8.5 AQUATIC ENVIRONMENT

The Aquatic Environment includes freshwater watercourses (rivers, lakes, and streams) that provide habitat for fish, benthic communities, and other aquatic species. It is identified as a valued environmental component (VEC) based on its importance in supporting freshwater aquatic life as a fisheries resource, as food for other organisms (birds or mammals), and in providing recreational opportunities, all of which are of importance to the public, stakeholders, and Aboriginal communities. The Aquatic Environment is protected through the federal *Fisheries Act* and other federal and provincial laws and other guidelines that are intended to protect or regulate the use of the Aquatic Environment and the species it supports.

The Project will be primarily located in the Napadogan Brook watershed, the major watershed considered as part of the Local Assessment Area (LAA, defined later) for this VEC. The Napadogan Brook watershed, which is part of the upper Nashwaak River watershed, includes several other named watercourses that include Bird Brook and Sisson Brook as well as numerous unnamed tributaries. A small portion of the Project is located in the McBean Brook watershed, which is also part of the upper Nashwaak River watershed. There is no known commercial fishery in the LAA, but there is a local recreational fishery that is used by both the public and Aboriginal persons for recreation and for subsistence, particularly for common species like brook trout. These watercourses offer generally suitable habitat for fish species that prefer cold water habitat (*i.e.,* Atlantic salmon, brook trout, and slimy sculpin) and warm water habitat (*i.e*., American eel, white sucker, longnose sucker, sea lamprey, blacknose dace, pearl dace, creek chub, common shiner, blacknose shiner). The habitat and the diversity of fish it contains does not differ substantially from other similar habitats that are common in Central New Brunswick.

The Project has the potential to affect the Aquatic Environment through changes in hydrology, fish habitat, water quality and quantity, productivity, usability of the fisheries resource, and the abundance and distribution of fish and benthic macroinvertebrate species. For convenience, the usability of the fisheries resource as it relates to the consumption by humans is addressed in the Public Health and Safety VEC, and as it relates to recreational fishing is addressed in the Land and Resource Use VEC.

The Project will affect the Aquatic Environment in the following important ways

- Development activities, such as the development of the tailings storage facility (TSF), preparation of the open pit, and relocation of the Fire Road, will result in the direct loss of fish habitat in Bird Brook, Sisson Brook, Tributary “A” to the West Branch Napadogan Brook, and a portion of some McBean Brook headwater tributaries.

- Development of the TSF and the open pit will result in displacement, mortality or active relocation of resident fish of Bird and Sisson brooks and other affected watercourses to other portions of the Napadogan Brook or Nashwaak River watershed.

- The retention of mine contact water in the TSF that was formerly the catchment of Sisson and Bird brooks during approximately the first seven years of Operation and again in the Closure phase, will result in the indirect loss or alteration of fish habitat in West Branch Napadogan Brook and Lower Napadogan Brook due to reduced flows downstream, and the creation of a partial barrier to fish passage at one location during extreme low flow conditions that are typical in the summer season.

- Seepage of water through the TSF embankments, and the release of treated surplus water from the water treatment plant, is predicted to result in increased concentrations of certain trace metals in downstream receiving waters during Operation and extending into the Closure and Post-Closure periods.

- The retention of mine contact water in the TSF, especially during Years 1-7 of Operation, may result in changes in dissolved oxygen (DO), temperature, pH, productivity, and benthic macroinvertebrate community in the downstream receiving waters.

As will be demonstrated in the assessment that follows and as further elaborated below, the environmental effects of the Project on the Aquatic Environment will be mitigated and not significant as follows.

- The loss of fish habitat will be compensated by restoring free-flow in the main stem of the Nashwaak River where an abandoned dam is currently considered a partial barrier to fish passage. This compensation will ensure that there is no-net-loss of productive fish habitat in accordance with Fisheries and Oceans Canada (DFO) policy and authorized under the *Fisheries Act*.

- Fish will be relocated from affected habitat prior to Construction activities to minimize fish mortality and facilitate productive use of habitat elsewhere.

- The mine waste and water management approach will maintain all mine contact water within the Project site in the TSF during Operation. The beneficial re-use of stored water from the TSF as process water in a closed cycle will minimize Project water demands on the Napadogan watershed. Potentially acid generating (PAG) tailings and waste rock will be stored under water in the TSF to effectively mitigate the potential for acid generation. The TSF embankments and associated water management systems will limit the amount of seepage that may enter surface waters.

- Surplus water stored in the TSF, and afterwards from the pit lake that will be formed during Closure of the mine, will be treated prior to release to comply with regulatory requirements, and monitored extensively to ensure that downstream water and environmental quality is not jeopardized by the Project.

- An adaptive management strategy and mitigation plan will be applied in the event that follow-up and monitoring identifies that seepage or treated surplus water releases lead to concentrations of metals in surface waters that pose a risk to ecological or fish health.

Construction activities will result in the direct loss of approximately 372 HADD units (where 1 unit = 100 m^2) of fish habitat. The direct loss is spread among Bird Brook (from the development of the TSF), Sisson Brook (from development of the TSF, open pit, and other components), McBean Brook (from the relocation of the Fire Road and, during the Project life, development of the open pit), and Tributary "A" to West Branch Napadogan Brook (from the development of the TSF), in descending order of magnitude. It is expected that the direct loss of fish habitat will be authorized by DFO under Section 35 of the *Fisheries Act* in order for the Project to proceed in view of the proposed mitigation, compensation, follow-up and monitoring, and adaptive management strategies proposed. Such authorization would include the requirement for compensation, subject to regulatory approval, with the objective of achieving no residual net loss of fish habitat.

During Construction, fish will be relocated from watercourses within the Project Development Area (PDA, defined later) to nearby watercourses containing suitable habitat within nearby sub-watersheds. Relocation may result in a temporary increase in fish density in the receiving watercourses where captured fish are deposited, though it is expected that fish will naturally relocate from these areas if necessary such that there is not a long-term burden on the available food source, shelter, and other habitats and therefore on fish health.

The fish species residing in the PDA, including brook trout, Atlantic salmon, and American eel, among others occur commonly throughout the region and habitat for them in the Nashwaak River watershed is abundant. The Construction activities are not anticipated to affect habitat that is limiting for any of the fish species currently residing therein,

Operation activities are projected to result in the indirect loss of approximately 123 HADD units of fish habitat in the residual stream segments of Bird Brook, Sisson Brook, and Tributary "A" to West Branch Napadogan Brook, in descending order of magnitude, due to decreased flow in these residual segments as a result of their smaller catchment area following Construction. Similarly, Operation activities will result in the indirect loss of approximately 67 HADD units of fish habitat in West Branch Napadogan Brook and Lower Napadogan Brook due to reduction in downstream flow arising from reduced flows from Bird Brook, Sisson Brook and Tributary "A". The projected indirect loss of fish habitat is expected to be authorized by DFO under the *Fisheries Act* concurrent with the direct loss of fish habitat compensation process.

Water quality modelling was conducted to predict the concentrations of various trace metals in the receiving waters as a result of the Operation, Closure, and Post-Closure of the Project (Section 7.6). Predictive modelling considered baseline concentrations of various trace metals in water in the LAA as measured through routine surface water monitoring, and considered the contributions to this baseline from the Project arising from seepage, and from the release of treated surplus water from the TSF. The predictive water quality modelling suggests that while concentrations of most parameters in receiving waters will meet the guidelines of various agencies to protect environmental quality during Operation, concentrations of some trace metals may intermittently and non-continuously exceed some of guidelines in receiving waters. Sediment quality may also be affected. The modelling involves a number of inherent conservatisms that would be expected to result in predictions that are likely to be over-estimates of what will actually occur (Section 7.6). However, the model assumptions do involve some level of uncertainty (see Section 7.6.3.4.1) that is addressed through follow-up and an adaptive management strategy to provide an early warning of undesirable change and of the need for appropriate additional measures to mitigate potential environmental effects. A robust Follow-up and

Monitoring Plan will monitor metals concentrations in groundwater, surface water, and fish tissue over time to compare against the model results and/or applicable guidelines, and an adaptive management mitigation plan will be applied if and as necessary.

The retention of water on the Project site will reduce stream flow in West Branch Napadogan Brook and Lower Napadogan Brook, particularly in Years 1-7 of Operation, and during Closure. A corresponding reduction in the size of thermal refugia will result both in the remaining portions of the streams themselves or in the thermal plume these streams create in the Napadogan Brook at their confluence. Temperature mapping of tributaries in the Napadogan Brook watershed has revealed that thermal refugia, with similar thermal and habitat characteristics as Bird and Sisson brooks, are distributed throughout these brooks and that the potential reduction in cold water refugia availability in the Sisson and Bird brooks will likely result in spatial re-distribution of the brook trout population (and other cold water species) into other tributaries of Napadogan Brook that continually provide thermal refugia during the summer months.

Dissolved oxygen concentrations in the Napadogan Brook may be slightly affected by the predicted increase in water temperature as described above. The average increase in water temperature is predicted to be from 0.2 to 1.4C° compared to the baseline condition, and the dissolved oxygen levels would still be considered suitable for supporting the fish species known to reside and migrate in this habitat. Similarly, the storage of PAG waste rock and tailings sub-aqueously in the TSF will effectively mitigate the potential for acid generation; thus, no downward movement in pH is predicted in the receiving waters.

During Years 1-7 of Operation, reductions in stream flow in West Branch Napadogan Brook below Bird Brook may result in a change in benthic macroinvertebrate abundance and community composition and a decrease in benthic macroinvertebrate community diversity and richness. Abundance or density may increase as a result of increased nutrient concentrations and resulting food resources, or decrease due to decreases in habitat availability and diversity, food quantity and quality, and/or changes in competition and predation. Benthic macroinvertebrate community composition may change as a result of the change in the habitat and the water velocity and the specific preferences of individual species; this in turn may decrease richness and diversity. The retention of water on the Project site may also result in changes to the periphyton community. It is predicted that the affected communities will be restored close to pre-Project conditions where it is affected by the Project through natural re-colonization during the times when water is being released from the Project site.

Fish passage conditions as a result of reduced stream flow and water depths were field-identified, and input into a model of future low water conditions. The model results indicated a negligible 1 cm reduction in water depth, with a single location where a partial barrier to fish greater than 13.5 cm in length may occur during extreme low flow events.

The potential changes to Atlantic salmon spawning habitat were considered and it was determined that the Project is not anticipated to result in changes to Atlantic salmon populations.

As demonstrated above and detailed in the sections that follow, when mitigation is considered, the Project will not result in significant adverse residual environmental effects (including cumulative environmental effects) on the Aquatic Environment. A follow-up program will be established to verify the environmental effects predictions, verify various model assumptions and results, and verify the

effectiveness of mitigation, and a monitoring program will be established to comply with applicable regulatory requirements, including the provincial Approval to Operate and the federal *Metal Mining Effluent Regulations.* The Follow-up and Monitoring Program will inform an adaptive management strategy should unanticipated environmental effects or changes be observed.

8.5.1 Scope of Assessment

This section defines the scope of the environmental assessment of the Aquatic Environment in consideration of the nature of the regulatory setting, issues identified during public and First Nations engagement activities, potential Project-VEC interactions, and existing knowledge.

8.5.1.1 Rationale for Selection of Valued Environmental Component, Regulatory Context, and Issues Raised During Engagement

The Aquatic Environment was selected as a valued environmental component (VEC) because of its value in the provision of fisheries resources, recreational opportunities, and as food for other organisms (birds or mammals), which are of importance to the public, stakeholders and Aboriginal communities, as well as to address provincial and federal regulatory requirements.

The regulatory requirements for the Project relating to the Aquatic Environment include, but are not limited to, the following federal and provincial legislation:

- *Fisheries Act* and associated regulations*;*
- *Species at Risk Act (SARA)*;
- New Brunswick *Species at Risk Act*; (NB *SARA*);
- New Brunswick *Fish and Wildlife Act*;
- New Brunswick *Clean Water Act* and associated regulations; and
- New Brunswick *Clean Environment Act* and associated regulations

The relevance of these acts and regulations, and their supporting policies, to the assessment of the Aquatic Environment is described in Section 8.5.1.5.

The Final Guidelines (NBENV 2009) for the environmental impact assessment (EIA) required an assessment of the environmental effects of the Project on the freshwater environment, including (but not limited to) water quality, fish and fish habitat, and benthic communities. The environmental effect of any potential changes in water quality and quantity on the freshwater environment was to be assessed, arising from the mineralogy of the deposit, tailings and waste rock over space and time. The EIA Terms of Reference (Stantec 2012a) outlined work plans for assessing environmental effects on the Aquatic Environment with a particular focus on the loss of fish habitat arising from the Project, changes to water quantity or quality in downstream watercourses, and potential environmental effects on fish and the fisheries resource. Characterization of the benthic macroinvertebrate communities, periphyton, and fisheries productivity were also to be assessed.

During public, stakeholder and Aboriginal engagement activities, the following general issues were raised regarding the relevance of the Aquatic Environment as a VEC:

- the potential environmental effects of the Project on Atlantic salmon, their habitat, and fish passage conditions;
- the potential environmental effects of the Project on brook trout and their habitat;
- the potential environmental effects of the Project on nearby lakes;
- the potential environmental effects of the Project on the aquatic ecosystem, and the terrestrial plants and animals that depend on it;
- the potential environmental effects of potential acid rock drainage caused by the Project on fish and fish habitat;
- potential environmental effects of dustfall on water quality during the spring thaw; and
- the potential environmental effects of a failure of water management facilities, including the TSF, on fish and fish habitat.

These and other issues are considered in this section, where appropriate, with the exception of the potential for a failure of water management facilities which is addressed in Section 8.17.

8.5.1.2 Selection of Environmental Effect and Measurable Parameters

The environmental assessment of the Aquatic Environment is focused on the following environmental effect:

- Change in the Aquatic Environment.

The Project has the potential to affect the Aquatic Environment through changes in hydrology, fish habitat, water quality and quantity, productivity, usability of the fisheries resource, and the abundance and distribution of fish and macroinvertebrate species. The aquatic environment is composed of many interlinked measurable parameters, where a change to a single parameter may affect many other parameters. In some cases, individual parameters are grouped where they are correlated or act together to affect the Aquatic Environment. Such is the case, for example, with the individual chemical parameters that comprise the “surface water quality” measurable parameter group.

The measurable parameters used for the assessment of the environmental effect noted above and the rationale for their selection is provided in Table 8.5.1.

Table 8.5.1 Measurable Parameters for Aquatic Environment

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
Change in the Aquatic Environment	Fish populations (catch per unit effort (CPUE) for qualitative sampling, population numbers estimated using regression method for quantitative sampling)	• Fish are protected under Section 32 of the *Fisheries Act*. Includes fish species assemblages and distribution, direct mortality, and productivity. The Project will result in changes in fish populations in Bird and Sisson brooks, and may affect fish populations in downstream watercourses.
	Fish habitat quality (multiple physical parameters as prescribed in the NBDNR/DFO method)	• Fish habitat quality directly determines many aspects of fish populations. The Project may affect fish habitat quality in downstream watercourses. The New Brunswick Department of Natural Resources (NBDNR)/Department of Fisheries and Oceans (DFO) has developed a methodology (known as the NBDNR/DFO method) for characterizing fish habitat through various physical parameters that include substrate composition, bankfull width, embeddedness, sinuosity, cover, etc.
	Fish habitat quantity (habitat area in 100 m^2 units)	• Fish habitat quantity has historically been the single most important determining factor for harmful alteration, disruption or destruction (HADD) compensation requirements. It is also important as a factor linked to fish population productivity. The Project will result in the loss of most fish habitat in Bird and Sisson brooks, and may result in the loss of some habitat in Napadogan Brook (downstream of Bird Brook) and McBean Brook due to reduced flow volumes.
	Surface water quality (multiple chemical parameters measured *in-situ* and/or analyzed in a laboratory, typically with units of µg/L)	• Surface water quality is strongly linked to fish habitat quality. Surface water quality is also linked to usability of the fisheries resource as a pathway for metals uptake in fish. The Project may result in an increase to dissolved metals in surface waters.
	Surface water quantity (as represented by flow in downstream watercourses, measured in m^3/s, and wetted perimeter area measured in m^2)	• Surface water quantity is strongly linked to fish habitat quantity. The results of the wetted perimeter study will be used to determine surface water quantity, and the measurable parameters will be flow and surface area in Napadogan Brook below Bird Brook.
	Sediment quality (multiple chemical parameters as determined in laboratory analyses, typically with units of mg/kg)	• Sediment quality is linked to fish habitat quality, in particular as it relates to the benthic community. Sediment quality is also linked to usability of the fisheries resource as a pathway for metals uptake in fish. The Project may increase/change metals concentrations in sediment.
	Periphyton community, measured as mass of periphyton per unit area (mg/m^2) through the known sample volume and area of rocks sampled	• Periphyton communities are linked to fish habitat, and provide food for benthic invertebrates, which in turn provide food for fish communities. Information on the periphyton community was collected to provide information on the primary producer communities within the watercourses.
	Benthic macroinvertebrate community structure	• The benthic macroinvertebrate communities are linked to fish habitat and provide food for fish communities. The abundance and structure of the benthic macroinvertebrate communities can influence the assemblages and productivity of the fisheries resource. The Project may result in changes to the benthic macroinvertebrate communities in downstream receiving waters, which may affect fish populations that rely on the habitat for non-migratory purposes.

Table 8.5.1 Measurable Parameters for Aquatic Environment

Environmental Effect	Measurable Parameter	Rationale for Selection of the Measurable Parameter
	Bioaccumulation of metals in fish (carcass and whole fish, measured as metals concentrations in mg/kg)	• The Project may result in an increase in dissolved metals in surface waters, and these metals may bioaccumulate in fish tissue and be consumed by other fish, birds, wildlife, or humans.
	Presence/absence of aquatic species at risk (SAR) or species of conservation concern (SOCC)	• Atlantic salmon (Outer Bay of Fundy stock) and American eel are currently under review by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), and may also be reviewed by the new provincial committee under the NB *SARA*. The Project may affect populations or individuals of these or possibly other species.

8.5.1.3 Temporal Boundaries

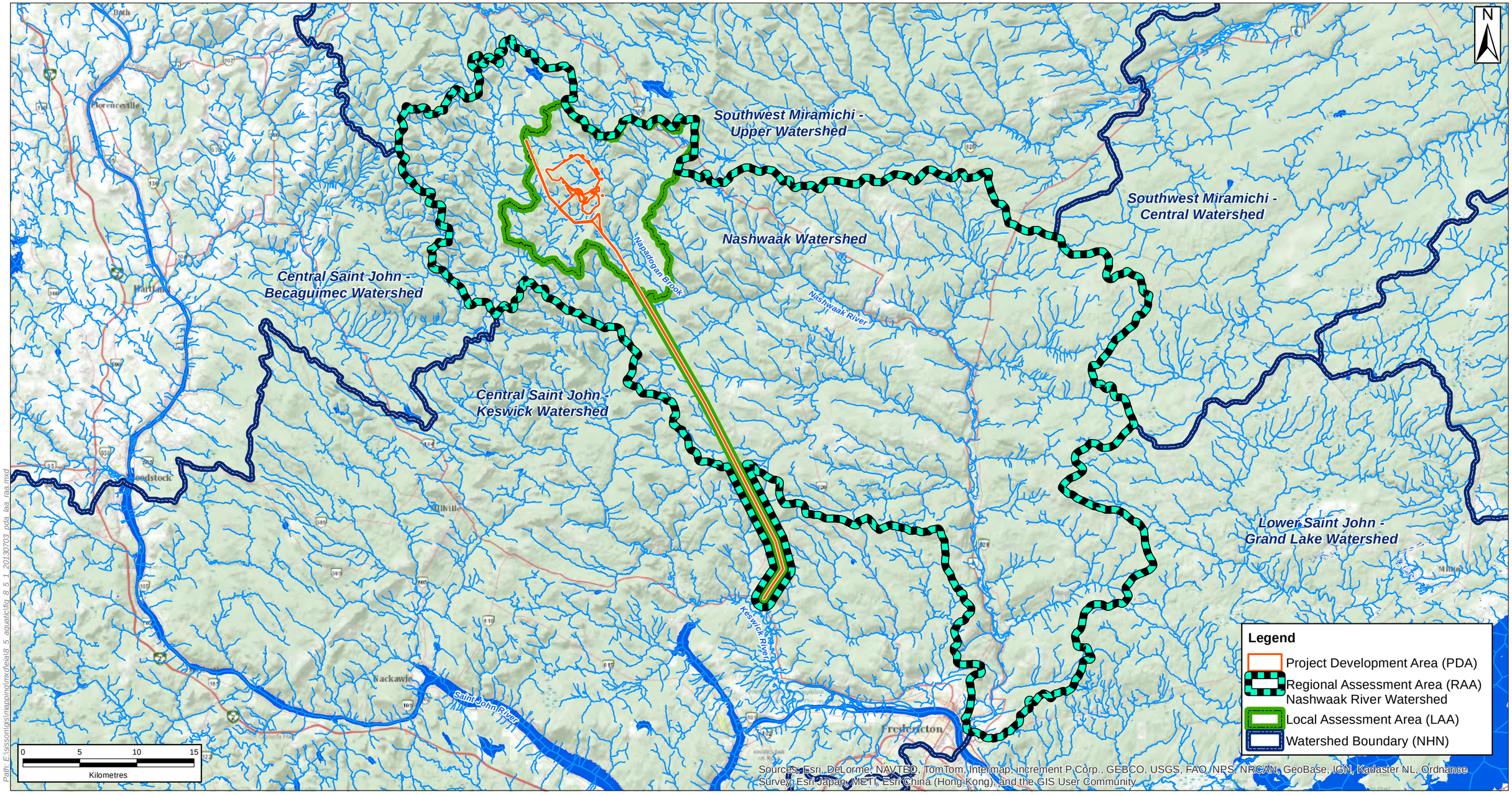
The temporal boundaries for the assessment of the potential environmental effects of the Project on the Aquatic Environment include the three phases of Construction, Operation, and Decommissioning, Reclamation and Closure (including Post-Closure), as described in Chapter 3.

8.5.1.4 Spatial Boundaries

The spatial boundaries for the environmental effects assessment of the Aquatic Environment are defined below and shown in Figure 8.5.1.

Project Development Area: The PDA is the most basic and immediate area of the Project, and consists of the area of physical disturbance associated with the Construction and Operation of the Project. Specifically, the PDA consists of an area of approximately 1,253 hectares that includes: the open pit; ore processing plant; storage areas; TSF; quarry; the relocated Fire Road and new Project site access road; and new and relocated and expanded power transmission lines. The PDA is the area represented by the physical Project footprint as detailed in Chapter 3. The PDA includes most of the fish habitat in Sisson and Bird Brooks, and a portion of three small tributaries to McBean Brook, and a portion of a small unnamed tributary to West Branch Napadogan Brook.

Local Assessment Area: The LAA is larger in extent than the PDA and includes the watersheds transited by the new electrical transmission line and access roads, and associated with upgrades to existing infrastructure (*e.g.*, roads, bridges, culverts) where watercourses may be directly or indirectly affected by the Project. The LAA includes the PDA and any adjacent areas where Project-related environmental effects may reasonably be expected to occur. In addition to the watercourses listed above as part of the PDA, the LAA also includes particularly the Napadogan and McBean brooks that are potentially the most affected by the Project. The spatial distribution of these environmental effects will be analyzed as far as is required to assess consequent environmental effects on aquatic organisms. For example, the potential environmental effects of the transmission line are limited to the PDA given the limited Project interaction and the standard mitigation to be applied during Construction and Operation. Environmental effects related to changes in water resources for human use were assessed in Section 8.4.



Path: E:\sisson\gis\mapping\mxd\eia\8_5_aquatic\fig_8_5_1_20130703_pda_laa_raa.mxd

NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Project Development Area (PDA), Local Assessment Area (LAA), and Regional Assessment Area (RAA) for the Aquatic Environment

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Northcliff Resources Ltd.

Scale:	Project No.:	Data Sources:	Fig. No.:
1:325,000	121810356	NBDNR NHN NBADW	8.5.1

Date: (dd/mm/yyyy):	Fig. By:	Appd. By:
03/07/2013	JAB	DLM

Coordinate System: NAD 1983 CSRS New Brunswick Stereographic

Regional Assessment Area: The RAA is the area within which the Project's environmental effects may overlap or accumulate with the environmental effects of other projects or activities that have been or will be carried out. For the Aquatic Environment, the RAA is defined as the Nashwaak River watershed, within which cumulative environmental effects may occur, and a 200 m-wide corridor which includes the 75 m right-of-way of the transmission lines where they traverse other watersheds. The extent to which cumulative environmental effects to the Aquatic Environment may occur depends on physical and biological conditions and the type and location of other past, present, or reasonably foreseeable future projects or activities that have been or will be carried out, as defined within the RAA.

8.5.1.5 Administrative and Technical Boundaries

Administrative and technical boundaries to the assessment of the Aquatic Environment include applicable federal and provincial legislation, federal water quality guidelines, and technical limitations of survey methods and equipment. These boundaries influence the scope of the assessment, the scope of the data collection surveys, the interpretation of results, mitigation measures, and the determination of significance.

8.5.1.5.1 Administrative Boundaries

The environmental effects of the Project on the Aquatic Environment are largely focused on fish and fish habitat as defined in the *Fisheries Act* before it was amended in 2012, as further discussed in the *Fisheries Act* sub-section below. For the purpose of the EIA, the following definitions will apply.

- Freshwater fish refers to fish (as defined in Section 2 of the *Fisheries Act*) that live in freshwater during at least part of their life cycle. As defined in the *Fisheries Act*, *"fish includes (a) parts of fish, (b) shellfish, crustaceans, marine animals and any parts of shellfish, crustaceans or marine animals, and (c) the eggs, sperm, spawn, larvae, spat and juvenile stages of fish, shellfish, crustaceans and marine animals."*

- As defined in Section 34(1) of the *Fisheries Act*, *"fish habitat includes spawning grounds and nursery, rearing, food supply and migration areas on which fish depend directly or indirectly in order to carry out their life processes"*. Fish habitat is assumed to include the physical (*e.g.,* substrate/sediment, temperature, flow velocity and volumes, water depth), chemical (*e.g.,* water quality), and biological (*e.g.,* fish, benthic macroinvertebrates, periphyton, aquatic macrophytes) attributes of the Aquatic Environment that are required by fish to carry out their life cycle processes.

The Aquatic Environment includes all fish as defined in the *Fisheries Act* and also includes freshwater species at risk and species of conservation concern (*i.e.,* those species that live for large parts of their life cycle in freshwater, and that have been identified by federal or provincial agencies as being rare, threatened or otherwise endangered). Ecologically sensitive, protected areas and critical habitat features of the aquatic environment are included in the assessment.

Administrative boundaries for the Aquatic Environment are further defined below.

Fisheries Act

DFO has the overall responsibility for the administration of the *Fisheries Act*, which provides the necessary provisions to protect fish and fish habitat in Canadian waters. Environment Canada has overall responsibility for the administration of the provisions of the *Fisheries Act* that relate to the release of deleterious substances in waters frequented by fish (Section 36).

On June 29, 2012, with the passing of Bill C-38, the *Fisheries Act* began a phased process of revision to several key sections, including Section 35 which previously protected fish habitat from harmful alteration, disruption or destruction (HADD). The process of revision is not yet complete, and new supporting policies or other guidance documentation is not yet available. Therefore, in keeping with the Final Guidelines (NBENV 2009) and Terms of Reference (Stantec 2012a), the assessment of the Aquatic Environment adheres to the pre-Bill C-38 *Fisheries Act* and the Policy for the Management of Fish Habitat (DFO 1986). The following sections of the *Fisheries Act* are of particular relevance to the assessment of the potential environmental effects of the Project on the Aquatic Environment:

- Section 32, administered by DFO, which prohibits the destruction of fish by any means other than fishing unless in accordance with the regulations or otherwise authorized by the Minister;
- Section 35, administered by DFO, which protects fish habitat from unauthorized HADD; and
- Section 36, administered by Environment Canada, which prohibits the deposit of a deleterious substance in waters frequented by fish unless in accordance with the regulations or otherwise authorized by the Minister of Environment.

Through Section 35, the loss or alteration of fish habitat may be authorized by DFO through the issuance of a HADD authorization in accordance with Policy for the Management of Fish Habitat (DFO 1986), and subject to suitable compensation as determined acceptable to DFO.

The *Metal Mining Effluent Regulations* (*MMER*), developed under Section 36 of the *Fisheries Act* and administered by Environment Canada, regulates the release of effluent, mine tailings, and waste rock produced during mining operations into fish bearing waters. *MMER* forms the basis of the federal mine effluent standards by, among other requirements, defining authorized limits for releasing selected deleterious substances from mining operations. In addition to limitations on pH, total suspended solids, and acute lethality, Schedule 4 of the *MMER* provides authorized discharge limits for eight deleterious substances, as shown in Table 8.5.2. It is noted that these discharge limits are currently under review.

Table 8.5.2 *MMER* Schedule 4 – Authorized Limits for Release of Deleterious Substances

Parameter	Maximum Authorized Monthly Mean Value	Maximum Authorized Value in a Composite Sample	Maximum Authorized Value in a Grab Sample
pH	6.0 ≤ pH ≤ 9.5	6.0 ≤ pH ≤ 9.5	6.0 ≤ pH ≤ 9.5
Acute lethality	Not acutely lethal	Not acutely lethal	Not acutely lethal
Arsenic (As)	0.50 mg/L	0.75 mg/L	1.00 mg/L
Copper (Cu)	0.30 mg/L	0.45 mg/L	0.60 mg/L
Cyanide (-CN)	1.00 mg/L	1.50 mg/L	2.00 mg/L
Lead (Pb)	0.20 mg/L	0.30 mg/L	0.40 mg/L
Nickel (Ni)	0.50 mg/L	0.75 mg/L	1.00 mg/L
Zinc (Zn)	0.50 mg/L	0.75 mg/L	1.00 mg/L
Total Suspended Solids (TSS)	15.00 mg/L	22.50 mg/L	30.00 mg/L
Radium-226 (Ra-226)	0.37 Bq/L	0.74 Bq/L	1.11 Bq/L

Notes:
1) All concentrations are total values.
2) Acute lethality tested according to Environment Canada Reference Method EPS 1/RM/13 for rainbow trout and EPS 1/RM/14 for *Daphnia magna*.

Source: *MMER* Schedule 4.

Canadian Council of Ministers of the Environment – Canadian Environmental Quality Guidelines for the Protection of Aquatic Life

The Canadian Council of Ministers of the Environment (CCME) has established environmental quality guidelines for contaminant concentrations in various environmental media, as established in its Canadian Environmental Quality Guidelines (CCME 1999). Relevant to the Aquatic Environment, the Canadian Environmental Quality Guidelines include the Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) (Table 8.5.3), hereinafter referred to as the "CCME FAL guidelines"; and the Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Freshwater) (Table 8.5.4) hereafter referred to as the "CCME SQG". Together, the CCME FAL guidelines and CCME SQG establish environmental quality guidelines for various parameters in freshwater systems to protect aquatic life. These guidelines do not have force of law. Sediments are compared against the probable effect level (PEL), which defines the level above which adverse effects are expected to occur frequently.

Table 8.5.3 CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) – Selected Limits Applicable to Soft Water (hardness < 60 mg/L)

Parameter	CCME Water Quality Guideline for the Protection of Freshwater Aquatic Life (CCME FAL Guideline) [a]
Aluminum (Al)	0.1 mg/L [b]
Arsenic (As)	0.005 mg/L
Cadmium (Cd)	0.004 - 0.017 µg/L [c]
Chromium (Cr)	0.001 mg/L [d]
Copper (Cu)	0.002 mg/L [e]
Iron (Fe)	0.30 mg/L
Lead (Pb)	0.001 mg/L [f]
Molybdenum (Mo)	0.073 mg/L
Nickel (Ni)	0.025 mg/L [g]
Selenium (Se)	0.001 mg/L
Silver (Ag)	0.0001 mg/L

Table 8.5.3 CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life (Freshwater) – Selected Limits Applicable to Soft Water (hardness < 60 mg/L)

Parameter	CCME Water Quality Guideline for the Protection of Freshwater Aquatic Life (CCME FAL Guideline) [a]
Thallium (Tl)	0.0008 mg/L
Zinc (Zn)	0.03 mg/L
pH	6.5 ≤ pH ≤ 9.0

Notes:
[a] CCME Canadian Water Quality Guidelines for the Protection of Freshwater Aquatic Life (abbreviated herein as CCME FAL guidelines). CCME (1999).
[b] At pH ≥ 6.5.
[c] Cadmium Guideline (µg/L) = 10^(0.86(log(hardness))-3.2), range given is representative of soft water.
[d] Chromium Guideline is for Cr(VI).
[e] Copper Guideline = 0.002 mg/L at hardness <120 mg/L, 0.003 mg/L at hardness 120-180 mg/L and 0.004 mg/L at hardness >180 mg/L.
[f] Lead Guideline = 0.001 mg/L at hardness <60 mg/L, 0.002 mg/L at hardness 60-120 mg/L, 0.004 mg/L at hardness 120-180 mg/L and 0.007 mg/L at hardness >180 mg/L.
[g] Nickel Guideline = 0.025 mg/L at hardness <60 mg/L, 0.065 mg/L at hardness 60-120 mg/L and 0.110 mg/L at hardness 120-180 mg/L and 0.150 mg/L at hardness >180 mg/L.

Table 8.5.4 CCME Canadian Sediment Quality Guidelines for the Protection of Aquatic Life (Freshwater)—Probable Effect Levels

Parameter	CCME Sediment Quality Guideline for the Protection of Freshwater Aquatic Life (CCME SQG (PEL)) [a]
Arsenic (As)	17 mg/kg
Cadmium (Cd)	3.5 mg/kg
Chromium (Cr)	90 mg/kg [b]
Copper (Cu)	197 mg/kg
Lead (Pb)	91.3 mg/kg
Mercury (Hg)	0.486 mg/kg
Molybdenum (Mo)	0.073 mg/L
Zinc (Zn)	315 mg/kg

Notes:
[a] CCME Canadian Sediment Quality Guidelines for the Protection of Freshwater Aquatic Life (abbreviated herein as CCME SQG). CCME (1999).
[b] Chromium Guideline is for total Cr.

Species at Risk Act

The protection of species at risk (SAR) is regulated by the federal *Species at Risk Act* (*SARA*), administered by Environment Canada. The purposes of *SARA* are:

- to prevent species from becoming extirpated or becoming extinct;
- to provide for the recovery of species that are extirpated, endangered, or threatened as a result of human activity; and
- to manage species of special concern to prevent them from becoming endangered or threatened.

General prohibitions of *SARA* include primarily Section 32(1) and Section 33. Section 32(1) states that no person shall kill, harm, harass, capture, or take an individual of a species that is listed as an extirpated, endangered, or threatened species. Section 33 states that no person shall damage or destroy the residence of one or more individuals of a species that is listed as an endangered or threatened species, or that is listed as an extirpated species if a recovery strategy has recommended the reintroduction of the species into the wild in Canada. In addition, critical habitat (defined as the habitat that is necessary for the survival or recovery of a listed species) may be defined and protected under Section 58. Only those species currently listed in Schedule 1 of *SARA* (*i.e*., those listed as "Extirpated", "Endangered", or "Threatened") are protected by the prohibitions of Sections 32-36 and 58. There is no known aquatic SAR in the LAA for the Project.

The process by which a species may become protected under *SARA* begins with a review by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Pending the results of the COSEWIC review, and subsequent regulatory actions, a species may be listed in Schedule 1 of *SARA* by ministerial decision. For example, the COSEWIC review of the Outer Bay of Fundy (OBoF) Atlantic salmon, which is native to the LAA, recommended that the species be classified as "Endangered". DFO is currently undertaking a Recovery Potential Assessment for the OBoF Atlantic salmon which will inform the listing decision by the Minister. Species that potentially occur within the LAA, for which a COSEWIC classification has been made, but which are not yet on Schedule 1 of *SARA*, include:

- Outer Bay of Fundy Atlantic salmon (*Salmo salar*; "Endangered", status A2b); and
- American eel (*Anguilla rostrata*; "Threatened", status A2b).

Additionally, the following Schedule 1 listed species were identified (Section 8.5.2.2 – Aquatic Species of Conservation Concern) as having the potential to occur within the LAA:

- pygmy snaketail (*Ophiogomphus howei*; "Special Concern"), a dragonfly;
- brook floater (*Alasmidonta varicose*; "Special Concern"), a freshwater mollusk;
- yellow lampmussel (*Lampsilis cariosa*; "Special Concern"), a freshwater mollusk; and
- prototype quillwort (*Isoetes prototypus*; "Special Concern"), an aquatic plant.

For the purpose of the EIA, these six species are considered as species of conservation concern (SOCC) under *SARA*.

New Brunswick *Species at Risk Act*

The protection of aquatic SAR is also regulated by the New Brunswick *Species at Risk Act* (NB *SARA*), which shares many similarities with the federal *SARA*. NB *SARA* is administered by the New Brunswick Department of Natural Resources (NBDNR) and applies to only those species listed within its Schedule A (as contained in the *List of Species at Risk Regulation 2013-38*), which is populated based on the previous New Brunswick *Endangered Species Act* (now repealed), and the status designations of COSEWIC for those species that reside in New Brunswick. However, unlike the federal *SARA* in which all species listed in Schedule 1 are protected by the prohibitions, a species on

Schedule A of NB *SARA* is not protected until a “protection assessment” has been completed, and the relevant prohibitions specified. Schedule A currently includes the following species:

- Outer Bay of Fundy Atlantic salmon (“Endangered”; protection assessment not completed);
- American eel (“Threatened”; protection assessment not completed);
- prototype quillwort (“Endangered”; prohibitions enacted under the *Prohibitions Regulation 2013-39*);
- pygmy snaketail (“Special Concern”; protection assessment not completed);
- brook floater (“Special Concern”; protection assessment not completed); and
- yellow lampmussel (“Special Concern”; protection assessment not completed).

Protection assessments have not been completed for any of these species, thus there are no prohibitions in place with the exception of prototype quillwort. For the purpose of the EIA, Atlantic salmon, American eel, and prototype quillwort are considered as SAR under NB *SARA*, and SOCC under *SARA*. The pygmy snaketail, brook floater, and yellow lampmussel are considered as SOCC under NB *SARA* and *SARA*.

New Brunswick *Fish and Wildlife Act*

Recreational fishing in New Brunswick is governed by the *Fish and Wildlife Act*, administered by NBDNR and its *General Angling Regulation*. Under the Act, angling licenses are required for recreational fishing for both residents and non-residents. Bag limits and prohibitions of fishing certain species in designated areas are also provided. Angling licenses provide angling opportunities to New Brunswickers while managing fish populations for future use. There are 17 classes of angling licenses in New Brunswick. Anglers may choose to ice fish from January to the end of March, and/or angle for "salmon and all other species" or "all species except salmon" in the general (summer) angling season. Salmon anglers may choose to purchase a "retention license" which includes salmon tags and allows them to keep a limited number of grilse (small salmon) or they may choose a "Live Release" salmon licence which does not include salmon tags, therefore all salmon must be released. The "All Species - Except Salmon" licenses are valid for recreational angling of all species except Atlantic salmon.

Specific requirements for anglers including the designation of Recreational Fishery Areas (RFAs), the identification of species that can be fished in each RFA, and associated bag and retention limits, are identified in the publication entitled “Fish 2013: A Part of our Heritage” (NBDNR 2013).

New Brunswick *Clean Water Act—Water Classification Regulation*

The *Water Classification Regulation* was promulgated in 2002, and gives the New Brunswick Minister of Environment the authority to classify all or any portion of the water of a watercourse as belonging to a particular class of water, for the purposes of managing or protecting water quality and associated aquatic life. Schedule A of the *Water Classification Regulation* defines the permitted activities and provides standards for receiving water quality within each class of watercourse designated by the Minister. However, no discharge limits from specific point sources are specified in these regulations.

Once a watercourse is classified by the Minister, the Regulation establishes environmental quality criteria for certain parameters in the receiving environment (*e.g.,* suspended solids, nutrients, dissolved oxygen) and may limit certain activities *(e.g.,* the creation of a new mixing zone), depending on the classification. Although many watercourses have been provisionally classified (*i.e.,* proposed) under the Regulation, no rivers and streams other than those within designated drinking water supply areas (Class AP) have been formally classified. All lakes, ponds and impoundments have been classified as Class AL.

A mixing zone is defined in the Regulation as "the immediate area within the receiving water of a watercourse, where a contaminant being released into the receiving water is initially diluted". The Regulation allows for the creation of a new mixing zone in water classified under the Regulation, if the mixing zone at all times meets water quality standards set out in Schedules A and B of the Regulation (limited to dissolved oxygen, *e. coli*, faecal coliform, and trophic status) . Neither the Nashwaak River nor any of its tributaries have been formally classified by the Minister to date, and thus the Regulation has no relevance to the Project at this time and is thus not discussed further in relation to this VEC.

New Brunswick *Clean Environment Act—Water Quality Regulation*

The *Water Quality Regulation* is the main regulatory instrument in New Brunswick for regulating the release of effluents to the waters of the province. Section 3(1) of the regulation requires that any source of contaminants that may directly or indirectly cause water pollution or release of contaminants to the waters of the province must apply for and obtain a Certificate of Approval under that regulation.

The Regulation defines "water pollution" as "*(a) any alteration of the physical, chemical, biological or aesthetic properties of the waters of the Province, including change of the temperature, colour, taste or odour of the waters, or (b) the addition of any liquid, solid, radioactive, gaseous or other substance to the waters of the Province or the removal of such substance from the waters of the Province, which renders or is likely to render the waters of the province harmful to the public health, safety or welfare or harmful or less useful for domestic, municipal, industrial, agricultural, recreational or other lawful uses or harmful or less useful to animals, birds or aquatic life.*"

The activities related to the operation of the source must be conducted in accordance with all terms and conditions outlined in the Approval. Approvals define site-specific requirements for individual facilities, including testing and monitoring, discharge limits, reporting, emergency response, and environmental management measures.

New Brunswick *Clean Water Act—Watercourse and Wetland Alteration Regulation*

Fish habitat is indirectly protected under the *Watercourse and Wetland Alteration Regulation 90-80* (WAWA Regulation). Under the WAWA Regulation, permits are required for vegetation clearing, soil excavation, construction or landscaping activities within 30 m of a watercourse.

8.5.1.5.2 Technical Boundaries

Technical boundaries for the Aquatic Environment include the temporal and spatial limitations of the field surveys, the effectiveness of methods and equipment used for data collection, seasonal variations affecting flows and water quality, and the detection limits of analytical instruments and processes.

Scientific limitations in the prediction of water quality results in the receiving environment, and associated prediction of environmental effects on fish and fish habitat, are a technical boundary in that the generation of source terms for the modelling and the complex physics of the fate and transport processes upon which model predictions are based are difficult to simulate numerically. Thus, interpretation and use of the results generally rely substantially upon the professional judgment of the study team. As with any model, there is also some inherent uncertainty in the results as models are simplified or idealized representations of what are complex physical phenomena. The source term estimates and modelling results are nonetheless conservative.

The technical boundaries are further described in the description of the methods (including in Stantec 2012d), results, and throughout the assessment as necessary.

8.5.1.6 Residual Environmental Effects Significance Criteria

As outlined in the Terms of Reference (Stantec 2012a), with respect to fish habitat, a significant adverse residual environmental effect on the Aquatic Environment will be defined as one that results in an unmitigated or uncompensated net loss of fish habitat as defined under the *Fisheries Act* and its associated no-net-loss policy. Such an environmental effect may alter the aquatic environment physically, chemically, or biologically, in quality or extent, that could include, for example, exceeding long-term CCME FAL guidelines (CCME 1999; and updates where relevant). A significant adverse residual environmental effect on fish habitat would also result from a discharge of a deleterious substance into fish habitat that is not authorized through the *MMER* and which would result in a violation of Section 36 of the *Fisheries Act*. A significant adverse residual environmental effect on fish habitat would also result from an unapproved Project-related alteration of water quality that would constitute water pollution as defined in the New Brunswick *Clean Environment Act*, or where applicable, violated the *Water Classification Regulation* of the New Brunswick *Clean Water Act*.

For fish populations, a significant adverse residual environmental effect on the Aquatic Environment would result from a Project-related destruction of fish that was not authorized under Section 32 of the *Fisheries Act*. However, it is recognized that the separation of fish and fish habitat is somewhat artificial, and that fish populations are also protected and sustained by protecting fish habitat, as explained above.

For aquatic species at risk or species of conservation concern, a significant adverse residual environmental effect on the Aquatic Environment will be defined as:

- one that alters the freshwater aquatic habitat within the assessment area physically, chemically, or biologically, in quality or extent after taking into consideration appropriate mitigation or compensation, in such a way as to cause a change or decline in the distribution or abundance of a viable population that is dependent upon that habitat such that the long-term survival of these rare, uncommon and/or non-secure population(s) within the Nashwaak River watershed is unlikely; or

- one that results in the direct mortality of individuals or communities such that the long-term survival of these rare, uncommon and/or non-secure population(s) within the Nashwaak River watershed is unlikely; or

- one that results in a non-permitted contravention of any of the prohibitions stated in Sections 32-36 of *SARA*; or

- in the case of species of special concern listed in Schedule 1 of *SARA*, where the Project activities are not in compliance with the objectives of management plans (developed as a result of Section 65 of *SARA*) that are in place at the time of relevant Project activities.

For the purposes of this EIA, "assessment area" referred to above is defined as the LAA.

8.5.2 Existing Conditions

This section provides a summary of the existing conditions within the PDA and the LAA, including:

- the physical aquatic habitat (physical habitat characteristics, surface water quality, and trace metal levels in surface water and sediments);

- the biological communities and their characteristics (periphyton, benthic macroinvertebrate communities, fish species distribution, abundance, and metal levels in the tissue); and

- SAR and SOCC.

Prior to the description of the existing conditions, a high-level description of the general setting is provided as context, and the methods used to characterize baseline conditions are also generally described. The summary of existing conditions provided herein has been adapted from the report entitled "Sisson Project: Baseline Aquatic Environment Technical Report" (Stantec 2012d), supported by several addenda, developed for the Project. For clarity and brevity, the entire contents of those documents are not provided here but rather summarized at a relatively high-level to provide a focused, concise summary of the existing conditions in the LAA as required to provide a basis for understanding the focused environmental effects assessment of the Project on the Aquatic Environment. The reader is referred to Stantec (2012d) and associated documents for a more comprehensive description of existing conditions in the LAA as documented by background research and field studies carried out in support of this EIA.

8.5.2.1 General Setting

The Project is located mostly within the Napadogan Brook watershed (Figure 8.5.2), while a small portion is within the McBean Brook watershed. Napadogan Brook and McBean Brook are tributaries of the Nashwaak River, which enters the St. John River at the city of Fredericton, New Brunswick.

The Nashwaak River watershed is located in the Beadle Ecodistrict, in the Southern portion of the Madawaska Uplands in the Central Uplands Ecoregion. This ecoregion is at a relatively higher elevation than other ecoregions in New Brunswick, resulting in slightly cooler temperatures and higher precipitation amounts than are generally found in the neighbouring areas (NBDNR 2007). The Nashwaak River watershed is approximately 1,700 km^2 of the 54,500 km^2 St. John River watershed, and the river is approximately 110 km in length (NWAI 2003). It is similar to other areas in rural New Brunswick, where the vast majority of the land is forested or wetland, with relatively small amounts of land used for development.

Recreational fisheries (NBDNR 2013) exist within the Nashwaak River and some of its tributaries for species other than Atlantic salmon, for which there is no permissible fishery. For example, there is an open season for smallmouth bass from May 1 to October 15 and for brook trout from April 15 to September 15. Fishing is also permitted for non-regulated fish during periods of the year when a sport fishery is open.

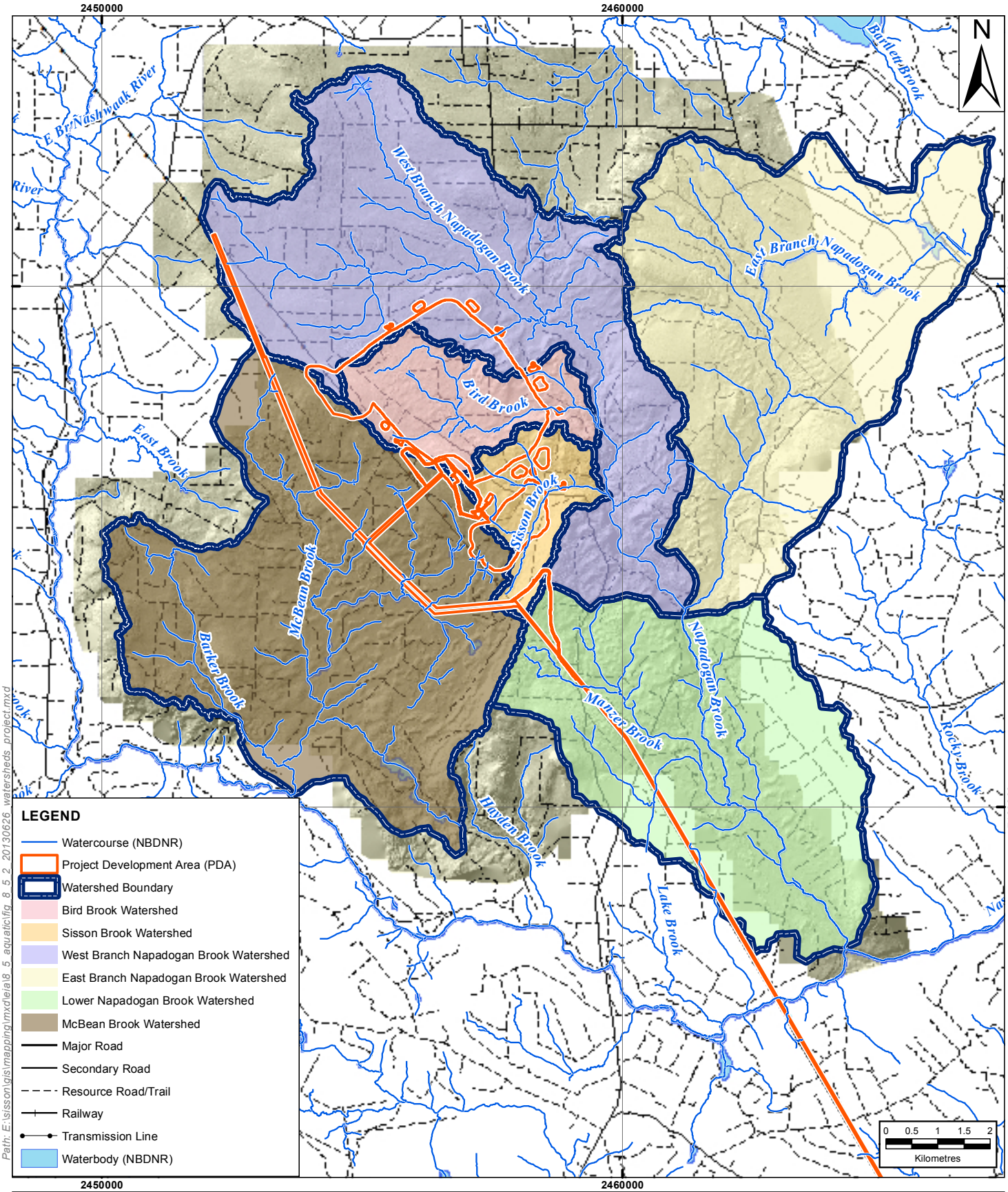
The following fish species (derived from CRI (2011); Scott and Crossman (1985); and Francis (1980)) may be present in the Nashwaak River, depending on the season: Atlantic salmon (*Salmo salar*); brook trout (*Salvelinus fontinalis*); burbot (*Lota lota*); American eel (*Anguilla rostrata*); alewife (*Alosa pseudoharengus*); muskellunge (*Esox masquinongy*); chain pickerel (*Esox niger*); American shad (*Alosa sapidissima*); rainbow smelt (*Osmerus mordax*); striped bass (*Morone saxatilis*); white perch (*Morone americana*); whitefish (*Coregonus sp.*); yellow perch (*Perca flavescens*); brown bullhead (*Ictalurus nebulosus*); shortnose sturgeon (*Acipenser brevirostrum*); Atlantic sturgeon (*Acipenser oxyrinchus*); lake chub (*Couesius plumbeus*); blacknose dace (*Rhinichthys atratulus*); creek chub (*Semotilus atromaculatus*); white sucker (*Catostomus commersoni*); longnose sucker (*Catostomus catostomus*); fallfish (*Semotilus corpalis*); common shiner (*Notropis cornutus*); ninespine stickleback (*Pungitius pungitius*), and sea lamprey (*Petromyzon marinus*).

8.5.2.2 Methods for the Characterization of Baseline Conditions

Various government agencies and stakeholder groups were consulted regarding the availability of existing information within the PDA and LAA. While some general information on existing conditions in the LAA was available, specific information sufficient to support an EIA was not. Therefore, a robust field-based data collection program was undertaken over two years, supported by the collection and analysis of current remote sensing imagery.

The majority of the aquatic environment field program to characterize existing conditions for this EIA was undertaken in 2011 (Stantec 2012d), based on the PDA as it was defined at that time and with a particular focus on the mine site (*i.e.,* the areas of the open pit, TSF, quarry, and processing plant) and adjoining watercourses. Subsequent to the 2011 field program, the PDA was reduced in size, and the current PDA is entirely within the outline of the PDA as was originally conceived in the CEAA Project Description (Stantec 2011); as a result, the 2011 aquatic field program collected information from the full extent of the PDA as it is currently conceived. The 2011 aquatic field program developed to characterize existing conditions for this EIA consisted of the following components, focused primarily in Bird Brook, Sisson Brook, and McBean Brook watersheds:

- watercourse and watershed analysis;
- fish habitat overview and rapid bioassessment;
- detailed fish habitat and qualitative fish surveys;
- quantitative fish population assessment;
- surface water and sediment quality;
- trace metals in fish tissue;



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Watersheds within the Local Assessment Area (LAA) Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B. Client: Northcliff Resources Ltd.	Scale: 1:100,000	Project No.: 121810356	Data Sources: NBDNR, Leading Edge Geomatics Ltd.	Fig. No.: 8.5.2	Stantec
	Date: (dd/mm/yyyy) 26/06/2013	Dwn. By: JAB	Appd. By: DLM		

Map: NAD83 CSRS NB Double Stereographic

- environmental effects monitoring (EEM) baseline;
- benthic community;
- periphyton; and
- identification of aquatic SAR and SOCC.

The methods and results for the above components are described in detail in the Sisson Project Baseline Aquatic Environment Technical Report (Stantec 2012d).

Additional aquatic surveys were undertaken in 2012 in watercourses that may potentially be affected by the linear facilities for the Project (*i.e.,* access road, new 138 kV electrical transmission line supplying electrical power to the Project site, relocation of the existing Fire Road, and relocation of an existing 345 kV electrical transmission line). In addition, other supplemental work to the 2011 aquatic field program was undertaken in 2012 in response to regulatory and stakeholder feedback on the results of the 2011 aquatic field program. The 2012 aquatic field program included the following components:

- a second year of EEM baseline, not including benthic macroinvertebrates;
- detailed fish habitat and quantitative fish population survey of watercourses within the linear facilities corridor where relocations around the Project site are required;
- identification of potential “pinch points” for fish passage under low flow conditions downstream of the PDA; and
- evaluation of the presence of brook trout habitat in other sub-watersheds proximal to the PDA.

Some detail on these additional surveys is provided below, since they have not previously been described in the Baseline Aquatic Environment Technical Report (Stantec 2012d).

Detailed Fish Habitat and Quantitative Fish Population Survey of Watercourses within the Linear Facilities Corridor

Nine watercourses that partially or fully intersect the linear facilities features (Figure 8.5.3) were surveyed from August 27 to 30, 2012. The surveys included the following components:

- watercourse and watershed analysis;
- detailed fish habitat and qualitative fish surveys;
- qualitative fish population assessment;
- surface water and sediment quality; and
- identification of aquatic SAR and SOCC.

The components were carried out following the same methods applied during the 2011 aquatic field program (as reported in Stantec 2012d). An electrofishing survey was conducted at up to two stations

along each watercourse where field conditions were suitable (*e.g.*, wetted or dry channel conditions) and depending on the length of the watercourse in the linear facilities corridor (*i.e.*, one electrofishing site for every 100 m of stream within the corridor). There were a total of eight electrofishing stations spread between five different watercourses.

In addition to the nine watercourses crossing the linear facilities corridor, an approximately 600 m section of McBean Brook runs parallel to the edge the corridor (Figure 8.5.3). As this watercourse was mostly outside of the corridor, a walkover survey was carried out on the whole length of the stream to establish the type and quantity of aquatic habitat found in this portion of the watercourse. A habitat survey and *in situ* water quality measurements were conducted approximately every 100 m of the watercourse, but no electrofishing surveys were conducted.

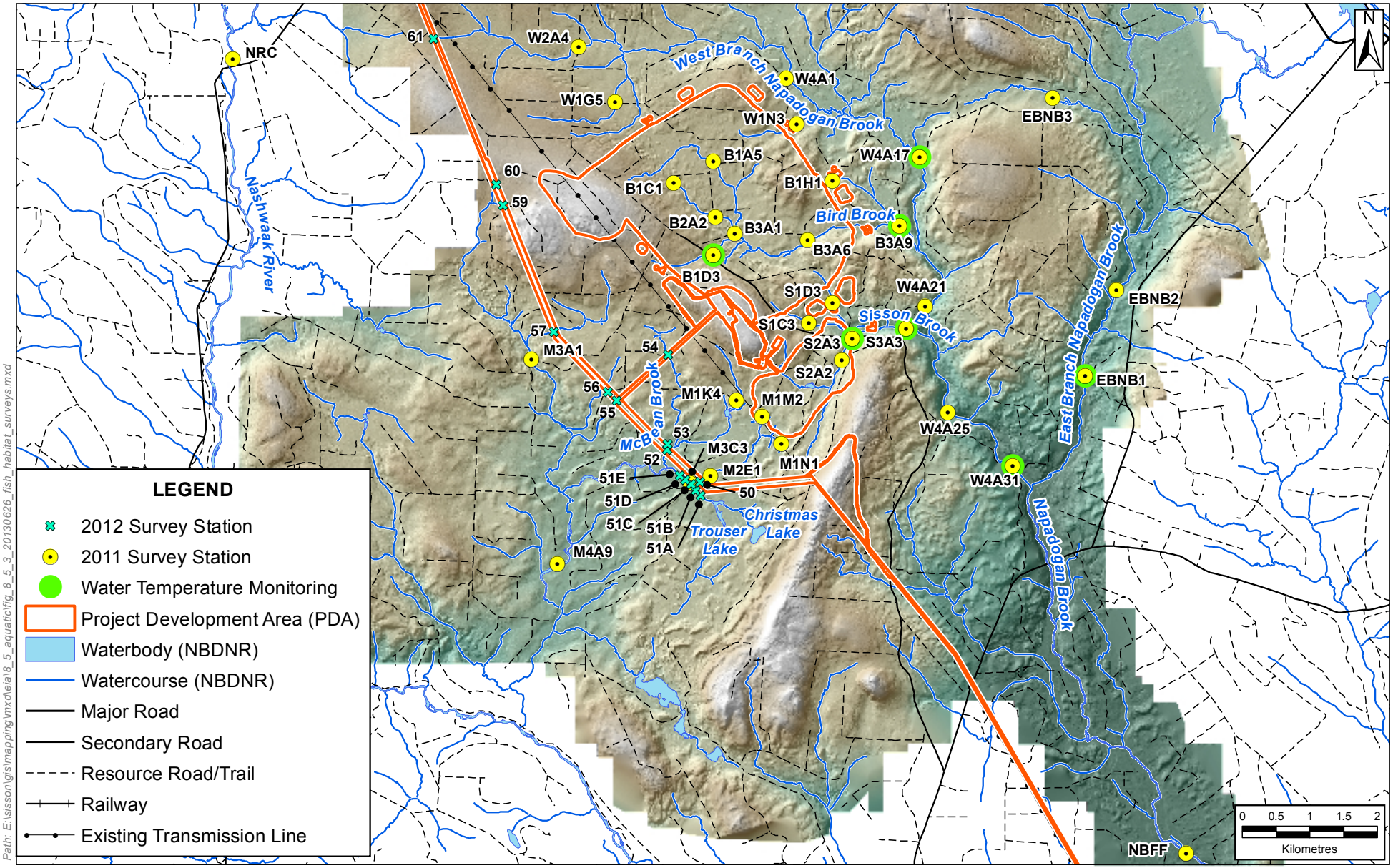
Identification of Potential "Pinch Points" for Fish Passage Under Low Flow Conditions Downstream of the PDA

To identify areas that may restrict fish movements as a result of reduced water depths, a walkover of lower Napadogan Brook was conducted during summer low flow conditions on July 16-17, and July 31, 2012. The survey, conducted in response to stakeholder concerns that withholding of water by the Project could exacerbate low flow conditions downstream, started at the confluence of Bird Brook and West Branch Napadogan Brook, and ended at the confluence of Napadogan Brook with the Nashwaak River. Any location where fish passage may be obstructed or impeded during extreme low flows was described, photographed, and water depths were measured across the shallowest part of the survey location. Potential fish passage barriers were categorized as follows:

- those caused by shallow depths from increased channel width (*e.g.,* riffles);
- those caused by abrupt changes in stream gradient (*e.g.,* a fall or drop); and
- tributaries that could become perched or disconnected due to reduced flows.

Evaluation of the Presence of Brook Trout Habitat in Other Sub-Watersheds Proximal to the PDA

This work was intended to determine the likely extent of brook trout habitat available in the portion of the Napadogan Brook watershed that will not be affected by the Project, in response to stakeholder concerns that the portions of Bird Brook and Sisson Brook that will be affected by the Project may provide some of the best brook trout habitat in the Napadogan Brook watershed. Key physical habitat characteristics (*i.e.,* gradient, sinuosity and riparian cover, and temperature) of Bird and Sisson brooks were compiled by stream order for comparison with the probable habitat characteristics of other watercourses in the Napadogan watershed as determined through LiDAR habitat analysis. The LiDAR habitat analysis estimated gradient, sinuosity and riparian cover for the other watercourses in the Napadogan Brook watershed, and *in situ* water temperature measurement at 50 locations throughout the Napadogan Brook watershed was used to characterize peak summer water temperatures. Water temperature was recorded on August 7-8, 2012, and these values were then correlated to a water temperature logger (miniPAT, VEMCO) at Bird Brook to account for differences in the water temperatures collected on different days or at different times of day.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Fish and Fish Habitat Survey Stations

Sisson Project:
Environmental Impact Assessment (EIA) Report, Napadogan, N.B.

Client: Northcliff Resources Ltd.

Scale:	Project No.:	Data Sources:	Fig. No.:
1:80,000	121810356	Leading Edge Geomatics NBDNR	8.5.3

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26/06/2013	JAB	DM

Stantec

Map: NAD83 CSRS NB Double Stereographic

8.5.2.3 Description of the Existing Aquatic Environment

This section describes the general baseline conditions of the aquatic environment of watercourses within the RAA (including the PDA and LAA). A brief explanation of fish habitat characteristics is presented, followed by a short summary of those characteristics for each main watercourse within the LAA. A summary of fish species assemblage and distribution throughout the LAA, as well as identified SOCC, is then presented. For a more detailed presentation and comprehensive analysis of the baseline conditions, the reader is referred to the reports entitled "Sisson Project: Baseline Aquatic Environment Technical Report" (Stantec 2012d) and "Baseline Water Quality Report, Sisson Project" (Knight Piésold 2012e), and the results of the Baseline Aquatic Field Surveys of the corridor for the Fire Road relocation (Stantec 2013f, in press).

8.5.2.3.1 Fish Habitat

Fish habitat is characterized through various physical parameters (*e.g.,* temperature, water depth, flow, substrate type, cover) and chemical parameters (*e.g*., dissolved oxygen concentration, pH, and concentration of dissolved metals) that are important to fish in their environment. These fish habitat parameters may collectively influence the speciation, population density and distribution, size, and age-class of fish that use the habitat. To aid in the understanding of the fish habitat in the LAA, some background information is provided below.

The geographic extent of a watershed, along with other factors such as climate and geology, influences the number and size of the watercourses contained within it, and consequently the quantity and quality of fish habitat. "Stream order" is a useful concept when considering fish habitat within a watershed. Headwater watercourses (where water is first collected in a defined channel) are assigned a stream order value of "1". If two watercourses of the same order meet they form a higher order watercourse. This concept is shown schematically in Figure 8.5.4 below.

Stream order generally correlates with the average size, temperature regime, and fish species assemblage found in the watercourse. Typically the lower stream orders are physically smaller, well oxygenated, and have colder temperatures, particularly during the summer when there is minimal precipitation input and the water volume in these low order streams is mostly from groundwater discharge. Lower order streams often provide limited habitat diversity and the shallow depths are not suitable for larger fish. As a result, lower order streams typically have low species diversity, with small cold-water fishes generally predominating. Moving downstream into medium and high stream orders (*i.e*., stream order 3 and greater), cool and warm-water fish gradually replace the cold-water species due to the relatively higher water temperatures.

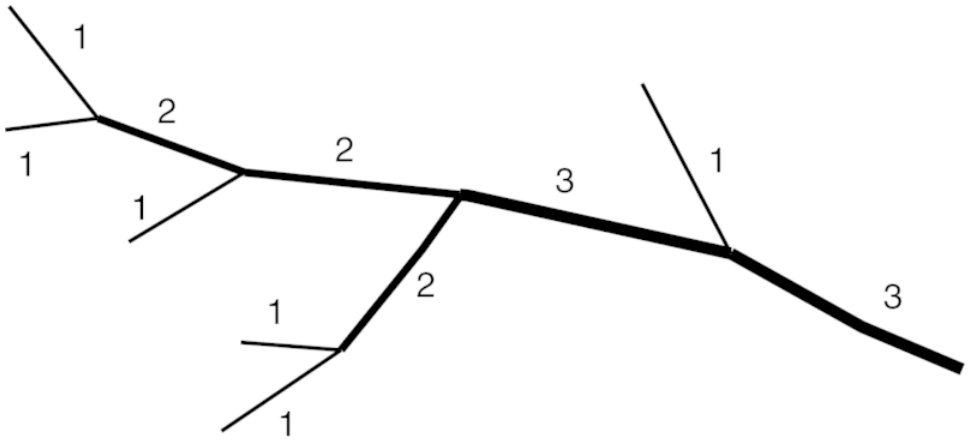


Figure 8.5.4 Schematic of Stream Order Concept

Substrate refers to the material forming the bottom of a watercourse and includes silt, sand, gravel, cobble, boulder, bedrock and woody debris or other organic material. Substrate is an important habitat feature that may provide refuge from predators or competitors, cover from physical disturbances, spawning habitat, and strongly influences the benthic community—a primary food source for fish.

Bank vegetation and woody debris, can provide cover for fish from predators in and out of the water, may provide shade from the sun, and may stabilize banks to reduce erosion. In general, the presence of bank vegetation and woody debris is considered to be a positive habitat characteristic.

Most aquatic organisms have a specific range of dissolved oxygen (DO), pH and temperatures within which they can successfully live. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. How much DO is needed depends on the species, its activity level and water temperature. Typically well-mixed water bodies (such as streams) have adequate amounts of oxygen to sustain aquatic life since DO concentrations increase wherever water flows over riffles and waterfalls. However, the decomposition of organic matter can occur in ponds and river sediments, reducing DO levels and making it difficult for some organisms to survive. Another physical process that affects DO is the temperature of the water. Since cold water can hold more DO than warm water, during the summer months when water temperatures are warmer, the ability of the water to hold more DO may be reduced. Low DO concentrations are rarely limiting in fast-flowing streams because the water is constantly being aerated by turbulence from riffles and falls, promoting lower temperatures and oxygen diffusion.

The geology of the watershed, the surrounding terrestrial or wetland vegetation cover, and the source of the water are the primary factors that influence the pH of the water. pH is a measure of the concentration of hydrogen ions in the water, with values ranging between 1 and 14; substances with pH less than 7 are acidic and substances with pH greater than 7 are basic (alkaline). The pH of most natural waters generally ranges between 6.5 and 8.5. The pH of water determines the solubility and biological availability of chemical constituents such as nutrients and heavy metals. Some species of fish are able to tolerate more acidic waters, while others (such as brook trout) are more sensitive to acidic waters. Generally, the early life stages (*e.g.,* eggs, yolk sack fry and fry) of most fish species are more

sensitive to lower pH than adults. At a pH of 5, eggs of most fish species are unable to hatch or develop normally.

Water temperature is important to aquatic life because it strongly influences the aquatic species that can live in a waterbody. Freshwater fishes are poikilothermic, meaning their body temperatures (and therefore their metabolic processes) are regulated by the temperatures of the surrounding environment. Each species has a preferred temperature range. If water temperatures get too far above or below this preferred range, individuals may exhibit health issues or may relocate where possible. In addition to variations in stream temperature caused by changing air temperatures, stream temperatures are also influenced by shoreline vegetation from shading, land-use practices such as vegetation clearing, water velocity, and the quantity of groundwater input.

Benthic macroinvertebrate communities are an important part of the aquatic food web. They represent a wide range of functional feeding groups, and are responsible for converting both non-living organic matter (*e.g.,* coarse and fine particulate matter, terrestrial plant detritus, and associated microbial assemblages) and living organic matter (including algal cells, microscopic multicellular animals, and other benthic invertebrates) into animal tissue that represents a major food resource for fish populations. The speciation and species diversity of a benthic macroinvertebrate community is an indicator of the longer-term overall health of the aquatic environment.

Periphyton is a form of biofilm, comprising a functionally-defined assemblage of algal and other species living attached to solid surfaces such as rocks or logs on the stream bed that produces a food supply for many aquatic organisms. The analysis of the periphyton community focuses on the algal species capable of using light energy as their primary energy source through photosynthesis. As a biofilm, the periphyton community also includes bacteria and fungi that degrade other living and non-living organic matter that is incorporated into the biofilm. In addition, the biofilm will contain small animals that feed on organic matter, bacteria, or algal cells present in the biofilm or filtered from the water.

Various metals in water may be toxic to fish or other aquatic life. Metals may bioaccumulate in the tissues of fish and other aquatic biota, a process whereby the resulting metal concentration in the animal tissue can become greater than what is present in the surrounding water. Metals may be dissolved or carried as particles in suspension in water, or be deposited or otherwise bonded to sediment particles. As a minor constituent of the water or sediment mass, they are referred to as “trace” metals. In a predominantly undeveloped setting as with the Project, the largest natural source of trace metals in surface waters is typically from the weathering of rocks and soils that contain these elements. Surface water may provide a pathway for these trace metals into the aquatic food web. Trace metal particles may also be deposited into substrate material where they accumulate over time, serving as long-term local sources of these metals that may, through re-suspension (or benthic uptake) affect the aquatic environment and the organisms living in it (CCME 1999).

With that general background established, a summary of the fish habitat in the PDA and LAA is provided below. For the fish habitat characterization of the portion of the PDA to be covered by the mine, the data obtained during the rapid bioassessment and qualitative surveys collected in 2011 field surveys were used for Bird Brook, Sisson Brook, the tributaries and lower sections of the West Branch Napadogan Brook (*i.e.,* the sections downstream of Bird Brook), McBean Brook, and Napadogan Brook. Habitat information from qualitative surveys and from habitat surveys carried out in connection to linear facilities in 2012 field surveys was used to describe the conditions found in the East Branch

Napadogan Brook, McBean Brook (and tributaries), and parts of the West Branch Napadogan Brook not covered by the rapid bioassessment (*i.e.*, areas upstream of Bird Brook). For a more comprehensive reporting of baseline fish habitat conditions, please refer to Stantec (2012d).

In general, habitat quality within the PDA, and outside of the PDA in residual watercourse segments where habitat loss is anticipated as described in Section 7.4, was classified based on a habitat suitability index (HSI) model for brook trout (Raleigh 1982) which was developed by the U.S. Fish and Wildlife Service to support EIA and habitat management initiatives. The model produces an index between 0 and 1, where 0 indicates unsuitable conditions and 1 indicates optimum conditions. The model incorporated habitat variables that affected all life stages of brook trout collected from the rapid bioassessment survey (Stantec 2012d). The equation is as follows:

$$HSI=(V_1*V_2*V_3*V_4*V_5*V_6*V_7)^{1/n}$$

Where:

HSI = habitat suitability index;

V_1 = average maximum temperature;

V_2 = dissolved oxygen;

V_3 = pH;

V_4 = average annual base flow;

V_5 = dominant substrate type;

V_6 = percent pools;

V_7 = percent shade; and

n = number of variables used in the equation.

For McBean Brook and tributaries to West Branch Napadogan Brook, average annual base flow (V_4) was excluded from the analysis because the information was not available. A non-compensatory model option was used where degraded water quality conditions (*i.e.*, DO, pH, and temperature) cannot be compensated for by good physical habitat characteristics. Therefore, if any water quality component (V_1, V_2 or V_3) was less than or equal to 0.4, HSI equaled the lowest component value of those water quality components.

For the characterization of water quality (excluding trace metals), the qualitative baseline data from 2011 were used, as representative for the sections where the aquatic habitat was assessed. The characterization represents typical summer conditions, with the exception of Napadogan Brook where the data were representative of late spring conditions. For the general description of surface water quality in long-term monitoring stations in the Napadogan and McBean Brook watersheds, refer to Section 8.4, and Knight Piésold (2012e).

The trace metal concentrations were obtained at the locations where fish, benthic invertebrates and periphyton were collected in 2011.

8.5.2.3.1.1 Bird Brook

Bird Brook (Figure 8.5.2) occupies a catchment area of 8.2 km^2 within the Napadogan Brook watershed. The watercourses within the Bird Brook catchment area include 55% first order streams (with a linear length of 7,048 m), 18% second order stream (2,254 m), and 27% third order streams (3,504 m).

There are six first order tributaries to Bird Brook within the PDA (Figure 8.5.2). First order stream habitat was generally suitable as rearing habitat for brook trout outside of the headwater sections. Typical habitat in first order sections of Bird Brook is shown in Photo 8.5.1.


Photo 8.5.1 Typical First Order Habitat in Bird Brook Within the PDA

There are two second order sections of tributaries to Bird Brook within the PDA. Second order watercourses were a mix of habitat for feeding and rearing and poor quality impounded habitat. Typical habitat found in second order sections of Bird Brook is shown in Photo 8.5.2.

Photo 8.5.2 Typical Second Order Habitat in Bird Brook Within the PDA

The main stem of Bird Brook is a third order watercourse. Third order habitat within the PDA contains fish habitat suitable for spawning, feeding and rearing of cold and warm water fish species. Typical habitat in third order sections of Bird Brook is shown in Photo 8.5.3, and typical third order habitat in the residual segment of Bird Brook directly downstream of the PDA is shown in Photo 8.5.4.

Photo 8.5.3 Typical Third Order Habitat in Bird Brook Within the PDA

Photo 8.5.4 Typical Third Order Habitat in the Residual Segment of Bird Brook Directly Downstream of the PDA

The composition of substrate within watercourses within the LAA is shown graphically in Figure 8.5.5.

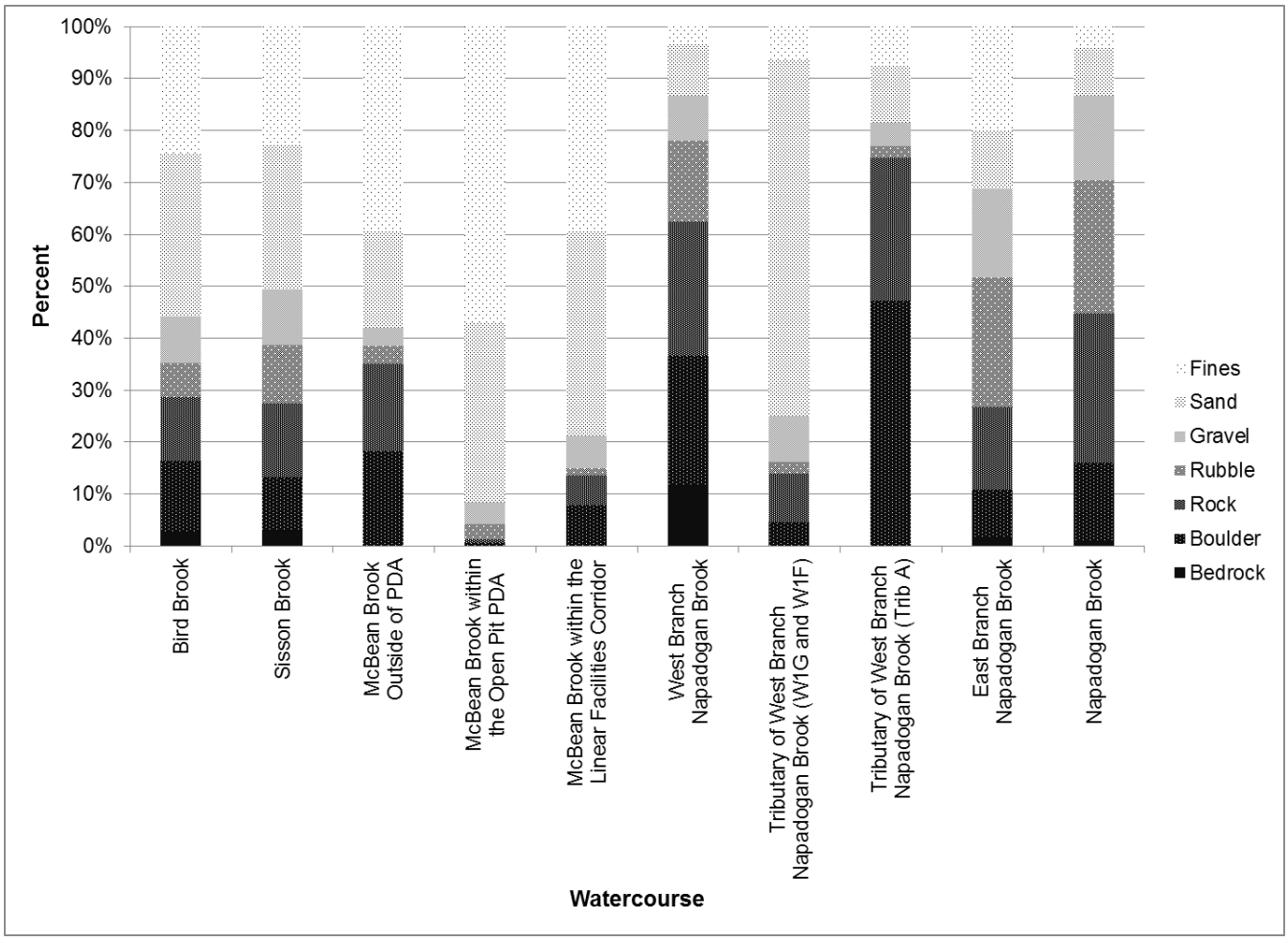


Figure 8.5.5 Substrate Composition of Watercourses Within the LAA

As seen in Figure 8.5.5, the substrate of Bird Brook is approximately 55% fines and sand, with the remaining 45% divided among the larger clast size categories. The distribution and concentration of fines is determined by the reduced flow velocity caused by beaver dams. In general, the substrate of Bird Brook does provide suitable habitat for small fish and eels.

The DO readings typically ranged from 7.1 to 9.5 mg/L with the majority of stations being slightly below the CCME FAL guideline of 9.5 mg/L for DO levels in early life stages of fish. DO concentrations in Bird Brook were acceptable for other life stages of fish in every reach. The pH of Bird Brook ranged from 5.4 to 7.0, which is slightly below the CCME (1999) recommended range. Water temperatures at the time of sampling (dry summer conditions) ranged from 11.6 to 15.2°C, with a maximum recorded value of 18.1°C occurring over a two-year sampling period. This relatively cold water during summer provides suitable (*i.e.,* habitat suitability is > 0.4) conditions for cold water fish species.

The benthic invertebrate community in Bird Brook exhibits variability between stations and is most similar to Sisson Brook in part because of similar stream characteristics between the brooks. Overall it is typical of a healthy stream environment and is able to provide a good food base for fish.

The measured surface water concentrations for arsenic, boron, copper, mercury, molybdenum[1], uranium and zinc in Bird Brook did not exceed the applicable CCME FAL guidelines. Aluminum concentrations exceeded the CCME FAL guidelines at 7 of 8 sampling stations, cadmium at 6 of 8 stations, iron at 3 of 8 stations, and lead at 1 of 8 stations. Concentrations of mercury and uranium were below the CCME FAL guidelines for all samples in Bird Brook.

The measured sediment concentrations for cadmium, copper, lead, mercury and zinc were all below CCME SQG. Arsenic concentration exceeded the CCME SQG at 1 of 8 sampling stations.

Overall, the fish habitat in Bird Brook has a habitat suitability index that ranges from 0.4 to 0.8 for brook trout (Figure 8.5.6). Headwater habitats vary from wetland beaver ponds to steep rocky valleys. The riparian vegetation is intact and provides excellent overhead cover and stable banks. In general, the substrate and water depth provides suitable habitat for small fish and eels. Dissolved oxygen and pH levels were slightly below the recommended ranges, however the relatively cold temperature during summer were suitable for cold water fish species. Benthic macroinvertebrate communities indicate a healthy aquatic environment and good food base. There are some trace metals that apparently naturally exceed applicable CCME FAL guideline and CCME SQG.

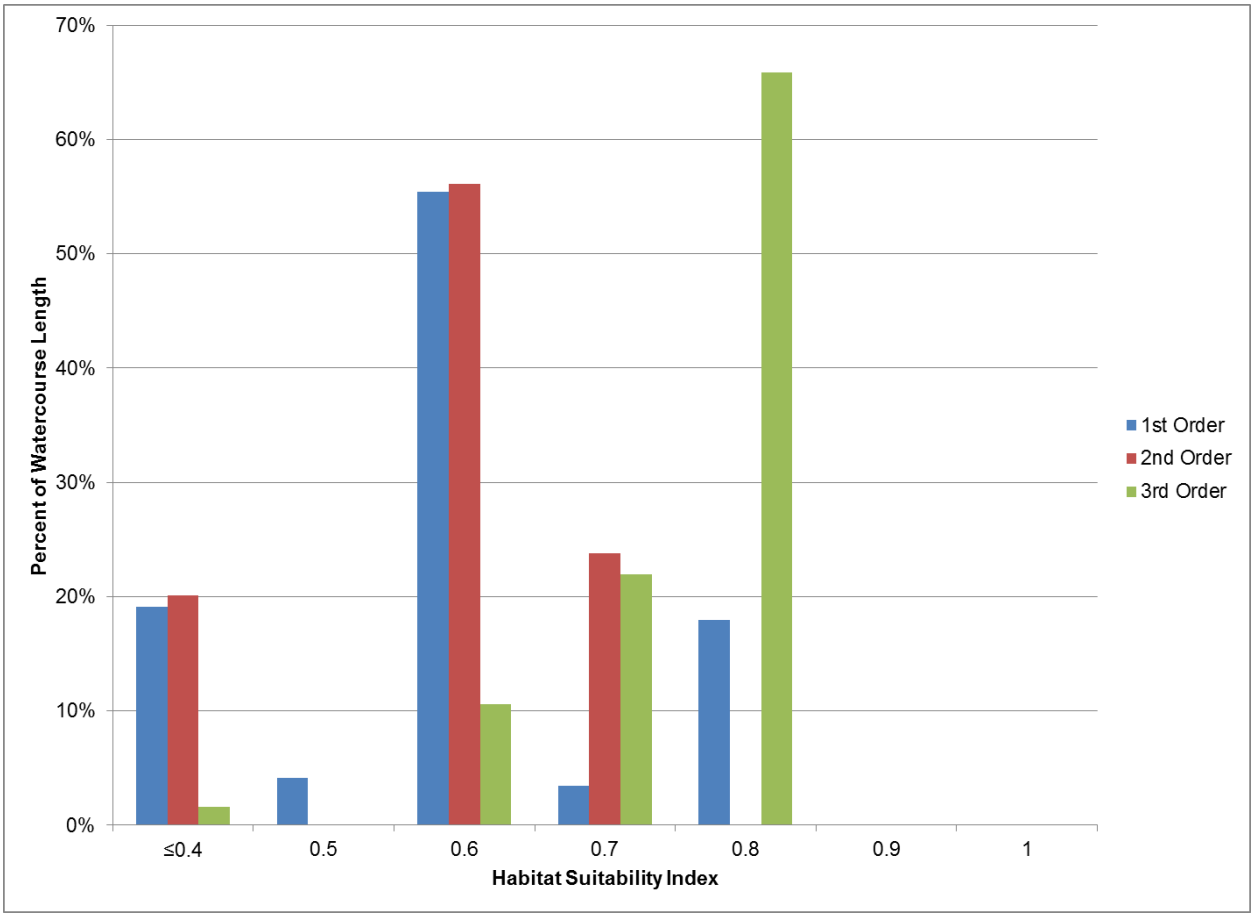


Figure 8.5.6 Brook Trout Habitat Suitability of Bird Brook

[1] Interim water quality guideline of 73 µg/L (CCME 1999).

8.5.2.3.1.2 Sisson Brook

Sisson Brook (Figure 8.5.2) occupies a catchment area of 5.2 km^2 within the Napadogan Brook watershed. The watercourses within the Sisson Brook catchment area include 69% first order streams (with a linear length of 5,562 m), 18% second order stream (1,491 m), and 13% third order streams (1,016 m).

There are four first order tributaries to Sisson Brook located within the PDA. A large beaver pond encompasses the majority of the tributary that lies in the centre of the open pit location, with a partial fish passage barrier at its downstream extent. In general, however, fish habitat within the first order tributaries of Sisson Brook contain suitable rearing habitat for brook trout. Typical habitat in first order sections of Sisson Brook is shown in Photo 8.5.5.

Photo 8.5.5 Typical First Order Habitat in Sisson Brook Within the PDA

There are two second order tributaries to Sisson Brook located within the PDA (Figure 8.5.2). Based on water quality and habitat measurements, second order tributaries of Sisson Brook contain brook trout habitat that is generally suitable for spawning, rearing and feeding. Typical habitat in second order sections of Sisson Brook is shown in Photo 8.5.6.

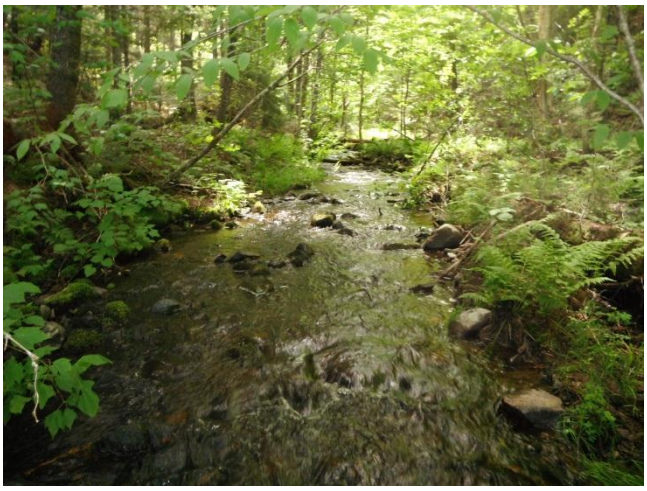



Photo 8.5.6 Typical Second Order Habitat in Sisson Brook Within the PDA

There is a single third order section of Sisson Brook. This approximately 900 m section of Sisson Brook occurs entirely outside of the PDA, within the residual stream segment as described in Section 7.4. This approximately 4 m wide section, with cobble and gravel dominated substrate, provides habitat that is generally suitable rearing and feeding habitat for brook trout, and is only limited in providing Atlantic salmon habitat by the presence of an impassible waterfall near to its confluence with West Branch Napadogan Brook. Typical habitat for this third order section of Sisson Brook is shown in Photo 8.5.7.


Photo 8.5.7 Typical Third Order habitat in Sisson Brook in the Residual Stream Segment Downstream of the Open Pit

As seen in Figure 8.5.5, the substrate of Sisson Brook is approximately 50% fines and sand, with the remaining 50% divided among the larger class size categories. The distribution and concentration of fines is largely the result of reduced flow velocity caused by beaver dams.

DO concentrations typically ranged from 9.3 to 10.4 mg/L with the majority of stations being near or above the CCME FAL guideline of 9.5 mg/L for DO levels in early life stages of fish. DO was acceptable for other life stages of fish in every reach. The pH ranged from 5.6 to 6.7, which is mostly below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 10.6 to 14.3°C, with a maximum recorded value of 17.8°C occurring over a two-year sampling period. This relatively cold water during summer provides suitable conditions for cold water fish species.

The benthic invertebrate community in Sisson Brook exhibits variability between sampling stations and is most similar to Bird Brook in part because of similar stream characteristics between the brooks. Overall, it is typical of a healthy stream environment and is able to provide a good food base for fish.

The measured surface water concentrations for arsenic, boron, lead, mercury, molybdenum, uranium and zinc in surface water were all below CCME FAL guideline values. Aluminum concentrations exceeded CCME FAL guidelines at 5 of 6 sampling stations, cadmium at all 6 stations, copper at 1 of 6 stations, and iron at 1 of 6 stations.

The measured sediment concentrations for cadmium, copper, lead, mercury and zinc were all below CCME SQG. Arsenic concentrations exceeded the CCME SQG at all six sampling stations.

Overall, Sisson Brook has a brook trout habitat suitability index that ranges from 0.4 to 0.9 (Figure 8.5.7). Headwater habitats vary from wetland beaver ponds to steep rocky valleys. There is a barrier to migration (*i.e.,* a waterfall) upstream of the mouth of Sisson Brook which prevents the in-migration of fish such as Atlantic salmon, although American eel can ascend. The riparian vegetation is intact and provides excellent overhead cover and stable banks. In general, the substrate and water depth provides suitable habitat for small fish and eels. DO and pH levels were slightly below the recommended ranges, however the relatively cold temperatures during summer were suitable for cold water fish species. Benthic macroinvertebrate communities indicate a healthy aquatic environment and good food base. There are some trace metals that apparently naturally exceed the applicable CCME FAL guideline and CCME SQG.

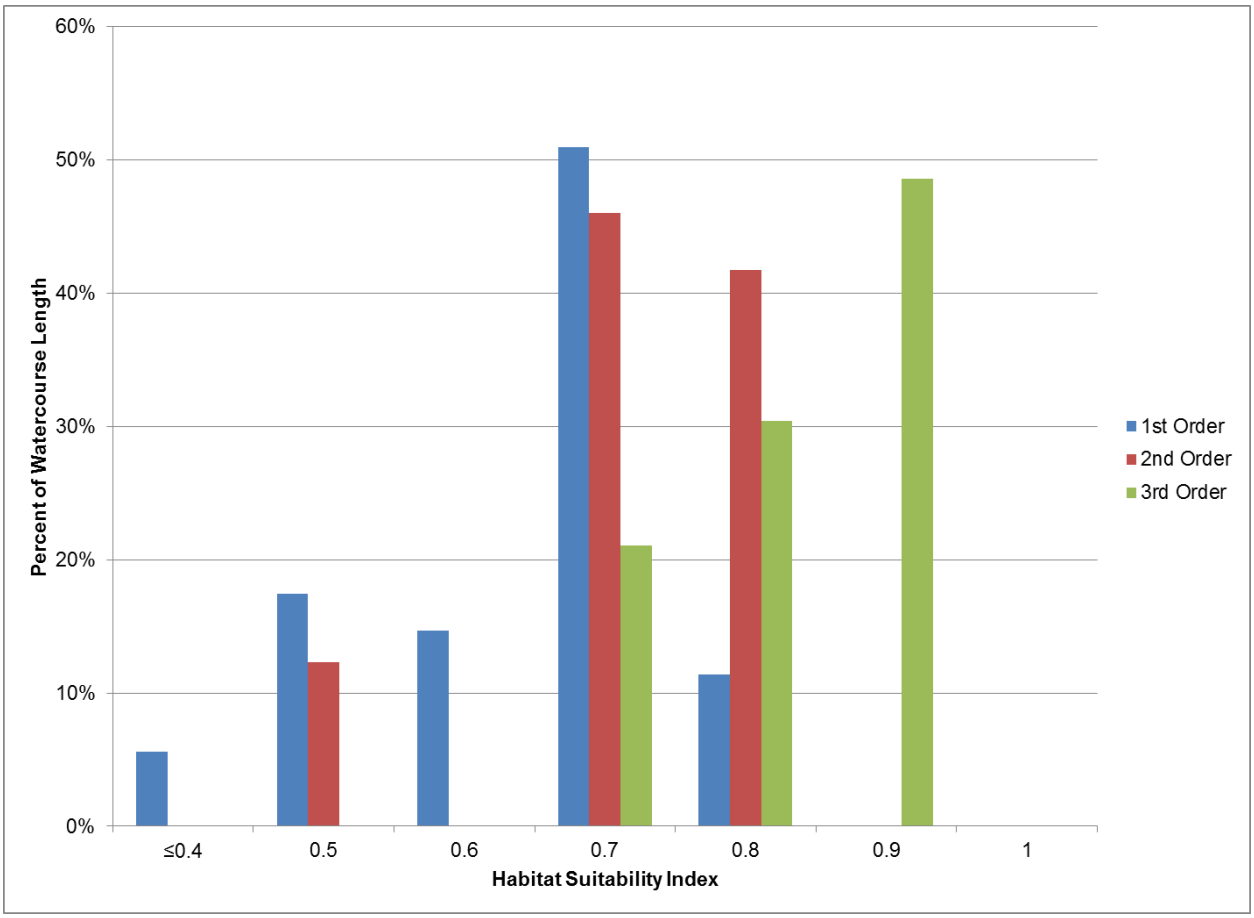


Figure 8.5.7 Brook Trout Habitat Suitability of Sisson Brook

8.5.2.3.1.3 McBean Brook

The McBean Brook watershed (Figure 8.5.2) is approximately 43 km^2. The watercourses within the McBean Brook watershed include 54% first order streams (with a linear length of 24,444 m), 23% second order streams (10,368 m), 11% third order streams (4,825 m), and 12% fourth order streams (5,409 m).

Within the PDA, the McBean Brook watershed includes three first order tributaries of McBean Brook within the open pit area and six tributaries to McBean Brook that pass through the linear facilities corridor. The majority of the McBean Brook watershed is outside of the PDA, was not surveyed in its entirety, and is not described herein as substantive interactions with the Project are not anticipated.

McBean Brook Within the Open Pit Area of the PDA

There is a total length of 415 m of first order tributaries of McBean Brook within the PDA where direct environmental effects are anticipated as described in Section 7.4 (excluding the linear facilities corridor, where direct environmental effects are not anticipated). Each of the three tributaries flows into a small beaver pond under the existing 345 kV transmission line, and each is surrounded by wetland meadow.

The channel substrate of these tributaries is primarily organic materials, fines and sand, consistent with the low gradient and slow flow conditions. Channel banks are stable and vegetated with grasses and shrubs and channel form is steady glide or pool except where watercourses are undefined or braided within a wetland. Typical habitat within the portion of the PDA where the open pit will be developed is shown in Photo 8.5.8.

Photo 8.5.8 Typical Habitat of McBean Brook Within the Open Pit Portion of the PDA

As seen in Figure 8.5.5, the substrate of McBean Brook within the open pit portion of the PDA is approximately 92% fines and sand, with the remaining 8% divided among the larger class size categories with no bedrock present. The distribution and concentration of fines is determined by the reduced flow velocity caused by beaver dams.

The DO levels of the tributaries to McBean Brook within the open pit area ranged from 8.0 to 9.2 mg/L with all stations having dissolved oxygen levels below the CCME FAL guideline of 9.5 mg/L for early life stages of fish. DO was acceptable for other life stages of fish in every reach. The pH ranged from 5.9 to 6.3, below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 11.7 to 12.6°C. The water quality of the first order tributaries in the PDA portion of McBean Brook were suitable for cold water and warm water fish species.

The benthic community was not surveyed in this portion of McBean Brook.

The measured concentrations for arsenic, boron, mercury, molybdenum, uranium and zinc in surface water samples in McBean Brook within the PDA were below CCME FAL guidelines. Aluminum cadmium, copper, iron, and lead concentrations were above the CCME FAL guidelines.

The measured concentrations for cadmium, copper, lead, mercury and zinc in sediment were all below CCME SQG. Arsenic was the only sediment trace metal concentration that exceeded the CCME SQG. Molybdenum concentrations in sediment at station M1M2 of McBean Brook located within the open pit area, was the highest of all the 32 stations sampled (503 mg/kg).

McBean Brook Within the Linear Facilities Corridor Portion of the PDA

There are six tributaries of McBean Brook that pass through the linear facilities corridor, ranging from first to third order, with most being second order. The substrate of these tributaries is primarily sand and fines, with abundant aquatic vegetation in reaches that provide sufficient depth. The condition of the stream channels is good overall but braided in parts and intermittent in headwater areas, flowing under and/or around boulders. Riparian vegetation is well established and is primarily grasses and shrubs that provide substantive shade. Photo 8.5.9 provides examples of habitat within the linear facilities corridor. The habitat is similar to that observed in McBean Brook near the open pit area.


Photo 8.5.9 Typical Habitat of McBean Brook Within the Linear Facilities Corridor Portion of the PDA

As seen in Figure 8.5.5, the substrate of McBean Brook within the linear facilities corridor is approximately 79% fines and sand, with the remaining 21% divided among the larger class size categories with no bedrock present. The distribution and concentration of fines is determined by the reduced flow velocity caused by beaver dams.

The DO levels of the tributaries to McBean Brook within the linear facilities corridor ranged from 6.5 to 10.8 mg/L, typically above 8.5 mg/L, though many sampling stations had DO levels below the CCME FAL guideline of 9.5 mg/L for early life stages of fish. DO was acceptable for other life stages of fish in every reach. The pH ranged from 5.8 to 6.7, which is mostly below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 12.6 to 15.8°C (the two-year maximum value is not available for these tributaries).

The benthic community, trace metals in water and sediments were not recorded in the tributaries to McBean Brook within the linear facilities corridor.

Overall, the habitat suitability index for brook trout ranged from 0.6 to 0.7 in McBean Brook within the PDA (Figure 8.5.8).

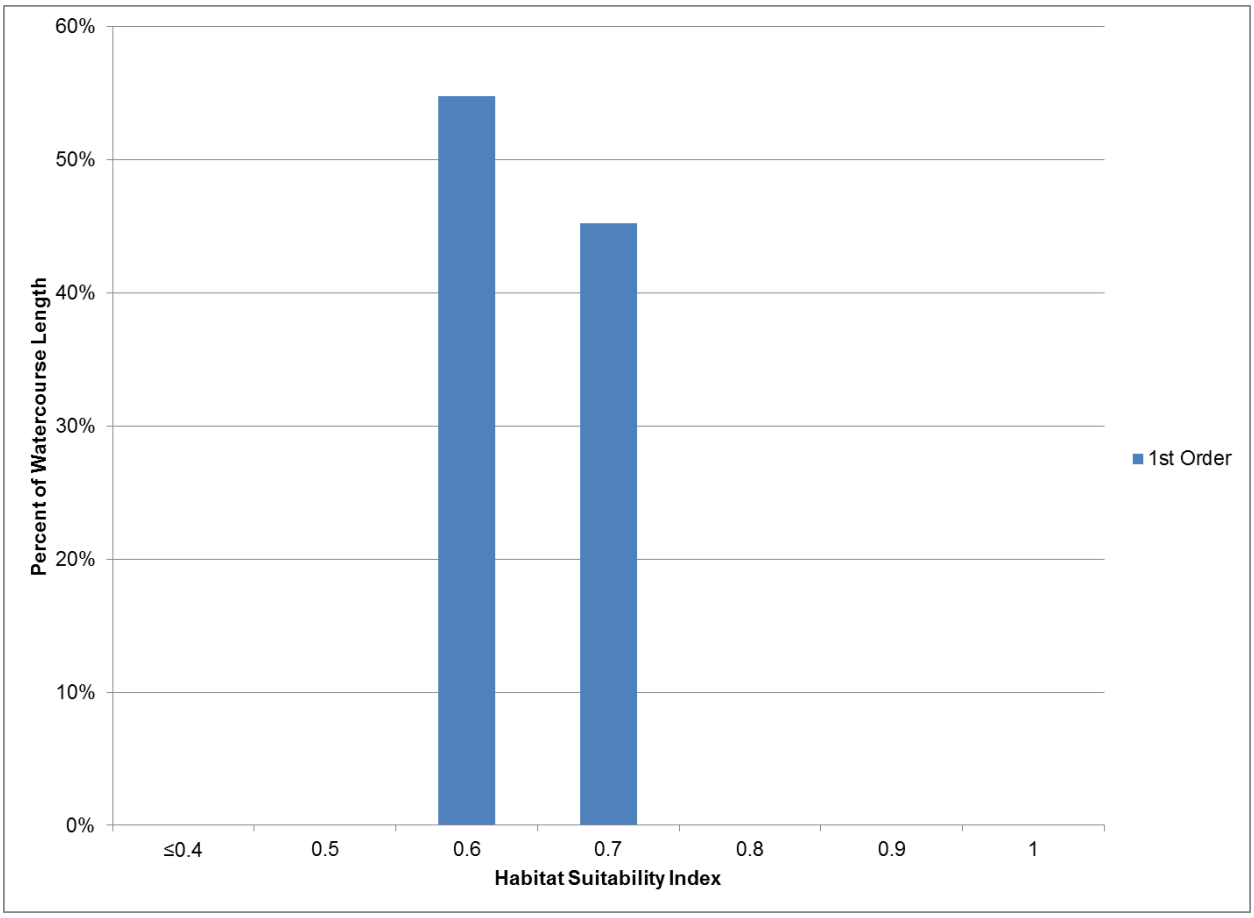


Figure 8.5.8 Brook Trout Habitat Suitability of McBean Brook within the PDA

McBean Brook Outside of the PDA

There is a total length of 22,818 m (linear length) of first order tributaries, 10,368 m of second order tributaries, 4,825 m of third order tributaries, and 5,409 m of fourth order tributaries of McBean Brook outside of the PDA. The fish habitat within tributaries outside of McBean Brook that were surveyed is similar to sections within the open pit area and the linear facilities corridor. The channel substrate of these tributaries is primarily fines and sand, which is consistent with the low gradient and slow flow conditions. Channel banks are stable and vegetated with grasses and shrubs. Photo 8.5.10 provides examples of McBean Brook habitat outside of the PDA.

Photo 8.5.10 Typical Habitat of McBean Brook Outside of the PDA

As seen in Figure 8.5.5, the substrate of McBean Brook outside of the PDA is approximately 58% fines and sand, with the remaining 42% divided among the larger clast size categories with less than 1% bedrock present. The distribution and concentration of fines is determined in part by the reduced flow velocity caused by beaver dams and the run habitat with lower gradient.

The DO levels of the tributaries to McBean Brook outside of the PDA from 6.3 to 9.2 mg/L, with all stations having DO levels below the CCME FAL guideline of 9.5 mg/L for early life stages of fish. DO was acceptable for other life stages of fish in every reach. The pH ranged from 5.2 to 6.7, which is mostly below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 13.7 to 19.1°C, with a maximum recorded value of 20.8°C occurring over a two-year sampling period. The relatively warmer water of these first order slow-flowing tributaries, combined with less than ideal DO levels, provides less suitable conditions for cold water fish species and suitable conditions for warm water fish species.

The benthic communities in McBean Brook outside of the PDA are statistically distinct between sites and from those of Bird and Sisson brooks and West Branch and East Branch Napadogan Brook, though there are many similarities when comparing between benthic communities in these nearby and/or adjacent watersheds and the benthic communities at this station. The differences observed in McBean Brook could be attributable to the large amount of wetland area in its drainage basin. As with the Napadogan watershed benthic communities, the benthic communities of the tributaries to McBean Brook outside of the PDA are typical of a natural stream environment under the current conditions.

The measured concentrations for arsenic, boron, mercury, molybdenum, uranium and zinc in surface water were below CCME FAL guidelines. Aluminum and cadmium concentrations were above the CCME FAL guidelines at all sampling stations, copper met or exceed the CCME FAL guidelines in three of six stations, iron in two of six stations, lead in one of six stations.

The measured concentrations for copper, lead, mercury and zinc in sediment were all below CCME SQG. Arsenic concentrations exceeded the CCME SQG in one of seven of the sediment samples from McBean Brook outside of the PDA, and cadmium concentrations exceeded the CCME SQG in one of seven sediment samples. On McBean Brook, the highest concentration for six of seven of the analyzed trace metals was observed at station M1K4, likely due to its proximity to the ore body.

Overall, the habitat within McBean Brook (within and outside of the PDA) is low gradient sections of riffle-run habitat, interspersed with wetlands and/or beaver ponds. The channel substrate of these tributaries is primarily fines and sand, which is consistent with the low gradient and low velocity conditions. Channel banks are stable and vegetated with grasses and shrubs. McBean Brook has relatively warmer water temperatures and lower DO levels compared to Bird and Sisson brooks. As a result, McBean Brook is more typical of a warm water habitat watercourse. Benthic macroinvetebrate communities indicate a healthy aquatic environment and good food base. There are some trace metals that apparently naturally exceed applicable CCME FAL guideline and the CCME SQG.

8.5.2.3.1.4 West Branch Napadogan Brook

The West Branch Napadogan Brook (Figure 8.5.2) occupies a catchment area of 38.9 km^2 within the Napadogan Brook watershed. The watercourses within the West Branch Napadogan Brook catchment area include 55% first order streams (with a linear length of 29,825 m), 19% second order stream (9,943 m), 7% third order streams (3,904 m), and 19% fourth order streams (10,459 m).

West Branch Napadogan Brook within the PDA

There is a total length of 971 m of first order Tributary “A” of West Branch Napadogan Brook within the PDA where direct environmental effects are anticipated as described in Section 7.4. The tributary is mostly riffle and run, with several sections of dead water and evidence of beaver activity throughout. The upper 130 m of mapped watercourse for this tributary was steep grade with no defined channel. The channel substrate of this tributary is primarily boulder and rock. Channel banks are stable and vegetated by a mix of grasses and trees. Typical habitat within the portion of the PDA where the TSF will be developed is shown in Photo 8.5.11.

Photo 8.5.11 Typical Habitat of the Tributary to West Branch Napadogan Brook Within the PDA

As seen in Figure 8.5.5, the substrate of the Tributary "A" to West Branch Napadogan Brook within the PDA is approximately 75% boulder and rock, with the remaining 25% divided among the smaller size categories.

The DO levels of the tributary to West Branch Napadogan Brook within the PDA ranged from 8.5 to 10.3 mg/L with the majority of stations having DO levels above the CCME FAL guideline of 9.5 mg/L for early life stages of fish. The pH ranged from 5.6 to 6.5, which is at or slightly below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 9.8 to 12.0°C. Overall, habitat in the lower reaches was suitable for spawning and rearing of brook trout and other warm water species.

The benthic community was not surveyed in Tributary "A" of the West Branch Napadogan Brook.

The measured concentrations for arsenic, boron, lead, molybdenum, uranium and zinc in surface water were all below CCME FAL guidelines. Aluminum, cadmium, and iron concentrations were above the CCME FAL guidelines in surface water samples in Tributary "A" West Branch Napadogan Brook.

The measured concentrations for cadmium, copper, lead, mercury and zinc in sediment were all below CCME SQG. Arsenic was the only trace metal which exceeded the CCME SQG.

The habitat suitability index in Tributary "A" of the West Branch Napadogan Brook ranged from 0.7 to 0.9. The habitat suitability was relatively equally distributed with 33% being a habitat suitability of 0.7, 41% being 0.8, and 25% being 0.9. Overall, habitat was suitable for brook trout.

West Branch Napadogan Brook Outside of the PDA

There is a total length of 2,031 m of first order tributaries to West Branch Napadogan Brook outside of the PDA that may be indirectly affected by the Project. The two tributaries are mostly riffle and run with some pool habitat. The tributaries are intermittent in the headwaters and there is evidence of beaver activity in downstream sections. The channel substrate in tributary W1G is primarily sand and gravel with stable banks well vegetated with grasses and shrubs. The channel substrate in tributary W1F is primarily sand with rock/boulder substrates, stable, well vegetated banks with grasses and trees. Typical habitat of tributaries to West Branch Napadogan Brook outside of the PDA (W1G and W1F) is shown in Photo 8.5.12.

Photo 8.5.12 Typical Habitat of the Tributaries to West Branch Napadogan Brook Outside of the PDA (W1G and W1F)

As seen in Figure 8.5.5, the substrate of the tributary to West Branch Napadogan Brook outside the PDA is approximately 69% sand, with the remaining 31% divided primarily among the larger size categories.

The DO levels of the tributary to West Branch Napadogan Brook outside of the PDA ranged from 8.5 to 11.9 mg/L with the majority of stations having DO levels above the CCME FAL guideline of 9.5 mg/L for early life stages of fish. The pH ranged from 5.7 to 6.5, which is at or slightly below the CCME (1999) recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 9.1 to 12.7°C. The benthic community was not surveyed in these tributaries to West Branch Napadogan Brook.

The measured concentrations for arsenic, boron, lead, iron, molybdenum, uranium and zinc in surface water were all below CCME FAL guidelines. Aluminum and cadmium concentrations were above the CCME FAL guidelines in surface water samples in tributary (W1G) of West Branch Napadogan Brook.

The measured concentrations for arsenic, cadmium, copper, lead, mercury and zinc in sediment in the tributary to West Branch Napadogan Brook were all below CCME SQG.

The habitat suitability index for brook trout in tributaries of the West Branch Napadogan Brook outside of the PDA (W1G and W1F) ranged from 0.6 to 0.8. The majority of the habitat (92%) had a habitat suitability index of 0.7 and 0.8 in the first order tributaries and habitat in the second order tributary had a habitat suitability index of 0.7.

There is a total linear length of 28,853 m of first order tributaries, 9,943 m of second order tributaries, 3,903 m of third order tributaries, and 10,458 m of fourth order tributaries of West Branch Napadogan Brook outside of the PDA. Fish habitat in West Branch Napadogan Brook is based in part on stream order. The habitat within the first and second order tributaries is similar to that described in tributaries of the West Branch Napadogan Brook within and outside of the PDA (Tributary A, W1G and W1F). The main stem of West Branch Napadogan Brook is mostly riffle-run habitat. The channel substrate is rock

and boulder with minor components of small substrates. Channel banks are stable and vegetated with grasses and shrubs. Typical habitat of West Branch Napadogan Brook outside of the PDA is shown in Photo 8.5.13.

Photo 8.5.13 Typical Habitat of West Branch Napadogan Brook Outside of the PDA

As seen in Figure 8.5.5, the substrate of West Branch Napadogan Brook outside of the PDA is approximately 63% rock, boulder and bedrock, with the remaining 37% divided among the smaller class size categories.

The DO levels in West Branch Napadogan Brook outside of the PDA from 7.8 to 10.5 mg/L with more than half of stations equal to or greater than the CCME FAL guideline for early life stages of fish. The pH ranged from 5.3 to 7.0, with more than half of stations being within the CCME recommended range of 6.5-9.0. Water temperatures at the time of sampling (dry summer conditions) ranged from 9.1 to 16.7°C. Average daily summer water temperatures in West Branch Napadogan Brook ranged from 14 to 18°C. Overall, West Branch Napadogan Brook has good DO levels, and provided suitable habitat conditions for cold water fish and less suitable habitat for warm water fish species.

The benthic invertebrate community in West Branch Napadogan Brook exhibits variability between stations and the community shows similarities based on characteristics of that stream. The benthic community is influenced in part by conductivity, general water quality parameters (*i.e.,* hardness) and sediment nickel. West Branch Napadogan Brook is most similar to East Branch Napadogan Brook in part because of their larger stream orders when compared to Bird and Sisson Brooks. Overall it is typical of a healthy stream environment and is able to provide a good food base for fish.

The measured concentrations for arsenic, boron, iron, lead, molybdenum, uranium and zinc in surface water were all below CCME FAL guidelines. Aluminum and cadmium concentrations met or exceeded the CCME FAL guidelines in all of the sampling stations, copper exceeded in four out of six stations, and mercury exceeded in one out of six stations.

The measured concentrations for cadmium, copper, lead, mercury and zinc in sediment from West Branch Napadogan Brook were all below CCME SQG. Arsenic concentrations exceeded the CCME SQG at three out of six of the sediment stations, which were all collected at the stations located farthest downstream.

Overall, West Branch Napadogan Brook has fish habitat that ranges from fair to excellent quality for cold water fish species. Headwater habitats vary from wetland beaver ponds to steep rocky valleys. The riparian vegetation is intact and provides good overhead cover in lower stream orders and stable banks. In general, the substrate and water depth provides suitable habitat for a variety of cold water and warm water fish species. DO levels were generally above the recommended ranges, pH levels in some tributaries were slightly below the recommended ranges, and water temperatures were relatively cold during the summer months. Benthic macroinvetebrate communities indicate a healthy aquatic environment and good food base. There are some trace metals that apparently naturally exceed applicable CCME FAL and SQG guidelines.

8.5.2.3.1.5 East Branch Napadogan Brook

The East Branch Napadogan Brook (Figure 8.5.2) occupies a catchment area of 39.3 km^2 within the Napadogan Brook watershed. The watercourses within the East Branch Napadogan Brook catchment area include 60% first order streams (linear length of 20,060 m), 11% second order stream (3,722 m), and 29% third order streams (9,829 m).

The channel substrate in East Branch Napadogan Brook is primarily rock, rubble and gravel, consistent with the lower gradient relative to West Branch Napadogan Brook. As seen in Figure 8.5.5, the substrate of East Branch Napadogan Brook is approximately 58% rock, rubble, and gravel, with the remaining being primarily sand and fines. Channel banks are stable and vegetated with grasses and shrubs and channel form primarily riffle-run with some pool.

DO levels typically ranged from 8.6 to 9.7 mg/L, and exceeded the CCME FAL guideline of 9.5 mg/L for early life stages at two stations and was acceptable for other life stages at every station. The pH ranged from 6.1 to 7.0, which is less than the CCME recommended range of 6.5-9.0. Water temperatures during qualitative electrofishing ranged from 16.8 to 17.7°C. Average daily summer water temperatures in East Branch Napadogan Brook (EBNB1) typically ranged from 16 to 20°C. Typical habitat of East Branch Napadogan Brook is shown in Photo 8.5.14.

Photo 8.5.14 Typical Habitat of East Branch Napadogan Brook

The benthic invertebrate community in East Branch Napadogan Brook is most similar to West Branch Napadogan Brook and Nashwaak River, in part because of their larger stream orders. Overall, it is typical of a healthy stream environment and is able to provide a good food base for fish.

The measured concentrations for arsenic, boron, copper, lead, molybdenum, uranium and zinc in surface water samples in East Branch Napadogan Brook were at or below CCME FAL guidelines. Aluminum concentrations were above the CCME FAL guideline in one out of three stations, cadmium in one out of three stations, iron in all stations, and mercury in two out of three stations.

The measured concentrations for cadmium, copper, lead, and zinc in sediment samples analyzed from East Branch Napadogan Brook were all below CCME SQG (PEL) guidelines. Arsenic and mercury concentrations exceeded the CCME SQG (PEL) guideline in one out of three stations.

Overall, East Branch Napadogan Brook has slightly warmer water temperatures, lower overall gradient and smaller substrate sizes than West Branch Napadogan Brook. Similarly to West Branch Napadogan Brook, portions of the watercourse contain evidence of beaver activity. The riparian vegetation is intact and provides good overhead cover and stable banks. In general, the substrate and water depth provides suitable habitat for a variety of cold water and warm water fish species. DO levels were above the recommended ranges, pH levels in some tributaries were slightly below the recommended ranges, however the relatively cold water temperature was good for summer conditions. Benthic macroinvetebrate communities indicate a healthy aquatic environment and good food base. There are some trace metals that apparently naturally exceed applicable CCME FAL and SQG guidelines.

8.5.2.3.1.6 Napadogan Brook

The main stem of Napadogan Brook (below the confluence of the west and east branches, also referred to as Lower Napadogan Brook in Figure 8.5.2) occupies a catchment area of 31.3 km^2 within the Napadogan Brook watershed. The watercourses within the main stem Napadogan Brook

catchment area include 39% first order streams (12,489 m linear length), 20% second order stream (6,441 m), 15% third order streams (4,892 m), and 26% of fourth order stream (8,565 m).

Overall the fish habitat in Napadogan Brook is similar to the lower portion of West Branch Napadogan Brook. The channel substrate in Napadogan Brook is primarily rock and rubble. As seen in Figure 8.5.5, the substrate of Napadogan Brook is approximately 86% boulder, rock, rubble, and gravel, with the remaining being primarily sand and fines. Channel banks are stable and vegetated with shrubs and grasses and channel form primarily riffle-run with small quantities of pool habitat.

DO ranged from 8.4 to 10.15 mg/L, and did not exceed the minimum value of 9.5 mg/L for early life stages of cold water species in any reach except for reach 57, though was acceptable for other life stages in every reach. The pH of Napadogan Brook ranged from 6.9 to 7.6, within the recommended range of 6.5-9.0. The range of water temperatures (14.7-23°C) is considered typical for the time of year for a shallow and rocky watercourse of this size. The water temperatures represent suitable summer conditions for Atlantic salmon and less suitable summer conditions for brook trout. Typical habitat of Napadogan Brook is shown in Photo 8.5.15.

Photo 8.5.15 Typical Habitat of Napadogan Brook

The periphyton biomass and chlorophyll *a* concentrations in Napadogan Brook are similar to those of the other brooks in the Napadogan watershed, and indicate a moderate level of primary productivity and moderate availability of organic matter in the periphyton biofilm. The periphyton community is dominated by diatoms that comprise a high quality food resource for benthic invertebrates.

In general, the benthic communities in Napadogan Brook were in some cases statistically distinct from those of Bird, Sisson and West Branch Napadogan Brooks for some of the measured indices. The benthic invertebrate communities in East Branch Napadogan Brook were most similar to the Nashwaak River, and West Branch Napadogan Brook stations and were consistent with higher order streams having high water quality. As with the other Napadogan watershed benthic communities, the benthic communities of the Napadogan Brook are typical of a natural stream environment under the current conditions.

Overall, Napadogan Brook has fish habitat that that is suitable for cold water fish species, though during peak summer conditions may be too warm for brook trout. The habitat in Napadogan Brook is similar to that of West Branch Napadogan Brook and East Branch Napadogan Brook. There are partial barriers (pinch points) to larger fish migration in the main stem Napadogan Brook during summer low flow conditions primarily as a result of shallow riffles. The riparian vegetation is intact but provides little overhead cover and stable banks. In general, the substrate and water depth provides suitable habitat for cold and warm water fish species for spawning and rearing. DO and pH levels were generally within the recommended ranges given the time of year.

8.5.2.3.1.7 Nashwaak River

The general characteristics of the Nashwaak River are described in Section 8.5.2.1. With the exception of some EEM reference stations, the field program did not include surveys of the Nashwaak River.

8.5.2.3.2 Fish

The fish species composition, abundance and distribution, as reported in this section, were determined by qualitative and quantitative fish surveys in 2011 (Stantec 2012d) and 2012 (Section 8.5.2.2). The following sub-sections present key information from those studies regarding fish population (distribution and relative species abundance), metals in fish, and SAR/SOCC.

8.5.2.3.2.1 Fish Populations

Table 8.5.5 presents the fish species composition at each station where qualitative fish capture and identification were carried out. The shaded cells indicate the presence of three family groups: “salmonidae/cottidae” (*i.e.,* cold-water fish like trout, salmon, and sculpin); “cyprinidae” (*i.e.,* warmer-water fish like minnows and dace); and “other families” (*i.e.,* bottom dwelling fish like eel, sucker, and sea lamprey). The stations are presented in increasing order within a watercourse, providing a comparative distribution of species by stream order. Species distribution can also be compared between watercourses. The “habitat area change category” rating is assigned based on the assumed or predicted loss of fish habitat. A rating of “2” is assigned where it is reasonably assumed that the habitat will be completely lost as a result of the Project, which includes watercourses within the PDA and some residual watercourse segments as described in Sections 7.4.2 and 7.4.3.1. A rating of “1” is assigned where it is predicted, based on the wetted perimeter model, that habitat will be partially lost or altered as a result of the Project as described in Sections 7.4.3.2 and 7.4.3.3. A rating of “0” is assigned where a change to fish habitat area or quality is neither predicted nor assumed.

The fish assemblage in the LAA is composed of 12 different species, which represent six families of fish (Table 8.5.5). Of the 12 species documented, nine were observed in the LAA of the Napadogan Brook watershed (Atlantic salmon; brook trout; blacknose dace; creek chub; common shiner; American eel; slimy sculpin, *Cottus cognatus*; sea lamprey; and white sucker). In McBean Brook, three additional species were observed (pearl dace, *Semotilus margarita*; blacknose shiner, *Notropis heterolepis*; and longnose sucker), while slimy sculpin was not found.

The fish assemblage in watercourses where the total loss of habitat is assumed (habitat area change rank “2”) is composed of six different species, which represent four families of fish (Table 8.5.5). Sisson Brook had the lowest diversity of fish species, with only brook trout and American eel. In Bird

Brook, the fish assemblage consisted of brook trout, slimy sculpin, American eel, and one juvenile Atlantic salmon observed just above the confluence of West Branch Napadogan Brook. In McBean Brook, creek chub and pearl dace were observed in the PDA stations affected by the open pit, while brook trout, blacknose dace, creek chub and American eel were observed in watercourses crossing the linear facilities corridor. Two juvenile Atlantic salmon were observed at one McBean Brook location during the 2011 survey.

The West Branch Napadogan Brook and East Branch Napadogan Brook both contained brook trout, Atlantic salmon, blacknose dace, American eel, sea lamprey, slimy sculpin, and white sucker. This species composition was the same in Napadogan Brook, with the exception of the absence of slimy sculpin.

Brook trout was the most prevalent species found in the watercourses in and near the PDA. Within the Napadogan Brook watershed it was absent from only 3 of 36 stations sampled, and was observed in all of the surveyed watersheds. Brook trout may also have been present at two of the three stations where it was not observed, but the minnow traps used at these two stations instead of electrofishing (due to health and safety considerations) may have been inefficient in capturing them. Brook trout densities ranged from 6.3 to 86.4 fish per 100 m^2 in the PDA, and 1.1 to 26.8 fish per 100 m^2 in the LAA (Stantec 2012d). The highest abundance of brook trout was observed at station W1G (with a catch per unit effort (CPUE) of 7.21 fish captured per 100 s of fishing effort). These brook trout densities are similar to those found in other parts of the Nashwaak River watershed.

American eel was observed in all of the watercourses that were sampled, and densities were similar to other tributaries on the Nashwaak River (Stantec 2012d).

Juvenile Atlantic salmon of various ages were observed in the Napadogan Brook watershed, and two juvenile Atlantic salmon were captured in McBean Brook. Juvenile Atlantic salmon were absent from the PDA in Sisson Brook (Table 8.5.3). One Atlantic salmon parr was found at the most downstream site on Bird Brook located approximately 350 m from the West Branch Napadogan Brook in the LAA. Parr were observed in the East Branch Napadogan Brook, West Branch Napadogan Brook, and Napadogan Brook, and are distributed throughout the rest of the Nashwaak River system, albeit in low densities (DFO 2004). Atlantic salmon densities were similar to other tributaries of the Nashwaak River and ranged from 1.3 to 21.6 fish per 100 m^2. The greatest relative abundance of Atlantic salmon was found in Napadogan Brook, followed by West Branch Napadogan Brook, and East Branch Napadogan Brook (Figure 8.5.9).

Table 8.5.5 Fish Species Composition and Distribution Within the LAA

Watercourse Name	Station[a]	Salmonidae / Cottidae	Cyprinidae	Other Families	Habitat Area Change Category
Bird Brook	B1A5	BT			2
Bird Brook	B1C1	BT			2
Bird Brook	B1D3	BT			2
Bird Brook	B2A2	BT/SS		AE	2
Bird Brook	B3A1	BT		AE	2
Bird Brook	B3A6	BT, SS		AE	2
Bird Brook	B3A9	BT, AS, SS		AE	2

Table 8.5.5 Fish Species Composition and Distribution Within the LAA

Watercourse Name	Station[a]	Salmonidae / Cottidae	Cyprinidae	Other Families	Habitat Area Change Category
Sisson Brook	S1C3	BT			2
Sisson Brook	S1D3	BT			2
Sisson Brook	S2A2	BT			2
Sisson Brook	S2A3	BT		AE	2
Sisson Brook	S3A3	BT		AE	2
McBean Brook	M1K4	BT			1
McBean Brook	M1M2		CC, PD		2
McBean Brook	M1N1		CC, PD		2
McBean Brook	M2E1	BT	BND	AE	1
McBean Brook	M3A1	BT	BND	SL	0
McBean Brook	M3C3	BT, AS	BND, CS, CC, BNS	AE, LS, SL, WS	0
McBean Brook	M4A9		BND, CS, CC	AE, LS	0
McBean Brook	50 (TL)	BT	BND, CC	AE	0
McBean Brook	52 (TL)	BT	BND, CC	AE	0
McBean Brook	54 (TL)	BT			0
McBean Brook	57 (TL)	BT		AE	0
McBean Brook	53 (TL)	BT			0
West Branch Napadogan Brook	W1G5	BT			0
Tributary "A" to the West Branch Napadogan Brook	W1N3	BT, SS			2
West Branch Napadogan Brook	W2A4	BT, SS		SL	0
West Branch Napadogan Brook	W4A1	BT, AS, SS		AE, SL, WS	0
West Branch Napadogan Brook	W4A17	BT, AS, SS		AE, SL, WS	1
West Branch Napadogan Brook	W4A21	BT, AS, SS	BND	AE, SL, WS	1
West Branch Napadogan Brook	W4A25	BT, AS		AE, SL	1
West Branch Napadogan Brook	W4A31	BT, AS, SS	BND	AE, WS, SL	1
East Branch Napadogan Brook	EBNB3	BT			0
East Branch Napadogan Brook	EBNB2	BT, AS	BND	AE, SL, WS	0
East Branch Napadogan Brook	EBNB1	BT, AS, SS	BND	AE, SL, WS	0
Napadogan Brook	NBFF	BT, AS	BND, CC, CS	AE, SL, WS	1

KEY

Present during field surveys in 2011 or 2012

Absent during field surveys in 2011 or 2012

[a] Station names as contained in Stantec (2012d) and other unpublished reports.

Habitat Area Change Category:

0 = No loss of habitat predicted or assumed.
1 = Partial loss of habitat predicted based on results of wetted perimeter model.
2 = Total loss of habitat assumed due to Construction activities or substantive reduction in upstream watershed (*i.e.,* residual stream segments).

Salmonidae/Cottidae:

BT = Brook Trout
AS = Atlantic Salmon
SS = Slimy Sculpin

Cyprinidae:

BND = Blacknose Dace
PD = Pearl Dace
CC = Creek Chub
CS = Common Shiner
BNS = Blacknose Shiner

Other Families:

Anguillidae:
AE = American Eel

Catostomatidae:
WS = White Sucker
LS = Longnose Sucker

Petromyzontidae:
SL = Sea Lamprey

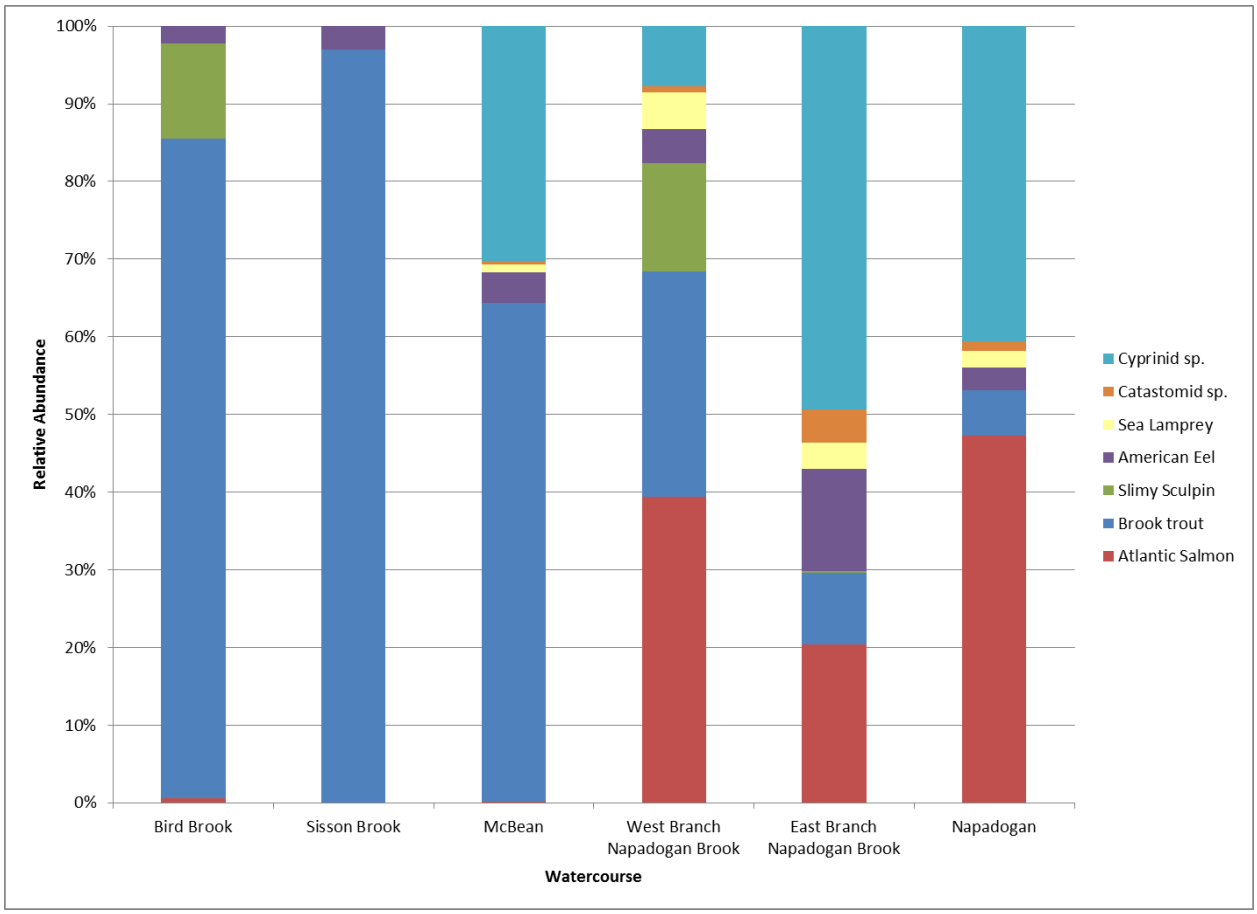


Figure 8.5.9 Relative Abundance of Fish Species by Watercourse in the LAA

8.5.2.3.2.2 Baseline Concentrations of Metals in Fish

The baseline concentrations of trace metals of interest in the whole fish are shown in Table 8.5.6. Mercury concentrations in whole brook trout in the Napadogan Brook watershed were typically between 0.08 and 0.14 mg/kg, with 0.24 mg/kg being the maximum measured concentration. Additional information on metal concentrations in whole fish and carcasses of fish can be found in Stantec (2012h).

Table 8.5.6 Baseline Concentrations for Selected Trace Metals in Whole Fish (Average, with Minimum and Maximum Values Shown in Brackets)

Trace Metal (mg/kg)	Watercourse			
	Bird Brook	Sisson Brook	McBean Brook	West Branch Napadogan Brook
Number of samples (n)	n=19	n=18	n=10	n=29
Aluminum (Al)	13.14 (1.14-63.16)	5.384 (0.476-44.27)	9.104 (1.05-55.94)	13.9 (0.521-53.16)
Arsenic (As)	0.161 (0.0318-0.363)	0.15 (0.0258-0.393)	0.0657 (0.0342-0.094)	0.377 (0.0255-1.341)
Boron (B)	0.0282 (0.0253-0.0514)	0.0256 (0.0251-0.0269)	0.02 (0.0255-0.0367)	0.026 (0.0252-0.0351)
Cadmium (Cd)	0.0493 (0.012-0.108)	0.084 (0.0239-0.175)	0.0633 (0.0252-0.103)	0.049 (0.0127-0.152)
Copper (Cu)	0.761 (0.551-1.116)	0.837 (0.579-1.408)	0.695 (0.489-0.915)	0.739 (0.435-1.224)
Iron (Fe)	19.77 (12.66-42.87)	16.41 (10.65-47.14)	17.97 (11.19-52.58)	25.53 (9.766-137.9)
Lead (Pb)	0.0474 (0.0115-0.1)	0.0193 (0.00806-0.0451)	0.0384 (0.0259-0.0649)	0.039 (0.00647-0.124)
Mercury (Hg)	0.143 (0.0853-0.242)	0.113 (0.0811-0.17)	0.0934 (0.0542-0.143)	0.101 (0.0504-0.195)
Molybdenum (Mo)	0.0148 (0.00985-0.0206)	0.0395 (0.0184-0.0971)	0.029 (0.0118-0.108)	0.014 (0.00577-0.026)
Tungsten (W)	0.0108 (0.00263-0.0224)	0.099 (0.0388-0.214)	0.0206 (0.00576-0.0659)	0.00594 (0.00252-0.022)
Uranium (U)	0.00434 (0.00253-0.0125)	0.00272 (0.00251-0.00493)	0.00454 (0.00256-0.00941)	0.00727 (0.00252-0.0191)
Zinc (Zn)	24.51 (16.65-31.32)	23.33 (19.17-26.54)	23.31 (19.04-27.77)	42.78 (18.96-32.46)

8.5.2.3.2.3 Fish Species at Risk and Species of Conservation Concern

Of the potential SAR and SOCC species identified in Section 8.5.1.5, only the Atlantic salmon and American eel were observed in the LAA. Although the field surveys were carried out as discrete "one-time" sampling events, a technical limitation of the baseline information, the species that were not observed are generally sedentary in nature and would likely have been found if present at the time of the surveys.

The Atlantic salmon, a federal SOCC and provincial SAR, was not observed directly in the PDA, but was well distributed throughout much of the rest of the Napadogan Brook watershed, including one individual parr within Bird Brook near to its confluence with West Branch Napadogan Brook. Atlantic salmon were not common in the portion of McBean Brook watershed that was surveyed, with only two juvenile salmon captured at a single location in 2011.

American eel, also a federal SOCC and provincial SAR, was found in all of the watercourses surveyed in the LAA. American eel was collected at twenty out of the thirty-six stations (Table 8.5.5), in second order and higher reaches throughout the LAA, including reaches of Bird and Sisson brooks within the PDA. The density of American eel ranged from 1 to 6 fish/100 m^2 in 2011.

8.5.3 Potential Project-VEC Interactions

Table 8.5.7 below lists each Project activity and physical work for the Project, and ranks each interaction as 0, 1, or 2 based on the level of interaction each activity or physical work will have with the Aquatic Environment.

Table 8.5.7 Potential Project Environmental Effects to the Aquatic Environment

Project Activities and Physical Works	Potential Environmental Effects
	Change in the Aquatic Environment
Construction	
Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities	2
Physical Construction and Installation of Project Facilities	2
Physical Construction of Transmission Lines and Associated Infrastructure	1
Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads	2
Implementation of Fish Habitat Compensation Initiatives	1
Emissions and Wastes	1
Transportation	0
Employment and Expenditure	0
Operation	
Mining	0
Ore Processing	0
Mine Waste and Water Management	2
Linear Facilities Presence, Operation, and Maintenance	1
Emissions and Wastes	2
Transportation	0
Employment and Expenditure	0

Table 8.5.7 Potential Project Environmental Effects to the Aquatic Environment

Project Activities and Physical Works	Potential Environmental Effects
	Change in the Aquatic Environment
Decommissioning, Reclamation and Closure	
Decommissioning	0
Reclamation	2
Closure	2
Post-Closure	2
Emissions and Wastes	2
Transportation	0
Employment and Expenditure	0

Project-Related Environmental Effects

Notes:

Project-Related Environmental Effects were ranked as follows:

0 No substantive interaction. The environmental effects are rated not significant and are not considered further in this report.

1 Interaction will occur. However, based on past experience and professional judgment, the interaction would not result in a significant environmental effect, even without mitigation, or the interaction would clearly not be significant due to application of codified practices and/or permit conditions. The environmental effects are rated not significant and are not considered further in this report.

2 Interaction may, even with codified mitigation and/or permit conditions, result in a potentially significant environmental effect and/or is important to regulatory and/or public interest. Potential environmental effects are considered further and in more detail in the EIA.

8.5.3.1 Construction: Activities With a Ranking of 0 or 1

Transportation was assigned a ranking of 0 in Table 8.5.7, as it is not anticipated to interact with the Aquatic Environment. Vehicles will travel within designated areas, and fording of watercourses will not be permitted. The potential adverse environmental effects associated with transportation accidents, such as a release of chemical reagent or fuel into the Aquatic Environment, are considered separately in Section 8.17. Dust generation and exhaust emissions associated with vehicle traffic are considered in the Emissions and Wastes activity.

Employment and Expenditure was assigned a ranking of 0 in Table 8.5.7, as it is not anticipated to interact with the Aquatic Environment.

Emissions and Wastes is ranked as 1 in Table 8.5.7 including site run-off and airborne dust and fuel combustion contaminants. Although these activities are likely to result in minor adverse environmental effects to the Aquatic Environment, the interactions are typical of construction projects and successful best management practices are available and well understood, as explained below.

Site run-off may result in minor quantities of suspended sediment entering adjacent watercourses. Site run-off will be managed using standard best management practices, such as locally placed erosion and sediment control barriers (*e.g.,* silt fences, straw bales), and through the installation of large coffer dams on the main branch of Bird and Sisson brooks, downstream of the TSF starter embankments. In the event that sediment is mobilized within the TSF, it will be deposited in the low-energy environment of the settling ponds created by the coffer dams. Relatively clear water will be pumped from the near surface of the settling ponds and released downstream of the construction sites. Total suspended solids (TSS) in the receiving water in the residual segment of the brooks will be monitored, and if CCME FAL guidelines are exceeded, additional adaptive sediment management solutions will be considered and implemented as necessary. The potential failure of the coffer dams or the pumps is considered as a possible accident scenario (Section 8.17). Therefore, site run-off associated with the

Emissions and Wastes activity is not anticipated to result in significant adverse environmental effects on the Aquatic Environment.

The new 138 kV transmission line will be constructed by increasing the width of the existing 345 kV transmission line right-of-way (ROW) from 50 m to 75 m. Access for construction will be provided via the existing ROW using established travel routes and access and following NB Power established environmental protection planning procedures. Transmission line towers or other transmission line infrastructure will be located at minimum distance of 30 m from all watercourses, and the underlying riparian vegetation will be left intact. With this avoidance and the implementation of standard mitigation measures (*e.g.*, standard erosion and sediment control measures) to avoid environmental effects from its construction, the potential for adverse environmental effects to fish and fish habitat in watercourses crossed by the new 138 kV transmission line is very low. It should be noted that baseline conditions were not established in watercourses crossed by the new 138 kV transmission line, where it is planned adjacent to the existing 345 kV transmission line. Baseline conditions were established where the new 138 kV transmission line will be developed within a new ROW alongside the relocated 345 kV transmission line around the Project site.

The location of transmission line towers and other infrastructure associated with the relocated 345 kV transmission line will follow the same procedures as described for the 138 kV transmission line, and is anticipated to have similarly low potential for environmental effects on the Aquatic Environment. The potential environmental effects of the adjacent relocated Fire Road are ranked as 2 and are considered separately in Section 8.5.4. As a result, the Physical Construction of Transmission Lines and Associated Infrastructure activity is not anticipated to result in significant adverse environmental effects on the Aquatic Environment.

For the purpose of the EIA, the Implementation of Fish Habitat Compensation Initiatives is the removal of the Lower Lake Dam, as described in Section 7.4.5 and detailed in Appendix E. The removal of the dam will involve demolition activities within the channel of the Nashwaak River, though it is anticipated that this work can be done in the dry. There may be temporary disturbance to local fish from noise and general activity. There appears to be a negligible amount of impounded sediments on the upstream side of the dam so the re-suspension of sediment due to the opening of the channel is anticipated to minor and of short duration.

The generation of TSS during demolition will be managed such that CCME FAL long-term TSS guideline is not exceeded. The final Fish Habitat Compensation Plan will include a detailed demolition plan. It is believed at this time that a coffer dam can direct water away from the rock and sheet metal wing, which can then be removed in the dry. The coffer dam will then be relocated such that water is directed away from the open dam gates, through the now open channel where the wing was located, and the concrete piers, apron and sill will be removed in the dry.

Given that the objective of the removal of Lower Lake Dam is to improve fish passage conditions at this location, and in consideration of the small magnitude and temporary nature of the potential environmental effects, the Implementation of Fish Habitat Compensation Initiatives activity is not anticipated to result in significant adverse environmental effects on the Aquatic Environment.

During Construction, emissions will occur as a result of exhaust emissions associated with the combustion of fuel, and the generation of dust due to exposed disturbed ground surfaces. Exhaust

emissions will result from the operation of heavy construction equipment, trucks, and machinery. Machinery-generated emissions are controlled with industry standard equipment (*e.g.,* catalytic converters) which will be maintained in good working order. Dust dispersion into watercourses can result where vegetation has been removed and the exposed ground is dry and disturbed by vehicle movement or wind. The generation of dust will be controlled with standard dust mitigation (Section 8.2.4.2) such that dust dispersion is not anticipated to result in an exceedance of CCME FAL guidelines for TSS or metals. In the event that applicable CCME FAL guidelines are exceeded as a result of dust, additional adaptive dust management solutions will be considered and implemented as necessary. Wastes will be stored in designated areas, in suitable containers (approved where applicable), and in the case of hazardous materials, at least 100 m from the nearest watercourse (does not include standing water within the TSF). Therefore, the Emissions and Wastes activity is not anticipated to result in significant adverse environmental effects on the Aquatic Environment.

8.5.3.2 Operation: Activities With a Ranking of 0 or 1

Mining was assigned a ranking of 0 in Table 8.5.7, as it is not anticipated to interact with the Aquatic Environment. The potential vibration from blasting within the mine is considered in the Emissions and Wastes activity. The potential for water contamination from blasting residue is considered in the Mine Waste and Water Management activity, as is the fate of the water from pit dewatering. The potential generation of dust from blasting, crushing and ore conveyance is considered in the Emissions and Waste activity.

The Ore Processing activity was assigned a ranking of 0 in Table 8.5.7, as it is not anticipated to interact with the Aquatic Environment. The management of tailings water arising from ore processing is considered in the Mine Waste and Water Management activity.

Transportation was assigned a ranking of 0 in Table 8.5.7 and is not anticipated to interact with the Aquatic Environment for the same reasons as discussed for the Construction phase (Section 8.5.3.1).

The Employment and Expenditure activity was assigned a ranking of 0 in Table 8.5.7 and is not anticipated to interact with the Aquatic Environment for the same reasons as discussed for the Construction phase (Section 8.5.3.1).

The Linear Facilities Presence, Operation, and Maintenance activity was assigned a ranking of 1 in Table 8.5.7 and includes the presence of site access roads and associated watercourse crossing structures which may have potential adverse environmental effects on the Aquatic Environment. The presence of site access roads may increase TSS in watercourses due to run-off from the road surface. Drainage ditches will be designed to discharge into the terrestrial environment at least 30 m away from a watercourse, or will pass through a settling pond prior to release to a watercourse. TSS in the receiving waters will be monitored, and if CCME FAL guidelines are exceeded, additional adaptive sediment management solutions will be considered and implemented as necessary. Watercourse crossing structures will be designed to provide fish passage for all resident species of fish and to minimize changes to watercourse hydrology. Therefore, the Linear Facilities Presence, Operation, and Maintenance activity is not anticipated to result in significant adverse environmental effects on the Aquatic Environment.

8.5.3.3 Decommissioning, Reclamation and Closure: Activities With a Ranking of 0 or 1

The Decommissioning activity was assigned a ranking of 0 in Table 8.5.7 and is not anticipated to interact with the Aquatic Environment. The equipment, buildings, and structures to be removed are not located near to a watercourse, and demolition and removal will be undertaken in a controlled manner such that fugitive emissions and wastes will not result.

Transportation activity was assigned a ranking of 0 in Table 8.5.7 and is not anticipated to interact with the Aquatic Environment for the same reasons as discussed for the Construction phase (Section 8.5.3.1).

The Employment and Expenditure activity was assigned a ranking of 0 in Table 8.5.7 and is not anticipated to interact with the Aquatic Environment for the same reasons as discussed for the Construction phase (Section 8.5.3.1).

8.5.3.4 Summary of Activities with a Ranking of 0 or 1

In consideration of the nature of the interactions and the planned implementation of known and proven mitigation, the potential environmental effects of all Project activities and physical works that were ranked as 0 or 1 in Table 8.5.7, including cumulative environmental effects, on the Aquatic Environment during any phase of the Project are rated not significant with a high level of confidence, and are not considered further in the assessment.

8.5.4 Assessment of Project-Related Environmental Effects

A summary of the environmental effects assessment and prediction of residual environmental effects resulting from interactions of the Project with the Aquatic Environment ranked as 2 in Table 8.5.7 is provided in Table 8.5.8.

Table 8.5.8 Summary of Residual Project-Related Environmental Effects on the Aquatic Environment

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context					
Change in the Aquatic Environment	Construction • Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities. • Physical Construction and Installation of Project Facilities. • Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads.	• Fish habitat compensation for direct loss of fish habitat. • Relocation of fish from watercourses within the TSF and open pit to nearby watercourses with suitable habitat. • Maintain existing drainage patterns to the extent possible. • Comply with the Wetland and Watercourse Alteration (WAWA) permit. • Implement erosion and sedimentation control during Construction and document measures taken as prescribed in the EPP. • Siting of Project facilities to minimize disturbance of watersheds and watercourses	A	L	L	P/O	I	D	N	H	--	Y	• Monitor TSS in discharge from construction sites to verify predictions and confirm compliance and identify need for further mitigation. • Monitor water quality of discharge from starter pit dewatering to evaluate treatment requirements, if any.
Change in the Aquatic Environment	Operation • Mine Waste and Water Management.	• Fish habitat compensation for indirect loss of fish habitat. • Erosion and sedimentation control during progressive construction of the TSF and other earth moving activities. • Design water management structures to reduce erosion and assure adequate water conveyance in extreme events.	A	M/ H	L	LT/C	I	D	N	M	--	Y	• Monitor to verify the seepage from the TSF is not adversely affecting downstream groundwater quality, surface water quality, or metals in fish tissue, and to identify the potential need for mitigation.

Table 8.5.8 Summary of Residual Project-Related Environmental Effects on the Aquatic Environment

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context					
		• Recycle water from the TSF for use in the ore processing to minimize Project demands on the environment for water, and to reduce the production of contact water. • Treat (as required) surplus mine contact water before discharge to the environment. • Construct engineered drainage collection channels to collect TSF embankment run-off and seepage and associated collection in lined WMPs which are pumped back to the TSF. • Install and operate groundwater pump-back wells below the northwestern TSF embankment to collect some groundwater seepage for return to the TSF. • Implement an adaptive management plan integrated with Follow-up and Monitoring Program to identify the need for and install groundwater monitoring wells below the TSF WMPs to monitor the groundwater quality, which can be converted to groundwater pump-back wells should downstream water quality monitoring indicate that seepage is											• Monitor WTP effluent for compliance with conditions of Approval to Operate. • Verify water temperature modeling by comparing the predicted values against an observed temperature at two different time periods. • The stream flow at the existing hydrometric stations (B-2, SB-1, NB-2B, TL-2 and MBB-2) will be observed and compared to the equivalent pre-Project stream flow rates calculated from the Narrows Mountain Brook (NMB) station. • Fish passage conditions comparative survey will be undertaken during low-water conditions, and a spawner survey for adult Atlantic salmon will be carried out in

Table 8.5.8 Summary of Residual Project-Related Environmental Effects on the Aquatic Environment

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context					
		jeopardizing downstream water quality objectives. • Construct engineered drainage and diversion channels to divert non-contact water around the Project facilities wherever possible. • Construct and operate a water treatment facility to treat surplus water from the Project before discharge, as required. • Adaptive management measures to further reduce seepage in the event that Follow-up and Monitoring Program identifies further mitigation is required.											Napadogan Brook. • Deleterious substance, pH, and acute lethality testing (*MMER* Sections 12-17) • Effluent characterization, sub-lethal toxicity testing and water quality monitoring (*MMER*, Schedule 5, Part 1) • Biological monitoring studies of fish, fish habitat, benthic macroinvertebrates, and the usability of fisheries resources (*MMER*, Schedule 5, Part 2).
Change in the Aquatic Environment	Decommissioning, Reclamation and Closure • Reclamation; Closure; Post-Closure.	• Fish habitat compensation for indirect loss of fish habitat. • Flood the open pit to minimize potential metal leaching and acid rock drainage (ML/ARD) from remaining pit walls. • Maintain ponded water over PAG tailings and waste rock within the TSF to prevent ML/ARD.	A	M/ H	L	LT/C	I	D	N	M	--	Y	• Monitor discharge from the TSF, and water in the open pit, to evaluate need for treatment before discharge to Sisson Brook.

Table 8.5.8 Summary of Residual Project-Related Environmental Effects on the Aquatic Environment

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context					
		• Treat water released from Project following Closure, as required to meet the conditions of the Approval to Operate. • Maintain pit lake level to ensure it is a groundwater sink until water quality meets discharge conditions of the Approval to Operate. • Adaptive management measures to further reduce seepage in the event that Follow-up and Monitoring Program identifies further mitigation to be required.											
	Residual Environmental Effects for all Phases								N	M	--	Y	

Table 8.5.8 Summary of Residual Project-Related Environmental Effects on the Aquatic Environment

Potential Residual Project-Related Environmental Effects	Project Phases, Activities, and Physical Works	Mitigation / Compensation Measures	Residual Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Cumulative Environmental Effects?	Recommended Follow-up or Monitoring
			Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context					

KEY

Direction
- P Positive.
- A Adverse.

Magnitude
- L Low: No change, or negligible change in the Aquatic Environment.
- M Medium: Measurable change to the Aquatic Environment that is within applicable guidelines, legislated requirements, and/or federal and provincial management objectives, or that does not affect the sustainability of fish populations.
- H High: Measurable change to the Aquatic Environment that is not within applicable guidelines, legislated requirements, and/or federal and provincial management objectives, or that results in a change in the sustainability of fish populations.

Geographic Extent
- S Site-specific: Within the PDA.
- L Local: Within the LAA.
- R Regional: Within the RAA.

Duration
- ST Short-term: Occurs and lasts for short periods (*e.g.,* days/weeks).
- MT Medium-term: Occurs and lasts for extended periods of time (*e.g.,* years).
- LT Long-term: Occurs during Construction and/or Operation and lasts for the life of Project.
- P Permanent: Occurs during Construction and Operation and beyond.

Frequency
- O Occurs once.
- S Occurs sporadically at irregular intervals.
- R Occurs on a regular basis and at regular intervals.
- C Continuous.

Reversibility
- R Reversible.
- I Irreversible.

Ecological/Socioeconomic Context
- U Undisturbed: Area relatively or not adversely affected by human activity.
- D Developed: Area has been substantially previously disturbed by human development or human development is still present.
- N/A Not Applicable.

Significance
- S Significant.
- N Not Significant.

Prediction Confidence

Confidence in the significance prediction, based on scientific information and statistical analysis, professional judgment and known effectiveness of mitigation:
- L Low level of confidence.
- M Moderate level of confidence.
- H High level of confidence.

Likelihood

If a significant environmental effect is predicted, the likelihood of that significant environmental effect occurring, based on professional judgment:
- L Low probability of occurrence.
- M Medium probability of occurrence.
- H High probability of occurrence.

Cumulative Environmental Effects?
- Y Potential for environmental effect to interact with the environmental effects of other past, present or foreseeable projects or activities in RAA.
- N Environmental effect will not or is not likely to interact with the environmental effects of other past, present or foreseeable projects or activities in RAA.

8.5.4.1 Potential Project Environmental Effects Mechanisms

The following Project activities and physical works are considered to have the potential to result in a Change in the Aquatic Environment that requires further evaluation in this EIA, and will thus be considered in more detail in the sub-sections that follow:

- **Construction:**
  - Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities;
  - Physical Construction and Installation of Project Facilities; and
  - Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads;
- **Operation:**
  - Mine Waste and Water Management; and
  - Emissions and Wastes;
- **Decommissioning, Reclamation and Closure:**
  - Reclamation;
  - Closure;
  - Post-Closure; and
  - Emissions and Wastes.

The nature of the potential environmental effects mechanisms with the Aquatic Environment is described further below.

8.5.4.1.1 Construction

During Construction, the Project activities “Site Preparation of Open Pit, TSF, and Buildings and Ancillary Facilities”, “Physical Construction and Installation of Project Facilities”, and “Physical Construction of Realigned Fire Road, New Site Access Road, and Internal Site Roads” are all anticipated to affect the Aquatic Environment in a similar manner, and therefore they are collectively referred to below as “Construction activities”. The specific mitigation and compensation measures proposed and recommended follow-up and mitigation are provided in Table 8.5.8.

8.5.4.1.1.1 Fish Habitat Area

Construction activities may result in the direct loss of fish habitat area, from:

- the direct loss of parts of Bird Brook and part of a small unnamed tributary to West Branch Napadogan Brook (referred to as Tributary "A") due to the construction of the TSF embankments and infilling of these brooks from the storage of tailings within the TSF;
- the direct loss of Sisson Brook in areas to be occupied by the open pit and related flow diversions around the PDA;
- the direct loss of some McBean Brook headwaters in the area of the open pit; and
- the loss of various watercourse fragments of Bird and Sisson brooks where they occur, for example, between the TSF and the open pit.

Collectively, these are hereinafter referred to as the "affected watercourses".

8.5.4.1.1.2 Fish Health

As indicated in Table 8.5.5, there are fish residing in all of the watercourses, with brook trout the predominant species in all four watercourses as presented in Figure 8.5.9. There is potential for Construction activities to result in the direct mortality of these fish, particularly during the Site Preparation of the TSF where the infilling of watercourses will begin in the first year of Construction. A TSF preparation plan has been prepared (Section 3.4.1.2.7) as a means of relocating fish and to avoid direct mortality from such activities. Direct mortality of fish may also occur in the watercourses within the open pit area as these are drained.

8.5.4.1.1.3 Fish Populations

Construction activities will reduce primary brook trout nursery, rearing and spawning habitat area, and all reasonable efforts will be made to relocate the fish within the affected watercourses to nearby watercourses within the Napadogan or McBean Brook watersheds, as appropriate. This will reduce the spatial distribution of fish populations within the LAA, and temporarily increase fish density in watercourses receiving the relocated fish.

8.5.4.1.2 Operation

During Operation, Mine Waste and Water Management has the potential to alter fish habitat area, water quality, productivity, the benthic macroinvertebrate community, fish passage, fish health, and fish populations. Though mine contact water on-site will be collected and stored in the TSF along with tailings, seepage through and under the TSF embankments and treated water released from the water treatment plant beginning in about Year 8 of Operation may affect downstream water quality and result in the aforementioned environmental effects.

The primary environmental effects mechanisms of this activity are:

- the controlled point-source release of treated water;

- the withholding of water in the TSF in Years 1-7 such that there is no release of treated water;
- the non-point source release of untreated mine contact water via seepage through and under the TSF embankments that is not captured by collection ditches and WMPs; and
- the non-point source release of dust-laden snow into the Aquatic Environment during periods of snow melt.

8.5.4.1.2.1 Fish Habitat Area

Operation activities may result in the indirect loss of fish habitat area due to reduced stream flow in residual stream segments of Sisson and Bird brooks, and consequently further downstream in Napadogan Brook. The environmental effect mechanisms, and extent, of indirect loss of fish habitat area for residual stream segments and for stream flow reductions in Napadogan Brook are described in Section 7.4.3.

8.5.4.1.2.2 Water Quality

Operation activities may affect water quality through changes in:

- water quantity, depending on whether water is being withheld or released;
- water quality (due to the release of trace metals);
- temperature; and
- dissolved oxygen (DO) and pH.

Trace Metals

The storage of tailings and waste rock in the TSF may result in metals enrichment in water that comes into contact with these materials in the TSF. Water within the TSF may reach the aquatic environment from:

- surplus water in the TSF that is treated and released as a point source into the former Sisson Brook channel which will discharge to the West Branch Napadogan Brook, starting about Year 8 of Operation; and
- non-point source seepage through and under the TSF embankments that gets past the collection ditches and water management ponds (WMPs).

For Years 1-7 of Operation, there will be no need to release water from the TSF, as all stored water will be reclaimed from the TSF, treated, and reused in the ore processing plant. Following use in the ore processing operation, process water will be pumped back into the TSF. However, starting in about Year 8 of Operation, it is projected that the TSF will have a surplus of water that will be treated to comply with *MMER* requirements and conditions of provincial Approvals, and then released into the residual segment of the former Sisson Brook channel, eventually discharging into West Branch Napadogan Brook.

The storage of tailings, waste rock and collected mine contact water in the TSF may also result in seepage of water contained in the TSF through the embankments and/or underlying material, some of which will get past the collection ditches and WMPs. For the purpose of the EIA, it is assumed that all this "bypass" seepage will end up as surface water in the nearest down-gradient watercourse to the area of seepage, and that all metals contained in the TSF seepage will remain in the seepage until emerging as surface water. This assumption allows for a consideration of the worst case scenario.

Finally, an indirect environmental effects mechanism is the emission of dust originating from various point and area sources of air contaminants to the atmosphere, and their associated dispersion in the atmosphere and deposition onto land, as discussed in Section 8.2. The deposited dust may result in accumulated trace metals in the snowpack during winter months to be released to the Aquatic Environment as non-point surface run-off as the snowpack melts during the spring freshet.

Temperature

The substantive reduction in the discharge from Bird Brook and Sisson Brook (Section 7.4.3) will reduce the cold water plume that these streams currently form at their confluence with West Branch Napadogan Brook. The cold water habitat currently provided by these streams will therefore also be reduced. Such cold water plumes may be used as cold water refugia by salmonid fish species during summer months when the water temperatures may be elevated beyond thresholds causing physiological stress.

The loss or reduction of the cold water plume also has the potential to change the water temperature regime further downstream (beyond the extent of the plume) in the West Branch Napadogan Brook, and therefore, indirectly affect the habitat suitability for cold water fishes in this area. In general, the water temperature regime may be affected by:

- the reduction or elimination of flow from Bird and Sisson brooks, which have a temperature regime about 2C^{o} colder (on average) than that of Napadogan Brook and may cause an increase in the water temperature of downstream waters;
- the sequestration of water in the TSF during Years 1-7 will reduce the flow volume of downstream waters resulting in a smaller, potentially slower-moving water mass in downstream waters with increased susceptibility to heat flux processes; and
- the treated effluent that is released starting in about Year 8 may be warmer than the receiving waters due to the lacustrine nature of the ponded water in the TSF.

Dissolved Oxygen (DO) and pH

DO levels in the receiving waters may be affected due to changes in water temperature, as the solubility of oxygen is lower in warmer water. Seepage from the TSF and the discharge of the treated TSF surplus water may cause an increase in biochemical oxygen demand (BOD) in the receiving waters, leading to reduction in DO. The Project is not predicted to result in acidic drainage thus no downward movement in pH is anticipated in the receiving waters.

8.5.4.1.2.3 Sediment Quality

The mechanisms for a change in sediment quality are the same as those described for metals in water quality. Dissolved metals that come into contact with the substrate may be adsorbed by fine sediment particles, or may attach to particles in suspension that are subsequently deposited in the substrate. There could also be precipitation reactions if some mineral phases are super-saturated (*e.g.,* aluminum, iron, manganese), and other trace metals could be co-precipitated within these metals to sediment.

8.5.4.1.2.4 Productivity

Stream current can have both beneficial and detrimental effects on benthic algae, and alterations to flow may alter the species composition and biomass of algae. Changes in stream temperature may alter algal growth rates, and consequently periphyton assemblage composition. The periphyton community may also be altered via changes in macroinvertebrate community (increase / reduction in grazers). The reduction in flow and nutrient availability in West Branch Napadogan Brook, as described in Section 7.4.3, has the potential to affect the periphyton community structure.

8.5.4.1.2.5 Benthic Macroinvertebrate Community

All of the above-noted mechanisms may act independently or cumulatively to alter the benthic macroinvertebrate community. Changes in water levels, discharge, wetted channel perimeter (*i.e*., available habitat), water temperature, water quality, sedimentation, and productivity may affect benthic macroinvertebrate abundance, species composition, community richness, and community diversity.

8.5.4.1.2.6 Fish Passage

Migrating or otherwise mobile fish species require sufficient water depth (which varies according to species and size) in order to provide enough propulsion to swim in a forward direction. A reduction in water levels may render some sections of a watercourse too shallow (particularly during the lowest summer flows) to provide sufficient depth for fish passage for larger fish. This may lead to habitat fragmentation, inability of a fish to reach its spawning habitat, temporary increased exposure to predators, or mortality caused by thermal stress. Also, lower water depths in a larger watercourse (*e.g.,* West Branch Napadogan Brook) may result in confluences with tributaries that are perched or disconnected from the main channel. The flow reduction in West Branch Napadogan Brook that is projected to occur at varying levels throughout Operation may potentially affect fish migration and passage in West Branch Napadogan Brook downstream of its confluence with Bird and Sisson brooks. As previously described, the potential reduction in flow is greatest during Years 1-7 of in the reach of West Branch Napadogan Brook between Sisson Brook and the confluence of West Branch Napadogan Brook with East Branch Napadogan Brook.

8.5.4.1.2.7 Fish Health

Individual fish health may be affected by any or all of the above-noted mechanisms when and where these result in changes to baseline fish habitat parameters such that the most relevant water quality guidelines are exceeded in the long-term.

8.5.4.1.2.8 Fish Populations

Fish populations may be affected at the larger scale via the same mechanisms that affect fish health if the magnitude and extent of the potential environmental effects are sufficient to affect a population. Collectively, the mechanisms discussed previously may alter the habitat suitability of downstream watercourses within the LAA, which may result in changes in fish population density, fish species assemblage, and fish species distribution.

8.5.4.1.3 Decommissioning, Reclamation and Closure

As part of the Reclamation activities described in Section 3.4.3, the TSF beaches and embankments will be capped and vegetated with native species. Surplus water from the TSF will be diverted to the open pit to convert it to a pit lake. Appropriate surface water and groundwater drainages from the site will be established, along with the ongoing restoration of all surrounding watercourses to open water with shrub-riparian and aquatic habitats suitable for use by wildlife and fish.

During Closure (approximately Years 28-39), surplus water from the TSF will be directed to the open pit and will no longer be released to the former Sisson Brook channel as was the case during Years 8-27 of Operation. The filling of the open pit with water is projected to take approximately 12 years. As well, water will continue to be returned to the TSF from the WMPs and any established groundwater pump-back wells. Thus, all water within the TSF and open pit will no longer be discharged to the receiving environment beginning in Year 28 until about Year 39.

During Post-Closure (starting about Year 40 onward), when the pit lake is at an elevation that ensures it is a groundwater sink, the lake water will be pumped to the WTP for treatment before discharge to the residual segment of Sisson Brook for as long as required to meet discharge requirements established by the government's Approval to Operate. When the lake water is of acceptable quality for direct discharge, pumping and treatment will cease, an engineered channel will be established from the north end of the pit lake to the residual segment of Sisson Brook, and the lake level will be allowed to rise to discharge through that channel.

How these Decommissioning, Reclamation and Closure activities may affect the key aspects such that a Change in the Aquatic Environment occurs is described below. Mitigation measures and planned follow-up and monitoring are provided in Table 8.5.8.

8.5.4.1.3.1 Fish Habitat Area

The mechanisms for change in fish habitat area during Decommissioning, Reclamation and Closure are the same as described for Operation, with the only difference being that there will be no discharge of treated Project surplus water during Years 28-39 while the open pit is filling with water, much the same as during Years 1-7 of Operation. Surplus water from the open pit would be treated as necessary and discharged to the receiving environment beginning about Year 40.

8.5.4.1.3.2 Water Quality and Sediment Quality

Closure will have similar effects mechanisms on water quality (*i.e*., metals, temperature, pH, DO) and sediment quality (*i.e.,* metals) as are predicted to occur during Years 1-7 of Operation. During Post-Closure, the release of water from the pit lake into the receiving environment has the potential to alter water temperature of West Branch Napadogan Brook downstream of Sisson Brook, depending on the temperature of the lake water.

During the Closure period (Years 28-39), discharge of treated surplus water to the receiving environment ceases and all surplus water from the TSF is diverted to the open pit to convert it into a lake. Downstream water quality may change compared to Operation as water is again withheld and no longer released. In the Post-Closure period (once the pit lake is full), surplus water is treated as necessary and is released to the receiving environment from the pit lake.

The lake will be relatively deep compared to its surface area and may become meromictic (*i.e.,* having a thin mixing surface layer of water lying above a deeper water mass that does not mix, or mixes only infrequently, and which may become anoxic and may contain high concentrations of dissolved trace metals). If the thermal layers turn over during the open-water season, the pit lake water that discharges to Sisson Brook, treated as required, may be lower in DO and elevated in metals concentrations as compared to the receiving waters.

Seepage of some TSF contact water will continue throughout Decommissioning, Reclamation and Closure as was described for Operation.

8.5.4.1.3.3 Productivity and Benthic Macroinvertebrate Community

The environmental effects mechanisms on productivity (periphyton) and benthic macroinvertebrates during Closure will be similar to those during Years 1-7 of Operation, and in Post-Closure will be similar to those of Years 8-27 of Operation.

8.5.4.1.3.4 Fish Passage, Fish Health, and Fish Populations

The environmental effects mechanisms on fish passage, fish health, and fish populations during Closure will be similar to those during Years 1-7 of Operation, and in Post-Closure will be similar to those of Years 8-27 of Operation.

8.5.4.2 Mitigation of Project Environmental Effects

The following mitigation measures (summarized in Table 8.5.8), through careful design and planning, will be employed to avoid or reduce the environmental effects of the Project on the Aquatic Environment that could otherwise potentially result from the environmental effects mechanisms described above:

- TSF Site Selection and Design;
- Fish Relocation;
- Mine Waste and Water Management; and

- Fish Habitat Compensation.

These mitigation measures are further discussed below.

8.5.4.2.1 TSF Site Selection and Design

The site selection process for the TSF, and its design and construction methods, are considered as mitigation for the potential Change in the Aquatic Environment and are described in Section 3.3.3. Along with the various factors considered for selecting the TSF location as described in Section 3.3.3, the selected TSF location had the added benefits of being entirely within a single watershed (Napadogan Brook), and did not affect any lakes. In addition, the northwestern embankment of the TSF was moved inward to avoid contact with two tributaries to the West Branch Napadogan Brook (W1F and W1G), thereby avoiding these watercourses compared to the TSF footprint initially proposed in the *CEAA* Project Description (Stantec 2011).

8.5.4.2.2 Fish Relocation

During the early stages of the construction of the TSF, all reasonable efforts will be made to relocate the fish residing in Bird and Sisson brooks within the PDA following the methods described in Section 3.4.1.2.7, thereby minimizing the potential for direct mortality to occur from construction activities. Fish would be trapped and transported out of the PDA and released in nearby suitable habitat.

A similar process will take place in Sisson Brook within the future area of the open pit. In Sisson Brook, fish will be released below the lower water management pond and will not be able to move back into the system.

8.5.4.2.3 Mine Waste and Water Management

The Mine Waste and Water Management activity includes many separate mitigation measures, including but not limited to:

- reclaim and reuse of water contained in the TSF for ore processing;
- operation of a water treatment plant; and
- seepage management.

The details of these and other mitigation measures are provided in Section 3.2.4.

Planned seepage management includes:

- seepage collection drains under the TSF embankments;
- surface water collection channels and water management ponds surrounding the TSF embankments;

- groundwater monitoring wells along the TSF embankments to assist in monitoring of seepage water quality; and

- groundwater pump-back wells in the area between the north embankment and tributary to West Branch Napadogan Brook (W1F), and associated pump-back of groundwater to the TSF.

Prior to Construction, further geotechnical and hydrogeological investigations will be undertaken in the TSF area to support basic engineering and detailed design studies for the TSF embankments and associated seepage and water management systems. These investigations include geotechnical drilling with associated groundwater testing, test pits and seismic surveys. They are important to enhancing the characterization of existing site conditions, and to advancing the design of the environmental management features of the TSF. In particular, they are important to refining the assumptions, and confirming the conservatisms, in the seepage and water quality modelling, both for facility design purposes and to inform the possible selection of adaptive management and mitigation measures as described in Section 8.5.4.2, should they be needed as determined through the Follow-up and Monitoring Program. A key purpose of the further site investigations, predictive modelling refinements, increasingly detailed environmental design of the TSF and associated seepage and water management systems, and planning for adaptive management during Operation is to ensure that environmental effects due to Project-related water quality changes will not risk ecological or fish health.

Follow-up and monitoring measures to monitor the environmental effects of the Project on the Aquatic Environment (Section 8.5.7 and Chapter 9), and adaptive management strategies developed in response to follow-up and monitoring results, will assist in defining further mitigation measures as may be necessary throughout the Operation of the Project. Specifically, the quality of the receiving waters will be monitored for changes in specific metals concentrations, and the results compared to the CCME FAL or other relevant guidelines as described in this EIA, and the results of the water quality modelling.

In the unlikely event that measured concentrations are at or above levels above those projected conservatively by the refined water quality modelling in a continuous long-term manner, then additional mitigation measures can be considered as part of an adaptive management plan. These measures may include:

- installation of additional groundwater collection and pump-back wells and systems to intercept the seepage in the area of the determined pathways; and

- irrigating the tailings beaches with supernatant water during dry periods to minimize oxygen diffusion through the beaches and thus improve the quality of seepage water; and

- various methods of blocking the seepage pathways such as grouting of bedrock fracture zones outside the TSF embankments.

8.5.4.2.4 Fish Habitat Compensation

Fish habitat compensation is the primary mitigation for the unavoidable direct and indirect loss of fish habitat area. Compensation is the least preferred mitigation approach, though it is envisioned by the *Fisheries Act* and is often necessary where there are no alternative mitigation measures that are technically and economically feasible that would mitigate any significant adverse environmental effects

of a project. The process for developing the plan for compensating for the loss of fish habitat is described in Section 7.4.5, and the complete Conceptual Fish Habitat Compensation Plan for consideration by DFO is provided in Appendix E.

8.5.4.3 Characterization of Residual Project Environmental Effects

8.5.4.3.1 Construction

As noted in Section 8.5.4.1, Construction activities may result in changes to the following key aspects of the Aquatic Environment:

- fish habitat area;
- fish health; and
- fish populations.

The following sub-sections assess the residual environmental effect of potential changes in these key aspects on the Aquatic Environment.

8.5.4.3.1.1 Fish Habitat Area

As described in Section 7.4.2 and as indicated in Table 7.4.1, Construction activities will result in the direct loss of approximately 372 HADD units (where 1 unit = 100 m^2) of fish habitat within the PDA. The direct loss is spread between Bird Brook (from the development of the TSF), Sisson Brook (from development of the TSF, open pit, and other components), McBean Brook (from the development of the open pit and relocation of the Fire Road), and Tributary "A" to West Branch Napadogan Brook (from the development of the TSF), in descending order of magnitude. Although considered as part of Construction activities, the development of the new 138 kV transmission line and the relocation of the existing 345 kV is not anticipated to result in the direct loss of fish habitat or any adverse environmental effects to the Aquatic Environment as no disturbance will occur within 30 m on either side of each watercourse from these activities.

The fish habitat to be directly lost consists mostly of first and second order streams and ranges from habitat with low suitability for brook trout (*e.g.,* wetland ponds and beaver ponds) to riffle-run habitat with high suitability for brook trout spawning, rearing, and feeding. The potentially affected habitat is described in Section 8.5.2.3.1.

It is expected that the direct loss of fish habitat will be authorized by DFO under Section 35 of the *Fisheries Act* in order for the Project to proceed. Such authorization would include a requirement for compensation as described in the Conceptual Fish Habitat Compensation Plan (Appendix E), subject to regulatory approval, with the objective of achieving no residual net loss of fish habitat. With this authorization and associated compensation for residual environmental effects from direct loss of fish habitat, the residual adverse environmental effects of Construction on the Aquatic Environment with respect to the loss of fish habitat area are rated not significant.

8.5.4.3.1.2 Fish Health

During Construction, fish will be relocated from Bird Brook within the PDA to nearby watercourses outside of the PDA prior to carrying out Construction activities associated with the TSF. The exact capture methods and relocation points where captured fish are deposited will be determined in consultation with DFO and NBDNR, and will take into consideration the species assemblage of the receiving watercourse/reach, habitat conditions, fish density, site access, and other factors as warranted. Relocation will be undertaken as described in the TSF preparation plan (Section 3.4.1.2.7), using an approach and a variety of standard fish trapping techniques intended to minimize fish mortality.

Relocation may result in a temporary increase in fish density in the receiving watercourses where captured fish are deposited, though it is expected that fish will naturally relocate from these areas if necessary such that there is not a long-term burden on the available food source, shelter, and other habitats and therefore on fish health. With this fish capture and relocation program intended to minimize direct mortality and sub-lethal environmental effects on fish from Construction activities, the environmental effects of Construction on the Aquatic Environment with respect to environmental effects on fish health would not be significant.

8.5.4.3.1.3 Fish Populations

The loss of Bird and Sisson brooks, and portions of McBean Brook and Tributary “A” to West Branch Napadogan Brook within the PDA, will locally alter the spatial distribution of the relevant fish species (Table 8.5.5). This is particularly the case for the brook trout population of the Napadogan watershed. While greater than 80% of Bird Brook and greater than 95% of Sisson Brook is suitable habitat for brook trout, they are not the only areas of the Napadogan watershed with suitable brook trout habitat. A spatial analysis of landscape level habitat variables (*e.g.,* sinuosity, gradient and percent cover) and water temperatures across the entire Napadogan Brook watershed was conducted in support of the EIA; the results indicate that standalone and seasonal brook trout habitat is abundant in the West Branch Napadogan Brook watershed, in a few tributaries of East Branch Napadogan Brook, and in Manzer Brook, ensuring that brook trout populations will be maintained in the Napadogan Brook watershed overall.

Atlantic salmon, a federal SOCC and provincial SAR, were not present in these watercourses within the PDA. A single Atlantic salmon parr was observed in Bird Brook downstream of the PDA, near to the confluence with West Branch Napadogan Brook and two were identified in McBean Brook downstream of the PDA. Atlantic salmon habitat is abundant in the LAA and RAA in the Napadogan and Nashwaak watershed outside of the PDA. The COSEWIC (2010) assessment and status report on the Atlantic salmon in Canada suggests poor marine survival rates as the primary cause of declining populations in the Maritime provinces, followed by climate change. Although degradation and fragmentation of freshwater habitats are noted as possible causes, these are not known to be factors in the LAA and RAA. The affected habitat is therefore not likely critical to Atlantic salmon and is not likely a limiting factor in their status. Therefore, the direct loss of these watercourses is not anticipated to result in an adverse significant environmental effect on Atlantic salmon populations.

American eel, also a federal SOCC and provincial SAR, were present in the second and third-order sections of these watercourses where suitable substrate habitat was present. In general, the habitat of

these watercourses is not ideal for American eel, and this was reflected in the 2011 baseline quantitative fish survey where the greatest number of American eels captured at a single location was 6 fish, and the proportion that American eels were of the total number of fish was always less than 20%. American eel habitat is not known to be limiting in New Brunswick, where as a catadromous species, they use freshwater habitat to grow and mature typically seeking out loose fine-grained substrate in which to burrow. It is expected that the relocated American eels will be able to adapt to their new habitat and that the direct loss of these watercourses is not anticipated to result in an adverse significant environmental effect on American eel.

The fish species contained in Sisson Brook, Bird Brook or the areas of McBean Brook that are situated in the PDA, do not contain any fish species which only exist in these areas. All species were commonly found throughout the LAA (Table 8.5.5) and are known to occur commonly throughout the RAA. Therefore, the Construction activities are not anticipated to affect habitat that is limiting for any of the fish species currently residing therein, and the environmental effects of Construction on the Aquatic Environment with respect to environmental effects on fish populations would not be significant.

8.5.4.3.1.4 Summary of the Residual Environmental Effects of Construction

With the proposed mitigation and environmental protection measures, the residual environmental effects of Construction activities on the Aquatic Environment are rated not significant. This determination has been made with a high level of confidence for all key aspects of the Aquatic Environment, and particularly in consideration of the compensation measures as mitigation for the direct loss of fish habitat, and the relocation of fish from within the PDA.

8.5.4.3.2 Operation

As noted in Section 8.5.4.1, Operation activities may result in changes to the following key aspects of the Aquatic Environment:

- fish habitat area;
- water quality (metals, temperature, and DO and pH);
- sediment quality;
- productivity;
- benthic macroinvertebrate community;
- fish health; and
- fish populations.

The following sub-sections assess the residual environmental effects of potential changes in these key aspects of the Aquatic Environment, with an overall assessment of the Operation phase provided in Section 8.5.4.3.2.11.

8.5.4.3.2.1 Fish Habitat Area

As described in Section 7.4.3 and as indicated in Table 7.4.3, Operation activities are projected to result in the indirect loss of approximately 123 HADD units of fish habitat in the residual stream segments of Bird Brook, Sisson Brook, and Tributary "A" to West Branch Napadogan Brook, in descending order of magnitude. This will begin at the end of Construction when water begins to be withheld in the TSF starter pond and will continue for the duration of the Operation phase. Though there is no physical activity planned in these residual stream segments, because such a large portion of the catchment of Bird and Sisson brooks as well as Tributary "A" to West Branch Napadogan Brook will be lost to the Project, it has been conservatively assumed that the remaining catchment of these watercourses would be too small to maintain suitable flow in the residual segments of these watercourses to consider them to be suitable fish habitat and they are thus conservatively assumed to be indirectly lost.

The fish habitat in the residual stream segments considered to be indirectly lost ranges from first to third order streams, and is suitable for brook trout spawning, rearing, and feeding. The potentially affected habitat is described in Section 8.5.2.3.1. The importance of the potentially affected habitat, as it relates to fish populations (including Atlantic salmon and American eel) is assessed under Fish Populations later in this section.

Similarly, as described in Section 7.4.3 and as indicated in Table 7.4.8, Operation activities will result in the indirect loss of up to approximately 67 HADD units of fish habitat in West Branch Napadogan Brook and Lower Napadogan Brook due to reduction in downstream flow arising from retaining water within the catchments of Bird Brook and Sisson Brook for the Project. This indirect loss will begin during Construction when water begins to be withheld in the TSF starter pond and will continue for Years 1-7 of the Operation phase, as a result of decreased water volume as measured at the wetted perimeter. Beginning at about Year 8, water levels in West Branch Napadogan Brook and Lower Napadogan Brook will approach pre-Project levels as treated water discharge from the TSF partially restores the lost flow. However, the flows within the reach between the confluences of Bird Brook and Sisson Brook with West Branch Napadogan Brook will continue to be as they were in Years 1-7.

In order for the Project to proceed, the indirect loss of fish habitat in both the residual stream segments as well as in the Lower Napadogan Brook will need to be authorized by DFO and compensated for as described in Section 7.4 and the Conceptual Fish Habitat Compensation Plan (Appendix E) with the objective of achieving no residual loss of fish habitat. With this authorization and associated compensation for residual environmental effects from indirect loss of fish habitat, the adverse environmental effects of Operation on the Aquatic Environment with respect to the loss of fish habitat area would not be significant.

8.5.4.3.2.2 Water Quality (Trace Metals)

Environmental Effects to Water Quality from Seepage and Water Treatment Plant Release

As was summarized in Section 7.6 of this EIA Report, predictive water quality modelling was conducted by Knight Piésold (2013c) to predict the concentrations of various trace metals in the receiving waters as a result of the Operation of the Project. Predictive modelling considered baseline concentrations of various trace metals in the LAA as measured through routine surface water monitoring conducted since 2008 (Knight Piésold 2012e), and considered the contributions to this baseline from the Project arising from seepage from the TSF, and from the release of treated effluent from the water treatment plant starting in about Year 8 of Operation. The predictive water quality modelling suggests that while concentrations of most parameters in receiving waters will meet the CCME FAL guidelines during Operation, concentrations of some trace metals may intermittently and non-continuously exceed CCME FAL guidelines in receiving waters. The model approach and a summary of the results are provided in Section 7.6 of this EIA Report. Importantly, the water quality modelling has inherent conservatism and assumptions that may be overestimating predicted concentrations. An integrated Follow-up and Monitoring Program and adaptive management strategy will be implemented to verify environmental effects predictions and the effectiveness of mitigation, and take appropriate measures to further mitigate environmental effects where unexpected undesirable change is identified. The approach is coupled with a robust mitigation strategy that includes further refinement in the understanding of hydrogeological conditions to support model refinement and enhanced environmental design of the TSF. Figure 7.6.2 shows the location of the model nodes that are referred to throughout the discussion that follows. For brevity, only those parameters that exceeded the CCME FAL guidelines or other suitable environmental quality objectives as discussed in Section 7.6 and in Knight Piésold (2013c) (specifically aluminum, cadmium, fluoride, arsenic, chromium, selenium, and copper) are assessed below. The environmental effects of all other parameters meeting the relevant guidelines as predicted by the modelling are rated not significant.

The predicted McBean Brook water chemistry is not altered by mine seepage; however, changes are modelled as a result of water diverted around the open pit from the Sisson Brook catchment to McBean Brook. Surface water diversion structures will direct run-off that would naturally have drained through Sisson Brook into the McBean Brook catchment. No parameters were noted to increase to a point where guidelines were encroached upon, except for those that were observed to exceed guidelines in the baseline data (*e.g.*, fluoride). Thus, the Project is not predicted to result in the exceedance of CCME FAL or other relevant guidelines in McBean Brook. The environmental effects in this brook are therefore not significant, and McBean Brook is not discussed further below in relation to potential changes in water quality.

<u>Aluminum</u>

As demonstrated by the baseline aquatic environment sampling program carried out in the PDA and LAA by Stantec in 2011 field surveys (Stantec 2012d), aluminum concentrations are naturally elevated in the LAA, particularly at locations in the upper portion of the Napadogan Brook watershed, decreasing with increasing distance downstream from the Project. During Operation, concentrations of aluminum in West Branch Napadogan Brook are predicted to be intermittently greater than the CCME FAL guideline (100 µg/L at pH ≥ 6.5), as shown in Figure 7.6.7; however the predicted maximum concentration at all but one of the modelled locations (specifically at model node NAP1) were within the

typical range of baseline aluminum concentrations (120 to 200 µg/L) measured in the LAA. The maximum aluminum concentration at model node NAP1 during Operation is predicted to be less than 250 µg/L (Knight Piésold 2013c). Aluminum concentrations in West Branch Napadogan Brook can be expected to temporarily exceed the CCME FAL guideline annually during Years 1-7 of Operation, and semi-annually for the remainder of Operation. The aluminum concentrations in West Branch Napadogan Brook are expected to be highest at locations close to the Project; farther downstream, maximum aluminum concentrations will be lower (less than 125 µg/L). However, the determination of potential for aluminum toxicity requires measurement of inorganic monomeric aluminum concentrations in water. Factoring into consideration the baseline and predicted total aluminum concentrations and pH values measured in the LAA, it is predicted that Operation activities will not result in aluminum concentrations in receiving waters exceeding the CCME FAL guideline in a continuous, long-term manner, and the environmental effects are therefore not significant.

Cadmium

Concentrations of cadmium in West Branch Napadogan Brook are predicted to be intermittently greater than the CCME FAL Interim Guideline (0.017 µg/L; hardness dependent). The typical range of baseline cadmium concentrations measured in the LAA in 2011 field surveys was 0.04 to 0.06 µg/L (Stantec 2012d). The maximum cadmium concentration in West Branch Napadogan Brook during Operation is predicted to be less than 0.15 µg/L (Knight Piésold 2013), as shown in Figure 7.6.9.

The CCME FAL Interim Guideline for cadmium is based on the lowest observable effects on the most sensitive organism (*Daphnia magna*) at 0.17 µg/L (CCME 1999). Fish and plants have been observed to be less sensitive to cadmium than *Daphnia magna*, with chronic effects in Atlantic salmon at 0.47 µg/L and aquatic algae and plants at concentrations greater than 1 µg/L (CCME 1999). The current CCME FAL Interim Guideline for cadmium is under review and proposed guidelines for cadmium include short-term and long-term exposure guidelines. The proposed CCME (2012) long-term guideline value, based on a threshold effect on a sensitive species and corrected for hardness during Operation, is 0.12 µg/L (adjusted for the average site-specific predicted hardness concentration). At all but one modelled location, where the maximum cadmium concentration approached 0.15 µg/L, cadmium concentrations are predicted to be less than the proposed long-term exposure guideline, thus it is predicted that Operation activities will not result in cadmium concentrations in receiving waters exceeding the CCME FAL guideline in a continuous, long-term manner, and the environmental effects are therefore not significant.

Fluoride

The CCME FAL interim guideline for fluoride (0.12 mg/L) is based on the lowest acceptable adverse effects on the most sensitive organism (a caddisfly, *Hydropsyche bronta*) at 11.5 mg/L (CCME 1999). The range of reported 96-hour LC_{50} (*i.e.,* concentration at which 50% mortality occurs) values for freshwater fish (Camargo 2003) is generally above 50 mg/L (ranging from 51 mg/L for rainbow trout, *Oncorhynchus mykiss,* to 460 mg/L for three-spined stickleback, *Gasterosteus aculeatus*). Thus, the interim guideline is conservatively set in regards to protecting finfish.

During Operation, concentrations of fluoride are predicted to be frequently greater than the CCME FAL guideline in West Branch Napadogan Brook (Knight Piésold 2013) and as shown in Figure 7.6.6. Based on surface water quality monitoring completed to date for the PDA (Knight Piésold 2012e),

baseline concentrations of fluoride regularly exceed the CCME FAL guideline of 0.12 mg/L, with median fluoride concentrations measured across 18 monitoring stations typically in the range of 0.10 to 0.17 mg/L. The predicted maximum values (seasonal high values) occasionally exceed 0.4 mg/L, though there is the uncertain potential for a concentration of 1.34 mg/L in Year 24 at model location UT1 on a tributary of West Branch Napadogan Brook. The greatest fluoride concentrations in West Branch Napadogan Brook can be expected beginning in Year 8 of Operation and will generally be less than 0.8 mg/L. The maximum fluoride concentration in West Branch Napadogan Brook during Operation has been modelled to be 1.26 mg/L at model node NAP5 (Knight Piésold 2013) due to discharge from the WTP after Year 7.

Although the CCME FAL guideline for fluoride is considered to be over-protective in regards to finfish, and since the future fluoride concentrations are predicted to be intermittently over the CCME FAL interim guideline, additional hydrogeological and geotechnical investigation prior to Construction, refined predictive water quality modelling and perhaps Project design, and follow-up and monitoring components are warranted. The follow-up and monitoring program for water quality in all metals, including fluoride, is provided in Section 9, and includes metal concentrations in groundwater, surface water, and fish tissue. Adaptive management measures to further reduce seepage in the event that follow-up identifies further mitigation to be required are described in Section 8.5.4.2.3. In consideration of the baseline conditions, the mitigation built into the Mine Waste and Water Management activity, the conservative assumptions of the predictive water quality model and of the CCME FAL interim fluoride guideline with respect to fish, the Follow-up and Monitoring Plan, and the adaptive management measures, Operation activities are not expected to result in fluoride concentrations that substantially alter water quality of the receiving waters over the long-term, and the environmental effects are therefore not significant.

Arsenic

The CCME FAL guideline for arsenic is based on a single study of effects on growth of a species of algae (*Scenedesmus obliquus*) at arsenic concentrations of 50 µg/L (CCME 1999), a study that does not meet current quality criteria for establishing such guidelines. International guidelines for arsenic in ambient waters are generally much higher than the CCME value. Fish and invertebrates have been observed to be less sensitive to arsenic, with effects on fish (rainbow trout) at 550 µg/L and aquatic invertebrates at concentrations of 320 µg/L or greater (CCME 1999). International reviews support water quality guidelines for arsenic that are greater than 10 µg/L. Australia and New Zealand have jointly developed guidelines that range from 13 µg/L (as arsenate) to 24 µg/L (as arsenite). The Netherlands independently developed a guideline of 24 µg/L as the 5^{th} percentile value in a species sensitivity distribution for no-effect concentrations. The USEPA has a chronic exposure concentration of 150 µg/L, and this has been applied in Ontario in the development of groundwater standards for protection of aquatic life, in preference to their own provincial surface water quality objective of 100 µg/L. Thus, an arsenic guideline of 10 µg/L is considered appropriate for the assessment of the environmental effects of the Project on water quality as it relates to fish.

As shown in Figure 7.6.8, the maximum arsenic concentration in West Branch Napadogan Brook is predicted to be less than 8 µg/L (Knight Piésold 2013), which is less than the 10 µg/L guideline. Therefore, Operation activities are not expected to result in arsenic concentrations that substantially alter water quality of the receiving waters over the long-term, and the environmental effects are therefore not significant.

Chromium

The CCME FAL guideline for chromium (hexavalent) is based on the lowest observable effects level on the most sensitive species (*Ceriodaphnia duba*) at a chromium concentration of 10 µg/L (CCME 1999). Fish (Atlantic salmon) have been observed to be equally sensitive to chromium, with chronic effects observed at concentrations as low as 10 µg/L (CCME 1999). The CCME FAL guideline is conservatively set at 1.0 µg/L for hexavalent chromium.

Concentrations of dissolved chromium in West Branch Napadogan Brook are predicted to be intermittently (seasonally) greater than the CCME FAL guideline. As shown in Figure 7.6.10, chromium concentrations in West Branch Napadogan Brook can be expected to temporarily (annually or semi-annually) exceed the CCME FAL guideline after approximately Year 9 of Operation, with a maximum dissolved chromium concentration in the West Branch Napadogan Brook predicted to be less than 2.5 µg/L (Knight Piésold 2013). Therefore, in consideration of the intermittent and localized nature of the predicted exceedances of the CCME FAL guideline, the conservative assumptions of the predictive water quality model and of the CCME FAL chromium guideline with respect to fish, Operation activities are not expected to result in chromium concentrations that substantially alter water quality of the receiving waters over the long-term, and the environmental effects are therefore not significant.

Selenium

Green algae are most sensitive to selenium, with effects observed at 50 µg/L (CCREM 1987). Invertebrates and fish are less sensitive, with toxic effects observed in *Hyallela azteca* at 340 µg/L and fathead minnow at 600 µg/L, and no effects found in rainbow trout at 40 to 80 µg/L (CCREM 1987). The CCME FAL guideline is conservatively set at 1 µg/L.

As shown in Figure Figure 7.6.12, selenium concentrations are predicted to exceed the CCME FAL guideline in West Branch Napadogan Brook for an approximate 10 year period (from Year 10 to Year 20); this result was only observed at one modelled location (model node NAP5 below Sisson Brook and the WTP discharge). Predicted maximum selenium concentrations exceed the CCME FAL guideline by only a small amount (predicted value of 1.1 µg/L; Knight Piésold 2013c), and in an intermittent and non-chronic exposure manner. Therefore, in consideration of the intermittent and localized (single location) nature of the predicted exceedances of the CCME FAL guideline, the conservative assumptions of the predictive water quality model and of the CCME FAL selenium guideline with respect to fish, Operation activities are not predicted to result in selenium concentrations that substantially alter water quality of the receiving waters over the long-term, and the environmental effects are therefore not significant.

Copper

Copper has been observed to have chronic effects on brook trout at 3.873 µg/L, and at a copper concentration of 4.3 µg/L changes in fish behaviour have been documented (CCREM 1987). *Daphnia magna* has been observed to be most sensitive, with acute toxicity at copper concentration of 6.5 µg/L (CCREM 1987). Acute effects in rainbow trout have been observed at copper concentrations of 110 µg/L (CCREM 1987).

The current CCME FAL guideline (1999) for copper is adjusted for hardness in a stepped manner, with a lower limit of 2 µg/L (for continuous exposure) where hardness is less than 83 mg/L as occurs throughout the LAA under baseline conditions. There is no CCME fact sheet for copper, though this guideline has been in place since 1987 and is based on the work of Demayo and Taylor (1981).

The CCME FAL guideline does not adjust for the binding of copper below hardness of 83 mg/L, instead applying the aforementioned fixed limit of 2 µg/L. Watercourses in the LAA typically have soft water, with hardness generally less than 10 mg/L. Operation activities result in an increase in hardness in receiving waters, though the water remains soft with typical predicted hardness less than 70 mg/L. In consideration of this, alternative guidelines based on more recent science were considered that would provide a more accurate guideline for soft water.

The United States Environmental Protection Agency's 2006 National Recommended Water Quality Criteria for Priority Toxic Pollutants (USEPA 2006d) included a simple hardness based calculation to determine the chronic exposure (CCC) value for copper, with a resulting guideline that is increasingly higher than the CCME FAL guideline at hardness greater than 20 mg/L as $CaCO_3$.

In 2007 the USEPA issued an update to the copper guideline which was formally adopted in the 2009 National Recommended Water Quality Criteria for Priority Toxic Pollutants (USEPA 2009). The 2007 copper guideline applies a complex biotic ligand model (BLM) that was developed to assess the effects of multiple water chemistry covariates on the bioavailability of copper (USEPA 2007). The generation of a site-specific guideline using the BLM approach requires the input of multiple parameters into a mathematical model. Alternatively, an estimated guideline can be produced using the tablature approach provided in the USEPA (2007) report. The tablature approach uses fixed values for hardness, pH, and dissolved organic copper (DOC) to generate the instantaneous acute exposure limit for copper. This value can be converted to chronic exposure limit using an acute to chronic ratio (ACR) of 3.22:1. For the purpose of the EIA, the tablature approach was applied at NAP5 (see Figure 7.6.2 for its location). It should be noted that the minimum hardness value available in the table is 40 mg/L, thus the guideline is not available for hardness less than 40 mg/L using this method. Site-specific copper guidelines that cover the baseline and predicted hardness values will be generated using the equation approach prior to the initiation of the applicable Follow-up and Monitoring Program.

The BLM equation factors into account that higher DOC values, if present in the water, reduce the toxicity of copper. While the organic carbon levels have been measured as the total organic carbon (TOC), it is reasonably assumed that the TOC measured for baseline conditions is predominantly DOC. For example, the mean DOC:TOC ratio in the streams across all states in the USA is approximately 86% (USEPA 2007). For the purpose of the EIA, the predicted TOC values at NAP5 TOC average 5.6 mg/L, so a DOC value of 4.0 mg/L is used in the BLM at NAP5. It should be noted that table DOC values are in factor of 4, so rounding to the nearest available DOC value was required.

Figure 8.5.10 compares the modelled future case copper concentrations against projected hardness at model node NAP5, which is in the West Branch Napadogan Brook just downstream of the confluence with Sisson Brook. As seen in Figure 8.5.10, there are five distinct periods in which the resulting copper concentrations are grouped. During Years 1-7 of Operation, copper concentrations remain similar to the baseline conditions and are below both the CCME FAL and the USEPA (2007) guidelines. Once the TSF is in a surplus condition, the treated water from the water treatment plant will be discharged into the residual segment of Sisson Brook. This water contains elevated hardness as

compared to the baseline conditions. As this water enters West Branch Napadogan Brook, it increases the hardness thereby decreasing the toxicity of the copper to fish, according to the USEPA (2007) guideline.

The Predictive Water Quality Modelling Report (Knight Piésold 2013c) determined that copper concentrations in the nearby receiving surface waters of the LAA are influenced by seepage and by treated water discharge (effluent discharge limit of 0.002 mg/L); however, the point source discharge does not affect the trend to lower predicted concentrations moving downstream along West Branch Napadogan Brook and then Napadogan Brook. The changes are predominantly driven by seepage from the TSF. Although the volume and rate of seepage is assumed to stay relatively constant, the concentrations of metals in surface waters vary seasonally due to varying stream flows associated with wet and dry seasons. For example, the higher concentrations occur during the dry months of July and August; during this period of lower stream flow, seepage comprises a greater percentage of the total flow volume.

As shown in Figure 7.6.10, the maximum copper concentrations at model node NAP5 and all upstream model nodes of the main branch of the West Branch Napadogan Brook during Operation are predicted to exceed the CCME FAL guideline from May through October, and again in February. These seasonal fluctuations, with copper concentrations below the CCME FAL guideline for more than half of the year, prevent the exposure from being continuous and chronic. Maximum copper concentrations are reached in late-Operation and early-Closure. The highest concentration is predicted at model node NAP1, with a maximum concentration of 0.0038 mg/L. Predicted copper concentrations decrease to levels at or below the CCME FAL guideline in lower Napadogan Brook (at model nodes NAP7 and NAP8) during all project Phases, due to dilution from the contribution of East Branch Napadogan Brook.

The predictive water quality modelling (Section 7.6; Knight Piésold 2013c)) indicates that copper concentrations in the small tributary draining to the West Branch Napadogan Brook northwest of the TSF may be higher than in the brook itself, as reported for location UT1. As explained above (Section 7.6.3.5.3), there is greater uncertainty with, and less confidence in, the UT1 results than with the modeled nodes on Napadogan Brook itself. The results are primarily useful for indicating where additional studies are needed to better understand site conditions, likely seepage and water quality effects, and the TSF design features needed to ensure that downstream water quality is acceptable. At UT1, indicated copper concentrations exceed the CCME FAL and USEPA (2007) guidelines beginning in approximately Year 8 of Operation and continuing throughout Operation. Maximum copper concentrations are indicated in late-Operation and early-Closure with a peak value of 0.0114 mg/L.

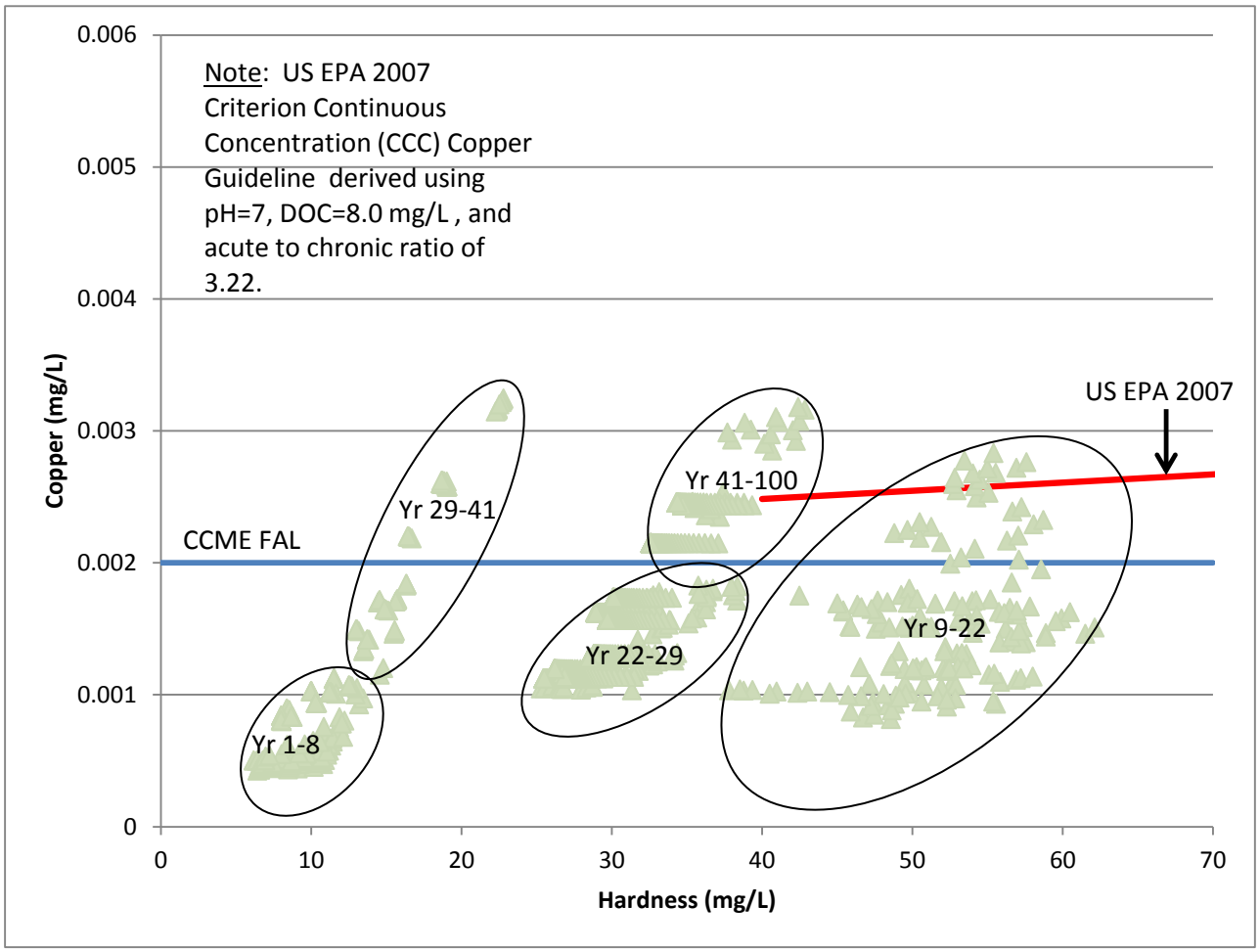


Figure 8.5.10 Relationship of Modelled Copper and Hardness at NAP5 for All Project Phases

The copper concentrations reported as baseline (Stantec 2012d) and future predicted conditions (Knight Piésold 2013c) are for total dissolved copper. Copper is most toxic to fish in its +2 valence (cupric) free ion form (Alberta Environmental Protection 1996). Fortunately, the cupric ion in water is typically bound with other compounds, which reduces cupric ion concentrations (and its toxicity) substantially. Demayo and Taylor (1981) reported that cupric free ion concentrations ranged from <0.02% to 0.37% of the dissolved copper in central Canadian lakes. Thus, it is reasonable to assume that only a portion of the total dissolved copper reported in the baseline and future predicted case conditions is potentially toxic to fish, and the total dissolved value represents the worst projected future case concentrations.

As previously discussed in Section 7.6.3.4.1, the water quality modelling incorporated conservative assumptions such that the final predictions of chemical concentrations at each node are expected to be lowered with additional site information and modelling during more detailed Project design. It is acknowledged that the current predicted copper concentrations at NAP1 to NAP5 would likely be considered unacceptable, should they actually occur. Similarly, indicated though uncertain concentrations at UT1 might also occur and be unacceptable. As presented in Section 8.5.4.2, further studies and Project design mitigation to further reduce copper (and other seepage-related metals)

concentrations will be undertaken, beginning with a detailed geotechnical and hydrological investigation prior to basic engineering design and Construction. A robust Follow-up and Monitoring program (Section 8.5.7 and Section 9.0) will be carried out to confirm the results of the refined predictive water quality modelling. Adaptive management mitigation measures may also be considered based on the results of the Follow-up and Monitoring Program. Therefore, in consideration of the conservative assumptions of the predictive water quality model, and the above described approach, Operation activities are not expected to result in copper concentrations that substantially alter water quality of the receiving waters over the long-term, and the environmental effects are therefore not significant.

Environmental Effects on Water Quality from Dust Deposition onto Snowpack

During engagement activities undertaken for the Project, stakeholders identified the concern that deposition of particulate matter from the Project onto snowpack could adversely affect water quality in receiving waters as the accumulated trace metals in the snowpack are released during the spring freshet. To address this concern, the release, dispersion and deposition of dust (fine particulate matter) emissions from Operation activities were simulated using the AERMOD modelling system (USEPA 2009). The analysis included predicted total winter deposition of a variety of metals that result from the deposition of emissions across the LAA. The winter emissions and deposition only included those activities that would produce emissions over the winter months, specifically: ore blasting, crushing, and loading and unloading at various transfer points, as well as emissions from the boiler at the APT plant. Emissions from unpaved roads and other potential sources of fugitive particulate matter (*e.g.,* the ore storage pile) were not modelled as dust would not be expected to be released from these sources in the winter.

The volume of snow in the snowpack was estimated from the historical total snowfall accumulation observed over the winter months of December, January, February and March (Knight Piésold 2012d). Snowfall is also observed in other months (*e.g.,* November and April), however the snowfall during these months does not often contribute to the snowpack. The total accumulation of the snowpack used in this analysis is 277 cm. This results in a total potential snowmelt of 277 L/m^2 once all of the snowpack has melted.

In order to provide a conservative estimate of the concentration of the metal constituents contained in the dust, the following assumptions were applied:

- the dust and all constituents are completely and immediately dissolved in the snowmelt resulting from the first thaw of the year; and
- a total of five percent of the accumulated snowpack would melt during the first thaw.

The resulting concentrations in snowmelt at the ecological risk assessment receptor locations (Section 7.7) are presented in Table 8.5.9.

Table 8.5.9 Comparison of Maximum Predicted Snowmelt Concentrations to CCME FAL Guidelines

Parameter	Predicted Maximum Concentration in Snowmelt within LAA (µg/L)	CCME FAL Guideline[a]
Aluminum (Al)	2.34	5
Arsenic (As)	0.00537	5
Cadmium (Cd)	0.000137	0.018
Chromium (Cr)	0.00868	1
Copper (Cu)	0.0237	2
Lead (Pb)	0.00586	1
Mercury (Hg)	0.0000905	0.026
Molybdenum (Mo)	0.0386	73
Nickel (Ni)	0.00258	25
Selenium (Se)	0.000306	1
Tungsten (W)	0.0684	--
Zinc (Zn)	0.0196	30
Sulphur (S)	0.583	--
Boron (B)	0.00257	1500
Cobalt (Co)	0.00169	--
Manganese (Mn)	0.0937	--
Tellurium (Tl)	0.000125	0.8
Uranium (U)	0.000360	15
Vanadium V)	0.0103	--
Lithium (Li)	0.00556	--

Notes:
[a] reported guidelines are for water hardness < 60 mg/L where applicable.
-- means no CCME FAL guideline exists.

The maximum concentrations of all parameters at the receptor locations are well below the CCME FAL guidelines, and therefore would not result in any other parameters to exceed these guidelines when the snowmelt arrives and is mixed into the receiving surface waters.

Summary

In consideration of the results of the predictive modelling for all metals as compared to the relevant guidelines, the described mitigation, the proposed hydrogeological and geotechnical studies to be carried out prior to Construction to inform Project design and to refine the assumptions of the water quality modelling, the Follow-up and Monitoring Program, adaptive management approach for addressing seepage-related issues should they occur, and the results of the dust dispersion model, the contribution of dissolved trace metals from Operation activities to the Aquatic Environment are not likely to result in a significant adverse environmental effect on the Aquatic Environment.

8.5.4.3.2.3 Water Quality (Temperature)

The direct loss of large portions of Bird and Sisson brooks due to the construction of the TSF and the open pit will result in a reduction in flow in these residual stream segments as well as downstream. A corresponding reduction in the size of thermal refugia will result both in the remaining portions of the streams themselves or in the thermal plume these streams create in the Napadogan Brook at their confluence. Temperature refugia are important to cold water fish species (such as brook trout, Atlantic salmon, and slimy sculpin) during conditions when species-specific temperature thresholds are exceeded. During such conditions, warm water temperatures can impose physiological stress response in fish, and make the freshwater habitat unsuitable unless fish can readily access patches of cooler water. As the water temperature approaches the species-specific temperature thresholds, the fish will seek areas of colder water that will alleviate the physiological stress.

Temperature mapping of tributaries in the Napadogan Brook watershed has revealed that thermal refugia, with similar thermal and habitat characteristics as Bird and Sisson brooks, are distributed throughout West Branch Napadogan and Lower Napadogan Brook as shown in Figure 8.5.11. Movement capabilities of salmonid fishes during conditions leading to thermal stress have been shown to be extensive (Breau *et al.* 2011), and such observations indicate that brook trout and juvenile salmon are capable of finding and moving into cold water refugia from considerable distances. Therefore, the potential reduction in cold water refugia availability in the Sisson and Bird brooks will likely result in spatial re-distributions of the brook trout population (and other cold water species) into other tributaries of Napadogan Brook that continually provide thermal refugia during the summer months.

Operation activities are predicted to affect the water temperature in the receiving downstream waters of Napadogan Brook, though differently during the two periods of Operation (*i.e.,* Years 1-7 vs. Years 8-27). The reduction of water flow in Bird and Sisson brooks during Years 1-7 of Operation may affect the water temperature in the Napadogan Brook in areas downstream of these brooks due to the elimination or reduction of cold water input, and secondarily due to potentially faster heating of water in Napadogan Brook due to flow reductions. Beginning in about Year 8 of Operation, the release of treated surplus water from the TSF may also result in warming of the water in Napadogan Brook.

Water temperature modelling, using three different scenarios, was undertaken to evaluate potential environmental effects on the water temperature in Napadogan Brook, and to assess how the change in water temperatures may affect resident and migratory cold water fish species. The temperature modelling used the water temperature data in 2012 as a base case (a year with higher than normal average temperatures; Stantec 2013f, in press).

The first scenario evaluated the environmental effects of reduced flows from the observed 2012 rates in Bird and Sisson brooks using areal proration in order to predict the effect of reducing the inflow of cooler temperature water from these brooks on the water temperatures in Napadogan Brook. The water reduction from Bird and Sisson brooks used in this scenario corresponded to the situation that would be experienced during Years 1-7, when the greatest potential downstream flow reductions would occur in the Operation phase.

The second and third scenarios used the (reduced) cold water flows from Scenario 1, but added the predicted maximum discharge rate of treated surplus water from the TSF as predicted by Knight Piésold for a normal year. The temperature of the discharge to Sisson Brook was assumed to be

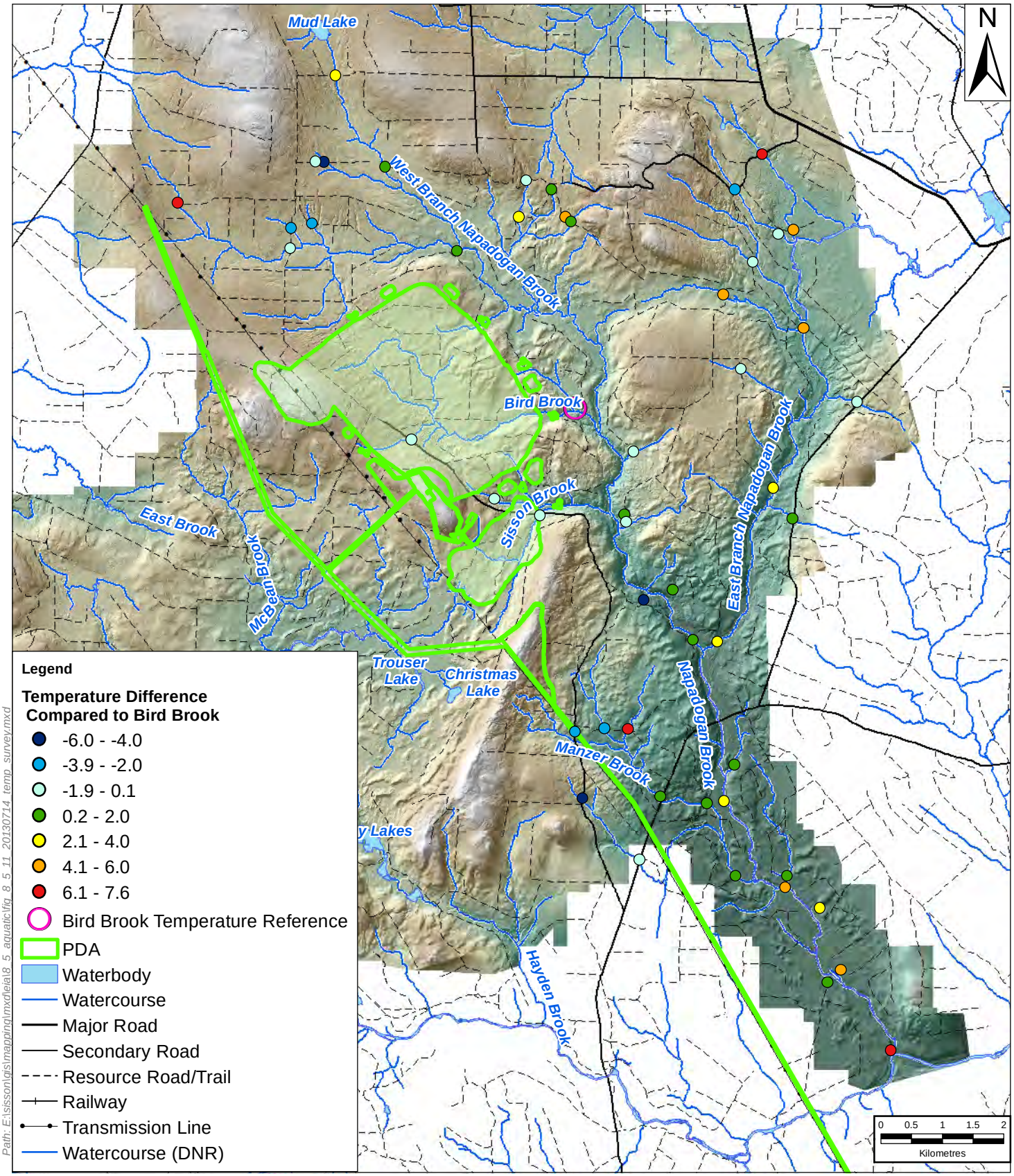
warmer, at 20°C and at 25°C, to gain an understanding of how effluent release during Years 8-27 of Operation might affect water temperatures in Napadogan Brook.

The modelled three scenarios suggest that a general increase in water temperature will result due to the Operation activities in comparison to the pre-Project baseline (*i.e.*, 2012 modelled conditions). The predicted effect of decreasing the inflow of cooler water from Bird and Sisson brooks by a maximum amount (as will be experienced during Years 1-7) is a 0.2C° increase in average stream temperatures in Napadogan Brook just above the confluence of West and East Branch Napadogan Brooks. Similarly, decreased cooler inflow combined with discharge of warmer, treated surplus water from the TSF resulted in a 0.7 to 1.4C° increase in stream temperature in Napadogan Brook, for effluent temperatures of 20 and 25°C, respectively.

The modelled data of the three scenarios were further used to estimate whether the number or duration of thermal events would increase as a result of the Project, where a "thermal event" was defined as a minimum 1 day period where water temperature exceeds the physiological thresholds for cold water fish species (*i.e.,* brook trout, juvenile and adult Atlantic salmon; physiological limits considered at 19°C, 27°C and 23°C, respectively).

Six thermal events were observed during the modelled year (2012), with a duration range of 1 to 6 days per event. Applying the model scenarios, the total number of days exceeding the physiological temperature threshold for brook trout would increase by 6 to 12 days per year, which means that the expected duration of a thermal event would increase from the actual range of 1-6 days to a range of 2-7 days. As a result of the increased duration, two of the thermal events overlapped making one extended thermal event and therefore the total number of thermal events decreased from six (actual) to five under the modelled scenarios. Thus, the model indicates that the thermal events were prolonged under the predicted scenarios though there was one fewer thermal event, suggesting that the frequency of when brook trout would seek cold water refugia would not increase compared to the baseline data.

More importantly, the temperature threshold of 19°C was predicted to be exceeded relatively frequently already in the baseline conditions, and thus the habitat in the Napadogan Brook downstream of Bird and Sisson brooks is already currently frequently too warm for brook trout as year-round standalone habitat. This assertion is supported by the baseline electrofishing data both from 2011 and 2012, which indicates that brook trout abundance is low in comparison to juvenile salmon abundance, with juvenile salmon to brook trout abundance ratio at the adjacent W4A31 station is 26:1 and 11:1 in 2011 and 2012, respectively. Therefore, the increase in water temperature in West Branch Napadogan Brook is not predicted to result in a change in thermal suitability for brook trout in West Branch Napadogan Brook as it is considered to be unsuitable as year-round habitat under current conditions.



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NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Water Temperature Survey Locations Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B. Client: Northcliff Resources Ltd.	Scale: 1:85,000	Project No.: 121810356	Data Sources: NBDNR, Leading Edge Geomatics Ltd.	Fig. No.: 8.5.11	Stantec
	Date: (dd/mm/yyyy) 14/07/2013	Dwn. By: JAB	Appd. By: DLM		

Map: NAD83 CSRS NB Double Stereographic

For adult Atlantic salmon, the 23°C physiological threshold was only exceeded in the scenario with TSF surplus water at a 25°C release temperature, where the threshold was predicted to be exceeded during two days per year (Stantec 2013f, in press). The temperature threshold was exceeded only slightly (by 0.3 and 0.4 C°) and for a very short period (2 hours and 4 hours for the two days, respectively). It is also noted that both instances when temperature exceeded the threshold were followed by a cool night when water temperature declined to levels that allowed physiological recovery; therefore, the temporary temperature elevation would not likely be long enough to trigger a large scale movement response in adult Atlantic salmon. It is also noteworthy that adult Atlantic salmon are not expected to be present in the Napadogan Brook watershed during the time when thermally stressful conditions are likely to occur (*i.e*., the July-August period). Although the early run of adult salmon typically ascend the Nashwaak system in June-July (Jones *et al.* 2010), it is believed that the adult salmon remain in the deep holding pools in the Nashwaak River until later in the autumn, and enter Napadogan Brook just prior to spawning in October, triggered by reduced water temperatures and increases in stream flow. Such behavior is commonly observed in other similar, relatively shallow spawning tributaries in New Brunswick (Mitchell and Cunjak 2007). The notion is also supported by direct observations made during various field surveys in support of the EIA that adult Atlantic salmon were absent until autumn (late September), and by similar comments in this regard from a stakeholder (Spencer, G. Personal communication, September 19, 2012).

In general, the water temperatures remained below 24°C for all scenarios under most conditions, suggesting physiologically benign conditions for juvenile and adult Atlantic salmon (Breau *et al.* 2007; 2011). Where temperatures were predicted to exceed the threshold, none of the modelled scenarios suggested that the temperature regime would be elevated in magnitude or for a sufficient duration that would cause a behavioural thermoregulation response in juvenile or adult Atlantic salmon, or an adverse change in fish health. West Branch Napadogan and Lower Napadogan brooks currently do not provide year-round suitable habitat for brook trout. The Project is not predicted to increase the number of events requiring brook trout to seek thermal refugia. Accordingly, the environmental effects of Operation on the Aquatic Environment with respect to water temperature are not significant.

8.5.4.3.2.4 Water Quality (DO and pH)

Dissolved oxygen (DO) concentrations in the Napadogan Brook may be slightly affected by the predicted increase in water temperature as described above. The average increase in water temperature is predicted to be from 0.2 to 1.4C° compared to the baseline condition, and translates to a potential worst case reduction of 0.24 mg/L in DO at saturation, assessed at 101.3 kPa barometric pressure, using the mean conductivity of Napadogan Brook (17.0 µS/cm), and assuming the maximum average temperature increase of 1.4C° during warm summer conditions (*i.e*. from baseline of 20°C, to predicted 21.4°C; Benson and Krause 1980; 1984). The concentration of DO in future conditions would still be considered suitable (8.85 mg/L at 21.4°C) at saturation for supporting the fish species known to reside and migrate in this habitat. Therefore, the temperature effect on DO is considered negligible.

As described in Section 3.2.4, the mitigation measures for the management of potentially acid generating waste rock and tailings (*e.g*., the subaqueous storage within the TSF) will prevent the formation of acid and corresponding acidic drainage from entering surface waters via seepage. The treated surplus water that is released after about Year 8 may have slightly higher pH than the receiving waters and may result in a small and localized increase in pH. Thus, no downward movement in pH is

predicted in the receiving waters. Accordingly, the environmental effects of Operation on the Aquatic Environment with respect to the changes in pH and DO would not be significant.

8.5.4.3.2.5 Sediment Quality

As was summarized in Section 7.6 of this EIA Report, predictive water quality modelling was conducted by Knight Piésold (2013c) to predict the concentrations of various trace metals in the receiving waters as a result of the Operation of the Project. Predictive modelling considered baseline concentrations of various trace metals in the LAA as measured through routine surface water monitoring conducted since 2008 (Knight Piésold 2012e), and considers the contributions to this baseline from the Project arising from seepage from the TSF, and from the release of treated effluent from the water treatment plant starting about Year 8 of Operation. Detailed predictive modelling was not undertaken for metal concentrations in sediments; however, as part of the HHERA (Section 7.7), the predictive water quality modelling results, together with published uptake factors for water-to-sediment, were used to estimate future concentrations of selected metals in sediment.

A comparison of sediment concentrations to the CCME SQG (probable effect levels) (Table 7.7.51) revealed exceedances of the arsenic guideline. Predicted future (Project + Baseline Case) sediment concentrations are mainly related to pre-existing (Baseline Case) metal concentrations. The CCME SQG guidelines are meant to be protective for a range of species and as such, sediment concentrations less than these guidelines are indicative of a negligible probability of adverse environmental effects. Where concentrations are greater than these guidelines, there is a possibility (but not a certainty) of adverse environmental effects to ecological receptors.

8.5.4.3.2.6 Productivity

The reduction in stream flow in Napadogan Brook due to withholding mine contact water within the TSF was predicted as described in Section 7.4.3.2. The predicted average reduction of 2 cm/s in current velocity during mean annual flow conditions is considered negligible and is unlikely to cause a measurable or substantive change in the periphyton community. For example, the arrival rates of algal cells, and therefore the process of colonization, are not expected to be altered. While a linear trend between dry-mass of periphyton and near-bed velocities exists (*e.g.*, Biggs *et al.* 1998), the small predicted change in current velocity is reasonably presumed insufficient to cause a substantive change in the periphyton community.

Similarly, the previously described changes in water temperature in West Branch Napadogan Brook are not considered to be large enough to affect dominance trends from mainly diatom benthic algae to yellow-brown algae dominance in Napadogan Brook (DeNicola 1996).

There are no other Project-caused changes in water nutrient availability, light conditions, or benthic grazer abundance (see the benthic macroinvertebrate community discussion that follows below) that may cause a substantive change in the periphyton community. Accordingly, the environmental effects of Operation on the Aquatic Environment with respect to fish habitat productivity are rated not significant.

8.5.4.3.2.7 Benthic Macroinvertebrate Community

During Years 1-7 of Operation, reductions in stream flows in West Branch Napadogan Brook below Bird Brook may result in a change in benthic macroinvertebrate abundance and community composition and a decrease in benthic macroinvertebrate community diversity and richness. Abundance or density can either increase as a result of increased nutrient concentrations and resulting food resources, or it can decrease due to decreases in habitat availability and diversity, food quantity and quality, and/or changes in competition and predation (Dewson *et al.* 2007, Mattson *et al.* 2012). Benthic macroinvertebrate community composition can change as a result of the change in the habitat and the water velocity preferences of individual species; this in turn can decrease richness and diversity (Dewson *et al.* 2007, Mattson *et al.* 2012).

Starting in Year 8, when treated surplus water begins to be released into the residual stream segment of Sisson Brook, increased stream flow downstream of its confluence with West Branch Napadogan Brook may result in changes to benthic macroinvertebrate communities compared to those experienced during Operation in Years 1-7. In West Branch Napadogan Brook below Sisson Brook, benthic macroinvertebrate communities may be restored close to pre-Project conditions through natural re-colonization. The portion of West Branch Napadogan Brook between the confluences of Bird and Sisson brooks will continue to have reduced stream flow, and the benthic macroinvertebrate community is expected to remain similar to those seen in Years 1-7, for the duration of Operation.

While changes in benthic macroinvertebrate community structure are likely, changes in productivity and other community functions tend to be minor due to the robustness of the overall community and the ability of different species to adapt to altered conditions such that community function remains robust. Accordingly, the environmental effects of Operation on the Aquatic Environment with respect to changes in the benthic macroinvertebrate community would are rated not significant.

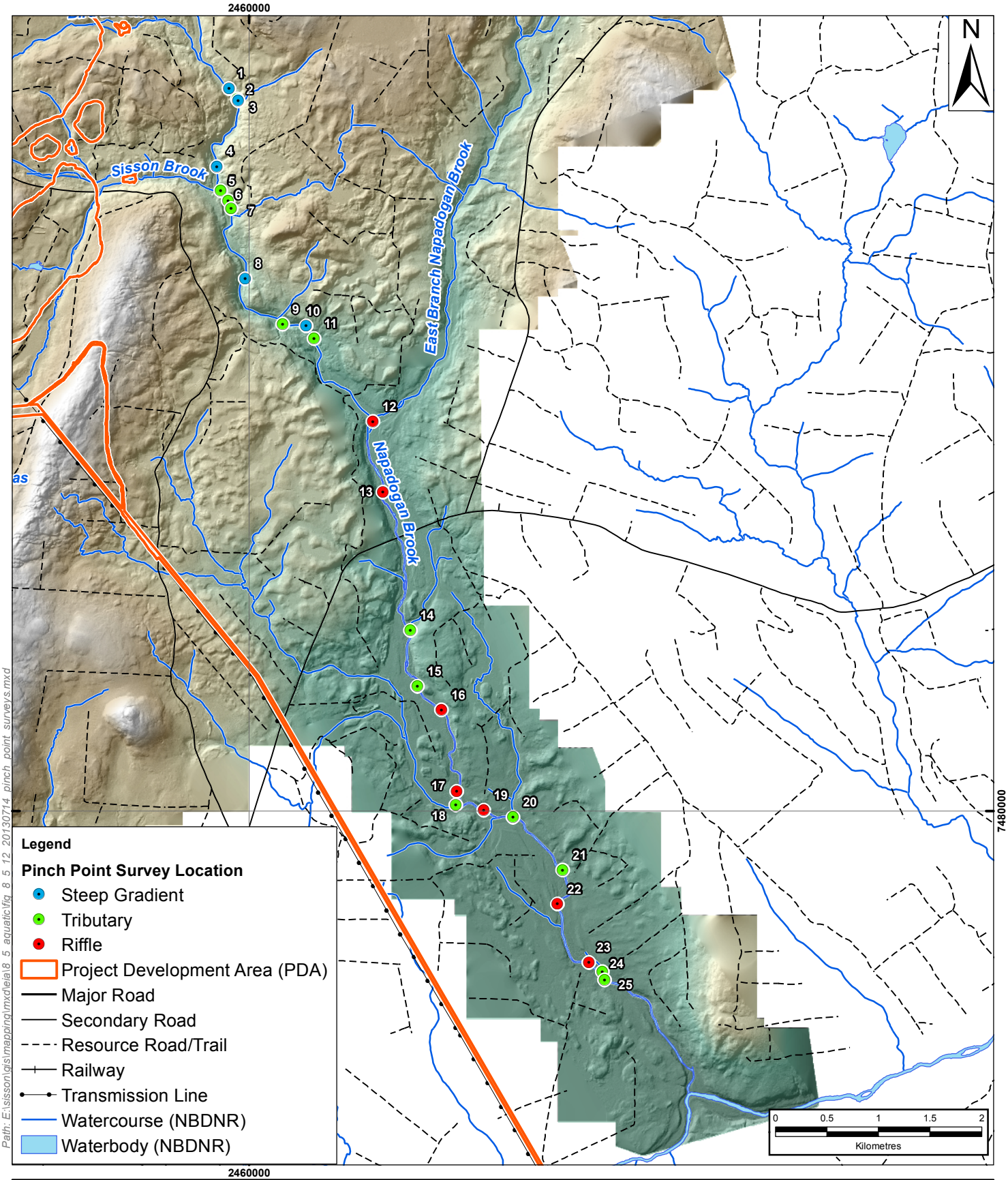
8.5.4.3.2.8 Fish Passage

As discussed in Section 7.4.3.2, withholding of mine contact water in the TSF during Operation will result in reduced stream flows in West Branch Napadogan Brook and Lower Napadogan Brook. The highest reduction in downstream flow during Operation will occur in Years 1-7, when there is no treated surplus water discharge.

The predicted flow reduction, and its potential influence on fish passage conditions, is greatest during the time period when water flows are naturally the lowest in Napadogan Brook, which typically occurs in late summer (*i.e*., July-September) or late winter (*i.e.*, February). In winter, cyprinid fish remain inactive and hiding in the gravel (Cunjak 1996), and habitat connectivity is not of concern due to their lethargic behaviour caused by reduced body temperature and rate of metabolism. Salmonid fish (*e.g.,* brook trout, Atlantic salmon) remain active throughout winter, but their behaviour has been shown to be localized with no directed movements in the late winter period (Huusko *et al.* 2007). During the low flow period in summer, however, habitat connectivity along the river corridor is important, especially for the salmonid fish that may require access to thermally suitable habitat during conditions that may be physiologically stressful due to warmer water temperatures, as described previously.

As previously discussed, fish passage is not a relevant consideration for adult Atlantic salmon during the low-flow period in the summer months, as adult salmon are not typically present in Napadogan Brook until later in the fall when they normally ascend to the brook, triggered by declining water temperatures and increased stream flow. Similarly, fish passage is not a relevant consideration for "sea-run" brook trout during low-flow months in the summer, as these larger fish are not known to be present in Napadogan Brook during this period (Stantec 2012d; Spencer, G. Personal communication, September 19, 2012). However, reduced flows in the summer low-flow period and associated potential alteration in fish passage will be relevant for Juvenile Atlantic salmon and relatively small-sized brook trout at these life stages.

To assess the potential alteration of fish passage conditions during Operation, potential areas that may restrict fish movements as a result of reduced water depths were field-identified. The survey was completed during relatively low-flow summer conditions (*i.e.*, Q_{74} conditions, or flow level that is exceeded 74% of the time). A total of 25 locations were identified where habitat connectivity may be or may become limited during low-flow conditions, as shown in Figure 8.5.12 and as listed in Table 8.5.10.



NOTE: THIS DRAWING ILLUSTRATES SUPPORTING INFORMATION SPECIFIC TO A STANTEC PROJECT AND SHOULD NOT BE USED FOR OTHER PURPOSES.

Potential Barriers to Fish Passage at Low Flow Sisson Project: Environmental Impact Assessment (EIA) Report, Napadogan, N.B. Client: Northcliff Resources Ltd.	Scale: 1:50,000	Project No.: 121810356	Data Sources: NBDNR Leading Edge Geomatics Ltd.	Fig. No.: 8.5.12	Stantec
	Date: (dd/mm/yyyy) 14/07/2013	Dwn. By: JAB	Appd. By: DLM		

Map: NAD83 CSRS NB Double Stereographic

Table 8.5.10 Observed and Predicted Fish Habitat Connectivity Conditions at Identified Locations in West Branch Napadogan Brook and the Main Branch Napadogan Brook

Survey Location[a]	Potential Habitat Connectivity Barrier Type[b]	Fish Habitat Connectivity Conditions		
		Observed Conditions During Field Survey (Q_{74})[c]	Observed Conditions Modelled at Low Flow (Q_{95})[d]	Modelled Project Case at Low Flow (Q_{95})[d]
1	2	Accessible	Accessible	Partial Barrier, accessible only to fish < 13.5 cm
2	3	Barrier	Barrier	Barrier
3	2	Barrier	Barrier	Barrier
4	2	Accessible	Accessible	Accessible
5	3	Accessible	Accessible	Accessible
6	3	Barrier	Barrier	Barrier
7	3	Barrier	Barrier	Barrier
8	2	Accessible	Accessible	Accessible
9	3	Barrier	Barrier	Barrier
10	2	Accessible	Accessible	Accessible
11	3	Barrier	Barrier	Barrier
12	1	Accessible	Barrier	Barrier
13	1	Accessible	Barrier	Barrier
14	3	Accessible	Barrier	Barrier
15	3	Accessible	Barrier	Barrier
16	1	Accessible	Barrier	Barrier
17	1	Accessible	Barrier	Barrier
18	3	Accessible	Barrier	Barrier
19	1	Accessible	Barrier	Barrier
20	3	Accessible	Accessible	Accessible
21	3	Accessible	Barrier	Barrier
22	1	Accessible	Barrier	Barrier
23	1	Accessible	Accessible	Accessible
24	3	Accessible	Barrier	Barrier
25	3	Accessible	Accessible	Accessible

Notes:
[a] Survey location reference numbers are shown on Figure 8.5.14.
[b] Type corresponds to following classifications: 1 = channel widening / riffle; 2 = abrupt changes in stream gradient (*i.e.*, a fall or drop); 3 = tributary that may become inaccessible.
[c] Q_{74} = flow level that is exceeded 74% of the time.
[d] Q_{95} = flow level that is exceeded 95% of the time.

To evaluate the fish passage barriers during extreme low-flow conditions, the HEC-RAS model (calibrated for Napadogan Brook) was used to simulate the water depths at the identified 25 locations of interest at flows that are exceeded 95% (*i.e.*, Q_{95}) of the time in the current baseline conditions (*i.e.,* Q_{95} conditions). Furthermore, the water depths were estimated for a Project Case at the same locations for Years 1-7 (when flow reductions are the greatest during Operation due to withholding water in the TSF without release) during Q_{95} flows. The model results indicated a negligible 1 cm reduction in water depth due to withholding water in the TSF for all reaches of Napadogan Brook downstream of Bird Brook.

The water depth reduction in the Project Case scenario translates into an alteration of the fish passage capabilities at Survey Location 1 only (Figure 8.5.12, Table 8.5.10). With the assumption that water depths of 1.5 times body depth are required for fish passage, fish passage at this location would be altered such that while fish up to 17 cm in fork length are able to pass in the baseline Q_{95} conditions; during Years 1-7 of Operation, the size threshold of fish able to pass this location would be reduced to 13.5 cm in fork length under Q_{95} flow conditions. In essence, the alteration at this location means that sufficient depths exist for Atlantic salmon parr and smaller brook trout (age 0-2+) to pass, but may present a barrier to passage of brook trout (or other fish) greater than 13.5 cm.

As described earlier, fish passage during the summer low flows is needed for fish to access areas of cooler water that provides temperature refugia when water temperatures are exceeding species-specific physiological thresholds for stress. At Survey Location 1 (on West Branch Napadogan Brook, approximately halfway between its confluence with Bird and Sisson brooks), water temperature is likely to exceed the upper thermal tolerance (*i.e.*, 19°C) for brook trout on the warmest summer days. An unnamed tributary with similar thermal characteristics as Bird and Sisson brooks is located approximately 150 m downstream of the pinch point (barrier) at Survey Location 3 (Figure 8.5.12 and Table 8.5.10). The distance between the pinch point and the cool water source is within the distance that Atlantic salmon parr from the Miramichi River have been observed to travel (Breau *et al.* 2011). Brook trout have similar swimming abilities as Atlantic salmon of the same size, and thus are likely able to access this cool water source if required.

Overall, the analysis of potential for habitat fragmentation due to lower flows as may occur as a result of Operation activities suggests that passage of Atlantic salmon is not expected to be impeded at any location. Since brook trout abundance is low in West Branch Napadogan Brook downstream of Bird Brook, and thermal refuge exists within the vicinity of the partial obstruction for brook trout which reside in that area, passage of brook trout is not expected to be adversely affected. Accordingly, the environmental effects of Operation on the Aquatic Environment with respect to fish passage are rated not significant.

8.5.4.3.2.9 Fish Health

Various Project-related activities during Operation may individually or collectively affect fish health; however, fish health is potentially most affected by increases in dissolved metals concentrations and increases in temperature. In both cases, as previously described, the residual changes arising from the Project are not anticipated to result in a decline of fish health.

In terms of the usability of the fisheries resource, the HHERA (Section 7.7) modelled the potential uptake of contaminants by fish and determined that risks to human or ecological health would not be substantive as a result of this pathway. Additionally, as will be discussed in Section 8.12 (Land and Resource Use), though recreational fishing will no longer be possible within the PDA, fishing in other parts of the LAA or RAA will continue to be possible and not substantially affected by the Project. Given these facts, and since fish health is not expected to decline as a result of the Project, the usability of the fisheries resource is not expected to be adversely affected in any substantive way and the environmental effects of the Project are considered not significant.

8.5.4.3.2.10 Fish Populations

The predicted downstream flow reduction and its potential to adversely alter habitat suitability in Napadogan Brook were examined by considering changes to adult Atlantic salmon spawning habitat. This species and life stage was selected because its requirements for habitat are explicitly known (Louhi *et al.* 2008), the requirements are narrower than habitat suitability requirement for other species and life stages inhabiting Napadogan Brook, and because of the Atlantic salmon is a federal SOCC and provincial SAR.

Atlantic salmon were present in the West Branch Napadogan and Lower Napadogan brooks. A single Atlantic salmon parr was observed in the residual segment of Bird Brook, near to the confluence with West Branch Napadogan Brook and two were identified in McBean Brook downstream of the PDA. As previously discussed for the residual environmental effects of the Construction phase, Atlantic salmon habitat is abundant in the LAA and RAA in the Napadogan and Nashwaak watershed outside of the PDA. The COSEWIC (2010) assessment and status report on the Atlantic salmon in Canada suggests poor marine survival rates as the primary cause of declining populations in the Maritime provinces, followed by climate change. Although degradation and fragmentation of freshwater habitats are noted as possible causes, these are not known to be factors in the LAA and RAA. The affected habitat is therefore not likely critical to Atlantic salmon and is not likely a limiting factor in their status.

The effects of flow reductions on average transect water velocity was examined using 62 cross-sections in the Napadogan Brook using the HEC-RAS model. The average water velocity reduction due to the flow changes was 3 cm/s in transects that were considered suitable for Atlantic salmon spawning (*i.e.,* 58 of the 62 examined transects), based on generalized spawning habitat preference curves in small streams (Louhi *et al.* 2008). The 3 cm/s velocity reduction did not affect the number of suitable transects for spawning (*i.e*., average velocity conditions between 20-90 cm/s), which means that all 58 transects with suitable average velocity conditions for spawning of Atlantic salmon in their existing condition would remain to be suitable during Operation. The modelling also resulted in an increase in the number of transects that provide preferable spawning velocities (*i.e*., average velocity conditions between 40-62 cm/s; Louhi *et al.* 2008) from 28 to 30 transects.

Poff and Zimmerman (2010) recently collated numerous studies examining the extent of flow alteration and the consequent ecological responses. Their meta-analysis did not support any general threshold level for flow alteration after which negative consequences would follow, but did conclude that the risk of ecological change increases with increasing level of alteration. Adverse changes in fish population abundance, demographic parameters, or diversity of fish populations resulting from flow reductions have been observed elsewhere when the flow magnitude is changed in excess of 50% relative to a pre-development reference condition. In the case of Napadogan and McBean brooks, the flow reductions are predicted in the range of 5 to 24% during the base flow conditions (Tables 7.4.7 and 7.4.9), well below the noted 50%.

The average reduction in water depth in Napadogan Brook modelled under mean annual flow conditions was 2 ± 1 cm for all transects. The effect of a reduction in water depth on habitat suitability for spawning of Atlantic salmon was considered to be biologically negligible, as Atlantic salmon spawning preferences show flexibility over a range of 5 to 40 cm water depth (Louhi *et al.* 2008). It should also be noted that the extent of the depth alteration attributable to Operation would be smaller

than typical daily fluctuations in water levels during the spawning season in the fall, when rainfall events are frequent.

Predicted changes in Atlantic salmon spawning habitat availability based on changes in stream width were modelled using mean annual flow (Q_{32}; see Section 7.4) during seasonal conditions that would be typical for spawning of Atlantic salmon. The results of the model suggest that any habitat loss will be limited to narrow strips of habitat at the stream edges, and is unlikely to render a spawning area unsuitable.

It is also recognized that spawning habitat selection of salmonid fishes is further affected by a range of other complex variables such as flow vorticity and velocity-energy gradients (Crowder and Diplas 2002). While potential changes in these variables were not directly assessed, the small predicted changes in hydraulic variables and high natural flow variability during the spawning season would be likely to maintain the integrity of spawning habitat.

Overall, Operation activities are not anticipated to result in changes to Atlantic salmon populations, and it is reasonably inferred that this will also be the case for other fish species that prefer the cool water habitat of West Branch Napadogan and Lower Napadogan brooks. The affected habitat is not likely critical to Atlantic salmon or American eel and is not likely a limiting factor in their status. The environmental effects of Operation on the Aquatic Environment with respect to fish populations are not significant.

8.5.4.3.2.11 Summary of the Residual Environmental Effects of Operation

With the proposed mitigation and environmental protection measures, the residual environmental effects of Operation activities on the Aquatic Environment are rated not significant. This determination has been made with a high level of confidence for most key aspects of the Aquatic Environment, and particularly in consideration of the compensation measures as mitigation for the indirect loss of fish habitat, and the planned water management measures, including the ability to apply adaptive management measures if needed, to mitigate the potential indirect environmental effects on fish and fish habitat downstream of the Project. However, where the results of predictive models are relied upon in assessing the potential environmental effects, a moderate level of confidence is ascribed to the significance determination, given the uncertainties previously identified. Further investigation and modelling prior to Construction will inform Project design and establish performance commitments for use in the rigorous Follow-up and Monitoring Program, which meets or exceeds the *MMER* requirements under Section 36 of the *Fisheries Act.* The Follow-up and Monitoring Program also includes programs to verify the EIA environmental effects predictions, provides multiple early warning mechanisms that are aimed at identifying potential adverse environmental effects, and will assist in the implementation of adaptive management measures to minimize the extent, magnitude, and duration of adverse environmental effects, in the unlikely event that they should occur.

8.5.4.3.3 Decommissioning, Reclamation and Closure

As noted in Section 8.5.4.1, the activities of Reclamation, Closure, Post-Closure, and Emissions and Wastes during Decommissioning, Reclamation and Closure may affect the following key aspects of the Aquatic Environment:

- Fish Habitat Area;
- Water and Sediment Quality;
- Productivity and the Benthic Macroinvertebrate Community; and
- Fish Passage, Fish Health, and Fish Populations.

The following sub-sections assess the residual environmental effects of potential changes in these key aspects on the Aquatic Environment during Decommissioning, Reclamation and Closure.

8.5.4.3.3.1 Fish Habitat Area

The indirect loss of approximately 67 units of fish habitat in West Branch Napadogan Brook as a result of decreased water volume as measured at the wetted perimeter (as was the case for Years 1-7 of Operation) will again occur during the approximately first 10 years of Closure as surplus water from the TSF is diverted to the open pit to fill it. During Post-Closure, once the pit is full, surplus water from the pit lake will be treated and discharged as necessary to the former Sisson Brook channel, thereby re-establishing flow and water levels in West Branch Napadogan Brook below the confluence with Sisson Brook to near pre-Project levels. The reach between Bird Brook and Sisson Brook confluences will continue to be as it was in Closure. These indirect losses of fish habitat are included in the Fish Habitat Compensation Plan, and thus there is no planned residual loss of fish habitat that is not compensated. With the associated compensation for residual environmental effects from indirect loss of fish habitat, and the consequent authorization under the *Fisheries Act*, the environmental effects of Decommissioning, Reclamation and Closure on the Aquatic Environment with respect to the loss of fish habitat area are rated not significant.

8.5.4.3.3.2 Water and Sediment Quality

The potential for the Reclamation, Closure, Post-Closure, and Emissions and Wastes activities to alter water and sediment quality is similar to that assessed for activities during Operation. Just as no surplus water was released during Years 1-7, surplus water will also not be released during the approximately 12 year Closure period as the open pit is being filled. During Post-Closure, treated surplus water will be released from the pit lake at an assumed similar discharge volume and chemistry to that which was released during Years 8-27 of Operation. Seepage will continue throughout the Closure and Post-Closure periods, with a composition and volumetric input into surface waters assumed to be constant in perpetuity and similar to that occurring during Operation, a conservative assumption. In reality, seepage composition and flow rate would be expected to improve over time during Decommissioning, Reclamation and Closure as there will no longer be new tailings and waste rock deposited into the TSF, and the metals enrichment of water passing through the TSF will decrease over time as the available metals on the surface of the tailings and waste rock particles are depleted. This is observed in the

results of the predictive water quality modelling (Knight Piésold 2013) as a decrease in the annual maximum metals concentrations at all modelling nodes. In most cases, where it also occurred during Operation, the modelling does predict the continued intermittent but non-chronic exceedances of applicable guidelines.

It is important to note that the predictive water quality modelling for the Decommissioning, Reclamation and Closure phase did not consider adaptive management mitigation measures, or the environmental benefits of reclamation activities (*e.g.,* capping of the tailings beaches), and therefore the results represent a potential worst case. It is anticipated that if adaptive management measures are required to avoid long-term exceedances of applicable guidelines from the release of seepage into surface waters, these measures would have already been implemented during Operation. In this case, mitigation measures would be in place prior to initiating Decommissioning, Reclamation and Closure, and significant adverse changes in metals concentrations would be avoided.

The above noted mechanisms will result in similarly reduced magnitudes of change for temperature, pH, DO and sediment quality during the Decommissioning, Reclamation and Closure phase as compared to those predicted for Operation. The environmental effects of Decommissioning, Reclamation and Closure on the Aquatic Environment with respect to water and sediment quality are thus rated not significant.

8.5.4.3.3.3 Productivity and Benthic Macroinvertebrate Community

As previously described for the Operation phase, the potential changes in the periphyton and benthic macroinvertebrate communities are related to the predicted changes in stream flow. Therefore, the potential residual environmental effects of Closure will be similar to those during Years 1-7 of Operation, and in the Post-Closure period will be similar to Years 8-27 of Operation. As with the Operation phase, the environmental effects of Decommissioning, Reclamation and Closure on the Aquatic Environment with respect to fish habitat productivity and the benthic macroinvertebrate community are rated not significant.

8.5.4.3.3.4 Fish Passage, Fish Health, and Fish Populations

As previously described for the Operation phase, the potential changes in fish passage, and some of the consequent environmental effects on fish populations, are primarily related to the predicted changes in stream flow. Therefore, the potential residual environmental effects of Closure on fish passage and fish populations will be similar to those during Years 1-7 of Operation, and in the Post-Closure period will be similar to Years 8-27 of Operation. Similarly, the potential changes to fish health, and some of the potential changes to fish populations, are related primarily to the changes in water quality and will therefore be similar to those during Years 1-7 of Operation, and in the Post-Closure period will be similar to Years 8-27 of Operation. As with the Operation phase, the environmental effects of Decommissioning, Reclamation and Closure on the Aquatic Environment with respect to fish passage, fish health, and fish populations are rated not significant.

8.5.4.3.4 Summary of the Residual Environmental Effects of Decommissioning, Reclamation and Closure

The residual environmental effects of Decommissioning, Reclamation and Closure are predicted to be very similar to those assessed for Operation, in most cases. With the proposed mitigation and environmental protection measures, the residual environmental effects of Decommissioning, Reclamation and Closure activities on the Aquatic Environment are rated not significant. This determination has been made with a high level of confidence for most key aspects of the Aquatic Environment, and particularly in consideration of the compensation measures as mitigation for the indirect loss of fish habitat, and the planned water management measures, including the ability to apply adaptive management measures if needed, to mitigate the potential indirect environmental effects on fish and fish habitat downstream of the Project. However, as with Operation, where the results of predictive models are relied upon in assessing the potential environmental effects, a moderate level of confidence is ascribed to the significance determination, given the uncertainties previously identified. Further investigation and modelling prior to Construction will inform Project design and establish performance commitments for use in the rigorous Follow-up and Monitoring Program, which meets or exceeds the *MMER* requirements under Section 36 of the *Fisheries Act.* The Follow-up and Monitoring Program also includes programs to verify the EIA environmental effects predictions, provides multiple early warning mechanisms that are aimed at identifying potential adverse environmental effects and will assist in the implementation of adaptive management measures to minimize the extent, magnitude, and duration of adverse environmental effects, in the unlikely event that they should occur.

8.5.5 Assessment of Cumulative Environmental Effects

In addition to the Project environmental effects discussed above, an assessment of the potential cumulative environmental effects was conducted for other projects or activities that have potential to cause environmental effects that overlap with those of the Project, as identified in Table 8.5.7. Table 8.5.11 below presents the potential cumulative environmental effects to the Aquatic Environment, and ranks each interaction with other projects or activities as 0, 1, or 2 with respect to the nature and degree to which important Project-related environmental effects overlap with those of other projects or activities.

Table 8.5.11 Potential Cumulative Environmental Effects to the Aquatic Environment

Other Projects or Activities With Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects Change in the Aquatic Environment
Past or Present Projects or Activities That Have Been Carried Out	
Industrial Land Use (Past or Present)	0
Forestry and Agricultural Land Use (Past or Present)	2
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Past or Present)	1
Recreational Land Use (Past or Present)	1
Residential Land Use (Past or Present)	0
Potential Future Projects or Activities That Will Be Carried Out	
Industrial Land Use (Future)	0
Forestry and Agricultural Land Use (Future)	2
Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons (Future)	1

Table 8.5.11 Potential Cumulative Environmental Effects to the Aquatic Environment

Other Projects or Activities With Potential for Cumulative Environmental Effects	Potential Cumulative Environmental Effects
	Change in the Aquatic Environment
Recreational Land Use (Future)	1
Planned Residential Development (Future)	0

Cumulative Environmental Effects
Notes:
Cumulative environmental effects were ranked as follows:
0 Project environmental effects do not act cumulatively with those of other projects or activities that have been or will be carried out.
1 Project environmental effects act cumulatively with those of other projects or activities that have been or will be carried out, but are unlikely to result in significant cumulative environmental effects; or Project environmental effects act cumulatively with existing significant levels of cumulative environmental effects but the Project will not measurably contribute to these cumulative environmental effects on the VEC.
2 Project environmental effects act cumulatively with those of other projects or activities that have been or will be carried out, and may result in significant cumulative environmental effects; or Project environmental effects act cumulatively with existing significant levels of cumulative environmental effects and the Project may measurably contribute to adverse changes in the state of the VEC.

No interactions are anticipated between the environmental effects of the Project and those of past, present or future Industrial Land use or Residential Land Use, and thus these interactions have been ranked as 0 in Table 8.5.11. Past or present Industrial Land Use within the vicinity of the Project is limited to a veneer mill located in Napadogan and former forest processing operations in Deersdale and Juniper, both of which have permanently ceased operation, and no known industrial facilities are planned near the LAA. Residential Land Use is most prevalent in urban areas of the RAA that are not near the LAA, and there are no known large-scale future residential developments planned for the vicinity of the LAA. Environmental effects on the Aquatic Environment resulting from past, present, or future Industrial Land Use and Residential Land Use in the RAA are thus not anticipated, and a measurable adverse cumulative environmental effect on the Aquatic Environment is not expected to occur.

Past, present and future Current Use of Land and Resources for Traditional Purposes by Aboriginal Persons were identified as having some potential for cumulative environmental effects to occur in combination with the Project, and were ranked as 1 in Table 8.5.11. Land and resources within the RAA have been, and will likely continue to be, used for traditional purposes by Aboriginal persons. With respect to the Aquatic Environment, this includes activities such as fishing and timber harvesting. These activities are currently occurring at presumably sustainable levels within the RAA. Timber harvesting by the 15 First Nations communities in New Brunswick is conducted under agreements with NBDNR. The environmental effects of past, present and future current use of land and resources for traditional purposes by Aboriginal persons in combination with the environmental effects of the Project are thus not likely to result in significant adverse cumulative environmental effects on the Aquatic Environment.

Past, present and future Recreational Land Use were identified as having some potential for cumulative environmental effects to occur in combination with the Project, and were ranked as 1 in Table 8.5.11. Recreational land use, including recreational fishing, trail development and all-terrain vehicle use, occurs and will continue to occur within the RAA. Fishing may affect the Aquatic Environment through direct mortality of recreational fish species (*e.g.*, brook trout) but is an authorized activity under the New Brunswick *Fish and Wildlife Act*. Trail development and all-terrain vehicle use may affect the Aquatic Environment through activities related to watercourse crossings and have the potential to result in HADD of fish habitat, obstruction of fish passage, and direct mortality of fish. However, these activities

occur on a very small spatial and temporal scale, and the environmental effects of past, present and future Recreational Land Use in combination with the environmental effects of the Project are not likely to result in significant adverse cumulative environmental effects on the Aquatic Environment.

Therefore, the cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out for all interactions that were ranked as 0 or 1 in Table 8.5.11 on the Aquatic Environment are rated not significant and are not discussed further.

The environmental effects of projects or activities that will potentially overlap with the environmental effects of the Project ranked as 2 in Table 8.5.11 (and thus have the potential to result in cumulative environmental effects in combination with the Project) include past, present and future Forestry and Agricultural Land Use. To address the potential cumulative interactions listed above and ranked as 2, a cumulative environmental effects assessment for Change in the Aquatic Environment was conducted in relation to the Project. The cumulative environmental effect mechanisms, mitigation measures and characterization of residual cumulative environmental effects are presented in Table 8.5.12 below.

Table 8.5.12 Summary of Residual Cumulative Environmental Effects on the Aquatic Environment

Cumulative Environmental Effects	Case	Other Projects, Activities and Actions	Mitigation / Compensation Measures	Residual Cumulative Environmental Effects Characteristics						Significance	Prediction Confidence	Likelihood	Recommended Follow-up or Monitoring
				Direction	Magnitude	Geographic Extent	Duration and Frequency	Reversibility	Ecological/ Socioeconomic Context				
Change in the Aquatic Environment	Cumulative Environmental Effects with Project	• Past or Present Forestry and Agricultural Land Use. • Potential Future Forestry and Agricultural Land Use.	• As listed in Table 8.5.8.	A	L	R	P/ C	R	D	N	H	-	• None recommended beyond those measures recommended in Table 8.5.8.
	Project Contribution to Cumulative Environmental Effects			A	L	L	LT/ O	R	D	N	H	-	

KEY

Direction
- P Positive.
- A Adverse.

Magnitude
- L Low: No change, or negligible Change in the Aquatic Environment.
- M Medium: Measurable change to the Aquatic Environment that is within applicable guidelines, legislated requirements, and/or federal and provincial management objectives, or that does not affect the sustainability of fish populations.
- H High: Measurable change to the Aquatic Environment that is not within applicable guidelines, legislated requirements, and/or federal and provincial management objectives, or that results in a change in the sustainability of fish populations.

Geographic Extent
- S Site-specific: Within the PDA.
- L Local: Within the LAA.
- R Regional: Within the RAA.

Duration
- ST Short-term: Occurs and lasts for short periods (*e.g.,* days/weeks).
- MT Medium-term: Occurs and lasts for extended periods of time (*e.g.,* years).
- LT Long-term: Occurs during Construction and/or Operation and lasts for the life of Project.
- P Permanent: Occurs during Construction and Operation and beyond.

Frequency
- O Occurs once.
- S Occurs sporadically at irregular intervals.
- R Occurs on a regular basis and at regular intervals.
- C Continuous.

Reversibility
- R Reversible.
- I Irreversible.

Ecological/Socioeconomic Context
- U Undisturbed: Area relatively or not adversely affected by human activity.
- D Developed: Area has been substantially previously disturbed by human development or human development is still present.
- N/A Not Applicable.

Significance
- S Significant.
- N Not Significant.

Prediction Confidence

Confidence in the significance prediction, based on scientific information and statistical analysis, professional judgment and known effectiveness of mitigation:
- L Low level of confidence.
- M Moderate level of confidence.
- H High level of confidence.

Likelihood

If a significant environmental effect is predicted, the likelihood of that significant environmental effect occurring (if applicable), based on professional judgment:
- L Low probability of occurrence.
- M Medium probability of occurrence.
- H High probability of occurrence.

Other Projects, Activities, and Actions

List of specific projects and activities that would contribute to the cumulative environmental effects.

8.5.5.1 Cumulative Environmental Effects Mechanisms

The cumulative environmental effects mechanisms for a Change in the Aquatic Environment are described below. Projects or activities with the potential to overlap with the environmental effects of the Project are limited to past, present and future Forestry and Agricultural Land Use.

Past, present and future agricultural land use is not expected to act cumulatively with the Project on the Aquatic Environment; there is no known existing or planned agricultural developments within the LAA. Agricultural activities are mostly limited to southern regions of the RAA, which contain more private land. Forestry activities have occurred in much of the RAA for several decades, and will continue to occur for the foreseeable future; however, a recent downturn in the forestry sector (Government of New Brunswick 2010) suggests that future forestry activities may be reduced relative to past forestry activities.

Environmental effects of past, present and future forestry activities on the Aquatic Environment can occur as a result of watercourse crossings for forest roads, as well as timber harvesting practices such as clear cutting. Watercourse crossings for forest road development have the potential to result in HADD of fish habitat, obstruction of fish passage, and direct mortality of fish. Clear cutting can increase soil erosion, potentially resulting in sedimentation in fish-bearing watercourses. Timber harvest in riparian buffers can reduce the forest canopy over fish-bearing watercourses, potentially resulting in increased water temperature. Forestry activities can affect water quality through increases in nutrients, increases in suspended sediment, increases in dissolved organic carbon and increases in mercury (Dallaire 2006). Forestry activities can alter benthic macroinvertebrate communities and these effects can continue for up to 15 years or more after timber harvest (Martel *et al.* 2007).

Forest harvesting and management on New Brunswick's Crown land is an industry that is tightly controlled and managed by NBDNR. The Crown lands are divided into 10 licenses that are leased to licensees. NBDNR and forest licensees work together to achieve specific objectives relative to economics, wood supply, and social and environmental goals. These goals are achieved through 25-year management plans (updated every five years) that are produced by the licensee to demonstrate how they will meet NBDNR's sustainability goals and objectives. In addition, licensees must submit detailed annual operating plans that specify where harvesting and other silvicultural operations will be carried out. The annual maximum volume per tree species that can be harvested sustainably within a particular forest licence is known as the annual allowable cut (AAC). Typical modern forest management practices would avoid cutting of any vegetation and timber within 30 m of a watercourse or wetland, otherwise such activities would need to be conducted under a permit issued under the New Brunswick *Watercourse and Wetland Alteration Regulation.*

Nonetheless, residual Project environmental effects may act in combination with environmental effects of past, present or future forestry activities and potentially result in cumulative environmental effects on the Aquatic Environment.

8.5.5.2 Mitigation of Cumulative Environmental Effects

Mitigation measures for Project-related environmental effects (Section 8.5.4.2) are also anticipated to be effective in mitigating any cumulative environmental effects. There are no additional mitigation measures recommended or required beyond these previously described mitigation measures.

8.5.5.3 Characterization of Residual Cumulative Environmental Effects

Base Case

Overall, fish habitat in the RAA is of high quality and the watercourses in the vicinity of the Project support fish communities that are typical of a central New Brunswick watershed. That said, Atlantic salmon populations have declined at a precipitous and alarming rate in recent decades, such that the Outer Bay of Fundy stock has been ranked as "Endangered" by COSEWIC, and listed as "Endangered" by NB *SARA*. The primary reasons attributed by COSEWIC (2010) to this decline are believed to be reduced marine survival rates and climate change. Degradation and fragmentation of freshwater habitat are also believed by COSEWIC to be contributing factors, though these are not known to be habitat limiting factors in the RAA in the base case, with the exception of Lower Lake Dam which is believed to be a partial obstruction to Atlantic salmon passage during low flow periods. A Recovery Potential Assessment is currently being undertaken in support of the decision to list the species in SARA, though it is considered improbable that OBoF Atlantic salmon populations will recover beyond their current numbers (CRI 2011). These baseline conditions reflect the past and present forest management practices within the LAA and RAA.

Project Case

As presented in Table 8.5.7, the Project-related environmental effects on Aquatic Environment will be mitigated through the use of well-established and proven mitigation measures, as well as Project-specific mitigation measures. Project-related loss of fish habitat will be mitigated with fish habitat compensation such that no residual environmental effects occur. The primary residual environmental effects of the Project on key aspects of the Aquatic Environment are the predicted changes in water quality (*i.e.*, metals, temperature, pH, DO) during Operation as well as during Decommissioning, Reclamation and Closure. The Project is not anticipated to result in the loss of habitat that is considered critical for Atlantic salmon, or in effects to the health of Atlantic salmon such that their populations decline or are prevented from recovering.

Future Case

Environmental effects of future forestry activities in the Napadogan watershed could act in combination with residual environmental effects of the Project during Operation as well as Decommissioning, Reclamation and Closure, resulting in a cumulative environmental effect on water quality. Forest harvesting has occurred for more than a century in the RAA. While some past forest harvesting practices (*e.g.*, installation of water control dams) undoubtedly had significant environmental effects on Atlantic salmon, with mature forest management practices that are reviewed periodically and subject to government oversight (which include avoidance of any forest harvesting activity within 30 m of a watercourse), significant adverse environmental effects to the Aquatic Environment are not expected from such activities. Other than those associated with the Project, it is not likely that any new forest roads will be required in the LAA; however, if constructed, watercourse crossings will be designed in compliance with the *Fisheries Act* and the New Brunswick *Watercourse and Wetland Alteration Regulation*. With the continued implementation and updating of forest management plans, future forestry activities can be expected to be carried out in a manner that will sustain the fish and fish habitat in the RAA.

8.5.6 Determination of Significance

8.5.6.1 Residual Project Environmental Effects

The direct and indirect loss of fish habitat will be authorized by DFO prior to beginning the Project, and compensated for as described in the Conceptual Fish Habitat Compensation Plan. Therefore, no residual change in fish habitat is expected as a result of direct and indirect loss of fish habitat arising from the Project.

Predictive water quality modelling conducted for this EIA has shown that the concentrations of certain trace metals released by the Project through seepage and/or treated surplus water release may exceed the CCME FAL or other applicable guideline values for some parameters in downstream receiving watercourses on an intermittent, short-term, and localized basis. While potential exceedances of guideline values as predicted by the model (with its inherent conservatism and assumptions) are certainly a cause for close oversight, monitoring, and adaptive management by Northcliff, such potential exceedances are not sufficient to result in a determination of significant residual environmental effects on the Aquatic Environment. This is because the conservative nature of the assumptions and methods used to generate the source terms for the release of these metals, the associated conservatisms in the predictive modelling techniques that attempt to represent anticipated conditions well into the future, and the inherent limitations of predictive models themselves (which generally use simplified representations of what are actually very complex physical and chemical processes), all result in predicted water quality concentrations that will tend to be lowered with additional site investigations and refined modelling during detailed Project design. Follow-up and monitoring will be conducted throughout the Project life to verify these model results and associated environmental effects predictions, and Northcliff will actively respond to any elevated concentrations of concern through adaptive management and implementation of additional mitigation as necessary so as to remain in compliance with environmental legislation. Regardless, the Project will necessarily need to comply with the discharge limits of *MMER* and those of the provincial Approval to Operate.

Specifically with respect to total dissolved copper levels, the water quality model has predicted that copper concentrations in downstream watercourses will exceed both CCME and USEPA guidelines throughout most of the Operation and Decommissioning, Reclamation and Closure phases. However, the predicted copper levels are intermittent (*i.e.,* seasonal, not chronic or continuous), reflect total dissolved copper (*i.e*., the toxic cupric ion will be only a portion of the projected totals), and are based on a water quality model that makes conservative assumptions regarding metal leaching and seepage migration. The Follow-up and Monitoring Program (Section 8.5.7 and Chapter 9) includes several studies designed to confirm this prediction (*e.g*., surface water quality monitoring, and metals in fish tissue). In addition, hydrogeological and geotechnical investigations will be undertaken in the TSF area prior to Construction to improve Project understanding of the hydrogeology of the area and thus support detailed design of the water management systems. These investigations will also support refining the assumptions of the water quality modeling, and the possible selection of adaptive management and mitigation measures as described in Section 8.5.4.2, should they be needed as determined through the Follow-up and Monitoring Program. The refined information will be used to confirm conservatisms and assumptions made in modeling and ensure that actual water quality will assure that environmental effects will not risk ecological or fish health. Similarly to copper, the other metals that were assessed will also be subject to the Follow-up and Monitoring Program and the adaptive management mitigation measures. In consideration of these factors and the residual environmental effects significance criteria,

and with proposed follow-up, monitoring, and adaptive management by Northcliff in the event of elevated water quality parameters of concern, the likely residual environmental effects of incremental changes in metals concentrations and other related water quality parameters in fish-bearing waters resulting from the Project on the Aquatic Environment are anticipated to be not significant, subject to confirmation in the follow-up program.

The West Branch Napadogan Brook below the confluence of Bird Brook is at present frequently exceeding critical temperature thresholds for brook trout, and therefore this stream section is considered to be generally unsuitable for brook trout during the warmest summer months. The predicted minor increase of temperature in this stream section is therefore not likely to exacerbate these conditions on brook trout to any substantive degree. For Atlantic salmon, a federal SOCC and provincial SAR, the increase in water temperature will not limit habitat suitability at the modelled temperatures and flows. Therefore, slight warming of water temperature as is predicted during the Operation and Decommissioning, Reclamation, and Closure phases is not anticipated to result in a significant residual adverse environmental effect on the Aquatic Environment. Potential changes to sediment quality, fish habitat productivity, the benthic macroinvertebrate community, fish passage, fish health, and fish populations are similarly not expected to result in a significant adverse environmental effect on the Aquatic Environment.

With the proposed mitigation and environmental protection measures, the residual environmental effects of the Project on the Aquatic Environment during all phases are rated not significant. This determination has been made with a high level of confidence for most key aspects of the Aquatic Environment, and particularly in consideration of the compensation measures as mitigation for the direct and indirect loss of fish habitat resulting from the construction of the Project, and the planned water management measures—including the ability to apply adaptive management measures if needed—to mitigate the potential indirect environmental effects on fish and fish habitat downstream of the Project during Operation and Decommissioning, Reclamation and Closure. However, where the results of predictive models are relied upon in assessing the potential environmental effects a moderate level of confidence is ascribed to the significance determination, given the uncertainties previously identified. In all cases, the rigorous Follow-up and Monitoring Program, which meets or exceeds the *MMER* requirements under Section 36 of the *Fisheries Act* and also includes programs to verify the EIA environmental effects predictions, provides multiple early warning mechanisms that are aimed at identifying potential adverse environmental effects and will assist in the implementation of adaptive management measures to minimize the extent, magnitude, and duration of adverse environmental effects, in the unlikely event that they occur.

8.5.6.2 Residual Cumulative Environmental Effects

The characterization of the potential cumulative environmental effects and associated mechanisms, combined with the mitigation measures proposed in Section 8.5.4.2, have led to the conclusion that the residual cumulative environmental effects of the Project in combination with other projects or activities that have been or will be carried out (particularly with respect to past, present or future forestry land use) on the Aquatic Environment are rated not significant. This determination has been made with a high level of confidence as a result of the combination of careful Project design and planning, the application of well-established and proven mitigation measures, and NBDNR regulated forestry management.

Additionally, the proposed mitigation measures demonstrate that the Project contribution to the cumulative environmental effects on the Aquatic Environment is rated not significant. This determination has been made with a high level of confidence.

8.5.7 Follow-up or Monitoring

Follow-up or monitoring programs will be implemented for the Aquatic Environment as presented in Table 8.5.7 and as listed below. Additional details on the follow-up and monitoring programs are presented in Chapter 9.

Follow-up to verify the environmental effects predictions or the effectiveness of mitigation is proposed as follows.

- To confirm the residual environmental effects of Project-related changes in water temperature on the Aquatic Environment, the predictions of the water temperature modelling will be verified by comparing the predicted values against an observed temperature at two different time periods during the Operation phase.

- To confirm the residual environmental effects of Project-related changes in stream flows on the Aquatic Environment, the stream flow at the existing hydrometric stations (B-2, SB-1, NB-2B, TL-2 and MBB-2) will be observed. The measured flows will be compared to the equivalent pre-Project stream flow rates calculated from the Narrows Mountain Brook (NMB) station operated by Environment Canada. Knight Piésold (2012d) has demonstrated a strong correlation of pre-Project flows at the Project hydrometric stations to the NMB station.

- To verify the accuracy of the predictions related to the fish passage analysis in the Napadogan Brook in the areas downstream of Bird Brook, a comparative survey will be undertaken during low-water conditions (flows below Q_{85}). In the autumn of the same year, a spawner survey for adult Atlantic salmon will be carried out in Napadogan Brook to further confirm that the fish can ascend to areas above Bird Brook.

- To ensure that the lower flows have not resulted in accumulation of fine sediments in the Napadogan Brook, a survey of substrate embeddedness will be carried out between Years 1-7 of Operation.

- Fish tissue studies will be undertaken to verify that potential changes in trace metal concentrations in water, as are predicted by the water quality model, have not caused adverse environmental effects to fish (*i.e.*, their population, distribution, fecundity) to the extent that would be considered a significant change. While specific regulatory guidelines or threshold levels to define an “effect” on fish tissue do not currently exist for the trace metals apart from mercury, the data will be collected so that trends can be analyzed against the known baseline information. The sampling will be carried out in ten study sites that will subsequently be used for compliance Environmental Effects Monitoring.

- As part of the Water Resources Follow-up Program, water quality released from the starter pit will be sampled to determine the requirement for water treatment during Construction. This will include the collection of water samples from the outlet of the sedimentation pond, which will be submitted for laboratory analysis of general chemistry and metals.

- As part of the Water Resources Follow-up Program, the surface water quality in McBean and Napadogan brooks will be sampled to confirm the predicted water quality in the receiving environments, with comparison to the Health Canada GCDWQ and CCME FAL or other applicable guidelines.

Monitoring will be conducted to ensure the Project meets applicable legislation, regulations and guidelines, as follows.

- Regulatory compliance monitoring studies will consist of three main components, pursuant to *MMER*, as follows:

  - deleterious substance, pH, and acute lethality testing (*MMER* Sections 12-17);

  - effluent and water quality monitoring studies comprising of effluent characterization, sub-lethal toxicity testing and water quality monitoring (*MMER*, Schedule 5, Part 1); and

  - biological monitoring studies in the aquatic receiving environment to determine if mine effluent is having an effect on fish, fish habitat, benthic macroinvertebrates, or the usability of fisheries resources (*MMER*, Schedule 5, Part 2).

- As part of the Water Resources Monitoring Program, TSS will be monitored in run-off from construction sites.

- As part of the Water Resources Monitoring Program, water quality monitoring from TSF water management ponds and groundwater monitoring wells around the perimeter of the TSF will begin during Operation, and continue Post-Closure until such time that the water quality is of acceptable quality that can justify the termination of monitoring.