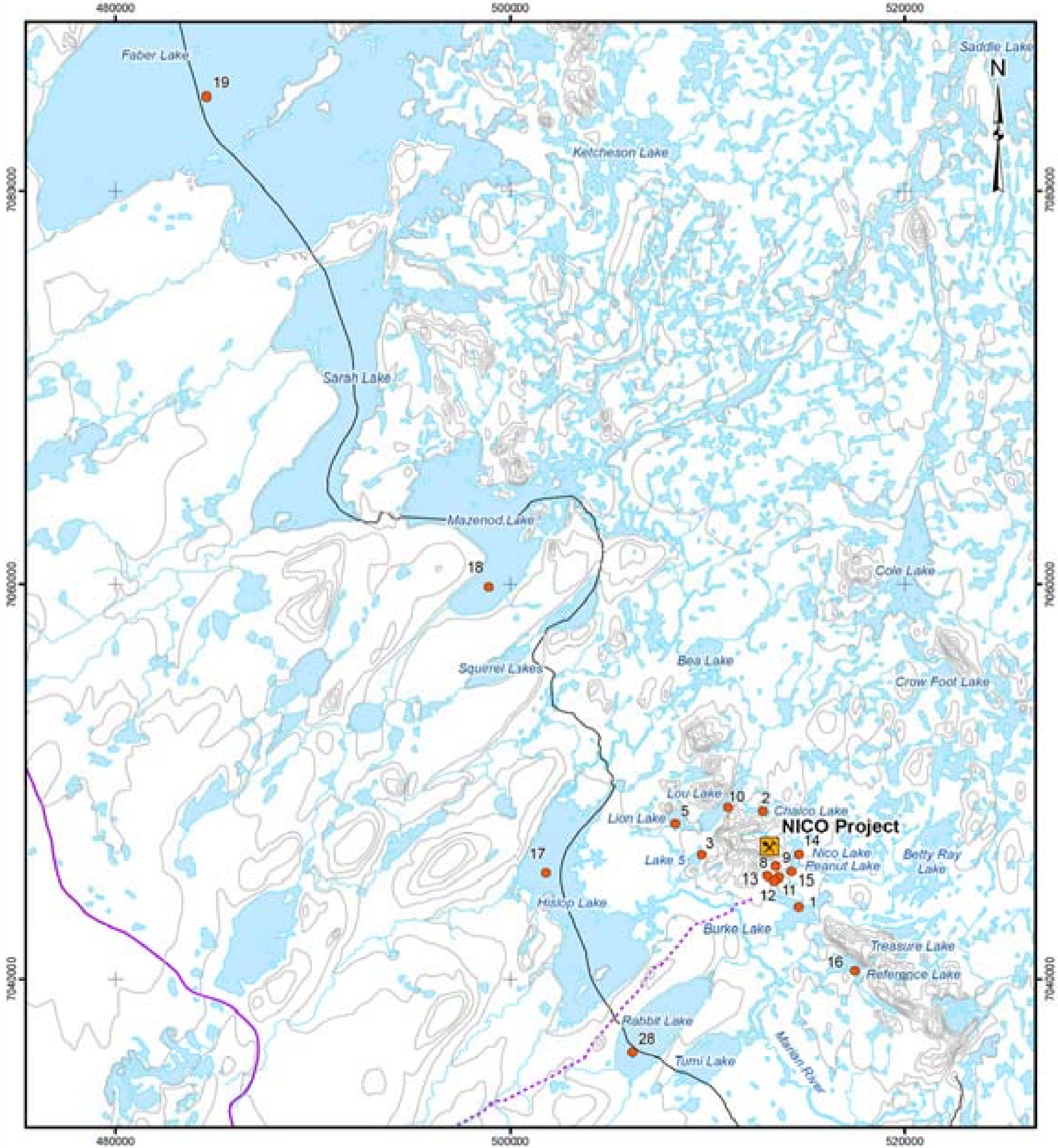
The effects of NICO Project-related SO_4^{2-} and NO_3^- deposition on nearby surface waters were evaluated by comparing modelled acid deposition rates to lake-specific critical loads. Acid deposition was expressed as the PAI. The critical load is an estimate of the amount of acidifying input above which a change in pH corresponding to adverse effects to aquatic life may occur. A PAI value above the critical load was considered an indication that a lake's buffering capacity may be exceeded, with a subsequent drop in pH below a specified threshold value.

Potential acid input is usually calculated as the sum of SO_4^{2-} and NO_3^- deposition minus base cation deposition, as estimated by air dispersion modelling. This calculation includes deposition from all sources and is therefore referred to as the gross PAI. The gross PAI is commonly used to evaluate the effects of acid deposition on terrestrial ecosystems. A more refined estimate of the PAI was used in this assessment to evaluate aquatic effects, by incorporating retention of a portion of deposited nitrogen by the terrestrial ecosystem. The retained portion does not contribute to surface water acidification. The resulting PAI is referred to as the net PAI.

The net PAI does not incorporate the mitigating effect of base cation deposition. In the Steady-State Water Chemistry model (Henriksen and Posch 2001) used to estimate critical loads, the base cation component of the critical load is assumed to represent the current base cation flux to the waterbody from all sources, including base cation deposition from the atmosphere. Therefore, accounting for the neutralizing effect of base cation deposition, as done when using the gross PAI, would result in double-counting of base cations.

7.6.1.3 Study Area

The effects of acidifying emissions were assessed for 17 lakes within the Air Quality RSA (Figure 7.6-1). These lakes were selected on the basis of available water quality data and position relative to the NICO Project footprint. Lakes with available data and located outside the NICO Project footprint were included in the analysis. Lakes within the NICO Project footprint were included if they were expected to remain largely undisturbed during construction and operations, and were not surrounded by NICO Project infrastructure. The lakes excluded from the analysis are expected to be lost during operations (i.e., Grid Pond, Little Grid Pond, and Pond 4).



LEGEND

- NICO PROJECT
- LAKE SURVEYED FOR EFFECTS OF ACID DEPOSITION
- CONTOUR (20 METRE INTERVAL)
- EXISTING WINTER ROAD
- PROPOSED NICO PROJECT ACCESS ROAD
- PROPOSED TLICHO ROAD ROUTE
- WATERCOURSE
- WATERBODY

7.5 0 7.5

SCALE 1:275,000 KILOMETRES

REFERENCE

Base data obtained from Atlas of Canada, DMTI, and GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE

LAKES IN THE AIR QUALITY REGIONAL STUDY AREA SURVEYED FOR EFFECTS OF ACID DEPOSITION

Golder Associates
Edmonton, Alberta

FILE No. E-WQ-001-GIS

PROJECT No. 09-1373-1004		SCALE AS SHOWN	REV. 0
DESIGN	HM	24 Mar. 2011	
GIS	AB	05 Apr. 2011	
CHECK	JG	13 May 2011	
REVIEW	JG	13 May 2011	

FIGURE: 7.6-1

7.6.1.4 Assessment Methods

Indicators of Acid Sensitivity

Sensitivity of surface waters to acid deposition can be evaluated based on alkalinity or acid neutralizing capacity (ANC). These terms are now used interchangeably and refer to the capacity of water to neutralize strong inorganic acids (Wetzel 2001). The term “alkalinity” is typically used when acid neutralizing capacity is estimated using titration, whereas ANC is usually used when it is calculated. Alkalinity is frequently expressed in units of mg/L as calcium carbonate ($CaCO_3$), assuming that alkalinity results only from calcium carbonate and bicarbonate, which may or may not be applicable to a given lake. Therefore, the clearest expression of alkalinity is in terms of microequivalents per litre (µeq/L) or milliequivalents per litre (meq/L). For comparative purposes, alkalinity of 1 mg/L as $CaCO_3$ = 20 µeq/L, or 50 mg/L as $CaCO_3$ = 1 meq/L.

Saffran and Trew (1996) presented a scale of lake sensitivity to acidification based on alkalinity/ANC (Table 7.6-1).

Table 7.6-1: Acid Sensitivity Scale for Lakes Based on Alkalinity/Acid Neutralizing Capacity

Acid Sensitivity	Alkalinity/Acid Neutralizing Capacity (mg/L)	
	(mg/L as $CaCO_3$)	(µeq/L)
high	0 to 10	0 to 200
moderate	>10 to 20	>200 to 400
low	>20 to 40	>400 to 800
least	>40	>800

Source: Saffran and Trew (1996).

mg/L = milligrams per litre; $CaCO_3$ = calcium carbonate; µeq/L = microequivalents per litre; > = greater than.

Acid sensitive lakes are situated in areas where soils have little or no capacity to reduce the acidity of the atmospheric deposition. Soil chemistry (i.e., particle size, texture, soil pH, and cation exchange capacity), soil depth, drainage, vegetation cover and type, bedrock geology and topographic relief are all factors that determine the sensitivity of the drainage basin to acid deposition (Lucas and Cowell 1984; Holowaychuk and Fessenden 1987; Sullivan 2000). Surface waters that are sensitive to acidification usually have the following characteristics, as summarized by Sullivan (2000):

- They are dilute, with low concentrations of major ions (i.e., specific conductance is less than 25 µS/cm.
- Alkalinity/ANC are low (i.e., less than 10 mg/L as $CaCO_3$ or less than 200 µeq/L).
- Base cation concentrations are low (i.e., in relatively pristine areas, the combined concentration of calcium, magnesium, potassium, and sodium in sensitive waters is generally less than 50 to 100 µeq/L).
- Organic acid concentrations are low (i.e., dissolved organic carbon concentration is generally less than 3 to 5 mg/L).
- The pH is low (i.e., less than 6).
- Physical characteristics are as follows:

- elevation is moderate to high;
- lakes are located in areas of high relief;
- lakes are subject to severe, short-term changes in hydrology;
- there is minimal contact between drainage waters and soils or geologic material that may contribute weathering products to solution; and
- sensitive lakes may have small drainage basins that derive much of their hydrologic input as direct precipitation to the lake surface.

Calculation of Critical Loads

General Application

The assessment approach was based on the application of critical loads according to the Steady-State Water Chemistry model. Critical loads of acidity can be used to evaluate the likelihood of lake acidification (Henriksen et al. 1992; Kämäri et al. 1992a, b, c; Posch et al. 1992; Rihm 1995; RMCC 1990; WHO 1994). The critical load has been defined in general terms as “a quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment do not occur according to present knowledge” (Nilsson and Grennfelt 1988). For evaluating the effects of acid deposition, the critical load can be thought of as an estimate of the amount of acidic deposition below which no significant harmful effects occur to a specified component of a lake’s ecosystem (e.g., a valued fish species) (Sullivan 2000).

The calculation of critical loads is based on a dose-response relationship between ANC and an aquatic organism considered important to the ecosystem. Many studies have shown that the effects of acidification on aquatic organisms are better correlated with ANC than with pH (as reviewed by Sullivan 2000) because pH measurements are sensitive to carbon dioxide (CO_2) effects (Stumm and Morgan 1981).

The following formula was used to calculate the critical load for each lake included in the analysis (Henriksen et al. 1992):

$$CL = ([BC^*]_0 - [ANC]_{lim}) \times Q$$

where:

CL = critical load (kilo-equivalents per hectare per year [keq/ha/y]);

$[BC^*]_0$ = pre-industrial non-marine base cation concentration (kilo-equivalents per litre [keq/L]), assumed to correspond to the current values in lakes near the Project, because they are considered unaffected by acidification at the present;

$[ANC]_{lim}$ = critical value for acid neutralizing capacity (20 µeq/L = 2×10^{-8} keq/L) based on observed effects to brown trout (*Salmo trutta*), a European species; and

Q = mean annual runoff to the lake (litres per hectare per year [L/ha/y]).

Data used to calculate critical loads and resulting critical loads of acidity are provided in Table 7.6-2. Additional details related to the input data for calculating critical loads are provided in subsequent sections.

Table 7.6-2: Critical Loads of Acidity for Lakes Included in the Assessment

Lake ID[a]	Lake Name	Easting[b]	Northing[b]	Distance[c] (km)	Direction[c]	Gross Catchment Area (km^2)	Base Cations (µeq/L)	Mean Annual Discharge (m^3/s)	Critical Load (keq/ha/y)
8	Pond 8	513465	7045732	0.8	S	0.1	845	0.0003	0.710
9	Pond 9	513458	7045716	0.8	S	1.5	955	0.004	0.810
14	Nico	514648	7046310	1.2	E	20.0	884	0.041	0.555
11	Pond 11	513612	7045145	1.4	S	2.0	832	0.005	0.644
15	Peanut	514270	7045424	1.4	SE	42.3	1157	0.104	0.881
13	Pond 13	513039	7045217	1.4	SSW	1.3	634	0.003	0.478
12	Pond 12	513393	7044996	1.5	S	1.4	851	0.003	0.591
2	Chalco	512810	7048511	2.1	NNW	2.4	510	0.005	0.335
1	Burke	514637	7043665	3.5	SSE	89.6	840	0.193	0.556
10	Lou	511054	7048725	3.7	NW	40.7	697	0.107	0.559
3	Unnamed	509720	7046295	3.9	W	2.8	562	0.005	0.315
5	Lion	508382	7047882	5.3	WNW	49.9	727	0.129	0.577
16	Reference	517471	7040430	7.0	SSE	13.5	1232	0.029	0.825
17	Hislop	498053	7045665	15.5	W	2697.0	3721	4.915	2.127
18	Mazenod	496273	7058821	21.2	NW	28.8	3008	0.029	0.936
28	Rabbit	492357	7037347	23.0	WSW	44.1	2856	0.037	0.748
19	Faber	504346	7078879	33.6	NNW	2954.0	3198	6.468	2.194

[a] Identifier used on map showing lake location (Figure 7.1-1).

[b] Universal transverse Mercator (UTM) co-ordinates; north American datum (NAD83), Zone 12.

[c] Distance and direction relative to the NICO Project.

km = kilometre; µeq/L = microequivalents per litre; m^3/s = cubic metres per second; keq/ha/y = kiloequivalents per hectare per year.

Base Cation Concentration

Henriksen and Posch (2001) and Henriksen et al. (2002) converted the present day base cation flux (i.e., the $[BC^*]_0$ term in the critical load equation) to a pre-acidification flux for European lakes and Ontario lakes, respectively. The procedure applied here assumed that the conditions before construction of the Project were representative of pre-industrial conditions.

The average concentration of each base cation was calculated for each lake based on available data shown in Table 7.6-3. This table also presents average concentrations of other indicators of acid sensitivity or modifying factors, such as pH, specific conductivity, TDS, alkalinity, dissolved organic carbon, colour, nitrate+nitrite, and sulphate.

Table 7.6-3: Summary of Water Chemistry Data for the 17 Lakes Included in the Assessment

Lake ID[a]	Lake Name	Specific Conductivity (µS/cm)	TDS (mg/L)	DOC (mg/L)	Colour (TCU)	pH	Sulphate (mg/L)	Nitrate + Nitrite (mg/L)	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Alkalinity (mg/L as $CaCO_3$)	Alkalinity (µeq/L)	Critical Load (keq ha/y)	Acid Sensitivity[b]
8	Pond 8	147	70	18	-	7.6	-	0.008	9.6	3.4	1.9	0.3	-	-	0.710	-
9	Pond 9	124	110	17	60	7.3	4.2	0.029	11.4	3.6	1.7	0.5	36.2	724.0	0.810	low
14	Nico	81	67	18	-	7.4	4.1	0.092	8.8	3.8	2.4	1.1	33.5	670.5	0.555	low
11	Pond 11	90	58	13	-	7.4	1.3	0.054	7.5	3.7	2.7	1.3	33.9	677.0	0.644	low
15	Peanut	70	61	15	-	7.5	1.4	0.081	7.6	7.6	2.7	1.3	34.3	686.4	0.881	low
13	Pond 13	56	71	19	60	7.1	4.1	0.058	5.8	2.9	2.0	0.7	20.3	406.8	0.478	low
12	Pond 12	84	71	14	30	7.6	2.4	0.043	7.9	3.8	2.6	1.3	35.5	710.5	0.591	low
2	Chalco	50	-	-	-	7.4	3.6	0.003	6.0	1.8	1.0	0.7	17.0	340.0	0.335	moderate
1	Burke	72	66	14	-	7.5	2.0	0.066	8.1	3.5	2.6	1.2	35.1	701.2	0.556	low
10	Lou	64	48	14	-	7.4	1.7	0.059	6.3	3.1	2.3	1.1	27.5	549.9	0.559	low
3	Unnamed	54	-	-	-	7.4	2.2	0.011	5.4	2.1	2.3	0.9	18.5	370.0	0.315	moderate
5	Lion	68	33	-	-	7.6	1.5	0.100	6.3	3.4	2.4	1.4	29.0	580.0	0.577	low
16	Reference	104	82	13	-	7.7	2.9	0.085	14.3	4.3	3.0	1.2	51.6	1031.0	0.825	least
17	Hislop	150	-	-	16	8.2	14.0	0.004	15.1	34.4	2.3	1.4	51.3	1026.0	2.127	least
18	Mazenod	270	-	-	8	8.7	7.0	0.004	27.0	18.4	2.0	2.2	140.0	2800.0	0.936	least
28	Rabbit	246	-	-	25	9.0	6.0	0.004	27.7	14.8	4.4	2.4	121.2	2424.0	0.748	least
19	Faber	320	-	-	3	8.2	45.0	0.004	35.8	13.9	5.0	1.8	99.8	1995.5	2.194	least

[a] Identifier used on map showing lake location (Figure 7.1-1).

[b] Acid sensitivity using categories as defined by Saffran and Trew (1996).

µS/cm = microSiemens per centimetre; mg/L = milligrams per litre; TCU = true colour unit; TDS = total dissolved solids; DOC = dissolved organic carbon; µeq/L = microequivalents per litre; keq/ha/y = kiloequivalents per hectare per year; "-"= no available data.

Verification of the ANC Threshold

The critical value for ANC (ANC_{lim}) is the value below which biological effects could occur. Based on the value used by Henriksen et al. (1992), an ANC_{lim} value of 20 µeq/L was used in this evaluation. To verify this value, an additional analysis was conducted using data for lakes in the Slave Geological Province, within which the majority of the Air Quality RSA is located.

In the Henriksen model, ANC_{lim} was set to protect brown trout, the most common European salmonid, from toxic acidic episodes during the year. The ANC_{lim} was derived from water chemistry, critical load exceedances, and fish population status data from 1000 Norwegian lakes (Henriksen et al. 1992; Lien et al. 1992). A value of 20 µeq/L was deemed most appropriate for Norwegian lakes and most Scandinavian countries have adopted this value (Henriksen et al. 1992). However, ANC_{lim} values have been set at 0, 20, and 50 µeq/L in various applications (e.g., Kämäri et al 1992c; Harriman et al. 1995). These values were intended to protect salmonid fisheries (Harriman et al. 1995), or correspond to the ANC where significant changes are expected to occur in a lake's diatom flora (Jenkins et al. 1997).

Brown trout is a European species that was introduced to North America, and as such, may not be an appropriate species for calculating critical loads outside Europe. In North America, there has not been a large-scale investigation of critical loads and ANC_{lim} values similar to that conducted in Norway. One approach that has been used in North America involves relating ANC_{lim} to a pH effects threshold (WRS 2002). Numerous studies have shown that a pH of 6 is sufficient to maintain a healthy aquatic ecosystem, and protect fish and other aquatic organisms (based on reviews by RMCC 1990; Environment Canada 1997; Jeffries and Lam 1993; Sullivan 2000). This approach was also adopted in this assessment to verify the appropriateness of the chosen ANC_{lim} value.

To convert the pH threshold of 6 to an estimated ANC for the lakes included in the assessment, the relationship between pH and ANC was analyzed using the results of a water quality survey (Puznicki 1996) of over 500 lakes in the Slave Geological Province. The Slave Geological Province includes the NICO Project area, as well as the watersheds included in the assessment. A number of lakes outside the watersheds used in this assessment were also included in the analysis to incorporate a wider range of pH and alkalinity values (Puznicki 1996). Field measured alkalinity was used to estimate ANC. For this analysis, lakes with tea stained, highly coloured water (>15 true colour units) were omitted, as this colouration typically resulted from contact with humic or peaty materials and is generally indicative of elevated dissolved organic carbon concentration (Puznicki 1996).

Regression analysis showed that for lakes in the Slave Geological Province, a pH of 6 corresponds to an ANC value of about 7 µeq/L (Figure 7.6-2). This suggests that the ANC_{lim} value of 20 µeq/L is conservative, and is reasonably close to the level where pH may drop below a level where effects on aquatic biota would be expected to occur. The ANC_{lim} value of 20 µeq/L was also used in an assessment of nearby lakes for the Snap Lake Environmental Assessment Report (De Beers 2002).

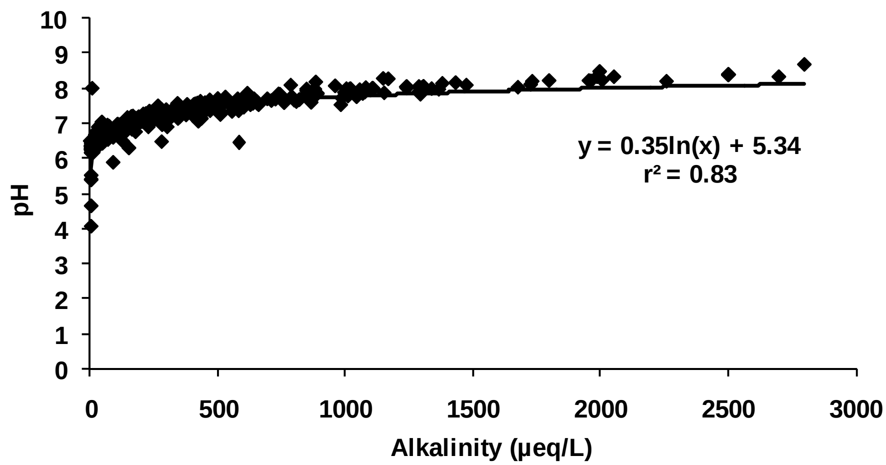


Figure 7.6-2: Alkalinity versus pH for Lakes with Colour ≤15 TCU in the Slave Geological Province

Data source: Puznicki (1996).

TCU = true colour unit; µeq/L = microequivalents per litre.

Lake Water Balance

The mean annual discharge (cubic metres per year [m^3/y]), which is required to calculate mean annual runoff (Q) to a lake, was calculated with a climatic water balance using baseline hydrologic data, where available. This approach uses total precipitation, actual evapotranspiration, lake evaporation, and spatial parameters including land and lake surface areas to estimate mean annual discharge from each sub basin (Section 11.2.1.2). The approach assumes that seepage losses to (or gains from) groundwater are negligible and that water storage in soils is relatively static. Where baseline data were not available, watersheds were delineated using National Topographic Service maps, flow records for similar drainage basins were obtained from Water Survey of Canada Hydrometric Network and data were extrapolated from the Water Survey of Canada and the Environment Canada HYDAT Database (Environment Canada 2011).

Acid Input Rates

Background Deposition Rate

A background deposition rate of 0.066 keq/ha/y was derived by combining dry deposition of 0.033 keq/ha/y from the Alberta Environment Regional Lagrangian Acid Deposition (AENV RELAD) model (0.020 keq/ha/y SO_4^{2-} and 0.013 keq/ha/y NO_3^-) for the extreme northeast portion of Alberta and the wet deposition rate of 0.033 keq/ha/y based on Environment Canada's monitoring data at Snare Rapids, NWT (0.019 keq/ha/y SO_4^{2-} and 0.015 keq/ha/y NO_3^-) (Section 10.1.4.6, Appendix 10.I).

Potential Acid Input

The net PAI was derived by taking into account changes in the seasonal retention pattern of deposited substances. Since winter (under-ice) conditions effectively prevent direct acid deposition to lakes for about 7 months of the year, SO_4^{2-} and NO_3^- deposited during winter accumulates on the snow and ice. During spring freshet, the melting of snow and ice releases the SO_4^{2-} and NO_3^- accumulated over the winter in the watershed into lake water. Plants may not assimilate the NO_3^- during this period because the ground is still frozen and the snowmelt may run overland rather than infiltrating. Thus, it was assumed that the entire NO_3^- deposition accumulated over the winter enters the lake water. Therefore, net annual PAI was calculated using the gross PAI for the winter period.

Nitrogen Retention

During open water conditions, when the short growing season occurs, plants assimilate NO_3^- deposition up to 5 to 15 kilograms per hectare per year (kg/ha/y) (Gordon et al. 2001). Therefore, net NO_3^- deposition above 5 kg/ha/y and all SO_4^{2-} deposition were assumed to enter waterbodies during open water conditions. When the modelled annual deposition of NO_3^- was below the threshold of 5 kg/ha/y, only the SO_4^{2-} deposition was included in the calculation of the net PAI for open water conditions. When NO_3^- deposition was above the threshold, both SO_4^{2-} and the load of NO_3^- over the threshold were included in the calculation of net PAI. As described above, during winter conditions, all NO_3^- is considered acidifying and assumed to enter the lake water.

Data Sources

Baseline water quality data were collected in the aquatic LSA between 2003 and 2010 during both open water and ice-covered conditions (Annex C). Additional background water quality data were available for 4 lakes in the RSA from a study of water quality in the Slave Geological Province (Puznicki 1996). Data from all sources and seasons were used to evaluate acid sensitivity and calculate critical loads.

7.6.1.5 Results

The potential for acidification of lakes was evaluated by comparison of net PAI values to critical loads for baseline conditions, and during construction and operations. Peak emissions during operation were considered in the assessment, which represents a conservative, worst-case scenario as outlined in the SON: Air Quality (Section 10.1.4.1, Appendix 10.I).

Effects of Acidifying Emissions under Baseline Conditions

Predicted net PAI values for baseline conditions are below critical loads for the 17 lakes included in the assessment (Table 7.6-4). Nitrogen deposition under baseline conditions was less than 5 kg/ha/y for all lakes included in the analysis. These results are consistent with the observed lack of acidified lakes in the RSA.

Effects of Acidifying Emissions from the NICO Project

Predicted net PAI values representing peak emissions during construction and operations are below the critical loads for the 17 lakes included in the evaluation of NICO Project-related effects (Table 7.6-4). The annual deposition of nitrogen during construction and operations was less than 5 kg/ha/y for all lakes. Based on these results, NICO Project-related deposition of SO_4^{2-} and NO_3^- in the RSA is not predicted to result in lake acidification.

Table 7.6-4: Critical Loads and Predicted Net Acid Input Rates for Lakes Included in the Assessment

Lake ID[a]	Lake Name	Distance[b] (km)	Direction[b]	Critical Load (keq/ha/y)	Net Potential Acid Input (keq/ha/y)		
					Background	Baseline	Construction and Operations
8	Pond 8	0.8	S	0.710	0.055	0.055	0.117
9	Pond 9	0.8	S	0.810	0.055	0.055	0.116
14	Nico	1.2	E	0.555	0.055	0.055	0.064
11	Pond 11	1.4	S	0.644	0.055	0.055	0.087
15	Peanut	1.4	SE	0.881	0.055	0.055	0.071
13	Pond 13	1.4	SSW	0.478	0.055	0.055	0.079
12	Pond 12	1.5	S	0.591	0.055	0.055	0.080
2	Chalco	2.1	NNW	0.335	0.055	0.055	0.109
1	Burke	3.5	SSE	0.556	0.055	0.055	0.065
10	Lou	3.7	NW	0.559	0.055	0.055	0.076
3	Unnamed	3.9	W	0.315	0.055	0.055	0.062
5	Lion	5.3	WNW	0.577	0.055	0.055	0.058
16	Reference	7.0	SSE	0.825	0.055	0.055	0.059
17	Hislop	15.5	W	2.127	0.055	0.055	0.058
18	Mazenod	21.2	NW	0.936	0.055	0.055	0.060
28	Rabbit	23.0	WSW	0.748	0.055	0.055	0.057
19	Faber	33.6	NNW	2.194	0.055	0.055	0.057

[a] Identifier used on map showing waterbody locations (Figure 7.1-1).

[b] Distance and direction relative to the NICO Project.

km = kilometre; keq/ha/y = kiloequivalents per hectare per year; SO_4^{2-} = sulphate; NO_3^- = nitrate; PAI = Potential Acid input.

7.6.2 Deposition of Dust and Metals from Air Emissions to Waterbodies in the Regional Study Area during Construction and Operations

7.6.2.1 Introduction

Windborne dust from the NICO Project facilities and exposed lake bed sediments, and air emissions from the NICO Project facilities may result in increased deposition of dust and associated metals in the surrounding area. The deposited dust may enter surface waters, particularly during spring freshet, and could result in increased concentrations of suspended sediments and associated metals in lake water.

This section evaluates potential changes in the concentrations of suspended sediments and metals from NICO Project-related atmospheric deposition for lakes in the Air Quality RSA. Sections 7.6.2.2 and 7.6.2.3 describe the assessment approach and the study area, respectively. Section 7.6.2.4 summarizes the assessment methods. Section 7.6.2.5 provides the results of the analysis for baseline conditions, and during construction and operations.

7.6.2.2 Assessment Approach

A simple mass balance calculation was used to predict changes in TSS and metal concentrations in lake water from deposition on the lake surface and within the watershed, for selected lakes in the Air Quality RSA. Changes in TSS and metal concentrations were calculated based on TSP deposition rate and individual metal deposition rates, respectively, as predicted by air dispersion modelling (Section 10.4.1.3). The calculation was performed for baseline conditions and using maximum deposition rates during construction and operations. Predicted TSS concentrations are evaluated in Section 12.4.1.1 (SON: Fish and Aquatic Habitat); predicted metal concentrations were compared to SSWQOs or chronic water quality guidelines for the protection of aquatic life (CCME 1999) and background concentrations.

A factor was applied to metals and TSS concentrations for the assessment of the construction and operations phase dust deposition effects to account for settling of larger-sized particles. Fractions of TSP deposition greater than 10 µm were calculated based on modelled TSP and PM_{10} at each lake (Section 10.4.2). This fraction was then applied to TSS and metal deposition values. Therefore, only the fraction of metals and TSS less than 10 µm were assumed to remain suspended in the water column as everything greater than 10 µm will likely settle rapidly and have no effect on water quality.

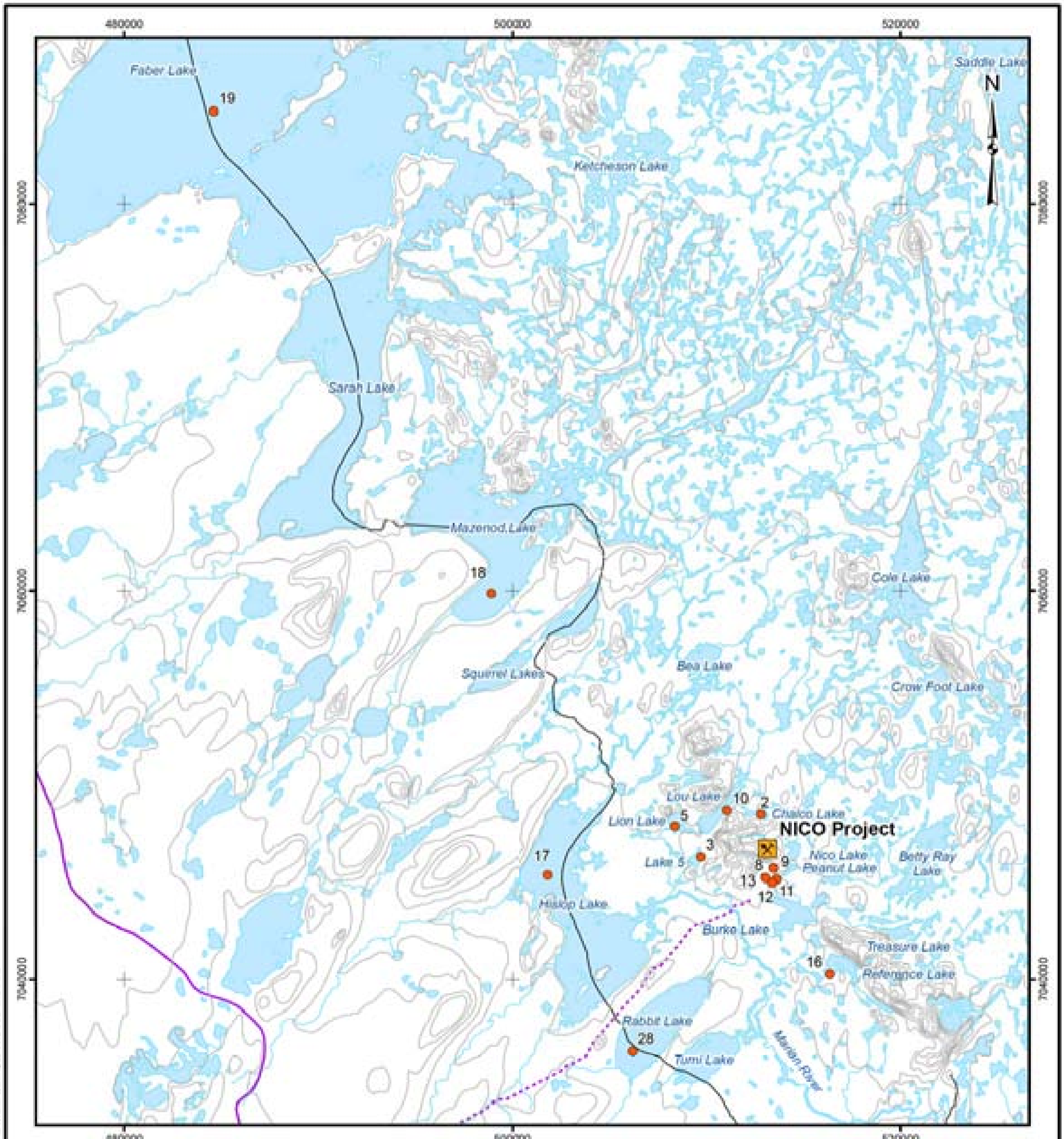
The approach used for this evaluation is conservative for the following reasons:

- It is based on air quality modelling, which incorporates conservative assumptions for emissions of dust and metals; in particular, 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 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. Concentrations of these metals were set at the detection limit for air quality and deposition modelling.

As a result of these factors, predicted changes in TSS and metal concentrations in local lakes are considered to be conservative estimates of the maximum potential changes that could occur during construction and operations.

7.6.2.3 Study Area

The effects of atmospheric deposition of dust and metals were evaluated for 14 lakes within the Air Quality RSA (Figure 7.6-3). These lakes were selected on the basis of available water quality data and position relative to the NICO Project footprint. Lakes with available data and located outside the NICO Project footprint were also included in the analysis. Lakes within the NICO Project footprint were included if they were expected to remain largely undisturbed during construction and operations, and were not surrounded by NICO Project infrastructure. The lakes excluded from the analysis are expected to be lost or modified during operations (i.e., Grid Pond, Little Grid Pond, and location of optional Contingency Pond).



LEGEND

- NICO PROJECT
- CONTOUR (20 METRE INTERVAL)
- EXISTING WINTER ROAD
- PROPOSED NICO PROJECT ACCESS ROAD
- PROPOSED TLICHO ROAD ROUTE
- WATERCOURSE
- WATERBODY
- LAKE ASSESSED FOR ANNUAL DEPOSITION OF DUST AND METALS

7.5 0 7.5

SCALE 1:275,000 KILOMETRES

REFERENCE

Base data obtained from Atlas of Canada, DMTI, and GeoGratis.
Projection: UTM Zone 11 Datum: NAD 83

FORTUNE MINERALS LIMITED
NICO DEVELOPER'S ASSESSMENT REPORT

TITLE
LAKES IN THE AIR QUALITY REGIONAL STUDY AREA ASSESSED FOR ANNUAL DEPOSITION OF DUST AND METALS

Golder Associates
Edmonton, Alberta

FILE No. E-WQ-002-GIS

PROJECT No. 09-1373-1004		SCALE AS SHOWN	REV. 0
DESIGN	HM	24 Mar. 2011	
GIS	CW	13 May 2011	
CHECK	JG	13 May 2011	
REVIEW	JG	13 May 2011	

FIGURE: 7.6-3

Water quality of Nico, Peanut, and Burke lakes during construction and operations were predicted using a water quality model that accounted for all inputs from the NICO Project, including dust and metals deposition. Results for these 3 lakes are presented in Section 7.6.3.

7.6.2.4 Assessment Methods

Parameters Included in the Analysis

Parameters included in the analysis with respective SSWQOs (Appendix 7.VII) and water quality guidelines for the protection of aquatic life are shown in Table 7.6-5. Parameters included a suite of metals and TSS, selected based on availability of chemistry data for particulate materials expected to contribute to dust released from roads and NICO Project facilities.

Table 7.6-5: Parameters and Water Quality Guidelines Used to Evaluate Changes from Deposition of Dust and Metals

Parameter	Site-specific Water Quality Objective (mg/L)	Chronic Guidelines for the Protection of Aquatic Life [a] (mg/L)
Aluminum	0.41	0.1
Antimony	0.03	-
Arsenic	0.05	0.005
Cadmium	0.00015	0.000039
Chromium	-	0.001
Cobalt	0.01	-
Copper	0.022	0.002
Iron	1.5	0.3
Lead	0.008	0.002
Mercury	-	0.000026
Molybdenum	-	0.073
Nickel	-	0.065
Selenium	0.005	0.001
Silver	-	0.0001
Thallium	-	0.0008
Uranium	0.027	0.015
Zinc	0.11	0.03

[a] CCME 1999.

mg/L = milligrams per litre; - = not available or not applicable.

Mass Balance Calculation

Sources of metals and solids loading to lakes from atmospheric deposition include direct deposition on the lake surface and deposition to surfaces within the watershed and subsequent runoff. A simple mass balance calculation was used to predict changes in TSS and metal concentrations for the lakes included in the assessment under baseline conditions, and during construction and operations. The calculation was based on the conservative assumption that the watershed consisted only of impervious surfaces and therefore all deposited material entered the lake. This represents an upper-bound prediction, corresponding to the maximum potential change in concentrations of metals and TSS in lake water.

Lake Water Balance

Summary hydrology data for each of the assessed lakes are provided in Table 7.6-6. The mean annual discharge (m^3/y), which is required to calculate mean annual runoff (Q) to a lake, was calculated with a climatic water balance using baseline hydrologic data, where available. This approach uses total precipitation, actual evapotranspiration, lake evaporation, and spatial parameters including land and lake surface areas to estimate mean annual discharge from each sub-basin (Section 11.2.1.2). The approach assumes that seepage losses to (or gains from) groundwater are negligible and that water storage in soils is relatively static. Where baseline data were not available, watersheds were delineated using National Topographic Service maps, flow records for similar drainage basins were obtained from Water Survey of Canada Hydrometric, Network and data were extrapolated from the Water Survey of Canada and the Environment Canada HYDAT Database (Environment Canada 2011).

Table 7.6-6: Hydrology Data for Lakes Included in the Evaluation of Dust and Metals Deposition

Lake ID[a]	Lake Name	Easting[b]	Northing[b]	Distance[c] (km^2)	Gross Catchment Area (km^2)	Lake Area (km^2)	Annual Water Yield (mm/y)	Mean Annual Discharge (m^3/s)
8	Pond 8	513465	7045732	0.8	0.1	0.001	87	0.0003
9	Pond 9	513458	7045716	0.8	1.5	0.004	87	0.004
11	Pond 11	513612	7045145	1.4	2.0	0.003	86	0.005
13	Pond 13	513039	7045217	1.4	1.3	0.053	87	0.003
12	Pond 12	513393	7044996	1.5	1.4	0.017	79	0.003
2	Chalco	512810	7048511	2.1	2.4	0.328	85	0.005
10	Lou	511054	7048725	3.3	40.7	0.194	58	0.107
3	Unnamed	509720	7046295	3.8	2.8	0.362	87	0.005
5	Lion	508382	7047882	5.3	49.9	0.824	59	0.129
16	Reference	516360	7040283	6.8	13.5	1.2	64	0.029
17	Hislop	498053	7045665	15.5	2697.0	34.7	48	4.915
18	Mazenod	496273	7058821	21.2	28.8	3.6	55	0.029
28	Rabbit	492357	7037347	23.0	44.1	11.7	85	0.037
19	Faber	504346	7078879	36.2	2954.0	403.0	49	6.468

[a] Identifier used on map showing waterbody locations (Figure 7.1-3).

[b] Universal Transverse Mercator (UTM) co-ordinates, north American datum (NAD83), Zone 12.

[c] Distance relative to the NICO Project.

km^2 = square kilometres; mm/y = millimetres per year; m^3/s = cubic metres per second.

Air Modelling

Change in metal deposition was estimated from air dispersion modelling for the Baseline and Application Cases described in the SON: Air Quality (Section 10.4.1.3). The modelling results represent the highest predicted emissions near each lake and are therefore considered to be conservative. Total change in deposition for each parameter was estimated as a sum of both wet and dry deposition.

The modelled results do not include background emissions and represent only the change in deposition related to the NICO Project. No emissions from other developments were included because all other sources of emissions are distant from the NICO Project and were assumed to represent negligible sources.

Emissions of metals and dust were modelled based on erosion sources (e.g., fugitive dust from roads) and NICO Project-related industrial sources (e.g., power generators and vehicles). A full list of emission sources included in the model is provided in the SON: Air Quality (Section 10.4.2.1, Table 10.4.3).

Data Sources

Background concentrations of metals and TSS were estimated from baseline water quality data collected in the LSA between 2003 and 2010 during both open water and ice-covered conditions (Annex C). Additional background water quality data were available for 5 lakes in the Air Quality RSA from a study conducted on water quality in the Slave Geological Province (Puznicki 1996). Data from all sources and seasons were used to calculate background concentrations of metals and TSS for lakes included in the assessment.

Median background concentrations were calculated for each individual lake using all available data (Table 7.6-7). Data for which the detection limit was above the guideline were not included. Data below the detection limit were replaced with half the detection limit. Final background values were based on median concentrations for each parameter at each lake. If lake-specific data were not available for a given parameter, the median concentration from all available baseline data in the RSA was used.

Background concentrations indicate that chromium concentrations are above the CCME guideline in 4 of the 14 lakes and the iron concentration was above the SSWQO in Pond 8 (Table 7.6-7).

Table 7.6-7: Median Background Metal and Total Suspended Solids Concentrations for the 14 Lakes Included in the Assessment

Parameter	SSWQO (mg/L)	Median Background Metal Concentrations (mg/L)													
		Pond 8 [8]	Pond 9 [9]	Pond 11 [11]	Pond 13 [13]	Pond 12 [12]	Chalco [2]	Lou [10]	Unnamed [3]	Lion [5]	Reference [16]	Hislop [17]	Mazenod [18]	Rabbit [28]	Faber [19]
Distance from Project (km^2)		0.8	0.8	1.4	1.4	1.5	2.1	3.7	3.9	5.3	7.0	15.5	21.2	23.0	33.6
Aluminum	0.41	0.402	0.110	0.140	0.221	0.048	0.070	0.049	0.155	0.050	0.032	0.041	<0.001	0.044	0.007
Antimony	0.03	<0.0001	0.0002	0.0002	0.0002	0.0002	0.0007	0.0002	0.0008	0.0007	0.0002	0.0007	0.0002	0.0007	0.0007
Arsenic	0.05	0.002	0.001	0.005	0.002	0.004	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001
Barium	-	0.010	0.006	0.009	0.007	0.007	0.007	0.006	0.008	0.005	0.012	0.007	0.033	0.018	0.017
Beryllium	-	0.00002	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0001	0.0001	0.0001	0.0001
Cadmium	0.00015	0.000037	0.000009	0.000005	0.000005	0.000010	**0.00001**	0.000005	**0.00001**	0.000035	0.000005	**0.00001**	**0.00001**	**0.00001**	**0.00001**
Chromium	0.001[a]	0.0014	0.0005	0.0010	0.0008	0.0004	0.0004	0.0004	0.0009	**0.0006**	0.0004	0.0012	0.0014	0.0019	0.0006
Cobalt	0.01	0.0010	0.0010	0.0010	0.0010	0.0002	0.0001	0.0003	0.0003	0.0002	0.0010	0.0001	0.0001	0.0001	0.0001
Copper	0.022	0.002	0.002	0.001	0.002	0.001	0.005	0.002	0.004	0.001	0.001	0.001	<0.001	0.001	<0.001
Iron	1.5	3.86	0.14	0.54	0.19	0.27	0.11	0.16	0.29	0.07	0.15	0.05	0.01	0.09	0.02
Lead	0.008	0.00030	0.00005	0.00005	0.00013	0.00007	0.00005	0.00006	0.00008	0.00010	0.00010	0.00053	0.00049	0.00010	0.00021
Manganese	-	0.054	0.003	0.039	0.003	0.014	0.018	0.014	0.021	0.006	0.029	0.014	0.036	0.072	0.001
Mercury	0.000026[a]	0.00001	0.00001	0.00001	0.00001	0.00001	**0.00001**	0.00001	**0.00001**	0.00003	0.00001	**0.00001**	**0.00001**	**0.00001**	**0.00001**
Molybdenum	0.073[a]	0.0003	0.0009	0.0002	0.0005	0.0002	0.0003	0.0001	0.0004	0.0002	0.0002	0.0003	<0.0001	<0.0001	0.0004
Nickel	-	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001
Selenium	0.005	0.00002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0005	0.0005	0.0005
Silver	0.0001[a]	0.000009	**0.000007**	0.000003	0.000003	0.000026	**0.000007**	0.000005	**0.000007**	**0.000007**	0.000005	0.000050	0.000050	0.000050	0.000050
Strontium	-	0.03	0.02	0.03	0.02	0.03	0.02	0.03	0.03	0.03	0.04	0.05	0.11	0.08	0.18
Thallium	0.0008[a]	0.000001	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00010	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium	-	0.0213	0.0018	0.0025	0.0050	0.0017	0.0025	0.0020	0.0043	0.0025	0.0014	<0.0001	0.0064	<0.0001	<0.0001
Uranium	0.027	0.0011	0.0013	0.0003	0.0007	0.0002	0.0006	0.0003	0.0006	0.0002	0.0002	0.0008	0.0001	0.0002	0.0013
Vanadium	-	0.0026	0.0005	0.0005	0.0010	0.0005	0.0001	0.0005	0.0005	0.0020	0.0005	0.0005	0.0004	0.0010	0.0003
Zinc	0.11	0.003	0.002	0.002	0.002	0.002	0.008	0.002	0.008	0.003	0.002	0.001	<0.001	0.001	<0.001
Total Suspended Solids	-	8.0	3.3	21.5	3.0	1.5	8.0	1.5	5.8	1.5	3.0	**4.6**	**4.6**	**4.6**	**4.6**

[a] no SSWQO available; therefore CCME guideline was used.

SSWQO = site-specific Water Quality Objective; mg/L = milligrams per litre; - = not available or not applicable.

Shaded cells = background concentration is greater than the SSWQO.

Bolded cells = no background data available, median based on all other lakes is shown.

7.6.2.5 Results

The potential effects of dust and associated metal deposition on water quality were evaluated for 14 lakes within the Air Quality RSA.

Effects of Deposition of Dust and Metals under Baseline Conditions

Under baseline conditions, predicted increases in TSS and metal concentrations relative to background were very small (i.e., <1% for most parameters, Table 7.6-8). Concentrations of chromium and iron were greater than the SSWQO in some lakes, which is consistent with exceedances by background concentrations (Table 7.6-7). These results are consistent with the absence of development in the NICO Project area at the time of start-up.

Effects of Deposition of Dust and Metals from the NICO Project

Predicted maximum concentrations of aluminum, iron, and chromium during construction and operations are above the SSWQO or CCME guideline in 2 or more lakes (Table 7.6-9). As previously noted, concentrations of iron and chromium were above guidelines in several lakes under background and baseline conditions. However, in the previous section, predicted concentrations reflect the conservative assumptions used in the air quality modelling and mass balance analysis.

The spatial extent of dust and metal deposition is anticipated to be restricted to localized areas within and close to the NICO Project footprint. Maximum deposition is expected to occur in the middle of the NICO Project footprint in the vicinity of the Plant, Open Pit, and haul roads (Section 10.4.2.3.2). In general, elevated deposition of dust and metals is predicted to occur to a distance of approximately 2 km from the NICO Project Lease Boundary.

The period of elevated TSS and metal concentrations in affected lakes is expected to be relatively short. During construction and operations, the largest load of suspended sediments to surface waters during the year will 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 and metal concentrations in lakes, except in localized areas near stream mouths during and immediately after precipitation events.

The length of the freshet period is estimated to range from approximately 2 days for small lakes to a maximum of 1 to 2 weeks. This would be followed by a period of settling, estimated as less than a month based on observations at Snap Lake (De Beers 2010). Snap Lake is a small lake located adjacent an operating diamond mine approximately 290 km east of the NICO Project. Post-freshet sampling of Snap Lake typically occurs in early to mid-July (i.e., less than a month after freshet), by which time TSS concentrations in lake water are typically below the analytical detection limit of 3 mg/L.

Table 7.6-8: Predicted Concentrations of Metals and Total Suspended Solids in Lakes under the Baseline Case

Parameter	SSWQO (mg/L)	Predicted Concentration under the Baseline Case (mg/L)													
		Pond 8 [8]	Pond 9 [9]	Pond 11 [11]	Pond 13 [13]	Pond 12 [12]	Chalco [2]	Lou [10]	Unnamed [3]	Lion [5]	Reference [16]	Hislop [17]	Mazenod [18]	Rabbit [28]	Faber [19]
Distance from Project (km^2)		0.8	0.8	1.4	1.4	1.5	2.1	3.7	3.9	5.3	7.0	15.5	21.2	23.0	33.6
Aluminum	0.41	0.40	0.11	0.14	0.22	0.05	0.07	0.05	0.16	0.05	0.03	0.04	<0.01	0.04	0.01
Antimony	0.03	0.0000	0.0002	0.0002	0.0002	0.0002	0.0007	0.0002	0.0008	0.0007	0.0002	0.0007	0.0002	0.0007	0.0007
Arsenic	0.05	0.002	0.001	0.005	0.002	0.004	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001
Barium	-	0.010	0.006	0.009	0.007	0.007	0.007	0.006	0.008	0.005	0.012	0.007	0.033	0.018	0.017
Beryllium	-	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001	0.0001	0.0001
Cadmium	0.00015	0.000037	0.000009	0.000005	0.000005	0.000010	0.000012	0.000006	0.000012	0.000035	0.000006	0.000012	0.000014	0.000013	0.000012
Chromium	0.001[a]	0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	0.001	0.001	<0.001	0.001	0.001	0.002	0.001
Cobalt	0.01	0.001	0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	0.0001	0.0001	0.0001	0.0001
Copper	0.022	0.002	0.002	0.001	0.002	0.001	0.005	0.002	0.004	0.001	0.001	0.001	0.0001	0.001	<0.001
Iron	1.5	3.9	0.1	0.5	0.2	0.3	0.1	0.2	0.3	0.1	0.2	0.1	<0.1	0.1	0.02
Lead	0.008	0.0003	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0001	0.0002
Manganese	-	0.054	0.003	0.039	0.003	0.014	0.018	0.014	0.021	0.006	0.029	0.014	0.036	0.072	0.001
Mercury	0.000026[a]	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	0.073[a]	0.0003	0.0009	0.0002	0.0005	0.0002	0.0003	0.0001	0.0004	0.0002	0.0002	0.0003	<0.0001	<0.0001	0.0004
Nickel	-	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001
Selenium	0.005	0.0000	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0002	0.0005	0.0005	0.0005	0.0005
Silver	0.0001[a]	0.00001	0.00001	<0.00001	<0.00001	0.00003	0.00001	0.00001	0.00001	0.00001	0.00001	0.00005	0.00005	0.00005	0.00005
Strontium	-	0.030	0.022	0.034	0.016	0.034	0.021	0.027	0.025	0.025	0.035	0.054	0.109	0.077	0.177
Thallium	0.0008[a]	<0.00001	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00010	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium	-	0.021	0.002	0.003	0.005	0.002	0.003	0.002	0.004	0.003	0.001	<0.001	0.006	<0.001	<0.001
Uranium	0.027	0.0011	0.0013	0.0003	0.0007	0.0002	0.0006	0.0003	0.0006	0.0002	0.0002	0.0008	0.0001	0.0002	0.0013
Vanadium	-	0.0026	0.0005	0.0005	0.0010	0.0005	0.0001	0.0005	0.0005	0.0020	0.0005	0.0005	0.0004	0.0010	0.0003
Zinc	0.11	0.003	0.002	0.002	0.002	0.002	0.008	0.002	0.008	0.003	0.002	0.001	<0.001	0.001	<0.001
Total Suspended Solids	-	8	3	22	3	2	8	2	6	2	3	5	5	5	5

[a] no SSWQO available; therefore CCME guideline was used.

SSWQO = site-specific Water Quality Objective; mg/L = milligrams per litre; - = not available or not applicable.

Shaded cells = background concentration is greater than the SSWQO.

Table 7.6-9: Predicted Concentrations of Metals and Total Suspended Solids in Lakes during Construction and Operations

Parameter	SSWQO (mg/L)	Predicted Maximum Concentration under the Application Case (mg/L)													
		Pond 8 [8]	Pond 9 [9]	Pond 11 [11]	Pond 13 [13]	Pond 8 [8]	Chalco [2]	Lou [10]	Unnamed [3]	Lion [5]	Reference [16]	Hislop [17]	Mazenod [18]	Rabbit [28]	Faber [19]
Distance from Project (km^2)		0.8	0.8	1.4	1.4	1.5	2.1	3.7	3.9	5.3	7.0	15.5	21.2	23.0	33.6
Aluminum	0.41	1.10	0.81	0.63	0.70	0.50	1.40	0.33	0.42	0.16	0.13	0.10	0.10	0.09	0.01
Antimony	0.03	0.0002	0.0004	0.0003	0.0003	0.0003	0.0010	0.0003	0.0009	0.0007	0.0002	0.0007	0.0003	0.0007	0.0007
Arsenic	0.05	0.027	0.026	0.022	0.017	0.019	0.035	0.008	0.010	0.004	0.004	0.002	0.003	0.002	0.000
Barium	-	0.017	0.013	0.015	0.012	0.012	0.021	0.009	0.011	0.006	0.013	0.008	0.034	0.018	0.017
Beryllium	-	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.0001	0.0001	0.0001	0.0001
Cadmium	0.00015	0.000067	0.000038	0.000025	0.000023	0.000030	0.000044	0.000018	0.000023	0.000040	0.000009	0.000017	0.000029	0.000026	0.000016
Chromium	0.001[a]	0.002	0.001	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
Cobalt	0.01	0.004	0.004	0.003	0.003	0.002	0.004	0.001	0.001	0.001	0.001	0.0003	0.0004	0.0003	0.0001
Copper	0.022	0.004	0.004	0.002	0.003	0.002	0.009	0.002	0.004	0.002	0.001	0.001	0.0004	0.001	0.001
Iron	1.5	5.4	1.7	1.6	1.2	1.3	2.8	0.7	0.9	0.3	0.4	0.2	0.2	0.2	0.03
Lead	0.008	0.0004	0.0002	0.0001	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001	0.0001	0.0005	0.0005	0.0001	0.0002
Manganese	-	0.063	0.012	0.045	0.009	0.020	0.032	0.017	0.024	0.007	0.030	0.015	0.037	0.073	0.001
Mercury	0.000026[a]	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00001	0.00003	0.00001	0.00001	0.00001	0.00001	0.00001
Molybdenum	0.073[a]	0.0004	0.0010	0.0002	0.0005	0.0002	0.0004	0.0001	0.0004	0.0002	0.0002	0.0003	0.0000	0.0000	0.0004
Nickel	-	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.000	0.001	0.000	0.000
Selenium	0.005	0.0001	0.0003	0.0002	0.0002	0.0002	0.0003	0.0002	0.0002	0.0002	0.0002	0.0005	0.0005	0.0005	0.0005
Silver	0.0001[a]	0.00002	0.00001	0.00001	0.00001	0.00003	0.00002	0.00001	0.00001	0.00001	0.00001	0.00005	0.00005	0.00005	0.00005
Strontium	-	0.030	0.023	0.034	0.017	0.034	0.022	0.027	0.025	0.025	0.035	0.054	0.109	0.077	0.177
Thallium	0.0008[a]	0.00001	0.00006	0.00006	0.00006	0.00006	0.00006	0.00005	0.00005	0.00010	0.00005	0.00005	0.00005	0.00005	0.00005
Titanium	-	0.045	0.026	0.019	0.021	0.017	0.046	0.011	0.013	0.006	0.005	0.002	0.010	0.002	0.000
Uranium	0.027	0.0012	0.0014	0.0004	0.0008	0.0002	0.0008	0.0003	0.0006	0.0002	0.0002	0.0008	0.0001	0.0002	0.0013
Vanadium	-	0.0031	0.0010	0.0009	0.0014	0.0008	0.0011	0.0007	0.0006	0.0021	0.0006	0.0005	0.0005	0.0011	0.0003
Zinc	0.11	0.003	0.002	0.002	0.002	0.002	0.009	0.002	0.008	0.003	0.002	0.001	0.000	0.001	0.000
Total Suspended Solids	-	23	18	32	13	11	36	7	12	4	5	6	7	6	5

[a] no SSWQO available; therefore CCME guideline was used.

SSWQO = site-specific Water Quality Objective; mg/L = milligrams per litre; - = not available or not applicable.

Shaded cells = background concentration is greater than the SSWQO.

7.6.2.6 Summary

An analysis was conducted to estimate maximum potential changes in TSS and metal concentrations in lakes within the air quality regional study area, to evaluate potential effects of dust and air emissions during construction and operation of the NICO Project. The results of this analysis indicate the concentrations of TSS and certain metals may be elevated during and after freshet, potentially to levels above SSWQOs values or water quality guidelines. Effects on TSS and metal concentrations are expected to be localized in the immediate vicinity of the NICO Project and temporally restricted to the period during and after freshet.

Predictions of TSS and metal concentrations presented in this section are subject to a high degree of uncertainty, in the direction of predicting higher concentrations than can be realistically expected, based on the degree of conservatism incorporated in the evaluation and experience at operating diamond mines in the NWT.

7.6.3 Water Quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

The NICO Project water quality model was developed in the GoldSim™ modelling environment for continuous simulation of water quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River immediately downstream of the Burke Creek outlet, for the Baseline and Application Cases. The Baseline Case is calibrated to surface water quality conditions observed during baseline monitoring programs and used as a benchmark, against which the Application Case is compared. The model uses conservative assumptions to minimize the potential for changes to be underestimated.

The following sections contain an overview of the development and calibration of the NICO Project water quality model, development of the calibrated model to represent conditions under the Application Case during the construction, operations, active closure, and post-closure phases of the NICO Project, and the approach used for the assessment of modelling results. Additional detail on model inputs and calibration is provided in Appendix 7.I.

7.6.3.1 Baseline Case Model Development and Calibration

The Baseline Case water quality model is a coupled flow and mass balance model operating on a daily time step. It is based on daily background surface water flow time series, derived for each sub-watershed in the Lou Lake and Burke Lake watersheds, and for the Marian River immediately upstream of the confluence with the Burke Lake watershed outlet (i.e., Burke Creek). The daily background surface water flow time series within the Burke Lake watershed and for the Marian River were derived from concurrent hydrometric monitoring records over a period of 26 years, from 2 Water Survey of Canada stations with similar latitudes and watershed areas that are similar to the Burke Lake and Marian River watershed areas. These background surface water flow time series were calibrated to flows observed during baseline monitoring programs (Annex G, Sections 5.6 and 5.7).

The Baseline Case model was constructed as a network of waterbodies, each with a defined surface area and average volume as determined by baseline bathymetric surveys (Annex C, Section 2.2), that ultimately flow into the Marian River. The background surface water flow time series were used to define the inflows to and outflows from each waterbody, using a constant volume assumption (i.e., outflows = sum of inflows), and in the Marian River immediately upstream of Burke Creek.

Constituent concentration and suspended sediment concentration inputs for background flow sources were sampled on a daily basis, from statistical distributions derived from baseline monitoring program results for the open water and ice-covered seasons. Concentrations within each waterbody were determined by mass balance calculations, and assumed complete mixing within each time step. Calculated fully mixed constituent concentrations in each outflow from the previous time step were, in turn, the input concentrations for the corresponding inflow to each downstream waterbody. Predicted concentrations in the Marian River, downstream of outflows from Burke Lake, were determined by a simple flow and mass balance calculation using the assumption of complete mixing in the Marian River.

Total constituent concentration predictions were checked against baseline monitoring results in each of Nico, Peanut, and Burke lakes. Calibration factors were applied to background constituent concentration profiles, where required, to improve the fit between predicted and observed concentration statistics.

Following development and calibration of the Baseline Case model, the model configuration was updated to accommodate simulation of a period longer than 26 years by allowing the background flow time series to repeat sequentially. This was done to facilitate generation of continuous baseline water quality predictions in parallel with the Application Case model, which requires a continuous simulation period longer than 26 years to include all NICO Project phases.

Statistical distributions of surface water partition coefficients were incorporated into the Baseline Case model, prior to development of the Application Case model, to accommodate predictions of both total and dissolved metals concentrations in the receiving environment. Surface water partition coefficients were derived from suspended solids concentrations and associated total and dissolved constituent concentrations measured in water samples collected during the baseline monitoring program.

7.6.3.2 Application Case Model Development

The Application Case model was developed from, and runs in parallel with, the calibrated Baseline Case model, incorporating alterations that reflect changes in surface water quantity and quality inputs that result from NICO Project activities. Both cases run continuously from the start of the construction phase, continuing through operations to active closure and post-closure prior to discharge from the Flooded Open Pit. The Application Case model accounts for the following NICO Project-related changes:

- reductions in background flows associated with:
  - changes in watershed areas due to mine footprint development and reclamation (Appendix 3.III);
  - predicted reductions in base flow recharge (Appendix 11.I); and
  - water withdrawals from Lou Lake (Appendix 11.II);
- discharges from the ETF to Peanut Lake;
- seepages to Nico Lake during operations from the Surge Pond, Plant Site Sump, and SCPs;
- flows from Wetland Treatment Systems to Nico Lake beginning at closure, which are assumed to intercept seepage flows from the Surge Pond and SCPs; and
- deposition of suspended particulates and associated metals during the construction and operations phases, using assumptions consistent with those described in Section 7.6.2 that have been modified for application on a daily versus annual basis:

- particulates deposited throughout the Burke Lake watershed area are not retained on the landscape and report to surface waters;
- the particulate mass fraction (and associated metals) less than or equal to 10 µm (i.e., PM_{10} fraction) remains in suspension indefinitely;
- the particulate mass fraction (and associated metals) greater than 10 µm (i.e., larger than PM_{10} fraction) is transient and assumed to settle to lake sediments instantaneously;
- metals concentrations were assumed to be uniformly distributed among all particulate mass fractions;
- annual maximum rates of particulate deposition report to surface waters during the open-water season (i.e., May through October); and
- particulate deposition accumulates during winter and the accumulated mass reports to surface waters at a constant rate during May and June.

Discharge from the STP to Peanut Lake was not included in the model, as ammonia concentrations in the STP effluent are expected to be below the SSWQOs value.

NICO Project flow sources were included in the Application Case model with rates based on average climatic conditions. Water quality inputs for these sources were based on-site water chemistry predictions presented in Appendix 7.II, which incorporated results of baseline monitoring of surface water (Annex C) and groundwater (Appendix 7.III). Site water quality inputs to the model were either constant (e.g., seepages) or updated on an annual or monthly basis (e.g., ETF effluent and closure Wetland Treatment Systems, respectively). These average condition flows and associated loading rates were conservatively applied to a variable receiving environment (i.e., variable background flow time series).

A conceptual design for the ETF discharge diffuser in Peanut Lake was developed and is provided in Appendix 7.IV. The conceptual diffuser design analysis indicated that bulk dilution rates in the near field zone (i.e., within 14 m of the diffuser) would be greater than 19:1. This predicted dilution could be limited during periods of low surface water flows through Peanut Lake, when recirculation of the mixed effluent plume and accumulation of mass could occur within the lake. The complete mixing assumption was retained to maximize effluent discharge residence time in Peanut Lake and capture potential accumulation of mass during periods of low surface flows.

Although seepage from the CDF during operations was identified as a secondary pathway due to environmental design features (e.g., Surge Pond and SCP dams will be lined to limit seepage out of these ponds, and ditches will be placed at the toe of the dams to intercept seepage escaping from these dams), the seepage losses indicated in the site water balance (summarized in Section 3.9.3 and detailed in Attachment 7.II-II of Appendix 7.II) were incorporated into the water quality model. This was done to verify that potential incremental effects associated with seepages reaching Nico Lake during operations, along with deposition of dust and associated metals, would not be underestimated. There is a moderate to high level of conservatism in including these seepages, as seepage modelling has not yet been completed, no interception was assumed, and attenuation of constituent concentrations in seepages along the flow path to Nico Lake (i.e., as observed in the Grid Ponds) was not included. Seepage modelling for the NICO Project will be completed as part of the detailed design of the seepage collection dams.

Uncertainty and variability in model inputs was addressed by using a Monte Carlo analysis with 100 realizations. The starting year of the 26-year background surface water flow time series was randomly selected for each realization and repeated in a loop, ensuring that the range of modelled receiving water flow conditions was captured during each phase of the NICO Project. Latin Hypercube Sampling of background surface water concentrations (on a daily basis) and surface water partition coefficient distributions (on a per-realization basis) ensured that the range of these stochastic inputs were sampled and represented in the model results.

7.6.3.3 Water Quality Modelling Results

Results of the water quality modelling for Nico Lake, Peanut Lake, Burke Lake, and the Marian River are presented and discussed in the following sections. Within each section, water quality modelling results have been grouped into 4 categories:

- TSS;
- TDS and major ions;
- nutrients; and
- metals.

Summaries of water quality modelling predictions for all modelled constituents are presented in tables that include comparisons to Canadian Water Quality Guidelines for the Protection of Aquatic Life (CCME 2011) and SSWQOs developed for the NICO Project (Appendix 7.VII) for reference. The assessment of effects of changes in water quality to aquatic life is presented in Section 7.7, and the assessment of effects to wildlife and human health is presented in Sections 7.8 and 7.9, respectively. For Nico Lake and Peanut Lake, CCME guidelines are only included for comparison to constituents without SSWQOs, as the SSWQO values are criteria that are relevant to waterbodies directly influenced by the NICO Project site. For Burke Lake and the Marian River, comparisons are made to both CCME guidelines and SSWQOs, as Burke Lake is further removed from the NICO Project site inputs, and the Marian River at Burke Creek is a point of transition between local and regional study areas.

The summary tables include the average and 95th percentile of predicted Baseline Case concentrations and Application Case concentrations during the construction phase (mine years -2 through -1), operations phase (mine years 1 through 19), active closure (mine years 20 through 21), and post-closure (mine years 27 through 33). The post-closure summary period was based on a period beginning when predicted concentrations are approaching a steady state condition.

Time series plots of 95th percentile Application Case predictions for selected water quality constituents within the 3 categories listed above are also presented in the following sections. These plots include the median value of 95th percentile simulated Baseline Case concentrations. Time series plots for all modelled water quality constituents are provided in Appendix 7.V.

7.6.3.3.1 Nico Lake

Water quality in Nico Lake may be directly affected by NICO Project activities, including deposition of dust and associated metals during construction and operations, changes in watershed areas and associated inflow quantity and quality due to development of the NICO Project footprint during construction and operations, and discharge of passively treated waters from Wetland Treatment Systems No. 1, 2, and 3 after operations. A summary of water quality modelling predictions for Nico Lake are presented in Table 7.6-10, while predictions related to deposition of acidifying substances are provided separately in Section 7.6.1.

7.6.3.3.1.1 Total Suspended Solids

Total suspended solids concentrations in Nico Lake are predicted to increase as a result of fugitive dust and air emissions from NICO Project facilities. Discharges to Nico Lake from the Wetland Treatment Systems following closure are not expected to affect TSS concentrations, as the design of the wetlands is expected to reduce TSS concentrations in the influent waters to a level consistent with the range of TSS concentrations naturally expected in the receiving environment. The predicted maximum (95th percentile) TSS concentrations in Nico Lake are projected to be 9.1 mg/L during construction and 27.9 mg/L during operations (Table 7.6-10). Concentrations of TSS are expected to decrease during closure and reclamation, and return to levels consistent with baseline values.

Incremental changes to TSS concentrations due to deposition of air emissions are likely an overestimation due to the degree of conservatism incorporated in the air quality assessment, and the assumption that the TSP mass fraction less than or equal to 10 µm (i.e., PM_{10} fraction) remains in suspension indefinitely. Predicted changes in TSS are thus considered to be higher concentrations than can be realistically expected during construction and operations, which also extend into early periods of closure and reclamation due to the 3 year (approximate) residence time in Nico Lake.

Peak TSS concentrations are expected to be transitory, with the particulate matter greater than 10 µm settling very quickly after freshet flows and a large proportion particulate matter less than 10 µm settling within several days following freshet. As a result, the model likely overestimates the duration period of elevated TSS in the lakes. Nevertheless, the overestimation is carried forward as a worse-case scenario for prediction of total metals concentrations that are associated with the TSS.

7.6.3.3.1.2 Total Dissolved Solids and Major Ions

Concentrations of TDS in Nico Lake are predicted to decrease relative to baseline conditions during operations, primarily due to completion of the CDF starter dike and seepage collection ponds during the construction phase, which are assumed to effectively cut off flow contributions from the Grid Pond System (Figure 7.6-4). Concentrations of TDS are predicted to increase in Nico Lake during closure due to flows of higher TDS waters from Wetland Treatment Systems No. 1, 2, and 3. Calcium and magnesium are predicted to mirror the trends displayed by TDS in Figure 7.6-4. Time series plots for these constituents are provided in Appendix 7.V.

Concentrations of chloride (Figure 7.6-5), potassium, sodium, and sulphate are predicted to increase in Nico Lake during operations, due to predicted concentrations of these constituents in low volumes of seepages from the Surge Pond, Plant Site Sump and SCPs. Concentrations are predicted to increase further during closure due to flows of higher TDS waters from Wetland Treatment Systems No. 1, 2, and 3.

The results presented for the post-closure period are conservative. Concentrations of TDS and major ions are predicted to remain elevated above background because the loadings of these constituents from the NICO Project closure wetlands include loading from geochemical sources (e.g., from materials inside the CDF), which are assumed to continue indefinitely. Processes such as sealing by permafrost and source depletion were not incorporated into the modelling.

Table 7.6-10: Predicted Water Quality in Nico Lake

Modelled Constituents	Unit	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
			Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Conventional Parameters													
Total Dissolved Solids	mg/L	-	70 (47 - 90); n = 17	54.0	78.2	64.3	74.2	56.9	70.6	71.1	80.9	82.8	104
Total Suspended Solids	mg/L	-	3 (<1 - 12); n = 26	3.2	3.4	8.2	9.1	18.6	27.9	13.8	22.4	3.6	3.9
Major Ions													
Calcium	mg/L	-	8.58 (6.1 - 14.3); n = 40	9.13	11.7	8.66	9.6	6.78	8.3	7.83	8.9	9.10	10.8
Chloride	mg/L	353	1 (0.51 - 3); n = 37	0.80	1.27	0.93	1.15	1.63	2.07	3.52	4.02	6.40	9.6
Magnesium	mg/L	-	3.46 (2.6 - 5.19); n = 40	4.21	5.53	3.69	4.55	3.53	4.36	3.98	4.64	4.49	5.18
Potassium	mg/L	-	1.09 (0.77 - 1.7); n = 40	1.13	1.55	1.10	1.30	5.32	7.6	11.69	15.4	17.8	27.8
Sodium	mg/L	-	2.2 (2 - 3.9); n = 40	2.68	3.60	2.37	2.96	2.99	3.49	3.80	4.39	3.96	4.88
Sulphate	mg/L	500	3.94 (1 - 6.6); n = 35	3.92	5.51	3.89	4.36	4.72	6.4	10.90	14.0	17.3	26.8
Nutrients													
Ammonia	mg-N/L	4.16[a]	0.023 (<0.005 - 0.603); n = 40	0.025	0.048	0.024	0.034	0.41	0.65	0.35	0.58	0.11	0.17
Nitrate	mg-N/L	30	0.1 (<0.002 - 0.4); n = 40	0.070	0.14	0.089	0.12	0.45	0.68	0.39	0.61	0.14	0.19
Total Kjeldahl Nitrogen	mg/L	-	0.74 (0.34 - 1.58); n = 40	0.72	1.05	0.74	0.90	1.07	1.28	0.98	1.18	0.62	0.86
Total Phosphorus	mg/L	-	0.02 (0.012 - 0.1); n = 40	0.020	0.023	0.020	0.022	0.019	0.023	0.018	0.022	0.017	0.020
Total Metals													
Al	mg/L	0.41[b]	0.0418 (<0.01 - 0.15); n = 40	0.056	0.07	0.29	0.33	**0.84**	**1.31**	**0.64**	**1.09**	0.15	0.20
Sb	mg/L	0.03	<0.0004 (0.00011 - 0.0007); n = 40	0.00032	0.00039	0.00029	0.00035	0.00092	0.0013	0.00165	0.0022	0.0024	0.0037
As	mg/L	0.05	0.0119 (0.001 - 0.163); n = 40	0.014	0.016	0.019	0.021	0.028	0.044	0.024	0.040	0.012	0.019
Ba	mg/L	-	0.00787 (0.0059 - 0.0193); n = 40	0.0078	0.011	0.011	0.013	0.018	0.023	0.018	0.024	0.016	0.021
Be	mg/L	-	<0.00003 (<0.00001 - 0.00005); n = 8	0.000013	0.000014	0.000032	0.000038	0.000071	0.00011	0.000091	0.00013	0.000097	0.00015
B	mg/L	1.5[c]	0.0085 (<0.008 - 0.011); n = 4	0.0070	0.011	0.0079	0.009	0.011	0.015	0.017	0.020	0.019	0.025
Cd	mg/L	0.00015	0.0000165 (<0.000005 - 0.00056); n = 32	0.000011	0.000019	0.000021	0.000025	0.000041	0.000058	0.000036	0.000050	0.000032	0.000042
Cr	mg/L	0.001[c]	<0.0008 (<0.0001 - 0.0016); n = 24	0.00043	0.00052	0.00065	0.00072	**0.0013**	**0.0018**	**0.0013**	**0.0018**	**0.0014**	**0.0020**
Co	mg/L	0.01	<0.0015 (0.00017 - 0.0064); n = 40	0.00036	0.0006	0.0016	0.0019	0.0045	0.0070	0.0041	0.0066	0.0023	0.0036
Cu	mg/L	0.022	0.00167 (0.0007 - 0.0031); n = 40	0.0018	0.0020	0.0023	0.0025	0.0035	0.0049	0.0034	0.0048	0.0030	0.0041
Fe	mg/L	1.5	0.344 (0.08 - 6.99); n = 40	0.38	0.46	0.85	0.95	**2.21**	**3.29**	**1.79**	**2.89**	0.72	0.87
Pb	mg/L	0.008	<0.0001 (0.000028 - 0.0004); n = 32	0.000070	0.00010	0.00012	0.00014	0.00030	0.00043	0.00061	0.00078	0.0012	0.0018
Mn	mg/L	-	0.023 (0.004 - 0.897); n = 40	0.022	0.037	0.026	0.034	0.038	0.048	0.047	0.058	0.058	0.078
Hg	mg/L	0.000026[c]	<0.00002 (<0.00001 - 0.00023); n = 28	0.0000084	0.000011	0.0000096	0.000011	0.000012	0.000015	0.000013	0.000015	0.000020	**0.000026**
Mo	mg/L	0.073[c]	0.000495 (<0.0002 - 0.0007); n = 20	0.00049	0.00058	0.00051	0.00054	0.00093	0.0013	0.00219	0.0028	0.0037	0.0059
Ni	mg/L	0.025[c,d]	0.00056 (0.00035 - 0.0014); n = 20	0.00052	0.0009	0.00062	0.0008	0.00085	0.0011	0.00104	0.0012	0.0012	0.0016
Se	mg/L	0.005	<0.0004 (<0.00004 - 0.00051); n = 36	0.00014	0.00019	0.00020	0.00023	0.0011	0.0017	0.0017	0.0027	0.0012	0.0018
Ag	mg/L	0.0001[c]	<0.0000075 (<0.000005 - 0.00004); n = 8	0.0000064	0.000009	0.0000088	0.000010	0.000054	0.00008	0.000047	0.00007	0.000067	**0.00010**
Tl	mg/L	0.0008[c]	<0.000002 (<0.000002 - 0.000003); n = 4	0.0000017	0.0000021	0.0000046	0.0000051	0.00043	0.00070	0.00034	0.00052	0.00053	**0.0009**
U	mg/L	0.027	0.000295 (0.0002 - 0.00067); n = 32	0.00032	0.00041	0.00032	0.00037	0.0026	0.0040	0.0046	0.0064	0.0060	0.010
V	mg/L	-	<0.001 (0.00014 - 0.001); n = 40	0.00033	0.00052	0.00063	0.00073	0.00092	0.0012	0.00089	0.0012	0.00074	0.0009
Zn	mg/L	0.11	<0.004 (0.0004 - 0.013); n = 40	0.0044	0.0053	0.0043	0.0049	0.0064	0.0080	0.0112	0.0133	0.019	0.028
Dissolved Metals													
Al	mg/L	0.41[b]	0.03 (0.0072 - 0.06); n = 40	0.025	0.05	0.08	0.21	0.14	0.39	0.12	0.31	0.06	0.13

Table 7.6-10: Predicted Water Quality in Nico Lake (continued)

Modelled Constituents	Unit	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
			Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Sb	mg/L	0.03	<0.0004 (0.00011 - 0.0009); n = 40	0.00023	0.00033	0.00016	0.00024	0.00033	0.00061	0.00071	0.00128	0.0017	0.0031
As	mg/L	0.05	0.0103 (0.002 - 0.0941); n = 40	0.011	0.015	0.013	0.019	0.016	0.031	0.015	0.027	0.010	0.017
Ba	mg/L	-	0.00716 (0.005 - 0.0175); n = 40	0.0068	0.009	0.0079	0.010	0.011	0.018	0.012	0.019	0.014	0.020
Be	mg/L	-	<0.00003 (<0.00001 - <0.00005); n = 8	0.0000092	0.000011	0.000017	0.000025	0.000023	0.000038	0.000036	0.000055	0.000068	0.00011
B	mg/L	1.5[c]	0.008 (<0.002 - 0.013); n = 12	0.0058	0.009	0.0054	0.008	0.0059	0.010	0.0097	0.015	0.015	0.022
Cd	mg/L	0.00015	<0.000011 (<0.000005 - 0.0007); n = 32	0.0000046	0.000010	0.0000048	0.000012	0.0000054	0.000016	0.0000060	0.000017	0.000012	0.000027
Cr	mg/L	0.001[c]	<0.0006 (<0.0001 - 0.0012); n = 24	0.00022	0.00039	0.00021	0.00045	0.00025	0.00063	0.00031	0.00068	0.00067	**0.0013**
Co	mg/L	0.01	<0.002 (0.00006 - 0.0061); n = 40	0.00024	0.00045	0.00082	0.0016	0.0015	0.0034	0.0016	0.0038	0.00152	0.0030
Cu	mg/L	0.022	0.0014 (0.0007 - 0.0038); n = 40	0.0013	0.0018	0.0012	0.0020	0.0013	0.0025	0.0015	0.0028	0.0021	0.0034
Fe	mg/L	1.5	0.24 (0.037 - 3.79); n = 40	0.21	0.36	0.32	0.70	0.53	1.33	0.51	1.13	0.39	0.68
Pb	mg/L	0.008	<0.0001 (0.000006 - 0.0005); n = 32	0.000042	0.00008	0.000051	0.00011	0.000085	0.00020	0.000209	0.00047	0.00067	0.0014
Mn	mg/L	-	0.012 (0.00021 - 0.86); n = 40	0.013	0.028	0.011	0.026	0.012	0.033	0.018	0.044	0.034	0.066
Hg	mg/L	0.000026[c]	<0.00002 (<0.00001 - 0.00004); n = 20	0.0000018	0.0000033	0.0000010	0.0000019	0.00000063	0.0000013	0.00000098	0.0000021	0.0000041	0.000007
Mo	mg/L	0.073[c]	0.0005 (<0.0002 - 0.0007); n = 20	0.00041	0.00052	0.00036	0.00048	0.00050	0.0009	0.00134	0.0021	0.0031	0.0053
Ni	mg/L	0.025[c,d]	0.00055 (0.00032 - 0.0011); n = 20	0.00040	0.0007	0.00038	0.0006	0.00040	0.0008	0.00056	0.0011	0.00091	0.0014
Se	mg/L	0.005	<0.0004 (<0.00004 - 0.0006); n = 36	0.00012	0.00017	0.00014	0.00016	0.00059	0.0007	0.00100	0.0012	0.0010	0.0015
U	mg/L	0.027	0.000265 (0.0002 - 0.00059); n = 32	0.00027	0.00037	0.00024	0.00032	0.0015	0.0030	0.0029	0.0049	0.0050	0.009
V	mg/L	-	<0.001 (0.00005 - 0.002); n = 40	0.00018	0.00034	0.00022	0.00046	0.00020	0.00050	0.00024	0.00058	0.00038	0.00069
Zn	mg/L	0.11	0.004 (0.0005 - 0.0149); n = 40	0.0026	0.0044	0.0017	0.0036	0.0017	0.0042	0.0036	0.0088	0.0105	0.019

Notes: Elements not included in the dissolved metals list that are present in the total metals list did not have sufficient detectable baseline dissolved concentrations to derive partition coefficients.
Modelling result summaries represent the median values from daily average and 95th percentile concentration predictions from 100 modelling realizations.
Predicted values in **bold** are higher than site-specific water quality objectives.

[a] Objective for total ammonia based on a pH of 7.44 and a water temperature of 11.4°C.

[b] Objective for dissolved aluminum based on a pH of 7.45, which was the typical baseline pH. No change in pH in any waterbodies were expected based on geochemical characteristics and acidification assessment of local waterbodies

[c] No SSWQO available; therefore applicable CCME guideline was used.

[d] Guideline for nickel based on a water hardness of 60 mg/L.

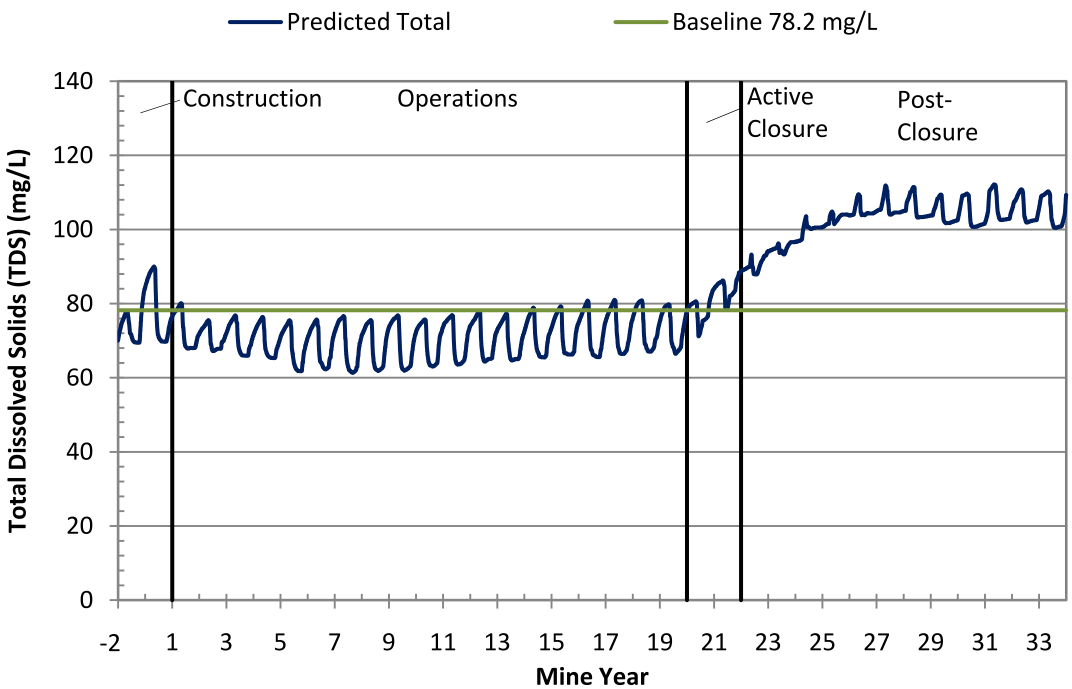


Figure 7.6-4: Predicted Total Dissolved Solids Concentrations in Nico Lake

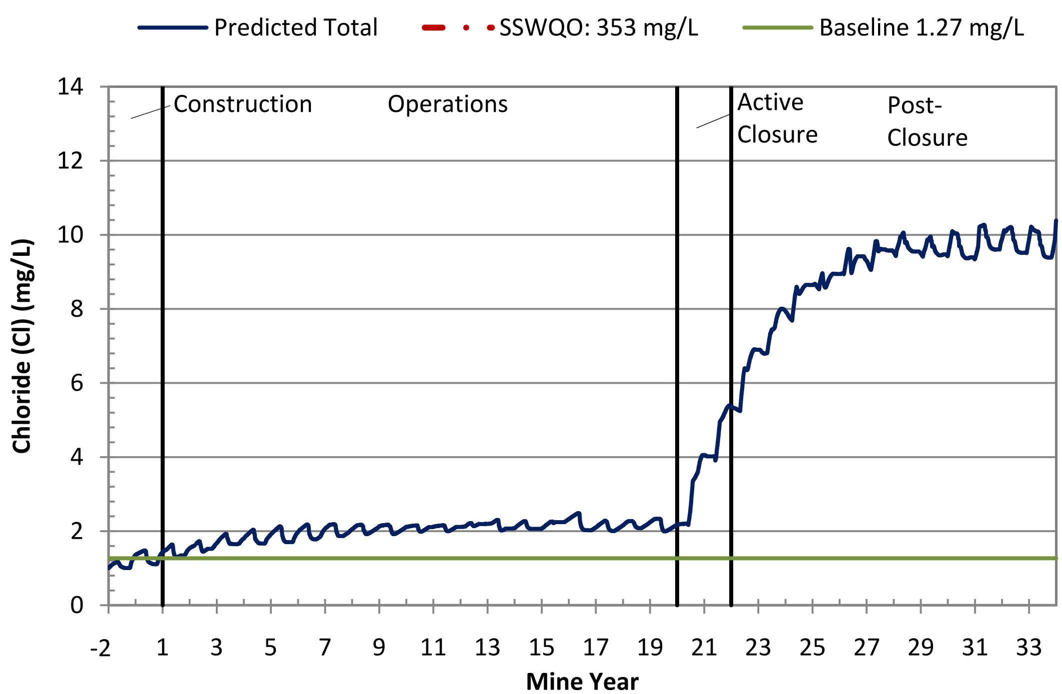


Figure 7.6-5: Predicted Chloride Concentrations in Nico Lake

7.6.3.3.1.3 Nutrients

Nitrogen

In freshwater systems, nitrogen exists in several forms, including molecular nitrogen, nitrate, nitrite, ammonia, and organic nitrogen. The water quality modelling focused on nitrate and ammonia, because they are:

- the most bioavailable forms of nitrogen;
- potential contributors to aquatic toxicity; and
- the predominant forms released in explosives residue.

Total Kjeldahl nitrogen was modelled to account for combined background concentrations of organic nitrogen and ammonia and thereby allow calculation of fixed nitrogen in the modelled system. Mining activities are not anticipated to affect concentrations of molecular nitrogen, nitrite and organic nitrogen in the receiving environment. The modelling considered all forms of nitrogen as conservative masses (i.e., the model did not explicitly account for source terms, such as nitrogen fixation, and sink terms, such as volatilization, uptake, and nitrification/denitrification).

Concentrations of ammonia and nitrate in Nico Lake are predicted to increase during operations, primarily due to small quantities of seepage inputs containing blasting residue (Figures 7.6-6 and 7.6-7). These constituent concentrations are predicted to decrease during closure, as seepage and surface waters reporting to Wetland Treatment Systems No. 1, 2, and 3 are expected to have little nitrate and ammonia concentrations remaining from blast residues. Ammonia and nitrate concentrations in Nico Lake are predicted to remain below water quality objectives during all phases of the NICO Project.

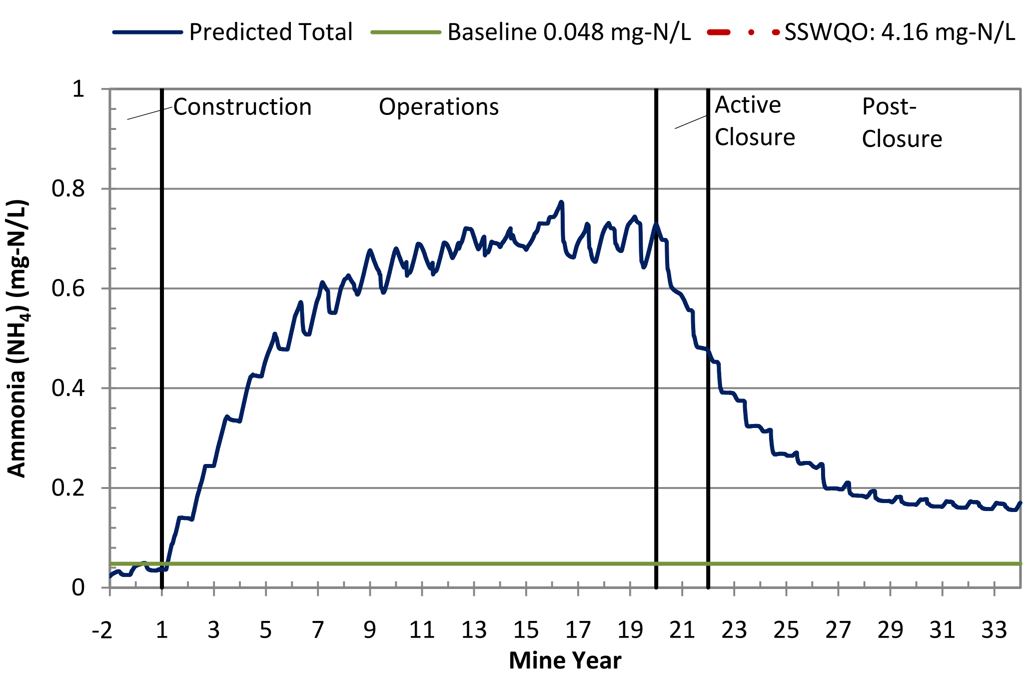


Figure 7.6-6: Predicted Ammonia Concentrations in Nico Lake

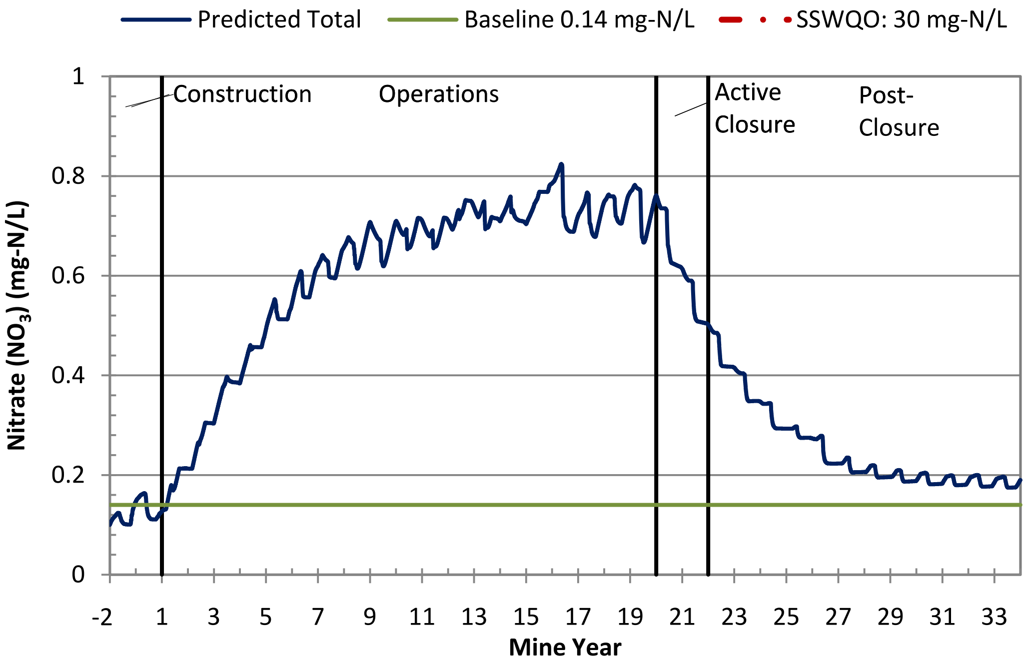


Figure 7.6-7: Predicted Nitrate Concentrations in Nico Lake

Total Kjeldahl nitrogen and total nitrogen, for which there are no SSWQOs or CCME guidelines, are predicted to follow a similar pattern, as they include loading of ammonia, and ammonia and nitrate, respectively, from the NICO Project.

Phosphorus

Phosphorus plays an important role in aquatic ecosystems, primarily due to its role in biological metabolism. In contrast to the availability of other nutrients to biota, such as carbon and nitrogen, phosphorus is generally the least abundant. This lack of natural availability commonly results in phosphorus limitation in aquatic ecosystems, which affects biological productivity. Most natural lakes are considered phosphorus limited or co-limited with nitrogen (Wetzel 2001).

Total phosphorus concentrations in Nico Lake are predicted to generally remain consistent with baseline concentrations during operations (Table 7.6-10), resulting from a balance between reduced background mass inputs from the Grid Pond system, low loading in seepages from the NICO Project site, and addition of loading from dust deposition during construction and operations. Concentrations are predicted to decrease during closure, as dust deposition due to NICO Project activities will cease and phosphorus loading from Wetland Treatment Systems No. 1, 2, and 3 are expected to be lower than from the Grid Pond system in the Baseline Case (Figure 7.6-8).

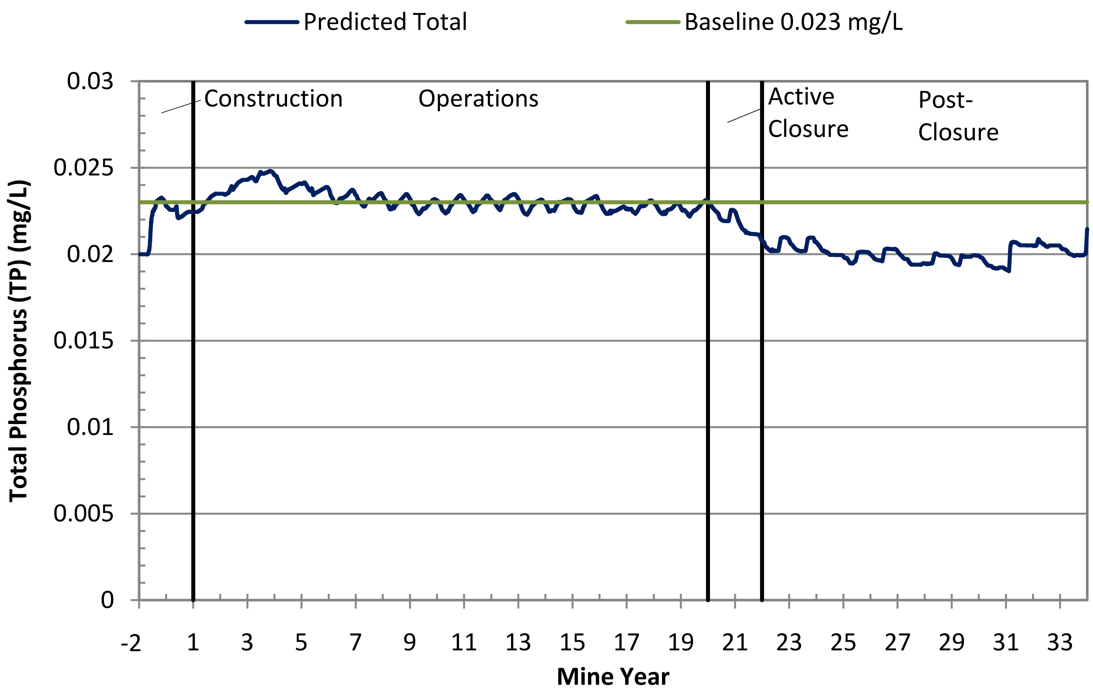


Figure 7.6-8: Predicted Phosphorus Concentrations in Nico Lake

7.6.3.3.1.4 Metals

Predicted metals concentrations in Nico Lake are discussed below, and are grouped according to predicted trends over time.

Metals Concentrations Predicted to Increase during Operations and Decline Following Closure

Of the 22 metals that were modelled for this assessment, 6 are predicted to increase in concentration during the construction and operation phases, and then decline in concentration as Nico Lake is flushed following closure. These metals are aluminum, arsenic, cadmium, cobalt, iron and selenium. A time series plot of aluminum (Figure 7.6-9) illustrates the general trend predicted for these metals.

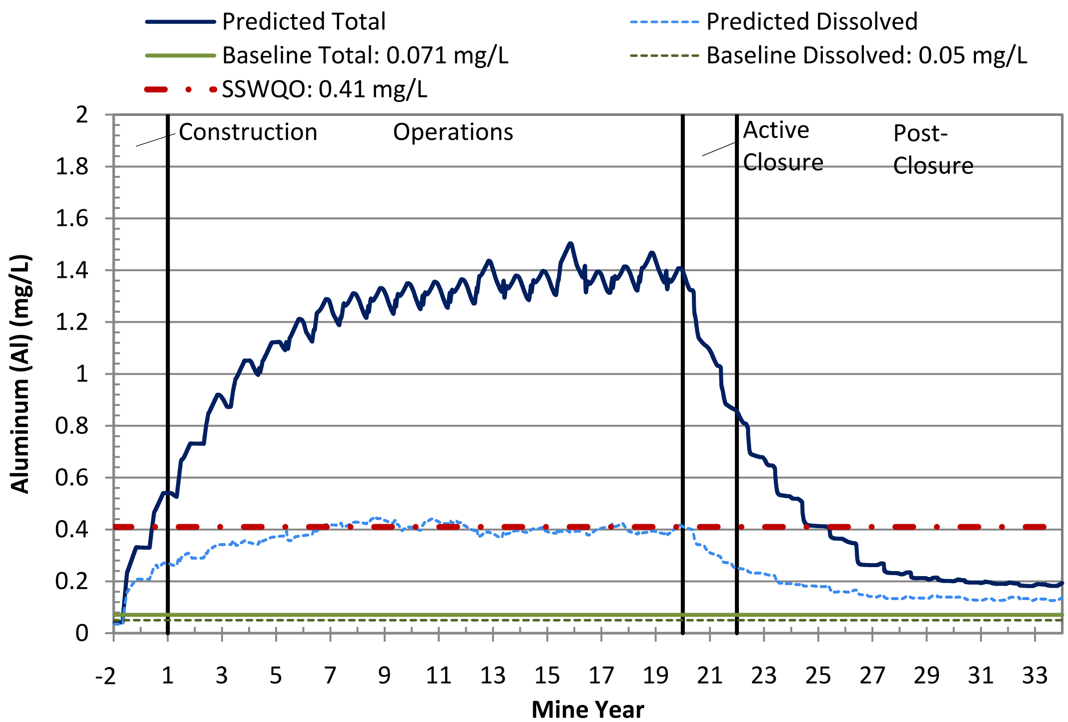


Figure 7.6-9: Predicted Aluminum Concentrations in Nico Lake

The loading sources of these metals are dust deposition and small quantities of seepage from the NICO Project site during operations, and flows from Wetland Treatment Systems No. 1, 2, and 3 during closure. The expected loading of these metals during operations is higher than during closure, resulting in declining concentrations in the post-closure period. Of these 6 metals, total aluminum and iron are predicted to exceed SSWQO values during operations. However, the SSWQO for aluminum is based on dissolved concentrations, which are predicted to exceed the SSWQO value infrequently during operations, and dissolved iron concentrations are not predicted to exceed the SSWQO value. Arsenic concentrations exceed CCME guidelines under baseline conditions and are predicted to increase further due to NICO Project sources (Table 7.6-10), but are not predicted to exceed SSWQO values for extended periods (Figure 7.6-10). Cadmium, cobalt, and selenium (Figure 7.6-11) concentrations are not predicted to exceed SSWQO values at any time.

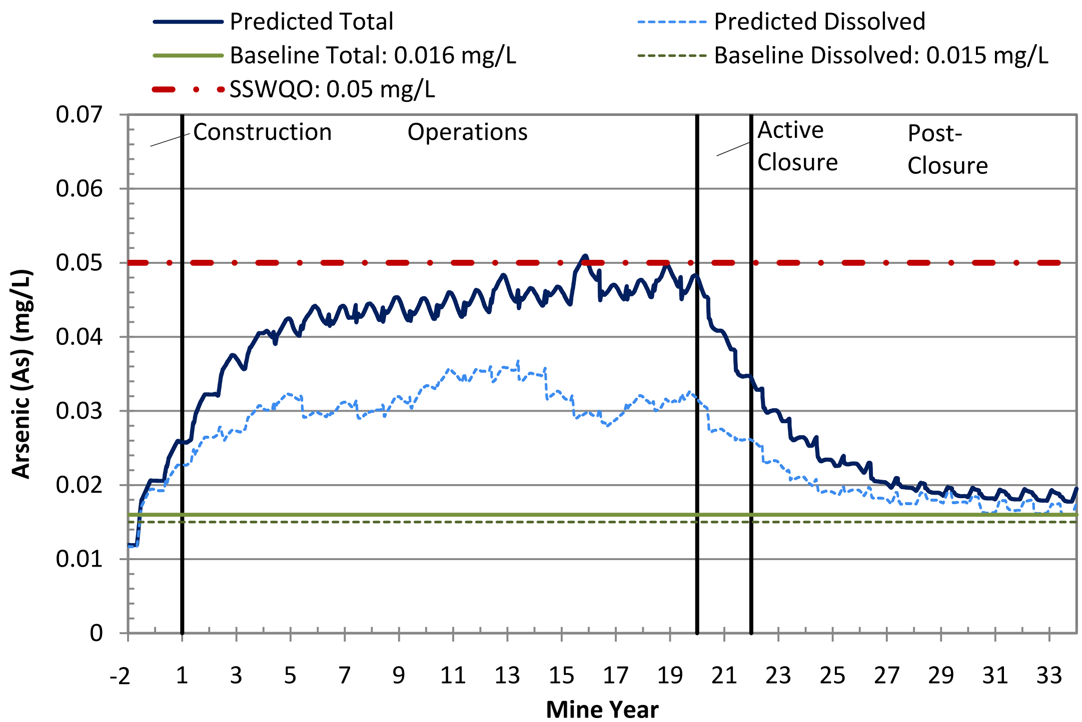


Figure 7.6-10: Predicted Arsenic Concentrations in Nico Lake

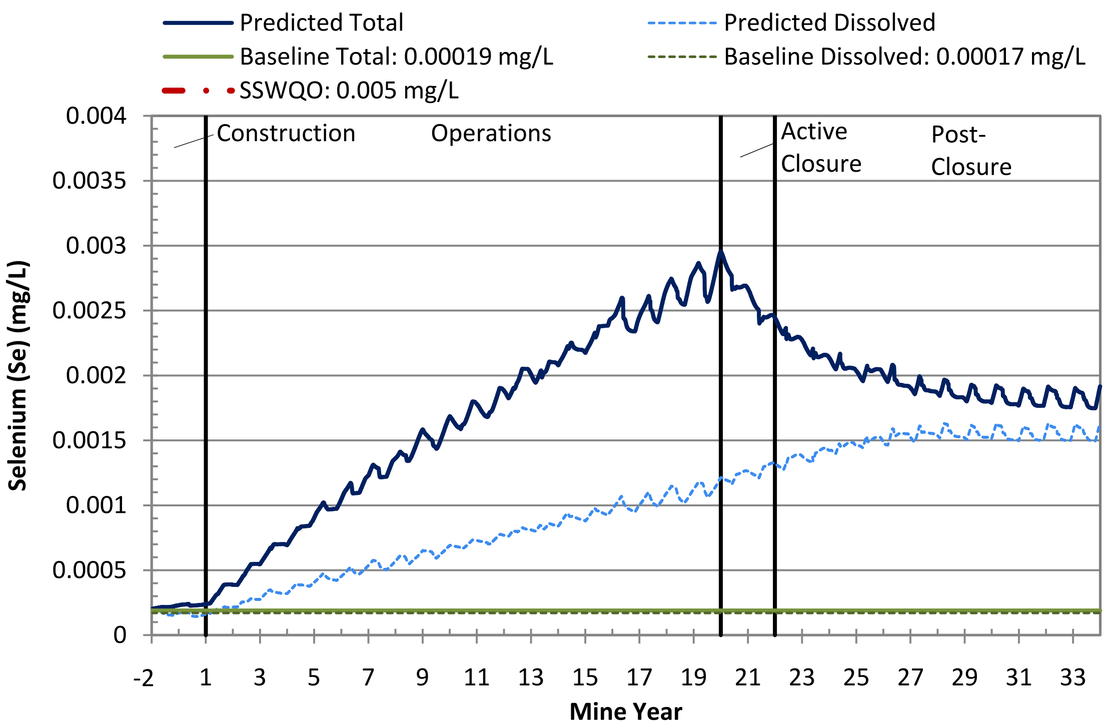


Figure 7.6-11: Predicted Selenium Concentrations in Nico Lake

Metals concentration predictions for the construction and operations phases are conservative due to modelling assumptions used to incorporate metals loading associated with dust deposition (i.e., zero landscape retention and perpetual suspension of all particulate mass [and associated metals] less than or equal to 10 µm in diameter).

Metal Concentrations Predicted to Increase during Operations and Remain Elevated Following Closure

A second group of metals are predicted to increase in concentration in Nico Lake during the construction and operation phases, and remain near the same concentrations following closure. As noted for the first group of metals, the loading sources during operations are dust deposition and small quantities of seepage from the NICO Project, and flows from Wetland Treatment Systems No. 1, 2, and 3 during closure. Unlike the first group of metals, the expected loading of this second group of metals from Wetland Treatment Systems No. 1, 2, and 3 is similar to loading during operations, resulting in predicted concentrations during the post-closure period that are similar to concentrations predicted during operations.

The 4 metals that follow this trend are barium, chromium, copper, and vanadium. Of these 4 metals, chromium is predicted to exceed CCME guidelines during operations and copper is predicted to remain below the SSWQO values. Barium and vanadium do not have CCME guidelines or SSWQO values. Representative time series plots are shown for chromium (Figure 7.6-12) and copper (Figure 7.6-13) to illustrate the general trend predicted for this group of metals.

The post-closure metals concentration predictions in Nico Lake are conservative, as attenuation of constituent concentrations predicted for waters influent to Wetland Treatment Systems No. 1, 2, and 3 was limited to times when the concentrations were greater than SSWQOs. When this occurred, the wetlands outflow concentrations were assumed to be at the SSWQO concentrations. No further attenuation was applied in the modelling due to uncertainty regarding how effective the planned wetlands treatment system will be for various metals (Section 9). Metals concentrations in outflows from the Wetland Treatment Systems may, therefore, be lower than assumed in the modelling.

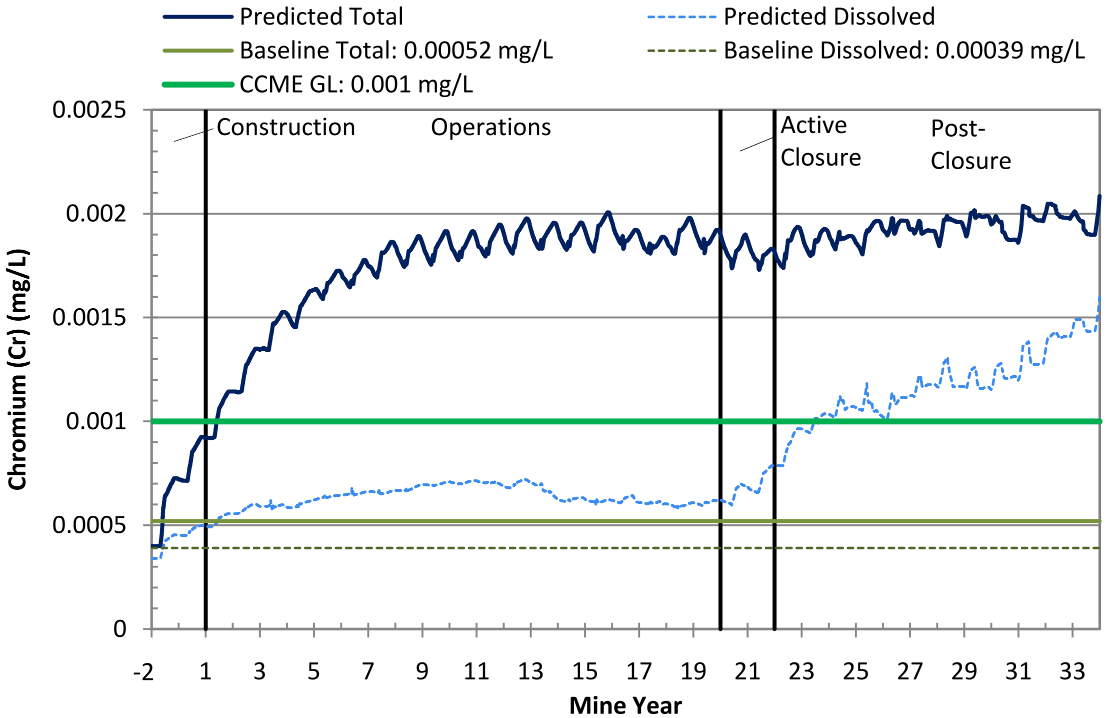


Figure 7.6-12: Predicted Chromium Concentrations in Nico Lake

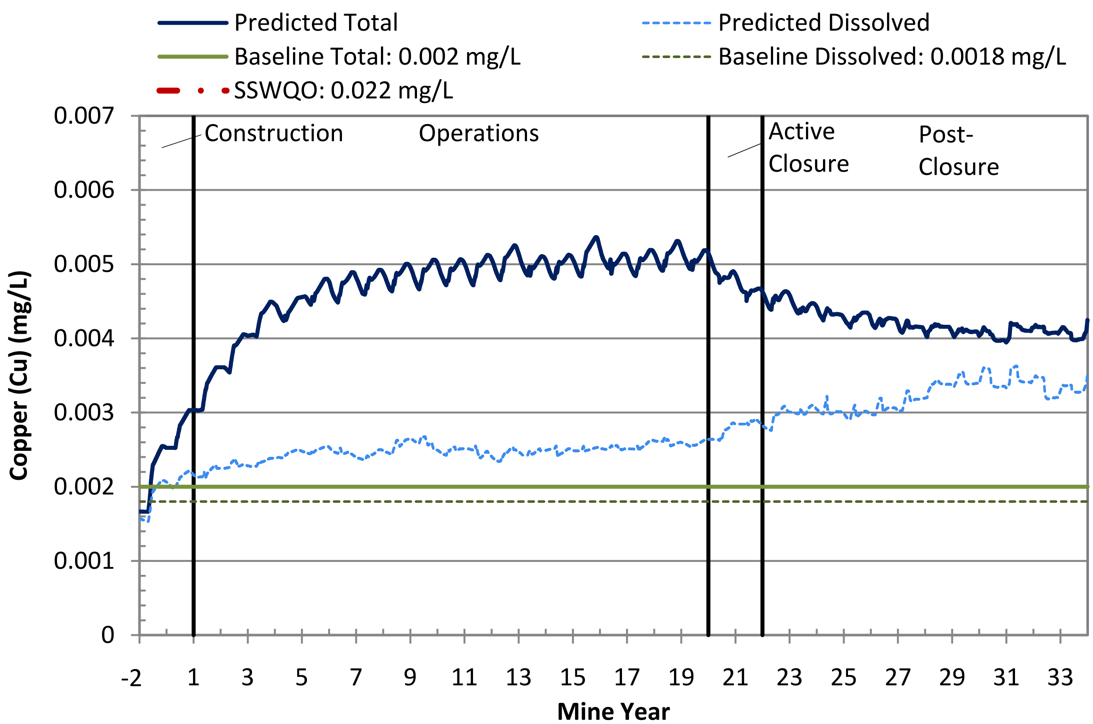


Figure 7.6-13: Predicted Copper Concentrations in Nico Lake

Metal Concentrations Predicted to Increase during Operations and Increase Further Following Closure

The 12 remaining metals that were modelled are predicted to continue to increase in concentration in Nico Lake following closure. The primary loading sources for these metals are small quantities of seepage from the NICO Project during operations and flows from Wetland Treatment Systems No. 1, 2, and 3 during closure. The expected loading of this third group of metals from Wetland Treatment Systems No. 1, 2, and 3 is predicted to be greater than loading during operations, resulting in predicted concentrations during the post-closure period that continue to increase in Nico Lake following closure.

The metals that follow this trend are antimony, beryllium, boron, lead, manganese, mercury, molybdenum, nickel, silver, thallium, uranium, and zinc. Of these metals, beryllium and manganese do not have CCME guidelines or SSWQO values, and boron, molybdenum, and nickel are predicted remain below CCME guidelines. Mercury and silver concentrations are predicted to exceed CCME guideline values during the post-closure period. Antimony, lead, uranium, and zinc concentrations are predicted to remain below SSWQO values, and SSWQOs have not been developed for mercury and silver. Thallium concentrations are predicted to exceed CCME guidelines during closure and occasionally during operations. Representative time series plots are shown for mercury (Figure 7.6-14), thallium (Figure 7.6-15), and uranium (Figure 7.6-16) to illustrate the general trend predicted for this group of metals.

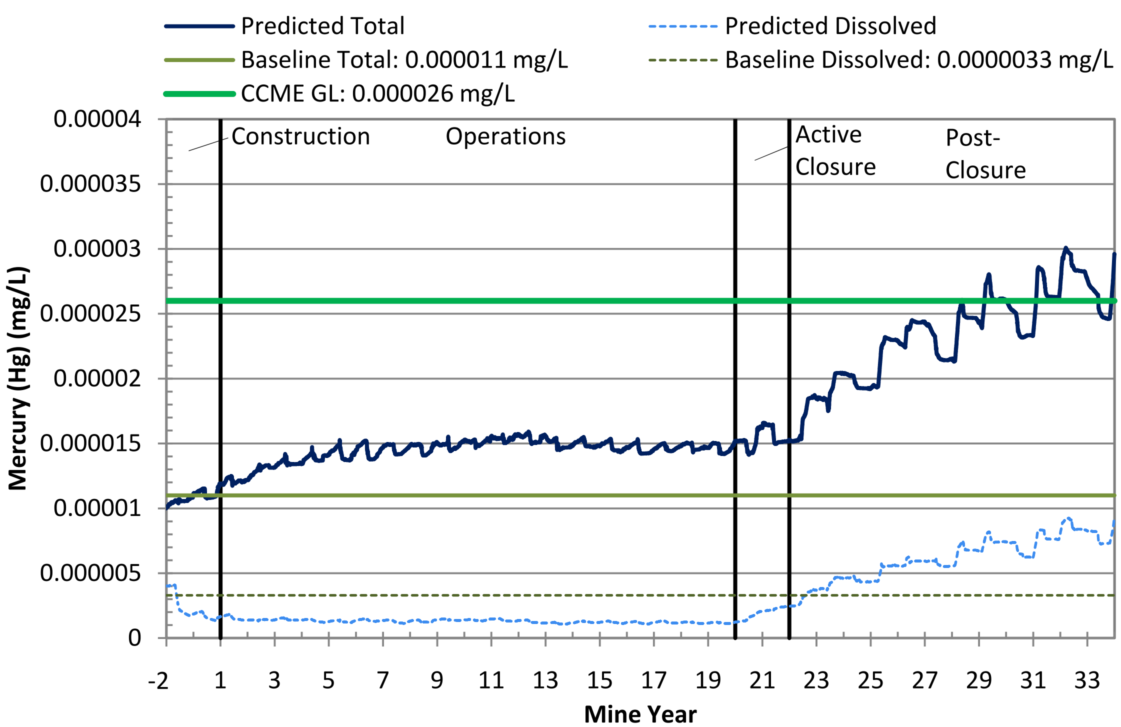


Figure 7.6-15: Predicted Mercury Concentrations in Nico Lake

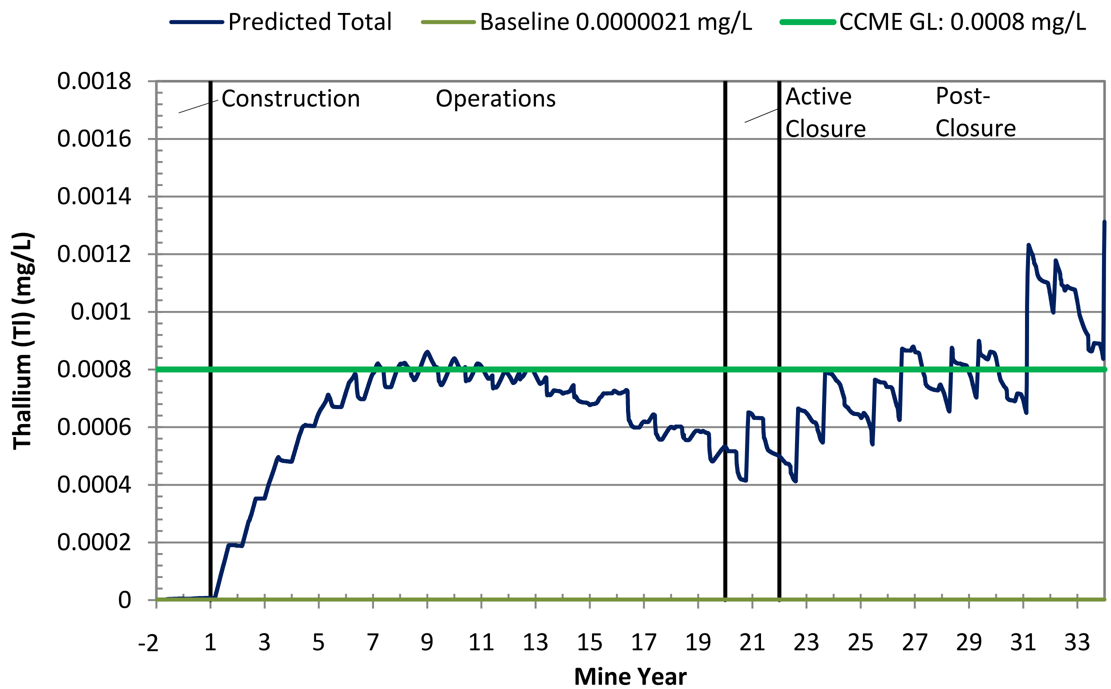


Figure 7.6-15: Predicted Thallium Concentrations in Nico Lake

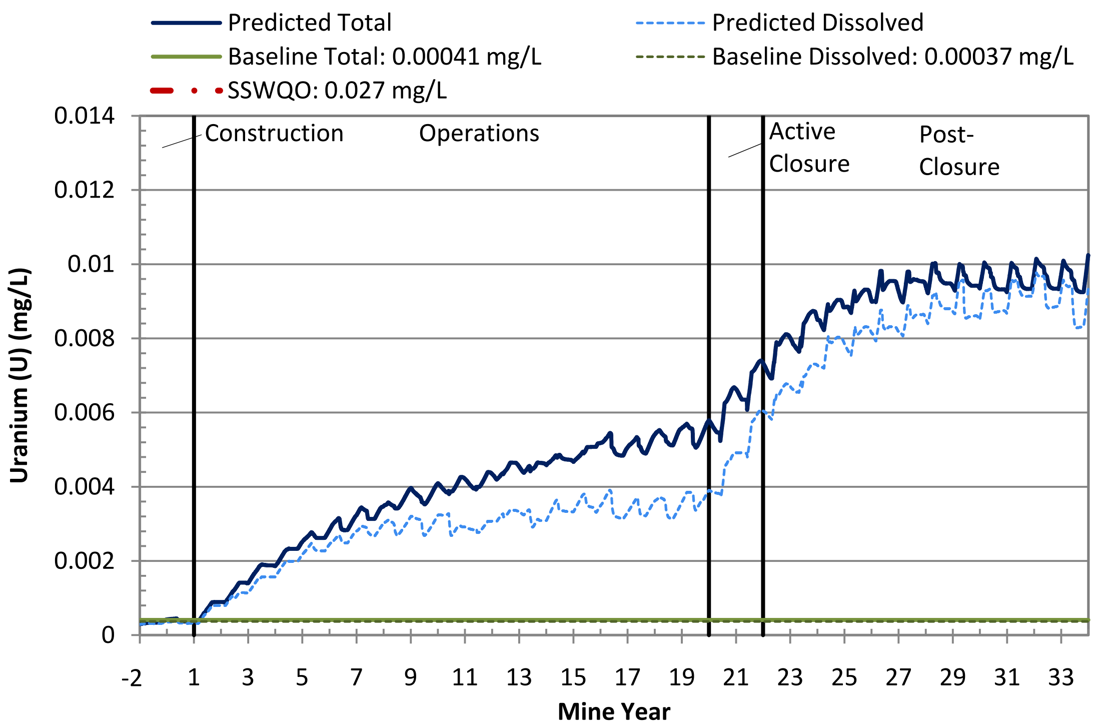


Figure 7.6-16: Predicted Uranium Concentrations in Nico Lake

7.6.3.3.2 Peanut Lake

Water quality in Peanut Lake may be directly affected by NICO Project activities, including deposition of dust and associated metals during construction and operations, and discharge of treated effluent from the ETF during operations. Peanut Lake water quality may also change due to upstream NICO Project related changes in water quality of Nico Lake during construction, operations, and throughout the post-closure period.

Further changes in Peanut Lake water quality may result from discharges from the Flooded Open Pit during the post-closure period, approximately 120 years following closure, but have not been included in the model. Fortune has committed to ensuring that waters in the Flooded Open Pit will be treated by passive or active means, as necessary, to an acceptable level of quality prior to discharge to Peanut Lake. Based on this commitment, additional effects on water quality within and downstream of Peanut Lake are not expected due to discharge from the Flooded Open Pit. A summary of water quality modelling predictions for Peanut Lake are presented in Table 7.6-11, while predictions related to deposition of acidifying substances are provided separately in Section 7.6.1.

7.6.3.3.2.1 Total Suspended Solids

Total suspended solids concentrations in Peanut Lake are predicted to increase, primarily as a result of fugitive dust and air emissions from NICO Project facilities. Discharges to Peanut Lake from the ETF and STP during operations are expected to be minor contributors to changes in TSS concentrations, as the design of the treatment systems are expected to reduce TSS concentrations in the influent waters to a level consistent with the range of TSS concentrations naturally expected in the receiving environment. The predicted maximum (95th percentile) TSS concentrations in Peanut Lake are projected to be 11.7 mg/L during construction and 17.2 mg/L during operations (Table 7.6-11). TSS concentrations are expected to decrease during closure and reclamation, and return to levels consistent with baseline values.

As noted for Nico Lake, incremental changes to TSS concentrations due to deposition of air emissions are likely an overestimation due to conservatism incorporated in the air quality assessment and assumptions used to incorporate these inputs in the water quality model. Peak TSS concentrations are expected to be transitory, with the particulate matter greater than 10 µm settling very quickly after freshet flows and a large proportion particulate matter less than 10 µm settling within several days following freshet.

7.6.3.3.2.2 Total Dissolved Solids and Major Ions

Concentrations of TDS, calcium, and magnesium in Peanut Lake are predicted to begin decreasing relative to baseline conditions during construction and early operations, primarily due to lower influent concentrations from Nico Lake (Figure 7.6-17). Concentrations of TDS in Peanut Lake are predicted to increase during operations as discharge rates from the ETF increase, and during closure due to higher influent concentrations from Nico Lake. Calcium and magnesium are predicted to remain slightly lower than baseline concentrations during operations and during closure, and generally mirror the trends displayed by TDS in Figure 7.6-17. Time series plots for these constituents are provided in Appendix 7.V. The seasonal oscillation in TDS concentrations shown in Figure 7.6-17 is primarily due to seasonal changes in background surface water inputs (i.e., open water versus under-ice concentrations), which are also reflected in the average and 95th percentile baseline predictions in Table 7.6-11.

Table 7.6-11: Predicted Water Quality in Peanut Lake

Modelled Constituents	Unit	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
			Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Conventional Parameters													
Total Dissolved Solids	mg/L	-	64 (44 - 80); n = 13	42.6	70.3	46.8	68.3	47.4	70.1	49.0	72.8	49.0	74.1
Total Suspended Solids	mg/L	-	<3 (2 - 5); n = 21	3.3	3.7	8.3	11.7	10.5	17.2	7.3	12.2	3.4	3.9
Major Ions													
Calcium	mg/L	-	7.8 (6 - 8.78); n = 36	8.07	10.8	7.94	9.6	6.95	9.9	7.53	10.4	8.07	10.6
Chloride	mg/L	353	1 (0.63 - 8); n = 32	0.91	1.29	0.95	1.18	1.45	1.88	1.60	2.05	2.20	3.49
Magnesium	mg/L	-	3.57 (2.9 - 4.2); n = 36	3.53	5.66	3.45	4.66	3.06	5.33	3.39	5.62	3.58	5.62
Potassium	mg/L	-	1.22 (0.9 - 1.7); n = 36	1.13	1.67	1.14	1.47	6.75	12.5	5.10	12.3	5.04	8.9
Sodium	mg/L	-	2.77 (2 - 3.7); n = 36	2.73	3.82	2.67	3.32	3.41	4.22	3.33	4.45	3.03	4.08
Sulphate	mg/L	500	1.33 (<0.5 - 4.9); n = 31	1.60	2.51	1.48	1.94	3.25	5.1	3.74	6.5	4.71	8.5
Nutrients													
Ammonia	mg-N/L	4.16[a]	0.021 (<0.005 - 0.308); n = 36	0.020	0.05	0.021	0.04	0.27	0.52	0.17	0.40	0.041	0.07
Nitrate	mg-N/L	30	<0.1 (0.011 - 0.451); n = 36	0.056	0.15	0.065	0.13	0.31	0.54	0.20	0.42	0.072	0.16
Total Kjeldahl Nitrogen	mg/L	-	0.57 (0.12 - 1.2); n = 36	0.60	1.11	0.60	0.89	0.78	1.20	0.72	1.17	0.58	1.08
Total Phosphorus	mg/L	-	0.017 (0.009 - 0.04); n = 35	0.015	0.018	0.016	0.019	0.016	0.020	0.016	0.019	0.015	0.017
Total Metals													
Al	mg/L	0.41[b]	0.0993 (0.038 - 0.18); n = 36	0.099	0.14	0.33	**0.51**	**0.43**	**0.73**	0.29	**0.53**	0.12	0.17
Sb	mg/L	0.03	<0.0004 (<0.00005 - 0.0008); n = 36	0.00025	0.0003	0.00029	0.00036	0.00040	0.0005	0.00054	0.0007	0.00076	0.0012
As	mg/L	0.05	0.004365 (0.0005 - 0.0119); n = 36	0.0040	0.0047	0.011	0.017	0.013	0.024	0.009	0.017	0.0038	0.006
Ba	mg/L	-	0.0089 (0.00588 - 0.049); n = 36	0.0092	0.011	0.012	0.013	0.013	0.016	0.012	0.015	0.011	0.013
Be	mg/L	-	<0.001 (<0.00001 - <0.002); n = 36	0.000011	0.000013	0.000025	0.000037	0.000041	0.00007	0.000035	0.00007	0.000031	0.000051
B	mg/L	1.5[c]	0.009 (<0.008 - 0.009); n = 3	0.0073	0.009	0.0076	0.009	0.012	0.016	0.011	0.018	0.010	0.013
Cd	mg/L	0.00015	<0.00001 (<0.000005 - 0.0008); n = 28	0.000010	0.000025	0.000018	0.000029	0.000027	0.000040	0.000019	0.000032	0.000015	0.000029
Cr	mg/L	0.001[c]	<0.0008 (0.0001 - 0.0012); n = 20	0.00055	0.0007	0.00078	**0.0010**	0.00088	**0.0012**	0.00078	**0.0011**	0.00078	**0.0010**
Co	mg/L	0.01	0.0002 (0.00007 - 0.000475); n = 16	0.00020	0.00037	0.0012	0.0019	0.0023	0.0042	0.0015	0.0030	0.00065	0.0012
Cu	mg/L	0.022	0.001 (0.0009 - 0.0028); n = 36	0.0011	0.0014	0.0018	0.0022	0.0020	0.0030	0.0017	0.0025	0.0015	0.0019
Fe	mg/L	1.5	0.271 (0.129 - 0.761); n = 36	0.37	0.48	0.85	1.22	1.12	**1.81**	0.83	1.42	0.46	0.58
Pb	mg/L	0.008	<0.0001 (0.000048 - 0.00026); n = 28	0.000075	0.00015	0.00011	0.00015	0.00014	0.00020	0.00018	0.00026	0.00032	0.00058
Mn	mg/L	-	0.016 (<0.001 - 0.173); n = 36	0.024	0.05	0.025	0.04	0.027	0.06	0.030	0.06	0.032	0.06
Hg	mg/L	0.000026[c]	<0.00002 (<0.00001 - 0.00007); n = 21	0.0000088	0.000014	0.0000096	0.000013	0.0000086	0.000014	0.0000095	0.000014	0.000011	0.000016
Mo	mg/L	0.073[c]	0.0002 (<0.0001 - 0.00033); n = 16	0.00022	0.00030	0.00023	0.00028	0.00080	0.0014	0.00074	0.0015	0.00098	0.0018
Ni	mg/L	0.025[c,d]	<0.002 (0.0004 - 0.0022); n = 36	0.00079	0.0013	0.00091	0.0012	0.00100	0.0014	0.00094	0.0015	0.00095	0.0014
Se	mg/L	0.005	<0.0004 (<0.00004 - 0.0008); n = 34	0.00014	0.00024	0.00018	0.00024	0.00086	0.0015	0.00077	0.0017	0.00039	0.0006
Ag	mg/L	0.0001[c]	<0.0001 (<0.000005 - <0.005); n = 36	0.0000064	0.000012	0.0000086	0.000011	0.000049	0.00009	0.000025	0.00006	0.000022	0.00004
Tl	mg/L	0.0008[c]	0.0000025 (<0.000002 - 0.000003); n = 4	0.0000016	0.0000022	0.0000044	0.0000063	0.00011	0.00017	0.00009	0.00015	0.00014	0.00025
U	mg/L	0.027	0.00019 (0.00015 - 0.000278); n = 28	0.00020	0.00029	0.00022	0.00027	0.0012	0.0019	0.0014	0.0025	0.0015	0.0029
V	mg/L	-	<0.001 (<0.0002 - 0.001); n = 36	0.00034	0.0008	0.00057	0.0008	0.00060	0.0009	0.00051	0.0009	0.00043	0.0009
Zn	mg/L	0.11	<0.004 (0.0004 - 0.038); n = 36	0.0044	0.006	0.0044	0.006	0.0049	0.006	0.0055	0.007	0.0082	0.012
Dissolved Metals													
Al	mg/L	0.41[b]	0.027 (<0.005 - 0.0537); n = 36	0.044	0.09	0.09	0.24	0.10	0.27	0.08	0.18	0.06	0.11

Table 7.6-11: Predicted Water Quality in Peanut Lake (continued)

Modelled Constituents	Unit	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
			Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Sb	mg/L	0.03	<0.0004 (0.00004 - 0.0005); n = 36	0.00018	0.00028	0.00015	0.00026	0.00019	0.00034	0.00030	0.00048	0.00054	0.0010
As	mg/L	0.05	0.0034 (0.0006 - 0.0104); n = 36	0.0034	0.0044	0.0078	0.014	0.0085	0.018	0.0060	0.013	0.0032	0.006
Ba	mg/L	-	0.007 (0.00488 - 0.01); n = 36	0.0079	0.010	0.0087	0.012	0.0093	0.013	0.0095	0.013	0.0096	0.012
Be	mg/L	-	<0.001 (<0.00001 - <0.001); n = 36	0.0000080	0.000010	0.000012	0.000020	0.000018	0.000029	0.000019	0.000032	0.000022	0.000039
B	mg/L	1.5[c]	0.008 (<0.002 - 0.011); n = 10	0.0059	0.008	0.0052	0.008	0.0076	0.012	0.0078	0.013	0.0080	0.011
Cd	mg/L	0.00015	<0.00001 (<0.000005 - 0.0005); n = 28	0.0000041	0.000010	0.0000046	0.000011	0.0000054	0.000015	0.0000050	0.000013	0.0000059	0.000015
Cr	mg/L	0.001[c]	0.00065 (<0.0001 - 0.0011); n = 20	0.00028	0.0005	0.00025	0.0006	0.00024	0.0006	0.00026	0.0005	0.00039	0.0007
Co	mg/L	0.01	0.0001 (0.00004 - 0.0015); n = 16	0.00013	0.00028	0.00060	0.0013	0.00101	0.0023	0.00075	0.0021	0.00043	0.0009
Cu	mg/L	0.022	0.001 (0.0007 - 0.002); n = 36	0.00082	0.0012	0.00094	0.0016	0.00097	0.0017	0.00096	0.0017	0.0011	0.0016
Fe	mg/L	1.5	0.148 (0.035 - 0.347); n = 36	0.21	0.37	0.32	0.72	0.37	0.85	0.34	0.72	0.26	0.45
Pb	mg/L	0.008	<0.0001 (0.000036 - 0.00015); n = 26	0.000044	0.00010	0.000050	0.00011	0.000055	0.00013	0.000085	0.00017	0.00019	0.00044
Mn	mg/L	-	0.00826 (0.00057 - 0.216); n = 36	0.014	0.04	0.011	0.029	0.011	0.03	0.014	0.04	0.019	0.04
Hg	mg/L	0.000026[c]	<0.00002 (<0.00001 - 0.00008); n = 20	0.0000019	0.000004	0.0000010	0.0000024	0.00000077	0.0000019	0.0000013	0.0000027	0.0000024	0.000005
Mo	mg/L	0.073[c]	0.00019 (0.0001 - 0.00031); n = 16	0.00019	0.00026	0.00017	0.00023	0.00051	0.0010	0.00053	0.0010	0.00082	0.0016
Ni	mg/L	0.025[c,d]	0.0005 (0.0003 - 0.0014); n = 16	0.00060	0.0010	0.00055	0.0010	0.00057	0.0010	0.00062	0.0012	0.00072	0.0012
Se	mg/L	0.005	<0.0004 (<0.00004 - 0.0005); n = 34	0.00012	0.00020	0.00012	0.00019	0.00055	0.0008	0.00054	0.0011	0.00033	0.0005
U	mg/L	0.027	0.00017 (0.0001 - 0.00026); n = 28	0.00017	0.00026	0.00016	0.00023	0.00078	0.0015	0.00100	0.0020	0.0013	0.0027
V	mg/L	-	<0.001 (<0.0001 - 0.002); n = 36	0.00018	0.0004	0.00020	0.0005	0.00019	0.0005	0.00020	0.0005	0.00023	0.0005
Zn	mg/L	0.11	0.004 (<0.002 - 0.012); n = 36	0.0025	0.005	0.0019	0.0038	0.0017	0.004	0.0024	0.005	0.0046	0.008

Notes: Elements not included in the dissolved metals list that are present in the total metals list did not have sufficient detectable baseline dissolved concentrations to derive partition coefficients.
Modelling result summaries represent the median values from daily average and 95th percentile concentration predictions from 100 modelling realizations.
Predicted values in **bold** are higher than SSWQO.

[a] Objective for total ammonia based on a pH of 7.44 and a water temperature of 11.4°C.

[b] Objective for dissolved aluminum based on a pH of 7.45, which was the typical baseline pH. No change in pH in any waterbodies were expected based on geochemical characteristics and acidification assessment of local waterbodies.

[c] No SSWQO available; therefore CCME guideline was used.

[d] Guideline for nickel based on a water hardness of 60 mg/L.

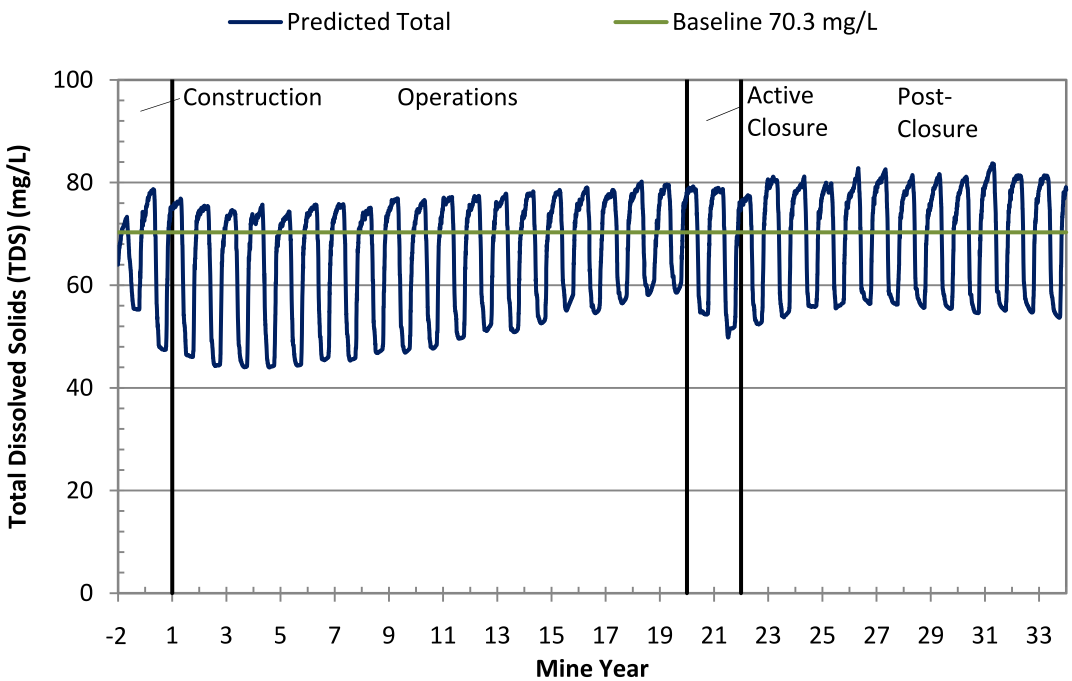


Figure 7.6-17: Predicted Total Dissolved Solids Concentrations in Peanut Lake

Concentrations of chloride, potassium, sodium, and sulphate are predicted to increase in Peanut Lake during operations, primarily due to predicted increases in concentrations and loadings in discharges from the ETF. Concentrations of these constituents are predicted to decline after ETF discharges cease at the beginning of active closure. Chloride and sulphate concentrations are predicted to increase again during the post-closure period, while potassium and sodium concentrations are predicted to stabilize at concentrations lower than predicted during operations, due to predicted post-closure concentration changes in Nico Lake. Representative time series plots are shown for chloride (Figure 7.6-18) and potassium (Figure 7.6-19) to illustrate the trends predicted for chloride and sulphate, and potassium and sodium, respectively.

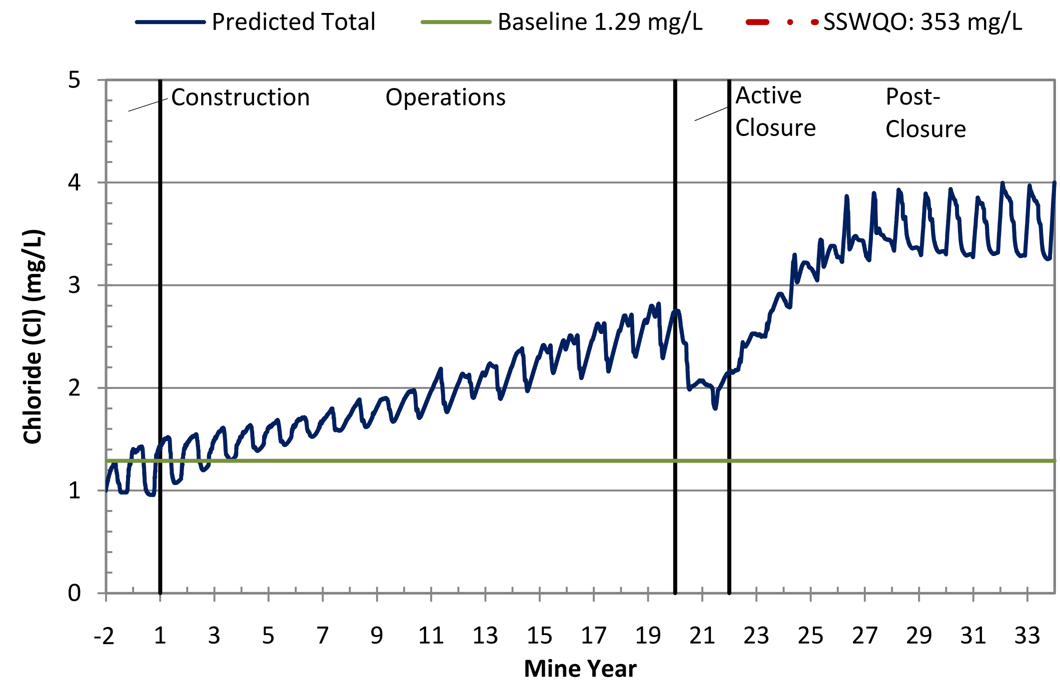


Figure 7.6-18: Predicted Chloride Concentrations in Peanut Lake

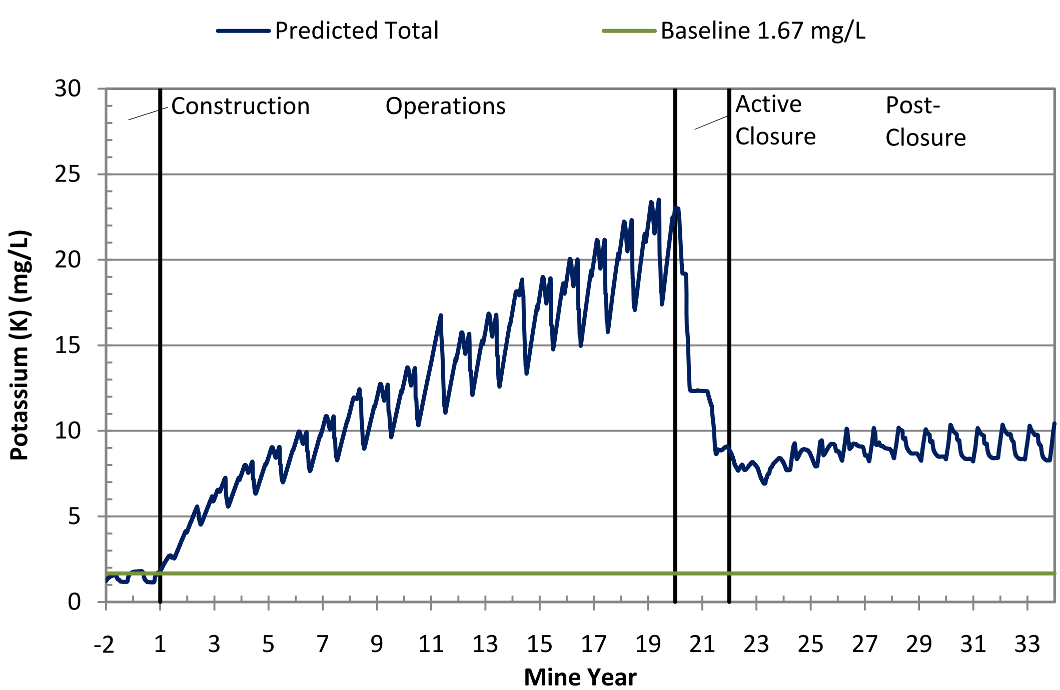


Figure 7.6-19: Predicted Potassium Concentrations in Peanut Lake

7.6.3.3.2.3 Nutrients

Nitrogen

Concentrations of ammonia and nitrate in Peanut Lake are predicted to increase during operations, primarily due to treated effluent discharges from the ETF (Figures 7.6-20 and 7.6-21). These constituent concentrations are predicted to decrease following closure, as ETF discharges will cease at the end of operations and influent concentrations from Nico Lake are predicted to decline following closure. Ammonia and nitrate concentrations in Peanut Lake are predicted to remain below SSWQOs during all phases of the NICO Project.

Total Kjeldahl nitrogen and total nitrogen, for which there are no SSWQO values or CCME guidelines, are predicted to follow a similar pattern, as they include loading of ammonia, and ammonia and nitrate, respectively, from the NICO Project.

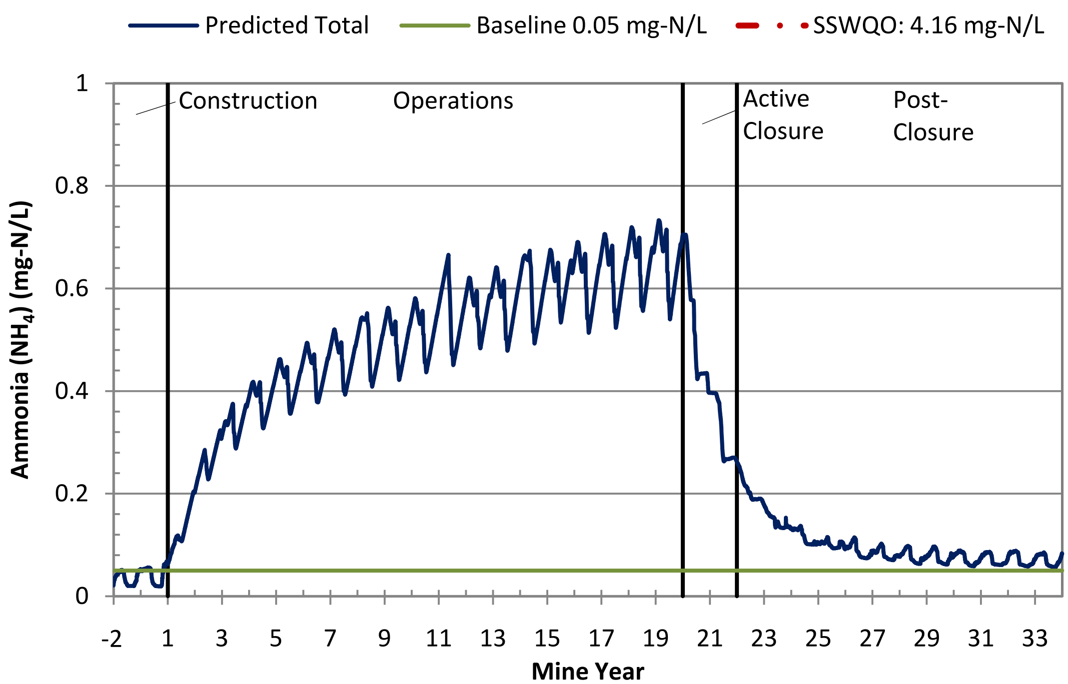


Figure 7.6-20: Predicted Ammonia Concentrations in Peanut Lake

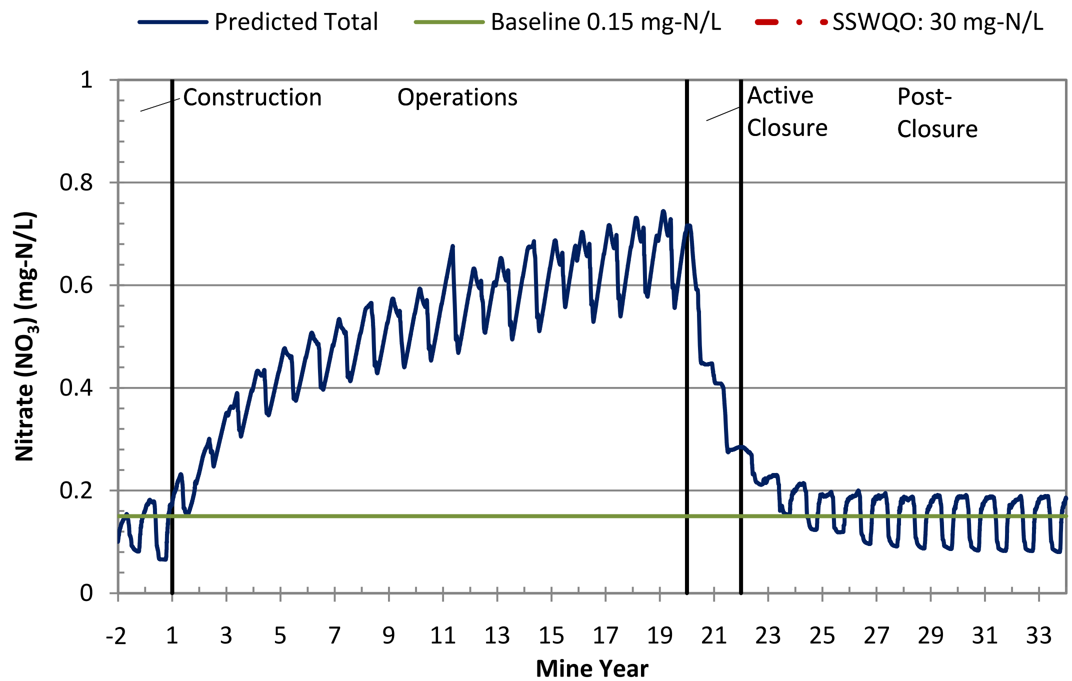


Figure 7.6-21: Predicted Nitrate Concentrations in Peanut Lake

Phosphorus

Total phosphorus concentrations in Peanut Lake are predicted to increase relative to baseline concentrations during construction and operations (Table 7.6-11), primarily due to loading from dust deposition during construction and operations and discharges from the ETF during operations. Concentrations are predicted to decrease during closure, to levels consistent with baseline concentrations, as discharges from the ETF and dust deposition due to NICO Project activities will cease (Figure 7.6-22).

7.6.3.3.2.4 Metals

Predicted metals concentrations in Peanut Lake are discussed below, and are grouped according to predicted trends over time.

Metal Concentrations Predicted to Increase During Operations and Decline Following Closure

Of the 22 metals that were modelled for this assessment, 10 are predicted to increase in concentration during the construction and operation phases, and then decline in concentration as Peanut Lake is flushed following closure. These metals are aluminum, arsenic, beryllium, boron, cadmium, cobalt, copper, iron, selenium, and silver. A time series plot of aluminum (Figure 7.6-23) illustrates the general trend predicted for these metals.

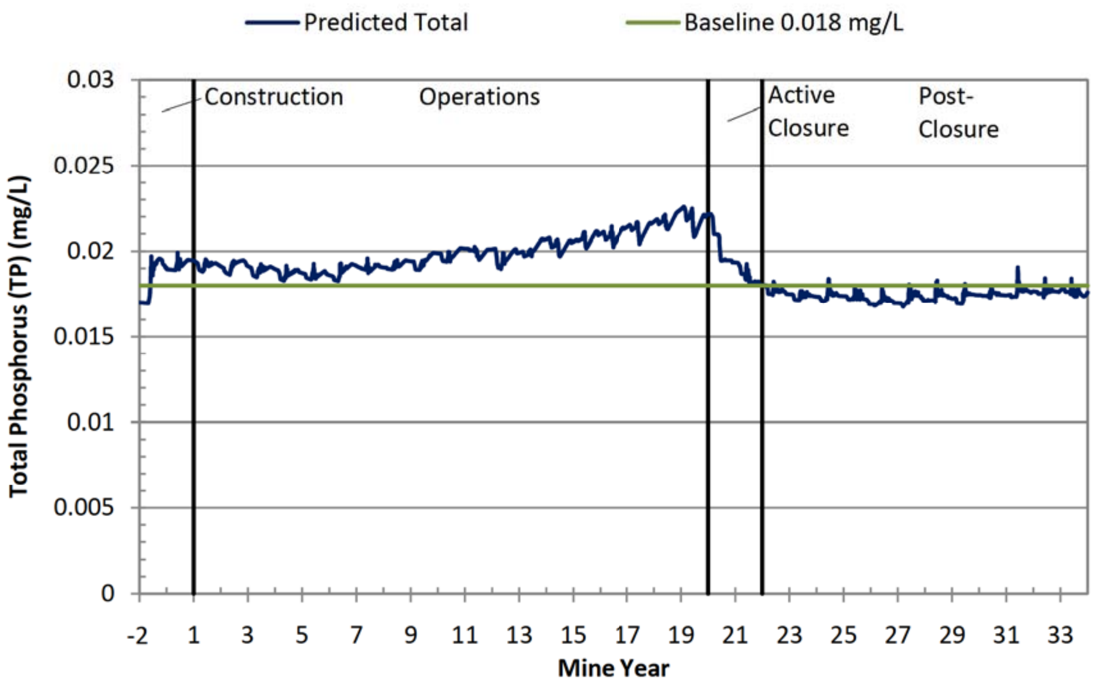


Figure 7.6-22: Predicted Total Phosphorus Concentrations in Peanut Lake

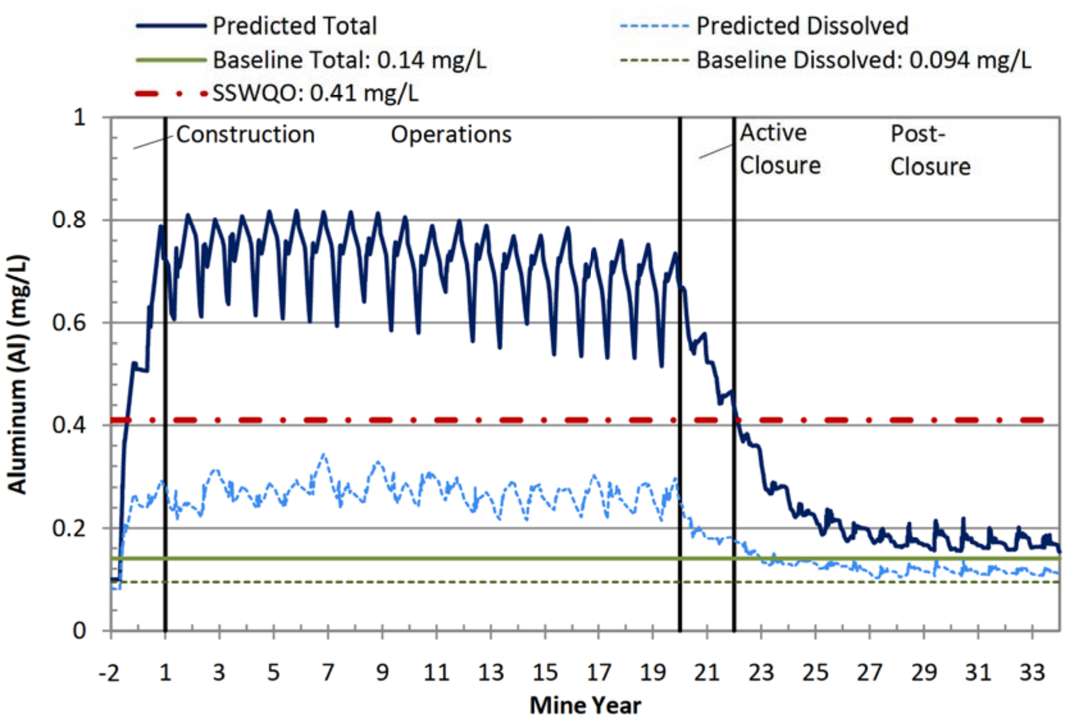


Figure 7.6-23: Predicted Aluminum Concentrations in Peanut Lake

The primary NICO Project related loading sources of these metals are dust deposition during construction and operations, discharges from the ETF during operations, and inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake after the end of operations. The expected loading of these metals during construction and operations is higher than after operations, resulting in declining concentrations in the post-closure period. Of these 10 metals, total aluminum and iron are predicted to exceed SSWQO values during operations, while arsenic (Figure 7.6-24), cadmium, cobalt, copper, and selenium (Figure 7.6-25) are predicted to remain below SSWQO values. However, dissolved aluminum and iron concentrations are predicted to remain below SSWQO values. Silver concentrations (Figure 7.6-26) are predicted to exceed CCME guidelines during operations and decline to concentrations below the guideline value during the post-closure period. Boron concentrations are not predicted to exceed CCME guidelines at any time. Beryllium does not have a CCME guideline.

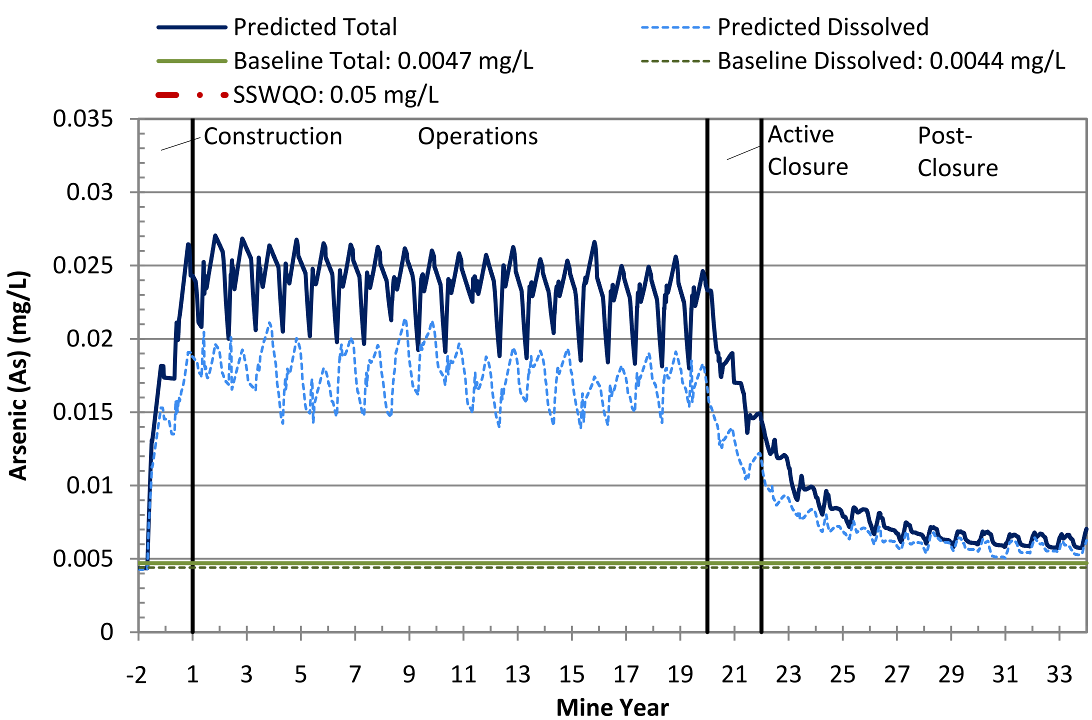


Figure 7.6-24: Predicted Arsenic Concentrations in Peanut Lake

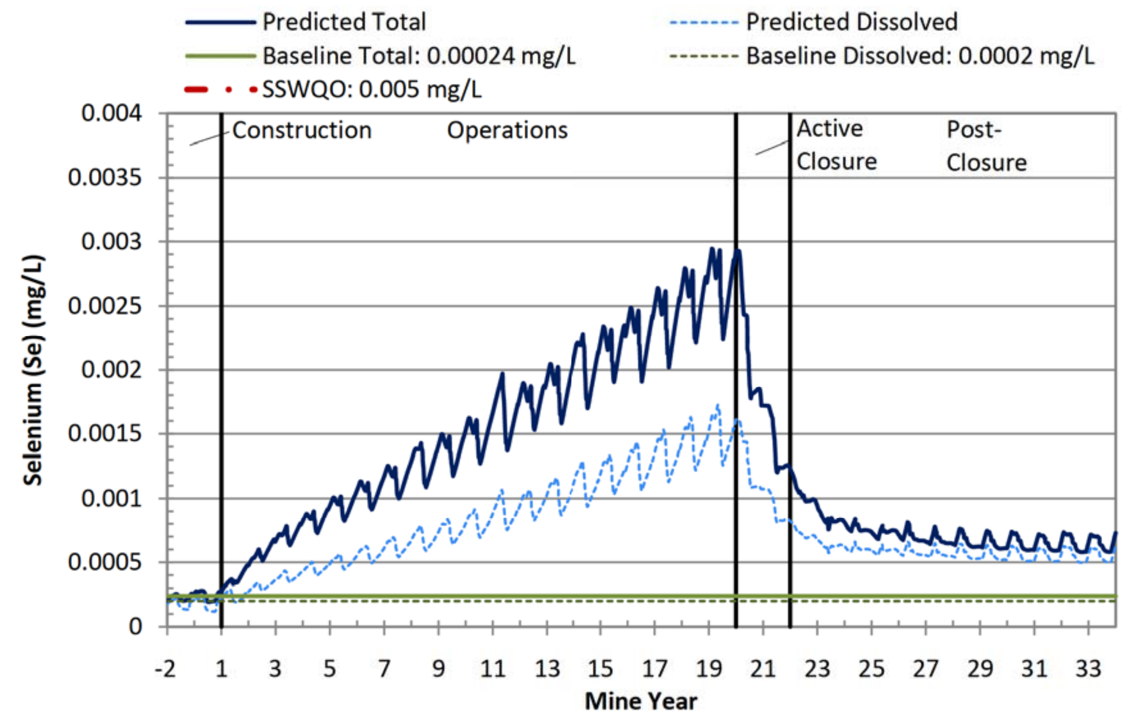


Figure 7.6-25: Predicted Selenium Concentrations in Peanut Lake

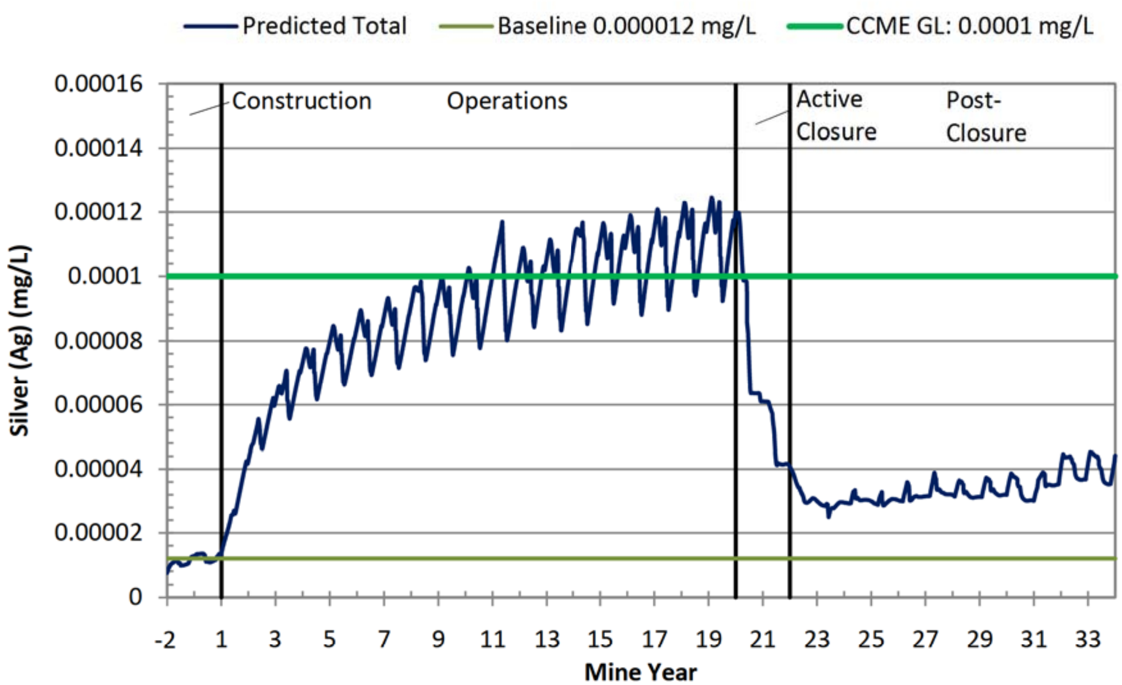


Figure 7.6-26: Predicted Silver Concentrations in Peanut Lake

Metal Concentrations Predicted to Increase during Operations and Remain Elevated Following Closure

A second group of metals are predicted to increase in concentration in Peanut Lake during the construction and operations phases, and remain near the same concentrations following closure. As noted for the first group of metals, the primary loading sources are dust deposition during construction and operations, discharges from the ETF during operations, and inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake after the end of operations. Unlike the first group of metals, the expected loading of this second group of metals after operations is similar to loading during operations, resulting in predicted concentrations during the post-closure period that are similar to concentrations predicted during operations.

The 3 metals that follow this trend are barium, chromium, and vanadium. Of these 3 metals, chromium is predicted to exceed CCME guidelines beginning during construction. Barium and vanadium do not have CCME guidelines or site specific water quality objectives. A time series plot for chromium (Figure 7.6-27) illustrates the general trend predicted for this group of metals.

As noted for Nico Lake, metals concentration predictions for the construction and operations phases are conservative due to modelling assumptions used to incorporate metals loading associated with dust deposition. Similarly, post-closure metals concentration predictions in Peanut Lake are conservative due to the assumptions applied to water quality in flows from Wetland Treatment Systems No. 1, 2, and 3 noted for Nico Lake predictions.

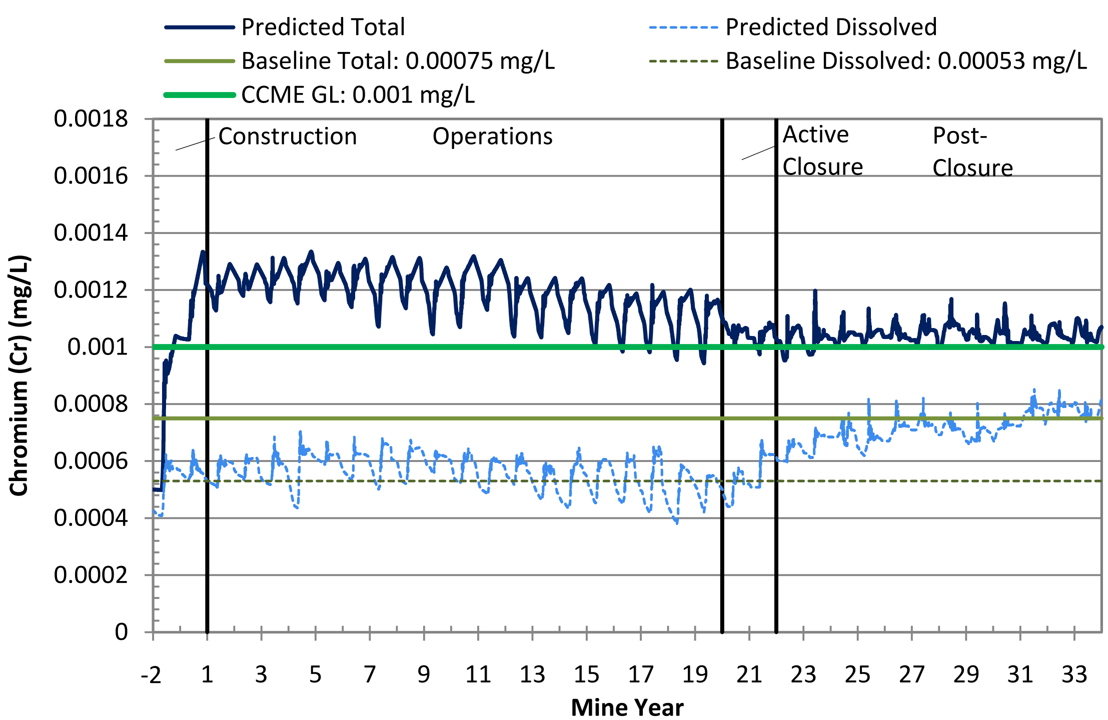


Figure 7.6-27: Predicted Chromium Concentrations in Peanut Lake

Metal Concentrations Predicted to Increase during Operations and Increase Further Following Closure

The 9 remaining metals that were modelled are predicted to continue to increase in concentration in Peanut Lake following closure. The primary loading source for these metals are inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake after the end of operations. The expected loading of this third group of metals during the post-closure period is predicted to be greater than loading during operations, resulting in predicted concentrations during the post-closure period that continue to increase in Peanut Lake.

The metals that follow this trend are antimony, lead, manganese, mercury, molybdenum, nickel, thallium, uranium, and zinc. Of these metals, antimony, lead, uranium, and zinc are predicted to remain below SSWQO values, and mercury, molybdenum, nickel, and thallium are predicted remain below CCME guidelines. Manganese does not have CCME guideline or SSWQO values. Representative time series plots are shown for uranium (Figure 7.6-28) and mercury (Figure 7.6-29) to illustrate the general trend predicted for this group of metals.

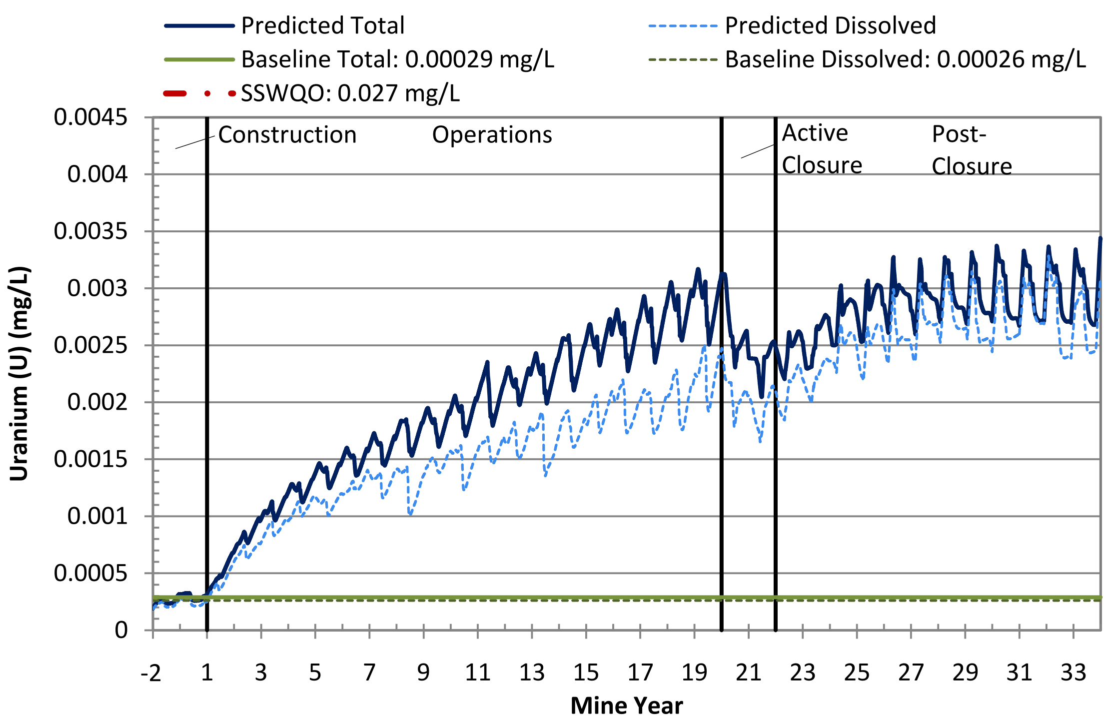


Figure 7.6-28: Predicted Uranium Concentrations in Peanut Lake

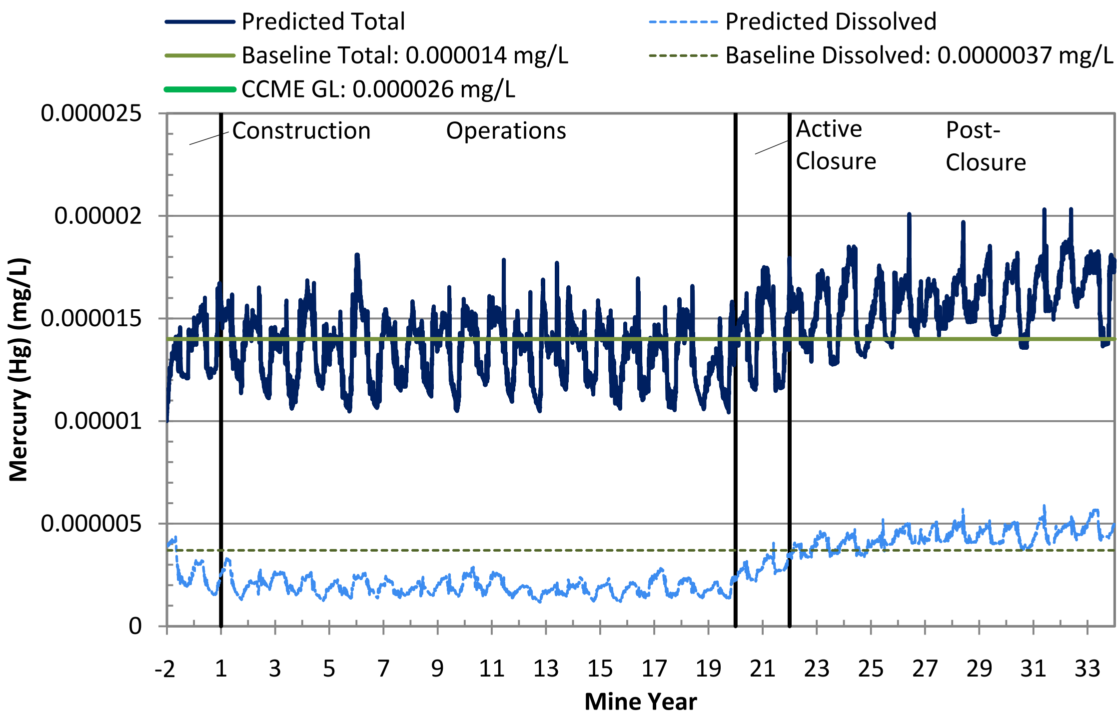


Figure 7.6-29: Predicted Mercury Concentrations in Peanut Lake

7.6.3.3.3 Burke Lake

Water quality in Burke Lake may be directly affected by deposition of dust and associated metals during NICO Project construction and operations, and upstream effects on water quality in Peanut Lake described above. A summary of water quality modelling predictions for Burke Lake are presented in Table 7.6-12, while predictions related to deposition of acidifying substances are provided separately in Section 7.6.1.

7.6.3.3.3.1 Total Suspended Solids

Total suspended solids concentrations in Burke Lake are predicted to increase, primarily as a result of fugitive dust and air emissions from NICO Project facilities. The predicted maximum (95^{th} percentile) TSS concentrations in Burke Lake are projected to be 5.9 mg/L during construction and 14 mg/L during operations (Table 7.6-12). Concentrations of TSS are expected to decrease during closure and reclamation, and return to levels consistent with baseline values.

As noted for Nico and Peanut lakes, incremental changes to TSS concentrations due to deposition of air emissions are likely an overestimation due to conservatism incorporated in the air quality assessment and assumptions used to incorporate these inputs in the water quality model. Peak TSS concentrations are expected to be transitory, with the particulate matter greater than 10 µm settling very quickly after freshet flows and a large proportion particulate matter less than 10 µm settling within several days following freshet.

Table 7.6-12: Predicted Water Quality in Burke Lake

Modelled Constituents	Unit	CCME Freshwater Aquatic Life Guidelines	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
				Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Conventional Parameters														
Total Dissolved Solids	mg/L	-	-	66 (50 - 86); n = 22	42.3	66.9	52.8	67.9	43.6	66.5	45.6	68.6	45.3	68.2
Total Suspended Solids	mg/L	-	-	3 (<1 - 64); n = 31	3.4	3.7	5.4	5.9	8.8	14.0	6.7	11.8	3.4	3.8
Major Ions														
Calcium	mg/L	-	-	7.6 (5 - 15.2); n = 44	8.73	12.8	8.31	10.3	8.24	12.5	8.48	12.7	8.73	12.8
Chloride	mg/L	-	353	1.76 (0.67 - 3); n = 44	1.18	1.65	1.39	1.73	1.39	1.85	1.49	1.96	1.88	2.53
Magnesium	mg/L	-	-	3.3 (2.2 - 5.66); n = 44	3.52	5.41	3.44	4.24	3.32	5.25	3.42	5.42	3.54	5.44
Potassium	mg/L	-	-	1.2 (0.8 - 1.8); n = 44	1.28	1.56	1.25	1.38	3.38	5.5	4.19	8.8	3.42	5.3
Sodium	mg/L	-	-	2.67 (1.9 - 4.1); n = 44	2.80	3.83	2.75	3.20	3.06	4.11	3.31	4.20	2.97	3.99
Sulphate	mg/L	-	500	2 (<0.5 - 4.1); n = 39	1.97	2.93	1.97	2.37	2.48	3.43	3.11	4.68	3.66	5.52
Nutrients														
Ammonia	mg-N/L	2.6[a]	4.16[a]	0.014 (<0.005 - 0.639); n = 44	0.020	0.04	0.018	0.029	0.13	0.23	0.13	0.26	0.032	0.05
Nitrate	mg-N/L	2.93	30	<0.1 (0.003 - 0.2); n = 44	0.052	0.12	0.073	0.11	0.16	0.26	0.16	0.29	0.059	0.12
Total Kjeldahl Nitrogen	mg-/L	-	-	0.623 (0.38 - 1.91); n = 44	0.60	0.93	0.62	0.75	0.67	0.99	0.68	0.99	0.59	0.92
Total Phosphorus	mg-/L	-	-	0.02 (0.0068 - 0.1); n = 44	0.015	0.017	0.017	0.020	0.016	0.018	0.015	0.018	0.014	0.017
Total Metals														
Al	mg/L	0.1[b]	0.41[b]	0.07 (0.017 - 1.56); n = 45	0.090	**0.12**	**0.18**	**0.21**	**0.34**	***0.58***	**0.25**	***0.49***	**0.11**	**0.14**
Sb	mg/L	-	0.03	<0.0004 (0.00003 - 0.0035); n = 45	0.00025	0.00032	0.00024	0.00030	0.00035	0.00043	0.00038	0.00047	0.00052	0.00073
As	mg/L	0.005	0.05	0.0025 (0.001 - 0.0389); n = 45	0.0028	0.0032	**0.0059**	**0.007**	**0.0100**	**0.018**	**0.0068**	**0.015**	0.0025	0.004
Ba	mg/L	-	-	0.0082 (0.007 - 0.0277); n = 45	0.0090	0.011	0.010	0.011	0.012	0.014	0.011	0.014	0.010	0.013
Be	mg/L	-	-	<0.00001 (<0.00001 - 0.00001); n = 5	0.000011	0.000012	0.000017	0.000019	0.000027	0.000042	0.000027	0.000048	0.000022	0.000031
B	mg/L	1.5	-	<0.008 (0.007 - <0.008); n = 4	0.0061	0.008	0.0069	0.008	0.0079	0.010	0.0092	0.013	0.0075	0.010
Cd	mg/L	0.000017[c]	0.00015	<0.00001 (<0.000005 - 0.000099); n = 27	0.0000097	**0.000019**	0.000014	**0.000020**	**0.000020**	**0.000031**	**0.000017**	**0.000028**	0.000012	**0.000022**
Cr	mg/L	0.001	-	0.0008 (0.00018 - 0.0036); n = 24	0.00058	0.0008	0.00064	0.0008	0.00083	**0.0011**	0.00073	0.0010	0.00070	0.0009
Co	mg/L	-	0.01	<0.002 (0.00006 - 0.0052); n = 45	0.00017	0.00030	0.00073	0.0009	0.0015	0.0027	0.0011	0.0024	0.00042	0.0007
Cu	mg/L	0.002[c]	0.022	0.001 (0.00071 - 0.004); n = 45	0.0012	0.0014	0.0014	0.0017	0.0019	**0.0026**	0.0016	**0.0024**	0.0014	0.0016
Fe	mg/L	0.3	1.5	0.302 (0.044 - 12.8); n = 45	**0.38**	**0.47**	**0.55**	**0.64**	**0.94**	**1.48**	**0.73**	**1.31**	**0.43**	**0.51**
Pb	mg/L	0.001[c]	0.008	<0.0001 (0.00008 - 0.0006); n = 34	0.000080	0.00013	0.00010	0.00013	0.00013	0.00017	0.00013	0.00019	0.00022	0.00034
Mn	mg/L	-	-	0.019 (0.002 - 3.2); n = 45	0.025	0.05	0.024	0.035	0.028	0.05	0.028	0.05	0.029	0.05
Hg	mg/L	0.000026	-	<0.00005 (<0.00001 - 0.00029); n = 45	0.0000087	0.000012	0.0000094	0.000012	0.0000088	0.000013	0.0000090	0.000013	0.0000101	0.000014
Mo	mg/L	0.073	-	0.0002 (0.00016 - 0.0003); n = 19	0.00021	0.00025	0.00021	0.00024	0.00043	0.0007	0.00052	0.0010	0.00062	0.0010
Ni	mg/L	0.025[c]	-	<0.002 (0.00038 - 0.0021); n = 45	0.00073	0.0011	0.00086	0.0011	0.00085	0.0012	0.00085	0.0012	0.00081	0.0012
Se	mg/L	0.001	0.005	<0.0004 (<0.00004 - 0.0012); n = 45	0.00013	0.00021	0.00017	0.00021	0.00042	0.0007	0.00057	**0.0011**	0.00027	0.0004
Ag	mg/L	0.0001	-	<0.000005 (<0.000005 - 0.000006); n = 5	0.0000062	0.000010	0.0000070	0.000009	0.000025	0.000043	0.000022	0.000047	0.000014	0.000021
Tl	mg/L	0.0008	-	<0.0001 (<0.000002 - <0.05); n = 45	0.0000015	0.0000020	0.0000029	0.0000034	0.000056	0.00009	0.000045	0.00008	0.000067	0.00012
U	mg/L	0.015	0.027	0.00022 (0.000149 - 0.00051); n = 34	0.00023	0.00033	0.00023	0.00028	0.00065	0.0010	0.00083	0.0014	0.00096	0.0016
V	mg/L	-	-	0.001 (<0.0002 - 0.0273); n = 45	0.00040	0.0007	0.00053	0.0007	0.00058	0.0009	0.00052	0.0008	0.00045	0.0008
Zn	mg/L	0.03	0.11	0.004 (<0.001 - 0.049); n = 45	0.0045	0.0057	0.0043	0.0054	0.0048	0.0060	0.0049	0.0060	0.0064	0.0078
Dissolved Metals														
Al	mg/L	0.1[b]	0.41[b]	0.02 (0.005 - 0.13); n = 44	0.040	0.08	0.06	**0.14**	0.09	**0.23**	0.07	**0.16**	0.05	0.10

Table 7.6-12: Predicted Water Quality in Burke Lake (continued)

Modelled Constituents	Unit	CCME Freshwater Aquatic Life Guidelines	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
				Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Sb	mg/L	-	0.03	<0.0004 (0.00003 - 0.0006); n = 44	0.00018	0.00027	0.00015	0.00022	0.00018	0.00030	0.00021	0.00034	0.00036	0.00062
As	mg/L	0.005	0.05	0.0021 (<0.001 - 0.0385); n = 44	0.0023	0.0030	0.0046	**0.006**	**0.0068**	**0.014**	0.0048	**0.011**	0.0021	0.003
Ba	mg/L	-	-	0.0073 (0.0059 - 0.0251); n = 44	0.0077	0.010	0.0080	0.010	0.0088	0.013	0.0087	0.012	0.0086	0.011
Be	mg/L	-	-	<0.00001 (<0.00001 - 0.00006); n = 8	0.0000078	0.000010	0.000010	0.000014	0.000013	0.000021	0.000015	0.000023	0.000015	0.000024
B	mg/L	1.5	-	0.008 (<0.002 - 0.011); n = 10	0.0050	0.007	0.0052	0.0070	0.0052	0.008	0.0065	0.010	0.0061	0.008
Cd	mg/L	0.000017[c]	0.00015	0.000065 (0.000009 - 0.00687); n = 44	0.0000038	0.000009	0.0000042	0.000009	0.0000046	0.000012	0.0000046	0.000010	0.0000047	0.000012
Cr	mg/L	0.001	-	0.0003 (<0.0002 - 0.0008); n = 15	0.00029	0.00053	0.00026	0.00053	0.00026	0.00057	0.00026	0.00050	0.00035	0.00064
Co	mg/L	-	0.01	<0.002 (0.000035 - 0.005); n = 44	0.00011	0.00021	0.00042	0.0008	0.00071	0.0016	0.00058	0.0017	0.00028	0.0005
Cu	mg/L	0.002[c]	0.022	0.001 (0.00065 - 0.0069); n = 44	0.00086	0.0012	0.00087	0.0013	0.00097	0.0016	0.00096	0.0017	0.00096	0.0014
Fe	mg/L	0.3	1.5	0.207 (0.02 - 9.5); n = 44	0.21	**0.36**	0.25	**0.47**	**0.34**	**0.76**	0.30	**0.64**	0.24	**0.41**
Pb	mg/L	0.001[c]	0.008	<0.0001 (0.000088 - 0.00074); n = 33	0.000048	0.00009	0.000053	0.00010	0.000053	0.00011	0.000061	0.00013	0.00013	0.00026
Mn	mg/L	-	-	0.005 (<0.001 - 2.97); n = 44	0.014	0.03	0.012	0.026	0.012	0.032	0.013	0.035	0.017	0.04
Hg	mg/L	0.000026	-	<0.00002 (<0.00001 - 0.00028); n = 40	0.0000019	0.0000036	0.0000014	0.0000027	0.00000091	0.0000020	0.0000013	0.0000027	0.0000021	0.0000039
Mo	mg/L	0.073	-	0.0002 (0.0001 - 0.00057); n = 18	0.00017	0.00022	0.00016	0.00021	0.00029	0.0005	0.00038	0.0008	0.00052	0.0009
Ni	mg/L	0.025[c]	-	<0.002 (0.0003 - 0.0043); n = 44	0.00056	0.0009	0.00060	0.0009	0.00052	0.0009	0.00056	0.0010	0.00062	0.0009
Se	mg/L	0.001	0.005	<0.0004 (<0.00004 - <0.0005); n = 41	0.00011	0.00018	0.00014	0.00018	0.00029	0.00041	0.00041	0.00071	0.00023	0.00034
U	mg/L	0.015	0.027	0.0002 (0.0001 - 0.00049); n = 33	0.00019	0.00028	0.00018	0.00025	0.00046	0.0008	0.00061	0.0011	0.00081	0.0015
V	mg/L	-	-	<0.001 (<0.0001 - 0.001); n = 44	0.00021	0.0004	0.00023	0.0005	0.00020	0.00045	0.00021	0.00045	0.00023	0.0005
Zn	mg/L	0.03	0.11	0.0038 (<0.001 - 0.015); n = 44	0.0025	0.0045	0.0020	0.0038	0.0019	0.0041	0.0022	0.0045	0.0036	0.0061

Notes: Elements not included in the dissolved metals list that are present in the total metals list did not have sufficient detectable baseline dissolved concentrations to derive partition coefficients.

Modelling result summaries represent the median values from daily average and 95th percentile concentration predictions from 100 modelling realizations.

Predicted values in **bold** are higher than CCME guidelines; values in ***bold italics*** are higher than site specific water quality objectives.

[a] Guideline/objective for total ammonia based on a pH of 7.44 and a water temperature of 11.4°C.

[b] Guideline/objective for aluminum based on a pH of 7.45, which was the typical baseline pH. No change in pH in any waterbodies was expected based on geochemical characteristics and acidification assessment of local waterbodies.

[c] Guidelines for cadmium, copper, lead, and nickel are based on a water hardness of 60 mg/L.

7.6.3.3.3.2 Total Dissolved Solids and Major Ions

Concentrations of TDS, calcium, and magnesium in Burke Lake are predicted to begin to decrease relative to baseline conditions during construction and early operations, primarily due to lower influent concentrations from Peanut Lake (Figure 7.6-30). Concentrations of TDS in Burke Lake are predicted to increase during operations as discharge rates from the ETF to Peanut Lake increase, and during closure due to higher concentrations influent to Peanut Lake from Nico Lake. Calcium and magnesium are predicted to remain slightly lower than baseline concentrations during operations and consistent with baseline concentrations during closure, and generally mirror the trends displayed by TDS in Figure 7.6-30. Time series plots for these constituents are provided in Appendix 7.V.

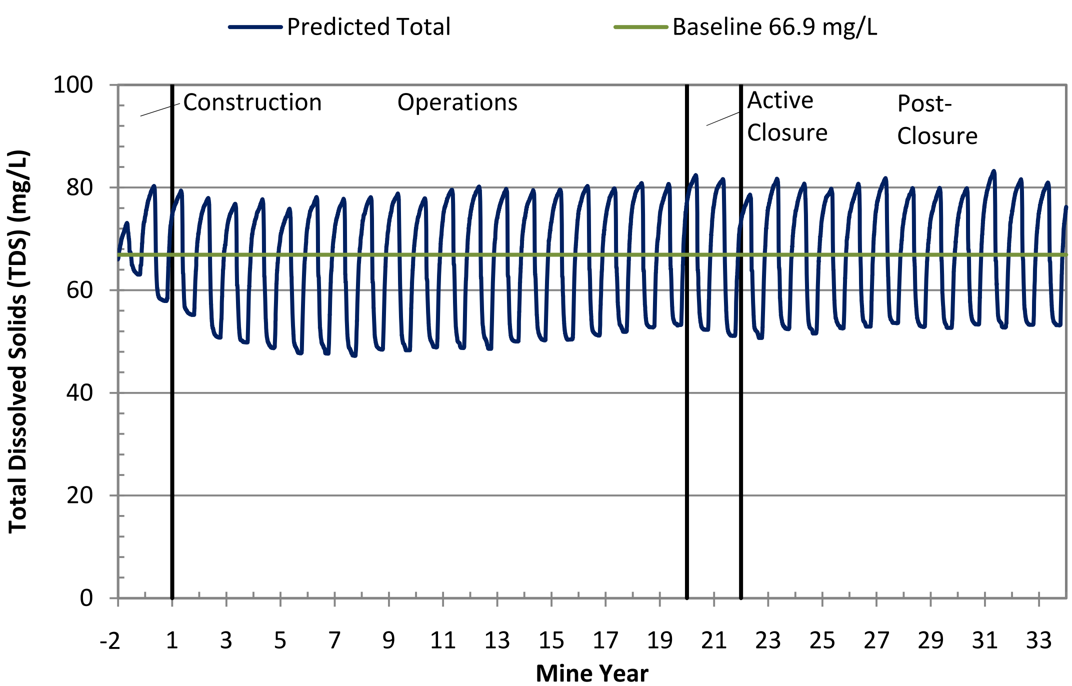


Figure 7.6-30: Predicted Total Dissolved Solids Concentrations in Burke Lake

Concentrations of chloride, potassium, sodium, and sulphate are predicted to increase in Burke Lake during operations, primarily due to predicted increases in concentrations and loading of these constituents in discharges from the ETF to Peanut Lake. Concentrations of these constituents are predicted to decline after ETF discharges cease at the beginning of active closure. Chloride and sulphate concentrations are predicted to increase again during the post-closure period, while potassium and sodium concentrations are predicted to stabilize at concentrations lower than predicted during operations, due to predicted post-closure concentration changes in Nico Lake. Representative time series plots are shown for chloride (Figure 7.6-31) and potassium (Figure 7.6-32) to illustrate the trends predicted for chloride and sulphate, and potassium and sodium, respectively.

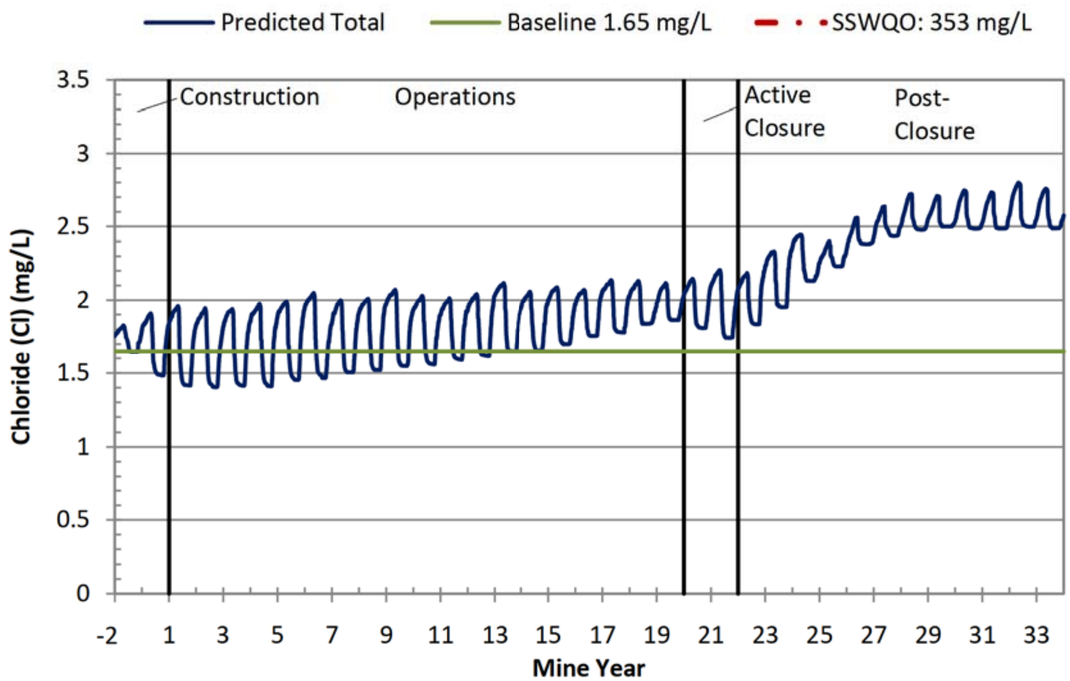


Figure 7.6-31: Predicted Chloride Concentrations in Burke Lake

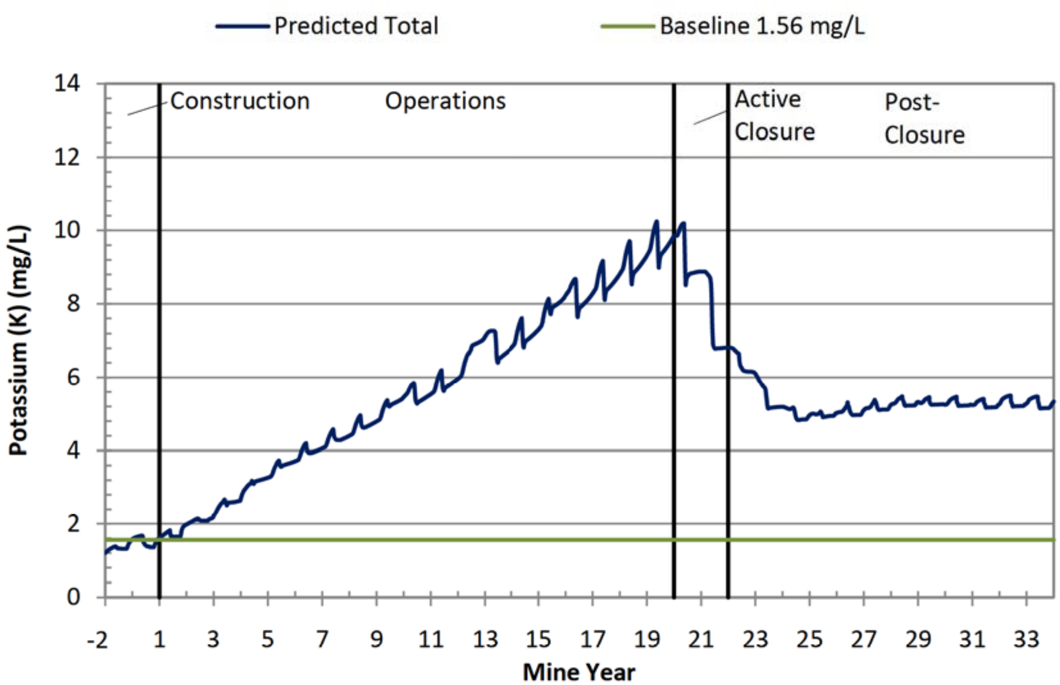


Figure 7.6-32: Predicted Potassium Concentrations in Burke Lake

As discussed for Nico Lake predictions, the results presented for the post-closure period are conservative due to the modelling assumptions used to predict constituent concentrations in the NICO Project closure wetlands.

7.6.3.3.3.3 Nutrients

Nitrogen

Concentrations of ammonia and nitrate in Burke Lake are predicted to increase during operations, primarily due to upstream influences on Peanut Lake waters from treated effluent discharges from the ETF (Figures 7.6-33 and 7.6-34). These constituent concentrations are predicted to decrease following closure, as ETF discharges will cease at the end of operations and influent concentrations to Peanut Lake from Nico Lake are predicted to decline following closure. Ammonia and nitrate concentrations in Burke Lake are predicted to remain below SSWQO values and CCME guidelines during all phases of the NICO Project.

Total Kjeldahl nitrogen and total nitrogen, for which there are no SSWQOs or CCME guidelines, are predicted to follow a similar pattern, as they include loading of ammonia, and ammonia and nitrate, respectively, from the NICO Project.

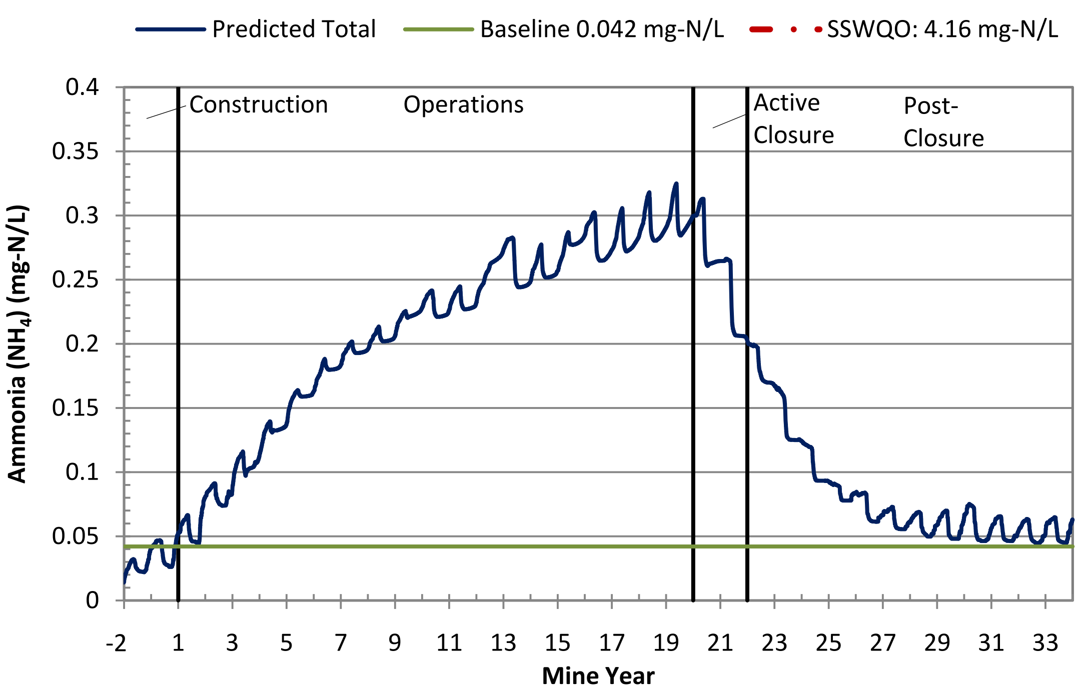


Figure 7.6-33: Predicted Ammonia Concentrations in Burke Lake

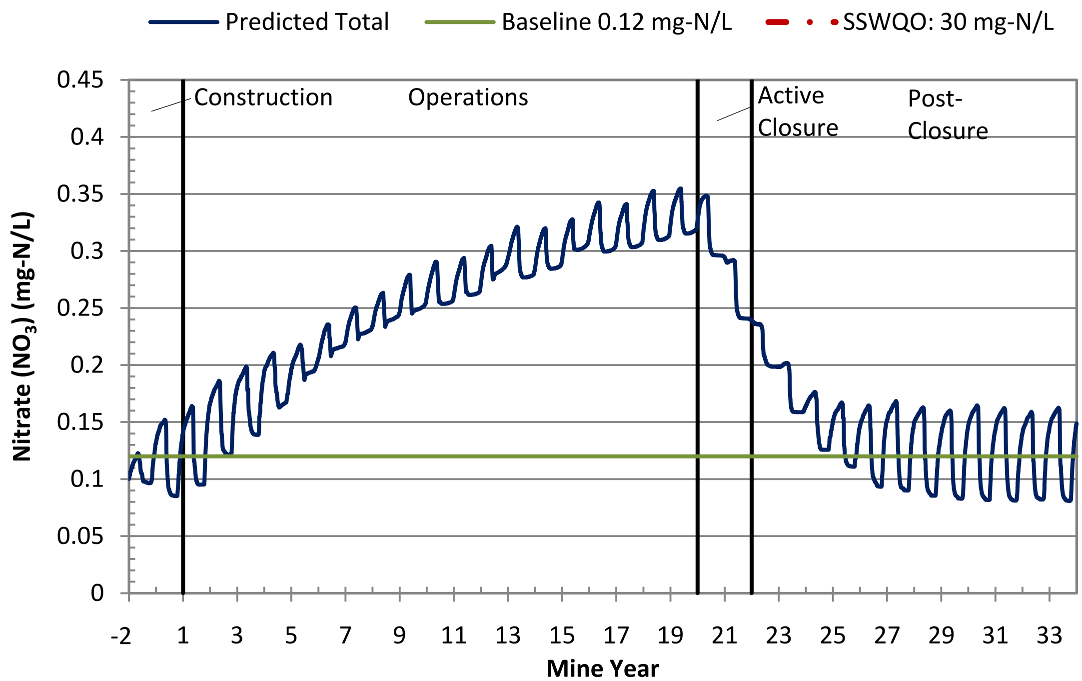


Figure 7.6-34: Predicted Nitrate Concentrations in Burke Lake

Phosphorus

Total phosphorus concentrations in Burke Lake are predicted to increase slightly relative to baseline concentrations during construction and operations (Table 7.6-13), primarily due to loading from dust deposition during construction and operations and upstream influences on waters from Peanut Lake due to ETF discharges during operations. Concentrations are predicted to decrease during closure, to levels consistent with baseline concentrations, as discharges from the ETF and dust deposition due to NICO Project activities will cease (Figure 7.6-35).

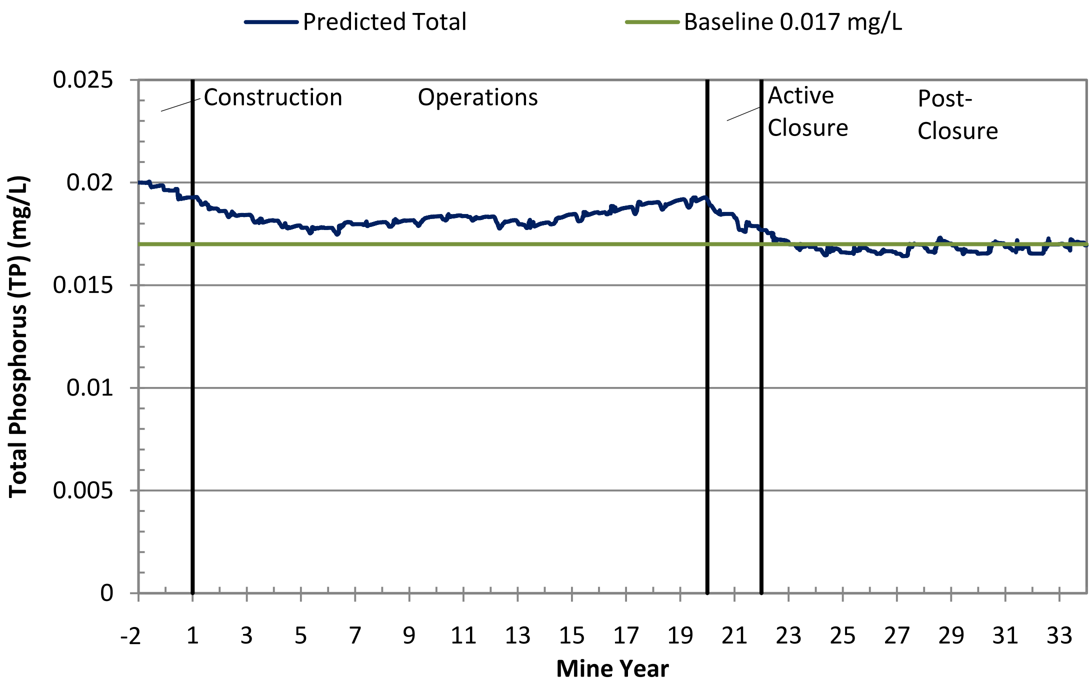


Figure 7.6-35: Predicted Total Phosphorus Concentrations in Burke Lake

7.6.3.3.3.4 Metals

Predicted metals concentrations in Burke Lake are discussed below, and are grouped according to predicted trends over time.

Metal Concentrations Predicted to Increase during Operations and Decline Following Closure

Of the 22 metals that were modelled for this assessment, 13 are predicted to increase in concentration during the construction and operations phases, and then decline in concentration as Burke Lake is flushed following closure. These metals are aluminum, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, selenium, silver, and vanadium. A time series plot of aluminum (Figure 7.6-36) illustrates the general trend predicted for these metals.

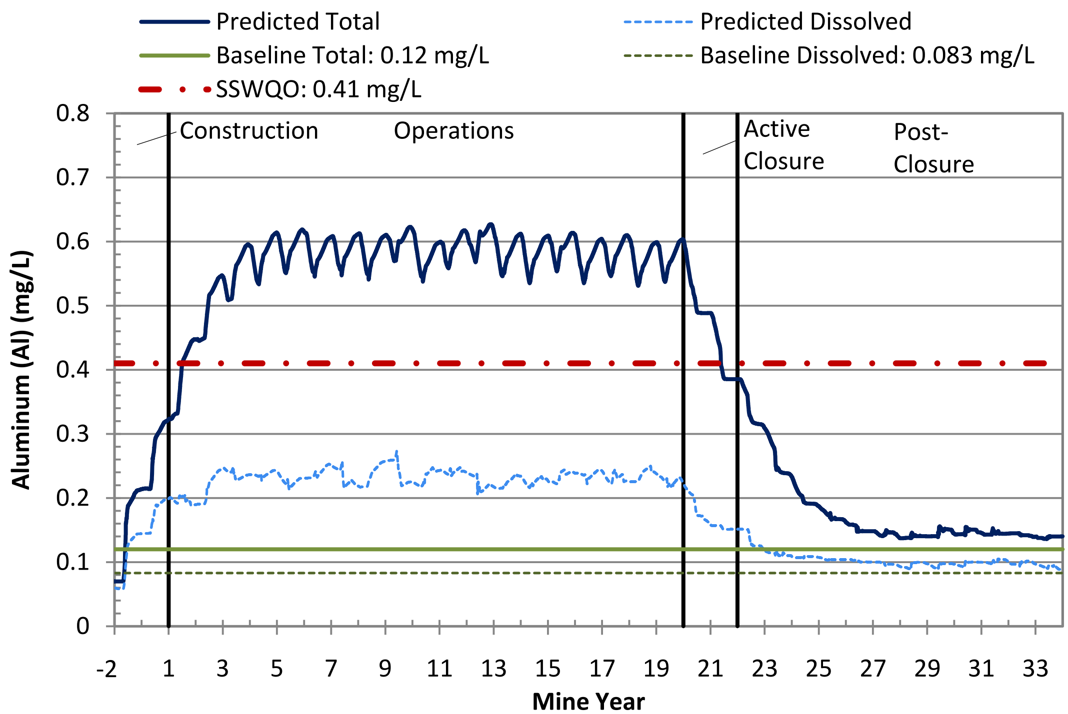


Figure 7.6-36: Predicted Aluminum Concentrations in Burke Lake

The primary NICO Project related loading sources of these metals are dust deposition during construction and operations, discharges from the ETF to Peanut Lake during operations, and inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake after the end of operations. The expected loading of these metals during construction and operations is higher than after operations, resulting in declining concentrations in the post-closure period. Of these 13 metals, total aluminum is predicted to exceed both the CCME guideline and SSWQO value during operations and may continue to exceed the CCME guideline during the post-closure period at concentrations near baseline conditions. However, dissolved aluminum is not predicted to exceed the SSWQO. Total iron is predicted to exceed the CCME guideline and may exceed the SSWQO value during operations and may continue to exceed the CCME guideline, during the post-closure period at concentrations near baseline conditions. However, dissolved iron concentrations are predicted to remain below the SSWQO value. Cadmium is predicted to exceed CCME guidelines, without exceeding the SSWQO value, during operations and decline to concentrations that exceed CCME guidelines less frequently during the post-closure period. Arsenic (Figure 7.6-37), chromium (Figure 7.6-38), copper, and selenium (Figure 7.6-39) are predicted to exceed CCME guidelines during operations and decline to concentrations below these guidelines during the post-closure period without exceeding available SSWQO values. Boron and silver concentrations are not predicted to exceed CCME guidelines in Burke Lake. Barium, beryllium, cobalt, and vanadium do not have CCME guidelines and predicted cobalt concentrations are not predicted to exceed SSWQO values.

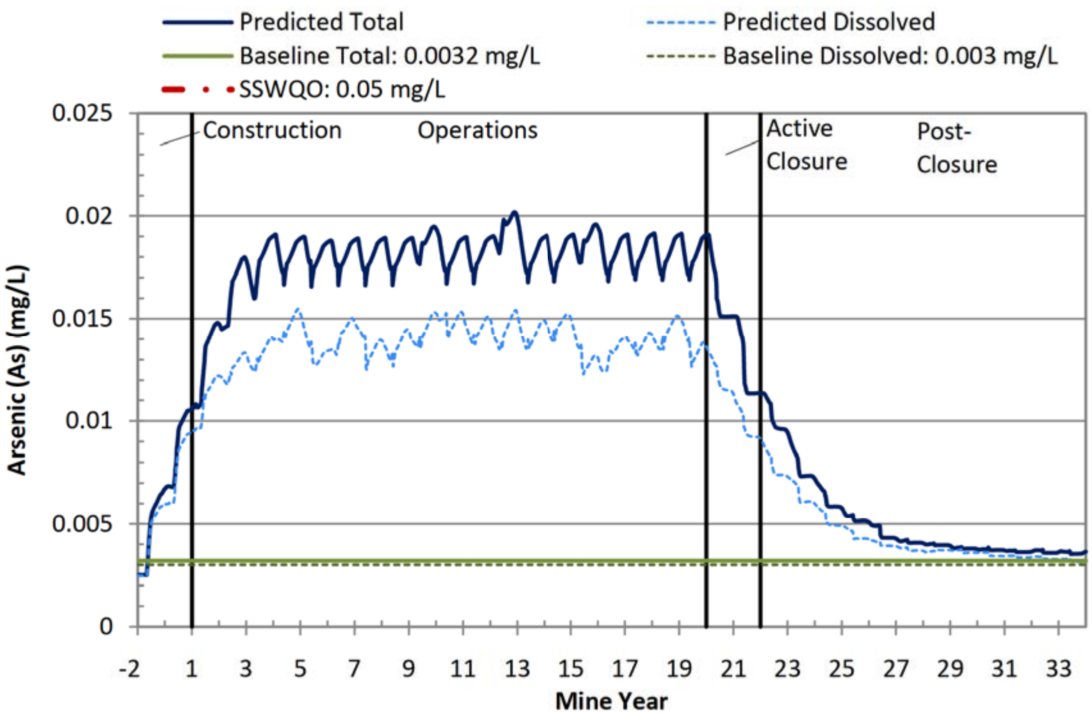


Figure 7.6-37: Predicted Arsenic Concentrations in Burke Lake

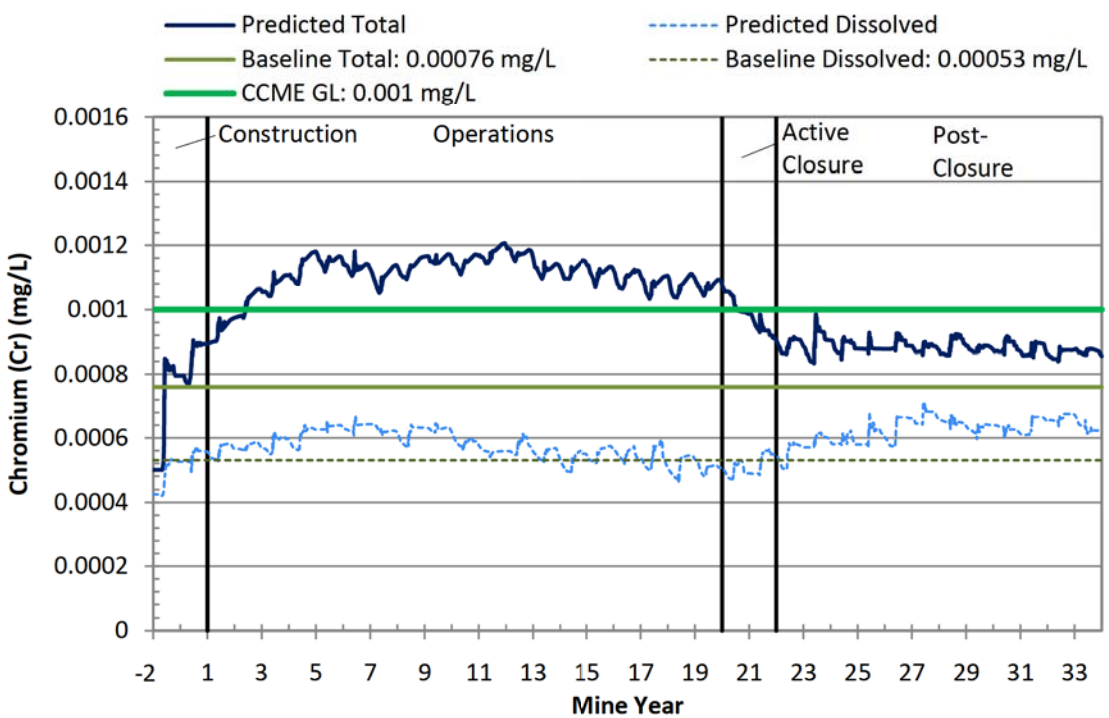


Figure 7.6-38: Predicted Chromium Concentrations in Burke Lake

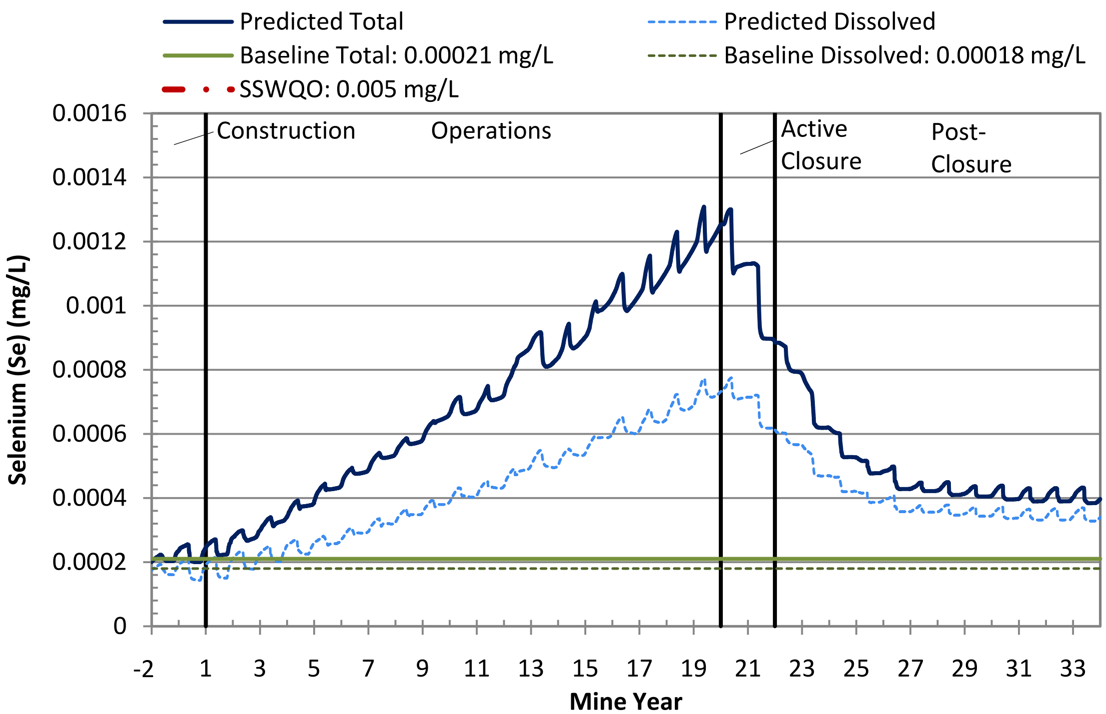


Figure 7.6-39: Predicted Selenium Concentrations in Burke Lake

As noted for Nico and Peanut lakes, metals concentration predictions for the construction and operations phases are conservative due to modelling assumptions used to incorporate metals loading associated with dust deposition. Similarly, post-closure metals concentration predictions in Burke Lake are conservative due to the assumptions applied to water quality in flows from Wetland Treatment Systems No. 1, 2, and 3 noted for Nico Lake predictions.

Metal Concentrations Predicted to Increase during Operations and Remain Elevated Following Closure

A second group of metals are predicted to increase in concentration in Burke Lake during the construction and operations phases, and remain near the same concentrations following closure. As noted for the first group of metals, the primary loading sources are dust deposition during construction and operations, discharges from the ETF to Peanut Lake during operations, and inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake after the end of operations. Unlike the first group of metals, the expected loading of this second group of metals after operations is similar to loading during operations, resulting in predicted concentrations during the post-closure period that are similar to concentrations predicted during operations.

The 2 metals that follow this trend are manganese and nickel. Nickel concentrations are predicted to remain below CCME guidelines, and manganese does not have a SSWQO value or CCME guideline. A time series plot for nickel (Figure 7.6-40) illustrates the general trend predicted for this group of metals.

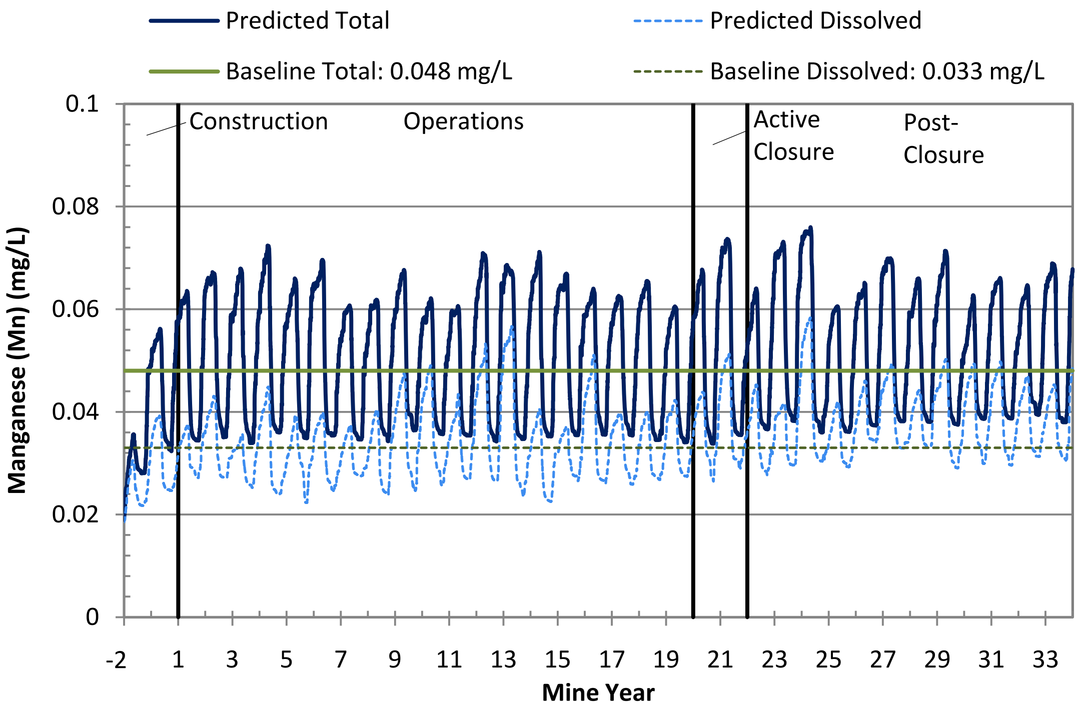


Figure 7.6-40: Predicted Manganese Concentrations in Burke Lake

Metals Predicted to Increase during Operations and Further Increase Following Closure

The 6 remaining metals that were modelled are predicted to continue to increase in concentration in Burke Lake following closure. The primary NICO Project loading source for these metals after the end of operations are inflow of Wetland Treatment Systems No. 1, 2, and 3 influenced waters from Nico Lake. The expected loading of this third group of metals during the post-closure period is predicted to be greater than loading during operations, resulting in predicted concentrations during the post-closure period that continue to increase in Burke Lake.

The metals that follow this trend are antimony, lead, mercury, molybdenum, thallium, uranium, and zinc. All of these metals are predicted remain below available CCME guidelines and SSWQOs. Representative time series plots are shown for uranium (Figure 7.6-41) and mercury (Figure 7.6-42) to illustrate the general trend predicted for this group of metals.

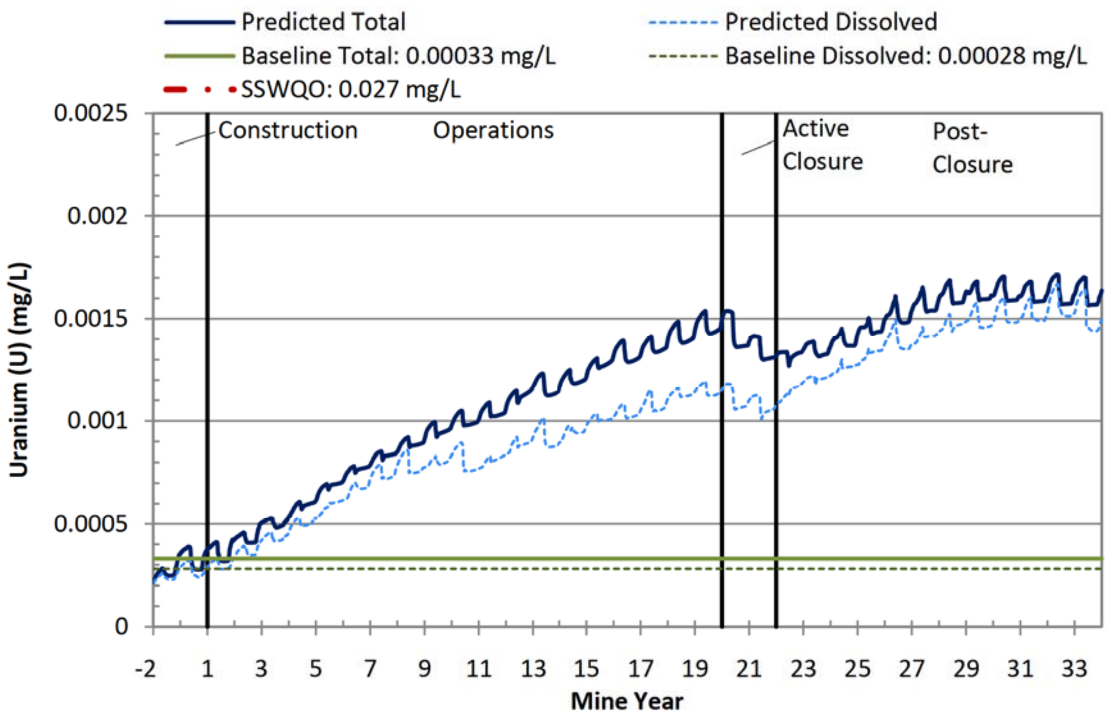


Figure 7.6-41: Predicted Uranium Concentrations in Burke Lake

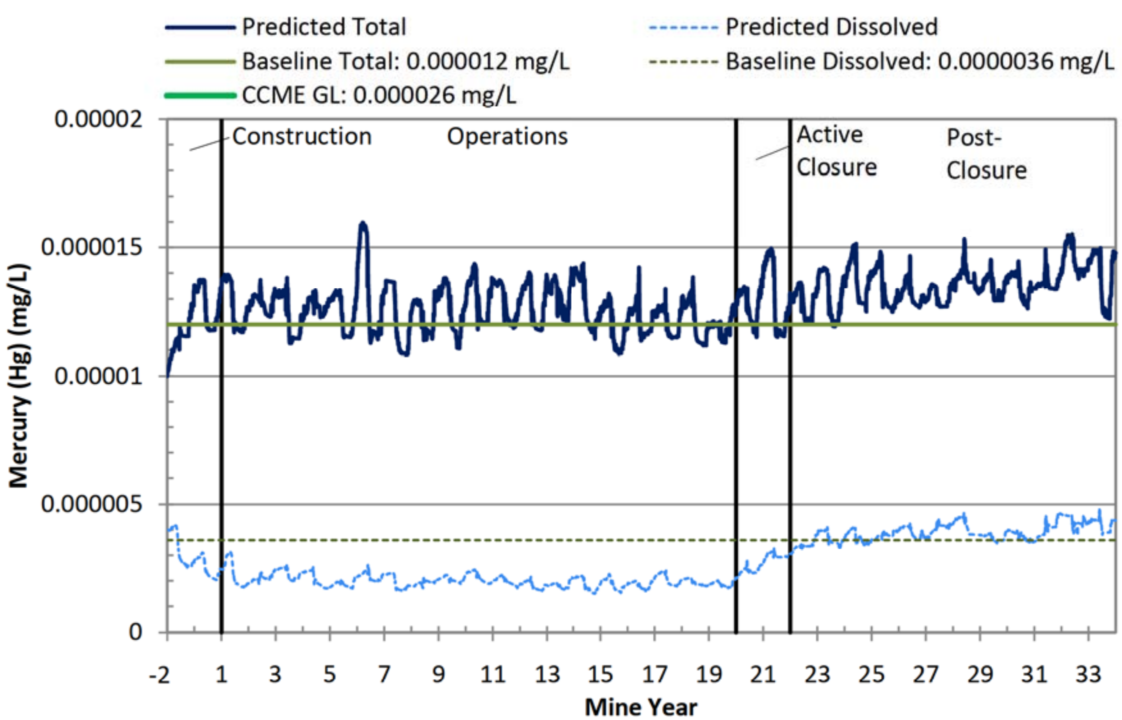


Figure 7.6-42: Predicted Mercury Concentrations in Burke Lake

7.6.3.3.4 Marian River

Water quality in the Marian River downstream of Burke Creek may be affected by NICO Project activities affecting water quality in the Burke Lake watershed as described above. A summary of water quality modelling predictions for the Marian River are presented in Table 7.6-13.

7.6.3.3.4.1 Total Suspended Solids

Total suspended solids concentrations in the Marian River are predicted to remain similar to baseline values during all phases of the NICO Project (Table 7.6-13). The largest increase in 95th percentile concentrations from the baseline case is less than 3%, which is unlikely to be distinguishable from natural background variation.

7.6.3.3.4.2 Total Dissolved Solids and Major Ions

Concentrations of TDS and all modelled major ions in the Marian River are predicted to remain similar to baseline conditions during all phases of the NICO Project. Concentrations of calcium, chloride, magnesium, potassium, sodium, and sulphate mirror the seasonal trends displayed by TDS in Figure 7.6-43. Predicted changes from the baseline case are less than 4%, which is unlikely to be distinguishable from natural background variation.

Table 7.6-13: Predicted Water Quality in the Marian River

Modelled Constituents	Unit	CCME Freshwater Aquatic Life Guidelines	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
				Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Conventional Parameters														
Total Dissolved Solids	mg/L	-	-	130 (70 - 149); n = 11	119	239	120	238	119	238	119	241	119	241
Total Suspended Solids	mg/L	-	-	3 (<1 - 6); n = 17	3.4	8.9	3.5	9.0	3.7	9.0	3.6	9.1	3.4	8.9
Major Ions														
Calcium	mg/L	-	-	19.2 (7.4 - 34); n = 25	25.5	51.1	25.4	51.1	25.4	50.9	25.5	50.8	25.4	50.6
Chloride	mg/L	-	353	2.99 (1.36 - 4); n = 25	2.68	5.36	2.70	5.38	2.67	5.33	2.68	5.33	2.69	5.38
Magnesium	mg/L	-	-	8.56 (3.1 - 15); n = 25	11.0	22.0	11.0	22.2	10.9	21.8	11.0	22.1	10.9	21.8
Potassium	mg/L	-	-	1.42 (0.91 - 2.9); n = 25	1.94	3.88	1.95	3.87	2.00	3.93	2.00	3.95	2.01	3.95
Sodium	mg/L	-	-	3 (1.5 - 5.6); n = 25	3.79	7.5	3.79	7.6	3.79	7.5	3.79	7.4	3.79	7.5
Sulphate	mg/L	-	500	15.8 (2.2 - 26.5); n = 22	20.9	42	21.0	42	20.8	42	20.8	42	20.7	42
Nutrients														
Ammonia	mg-N/L	2.6[a]	4.16[a]	0.027 (<0.005 - 0.11); n = 25	0.028	0.07	0.028	0.07	0.031	0.07	0.031	0.07	0.028	0.07
Nitrate	mg-N/L	2.93	30	<0.071 (<0.006 - 0.1); n = 22	0.057	0.15	0.058	0.15	0.061	0.16	0.061	0.16	0.058	0.15
Total Kjeldahl Nitrogen	mg/L	-	-	0.6 (0.37 - 1.13); n = 25	0.76	1.51	0.76	1.52	0.76	1.51	0.77	1.51	0.76	1.51
Total Phosphorus	mg/L	-	-	0.0137 (0.0061 - 0.03); n = 25	0.0088	0.018	0.0089	0.018	0.0089	0.018	0.0088	0.018	0.0088	0.018
Total Metals														
Al	mg/L	0.1[b]	0.41[b]	0.0554 (0.0155 - 0.253); n = 25	0.032	0.07	0.035	0.07	0.044	**0.10**	0.040	0.09	0.033	0.07
Sb	mg/L	-	0.03	0.00003 (0.00002 - 0.00004); n = 3	0.000025	0.00005	0.000025	0.00005	0.000029	0.00006	0.000028	0.00006	0.000034	0.00007
As	mg/L	0.005	0.05	0.00054 (<0.0004 - 0.0027); n = 25	0.00041	0.0010	0.00047	0.0012	0.00063	0.002	0.00053	0.001	0.00043	0.001
Ba	mg/L	-	-	0.0145 (0.009 - 0.02); n = 25	0.015	0.030	0.015	0.030	0.015	0.030	0.015	0.030	0.015	0.030
Be	mg/L	-	-	<0.00001 (<0.00001 - 0.00001); n = 3	0.000011	0.000031	0.000011	0.000032	0.000011	0.000032	0.000011	0.000032	0.000011	0.000032
B	mg/L	1.5	-	0.02 (<0.02 - 0.03); n = 8	0.017	0.035	0.017	0.035	0.017	0.035	0.017	0.035	0.017	0.035
Cd	mg/L	0.000017[c]	0.00015	<0.00001 (<0.000005 - 0.000065); n = 16	0.000016	**0.000047**	0.000016	**0.000047**	0.000016	**0.000047**	0.000016	**0.000047**	0.000016	**0.000047**
Cr	mg/L	0.001	-	0.0003 (0.0003 - 0.0007); n = 3	0.00038	0.00076	0.00039	0.00076	0.00039	0.00077	0.00039	0.00077	0.00039	0.00077
Co	mg/L	-	0.01	<0.0002 (0.000085 - 0.000291); n = 8	0.00010	0.00020	0.00011	0.00022	0.00014	0.00028	0.00013	0.00027	0.00011	0.00022
Cu	mg/L	0.002[c]	0.022	<0.001 (0.00072 - 0.002); n = 25	0.00064	0.0017	0.00063	0.0017	0.00067	0.0017	0.00066	0.0017	0.00065	0.0017
Fe	mg/L	0.3	1.5	0.112 (0.064 - 0.653); n = 25	0.14	0.27	0.14	0.28	0.16	**0.31**	0.15	0.30	0.14	0.28
Pb	mg/L	0.001[c]	0.008	<0.0001 (<0.0001 - 0.000202); n = 21	0.000068	0.00029	0.000069	0.00029	0.000070	0.00029	0.000069	0.00029	0.000073	0.00029
Mn	mg/L	-	-	0.022 (0.0097 - 0.056); n = 25	0.031	0.06	0.031	0.06	0.031	0.06	0.032	0.06	0.031	0.06
Hg	mg/L	0.000026	-	<0.00002 (<0.00001 - <0.0002); n = 25	0.000011	**0.000078**	0.000011	**0.000080**	0.000011	**0.000077**	0.000011	**0.000080**	0.000011	**0.000078**
Mo	mg/L	0.073	-	0.0002 (0.00016 - 0.0004); n = 11	0.00021	0.00042	0.00021	0.00043	0.00021	0.00043	0.00022	0.00044	0.00022	0.00044
Ni	mg/L	0.025[c]	-	0.0006 (<0.0002 - 0.0019); n = 11	0.00100	0.0020	0.0010	0.0020	0.0010	0.0020	0.0010	0.0020	0.0010	0.0020
Se	mg/L	0.001	0.005	<0.0004 (<0.00004 - 0.0009); n = 22	0.00018	0.0007	0.00018	0.0007	0.00019	0.0007	0.00020	0.0007	0.00019	0.0007
Ag	mg/L	0.0001	-	<0.0001 (<0.000005 - 0.00013); n = 16	0.0000027	0.000011	0.0000027	0.000012	0.0000035	0.000012	0.0000033	0.000012	0.0000030	0.000012
Tl	mg/L	0.0008	-	<0.000002 (<0.000002 - 0.000003); n = 3	0.0000013	0.0000022	0.0000013	0.0000023	0.0000026	0.0000055	0.0000024	0.0000055	0.0000035	0.0000079
U	mg/L	0.015	0.027	0.0007 (0.000207 - 0.0014); n = 21	0.00086	0.0017	0.00086	0.0017	0.00088	0.0017	0.00088	0.0017	0.00089	0.0018
V	mg/L	-	-	<0.001 (<0.0002 - 0.0014); n = 25	0.00042	0.0011	0.00042	0.0011	0.00042	0.0011	0.00042	0.0011	0.00042	0.0011
Zn	mg/L	0.03	0.11	<0.004 (0.002 - 0.07); n = 25	0.0070	0.02	0.0070	0.02	0.0070	0.02	0.0071	0.02	0.0071	0.02
Dissolved Metals														
Al	mg/L	0.1[b]	0.41[b]	0.01 (0.004 - 0.0664); n = 24	0.016	0.04	0.017	0.05	0.021	0.06	0.019	0.05	0.017	0.04

Table 7.6-13: Predicted Water Quality in the Marian River (continued)

Modelled Constituents	Unit	CCME Freshwater Aquatic Life Guidelines	Site-Specific Water Quality Objectives	Observed Baseline	Modelled Baseline		Construction		Operations		Active Closure		Post-Closure	
				Median (Min - Max); n observations	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile	Average	95th Percentile
Sb	mg/L	-	0.03	<0.0004 (<0.00002 - 0.0005); n = 24	0.000018	0.00004	0.000018	0.00004	0.000021	0.00004	0.000021	0.00005	0.000025	0.00006
As	mg/L	0.005	0.05	0.00057 (<0.0004 - 0.0022); n = 24	0.00035	0.0009	0.00040	0.0010	0.00053	0.001	0.00045	0.001	0.00036	0.001
Ba	mg/L	-	-	0.01175 (0.008 - 0.02); n = 24	0.013	0.027	0.013	0.027	0.013	0.027	0.013	0.027	0.013	0.027
Be	mg/L	-	-	<0.001 (<0.00001 - <0.001); n = 24	0.0000078	0.000024	0.0000079	0.000024	0.0000081	0.000024	0.0000080	0.000024	0.0000081	0.000024
B	mg/L	1.5	-	0.022 (0.018 - 0.03); n = 7	0.014	0.030	0.014	0.030	0.014	0.030	0.014	0.030	0.014	0.030
Cd	mg/L	0.000017[c]	0.00015	<0.00001 (0.000006 - 0.00004); n = 16	0.0000073	**0.000024**	0.0000072	**0.000024**	0.0000071	**0.000024**	0.0000072	**0.000024**	0.0000072	**0.000024**
Cr	mg/L	0.001	-	<0.0004 (<0.0001 - 0.0004); n = 7	0.00021	0.0005	0.00021	0.0005	0.00021	0.0005	0.00021	0.0005	0.00021	0.0005
Co	mg/L	-	0.01	0.0001 (0.000043 - 0.000213); n = 7	0.000070	0.00016	0.000079	0.00018	0.000096	0.0002	0.000088	0.0002	0.000076	0.0002
Cu	mg/L	0.002[c]	0.022	0.001 (0.0006 - 0.001); n = 24	0.00048	0.0013	0.00047	0.0013	0.00049	0.0013	0.00049	0.0013	0.00048	0.0013
Fe	mg/L	0.3	1.5	0.054 (0.02 - 0.431); n = 24	0.082	0.19	0.084	0.19	0.092	0.21	0.088	0.21	0.084	0.19
Pb	mg/L	0.001[c]	0.008	<0.0001 (0.000063 - <0.0002); n = 20	0.000043	0.00019	0.000043	0.00019	0.000043	0.00019	0.000043	0.00020	0.000046	0.00020
Mn	mg/L	-	-	0.011 (<0.001 - 0.049); n = 24	0.019	0.046	0.019	0.045	0.019	0.045	0.019	0.046	0.019	0.046
Hg	mg/L	0.000026	-	<0.00002 (<0.00001 - <0.0002); n = 24	0.0000030	0.000019	0.0000030	0.000019	0.0000028	0.000018	0.0000028	0.000018	0.0000030	0.000019
Mo	mg/L	0.073	-	0.0002 (0.00014 - 0.0002); n = 10	0.00017	0.00037	0.00017	0.00037	0.00018	0.00037	0.00018	0.00038	0.00019	0.00038
Ni	mg/L	0.025[c]	-	0.0006 (0.00025 - 0.0021); n = 10	0.00078	0.0016	0.00078	0.0017	0.00077	0.0016	0.00078	0.0016	0.00078	0.0017
Se	mg/L	0.001	0.005	<0.0004 (<0.00004 - <0.0005); n = 21	0.00016	0.0006	0.00016	0.0006	0.00017	0.0006	0.00017	0.0006	0.00016	0.0006
U	mg/L	0.015	0.027	0.0007 (0.000183 - 0.001); n = 20	0.00073	0.0015	0.00073	0.0015	0.00074	0.0015	0.00074	0.0015	0.00075	0.0015
V	mg/L	-	-	<0.001 (<0.0001 - 0.001); n = 24	0.00025	0.0007	0.00025	0.0007	0.00024	0.0007	0.00025	0.0007	0.00024	0.0007
Zn	mg/L	0.03	0.11	<0.004 (<0.001 - 0.008); n = 24	0.0043	0.02	0.0043	0.015	0.0042	0.01	0.0042	0.02	0.0044	0.02

Notes: Elements not included in the dissolved metals list that are present in the total metals list did not have sufficient detectable baseline dissolved concentrations to derive partition coefficients.
Modelling result summaries represent the median values from daily average and 95th percentile concentration predictions from 100 modelling realizations.
Predicted values in **bold** are higher than CCME guidelines; values in ***bold italics*** are higher than site specific water quality objectives.

[a] Guideline/objective for total ammonia based on a pH of 7.44 and a water temperature of 11.4°C.

[b] Guideline/objective for aluminum based on a pH of 7.45, which was the typical baseline pH. No change in pH in any waterbodies were expected based on geochemical characteristics and acidification assessment of local waterbodies

[c] Guidelines for cadmium, copper, lead, and nickel are based on a water hardness of 60 mg/L.

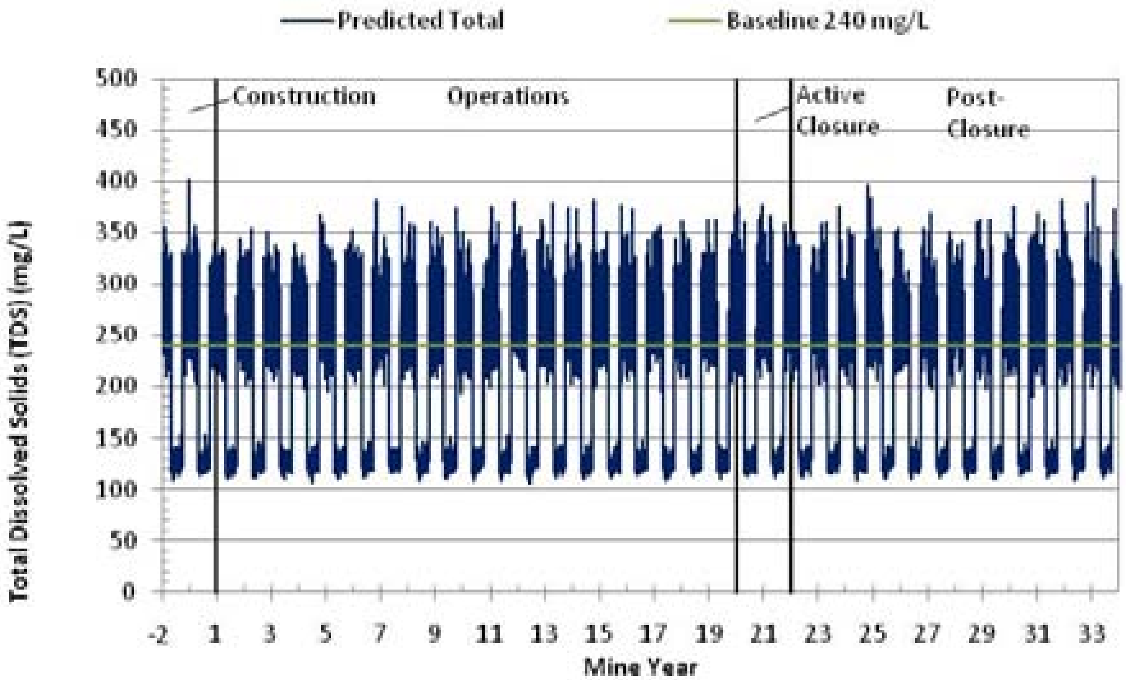


Figure 7.6-43: Predicted Total Dissolved Solids Concentrations in the Marian River

7.6.3.3.4.3 Nutrients

Nitrogen

Concentrations of ammonia and nitrate in the Marian River are predicted to increase slightly during operations and decrease to concentrations similar to the Baseline Case following closure (Figures 7.6-44 and 7.6-45). Ammonia and nitrate concentrations in the Marian River are predicted to remain below CCME guidelines and SSWQOs during all phases of the NICO Project, and the predicted changes in concentrations during operations are less than 12% for ammonia and less than 7% for nitrate (Table 7.6-13), which will be difficult to distinguish from natural variation.

Total Kjeldahl nitrogen and total nitrogen, for which there are no CCME guidelines, are predicted to follow a similar pattern, as they include loading of ammonia, and ammonia and nitrate, respectively, from the NICO Project.

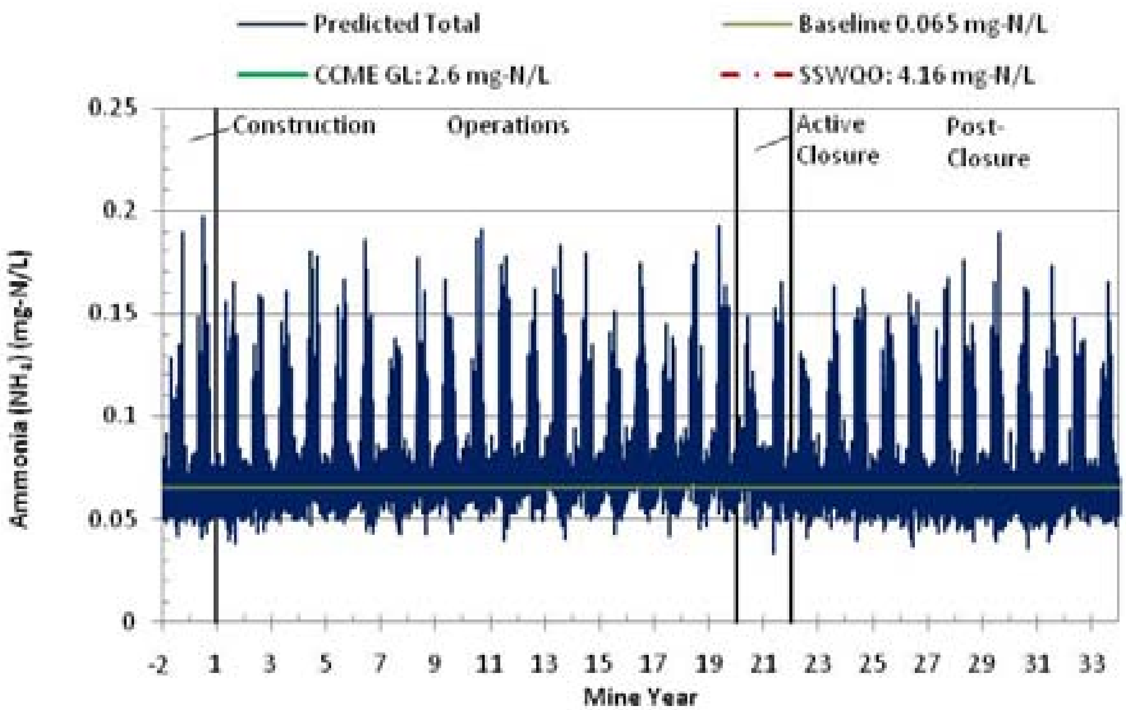


Figure 7.6-44: Predicted Ammonia Concentrations in the Marian River

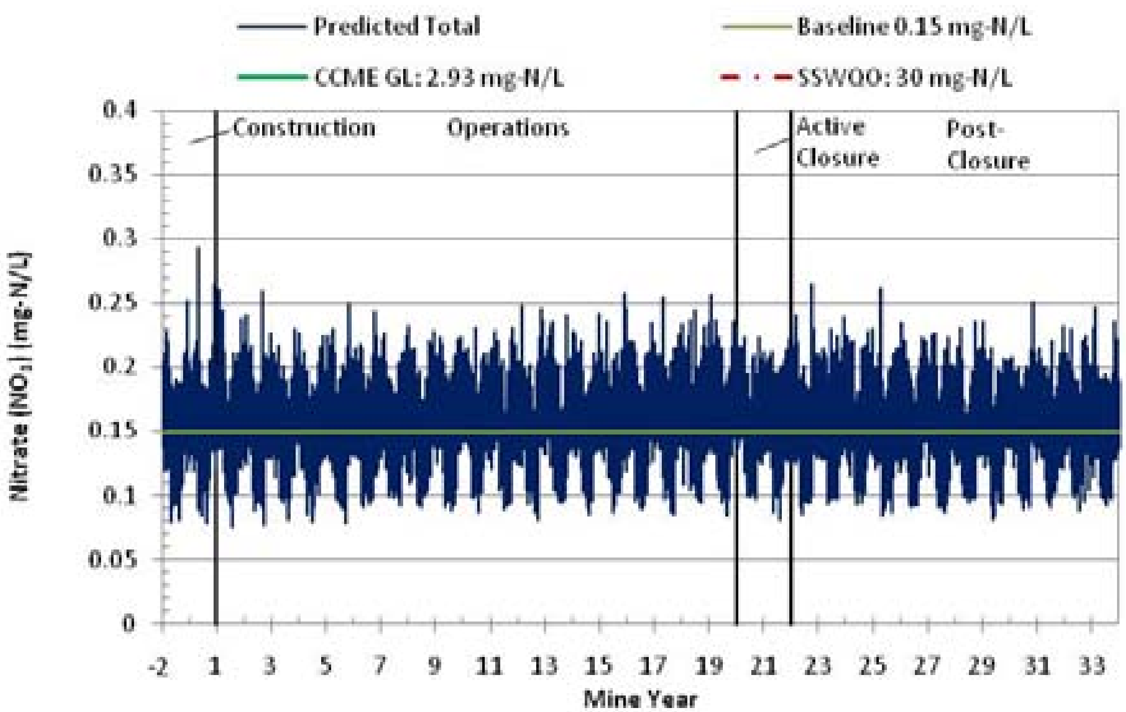


Figure 7.6-45: Predicted Nitrate Concentrations in the Marian River

Phosphorus

Total phosphorus concentrations in the Marian River (Figure 7.6-46) are predicted to change by less than 1% during NICO Project construction and operations relative to modelled baseline concentrations (Table 7.6-13). Such a level of change is expected to be indistinguishable from natural background variation. Total phosphorus concentrations in the Marian River during closure are predicted to be similar to baseline concentrations.

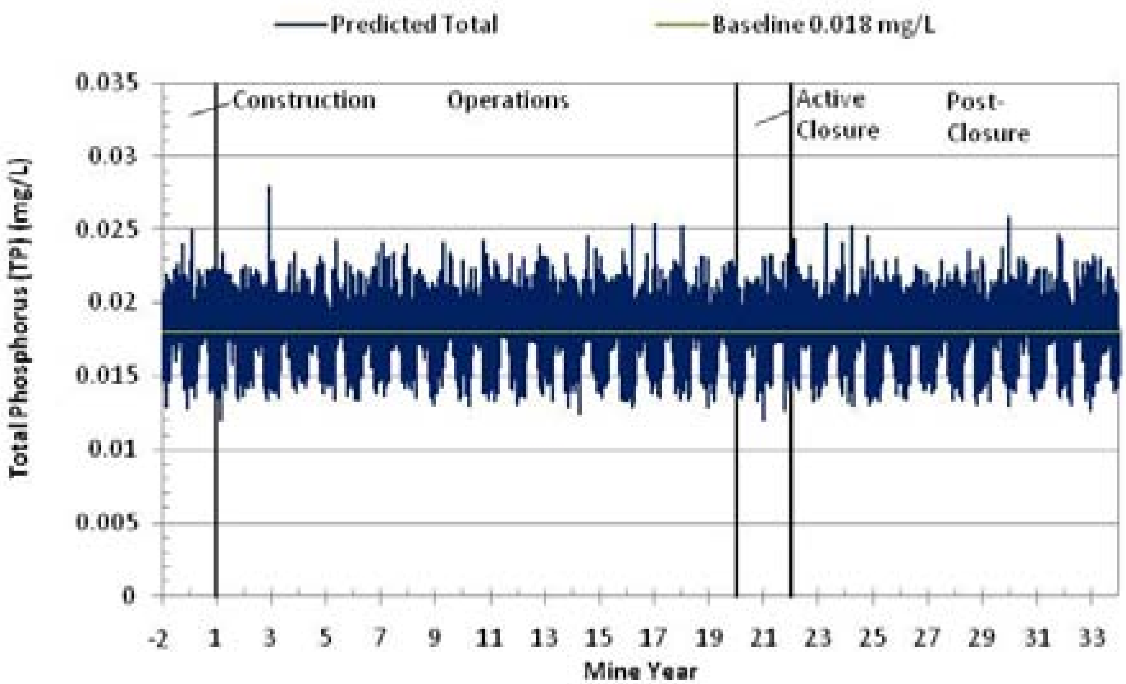


Figure 7.6-46: Predicted Total Phosphorus Concentrations in the Marian River

7.6.3.3.4.4 Metals

Predicted metals concentrations in the Marian River are discussed below, and are grouped according to predicted trends.

Metal Concentrations Predicted to Increase during Operations and Decline Following Closure

Of the 22 metals that were modelled for this assessment, 8 are predicted to increase in concentration during the construction and operations phases, and then decline in concentration as the Burke Lake watershed is flushed following closure. These metals are aluminum, arsenic, beryllium, cobalt, copper, iron, selenium, silver, and vanadium. A time series plot of aluminum (Figure 7.6-47) illustrates the general trend predicted for these metals.

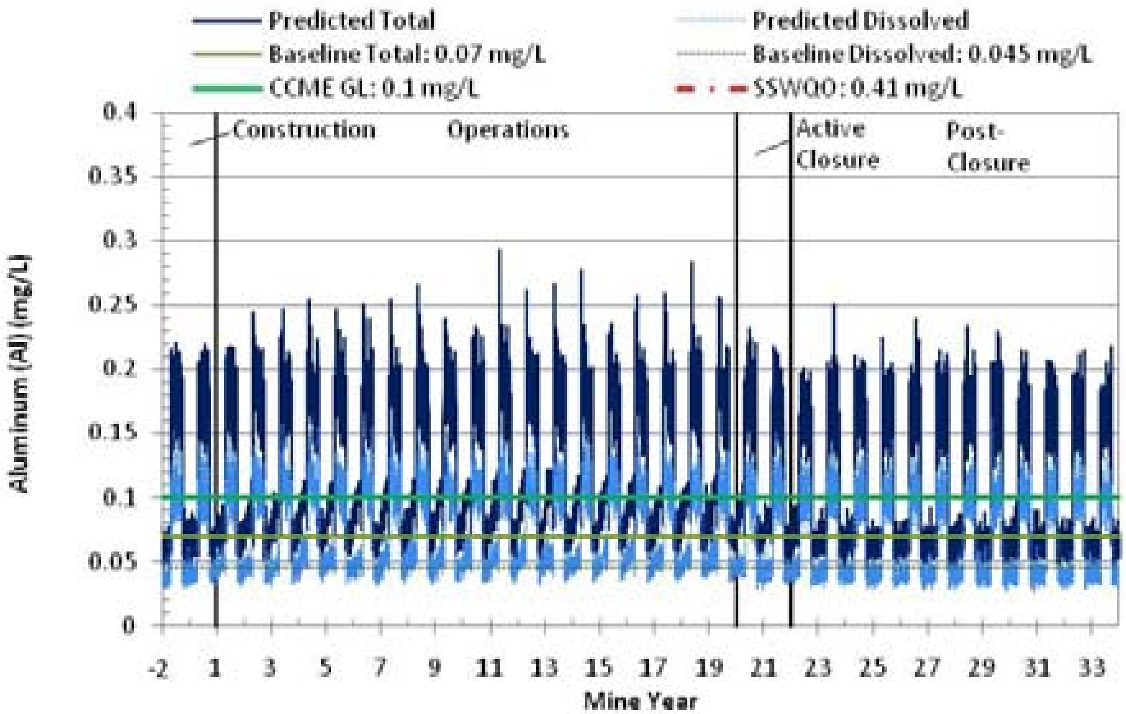


Figure 7.6-47: Predicted Aluminum Concentrations in the Marian River

The primary NICO Project related loading sources of these metals within the Burke Lake watershed are dust deposition during construction and operations, discharges from the ETF to Peanut Lake during operations, and Wetland Treatment Systems No. 1, 2, and 3 influenced water quality influent from Nico Lake to Peanut Lake after the end of operations. The expected loading of these metals during construction and operations is higher than after operations, resulting in declining concentrations in the post-closure period. Of these 8 metals, aluminum, copper, iron, and selenium (Figure 7.6-48) are predicted to exceed CCME guidelines during operations and continue to exceed CCME guidelines during the post-closure period, without exceeding SSWQO values. Arsenic (Figure 7.6-49) concentrations are predicted to exceed CCME guidelines infrequently during operations and decline to concentrations below these guidelines during the post-closure period without exceeding available SSWQO values. Silver concentrations are not predicted to exceed CCME guidelines in the Marian River due to NICO Project activities. Beryllium and cobalt do not have CCME guidelines, and predicted cobalt concentrations are not predicted to exceed SSWQO values.

A large proportion of the modelled guideline exceedances are attributable to natural background variability in the Marian River during the open water season, with infrequent short term peaks driven by inputs from the Burke Lake watershed due to a lag in modelled freshet flow increases in the Marian River relative to the modelled flow series derived for the Burke Lake watershed. This relative lag in freshet flow results in brief periods where the Burke Lake watershed contributes up to 50% of predicted flows in the Marian River, downstream of Burke Creek, under baseline conditions.

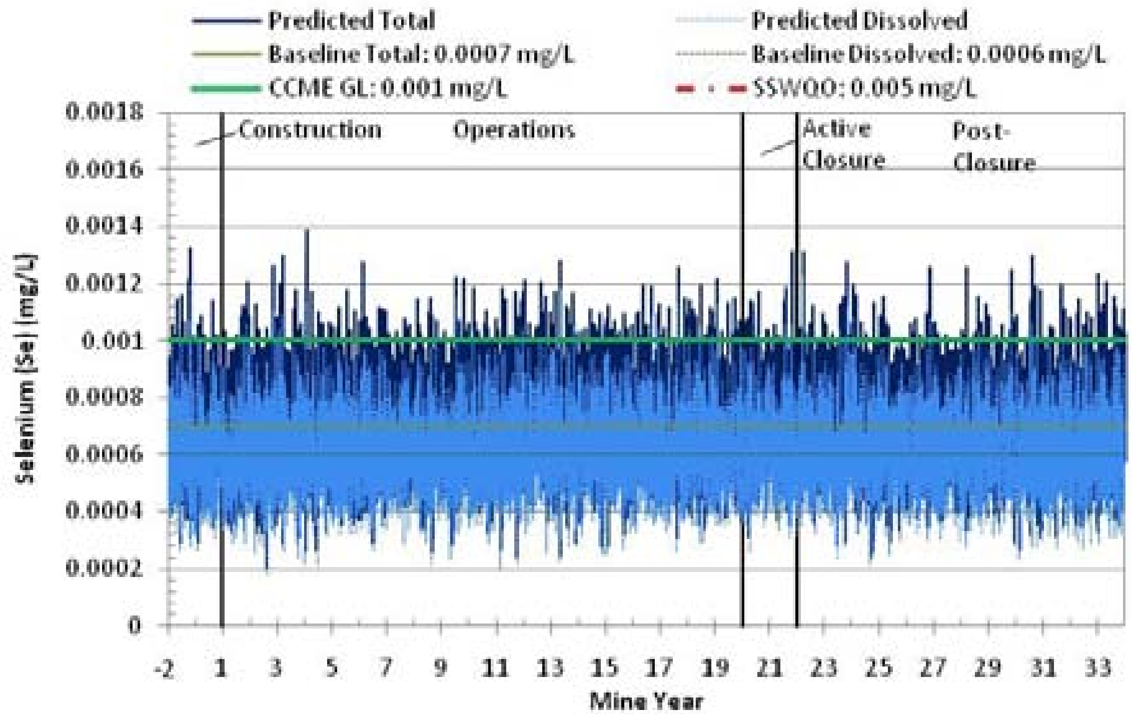


Figure 7.6-48: Predicted Selenium Concentrations in Marian River

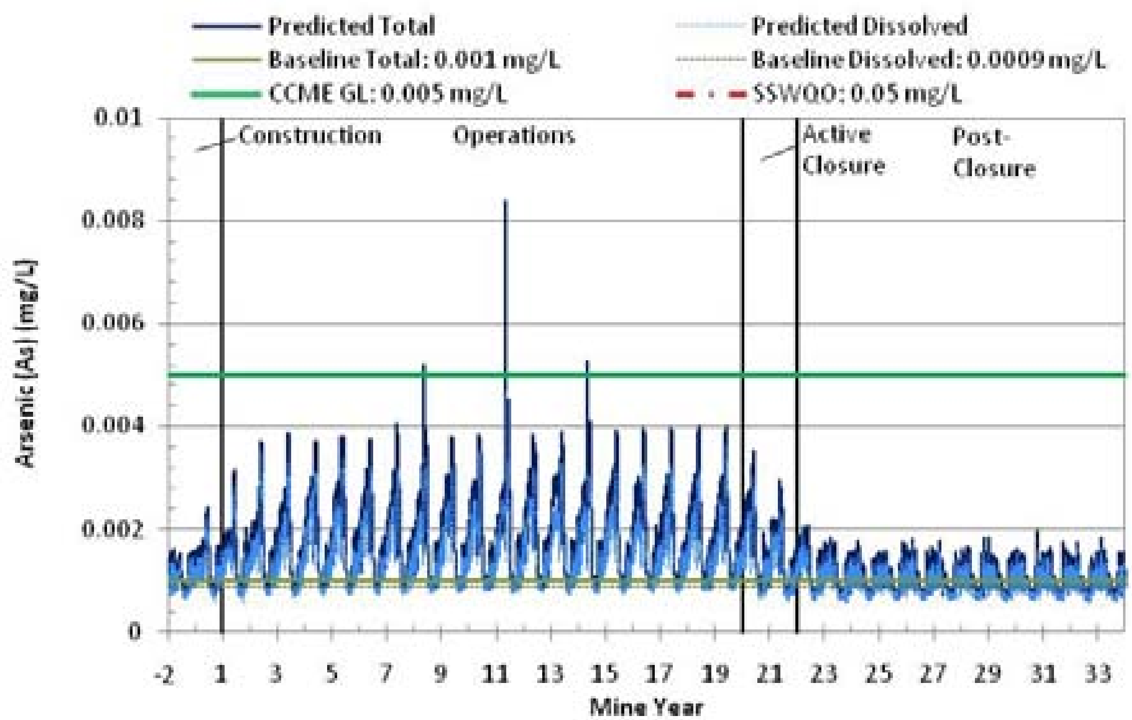


Figure 7.6-49: Predicted Arsenic Concentrations in the Marian River

Metal Concentrations Predicted to Increase during Operations and Increase Further Following Closure

Five of the remaining metals that were modelled are predicted to continue to increase in concentration in the Marian River following closure. The primary NICO Project loading source for these metals after the end of operations are inflows of Wetland Treatment Systems No. 1, 2, and 3 influenced waters to the Marian River through Nico, Peanut, and Burke lakes. The expected loading of this third group of metals during the post-closure period is predicted to be greater on average than loading during operations, resulting in predicted peak concentrations during the post-closure period that continue to increase in the Marian River.

The metals that follow this trend are antimony, lead, molybdenum, thallium, uranium, and zinc. All of these metals are predicted remain below available CCME guidelines and SSWQOs. Representative time series plots are shown for uranium (Figure 7.6-50) and thallium (Figure 7.6-51) to illustrate the general trend predicted for this group of metals. In the case of uranium, the trend seen in the Table 7.6-13 prediction summary is indistinguishable from modelled daily and seasonal variability in Marian River background concentrations shown in Figure 7.6-50.

As noted previously, the post-closure metals concentration predictions are conservative as a result of assumptions used in the modelling due to uncertainty regarding the degree of effectiveness of the planned Wetlands Treatment Systems for various metals. Metals concentrations in outflows from the treatment wetlands may, therefore, be lower than assumed in the modelling.

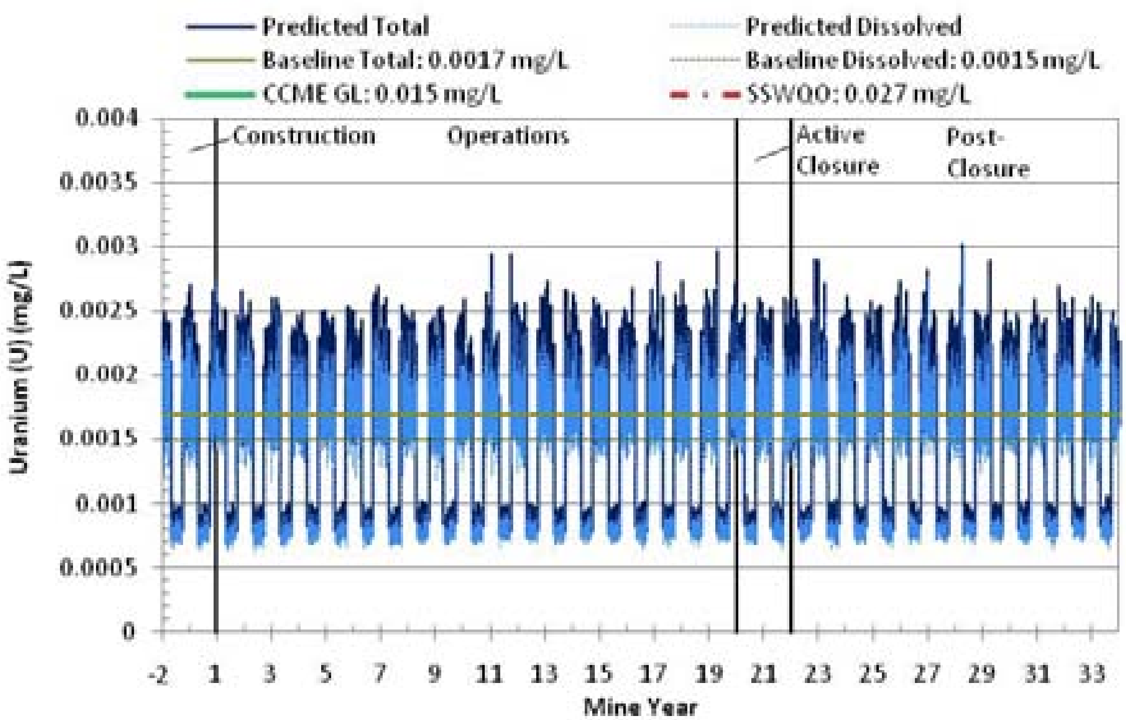


Figure 7.6-50: Predicted Uranium Concentrations in the Marian River

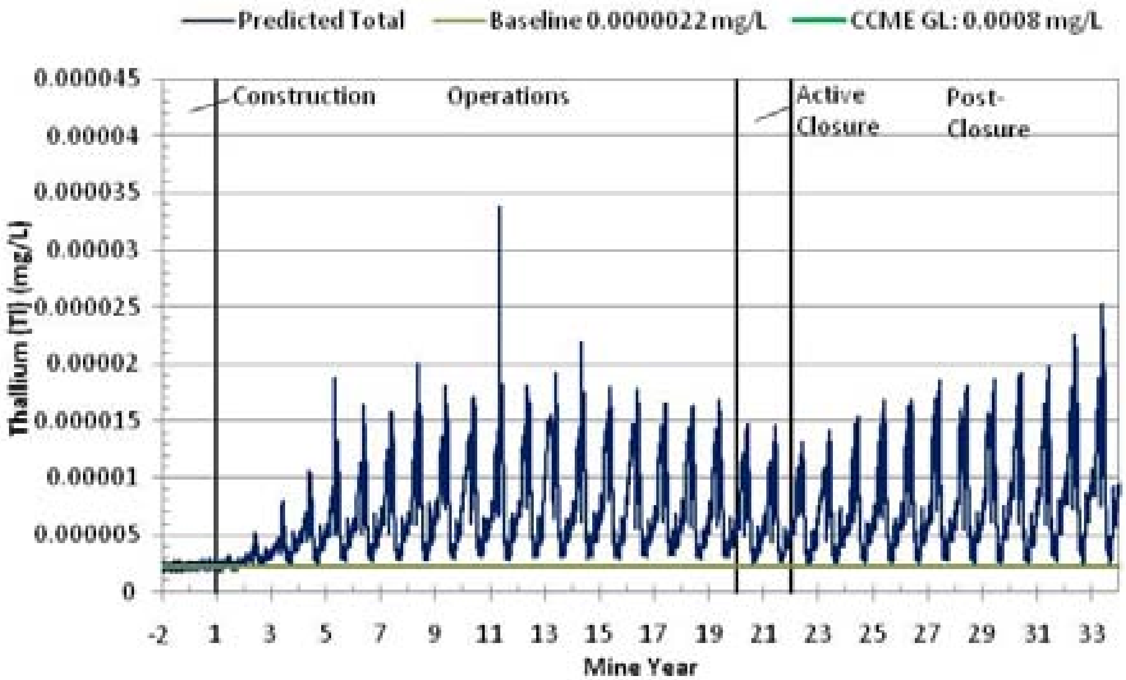


Figure 7.6-51: Predicted Thallium Concentrations in the Marian River

Metals Concentrations Predicted to be Similar to the Baseline Case

The remaining 8 metals that were modelled are predicted to have Application Case concentrations that are similar to Baseline Case concentrations throughout all phases of the NICO Project. The metals in this group are barium, boron, cadmium, chromium, manganese, mercury, nickel, and vanadium. These metals are predicted to change less than 5% from Baseline Case predictions (Table 7.6-13), which would be indistinguishable from natural background variability. Representative time series plots are shown for cadmium (Figure 7.6-52) and chromium (Figure 7.6-53) to illustrate the general trend predicted for this group of metals.

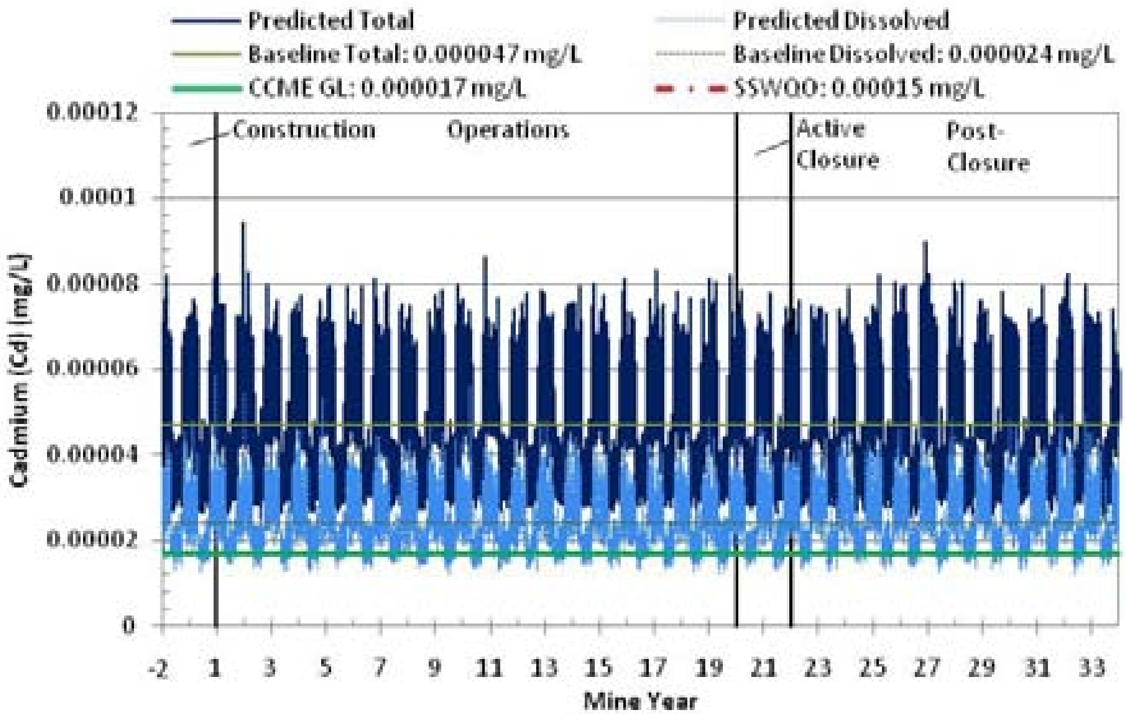


Figure 7.6-52: Predicted Cadmium Concentrations in the Marian River

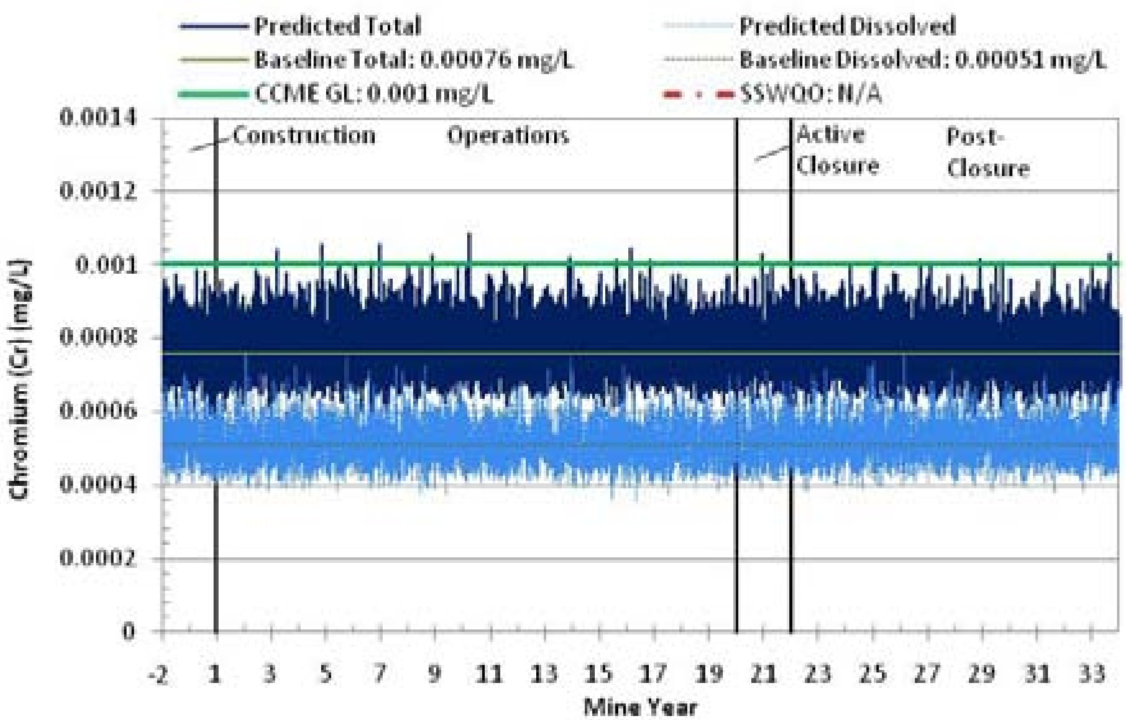


Figure 7.6-53: Predicted Chromium Concentrations in the Marian River

7.6.4 Sediment Quality in Nico Lake, Peanut Lake, and Burke Lake

7.6.4.1 Methods

Sediment quality predictions were prepared for Nico, Peanut, and Burke lakes at closure. These predictions were based on observed baseline concentrations and calculated using assumptions consistent with the water quality predictions described in Sections 7.6.2 and 7.6.3. The predictions account for incremental deposition of suspended particulates and associated metals, provided by the air component, during the construction and operations phases, including the following assumptions:

- particulates deposited throughout the Burke Lake watershed area are not retained on the landscape and report to surface waters;
- the particulate mass fraction (and associated metals) less than or equal to 10 µm (i.e., PM_{10} fraction) remains in suspension indefinitely (i.e., does not settle to sediments);
- the particulate mass fraction (and associated metals) greater than 10 µm (i.e., larger than PM_{10} fraction) is transient in the water column, assumed to settle to lake sediments instantaneously, and is not re-suspended; and
- metals concentrations were assumed to be uniformly distributed among all particulate mass fractions.

These predictions do not explicitly account for potential changes in sediment quality due to changes in water quality (e.g., changes to constituent concentrations in porewater and associated sorption to sediment particles due to changes in dissolved constituent concentrations in the water column).

Baseline minimum, median, and maximum constituent concentrations in each lake were applied on a unit area basis to the expected mass of sediment solids in a 15 cm deep layer, consistent with the depth of an Ekman grab sample, with an assumed porosity of 62%. This porosity assumption is consistent with those described for sediment quality prediction modelling in U.S. EPA (2005) human health risk assessment protocols. Where concentrations were below detection limits, the detection limit value was used. The cumulative mass per unit area of the settled TSP fraction (and associated metals) was added to the top of this baseline layer. The sums of constituent masses were divided by the sum of solid masses to calculate the constituent concentrations in sediment at closure.

Where the deposited particulate concentrations were lower than the baseline sediment concentrations, this prediction calculation would result in lower predicted concentrations than baseline. In such cases, it was simply assumed that the particulate deposition from the NICO Project would not result in changes from baseline concentrations.

7.6.4.2 Results

Predicted changes in sediment quality at closure, due to dust deposition from NICO project activities during construction and operations, are presented and discussed in the following sections. Summaries of sediment quality predictions are presented in tables that include comparisons to Canadian Sediment Quality Guidelines (CCME 2011) and the GNWT remediation objective (GNWT 2003) for arsenic.

7.6.4.2.1 Nico Lake

A summary of existing metals concentrations in Nico Lake and predicted concentrations at closure are presented in Table 7.6-14. Concentrations of lead, mercury, molybdenum, nickel, silver, thallium, uranium, vanadium, and zinc are not expected to change from baseline, as the expected concentrations of these metals in suspended particulates are lower than those observed in baseline sediment samples. With the exception of antimony, concentrations of other metals in Nico Lake are predicted to increase by less than 2% from observed baseline concentrations. This potential level of change is well within the limits of analytical uncertainty and would be indistinguishable from existing natural variability.

Antimony concentrations at closure are predicted to increase by 10 to 16% from the median and minimum observed concentrations, respectively, but by less than 1% based on the maximum observed concentration. Since the predicted changes in concentrations from the median and minimum observed concentrations are less than 20% and well within the observed baseline range, and the predicted change in concentration from the maximum observed value is less than 1%, it is unlikely that these predicted changes in antimony concentrations would be distinguishable from existing natural variation.

Predicted changes in sediment quality in Nico Lake due to dust deposition are not expected to result in exceedance of available sediment quality guidelines where none had previously existed under baseline conditions, or exceedance of probable effect level guidelines for constituent concentrations exceeding interim sediment quality guidelines under baseline conditions.

7.6.4.2.2 Peanut Lake

A summary of existing metals concentrations in Peanut Lake and predicted concentrations at closure are presented in Table 7.6-15. Concentrations of chromium, lead, mercury, nickel, silver, thallium, uranium, vanadium, and zinc are not expected to change from baseline, as the expected concentrations of these metals in dust are lower than those observed in baseline sediment samples. With the exception of antimony and arsenic, concentrations of other metals in Nico Lake are predicted to increase by less than 13% from observed baseline concentrations. This potential level of change is within the limits of analytical uncertainty and would likely be indistinguishable from existing natural variability.

Antimony concentrations at closure are predicted to increase by more than 22% from observed baseline concentrations, while arsenic concentrations are predicted to increase by 17 to 35%. Existing arsenic concentrations in Peanut Lake are above the probable effects level sediment quality guideline and are not expected to exceed the GNWT remediation objective due to dust deposition from NICO Project activities.

Predicted changes in sediment quality in Peanut Lake due to dust deposition are not expected to result in exceedance of available sediment quality guidelines where none had previously existed under baseline conditions or exceedance of probable effect level guidelines for constituent concentrations exceeding interim sediment quality guidelines under baseline conditions.

Table 7.6-14: Observed Baseline and Predicted Closure Sediment Quality in Nico Lake

Parameter	Units	CCME Sediment Quality Guidelines		GNWT Remediation Objective[c]	Baseline Sediment Concentration Summary				Predicted Sediment Concentrations at Closure		
		ISQG[a]	PEL[b]		Median	Minimum	Maximum	n	Median	Minimum	Maximum
Aluminum[d]	mg/kg	-	-	-	19,400	-	-	0	19,495	-	-
Antimony	mg/kg	-	-	-	0.3	<0.2	2.56	5	0.33	0.23	2.58
Arsenic	mg/kg	5.9	17	150	**433**(P,G)	**168**(P,G)	**1090**(P,G)	5	**436**(P,G)	**171**(P,G)	**1090**(P,G)
Barium	mg/kg	-	-	-	141	95	240	5	142	96	241
Beryllium	mg/kg	-	-	-	<1	<1	1.7	5	1.0	1.0	1.7
Cadmium	mg/kg	0.6	3.5	-	<0.5	<0.5	0.53	5	0.50	0.50	0.53
Chromium	mg/kg	37.3	90	-	**44.4**(I)	32.7	**45.3**(I)	5	**44.4**(I)	32.8	**45.3**(I)
Cobalt	mg/kg	-	-	-	39.0	30.0	54.3	5	39.4	30.4	54.6
Copper	mg/kg	35.7	197	-	**60.3**(I)	**53**(I)	**65**(I)	5	**60.5**(I)	**53.2**(I)	**65.2**(I)
Iron[d]	mg/kg	-	-	-	23,200	-	-	0	23,451	-	-
Lead	mg/kg	35	91.3	-	8.9	7	9.1	5	8.9	7.0	9.1
Manganese[d]	mg/kg	-	-	-	478	-	-	0	478	-	-
Mercury	mg/kg	0.17	0.486	-	0.09	<0.05	0.098	5	0.09	0.05	0.098
Molybdenum	mg/kg	-	-	-	6.0	5.0	12.2	5	6.0	5.0	12.2
Nickel	mg/kg	-	-	-	30.3	22.0	32.0	5	30.3	22.0	32.0
Selenium	mg/kg	-	-	-	0.90	0.70	1.01	5	0.91	0.71	1.02
Silver	mg/kg	-	-	-	<1	<1	<1	5	<1	<1	<1
Thallium	mg/kg	-	-	-	<1	<1	<1	5	<1	<1	<1
Uranium	mg/kg	-	-	-	14.0	12.9	17.9	4	14.0	12.9	17.9
Vanadium	mg/kg	-	-	-	41.1	32.0	70.2	5	41.1	32.0	70.2
Zinc	mg/kg	123	315	-	**140**(I)	121	**189**(I)	5	**140**(I)	121	**189**(I)

[a] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, ISQG = Interim Sediment Quality Guideline (CCME 2002).
[b] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, PEL = Probable Effects Level (CCME 2002).
[c] GNWT Remediation Objective for arsenic is based on average natural background concentrations in and around Yellowknife, and was developed for non-residential, publically-accessible areas (i.e., public boat launch) (GNWT 2003).
[d] Sediment samples for these waterbodies were not analyzed for the noted constituents; values are from a single sample collected from Pond 11.
(I) Concentration is higher than the interim sediment quality guideline (CCME 1999)
(P) Concentration is higher than the probable effects level defined by CCME (1999)
(G) Concentration is higher than the GNWT Remediation Objective for Arsenic (GNWT 2003)
- = no data / no guideline

Table 7.6-15: Observed Baseline and Predicted Closure Sediment Quality in Peanut Lake

Parameter	Units	CCME Sediment Quality Guidelines		GNWT Remediation Objective[c]	Baseline Sediment Concentration Summary				Predicted Sediment Concentrations at Closure		
		ISQG[a]	PEL[b]		Median	Minimum	Maximum	n	Median	Minimum	Maximum
Aluminum[d]	mg/kg	-	-	-	19,400	-	-	0	19,664	-	-
Antimony	mg/kg	-	-	-	<0.2	<0.2	0.41	5	0.30	0.30	0.50
Arsenic	mg/kg	5.9	17	150	**52.9(P)**	**35.8(P)**	**70.3(P)**	5	**65(P)**	**48(P)**	**82(P)**
Barium	mg/kg	-	-	-	190	157	222	5	193	160	225
Beryllium	mg/kg	-	-	-	<1	<1	1	5	1.01	1.01	1.01
Cadmium	mg/kg	0.6	3.5	-	<0.5	<0.5	<0.5	5	0.51	0.51	0.51
Chromium	mg/kg	37.3	90	-	**72.7(I)**	**55.9(I)**	**73.3(I)**	5	**72.7(I)**	**55.9(I)**	**73.3(I)**
Cobalt	mg/kg	-	-	-	18.1	16.3	25	5	19.5	17.7	26.4
Copper	mg/kg	35.7	197	-	35.4	32	**43(I)**	5	**36.3(I)**	32.9	**43.8(I)**
Iron[d]	mg/kg	-	-	-	23,200	-	-	0	23,921	-	-
Lead	mg/kg	35	91.3	-	11	9.4	12	5	11.0	9.4	12
Manganese[d]	mg/kg	-	-	-	478	-	-	0	478	-	-
Mercury	mg/kg	0.17	0.486	-	<0.05	<0.05	0.067	5	<0.05	<0.05	0.067
Molybdenum	mg/kg	-	-	-	1.3	1	2	5	1.33	1.03	2.02
Nickel	mg/kg	-	-	-	41	36.4	44	5	41	36.4	44
Selenium	mg/kg	-	-	-	0.3	0.3	0.66	5	0.34	0.34	0.69
Silver	mg/kg	-	-	-	<1	<1	<1	5	<1	<1	<1
Thallium	mg/kg	-	-	-	<1	<1	<1	5	<1	<1	<1
Uranium	mg/kg	-	-	-	7.6	6.5	8	4	7.6	6.5	8.0
Vanadium	mg/kg	-	-	-	58	41.9	63	5	58	41.9	63
Zinc	mg/kg	123	315	-	110	89	**160(I)**	5	110	89	**160(I)**

[a] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, ISQG = Interim Sediment Quality Guideline (CCME 2002).
[b] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, PEL = Probable Effects Level (CCME 2002).
[c] GNWT Remediation Objective for arsenic is based on average natural background concentrations in and around Yellowknife, and was developed for non-residential, publically-accessible areas (i.e., public boat launch) (GNWT 2003).
[d] Sediment samples for these waterbodies were not analyzed for the noted constituents; values are from a single sample collected from Pond 11.
(I) Concentration is higher than the interim sediment quality guideline CCME (1999)
(P) Concentration is higher than the probable effects level defined by CCME (1999)
(G) Concentration is higher than the GNWT Remediation Objective for Arsenic (GNWT 2003)
- = no data / no guideline

7.6.4.2.3 Burke Lake

A summary of existing metals concentrations in Burke Lake and predicted concentrations at closure is presented in Table 7.6-16. Concentrations of chromium, lead, mercury, nickel, silver, thallium, uranium, vanadium, and zinc are not expected to change from baseline, as the expected concentrations of these metals in dust are lower than those observed in baseline sediment samples. With the exception of arsenic, concentrations of other metals in Nico Lake are predicted to increase by less than 14% from observed baseline concentrations. This potential level of change is within the limits of analytical uncertainty and would likely be indistinguishable from existing natural variability.

Arsenic concentrations are predicted to increase by 10 to 21% from the maximum and minimum observed baseline concentrations, respectively. However, existing arsenic concentrations in Burke Lake are above the probable effects level sediment quality guideline and are not expected to exceed the GNWT remediation objective due to dust deposition from NICO Project activities.

Predicted changes in sediment quality in Nico Lake due to dust deposition are not expected to result in exceedance of available sediment quality guidelines where none had previously existed under baseline conditions or exceedance of probable effect level guidelines for constituent concentrations exceeding interim sediment quality guidelines under baseline conditions.

Table 7.6-16: Observed Baseline and Predicted Closure Sediment Quality in Peanut Lake

Parameter	Units	CCME Sediment Quality Guidelines		GNWT Remediation Objective[c]	Baseline Sediment Concentration Summary				Predicted Sediment Concentrations at Closure		
		ISQG[a]	PEL[b]		Median	Minimum	Maximum	n	Median	Minimum	Maximum
Aluminum[d]	mg/kg	-	-	-	19,400	-	-	0	19,474	-	-
Antimony	mg/kg	-	-	-	<0.2	<0.2	0.39	6	0.23	0.23	0.42
Arsenic	mg/kg	5.9	17	150	**25.9(P)**	**18.1(P)**	**37.1(P)**	6	**29.6(P)**	**21.8(P)**	**40.8(P)**
Barium	mg/kg	-	-	-	230	166	317	6	231	167	317
Beryllium	mg/kg	-	-	-	<1	<1	1	6	1.00	1.00	1.00
Cadmium	mg/kg	0.6	3.5	-	<0.5	<0.5	<0.5	6	0.50	0.50	0.50
Chromium	mg/kg	37.3	90	-	**71.1(I)**	**59.9(I)**	**83(I)**	6	**71.0(I)**	**59.9(I)**	**82.9(I)**
Cobalt	mg/kg	-	-	-	15.5	14.4	20	6	15.9	14.8	20.4
Copper	mg/kg	35.7	197	-	34	31	**42(I)**	6	34.3	31.3	**42.2(I)**
Iron[d]	mg/kg	-	-	-	23,200	-	-	0	23,404	-	-
Lead	mg/kg	35	91.3	-	10	8.9	12	6	10	8.9	12
Manganese[d]	mg/kg	-	-	-	478	-	-	0	478	-	-
Mercury	mg/kg	0.17	0.486	-	<0.05	<0.05	0.06	6	<0.05	<0.05	0.060
Molybdenum	mg/kg	-	-	-	1	1	1.4	6	1.01	1.01	1.41
Nickel	mg/kg	-	-	-	43.5	38.3	51	6	43.5	38.3	51
Selenium	mg/kg	-	-	-	0.2	<0.2	0.58	6	0.21	0.21	0.59
Silver	mg/kg	-	-	-	<1	<1	<1	6	<1	<1	<1
Thallium	mg/kg	-	-	-	<1	<1	<1	6	<1	<1	<1
Uranium	mg/kg	-	-	-	7.1	5.4	9	4	7.1	5.4	9
Vanadium	mg/kg	-	-	-	61.5	51.8	72	6	61.5	51.8	72
Zinc	mg/kg	123	315	-	100	83	**140(I)**	6	100	83	**140(I)**

[a] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, ISQG = Interim Sediment Quality Guideline (CCME 2002).
[b] Canadian Sediment Quality Guidelines for the Protection of Aquatic Life, PEL = Probable Effects Level (CCME 2002).
[c] GNWT Remediation Objective for arsenic is based on average natural background concentrations in and around Yellowknife, and was developed for non-residential, publically-accessible areas (i.e., public boat launch) (GNWT 2003).
[d] Sediment samples for these waterbodies were not analyzed for the noted constituents; values are from a single sample collected from Pond 11.
(I) Concentration is higher than the interim sediment quality guideline (CCME 1999)
(P) Concentration is higher than the probable effects level defined by CCME (1999)
(G) Concentration is higher than the GNWT Remediation Objective for Arsenic (GNWT 2003)
\- = no data / no guideline

7.7 Related Effects to Fish

7.7.1 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 Wetland Treatment Systems No. 1, 2, and 3.

Nutrient predictions for the NICO Project lakes show increases in nitrogen from the mine discharge, which 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). 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.

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. Therefore, a change in trophic status, based on TP concentrations, is not predicted for Nico, Peanut, or Burke lakes.

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. 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. The rock cover over the water intake and effluent diffuser lines likely will provide additional spawning and nursery habitat for some fish species.

7.7.2 Effects of Changes in Metal Levels

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 (Section 12.6.3).

As the NICO Project 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.

7.7.3 Risks to Aquatic 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 water quality parameter increases associated with dust deposition to surface water, as well as ETF and wetland 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 water quality parameters and all phases of the NICO Project, the NICO Project-related risks to aquatic life are considered 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 in the NICO Project LSA or RSA. Particular concern has been expressed by the Tłįchǫ Government, Tłįchǫ 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 from the NICO Project 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.

7.8 Related Effects to Wildlife

An ecological risk assessment was completed to evaluate the potential for adverse effects to individual animal health associated with exposure to materials released from the NICO Project. Sources of chemicals considered in the assessment include fugitive dust, air emissions, treated effluents, and surface water runoff and seepage. The potential for effects to the health of wildlife evaluated for the NICO Project included changes in air, water, soil, and vegetation quality.

Based on the calculated exposure ratios it is anticipated that atmospheric depositions and surface water discharges from the NICO Project will result in negligible health risks to wildlife. Because no unacceptable health risks to wildlife are anticipated during these phases of the NICO Project, it is predicted that wildlife health risks will also be negligible during the construction and operations phases of the NICO Project (i.e., contaminants of possible concern, are anticipated to be present at lower concentrations during construction and operation).

7.9 Related Effects to People

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 hydrological discharges from the NICO Project will result in no anticipated change in human health outcomes from the NICO Project in comparison to baseline conditions. 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.

7.10 Residual Effects Summary

Residual effects to water and sediment quality include effects of the deposition of acidifying substances, dust, and associated metals to nearby surface waters, effects of operational discharges from the ETF via a diffuser to Peanut Lake, and operational and closure discharges of CDF seepage through the Wetland Treatment Systems to Nico Lake. Summaries of the effects analyses in Section 7.6 are provided in the following sections.

7.10.1 NICO Project Effects to Water Quality in Lakes in the Regional Study Area

7.10.1.1 Deposition of Acidifying Substances

Potential for acidification (i.e., changes in pH) in waterbodies within the air quality RSA due to deposition of acidifying substances from air emissions from the NICO Project was evaluated in Section 7.6.1. Predicted net PAI values representing peak emissions during construction and operations are below the critical loads for the 17 lakes included in the analysis. The annual deposition of nitrogen during construction and operations was less than 5 kg/ha/y for all lakes. Based on these results, NICO Project-related deposition of sulfur oxides and nitrogen oxides in the RSA is predicted to not result in lake acidification.

7.10.1.2 Deposition of Dust and Associated Metals to Selected Lakes in the Regional Study Area

Maximum potential changes in TSS and metal concentrations in lakes within the air quality RSA were estimated to evaluate potential effects of dust and air emissions to water quality during construction and operation of the NICO Project (Section 7.6.2). This analysis excluded Nico, Peanut, and Burke lakes, as the water quality modelling for the Burke Lake watershed included dust deposition to these lakes as a NICO Project-related input source (Section 7.6.3).

The effects of dust and associated metal deposition on water quality were evaluated for 14 lakes within the RSA. Changes to TSS and trace metals concentrations in these lakes from deposition of total suspended particulates and metals will potentially exceed average baseline concentrations by greater than 100%. However, the spatial extent of dust and metal deposition is anticipated to be restricted to localized areas within and close to the active mine area. Maximum deposition is expected to occur to the north and east of the NICO Project mine footprint, reflecting the haul road traffic to and from the CDF and prevailing wind direction. In general, no concentration of TSP above the NWT air quality standard is predicted beyond approximately 2 km from the development area boundary (Section 10.4.2.3).

Based on annual cumulative loading of TSS and metals, predicted maximum concentrations of aluminium, chromium, and iron are anticipated to occasionally be above SSWQOs and water quality guidelines in lakes near the NICO Project footprint during construction and operations. However, the estimated maximum changes in

TSS and metal concentrations in regional lakes are conservatively based on air quality modelling results representing a peak production period during mine operation (i.e., Year 4). Predictions of TSS and metal concentrations presented in Section 7.6.2, therefore, are subject to a high degree of uncertainty, in the direction of predicting higher concentrations than can be realistically expected. Other assumptions carried through in the model that contribute to the conservatism include the following:

- no dust suppression was assumed during the winter months even though precipitation and snow accumulation on the ground surface will likely 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 lake catchment areas; and
- geochemistry data used to estimate metal concentrations in dust included a large proportion of concentrations below the analytical detection limit for cadmium and selenium. Concentrations of these metals were set at the detection limit for air quality and deposition modelling.

Elevated TSS and metal concentrations in affected lakes is expected to occur on a seasonal basis, and be of short duration. During construction and operations, the largest load of suspended sediments to surface waters during the year will occur during spring freshet, when dust deposited to snow during winter and eroded materials enter surface waters. During the freshet period, TSS and metals concentrations are naturally elevated above average baseline conditions due to the peak watershed runoff through the lakes. Sediment inputs during other times of the year are anticipated to be sporadic and too small to result in measurable changes in TSS and metal concentrations in lakes, except in localized areas near stream mouths during and immediately after precipitation events.

The length of the freshet period is estimated to range from approximately 2 days for small lakes to a maximum of 1 to 2 weeks based on the length of the freshet for watersheds around the NICO Project. This would be followed by a period of settling, estimated as less than a month based on observations at other northern mines (e.g., Snap Lake [De Beers 2010]), by which time TSS concentrations in lake water are expected to be similar to background concentrations. Therefore, the effects on TSS and metal concentrations are expected to be localized in the immediate vicinity of the NICO Project and temporally restricted to the period during and after freshet.

7.10.2 NICO Project Effects to Water and Sediment Quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

Water quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River is predicted to change as a result of NICO Project activities during the construction, operations, and closure phases of the NICO Project.

7.10.2.1 Effects to Water Quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

To estimate changes to the water quality in receiving waterbodies of the Burke Lake watershed, and at the confluence of the Burke Lake outlet stream with the Marian River, a dynamic, mass-balance water quality model was developed in GoldSim™ (Section 7.6.3). For this assessment, the water quality model was based on daily background surface water flow time series within the Burke Lake watershed and for the Marian River. The flow series were derived from concurrent hydrometric monitoring records over a period of 26 years, from 2 Water

Survey of Canada stations with similar latitudes and watershed areas that are similar to the Burke Lake and Marian River watershed areas.

The Water Management Plan for the NICO Project includes the loss of the Grid Ponds within the Nico Lake watershed with construction of the CDF, and the influx of fresh water withdrawn from Lou Lake during construction and operations for NICO Project water use needs (Appendix 3.III). These needs include potable water supply, concrete production requirements, dust control, and process water for the Plant. Water within the NICO Project footprint will be contained in Water Management Ponds, including a Reclaim Pond on the CDF, SCPs designed to intercept seepage from the CDF, Surge Pond, and Plant site runoff pond, which will not be released to the environment without treatment. Site waters will ultimately be directed to the Surge Pond, where they will be re-used in the Plant or pumped to the ETF for treatment and discharged to Peanut Lake. Camp sewage and grey water will be treated with a Rotary Biologic Contactor unit. Treated sewage effluent will be discharged to Peanut Lake along with the ETF effluent, or to the CDF Reclaim Pond if the sewage effluent does not meet SSWQO values. At closure, seepage from the CDF will continue to flow to Wetland Treatment Systems, which will ultimately discharge to Nico Lake.

Water quality in Nico, Peanut, and Burke lakes, and the Marian River, will be influenced by the following sources:

- natural watershed runoff with a background surface water quality;
- deposition of dust and associated metals during construction and operations.
- ETF discharge to Peanut Lake during operations;
- small volumes of seepage from the Plant Site Sump, Surge Pond, SCPs, and CDF during operations; and
- treatment wetland discharge that will receive seepage from the CDF at closure.

Discharge from the STP to Peanut Lake was not included in the model, as ammonia concentrations in the STP effluent are expected to be below the SSWQO value.

Potential for acidification (i.e., changes in pH) in Nico Lake, Peanut Lake, Burke Lake, and the Marian River due to deposition of acidifying substances from air emissions from the NICO Project was not included in the water quality model, as this effect pathway was evaluated in Section 7.6.1 and summarized in Section 7.10.1.1 above. The analysis included Nico, Peanut, and Burke lakes, and 4 lakes in the Marian River watershed upstream of the confluence of Burke Creek and the Marian River. Based on the results of the analysis, NICO Project-related deposition of sulfur oxides and nitrogen oxides is not predicted to result in acidification in Nico Lake, Peanut Lake, Burke Lake, or in the Marian River.

Although seepage from the CDF during operations was identified as a secondary pathway due to environmental design features (e.g., Surge Pond and SCP dams will be lined to limit seepage out of these ponds, and ditches will be placed at the toe of the dams to intercept seepage escaping from these dams), the seepage losses indicated in the site water balance (summarized in Section 3.9.3 and detailed in Attachment 7.II-II of Appendix 7.II) were incorporated into the water quality model. This was done to verify that potential incremental effects associated with seepages reaching Nico Lake during operations, along with deposition of dust and associated metals, would not be underestimated. There is a moderate to high level of conservatism in including these seepages, as seepage modelling has not yet been completed, no interception was assumed, and attenuation of constituent concentrations in seepages along the flow path to Nico Lake (i.e., as observed in the

Grid Ponds) was not included. Seepage modelling for the NICO Project will be completed as part of the detailed design of the seepage collection dams.

Concentrations of all modelled parameters are predicted to increase in Nico, Peanut, and Burke lakes as a result of NICO Project activities. In most cases, concentrations are predicted to peak in Peanut and Nico lakes during operations due to NICO Project discharges and air emissions. Concentrations are generally predicted to decline with time following closure and reclamation. In a few cases, however, concentrations are predicted to increase further during the post-closure period and reach a long-term steady state concentration within several years. A summary of the changes to specific water quality groups are provided in the following sections.

7.10.2.1.1 Total Suspended Solids

Discharges to Nico and Peanut lakes from the Wetland Treatment Systems and ETF, respectively, are not expected to affect TSS concentrations in these lakes or downstream waterbodies and watercourses. This will be a consequence of the design of the treatment systems, which are expected to reduce TSS concentrations in the influent waters to a level consistent with the range of TSS concentrations naturally expected in the receiving environment.

Total suspended solids concentrations in Nico, Peanut, and Burke lakes are expected to change as a result of fugitive dust and air emissions from NICO Project facilities. During construction, the predicted maximum (95^{th} percentile) TSS concentrations are projected to be 11.7 mg/L in Peanut Lake to 5.9 mg/L in Burke Lake. During operations, the predicted maximum TSS concentrations are anticipated to be 27.9 mg/L in Nico Lake and 9.0 mg/L in the Marian River (Section 12.4.2, Table 12.4-2). Total suspended solid concentrations are generally expected to peak during the operations phase, decrease during closure and reclamation, and return to baseline values post-closure.

The largest predicted maximum TSS concentrations during operations are 27.9 mg/L in Nico Lake and 17.2 mg/L in Peanut Lake, which are nearly 6 and 3 times higher than average baseline concentrations, respectively (Section 12.4.2, Table 12.4-2). For the Marian River, the farthest downstream site under examination in this assessment, TSS concentrations are predicted to remain similar to baseline values over the period of the assessment (i.e., the application of the NICO Project to the landscape).

Incremental increases to TSS concentrations sourced from the deposition of air emissions are likely an overestimation due to the degree of conservatism incorporated in the air quality assessment and the assumption that the TSP mass fraction less than or equal to 10 microns (µm) (i.e., PM_{10} fraction) remains in suspension indefinitely. Predicted changes in TSS are thus considered to be higher concentrations than can be realistically expected during construction and operations, which also extend into early periods of closure and reclamation due to the 3 year (approximate) residence time in Nico Lake (Sections 7.6.2 and 7.6.3).

Peak TSS concentrations are expected to be transitory, with the particulate matter greater than 10 µm settling quickly after freshet flows. As a result, the model likely overestimates the duration period of elevated TSS in the lakes. Nevertheless, the overestimation is carried forward as a worse-case scenario for prediction of total metals concentrations that are associated with the TSS.

In summary, effects to TSS concentrations 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 limited to the weeks during and after freshet during the construction and operations phases. As the NICO Project timeline approaches closure and reclamation and TSS concentrations are reduced, effects should be eliminated from all waterbodies upon the post-closure phase.

7.10.2.1.2 Total Dissolved Solids and Major Ions

Concentrations of TDS and major ions are expected to change in the chain of lakes within the Burke Lake watershed during construction and operations, and post-closure, as a result of NICO Project activities. Concentrations of TDS, and 2 of the associated major ions (i.e., calcium and magnesium), are predicted to decrease in Nico Lake relative to baseline conditions during operations due to a decrease in loadings from the Grid Pond system, which is lost from the upper watershed during NICO Project construction. However, following closure, calcium and magnesium are predicted to return to concentrations similar to baseline conditions due to the discharge of higher TDS waters from the Wetland Treatment Systems, which receive seepage from the CDF. Concentrations of the other major ions (i.e., chloride, potassium, sodium, and sulphate) are predicted to increase in Nico Lake during operations, and increase further post-closure, due to higher loadings of these constituents in the low volumes of seepage from the CDF, which discharge through the Wetland Treatment Systems, relative to loadings from the Grid Pond system under baseline conditions. Potassium concentrations have the largest predicted change among TDS and the major ions during operations and closure in Nico Lake. Potassium concentrations in Nico Lake are predicted to increase above baseline concentrations by nearly 5-fold during operations, and up to 18-fold post-closure.

Concentrations of TDS, calcium, and magnesium in Peanut Lake are predicted to decrease relative to baseline conditions during the latter stages of construction and the early stages of operations, primarily as a result of lower influent concentrations from Nico Lake. However, as discharge rates from the ETF increase during operations, concentrations of TDS and all modelled major ions (i.e., calcium, chloride, magnesium, potassium, sodium, and sulphate) in Peanut Lake are predicted to increase. This increase is predicted to continue during closure as a consequence of higher influent concentrations from Nico Lake. Calcium and magnesium are predicted to remain slightly lower than baseline concentrations during operations and are predicted to be consistent with baseline concentrations following closure. Concentrations of TDS, chloride, potassium, sodium, and sulphate are predicted to increase in Peanut Lake during operations, and remain higher than baseline concentrations following closure. Predicted potassium concentration changes are the largest in Peanut Lake, increasing from baseline concentrations by 6- to 7-fold during operations, and 4- to 5-fold post-closure.

Temporal concentrations trends of TDS and constituent major ions in Burke Lake will be similar to Peanut Lake, although the range of predicted concentrations of these parameters will be lower.

Concentrations of TDS and all modelled major ions in the Marian River are predicted to remain similar to baseline conditions during all phases of the NICO Project. Predicted changes from the baseline case are less than 4%, which is unlikely to be distinguishable from natural background variation.

The predicted changes in TDS and major ions concentrations in Nico, Peanut, and Burke lakes during the post-closure period are conservative, and are not expected to impact aquatic life. Predicted concentrations for chloride and sulphate are predicted to remain well below available SSWQO values in Nico, Peanut, and Burke lakes during all phases of the NICO Project. Concentrations of TDS and some constituent major ions are predicted to remain elevated above background because the loadings of these constituents from the Wetland Treatment Systems include loading from geochemical sources (e.g., from materials inside the CDF), which are assumed to continue indefinitely. Processes such as sealing by permafrost and source depletion, which would lower the predicted concentrations, were not incorporated into the modelling.

7.10.2.1.3 Nutrients

Concentrations of ammonia and nitrate in Nico, Peanut, and Burke lakes are predicted to increase during operations, primarily due to seepage inputs to Nico Lake from the treatment wetland containing blasting residue, and treated effluent discharges (including sewage treatment effluent) from the ETF to Peanut Lake. Ammonia concentrations in Nico, Peanut, and Burke lakes during operations are predicted to be as much as 16, 7.5, and 5.5 times higher than average baseline concentrations, respectively. Nitrate concentrations in Nico, Peanut, and Burke lakes during operations are predicted to be as much as 5.5, 4.5, and 3.5 times higher than baseline concentrations, respectively. These constituent nutrient concentrations are predicted to decrease during closure, as seepage and surface waters reporting to Nico Lake via the Wetland Treatment Systems are expected to have little nitrate and ammonia concentrations remaining from blast residues, and as a result of the cessation of ETF discharges. Ammonia and nitrate concentrations in Nico, Peanut, and Burke lakes are predicted to remain below SSWQO values during all phases of the NICO Project. Total Kjeldahl nitrogen and total nitrogen, for which there are no SSWQO values or CCME guidelines, are predicted to follow a similar temporal trend to ammonia and nitrate.

Ammonia and nitrate concentrations in the Marian River are predicted to remain below SSWQO values and CCME guidelines during all phases of the NICO Project. The predicted changes in concentrations during operations are increases above average baseline conditions of less than 12% for ammonia and less than 7% for nitrate, which are considered to lie within the range of natural variation.

Total phosphorus concentrations in Nico Lake are predicted to remain consistent with baseline concentrations during operations, resulting from a balance between reduced background mass inputs from the Grid Pond System, low loading in seepages from the NICO Project site through the Wetland Treatment Systems, and the addition of loading from fugitive dust deposition during construction and operations. Concentrations are predicted to decrease during closure, as dust deposition due to NICO Project activities ceases. Phosphorus loading from discharges through the Wetland Treatment Systems is expected to be lower than the loading from the Grid Ponds under baseline conditions.

Total phosphorus concentrations in Peanut Lake and Burke Lake are predicted to increase (i.e., by up to 9 and 6%, respectively) relative to baseline concentrations during construction and operations, primarily due to loading from dust deposition during construction and operations and discharges from the ETF during operations. Concentrations are predicted to decrease during closure, to levels consistent with baseline concentrations, as discharges from the ETF and dust deposition due to NICO Project activities will cease.

Total phosphorus concentrations in the Marian River are predicted to change by less than 1% during NICO Project construction and operations relative to modelled baseline concentrations, and are expected to be indistinguishable from natural background variability. Total phosphorus concentrations in the Marian River during closure are predicted to be similar to baseline concentrations.

7.10.2.1.4 Metals

Metals concentrations in Nico, Peanut, and Burke lakes, and the Marian River, are expected to change as a result of fugitive dust and air emissions from NICO Project facilities, seepage inputs in the treatment wetland system to Nico Lake, and treated effluent discharges (including sewage treatment effluent) from the ETF to

Peanut Lake. Three general trends in metals concentration changes due to NICO Project inputs were identified in the water quality modelling results for Nico, Peanut, and Burke lakes, which include:

- an increase during operations and decline post-closure;
- an increase during operations and remain elevated post-closure; and
- an increase during operations and further increase post-closure.

These are described in more detail in the following sections. In the Marian River, changes in metals concentrations as a result of the NICO Project were predicted to remain similar to the natural range of baseline concentrations.

There is a high level of conservatism associated with the metals concentrations predicted during construction and operations due to modelling assumptions used to incorporate metals loading associated with fugitive dust deposition (i.e., zero landscape retention and perpetual suspension of all particulate mass [and associated metals] less than or equal to 10 µm in diameter). Conservatism is linked to the assumption that the TSP mass fraction less than or equal to 10 µm (i.e., PM_{10} fraction) remains in suspension indefinitely. As a result, the predicted metals concentrations associated with TSP deposition are likely higher concentrations than can be realistically expected during construction and operations.

Summary of Predicted Metals Concentration Trends in Nico Lake, Peanut Lake, and Burke Lake

Concentrations of aluminum, arsenic, cadmium, cobalt, iron, and selenium are predicted to increase in Nico, Peanut, and Burke lakes during the construction and operations phases, and decline post-closure. This trend is also predicted for concentrations of beryllium, boron, copper, and silver in Peanut Lake and Burke Lake, and concentrations of barium, chromium, and vanadium in Burke Lake. The predicted temporal pattern of these metals is primarily a result of higher loadings of these metals associated with the deposition of TSP in air emissions distributed throughout the Burke Lake watershed during construction and operations, and discharges from the ETF to Peanut Lake during operations, relative to loadings from the Wetland Treatment Systems to Nico Lake post-closure.

Concentrations of barium, chromium, and vanadium are predicted to increase in Nico Lake and Peanut Lake during the construction and operations phases, and remain at similar concentrations following closure. This trend is also predicted for copper in Nico Lake, and for manganese and nickel in Burke Lake. The source of loading of these metals is from CDF seepage directed through the treatment wetlands to Nico Lake.

Concentrations of antimony, lead, mercury, molybdenum, thallium, uranium, and zinc are predicted to further increase in Nico Lake, Peanut Lake, and Burke Lake post-closure. This trend is also predicted for manganese and nickel in Nico Lake and Peanut Lake, and for beryllium, boron, and silver in Nico Lake. The source of loading of these metals is CDF seepage directed through the Wetland Treatment Systems, which is anticipated to be greater than loading to these respective lakes during operations due to a higher rate of seepage reporting to Nico Lake post-closure.

The post-closure metals concentration predictions are conservative, as loadings of constituents from Wetland Treatment Systems No. 1, 2, and 3 include loading from geochemical sources (e.g., from materials inside the CDF), which are assumed to continue indefinitely. Processes such as sealing by permafrost and source depletion, which would lower the predicted concentrations, were not incorporated into the modelling.

Furthermore, attenuation of constituent concentrations predicted for waters influent to Wetland Treatment Systems No. 1, 2, and 3 was limited to times when the concentrations were greater than SSWQOs. When this occurred, the wetlands outflow concentrations were assumed to be at the SSWQO concentrations. No further attenuation was applied in the modelling due to uncertainty regarding how effective the planned wetlands treatment system will be for various metals (Section 9). Metals concentrations in outflows from the Wetland Treatment Systems may, therefore, be lower than assumed in the model.

Summary of Predicted Metals Concentrations in Nico Lake, Peanut Lake, and Burke Lake

During construction, operations, and closure phases of the NICO Project, a number of metals will increase to concentrations that will occasionally exceed SSWQOs or CCME guidelines for the protection of aquatic health. These exceedances are predicted to occur primarily in Nico and Peanut lakes, as they are subject to a higher exposure to the deposition of air emissions than other lakes in the RSA given their proximity to the NICO Project area, as well as receiving direct mine-related discharge through the ETF or Wetland Treatment Systems. The metals that are predicted to exceed SSWQOs and CCME guideline are discussed below.

Concentrations of total aluminum and iron are predicted to exceed SSWQO values during operations in Nico, Peanut, and Burke lakes primarily as a result of the deposition of fugitive dust. Total aluminum concentrations are predicted to exceed the SSWQO value by up to 250% continuously in Nico Lake, by up to 100% continuously in Peanut Lake, and by up to 50% at the 95th percentile prediction level in Burke Lake. Total iron concentrations are predicted to exceed the SSWQO value by up to 140% continuously in Nico Lake, by up to 33% intermittently in Peanut Lake, and by up to 6% occasionally in Burke Lake. However, dissolved aluminum and iron concentrations may only exceed SSWQO values occasionally in Nico Lake, and are expected to remain below SSWQO values in Peanut Lake and Burke Lake. Total arsenic concentrations may exceed the SSWQO value of 0.05 mg/L on rare occasions in Nico Lake due to dust deposition during operations and are predicted to be below the SSWQO value in Peanut Lake and Burke Lake.

Concentrations of total antimony, cadmium, cobalt, copper, lead, selenium, uranium, and zinc are predicted to remain below their respective SSWQO values in Nico, Peanut, and Burke lakes through operations and closure.

Of the remaining modelled metals that do not have developed SSWQO values (e.g., boron, chromium, mercury, molybdenum, nickel, silver, and thallium), predicted concentrations have been compared to CCME guidelines for the protection of aquatic life. Of the metals with CCME guidelines:

- concentrations of total boron, molybdenum, and nickel are predicted to remain below their respective guideline values in Nico, Peanut, and Burke lakes during operations and post-closure;
- concentrations of total chromium are predicted to exceed the CCME guideline value of 0.001 mg/L during operations and post-closure in Nico Lake and Peanut Lake, and only during operations in Burke Lake. However, dissolved chromium concentrations are predicted to remain below the CCME guideline value in these lakes during operations, but may exceed the guideline value in Nico Lake following closure. However, the CCME guideline value is 0.001 mg/L for hexavalent chromium (Cr_{VI}) and 0.0089 mg/L for trivalent chromium (Cr_{III}); the proportion of total chromium that is hexavalent chromium has not been determined for the modelled period;

- concentrations of mercury may exceed the CCME guideline value of 0.000026 mg/L in Nico Lake following closure due to concentrations in the discharge from the Wetland Treatment Systems, but are expected to remain below the guideline value in Peanut Lake and Burke Lake; and
- concentrations of silver and thallium in Nico Lake may exceed CCME guideline values during operations and post-closure, while silver concentrations are predicted to exceed the CCME guideline in Peanut Lake only near the end of operations. Thallium concentrations are predicted to remain below the CCME guideline in Peanut Lake and Burke Lake, as are silver concentrations in Burke Lake.

Site-specific water quality objectives and CCME guidelines do not exist for barium, beryllium, manganese, and vanadium. Of the modelled metals without CCME guidelines:

- concentrations of barium are predicted to increase 2-fold in Nico Lake relative to baseline concentrations and remain elevated post-closure. Barium concentrations are predicted to increase by up to 50% and 32% in Peanut Lake and Burke Lake, respectively, during operations and remain 22% and 10% higher, respectively, than baseline concentrations post-closure;
- beryllium concentrations in Nico Lake are predicted to increase during operations and continue to increase post-closure to levels 7 to 10 times higher than average baseline concentrations. Beryllium concentrations in Peanut Lake and Burke Lake are expected to increase from baseline concentrations by up to 420 and 230%, respectively, during operations and remain up to 300 and 150% higher, respectively, than baseline concentrations post-closure;
- manganese concentrations are predicted to increase through operations and continue to increase post-closure, to levels 160%, 36%, and 19% higher than baseline in Nico, Peanut, and Burke lakes, respectively; and
- vanadium concentrations are predicted to increase in Nico, Peanut, and Burke lakes during operations relative to baseline concentrations by up to 180%, 80%, and 45%, respectively, and decline post-closure, remaining above baseline concentrations by up to 125%, 27%, and 11%, respectively.

Predicted Metals Concentrations and Trends in the Marian River

Concentrations of aluminum, arsenic, beryllium, cobalt, copper, iron, selenium, and silver in the Marian River are predicted to increase by up to 60% relative to baseline conditions during the construction and operations phases due primarily to dust deposition and treated effluent discharges within the Burke Lake watershed, and then decline post-closure. However, concentrations of aluminum, arsenic, cobalt, copper, iron, and selenium are predicted to remain below SSWQO values throughout the active phases of the NICO Project and post-closure. Silver concentrations are not predicted to exceed CCME guidelines in the Marian River due to NICO Project activities. Beryllium does not have a CCME guideline or SSWQO value, and concentrations are predicted to increase by less than 6% relative to simulated baseline concentrations. Concentrations of antimony, lead, molybdenum, and thallium are predicted to remain elevated in the Marian River post-closure relative to baseline conditions; however, all of these metals are predicted remain below applicable SSWQO values and CCME guidelines.

Concentrations of barium, boron, cadmium, chromium, manganese, mercury, nickel, uranium, vanadium, and zinc throughout all phases of the NICO Project are predicted to be similar to baseline concentrations. These metals are predicted to change less than 5% from average baseline conditions, which would be indistinguishable from natural background variability.

7.10.2.2 Effects to Sediment Quality in Nico, Peanut, and Burke Lakes

Sediment quality is expected to change in the chain of lakes within the Burke Lake watershed during construction and operations as a result of NICO Project activities. The primary cause of these changes in Nico, Peanut, and Burke lakes is the cumulative dust deposition during construction and operations, which was evaluated in Section 7.6.4. Predicted changes in sediment quality in Nico, Peanut, and Burke lakes due to the deposition of fugitive dust and other air emissions are not expected to result in the exceedance of available sediment quality guidelines, where none had previously existed under baseline conditions.

Concentrations of lead, mercury, nickel, silver, thallium, uranium, vanadium, and zinc are not expected to change substantially from baseline conditions, as the expected concentrations of these metals associated with fugitive dust are lower than measured in baseline sediment samples collected from Nico, Peanut, and Burke lakes. Concentrations of most other metals are predicted to increase by less than 20% from minimum observed baseline concentrations to less than 10% from maximum observed baseline concentrations. These predicted changes are within the limits of uncertainty for analysis of metals concentrations in sediment samples, and would likely be indistinguishable from existing natural variability.

Notable incremental increases in metals are predicted in Peanut and Burke lakes for antimony and arsenic. Antimony concentrations in Peanut Lake sediments may increase by more than 22%, and arsenic concentrations in Peanut Lake and Burke Lake are predicted to increase by 17 to 35% and 10 to 21%, respectively. However, existing arsenic concentrations in Peanut Lake and Burke Lake are above the probable effects level sediment quality guideline (CCME 1999), but are not expected to exceed the GNWT remediation objective (GNWT 2003) of 150 mg/kg as a result of NICO Project activities.

7.11 Residual Impact Classification

The purpose of the residual impact classification is to describe the residual effects of the NICO Project on water and sediment quality 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 NICO Project:

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

7.11.1 Methods

Pathways to effects to water and sediment quality were analyzed in Section 7.5. The pathways identified as primary pathways (i.e., likely to result in a measurable environmental change that could contribute to residual effects on a VC relative to baseline or guideline values) were summarized in effects statements (e.g., NICO Project effects to water and sediment quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River). These effects statements set the direction for the residual effects analysis (Section 7.6), which considered the key NICO Project activities (e.g., treated effluent release), to determine the magnitude and extent of the change to water and sediment quality. Effects statements focus the analysis of changes to water and sediment quality resulting from one or more primary pathways.

The objective of the residual effects analysis was to determine how NICO Project activities would affect an individual measurement endpoint, or a given set of measurement endpoints for a VC (e.g., nutrient concentrations in Nico Lake). The measurement endpoints are, in turn, connected to the broader-scale VC endpoints, which represent the ultimate properties of the system that are of interest or concern, and reflect statements of what are most important to future generations.

The effects analyses (Section 7.6) and residual effects summary to water and sediment quality (Section 7.10) presented the incremental changes to water quality and sediment quality projected to occur during construction, operation, and following closure and reclamation of the NICO Project. Incremental effects represent the NICO Project-specific changes relative to baseline conditions assessed between 2003 and 2010. For this KLOI, the primary focus of NICO Project-specific effects is at the scale of the LSA (i.e., within the streams and lakes of the Burke Lake watershed and immediately adjacent the NICO Project area to the Marian River at the confluence with the Burke Lake watershed), corresponding to the extent that potential effects are detectable downstream as required by the TOR (MVRB 2009). This approach is consistent with the scales used to evaluate geographic extent across the subjects of note that focus on aquatic ecosystems.

The term “effect”, used in effects statements, has been changed to “impact” in this section and is only used during the classification process. To assess the environmental significance of the NICO Project’s incremental changes, a residual impact classification system was developed and applied to the VC endpoints considered in this KLOI. For this KLOI, the VCs consist of water and sediment quality, and the relevant VC endpoint is the suitability of water and sediment quality to support a viable aquatic ecosystem (Section 7.5).

Residual impacts to the VC endpoints were classified based on the results of the effects analyses and their linkage to these endpoints. The classification was carried out on residual impacts (i.e., impacts with environmental design features and mitigation considered). Environmental design features and mitigation were incorporated in the engineering design or the management plans, and were incorporated in the NICO Project as it evolved (i.e., as the engineers received input from various scientists and traditional knowledge holders, the design evolved).

Generic definitions have been provided for each impact criterion in the Assessment Approach (Section 6). For criteria such as frequency and likelihood, the definitions can be applied consistently across all VCs (Table 7.11-1). Similarly, reversibility is defined as the likelihood and time required for a component or system (e.g., aquatic habitat or ecosystem) to recover after removal of the stressor; it is also a function of the resilience of the system. Reversibility is applied to all combinations of magnitude, geographic extent, and duration.

The scale of classifications (e.g., high, low, local, regional, short and long-term) for magnitude, geographic extent, and duration is dependent on each VC, and the associated effects statement. To provide transparency in the DAR, the definitions of these scales are specifically applied to water quality. 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. More detailed explanations for magnitude, geographic extent, and duration are provided below.

Where quantitative projections or predictions have been evaluated (e.g., changes to nutrients and metals concentrations in water), the magnitude of an effect on water quality was determined as follows:

- negligible: no detectable change from the NICO Project relative to baseline values;
- low: less than 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.

The definition of magnitude provided in Table 7.11-1 is also applicable to qualitative results (e.g. effects on sediment quality).

Existing and other planned projects in the NWT are located outside of the Burke Lake watershed. As such, there is no opportunity for the releases of those projects to interact with those of the NICO Project within the Burke Lake watershed. Consequently, there is no potential for cumulative effects to surface water quality in the Burke Lake watershed or to the Marian River in proximity to, and downstream of, the NICO Project.

Table 7.11-1: Definitions of Scales for Criteria Used in the Residual Impact Classification

Direction	Magnitude[a]	Geographic Extent	Duration	Frequency	Reversibility[b]	Likelihood
Neutral: no measurable change to a VC from existing conditions **Negative:** the NICO Project will result in an adverse effect to a VC **Positive:** the NICO Project will result in a beneficial effect to a VC	**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:** projected impact is confined to the Burke Lake watershed above the confluence with the Marian River; small scale direct and indirect impacts from the NICO Project (e.g., footprint, dust deposition, dewatering) **Regional:** projected impact extends beyond the confluence of the Burke Lake watershed with the Marian River; the predicted maximum spatial extent of combined direct and indirect impacts from the NICO Project that exceed local scale effects **Beyond Regional:** cumulative local and regional impacts from the NICO Project and other developments extend beyond the regional scale	**Short-term:** projected impact is reversible by the end of construction **Medium-term:** projected impact is reversible upon completion of closure (e.g., approximately 2 years following the end of operations) **Long-term:** projected impact is reversible some time beyond closure or not reversible	**Isolated:** projected impact occurs once, with an associated short-term duration (i.e., is confined to a specific discrete period) **Periodic:** projected impact occurs intermittently, but repeatedly over the assessment period **Continuous:** projected impact occurs continually over the assessment period	**Reversible:** projected impact will not result in a permanent change from existing conditions or conditions compared to similar environments not influenced by the NICO Project **Not reversible:** projected impact is not reversible (i.e., duration of impact is unknown or permanent)	**Unlikely:** projected impact is likely to occur less than one in 100 years **Possible:** projected impact will have at least one chance of occurring in the next 100 years **Likely:** projected impact will have at least one chance of occurring in the next 10 years **Highly Likely:** projected impact is very probable (100% chance) within a year

[a] baseline includes range of predicted values from reference conditions (no development) through to 2010 baseline conditions.

[b] "similar" implies a waterbody that is similar in size, shape, location, and general characteristics to that affected by the NICO Project (e.g., Peanut Lake).

7.11.1.1 Magnitude

Magnitude (i.e., intensity of the impact) for NICO Project-specific impacts is scaled to the size of the expected change from baseline conditions to application of the NICO Project. Baseline conditions represent the historical and current environmental conditions that have shaped background water and sediment quality. In the LSA, environmental conditions include primarily natural influences (e.g., climate, hydrology, mineralogy of the watershed, groundwater inflows and quality, and fires). As a result of these influences, baseline conditions can typically fluctuate on a temporal basis. The evaluation of the size of a change from baseline conditions takes into account the extent of natural variability of baseline conditions.

The approach used to classify the magnitude of changes in measurement endpoints (and related impacts) was based on scientific literature and professional opinion, and incorporated conservatism. Ideally, effect threshold values would be known, and measurement endpoints could be quantified accurately with a high degree of confidence; however, little is known about ecological thresholds, and biological parameters are typically associated with large amounts of natural variation. As a consequence, the classification of magnitude included a level of conservatism so that the impacts would not be underestimated.

7.11.1.2 Geographic Extent

Geographic extent is the area or distance influenced by the direct and indirect impacts from the NICO Project. The geographic extent of impacts can occur on a number of scales within the spatial boundary of the assessment. As defined in Table 7.11-1, geographic extent for classifying impacts is based on 3 scales: local, regional, and beyond regional. Local-scale impacts mostly represent incremental changes to water quality and sediment quality directly related to the NICO Project footprint and activities (e.g., plant emissions, haulage truck transport, treated effluent release), and in the Burke Lake watershed above the confluence with the Marian River. Changes at the regional scale are largely associated with the predicted maximum extent of incremental impacts or air emissions from the NICO Project on water quality within the Marian River, downstream of the confluence with the Burke Lake outlet stream (i.e., more than 5 km from the NICO Project). Beyond regional impacts consider cumulative local and regional impacts from the NICO Project and other developments that extend beyond the regional scale.

7.11.1.3 Duration

Duration has 2 components. It is the amount of time between the start and end of a NICO Project activity (which is related to NICO Project development phases), plus the time required for the impact to be reversed. Essentially, duration is a function of the length of time that lakes are subject to NICO Project activities (i.e., NICO Project emissions and treated effluent releases), and reversibility.

By definition, impacts that are short-term, medium-term, or long-term in duration are reversible. NICO Project activities may end at closure, but the impact to water and sediment quality may continue beyond closure. The transitional time between the end of operations and the closure phase has been described as the closure period; this is approximately a 2-year period during which the majority of closure activities will be completed that have not already been completed during operations with progressive reclamation. Closure activities during this period will include, but are not limited to, completion and re-vegetation of a closure cover over the surface of the CDF, construction of a boulder wall around the Flooded Open Pit, and re-vegetation of borrow and disturbance areas (Section 9.4). Some impacts may be reversible soon after removal of a stressor, such as effects of dust deposition to lakes following the cessation of power generation and equipment operation (e.g., medium-term impact).

For water quality, the amount of time required for the impact to be reversed (i.e., duration of the effect) is presented in context of the cessation of an activity that will result in a change (i.e., a mine-related chemical of potential concern input to a lake) and the residence time of a waterbody (i.e., the time for existing water volume to be replaced). In this manner, the impact assessment links the duration of NICO Project impacts on water and sediment quality to the amount of time that a lake is exposed to a concentration that is elevated beyond background levels, or above SSWQO values or guideline values.

For impacts that are permanent, the duration of the effect is determined to be irreversible. An example of an irreversible impact may include the permanent or long-term discharge of mine-related seepage from the CDF to Nico Lake through the constructed Wetland Treatment Systems.

7.11.2 Results

In Section 7.6, the effects of the NICO Project on water quality in lakes in the air quality RSA, and on water and sediment quality in Nico, Peanut, and Burke lakes, and the Marian River at the confluence with the Burke Lake outlet stream, were assessed for the construction, operations, and closure (including post-closure) phases. The residual effects were summarized in Section 7.10.

Cumulative impacts from the NICO Project and other developments, and natural factors, are beyond regional. Of the reasonably foreseeable projects identified in the DAR, none are expected to result in changes to water and sediment quality. The potential for cumulative effects from the Rayrock and Colomac mines to water quality has been expressed by the Tłįchǫ Government and Tłįchǫ citizens, and has been identified in the TOR (MVRB 2009). However, as impacts to water quality and subsequently aquatic health from the NICO Project are considered negligible downstream of Burke Lake. The former Rayrock mine site is located at least 15 km downstream of Burke Lake, so 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 to water quality with the NICO Project. Therefore, beyond regional impacts are not predicted.

7.11.2.1 NICO Project Effects to Water Quality in Lakes in the Regional Study Area

The primary sources of chemicals of potential concern from the NICO Project to lakes and watercourses within the air quality RSA, that do not receive treated effluent discharges and are not downstream of lakes that receive treated effluent (i.e., Nico, Peanut, and Burke lakes and the Marian River), will be acidifying emissions and fugitive dust deposition.

During construction and operations, the magnitude of sulphur and nitrogen oxides deposition related to NICO Project emissions is predicted to be low, and is not predicted to result in lake acidification within the RSA. Predicted maximum concentrations of suspended solids and some metals may increase above SSWQOs and water quality guidelines, because of fugitive dust and metals deposition in some fish-bearing lakes within 2 km of the NICO Project Lease Boundary.

Chemicals of potential concern associated with fugitive dust will primarily be in particulate form, as part of the deposition of total suspended particulates to lakes. Concentrations of TSS and metals that deposit directly to lakes, or from transport from the watershed to the lakes, may be elevated on a seasonal basis (i.e., during and after peak flows associated with freshet). Some metals, such as total aluminum, chromium, and iron, may potentially occur in concentrations above SSWQOs, or above guideline values where SSWQOs have not been established. Elevated concentrations of metals in water and sediment will decline gradually with distance from the NICO Project as a result of diminishing deposition rates with distance from the source. As a consequence, the magnitude of the impacts from changes in concentrations of TSS and metals in water and sediment from dust deposition is predicted to be high to negligible with distance from the NICO Project. Changes in TSS and metals concentrations from fugitive dust emissions are expected to remain within the range of baseline values beyond the Burke Lake and Lou Lake watersheds.

Therefore, direct impacts from air emissions from the NICO Project to regional waterbodies and streams will be local in geographic extent, and the duration of the fugitive dust emissions is anticipated to be medium-term, as NICO Project emissions will cease at the end of closure (i.e., following reclamation activities) (Table 7.11-2). Impacts from dust deposition will be periodic and reversible (Table 7.11-2). Given the conservatism in the predicted concentrations, and the potential for exposure to elevated concentrations being limited to the peak watershed flows associated with freshet, the potential for adverse effects to aquatic life from dust and metals deposition is considered to be low. Following closure, a return to conditions similar to existing (i.e., pre-development) conditions is anticipated.

7.11.2.2 NICO Project Effects to Water and Sediment Quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River

Primary sources of chemicals of potential concern from the NICO Project to Nico, Peanut, and Burke lakes, and the Marian River will be acidifying emissions, fugitive dust, discharge of treated effluent from the ETF to Peanut Lake from construction to closure, and discharge of CDF seepage water from the Wetland Treatment Systems to Nico Lake during closure and post-closure. Seepage from the NICO Project to Nico Lake, identified as a secondary pathway in Section 7.5, was also included so that potential incremental effects from the NICO Project would not be underestimated.

During construction and operations, the magnitude of sulphur and nitrogen oxides deposition related to NICO Project emissions is predicted to be low, and is not predicted to result in acidification in Nico, Peanut, and Burke lakes, or the Marian River. Concentrations of TSS and metals associated with fugitive dust emissions and TSP deposition may be elevated on a seasonal basis, particularly in Nico and Peanut lakes (i.e., during and after peak flows associated with freshet).

Effluent discharges are projected to consistently meet SSWQOs over the assessment period, with the possible exception of selenium in ETF discharges to Peanut Lake near the end of operations. Modelling simulations predict that changes to water quality in Nico, Peanut, and Burke lakes will exceed the range of baseline values for a number of metals during operations, with aluminum, arsenic, and iron concentrations potentially occurring in concentrations above SSWQOs, or above guideline values where SSWQOs have not been established. Metals such as chromium, mercury, silver, and thallium do not have established SSWQO values, and simulated concentrations during operations and following closure may exceed CCME guidelines in Nico and Peanut lakes during dry periods when receiving water flows are low. However, there is a high degree of conservatism incorporated in the water quality modelling inputs related to the NICO Project, as described in previous sections, and metals concentration predictions are therefore likely to be overestimated.

Table 7.11-2: Summary of Residual Impact Classification of Primary Pathways for Incremental and Cumulative Effects to Water Quality and Sediment Quality

Effects Statement	Direction	Magnitude		Geographic Extent		Duration	Frequency	Reversibility	Likelihood
		Incremental	Cumulative	Incremental	Cumulative				
NICO Project effects to water quality in lakes in the regional study area	Negative	Negligible to high	N/A	Local	N/A	Medium-term	Periodic	Reversible	Highly likely
NICO Project effects to water and sediment quality in Nico Lake, Peanut Lake, Burke Lake, and the Marian River	Negative	Negligible to high	N/A	Local	N/A	Medium to long-term	Continuous to periodic	Reversible to irreversible	Highly likely

Predicted changes in sediment quality in Nico, Peanut, and Burke lakes are generally not expected to be distinguishable from natural variation for most metals, or result in the exceedance of sediment quality guidelines, where no exceedances were observed under baseline conditions. Notable changes in antimony concentrations may occur in Peanut Lake and Burke Lake sediments. However, changes are expected to be reversible over time with natural deposition of inorganic and organic materials to lake sediments.

Elevated concentrations of metals in water and in sediment will decline gradually through the chain of lakes of the Burke Lake watershed to the confluence with the Marian River as a result of diminishing deposition rates with increasing distance from the source, and dilution through the watershed.

The magnitude of change associated with NICO Project inputs, therefore, is predicted to be high in Nico and Peanut lakes, moderate in Burke Lake, and low to negligible in the Marian River, with a declining gradient from Nico Lake to the Marian River. Higher concentrations of chemicals of potential concern are predicted in the lakes receiving higher amounts of dust and direct discharges from the NICO Project, but CCME guideline exceedances at the Marian River throughout the operational phases of the NICO Project are expected to be largely associated with background variability, and SSWQOs will not be exceeded in the Marian River. Water quality in Burke Lake and downstream reaches of the Marian River should remain within the range of baseline conditions for TSS, nutrients, and metals. Following operations, the cessation of dust deposition and treated effluent release from the ETF will reduce the impact of NICO Project-related discharges to the Burke Lake watershed, with only the discharge from the Wetland Treatment Systems to Nico Lake persisting beyond closure, and ultimately Open Pit overflow, which is projected to flow to Peanut Lake approximately 120 years following closure.

The geographic extent of the impact during the assessment period, therefore, will be limited to a local scale (i.e., within the Burke Lake watershed). The duration of the change to water quality within the Burke Lake watershed will be medium-term for dust deposition and the ETF discharge (which will cease at closure), and long-term for the treatment wetland discharge (which extends beyond closure).

Impacts due to the NICO Project will be continuous or periodic over the duration of the assessment period (Table 7.11-2). Although treated effluent discharges from the ETF will be continuous (the ETF discharge may be intermittent near the beginning of operations during dry years, but is expected to be continuous near the end of operations), inputs from dust deposition will be most pronounced during and immediately after freshet, and discharges from Wetland Treatment Systems are expected to occur only during the open water season. Impacts during operations, therefore, will be continuous, but more prominent during, and immediately after, spring freshet. Impacts following closure will be seasonal, and, therefore, will be periodic.

There is a high likelihood of impact from NICO Project inputs; however, conservatism applied to the site water quality predictions for NICO Project discharges, air quality dispersion modelling, and metals concentrations associated with fugitive dust, will result in predictions of TSS and metal concentrations in Nico, Peanut, and Burke lakes that are subject to a high degree of uncertainty, in the direction of predicting higher concentrations than can be realistically expected. Some uncertainty is also associated with the time required for a complete recovery of water quality in Nico and Peanut lakes. This uncertainty is due to the unknown duration of the seepage discharge through the Wetland Treatment Systems (i.e., impacts will be reversible to irreversible). Processes such as permafrost development and source depletion in the CDF were not considered in the assessment, which also contribute to conservatism.

7.12 Environmental Significance

7.12.1 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 has been used to evaluate incremental impacts from the NICO Project on water and sediment quality, and by extension, aquatic health. To the extent possible, this evaluation has been based on scientific principles, as well as professional judgment.

The classification of residual impacts provides the foundation for determining environmental significance from the NICO Project on the VC endpoint identified for the KLOI: Water Quality. Significance is only determined for this VC endpoint, and not the individual primary pathways to effects, as assessment endpoints represent the ultimate environmental condition and characteristics that should be protected (Section 6). However, the relative contribution of each pathway is considered in the determination of the significance of the NICO Project to the assessment endpoint. For example, a pathway resulting in an effect of a high magnitude, large geographic extent, and long-term duration would be given more weight in determining significance relative to pathways with smaller scale effects. Magnitude, geographic extent, and duration of impacts are the principal criteria used to predict significance. Other criteria, such as frequency and likelihood, and reversibility (linked to duration) are used as modifiers (where applicable) in the determination of significance.

Environmental significance is used to identify predicted impacts that have sufficient magnitude, duration, and geographic extent to cause fundamental changes to water and sediment quality. The following definitions are used for assessing the significance of impacts on water and sediment quality, and the associated impact on aquatic health.

Not significant – impacts are measurable at the local scale, and may be strong enough to be detectable at the regional scale, but are not likely to increase the risk to aquatic health.

Significant – impacts are measurable at the regional scale and are irreversible, and are likely to increase the risk to aquatic health. High magnitude and irreversible impacts at the regional scale would likely be significant.

7.12.2 Results

The results suggest that impacts from the NICO Project should not significantly influence the suitability of water quality and sediment quality to support a viable and self-sustaining aquatic ecosystem. For all primary pathways contributing to the effects of the NICO Project on water and sediment quality, incremental impacts were determined to be local in geographic extent (Table 7.11-2), with a gradient of effects that extend from lakes immediately adjacent to the NICO Project footprint (i.e., Nico and Peanut lakes, which will receive direct discharge of treated mine effluent) to Burke Lake and the Marian River.

The primary sources of chemicals of potential concern from the NICO Project to lakes and watercourses within the air quality RSA that do not receive NICO Project-related discharges will be acidifying emissions and fugitive dust from vehicle operation along the haul roads and plant operation. The magnitude of acidifying emissions will be low, and lake acidification is not predicted to occur within the RSA. Impacts to water and sediment quality from the deposition of fugitive dust emissions from the NICO Project are predicted to primarily affect waterbodies within a distance of 2 km from the NICO Project Lease Boundary. The magnitude of effects from dust deposition will be low to negligible with increasing distance beyond the aquatic LSA boundary; increasing TSS and associated metals concentrations associated with dust deposition will remain localized and are not expected to change the ranges of water and sediment quality parameters substantially above natural baseline variability beyond the Burke and Lou Lake watersheds. Dust deposition impacts are anticipated to occur continuously throughout the life of the NICO Project and will be reversible after completion of mine operation (i.e., 18 years).

The primary sources of chemicals of potential concern from the NICO Project to lakes and watercourses within the LSA, including Nico, Peanut, and Burke lakes and the Marian River at the confluence with the Burke Lake outlet, will be NICO Project-related discharges, and fugitive dust deposition. The impacts are expected to be “highly likely”, with a magnitude ranging from high to negligible from Nico Lake to the Marian River. Based on simulated water quality predictions, the primary source of elevated concentrations of chemicals of potential concern (in particular, metals) will be dust deposition in Nico, Peanut, and Burke lakes from air emissions during operations, mine discharges to Peanut Lake from the ETF during operations, and CDF seepage flow through Wetland Treatment Systems to Nico Lake in post-closure. Higher concentrations of chemicals of potential concern associated with direct treated effluent discharge from the NICO Project site are predicted in Nico and Peanut lakes, but the discharges will conform to SSWQOs that will not be exceeded throughout the operational and closure phases of the NICO Project.

For dust deposition, the primary source of metals to the lakes will be associated with suspended particulate matter in dust. A seasonal trend is predicted; during winter, air emissions will deposit to the snow and ice, and during spring, the deposited material will mobilize with runoff and drainage associated with the snow melt to the lakes in a pulse response that lasts for the period of elevated flow conditions. Much of the TSS and metals that result from the inflowing suspended sediments in the receiving lakes is expected to settle to the sediment bed rapidly as flows reduce following the freshet. During this period, aquatic habitat and aquatic life will be subject to brief periods of turbid conditions and associated elevated levels of total metals. As the freshet flows subside, a large proportion of the total TSP deposited to the lake surface will result in a proportion of the particulate matter (i.e., >10 µm size) settling rapidly. Predicted changes in sediment quality in Nico, Peanut, and Burke lakes due to deposition of fugitive dust and other air emissions during construction and operations are generally not expected to be distinguishable from natural variation for most metals, or result in the exceedance of available sediment quality guidelines, where no exceedance existed under baseline conditions.

Impacts of treated effluent discharge from the ETF to water and sediment quality of Peanut Lake during operations are predicted to contribute to changes to water quality in Peanut and Burke lakes, although concentrations within discharges will be within SSWQOs. The impact of treated effluent discharge to Peanut and Burke lakes is anticipated to be reversible following mine operation and closure (i.e., approximately 25 years) with the cessation of ETF discharge to Peanut Lake at closure. Discharge from the ETF will be through diffusers that will actively disperse the treated effluent in Peanut Lake.

Treatment wetland discharge to Nico Lake, sourced from CDF seepage, will continue on a periodic basis (i.e., seasonally) during post-closure. Discharge will be limited primarily to the open water season and will meet SSWQOs. Predicted changes to water quality from these discharges during post-closure do not account for natural mitigative processes such as permafrost development and source depletion in the CDF, which would reduce the loading to seepage that would flow to the Wetland Treatment Systems.

The magnitude of change associated with the ETF discharges and treatment wetland discharges is predicted to be high in Nico and Peanut lakes, moderate in Burke Lake, and low in the Marian River, with a declining concentration gradient from Nico Lake to the Marian River. Discharge from the ETF will be of medium duration, whereas the CDF seepage flows through the Wetland Treatment Systems will be long-term, with periodic to continuous frequency, to which the Open Pit overflow will be incorporated approximately 120 years following closure. Water quality in the Marian River should remain similar to the range of baseline conditions for TSS, nutrients, and metals.

Despite operational and closure mine discharges to Nico and Peanut Lake being within SSWQOs, the cumulative impacts of air emissions and treated effluent releases are predicted to occasionally result in exceedances of SSWQO values for aluminum, iron, and arsenic in Nico, Peanut, and Burke lakes during operations. Metals such as chromium, mercury, silver, and thallium, which do not have established SSWQO values, are predicted to exceed CCME guidelines in Nico and Peanut lakes during operations. For all predicted water quality and sediment quality changes, the NICO Project-related risks to aquatic life are considered to be either negligible, or low and likely negligible.

There is a moderate degree of uncertainty associated with the prediction of no significant adverse impacts on water and sediment quality. This conservatism is primarily related to the prediction of changes to water and sediment quality from air emissions and dust deposition, the quality of treated effluent discharges from the NICO Project, and the primary mechanisms for elevated TSS and metal concentrations in Nico and Peanut lakes. For example, the assessment of air emission effects assumes that mine production would be at peak capacity over the life of the mine, and that fugitive dust emissions would not be naturally mitigated. Additionally, the assessment of effects of treated effluent discharges to water and sediment quality was based on water quality predictions at the 95th percentile, which are highly conservative estimates despite mine site discharges during operations and closure meeting SSWQOs. These approaches were used to increase confidence that the assessment would not underestimate impacts.

The implementation of environmental design features at the NICO Project, such as dust emission controls, maintenance of treatment efficiency for mine effluent, and releases from the ETF and Wetland Treatment Systems, should mitigate the potential for most adverse effects described in this KLOI.

Under existing conditions, Nico and Peanut lakes are subject to direct and indirect inflows with elevated metals concentrations characteristic of the highly mineralized geology of the upper watershed. The NICO Project will eliminate this inflow source and replace it with active operational and post-closure point source discharges to Peanut and Nico lakes, respectively. These changes will alter water quality in the Burke Lake watershed through operations and closure; however, changes are not anticipated to extend beyond Burke Lake. Overall, the weight of evidence from the analysis of the primary pathways predicts that the incremental impacts from the NICO Project will result in changes to water and sediment quality in Nico, Peanut, and Burke lakes, but that these changes will not have a significant adverse impact on the suitability of water in these lakes to support a viable and self-sustaining aquatic ecosystem.

7.13 Uncertainty

Key areas of uncertainty for the assessment of effects to water and sediment quality due to NICO Project activities include the following:

- dust and metals deposition to lakes near the NICO Project; and
- water quality modelling, with specific reference to:

- receiving environment background surface water flows and chemistry (i.e., natural variability); and
- NICO Project site water balance and chemistry;

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 and sediment quality.

7.13.1 Deposition of Dust and Metals to Lakes near the NICO Project

Predictions of changes in TSS and metals concentrations in Nico, Peanut, and Burke lakes, and other lakes within the air quality RSA were presented in Sections 7.6.3 and 7.6.2, and predicted sediment quality changes were presented in Section 7.6.4. These predictions were based, in whole or in part, on TSP deposition rates and individual metal deposition rates, as predicted by air quality dispersion modelling (Section 10.4.2). The TSP and metals deposition predictions were incorporated as inputs for the water quality model for Nico, Peanut, and Burke lakes, and were used in simple mass balance calculations to predict changes in TSS and metal concentrations for other lakes in the air quality RSA and changes in sediment quality in Nico, Peanut, and Burke lakes.

A major source of uncertainty in the assessment of dust and metals deposition to lakes in and around the NICO Project area relates to the air quality predictions (Section 10.8). The dispersion models used in the air quality assessment 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, coupled with their model inputs, are generally designed to conservatively model concentration and deposition values, so that practitioners can apply model results with the understanding that effects are likely to be over-estimated.

The following general comments are made with respect to air quality modelling results for this NICO Project.

- Parameterization of emissions from diffuse area sources is difficult to simulate in dispersion models. Modelled results near mine pits and other sources of mechanically generated particulates are most 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 (i.e., typically south-western United States coal mines). Based on experience, it is expected that emissions estimated using this approach would be conservative.
- The air quality and deposition rate predictions used the maximum emission rates from the NICO Project during construction and operations. Predicted annual deposition rates were based on the maximum of the daily road dust emissions during summer and winter.
- Emissions of road dust from on-site haul roads, the primary sources of particulate matter and metal compounds, do not include potential mitigating effects of weather (such as precipitation or snow-covered ground), which will result in an overestimate of annual air quality predictions and deposition rates.
- Geochemistry data used to estimate metal concentrations in dust included a large proportion of concentrations below the analytical detection limit for cadmium and selenium. Concentrations of these metals were set at the detection limit for air quality and deposition modelling.

- Based on a review of the particulate material monitoring data at the Snap Lake (De Beers 2010) and Ekati (BHPB 2010) mines, the elevated particulate matter deposition rates identified in this assessment are due in part to the conservative emission estimates.

The approach used to estimate incremental changes in concentrations of TSS and metals in surface waters using the modelled deposition rates was also conservative because no retention of particulate matter or metals was assumed in lake watersheds (i.e., all deposited material was assumed to enter the lakes).

As a result of these factors, predicted changes in TSS and metal concentrations in lakes are considered to be conservative estimates of the maximum potential changes that could occur during construction and operations.

7.13.2 Water Quality Modelling

Water quality in Nico, Peanut, and Burke lakes, and the Marian River will be dependent on the quality of the influent streams entering each respective lake and confluent in the Marian River. The predictions of water quality in Nico Lake, Peanut Lake, Burke Lake, 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.

Uncertainty and conservatism in deposition of dust and metals is discussed in Section 7.13.1.

Natural Variability

Natural variability in background surface water flow rates was incorporated in the water quality model through the use of daily background surface water flow time series. The surface water flow time series derived for each sub-watershed within the Burke Lake and Lou Lake watersheds, and for the Marian River at the confluence with the outlet of Burke Lake, were derived from concurrent hydrometric monitoring records over a period of 26 years, from 2 Water Survey of Canada stations with similar latitudes, and watershed areas that are similar to the Burke Lake and Marian River watershed areas. These background surface water flow time series were calibrated to flows observed during baseline monitoring programs (Annex G, Sections 5.6 and 5.7).

Natural variability in background surface water quality was also incorporated in the water quality model. Analytical results from water quality samples collected during baseline monitoring programs were used to derive statistical distributions of water quality constituent and suspended sediment concentrations, for both open water and ice-covered seasons, for each of 3 background flow sources. These included the Grid Pond system (i.e., ore-influenced waters), the rest of the Burke Lake watershed (i.e., non-ore-influenced surface waters), and the Marian River. Constituent concentrations and suspended sediment concentrations were sampled from the derived statistical distributions on a daily basis and applied to each background flow source.

Total constituent concentration predictions were checked against baseline monitoring results in each of Nico, Peanut, and Burke lakes. Calibration factors were applied to background constituent concentration profiles, where required, to improve the fit between predicted and observed concentration statistics and improve confidence in the model predictions.

Statistical distributions of surface water partition coefficients were incorporated into the water quality model to facilitate predictions of both total and dissolved metals concentrations in the receiving environment. Surface water partition coefficients were derived from suspended solids concentrations and associated total and dissolved constituent concentrations measured in water samples collected during the baseline monitoring program.

Uncertainty and variability in background model inputs was further addressed in the water quality model by using a Monte Carlo analysis with 100 realizations:

- the starting year of the 26-year background surface water flow time series was randomly selected for each realization and repeated in a loop, ensuring that the range of modelled receiving water flow conditions was captured during each phase of the NICO Project; and
- Latin Hypercube Sampling of background surface water concentrations (on a daily basis) and surface water partition coefficient distributions (on a per-realization basis) was completed so that that the range of these stochastic inputs were sampled and represented in the model results.

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

NICO Project Site Water Balance and Chemistry

The NICO Project site water balances summarized in Section 3.9 were developed for early operations, late operations, and at closure based on the Water Management Plan (Appendix 3.III) and the maximum extent of the proposed NICO Project footprint for each of the proposed mine facilities. These deterministic water balances were developed on a monthly time step using climatic statistics for precipitation and evaporation.

Site water chemistry predictions were prepared based on the site water balances for average conditions (i.e., 1:2 year climate statistic basis). The effects of water loss, including evaporation, seepage from the sumps, and recycling were considered as a part of the deterministic site water balances and water quality predictions. Site water quality predictions were prepared on a monthly basis, and the maximum monthly concentrations were conservatively carried forward to a water treatment option analysis, which included predictions of ETF discharge quality used as an input to the GoldSim™ water quality model. Maximum site water quality predictions were also used directly in the GoldSim™ model for seepages to Nico Lake during operations and monthly concentration predictions were applied to flows from the treatment wetlands (Wetland Treatment Systems No. 1, 2, and 3) to Nico Lake during closure. A linear interpolation was applied annually between the 2 sets of predictions for each source reporting to Nico and Peanut lakes during operations.

The 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. However, it generally would be expected that loading of chemical constituents in treated effluent discharges would remain similar to the average condition prediction, as higher concentrations due to evapoconcentration in drier years would be subject to lower volumes of mine water requiring treatment and discharge and, therefore, a lower discharge rate. In extremely dry conditions, zero discharge from the ETF is possible during early operations, and is expected to be achievable later in operations by temporarily suspending dewatering of the Open Pit. Furthermore, the average condition discharge rates were applied to a 26-year background surface water flow series that is expected to capture the range in receiving environment flow conditions.

Details on the methods, assumptions, inputs, and results of the site water quality model during operations and closure are provided in Appendix 7.II. The following key assumptions were used in the site water chemistry prediction modelling:

- fully mixed conditions were assumed in all Water Management Ponds;
- all Water Management Ponds were assumed to be oxidizing, limiting metal mobility from reductive transport;
- measured water quality constituents that were less than the analytical detection limit were assumed to be equal to the detection limit;
- only dissolved concentrations were simulated for the Water Management Ponds; and
- mineral precipitation and metal sorption processes were not permitted.

Two of these key assumptions are conservative. Using 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 will tend to overestimate constituent concentrations in the predictions. Estimated concentrations in seepages, treated effluent discharges, and waters influent to Wetland Treatment Systems, therefore, may be biased high (i.e., result in overestimation) for some constituents.

The potential influence of ammonia and nitrate mass release associated with mining activities was estimated based on the mining schedule and projected explosive use rate for the NICO Project. Ammonia and nitrate concentrations were determined on an annual basis for steady state and upper bound (worst case) conditions, with peak concentrations predicted in Year 5. The upper bound ammonia and nitrate concentrations predicted for Year 5 were carried forward to the effluent treatment option analysis and associated treated ETF effluent quality predictions, and conservatively applied to all seepage sources during operations.

Seepage losses were included in the water balance for the Plant Sump, Surge Pond, and SCPs, and the seepage flows and maximum of the predicted monthly chemical concentrations for each of the respective ponds were included as inputs to the GoldSim™ water quality model. However, Surge Pond and SCP dams will be lined to limit seepage out of these ponds, and ditches will be placed at the toe of the dams to intercept seepage escaping from these dams. Therefore, there is a moderate to high level of conservatism in including these seepages in the 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 (i.e., as observed in the Grid Ponds) was not included.

Some conservatism was similarly applied to the quality of the discharge from the Wetland Treatment Systems after closure, in that the predicted outflow quality is generally expected be better than the influent quality predictions that were applied to the outflows. However, influent concentrations were only adjusted to cap predicted exceedances of SSWQO concentrations at the respective objective concentrations. No further adjustments were applied due to uncertainty regarding the constituent-specific effectiveness of the planned passive treatment system. Therefore, predicted water quality at closure is expected to be conservative for constituents without SSWQO values.

Modelled Receiving Water Quality Predictions

Water quality predictions were presented and interpreted at the 95th 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 95th percentile prediction output would be representative of upper bound of concentrations during a dry year.

7.14 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 a 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 effects predictions, and where applicable and necessary, update effects 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 KLOI will include effluent characterization (i.e., physical, chemical, and toxicological characteristics), effluent plume modelling in Peanut Lake, water quality in Nico, Peanut, Burke, and Reference lakes and downstream locations in Marian River, and sediment quality in Peanut, Nico, Burke, and Reference lakes (Appendix 18.I, Section 18.I.3.1.1.5). More information regarding the AEMP can be found in Appendix 18.I.

7.15 References

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